North 25

Dubai Harbour

Environmental Impact Assessment

January 2018

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Executive Summary

Project Description

North 25 LLC (North 25) proposes the development of Dubai Harbour (Project), a waterfront development featuring the Middle East's largest marina. The Project site is located around Logo Island at the base of the Palm Jumeirah between Mina Seyahi and Skydive Dubai and it will cover an area of approximately 2 million square metres (m^2).

The Project will integrate Skydive Dubai, Dubai International Marine Club (DIMC) and Logo Island into one suburb and will include commercial, residential, transport and community facility land uses. Key developments proposed include four marinas, an iconic lighthouse, a cruise ship terminal, a shopping mall, high and medium density residential towers and hotels, retail spaces and a sports and events destination area.

North 25 propose to modify Logo Island by extending the reclaimed area, developing beaches on the north and south side and undertaking demolition works to remove existing reinforced concrete foundations, pre-cast elements and rock structures. A temporary causeway to connect Logo Island and DIMC was completed in May 2017. In addition, the dredging of a new channel is required to allow cruise liner access to the development, which will be partly following an existing trench along Palm Jumeirah to limit dredging volumes and dredge material will be re-used as reclamation fill wherever possible.

Objectives of the Environmental Impact Assessment (EIA)

The EIA is considered an important planning tool in ensuring that developments are undertaken without undermining the conservation and protection of the environment.

An EIA aims to identify and assess the environmental impacts of a project, and subsequently incorporate appropriate preventative and mitigation measures in the project planning and design process as well as during the construction and operational stages. It is in line with these principles and objectives that the Dubai Harbour EIA has been undertaken.

The EIA was prepared primarily in accordance with requirements set out in the following guidelines, as well as the applicable local, regional and international laws and regulations:

- Technical Guideline No. 1 – Environmental Impact Assessment (January 2017); and
- Technical Guideline No. 2 – EIA Requirements for Land Development, Infrastructure and Utility Projects (January 2017).

EIA Methodology

The EIA adopted a combination of the following:

- Stakeholder consultation;
- Environmental site inspections;
- Literature review;
- Field surveys to collect quantitative baseline data;
- Qualitative and quantitative impact assessments including modelling assessments;
- Identification of appropriate mitigation measures; and
- Establishment of an environmental management and monitoring programme for the construction and operation phases of the Project.

Key Sensitive Receptors

The principal environmentally sensitive receptors that have the potential to be impacted by the proposed development are:

- Existing and future residents in the in the vicinity of the Project in Pearl Jumeirah, Dubai Marina and Jumeirah Beach Residences and Nakheel;
- Employees and guests at the commercial and retail facilities in the vicinity of the Project (e.g. Skydive Dubai, DIMC, Bluewaters Island, boat tour companies who operate in the area, and hotels within 1 km of the project (e.g. Westin, Le Meridian Hotels, One and Only Royal Mirage, Fairmont, The Palm, FIVE Palm, Ritz Carlton JBR, Habtoor Grand Resort, Le Meridien Mina Seyahi, Hilton Jumeirah Beach and Sheraton Jumeirah beach), and properties and hotels on the west of The Palm Crescent Road, which may be affected by channel dredging activities (e.g. Grandeur Residences, W Dubai The Palm, Alef Residences, Kempinski Hotel and Residences, The 8 Hotel and Residences, Kingdom of Sheba, etc.));
- Visitors to the area that use leisure amenities in the vicinity and adjacent beaches;
- Marine water and sediment quality; and
- The flora and fauna in the marine environment, although this was generally recorded to be of low density and diversity within the impact zone, likely due to historic disturbance from nearby existing projects.

Project Development

The Project will comprise four main zones (Cruise Terminal and Lighthouse Platform Zone, Palm View Marina and Beachfront Zone, Harbour View Zone, Bay Marina and Operational zone, and Main Marina Zone), which will be constructed concurrently. An early works No-Objection Certificate (NOC) was obtained in March 2017 to commence site enabling works such as demolition of existing structures, removal of debris and construction of a temporary causeway, which was completed in May 2017. Marine works are expected to take at least 18 months and would be completed by the end of 2018. Once marine works are completed, construction works will commence and are scheduled for completion by the end of 2021.

Major Environmental Impacts

It is anticipated that relatively minor environmental impacts will be generated on climate, geology, soil and groundwater, terrestrial ecology, waste management and socio-economics. The major potential impacts identified in the EIA for the construction and operational phases of the proposed development are summarised below.

Construction Phase

Marine Ecology – Habitat Loss and Modification

The proposed project works include the deconstruction of existing breakwaters and groynes, the reclamation of land and the dredging of an access channel. In terms of the removal of breakwaters, the areas of breakwaters that would be removed are located around Logo Island, which was constructed relatively recently and is therefore predominantly comprised of a bivalve dominated fouling community. For the dredging activities, much of the area to be dredged has already been dredged as part of previous Projects and is therefore already highly disturbed.

While the loss and modification of habitat within the Project site is considered permanent, irreversible and cumulative for the replacement of marine habitat with land, the effect on the marine community from removal of breakwaters and the dredged areas is reversible and temporary as infauna can recolonise disturbed habitats and fishes will return to the habitats once construction ceases. Further, the existing marine communities in the areas to be dredged or reclaimed are considered to be of low ecological value and as such the impact is considered to be moderate.

Dispersion and Deposition of Fine Sediments

Dredging and reclamation activities generate plumes of suspended sediments that can remain suspended in the water column for an extended period of time. The impact can be divided into two aspects, increased suspended sediments load in the water which increases shading on the seabed and may have a deleterious effect on photosynthetic organisms, and sediment deposition, which can cause smothering of benthic communities.

Modelling of the suspended sediments predicted that values will generally remain within guideline limits and will not disperse to sensitive receivers. However, it is predicted that some deposition may occur within the Palm Jumeirah flushing channel and towards the Dubai Marina. The use of silt curtains to prevent dispersion to these areas will be important.

Short term and localised increases in turbidity associated with dredging and reclamation are considered unlikely to impact long term on the broader distribution of seagrass and other benthic communities within the Project site and surrounding areas. However, a moderate short-term impact is likely.

Noise Emissions from Construction Works

Earthworks, piling and reclamation are likely to generate the greatest noise levels during the construction phase. Due to elevated baseline noise levels, noise modelling results were compared to incremental allowable noise limits. Noise modelling predicted that cumulative noise levels would be within the allowable incremental noise levels at the majority of assessed sensitive receivers during the day time and night time, with the exception of two locations, namely southwest of the Palm Jumeirah and at the DIMC breakwaters. However, if modelled noise levels are compared against the standard guideline limits (rather than the incremental limit), noise levels are predicted to exceed the limits at all assessed sites during the night time and at 66% of the sites during the daytime. It must be noted that the assessment conservatively considered all construction equipment operating across the Project site simultaneously, and that the assessment predicts somewhat conservative noise levels. However, elevated noise levels are anticipated, which could result in detrimental impacts such as sleep disturbance and potential minor hearing loss for nearby sensitive receivers and workers within the construction site.

Fugitive Dust Emissions

Operations such as earthworks, material loading, concrete grinding and vehicle movements over unpaved surfaces will generate dust during the construction phase. It is anticipated that the extent of dust emissions would vary from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions. It is anticipated that there will be earthworks and excavations within 1 km of the sensitive receptors, although separated by sea. Given that the prevailing wind direction is from the north-west, and in the absence of mitigation measures, dust levels would be expected to be elevated at the sensitive receptors during construction. Elevated dust emissions can cause irritation to the eyes and throat for both human and animal receptors, in addition to increasing the likelihood of respiratory diseases such as asthma. Implementation of appropriate mitigation measures is essential to reducing the level of dust associated with construction.

Impacts of Disposal of Unsuitable Dredged Materials

An estimated 4.7 million m^3 of materials will be generated during the dredging of the navigation channel where unsuitable material may range from 922,300 m^3 to 3,864,000 m^3 before mitigation measures are applied. Disposal of unsuitable dredged materials at sea (offshore) may impact the physical as well as chemical characteristics of water. Benthic organisms are mostly affected during disposal as these organisms as well as other animals may become smothered and die of suffocation. Onshore disposal usually requires processing of raw material in a nearshore environment, which will have direct impact on the land used for the process, as well as potentially releasing suspended sediments adjacent sensitive receptors in the nearshore environment. Transportation of the dredged material from the processing area to the disposal site would require an estimated 30,000 to 50,000 truck movements and would create significant traffic impact. There would also be direct physical impacts and potential to contaminate the disposal site.

Amenity Impacts

During construction of the Project, the surrounding residential and commercial areas are expected to experience a reduction in amenity. This would include the visual impact of construction (cranes and equipment blocking the existing views), an increase in dust and noise levels, increased traffic and congestion from construction vehicles and an influx of migrant workers to the area. While the residents of Dubai are accustomed to these impacts to a degree, this could result in complaints from the community and local business owners.

Operational Phase

Altered Hydrodynamics and Flushing

The addition of the Dubai Harbour structures and reclaimed land will alter the existing coastal processes and flushing in the surrounding area. Hydrodynamic modelling predicted that peak current speeds will generally remain within ±0.05 m/s of existing conditions, indicating minimal alterations. However, there are some localised areas which are predicted to alter by up to ±0.2 m/s, including the channel between the southern breakwater of Palm Jumeirah and Logo Island (increased current speed) and in vicinity of the proposed Main Marina (reduced current speed). These alterations could result in increased erosion and sedimentation, respectively, with associated impacts to the surrounding marine ecology.

With regards to flushing, the proposed Project is predicted to improve conditions at the existing DIMC marina through reconfiguration into a more open marina. Further, flushing conditions at JBR beach are predicted to be improved. At Mina Al Seyahi Beach, a slight reduction in water exchange is expected, however; flushing will remain very good, meeting the required flushing criteria, therefore water quality is not expected to deteriorate.

A reduction in the flushing rate is predicted for the Dubai Marina Canal, which has the potential to contribute to poor water quality. However, modelled water exchange in the Canal currently exceeds the flushing criteria, and there has been no recorded impact on water quality. Should a significant negative impact on the water quality be observed as a result of Dubai Harbour, appropriate mitigation measures will be undertaken to ensure that water quality continues to comply with the DM Water Quality Objectives. Modelling has shown that pumping seawater into the middle of the channel would be an effective mitigation measure.

Increased Traffic Volumes

An increase in road and marine traffic on the surrounding networks and the associated noise level increase is anticipated once the Project becomes fully operational. The anticipated road traffic increase will contribute to the cumulative strain placed on the existing road network and additional congestion is probable without upgrades to the road network or implementation of traffic management strategies.

Utilities

The operational phase of the Project will increase the demand for utilities including power, potable water and sewage networks. The additional strain on the available resources will contribute to an increase in GHG emissions associated with the operation of the power plant and the potential marine impacts from the desalination plants and stormwater discharges.

Socio-economic

The Project will greatly enhance tourism in Dubai while playing a vital role in raising Dubai's global profile as a cruise ship hub capable of accommodating 6000 passengers at one time. The Project is also anticipated to enhance the amenity of the surrounding communities such as JBR, Dubai Marina and Palm Jumeirah, as it will provide a range of services and facilities including sports, recreation, food and beverage. Further, the Dubai Lighthouse is expected to provide a visual highlight for the area. The long-term positive impact or contribution of the Project on the Emirate's socio-economic development is considered significant as business and employment opportunities will be generated once hotel resorts, commercial and retail establishments as well as entertainment and leisure facilities are completed.

Proposed Mitigation Measures

Construction Phase

Dredged Material from the Navigational Channel

Various options may be applied to reduce the volume of unsuitable material. These measures include:

- Reusing fill material with high fines content by compacting, used in landscaping and exporting to other project sites;
- Application of different compaction techniques (such as dynamic compaction) for reclaimed dredged rock material with higher coarse fraction;
- Crushing and reducing the size for high content boulders;
- Mixing non-complying material with other material to meet Project requirement;
- Use of material above water level with specific compaction requirement;
- Additional ground improvement measures; and
- Use of deep foundations to offset larger settlement.

Material still considered unsuitable for reclamation purposes will be disposed offsite. Options to manage the environmental impacts of dredged material disposal are being investigated and will be presented to DM-CWMS for review and approval. Disposal of unsuitable material will not be undertaken until the appropriate approvals and NOCs have been obtained. Preliminary desktop investigations to dispose dredged material are provided in this report (Section 7.9.1.4).

Silt Management

Prepare a detailed silt control plan as part of the CEMP, which would include the following measures as a minimum:

- Containment of fine material within designated reclamation areas, either through construction of rock revetments, temporary sand bunds or installation of low permeability silt screens between dredging / reclamation activities and sensitive areas, particularly Dubai Marina which exhibits poor flushing;

- Careful management of dredging activities and mitigation measures to control suspended sediment load, taking into account met-ocean conditions (currents and tides) and areas of elevated TSS; and
- Aim to undertake as much of the beach re-profiling works during low tide and calm sea conditions as is feasible.

Dust Suppression

Prepare a detailed dust control plan as part of the CEMP, which would include the following measures as a minimum:

- Site layout: Locate the dust generating activities, haulage routes, stockpiles and dusty materials away from the sensitive receivers as far as possible (taking the predominant wind direction into consideration).
- Surfacing and / or compaction of site access roads to minimise dust generated by vehicle movements on-site;
- Application of water for dust suppression on stockpiles and haulage roads and during dust generating activities (e.g. concrete grinding);
- Erection of hoarding.
- Limit the traffic speed on-site.

Noise Reduction

Prepare a detailed noise control plan as part of the CEMP, which would include the following measures as a minimum:

- Erection of hoarding / noise barrier along the site boundary and/or areas where activities emitting high noise levels are performed;
- For construction works carried out adjacent to NSRs and particularly at N1 and N5, which have exceeded the guideline values in the modelling study, erection of noise barriers made of sound absorbent materials is required;
- Construction work programme (i.e. timings) and method to be sequenced so as to minimize noise emissions impacts, particularly during night time; and
- Deployment of quiet equipment.

Operational Phase

Increase Public Transport Access

Given the large scale and strategic developments ongoing and proposed in the area, increased traffic is considered an unavoidable impact of the Project; however, increased access to the Project via public transport such as Dubai Metro and Tram will reduce traffic congestion and associated noise and GHG emissions.

Flushing in Dubai Marina

Regular water quality monitoring will be undertaken in the Marina, both during construction and operation. Should water quality deteriorate significantly, appropriate mitigation measures to improve water quality will be implemented.

Models show that pumping water from the sea into the Canal at a rate of 0.5 $m^3 s^{-1}$ would maintain the current flushing regime. A preliminary feasibility study will be provided to DM once ongoing investigations are completed, along with a commitment from North 25 to undertake the detailed mitigation (or suitable alternative, if approved by DM), should water quality deteriorate significantly.

Operation Environmental Management Plans

A specific operation environmental management plan should be provided for each of the key areas / facilities of the Project, including but not limited to:

- Cruise terminal;
- Marinas (including all maintenance and fuelling facilities);
- Beaches;
- Dredged access channel;
- Utilities and connections (water, power, stormwater).

The management plan would provide details on maintenance requirements, environmental management and monitoring and responsibilities to reduce the operational impact. Measures should include use of bunded areas for fuel storage / maintenance areas, use of oil interceptor traps, provision of spill kits and drip trays, regular inspections for leaks in the pipeline networks.

Proposed Monitoring Program

To ensure the effectiveness of the proposed mitigation measures, the following environmental monitoring should be performed during construction:

- Noise monitoring to be performed twice a week (once on weekday, once on weekend day) during day time and night time at two locations near noise sensitive receivers of the Project site.
- Dust monitoring (TSP and PM_{10}) at weekly intervals at two locations near the air sensitive receivers of the Project site.
- During marine works, water quality monitoring, including:
  - Real-time, continuous water quality monitoring at five locations. The parameters should include turbidity, pH, conductivity, dissolved oxygen, temperature and salinity;
  - Real-time, continuous current speed and direction and wave speed and direction at two stations;
  - Real-time, continuous tide and weather data.
  - Daily *in-situ* water quality meaurements (turbidity, pH, conductivity, dissolved oxygen, temperature and salinity) around key sensitive receptors, key Project components and in the Dubai Marina;
  - Twice monthly analytical water sampling around key sensitive receptors, key Project components and in the Dubai Marina; and
  - Marine sediment quality monitoring around key sensitive receptors, key Project components and in the Dubai Marina.
- Dewatering effluent monitoring on a monthly basis.
- Reclamation fill material monitoring on a monthly basis prior to placement.
- Benthic infauna sampling and taxonomic identification on an annual basis.

During operation, to ensure that water quality in Dubai Marina does not deteriorate significantly; quarterly monitoring of *in-situ* parameters and TSS, metals, BOD, COD, nutrients, chlorophyll-a, oil and grease, TDS and feacal coliforms at two Dubai Marina locations.

Conclusion

Although some environmental impacts associated with the construction and operation of the Project have been identified, it is considered that with appropriate implementation of the proposed mitigation measures, and with the on-going monitoring program, the environmental impacts can be reduced to an acceptable level.

List of Abbreviations

Abbreviation	Definition
AED	Arab Emirate Dirhams
Al	Aluminium
Ag	Silver
As	Arsenic
B	Boron
Ba	Barium
Be	Beryllium
BOD	Biochemical Oxygen Demand
CoRTN	Calculation of Road Traffic Noise
Cd	Cadmium
CEMP	Construction Environmental Management Plan
CH4	Methane
CN	Cyanide
Co	Cobalt
CO	Carbon Monoxide
CO_2	Carbon Dioxide
Cr	Chromium
COD	Chemical Oxygen Demand
$C_6 H_6$	Benzene
CSD	Cutter Suction Dredger
Cu	Copper
DED	Dubai Economic Development
DEWA	Dubai Electric and Water Authority
DIES	Dubai Integrated Energy Strategy
DIMC	Dubai International Marine Club
DM	Dubai Municipality
DM-EPSS	Dubai Municipality-Environmental Planning and Studies Section
DMD	Dubai Municipality Datum
DSC	Dubai Statistics Centre

Abbreviation	Definition
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EMMP	Environmental Management and Monitoring Plan
EPA	Environment Protection Agency
EPSS	Environmental Planning and Studies Section
Fe	Iron
GDA	Gross Development Areas
GDP	Gross Domestic Product
GHG	Greenhouse Gases
HF	Hydrogen fluoride
Hg	Mercury
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
JBR	Jumeirah Beach Residences
LAeq	Equivalent Continuous Sound Level
MoEW	Ministry of Environment and Water
Mg	Magnesium
MIGD	Million imperial gallons per day
Mn	Manganese
MPN	Most Probable Number
MSDS	Material Safety Data Sheet
Mo	Molybdenum
N	Nitrogen
Na	Sodium
NH_3	Ammonia
Ni	Nickel
NOAA	National Oceanographic and Atmospheric Administration
NADG	National Assessment Guideline for Dredging
NO_2	Nitrogen Dioxide
NO_3	Nitrate

Abbreviation	Definition
NOx	Total reactive Nitrogen oxide
NOC	No Objection Certificate
O_3	Ozone
OEMP	Operation Environmental Management Plan
Pb	Lead
PFU	Plaque Forming Units
POPs	Persistent Organic Pollutants
ROPME	Regional Organization for the Protection of the Marine Environment
RTA	Roads and Transport Authority
Rw	Weighted Sound Reduction Index
S	Sulphur
Se	Selenium
SO_2	Sulphur dioxide
STP	Sewage Treatment Plant
TDS	Total Dissolved Solids
TG	Technical Guidelines
TIS	Traffic Impact Study
TSE	Treated Sewage Effluent
TSP	Total suspended particulates
TSS	Total Suspended Solids
UAE	United Arab Emirates
UN	United Nations
US	United States of America
VI	Six
VOC	Volatile Organic Compounds
WHO	World Health Organisation
Zn	Zinc

List of Units

Unit	Definition
cm^2	Square centimetre
dB	Decibels
g	Gram
Gg	Gigagrams (1,000,000,000 g)
kg	Kilogram
km^2	Square kilometre
kV	Kilovolt
L	Litre
L/sec	Litres per second
m	Metre
m^2	Square meters
m^3	Metres cubed
Mm^3	Million metres cubed
mg	Milligram
ml	Millilitre
mm	Millimetre
MSL	Mean sea level
MW	Megawatt
Nm^3	Normal cubic meter
NTU	Nephelometric Turbidity Unit
PM_{10}	Particulate matter (10 microns or less in diameter)
µg	Microgram
10^3	10 to the power of 3, i.e. 1000
º C	Degrees Celsius
$	Dollar
%	Percent
>	Greater than
<	Less than

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Appendices

Appendix A – Scope of Work Approval and DM Correspondence

Appendix B – North 25 Trade Licence

Appendix C – Masterplan and Approved Site Affection Plan

Appendix D – Calibration Certificates

Appendix E – Modelling Reports

Appendix F – Marine Environmental Baseline Survey Report

Appendix G – Bird Survey Report

Appendix H – Emission Factors

Appendix I – Noise Modelling Report

Appendix J – Traffic Impact Study

Appendix K – Sewage Network Preliminary Design Report and Drawings

Appendix L – Logistics Maps

Appendix M – Construction Schedule

1. Introduction

1.1 Project Overview

Shamal LLC (Shamal) proposes the development of Dubai Harbour (Project), a waterfront development featuring the Middle East's largest marina. In addition, the development will have a high-end mixed-use nature featuring hospitality, residential, retail, food and beverage components, and various community leisure and entertainment facilities and public amenities.

The Project site is located around Logo Island at the base of the Palm Jumeirah between Mina Seyahi and Skydive Dubai and it will cover an area of approximately 2 million square metres. The Project will require dredging, reclamation, demolition and building activities.

GHD Global Pty Ltd (GHD) has been engaged by North 25 LLC (North 25), Shamal's representatives, to undertake the Environmental Impact Assessment (EIA) for construction and operation of the Project in compliance with the requirements of the Dubai Municipality Environmental Planning and Studies Section (DM-EPSS) Technical Guidelines No. 1 and 2 (January, 2017). Approval from the DM-EPSS on the scope of works for the Project EIA is provided in Appendix A.

1.2 Project Title and Project Proponent

The details of the proposed Project and the Project Proponent are provided in Table 1-1.

Table 1-1 Details of the Project and Project Proponent

Project Title	Dubai Harbour
Owner/Project Proponent	Shamal LLC
Trade License No.	772987. A copy is provided in Appendix B
Project Proponent Representative	North 25 LLC
Trade License No.	603590. A copy is provided in Appendix B
Address	PO Box 123311 Dubai, UAE
Contact Person / Designation	Richard Brewer Heads of Projects Project Division
Telephone Number	+971 4 4768116
Mobile Number	+971 56 3116226
Email Address	richard.brewer@north25.ae
Affection Plan No.	392-7017. A copy is provided in Appendix C*

**Appendix C also includes a copy of the master plan.*

1.3 Project Rationale

In 2013, the United Arab Emirates (UAE) was ranked first in the Middle East and North Africa region and 28th in the world for tourism (WEF, 2013). Statistics show that Dubai welcomed ten million tourists in 2013 (WTTC, 2014) and expects to double this number by 2020 as part of the Dubai's Department of Tourism and Commerce Marketing Vision 2020 Plan. This ambition to grow the tourism industry requires significant development of the travel industry to cope with the number of tourists. Major development projects for several sectors within the UAE's travel industry have been launched including its cruise sector (Dowling and Weeden, 2016).

Dubai Harbour is expected to become a major destination in Dubai that will contribute positively to the image and positioning of Dubai as well as the growth of the tourism sector. The proposed Dubai Harbour will provide a strong foundation for welcoming cruise vessels and events, which will provide further incentives for tourists from the Middle East and North Africa regions and beyond to visit the Emirate, as well as providing a range of real estate options for local residents and foreign investors. The Project will contribute to the continued drive to diversify the economy of the Emirate of Dubai through enhancing and diversifying the Emirate's economic and tourism sectors. It is envisaged that the development of the Project will contribute to the overall growth in the UAE's Gross Domestic Product (GDP) through the creation of job opportunities both during construction and operational phases.

Developments of this nature are a key component of Dubai's strategic plan aimed at diversifying Dubai's economy and helping achieve its economic development goal.

1.4 Project Alternatives

Dubai Harbour's location was chosen for its good infrastructure connections to other key landmarks in the Emirate including Bluewaters, Palm Jumeirah and Dubai Marina. In addition, the reclaimed Logo Island, which is currently out of use, would become utilised rather than leaving it dormant. As such, there were no other project alternatives other than the "no development" option and minor alternatives for the relocation of DIMC during the construction works.

Regarding the surrounding land uses, which include SkyDive Dubai, Palm Jumeirah and other hotels, North 25 is committed to addressing the potential environmental and social impacts of the Project identified in this report. The mitigation measures proposed in Section 7 of this report demonstrate that potential impacts can be managed during the Project's construction and operation phases.

1.4.1 No Development

The "no development" option has a number of advantages and disadvantages, outlined in Table 1-2.

The "No Development" option allows for environmental site conditions to be maintained in their current condition on and around Logo Island. However, this area is already highly disturbed as a result of existing developments within and surrounding the proposed Project location.

The "No Development" option was rejected on the basis that the opportunity to enhance Dubai's economic growth and diversification through developing the tourism sector was considered to outweigh the benefits of leaving the site in its current condition.

Table 1-2 Advantages and Disadvantages of 'No Development' Alternative

Advantages	Disadvantages
• Potential environmental impacts of construction and operation of Dubai Harbour would be avoided • Natural habitat and features are kept unaffected by human intervention.	• Loss of opportunity for enhanced tourism; • Loss of potential contribution / support to socio-economic growth and diversification (local and international real estate investment); and • Loss of opportunity to provide an enhanced entertainment and leisure venue in Dubai.

1.4.2 DIMC Relocation

A feasibility assessment was undertaken by North 25 to determine the viability of establishing a temporary marina adjacent to Jebel Ali Hotel and Palm Jebel Ali (shown in red in Figure 1-1), which could be used to relocate the existing 325 boats from DIMC during the construction works. However, due to time constraints and availability of infrastructure and utilities near the Jebel Ali Hotel, the preferred option is for the vessels currently located at DIMC to remain in the current location.

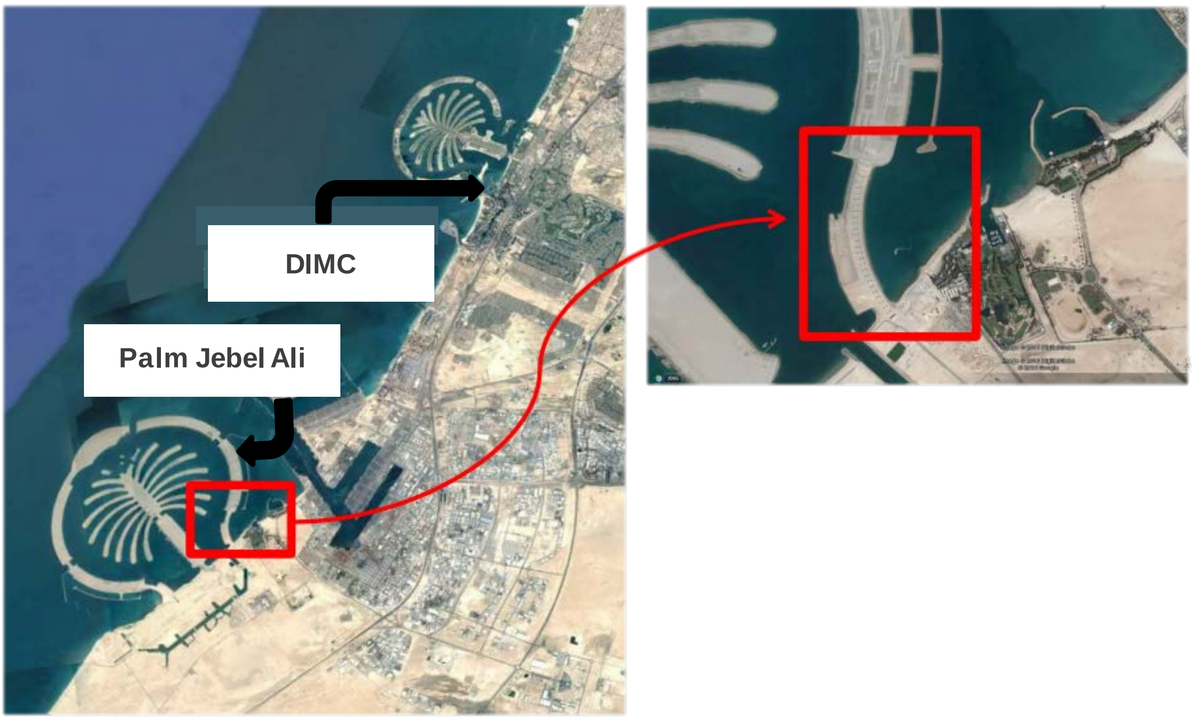

Figure 1-1 Proposed Location of Temporary Marina

While a number of vessels will not need to be relocated, a phased relocation of the remaining vessels at DIMC is proposed, with vessels being progressively relocated to completed marinas within Zone 4 as the construction works progress. The Bay Marina in Zone 4 will be able to accommodate a number of vessels from 10 to 60 meters long (Figure 1-2). Other marinas in Dubai will accommodate remaining vessels.

Figure 1-2 Bay Marina Layout (Zone 4)

1.5 The Need for an EIA

In the DM Local Order 61 of 1991 on the Environment Protection Regulations in the Emirate of Dubai, EIA is considered an important planning tool in ensuring that developments are undertaken without undermining the conservation and protection of the environment.

An EIA aims to identify and assess the environmental impacts of a project, and subsequently incorporate appropriate preventive and mitigation measures in the project planning and design process as well as during the construction and operational stages. It is in line with these principles and objectives that the Dubai Harbour EIA has been undertaken.

The DM EPSS *Technical Guidelines No. 1 - Environmental Impact Assessment (January 2017)*, specifies that projects (Category A projects) are required to undergo an EIA as part of the Environmental Clearance application. Considering the project location, nature and scale of the development, an EIA Report is deemed necessary. The EIA will be carried out in accordance with requirements set out in the DM EPSS *Technical Guidelines No. 2 – EIA Requirements for Land Developments, Infrastructure, and Utility Projects (January 2017).*

This report presents the detailed findings of the Dubai Harbour EIA and has the following structure with supporting appendices:

- Executive Summary;
- Introduction;
- Description of the EIA Process;
- Legal Framework;
- Description of the Project;
- Description of the Environment;
- Assessment of the Environmental Impacts;
- Mitigating Measures and Enhancement Plan;
- Environmental Management and Monitoring Program;
- Conclusions; and
- References.

2. Description of the Project's EIA Process

2.1 EIA Scope of Work

The scope of the EIA is to describe the following:

- The Project description, which includes project information, rationale, alternatives and any associated activities during all phases of project development;
- Reference laws, regulations and standards;
- The existing environmental conditions and potential environmental impacts associated with both construction and operation of the Project; and
- Environmental Management and Monitoring Programme (EMMP) for the Project.

The EIA for the proposed Project is undertaken in accordance with the requirements of the following key documents:

- DM EPSS Technical Guidelines No. 1 – Environmental Impact Assessment (January, 2017);
- DM EPSS Technical Guidelines No. 2 – EIA Requirements for Land Development, Infrastructure, and Utility Projects (January, 2017);
- Scoping Report for the Project EIA (GHD, 2017) as approved by the DM EPSS (Appendix A); and
- DM EPSS approval of the SoW Report (Pending DM approval of Rev 2). Comments on Rev 1 were received on 30 May 2017 (Ref. EPSS/L/2017/394).

The detailed scope of works for the EIA is provided in the approved SoW report in Appendix A while a list of the environmental aspects included in the scope are provided below:

- Climate and Meteorology;
- Air Quality;
- Noise;
- Geology and Seismicity;
- Coastal Processes;
- Marine Ecosystem;
- Terrestrial Ecology;
- Traffic and Transport (urban and marine);
- Waste and waste management;
- Utilities; and
- Socio-economic environment.

2.2 EIA Team

GHD was appointed as Environmental Consultant for the Project. This EIA has been undertaken and prepared by GHD on behalf of North 25. The contact details for GHD are provided in Table 2-1.

Table 2-1 Contact Details of Environmental Consultant

Name	GHD Global Pty Ltd.
Address	3rd Floor Guardian Tower, Danet Community P.O. Box 45921 Abu Dhabi United Arab Emirates
Telephone Number	+971 2 696 8750
Facsimile Number	+971 2 447 2915
Contact Person	Salma Bin Breik Project Director

GHD is a Dubai Municipality approved environmental services provider for the following environmental services (January 2017):

- A: Environmental Impact Assessment (EIA) Report for Category A Projects and Category B-Type A Projects (Major Industrial Activities);
- B: Land Contamination Investigation and Environmental Site Assessment;
- C: Waste Audits and Waste Management Studies;
- E_2: Air Quality Monitoring;
- F_2: Noise Monitoring;
- H: Marine and Estuarine Ecology Studies;
- I: Soil and Hydro-Geological (Groundwater) Studies; and
- J: Terrestrial Ecology and Biodiversity Studies, Wildlife Survey, Capturing and Translocation of Indigenous Flora and Fauna.

The professional GHD staff involved in the preparation of the EIA and their relevant expertise are provided in Table 2-2, while aspects of the EIA undertaken by third party specialists are provided in Table 2-3.

Table 2-2 Expertise of Key GHD Team Members

Name	Key Role in EIA	Expertise
Salma Bin Breik	Project Director Oversee the program management to ensure delivery in accordance with North 25's expectations and DM-EM requirements.	EIA Study Contract Management

Name	Key Role in EIA	Expertise
Edwin Palmer	Project Manager Responsible for the day-to-day management of the project and ensures the quality of deliverables. Marine Ecologist Leads marine assessment and preparation of the marine ecology section.	EIA Study Project Management Marine Ecology
Dr Kerry Neil	Principal Environmental Consultant – Marine Technical lead for the marine survey and review marine section of all technical deliverables.	EIA Study Marine Ecology
Katie Ward	Technical Lead Provides technical advice throughout the project and reviews all technical deliverables.	EIA Study Marine Ecology
Gheeda Jaouhari	Deputy Project Manager Assist the Project Manager in day-to-day activities. Baseline survey co-ordinator.	EIA Study Baseline Survey
Stacey Dorman	Environmental Scientist Responsible for gathering required information for the EIA from the client and consultants. Assist in EIA preparation.	EIA Study
Kristina Downey	Senior Marine Scientist Marine assessment support.	EIA Study Marine Ecology
Jennifer Calpo	Environmental Scientist Assist with all aspects of SoW Report and EIA study.	EIA Study Social Sustainability and Stakeholder Engagement
Tom Sullivan	Environmental Engineer Assisted in reviewing modelling studies.	EIA Study Coastal Processes
Amit Nevase	Marine Ecologist Field and office support for the marine ecology aspect of the Project.	Marine Baseline Survey
Avnika Puri	Environmental Scientist Field and office support.	Baseline Survey

Table 2-3 Third Party Specialists Utilised

Company	Key Role in EIA	Expertise
WKG Group	Noise modelling	Registered with the DM for air quality and noise modelling (Code E_1 and F_1)
Artelia (formerly Sogreah Gulf)	Commissioned separately by North 25 as the marine engineer for the Project to undertake the following modelling and assessments: - Hydrodynamic modelling - Stormwater modelling - Nearshore wave modelling - Wave penetration modelling - Sediment transport modelling - Oil spill modelling - Shoreline evolution modelling - Marine risk assessment - Flussing assessment - Navigation simulation study - Beach stability assessment - 3D physical modelling - Marine traffic impact assessment	Maritime and port engineering and coastal modelling assessments
AECOM	Traffic Impact Study	Architecture and Engineering
Nautica Environmental Associates LLC	- Avifauna survey - Phytoplankton, zooplankton, harmful algal bloom cyst and benthic infauna taxonomic identification	Established in Abu Dhabi since 2005 and working mainly in marine biology, terrestrial ecology, ornithology and geomorphology
Lonestar Technical Services	Air and noise monitoring	Approved by the Dubai Accreditation Centre for air quality monitoring
Al Hoty-Stanger Laboratories	Analytical laboratory analysis of marine water and sediment samples	Approved by the Dubai Accreditation Centre for environmental testing

2.3 EIA Methodology

2.3.1 Overview

In order to identify, assess and minimise impacts of the proposed project on the surrounding environmental and social receptors, coupled with addressing relevant policies and regulations in the UAE, the EIA adopted a combination of the following.

- Stakeholder consultation;
- Environmental site inspections;
- Literature review;
- Field surveys to collect quantitative baseline data;
- Qualitative and quantitative impact assessments;
- Identification of appropriate mitigation measures; and
- Establishment of an environmental management programme for the construction and operation phases of the Project.

The key tasks and methodology for the EIA are outlined in Table 2-4.

Table 2-4 EIA Approach and Methodology

EIA Task Description	Methodology
1. Understanding the DM's requirements	• Review of DM Technical Guidelines on EIA and environmental management; • Review of Federal and Emirates environmental regulatory requirements; and • Preparation and submission of Scoping Report for DM EPSS approval (Appendix A).
2. Understanding the Project	• Liaison with the Project proponent including its consultants and contractors; and • Literature review of Project reports issued by the consultants and contractors.
3. Understanding the Project site	• Site walk-over / inspections; • Literature review of relevant environmental data; • Baseline data collection (desktop research); and • Field surveys to collect quantitative baseline data of the project site (refer to Items 3.1 to 3.4).
3.1 Baseline ambient air monitoring	• Installation of air quality monitoring stations for a duration of two weeks at six locations on the Project site; and • Evaluation of air baseline data against the Federal and DM ambient air standards.
3.2 Baseline noise monitoring	• Noise measurements at six locations;

EIA Task Description	Methodology
	• Evaluation of noise baseline data against the Federal and Emirate ambient noise standards.
3.3 Marine environment baseline survey	• Collection of water, sediment and infauna samples for laboratory analysis at 35 locations; • Habitat identification surveys at 38 locations; • Phytoplankton and zooplankton analysis at eight locations; and • Harmful Algal Bloom species analysis at five locations.
3.4 Terrestrial ecology	• Avifauna survey at one location to record bird species both on and flying over the area.
4. Impact identification and assessment	• Identification of Project activities, equipment and utilities which could potentially cause environmental impacts; • Qualitative assessment of impacts; and • Quantitative assessment / modelling of noise and marine impacts (refer to Items 4.1 and 4.2).
4.1 Noise impact modelling	• Review of construction and traffic data for the Project; • Assessment of construction noise using British Standard 52281:2009+A1:2014 – Code of Practice for Noise and Vibration Control on Construction and Open Sites; and • Modelling of traffic noise impacts of the proposed road network on the project site (by numerical modelling software SoundPLAN).
4.2 Marine impacts modelling	• Hydrodynamic modelling; • Stormwater modelling; • Nearshore wave modelling; • Wave penetration modelling; • Sediment transport and sedimentation modelling; • Oil spill response modelling; • Shoreline evolution modelling; and • Marine risk assessment.
5. Development of environmental mitigation measures	• Review of environmental regulatory standards and requirements applicable to the Project; and • Identification of mitigation measures based on previous experience, best practise and available options.

EIA Task Description	Methodology
6. Environmental Management and Monitoring Programme	• Development of an Environmental Management and Monitoring Programme for the construction and operation phase.

2.3.2 Impact Assessment Methodology

This EIA assesses the degree of impact associated with the Project both prior to and following implementation of mitigation measures. Assessment of the level of impact is based on two criteria:

- Likelihood of the impact (Table 2-5); and
- Consequence level of the impact (Table 2-6).

The impact significance level is based on the following calculation:

Significance of impact = Likelihood Level x Consequence Level

Based on the above calculation, the level of the impact is classified in the following five levels and can be expressed in a matrix, as illustrated in Table 2-7.

- Extreme;
- High;
- Medium;
- Low; and
- Negligible.

Table 2-5 Likelihood of Impact

Likelihood Rating	Explanation
5 = Almost Certain	The impact is expected to occur in most circumstances.
4 = Likely	The impact will probably occur in most circumstances.
3 = Possible	The impact could occur.
2 = Unlikely	The impact could occur but is not expected.
1 = Rare	The impact may occur only in exceptional circumstances.

Table 2-6 Consequence of Impact

Consequence Rating	Explanation			
	Magnitude	Permanence	Reversibility	Example
1 = Insignificant	Only within the project site	No change or Temporary	No change or reversible	• Negligible and short-term disruption to flora, fauna, habitats. • Minor soil erosion. • Temporary nuisances from emission / minor injuries requiring self-administered first aid. • No health effect on surrounding communities. • Minimal use of energy and natural resources. • Generation of non-hazardous wastes. • Minor repairable damage to structure.
2 = Minor	Only within the project site	Temporary	Reversible	• Minor impact on fauna, flora and habitat at non-ecologically sensitive areas. • No significant loss of land / marine resources. • Minor emissions with no lasting detrimental effect. • No health effect on surrounding communities. • Significant use of energy and natural resources. • Minor infringement of cultural values. • Injuries requiring on-site treatment by medical practitioner.
3 = Moderate	Effect to areas immediately outside the project site	Temporary or Permanent	Reversible	• Significant changes in flora and fauna communities (e.g. population, biodiversity), but yet to result in eradication of endangered species. • Impact on the ecosystem is short-term (less than one year).

Consequence Rating	Explanation			
	Magnitude	Permanence	Reversibility	Example
				• Non-persistent but possibly widespread damage to land, which could be remediated without long-term loss. • Minor health effect on surrounding communities • Localised persistent damage • Emission at significant nuisance levels • Generation of hazardous wastes • Significant infringement of cultural values • On-going complaints raised by the surrounding communities • Serious injuries requiring off-site treatment by medical practitioner or immediate evacuation to hospital
4 = Major	Regional or national change or effects	Permanent	Irreversible	• Continuous and serious damage by erosion • Significant impact on ecologically sensitive areas / protected areas (e.g. causing death) • Emission due to uncontained release, fire or explosion • Significant health effect on surrounding communities • Significant damage to the structure, infringement of cultural values
5 = Catastrophic	Regional, national or international change or effects	Permanent	Irreversible	• Long-term and extensive change in the habitats, population of flora and fauna and biodiversity, eradication of endangered species. • Depletion of groundwater resources.

Consequence Rating	Explanation			
	Magnitude	Permanence	Reversibility	Example
				• Extensive chronic discharge of persistent hazardous pollutants / transboundary dispersion of the pollutants. • Significant quantities of hazardous wastes generated. • Irreparable damage to highly valued buildings / structures / location of cultural significance. • Death in surrounding communities. • Multiple fatalities.

Table 2-7 Significance of Environmental Impacts

Likelihood Rating	Consequence Rating				
	1 = Insignificant	2 = Minor	3 = Moderate	4 = Major	5 = Catastrophic
5 = Almost Certain	Low	Medium	High	Extreme	Extreme
4 = Likely	Low	Medium	High	High	Extreme
3 = Possible	Negligible	Low	Medium	High	High
2 = Unlikely	Negligible	Low	Medium	Medium	High
1 = Rare	Negligible	Negligible	Low	Medium	Medium

Note – The above colours are utilised to denote negative impacts. Where an impact is deemed to be positive, it will be represented by a dark grey colour.

Positive impact

2.4 Assumptions and Limitations

2.4.1 Marine Engineering Studies

North 25 contracted Artelia to provide marine consultancy services for the Project. Artelia's scope of work includes, but is not limited to, preparation of the following marine engineering studies:

- Hydrodynamic modelling;
- Nearshore wave modelling;
- Wave penetration modelling;
- Sediment transport modelling;
- Flushing Assessments;
- Stormwater Outfall Dispersion;
- 3D physical modelling;
- Navigation Simulations;
- Oil Spill Modelling; and
- Marine Risk Assessment.

The major findings of the above studies have been presented in this EIA Report. GHD has prepared the EIA on the basis that:

- All pertinent information with regard to the Project was made available to GHD to form the basis of this EIA; and
- All information provided by the Project Proponent and its project consultants is correct.

2.4.2 Project Stage

It should be noted that at the time of preparing this EIA, the Project was at the concept design stage. It is not anticipated that there will be any significant alterations to the Masterplan during the detailed design stage (refer to Appendix C); however, in the event that there are changes to the Project design, DM will be consulted to determine whether there is a necessity to update the EIA.

2.4.3 Borrow Area

It is proposed that the Project will use material dredged from the cruise access channel as reclamation material. However, following geotechnical investigations, a shortfall in total volume is anticipated. Consequently, additional material will require, which will be sourced from a borrow area. The borrow area from which reclamation material will be sourced has been excluded from this EIA as per the SoW Report (Appendix A). The dredging contractor will source fill material and beach sand and undertake relevant studies, ensuring that all necessary approvals are obtained.

3. Legal Framework

3.1 Overview

The regulatory framework expected to govern the environmental performance of the Project comprises the following:

- UAE Federal environmental legislation and policy;
- Dubai Municipality (DM) legislation, guidelines, policies and procedures; and
- International conventions, protocols and guidance documents.

The following sections provide an overview of key environmental requirements relevant to the construction and operational activities of the Project. It is to be noted that these are based on GHD's understanding and interpretation of current environmental and regulatory standards applicable to the Project, and should not be construed as legal opinion.

Similarly, this is a general analysis based on the facilities and land uses that are currently known to be built as part of the Project. As development progresses, the proposed activities should be assessed against the relevant policy, legal and administrative frameworks.

3.2 Federal Regulatory Framework

The UAE Federal Environment Agency was established in 1993 as the federal agency responsible for the regulation and enforcement of environmental standards and development of environmental policies in the UAE. However, the recently issued Federal Law No. 7 of 2009 effectively abolishes UAE Federal Environment Agency and transfers the agency's responsibilities and functions to the UAE Ministry of Environment and Water (MoEW).

UAE Federal laws and regulations relevant to construction and operation of the Project are provided in Table 3-1 and summarised in the succeeding subsections.

Table 3-1 Federal Environmental Laws and Regulations relevant to the Project

Legislation	Project Relevance	Aspect
Federal Law No. 24 of 1999 – Concerning Protection and Development of the Environment and its Executive Order issued by Council of Ministers Decree No. 37 of 2001	The Federal Law essentially requires that all development projects in the UAE be undertaken in a manner that will not cause significant adverse impacts.	Overarching environmental assessment
Executive Order issued by Council of Ministers Decree No. 37 of 2001 – Regulation concerning Environmental Impacts of the Project	As stipulated in the Executive Order, an EIA is required prior to development of any Project.	Overarching environmental assessment
Executive Order issued by Council of Ministers Decree No. 12 of 2006 – Regulation concerning Protection of Air from Pollution	The standards and limits specified in this Regulation are applicable to the Project and shall be maintained, where possible, to safeguard human health in UAE.	Air and noise

Legislation	Project Relevance	Aspect
Federal Law No. 23 of 1999 – Concerning Exploitation, Protection and Development of the Living Aquatic Resources in the Waters of the UAE	The provisions of this law may not directly or entirely apply to the Project; however, given the location of the Project within the marine environment, there is a need for careful and committed effort to ensure that the Project shall not generate unacceptable adverse impacts on the ecological species including fish.	Marine environment
Executive Order issued by the Council of Ministers Decree no. 37 of 2001 on Regulation concerning Protection of Marine Environment	Any discharge during the construction and operation phases of the Project should comply with the allowable limits specified in this Regulation.	Marine environment
Executive Order issued by Council of Ministers Decree No. 37 of 2001 – Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes	Wastes generated during the construction and operation of the Project should be managed in accordance with this Executive Order	Waste management
Federal Law No. 12 of 1986 – Concerning Regulations on Labour Relations	The Project needs to comply with the provisions stated in the Law regarding employment of women and children, employment contracts, records and wages, working hours, workers' safety, protection, health and social care, reporting and compensation for work-related injuries and occupational disease.	Social

3.2.1 Federal Law No. 24 of 1999 – Concerning Protection and Development of the Environment and its Executive Order issued by the Council of Ministers Decree No. 37 of 2001

Federal Law No. 24 of 1999 relates to the protection of the environment by preserving its diversity and natural equilibrium, and by preventing all forms of pollution. The intent of the law is to provide a coordinated approach to addressing environmental issues across the UAE. This law aims to achieve the following goals:

- Protection and conservation of the quality and natural balance of the environment;
- Control of all forms of pollution and avoidance of any immediate or long-term harmful effects resulting from economic, agricultural, industrial, development or other programmes aiming at improving life standards and co-ordination among the Agency, Competent Authorities and Parties concerned with the protection of the environment and conservation of the quality, natural balance and consolidation of environmental awareness and principles of pollution control;

- Development of natural resources and conservation of biological diversity in the region or the state and the exploitation of such resources with consideration of present and future generations;
- Protection of society, human health and the health of other living creatures from activities and acts, which are environmentally harmful or impede authorized use of the environmental setting;
- Protection of the State environment from the harmful effects of activities undertaken outside the region of the State; and
- Compliance with international and regional agreements ratified or approved by the State regarding environmental protection, control of pollution and conservation of natural resources.

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

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

This EIA clearly demonstrates the Project's commitment to environmental protection. In addition to this, the Project shall ensure compliance and support to all other provisions of this Federal Law throughout its construction and operation phases.

This Federal Law provides general requirements while specific provisions, standards and guidelines in line with these requirements are provided by DM in the form of local orders, administrative orders, decrees, technical guidelines and information bulletins.

3.2.2 Executive Order issued by Council of Ministers Decree No. 37 of 2001 – Regulation concerning Environmental Impacts of the Project

In line with objectives of Federal Law No. 24 of 1999, all projects, which have the potential to impact on the environment, shall be required to perform appropriate EIA. The EIA forms the basis for the issuance of environmental permits from the relevant regulatory agency, which in the case of the Project, is the DM-EPSS.

3.2.3 Executive Order issued by Council of Ministers – Regulation concerning Protection of Air from Pollution

This Minster Decree was enacted in line with the air pollution control objective of the Federal Law No. 24 of 1999. It provides maximum allowable limits of air pollutants emitted from different source installations, in work areas and in the ambient air. It also specifies the required ambient noise levels according to types of land uses such as residential, commercial and industrial.

The ambient air quality standards and allowable noise limits stipulated in the said Regulation are shown in Table 3-2 and Table 3-3, respectively.

Table 3-2 UAE Federal Ambient Air Quality Standards

Substance	Symbol	Maximum Allowable Limit (µg/Nm^3)	Average Time
Sulphur dioxide	SO_2	350	1 hour
		150	24 hours
		60	1 year
Carbon monoxide	CO	30 (mg/Nm^3)	1 year
		10 (mg/Nm^3)	8 hours
Nitrogen dioxide	NO_2	400	1 hour
		150	24 hours
Ozone	O_3	200	1 hour
		120	8 hours
Total suspended particulates	TSP	230	24 hours
		90	1 year
Particulate matter (10 microns or less in diameter)	PM_{10}	150	24 hours
Lead	Pb	1	1 year

Source: Regulation concerning Protection of Air from Pollution

Table 3-3 UAE Federal Allowable Noise Limits

Area	Allowable Limits dB(A) for Day (7 am to 8 pm)	Allowable Limits dB(A) for Night (8 pm to 7 am)
Residential areas with light traffic	40 – 50	30 – 40
Residential areas in downtown	45 – 55	30 – 45
Residential areas which include some workshops and commercial business or residential areas near highways	50 – 60	40 – 50
Commercial areas and downtown	55 – 65	45 – 55
Industrial areas (heavy industry)	60 – 70	50 – 60

Note: *dB(A) means decibels adjusted. dB(A) is used for determining the sound exposure to humans.

Source: Regulation concerning Protection of Air from Pollution

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

Federal Law 23 of 1999 generally governs the fishing trade, import and export in the UAE. This law ensures that protection and conservation of aquatic resources, particularly the fish stock in the UAE.

This law provides a number of prohibitions with regards to destruction of aquatic resources in relation to the fishing industry.

3.2.5 Executive Order issued by the Council of Ministers Decree No. 37 of 2001 on Regulations concerning Protection of the Marine Environment

This Ministerial Resolution provides the allowable limits for the parameters of effluent to be discharged into the marine environment (Table 3-4). These Federal standards may be adopted for parameters where there are no standards existing for Dubai Emirates.

Table 3-4 Characteristics of Treated Industrial Wastewater at Point of Discharge into the Sea

Parameter	Unit	Suggested Limits
Physical		
Total Suspended Solids (TSS)	mg/L	50
Total Dissolved Solids (TDS)	mg/L	1500
pH	pH units	6 – 9
Floating Particles	mg/m^2	None
Temperature (higher than background)	ºC	5
Turbidity	NTU	75
Inorganic Chemical Properties		
Total Ammonia (as N)	mg/L	2
Nitrate (as N)	mg/L	40
Chloride residual	mg/L	1
Cyanide	mg/L	0.05
Dissolve Oxygen	mg/L	>3
Fluoride	mg/L	20
Sulfide	mg/L	0.1
Biochemical Oxygen Demand (BOD)	mg/L	50
Total Kjeldahl Nitrogen	mg/L	10
Total Phosphorus	mg/L	2

Parameter	Unit	Suggested Limits
Chemical Oxygen Demand (COD)	mg/L	100
Trace Metals		
Aluminium (Al)	mg/L	20
Antimony (Sb)	mg/L	0.1
Arsenic (As)	mg/L	0.05
Barium (Ba)	mg/L	2
Beryllium (Be)	mg/L	0.05
Cadmium (Cd)	mg/L	0.05
Total Chromium (Cr)	mg/L	0.2
Chromium VI	mg/L	0.15
Cobalt (Co)	mg/L	0.2
Copper (Cu)	mg/L	0.5
Iron (Fe)	mg/L	2
Lead (Pb)	mg/L	0.1
Manganese (Mn)	mg/L	0.2
Mercury (Hg)	mg/L	0.001
Nickel (Ni)	mg/L	0.1
Selenium (Se)	mg/L	0.02
Silver (Ag)	mg/L	0.005
Zinc (Zn)	mg/L	0.5
Organic Chemical Properties		
Halogenic Hydrocarbons & Pesticides	mg/L	Nil
Hydrocarbons	mg/L	15
Oil & Grease	mg/L	10
Phenols	mg/L	0.1
Solvents	mg/L	None
Total Organic Carbon	mg/L	75
Biological Properties		
Total Coliform	MPN/100 ml	1000

Parameter	Unit	Suggested Limits
Fecal Coliform Bacteria	Cells/100 ml	1000
Colon Group	No./100 cm^2	5000
Egg Parasites	--	None
Worm Parasites	--	None

Source: Executive Order issues by the Council of Ministers Decree No. 37 of 2001 on Regulations concerning Protection of the Marine Environment

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

This Ministers Decree provides the classification categories / criteria for hazardous materials and waste, as well as regulatory requirements on the appropriate storage, management, transport and disposal of hazardous materials and wastes. The following are provisions of this Decree which are relevant to the generation of hazardous waste:

- No import of hazardous materials specified in Schedule 1.1 of Annex 1 is allowed unless a Permit is acquired from the Competent Authority;
- Only licensed contractors should be engaged to collect hazardous and medical waste;
- Entities responsible for the production and handling of waste must take all necessary measures to ensure that no damage to the environment occurs;
- Entities responsible for the production and handling of waste and must keep a registry of all wastes produced, transported and disposed;
- Hazardous wastes cannot be transported via land or sea without a permit from the relevant regulatory agency;
- Hazardous materials and waste are classified in accordance with Schedules 1.1 and 1.2 of Annex 1;
- Segregation requirements are to be maintained when storing hazardous material (Schedule 1.3 of Annex 1); and
- Burial of hazardous wastes in special equipped burial holes isolated from other environment elements.

3.2.7 Federal Law No. 12 of 1986 – Concerning Regulations on Labour Relations

This Federal Law governs the regulations on labour in the UAE. This Law provides the Federal requirements with regards to the following:

- Employment of women and children;
- Employment contracts, records and wages;
- Wages and other payments;
- Working hours and leave entitled to workers;
- Workers' safety, protection, health and social care; and

- Regulatory reporting and compensation for work-related injuries and occupational diseases.

3.3 Dubai Emirates Regulatory Framework

The environmental laws and regulations in the Emirate of Dubai that are relevant to the Project are provided in Table 3-5 and summarised in the subsequent sections.

Table 3-5 Dubai Emirates Environmental Laws and Regulations Relevant to the Project

Legislation	Project Relevance	Aspect
DM Local Order No. 61 of 1991 on the Environment Protection Regulations in the Emirate of Dubai	The Project should comply with the environmental protection regulations stipulated in this Local Order	Overarching environmental protection
DM Administrative Order No. 211 of 1991 on the Issue of Executive Regulations for the Local Order No. 61 of 1991 on the Environment Protection Regulations in the Emirate of Dubai	This Administrative Order provides specific regulations on wastewater and sludge reuse and disposal, wastewater disposal to the marine environment and noise control that the Project needs to comply.	Overarching environmental protection
Local Order No. 22 of 2001 Regarding Conservation of Coastal Zone of Dubai	This decree stipulates requirements to ensure conservation of Dubai coastal zone, which is wholly applicable and should be complied with by the Project.	Coastal zone
Local Order No. 11 of 2003 Concerning Public Health and Safety of the Society in the Emirate of Dubai	This Local Order aims to ensure protection of public health and community safety, which should be complied with by the Project during construction and operation phases.	Public health and safety
Ambient Air Quality Standards	The Project will comply with the air quality standards prescribed by the DM	Air Quality
Local Order No. 2 of 1998 Establishing the Jebel Ali Marine Sanctuary		Marine Environment
Law No. (11) of 2003 on Nature Reserves within the Emirate of Dubai		Marine Environment
DM Environmental Planning and Studies Section		
Technical Guideline No. 1 – Environmental Impact Assessment (January 2017)	The EIA was undertaken in accordance with the requirements of this Technical Guideline.	Overarching Environmental Assessment

Legislation	Project Relevance	Aspect
Technical Guideline No. 2 – EIA Requirements for Land Development, Infrastructure, and Utility Projects (January 2017)	The EIA was undertaken in accordance with the requirements of this Technical Guideline.	Overarching Environmental Assessment
Technical Guideline (6) – Requirements for the Discharge of Waste Gases, Fumes and Particulates to the Atmosphere	The Project should comply with the requirements of this TG	Air Quality
Technical Guideline (7) – Policy on the Control of Ozone Depleting Substances (December 2014)	The Project should comply with the requirements of this TG	Air Quality
Technical Guideline (8) – Management of Recyclable Waste Material (December 2014)	The Project should comply with the requirements of this TG	Waste Management
Technical Guideline (10) – Waste Minimization (December 2014)	The Project should comply with the requirements of this TG	Waste Management
DM Coastal Zone and Waterways Management Section		
Technical Guideline No. 1 – Oil Spill Preparedness and Response (April 2011)	The wastewater discharge limits specified in the Information Bulletin are considered applicable to the Project since domestic sewage generated during operation phase is intended to be disposed into the existing DM sewerage network.	Waste Management
Technical Guideline No. 2 – Tourist and Leisure Travel within the Emirate of Dubai (November 2011)	Given that the Project is located within the marine environment, the guidelines in the TG are relevant to the Project.	Marine Environment
Technical Guideline No. 3 – Marina Environmental Management (June 2014)	Given that the Project is located within the marine environment, the guidelines in the TG are relevant to the Project.	Marine Environment
Environment and Coasts Circulars		
Circular No. 3 – Notification Regarding Disposal of Hazardous Wastes (July 2016)	The Project will comply with the permit requirements defined in this TG, if hazardous wastes are generated on-site.	Waste Management
Circular No. 5 – Regarding Management and Controlling the Handling and Disposal	The Project will comply with the permit requirements defined in this TG, if trade wastewater are generated on-site	Waste Management

Legislation	Project Relevance	Aspect
processes of Hazardous Wastes (November 2014)		
Other		
Technical Guideline (6) – Disposal of Hazardous Wastes (May 2017)	The Project should comply with the requirements of this TG	Waste Management
Hazardous and General Waste Processing and Recycling Premises in the Emirate of Dubai – 2017	Service providers to be engaged for waste management of Project shall include only the entities approved by DM.	Waste Management
Approved Hazardous Waste Transporter (2017)		
Companies Permitted to Collect & Transport Oily Waste in the Emirate of Dubai for Purpose of Recycling / Re-Use (2017)		Waste Management
Green Building Regulations and Specifications in the Emirate of Dubai	This regulation is relevant to the Project since it is applicable to all new buildings in the Emirate of Dubai.	Conceptual Design

3.3.1 DM Local Order No. 61 of 1991 on the Environment Protection Regulations in the Emirate of Dubai

In 1991, Dubai Municipality issued Local Order No. 61 of 1991 dealing with environment protection regulations in the Emirate of Dubai. This Local Order consists of 91 articles, which provide regulations concerning the following:

- Reuse and land disposal of wastewater and sewage sludge;
- Disposal of wastewater into the marine waters;
- Air pollution control from stationary sources;
- Occupational health and safety;
- Swimming pool safety;
- Safety of toys;
- Noise control;
- Protected Areas (Wildlife Sanctuaries); and
- General provisions on penalty and fines for non-compliances.

3.3.2 DM Administrative Order No. 211 of 1991 on the Issue of Executive Regulations for the Local Order No. 61 of 1991 on the Environment Protection Regulation in the Emirate of Dubai

This Administrative Order was enacted in line with the Local Order No. 61 (1991) on the Environment Protection Regulations in the Emirate of Dubai. Specific requirements of this regulation include:

- On wastewater and sludge reuse and disposal:
  - Permit for the reuse and land disposal of wastewater and sewage sludge shall be obtained from the Environment and Health Departments of DM; and
  - The quality of wastewater and sludge proposed to be reused should comply with the DM allowable limits.
- Concerning the disposal of wastewater into the marine environments:
  - Liquid effluent to be discharged into the marine environment shall comply with the prescribed standards (Table 3-6); and
  - Monitoring of the physical, chemical, heavy metals and biological parameters shall be carried out at the disposal site on a regular basis.
- On noise control:
  - Level of noise from premises should not exceed 55 dB(A) during the period from 7:00 am to 8:00 pm, and 45 dB(A) from 8:00 pm to 7:00 am except during holidays, official and popular celebrations; and
  - The limits for the exposure period for a worker (occupational exposure) in a noisy place are also provided.

Table 3-6 DM Effluent Standards for Marine Water Discharge

Parameter	Unit	Standard
Physical-Chemical		
Biological Oxygen Demand (BOD) 5-day	mg/L	30
Chloride (total)	mg/L	1.0
Cyanide	mg/L	0.10
Nitrogen, ammonia	mg/L	5.0
Oil and grease	mg/L	5.0
pH	pH unit	6 – 9
Phenols	mg/L	0.10
Phosphate	mg/L	0.10
Sulphide	mg/L	0.10
Suspended solids	mg/L	30
Turbidity	NTU	75
Metals		
Arsenic	mg/L	0.05
Cadmium	mg/L	0.05
Chromium	mg/L	0.50
Copper	mg/L	0.50

Parameter	Unit	Standard
Iron	mg/L	2.0
Lead	mg/L	0.10
Nickel	mg/L	0.10
Selenium	mg/L	0.02
Silver	mg/L	0.005
Zinc	mg/L	0.10
Bacteriological		
Faecal coliforms	MPN	100 MPN/100 mL (80% of samples)
Faecal streptococci	MPN	100 MPN/100 mL
Salmonella	MPN	Non-detectable (in 1L)
Entero viruses	PFU	Non-detectable (in 10L)

Source: DM Administrative Order No. 211

3.3.3 Local Decree No. 22 of 2001 Regarding Conservation of Coastal Zone of Dubai

This local decree was enacted to ensure conservation of Dubai coastal zone mainly through the requirements for:

- Protecting all coastal sand resources in a zone stretching 10 nautical miles offshore and 1 kilometre inshore;
- No Objection Certificate (NOC) from DM for construction and development works, including excavation, filling, dredging and transporting of sand within the Dubai coastal zone; and
- Soil test to verify the quality of sands to be extracted during excavation, and to furnish DM with copies of the test results.

This decree is wholly applicable to, and should be complied with by, the Project.

3.3.4 Local Order No. 11 of 2003 Concerning Public Health and Safety of the Society in the Emirate of Dubai

Local Order No. 11 of 2003 aims to ensure protection of public health and community safety in the Emirate of Dubai through provision of specific requirements for the following, which may be relevant to the Project:

- Health Hazard;
- Drinking Water;
- Fighting of Public Health Pest;
- Public Safety;
- Smoke Control;

- Health and Safety of Buildings; and
- Public Cleanliness.

This Local Order stipulates conditions for penalties in cases of violations.

3.3.5 Ambient Air Quality Standards

The ambient air quality standards stipulated in the Cabinet Degree (12) of 2006 are shown in Table 3-7, while ambient air quality standards prescribed by DM are provided in Table 3-8.

Table 3-7 UAE Federal Ambient Air Quality Standards

Substance	Symbol	Maximum Allowable Limit (µg/Nm^3)	Average Time
Carbon Monoxide	CO	30 (mg/Nm^3)	1 hour
		10 (mg/Nm^3)	8 hour
Nitrogen Dioxide	NO_2	400	1 hour
		150	24 hour
Ozone	O_3	200	1 hour
		120	8 hour
Total Suspended Particulates	TSP	230	24 hour
		90	1 year
Particulate Matter (10 microns or less in diameter)	PM_{10}	150	24 hour
Sulphur Dioxide	SO_2	350	1 hour
		150	24 hour
		60	1 year

Table 3-8 Dubai Municipality Air Quality Standards

Indicator	Averaging Time	Parts per billion	µg/Nm^3
Carbon monoxide (CO)	1 hour	20 x 10^3	23 x 10^3
Nitrogen dioxide (NO_2)	1 hour	150	290
	24 hours	60	110
Oxidants (as Ozone, O_3)	1 hour	80	160
Respirable dust (PM_{10})	1 hour	--	300
	24 hours	--	150
Sulphur dioxide (SO_2)	1 hour	130	350
	12 months	20	50

Indicator	Averaging Time	Parts per billion	µg/Nm^3
Benzene (C_6H_6)	1 hour	20	50
Lead (Pb)	3 months	--	1.0
Fluoride (as hydrogen fluoride, HF)	24 months	3.5	3.0
	3 months	0.6	0.5

3.3.6 Marine Sediments

Local standards are currently not available for the assessment of marine sediment quality; therefore, the following guidelines were adopted for the marine sediment quality baseline data and impact assessment in this EIA:

- The Australian New Zealand Guidelines for Fresh and Marine Water and Sediment Quality (2000) (Table 3-9);
- The National Oceanographic and Atmospheric Administration (NOAA) sediment quality guidelines (1999); and
- The Dutch Circular on Remediation of Water Bottoms (sediments) which lists Intervention Values (IV) for pollutants in sediments where serious contamination is deemed to exist if the IV is exceeded.

Table 3-9 Sediment Quality Guidelines

Contaminant	**ANZECC** - The Australian New Zealand Guidelines for Fresh and Marine Water and Sediment Quality (2000)		**NOAA** - The National Oceanographic and Atmospheric Administration (NOAA) sediment quality guidelines (1999)	
	ISQG-Low (Trigger value)	**ISQG-High**	**Effects range low (ERL)**	**Effects Range Medium (ERM)**
Metals (mg/kg dry wt)				
Antimony	2	25	–	–
Cadmium	1.5	10	1.2	9.6
Chromium	80	370	81	370
Copper	65	270	34	270
Lead	50	220	46.7	218
Mercury	0.15	1	0.15	0.71
Nickel	21	52	20.9	51.6
Silver	1	3.7	1	3.7
Zinc	200	410	150	410
Metalloids (mg/kg dry wt)				

Contaminant	ANZECC - The Australian New Zealand Guidelines for Fresh and Marine Water and Sediment Quality (2000)		NOAA - The National Oceanographic and Atmospheric Administration (NOAA) sediment quality guidelines (1999)	
	ISQG-Low (Trigger value)	**ISQG-High**	**Effects range low (ERL)**	**Effects Range Medium (ERM)**
Arsenic	20	70	8.2	70
Organics[a]				
Total PAHs	4000	45000	4022	44792
Total PCBs	23	–	22.7	180

[a] Normalised to 1% organic carbon;

Source: Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000), ANZECC and ARMCANZ

3.3.7 Dredged Marine Sediments

As there are currently no established standards for sediment quality in the UAE, international guidelines and standards will be adopted as criteria for the dredged fill material monitoring.

Given similarities in bio-geographic characteristics between the Arabian Gulf and Australia, project type (dredging and material disposal in a tropical marine environment) and the desire to minimise impacts associated with the project on nearby sensitive receptors, the National Assessment Guideline for Dredging (NAGD) was identified as an appropriate guideline to adopt for the assessment of sediment quality Table 3-10.

Table 3-10 Adopted Guidelines for Baseline Sediment Quality Investigation

Grouping	Analyte	Adopted Guideline Value (NAGD Screening Level; mg/kg)
Metals and Metalloids	Aluminium (Al)	-
	Arsenic (As)	20
	Cadmium (Cd)	1.5
	Chromium	80
	Copper (Cu)	65
	Lead (Pb)	50
	Mercury (Inorganic) (Hg)	0.15
	Nickel (Ni)	21
	Zinc (Zn)	200
Semi-volatile organic compounds	Total Polycyclic Aromatic Hydrocarbon (PAH)	10
Total Petroleum Hydrocarbons	Total Petroleum Hydrocarbons (TPH)	550

3.3.8 Circulars, Technical Guidelines and Information Bulletins from Dubai Municipality (DM)

3.3.8.1 Environmental Planning and Studies Section (EPSS) Requirements

Technical Guidelines (TG)

The DM-EPSS Section has also issued a number of Technical Guidelines (TG) to supplement Local Order No. 61 of 1991. Key requirements of the relevant TGs are outlined as follows:

- TG No. 1 – Environmental Impact Assessment (January 2017); and
- TG No. 2 – EIA Requirements for Land Development, Infrastructure, and Utility Project (January 2017).

This EIA was undertaken in accordance with the requirements of the above TGs.

Information Bulletin

DM Information Bulletin on Waste Processing Premises in the Emirate of Dubai (2017) provides the list of waste processing premises approved by DM EPSS for managing specific types of waste. Service providers to be engaged for waste management of Project shall include only the entities approved by DM.

3.3.8.2 Coastal Zone and Waterways Management Section Requirements

The Information Bulletin on Environmental Standards and Allowable Limits of Pollutants on Land, Water and Air Environment (May 2003) provides quick reference for wastewater discharge limits, marine water quality objectives, trace metals in sludge intended for land disposal and land contamination indicator levels.

The Water Quality Objectives for Sea and Coastal (Table 3-11) are particularly applicable to the Project given that the Project site is within the marine environment. The activities to be undertaken during the construction and operation phases should not result to / cause non-compliances with these objective standards.

The wastewater discharge limits outlined in Table 3-11 are considered applicable to the Project in that domestic sewage is intended to be disposed into the existing DM sewerage network.

Table 3-11 Dubai Municipality Wastewater Discharge Limits and Water Quality Objectives

Parameters	Unit	Wastewater Discharge Limits			Water Quality Objectives	
		Sewerage	Land for Irrigation		Sea & Coastal	Dubai Creek
			Drip	Spray		
Physico-Chemical						
Biochemical Oxygen Demand	mg/l	1000	20	10	20	10
Chemical Oxygen Demand	mg/l	3000	100	50	--	--
Chlorides	mg/l	--	500	350	--	--
Chlorine - residual	mg/l	10	Not less than 0.5 mg/l after 30 min contact time		0.01	0.01

Parameters	Unit	Wastewater Discharge Limits			Water Quality Objectives	
		Sewerage	Land for Irrigation		Sea & Coastal	Dubai Creek
			Drip	Spray		
Cyanide as CN	mg/l	1	0.05	0.05	--	--
Detergents	mg/l	30	--	--	--	--
Dissolved Oxygen	mg/l and % saturation	--	--	--	Not less than 5 mg/l or 90% saturation	Not less than 5 mg/l or 90% saturation
Fluorides	mg/l	--	1	1	--	--
Nitrogen, ammoniacal	mg/l	40	5	1	0.1	0.1
Nitrogen, nitrate	mg/l	--	--	--	0.5	0.5
Nitrogen, organic (Kjeldahl)	mg/l	--	10	5	--	--
Nitrogen, total	mg/l	--	50	30	2	2
Oil & Grease, emulsified	mg/l	150	--	--	--	--
Oil & Grease, Free oil	mg/l	50	5	5	--	--
pH	units	6 to 10	6 to 8	6 to 8	1 pH unit from ambient	1 pH unit from ambient
Pesticides, non-chlorinated	mg/l	5	--	--	--	--
Petroleum hydrocarbons	mg/l	--	--	--	0.001 (aromatic fraction)	0.001 (aromatic fraction)
Phenols	mg/l	50	0.1	0.1	--	--
Phosphate-Phosphorus	mg/l	30	20	20	0.05	0.05
Sulphates, total	mg/l	500	200	200	--	--
Sulphides as S	mg/l	10	0.05	0.05	--	--
Surfactants	mg/l	--	--	--	0.02	0.02
Total Suspended Solids (TSS)	mg/l	500	50	10	10 (mean) 25 (max)	10 (mean) 15 (max)
Temperature	ºC	45 or >5 of ambient	--	--	2 ºC from background level	2 ºC from background level
Total Dissolved Solids (TDS)	mg/l	3000	1500	1000	2% from background levels	2% from background levels

Parameters	Unit	Wastewater Discharge Limits			Water Quality Objectives	
		Sewerage	Land for Irrigation		Sea & Coastal	Dubai Creek
			Drip	Spray		
Turbidity	NTU	--	--	--	75 or none that will reduce light penetration by more than 20% from background levels	75 or none that will reduce light penetration by more than 20% from background levels
Metals						
Total Metals	mg/l	10	--	--	--	--
Aluminium (Al)	mg/l	--	2	2	0.2	0.2
Arsenic (As)	mg/l	0.5	0.05	0.05	0.01	0.01
Barium (Ba)	mg/l	--	1	1	--	--
Beryllium (Be)	mg/l	--	0.1	0.1	--	--
Boron (B)	mg/l	2	2	2	--	--
Cadmium (Cd)	mg/l	0.3	0.01	0.01	0.003	0.003
Chromium (Cr)	mg/l	1.0	0.1	0.1	0.01	0.01
Cobalt	mg/l	--	0.1	0.1	--	--
Copper (Cu)	mg/l	1.0	0.2	0.2	0.005	0.005
Iron (Fe)	mg/l	--	2.0	2.0	0.2	0.2
Lead (Pb)	mg/l	1.0	0.5	0.5	--	--
Magnesium (Mg)	mg/l	--	100	100	--	--
Manganese (Mn)	mg/l	1.0	0.2	0.2	--	--
Mercury (Hg)	mg/l	0.01	0.001	0.001	0.001	0.001
Molybdenum (Mo)	mg/l	--	0.01	0.01	--	--
Nickel (Ni)	mg/l	1	0.2	0.2	--	--
Selenium (Se)	mg/l	--	0.02	0.02	--	--
Silver (Ag)	mg/l	1	--	--	--	--
Sodium (Na)	mg/l	--	500	200	--	--
Zinc (Zn)	mg/l	2	0.5	0.2	0.02	0.02
Bacteriological						
E. coli	organisms/100ml	--	--	--	200	200

Parameters	Unit	Wastewater Discharge Limits			Water Quality Objectives	
		Sewerage	Land for Irrigation		Sea & Coastal	Dubai Creek
			Drip	Spray		
Faecal Coliforms	MPN/100 ml	500	20	--	--	--

-- means no available standard

3.3.8.3 Environmental Control Section Requirements

An outline of the DM Environmental Control Section TG requirements relevant to the Project is provided below:

- TG No. 1 – Disposal of Hazardous Waste (May 2017):
  - Hazardous waste generator shall apply for hazardous waste disposal permit online via the DM Waste Disposal Service system. The application shall be supported with documents including waste analysis report, and / or Material Safety Data Sheet (MSDS) such as in the case of expired chemicals;
  - All permitted waste shall be disposed of into the designated site within 60 days from date of approval / Waste Disposal Service permit;
  - Hazardous waste generator shall provide the transporter with a copy of the Waste Disposal Service permit.
- TG No. 2 – Disposal of Trade Wastewater (June 2011):
  - All proposed discharge of trade waste or industrial wastes into the sewer, land or marine requires permit from DM via the Waste Disposal Service system;
  - Domestic sewage discharged into the sewer;
- TG No. 3 – Marina Environmental Management Requirements (June 2014):
  - Prepare a marina specific environmental management plan, which includes standard operating procedures (SOPs);
  - Daily marina routine must include environmental monitoring and corrective actions must be taken if non-conformances are identified;
  - Records of activities covered the marina environmental management plant must be kept updated; and
  - Employees must be trained about environmental management responsibilities.
- TG No. 6 – Bunding of Storage Tanks and Transfer Facilities (June 2011):
  - Materials used for bunds (floor slab and bund walls) shall be impervious and compatible with the liquids to be contained;
  - The bund shall be constructed with drainage and collection;
  - For tank storage, the gross capacity of the bunded area shall be 110% of the biggest tank capacity, or 25% of the total capacity of all tanks stored within the bund, whichever is greater. Wall type bunds at tank storage facility shall be 0.5 m to 1.5 m high. A minimum distance of 1 m between the tank and bund walls shall be maintained;
  - For drum storage, the gross capacity of bunded area shall be of sufficient capacity to contain at least 25% of the total volume of drums stored up to 10 kL plus 10% of any volume in excess thereof;

- The capacity of bunded area for tank vehicle loading shall be at least 100% of the largest compartment of any tank vehicle using the filling facility and the maximum quantity capable of being discharged from the filling point with full flow during a period of 2 minutes;
- Bunded areas without any cover (roof) shall be at least 150 mm high;
- Stormwater collected from bunded area may be contaminated and as such may require disposal permit via the DM Waste Disposal Service system;
- Suitable fire precautions shall be out in place where there is risk of fire.

- TG No. 7 – Development of Emergency Response Procedures for Incidents Involving Dangerous Goods (June 2011):
  - Risk assessment to be undertaken and form the basis for planning emergency response procedures, resources and equipment;
  - Records of MSDS / manifests shall be maintained and kept updated and readily accessible;
  - Roles and responsibilities shall be clearly defined and communicated;
  - Incident specific response procedure shall be developed;
  - Emergency response equipment (e.g. fire extinguishers and spill kits) shall be made available, kept in good condition and inspected on a regular basis.
- TG No. 9 – Requirement for the Reduction of Construction and Demolition Noise (1999):
  - Specifies an incremental allowable noise level that may be implemented when the background noise at a sensitive receptor already exceeds the allowable noise limit on the receptor area zone;
  - The incremental allowable noise that may be implemented shall not exceed the sliding scale incremental noise level detailed in Table 3-12.

Table 3-12 Allowable Incremental Noise Level

Measured average noise level, dB(A)	Allowable increase, dB(A)
50 – 60	5
61 – 65	4
66 – 70	3
71 – 75	2
76 – 80	1

Source: Dubai Municipality, 1999

- Guidelines for the Disposal and Reuse of Used Chemical Containers:
  - Any disposal of used chemical containers shall require prior approval from the DM Environmental Control Section;
  - Wastewater generated from washing contaminated containers is considered hazardous waste and shall be managed in accordance with Environmental Control Section TG No. 1.
- TG No. 13 – Environmental Regulations for the Reuse of Treated Wastewater for Irrigation and Thermal Treated Sludge for Agricultural Purposes:
  - Treated wastewater used for irrigation purposes shall comply with the standard limits provided in Table 3-13.

Table 3-13 DM Accepted Limits of Treated Wastewater for Restricted and Unrestricted Irrigation

Parameters	Units	Unrestricted Irrigation	Restricted Irrigation
Physico-Chemical			
Biochemical Oxygen Demand	mg/l	5	20
Chemical Oxygen Demand	mg/l	150	200
Total Suspended Solids (TSS)	mg/l	15	30
Total Dissolved Solids (TDS)	mg/l	2000	2000
Dissolved Oxygen	mg/l	4 to 5	3
Free Residual Chlorine	mg/l	1 to 2	1 to 2
pH		6 to 8	6 to 8
Metals			
Total Metals	mg/l	--	--
Aluminium (Al)	mg/l	5	5
Arsenic (As)	mg/l	0.05	0.1
Barium (Ba)	mg/l	0.05	0.1
Beryllium (Be)	mg/l	0.1	0.3
Boron (B)	mg/l	0.5	1
Cadmium (Cd)	mg/l	0.01	0.01
Chromium (Cr+6)	mg/l	0.05	0.05
Cobalt	mg/l	0.05	0.05
Copper (Cu)	mg/l	0.5	1
Cyanide (Cn)	mg/l	0.05	0.05
Fluoride (F)	mg/l	1	2
Iron (Fe)	mg/l	1	5
Lead (Pb)	mg/l	0.1	0.2
Magnesium (Mg)	mg/l	150	150
Manganese (Mn)	mg/l	0.1	0.5
Mercury (Hg)	mg/l	0.001	0.05
Molybdenum (Mo)	mg/l	0.01	0.05
Nickel (Ni)	mg/l	0.1	0.1
Selenium (Se)	mg/l	0.02	0.02
Silver (Ag)	mg/l	0.01	0.01
Sodium (Na)	mg/l	200	300
Vanadium		0.1	0.1
Zinc (Zn)	mg/l	5	5

Parameters	Units	Unrestricted Irrigation	Restricted Irrigation
Organic Parameters			
Ammonia (NH_3)	mg/l	5	10
Nitrate (NO_3)	mg/l	50	50
Nitrogen, total	mg/l	5	50
Oil & Grease	mg/l	0.5	0.5
Phenols	mg/l	0.001	0.002
Phosphate	mg/l	30	30
Sulphate	mg/l	400	400
Sulphides as S	mg/l	0.1	0.1
Bacteriological			
E. coli	mg/l	100 >	1000 >
Worm eggs	mg/l	--	1 >
Protozoal Vesicle	mg/l	--	1 >
Pathogenic Bacteria	mg/l	--	1 >

3.3.8.4 Natural Resources and Conservation Section

The Natural Resources and Conservation Section (formerly the Marine Environment and Wildlife Section) of the DM Environment Department also developed TGs for ensuring protection of the marine environment. Key requirement of TGs relevant to the Project are outlined below:

- TG No. 2 – Tourist and Leisure Travel within the Emirate of Dubai (November 2011):
  - Provides general guidelines for tourism in Dubai Creek, Gulf Waters and on beaches.
- TG No. 3 – Marina Environmental Management (June 2014):
  - Requires a marina-specific Environmental Management Plan to be submitted to, and approved by DM. The Plan shall include Standard Operating Procedures (SOP) to reduce pollution based on Best Management Practices;
  - The EMP shall also include requirements and procedures for monitoring, corrective action implementation, record keeping and training programs to ensure that the marina is operated and maintained in an environmentally sound manner;
  - An example of an important record to maintain is a sewage pump-out log, with details on date of pump-out, approximate volume of sewage pumped-out, vessel identification, slip number and signature of person performing the pump-out.

3.3.9 Green Building Regulations and Specifications in the Emirate of Dubai

As stated in the Regulation itself, the primary purpose of the Green Building Regulations and Specifications in the Emirate of Dubai is *'to improve the performance of buildings in Dubai by reducing the consumption of energy, water and materials, improving public health, safety and general welfare and by enhancing the planning, design, construction and operation of buildings to create an excellent city that provides the essence of success and comfort of living.'*

The Regulation applies to all new buildings in the Emirate of Dubai; hence is considered directly relevant to the Project.

The Regulation provides specific requirements with regard to:

- Ecology and planning:
  - Access and mobility;
  - Ecology and Landscaping;
  - Neighbourhood Pollution;
  - Microclimate and Outdoor Comfort;
  - Responsible Construction;
  - Environmental Impact Assessment.
- Building Vitality:
  - Ventilation and Air Quality;
  - Thermal Comfort;
  - Acoustic Comfort;
  - Hazardous Materials;
  - Day Lighting and Visual Comfort;
  - Water Quality.
- Resource Effectiveness: Energy:
  - Conservation and Efficiency: Building Fabric;
  - Conservation and Efficiency: Building Systems;
  - Commissioning and Management;
  - On-site Systems: Generation & Renewable Energy;
- Resource Effectiveness: Water:
  - Conservation and Efficiency;
  - Commissioning and Management;
  - On-site Systems: Recovery and Treatment;
- Resource Effectiveness: Materials and Waste:
  - Materials and Resources;
  - Waste Management.

Where possible, the requirements applicable / relevant to the Project have been incorporated in the mitigation measures.

3.4 International Conventions, Protocols and Guidance Documents

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

3.4.1 Climate Change and Air Pollution Control

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

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

Montreal Protocol on Substances that Deplete Ozone Layer (1987)

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

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

United Nations Framework Convention on Climate Change (1992)

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

- Under the Convention, governments (Intergovernmental Panel on Climate Change – IPCC - website, 2010):
- Gather and share information on greenhouse gas emissions, national policies and best practices;
- Launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries; and
- Cooperate in preparing for adaptation to the impacts of climate change.

The UAE acceded to the convention in December 1995.

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

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

Under the Protocol, the Annex I countries have committed to reduce their emissions by an average of 5% against the 1990 levels over the period of 2008 to 2012. As a non-Annex I country, the UAE is not required to reduce its emissions below 1990 levels. However, the UAE ratified the Protocol on January 2005 and has submitted its First and Second Communications to the United Nations Framework Convention on Climate Change in January 2007 and January 2010, respectively. This initial communication presents options and initiatives that the UAE may undertake in order to reduce its GHG emissions.

United Nations (UN) Climate Change Conference – COP21 – CMP11 (Paris)

The 2015 UN Climate Change Conference or the 21st session of the Conference of the Parties (COP21) negotiated the Paris Agreement, a global agreement on the reduction of climate change from 30 November to 12 December 2015. The Paris agreement is due to take effect in 2020.

The UAE decided to ratify the Paris agreement in September 2016 as they aim to combat global warming. Countries that have ratified the agreement are committed to limiting the rise in global average temperatures to 1.5°C above pre-industrial levels.

The Institute of Air Quality Management – Construction Guidance

The assessment of dust from demolition and construction document (2014) provides guidance for developers, consultants and environmental health practitioners on assessing construction impact, including demolition and earthworks. The emphasis in this document is on classifying the risk of dust impacts from a site, which will then allow appropriate mitigation measures to be identified.

3.4.2 Waste Management

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

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

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

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

- If the state of export does not have the capability of managing or disposing of the hazardous waste in an environmentally sound manner;
- Upon prior written notification by the state of export to the designated authorities of the state of import and transit, where appropriate; and
- Each country that is a party to the Convention is required to report on its hazardous waste generation and movement. The UAE signed the Basel Convention on September 1989.

3.4.3 Chemicals and Dangerous Goods

Stockholm Convention on Persistent Organic Pollutants (2001)

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

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

3.4.4 Marine Pollution

MARPOL 73-76

MARPOL 73/78 is the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978. ("MARPOL" is short for marine pollution and 73/78 short for the years 1973 and 1978.). It was developed by the International Maritime Organization in an effort to minimize pollution of the oceans and seas, including dumping, oil and air pollution. The objective of this convention is to preserve the marine environment in an attempt to completely eliminate pollution by oil and other harmful substances and to minimize accidental spillage of such substances.

Specific regulations of this Convention are provided in the following annexes:

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

Activities during the construction and operation phase of the Project will be required to comply with the requirements of this Convention.

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

The "Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972", the "London Convention" for short, is one of the first global conventions to protect the marine environment from human activities and has been in force since 1975. Its objective is to promote the effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter. Currently, 87 States are Parties to this Convention.

The Project will prohibit marine dumping (except for possibly acceptable wastes) in compliance with this Convention.

International Convention for the Control and Management of Ships' Ballast Water and Sediments (2004)

The "International Convention for the Control and Management of Ships' Ballast Water and Sediments", is one of the major international agreements with a view to preventing, minimising and ultimately eliminating the risks of introduction of Harmful Aquatic Organisms and Pathogens through ships entering the ports.

3.4.5 Biodiversity

Convention on Biological Diversity (1992)

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

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

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

3.5 Regional Conventions

Regional Conventions relevant to the construction and operation of the Project is discussed below.

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

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

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

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

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

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

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

Given that the Project is located within the marine environment, it will comply with the provisions of this Convention.

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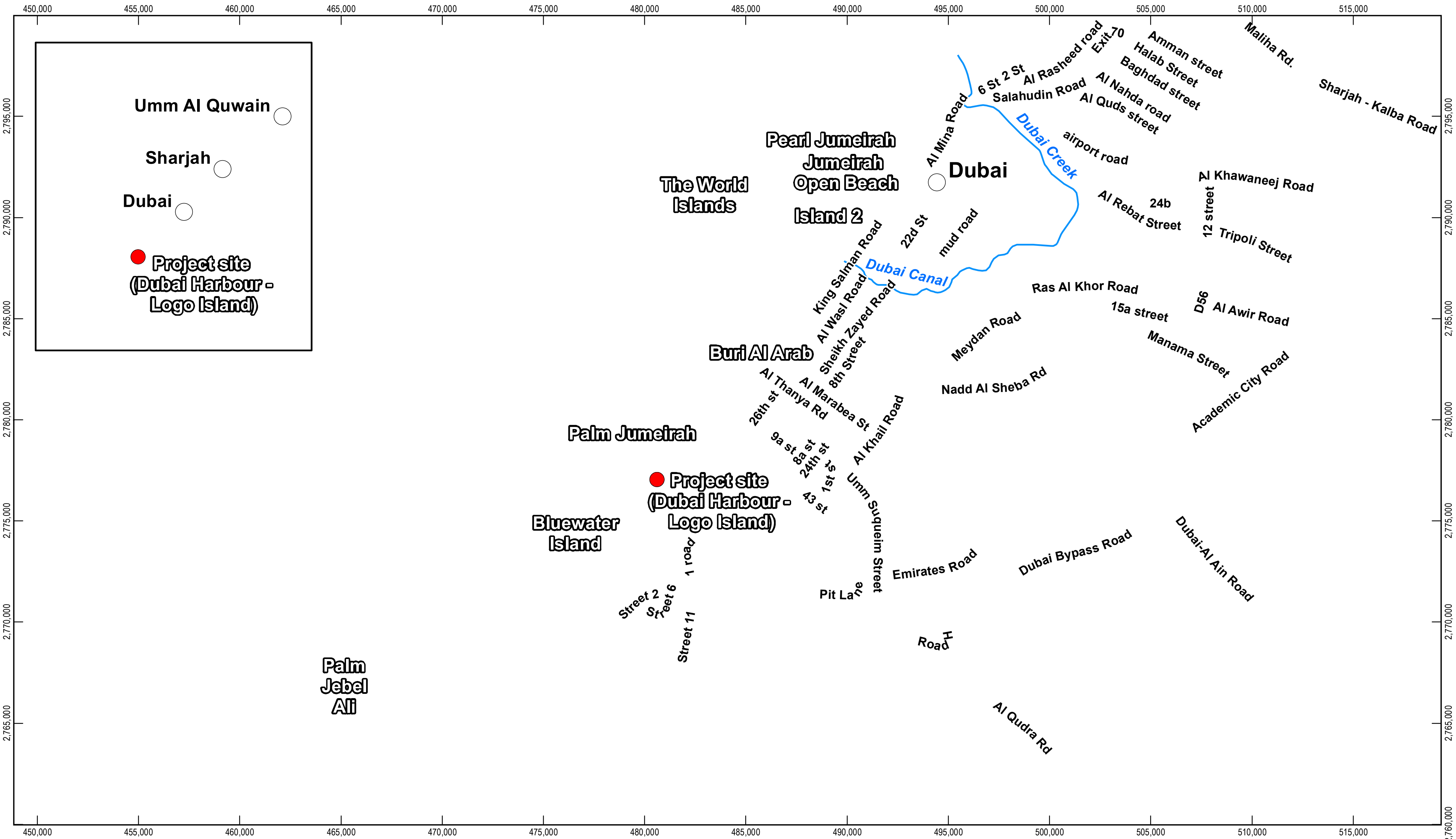
4. Description of the Project

4.1 Project Location

The Project site is located on the west coast of Dubai around Logo Island at the base of the Palm Jumeirah between Mina Seyahi and Skydive Dubai, as illustrated in Figure 4-1 and Figure 4-2.



Paper Size A4

0 2.5 5

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: WGS 1984
Grid: WGS 1984 Dubai Local TM

N

LEGEND

- Project site
- Waterways

MERAAS Holding
Dubai Harbour EIA

Job Number	76-10664
Revision	0
Date	02 Jun 2017

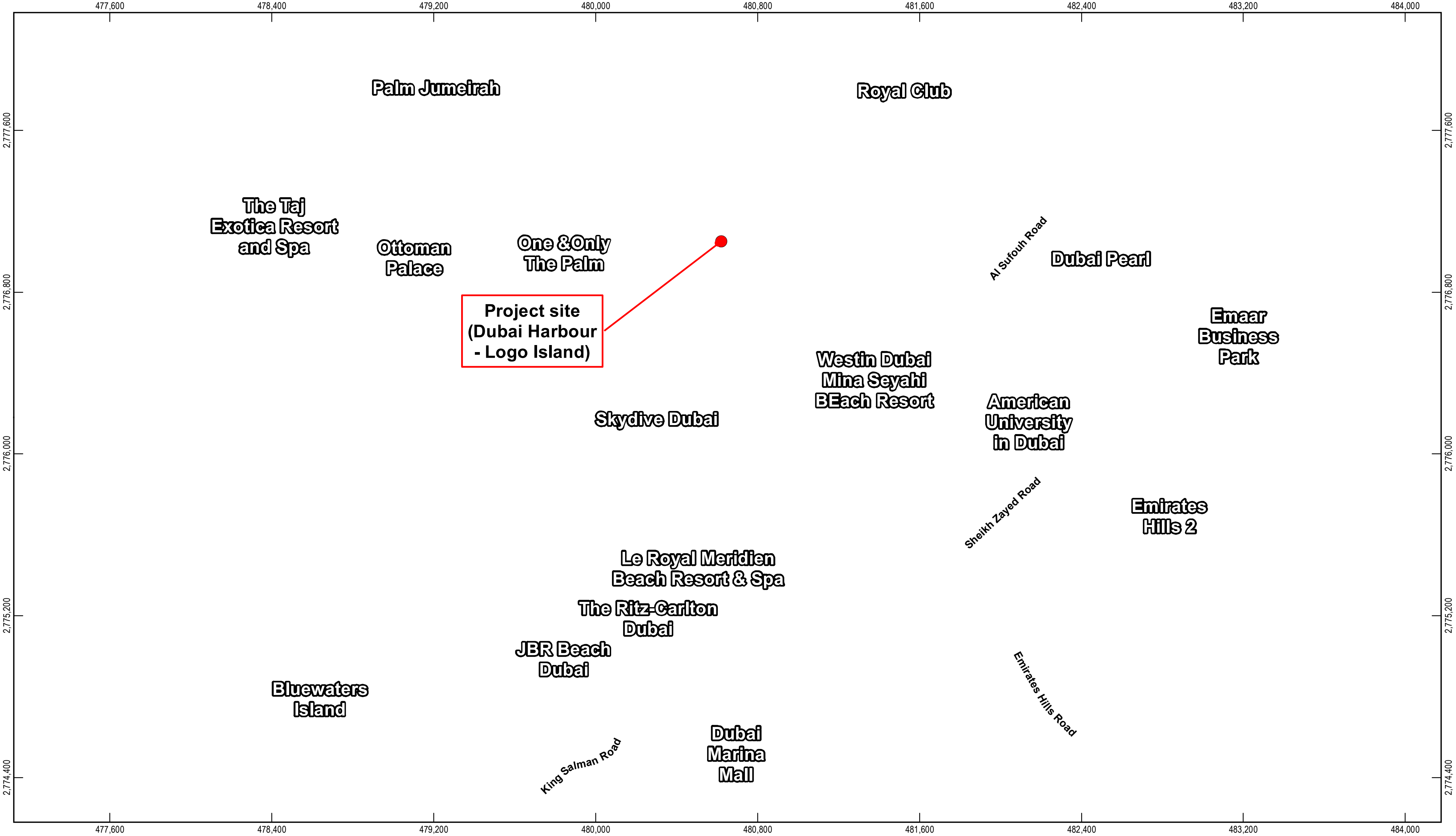
Regional setting of the project site

Figure 4-1

G:\71\12289\711228911_(7610664_Dubai Harbor EIA)\GIS\Maps\rev 0\7610664_RegionalSettingProjectSite_rev0.mxd

3rd floor Guardian Tower Danet Community Abu Dhabi United Arab Emirates W www.ghd.com

Data source: GHD - Project site, Place names - (2017). Image © Google Earth, Digital Globe. Natural Earth - Road. Created by:jcmatic



Paper Size A4

0 400 800

Meters

Map Projection: Transverse Mercator
Horizontal Datum: WGS 1984
Grid: WGS 1984 Dubai Local TM

N

LEGEND

Project site

GHD

MERAAS Holding
Dubai Harbour EIA

Job Number	76-10664
Revision	0
Date	02 Jun 2017

Proposed location of Dubai Harbour project

Figure 4-2

G:\71\12289\711228911_(7610664_Dubai Harbor EIA)\GIS\Maps\rev 0\7610664_PropLocationDubaiHarbour_rev0.mxd

3rd floor Guardian Tower Danet Community Abu Dhabi United Arab Emirates W www.ghd.com

Data source: GHD - Project site - (2017). Image © Google Earth, Digital Globe. Natural Earth - Road. Created by:jcmatic

4.2 Project Description

The Dubai Harbour Project will integrate Skydive Dubai, Dubai International Marine Club (DIMC) and Logo Island into one suburb (Figure 4-3) and will include commercial, residential, transport and community facility land uses. Key developments proposed include:

- The region's largest marina suitable for a total of 1,400 yachts, including super yachts;
- An iconic lighthouse;
- A 14,000 m^2 cruise ship terminal;
- Four marinas;
- A 57,000 m^2 shopping mall;
- High and medium density residential towers and hotels;
- Retail spaces;
- A sports and events destination area; and
- A navigation/access channel for yachts and cruise ships.

The Project will be connected to main roads and surrounding developments through a multimodal public transport system, which includes the group rapid transit, conventional buses and marine transport.

Figure 4-3 Proposed Dubai Harbour Project

The development would be subdivided into, along with protective offshore breakwaters as listed below and shown in Figure 4-4.

- Zone 1 – Cruise Terminal and Lighthouse Platform;
- Zone 2 – Logo Island Zone comprising Zone 2a Palm View and Zone 2b Palm View Beachfront Zone;

- Zone 3 – Harbour View Zone comprising the proposed shopping mall;
- Zone 4 (a – c) – Marina Zone comprising the Bay Marina, Operational and Main Marina Zones; and
- Detached Breakwater.

The entire area of development would be approximately 1.850 million m^2 and would require dredging, reclamation, demolition and building activities. North 25 propose to modify Logo Island by extending the reclaimed area, developing beaches on the north and south side and undertaking demolition works to remove existing reinforced concrete foundations, pre-cast elements and rock structures. A new channel is required to be dredged to allow cruise liner access to the development, which is will partially follow an existing trench along the Palm Jumeirah perimeter to limit dredging volumes. The construction of a causeway to connect Logo Island and DIMC was completed on 18 May 2017 as part of the early works for this Project. Further details on construction activities are provided in Section 4.6.

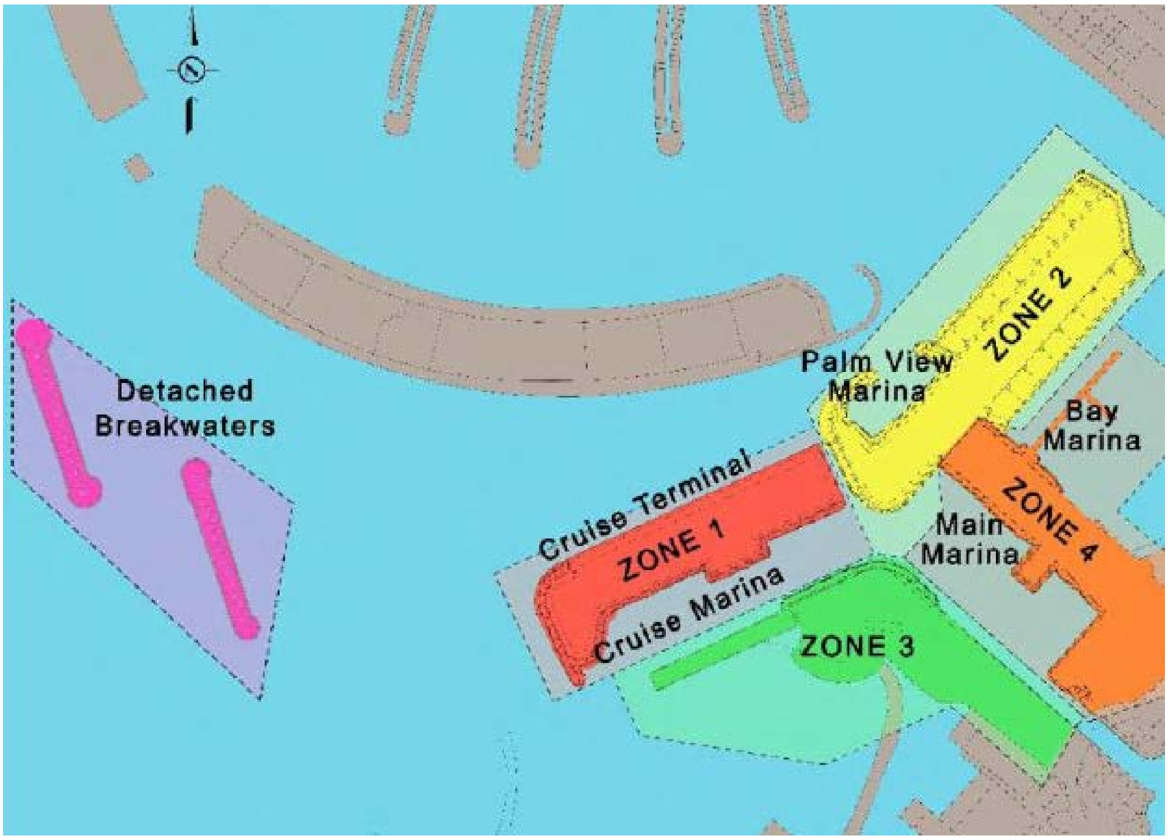


Figure 4-4 Proposed Dubai Harbour Zoning Plan

4.2.1 Project Zones

4.2.1.1 Zone 1 – Cruise Terminal and Lighthouse Platform Zone

Zone 1 will consist of a cruise terminal and a lighthouse as well as a staff clubhouse (Figure 4-5). The Zone will be predominantly a tourist hub, as visitors will be arriving to this Zone through the cruise terminal. Approximately 1.6 million visitors are expected from cruise ships in one season (eight months).The cruise terminal will be able to accommodate two Oasis Class vessels with the following dimensions: L=360 m, Beam=47 m, Draft = 9.15 m. The cruise terminal will be managed separately by a cruise terminal operator. As such, further details on the operation of the cruise terminal cannot be provided at this stage and will be included in an Operational Environmental Management Plan (OEMP). The zone will comprise two cruise terminal buildings and a Superyacht Marina on floating docks. The Superyacht marina will accommodate 62 vessels of 30, 60, 90 and 120 meters (Figure 4-6).

The lighthouse, which will be an iconic building, will be located at the tip of Zone 1.

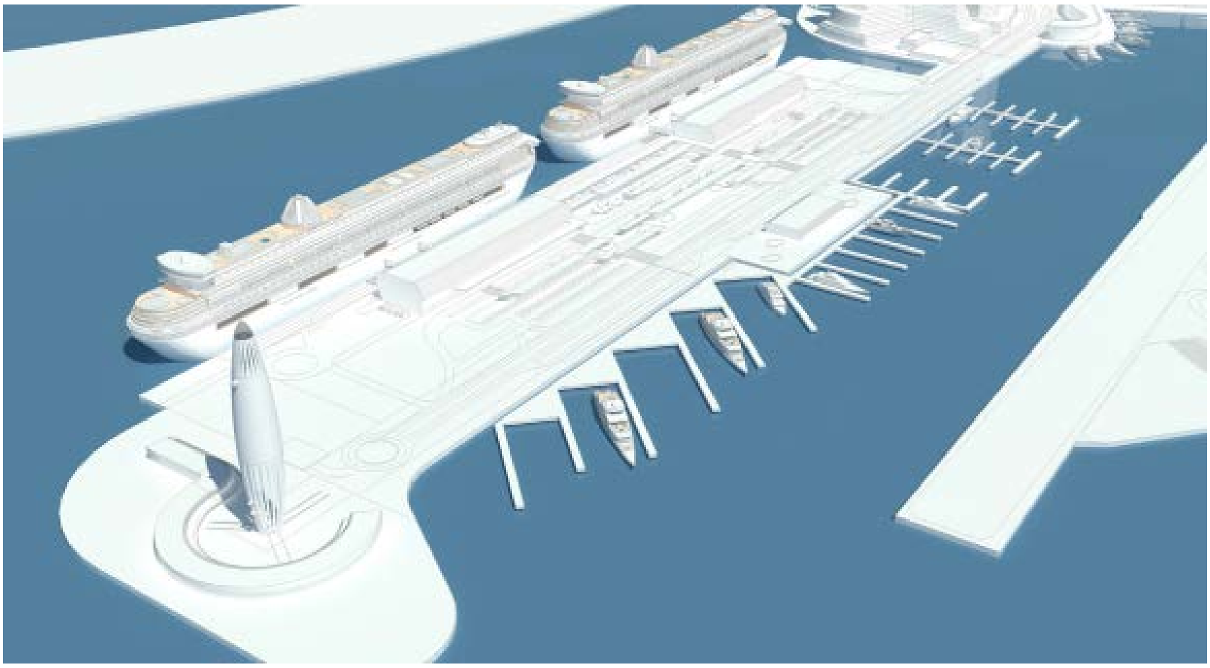


Figure 4-5 3D View of the Cruise Terminal Zone

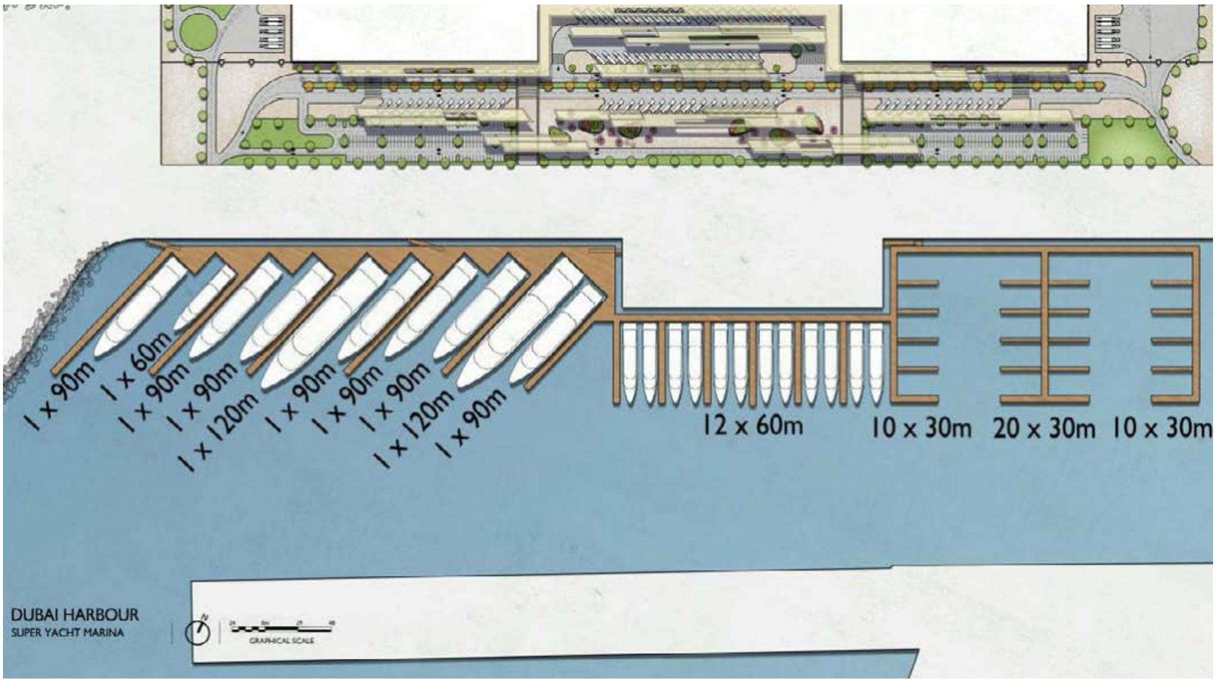


Figure 4-6 Superyacht Marina Configuration

4.2.1.2 Zone 2a – Palm View Marina Zone

The Palm View Marina will provide an area for up to 31 yachts and a few smaller boats. The Zone will be surrounded by high-rise residential buildings, a hotel as well as retail and food and beverage outlets (Figure 4-7). The Zone will provide a view corridor from the main trunk to the yachts and will also include an exclusive Yacht Club, which will provide unique views for visitors.

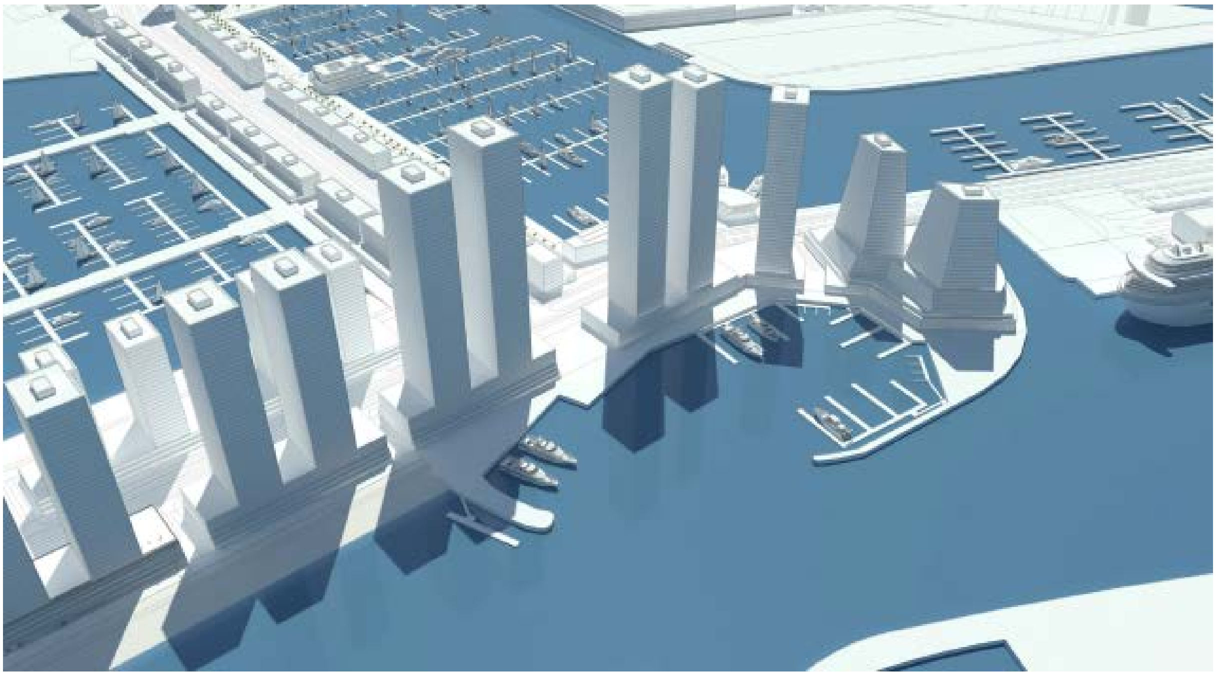


Figure 4-7 3D View of the Residential Buildings

4.2.1.3 Zone 2b – Palm View Beachfront Zone

The Palm View Beachfront area will consist of high-rise development with beachfronts facing either Palm Jumeirah or Mina Dubai Marina (Figure 4-8). A promenade will connect the residential buildings to allow residents to run, cycle or walk for approximately 2 km.

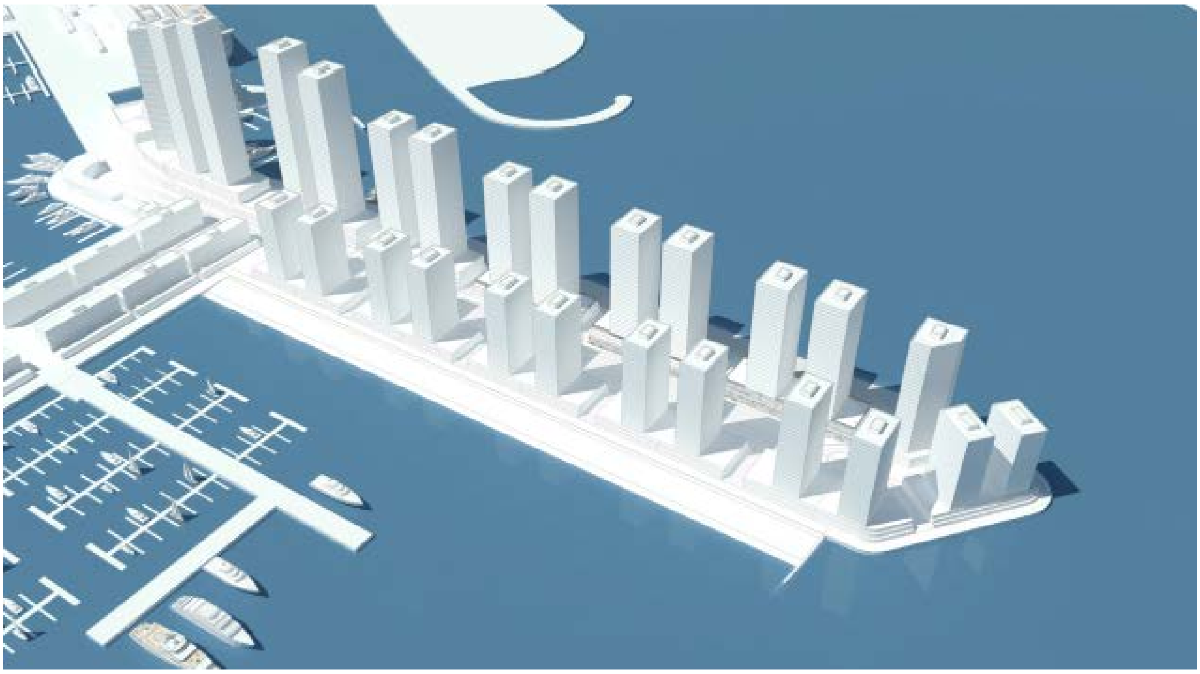


Figure 4-8 3D Views of the Beachfront Residential Buildings

4.2.1.4 Zone 3 – Harbour View Zone

The Harbour View Zone is anticipated to be the busiest day-to-day zone as it will consist of a shopping mall, world-class sporting facilities and event attractions. As shown in, the Harbour View Zone will integrate the existing Skydive Dubai within the development. This Zone will serve the development and other residents living nearby.

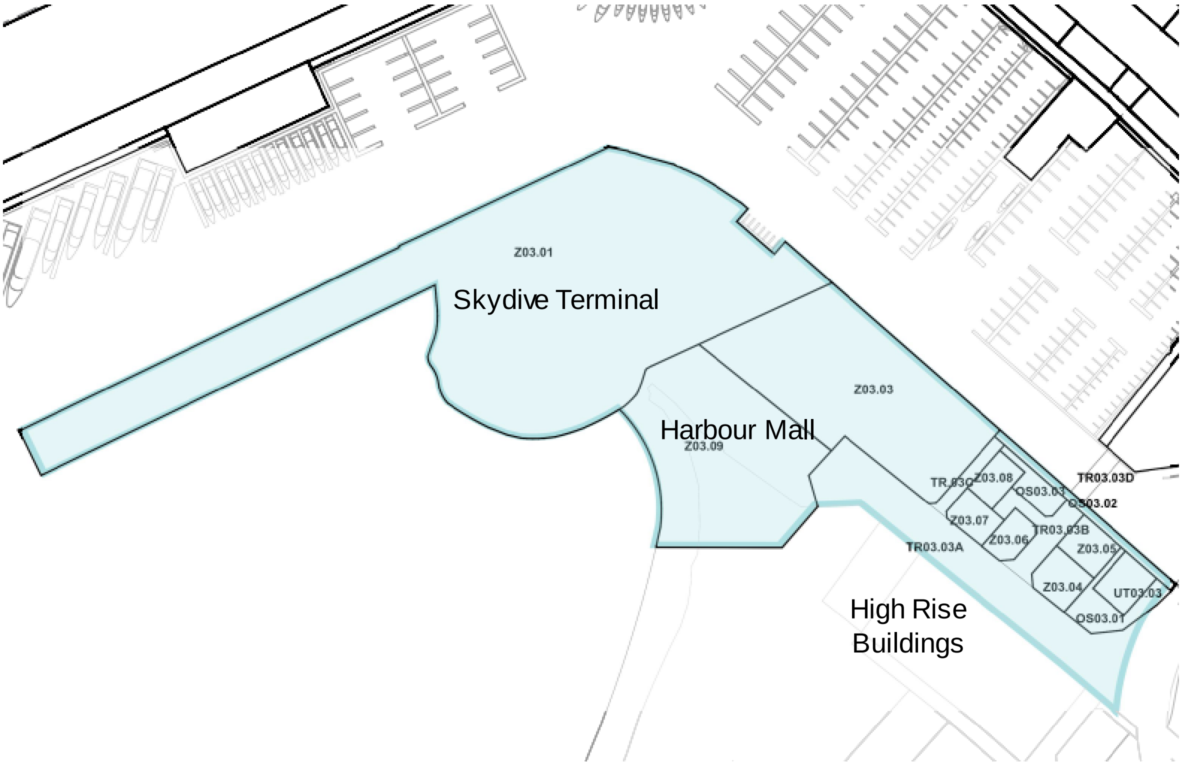


Figure 4-9 Harbour View Zone Plan View

4.2.1.5 Zone 4a – Bay Marina Zone

The Bay Marina Zone will consist predominately of low to mid-rise buildings with minimal retail and food and beverage outlets as shown in Figure 4-10. This Zone will be low-key in nature in comparison to other zones.

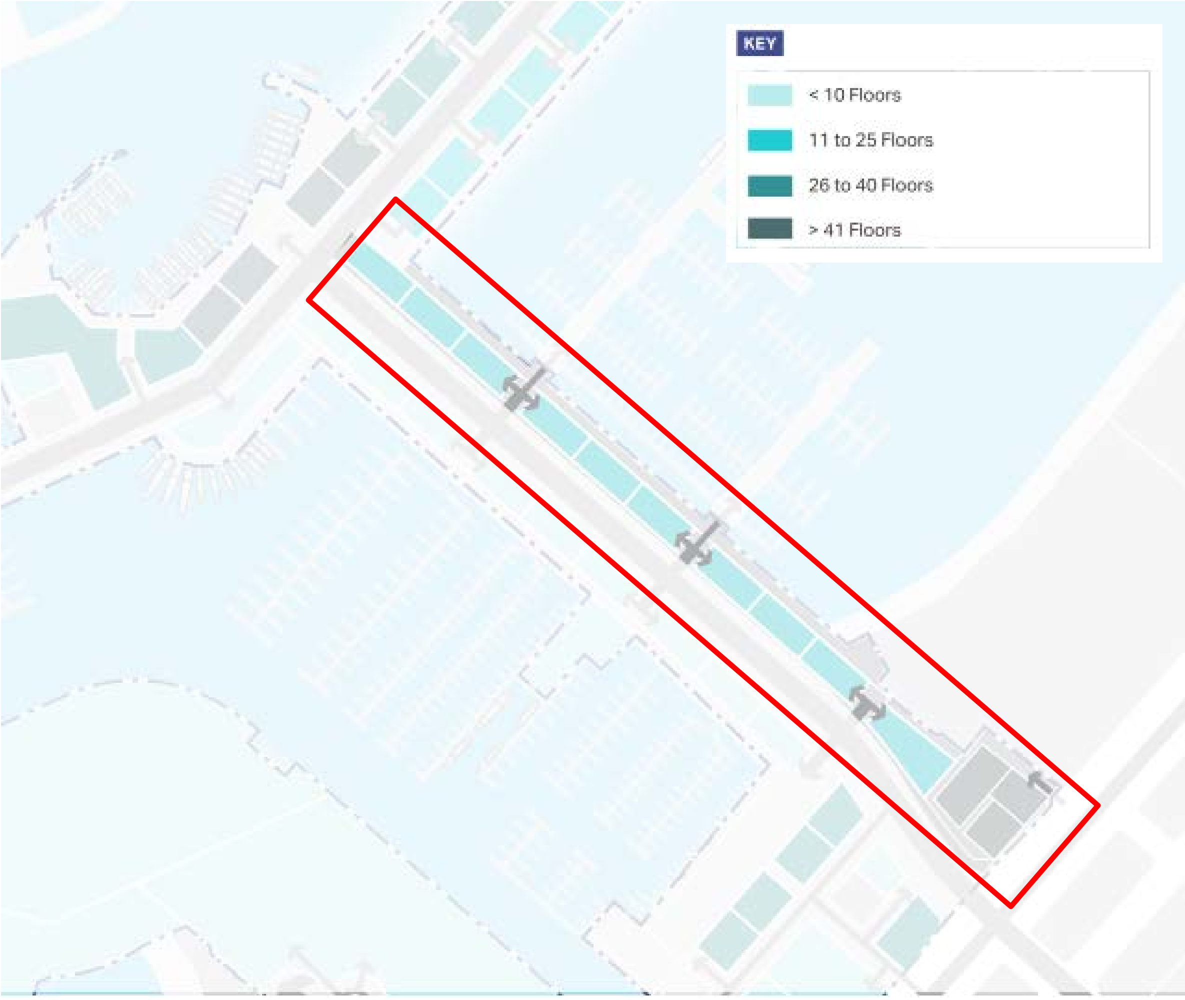


Figure 4-10 Zone 4a Bay Marina Building Heights

4.2.1.6 Zone 4b – Operational Zone

The Operational Zone will be in the heart of the boating community of the area. This Zone will host the major international boat show as well as providing maintenance facilities and an existing dry stack for 150 boats (currently part of the DIMC facilities). The Zone will include some high-rise residential units (Figure 4-11).

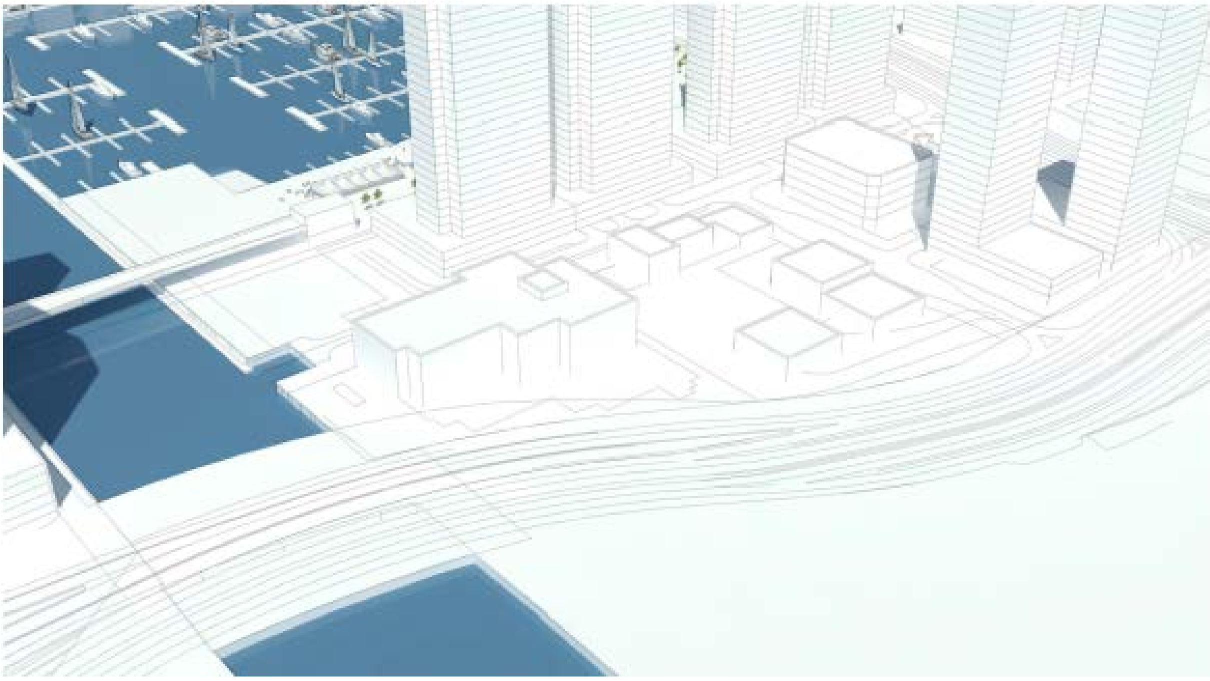


Figure 4-11 3D View of Zone 4b, Operational Zone

4.2.1.7 Zone 4c – Main Marina Zone

The Main Marina Zone (Figure 4-12) will be the most active zone with public waterfront access. The Zone will provide low rise residential buildings that will include retail and food and beverage stores at ground level and in close proximity to the water. The Zone will also include a Yacht Club open to the public (Sailor's Yacht Club), which will overlook the vessels moored in the main marina.

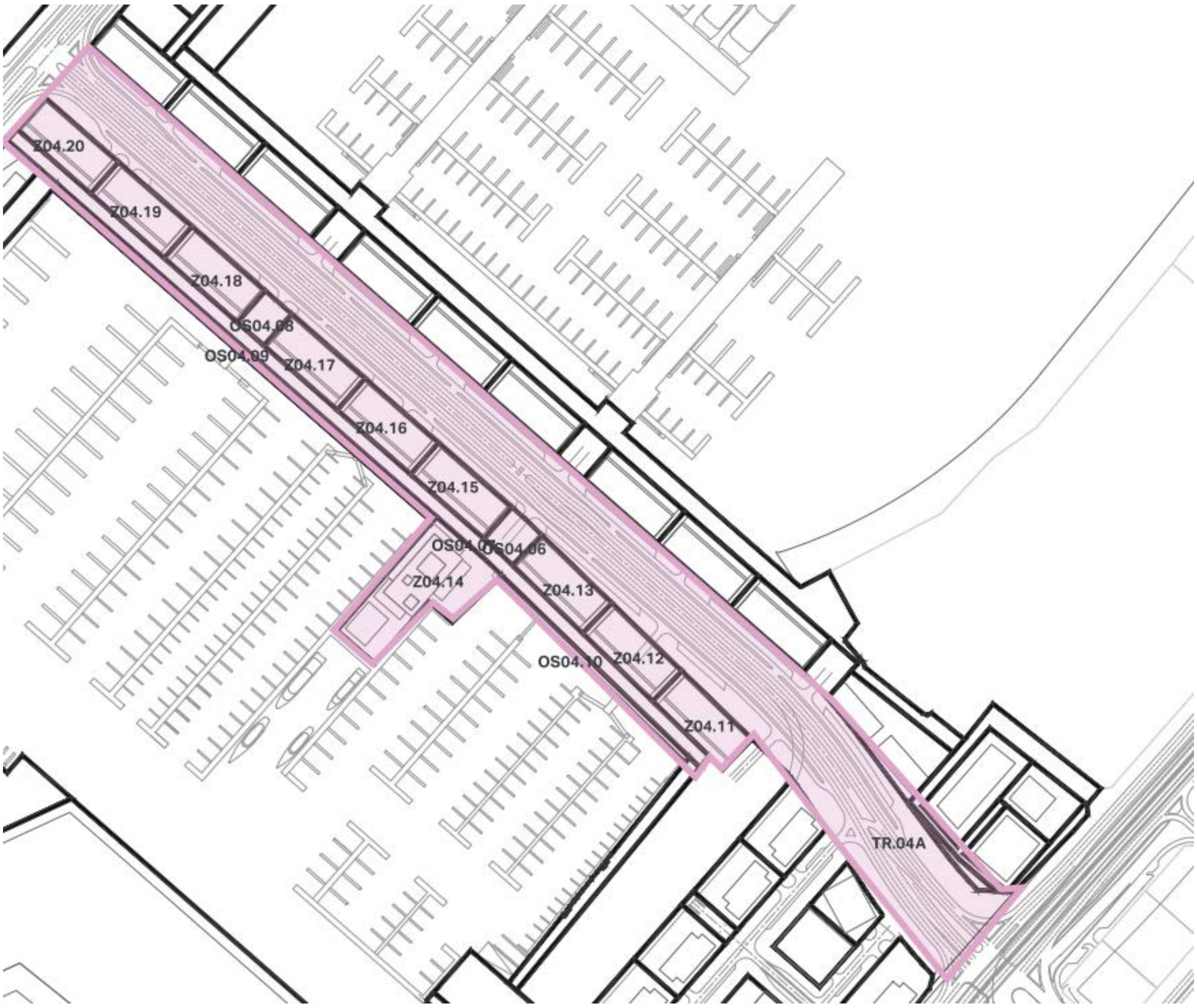


Figure 4-12 Plan View Main Marina Zone

4.2.1.8 Detached breakwaters

Two detached breakwaters, located offshore from the Project (Figure 4-4), will reduce wave height in Zone 1 during poor weather conditions, protecting moored cruise ships and limiting operational downtime at the cruise terminal.

4.2.2 Fuel Dock and Sanitary Pumps

The proposed location of fuel docks and sanitary pumps is provided in Figure 4-13, with the proposed fuelling station for boats shown in Figure 4-14 shows and fuel dispenser platforms in Figure 4-15. It is proposed that the sanitary pump-out systems be co-located with the fuel stations to allow a fuelling boat to simultaneously pump out waste systems. Sanitary piping will run underneath the decking to a centralized pump, which will lead to a holding tank on shore for emptying on a regular basis or discharging into a municipal sewer. The fuel station at the entrance of Zone 1 is feasible from a yachting standpoint and provides the added benefit that the storage tanks could be co-located with the manifold, allowing the superyachts to take on fuel from the storage tanks or directly from fuel trucks. In-slip pumps are proposed to be provided on berths in the Superyacht Marina and Palm View Marina to allow yachts to be continuously serviced without leaving the berth. Multiple berths can be fed from a single pump system with a manifold and switches for operation. It is envisaged that above-ground fuel storage tanks will be provided for the Project in the Operation Zone (Zone 4b).

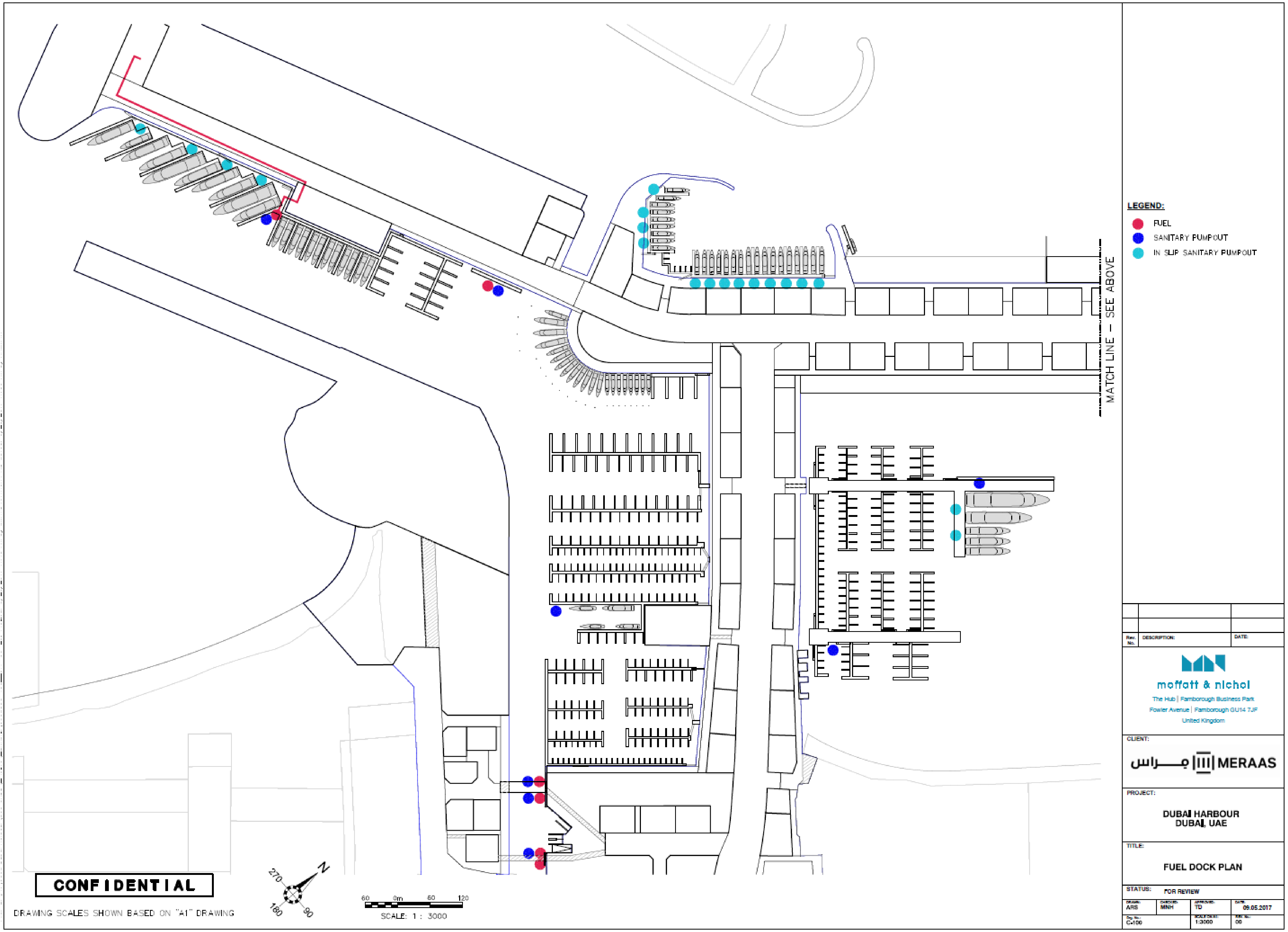


Figure 4-13 Proposed Fuel Stations and Sanitary Pump Out Plan

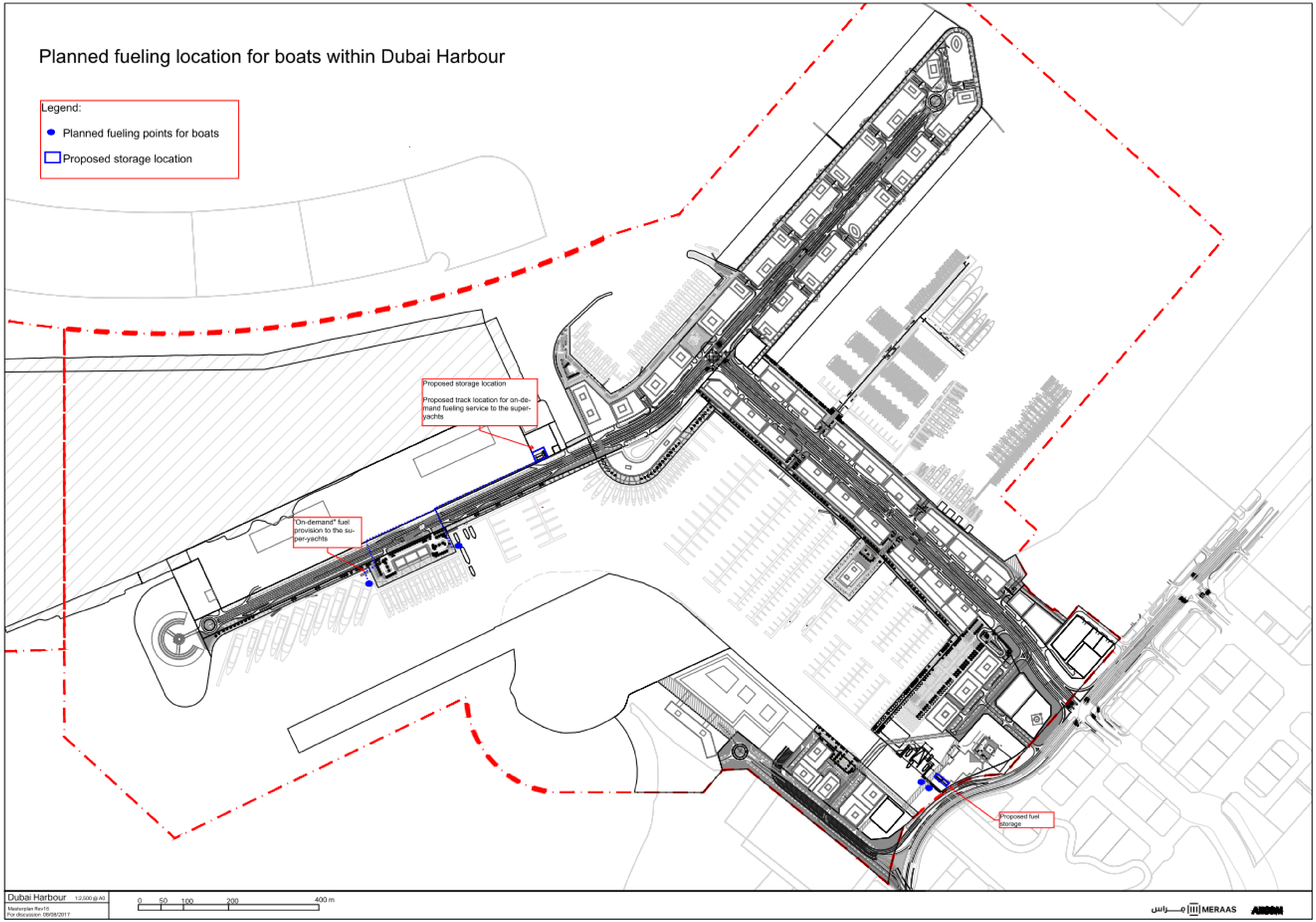


Figure 4-14 Proposed fuelling location for boats within Dubai Harbour

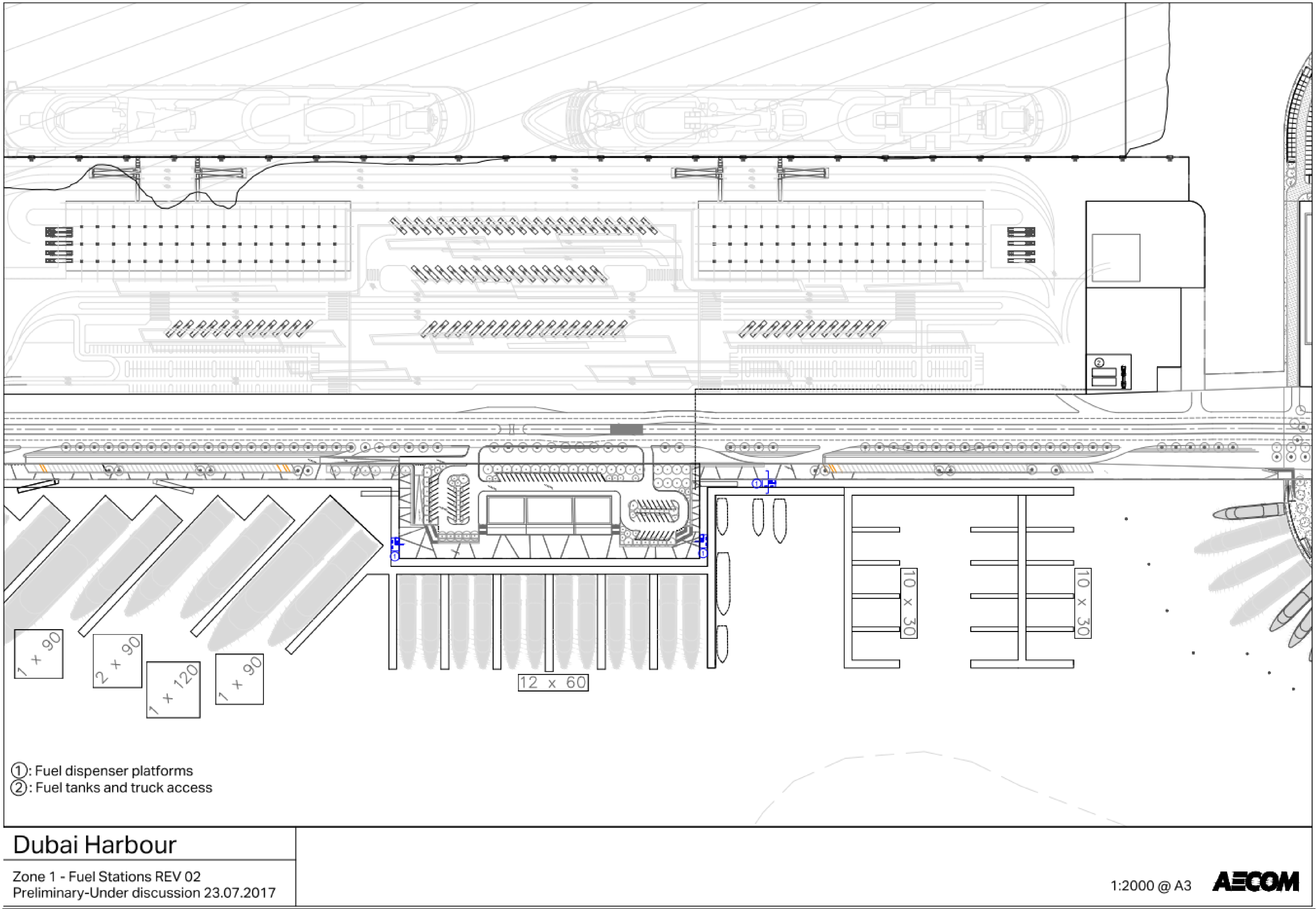


Figure 4-15 Proposed fuel dispenser platforms within Dubai Harbour

4.3 Project Land Use

The major land uses with associated gross development areas are provided in Table 4-1 below.

Table 4-1 Project Land Use Components

Zone	Land Area (m^2)	Total GFA (m^2)	Number of Residential Units	Residential Population
Zone 1	228,023	73,522	0	0
Zone 2	272,208	967,814	6,931	29,144
Zone 3	299,469	342,790	1,409	5,924
Zone 4	264,400	385,084	2,190	9,212
Total	1,064,100	1,769,210	10,530	44,280

4.4 Site Condition and Surrounding Land Use

An overview of the existing land uses of the Project area is provided below. The proposed project site comprises the following four areas:

- Skydive Dubai area (Figure 4-16);
- Dubai International Marine Club (Figure 4-16);
- Logo Island (Figure 4-17); and
- Dredged channel (Figure 4-18).

An overview of each area is discussed in the following sub-sections, while further detail on the baseline environmental conditions are provided in Section 5.

Figure 4-16 Dubai Skydive Area and Dubai International Marine Club

Figure 4-17 Logo Island

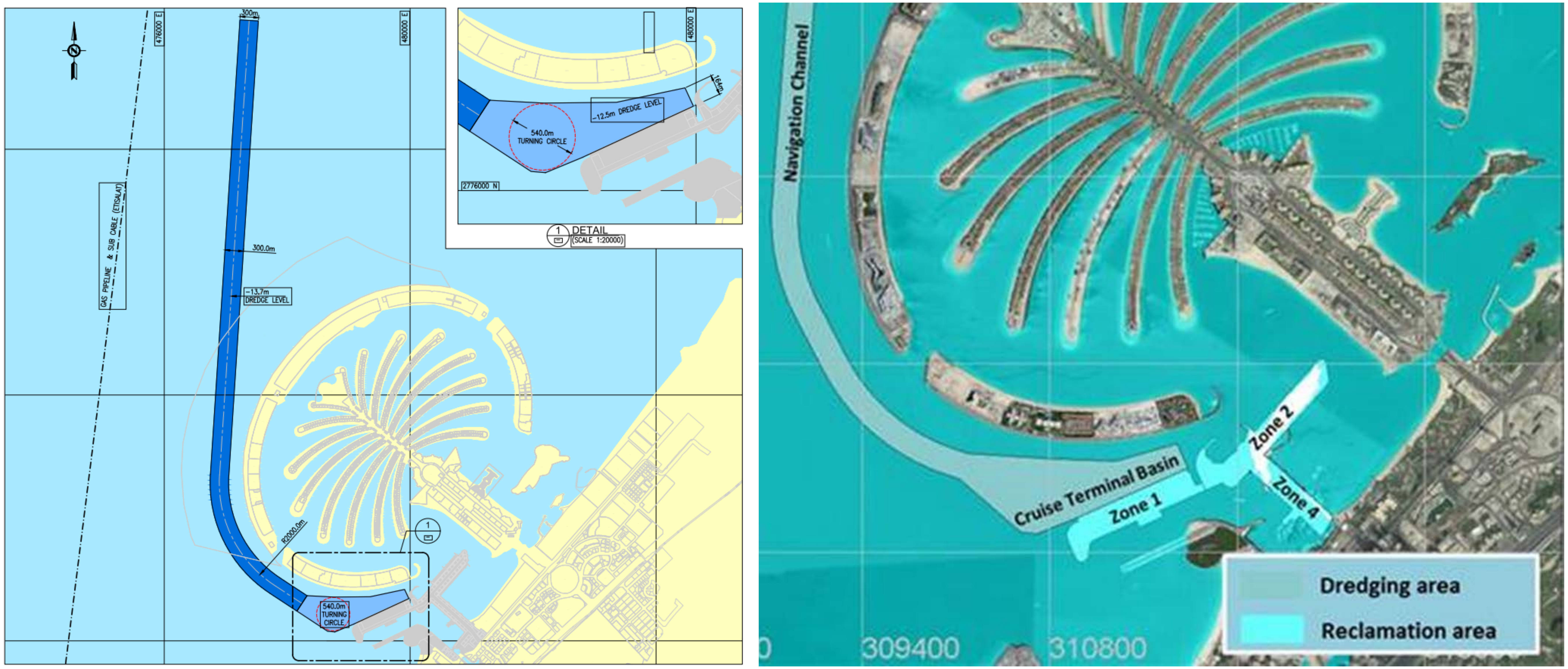


Figure 4-18 Proposed Channel to be Dredged

4.4.1 Skydive Dubai Area

The skydive Dubai area broadly comprises the following elements:

- A quay wall made of precast concrete blocks (Figure 4-19);
- Floating pontoons mounted on marine piles (Figure 4-20);
- Landscaped grass areas and a car park with two-way road (Figure 4-21);
- A breakwater made of armour rock, which prevents wave penetrating into the DIMC (Figure 4-22);
- A reclaimed airplane take-off/landing platform (Figure 4-23).

The area is highly disturbed and does not support marine communities of significant conservation values.

Figure 4-19 Edge of Dubai Marina Canal with Façade and Handrails

Figure 4-20 Floating Pontoons

Figure 4-21 Shaded Carpark and Two-Way Road

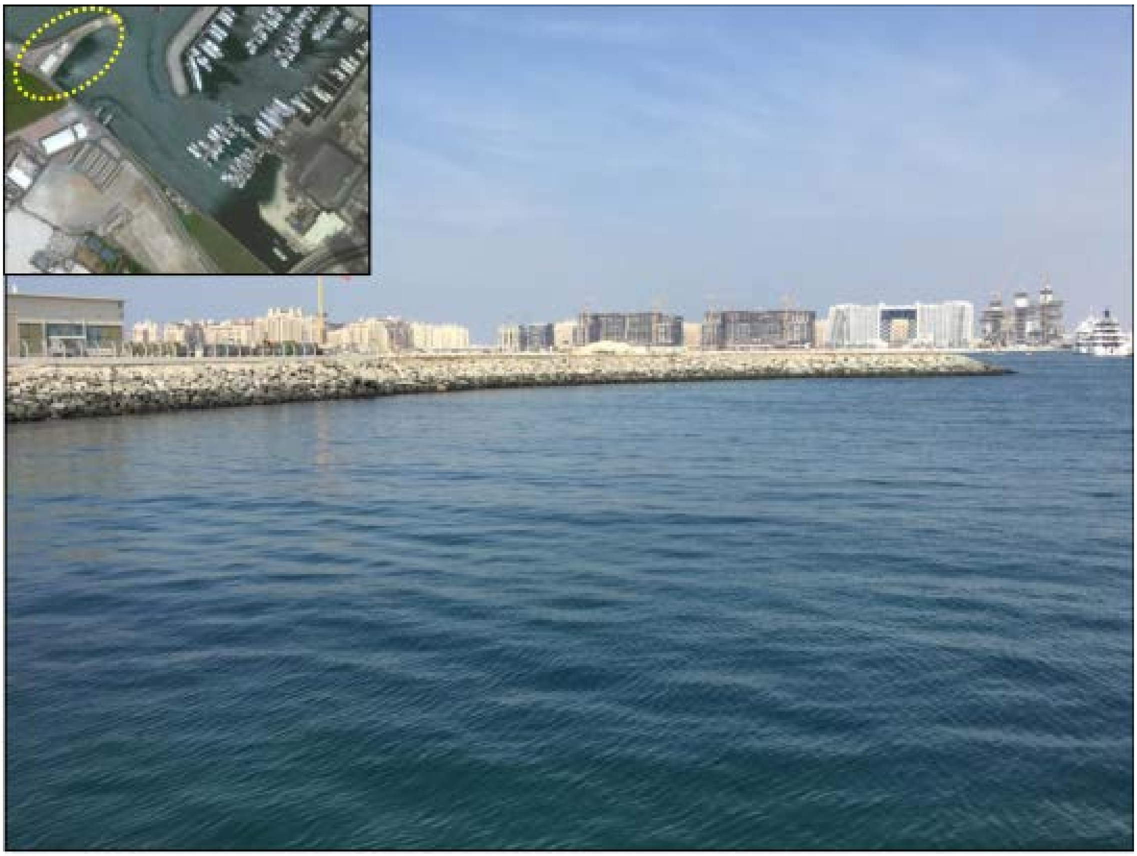


Figure 4-22 Breakwater

Figure 4-23 Airplane Take-off / Landing Area

4.4.2 Dubai International Marine Club

The DIMC is a fully functional and well-equipped marina, which features a breakwater accessible by car (Figure 4-24). The vessels berthed at the marina mostly comprise 10–30 m long vessels, the largest of which is estimated to have a length of 40 m. A set of berthing facilities (concrete pontoons with wood decking) are available at both the inner and outer sides of the breakwater supported on marine piles. The marina is estimated to be 3–4 m deep during low tide.

The southern part of the marina is protected by a pre-cast block quay wall, which has the following facilities:

- Medium-sized travel lift for vessels stacked onshore;
- Ramp for trailers (Figure 4-25); and
- Small sandy beach (Figure 4-26).

On the 9th of January 2016, GHD undertook a preliminary water quality sampling event to assess the water quality at two locations within the marina. Analytical and in-situ results showed that the water quality was good at all sites with no exceedances to the DM ambient water quality objectives.

Figure 4-24 Dubai International Marine Club – Breakwater

Figure 4-25 Ramp

Figure 4-26 Sandy Beach

4.4.3 Logo Island

Logo Island is a manmade island featuring a number of artificial beaches protected by rock groynes. Construction of Logo Island began in June 2003 and was completed in February 2005. Some infrastructure works were observed on the Island in 2013 but did not progress further. A series of piles and concrete foundations are located at the centre of the Island (Figure 4-27) along with waste material (re-bar) and a large stockpile of sand material (Figure 4-28) from abandoned historical construction activities. The majority of the beaches appear to be in good condition (Figure 4-29) with the exception of the beach at the southeast of the island (Figure 4-30). This is likely due to very low wave exposure and poor flushing of the seawater in this area due to the layout of the rock groynes.

Figure 4-27 Abandoned Construction Materials

Figure 4-28 Reclamation Materials Stockpile at the Northern End of Logo Island

Figure 4-29 Beach at the Southwest of Logo Island

Figure 4-30 Beach at the Southeast of Logo Island

4.4.4 Cruise Line Access Channel

An existing dredged trench is located along the Palm Jumeirah, which terminates close to Logo Island (Figure 4-31). The access channel proposed for the cruise terminal will be positioned along the existing trench as much as possible to minimize dredging volumes. The total volume of dredging is expected to be approximately 5 million m^3, including the basin and access channel. Suitable dredged material will be used in the reclamation areas. The dimensions of the largest vessel envisaged to visit the terminal, an Oasis Class vessel (L=360 m, Beam=47 m, Draft = 9.15 m) is being considered to design the navigation layout of the channel (Figure 4-18).

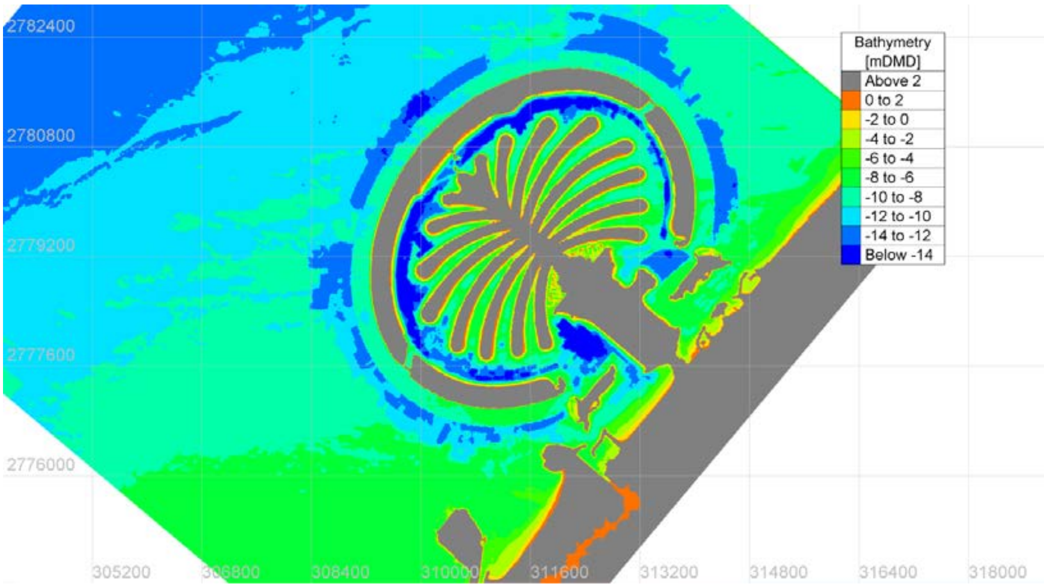


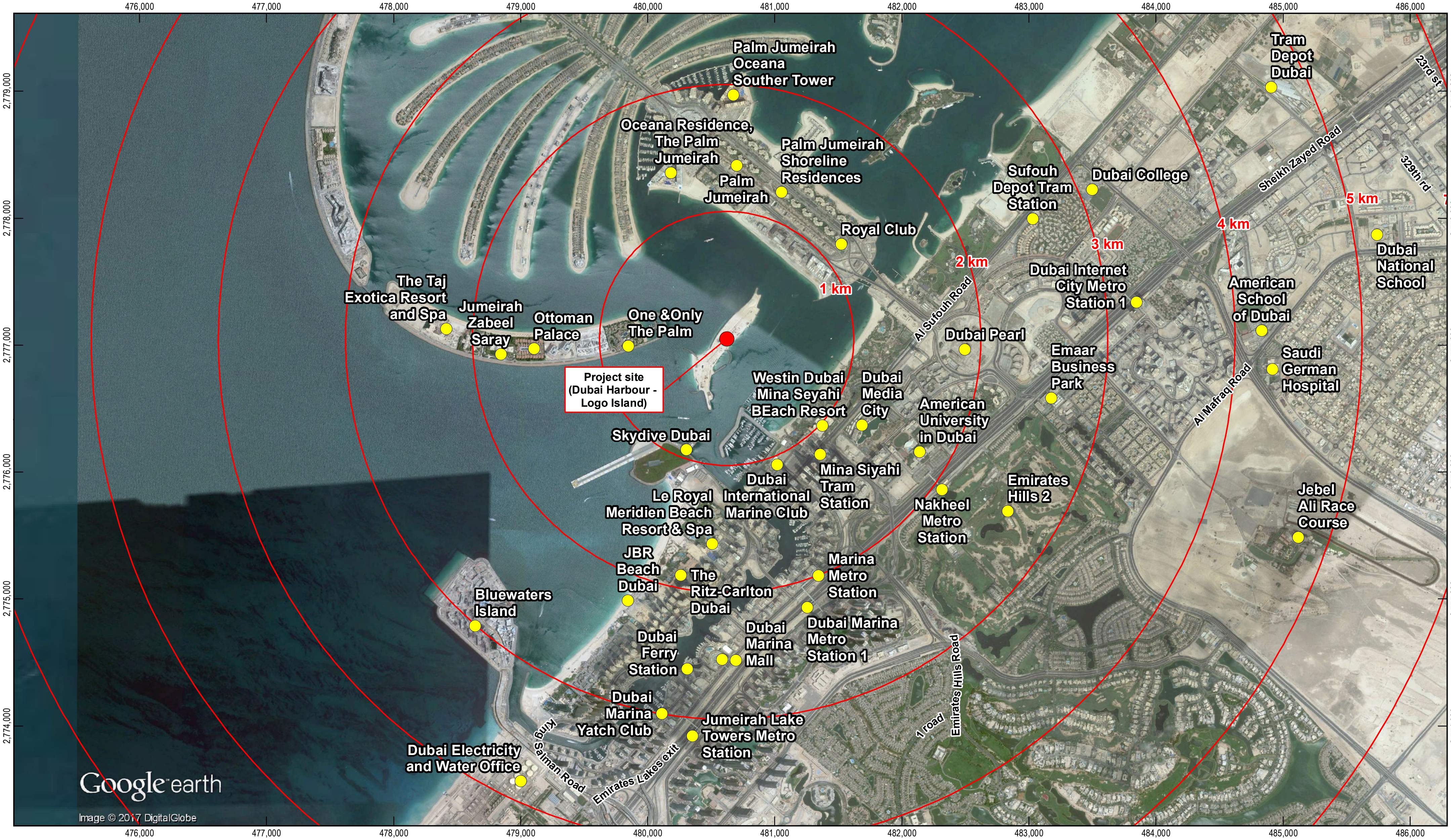
Figure 4-31 Existing Dredged Channel (Shown in Blue)

4.5 Key Sensitive Receptors

While Figure 4-32 shows the key sensitive receptors identified for this Project, the principal environmental sensitive receptors comprise:

- Existing and future residents in the vicinity of the Project in Pearl Jumeirah, Dubai Marina, Jumeirah Beach Residences and Nakheel;
- Employees and guests at the commercial and retail facilities in the vicinity of the Project (e.g. Skydive Dubai, DIMC, Bluewaters Island, boat tour companies who operate in the area, and hotels within 1 km of the project (e.g. Westin, Le Meridien Hotels, One & Only Royal Mirage, Fairmont, The Palm, FIVE Palm, Ritz Carlton JBR, Habtoor Grand Resort, Le Meridien Mina Seyahi, Hilton Jumeirah Beach and Sheraton Jumeirah beach), and properties and hotels on the west of The Palm Crescent Road, which may be affected by channel dredging activities (e.g. Grandeur Residences, W Dubai The Palm, Alef Residences, Kempinski Hotel and Residences, The 8 Hotel and Residences, Kingdom of Sheba, etc.));
- Visitors to the area that use leisure amenities in the vicinity and adjacent beaches;
- Marine water and sediment quality; and
- The flora and fauna in the marine environment.

The impacts on the above key sensitive receptors (and others) are discussed further in Section 6, while the proposed measures to mitigate the impact on these receivers are proposed in Section 7.



Paper Size A4

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Meters

Map Projection: Transverse Mercator
Horizontal Datum: WGS 1984
Grid: WGS 1984 Dubai Local TM

N

LEGEND

- Project site
- Sensitive receptors
- Ring buffers

MERAAS Holding
Dubai Harbour EIA

Job Number	76-10664
Revision	0
Date	02 Jun 2017

Figure 4-32

Key Sensitive Receptors

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3rd floor Guardian Tower Danet Community Abu Dhabi United Arab Emirates W www.ghd.com

Data source: GHD - Project site, Sensitive receptors (2017). Image © Google Earth, Digital Globe. Natural Earth - Road. Created by:jcmatic

4.6 Description of Project Phases

A description of the works proposed during the pre-construction, construction and operation and maintenance phases is provided below.

4.6.1 Pre-Construction Phase

The pre-construction phase primarily consists of tasks related to project development and feasibility studies, such as:

- Master planning, conceptual and detailed design – Conceptual and detailed design will be completed in accordance with the requirements of the Dubai Green Building Regulations;
- Engineering and environmental studies – These studies are undertaken to facilitate / inform decisions made at the detailed design phase. Further, these studies are undertaken to assess baseline conditions in the Project site and provide mitigation and / or enhancement measures, as necessary; and
- Acquisition of permits and NOCs from relevant regulatory bodies.

4.6.2 Early Works

An NOC was received from the DM to carry out early works on Logo Island (Reference No. CWMS150317MS0200), with subsequent amendments to include additional activities. All aspects of the planned early works (methodology, impacts and mitigation measures) have been included in the Early Works CEMP (Rev 7) (Ref. DHM-HSE-002 by ProjectsLink). The current early works scope (and completion status) includes:

- Survey Works – ongoing
- Demolition and removal from Logo Island of reinforced concrete structures – completed
- Demolition and removal from Logo Island of Pre – Cast Concrete Structures – completed
- Removal from Logo Island of underground (isolated) services – completed
- Removal & Stockpiling of Existing Rock Structures on Logo Island – ongoing
- Construction of temporary causeway – completed
- Beach toe construction in Zone 2B – ongoing
- Beach sand reclamation as per the approved design – completed
- Vibro-Compaction as per the geotechnical requirements – completed
- Zone 4B piling works – ongoing

Key activities are summarised in the subsections below.

It is planned that early works activities will be ongoing until the EIA is approved. A detailed short-term schedule of activities (November 2017 to April 2018) that may be conducted under the early works NOC is provided in Appendix M. Should additional activities be approved, the CEMP will be revised.

4.6.2.1 Bathymetric and Topographic Surveys

Bathymetric and topographic surveys have been carried out to record the exact depths of the seabed and relative ground floor levels on land. This will inform the construction methods and the required excavation / dredging / reclamation levels and quantities.

4.6.2.2 Demolition

Demolition works include the following:

- Concrete demolition works - Reinforced concrete and pre-cast concrete as identified in Figure 4-27, Section 4.4.3, are demolished using excavators with a jackhammer attachment. All demolished concrete material are disposed using trailers to approved disposal locations in Dubai;
- Underground services - Existing pipes are removed from trenches via excavation, with the trench then being refilled following removal of pipes;
- Removal and stockpiling of existing rock structures - Existing structures on Logo Island, such as revetment and breakwaters, are demolished (Figure 4-33). Stockpiled rock materials were re-used for construction of the causeway and will be used for the groynes for the project;
- Stockpiled sand on Logo Island – The existing sand will be used for reclamation and general fill for Zone 2; and
- Existing minimal vegetation and general debris will be removed.

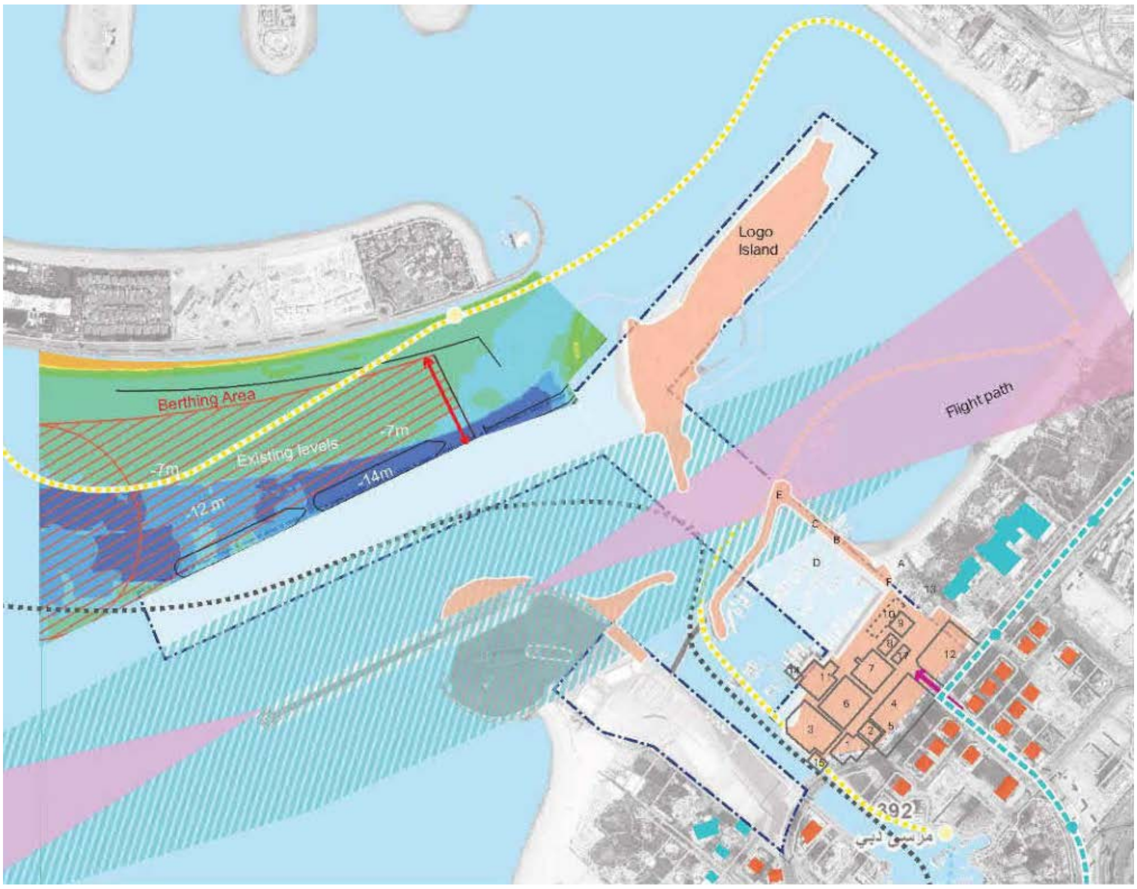


Figure 4-33 Existing Structures and Coastline (highlighted in orange) to be Removed or Reformed

4.6.2.3 Construction of Temporary Causeway

Construction of the temporary causeway to provide land access to Logo Island from DIMC for construction purposes was completed on 18 May 2017. This was undertaken following receipt of the NOC from the Coastal Zone & Waterways Management Section at the DM (Permit No. CWMS150317MS0200). The temporary causeway was constructed southwest of Logo Island where there is an existing breakwater to connect to the east side of DIMC (Figure 4-34). The temporary causeway is approximately 16 m wide by 380 m long.

Rocks and other suitable materials removed from the existing structures on Logo Island were used to construct the temporary causeway. Materials were placed using marine vessels and/or dump trucks positioned on the island. To prevent sedimentation, silt curtains were placed around the sediment deposition works. This temporary structure will be incorporated into the subsequent Project design, to prevent further disturbance and maximise use of installed structures.

Figure 4-34 Location of Proposed Temporary Causeway

ProjectsLink (2017)

4.6.2.4 Beach Profiling of Zone 2b

Limited profiling works to Logo Island (Zone 2b) may be undertaken as part of the Early Works NOC, which would include the construction of a beach toe or beach sill to stabilize the beach at Zone 2b (Figure 4-35). The beach toe structure will be constructed using 0.3 to 1 ton armour rocks. The rocks will be collected and placed using an excavator and a wheel loader from a barge followed by the placement of a 50 to 150 mm bedding layer on the landside of the armour rocks. Upon completion of bedding material, divers will place the geotextile on top of the bedding as a final layer. Beach reclamation and sand works will then commence as per an approved design. Silt curtains are proposed to ensure effective protection from plume spread.

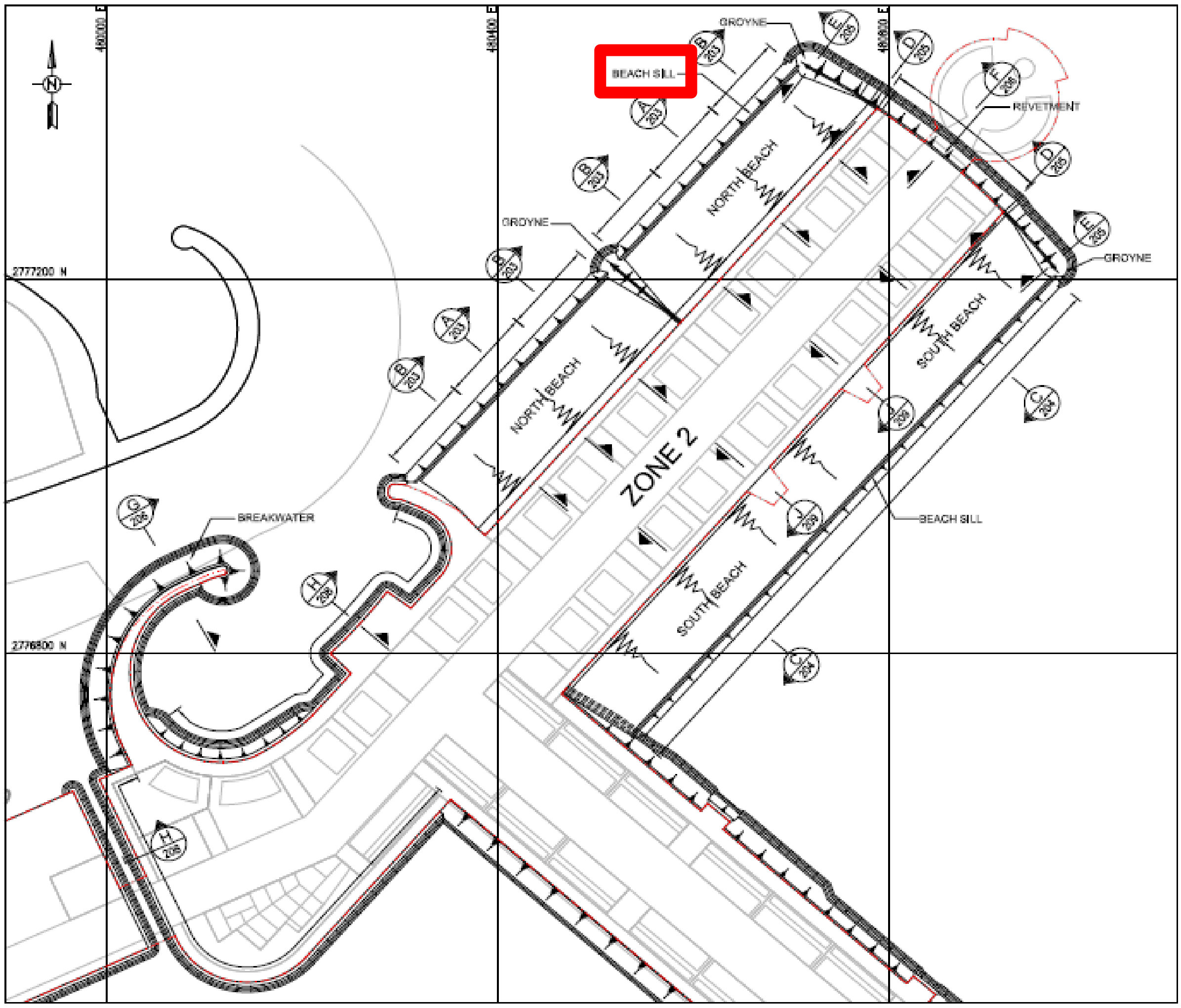


Figure 4-35 Location of Beach Sill

4.6.3 Construction Phase

Construction of all four zones will run in parallel and will comprise the key components discussed below.

4.6.3.1 Rock Revetment Construction

For areas of reclaimed land, the rock revetment will be placed first, commencing with placement of the breakwater core (Figure 4-36). Marine equipment will be used as far as possible for the placement of rocks starting with the quarry rock (1-500 kg). Quarry rock will be placed via direct dumping from wheel loaders working on feeder barges. Quarry rock will be placed to a depth of -2.9 Dubai Municipality Datum (DMD).

Rock revetments will be constructed to heights above mean sea level and geotextile liner will be placed on the inner wall of the revetment (Figure 4-37). Rockworks will involve slope profiling and geotextile placement followed by placement / positioning of rock materials according to design specifications. An under layer of armour rock (0.3 – 1 tonne) will be protected by an outer armour rock (3-6 tonne) layer. The finished level of the breakwaters will be +5.50 DMD.

Figure 4-36 Placement of Rock Revetment

Projects Link (2017)

Figure 4-37 Placement of Geotextile Liner

Projects Link (2017)

4.6.3.2 Access Channel Dredging

Based on simulations of the largest cruise vessel (Oasis class) (Sogreah 2017b), the proposed layout of the access channel and basin will have the following characteristics (Figure 4-18):

- Channel dredged to -12.5 meters DMD (currently at -11.6 meters DMD);
- Channel width = 300 meters;
- Straight section of approximately 7.5 km long and a curved section;
- 540 meter diameter turning section;
- Turning circle and port basin dredged to -12.50 meters DMD (currently at -10.2 meters DMD); and
- 910 meters long quay wall.

Trailer Suction Hopper Dredgers (TSHD) and/or Cutter Suction Dredgers (CSD) will be utilised for the dredging. Dredged material suitable for reclamation will be transported to the site, either via hoppers or by pipeline (pumping through floating or sinker lines).

The suitability of material for reclamation depends on the compactability of the material, which in turn depends on the proportion of fines and percentage of coarse fraction of the material after the dredging process. Material used in reclamation will have to comply with requirements detailed in the Earthworks, Dredging, Reclamation and Ground Improvement specifications, which includes limits for the large and small particle size fractions, shell content and plasticity index, in addition to several other metrics. Geotechnical investigations were undertaken to assess the suitability of material for reclamation. The results of the geotechnical investigations are presented in Section 5.4.3. During dredging operations, the contractor will have to demonstrate compliance by adhering to the sampling and testing regime detailed in the same document, as well as limiting fine content in discharge water.

Van Oord have been appointed as the marine works main contractor and will be undertaking the dredging operations.

4.6.3.3 Reclamation Works

A total reclamation volume of approximately 5 million m^3 is required to complete the Project. Suitable dredged material from the navigation channel will be used for reclamation, with material from borrow areas used for any shortfall. The results of geotechnical investigations assessing the suitability of material for reclamation are presented in Section 5.4.3. During dredging operations, the contractor will have to demonstrate compliance to the requirements detailed in the Earthworks, Dredging, Reclamation and Ground Improvement specifications by adhering to the documents sampling and testing regime, as well as limiting fine content in discharge water.

Reclamation will be undertaken via a combination of pipeline, by pumping through floating or sinker lines, and bottom dumping, depending on the pumping and sailing distance. As such, in addition to the dredgers, it is envisaged that the following ancillary infrastructure and equipment may be required:

- Land pipelines;
- Floating pipelines;
- Sinker pipelines; and
- Booster station.

The dredging cycle consists of the following activities:

- Sailing empty to the dredging area;
- Dredging in the channel or borrow area;
- Sailing loaded to the fill area; and
- Discharging fill material.

When pumping ashore via transfer lines, the dredger will sail to a mooring location where it will be coupled to the discharge line and will bring the material into suspension with seawater and commence pumping. The pressure pipeline will connect to a distribution network of land pipelines to redistribute fill material throughout the reclamation area (Figure 4-38). Pipelines will consist of steel pipes with standard lengths of 12 metres and an external diameter of 1000 mm. Bolted flange connections include a compressible gasket between flanges to provide a watertight seal. In the event that the pressure pipeline is too long to utilise dredge pumps alone, a booster station may be installed to aid the hydraulic transport process.

Figure 4-38 Distribution of Reclamation Material to Land

ProjectsLink (2017)

Once the fill material is above the existing water level, typical site development activities will be undertaken on-site (Figure 4-39). These will include:

- Earthmoving activities to redistribute fill material;
- Vibro-compaction; and
- Site grading according to the desired topographic profile of the island.

Reclamation works for the Project will be undertaken 24 hours a day, seven days a week. The contractor will ensure all necessary applications for permits and NOCs to operate the construction schedule are approved prior to the start of construction works. It is envisaged that reclamation and rock revetment works will take approximately 21 months to complete.

Figure 4-39 Site Development Activities

ProjectsLink (2017)

4.6.3.4 Construction Works

During the construction phase, the majority of the activities will involve excavation for the buildings foundations and various networks that will be installed on site (Figure 4-40). Considering the excavation activities that will be undertaken, it is anticipated that dewatering will be required during construction. Where dewatering is required, a suitable dewatering system will be installed on site. The effluent generated will be managed and disposed of according to regulatory standards (i.e. provision of treatment and monitoring of dewatering effluent to ensure compliance with relevant guidelines for effluent reuse and / or discharge to the environment).

All materials arising from excavation, demolition and site clearance activities, except materials specified for re-use, shall be removed from the site in a responsible manner. Materials removed from Logo Island (e.g. pipes, manholes and cables, if any) shall be disposed of in accordance with all applicable local and federal laws and regulations. Moreover, earthworks and site development activities shall be in accordance with applicable regulations, guidelines and clearance conditions for the project.

Figure 4-40 Excavation Works

ProjectsLink (2017)

4.6.3.4 Plant, Equipment and Tools

Construction Equipment

In addition to CSDs, the types of construction equipment to be used during the reclamation works include:

- Multi-purpose pontoon, swiber or similar;
- Shoalbuster and tugs, or similar;
- Rock barges;
- Multicats;
- Hydraulic excavators;
- Wheel loaders; and
- Dumper trucks.

The equipment used for building on land may include auger, backhoe loader, compressor, concrete mixer, crane, diesel generator, dump truck, excavator, grader, concrete / industrial saw, crushing / processing equipment, rollers, rough terrain forklifts, scrapers, tampers / rammers, trenches and welders. The complete list and description of dredging and reclamation as well as construction equipment are provided in the CEMP.

Construction Materials and Chemicals

Typical construction materials and chemicals will be used for the proposed Project, which will likely include ready mix concrete, concrete products, asphalt products, steel reinforcement, steel piling, rock, fill material, etc. Materials and chemicals will be sourced locally, where possible. The Material Safety Data Sheet (MSDS) of the materials and chemicals to be used during the construction are provided in the CEMP.

Temporary Facilities

To accommodate workers and facilitate the undertaking of construction activities, temporary facilities will be established on site. These facilities may include, but not limited to, the following:

- Construction site offices;
- Welfare facilities / clinic;
- Security facilities;
- Parking facilities;
- Fencing and barriers;
- Project signage;
- Traffic signage;
- Portable toilets;
- Water tanks;
- Septic tanks;
- Power generators;
- Fuel storage tanks;
- Storage areas and warehouse;
- Plant yards;
- Laydown areas;
- Solid waste management areas;
- Access roads; and
- Wash-down facilities

A series of logistics coordination maps covering each six months period of the project and showing the locations of key construction elements and components are provided in Appendix L. Required temporary facilites will be established within the Construction Logistic Zones on the 'landside' of the project (currently the DIMC area), as indicated on the layouts.

Manpower Requirements

It is projected that approximately 2000 to 5000 construction workers, both skilled and unskilled, will be required once building and infrastructure works commence. Approximately 500 workers will be required during the marine works. The construction workforce will most likely be accommodated in existing labour accommodation outside of the Project site, with no specific labour accommodation provided on site.

4.6.4 Operation Phase

4.6.4.1 Population

The projected population for the Project during the operation phase based on the proposed building GFA's is outlined in Table 4-2. The influx of population is anticipated to be staggered as the different phases of the development will be completed in different timeframes. Further, the population would vary greatly depending on the day of the week (weekends would receive a higher number of visitors), any ongoing events and the visiting of one or two cruise ships.

Table 4-2 Projected Population during Operation Phase

Item No.	Type	Estimated Population
1	Workforce	16,300
2	Residents	45,000
3	Visitors	Estimated 1.6 million visitors during cruise season (8 months)

4.6.4.2 Activities

Typical community and recreational activities will be centred around the mall area, the lighthouse and the beaches. The activities will include outdoors and indoors sports activities, gyms, water sports and shopping.

4.6.4.3 Infrastructure / Utility Requirements

Power Network

At the time of preparing this EIA report, limited information on the projected power demand was available; however, the total connected load calculated for the project is 547.43 Megawatts (MW) with a demand load at the substation level of 291.67 MW. As such, three 132/11 kilovolt (kV) primary substations are envisaged to cater the overall development of Dubai Harbour. The electrical network will be designed based on Dubai Electricity and Water Authority (DEWA) standards and guidelines. All electric networks (low voltage, 11kV and 132kV) shall be finalized in coordination with DEWA. A description on the existing power utilities is provided in Section 5.11.1.

District Cooling

A District Cooling Plant is not envisioned for the Dubai Harbour Project; each building will be designed to be self-sufficient.

Potable Water Network

The total average domestic potable water demand for the project is estimated at 23,111 m^3/day; while the total non-domestic flow would be around 170 litres per second (L/sec) from the marinas. The entire project area will be supplied by a proposed 900 mm pipe, which will tie-in to the existing 900 mm DEWA pipeline along King Salman Bin Abdul-Aziz Al Saud Street-D94. Another tie-in connection with a diameter of 300 mm is proposed from the existing 300 mm pipeline along King Salman Bin Abdul-Aziz Al Saud Street-D94 to serve the mall and provide a back-up supply for nearby plots. A description on the existing water utilities is provided in Section 5.11.1.

Telecommunication Network

The telecommunication network will consist of fixed lines as well as a wireless mobile network. The fixed lines will tie in to an existing network adjacent to the Project, and the infrastructure required for a wireless network will be coordinated with the telecom authorities (Etisalat and DU) for their approval. The network will follow the standards and guidelines set by Etisalat and DU.

Firefighting Network

The design criteria for the external fire hydrant will be as per the requirements of Dubai Civil Defence, UAE Fire Code and National Fire Protection Association. The source of water supply for the external fire hydrant system will be from the potable water network. An independent pump system as per National Fire Protection Association and Civil Defence requirements will be designed to meet the fire demands.

Irrigation Network

The irrigation network will be designed to cover irrigation water demand for the landscape design requirements and according to Dubai Municipality standards and regulations. Treated Sewage Effluent (TSE) from the existing DM TSE network will be the source of water for landscape irrigation subject to DM approval and availability of TSE water. The average TSE water requirement for the Project is estimated at 1,196 m^3/day. A storage tank will be designed to cater for the capacity of one day of irrigation requirements and 10% losses. As such, the total storage required for irrigation water is 1,320 m^3.

The irrigation network could be extended from the existing network within the vicinity of the Project area as follows:

- Existing 500 mm pipeline running along King Salman Bin Abdulaziz Al Saud Street (D94);
- Existing 600 mm pipeline running along Al Naseem Street (D61) towards Sheikh Zayed Road (E11); and
- Existing distribution and secondary irrigation network serving the existing roads adjacent to project area.

Currently the external TSE network does not have the capacity to supply Project TSE requirements. However, the network will be upgraded under a cost sharing agreement proposed by DM, to which Shamal have made a written commitment (Relevant correspondence is provided in Appendix K). Further studies and discussions are currently ongoing.

Stormwater Network

The proposed storm water drainage system will comprise of inlets, pipes, manholes and outfalls. The proposed gravity network will be laid in a specified corridor and will follow the road grading wherever possible. The collected runoff will be transferred through the positive piped system to the proposed inlets and manholes and will be discharged directly to sea after passing through the oil separation process.

The proposed storm water network serving the Project area is divided into seven subnetworks; six at the T–shape land and the seventh will serve the mall land (Figure 4-41). Each Subnetwork will have its own separate network and outfall to the sea and each outfall will be provided with an oil separator and a flap valve as per DM regulations.

The exact location of these outfalls will accommodate the discharges from each catchment and will require a free space for the placement of oil separator near each outfall. These locations will be finalized based on the discussions and approvals with DM.

The Proponent is looking into the possibility of relocating stormwater outfall A. In the event that the proposed relocation of stormwater outfall A is finalised, an EIA Addendum will be submitted to DM detailing the proposed relocation.

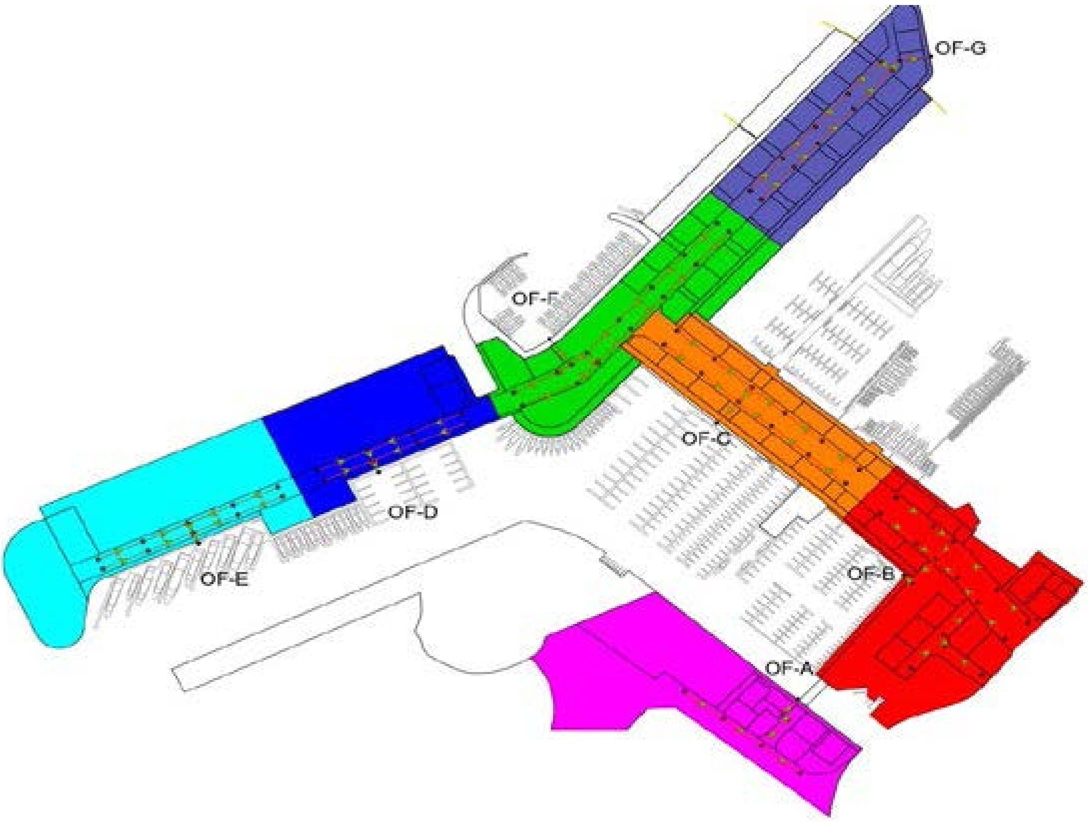


Figure 4-41 Proposed Drainage Network with Seven Outfalls

Sewerage Network

The average domestic sewerage generated flow for the Project is projected to be 19,661 m^3/day, while the overall peak sewerage flow from the project is estimated at 533.85 L/sec; split into 476.15 L/sec as domestic flow and 57.70 L/sec as non-domestic flow. The non-domestic sewerage flow comprises mostly marina wastewater, at 57.70 L/sec.

There will be no Sewage Treatment Plant (STP) at the site as all sewage will be discharged to the existing Dubai municipal network, which could be extended from the following:

- Existing 800 mm pipelines connecting to 1,200 mm along Al Nassem Street (D61) towards Sheikh Zayed Road (E11);
- One existing force main of 1200 mm diameter along the extension of Sheikh Zayed Road (E11);
- Existing system with pipes ranging between 200 mm to 800 mm serving the existing developments nearby the Project;
- Existing system with pipes ranging between 200 mm to 800 mm at Zone 3 mall area, which is serving Skydive Dubai. These lines would be relocated and the discharge from Skydive Dubai would be accommodated within the proposed network.

A schematic plan of the proposed sewerage network is provided in Figure 4-42 and detailed in Appendix K. Three lifting stations are proposed within the sewage network designed for the project, namely in Zone 1, Zone 3 and Zone 4. The design of the sewerage network will utilize the applicable design standards, guidelines and codes of practice as per Dubai Municipality standards and specifications for various components of the network. The revised plan for the network was submitted to DM for review / approval on 9 November 2017.

Currently the external sewaerage network will require upgrades to accommodate Project requirements. These upgrades will be undertaken under a cost sharing agreement proposed by

DM, to which Shamal have made a written commitment (relevant correspondence is provided in Appendix K). Further studies and discussions are currently ongoing.

4.6.4.4 Maintenance Dredging

Modelled infilling rates of the channel show that insignificant quantities of deposition are anticipated, at less than 1 cm per year at all locations. As a siltation allowance of 0.2 meters is being considered in the design of the navigation channel, the frequency of dredging maintenance operations is expected to be around 20 years. The disposal method of the maintenance dredging material is unknown, but would comprise the same options as discussed in Section 7.9.1.4. A management plan for the maintenance dredging would be included as part of the OEMP.

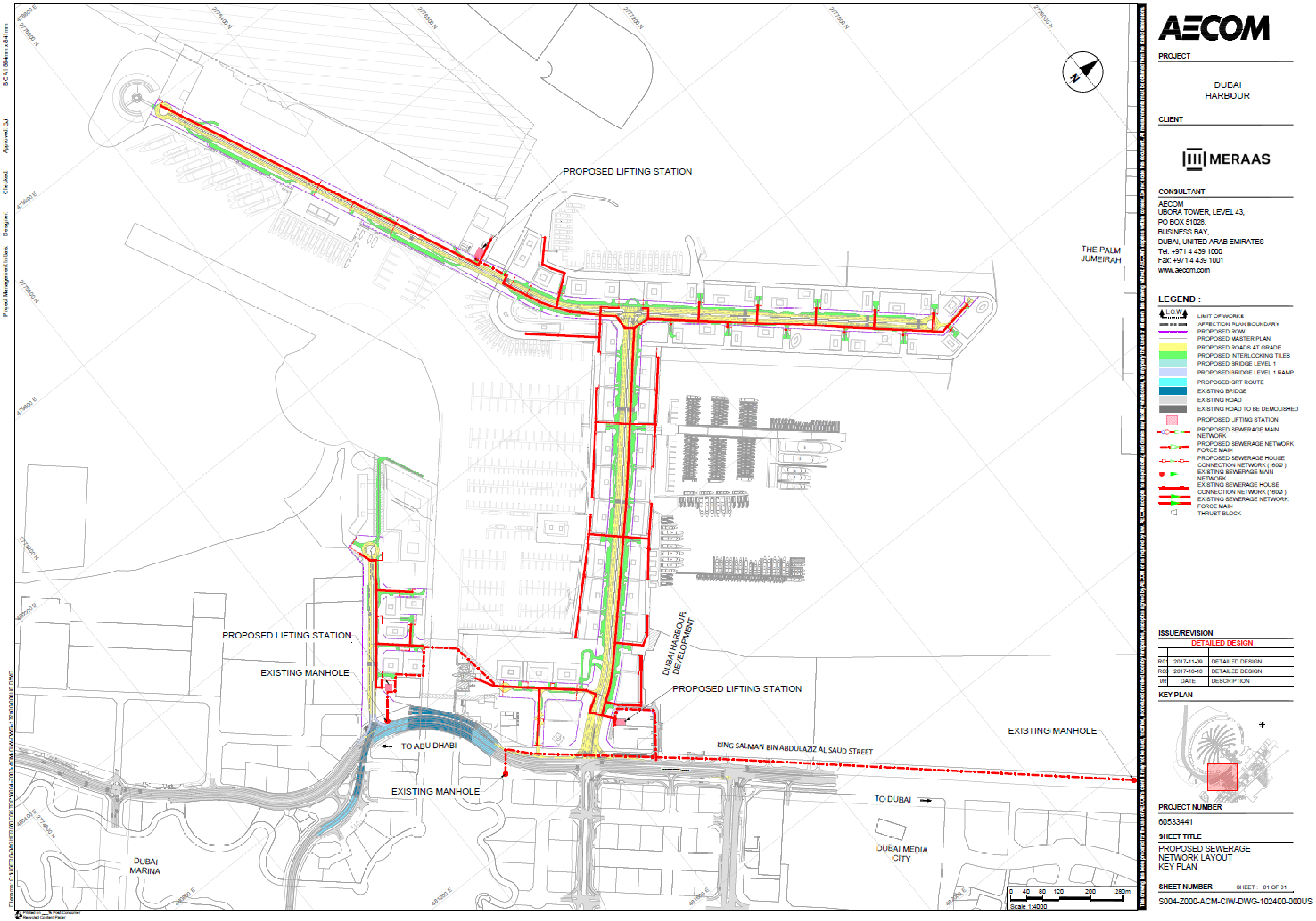


Figure 4-42 Proposed Sewerage Network Lay-out Key Plan

4.7 Project Cost

The Project Proponent has requested that costing figures relating to the Project remain confidential at this stage for commercial reasons.

4.8 Project Duration and Schedule

The Project commenced in the first quarter of 2017 and is expected to be completed in February 2022. A detailed construction schedule is provided in Appendix M, while a summary project schedule showing different phases of the development is provided in Table 4-3. A few key milestones are listed below:

- The concept master plan for the development was finalised in June 2017;
- The detailed Master Plan will be commenced upon approval of Concept Design and is expected to be completed by January 2018;
- Early works started in the first quarter of 2017 following the receipt of the Early Works NOC;
- Marine works are expected to take at least 18 months and would be completed in the first quarter of 2019 at the earliest; and
- Construction works will commence once marine works are complete and are scheduled for completion in the first quarter of 2022.

Normal day shift working hours for construction activities on site are as follows:

- Saturday to Thursday – 07:00 to 18:00; and
- UAE summertime working hours.

Table 4-3 Project Schedule

Activity Name	2017				2018				2019				2020				2021				2022			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Master Plan Development																								
Concept vision development	X																							
Concept master plan	X	X																						
Final master plan	X	X	X	X																				
Marine Works																								
Design works	X	X	X	X																				
Marine works (construction, reclamation and edge protection (all zones including detached breakwater)		X	X	X	X	X	X	X	X															
Infrastructure Works																								
Concept infrastructure master plan	X	X																						
Final infrastructure master plan		X	X	X																				
Traffic impact study		X	X	X																				
Preliminary infrastructure design		X	X																					
Detailed infrastructure design			X	X																				
Infrastructure construction (all zones)					X	X	X	X	X	X	X	X	X											

Activity Name	2017				2018				2019				2020				2021				2022			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Major Infrastructure Road Works (outside master plan)																								
Design				X	X	X																		
Construction				X	X	X	X	X	X	X	X	X	X	X	X									
Landscape Works																								
Design				X	X																			
Landscaping installations								X	X	X	X	X	X											
GRT Works																								
Design					X	X	X																	
GRT construction								X	X	X	X	X	X											
Marine Works (Pontoons)																								
Design					X	X	X																	
Construction – Zone 4A				X	X	X	X	X	X	X	X	X												
Construction – Zone 4B				X	X	X	X																	
Construction – Zone 2A									X	X	X	X												
Construction – Zone 1									X	X	X	X	X	X										
Construction Works (Design and Construction)																								
Zone 2A – Yacht Club									X	X	X	X	X	X	X	X	X							

Activity Name	2017				2018				2019				2020				2021				2022			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Zone 1 – Sailors Club									X	X	X	X	X	X										
Zone 4A – Harbour Club									X	X	X	X	X	X	X	X								
Zone 4C – Operational Zone												X	X											
Primary substation construction (Zone 2, 3 and 4)				X	X	X	X	X	X	X	X	X												
Zone 1 – Cruise Terminal		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
Zone 1 – Lighthouse		X	X	X	X	X	X	X	X	X	X	X	X											
Zone 1 – Civil Defence / Police Station					X	X	X	X	X	X														
Zone 2 – Buildings			X	X	X																			
Zone 3 – Skydive Dubai Apron				X	X	X																		
Zone 3 – New Skydive Facilities			X	X	X	X																		
Zone 3 – Zero Gravity Dismantling						X	X	X																
Zone 3 – Mall					X	X	X	X	X	X	X	X	X	X	X	X	X	X						
Zone 3 – Hotel					X	X	X	X	X	X	X	X	X	X	X	X	X	X						
Zone 3 – Mall Access Structure					X	X	X	X	X	X	X	X	X	X	X	X	X	X						
Zone 4A – Buildings				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Zone 4B – Bay Marina Services Provision			X	X	X	X																		

Activity Name	2017				2018				2019				2020				2021				2022			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Zone 4C – Branded Hoarding		X	X	X																				
Zone 4C – DIMC Area Demolition		X	X	X	X	X																		
Zone 4C – Office Refurbishment and Fit-out		X	X	X	X																			
Zone 4C- Tent Assembly and Removal				X	X																			
Zone 4C – Strengthening of the Forklift Pick-up Quay Wall		X	X	X	X																			
Zone 4C – Parking Structures					X	X	X	X	X	X	X	X	X	X										
Zone 4C – Buildings				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
Zone 4C – Private Clinic						X	X	X	X	X	X													
Zone 4C – Mosque						X	X	X	X	X	X													
Logistics Contractor			X	X	X	X	X	X	X	X	X	X	X	X	X									

5. Description of the Environment

5.1 Climate and Meteorology

5.1.1 Overview

5.1.1.1 Weather Patterns

The Gulf is located in the subtropical high-pressure region, where the climate is classified as arid. The climate can be divided into two main seasons with two transition periods as follows:

- The summer season – from June to September;
- Fall transition season – during October and November;
- The winter season – from December to March; and
- Spring transition season – during April and May) (Walters, 1990).

During transition periods, the weather is commonly unstable with no well-defined weather patterns, and tropical storms are common (Al Senafi and Anis, 2015).

Summer in the northern Gulf is influenced by two main pressure systems. The first is the stationary summer monsoon low pressure system centred over north west of India extending west to the south east of the Gulf. The second is the stationary high pressure system over the east of the Mediterranean with a ridge extending south east towards the north west of the Gulf. These two systems produce a steep pressure gradient in between, which lies over the north east of the Gulf (Nasrallah *et al,.* 2004) and produces strong north westerly winds (7–13 m/s^{-1}) (Bartlett, 2004) known as summer Shamals (Rao *et al.*, 2003), which could last up to weeks at a time (Wilkerson, 1991). The summer Shamals commonly bring dust or 'blazes' of hot (up to 51°C) and dry air.

The winter season in the northern Gulf is influenced by cold air carried into the region by the quasi-stationary Siberian high-pressure system in the east (Crook, 2009). This climate is often interrupted by frontal systems that build up in the eastern Mediterranean and move south east due to the upper-westerlies, namely the Polar Front Jet. These moisture bearing frontal systems are the primary source of precipitation in the region (Barlow et al., 2005). As the frontal system moves towards the Gulf, the Polar Front Jet behind the frontal system and the Sub-Tropical Jet ahead of it converge, strengthen the system and generate strong winds at the front. On the passage of the front over the northern Gulf, strong north westerly winds develop with fivefold the initial speed and reach values up to 15–20 m/s^{-1} near the surface at the centre of the Gulf (Thoppil and Hogan, 2010); these are known as winter Shamals. The duration of a winter Shamal event depends on the speed of the upper air moving through the region, however, typical duration of a Shamal event is two to five days (Ali, 1994).

5.1.1.2 Precipitation and Temperature

Precipitation occurs almost exclusively in winter and is highly variable in both volume and spatial occurrence. The annual precipitation levels in the Emirate of Dubai are low. Between 2010 and 2012, there were on average 20 rainy days per year and total annual rainfall was in the range of 22.8 mm to 53.7 mm (Dubai Statistical Centre, 2014).

The coastal areas of Dubai are influenced by the waters of the Arabian Gulf and as such have a lower maximum but a higher average temperature and a higher humidity. The mean monthly temperature in the Emirate of Dubai for 2013 - 2015 is shown in Figure 5-1, while the mean monthly relative humidity is presented in Figure 5-2.

The average daily temperature in 2015 ranged between 16.5 °C to 43.3 °C (Dubai Statistical Centre, 2016). The 2015 climate data showed that August had the highest average daily maximum temperatures while the lowest average daily minimum temperature was recorded in January.

The average monthly relative humidity from 2013 to 2015 ranged from 13% to 82%. In 2015, May had the lowest average daily minimum relative humidity whereas the highest average of daily maximum relative humidity was recorded in January.

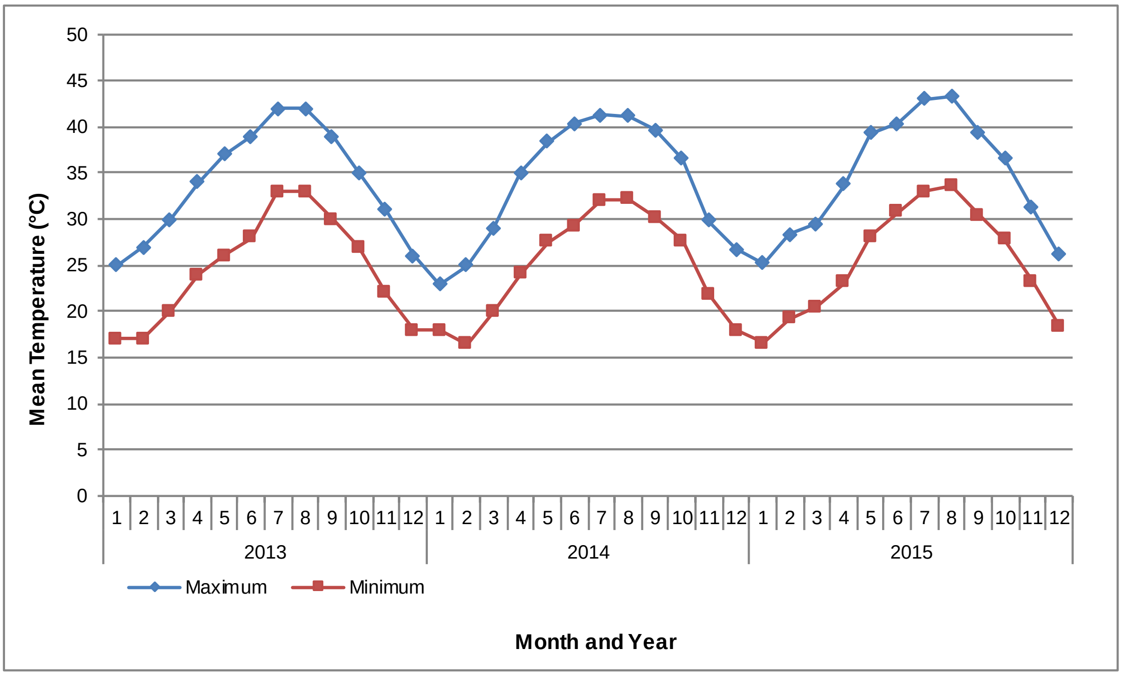


Figure 5-1 Mean Monthly Temperature in the Emirate of Dubai (2013–2015)

Source: Dubai Statistics Center, 2015a

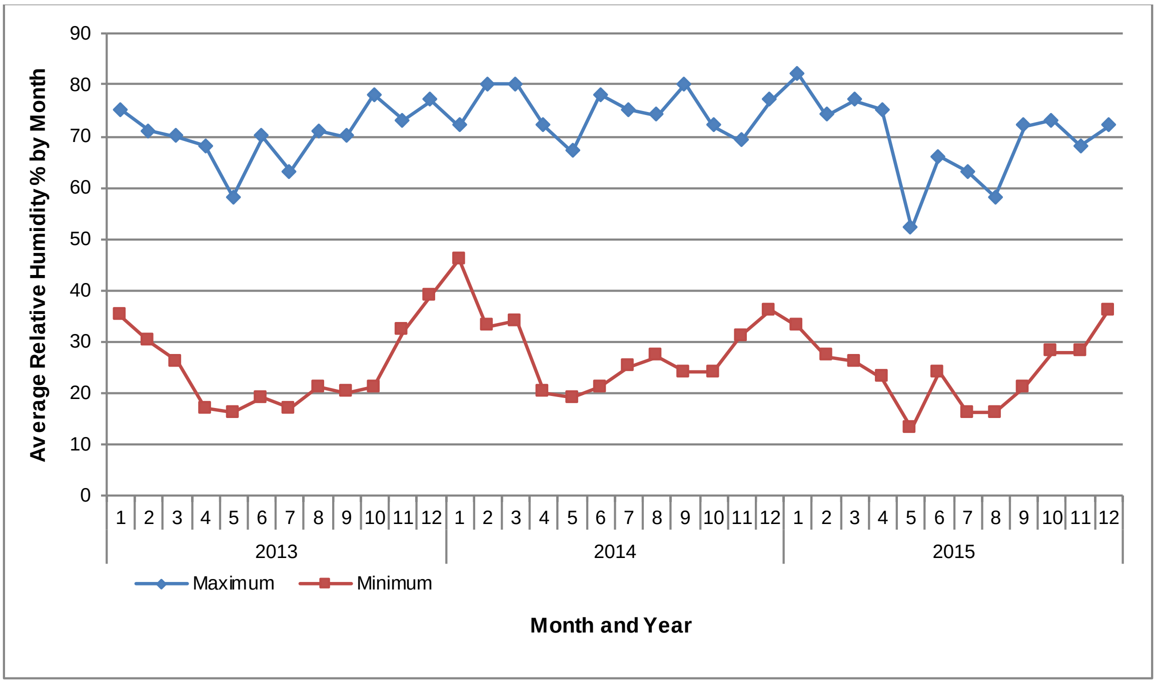


Figure 5-2 Mean Monthly Relative Humidity in the Emirate of Dubai (2013–2015)

Source: Dubai Statistics Center, 2015a

5.1.2 Climate Change

According to the estimates made in the Third National Communication to the Conference of Parties under the United Nations Framework Convention on Climate Change, the UAE's total GHG emissions in 2005 were 174,357 giga-grams (Gg) CO_2–equivalent. Taking into account the CO_2 sequestration of 13,223 Gg by the forestry and land use sector, the net GHG emissions are estimated at 161,134 Gg CO_2-equivalent. On a net CO_2–equivalent basis, emissions in the UAE increased by about 117% over the period of 1994 to 2005 or about 7.3% per year (Ministry of Energy, 2012).

UAE's total GHG emissions in 2005 are summarised in Table 5-1. Approximately 88% of these emissions are attributed to the energy sector (i.e. combustion of fossil fuels or release of fugitive emissions from oil and gas operations) while industrial, agriculture and waste sectors accounted for 6%, 2% and 4%, respectively.

Table 5-1 Total GHG Emissions in the UAE, 2005

Serial No.	GHG Sources and Sinks	Gg CO_2-equivalent	Percentage (%) of total emissions
1	Energy	153,833	88.23
2	Industrial processes	9,426	5.41
3	Solvent and other product use	0	0
4	Agriculture	3,976	2.28
5	Land-use change and forestry	-13,223	0
6	Waste	7,122	4.08
Total National Emissions		174,357	100
Net National Emissions		161,134	

Source: Ministry of Energy, December 2012

The Dubai Integrated Energy Strategy (DIES) 2030 was developed in 2010 to support the UAE's commitments to mitigate climate change. The strategy was implemented in January 2011 in order *'to set the strategic direction of Dubai towards securing sustainable supply of energy and enhancing demand efficiency (water, power and transportation fuel)* (Dubai Supreme Council of Energy, 2012).

The following strategies will be undertaken by the Dubai Supreme Council of Energy as part of the DIES 2030:

- Carbon dioxide baseline study;
- Complete a detailed inventory of Dubai's greenhouse gas emissions in line with the requirements of the IPCC, and the United Nations Framework Convention on Climate Change;
- Develop a monitoring, reporting and verification framework, in order to harmonise and streamline data collection from the Council's members, which include the main energy, manufacturing and utilities companies in Dubai; and

- Recommend / establish viable targets for reducing CO_2 and GHGs, and a methodology to monetise emissions, similar to the European Trading Scheme, the Clean Development Mechanism developed under the Kyoto Protocol, and other carbon reduction schemes.

In 2013, the 13 MW solar photovoltaic power plant, which comprised the first phase of the landmark Mohammed bin Rashid Al Maktoum Solar Park, was completed. The solar power plant is expected to generate approximately 24 million kilowatt hours of electricity per year, which will on average displace approximately 15,000 metric tons of CO_2 annually (Ministry of Environment and Water, 2014).

Under the DIES 2030, Dubai's projected fuel use will be altered towards use of sustainable energy (Figure 5-3).

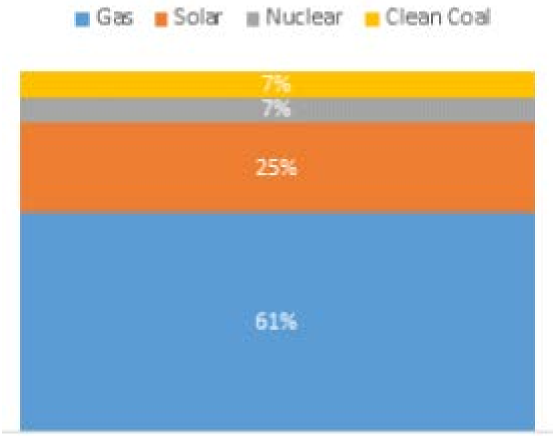


Figure 5-3 Projected Use of Fuel Types in Dubai, 2030

Adapted from Dubai Supreme Court of Energy (2017)

5.1.3 Sea Level Rise

Sea level rise has been occurring since the early 19th century, although anthropogenic observations have recorded a rapid increase in more recent times. Records of sea level rise throughout the 1900's saw an approximate increase of 1.7 millimetres per year, while Records from 1993 to 2010 showed an increase in this rate, at approximately 3.2 millimetres per year (Nicholls and Cazenave, 2010). Projections predict that the rate of sea level rise has the potential to increase by 30 to 180 centimetres by the year 2100 (Church et al. 2008, Nicholls and Cazenave 2010).

Sea level rise is caused by two factors: thermal expansion of water and the melting of land ice. Both factors are a result of increasing global atmospheric temperatures caused by GHG concentrations (Hoegh-Guldberg and Bruno, 2010). The ocean experiences thermal expansion as it increases in temperature, and currently accounts for 50 percent of sea level rise. The melting of ice accounts for approximately 30 percent of sea level rise. Changes in sea level occur over a broad range of temporal and spatial scales, with the many contributing factors making it an integral measure of climate change (Milne et al., 2009; Church et al., 2010). The rates of regional sea level change from climate variability can differ greatly from the global average rate. However, it is predicted that by the end of the 21st century most regions will experience a relative sea level rise within 20% of the predicted global mean sea level change (Intergovernmental Panel on Climate Change, 2013).

5.2 Air Quality

5.2.1 Overview

Air pollution has been stated as the primary environmental threat to public health in the UAE and ambient air quality has been recorded to be steadily deteriorating (Willis et al., 2010, Environment Agency Abu Dhabi, 2017). This Section provides a summary of national and regional air quality, while baseline air quality monitoring results from the Project site are provided in Section 5.2.2.

5.2.1.1 Gaseous Emissions

Common pollutants emitted by major sources in the UAE include sulphur dioxide (SO_2), ozone (O_3), NO, nitrogen dioxide (NO_2), cyanide (CN) and aerosols, largely produced by transportation and the construction industry (Climatology Research Group, 2004). According to the State of the Environment Report (Tolba and Saab, 2008), CO_2 emissions in the UAE increased from 80.8 million tonnes in 1990 to over 94 million tonnes in 2002. Pollution levels are generally highest along the coastal interface and over refineries and oilfields (Climatology Research Group, 2004).

Haze layers are commonly observed over the UAE due to stable air layers that reduce the vertical motion of air. These stable layers play a key role in the UAE's air quality, as gaseous emissions are frequently trapped at ground level resulting in elevated pollutants.

Emissions from the coastal areas are typically transported in-land through advection in the form of afternoon sea breezes, while transport offshore at night occurs through the reverse process.

Seasonal comparisons of average sulphur dioxide, ozone and NOy concentrations across urban areas of the UAE (Climatology Research Group, 2004) are provided in Figure 5-4 and are summarised as follows:

- Sulphur dioxide (SO_2) concentrations in Dubai are similar to those recorded in Abu Dhabi and Al Ain, at approximately 25 parts per billion. As sulphur dioxide has a relatively short residence time, concentrations are highly dependent on proximity to the source;
- Ozone (O_3) concentrations in Dubai are somewhat similar across the urban areas and are all generally higher in the winter seasons. Average Dubai concentrations are approximately 46 parts per billion; and
- Total reactive oxides (NOy) concentrations are significantly greater during summer than winter in all measured urban locations. This correlates with the reduced ozone during summer, as nitrogen oxides break down ozone molecules. Average Dubai concentrations range between 3 and 15 parts per billion for winter and summer, respectively.

Air monitoring within the Dubai Emirate has been undertaken by the Dubai Municipality-Environment Department at 13 sites across urban and industrial areas. The results from 2013 to 2015 are provided in Table 5-2 and show that ambient concentrations of CO, O_3 and SO_2 are generally within the ambient air quality objectives. Nitrogen dioxide exceeded the limits at eight of the 13 monitoring stations in 2013 and at one station in 2014. Exceedances of NO_2 often occur in areas of high road traffic volumes.

5.2.1.2 Particulates

According to the World Health Organisation (2017), the region including UAE, Kuwait, Saudi Arabia, Bahrain, Qatar and Oman recorded the highest levels of dust (PM_{10}) in the world from 2008 to 2015. In 2013, at the mean annual PM_{10} in UAE urban areas ranged between 123 and 146 µg/Nm^3, while $PM_{2.5}$ ranged between 52 and 62 µg/Nm^3 (WHO, 2016b). The mean annual concentration of fine particulate matter ($PM_{2.5}$) in urban areas of the UAE in 2014 was 64 µg/Nm^3, ranking 12th highest in the world (WHO, 2016a).

Ambient concentrations of airborne particulates (PM_{10} and Total Suspended Particles - TSP) throughout the UAE are commonly recorded in higher concentrations than the national limit of 150 µg/m^3 (Table 5-2). This is largely attributable to the prevalence of dry sandy soils inherent in the desert environment. Anthropogenic activities such as the large-scale construction projects, industrial discharges, increased number of vehicles on the roads, the removal of natural vegetation and increases in off-road driving activities all contribute to elevated ambient levels of airborne particulates in the UAE.

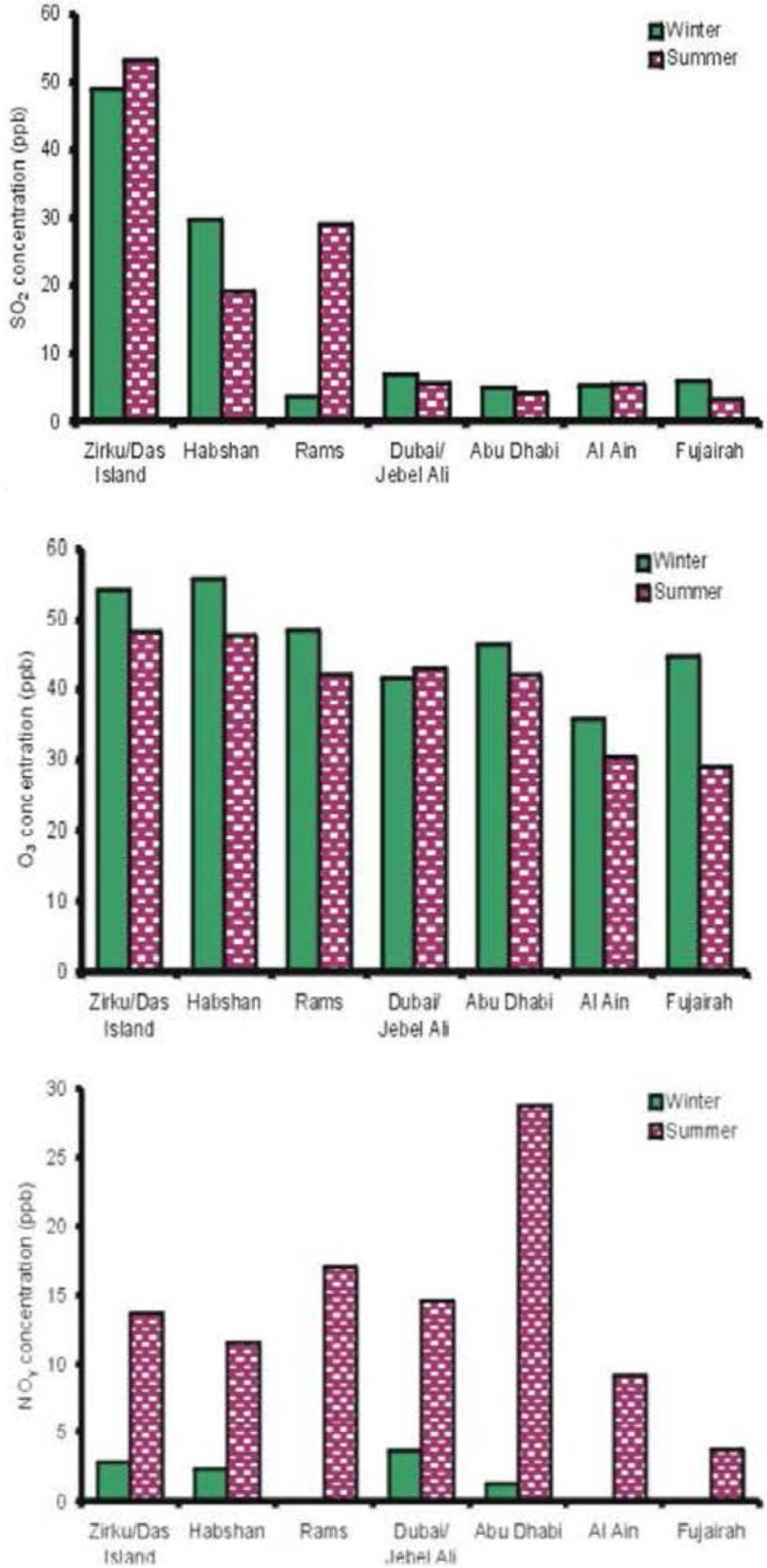


Figure 5-4 Seasonal Comparisons of Air Pollutants in UAE (from Climatology Research Group, 2004)

Table 5-2 Air Pollution Indicators at Monitoring Sites – Emirate of Dubai (2013–2015) taken from Dubai Statistics Centre (2015c)

Indicator	Carbon monoxide (CO)			Ozone (O_3)			Nitrogen dioxide (NO_2)			Sulphur dioxide (SO_2)			Particulate matter (PM_{10})			Particulate matter ($PM_{2.5}$)		
Objective	20 ppm			0.80 ppm			0.15 ppm			0.13 ppm			300 µg/Nm^3			300 µg/Nm^3		
Year	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
Sheikh Zayed Road	3.3	4.34	2.69	-	-	-	0.11	0.13	0.12	-	-	0.06	-	3875	3139	-	-	-
Dubai Airport	3.7	2.09	2.36	-	-	-	0.2	0.13	0.1	-	-	0.1	-	5340	4694	-	2080	2889
Emirates Hills	1.9	1.63	1.45	0.14	0.15	0.08	0.2	0.1	0.09	-	-	0.05	-	6942	5401	-	2320	2888
Zabeel Park	3.4	3.43	2.28	0.15	0.15	0.1	0.12	0.1	0.08	-	-	0.09	-	-	-	-	4160	6118
Al Karama	3	3.68	2.47	-	-	-	0.2	0.11	0.08	-	-	0.09	-	6821	3246	-	-	-
Safa Park	2.5	2.02	-	0.13	0.11	-	0.19	0.1	-	-	-	-	-	-	-	-	1878	-
Deira	2.7	0.28	2.27	0.15	0.15	0.09	0.14	0.1	0.11	-	-	0.07	-	-	-	-	2824	3248
Sheikh Mohammed Bin Zayed Road	2.9	4.52	1.87	-	-	-	0.12	0.17	0.1	-	-	0.09	-	3830	5356	-	2545	4021
Warsan	-	-	1.53	0.15	0.15	0.06	0.16	0.1	0.07	-	-	0.1	-	-	-	-	-	-
Hatta Station	-	-	1.27	0.14	0.15	0.1	0.2	0.1	0.08	-	-	-	-	3389	2168	-	-	-
Jebel Ali Port	2.4	1.71	-	-	-	-	0.2	0.13	0.13	-	-	0.08	-	1992	3951	-	-	-
Jebel Ali Village	1.9	2.61	1.53	0.15	0.15	0.1	0.2	0.12	0.08	-	-	0.06	-	-	-	-	-	-
Mushrif Park	-	-	-	0.13	0.15	0.1	0.14	0.12	0.11	-	-	-	-	-	-	-	5149	4751

5.2.2 Baseline Air Quality Survey

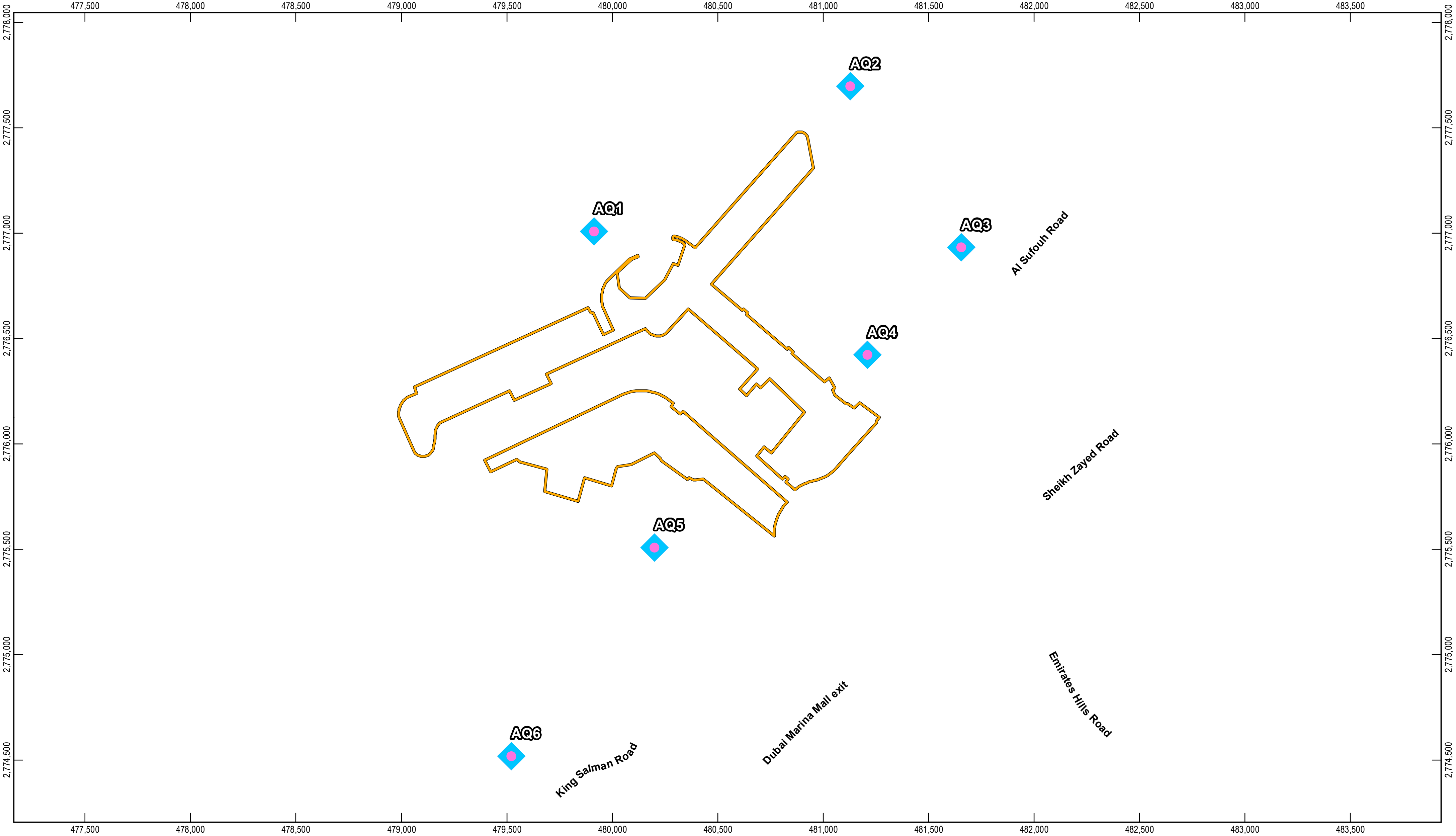
5.2.2.1 Monitoring Methodology

Baseline air monitoring was undertaken for two weeks at six sites in vicinity to the Project site between 12 and 26 April 2017. These locations are detailed in Table 5-3 and illustrated in Figure 5-5. The sites comprised areas that would be directly impacted (within the Project footprint) and identified sensitive receptors. The air quality monitoring parameters and monitoring methods utilised are summarised in Table 5-4

The calibration certificate for the air sampler is provided in Appendix D.

Table 5-3 Baseline Air Quality Monitoring Locations

Site Name	Site Description	Approximate Minimum Distance to Project (m)	Coordinates – *World Geodetic System of 1984 datum*
AQ1	Palm Jumeirah, north of Project. Near residential buildings and hotels	450	25.099313, 55.134607
AQ2	Palm Jumeirah, east of Project. Private beach and hotels.	450	25.104490, 55.146131
AQ3	Jumeirah Beach, south of Project. Retail and hotels.	750	25.099527, 55.152009
AQ4	Jumeirah Beach, south of Project. Public beach and hotels.	700	25.094017, 55.146988
AQ5	DIMC breakwater, south of Project.	250	25.092155, 55.141274
AQ6	Jumeirah Beach Residences, south of Project. Retails, restaurants, residential and public beaches.	500	25.086440, 55.136738



Paper Size A4

0 250 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: WGS 1984
Grid: WGS 1984 Dubai Local TM

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Air Quality

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Job Number	76-10664
Revision	0
Date	02 Jun 2017

Air quality monitoring locations

Figure 5-5

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3rd floor Guardian Tower Danet Community Abu Dhabi United Arab Emirates **W** www.ghd.com

Data source: GHD - Dubai Harbour Development, Air Quality Monitoring locations (2017). Image © Google Earth, Digital Globe. Natural Earth - Road. Created by:jcmatic

Table 5-4 Baseline Air Monitoring Parameters and Methodology

Air Quality Parameter	Monitoring Method / Principle	Monitoring Equipment
Particulate Matter (PM_{10}).	US CFR Title 40, Appendix B to Part 50	Fine Particulate Sampler APM 550
Total Suspended Particles (TSP)		
Oxides of Nitrogen (NOx) & Nitrogen Dioxide (NO_2)	US CFR Title 40, Appendix S to Part 50	Sampling: APM 433 Gaseous Pollutants Sampler Lab test: Spectrophotometer
Sulphur Dioxide (SO_2)	US CFR Title 40, Appendix A2 to Part 50	
Total Volatile Organic Compounds (VOC)	Electrochemical Sensors / Cells	RAE Monitoring System
Carbon monoxide (CO)		
Ozone (O_3)		

5.2.2.2 Guidelines

The results of the baseline monitoring were assessed against the following local standards (refer to Section 3.3.5):

- Ambient Air Quality Standards specified in Regulation concerning Protection of Air from Pollution (Council of Ministers Decree No. (12) of 2006) – UAE Federal Law; and
- Dubai Municipality ambient air quality standards.

5.2.2.3 Air Monitoring Results

Gaseous Pollutants

The results of the gaseous pollutant monitoring are provided in Table 5-5 and show that all parameters were well below the guideline limits at all stations.

Concentrations of all parameters were spatially similar across all monitoring locations, with Analysis of Variance statistical analysis confirming that there is no significant difference in pollutant concentrations between the six sites (P values ranged from 0.47 to 0.7).

It should be noted that the 2-week monitoring period provides only a snap shot of conditions at the Project site. Short-term measurements made over a limited sampling period involve a large uncertainty as to the representativeness throughout the various times of the year.

It is noted that there are no industrial facilities with point source emissions in close vicinity to the Project site. Ambient air quality at the Project site and in the surrounding areas is likely to be most heavily influenced by the following:

- Combustion emissions from vehicles using the surrounding road infrastructure; and
- Small scale construction activities such as building construction or road works.

Table 5-5 Baseline Ambient Air Quality Monitoring Results for NOx, CO, VOCs and O_3

Sampling Date / Limit	Parameter (24 hour average)													
	NO_x ($\mu g/m^3$) 150 $\mu g/m^3$ (UAE Federal) 110 $\mu g/m^3$ (DM Standards)						CO (mg/m^3) – 8 hour 10 mg/Nm^3 (UAE Federal)	O_3 ($\mu g/m^3$) – 8 hour 230 $\mu g/m^3$ (DM Standards)						VOC No standard available
	AN 1	AN 2	AN 3	AN 4	AN 5	AN 6	All sites	AN 1	AN 2	AN 3	AN 4	AN 5	AN 6	All Sites
12 Apr 2017	19	30	16	18	23	11	< 1.1	23	15	30	12	27	17	<50
13 Apr 2017	16	21	19	9.0	16	18	< 1.1	38	23	27	17	32	26	<50
14 Apr 2017	23	16	17	18	13	15	< 1.1	20	18	33	27	29	24	<50
15 Apr 2017	20	23	21	30	16	13	< 1.1	23	29	26	35	32	21	<50
16 Apr 2017	14	20	17	19	22	27	< 1.1	26	30	29	36	33	23	<50
17 Apr 2017	27	22	18	30	16	20	< 1.1	17	30	23	20	27	21	<50
18 Apr 2017	20	16	15	23	13	27	< 1.1	27	21	17	24	15	33	<50
19 Apr 2017	23	18	22	27	18	24	< 1.1	15	27	20	18	36	29	<50
20 Apr 2017	17	21	19	23	26	25	< 1.1	32	21	26	12	23	29	<50

Sampling Date / Limit	Parameter (24 hour average)													
	NO_x (µg/m³) 150 µg/m³ (UAE Federal) 110 µg/m³ (DM Standards)						CO (mg/m³) – 8 hour 10 mg/Nm³ (UAE Federal)	O_3 (µg/m³) – 8 hour 230 µg/m³ (DM Standards)						VOC No standard available
	AN 1	AN 2	AN 3	AN 4	AN 5	AN 6	All sites	AN 1	AN 2	AN 3	AN 4	AN 5	AN 6	All Sites
21 Apr 2017	22	15	25	19	22	18	< 1.1	20	15	39	30	27	32	<50
22 Apr 2017	19	17	22	24	21	28	< 1.1	38	24	17	23	32	29	<50
23 Apr 2017	27	20	18	26	25	21	< 1.1	24	29	20	36	27	15	<50
24 Apr 2017	18	15	21	18	16	26	< 1.1	12	24	38	18	30	21	<50
25 Apr 2017	15	18	22	16	20	19	< 1.1	38	26	17	30	20	29	<50
Averages	**20.00**	**19.43**	**19.43**	**21.43**	**19.07**	**20.86**	**-**	**25.21**	**23.71**	**25.86**	**21.14**	**27.86**	**24.93**	**-**

Dust

The results of the dust monitoring are provided in Table 5-6. All parameters remained within guideline values throughout the monitoring period and at all locations. The PM_{10} 24-hour average for the two-week monitoring period ranged between 98.43 and 109.07 $\mu g/m^3$, which is considered relatively low given the generally elevated ambient background levels as discussed in Section 5.2.1.

Table 5-6 Baseline Ambient Air Quality Monitoring Results for PM_{10} and TSP

Sampling Date / Limit	Parameter (24 hour average)											
	PM_{10} ($\mu g/m^3$) – 24hr - 150 $\mu g/m^3$ (DM and UAE Federal Standards)						TSP ($\mu g/m^3$) - 230 $\mu g/m^3$ (DM Standards)					
	AN 1	AN 2	AN 3	AN 4	AN 5	AN 6	AN 1	AN 2	AN 3	AN 4	AN 5	AN 6
12 Apr 2017	97	71	118	88	90	102	143	129	188	130	214	155
13 Apr 2017	104	83	68	92	123	111	170	147	138	165	174	201
14 Apr 2017	120	86	135	99	112	81	196	147	190	156	185	166
15 Apr 2017	103	130	112	120	109	89	153	191	184	204	177	150
16 Apr 2017	85	134	96	112	109	126	149	194	157	200	183	195
17 Apr 2017	109	83	96	119	91	132	192	122	175	215	173	198
18 Apr 2017	119	89	99	108	73	139	190	158	155	173	122	205
19 Apr 2017	115	97	134	107	86	120	195	145	217	187	163	208
20 Apr 2017	88	115	97	79	102	124	149	187	169	134	151	193
21 Apr 2017	127	86	95	112	100	74	195	151	174	176	204	125
22 Apr 2017	127	118	86	82	104	75	169	199	143	146	171	128
23 Apr 2017	95	126	80	118	109	68	158	195	177	196	191	111
24 Apr 2017	132	108	82	119	92	73	203	173	140	172	145	141
25 Apr 2017	106	88	134	94	78	104	149	161	198	164	120	175
Averages	**109**	**101**	**102**	**103**	**98**	**101**	**172**	**164**	**172**	**173**	**170**	**168**

5.3 Noise

5.3.1 Overview

The proposed Project is located within a reclaimed / marine area surrounded by residential, recreational and commercial land uses. The existing sources of noise in the vicinity of the proposed Project site include the following:

- Airplane noise from Skydive Dubai – planes landing and taking off;
- Traffic noise – the nearest main road (Kind Salman bin Abdulaziz Al Saud Street formerly Al Sufouh Road) is approximately 800 m away from the proposed site;
- Yachts, boats and jet-skis accessing DIMC and Dubai Marina.

Dubai is subject to relatively high levels of traffic and construction noise as a result of the high level of development and growth of the country. In a study conducted to evaluate the impact of air and noise from transportation in Dubai, noise levels recorded within the city of Dubai were higher than those recorded outside the city due to increased human activity. The main sources of noise included road traffic and aircraft movement from the Dubai Airport (Al Mehairi, 1995). In the absence of local noise data, this section details the methodology and results of a baseline noise survey undertaken around the Project site.

5.3.2 Baseline Noise Survey Methodology

Baseline noise monitoring was undertaken at six sites over two monitoring periods on the 15th and 16th of April and the 22nd and 23rd of April 2017. The noise monitoring locations illustrated in Figure 5-6 were chosen due to their proximity to the Project and potential to be impacted by noise (sensitive receptors). The objective of the baseline monitoring survey was to measure current daytime and night time ambient noise and assess the results against the Residential Areas With Light Traffic' specified in Allowable Limits for Noise Level in Different Areas - Regulation concerning Protection of Air from Pollution (Council of Ministers Decree No. 12 of 2006) – UAE Federal Law, which allows a maximum noise level of 60 dB during the day time and 50 dB during night time for this type of land use.

A total of four measurements were taken for a duration of 15-minutes at each site, comprising:

- One measurement on a week day (Sunday – Thursday) during day time (7 am to 8 pm);
- One measurement on a week day during night time (8 pm to 7 am);
- One measurement on the weekend (Friday or Saturday) during day time;
- One measurement on the weekend during night time.

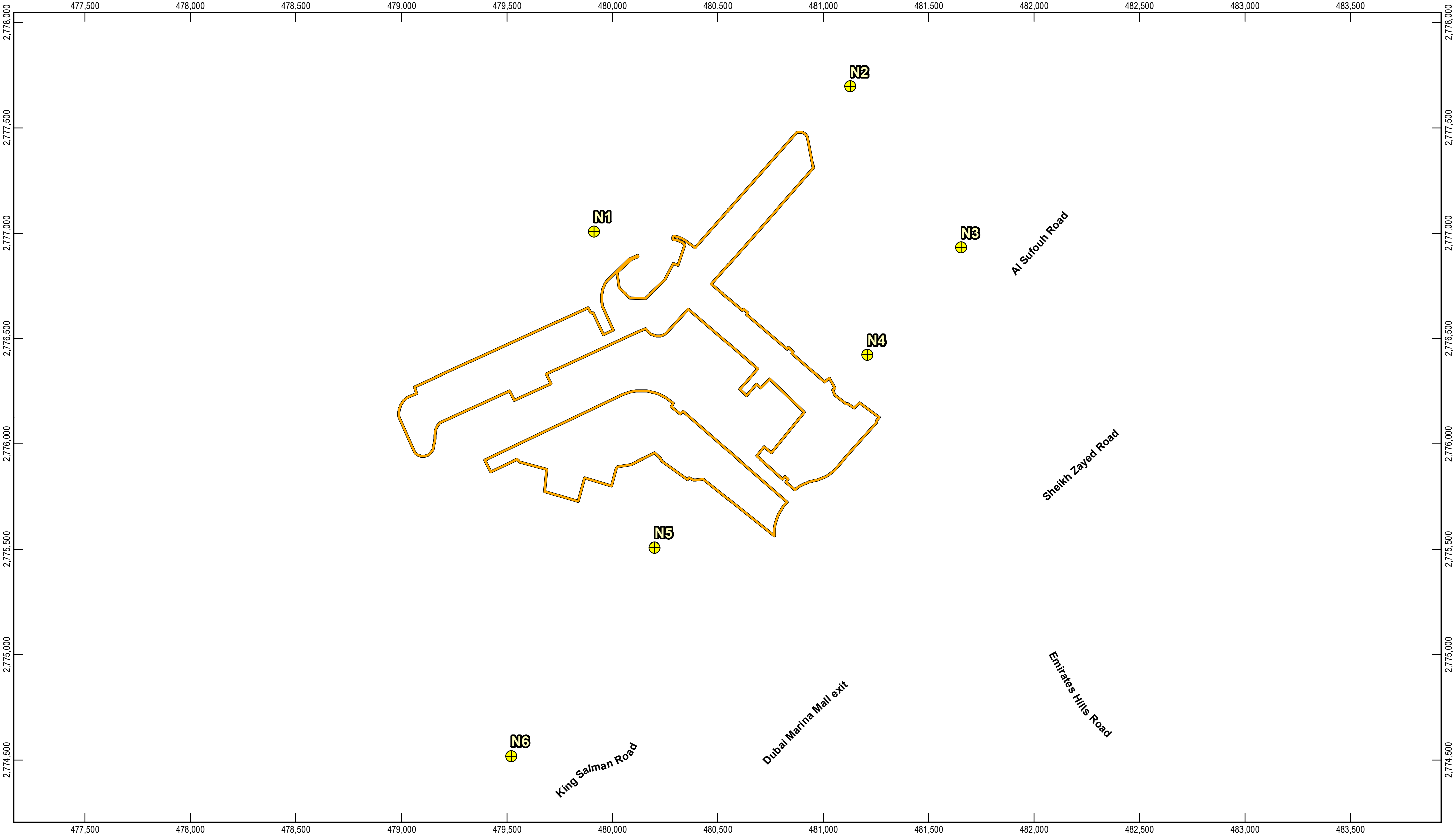
For each measurement, the following parameters were measured:

- L_{Aeq} – The average measured noise level;
- L_{Amax} – The highest single noise level;
- L_{Amin} – The lowest or minimum noise level measured;
- L_{A10} – The average noise level exceeded for ten percent of the duration of the measurement; and
- L_{A90} – The noise level which is exceeded for an average of 90 percent of the duration of the measurement.

Measurements were taken using a Cirrus CR:831A sound level meter in accordance with *ISO 1996-1:2003 - Acoustics - Description, Measurement and Assessment of Environmental Noise - Part 1: Basic Quantities and Assessment Procedures*. Readings were taken at approximately

1.5 metres above the ground level. Other details such as surrounding activities and noise sources at the time of measurement were noted.

Immediately prior to and following each noise measurement, the accuracy of the sound level meter was checked by a sound level calibrator generating a known sound pressure level at a known frequency. Measurements were accepted as valid only if the calibration levels before and after the noise measurements agreed to within 1.0 dB. Noise level data obtained during rain and wind with an average speed exceeding 5 m/s or wind with gusts exceeding 10 m/s was not accepted. The calibration certificates for the Type 1 sound level meter and calibrator are provided in Appendix D.



Paper Size A4

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: WGS 1984
Grid: WGS 1984 Dubai Local TM

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Noise monitoring locations

Dubai Harbour Development

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Job Number	76-10664
Revision	0
Date	02 Jun 2017

Noise monitoring locations

Figure 5-6

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3rd floor Guardian Tower Danet Community Abu Dhabi United Arab Emirates W www.ghd.com

Data source: GHD - Dubai Harbour Development, Noise Monitoring locations (2017). Image © Google Earth, Digital Globe. Natural Earth - Road. Created by:jcmatic

5.3.3 Baseline Noise Monitoring Results and Discussion

A summary of noise sources noted during the monitoring activity is provided in Table 5-7 , while site photos at each location are provided in Figure 5-7.

Table 5-7 Key Noise Sources at the Monitoring Sites

Principal Source of Noise	N1	N2	N3	N4	N5	N6
Construction-related						
Site staff		✓				✓
Site vehicle movement		✓				✓
Material unloading		✓				
Construction work (e.g. excavation)		✓				✓
Non construction related						
Hotel staff activities (e.g. beach cleaning, chair arrangements)	✓		✓	✓	✓	
Vehicle movement (e.g. passing cars)					✓	
Recreational water activities (e.g. jet skis, boat movement)	✓	✓	✓	✓	✓	✓

		
N1	N2	N3
		
N4	N5	N6

Figure 5-7 Site Photos at Noise Monitoring Stations

The noise monitoring results for day and night are provided in Table 5-8 and Table 5-9, respectively. Noise levels which exceed the Federal Limit of 60 dB(A) during the day and 50 dB(A) during the night are shown in red text.

Table 5-8 Results of Daytime Monitoring

Site Name	Measurement Period		Results, dB(A)				
	Start Time	End Time	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
N1							
Weekend	15 April 9:20 am	15 April 9:35 am	47.6	62.5	32.5	53.8	45.8
	22 April 9:39 am	22 April 9:54 am	54.6	79.5	35.6	59.6	50.2
Weekday	16 April 9:40 am	16 April 9:55 am	57.3	94.5	42.3	61.2	48.7
	23 April 9:28 am	23 April 9:43 am	58.2	79.4	32.6	59.4	55.3
N2							
Weekend	15 April 10:10 am	15 April 10:25 am	54.5	66.9	39.4	58.3	53.6
	22 April 10:40 am	22 April 10:55 am	64.1	92.6	45.1	62.3	59.4
Weekday	16 April 10:20 am	16 April 10:35 am	55.6	76.8	40.6	63.3	52.8
	23 April 10:24 am	23 April 10:39 am	66.5	96.5	48.2	66.7	60.8
N3							
Weekend	15 April 10:30 am	15 April 10:45 am	55.8	65.3	40.7	59.2	54.7
	22 April 11:30 am	22 April 11:45 am	60.2	86.6	38.0	59.6	49.0
Weekday	16 April 11:05 am	16 April 11:20 am	58.3	75.6	43.2	62.9	53.1
	23 April 11:00 am	23 April 11:15 am	59.4	79.5	43.6	60.4	52.1
N4							
Weekend	15 April 11:08 am	15 April 11:23 am	53.9	75.0	38.9	60.4	51.6
	22 April 12:08 pm	22 April 12:23 pm	62.0	88.4	36.1	60.2	53.4
Weekday	16 April 11:42 am	16 April 11:57 am	57.9	89.3	42.8	65.2	51.8
	23 April 11:35 am	23 April 11:50 am	62.1	95.6	47.2	64.2	58.1
N5							

Site Name	Measurement Period		Results, dB(A)				
	Start Time	End Time	L_{Aeq}	L_{Amax}	L_{Amin}	L_{A10}	L_{A90}
Weekend	15 April 11:40 am	15 April 11:55 am	55.0	84.0	39.9	60.6	52.0
	22 April 12:36 pm	22 April 12:51 pm	65.6	94.6	44.4	62.3	56.1
Weekday	16 April 12:10 pm	16 April 12:25 pm	56.8	89.0	41.7	61.2	51.6
	23 April 12:01 pm	23 April 12:16 pm	61.2	88.6	44.4	57.6	50.7
N6							
Weekend	15 April 12:12 pm	15 April 12:27 pm	57.9	79.8	42.8	62.8	56.5
	22 April 1:10 pm	22 April 1:25 pm	55.6	74.5	32.1	50.6	44.5
Weekday	16 April 12:40 pm	16 April 12:55 pm	54.1	90.4	39.1	62.3	51.2
	23 April 12:30 pm	23 April 12:45 pm	55.6	78.2	41.0	59.1	54.1
Federal allowable limit for residential areas with some workshops & commercial or near highways: **L_{Aeq} = 50–60**							

Table 5-9 Results of Night Time Monitoring

Site Name	Measurement Period		Results, dB(A)				
	Start Time	End Time	L_{Aeq}	L_{AMax}	L_{Amin}	L_{A10}	L_{A90}
N1							
Weekend	15 April 8:00 pm	15 April 8:15 pm	53.9	78.2	38.8	63.3	51.8
	22 April 8:35 pm	22 April 8:50 pm	59.6	86.4	40.2	60.3	55.4
Weekday	16 April 8.05 pm	16 April 8:20 pm	53.4	88.4	38.3	56.8	50.1
	23 April 8:45 pm	23 April 9:00 pm	59.2	85.1	41.6	61.6	52.9
N2							
Weekend	15 April 9:06 pm	15 April 9:21 pm	55.2	79.9	40.1	57.5	54.1
	22 April 9:30 pm	22 April 9:50 pm	62.3	92.4	49.5	68.1	61.2
Weekday	16 April 9:08 pm	16 April 9:23 pm	53.7	81.2	38.7	55.7	53.0
	23 April 9:35 pm	23 April 9:50 pm	60.1	87.2	49.8	67.2	57.8
N3							
Weekend	15 April 9:28 pm	15 April 9:43 pm	54.3	73.3	39.2	57.8	53.7
	22 April 10:20 pm	22 April 10:35 pm	57.6	80.4	40.1	57.6	52.6
Weekday	16 April 9:28 pm	16 April 9:43 pm	52.7	67.3	37.7	57.3	52.2
	23 April 10:10 pm	23 April 10:25 pm	57.6	86.4	33.4	61.8	56.8
N4							
Weekend	15 April 10:00 pm	15 April 10:15 pm	52.9	79.2	37.9	59.5	51.6
	22 April 10:52 pm	22 April 11:07 pm	59.1	78.7	36.3	53.6	50.9
Weekday	16 April 10:10 pm	16 April 10:25 pm	55.3	84.6	38.2	56.4	52.5
	23 April 10:36 pm	23 April 10:51 pm	61.4	89.4	41.2	62.4	56.4
N5							
Weekend	15 April 10:27 pm	15 April 10:42 pm	54.9	69.9	39.0	59.0	53.7
	22 April 11:20 pm	22 April 11:35 pm	64.3	88.9	44.5	60.3	55.4

Site Name	Measurement Period		Results, dB(A)				
	Start Time	End Time	L_{Aeq}	L_{AMax}	L_{Amin}	L_{A10}	L_{A90}
Weekday	16 April 10:41 pm	16 April 10:56 pm	52.2	78.4	37.1	54.3	50.9
	23 April 11:05 pm	23 April 11:20 pm	60.1	91.3	47.4	65.4	53.8
N6							
Weekend	15 April 10:55 pm	15 April 11:10 pm	65.7	84.1	50.7	75.0	58.3
	22 April 11:40 pm	22 April 11:55 pm	59.0	86.5	42.1	63.2	57.1
Weekday	16 April 11:10 pm	16 April 11:25 pm	55.2	83.3	40.1	59.5	54.1
	23 April 11:30 pm	23 April 11:45 pm	59.1	90.4	40.7	61.2	52.3
Federal allowable limit for residential areas with some workshops & commercial or near highways: **L_{Aeq} = 40–50**							

The results show that average measurements (L_{Aeq}) during the day were compliant with the Federal Limit of 60 dB(A) at N1 and N6 for all measurements, N3 for the majority of measurements (only one small exceedance of 0.2 dB on a weekend) and N2, N4 and N5 for half the measurements. The L_{A90} measurement complied with the day time guideline limit across all sites and measurements, with the exception of one small exceedance at N2 (0.8 dB), while the L_{A10} exceeded the limit in 62% of the measurements taken across all sites. The highest L_{A10} (66.7 dB) and L_{AMAX} (96.5 dB) was recorded at site N2 (eastern boundary of the Project on the southern part of Palm Jumeirah) between 10:24 am and 10:39 am. However, at the same site during a weekday in the previous week, L_{AEQ} values were compliant with the guideline at 55.6 dB, while the L_{AMAX} was 20 dB lower than the corresponding measurement the following week, demonstrating that the surrounding noise levels are highly variable. In general, average day time readings were as much as 6.9 dB(A) above the Federal allowable limit, confirming a relatively high baseline noise level in vicinity of the Project.

With regards to night time noise levels, all the measurements taken exceeded the Federal Limit of 50 dB(A), with exceedances as much as 15.7 dB(A) above the limit. Further, all L_{A90} measurements exceeded the guideline limit (although some by only 0.1 dB), demonstrating that the guideline limit is exceeded for at least 90% of the time.

Although the night time exceedances were worse than the day time, it is still noted that there was a general decrease in noise levels between the day time and night time readings.

The main sources of noise at the Project site are non-construction related activities associated with recreational marine activities, such as boat, jet ski and water sports movements. Construction works such as excavation, loading and unloading of materials and operation of diesel generators were observed at two sites (N2 and N6). However, it is worth nothing that the highest exceedances recorded during the baseline survey are most likely associated with the marine traffic movement during night time

These results will be used to inform the noise impact assessment, as detailed in Section 6.4.

5.4 Geology, Geomorphology and Seismicity

5.4.1 Geology and Geomorphology

The Arabian Gulf measures approximately 1000 kilometres in length and 200 to 300 kilometres in width. The water depth profile is generally shallow, with the deepest water (about 100 meters) being located near Iran. The Arabian Gulf is a shallow tectonic depression formed in the tertiary period (approximately 7 million years ago) in front of the rising Zagros Mountains (Zaghloul, 2008).

The asymmetry of the depression results in steep coastal slopes and deeper water on the Iranian side, and the low-lying Arabian coastline with adjacent shallow sea floor on the other. This geological structure has resulted in the UAE incorporating an extensive low-lying plain on the west side which gradually climbs to the Hajar Mountains in the east. In general, Dubai consists of a linear coastline dissected by creeks with superficial deposits comprising beach dune sands with marine sands and silts. Erosion, the capillary rise phenomena and evaporation have led to extensive silt deposits in some areas, especially near creeks. These superficial deposits are underlain by alternative layers of calcarenite, carbonate sandstone, sands as well as cemented sand layers (Tarawaneh and Matraji, 2014).

The Project site comprises mostly reclaimed land and therefore consists of marine-based sediments rather than natural coastline. Topography on Logo Island is generally flat. Whilst there are some areas that are slightly elevated compared to others due to localised filling and stockpiling of materials, the majority of the project area is level with the road base.

5.4.2 Seismicity

The Arabian Peninsula lies on the Arabian Plate, which is bordered to the south by the African Plate and to the east by the Indian Plate. To the west lies a lateral fault known as the Dead Sea Transform Fault and a divergent boundary, known as the Red Sea Rift, which runs the length of the Red Sea. To the north lies the Eurasian Plate. The Arabian, African and Indian plates are all moving northward, colliding with the Eurasian Plate and causing the uplift of mountain ranges, most notably the Zagros Mountains of Iran (Figure 5-8).

The Zagros Fold and Thrust Belt and Makran Subduction Zone are the only fault systems that have a direct effect on the seismicity of the UAE (Abdalla and Al-Homoud, 2004). In this region, the Arabian tectonic plate has been pushing against the Eurasian plate at a rate of approximately 22 mm per year (Johnson and Stern, 2010).

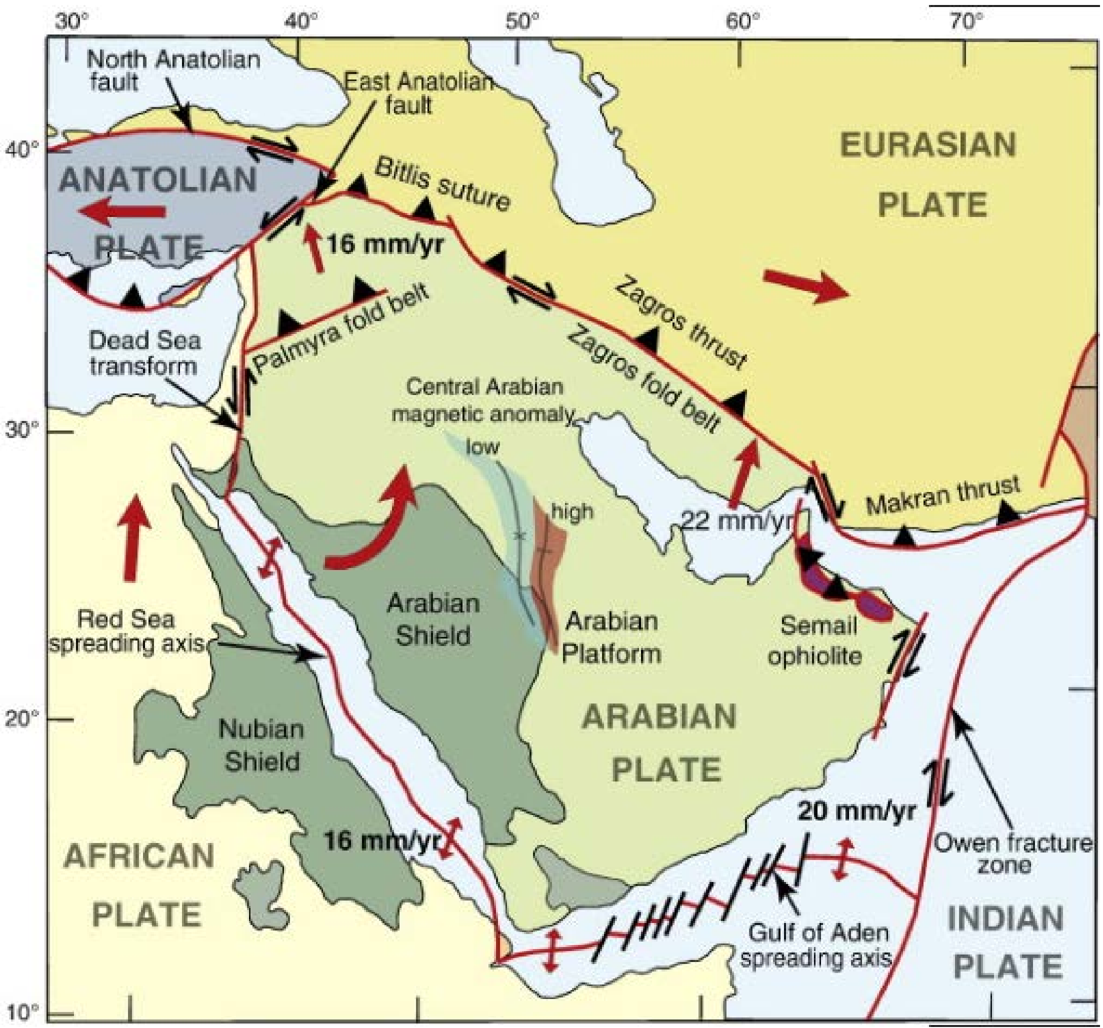


Figure 5-8 Tectonic Plates and Faults on Arabian Peninsula

Adapted from: Johnson and Stern, 2010

Limited seismic activity takes place at the UAE's local fault zones that are located in the vicinity of Dibba. Unlike the Western Region, the northern emirates have experienced earthquakes several times since March 1999. Almost all regional earthquakes are located on the northern side of the Arabian Gulf, within the Straits of Hormuz and Gulf of Oman and in southern Iran. Tremors from earthquakes in Southern Iran and South West Pakistan measuring 5.5 and 7.8 on the Richter scale were felt in Dubai in April 2014 and May 2016 respectively, indicating that there is a degree of seismic risk in the UAE (UAE Interact, 2014 and Time Out, 2016). On a lesser scale, tremors measuring 2.6 on the Richter scale were felt in Dibba in Fujairah on the east coast of the UAE in February and August 2016. The effects of the shudders were minimal, with no reports of injuries or structural damage (Time Out, 2016).

The Abu Dhabi Municipality Town Planning Sector publish seismic hazard assessment maps (Abu Dhabi Municipality, 2012). The maps identify Dubai as falling within a low seismic area with a peak ground acceleration of between 0.07 g and 0.08 g (0.7 to 0.8 m/s^2) for a 475 year return period event (typically used for design). Similarly, even for a 1 in 2475 year extreme event, peak ground acceleration values are below 0.2 g. Available maps plotting recent seismic activity from 1973 to 2006 (Figure 5-9) and December 2013 to March 2014 (Figure 5-10) indicate minimal seismic activity in the Dubai Emirate.

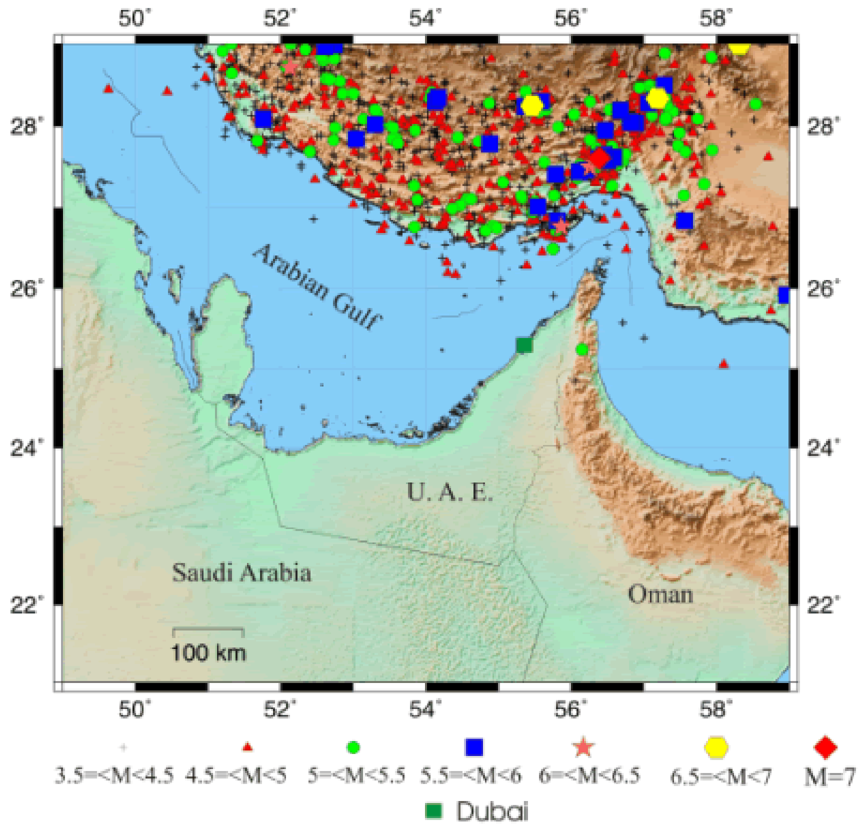


Figure 5-9 Seismic Activity In & Around the UAE 1973 – 2006

Source: http://www.seismo.geodesy.ae/images.aspx?img=figureS3.gif&wid=526

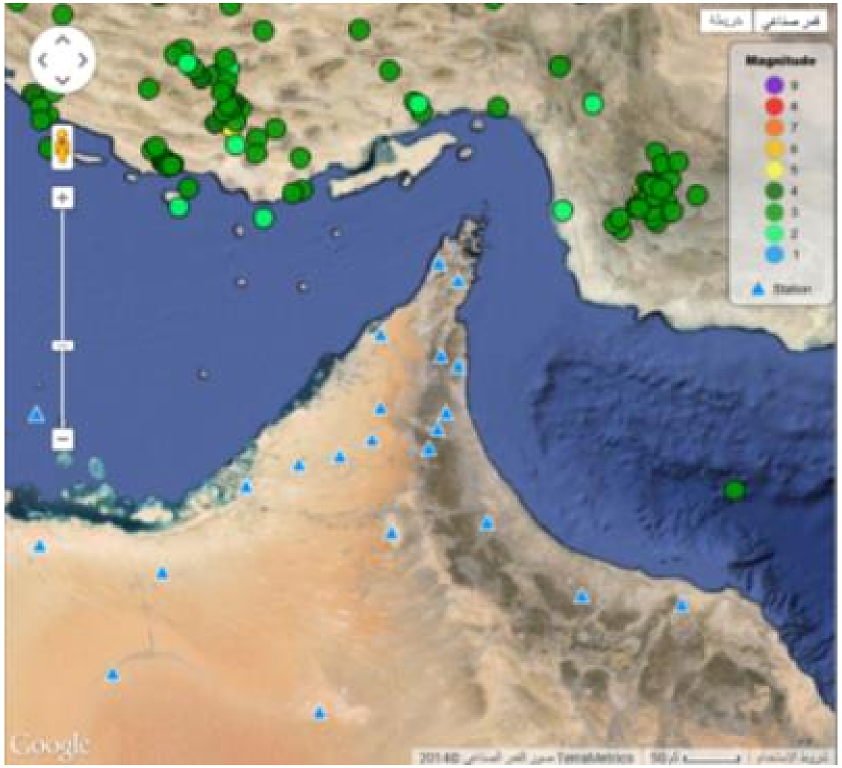


Figure 5-10 Seismic Activity In & Around the UAE Dec 2013 to Current

Source: http://seismology.ncms.ae/earthquakes

5.4.3 Geotechnical Investigation of the Navigation Channel Route

The bathymetric survey around the channel area shows the existence of dredged trenches and native areas (Figure 5-11).

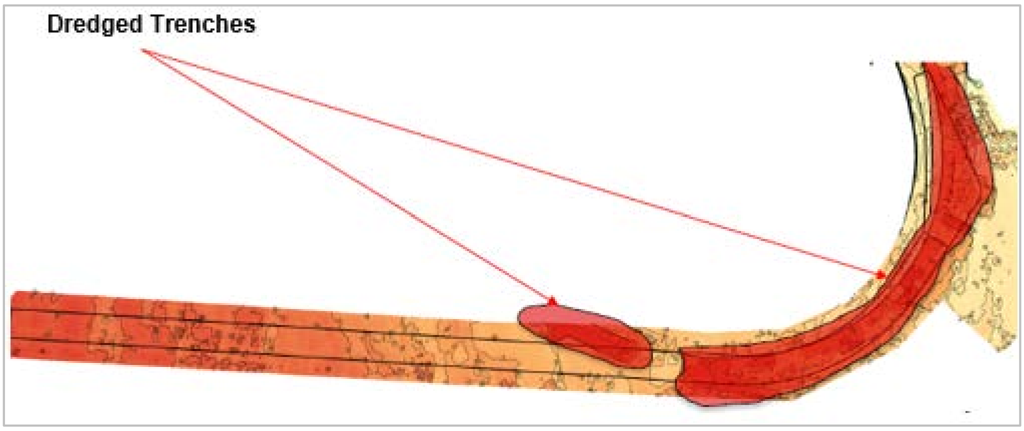


Figure 5-11 Result of Bathymetric Survey

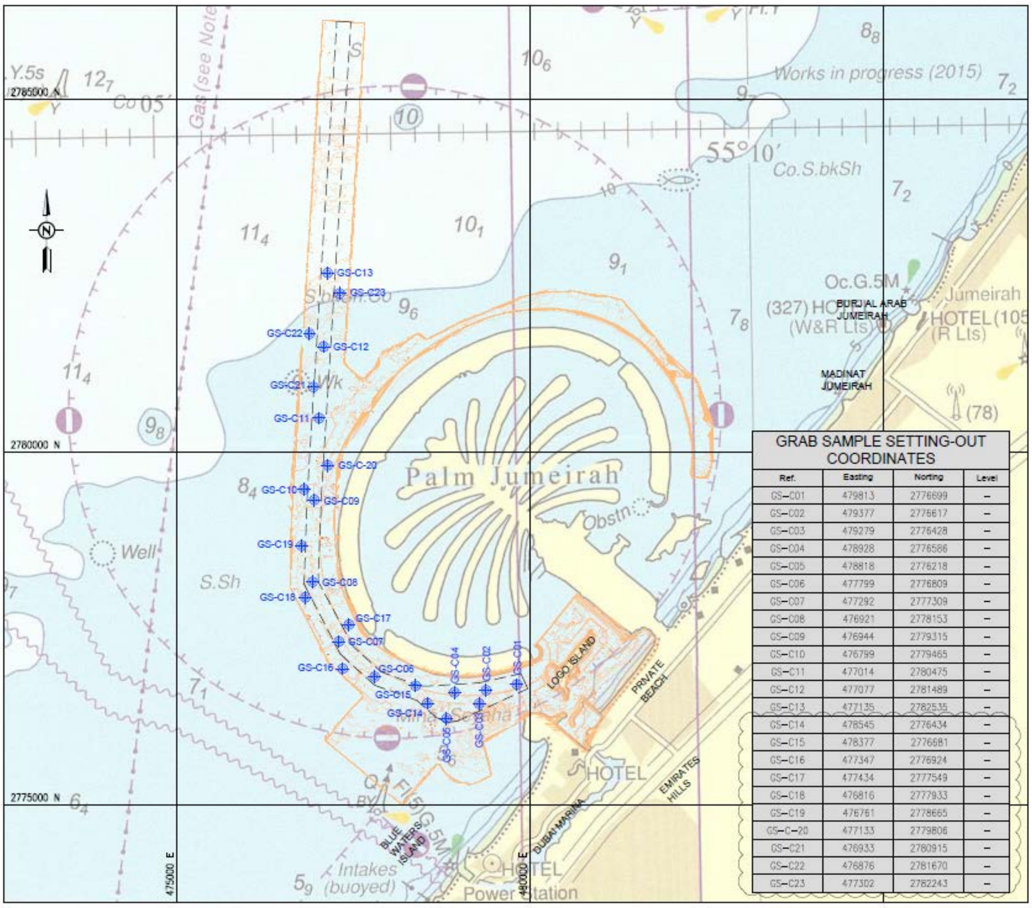
Geotechnical investigations were performed along the navigation channel route to assess geological composition and evaluate the suitability of the material to be dredged for reclamation. The survey comprised of:

- Magnetometer surveying;
- Sub-Bottom profiling (SBP);
- 23 Grab samples including particle size distribution test to determine the condition of the surface; and
- 24 Marine boreholes including particle size distribution and compressive strength test.

The ground investigations concluded that:

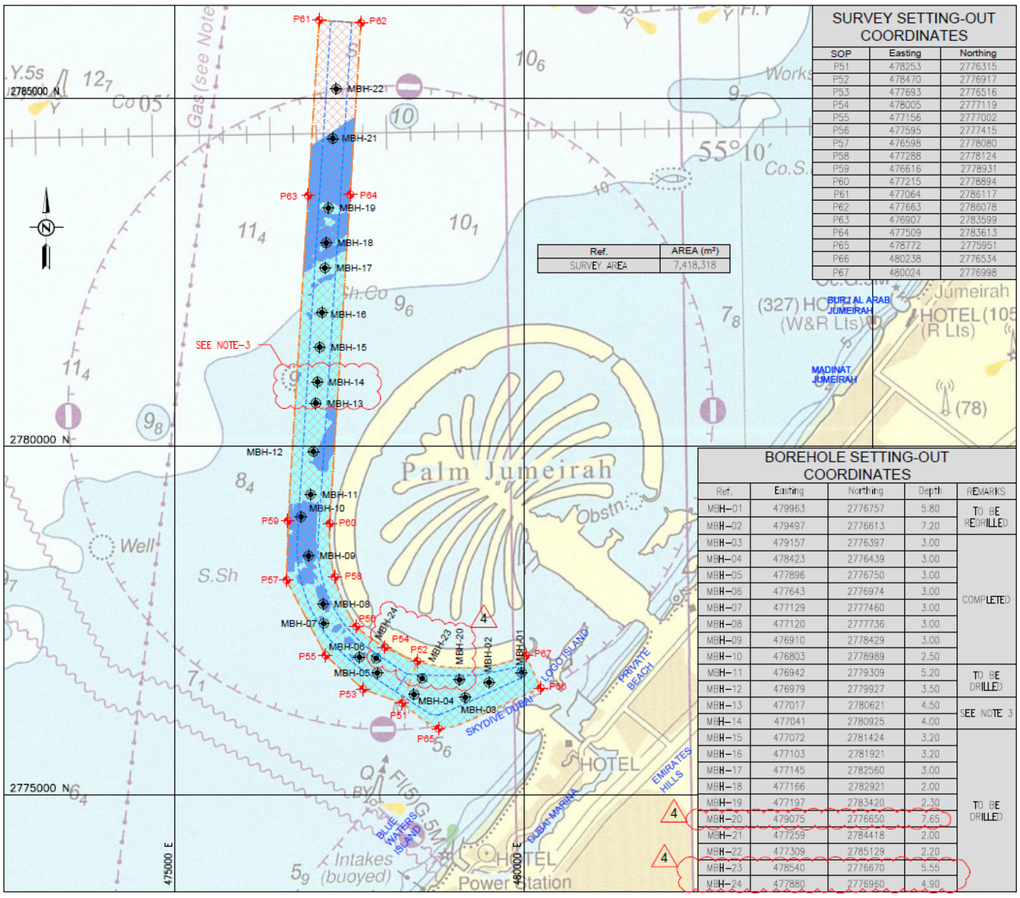
- The existing material consists of Siliceous Carbonate sand, mixtures of sand and silt, silt, Calcarenite cap rock and bedrock of very weak Calcarenite;
- Seabed varies between -7.5 m DMD to lower than -14 m DMD;
- Presence of cap rock in certain locations;
- Sediment thickness varies from 0 m to 5.8 m in some areas; and
- Bedrock is between -10 and -11 m DMD in native (un-dredged) ground.

A total of 882,600 m^3 of native sediment was considered suitable for reclamation, while an estimated 922,300 m^3 of sediment was considered unsuitable for reclamation, with a further 332,300 m^3 of sediment potentially unsuitable. Rock totalled 2,609,400 m^3. It is considered likely that the rock will be suitable for reclamation, however; this can only be accurately determined following dredging, as the fines and larger particulate content varies depending on numerous factors, including rock characteristics, dredging and transportation processes. Table 5-10 provides a detailed breakdown of material by channel area.



GRAB SAMPLE SETTING-OUT COORDINATES			
Ref.	Easting	Norting	Level
GS–C01	479813	2776699	–
GS–C02	479377	2776617	–
GS–C03	479279	2776428	–
GS–C04	478928	2776586	–
GS–C05	478818	2776218	–
GS–C06	477799	2776809	–
GS–C07	477292	2777309	–
GS–C08	476921	2778153	–
GS–C09	476944	2779315	–
GS–C10	476799	2779465	–
GS–C11	477014	2780475	–
GS–C12	477077	2781489	–
GS–C13	477135	2782535	–
GS–C14	478545	2776434	–
GS–C15	478377	2776681	–
GS–C16	477347	2776924	–
GS–C17	477434	2777549	–
GS–C18	476816	2777933	–
GS–C19	476761	2778665	–
GS–C–20	477133	2779806	–
GS–C21	476933	2780915	–
GS–C22	476876	2781670	–
GS–C23	477302	2782243	–

Figure 5-12 Geotechnical channel investigation: grab sample locations



SURVEY SETTING-OUT COORDINATES		
SOP	Easting	Northing
P51	478253	2776315
P52	478470	2776917
P53	477693	2776516
P54	478005	2777119
P55	477156	2777002
P56	477595	2777415
P57	476598	2778080
P58	477288	2778124
P59	476616	2778931
P60	477215	2778894
P61	477064	2786117
P62	477663	2786078
P63	476907	2783599
P64	477509	2783613
P65	478772	2775951
P66	480238	2776534
P67	480024	2776998

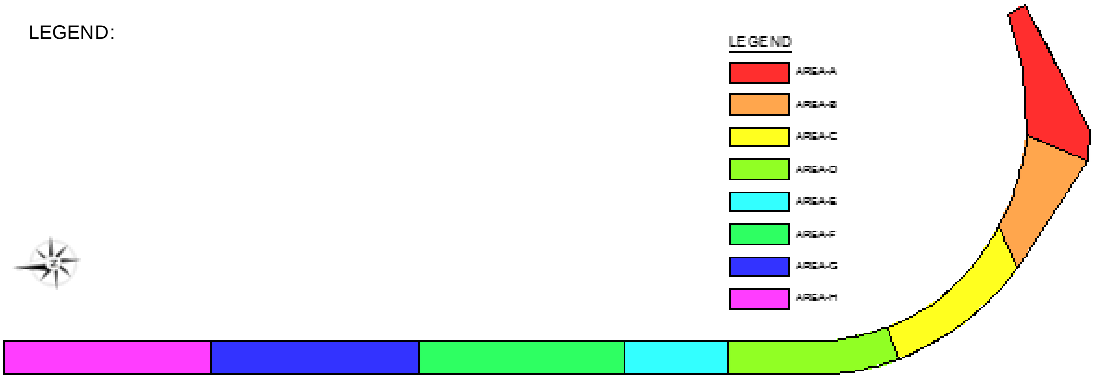
Ref.	AREA (m²)
SURVEY AREA	7,418,318

BOREHOLE SETTING-OUT COORDINATES				
Ref.	Easting	Northing	Depth	REMARKS
MBH–01	479963	2776757	5.80	TO BE REDRILLED
MBH–02	479497	2776613	7.20	
MBH–03	479157	2776397	3.00	COMPLETED
MBH–04	478423	2776439	3.00	
MBH–05	477896	2776750	3.00	
MBH–06	477643	2776974	3.00	
MBH–07	477129	2777460	3.00	
MBH–08	477120	2777736	3.00	
MBH–09	476910	2778429	3.00	
MBH–10	476803	2778989	2.50	
MBH–11	476942	2779309	5.20	TO BE DRILLED
MBH–12	476979	2779927	3.50	
MBH–13	477017	2780621	4.50	SEE NOTE 3
MBH–14	477041	2780925	4.00	
MBH–15	477072	2781424	3.20	TO BE DRILLED
MBH–16	477103	2781921	3.20	
MBH–17	477145	2782560	3.00	
MBH–18	477166	2782921	2.00	
MBH–19	477197	2783420	2.30	
MBH–20	479075	2776650	7.65	
MBH–21	477259	2784418	2.00	
MBH–22	477309	2785129	2.20	
MBH–23	478540	2776670	5.55	
MBH–24	477880	2776960	4.90	

Figure 5-13 Geotechnical channel investigation: borehole locations

Table 5-10 Suitability of Dredged Material

Areas	Potential Suitable Sediment (m^3)	Potential Unsuitable Sediment (m^3)	Unsuitable Sediment Volume (m^3)	Quantity of Rocks to be Dredged (m^3)
Area A	724,400	–	231,900	416,400
Area B	35,100	6700	194,000	511,800
Area C	47,700	29,800	120,500	418,100
Area D	-	-	269,400	212,400
Area E	-	269,800	72,200	184,200
Area F	61,500	26,000	34,300	765,100
Area G	3400	-	-	98,500
Area H	10,500	-	-	2900
Total	882,600	332,300	922,300	2,609,400



5.5 Soil and Groundwater

5.5.1 Soil

The most predominant soil deposits in the UAE desert environment are Aeolian deposits, which are formed through transportation of soil material via wind. Soil formed through this process are the least developed young soils without any horizon development and are very widely distributed in the Dubai Emirate in the form of loose sandy, hummocky dune soils (Shahid and Abdelfattah, 2008).

Sandy soils are characterised by a high infiltration rate, which is more than 250 mm/hr, very high drainage capacity, moderate to rapid permeability, low runoff and highly prone to wind erosion. Climatic conditions prevailing in the country, such as high temperatures, evaporation, relative humidity, and low average rainfall, play a major role in the degradation of land, and contribute greatly to the emergence of fragile ecosystems characterized by vulnerable vegetation and predominant erodible soil.

The majority of the Project will be constructed on reclaimed marine sediments, rather than naturally occurring soil. Extensive soil investigations are being performed in the navigation channel to determine the nature of the material, the dredgeability of the material and its usability as reclamation material. Based on the available soil data, the soil to be dredged can be classified in three main categories:

- Siliceous carbonate sand
- Calcarenite cap rock
- Bedrock of weak calcarenite

The shallow wedge in the northeastern corner of the future cruise terminal basin contains large amount of good native sand with a relatively limited fines fraction. At the lower places in the channel (presumably pre-dredged trench), fines content is rather higher, ranging from very silty sand to clay silty layers.

5.5.2 Groundwater

Groundwater is the main natural resource and most used water resource in the UAE accounting for 44% of the total water resources used (Ministry of Environment and Water (MOEW), 2015). Most of the groundwater is used in the agricultural sector. Over the years, pumping has exceeded annual feeding rates, resulting in a net reduction in groundwater levels of ten meters per decade until the mid-nineties and by 70 meters since then (MOEW, 2015).

A groundwater salinity map for the UAE is provided in Figure 5-14, which shows that hyper-saline waters in excess of 150,000 mg/L total dissolved solids (TDS) are found along the Abu Dhabi coastline, while lower values of around 50,000 mg/L are present further north along the Dubai coastline. Salinities generally decrease with distance from the coastline with some potable water being observed deep in the western and eastern regions of the Abu Dhabi Emirate (Environment Agency – Abu Dhabi, 2008).

No groundwater sampling has been undertaken within the Project site as it is mostly marine in nature with some reclaimed land areas. As such, the groundwater is expected to be generally representative of marine quality water.

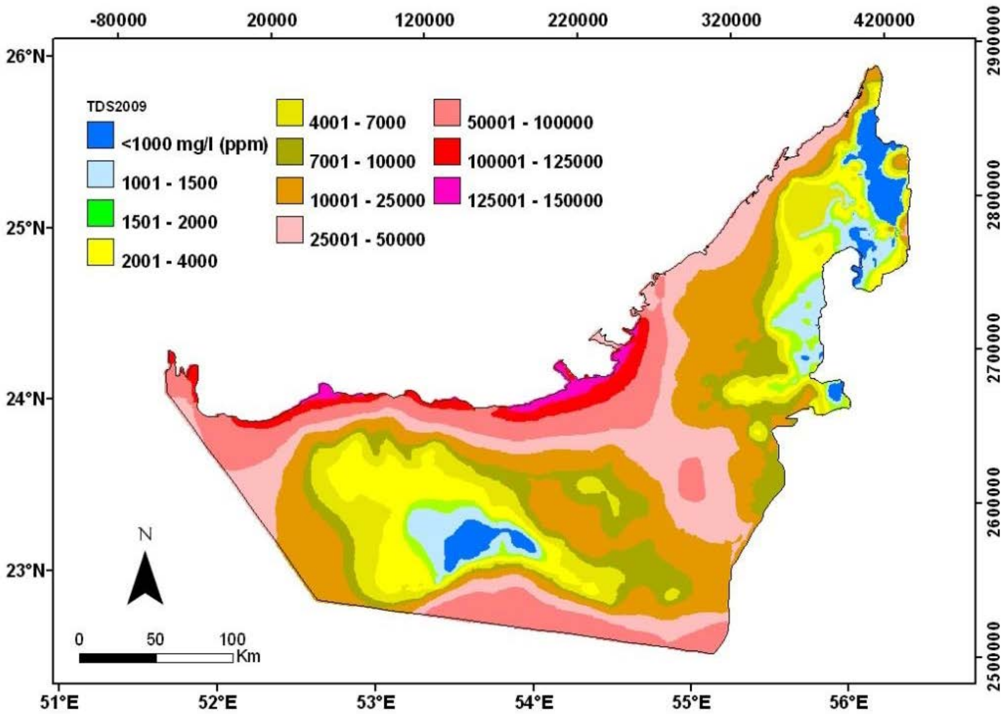


Figure 5-14 Groundwater Salinity Map of UAE

5.6 Coastal Processes

5.6.1 Arabian Gulf

The Arabian Gulf is a unique subtropical marine ecosystem, characterised by its relatively recent geological history, lack of continental shelf, shallow depths, substantial temperature and salinity gradients, and minimal water exchange. The Gulf experiences a process of net evaporation caused by elevated temperatures and prevailing winds, subsequently there is in a net inflow of seawater through the Straits of Hormuz. Further compounding this is the low inflow of freshwater to the Gulf, predicted to occur at less than the rate of evaporation (Sheppard *et al*., 2010).

The oceanography of the Gulf is influenced by synoptic and meso-scale winds. The dominant wind regime is the Shamal system – a NW wind which blows all year round. In summer, the Shamal is more consistent but weaker, while in winter it can reach gale force for several days on end but also has lull periods. A second synoptic scale meteorological phenomenon is the Kaus Wind – a SE system associated with the passage of cold fronts. Coastal waters also experience a significant sea-breeze effect driven by the diurnal cycle of land-sea thermal inequality. Wind generated surface currents in the Gulf can greatly influence the transport of surface water contaminants, while wind generated waves also have capacity to reach the seabed and influence re-suspension and sediment transport processes (Reynolds, 2002). As the Shamal wind blows consistently along the Gulf's longest axis it is associated with significant seas in the south of the Gulf, particularly during winter gales. The largest waves are therefore, predicted during the winter season, but due to limited fetch and duration of the winds significant wave heights usually tend to be below 2.5 m.

5.6.2 Project Site and Surroundings

A summary of the coastal processes at the Project Site and surroundings is provided below, while detailed coastal modelling reports completed by Sogreah are provided in Appendix E.

It must be noted that weak currents at Al Sufouh / Jumeirah Beach Residence (project location) has lead to poor comparison between the measured and simulated currents. As such, the results of studies that are dependent on the hydrodynamic model such as flushing, sediment dispersion, storm water dilution and oil spill will be less reliable. The proposed monitoring programmes, mitigation measures and rectification actions proposed in subsequent sections account and compensate for this potential limitation.

5.6.2.1 Shoreline Conditions

The Dubai coastline has experienced significant changes during the past 10 to 15 years because of the construction of numerous projects involving large reclamations. Projects relevant to the present study include:

- Pearl Jumeirah (reclamation between early 2010 and mid 2012);
- Bluewaters Island (reclamation between 2013 and 2014); and
- Dubai Marina (excavated in early 2000's).

The historical net longshore transport along the coastline of Dubai is north-eastwards; however, recent developments have caused significant changes to the nearshore conditions and associated sediment transport processes.

A shoreline evolution assessment is provided in Section 6.7.2.5.

5.6.2.2 Bathymetry

The existing bathymetric conditions pre-development are shown in Figure 5-15 where the existing dredged channel along the crescent of Palm Jumeirah is represented in blue.

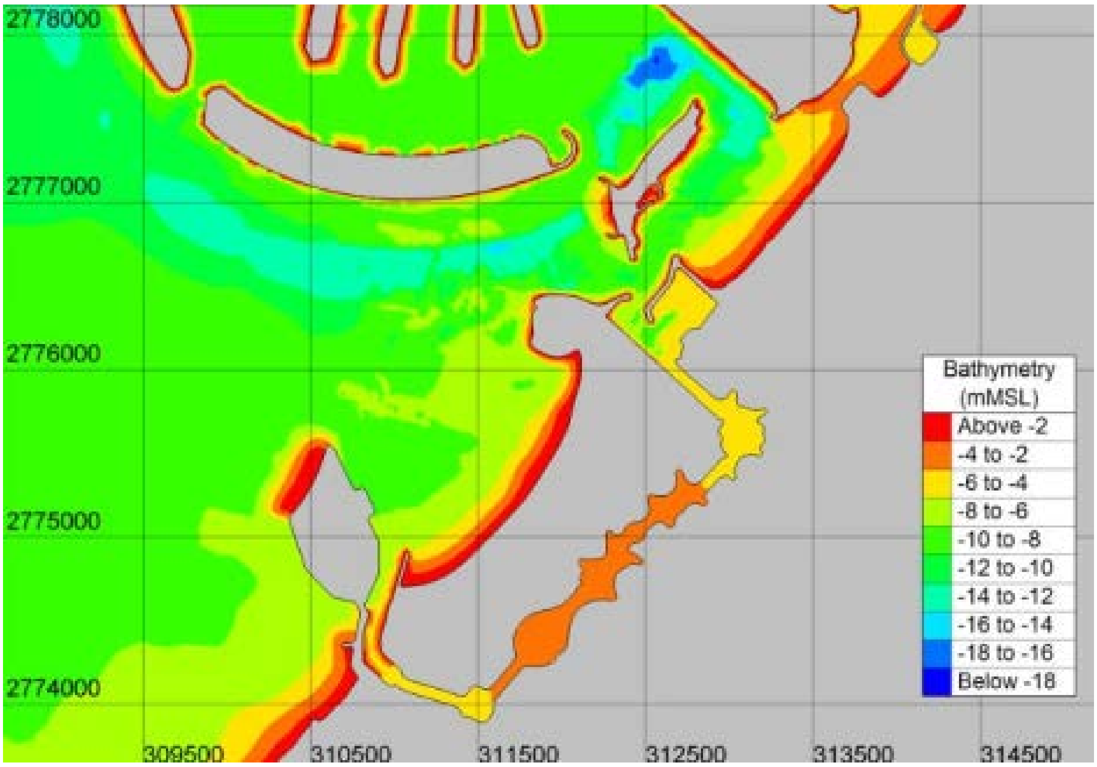


Figure 5-15 Bathymetry around the Project Site

5.6.2.3 Hydrodynamics

Hydrodynamic modelling undertaken by Sogreah (2017c) indicates that north-westerly currents are typical along the coast during ebb tides, reversing to south-easterly currents during flood tides. Peak depth-averaged current speeds generally do not exceed 0.5 m/s in the vicinity of the Palm Jumeirah, Bluewaters Island and the JBR (Figure 5-16).

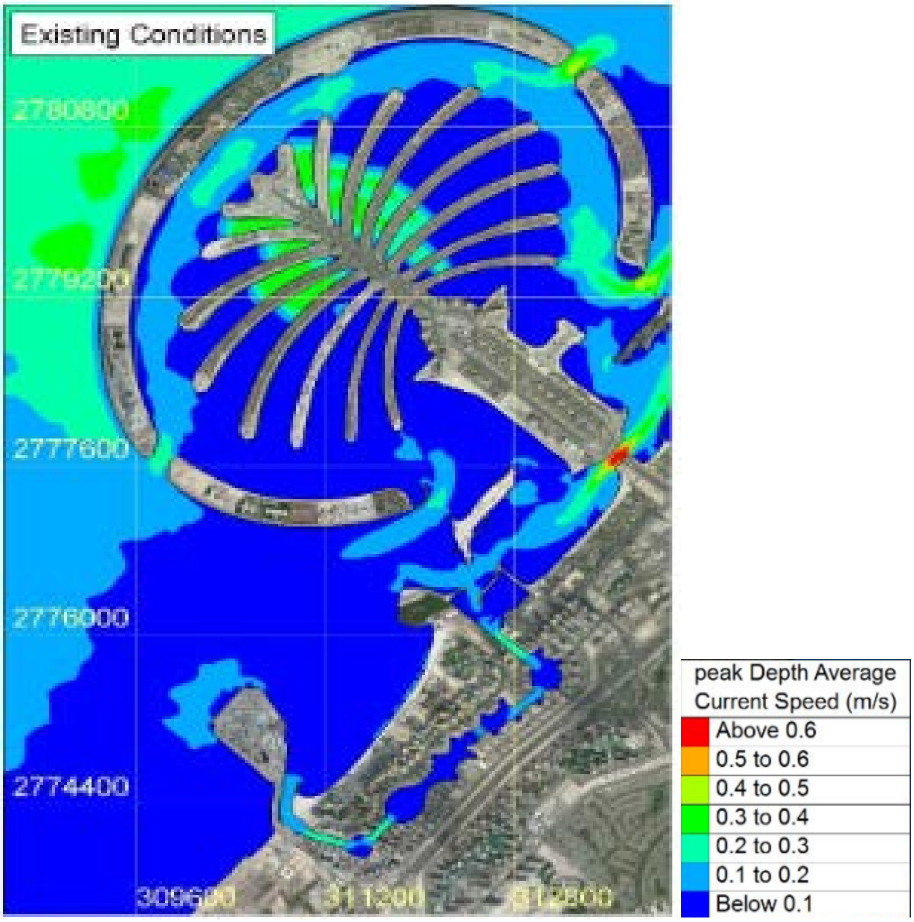


Figure 5-16 Peak simulated current speeds around the Project Site

Source: Sogreah (2017d)

5.6.2.4 Near-shore Wave Climate

A series of wave transformation simulations were undertaken for a combination of wave heights, periods and directions representative of offshore conditions as identified by long-term hindcast modelling (Sogreah, 2017d). The wave simulations included extreme conditions (1 in 1 year storms and 1 in 100 year storms) as well as conditions more representative of the wave climate near the Project Site.

For yearly extreme conditions (1 in 1 year storm), near-shore wave heights were predicted to range between 0.2 and 3.0 m in water depths between 8.7 and 16.3 m (Sogreah, 2017d). Larger wave heights were predicted for 1 in 100 year storms, ranging between 0.3 to 4.3 m in water depths of 8.3 – 15.4 m. In general, the near-shore wave climate is characterised by west-north-westerly wave directions and wave heights of 0.25 – 1 m. Waves from the north-west are uncommon due to the sheltering effects of nearby reclamation projects (Sogreah, 2017d). For the more sheltered regions of the Project Site (i.e. in the vicinity of the proposed Logo Island, the Mall and the Marina [Zones 2, 3 and 4]) wind-generated waves (i.e. seas) are predicted to result in the most severe wave conditions. For Zone 1 (i.e. in the vicinity of the proposed cruise terminal) the most severe wave conditions are predicted to result from offshore swells propagating from the west.

5.6.2.5 Flushing

Sogreah (2017e) evaluated flushing (i.e. water exchange) of the existing marine environment at four key areas of interest; namely, JBR beach, Mina Al Seyahi Beach, Dubai Marina and DIMC (Figure 5-17). Two-dimensional modelling was undertaken to determine the rates of exchange of conservative tracers initialised within these water bodies with the surrounding ambient waters. The four areas initialised with conservative tracers are presented in Figure 5-17.

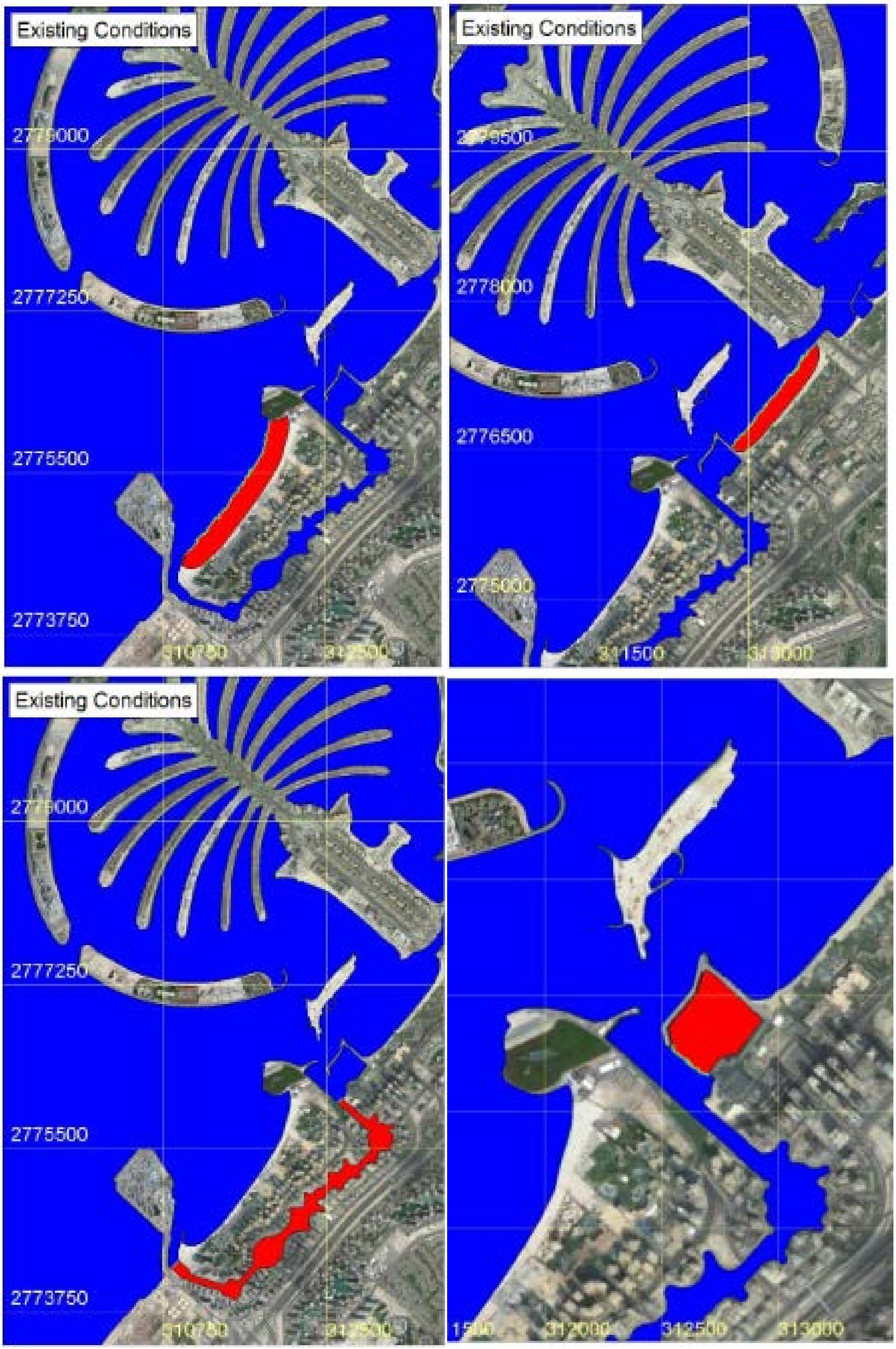


Figure 5-17 Existing condition flushing assessment, clockwise from top left: JBR Beach, Mina Al Seyahi Beach, DIMC and Dubai Marina

Source: Sogreah (2017c)

For JBR beach and Mina Al Seyahi Beach, a half-life residence time (T_{50}) of no more than 5-7 days was adopted as the flushing criterion to ensure good conditions for bathing (Sogreah 2017e). The half-life residence time refers to the time taken for half of the assessment volume to be replaced with surrounding ambient marine waters.

For the marina basins of DIMC and Dubai Marina, three flushing criteria were assessed, namely:

- **Mean flushing exchange coefficient (E) > 0.18:** The flushing exchange coefficient is a measure of the fraction of water within an assessment area that is exchanged with surrounding waters during a tidal cycle. A mean flushing exchange coefficient of 0.18 approximately corresponds to a daily exchange of 1/3 of marina waters with surrounding ambient waters.
- **E-folding time (T) ≤ 4 days:** The e-folding time is the time taken for 1/e (or approximately 63%) of the marina volume to be exchanged with surrounding ambient waters. Sogreah (2017e) adopted a target e-folding time of ≤ 4 days based on US Environmental Protection Agency standards.
- **Flushing uniformity index (ψ) > 0.1 and E > 0.15 for at least 95% of the marina:** The flushing uniformity index is a measure of the spatial uniformity of exchange rates within a control volume. As such, high measures of ψ correspond to spatially uniform flushing rates with reduced likelihood of localised stagnant zones within the assessment area (Sogreah 2017e). A second measure of spatial uniformity in flushing rates was adopted in this flushing criterion, whereby the mean flushing exchange coefficient should exceed 0.15 for at least 95% of the marina.

Flushing for each assessment area was simulated over a 15 day period (approximately 1 neap-spring tidal cycle) beginning during neap tides (i.e. relatively low initial exchange rates). The results of the flushing assessments are detailed in Table 5-11, which indicates that the beach flushing criterion is met for both the JBR beach and Mina Al Seyahi beach.

Regarding the three marina flushing criteria, none were met for either DIMC or the Dubai Marina, suggesting both enclosed marinas have relatively low exchange rates with the surrounding ambient waters. It is important to note that low flushing rates are not necessarily indicative of poor water quality. However, they do indicate the potential for generation of poor water quality if sources of pollution are introduced to enclosed water bodies. No existing water quality issues are known for the assessed water bodies (Sogreah 2017e).

Table 5-11 Summary of existing flushing conditions

Assessment Area	Flushing Criterion	Flushing Result – Sogreah 2017e
JBR Beach	T_{50} < 5-7 days	T_{50} = 6.9 days
Mina Al Seyahi Beach	T_{50} < 5-7 days	T_{50} = 0.6 days
Dubai Marina	E > 0.18	E = 0.03
	T ≤4 days	T = 14 days
	Ψ > 0.1 E > 0.15 for at least 95% of basin	Ψ = 0 E > 0.15 for 10% of basin

Assessment Area	Flushing Criterion	Flushing Result – Sogreah 2017e
DIMC	E > 0.18	E = 0.09
	T ≤4 days	T = 5.9 days
	Ψ > 0.1 E > 0.15 for at least 95% of basin	Ψ = 0.01 E > 0.15 for 38% of basin

Note - Green cells indicate results meeting the flushing criteria and red cells indicate results not meeting the flushing criteria.

5.7 Marine Ecosystem

5.7.1 Arabian Gulf

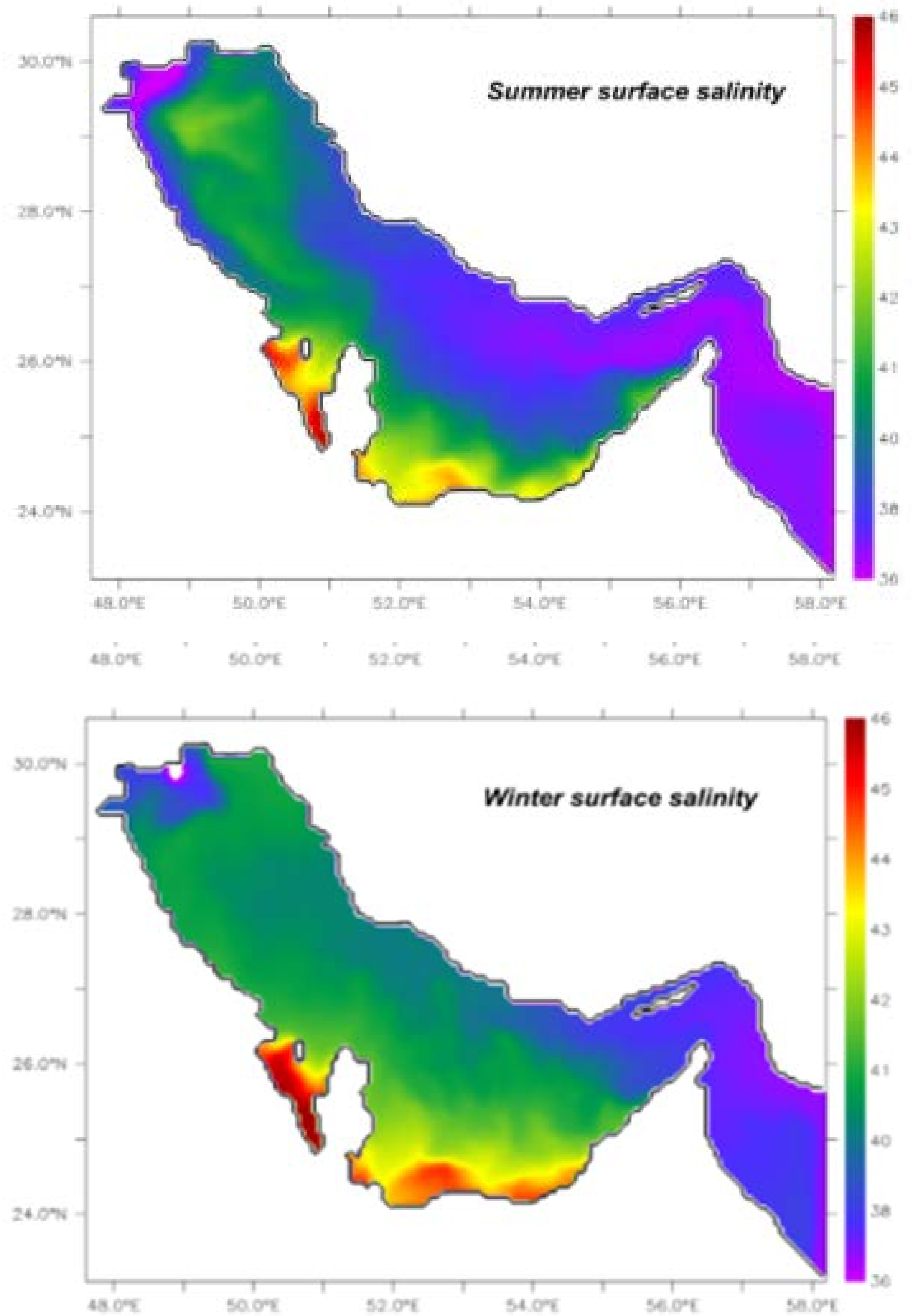
5.7.1.1 Physicochemical Water Processes

Seasonal changes in hydrodynamic and physicochemical water processes cause pronounced periodic shifts in water quality throughout the Gulf. A key driver of these processes is the Gulf salinity front (Figure 5-18). This front changes according to ambient temperature driven by seasonal (summer/winter) changes, and creates a distinctive and dynamic thermo-saline isopleth. In winter, circulation of relatively warmer less saline waters entering the Gulf from the Strait of Hormuz is restricted to the southern Gulf. However, during summer months relatively less saline water enters the Gulf from the Strait of Hormuz in surface levels, passing inwards along the Iranian coast before reaching the Arabian coasts in a broadly anticlockwise flow, resulting in enhanced circulation (Figure 5-15, Kampf and Sadrinasab, 2006).

The Gulf waters have high salinity of 38 - 45 parts per thousand, although areas of net evaporation such as the Gulf of Salwa exhibit substantially more saline water of over 55 parts per thousand. Water temperature ranges can be extreme fluxing from over 32°C in surface coastal waters in the summer to less than 17°C in the central and western Gulf in the winter. The elevated seawater temperatures and salinity have important effects on water quality by reducing the capacity for oxygen to remain dissolved in water. Increasing salinity also results in increased precipitation of calcium carbonate ($CaCO_3$) in seawater, which reduces its buffering capacity against increases in acidity. As a consequence, saline waters have a tendency to be more alkaline than freshwater bodies. Importantly, prevailing winds and tidal currents work in combination to increase wave action, which in-turn oxygenates surface waters and is considered an important process for maintaining marine life in the Gulf.

As a result of its gradual bathymetry and subsequent predominantly shallow nature, a high proportion of the Gulf seabed lies within the photic zone (i.e. a depth of water in which light can be utilised for photosynthesis), which provides an environment favourable to carbon producing biota. The shallow depths also result in a long slow fetch, causing slower waves and currents which benefits benthic biota with the Gulf comprising a predominantly soft benthic substratum.

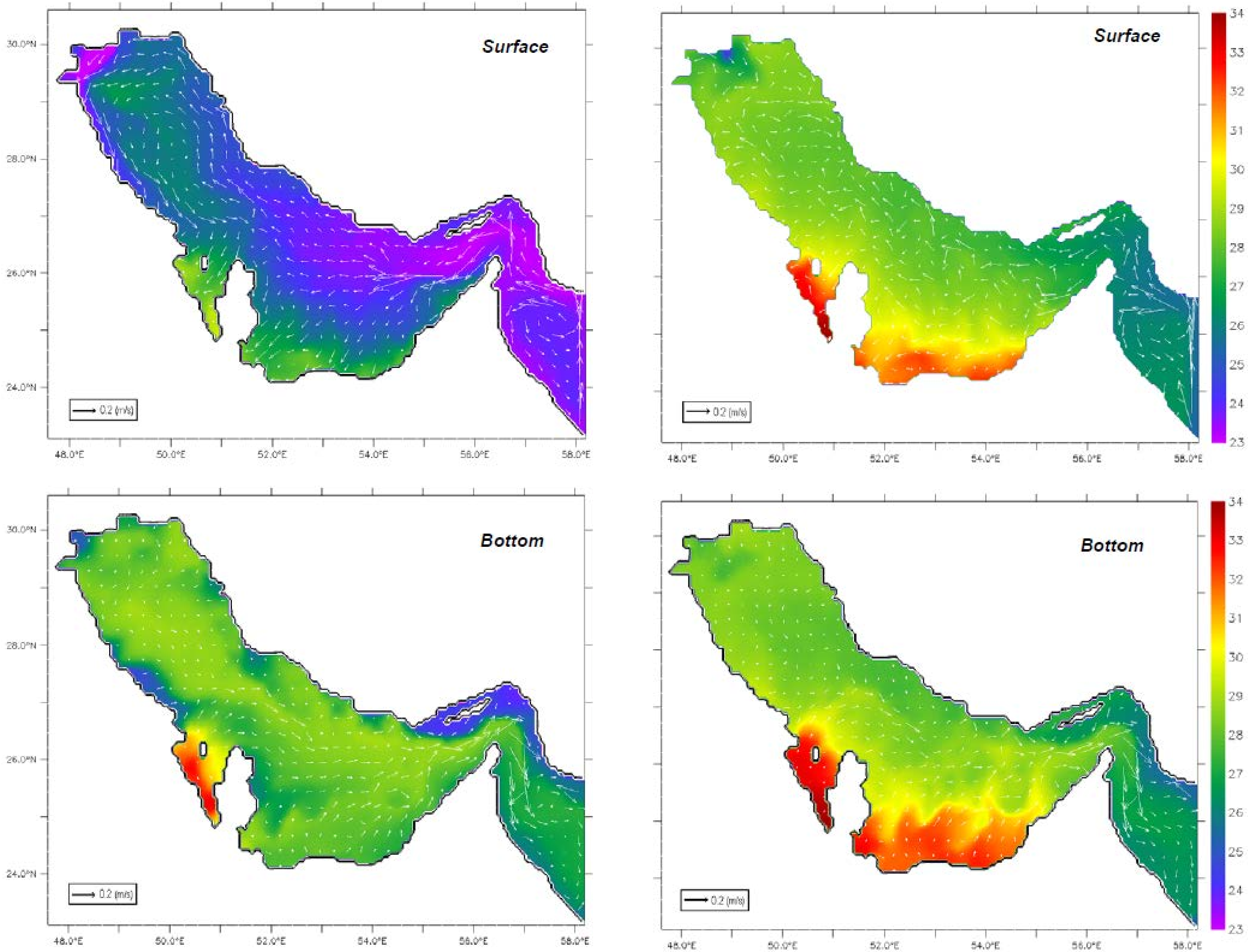
Carbonaceous sediments of biological origin (derived mainly from microfauna, especially foraminifera) predominate, but strong terrigenous (terrestrial derived) influences are apparent in the northwest end where the Shatt al-Arab comprises the dominant discharge to the Gulf (Sheppard *et al.*, 1992). Offshore, underlying salt domes have forced up numerous islands and banks of hard substrata that are now colonised by corals. Along the Arabian shoreline the slope is very subtle and as a consequence there is a large intertidal zone, sometimes extending over several kilometres. In contrast, on the Iranian side, the Zagros Mountains exceed 1,000 m elevation close to the shoreline and the water depth exceeds 60 m (Sheppard *et al*., 1992). This steep environment results in a less extensive intertidal zone.



Source: Kampf and Sadrinasab, 2006

Figure 5-18 Seasonal salinity fronts in the Gulf

Figure 5-19 **Surface and bottom flow vectors (arrows, m s−1) over density (colours, sigma**-t, kg m^3) averaged over (a) summer months (June–August), (b) winter months (December–February)



Kampf and Sadrinasab, 2005

5.7.1.2 Sediment Characteristics

As described in Section 5.1.1, meteorological conditions in the Gulf lead to the formation of strong winds, which transport large quantities of fine terrigenous sediment over marine and coastal areas. Bottom sediments are important sinks for pollutants and contaminants, and as such it is important to have an understanding of the nature of bottom sediment distribution and its sources.

Sediments in the Gulf show marked regional differences with carbonate sands predominating throughout the Saudi Arabian – UAE coast, whilst on the Iranian side these are mixed with a greater proportion of terrigenous sediments from aeolian (wind) and fluvial inputs (Al-Ghadban, 2002). On a more local scale, sediment compositions are influenced by a number of factors such as water depth, water agitation, light penetration, origin of sediment (autochthonous, allochthonous, calcareous, terrigenous, etc.) and hydrodynamic processes (Al-Ghadban and Abdali, 1998).

Grain size and biogenic processing in the gulf is tightly related. Where coarse sediments are dominant there is a high proportion of biogenic components (50-100%), whereas silt-clay fractions comprise a much smaller percentage of approximately 20 – 60% (Al-Ghabdan and Abdali, 1998). In addition, free oxygen and oxidizing salts within the water are more readily dissolved into larger size sediment fractions; therefore providing the oxygen supply necessary for benthic life.

5.7.1.3 Marine Ecology

Marine Habitats

A range of habitats including coral reefs, seagrass and algal beds and mangrove communities occur throughout the Gulf. These habitats contribute to a larger Arabian Sea ecosystem with many of the species present within the Gulf being common to the Indo Pacific (Price *et al*., 2002). The Gulf is however at the northerly limit of coral reef distribution and experiences significant fluctuations in temperature and salinity. This combination of highly variable temperature and salinity is thought to inhibit the presence of many marine habitats and associated biota and is instead dominated by species that are tolerant of extremes in temperature and high salinity concentrations (De Vantier and Pilcher, 2000). As a consequence, the habitats and fauna in the Arabian Gulf are both less diverse and less abundant than other tropical systems in which physicochemical conditions remain relatively stable, such as those found within the Red Sea.

Coral reefs

Coral reefs are essential spawning, nursery, breeding, and feeding grounds for numerous organisms. The variety of species living on a coral reef is greater than in any other shallow-water marine ecosystems and is one of the most diverse on the planet, yet coral reefs cover less than one tenth of one percent of the ocean floor (Spalding, Ravilious and Green, 2001). Of the 34 recognised animal Phyla, 32 are found on coral reefs (Wilkinson, 2002). In addition to invertebrate species and macrofauna (sharks, sea turtles, etc.), coral reefs support more than 800 hard coral species and more than 4,000 species of fish (Spalding, Ravilious and Green, 2001; Reaka-Kudla, 1997, Pauley, 1997).

The western Arabian Gulf has widespread areas of rock bottom that provide the hard substrate which supports establishment of suspension feeders such as corals (Al-Ghadban and Abdali, 1998). Despite the extremes in temperature and salinity, the reefs of the Arabian Gulf support more than 100 species of stony corals as well as a diversity of coral dependent species including around 600 species of reef associated fish (De Vantier and Pilcher, 2000).

The majority of the large coral reefs present in the UAE's Arabian Gulf coastal waters are fringing limestone platforms, comprising the massive poritid coral *Porites lutea* as the main building block, with *P. harrisoni* (= *P. compressa*), *P. lobata, P. solida* and *P. nodifera* sometimes present (Figure 5-20, left). Several faviid species are also present as fringing reefs in the UAE, with mounds of the brain coral *Platygyra daedalea* the most prominent and *P. lamellina* sometimes occurring. Siderastreid corals are also nearly always present, with the encrusting form of *Siderastrea savignyana* and the characteristically knobbly *Psammocora contigua* being the most frequently seen.

Where fringing reefs do not face the prevailing wind, the staghorn coral *Acropora* (Figure 5-20, right) appears amongst the poritids and faviids in shallower parts and forms the dominant reef structure in shallow sheltered positions (David George and David John, 2005).

A consequence of the extensive development of the coastal zone associated with the growth of the urban centres of Dubai and Abu Dhabi is that breakwaters are now one of the most common structures in coastal areas. The Dubai coastline has undergone significant change since the 1970s with numerous breakwaters constructed between Jumeirah and Jebel Ali. The result of this is that there is a significantly greater area of hard bottom habitat that provides many benefits associated with reef habitat. Diverse and abundant benthic communities have been recorded on breakwaters in Dubai and Abu Dhabi (Burt et al. 2010). The breakwaters provide substrate not only for coral assemblage development but also provide habitat for the settlement of oysters, urchins, anemones and other hard substrate taxa.

Figure 5-20 Coral Species in Dubai - *Porites* and *Acropora*

Seagrass

Seagrasses are specialised marine flowering plants of about 60 species worldwide, adapted to unconsolidated sediments of near-shore environments where they form extensive meadows (Green and Short, 2003). Seagrass beds have long been recognized as critical coastal nursery habitat for estuarine fisheries and wildlife (Basson and Burchard, 1977; Bell and Pollard, 1989; Kenworthy *et al*., 1988; Zieman and Zieman, 1989). They function as direct food sources for fish, waterfowl, dugongs, manatees, and sea turtles. They are also important for nutrient cycling processes, and are stabilizing agents in coastal sedimentation and erosion processes. Seagrasses have received attention as biological indicators of estuarine water quality and ecosystem health as a result of their sensitivity to nutrient enrichment and eutrophication (Dennison *et al.*, 1993). Seagrasses represent a strong natural carbon sink since they have the capacity to accumulate large stores of carbon in their sediments (Duarte *et. al*., 2013).

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

Seagrasses within the Arabian Gulf are regularly found in the shallow waters around scattered islands and covering most of the coastline from Kuwait south to the United Arab Emirates (UAE). Three species of seagrass commonly occur within the Arabian Gulf: *Halodule uninervis, Halophila ovalis*, and *Halophila stipulacea* (Green and Short, 2003; Phillips, 2003; Al-Ghais *et al*., 1998; KFUPM, 2001; Sheppard *et al*., 1992) (Figure 5-21). A fourth species, *Syringodium isoetifolium*, is also reported to occur in the Arabian Gulf (Sheppard *et al*., 1992) but is less common.

Figure 5-21 *Halodule uninervis* (left), *Halophila ovalis* (centre) and *Halophila stipulacea* (right)

Mangroves

Mangrove forests are among the world's most productive ecosystems. They enrich coastal waters, yield commercial forest products, protect coastlines, and support coastal fisheries (Meinardi, 2010). Mangroves have highly developed morphological, biological, ecological and physiological adaptations to extreme conditions such as high salinity, extreme tides, strong winds, high temperatures and muddy, anaerobic soils (Kathiresan and Bingham, 2001). In addition, mangroves are capable of absorbing land based pollutants such as heavy metals and other toxic substances prior to them reaching deeper waters (United Nations Environment Programme, 2006).

Mangroves provide a habitat and safe breeding ground for a number of turtles as well as commercially significant fisheries species including shrimp, snapper, grunt fish and sea bream. In addition, they offer a safe haven for bird nesting, feeding and migrating. Mangrove forests are found in intertidal areas and are important in the prevention of coastline erosion caused by wave action and ocean currents.

The grey mangrove, or *Avicennia marina*, is the only naturally occurring mangrove species within the UAE (Hegazy, 1998). This species grows within the intertidal region of estuaries, lagoons and breakwaters and can adapt to areas that are relatively dry and highly saline (FAO, 2007; Kathiresan, 2011). *Avicennia marina* is well established within the UAE in sandy/silty soils with a salinity of 36.4 ± 20.5 deciSiemens per meter and generally prefers middle-tidal amplitude (approximately 100 cm below the highest tide mark) (Abdulfatih *et al*., 2002; FAO, 2007).

Three other species (*Conocarpus* sp, *Laguncularia racemosa* and *Rhizophora mucronata*) have been introduced or reintroduced in small numbers into the intertidal zone in Abu Dhabi with very limited success (Benno Boer and Simon Aspinall, 2005).

Marine Megafauna

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

- **Turtles**: Of the seven recognized species of marine turtle, five are found in the waters of the UAE including the two most frequently occurring ones the green turtle (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*) listed as "endangered" and "critically endangered" respectively (IUCN, 1995) both of which feed and nest in the UAE. The remaining species include the loggerhead turtle (*Caretta caretta*), the leatherback turtle (*Dermochelys coriacea*) and a fifth species, the olive ridley turtle (*Lepidochelys olivacea*) that is known from neighbouring Oman but is almost certainly a visitor to UAE waters (Baldwin and Gardner, 2005).
- **Odontocete:** Ten different species of toothed whales and dolphins, the odontocetes, have been recorded in the UAE:
  - Finless porpoise *(Neophocaena phocaenoides)*;
  - Indo-Pacific humpback dolphin *(Sousa chinensis);*
  - Indo-Pacific bottle nose dolphin *(Tursiops aduncus);*
  - Indo-Pacific common bottlenose dolphin *(Tursiops. truncatus);*
  - Spinner dolphin *(Stenella longirostris);*
  - Long-beaked common dolphin *(Delphinus capensis);*
  - False killer whale *(Pseudorca crassidens);*
  - Killer whale *(Orcinus orca);*
  - Risso's dolphin *(Grampus griseus);* and
  - Sperm whale *(Physeter macrocephalus).*

  The finless porpoise is under two meters in length and finds retreat in coastal shallows, whereas the sperm whale, the largest of the toothed whales (up to 20 meters in length) is found in deeper water (Baldwin and Gardner, 2005).
- **Mysticeti (baleen whales):** A number of mysticeti's have been observed within the Arabian Gulf. These include the brydes whale, fin whale (endangered), pygmy blue whale and humpback whale (vulnerable) (Baldwin, 1995; Gillespie, 2005).
- **Dugongs:** Dugongs (*Dugong dugon*) belong to the order Sirenia and are herbivorous marine mammals feeding directly on seagrasses.

Fish

The marine biota of the Arabian Gulf is generally acknowledged to be impoverished due to the limited circulation, shallow depths (average of 35 m) and physicochemical characteristics, with relatively few marine species of animals and plants able to withstand such a huge variation of sea temperature and some unable to tolerate the high salinity. A list of reef associated fish, sharks and rays compiled from a wide variety of sources indicates that there are 302 species recorded for the Gulf from 70 families; compared to 3000 species of fish recorded in the Indo-Pacific region, followed by 1200 species present in the next richest marine region, the Western Atlantic (Helfman, Collette and Facey, 1997). The best represented families in the Gulf are Carangidae (trevally) with 30 species, Gobiidae (gobies) with 28 species, Apogonidae (cardinalfish) with 20 species and Pomacentridae (angelfish / chromis / damselfish) with 16 species (Riegl and Purkis, 2012).

The paucity of fishes in the Gulf is most apparent among the families of reef fishes, with only four species of butterflyfishes, two angelfishes, 10 damselfishes, 14 wrasses, five parrotfishes, two surgeonfishes and two triggerfishes recorded (Randall, 1995). Endemism is also low with only 16 species of fish thought to occur uniquely within the Arabian Gulf, although it is acknowledged that their distribution may in fact extend to the Gulf of Oman or beyond (Randall, 1995; Riegl and Purkis, 2012). Counts of reef fishes from underwater visual census surveys in the Arabian Gulf ranged from 71 species in Bahrain, to 106 species in Saudi Arabia, while 103 species were recorded off the coast of Dubai (Randall, 1995; Riegl and Purkis, 2012).

Due to the shallow-coastal nature of the marine environment in the UAE, corals, seagrass beds and mangroves represent some of the most important nursery grounds for many fish in the region. Unfortunately these habitats are under threat due to modern coastal development throughout the Arabian Gulf (Beech et al., 2005).

Sea snakes

Sea snakes are also present in the Arabian Gulf with nine species recorded - none of which are listed as endangered in the IUCN's Red List (Gallagher 1990; Gasperetti 1988). Common species in the Arabian Gulf comprise the yellow-bellied sea snake (*Pelamis platurus),* annulated sea snake *(Hydrophis cyanocinctus)*, reef sea snake *(Hydrophis ornatus)* and yellow sea snake *(Hydrophis spiralis)* (Baldwin and Gardner, 2005).

Benthic Infauna

Infauna is the collective name given to the (usually invertebrate) fauna that exist within, or are closely associated with, marine sediments. These biota are thought to form one of the richest species pools in the oceans (Petersen, 1913). Accurate estimates of species numbers are difficult because few sedimentary habitats have been well sampled; as such the number of described infauna is about 87,000, while the estimated actual number of species is approximately 725,000 (Snelgrove, 1997). Common infauna includes polychaete worms, bivalves, amphipods and decapods (Snelgrove, 1999).

Infaunal organisms play an important functional role in many marine ecosystem processes such as biochemical cycling of nutrients and providing a valuable habitat structure or food source for a range of organisms (Rosenberg, 2001; Levin *et al*., 2001; Thrush *et al*., 2001; Reise, 2002). Ecosystem changes reflected by shifts in the composition and distribution of sedimentary infauna are therefore predicted (Pinnegar *et al*., 2000). Measurements of change in infaunal communities have been widely used in identifying and monitoring man-made impacts on the sea (Poore and Kudenov, 1978; Anderlini and Wear, 1995; Ashton and Richardson, 1995). This is largely because infaunal organisms are relatively non-mobile and tend to accumulate the effects of pollutants over time (Warwick, 1993). This lack of mobility makes infauna particularly vulnerable to direct physical disturbances, such as dredging and reclamation which alters sedimentary structure (Hall, 1994).

Plankton

Zooplankton is one of the most important components of the marine ecosystem, containing a diverse array of species and playing a crucial role in energy transfer between the phytoplankton and the vast assemblages of marine food webs. Comprising both unicellular and multicellular organisms, zooplankton can range in size from the microscopic (smaller than 2µm) to organisms visible to the naked eye and can even include jellyfish several meters long (Nautica, 2014). Zooplankton contains representatives of almost all major phyla found in the sea and contributes a significant and vital component to the biodiversity of the oceans. Countless organisms fundamental to other marine habitats, including many commercially important fish species, start their lives as zooplankton as eggs or larvae (meroplankton), while others species, such as copepods spend their entire life as zooplankton (holoplankton) (Nautica, 2014).

The distribution of zooplankton is influenced by factors acting on many different scales. Geographic ranges are primarily determined by water temperatures, a function of both latitude and major ocean currents. Within a given temperature range, salinity is usually the largest factor affecting distribution with nearshore habitats ranging from lower salinity (brackish) water to hypersaline (lagoonal) areas. Many species show preferences for specific habitats or hydrographic conditions. Differences in depth, current velocity, wave energy and turbidity affect local distributions. There are also many environmental variables that can affect zooplankton assemblages, including water temperature, nutrient concentrations and salinity. Higher nutrient concentrations typically result in increased primary production leading to a greater abundance of zooplankton (Francis *et al*., 1998 in Nautica, 2014).

Harmful Algal Blooms

Dormant or zygotic life stages of dinoflagellate can accumulate as cysts within sediments. Dinoflagellates are naturally occurring and largely non-toxic. However, some species of dinoflagellates e.g. *Ceratium* spp and *Gymnodinium catenatum* and diatoms can, under the right conditions, create harmful algal blooms (HABs), or red tides. These 'red tides' can produce a range of deleterious effects, including neurotoxins that can cause death through bioaccumulation on ingestion and oxygen and light reduction to which affects marine flora and fauna in the ecosystem.

HABs have been known to occur without apparent cause but are often linked to human influence, especially elevated nutrient concentrations or sediment disturbance if cysts have settled there (Pospelova *et al*., 2002, Hallegraeff, 1998). The last catastrophic HAB to occur in the region occurred in 2008-2009 and impacted the east coast of the UAE. This resulted in fish kills, halted operations at desalination plans and a loss of tourism (Ministry of Climate Change & Environment, 2016).

5.7.2 Project Site Marine Baseline Survey Methodology

A marine baseline survey was undertaken within and in vicinity to the Project site, with the objective of characterising the current condition of the marine environment around the Project site. Baseline marine monitoring was undertaken at a total of thirty-eight sites between 13 February 2017 and 1 May 2017. Surveys were undertaken at two additional locations within the Dubai Marina Canal on 16 August 2017, in order to facilitate water quality assessment in areas of anticipated low flushing during the construction phase of the Project. The monitoring locations are illustrated in Figure 5-22. A summary of the findings is provided in the section below, while a full marine environmental baseline survey report is provided in Appendix F.

LEGEND

Marine Ecology Stations

- Habitat classification
- Habitat classification, infauna, seawater and sediment quality
- Habitat classification, infauna, seawater and sediment quality, plankton
- Habitat classification, infauna, seawater and sediment quality, plankton and HAB species
- Dubai Harbour development

Paper Size A4

0 1,000 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: WGS 1984
Grid: WGS 1984 Dubai Local TM

N

GHD

Shamal Development
Dubai Harbour EIA

Job Number	76-10664
Revision	B
Date	22 Aug 2017

Marine Ecology Baseline Survey - All Sites

Figure 5-22

3rd floor Guardian Tower Danet Community Abu Dhabi United Arab Emirates W www.ghd.com

G:\71\12289\711228911_(7610664_Dubai Harbor EIA)\GIS\Maps\7610664_AdditionalSites_revA.mxd

Data source: GHD - Dubai Harbour Development, Marine Ecology (2017). Google Earth/Digital Globe - Imagery (Date Extracted: 2017/04/27). Natural Earth - Road. Created by:jcmatic

The marine environmental parameters and monitoring methods utilised are summarised in Table 5-12.

Table 5-12 Baseline Marine Environmental Components and Methodology

Marine Component	Analytes or Parameters		Collection Equipment
Water and Sediment Quality			
In-situ water quality	Temperature Salinity Dissolved Oxygen	Turbidity pH Depth	Multi-parameter probe [Calibration certificate in Appendix D]
Analytical water quality	Total Suspended Solids (TSS) Total Dissolved Solids (TDS) Ammonia (NH_3-N) Nitrate (NO_3-N) Nitrite (NO_2) Total Phosphorus (P) Phosphate (PO_2) Biochemical Oxygen Demand (BOD) Enterococci Sulfide (S_2) Metals (Al, As, Cd, Cr, Cu, Fe, Pb, Hg, Ni, V, Zn)	*E. coli* Chlorophyll-a Total Coliform Total Organic Carbon Total Petroleum Hydrocarbons (TPH) Multiple Chlorinated Phenol Chemical Oxygen Demand (COD) Chlorine (Residual) Chlorine (Total) Cyanide (CN) Fluoride	4.2-litre vertical Beta water sampler and laboratory analysis
Surficial sediment geotechnical description	Description of surficial sediment		Van Veen sediment grab
Surficial sediment quality	Sulphide BTEX m&p Xylene VPH C5-C10 EPH C10-C40 PAH Phenols PCBs Organics (tributylin, dibutylin, monobutyltin) Total nitrogen Total phosphorus	Total Organic Carbon (TOC) Enterococci *E. coli* *Streptococci* Metals (Al, As, Cd, Cu, Pb, Hg, Ni, Zn) Particle size distribution (PSD	Van Veen sediment grab and laboratory analysis

Marine Component	Analytes or Parameters	Collection Equipment
Marine Habitat Assessment		
Benthic habitat	Benthic habitats types and coverage	Remote underwater video system (rapid) and diver assessment (detailed)
Marine Ecology Assessment		
Zooplankton	Diversity and abundance of infauna species	Zooplankton net and taxonomic identification
Phytoplankton	Diversity and abundance of phytoplankton species, presence of HAB species	Phytoplankton net and taxonomic identification
Benthic infauna	Diversity and abundance of infauna species	Van Veen sediment grab and taxonomic identification
Toxic dinoflagellate cysts (HAB species)	Diversity and abundance of harmful algal bloom species	
Fish	Diversity and abundance of fish species	Diver assessment
Marine megafauna	Diversity, abundance and behaviour of marine megafauna species	Incidental observations

Table 5-13 Number of Marine Baseline Locations

Marine Environmental Baseline Survey Component	Number of Sites Surveyed
In-situ Water Quality	37
Analytical Water Quality	37
Zooplankton and Phytoplankton	8
Analytical Sediment Quality	35
Benthic Infauna	35
Toxic dinoflagellate cysts (HAB species)	5
Benthic Habitat Classification (RUV)	38
Benthic Habitat Classification and Fish Survey (Diver)	14

5.7.2.1 Marine Water and Sediment Analysis

In-situ Water Quality

Physio-chemical water quality measurements were recorded using a hand-held calibrated multi-parameter water quality logger (YSI 6920 V2). This was lowered through the water column at each sampling site, with readings taken for the entire water profile (surface to seabed). The following parameters were measured:

- Depth;

- Temperature;
- pH;
- Turbidity;
- Salinity;
- Total Dissolved Solids;
- Conductivity; and
- Dissolved Oxygen.

Results are compared against the DM Water Quality Standards for Sea and Coastal Waters.

Analytical Water Quality

Water samples were collected from the top (-1m) of the water column using a 4.2 litre Beta Water Sampler. The Beta water sampler was deployed directly from the side of the vessel using a line with a trip mechanism that triggered when the sampler was positioned at the required depth, capturing the water sample inside the sampler. Upon retrieval, the sample was decanted into labelled sample containers provided by the laboratory.

The water samples were stored in cool boxes with ice on-board the survey vessel before being transferred on the same day of collection to the ISO 17025 and DM accredited laboratory (Al Hoty-Stanger Laboratories) for chemical analysis. Water samples were analysed for all parameters detailed in Table 5-12.

The results of the water sample analyses were compared to the Dubai Municipality Water Quality Objectives (DMWQO) where applicable.

Analytical Sediment Quality

Sediment samples were collected from the top 5-10 cm of the seabed using a stainless steel benthic grab sampler (Van Veen) deployed from the survey vessel. The sampling locations were identical to those used for water quality sampling. At each location, the grab was lowered to the seabed and a sediment sample retrieved. Samples were rejected and another sample collected in cases where:

- The sediment sampler doors opened on recovery, causing surface washout;
- Disruption of the sample occurred by obvious shaking or contamination (i.e. when a sample is badly handled or if the sediment sampler strikes the side of the vessel during operation);
- The sample represented less than 30% of the sediment sampler's total capacity; and/or
- The sample was collected at an unacceptable distance from the desired position.

Samples for chemical analysis were placed in sterilised glass jars supplied by the analytical laboratory. The sediment was stored in a chilled cool box on-board the survey vessel, before being transferred on the same day of collection to the laboratory for chemical analysis. Sediment samples were analysed for all parameters detailed in Table 5-12.

There are currently no UAE standards for marine sediment contamination. Where applicable, the results of the marine sediment analysis were compared to the following internationally recognised sets of guidelines for assessing potential contamination:

- The National Oceanographic and Atmospheric Administration (NOAA) sediment quality guidelines (NOAA, 1999) which lists Effects Range Low (ERL) values which are "indicative of concentrations below which adverse effects rarely occur"; and

- The Dutch Circular on Remediation of Water Bottoms (sediments), which lists Intervention Values (IV) for pollutants in sediments where serious contamination is deemed to exist if the IV is exceeded.

5.7.2.2 Marine Habitat Assessment

The marine habitat assessment comprised a rapid assessment of the Project area, followed by a detailed assessment at any areas of interest, as described below.

Rapid Assessment

Direct observation of the seabed was undertaken via a drop down video system, allowing characterisation of the seabed habitat in the project footprint and surrounding area. The rapid assessment of benthic habitat was undertaken on 13 February (DH23 – 29), 8 March (DH 10, 13 – 16, 20 – 22 and 30), 13 March (DH 1 – 8, 12 and 17) and 11 April 2017 (DH09, 11, 18, 19, and 31 – 38).

The drop down video footage was reviewed to identify the benthic habitat and for the presence of any species of ecological significance. This also informed the areas for further detailed assessment, as described below.

Detailed Assessment

Habitats of ecological significance (potential coral communities or seagrass beds) observed during the rapid assessment were further investigated with a detailed benthic habitat assessment. Scientifically trained divers undertook the detailed assessment at 14 sites (DH01, 03, 04, 06, 07, 17, 18, 21, 23, 24, 30, 34, 36 and 38) on 12 April 2017.

Spatial coverage of key sensitive species were assessed using the line intercept transect methodology. At each potential seagrass site, one 30-metre transect line was laid on the seabed, and the GPS co-ordinates recorded for the start point. Divers then swam the length of each transect and recorded the coverage in centimetres and density of seagrass along the tape, to provide an indication of variability and an average percentage cover at each site.

For coral sites, the detailed assessment of spatial cover and diversity of corals was undertaken across a vertical transect to capture any depth driven variability. During the vertical transect, the species, number and size class of all corals in a 5 m vertical section of the breakwater was recorded.

During the above assessments, a species list of all observed epibenthos, was compiled, with semi-quantitative abundance estimates recorded based on the Superabundant, Abundant, Common, Frequent, Occasional, Rare (SACFOR) scale (JNCC, 1990).

5.7.2.3 Marine Ecology

Phytoplankton

Phytoplankton samples were collected from eight sites (DH02, 05, 08, 10, 14, 16, 24 and 36) on 18 April 2017. Samples were collected by a weighted 250 micron sized phytoplankton net that was left to drift horizontally at the surface for 500 m at an even speed of 2 knots. The contents of the net was washed into the cod end using distilled water, where it was then transferred to dark containers and transported to the laboratory (Nautica Environmental Associated (Nautica)) on the same day for a taxonomic specialist to conduct a species identification and abundance assessment.

Toxic Dinoflagellate Cysts (HAB species)

A stainless steel Van Veen grab was used to collect sediment samples from the seabed for toxic dinoflagellate cysts species analysis. Samples were collected from five sites (DH02, 05, 08, 14 and 16) on 8 and 13 March 2017.

Samples were transported to the laboratory (Nautica) for a taxonomic specialist to determine species taxonomy and abundance. The data was subsequently analysed to determine the presence of toxic dinoflagellate cysts within the proposed dredge footprint.

Zooplankton

Zooplankton samples were collected from eight sites (2, 5, 8, 10, 14, 16, 24 and 36) on 13 March 2017. Each zooplankton sample was collected by a single vertical tow using a 120 µm mesh size plankton net (30 cm diameter and 90 cm length). The plankton net was towed manually from 1 metre above the seabed to the surface. On retrieval, the plankton net was washed down with seawater to ensure that all plankton was concentrated in the cod end.

Each sample was transferred to a dark container and transported to the laboratory (Nautica) on the same day for a taxonomic specialist to conduct a species identification and abundance assessment. The laboratory methodologies used were based on MOOPAM standard methodologies. Further information on zooplankton identification is provided in Appendix F.

Benthic Infauna

Sediment samples for infaunal analysis were collected on 13 February (26 and 27), 8 March (11, 14, 16, 17, 21 – 25 and 28 – 30), 13 March (1 – 4, 7, 8, 10, 12, 13 and 15), 11 April (5, 6, 9, 18 – 20, 31 and 32) and 12 April 2017 (34, 36 and 38).

Samples were collected from a 500 cm^2 area of seabed using a stainless steel grab (KC Denmark 250 cm^2 Van Veen grab), deployed from a vessel. Material was sieved through a 0.5 mm mesh sieve, preserved in a 4% formaldehyde solution, then transferred to Nautica for extraction, taxonomic analysis and enumeration.

Fish

The drop down video footage from the rapid assessment described in Section 5.7.2.2, was reviewed for the presence of fish, with a species list collated per site. Subsequently, an underwater visual census was undertaken during the detailed assessments along the 30-m transect line to provide a semi-quantitative assessment of fish communities. The census enumerated fish species up to 5 m ahead of the diver and up to 2.5 m either side of the transect line.

For particularly numerous species, abundances were estimated and transformed to a log-4 based, semi-quantitative abundance scale for ease of comparison. Additionally, fish recorded during the rapid benthic habitat assessment were identified to provide a qualitative assessment of fish communities at the rapid assessment sites. Any rare, unusual or commercially important (fisheries) species observed throughout all baseline surveys were also noted.

Marine Mammals and Reptiles

During all surveys, marine scientists were vigilant for the presence of marine mammals, turtles or other megafauna. However, there were no sightings during any of the field surveys. Public sightings from the UAE Dolphin Project website were investigated to indicate potential marine mammal presence within the study area (UAE Dolphin Project, 2017).

5.7.2.4 Statistical Analysis

For elements where quantitative or semi-quantitative data was collected (epibenthic ecology, infauna, zooplankton), trends in abundance, species richness and diversity across the project area, as well as multivariate analysis of community composition were investigated using the analytical statistical programme Primer-e v7 (Clarke and Gorley, 2015).

Communities that are numerically dominated by a few species suggest that a site or habitat endures harsh conditions or has undergone a recent impact, while a settled community will have a greater number of species, with organisms spread more evenly between them. Diversity indices use this information to provide a single comparable metric for the richness of a sample. Three diversity indices using slightly different aspects of the data have been employed in the analyses:

- Margalef species richness index (d) - heavily influenced by the number of species;
- Pielou evenness index (J’) - looking only at the spread of organisms between species, it ranges from 0 (complete dominance) to 1 (perfectly even); and
- Shannon-Weiner diversity index (H’) - balancing the number of species with relative abundance.

Multivariate analyses were used to investigate community composition based on all species present and their relative abundances. Analyses used a Bray-Curtis dissimilarity matrix (Bray and Curtis, 1957). This dissimilarity measure was chosen because it is not affected by joint absences, and it has consistently performed well in preserving ‘ecological distance’ in a variety of simulations on different types of data (Field *et al*., 1982; Faith *et al*., 1987). Prior to the analysis, numerical transformations may be applied in order to downplay numerically dominant species.

To identify samples or sites which shared common community type, the Bray-Curtis matrix formed the basis of a SIMPROF (SIMilarity PROFile) analysis, a permutation test which identifies samples with a statistically significant ($p<0.05$) level of similarity. The results may be displayed as a dendrogram which connects statistically significant groupings identified in the SIMPROF analysis by red lines, while black lines indicate the lack of a statistically significant similarity. The same Bray-Curtis values may also be displayed as a Multi-dimensional Scaling ordination. Sample groupings, including the results of the SIMPROF analysis, may be used in a SIMPER analysis (SIMilarity PERcentages) to assess the relative contribution of each taxon to differences between these groups of samples and identify key organisms driving changes the apparent changes.

5.7.3 Marine Baseline Survey Results and Discussion

Results of each component of the marine survey are provided in the following sub-sections.

5.7.3.1 In-situ Water Quality

The mean and range of *in-situ* readings for each site are detailed in the full MEBS report in Appendix F, while a summary of the results is provided below:

- Depths of sites ranged from 3.7 m at site 21 to 16.8 m at site 20;
- Temperature ranged from 20.7 °C (at the top of the water column at site 27) to 26.4°C (at the bottom of the water column at 18) with a mean reading of 23.8 °C across all survey stations (Figure 5-23). Some sites were well mixed with minimal thermal stratification, whilst some sites were warmer at depth indicating a pycnocline

- Specific conductivity ranged from 36,870 µS/cm (at the top of the water column at site 27) to 60,180 µS/cm (at the top of the water column at site 28) with a mean reading of 53,060 µS/cm across all survey stations (Figure 5-24);
- Salinity ranged from 23.4 ppt (at the top of the water column at site 27) to 42.0 ppt (at the top of the water column at site 17) with a mean reading of 35.03 ppt across all survey stations (Figure 5-25);
- pH ranged from 7.8 (at the top of the water column at site 30) to 8.2 (at the top of the water column at site 2) with a mean reading of 8.1 across all survey stations (Figure 5-26);
- Turbidity ranged from 0.1 NTU (at the top of the water column at site 17) to 11.7 NTU (at the bottom of site 28) with a mean reading of 1.4 NTU across all survey stations (Figure 5-27).
- Dissolved oxygen saturation ranged from 96.8% (at the bottom of the water column at site 20) to 126.7% (at the top of the water column at site 12) with a mean reading of 109.5% across all survey stations; and
- Dissolved oxygen concentration ranged from 6.2 mg/L (at the bottom of the water column at site 5) to 9.9 mg/L (at the bottom of the water column at site 17) with a mean reading of 7.60 mg/L across all survey stations (Figure 5-28).

Data has been compared against the DM Water Quality Standards for Sea and Coastal Waters and there were no exceedances of guideline values. Graphs showing the values for each of the above parameters with depth are provided in Figure 5-23 to Figure 5-28. Given that a total of 35 sample locations were assessed, separate distinguishable colours could not be provided for each site in the graphs below. As such, the sample locations were grouped according to location / depth; a key for which is provided in Table 5-14.

Table 5-14 Sample Site

Colour	Sites	Depth range (m)	Location
	1-9, 14	9.6 - 15.3	Inner access channel around Palm
	10-13, 15	6.7 - 9.3	Skydive Dubai
	26-28, 16, 19	6.3 - 11.6	Logo Island
	17, 18, 20, 22	9.5 - 16.8	Palm
	21, 23	3.7 - 4	Shallow areas around Logo Island/Palm
	24, 25	6.8 - 9.9	Mina Seyahi beach
	29, 30, 31	7.1 - 7.2	DIMC/Main Marina
	32-38	10.7-14.3	Outer access

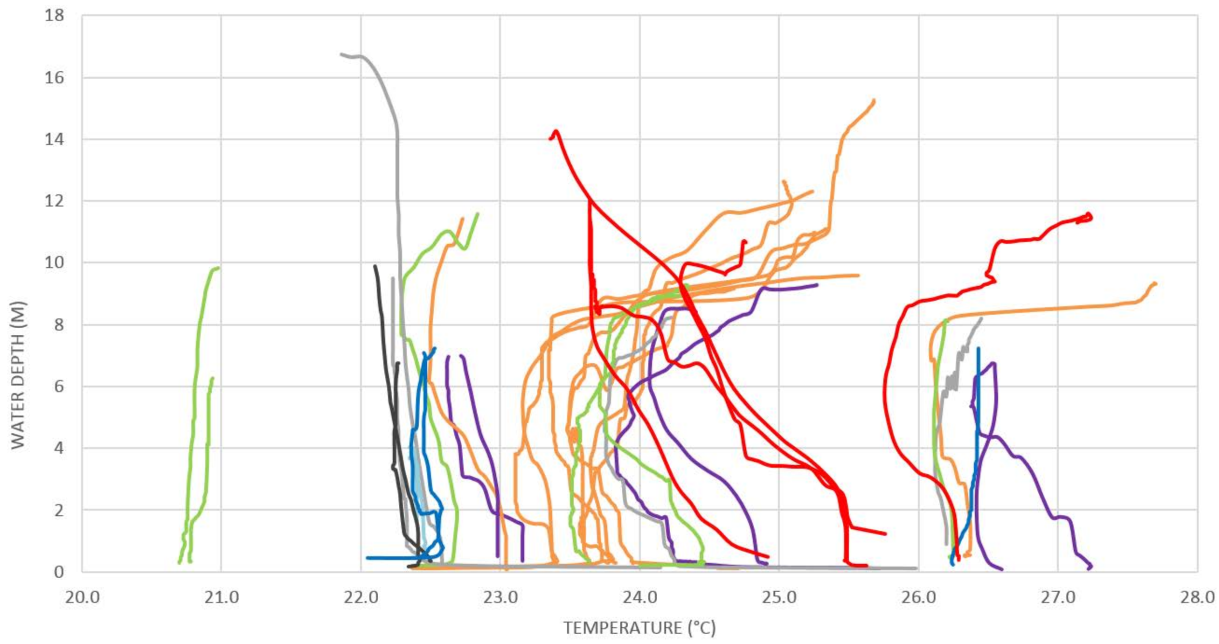


Figure 5-23 Temperature Measurements at Various Depths

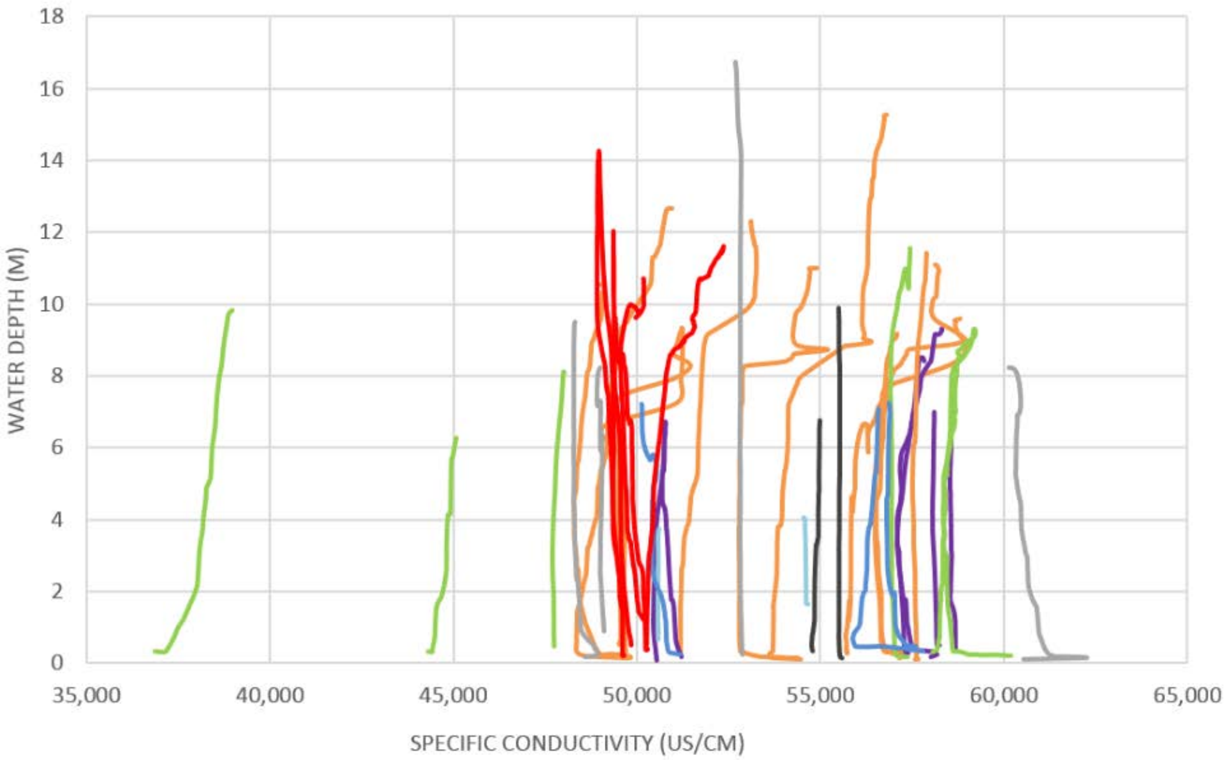


Figure 5-24 Conductivity Measurements at Various Depths

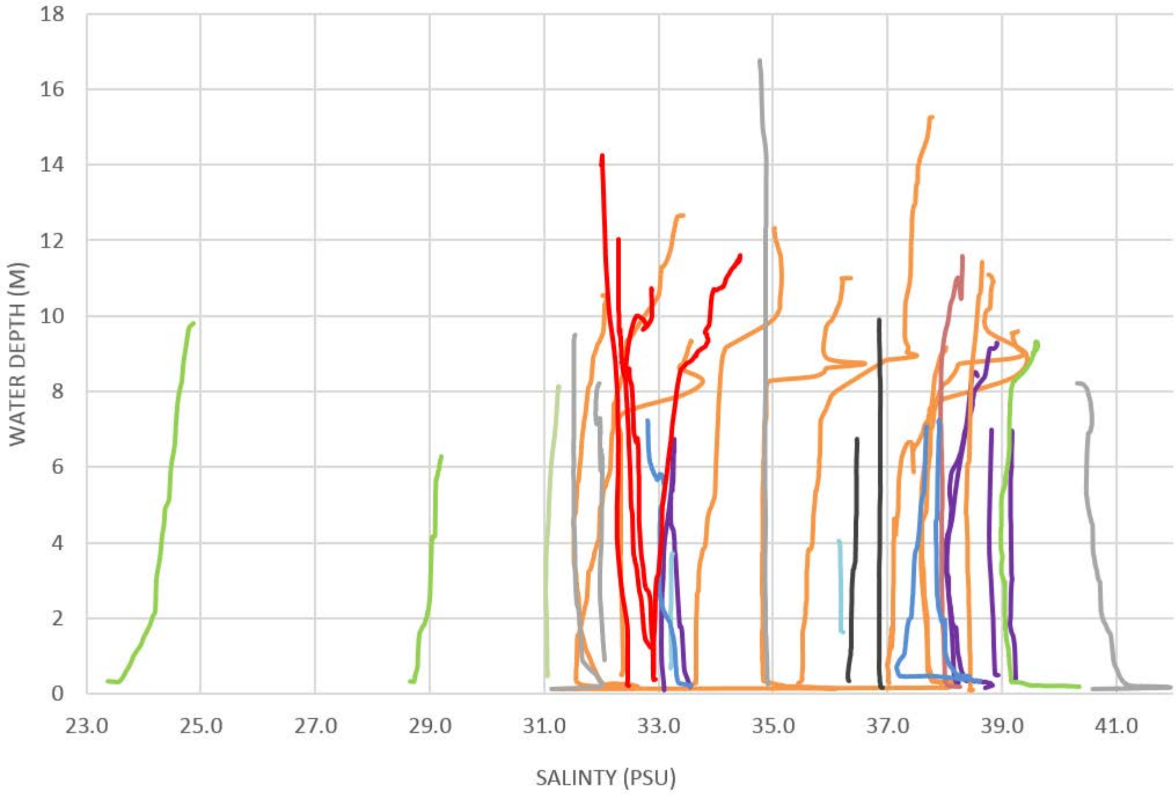


Figure 5-25 Salinity Measurements at Various Depths

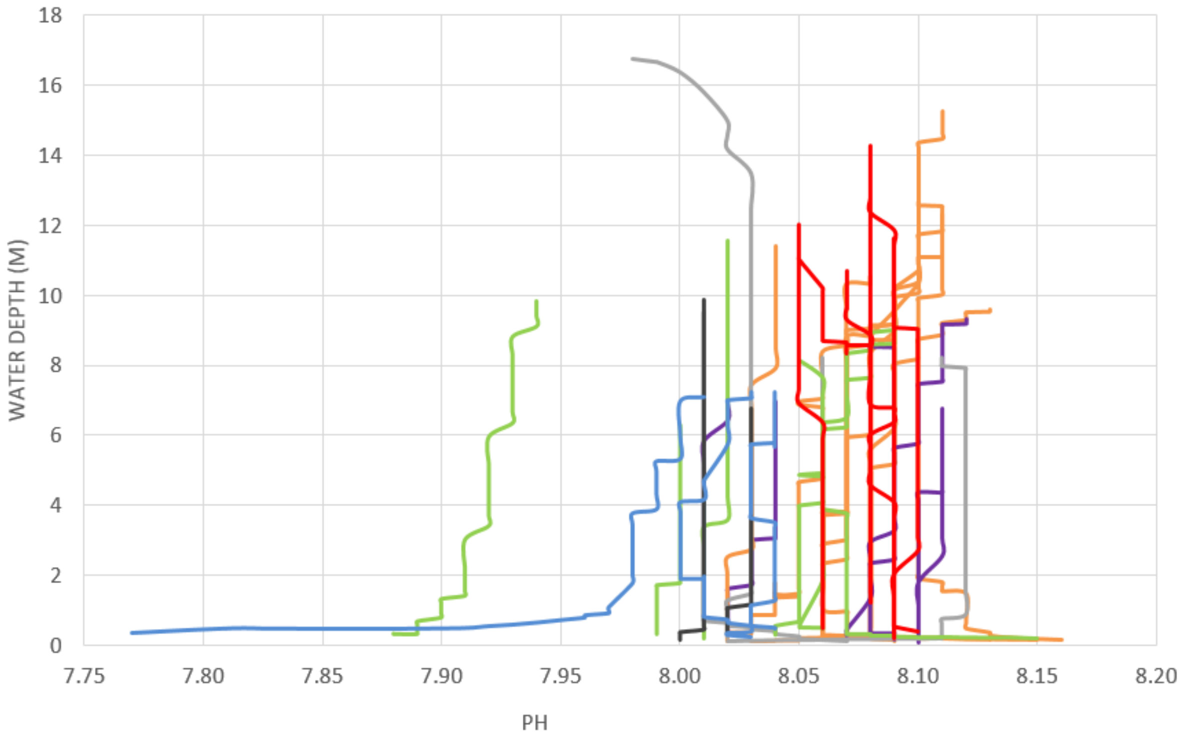


Figure 5-26 pH Measurements at Various Depths

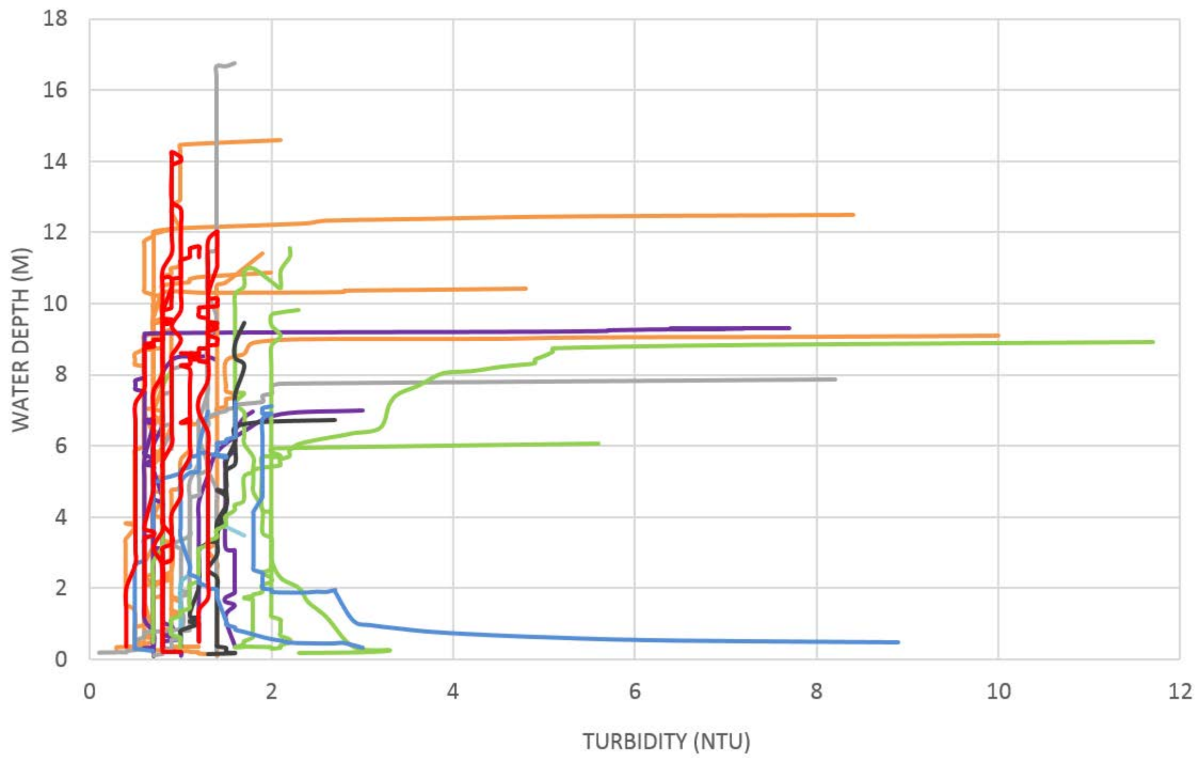


Figure 5-27 Turbidity Measurements at Various Depths

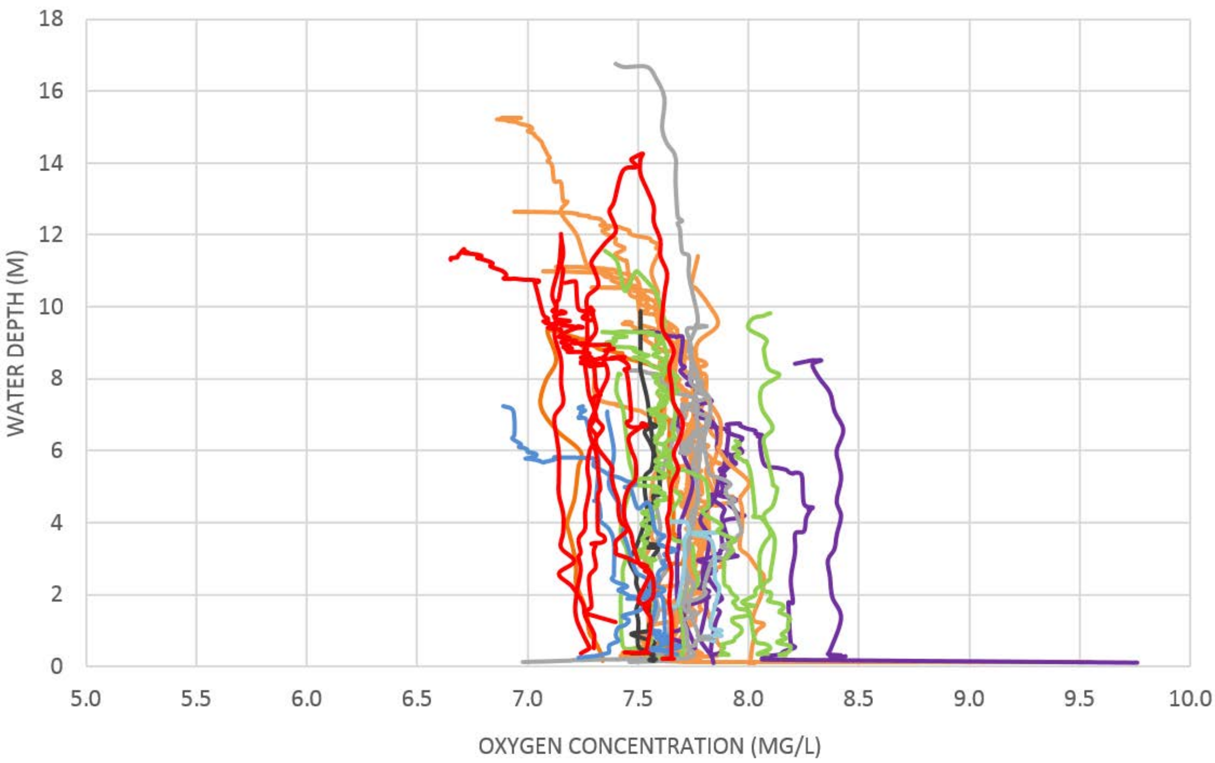


Figure 5-28 Oxygen Concentration Measurements at Various Depths

The physico-chemical water measurements recorded during the survey broadly reflect conditions typical of the Arabian Gulf in the spring (Sheppard et al., 1992; Reynolds, 2002; Al Abdessalaam, 2007). A relatively high temperature range was recorded of between 20.7 and 26.4 ° C, which is reflective of the fast transition in sea surface temperatures between winter and summer, given the duration across which the sampling was completed (mid-February to mid-March). Higher temperatures (of up to 36° C) were recorded during the survey of the two additional sites in August 2017, which is due to the difference in seasons between the two survey periods. High salinity values (mean of 35.33 ppt) and an alkaline pH range (7.8 – 8.2 pH units) were also recorded which are typical of natural conditions within the Arabian Gulf (Kampf and Sadrinasab, 2006). However, the salinity (along with temperature and conductivity) was particularly low at two sites (mean of 24.2 ppt at site 27 and 29.0 ppt at site 26). The highest salinity of 44.1 ppt (as well as temperature and conductivity) was recorded at site 39. These variations may be a consequence of these locations being sampled during a separate event (sites 26 and 27 in February 2017, sites 39 and 40 in August 2017) compared with the remaining sampling events (March and April 2017), which reflects a known seasonal change in salinity in the Arabian Gulf (Kampf and Sadrinasab, 2006).

The DO range recorded during the survey of 4.7 – 9.9 mg/L was indicative of a healthy marine ecosystem and is considered normal given the corresponding temperature and salinity ranges (Weiss 1970).

Turbidity readings remained low at all sites and all depths surveyed, with values remaining below 11.7 NTU, indicating that waters surrounding the Project site were relatively clear with minimal suspended solids at the time of the survey.

Marine waters in the Project site were relatively well mixed, with limited stratification evident. This is expected in a nearshore marine environment in the southern Arabian Gulf where water depths are shallow and vertical mixing is enhanced by the tidal exchange and coastal processes.

5.7.3.2 Analytical Water Quality

The results of the analytical water quality analysis were compared to the limits set out in the DMWQO. A summary of the results is presented in Table 5-15, while a more complete set of results for all samples analysed and associated laboratory reports is presented in Appendix F.

The results show that the majority of parameters were not detected in concentrations above respective laboratory reporting limits (LORs). Parameters that were recorded in concentrations above their respective LOR's include TDS, Nitrate, Flouride, Total Coliform, Enterococci, E. coli, COD and TOC, although all parameters were considered to be within expected natural background concentrations, with the exception of microbiology parameters, which were elevated at sampling locations 13, 17 and 20 although did not exceed DMWQO's.

Of all the parameters assessed, only two exceeded the DMWQO standards, comprising phosphorus and phosphate, which exceeded the guidelines at all sampling locations except 26, 27, 39 and 40[1]. Though the concentrations of microbiology parameters were not in excess of the DMWQO limit, all parameters were elevated at sampling locations 13, 17 and 20.

Table 5-15 Summary of Marine Water Analysis Results

Analyte	Unit	LOR	DMWQO	Min	Max	Mean
Chlorophyll-a	mg/m^3	0.01	--	<0.01	<0.01	N/A
Cyanide	mg/L	0.001	--	<0.001	<0.001	N/A

[1] Additional stations where samples were collected on 14 August 2017.

Analyte	Unit	LOR	DMWQO	Min	Max	Mean
Total Dissolved Solids	mg/L	5	--	40,225	45,950	44,658
Total Suspended Solids	mg/L	5	25	<5	<5	-
Total Chlorine	mg/L	0.01	--	<0.01	<0.02	-
Residual Chlorine	mg/L	0.01	--	<0.01	<0.02	-
Nitrate (NO_3-N)	µg/L	10	500	111	250	156
Nitrite (NO_2)	µg/L	10	--	<10	<10	-
Ammonia (NH_3-N)	mg/L	0.001	0.1	<0.001	<0.001	-
Phosphorus (P)	mg/L	0.001	0.05	<0.001	0.27	0.21
Phosphate (PO_2)	µg/L	10	50	<10	820	644
Sulphide	mg/L	0.001	--	<0.001	<0.001	-
Flouride	mg/L	0.01	--	1.2	3.9	2.1
Aluminium	mg/L	0.01	0.20	<0.01	<0.01	-
Arsenic	mg/L	0.001	0.01	<0.001	<0.001	-
Cadmium	mg/L	0.001	0.005	<0.001	<0.001	-
Chromium	mg/L	0.01	0.01	<0.01	<0.01	-
Copper	mg/L	0.01	0.01	<0.01	<0.01	-
Iron	mg/L	0.01	0.20	<0.01	<0.01	-
Lead	mg/L	0.01	--	<0.01	<0.01	-
Mercury	mg/L	0.01	0.001	<0.001	<0.001	-
Nickel	µg/L	10	--	<10	<10	-
Vanadium	µg/L	1	--	<1	<1	-
Zinc	mg/L	0.01	0.02	<0.01	<0.01	-
TPH	mg/L	0.001	--	<0.01	<0.01	-
MCP	mg/L	0.001	--	<0.001	<0.001	-
Total Coliform	cfu/ 100 mL	1	--	<1	80	-
Enterococci	cfu/ 100 mL	1	--	<1	80	-
E. coli	cfu/ 100 mL	1	200	<1	80	-
BOD	mg/L	2	20	<2	<2	-
COD	mg/L	5	--	13.6	17.6	15.0
TOC	mg/L	0.02	--	<0.02	0.39	-

Whilst phosphate and phosphorus exceeded the guideline limits, corresponding indicators of eutrophication such as very low dissolved oxygen, high BOD and high turbidity were not detected, suggesting that eutrophication was not occurring at the Project site at the time of the survey. Further, elevated phosphate levels have been detected along the Dubai coastline during a number of previous marine surveys and sampling events (including La Mer and Bluewaters baseline and construction-phase monitoring results), suggesting that it represents the natural background conditions in the area. Sampling locations 26, 27, 39 and 40 were notably lower in nutrient concentrations of phosphorus and phosphate (both reported below LOR's). This may be a consequence of these locations being sampled during a separate event (February 2017 for sites 26 and 27 and August 2017 for sites 39 and 40) compared with the remaining sampling events (March and April 2017), which may reflect a seasonal or temporal change in phosphorus and phosphate concentrations. Sampling locations 26 and 27 are not located near any outfalls that may influence nutrient levels at these locations.

BOD concentrations during the survey were all below the LOR of 2 mg/L. BOD is defined as the amount of oxygen microorganisms require in order to oxidise organic material into an inorganic form. It is one of the most common measures of polluted organic material in water, with low BOD concentrations indicating good water quality, while high BOD concentrations indicate polluted water (Breslow and Cengage, 2002). COD levels are expected to be greater than BOD concentrations for any given sample and should typically be below 20 mg/L in unpolluted waters. All samples were below 20 mg/L for COD. These results indicate that none of the survey sites were polluted by excessive amounts of organic material.

Chlorophyll-*a* is used as an estimate of phytoplankton biomass and also as a biological indicator of eutrophication (Ward *et al*., 1998; European Environment Agency, 2011). The primary effect of eutrophication is excessive growth of phytoplankton, which can cause changes in species composition and functioning of the pelagic food web, increased sedimentation of organic material, and increased oxygen consumption (European Environment Agency, 2011). It is thought that a chlorophyll-*a* concentration in excess of 0.5 mg/m^3 is the threshold for marine eutrophication (Clark, 2001). All samples collected reported concentrations below the LOR (0.01 mg/m^3).

It is noted that microbiology parameters were elevated at sites 13, 17 and 20 in comparison to results from the other sampling locations in the study area. This may be a consequence of the proximity of these sites to developed land (i.e. Skydive Dubai and Palm Jumeirah); although there are no existing wastewater outfalls near these sites.

In summary, results from the survey area were largely homogenous and indicative of good water quality, despite the elevated phosphorus and phosphate concentrations at sites sampled in March and April 2017. It is likely that given the relatively short modelled residence times of waters in the area (Sogreah 2017c; 2017d), regions of elevated nutrients are rapidly diluted to levels that do not promote eutrophication.

5.7.3.3 Sediments

Analytical Sediment Quality

There are currently no established standards for sediment contamination in the UAE. The results of the marine sediment analysis are therefore compared to two internationally recognised sets of guidelines, as follows:

- The National Oceanographic and Atmospheric Administration (NOAA) sediment quality guidelines; and
- The Dutch Circular on Remediation of Water Bottoms (sediments).

A summary of the results from the chemical analysis of sediments is presented in Table 5-16. A more comprehensive list of results for all samples analysed is presented in Appendix F.

Table 5-16 Summary of Sediment Chemistry Results

Analyte	Unit	LOR	NOAA*	Dutch IV	Min	Max	Mean
TOC	% by weight	0.01	--	--	0.04	0.09	0.07
PAHs	mg/kg	0.01	4,022	40	<0.01	<0.01	-
BTEX	mg/kg	0.01	--	1	<0.01	<0.01	-
m&p Xylene	mg/kg	0.01	--	25	<0.01	<0.01	-
VPH C5-C10	mg/kg	0.01	--	--	<0.01	<0.01	-
EPH C10-C40	mg/kg	0.01	--	--	<0.01	<0.01	-
PCB's	mg/kg	0.01	22.7	1	<0.01	<0.01	-
Phenols	mg/kg	0.01	--	40	<0.01	<0.01	-
Tributylin & Derivatives	mg/kg	0.01	--	--	<0.01	<0.01	-
Total Phosphorus	mg/kg	0.01	--	--	60.7	162.0	108.8
Sulphide	mg/kg	0.001	--	--	<0.001	<0.001	-
Total Nitrogen	mg/kg	0.01	--	--	357	888	646
Streptococci	cfu/100 mL	1	--	--	<1	50	-
Enterococci	cfu/100 mL	1	--	--	<1	50	-
E. coli	cfu/100 mL	1	--	--	<1	80	-
Aluminium	mg/kg	0.01	--	--	147	2,905	1,594
Cadmium	mg/kg	0.01	1.2	12	<0.01	7.5	-
Copper	mg/kg	0.01	43	190	<0.01	38.8	-
Nickel	mg/kg	0.01	20.9	210	<0.01	57.3	-
Zinc	mg/kg	0.01	150	720	<0.01	55.7	-
Mercury	mg/kg	0.001	0.15	10	<0.001	<0.001	-
Arsenic	mg/kg	0.001	8.2	55	<0.001	<0.001	-
Lead	mg/kg	0.01	46.7	530	<0.01	7.7	-

*NOAA Marine ER-L (Effects Range – Low) (10th percentile of included effects data)

^Dutch IV Earth/Sediment Intervention Value

The sediment quality indicates that two metals (cadmium and nickel) exceed the NOAA marine sediment guidelines in the “low effect” range threshold at several sites. Concentrations of Cadmium exceeded the NOAA marine sediment guidelines in the “low effect” range at sampling site 4 (7.5 mg/kg). However, concentrations were not high enough to exceed the “medium effect” guideline of 9.6 mg/kg. Nickel exceeded the NOAA marine sediment guidelines in the “low effect” range at sampling sites 5, 9, 12, 13, 15 and 38 and also exceeded the “medium effect” guideline of 51.6 mg/kg at site 5.

Concentrations of aluminium, copper, zinc and lead were detected above LOR’s. Detectable levels of aluminium, nickel, copper and lead are consistent with other studies previously undertaken in the Gulf and UAE coastal areas (De Mora et al., 2004). Fine sediment particle sizes being dominant at most sampling sites may contribute to elevated levels of metals, as finer grains tend to have a greater capacity to absorb contaminants (Parizanganeh, 2008).

Although there are no standards available for assessment nutrients and microbiology parameters, it should be noted that Total Phosphorus, Total Nitrogen, Streptococci, Enterococci and E. coli were reported above their respective LOR's at several sites. These parameters are potentially being stored in the sediment due to the presence of nutrients and microbiology parameters recorded in the water samples. Concentrations of BTEX, m&p Xylene, TBT and Derivatives, VPH, EPH, TPH, PAH, Phenols and PCBs all remained below their respective laboratory LOR. As a consequence, there is no evidence of petroleum hydrocarbon or volatile contamination of the sediments.

In summary, sediment quality results from the survey area are largely homogenous and indicative that sediment is not chronically impacts by metals or other contaminants.

Particle Sizes of Marine Sediments

The particle size distribution of the marine sediments was measured as per the international scale for soil classification (ISO 14688-1:2002), as summarised in Table 5-17. The marine sediments closest to the existing Dubai Harbour (sites 24 - 31) largely consist of fine sands (71 – 92%). Comparatively, reference sites in the channel between the Palm Jumeriah and Logo Island (sites 13, 14, 17, 18 and 20) largely consisted of silts and clays, with a smaller portion of fine sands. Sites furthest away in the proposed navigation channel (sites 34, 36 and 38), close to Bluewaters Beach (site 11) and close to the palm stem (site 21 and 22) all had a higher percentage of coarse sand than other sites. This undoubtedly results from calmer waters in the waters protected by Dubai Harbour and Logo Island relative to the higher currents in areas west of the Palm Jumeirah.

Table 5-17 Particle size distribution (percentage by volume)

Site	Silts and Clays (%)	Fine Sands (%)	Medium Sands (%)	Coarse Sands (%)	Fine Gravels (%)	Gravel (%)
Size range (mm)	> 0.063	0.063 – 0.2	0.2-0.63	0.63-2.0	2.0 – 6.3	> 6.3
1	1	20	70	8	0	1
2	3	77	16	1	0	3
3	5	61	20	4	5	5
4	3	65	18	3	4	7
5	14	80	5	1	0	0
6	3	81	8	3	3	2
7	14	80	5	1	0	0
8	5	60	18	7	6	4
9	44	48	4	2	2	0
10	24	62	11	2	1	0
11	26	24	31	12	7	0
12	5	63	20	8	3	1
13	80	17	2	1	0	0
14	63	31	5	1	0	0
15	3	54	34	6	1	2
16	18	76	5	1	0	0
17	48	46	4	1	1	0

Site	Silts and Clays (%)	Fine Sands (%)	Medium Sands (%)	Coarse Sands (%)	Fine Gravels (%)	Gravel (%)
18	27	63	8	2	0	0
19	22	56	16	4	2	0
20	68	27	4	1	0	0
21	4	23	48	23	2	0
22	7	60	21	8	2	2
23	15	78	7	0	0	0
24	13	76	7	2	1	1
25	14	77	6	2	1	0
26	4	92	3	1	0	0
27	3	92	4	1	0	0
28	8	82	8	1	1	0
29	10	82	7	0	1	0
30	15	80	4	1	0	0
31	22	71	6	1	0	0
32	5	92	3	0	0	0
34	2	14	72	8	4	0
36	5	8	56	28	3	0
38	5	17	72	6	0	0

5.7.3.4 Benthic Habitat Assessment

Benthic ecology investigations were conducted at a total of 38 sites across the study area. An initial survey using remote techniques (Drop-Down Video) provided a qualitative assessment. The results of this survey were subsequently used as a basis for a more detailed investigation targeting sites that potentially supported sensitive habitats, namely 1, 3, 4, 6, 7, 18, 21, 23, 24, 34, 36 and 38. A review of benthic ecology drop-down video data was undertaken, resulting in the survey sites being classified into four basic benthic habitat categories, with one sub-category.

- Breakwater;
- Unconsolidated sediment (‘Sediment’);
  - Unconsolidated sediment with sparse seagrass;
- Hardbottom with sand veneer (‘Hardbottom’); and
- Dredged.

The distribution of these habitats is provided in Table 5-18 and shown in Figure 5-29, while the sections below summarise their distribution, overall diversity and key species. Further details are provided in the Marine Environmental Baseline Survey (MEBS) report in Appendix F.

Table 5-18 Habitat classification by site

Site Name	Habitat		Site characteristics	
	Class	Sub-class	Depth (m)	Median grain size (Wentworth)
1	Breakwater		10.5	Medium sand
2	Dredged		12.6	Fine sand
3	Hardbottom		12.3	Fine sand
4	Breakwater		11.0	Fine sand
5	Dredged		15.3	Very fine sand
6	Sediment		9.6	Fine sand
7	Breakwater		9.2	Fine sand
8	Dredged		11.1	Fine sand
9	Sediment		9.3	Very fine sand
10	Sediment		9.3	Fine sand
11	Sediment		6.7	Fine sand
12	Sediment		8.5	Fine sand
13	Sediment		7.0	Silt
14	Dredged		11.4	Silt
15	Breakwater		7.0	Fine sand
16	Dredged		11.6	Fine sand
17	Breakwater		8.2	Very fine sand
18	Breakwater		8.2	Very fine sand
19	Breakwater		8.1	Fine sand
20	Dredged		16.8	Silt
21	Sediment	Sparse seagrass	3.7	Medium sand
22	Sediment		9.5	Fine sand
23	Breakwater		4.0	Fine sand
24	Sediment	Sparse seagrass	6.8	Fine sand
25	Sediment		9.9	Fine sand
26	Sediment		6.3	Fine sand
27	Sediment		9.8	Fine sand
28	Sediment		9.3	Fine sand
29	Breakwater		7.2	Fine sand
30	Breakwater		7.1	Fine sand
31	Sediment		7.2	Very fine sand
32	Dredged		11.6	Fine sand
33	Dredged		11.8	-
34	Hardbottom		10.7	Medium sand
35	Hardbottom		10.9	-
36	Hardbottom		12.0	Medium sand
37	Hardbottom		13.3	-
38	Hardbottom		14.3	Medium sand

LEGEND

Habitat

- Breakwater
- Unconsolidated sediment
- Hardbottom with sediment veneer
- Dredged channel
- Proposed channel route
- Dubai Harbour development

Paper Size A4

0 1,000 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: WGS 1984
Grid: WGS 1984 Dubai Local TM

N

GHD

Shamal Development
Dubai Harbour EIA

Job Number	76-10664
Revision	A
Date	06 Jun 2017

Habitat map

Figure 5-29

3rd floor Guardian Tower Danet Community Abu Dhabi United Arab Emirates W www.ghd.com

G:\71\12289\711228911_(7610664_Dubai Harbor EIA)\GIS\Maps\7610664_05-26_HabitatMap_revA.mxd

Data source: GHD - Habitat, Dubai Harbour development, Proposed channel route/2017. Image 2016 Google Earth, DIO, NOAA, US Navy/NGA/GENCO/Digital Globe - (Date Extracted: 2017/04/27). Natural Earth - Road.
Created by:jcmatic

Breakwaters

Extensive lengths of rock revetment are present across the study area, including the outer breakwater around Palm Jumeirah (Figure 5-30) and the DIMC marina, and rock armouring around Logo Island and Skydive Dubai. Breakwaters may develop diverse benthic communities including abundant corals, however; such communities take many years to become established and to flourish. Burt et al. (2011) found breakwaters of 5.5 years and less were dominated by turf algae, sponges, bivalves, and bare pavement, with coral cover accounting for 7% or less. On the other hand, breakwaters that were 25 years and older were dominated by corals (46% and 56% live cover on 25 and 31 years old breakwaters, respectively). It was conculded that diversity increases and coral comunities on breakwaters grow and mature significantly over time.

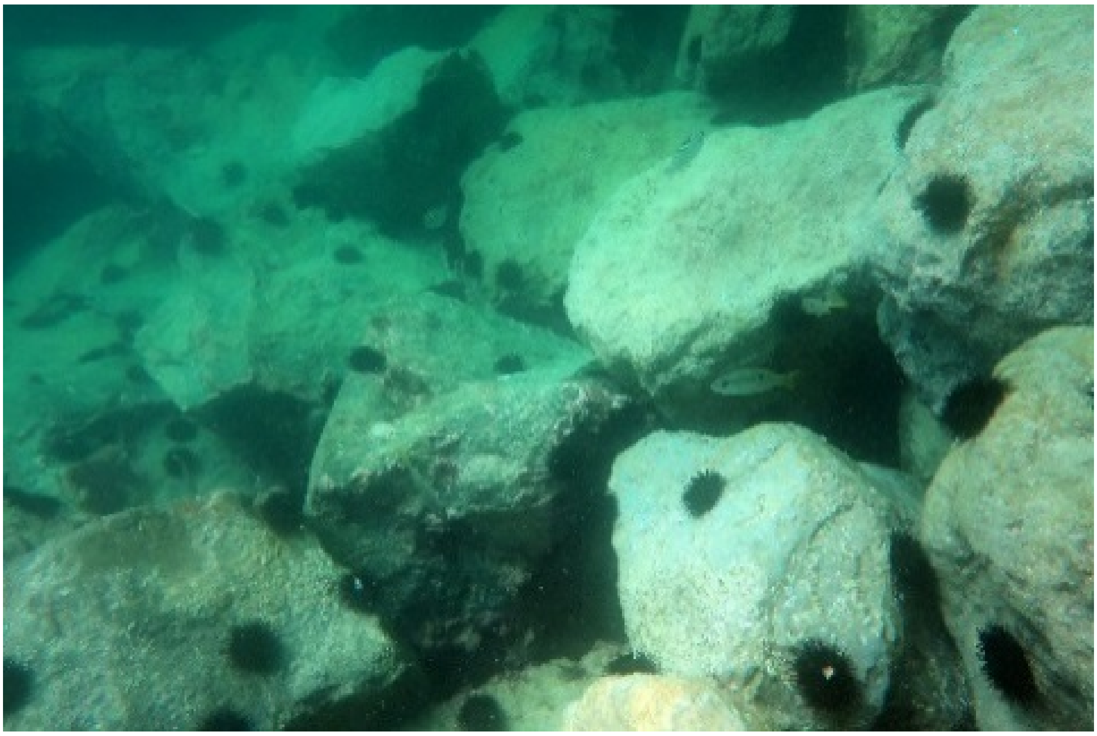


Figure 5-30 Typical rock breakwater around the Palm (site 1)

Of all the habitat types assessed, breakwaters supported the most diverse benthic community with a mean of 20.5 species per site (flora, fauna and fish combined), compared to between 8 and 9 species per site for the Sediment and Hardbottom habitats. However, when compared to coral communities detailed in Burt et al., 2011, those of the study area were less well developed than may be expected, with diversity and abundances considered modest. Coral colonies were found at all detailed breakwater survey sites across the study area, although live coral cover was particularly low (considerably less than 1% at all sites) and diversity was limited to five species, all of which are common in the Gulf and listed as ‘Least Concern’ on the IUCN red list (IUCN 2017).

The recorded community was relatively homogenous; multivariate analysis grouped five of the six sites as a statistically similar habitat type (SIMPROF, $P<0.05$), with the sixth site only slightly different due largely to areas of exposed sediment being interspersed with the rocks. Urchins, snappers, bivalves and turf algae were fundamental in characterising the community type (SIMPER analysis). Despite supporting largely similar benthic communities, the breakwater sites showed distinct trends across the study area. The more sheltered areas around Logo Island, Skydive Dubai, DIMC and the southern tip of the Palm often supported a flourishing fouling community; vertical or steeply sloping rock faces were usually the highest in density and were dominated by bivalves (*Malvufundus* spp., *Pinctada radiata*) interspersed with solitary ascidians (*Polycarp* sp.). Progressing to the west and north around the Palm, the density of the fouling community decreased, while the number of corals appeared to increase, although remained very low at all sites.

Macroalgal development was limited to occasional epilithic species such as *Padina boergesenii.* However, Crustose Coralline Algae were frequent and Turf algae were present on much of the available hard substrate, including rock faces and bivalve shells, in varying density. Sea urchins were abundant throughout.

A total of just 39 coral colonies from five species were recorded across the breakwater and maximum estimated coral was very low, at 0.2%. The hardy, encrusting *Siderastrea savignyana* (Figure 5-31) was by far the most widespread species, being noted at all breakwaters sites and accounting for 68% of all recorded colonies. The remaining taxa consisted of *Cyphastrea microphthalma, Porites* sp. (Figure 5-31), and two species of *Favia* (*Favia pallida* and *Favia speciosa*). Several colonies appeared to be bleached and / or suffering from partial mortality. A summary of the total number of coral colonies and estimated total coral cover by site is provided in Table 5-19. Two *S. savignyana* colonies were also observed in the Hardbottom habitat, although both were very small (see below). Nonetheless, there is potential for these breakwaters to develop considerably richer benthic communities, including substantial coral growth, especially at the more exposed locations, which have higher coral recruitment and survival rates (Burt et al., 2010).

Table 5-19 Number of coral colonies and estimated total coral cover by site for breakwater habitat

Site ID	1	4	7	17	18	23
Favia pallida					2	
Favia speciosa						1
Cyphastrea cf. *microphthalma*					2	
Porites spp.	7				1	
Siderastrea savignyana	11	6	3	2	2	1
Total colonies	18	6	3	2	7	1
Estimated total coral cover (%)	0.22%	0.06%	0.04%	0.03%	0.08%	0.02%

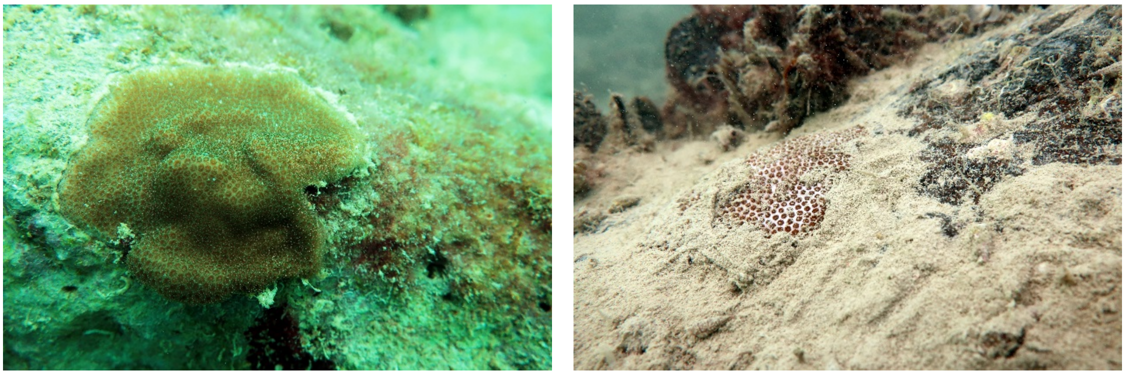


Figure 5-31 Breakwater coral colonies: *Porites* sp. at site 1 (left) and *Siderastrea savignyana* at site 23 (right)

Hardbottom with Sand Veneer

Hard bottom habitat comprised of a flat rock platform covered by a layer of mobile sand just a few centimetres thick (Figure 5-32). The 'Hardbottom with Sand Veneer' habitat (henceforth termed 'Hardbottom') dominated the offshore benthic habitats that have not been dredged. This habitat transitions gradually into the Unconsolidated Sediment habitat, and boundaries are largely subjective.

Recorded species diversity and abundances were low (mean of 8.3 species per site), with the mobility of the sediment layer impeding the development of significant benthic communities. Very infrequent corals were present: across four detailed site investigations (Table 5-20), only two coral colonies were recorded, both of which were approximately 1 cm in diameter (Figure 5-32).

There was considerable disparity in community composition between sites; multivariate analysis grouped two sites with the Unconsolidated Sediment habitat, while two sites showed little similarity to each other or to any of the other sites. As such, a 'typical' community cannot be described, although the most widespread taxa was the hermit crabs *Diogenes avarus*.

Table 5-20 Number of coral colonies and estimated total coral cover by site for hardbottom habitat

Site ID	3	34	35	36	37	38
Favia pallida						
Favia speciosa						
Cyphastrea cf. *microphthalma*						
Porites spp.						
Siderastrea savignyana	1			1		
Total colonies	1	0	0	1	0	0
Estimated total coral cover (%)	< 0.01%	0	0	< 0.01%	0	0

Figure 5-32 Left: the thin mobile sand veneer has been brushed away to expose underlying hardbottom. Right: very infrequent coral colony (finger shown for scale)

Unconsolidated Sediment

The Unconsolidated Sediment habitat (henceforth 'Sediment') is characterised by having a deeper and more stable sediment layer than the Hardbottom habitat. Where conditions are settled and the sediment is stable, diversity may increase and, in some cases, seagrass may develop. Seagrass (predominantly *Halophila ovalis*) was recorded at two of the survey sites, although density was very low estimated at 1.0 and 5.1 % total cover and distribution extremely patchy (Table 5-21). Of the three seagrass species known in the Gulf, *Halophila ovalis* (Figure 5-34) is more commonly associated with more turbid, marginal conditions, and was the most widespread species in the survey. *Halodule uninervis* was recorded very infrequently, while *Halodule stipulacea* was not observed. It is likely that similar patches of low-density seagrass were scattered across more sheltered areas of the habitat. The presence of seagrass is likely to slightly increase biodiversity and provide additional sediment stability; however, these areas will not fulfil the same ecological functions or provide the same ecosystem services as a seagrass bed (where density and distribution are significantly higher).

The mean number of species was 8.8 per site, with diversity and abundances generally very low (Figure 5-33) and largely comparable to the Hardbottom habitat. All sites were grouped as a statistically similar community type (SIMPROF, $P<0.05$), along with two of the Hardbottom sites. SIMPER analysis suggested sediment sites were particularly characterised by gastropods, especially the predatory muricid *Hexaplex kuesterianus* and the shell-less headshield slug *Philinopsis cyanea*.

In general, most of the sediment habitat is considered to be of relatively low conservation value, while areas with sparse seagrass may be considered to be of moderate value.

Table 5-21 Seagrass cover estimates

Seagrass cover class	Class cover (%)	Site 21		Site 24	
		LIT class cover (%)	Seagrass cover (%)	LIT class cover (%)	Seagrass cover (%)
Bare substrate	0%	90.3	0.0	10.7	0.0
Very sparse	0.5%	0.0	0.0	0.0	0.0
Sparse	2%	0.0	0.0	48.0	1.0
Medium sparse	10%	9.7	1.0	41.3	4.1
Medium	25%	0.0	0.0	0.0	0.0
Medium dense	50%	0.0	0.0	0.0	0.0
Dense	75%	0.0	0.0	0.0	0.0
Very dense	90%	0.0	0.0	0.0	0.0
	Total	100.0	**1.0**	100.0	**5.1**

Figure 5-33 Typical unconsolidated sediment habitat (site 21)

Figure 5-34 A patch (approximately 3 m in diameter) of the seagrass *Halophila ovalis* at site 21

Dredged Areas

A navigation channel has been dredged around the Palm, which will be deepened and widened as part of the Project. DDV video footage was recorded from within the channel, but detailed analysis of communities in the dredged channel habitat could not be undertaken due to health and safety concerns regarding diving in an active navigation channel.

The dredged channel beds supported very few species and was largely limited to infaunal wormholes (Figure 5-35). Such areas are commonly poorest of all benthic habitats. At the sides of the channel, dredging can expose underlying hard substrate, providing physical relief which may support a more developed fouling community (Figure 5-35), dominated by bivalves such as the Jewel-box clam (*Chama reflexa*) and Thorny oyster (*Spondylus marisrubri*), sponges and ascidians (e.g. *Phallusia nigra*).

Dredged channel beds are often depositional, smothering environments, with limited (or even absent) epibenthic communities, especially at the depths of those in the study area. Overall, the habitat is considered to be of low conservation value.

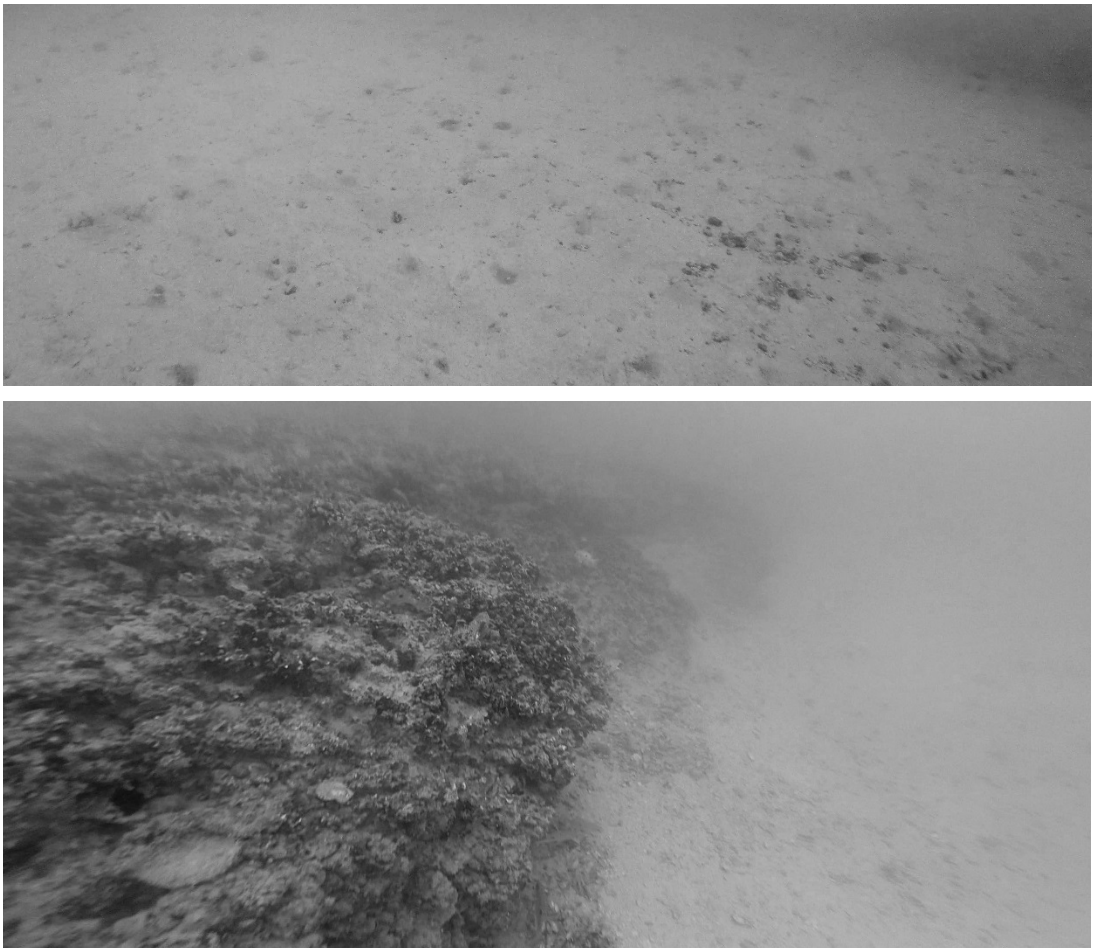


Figure 5-35 Top: Minimal benthic colonisation in the channel bed (site 5).
Bottom: Channel edge supporting a fouling community (site 8)

5.7.3.5 Fish

A total of 19 fish species were identified during the survey, as depicted in Table 5-22, along with relative abundance, IUCN red list status and overall contribution to the Abu Dhabi fisheries catch to provide an idea of overall background abundance. Of the species identified, none were considered rare or unusual or were listed as 'threatened' on the IUCN red list. Undoubtedly, other species will be resident or will frequent the area, especially as pelagic species which would not necessarily have been observed during the survey.

All but one species were either not listed or were 'Least Concern'. The exception to this was the Orange-spotted grouper, *Epinephelus coioides* (Figure 5-36), known locally as 'Hamour', which was rated 'near Threatened'. It is a major fisheries species, contributing 15.7% to the total catch in Abu Dhabi (Hartmann 2017), and is considered to be significantly overfished (Grandcourt 2012).

A total of nine fisheries species were recorded (including the Hamour), cumulatively accounting for 23.5% of total catch. The Orange spotted jack contributes 3.3% to the fishery, but is considered to be underexploited (Grandcourt 2012). The Golden trevally, which contributes 1.8% is overexploited (Grandcourt 2012). Other species contributed 1% or less to the fishery.

A considerably more diverse and abundant fish community was recorded on breakwaters than in other habiats. In addition to moderate levels of primary production, rock revetments provide a complex physical environment, which allows many species to hide from predators, and enables fish communities that mirror natural reefs to develop, with species frequently including the Hamour and Sordid sweetlips, *Plectorhinchus sordidus* (Figure 5-36).

Conversely, the lack of refuge and limited productivity of the hard bottom and unconsolidated sediment habitats tends to limit the associated fish community. The Rosy goatfish *Parupeneus margaritatus* uses the barbels on its chin to search the sediment for infaunal prey items. Bream such as the Black streak and the Arabian monocle (*Scolopsis taeniatus* and *S. Ghanam*) tend to be relatively frequent. Where the sand is deep and stable enough, shrimpgoby may prosper. However, both diversity and abundances of demersal fish tend to be low.

The physical relief of channel edges and the presence of potential prey may also result in a moderate abundance and diversity of fish (although observations from DDV footage were limited by poor visibility). Actual community composition will depend greatly on the water quality as well as the physical structure at that site, but assemblages may echo (poorly) those found on reefs and breakwaters. Dredged channel beds, however, tend to be poor habitats for fish and support very limited numbers and diversity.

While fishing has a relatively small contribution to the economy in the UAE, accounting for 0.1% of GDP in 2001 (FAO, 2003), it has an important contribution in terms of food security as well as considerable heritage value. Nine fisheries species were recorded, which cumulatively account for 23.5% of total catch in Abu Dhabi (Hartmann 2017). These included overexploited species such as the Orange-spotted grouper (*Epinephelus coioides*) and the Golden trevally (*Gnathanodon speciosus*) (Grandcourt 2012). The contribution of fish in the study area to the overall Dubai fishery cannot be determined from available data. The area in and around the Palm has some restrictions for marine activities; however, it is still believed that some commercial fishing activities are undertaken here.

Figure 5-36 The Orange-spotted grouper or 'Hamour' (*Epinephelus coioides*) at site 1

Table 5-22 Fish species observed during the survey

Fish name		IUCN red list*	Fisheries Catch (%)**	1	4	7	17	18	23	30	06	21	24	03	34	36	38	5
Scientific	Common			Breakwater						Sediment				Hard bottom				Dredged
Abudefduf vagiensis	Indo-pacific sargeant	NL	-			F		F	O									
Carangoides bajad	Orange-spotted jack	LC	3.3							F		R						
Cryptocentrus lutheri	Luther's shrimpgoby	NL	-						F						O	R		
Cheilodipterus novemstriatus	Twospot cardinalfish	NL	-						O									
Epinephelus coioides	Hamour	NT	15.7	F	O			R										
Gnathanodon speciosus	Golden trevally	LC	1.8	P	P													P
Lethrinus lentjan	Red-eared emperor	LC	0.9	R														
Lutjanus spp.***	Snappers	LC	1.0	A		F	C	F	F									
Pastinachus sephen	Cowtail stingray	LC	-	P														
Parupeneus margaritatus	Pearly goatfish	NL	0.0***	O		F			F									
Petroscirtes ancylodon	Arabian fangblenny	LC	-						R									
Plectorhinchus sordidus	Sordid sweetlips	NL	0.7	O														
Pomacanthus maculosus	Yellowbar angelfish	LC	0	F		O	O	C	O									
Pomacentrus arabicus	Arabian damsel	NL	-	F														
Scarus arabicus	Arabian parrotfish	LC	-	R														
Scolopsis taeniatus	Blackstreak bream	NL	0.1						F									
Scolopsis ghanam	Arabian monocle bream	NL	-	C			2											

Abundance scale: S – Superabundant / A – Abundant / C – Common / F – Frequent / O – Occasional / R – Rare / P – Present (seen in DDV footage only)

* Redlist status: NL – Not Listed / LC – Least Concern / NT – Near Threatened (IUCN 2017).

** Percentage by weight of Abu Dhabi total catch (Hartmann 2016)

*** Listed as a fisheries species, but no catch recorded

**** Differentiation between *Lutjanus fulviflama* and *Lutjanus erhenbergii* is often difficult in the field, therefore these two closely related species have been grouped together

5.7.3.6 Marine Mammals and Reptiles

No marine mammals or turtles were observed during the baseline survey, although one sea snake was captured on DDV. However, the area does have the potential for the presence of turtles and dolphins as described below.

Marine Mammals

Although no marine mammals were recorded during the baseline surveys, sightings of marine mammals made by members of the public may be uploaded to the UAE Dolphin Project website (UAE Dolphin Project, 2017). Although not peer reviewed, the website is run by a local cetacean specialist, Dr Ada Natoli of UAE University, and provides an indication of species and frequency of cetacean sightings around the Project footprint.

Two species are frequently observed adjacent to the current Logo Island and around the project footprint:

- Indo-Pacific humpback dolphin (*Sousa chinensis*) – commonly observed in nearshore areas, often in water as shallow as 1.5 m. Listed as 'Near Threatened' by the IUCN.
- Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) – usually seen in water over 10 m deep, though sometimes shallower. Listed as 'Data Deficient' on the IUCN Red List.

Both species have been observed across the study area, although observations of humpback dolphin sightings are more numerous within the Palm, while bottlenose dolphins are more commonly seen outside the breakwater and further out to sea. It is therefore considered likely that both humpback and bottlenose dolphins will be intermittently present in the Project area.

There was, in addition, a report on the UAE Dolphin Project Website of a pod of four Killer whale (*Orcinus orca*) slightly further offshore than the planned navigation channel. It is unlikely that they would be present around the footprint of the Islands, however, there is a potential for their presence during offshore dredging and associated works.

Other potential nearshore mammal species include the Finless porpoise (*Neophocaena phocaenoides*), although observations of this species are rare and it is considered unlikely that they would frequent the area. With only patchy, sparse seagrass, Dugong are unlikely to be resident. Species such as the Long-beaked common dolphin (*Delphinus capensis*) and even the Bryde's whale (*Balaenoptera edeni*) may very occasionally come be present in Dubai waters; however, their presence in the Project area is considered unlikely.

Marine Reptiles

Although no turtles were observed during the baseline surveys, of the five species of turtle recorded in the Gulf it is considered likely that Hawksbill turtles and, to a lesser extent, Green turtles are occasionally present, although unlikely to spend extended periods in the Project area. The presence of Loggerheads in the current study is considered possible but unlikely, while the presence of Olive-Ridleys or Leatherbacks is considered very unlikely.

A satellite tagging study of Hawksbill turtles by Pilcher et al. (2014) identified two distinct seasonal migrations, a nesting migration in spring and a summer migration away from warmer, shallow water. The study also identified important areas for Hawksbills, such as the foraging grounds in the southwest Gulf and nesting areas, often on offshore islands. The Project area was not one of the 'important turtle areas', and turtles did not appear to be present in large numbers, but the study did show occasional satellite tracks along this section of the Dubai coast. Hawksbills are also know to nest in Jebel Ali Marine Sanctuary, approximately 25 km down the coast. Hawksbill turtles feed on sponges and reef associated fauna, and, although there are no natural reefs in the area, the presence of breakwaters and other reef proxies means there is likely to be some food available. Much less is known about the movement of

Green turtles in the Gulf, although a satellite-tracking project is ongoing at the moment. They feed on seagrass and macroalgae, which is considerably less abundant in the Project area. Nonetheless, they are relative common in the Gulf, and undergo wide-ranging migrations. Occasional visits to the Project area would not be surprising. It is therefore likely that Hawksbill turtles and, to a lesser extent, Green turtles are occasional visitors. All four species tend to have broad home ranges or undergo considerable seasonal migrations, but while they may not be permanent residents, their potential presence in the area is of major significance, especially when considering their conservation status.

One sea snake was recorded during the survey, being captured on DDV footage at site 16, coming out of a goby hole. The snake could not be positively identified, but could potentially have been the Arabian Gulf sea snake *Hydrophis lapemoides* or Shaw's sea snake *Lapemis curtus*.

Sea snakes are specialised predators that use very potent venom to kill their prey. Having adapted to the marine environment, many species have lost their ability to move on land, although they still need to return to the surface to breathe. They generally preferring warmer, shallow waters but are also found in deeper areas of the Gulf. It is thought that many sea snakes spend the winter in the warmer waters of the southern Gulf, and move north for the summer; however, no detailed studies of sea snake migrations have yet been undertaken.

It is likely that several species of sea snakes visit the area frequently, although observations may be irregular as they are most regularly observed at night during winter. Although usually very placid and generally not problematic, marine contractors should be made aware of their presence and advised not to handle them due to their potential to envenomate.

5.7.3.7 Benthic Infauna

A total of 35 samples were collected for infauna analysis. The samples contained a total of 1,388 organisms, from at least 107 taxa, spanning 10 phyla (taxa is the term for the lowest taxonomic level for organisms which couldn't be identified to species). No rare, threatened, or endangered species of infauna were collected during the study.

Annelids were the most numerous phylum, although they were less dominant than typically found in samples from the UAE. Their diversity was considered to be fairly low. The most numerous family was Orbiniidae, of which most were thought to be of the genus Scoloplos (Figure 5-37). The numbers of Crustacea were moderate, although again diversity was relatively low. By far the most numerous Crustacean was Apseudidae (probably *Apseudes* sp.), a small shrimplike creature (Figure 5-37) only 3 to 4 mm long. Molluscs were well represented and reasonably diverse, including a single specimen of the gastropod *Oliva bulbosa* and *Cardiolucina semperiana* (Figure 5-38). Echinoderms were abundant but with only three taxa in total, very low in diversity. The remaining five phyla were Sipuncula, Cnidaria, Nematoda, Bryozoa and Chordata, which together accounted for just 5% of total abundance.

Figure 5-37 The polychaetes *Scoloplos* sp. (left); the Crustacean Apseudidae (right)

Figure 5-38 The molluscs: Oliva bulbosa (left); Cardiolucina semperiana (right)

No samples were afaunal and mean diversity indices (all samples combined) were considered moderately good. Only one sample (23) was considered to have especially poor diversity. None were thought to be particularly diverse, although two samples were considered species rich (24 and 26). The number of taxa per sample ranged from three to 30. Abundances were variable but largely in line with regional and depth expectations, ranging from four to 245 individuals per sample. There was little consistent correlation between diversity indices and benthic habitat.

Multivariate analysis of the infaunal community showed the samples fragmenting into 11 statistically distinct groups. These groups were not geographically linked and did not appear to correlate with benthic habitat, depth or any other obvious structuring factor, suggesting an irregular and discontinuous infaunal distribution.

Diversity indices were moderately good overall, with few samples considered either particularly rich or especially poor in terms of diversity, despite the relatively high level of anthropogenic activity in the area.

5.7.3.8 Phytoplankton

Phytoplankton are free-living, microscopic, photosynthetic organisms that live in the water column. They are the basis of many food webs and a fundamental component of any healthy marine ecosystem, however; excessive densities may be problematic for other biotic components of the environment. Phytoplankton are characterised by short life spans and fast turnover periods, which enable communities to rapidly take advantage of favourable conditions. Under certain conditions, they may reach excessively high densities, described as a bloom. A Harmful Algal Bloom (HAB) is an increase in phytoplankton abundance where the algae produce toxins and/or create conditions that are implicated in the deaths of fish and marine mammals. HAB events only occur when densities exceed a threshold; the presence of HAB species is not necessarily problematic, nonetheless, certain species are known to be toxic or been previously implicated in HAB events.

Eight phytoplankton samples were collected from across the study area. A total of 53 taxa spanning four phyla were identified. Phytoplankton diversity was relatively uniform across all sites, ranging from 30 – 36 taxa, except for site 36 (the offshore end of the navigation channel), which was notably less diverse with 19 taxa. Species were also assessed against the Intergovernmental Oceanographic Commission of UNESCO's Harmful Algal Bloom (HAB) database for species which have the potential to cause HABs (Table 5-23). Twelve toxic species were identified, comprising 43.1% of all phytoplankton recorded, with a further seven species considered potentially harmful, accounting for a further 32.4% of the phytoplankton. However, concentrations of toxic and harmful bacteria were well below the World Health Organisation guidance values (WHO, 1998), although the prevalence of these species shows considerable potential for a HAB events, should conditions become favourable. The presence of dormant HAB species algal cysts in the nearshore sediments of the dredge channel are also a cause for concern, and care should be taken to minimise sediment disturbance where possible.

Table 5-23 Harmful and toxic phytoplankton species recorded

Species	Toxicity	Effect	Density (cells/mL^{-1})
Oscillatoria sp.	Toxic	Produces toxins or acids	2,082
Pseudo-nitzchia multiseries			2,650
Pseudo-nitzschia australis			223
Prorocentrum sp.			1,586
Dinophysis sp.			16
Gonyaulax sp.			211
Protoperidinium sp.			500
Protoperidinium depressum			11
Protoperidinium divergens			4
Protoperidinium oceanicum			71
Protoperidinium steini			7
Akashiwa sanguinea			3
Coscinodiscus sp.	Harmful	Animal respiratory systems	1,096
Chaetoceros sp.			8,155
Chaetoceros coarctatus			1
Cylindrotheca closterium			279
Ceratium furca			469
Ceratium fusus			11
Ceratium horridum			17

Algal Cysts

In addition to the phytoplankton assessment, five sediment samples collected from the navigation channel route were analysed for dormant algal cysts. A total of seven species were identified (Table 5-24), of which five were listed as potential HAB species (IOC-UNESCO HAB, 2017). No cysts were found at the seaward end of the channel (site 2), but the number of species increased towards shore (Figure 5-39), where sediments tend to be more settled and stable. The total number of algal cysts followed a similar pattern, with the exception of site 8 (midway round the Palm) which contained considerably higher cyst densities, all of which were identified as HAB species (Figure 5-40).

Table 5-24 Algal cyst concentration (cysts / ml in processed samples)

Species	HAB species*	Site				
		2	5	8	14	16
Phrophacus harriologium	No					250
Protoperidinium sp.	No		750		750	500
Coolia sp.	Yes			250		
Gontaulacales	Yes				250	250
Peridinales	Yes			500	250	
Prorocentrum sp.	Yes			2250		250
Pyrodinium sp.	Yes				250	750
Total:		0	750	3000	1500	1750

* IOC-UNESCO HAB, 2017

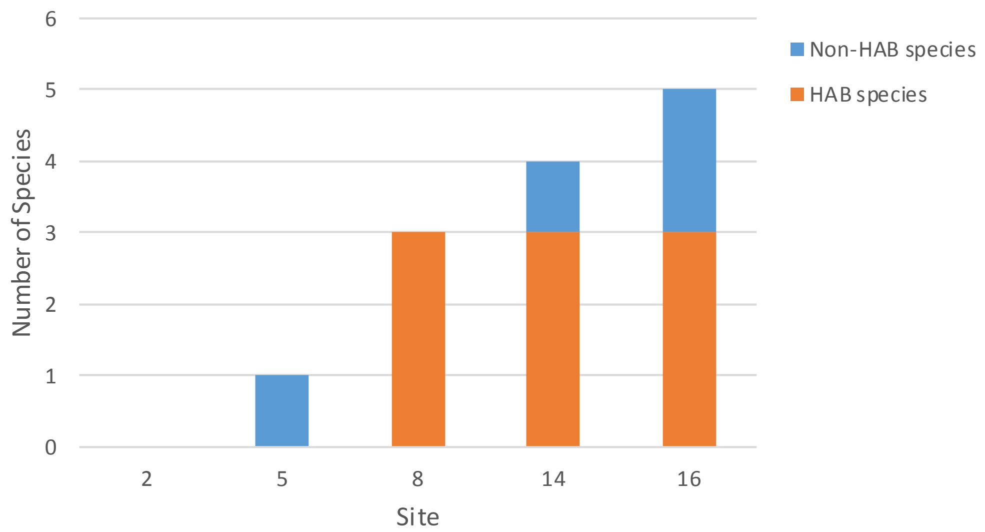


Figure 5-39 Number of Algal Cyst Species by Site

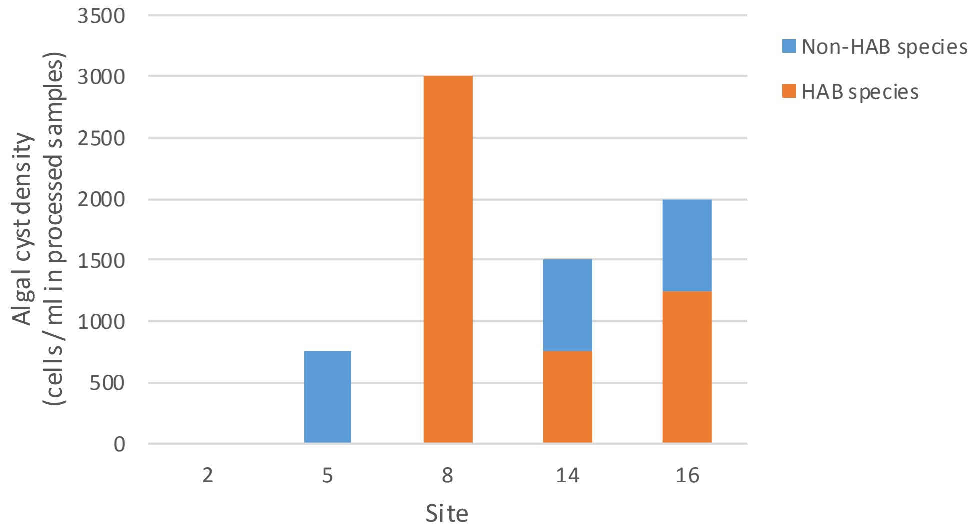


Figure 5-40 Algal Cyst Density by Site

5.7.3.9 Zooplankton

Zooplankton are one of the most important components of the marine ecosystem, containing a diverse array of species and playing a crucial role in energy transfer between the phytoplankton and the vast assemblages of marine food webs.

Eight samples were collected for of zooplankton analysis, which contained a total of 2,124 individuals spanning 32 taxa and nine phyla (Table 5-25). The total number of species represented is likely to be higher, as identification to species level is notoriously difficult. In comparison to other biological samples (for example infauna), zooplankton communities generally support relatively few taxa at very high abundances. The difficulty in identifying organisms to species level partially contributes to this, however; it is a largely natural phenomenon with samples potentially containing thousands of organisms of just a few key taxa. Notwithstanding such imbalances, diversity was considered low, with samples typically dominated by Calanoid Copepod (especially Acartia fossae and Temora turbinate). Arthropoda were the most abundant phylum by a considerable margin, accounting for 91.2% of total abundance. Within this phylum, Copepods were the most abundant and widespread group, and comprised 87.3% of all the arthropod individuals. Chordata was the second most abundant phylum with a total of 70 individuals (3.3%) from 3 taxa and was recorded at all sites except 8 and 24. The least abundant phyla, Cheatognatha and Echinodermata, each comprised just two individuals (0.09%) at site 36.

Site 36 (the offshore end of the navigation channel) contained the highest numbers of individuals (n=1,226) and the highest number of taxa (s=21). However, the sample was dominated by one species, the Calanoid Copepod *Acartia fossae*, which accounted for 77% of the sample and consequently returned a moderate Shannon-Weiner diversity index (H’=1.03). Site 5 contained the second highest number of taxa (s=12) and abundance (n=287), but was even more dominated by the same species, and retuned what was considered to be a poor Shannon-Weiner diversity index (H’=0.57). All other samples were considered moderately, although not excessively, poor in terms of zooplankton diversity.

There appeared to be a single, relatively homogenous community type across all sites, characterised by Calanoid Copepods. None of the samples were considered remarkable and overall zooplankton diversity was regarded as poor to modest.

Multivariate analysis found no significant difference in community structure across the study area, indicating the presence of a single homogenous community. While communities were reasonably consistent, zooplankton density was considerably higher offshore. Zooplankton are known to undergo significant diurnal migrations, and this density 'anomaly' at the furthest site may have been largely down to the time the sampling was collected.

Table 5-25 Taxonomic Breakdown of Zooplankton Results

Phylum / Sub-phylum	№ of taxa identified	% of total individuals
Chordata	3	3.2
Arthropoda	18	91.2
Annelida	2	0.3
Mollusca	2	0.5
Cheatognatha	1	0.09
Echinodermata	1	0.09
Cnidaria	3	0.5
Heliozoa	1	0.6
Foraminifera	1	0.6
TOTALS	**32**	**100**

5.8 Terrestrial Ecology

5.8.1 Overview

Located in the arid tropical zone extending across Asia and northern Africa, the UAE's major terrestrial habitat is sandy desert that supports varying amounts of sparse seasonal vegetation (WWF, 2017). The City of Dubai is characterised as a highly urbanised environment, where native vegetation and undisturbed environments are largely absent.

The Project site is largely comprised of marine habitat, with some natural and reclaimed terrestrial land. Native terrestrial fauna within the Project site is limited to bird life, which use nearby offshore islands and landscaped gardens on the mainland for feeding grounds and habitat.

Introduced terrestrial fauna species such as the adaptable five-striped palm squirrel (*Funambulus pennantii*), feral cats (*Felis catus*) and rats (*Rattus* sp.) may be present on the mainland, but are considered a pest species and likely to move out of any area under disturbance.

5.8.2 Methodology

Nautica Environmental Associates LLC (Nautica) undertook a survey of terrestrial fauna for the Project on 8 March 2017 (Nautica, 2017). Due to the absence of any other terrestrial flora or fauna, the survey focused on birds within and adjacent to the Project site.

The survey was undertaken by a visual assessment of birds from three areas within and adjacent to the Project site, namely Logo Island, the mainland and over water. Observations made during the survey included species identification, behaviour and number of individuals.

5.8.3 Results and Discussion

Approximately 500 individual birds representing 33 species were recorded during the survey. The number of bird species observed at Logo Island, at the mainland and over water were 15, 17 and 5 respectively. The Common Black-headed Gull dominates the population on Logo Island and over water, while the House Sparrow dominates the population on the mainland.

One IUCN Listed 'Vulnerable' species (Socotra Cormorant) and two 'Priority Bird Species' (Caspian Tern and Lesser Crested Tern) were observed during the survey. A summary of the survey results and conservation significance of observed species are presented in Table 5-26, while a discussion of the findings from each area is provided in the following sub-sections. A full description of the bird survey is provided in Appendix G.

Table 5-26 Summary of terrestrial ecology (bird) survey results (Nautica 2017)

Species	Number of Individuals Present			Conservation significance (IUCN and UAE)	Migratory / Movement Patterns
	LI	ML	OW		
Socotra Cormorant (*Phalacrocorx nigrogularis*)			1	Vulnerable (IUCN)	Migratory
Egyptian goose (*Alopochen aegyptiaca*)			2	Least Concern (IUCN)	Not migrantory[1]
Mallard (*Anas platyrhynchos*)	*			Least Concern (IUCN)	Migratory
Black-crowned Night Heron (*Nycticorax nycticorax*)		1		Least Concern (IUCN)	Migratory
Grey Heron (*Ardea cinerea*)	*			Least Concern (IUCN)	Migratory
Common Ringed Plover (*Charadrius hiaticula psammodroma*)	10			Least Concern (IUCN)	Migratory
Kentish Plover (*Charadrius alexandrinus*)	1			Least Concern (IUCN)	Migratory
Red-wattled Lapwing (*Hoplopterus indicus*)	2			Least Concern (IUCN)	Not migrantory[2]
Whimbrel (*Numenius phaeopus*)	2			Least Concern (IUCN)	Migratory
Common Sandpiper (*Actitis hypoleucos*)	1			Least Concern (IUCN)	Migratory
Common Black-headed Gull (*Chroicocephalus ridibundus*)	70	50	150	Least Concern (IUCN)	
Slender-billed Gull (*Larus genei*)	5		10	Least Concern (IUCN)	Migratory
Steppe Gull (*Laurs barabensis*)	^			Least Concern (IUCN)	

Species	Number of Individuals Present			Conservation significance (IUCN and UAE)	Migratory / Movement Patterns
	LI	ML	OW		
Armenian Gull (*Larus armenicus*)	1			Near Threatened (IUCN)	Migratory
Large White-headed Gulls (*Larus* sp.)			5	Least Concern (IUCN)	
Caspian Tern (*Hydroprogne caspia*)	2			Priority Bird Species (UAE) Least Concern (IUCN)	Migratory
Lesser Crested Tern (*Sterna bengalensis*)	1			Priority Bird Species (UAE) Least Concern (IUCN)	Migratory
Eurasian Collared Dove (*Streptopelia decaocto*)		4		Least Concern (IUCN)	Not migratory[2]
Laughing Dove (*Spilopelia senegalensis*)	2	10		Least Concern (IUCN)	Migratory
Rose-ringed Parakeet (*Psittacula krameri*)		1		Least Concern (IUCN)	Not migratory[1]
Pallid Swift (*Apus pallidus*)		10		Least Concern (IUCN)	Migratory
Eurasian Hoopoe (*Upupa epops*)		3		Least Concern (IUCN)	Migratory
Daurian Shrike (*Lanius isabellinus*)		1		Least Concern (IUCN)	Migratory
House Crow (*Corvus splendens*)	1	6		Least Concern (IUCN)	Not migratory[1]
White-eared Bulbul (*Pynconotus leucotis*)	1	20+		Least Concern (IUCN)	
Red-vented Bulbul (*Pynconotus cafer*)		1		Least Concern (IUCN)	
Pale Crag Martin (*Pytonopragne obsoleta*)		5		Least Concern (IUCN)	
Graceful Prinia (*Prinia gracilis*)		3		Least Concern (IUCN)	Not migratory[2]
Purple Sunbird (*Cinnyris asiaticus*)		4		Least Concern (IUCN)	Not migratory[2]
Common Mynah (*Acridotheres tristis*)		10+		Least Concern (IUCN)	Not migratory[1]
Pied Mynah (*Sturnus contra*)		1		Least Concern (IUCN)	

Species	Number of Individuals Present			Conservation significance (IUCN and UAE)	Migratory / Movement Patterns
	LI	ML	OW		
Desert Wheatear (*Oenanthe deserti*)	1			Least Concern (IUCN)	Migratory
House Sparrow (*Passer domesticus indicus*)	10	100's		Least Concern (IUCN)	Not migratory[2]

Notes:
LI – Logo Island
ML – Mainland
OW – Over Water
* Reported recently, not present on the date of the survey
^ Known to be a winter visitor, not present on the date of the survey
1 Introduced in the UAE
2 Native in the UAE

5.8.3.1 Logo Island

The current condition of Logo Island is highly disturbed and all birds present were observed resting on or near the shore. The most numerous species at Logo Island was the Common Black-headed Gull, which is a common, opportunistic species associated with human activity. This migratory species has a globally stable population and are most common in the UAE in the winter months.

Three 'Priority' listed birds (two Caspian Terns and one Lesser Crested Tern) were observed resting on Logo Island. Both species are priority listed because of the small number of breeding colonies in the UAE. Caspian Terns are present at a low density along the majority of the Gulf Coast of the UAE during most of the year and is a rare UAE breeding species. However, globally the species is not endangered and has a large breeding range. Lesser Crested Terns generally occur in flocks of hundreds, and it is unusual to see a singular species.

Logo Island was noted during the survey as serving as a temporary resting place for the following migratory birds; Common Ringed Plover, Whimbrel, Common Sandpiper, Desert Wheatear, Mallard and Grey Heron. None of these species are considered to be of conservation significance.

5.8.3.2 Mainland

The landscaped gardens onshore at Dubai Marina (i.e. Palm Island, Bluewaters Island and Skydive Dubai) support resident populations of several adaptable bird species and many migratory passerine species stop for short periods to rest and feed. These areas are too highly disturbed to support nesting or roosting, and are used primarily by opportunistic species such as Common Black-headed Gulls and House Crows.

The Black-Crowned Night Heron was sighted on the grounds of the Royal Mirage Hotel, which suggests a breeding colony is likely in mature trees beside the lakes within the grounds of the Royal Mirage Hotel or adjacent hotels. Breeding colonies of this species in the UAE are rare and it is estimated that only 1-5 breeding pairs occur in UAE, all of them in Dubai (Aspinall, 2010). This colony occurs outside of the Project area, but in proximity to the Project area.

The Daurian Shrike was the only species observed on the mainland that is not associated with cities, and was likely to be temporarily resting during migration. No conservation significant species were observed on the mainland.

5.8.3.3 Over Water

One conservation significant species (Socotra Cormorant) was observed over water within the Project area, which is listed as 'Vulnerable' on the IUCN Red List (IUCN, 2016). Breeding colonies of the Socotra Cormorant comprise a significant proportion of the global population; however, the nearest breeding colony occurs in Umm al Quwain, approximately 70 km north-west of the Project. It is likely that Socotra Cormorants commonly feed in Dubai waters, but they are not dependent on the Emirate or the city of Dubai for feeding grounds.

5.9 Traffic and Transport

The Project site is currently a marine environment and / or reclaimed land with no infrastructure; hence, there is no road traffic or other transport options existing within the site footprint. A summary of surrounding road, rail (metro / tram) and marine transport is provided below.

5.9.1 Road Transport

It is proposed that a secondary arterial road (three lanes in each direction) will provide access to the T-Island of Dubai Harbour (Zone 4) via King Salman bin Abdulaziz Al Saud Street (King Salman Street), formerly Al Sufouh Road. The Mall Area (Zone 3) will have a separate vehicular access point along King Salman Street. The Harbour Mall will also be accessible directly from the existing Al Emreet Street (Figure 5-41).

King Salman Street connects with Jumeirah Road leading into Jumeirah Beach Residences (JBR) and Dubai Marina and therefore consists mainly of local and through traffic. In addition to through traffic, the majority of road traffic travelling to and from the area around the Project site is generated by:

- DIMC;
- Visitors and employees of the hospitality outlets on King Salman Street (e.g. Le Meridien Mina Seyahi Beach Resort & Marina, The Westin Dubai, One & Only Royal Mirage);
- Employees at Dubai Media City;
- Residents of Dubai Marina and JBR;
- Visitors and employees in malls, shopping centres, doctors clinics and other commercial enterprises; and
- Tourism to attractions such as the hospitality outlets on King Salman Street (e.g. Le Meridien Mina Seyahi Beach Resort & Marina, Palm Jumeirah and The Walk at JBR), all of which are within a radius of 1 km of the Project site.

King Salman Street is accessible from the main arterial road of Dubai, Sheikh Zayed Road, via the D61 and from the exit for the Palm Jumeirah. This road provides a connection for visitors from the north and south of Dubai as well as from other Emirates including Abu Dhabi, Sharjah and Ras Al Khaimah. There are two main rush hours in Dubai during normal workdays (Sunday to Thursday); the first is from approximately 8 AM to 10 AM in the morning, and the second is from 5 PM to 8 PM in the evening, during which time the traffic can become extremely congested. These rush hour timings can be significantly extended by major events such as exhibitions, holidays or heavy rainfall.

5.9.2 Metro and Tram Lines

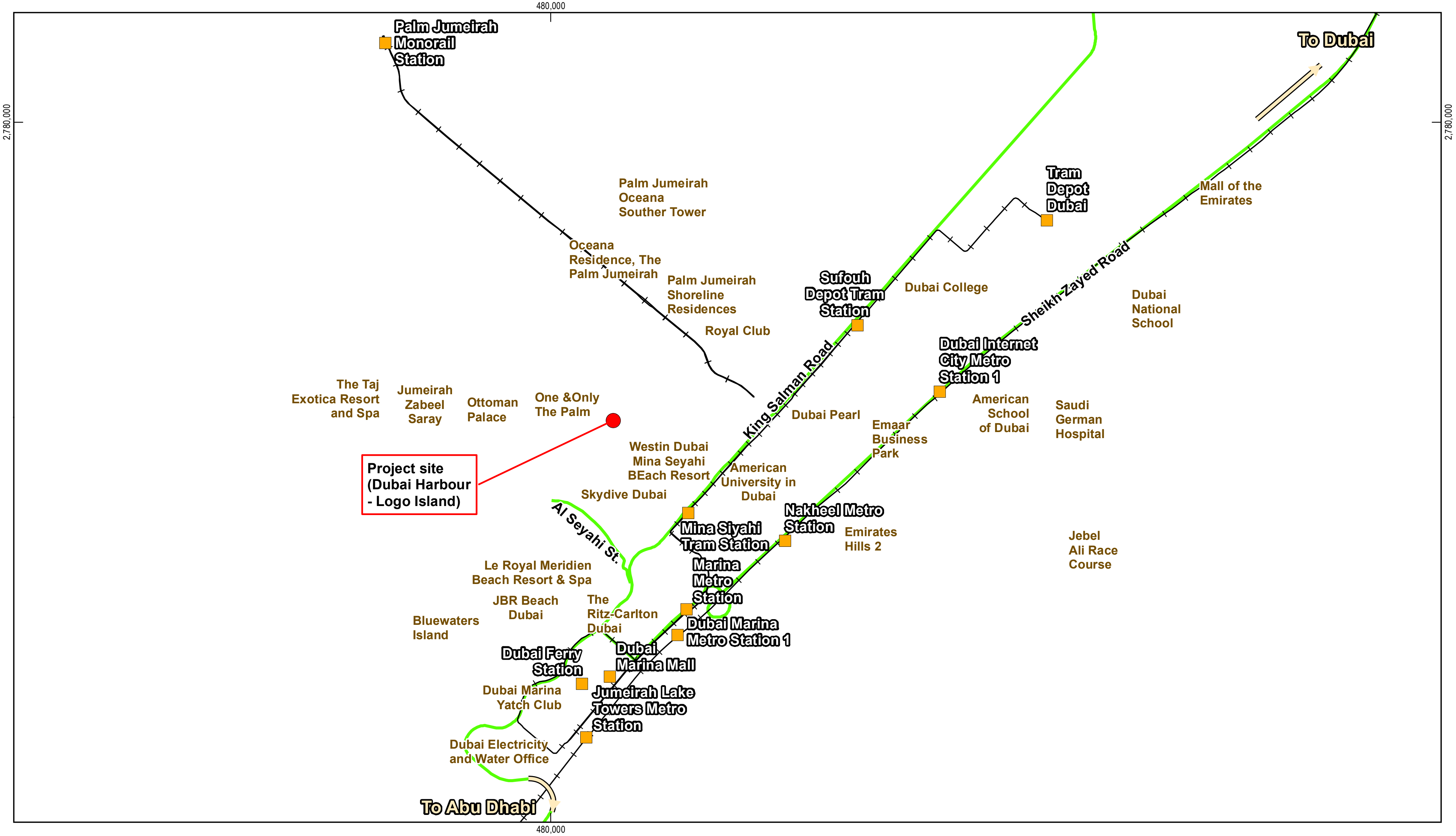
The Dubai Metro network comprises two lines namely the Red Line and the Green Line. The Red Line, which was completed on 28 April 2010, has 29 stations spanning 52 km and runs from Al Rashidiya to Jebel Ali. Most of its length travels along the Sheikh Zayed Road. The Green Line has 20 stations spanning 22.5 km and it runs through Deira and Bur Dubai, generally parallel to Dubai Creek. The nearest station from the Dubai Harbour is the Nakheel Metro Station on the Red Line alongside Sheikh Zayed Road.

The Dubai Tram, for which the first phase was completed in November 2014, forms a loop from and to Al Sufouh Depot. The Dubai Tram goes in one direction around JBR and Dubai Marina. The nearest Tram Station to the Project is the Mina Seyahi Station.

5.9.3 Marine Transport

There is also marine traffic that pass around the site. The composition of marine traffic is typically made up of private recreational motor boats, yachts and sailing vessels that either use the DIMC or marinas within the Dubai Marina Canal. One of the two openings of the Dubai Marina Canal towards the sea is near DIMC. The Dubai Ferry currently runs from four ferry terminals: Dubai Marina, Al Ghubaiba, Dubai Canal Station and Al Jadaf. The Dubai Ferry Station in Dubai Marina is located within 1 km of the Project site walking distance from Dubai Marina Mall. The Dubai Marina Ferry Station covers the following routes (Figure 5-42):

- Sightseeing circular route, which runs from Dubai Marina to Atlantis and back; and
- Dubai Marina Station / Al Ghubaiba Station route, which stops at the Dubai Canal Station.



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0 750 1,500

Meters

Map Projection: Transverse Mercator
Horizontal Datum: WGS 1984
Grid: WGS 1984 Dubai Local TM

N

LEGEND
- Project site
- Metro stations
- Route
- Railways

MERAAS Holding
Dubai Harbour EIA

Job Number	76-10664
Revision	0
Date	02 Jun 2017

Traffic and Transport around Dubai Harbour

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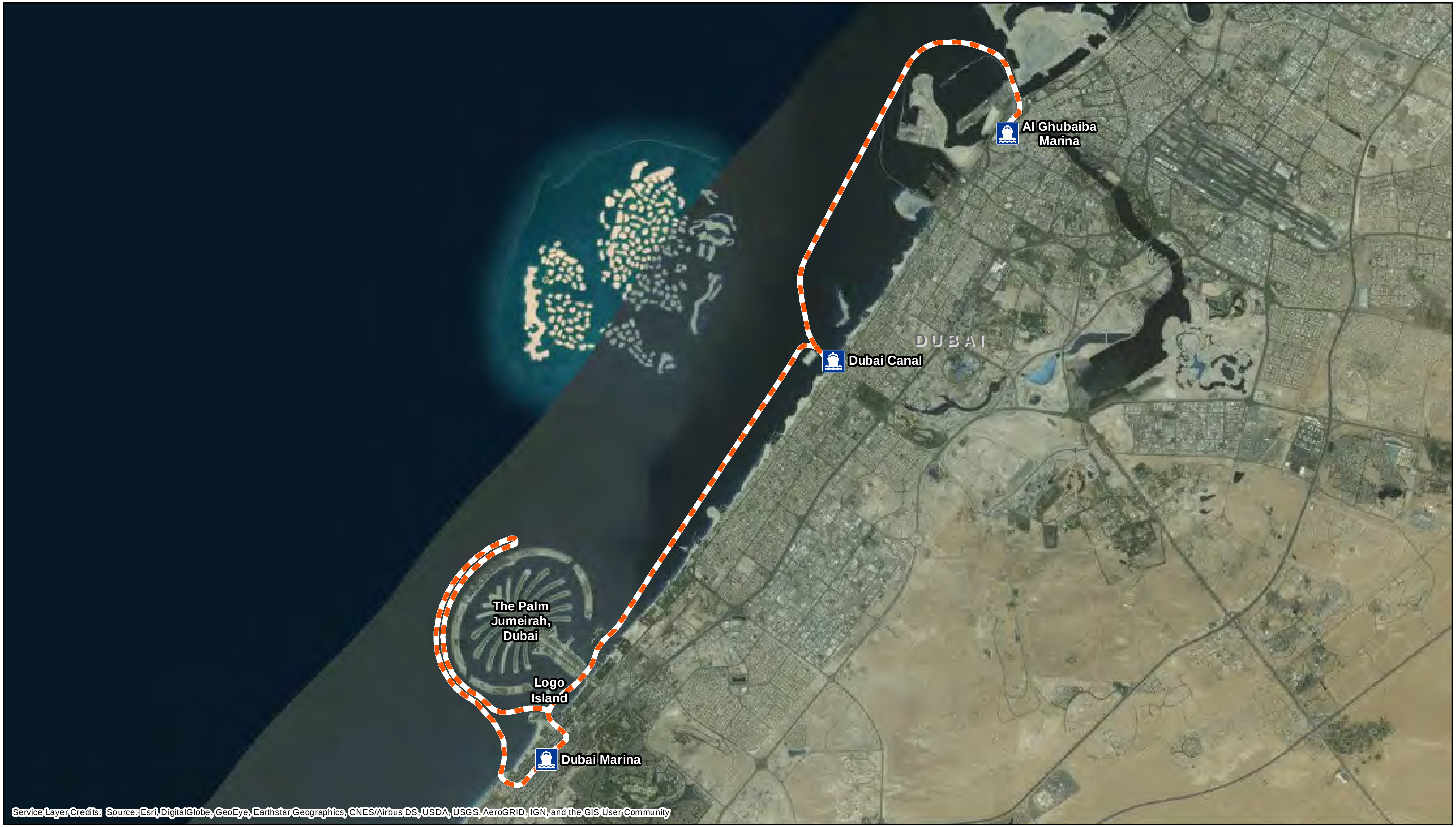
3rd floor Guardian Tower Danet Community Abu Dhabi United Arab Emirates W www.ghd.com

Data source: GHD - Project site, Metro stations - (2017). Image © Google Earth, Digital Globe. Natural Earth - Road. Created by:jcmatic



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Kilometers

Map Projection: Transverse Mercator
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Grid: WGS 1984 Dubai Local TM

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LEGEND

Ferry Stations

Ferry route

Meraas Development LLC
Dubai Harbour EIA

Job Number	76-10644
Revision	0
Date	07 Jun 2017

Dubai Marina Ferry Routes

Figure 5-42

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402, Al Masood Tower Airport Road, Deira T 971 4 294 9858 F 971 4 294 9740 E dbxmail@ghd.com W www.ghd.com.au

Data source: ESRI: Imagery, 2015. Created by: tmorton

5.10 Waste Management

5.10.1 Waste Generation

In 2016, the Dubai Statistics Centre (2016) reported that approximately 19.15 Mm^3 of solid waste was generated in the Emirate of Dubai, a significant increase of 32.8% compared to the waste generated in 2015. Of this, 78% was construction waste, which has increased by 41% compared to the total construction waste produced in 2015. Construction waste has increased on average by 43.5% per year over the past three years (2014-2016).

The daily domestic waste output in Dubai is 2.03 kg per person / day, based on the most recent data reported by DM (The National UAE, 2017). Statistics show that the daily generated domestic waste in Dubai reduced by 13% between 2014 and 2015 (Masudi, 2014).

The percentage distribution of collected solid waste in Dubai is provided in Table 5-27. Approximately 80% of the total sampling volume includes organics, paper and plastic. It is not clear whether the figures provided in the sample include construction and demolition waste.

Table 5-27 Percentage Distribution of Collected Solid Waste Components in Dubai

Type of waste	Percentage (%) of Sample			
	2016	2015	2014	2013
Organics	27	27.62	27	31.8
Paper carton	27	26.12	27	25.3
Metals	4	2.67	2	2.9
Plastics	26	24.96	26	23.9
Glass	3	3.4	4	4.6
Wood	2	1.71	2	1.6
Textiles	5	3.76	3	4.8
Sand and stones	3	5.38	5	1.6
Others	3	4.38	4	3.5
Total	**100**	**100**	**100**	**100**

Note: Percentages are result of Trial samples from solid waste and does not represent the total of collected waste.

Source: Dubai Statistics Center, 2016

5.10.2 Waste Management

The DM is the authority responsible for overall management of waste in the Emirate of Dubai. DM's waste management strategies and integrated approach for waste disposal to landfill are reportedly aimed at 25% by 2021 and 0% by 2030 (Dubai Municipality, 2016).

The municipality operates landfills at five different locations, the largest of which is located at Al Ghusais. Hazardous wastes are treated and disposed at the Jebel Ali Hazardous Waste Treatment Facility, which was inaugurated in 1999. In 2009, a medical waste incinerator was commissioned at the facility for the treatment of medical waste. The disposal of construction and demolition waste occurs at Al Bayada Disposal Site.

DM has entered into partnerships with a number of private companies for the collection, transport, segregation, recycling and treatment of various types of municipal wastes. According to DM (Nambiar, 2011) the efforts / approach of incorporating the 3Rs (Reduce, Reuse and Recycle) in the waste management system resulted in significant reduction of 20% of waste being sent to landfilling in 2011 compared to 2010. It does not appear that more recent data is available.

Clean Middle East (2013) reports the following waste management projects undertaken by DM:

- Contract with Tadweer Waste Treatment LLC for recycling of approximately 4000 tonnes of municipal solid waste per day;
- Contract with Emirates Recycling LLC for the construction of waste recovery and recycling plant which has the capacity of recycling 9.5 million tonnes per year of construction and demolition waste;
- Contract with Emirates Recycling for waste tyre recycling. The plant has the capacity of processing 1200 tyres per hour;
- Contract with Cycle to build and operate 30,000 tonnes per year capacity waste oil recycling facility; and
- Medical waste incinerator with the capacity of processing 19.2 tonnes per day.

DM has initiated a project wherein recycling bins are distributed to household areas to encourage residents to segregate their waste (Achkhanian, 2014). Part of DM's waste program is to provide every house with colour-coded waste bins (green for recyclables and black for general waste).

In June 2016, DM announced that it will establish the largest plant in the Middle East to convert solid waste into energy in Warsan District 2 in order to achieve the vision of making Dubai the most urban, sustainable and smart city by 2021 (WAM Emirates News Agency, 2016). The project is scheduled to be operational in the second quarter of 2020 during which it will receive 2000 metric tonnes of municipal solid waste per day to produce 60 MW of energy. The project is in line with the national agenda to reduce the landfill by 75% by 2021 and to minimise emissions of methane gas by the landfill.

5.11 Utilities

5.11.1 Power and Water Supply

Dubai Electricity and Water Authority (DEWA) is the service provider of electricity and water supply in the Emirate of Dubai. DEWA Sustainability Report (2015) stated that the existing capacity within the water and electrical generation system is sufficient to meet the demand with a reserved margin minimum of 15% (Figure 5-43). It reported that resources for future plant additions have already been identified and budgeted to meet forecasted demand until 2030.

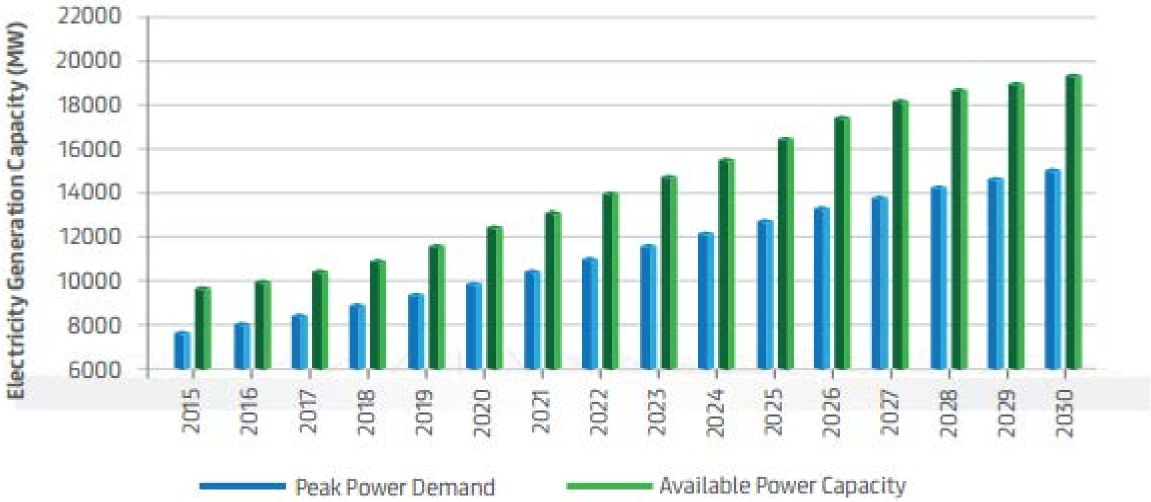


Figure 5-43 Peak Demand and Planned Capacity Additions

Source: DEWA Sustainability Report, 2015

DEWA has a number of power plants in Jebel Ali, Al Aweer, and Mohammed bin Rashid Al Maktoum Solar Park, located approximately 29 km east and 15 km north-east from the Project site respectively. The total installed capacity of the power plants is 10,000 Megawatts (MW), which is greater than the 2016 peak demand of 7982 MW (Figure 5-44). DEWA annual statistics for 2016 indicate that the annual average electricity consumption in 2016 was 43,093 Gigawatt hours (GWh), with the commercial sector reported as having the highest consumption of electricity, followed by residential areas (Figure 5-45). Energy consumption for the commercial sector has decreased by 0.37% over the past three years (2014-2016), while an increase of 0.32% is recorded for residential areas.

DEWA's desalination plants are located in Jebel Ali. The total installed desalination capacity available in Dubai is 470 million imperial gallons per day (MIGD) in addition to 32 MIGD from wells (Figure 5-46). Data shows that peak water demand increased by 2.96% (from 337 MIGD in 2015 to 347 MIGD in 2015). Residential areas consumed the most water in 2016 (60.72%) followed by commercial areas (26.57%) (Figure 5-47). Data indicates that water consumption in residential areas has increased by 3.68% since 2014, while consumption in commercial areas has decreased by 1.37% since 2014.

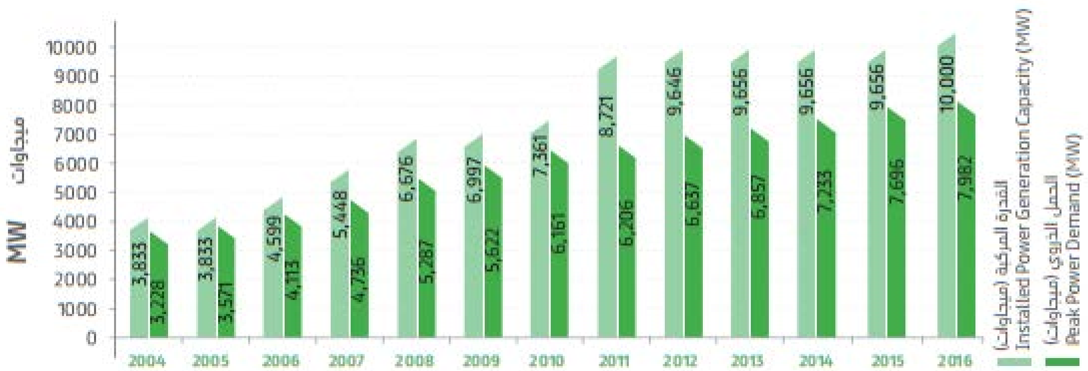


Figure 5-44 Power Installed Capacity and Peak Demand in the Emirate of Dubai

Source: DEWA Annual Statistics Report, 2016

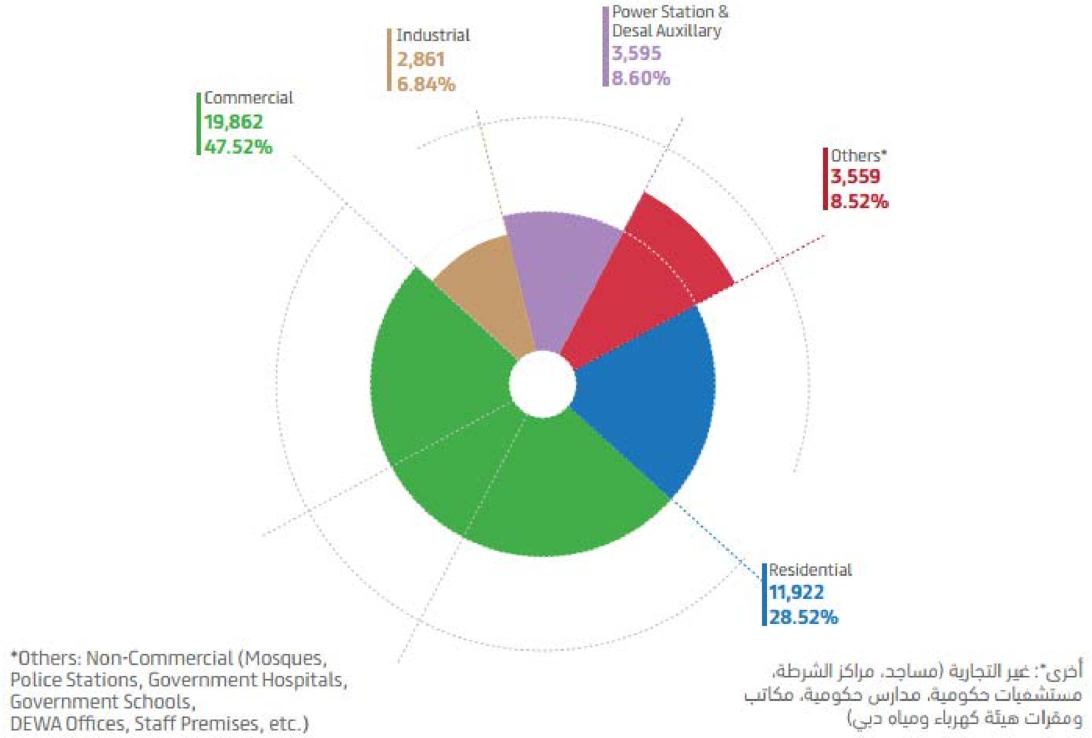


Figure 5-45 Electricity Consumption by Type of Consumer

Source: DEWA Annual Statistics Report, 2016

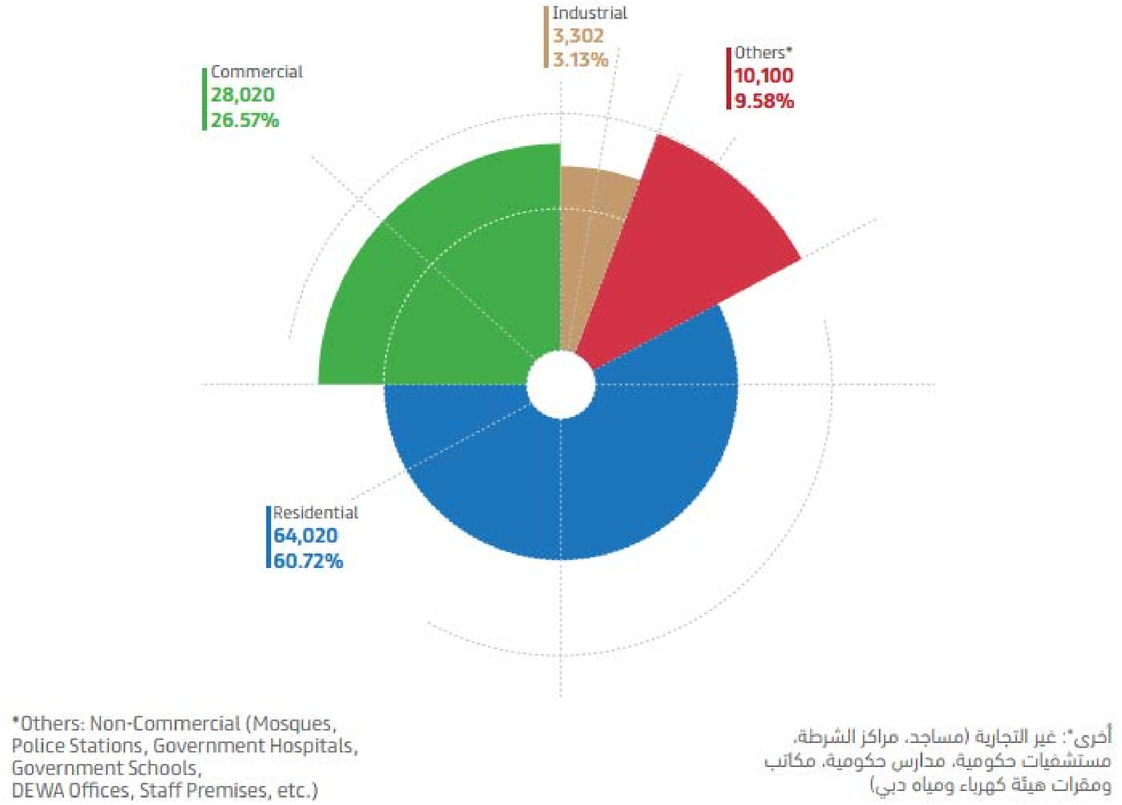


Figure 5-46 Desalination Capacity and Peak Water Demand in the Emirate of Dubai

Source: DEWA Annual Statistics Report, 2016

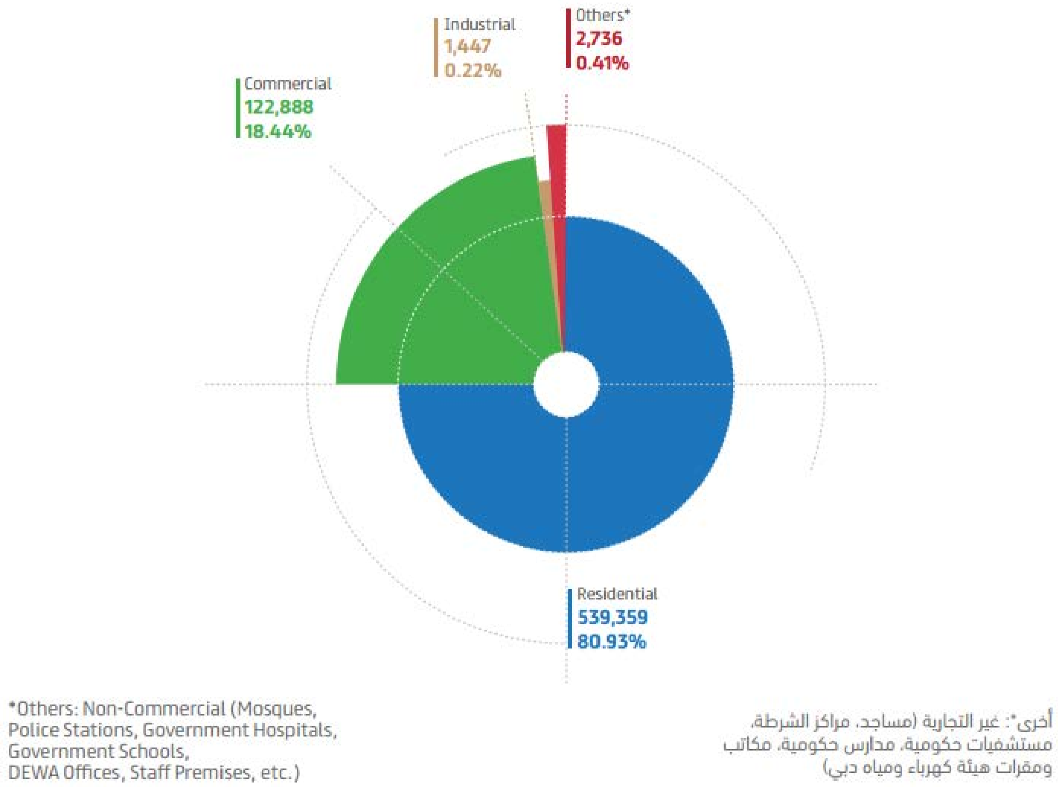


Figure 5-47 Water Consumption by Type of Customer

Source: DEWA Annual Statistics Report, 2016

The average water consumption in the UAE is reported to be 550 L/day per person, almost twice the international average of 170–300 L/day per person (Khaleej Times, 2016). According to the United Nations Environment Programme, the UAE has the world's third largest per capita consumption of water (Fisher, 2014). Water demand and scarcity was one of the three key issues raised by the United Nations Environment Programme report for the UAE (Fisher, 2014).

5.11.2 Sewage Treatment

DM operates the two main STP's in Dubai; namely the Al Aweer STP and the Jebel Ali STP, located approximately 29 km east and 30 km south of the Project site, respectively. Al Aweer STP has capacity to treat 260,000 m^3/day, with reports stating that a planned expansion will increase the plant's capacity to 325,000 m^3 /day as part of the DM strategic plan 2015-2021. The Jebel Ali STP has a sewage treatment capacity of 375,000 m^3/day, with reports stating that a planned expansion in six phases will increase the plant's capacity to 675,000 m^3 /day. While 19 percent of the work for Phase 2 has been completed since the start of the expansion in May 2017, there is no information available on the final completion date of all phases (Arabian Industry, 2017).

5.11.3 Landscape Irrigation Water Supply

Treated sewage effluent (TSE) generated from the DM's sewage treatment plants is largely used for irrigation purposes in Dubai. The quantity of treated drainage water and irrigation water as reported by DM is provided in Table 5-28. The source of landscape irrigation water for the Project will be TSE from the external DM network, subject to DM approval. The Dubai Statistics

Centre report (2016) indicates there is available TSE supply for any additional demand (e.g. Project demand, if needed).

Table 5-28 TSE Irrigation Supply and Consumption in Dubai (DSC, 2016)

Quantity (M m^3)	2013	2014	2015	2016
Treated water	199	212	231	248
Water used for irrigation	169	179	211	220

M m^3 – million cubic metres

Source: Dubai Statistics Center, 2016

5.12 Socio-Economic

5.12.1 Land Use

5.12.1.1 Surrounding Land Uses

The Project site is situated in close proximity to a number of commercial and hotel establishments including residential towers and villas (Figure 4-32). Key land uses noted in the surrounding area include the following:

- Palm Jumeirah adjacent to the northern boundary of the Project site. It consists of a number of hotels and resorts including Atlantis, Zaabeel Saray, Kempinski Hotel and Waldorf Astoria;
- Bluewaters Island to the southwest boundary of the Project site. This is an on-going island development, which will feature retail, residential, hospitality and entertainment zones including Ain Dubai, the world's largest observation wheel;
- Dubai Marina to the south of the Project site. An artificial canal city consisting of a number of residential towers, villas, commercial and retail establishments;
- Le Meridien Mina Seyahi Beach Resort & Marina, The Westin Dubai, One & Only Royal Mirage; and
- To the east of the Project site are the Dubai Internet City, Dubai Media City and the American University in Dubai.

5.12.1.2 Project Site Land Use

The proposed project site comprises the following areas, which will be linked to form a high-end mixed-used suburb:

- Skydive Dubai area;
- Dubai International Marine Club; and
- Logo Island.

5.12.2 Population and Demography

In 2015, the population of the Emirate of Dubai was approximately 2.4 million (Dubai Statistics Center, 2015). Around 80% of the population comprises expatriates while the remaining 20% are Emiratis. The Project site is located in Marsa Dubai (Al Mina Al Seyahi), which had a population of 35,005 at the end of 2015. The annual population growth rate from 2013 to 2015 was recorded at 5%, which indicated a decrease from the annual growth rate of 7% recorded between 2009 and 2010 (DED, 2016). The active day population comprises tourists, sailors, temporary residents and persons working in Dubai but living outside the city.

Based on data provided by Dubai Statistics Center (2015), the population in Dubai has the following associated demographics:

- At the end of 2015, Dubai's population consisted predominantly of males (69.62%). This is attributed to an influx of foreign workers consisting mostly of working-age males who are not accompanied by their family members;
- About 58% of the population is concentrated in the 25–44 age bracket, where the 30–34 age group has the highest number of individuals representing 17.75% of the total population;
- The total dependency ratio in 2015 was 20, which indicates that less than a quarter of the population in the Emirate comprise of children (aged under 15 years) or adults over 65 years; and
- The Project site is part of the Marsa Dubai Community, which had a reported population of 33,005 in 2015 equivalent to 1.35% of Dubai's population. At the end of 2016, Al Marsa had a reported population of 45,395 (Dubai Statistics Center, 2016a).

A breakdown of socio-demographic indicators in the Emirate of Dubai for the years 2013 to 2015 (DSC, 2015) is provided in Table 5-29. Economic indicators show that the majority of the workforce is male, while the education indicator shows a very high literacy rate and good health and living condition indicators.

Table 5-29 Socio-Demographic Indicators in the Emirate of Dubai

Indicators	2013	2014	2015
Economic indicators			
Males (population by thousands)	1579.1	1613.2	1703.4
Females (population by thousands)	634.7	714.2	743.3
% of Females in Labour Force (15+)	15.9	15.9	17.2
Refined economic activity rate for males	94.9	94.9	95.0
Refined economic activity rate for females	47.5	47.5	50.9
Unemployment rate for males	0.2	0.2	0.2
Unemployment rate for females	0.8	0.8	0.9
Educational indicators			
Literacy rate (15 years and above)	97.3	97.4	97.4
Illiteracy rate for males (15 years and above)	2.7	2.7	2.8
Illiteracy rate for females (15 years and above)	2.5	2.5	2.4
Health indicators			
Average number of doctors per 1000 population (excluding administrators)	3.7	3.0	3.6
Average number of beds per 1000 population	1.8	1.8	2.0

Indicators	2013	2014	2015
Number of hospitals	31	33	35
Living conditions			
% of households with access to potable water	100	100	100
% of households with access to electricity	100	100	100
% of households with access to sanitation facilities	100	100	100

5.12.3 Gross Domestic Product (GDP)

The Dubai Economic Profile (Department of Economic Development – Dubai (DED) 2016) shows that the Emirate of Dubai accounts for 30% of the UAE's total GDP. Since 2014, Dubai' GDP increased by 0.3% resulting in a growth rate of 4.1% in 2015 (DED, 2016). According to the Dubai Economic Profile (DED, 2015), the growth rate declined slightly in 2014 and 2015 compared with the previous two years (Table 5-30).

Table 5-30 Dubai GDP Growth Rate

Unit	2009	2010	2011	2012	2013	2014	2015
Annual growth, %	-2.7	3.5	3.4	4.4	4.6	3.8	4.1

In 2015, the wholesale, retail and repairing services sector (29.0%) has been contributing the most to Dubai's GDP followed by real estate and business services sector (15.0%). Transport, storage and communication (14.8%) came third, followed by financial corporations (11.7%), manufacturing activities (11.2%), hospitality (5.6%) and mining and quarrying activities (2.2%) (DED, 2016).

Real estate and business services were the fastest growing sector in 2015, which recorded a 1.7% increase. All sectors increased in their percent contribution in GDP with the exception of manufacturing and the transport, storage and communication services, both of which decreased in 2015 compared to 2014. Dubai's economic structure is provided in Table 5-31.

Table 5-31 Structure of Dubai's Economy

Sectors	Percent Contribution in GDP						
	2009	2010	2011	2012	2013	2014	2015
Wholesale, Retail and Repairing Services	29.9	30.1	30.9	30.3	29.2	28.9	29.0
Manufacturing Activity	12.3	13.1	14.2	15.4	13.7	13.8	11.2
Transport, Storage and Communication	13.3	14.1	14.0	14.4	14.8	15.5	14.8
Real Estate and Business Services	14.4	13.7	12.8	13.3	13.3	13.3	15.0
Financial Corporation Sector	11.3	11.3	11.7	11.2	11.2	11.1	11.7

Sectors	Percent Contribution in GDP						
	2009	2010	2011	2012	2013	2014	2015
Restaurants and Hotels	–	–	4.1	4.6	5.0	5.1	5.6
Mining and Quarrying Activity	1.9	1.7	1.5	1.5	1.4	1.3	2.2

Source: Dubai Economic Profile 2016

UAE Interact (2015) reported that the UAE government plans to increase the contribution of the non-oil sector to 80% of the nation's GDP from the present figure of 70% in the next 10 to 15 years. The government has a policy of economic diversification to reduce dependence on oil to the overall GDP of the country (UAE Interact, 2015).

The economic structure is further broken down by activity area in Table 5-32. This shows that the arts, entertainment and recreation sector only contributed 0.2% of economic activity in 2015 and construction activities contributed 6.8% of activity.

Table 5-32 Economic Activity Area

Economic Activity	Growth Rate (%)	2015		2014	
		Percentage Contribution	Value (Mill AED)	Percentage Contribution	Value (Mill AED)
Agriculture, forestry and fishing	3.0	0.1	475	0.1	461
Mining and quarrying	-3.0	1.8	6,699	2.0	6,904
Manufacturing	3.4	9.8	36,019	9.9	34,845
Electricity, gas, steam and air conditioning supply	5.7	2.4	8,882	2.4	8,406
Water supply; sewerage, waste management and remediation activities	2.1	0.0	103	0.0	101
Construction	0.9	6.8	24,925	7.0	24,698
Wholesale and retail trade; repair of motor vehicles and motorcycles	4.9	27.9	101,941	27.7	97,141
Transportation and storage	5.1	11.8	43,191	11.7	41,098
Accommodation and food service activities	8.0	4.4	16,150	4.3	14,949

Economic Activity	Growth Rate (%)	2015		2014	
		Percentage Contribution	Value (Mill AED)	Percentage Contribution	Value (Mill AED)
Information and communication	5.2	3.9	14,100	3.8	13,408
Financial and insurance activities	3.7	10.8	39,648	10.9	38,248
Real estate activities	3.5	6.3	23,106	6.4	22,327
Professional, scientific and technical activities	2.3	3.3	12,172	3.4	11,903
Administrative and support service activities	-0.3	2.5	9,187	2.6	9,219
Public administration and defence; compulsory social security	4.3	5.2	18,967	5.2	18,188
Education	9.5	0.6	2,302	0.6	2,101
Human health and social work activities	9.7	1.0	3,670	1.0	3,344
Arts, entertainment and recreation	7.3	0.2	820	0.2	764

Source: Dubai Statistics Centre 2015

6. Assessment of Environmental Impacts

6.1 Impact Assessment Overview

This section identifies and evaluates the environmental impacts of the construction (including early works / pre-construction) and operation of the proposed Project. The assessment of the impacts was based on the Project information provided by the Proponent and its consultants (Section 4) and the baseline conditions of the Project site and its vicinity (Section 5). The identification and assessment of impacts was performed through a process comprising on-site observations, field surveys for acquiring quantitative baseline data, literature review, consultation with DM and experience from similar projects. In addition, quantitative air, noise and coastal processes impact modelling was carried out for the construction and operational phases of the Project.

The degree of impact was classified into five levels (Extreme, High, Medium, Low and Negligible as per the methodology provided in Section 2.3.2), documented in this section along with the impacted parties and nature of the impact (i.e. negative or positive impact).

Where negative impacts are identified, mitigation measures are discussed to avoid or minimise the impact to an acceptable level (Section 7). Beneficial or positive effects of the proposed Project are also highlighted (Section 7).

The following aspects are examined for the potential impacts, detailed in the corresponding subsections of this section:

- Climate and meteorology;
- Air;
- Noise;
- Geology, Geomorphology and Seismicity
- Soils and Groundwater;
- Coastal Processes;
- Marine Ecosystem;
- Terrestrial Ecology
- Waste;
- Traffic and transport;
- Utilities; and
- Socio-economic.

6.2 Climate and Meteorology

6.2.1 Construction Phase

The construction of the Project will involve the following activities, which have associated GHG emissions:

- Use of fuel for the operation of construction equipment, plant, vehicles, tools, and support utilities (e.g. power generating units). The most common emission factors used in the construction industry indicate that 3.8 L of diesel, when combusted, can generate 10.15 kg of CO_2 while 3.8 L of gasoline can generate 8.86 kg of CO_2 (United States Environment Protection Agency - US EPA, 2009); and

- Generation of construction waste, which will require regular collection / transport and disposal to appropriate facilities. GHG emissions are associated with the use of fuel for the transport, treatment and/or recycling of wastes. Waste disposed of to landfill sites will contribute to the emission of methane (CH_4) gas, generated as waste decomposes in landfill sites.

Given the short-term, temporary and transient nature of construction, emissions generated during the Project construction phase are not expected to significantly increase the overall emission of GHG in Dubai. As such, impacts on local, regional and international climate change as a direct consequence of the construction activities are expected to be negligible.

The assessed impact level on the climate during construction phase (before implementing mitigation measures) is presented in Table 6-1:

Table 6-1 Potential unmitigated construction phase impacts on climate change and meteorology

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
GHG emissions from use of fuel for the operation of equipment, plant, tools and utilities (e.g. power plant)	Almost certain	Insignificant	**Low**	Workers and occupants on-site Surrounding communities	Negative
GHG emissions associated with construction waste transport and disposal to landfill	Almost certain	Insignificant	**Low**	Workers and occupants on-site Surrounding communities Occupants along the route for the waste transport and nearby landfill site	Negative
Use of construction / building materials with embodied energy	Likely	Minor	**Medium**	Workers and occupants on-site	Negative

6.2.2 Operation Phase

Similar to other mixed-used developed areas, the Dubai Harbour Project will require various utilities and maintenance activities that have associated GHG emissions that include the following:

- Consumption of electrical power generated from fossil fuel fired power plants (coal / gas), which generate significant GHG emissions;
- Consumption of potable water will generate increased emissions of GHGs. Potable water at the site will be sourced from DEWA's existing distribution network. The majority of potable water utilised in Dubai is sourced from Multi Stage Flash desalination of seawater. The DEWA desalination plant in Jebel Ali is powered by turbines driven by gas combustion. As such, significant volumes of GHG emissions will be associated with meeting water demands at the Project site during the operational phase;

- The Project is expected to generate significant volumes of vehicle trips to the site, especially during boat shows, sporting or other events. Although public transportation is considered in the traffic impact study, it is assumed that initially the majority of visitors and residents will access the site in private vehicles. The associated increase in road traffic, and potentially occasional traffic congestion on the existing road network, will generate emissions of CO_2, CO and nitrous oxides. Oxides of nitrogen chemically react with sunlight to produce ozone (O_3), another GHGs. The increased combustion emissions will directly increase the generation of ground-level ozone;
- The associated increase in marine traffic will also likely result in increased GHG combustion emissions;
- Refrigeration systems (i.e. for food sales) use large quantities of hydrofluorocarbons (HFC) refrigerants. Emissions of HFCs as a result of refrigerant use can be greater than the GHG emissions due to the system energy use (IPCC / Technology and Economic Assessment Panel, 2005);
- Vehicle traffic and back-up diesel generators are likely to generate the majority of GHG emissions within the Project site, however, the indirect impact of the Project on regional GHG emissions from power and desalination of water is expected to be greater; and
- Additional vehicle traffic generated by visitors, residents and services provision at the Project site will also contribute to a greater volume of GHG emissions in Dubai, which could contribute to climate change impacts such as global warming and sea level rise.

It is difficult to quantify the indirect contribution of the Project on regional and global GHG emissions as utility requirements, exact numbers of vehicle trips and volumes of HFCs that will be emitted are unknown. The consequences of climate change are also difficult to quantify due to the multitude of variables. However, sea level rise projections for the year 2100 were established in the Intergovernmental Panel on Climate Change Fifth Assessment Report. The projections were developed for four scenarios representing projections of a range of 21st century global climate policies. The scenarios are defined by approximate total radiative forcing in the year 2100 relative to 1750. Radiative forcing is the difference between the radiant energy received by the earth and reflected back into space (to which atmospheric GHG concentrations are a contributing factor) and therefore indicates the tendency for the earth's atmosphere to cool or heat. Scenario 1 includes one mitigation implemented as a global policy leading to a very low forcing level with a peak and decline by 2100, scenario 2 and 3 are two stabilization scenarios and scenario 4 is one with very high GHG emissions. The median model-based projections of global sea level rise for each scenario is presented in Table 6-2 for 50 years (2017 – 2067) and 100 years (2017-2117) from now (Sogreah, 2017a).

Table 6-2 Projected Global Mean Sea Level Rise (Median Estimates) over Design Lifetimes of 50 and 100 Years (Relative to 2017 Levels)

Scenario	Projected Global Mean Sea Level Rise Relative to 2017 Levels (m)	
	2067 (50 Years)	2117 (100 Years)
1	0.23	0.43
2	0.25	0.55
3	0.24	0.59
4	**0.32**	0.85

Adapted from Sogreah, (2017a)

The design life of the Project is 50 years and therefore, a conservative (worst case scenario) total sea level rise of 0.32 m is predicted. As such, the design and construction of the Project should allow for this increase as a minimum to prevent significant environmental impacts associated with flooding of the site, including loss of infrastructure and personal and business economic losses as well as the potential for contamination of the marine environment.

The assessed impact level on climate during operation phase (before implementing mitigation measures) is presented in Table 6-3.

Table 6-3 Potential unmitigated operation phase impacts on climate change and meteorology

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
GHG emissions (indirect) as a result of electricity and water consumption	Almost certain	Moderate	**High**	Contribution to global climate change causing potential sea level rise.	Negative
Use of materials for operation and maintenance with embodied energy	Likely	Minor	**Medium**	Residents and occupants on site and in vicinity to the relative material production, manufacturing and transport	Negative
GHG emissions from use of fuel for vehicles	Almost certain	Minor	**Medium**	Workers and occupants on-site Surrounding communities	Negative
GHG emissions from use of fuel for marine vessels	Almost certain	Insignificant	**Low**	Workers and occupants on-site Surrounding communities	Negative
GHG emissions associated with waste transport and disposal to landfill	Almost certain	Minor	**Medium**	Workers and occupants on-site Surrounding communities Occupants along the route for the waste transport and nearby landfill site	Negative

6.3 Air Quality

6.3.1 Construction Phase

The construction of the proposed Project will be performed in three distinct phases:

- Early works – demolition works and construction of temporary causeway;
- Marine works – reclamation of the four zones inclusive of installation of rock revetment; and

- Infrastructure works – construction of infrastructure and structures in the four zones.

The proposed Project will not include the development of any major stationary air emission sources on-site (e.g. stack emissions from industrial sources). During the construction phase, the key air quality impact is likely to be associated with the generation of airborne dust as a result of the following activities:

- Earthworks (excavations, grading, bulldozing and compaction);
- Demolition works and wind erosion of unpaved surfaces and stockpiles; and
- Rock and fill materials transfer and haulage.

In addition to dust re-suspension and emissions, the following gaseous emissions are anticipated during construction:

- Combustion gases from powered plant, construction equipment and vehicles accessing and working on-site (e.g. N, CO_2, H_2O, O_2, NOx, CO, PM, HC, SO_2);
- Volatile organic compounds (VOCs) emitted from chemicals used on-site; and
- Odour from sanitary and temporary waste disposal facilities on site.

The key air sensitive receptors during the construction phase are likely to include the workers and visitors to the site as well as residents and tourists of the residential and commercial areas adjacent to the Project site. Further details on the potential impact for each emission type is provided below.

6.3.1.1 Fugitive Dust Emissions

Construction activities including earthworks, stockpiling and transport of fine materials will generate airborne dust particulates. In the event that mitigation measures are not implemented, dust levels could be increased to levels significantly above the guideline limit, resulting in a nuisance and potential detrimental health impacts to local residents and visitors. Fugitive dust emissions can cause a range of impacts, which vary depending upon the size and composition (concentrations of metals, chemicals, minerals or biohazards) of the dust particles. One of the key concerns is human health, with elevated dust levels recorded to increase the likelihood of respiratory diseases such as asthma, which is common in the UAE (Mahboub *et. al*., 2012). Other affects include irritation of the eyes, which can also affect fauna. Taking into consideration the prevailing wind direction, the closest sensitive receptors likely to be affect by dust emissions are within 1 km from the Project Site and separated by the sea. These include the Westin Dubai, Mina Seyahi Beach Resort and One and Only, Royal Mirage, both located along the King Salman Street.

While the dust concentrations remained within guideline limits at all sample locations during the baseline survey, it is anticipated that dust levels will vary substantially from day to day depending on the level of activity, the specific operations, and the prevailing meteorological conditions. It is acknowledged that the ambient dust concentrations can vary greatly in Dubai depending on the prevalent meteorological conditions, with sand storms resulting in concentrations above the guidelines relatively frequently. Given the high moisture content of fill material, the reclamation works are unlikely to generate significant quantities of airborne dust. However, there will be generation of airborne dust during the construction of the revetments and during earthworks associated with construction of buildings and infrastructure.

Fugitive dust is also likely to be deposited into marine waters, increasing the total suspended solids and turbidity. Changes in water quality could directly impact on sensitive receptors in the marine environment, which is discussed further in Section 6.8.

6.3.1.2 Gases and Particulate Matter Emission

During baseline surveys, slightly higher levels of SO_2 were recorded at AN4 compared to other stations. Taking into consideration the north-westerly prevailing winds, it is likely that the vessels emission within DIMC could have contributed to the SO_2 levels. In a study on the effects ship emissions have on ambient air quality, the main evidence indicated that ship emissions influenced SO_2 concentrations more than any other pollutants analyzed (Prati et. al., 2015).

As described in Section 4.6.3.4, a range of marine vessels and land based construction machinery and equipment are required for the construction of the Project, with associated gases and particulate matter emissions. To enable semi-quantitative assessment of the air quality impact of the Project, a gas emission inventory for reclamation work and earthworks during a peak year of construction was compiled. Given that marine and land contractors had not been appointed at the time of preparing the EIA, emissions were estimated based on a project of similar nature in Dubai, La Mer Development. Table 6-4 details the sources from which the emission factors were obtained, while the estimated emissions inventories for reclamation and infrastructure works are provided in the following sub- sections, respectively.

Table 6-4 Source of Emission Factors

Phase / Equipment Type	Source of Emission Factors
Maritime equipment for the reclamation of two peninsulas	Methods for Estimating Atmospheric Emissions from E&P Operations, Report No. 2.59/197 (The Oil Industry International Exploration & Production Forum, 1994)
Construction equipment for site infrastructure and buildings	US EPA Non-road Engine and Vehicle Emission Study (NEVES), Report EPA-21A-2001 (US EPA, 1991)

Reclamation Works Emission Inventory

The emission inventory based on 1,000 tonnes of diesel fuel used per year is provided in Table 6-5.

Table 6-5 Annual Marine Vessel Emission Inventory

Gas	Emission Factor (Tonne Emission / Tonne Fuel)	Emission (Tonne / Year)
Sulphur dioxide *(Note)*	0.1	100
Carbon monoxide	0.008	8
Carbon dioxide	3.2	3,200*
Nitrogen oxide	0.059	59
Volatile organic compounds	0.0024	2.4

Note: The sulphur content is assumed 0.5% by weight.

*A car generates 4.73 tons CO_2 per year (EPA, 2014).

Exhaust emissions from marine vessel operations are unlikely to result in a significant impact on local air quality given the mobile nature of the equipment (IAQM, 2012). Marine vessels are required to conform to the ship pollution rules specified in the “International Convention on the Prevention of Pollution from Ships”, known as MARPOL 73/78 (IMO, 2013). As such, a significant long-term negative impact on local or regional air quality as a result of emissions from marine vessels is unlikely. Moreover, given the temporary and mobile nature of the equipment, exhaust emissions from marine vessels operations are unlikely to result in a significant impact on local air quality during construction.

Infrastructure and Building Construction Emission Inventory

The emission inventory of non-road vehicles and equipment for a peak year (operating 12 hours per day, 365 days a year) is provided in Table 6-6 (based on the equipment list, quantity and emission factors from La Mer provided in Appendix H). This inventory includes earthmoving activities associated with land preparation/clearance.

Table 6-6 Non-Road Vehicles and Equipment Emissions Inventory for the Construction of Infrastructure and Buildings

Carbon Monoxide	Carbon Dioxide	Hydrocarbon	Nitrogen Oxide	Sulphur Oxide	Particulate Matter	PM_{10}
Tonne / Peak Year						
195	60020	44	422	37	47	33

During construction, transportation to and from site of construction workers, engineers and contractors are expected on a daily basis in addition to trips related to the delivery of materials and equipment. The IAQM Technical Guidance on the Assessment of the Impacts of Construction on Air Quality and the Determination of their Significance (IAQM, 2012) suggests that exhaust emissions are unlikely to make a significant impact on local air quality given the temporary and mobile nature of the works and equipment.

6.3.1.3 VOC Emissions

The use, storage and waste products of chemicals will result in the emission of volatile organic compounds (VOCs), although appropriate management of the chemicals and waste storage areas will minimise VOCs emissions significantly. Exposure to VOCs without appropriate mitigation measures in place can result in significant health impacts such as respiratory and skin diseases. .

6.3.1.4 Odour Emissions

Poor management of sanitary and waste disposal facilities (e.g. septic tanks, putrescible waste bins) may result in odour causing a nuisance to people on or near the Project site. Good housekeeping, regular inspections and maintenance of waste disposal, transfer and storage facilities will minimise the risk of odour release. In addition, dredged material of poor quality may cause odour emissions during reclamation activities. Sediments will undergo analysis and only sediments of appropriate quality will be used. Contaminated sediments will be disposed of appropriately.

6.3.1.5 Summary

Localised increases in airborne particulates are anticipated as a result of the construction works. In the absence of mitigation measures, dust levels would be expected to be elevated at sensitive receptors. Negative impacts associated with minor increases in combustion gas and VOC emissions are unlikely to generate significant long-term local or regional changes in ambient air quality. Similarly, it is not anticipated that there will be significant issues associated with odour during the construction phase.

The impact level on air quality during Project construction phase (before implementing mitigation measures) is presented in Table 6-7.

Table 6-7 Potential unmitigated construction phase impacts on air quality

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Fugitive dust emission from site development / earthmoving works and wind erosion on unpaved surfaces	Almost certain	Moderate	High	Workers / staff and visitors on-site Occupants of surrounding residential and commercial areas	Negative
Deposition of dust to the marine environment	Almost certain	Minor	Medium	Marine community	Negative
Emission of exhaust gases from the operation of equipment, vessels, plant, tools and utilities using fuel	Almost certain	Insignificant	Low	Workers / staff and visitors on-site Occupants of surrounding residential and commercial areas	Negative
VOC emissions	Likely	Insignificant	Low	Workers / staff and visitors on-site Occupants of surrounding residential and commercial areas	Negative
Odour emission from sanitary and waste disposal facilities, and poor quality dredged material	Likely	Insignificant	Low	Workers / staff and visitors on-site Occupants of surrounding residential and commercial areas	Negative

6.3.2 Operation Phase

The key mobile and stationary sources of air emissions during the operational phase are likely to be associated with traffic (land and marine) and oil mist from catering kitchens. Minor emission sources (odour) could occur from leaks in the sewerage network and from waste management facilities on-site.

6.3.2.1 Fugitive Emissions

Areas consisting of unconsolidated sand, with the exception of beaches, will be paved or landscaped to reduce soil erosion by wind and dust generation.

6.3.2.2 Exhaust Gas and Particulate from Road and Marine Traffic

The Project is anticipated to generate significant volumes of vehicle trips to the site with an estimated 45,000 residents, in addition to visitors and employees travelling to and from the site on a daily basis. The Traffic Impact Study (TIS) is being undertaken and various modes of public transportation (e.g. monorail, tram, metro and boat) are being incorporated into the design of the Project to reduce the traffic impact and the associated impacts to air. However, it is anticipated that a number of visitors and residents will still access the site via motor vehicle. The associated increase in road traffic and potential increase in intermittent congestion on the road network will generate emissions of nitrogen dioxide, particulate matter, carbon monoxide and carbon dioxide and trace levels of sulphur dioxide. The increase in combustion emissions will directly increase the generation of ground level ozone.

Regarding marine traffic, the proposed development of a 1400 berth marina (including superyachts) will result in increased gaseous and particulate emissions associated with an increase in marine traffic. Oceangoing vessels (OGV) are powered predominantly by large compression-ignition engines that emit extremely high levels of particulate matter, sulphur oxides and nitrogen oxides (Natural Resources Defence Council, 2014). Bunker fuels are used by OGVs to provide propulsion, heat and electricity. After combustion in the engines, sulphur in marine fuel converts into sulphur dioxide and a small portion is oxidized to sulphur trioxide that leads to sulphuric acid and sulphate aerosols being emitted as direct particulate matter emissions (Natural Resources Defence Council, 2014). As a member of the International Maritime Organization, the UAE ratified and enforces the environmental regulations on international shipping through the International Convention for the Prevention of Maritime Pollution from Ships (MARPOL), including Annex VI of the Convention that specifically deals with the prevention of air pollution from vessels.

Long term exposure to air pollutants may potentially impact human health (primarily associated with respiratory diseases), vegetation and the marine ecosystem.

6.3.2.3 VOC Emissions

The storage of chemicals for vessel cleaning purposes and the use of chemicals such as vapour degreasers will result in the emission of VOCs during operation. Specific non-hazardous chemicals will be chosen or methods to minimize the toxic air emissions will be implemented as well as storage and management measures to mitigate the impact of emissions. As such, significant health impacts (e.g. respiratory or skin diseases) associated with exposure to VOC are not anticipated.

6.3.2.4 Oil Mist from Catering Kitchens

Oil mist emitted from catering kitchens is a potential nuisance to site employees, visitors and residents. In addition, the thermal and oxidative decomposition products (produced during the stir-frying or deep fat frying of foods in various seed oils) may contain toxic components[2] such as carcinogens (OSHA, 2014). The associated impacts are considered negligible if effective oil mist facilities are installed in kitchens.

6.3.2.5 Odour from Sewage Network and Waste Management Facilities

Odour emissions resulting from poor management of sanitary and waste disposal facilities (e.g. septic tanks, putrescible waste bins) may cause nuisance to occupants on-site and immediately surrounding the Project site. Odour emissions may also occur in the event of leaked sewage. Use of substandard TSE also has the potential to generate odour causing nuisance to occupants on-site and immediately surrounding the Project site. Monitors should be installed in the sewerage and TSE network to detect pressure in the system and provide immediate alert in the event of a leak. The impact is expected to be minimal should inspection and maintenance of the facilities be implemented appropriately.

6.3.2.6 Summary

The assessed impact level on air quality during Project operation phase (before implementing mitigation measures) is presented in Table 6-8.

[2] https://www.osha.gov/dts/chemicalsampling/data/CH_275150.html

Table 6-8 Potential unmitigated operation phase impacts on air quality

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Exhaust gases and particulates emitted from road and marine traffic	Almost certain	Minor	**Medium**	Residents, visitors and occupants of the Project site and surrounding residential and commercial areas	Negative
Oil mist emitted from catering kitchens	Almost certain	Minor	**Medium**	Residents, visitors and occupants on the Project site and surrounding residential and commercial areas	Negative
Odour emission from leaked sewage pipes and waste management facilities	Likely	Minor	**Medium**	Residents, visitors and occupants on the Project site	Negative
Use of chlorinated solvent vapour degreasers	Unlikely	Minor	**Low**	Residents, visitors and occupants on the Project site	Negative

6.4 Noise

6.4.1 Construction Phase

The major sources of noise during the construction phase of the project are expected to be from a range of earthmoving equipment, construction plant and shore piling operations. Such equipment will operate either simultaneously or sequentially across the construction site. Noise will also be generated by vehicles accessing the site during delivery and collection of construction materials and wastes as well as transporting employees and visitors to and from the Project site.

The increase in noise levels without appropriate noise abatement and management measures is likely to create adverse impact at the nearby noise sensitive receptors. The noise sensitive receptors include the occupants of the Project site, marine fauna as well as residents and visitors at the adjacent residential and commercial areas.

To evaluate the noise impact of construction, noise modelling was performed. The modelling methodology and results are provided in the sub-sections below.

6.4.1.1 Noise Modelling Methodology

A construction noise modelling assessment was undertaken by WKC using SoundPLAN for two Project construction phases. The propagation methodology adopted within SoundPLAN is the *ISO 9613 'Acoustics – Attenuation of Sound During Propagation Outdoors'.*

Construction equipment was integrated into the noise model as a large area source spread across the Project site where construction activities will take place. The project area has been separated into land and marine works, which may overlap in some areas due to the changing landscape with dredging and land reclamation activities.

The noise assessment of the Project has been undertaken for two scenarios representative of the anticipated loudest construction phases of the Project, comprising:

- Scenario 1 – Piles on deck platforms; and
- Scenario 2 – Land reclamation.

The Project noise contribution was assessed in isolation and cumulatively with existing baseline noise levels as measured during the baseline survey (described in Section 5.3). Predicted noise levels were extracted from the model at the same six locations at those monitored during the baseline survey as they represent the nearest noise sensitive receptor areas from the Project. The calculated Project construction noise levels were added to the existing background noise levels in order to carry out the cumulative noise level assessment. The cumulative noise levels have been assessed against the noise limits stipulated by the UAE Federal Environment Agency in context of the allowable incremental noise levels stipulated in the *Technical Guideline Number 9 – Requirements for the Reduction of Construction and Demolition Noise*. Where daytime baseline noise levels already exceed the UAE Federal Environment Agency limit of 60 dB(A) (N2, N4 and N5), the results were compared against the allowable noise level increase according to *Technical Guideline Number 9,* which allows an incremental increase in a sliding scale, depending on the recorded baseline value. This incremental guideline value has been provided within the results section for reference.

Precise details of the construction schedule or equipment requirements are not yet finalised; however, the assessment was conducted based on assumed equipment types and numbers based on previous similar projects (La Mer). It was assumed that during any one phase of construction, as a worst case assessment, all equipment items will be operating at the same time. The assumed construction equipment list for the various phases of construction is detailed in Table 5-1 of the Noise Modelling Report (Appendix I).

The following assumptions have been made for the modelling assessment, and wherever possible, a conservative approach has been taken:

- Noise sources have been modelled as an area source at a standard height of 1.5 m;
- Ground absorption has been modelled as hard (having an absorption coefficient of 0) to maintain a conservative assessment;
- The topography between noise source and the receptors is flat (in reality, the topography may undulate leading to attenuation of noise);
- Reasonable worst case meteorological conditions have been applied, i.e. steady wind conditions blowing in each direction. An average temperature of 25 °C and 70 percent humidity has been assumed for the Project.

6.4.1.2 Noise Modelling Results

The results of the daytime and night time isolated and cumulative noise assessments for each of the two scenarios are detailed in Table 6-9 and Table 6-10, respectively. The results show that under Scenario 1 (piling), the isolated project noise level contribution would not result in any exceedance to the day time guideline of 60 dB. However, should the full construction works be undertaken through the night, then night time limits would be exceeded at sites N1, N4, N5 and N6. For Scenario 2 (land reclamation), the project noise contribution would exceed night time limits at all sites and day time limits at sites N1, N4 and N5, although N4 would be within the incremental guideline limits.

For cumulative day and night time noise levels (existing baseline plus predicted construction levels), all sites under Scenario 1 are predicted to be within guideline limits, while all sites except N1 and N5 are within guideline limits for Scenario 2. The highest predicted noise levels for both day time and night time were at the DIMC breakwaters location, with cumulative values of up to 67.6 dB(A) predicted. It should be noted that while the majority of locations were predicted to be within incremental noise limits, all sites are predicted to exceed the UAE Federal Environment Agency night time noise level limit of 50 dB(A). Given that the sensitive receptors in the area are already experiencing noise levels above the guideline limit, they may have adjusted to the higher noise levels to an extent. However, detrimental impacts including sleep disturbance and potential health issues including minor hearing loss (from continuous levels of increased noise) could occur.

It must be noted that the assessment conservatively considered all construction equipment operating across the Project site simultaneously, and that the assessment predicts somewhat conservative noise levels, especially during the night time period when the construction activities are anticipated to be reduced. The implementation of construction noise mitigation measures (Section 7.3.1) is recommended in order reduce the anticipated construction noise impact at the nearest noise receptors.

Table 6-9 Construction Noise Assessment – Day-time Cumulative Noise Level Assessment, dB(A)

ID	Description	Background Noise Level L_{Aeq} (summary of all sample dates)	Allowable limit - UAE Federal Environment Agency with Incremental increase (*Technical Guideline Number 9*)	Daytime Noise Levels			
				Scenario 1 Isolated Contribution	**Scenario 1 Cumulative Noise Level**	**Scenario 2 Isolated Contribution**	**Scenario 2 Cumulative Noise Level**
N1	Southwest of Palm Jumeirah and north of Project site near residential buildings and hotels	55.8	60	57.2	58.2	66.0	66.1
N2	Eastern boundary of the Project on the southern part of Palm Jumeirah	62.8	66.8	48.5	60.3	58.4	62.3
N3	Southern boundary of the Project on Jumeirah Beach near retail and hotels	58.7	60	48.0	54.0	56.3	57.9
N4	Southwest of the project near public beaches and hotels	60.1	64.1	54.0	61.0	61.7	63.9
N5	DIMC breakwaters	61.6	65.6	55.9	61.4	66.8	67.6
N6	Jumeirah Beach Residence near retail, restaurants, residential towers and public beach	56	60	51.1	55.3	59.0	60.0

Table 6-10 Construction Noise Assessment – Night time Cumulative Noise Level Assessment, dB(A)

ID	Description	Background Noise Level (L_{Aeq}) (summary of all sample dates)	Allowable limit - UAE Federal Environment Agency with Incremental increase (*Technical Guideline Number 9*)	Night Time Noise Levels			
				Scenario 1 Isolated Contribution	Scenario 1 Cumulative Noise Level	Scenario 2 Isolated Contribution	Scenario 2 Cumulative Noise Level
N1	Southwest of Palm Jumeirah and north of Project site near residential buildings and hotels	57.4	62.4	57.2	58.6	66.0	66.2
N2	Eastern boundary of the Project on the southern part of Palm Jumeirah	59.1	64.1	48.5	58.2	58.4	61.1
N3	Southern boundary of the Project on Jumeirah Beach near retail and hotels	56.0	61	48.0	55.1	56.3	58.4
N4	Southwest of the project near public beaches and hotels	58.3	63.3	54.0	56.7	61.7	62.3
N5	DIMC breakwaters	60.2	64.2	55.9	57.9	66.8	67.0
N6	Jumeirah Beach Residence near retail, restaurants, residential towers and public beach	61.5	65.5	51.1	57.3	59.0	60.8

6.4.1.3 Summary

Based on the impact assessment method provided in Section 2.3.2, the potential unmitigated impacts associated with noise generated during the construction phase is summarised in Table 6-11.

Table 6-11 Potential Unmitigated Construction Phase Impacts on Noise

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Sleep disturbance	Almost certain	Moderate	**High**	Residents and occupants of surrounding communities	Negative
Annoyance	Almost certain	Moderate	**High**	Residents and occupants of surrounding communities	Negative
Hearing impairment	Possible	Moderate	**Medium**	Workers on Project site Residential receptors in close proximity to construction site	Negative

6.4.2 Operation Phase

During operation, the greatest noise source is considered to be from traffic. As the majority of the site will be located within the marine environment, there is currently no traffic within the Project area. Once the Project is completed, it will be connected to the mainland via the public transport system (e.g. monorail system or metro stop) and will be accessible by vehicle from King Salman bin Abdulaziz Al Saud Street, or a new bridge will be built linking the Project site directly from Sheikh Zayed Road.

Noise modelling was performed to evaluate the noise impact of road traffic during the operation phase of the Project. The modelling methodology and results are provided in the sub-sections below.

6.4.2.1 Noise Modelling Methodology

The methodology for the calculation of road traffic noise is based on the Department of Transport 'Calculation of Road Traffic Noise (CoRTN)' (1988). For the purposes of this assessment, the CoRTN interface, SoundPLAN is used to calculate and assess the road noise impacts throughout the Project area. Operational traffic noise has been calculated by considering the modelled traffic flows for the Project based on three peak periods, namely; morning, lunch time and evening peak hours. In order to provide a conservative assessment, only the highest traffic flows were considered in the modelling.

Traffic volumes were given in terms of a total vehicle volume in each direction during peak morning traffic (vehicles/hour) with details of the vehicle type breakdown and speeds taken from modelling assumptions by the traffic engineers. For the purposes of this assessment, heavy goods vehicles are assumed to constitute one percent of peak morning traffic flow.

Sensitive receptors for the purposes of noise modelling have been assumed to include the locations of the baseline noise survey as outlined in Figure 4-32. In addition, three sensitive receptor (SR) locations have been added at newly constructed residential/commercial buildings located on the Dubai Harbour development. The location of these buildings is shown in Figure 6-1.

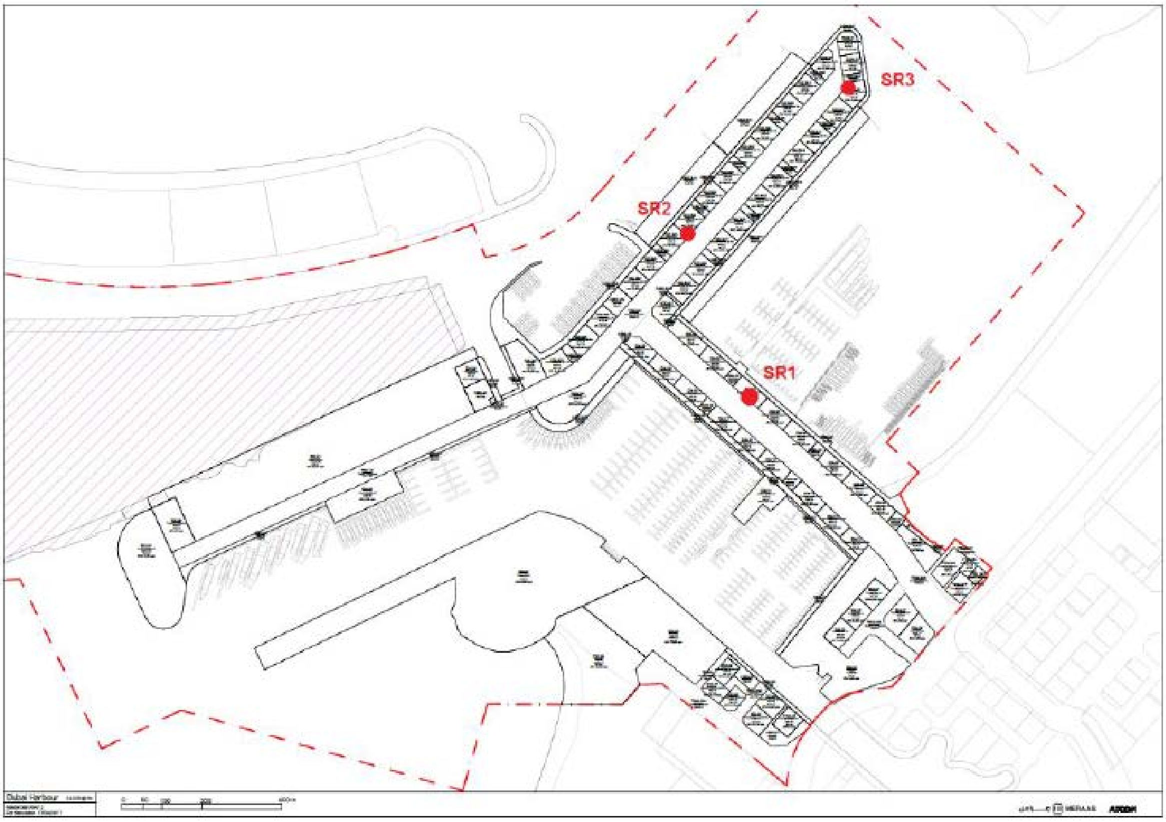


Figure 6-1 Additional Sensitive Receptor Locations

Only peak morning traffic flows have been included in this road noise modelling assessment.

The following assumptions have been made for the assessment, and wherever possible, a conservative approach has been taken:

- Road traffic noise modelling has been carried out using traffic flow data as provided by the design engineers;
- Peak hour traffic flow on each of the roads considered has been assumed to be constant and evenly spaced over the one-hour period;
- The road surface was modelled as impervious;
- The road gradient has been assumed to be consistent with the gradient of the terrain, i.e. flat;
- Vehicle speeds were modelled at 60 km/hr for main trunk road sections and 20 km/hr for the small branch and slip roads;
- All receptors (at SRs) have been placed at a height of 2 m;
- Ground absorption has been conservatively modelled as hard ground (with a low absorption factor of 0);

Although the UAE Federal Noise limits are defined over the entire day/night time periods, the modelling assessment uses only peak hour traffic volume data. This is expected to give a conservative result.

6.4.2.2 Noise Modelling Results

Table 5-5 shows the predicted noise levels at the eight identified noise monitoring locations and SRs, while a series of noise contour maps is presented in Attachment C of the Noise Modelling Report (Appendix I) for the assessment of road traffic noise across the Project area. The maximum noise levels within the project area were predicted to occur directly adjacent to the main trunk road with an overall maximum noise level of 77.9 dB(A). Note that no attenuation due to boundary walls is included and only the screening/attenuation effects of buildings and topography are factored into the modelling procedure. The noise modelling predicts that at ground level all three SR locations on the newly developed island will experience exceedances of the UAE Federal ambient noise limit for residential/commercial areas of 60 dB(A) during the peak morning traffic period.

With regards to the six existing locations that were assessed, the modelled levels are typically lower than the ambient noise levels measured, with the exception of N5 which has a relatively similar noise level. This is due to the generally large distance between the modelled road noise sources and the existing receptor locations. Despite the exceedances caused by the predicted road traffic, the difference between the existing and future noise levels are not considered to be significant at locations far removed from the Project (N1-4 and N6).

In general, it is expected that noise levels generated by road traffic during non-peak times will be significantly lower, even if the ratio of heavy versus light vehicles were to change. As a result, it is considered likely that road traffic noise will not constitute a significant impact to the general living conditions of residences and offices built on the Dubai Harbour.

Table 6-12 Road Traffic Noise Impact Assessment (Morning Peak Hour Traffic), dB(A)

Scenario 1		Ambient Noise Day Time			Traffic Noise	Total Noise	
ID	Classification	Ambient Level L_{Aeq}[1]	Ambient Limit	Ambient Exceedance	$L_{Aeq\ peak\ hr}$[1,2]	Total Predicted Noise Level	Change in Noise
N1	Residential	55.8	60	No	50.1	56.8	1.0
N2	Residential	62.8	60	Yes	37.1	62.8	0
N3	Residential	58.7	60	No	43.4	58.8	0.1
N4	Residential	60.1	60	Yes	52.8	60.8	0.7
N5	Residential	61.6	60	Yes	61.1	64.4	2.8
N6	Residential	56.0	60	No	49.6	56.9	0.9
SR1	Residential	-	60	-	68.6	68.8	-
SR2	Residential	-	60	-	67.7	67.7	-
SR3	Residential	-	60	-	61.4	61.4	-

Scenario 1		Ambient Noise Day Time			Traffic Noise	Total Noise	
ID	Classification	Ambient Level L_{Aeq}[1]	Ambient Limit	Ambient Exceedance	$L_{Aeq\ peak\ hr}$[1,2]	Total Predicted Noise Level	Change in Noise
Note 1	The modelled traffic noise contribution at each assessed location is included here for reference purposes only. The measured baseline noise level is inclusive of existing road traffic noise.						
Note 2	Maximum expected traffic noise generated during peak traffic period.						

6.4.2.3 Summary

Based on the impact assessment method provided in Section 2.3.2, the potential unmitigated impacts associated with noise generated during the operation phase is summarised in Table 6-13.

Table 6-13 Potential unmitigated operation phase impacts on noise

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Annoyance	Likely	Minor	**Medium**	Residents, tourists and occupants within the Project site and surrounding areas	Negative
Hearing impairment	Possible	Minor	**Low**	Residents, tourists and occupants within the Project site and surrounding areas	Negative

6.5 Geology, Geomorphology and Seismicity

6.5.1 Construction Phase

The level of seismic activity in Dubai and the southern emirates is low (Abdalla and Al-Homoud, 2004; Burohappold Engineering, 2015). However, earthquakes do occur and have been felt in Dubai in recent years, indicating that there is a degree of seismic risk in Dubai. The rapidly expanding building stock and population in Dubai has led to a marked increase in the emirate’s exposure to the risk of major events (Burohappold Engineering, 2015).

Seismic events felt in Dubai usually originate in Iran, where earthquakes are generally in the degree of 2.0 – 3.0 magnitude (National Center of Meteorology & Seismology, 2017). Because of the location of the earthquake epicentres, the characteristics of the shaking felt in Dubai will be filtered by hundreds of kilometres of rock and soil, resulting in the ground accelerations being dominated by low frequency, long wavelength motion. This type of motion affects tall buildings (10 – 40 storeys) to a greater degree than shorter buildings (Burohappold Engineering 2015).

Buildings under construction, by law, need to be designed for a high level of seismic hazard (magnitude-5.9) (Burohappold Engineering, 2015). As long as these regulations are adhered to, the risk of environmental impact and the risk to human safety will be negligible. However, if the risk of seismic activity is not mitigated appropriately, the potential consequence could be catastrophic.

There will be no environmental impacts to geology or geomorphology as a result of the construction of the Project. Based on the impact assessment method provided in Section 2.3.2, the potential unmitigated impacts associated with geology, geomorphology and seismicity generated during the construction phase is summarised in Table 6-14.

Table 6-14 Potential unmitigated construction and operation phase impacts on geology, geomorphology and seismicity

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Seismic tremor causing collapse of infrastructure, that is under construction and not yet able to withstand earthquake tremors	Rare	Catastrophic	**Medium**	Workers and visitors of the site during construction	Negative

6.5.1 Operation Phase

Dubai Harbour infrastructure will be designed and built by experienced consultants and contractors to the required building codes and regulations to minimise the risk of collapse or structural failure during an earthquake. The risk of seismic activity potentially damaging the environment in the operation phase is therefore negligible, given the low frequency and scale of earthquakes in the area and the design and build to required standards.

There will be no environmental impacts to geology or geomorphology as a result of the operation of the Project.

Based on the impact assessment method provided in Section 2.3.2, the potential unmitigated impacts associated with geology, geomorphology and seismicity during the operation phase is summarised in Table 6-15.

Table 6-15 Potential unmitigated construction and operation phase impacts on geology, geomorphology and seismicity

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Seismic tremor affecting established infrastructure, that has been designed to withstand earthquake tremors	Rare	Insignificant	**Negligible**	Residents, tourists and occupants within the Project site and surrounding areas	Negative

6.6 Soils and Groundwater

6.6.1 Construction Phase

6.6.1.1 Soil Contamination

Although no visible signs of contamination were observed within the Project site during the baseline assessment, there is potential for localised areas of contaminated soil to be present from the previous works undertaken at Logo Island. Removal of existing structures and stockpiling of rock materials during early works could uncover some potentially pre-existing contamination, which could then be spread to other areas of the site. Further, during construction works soil contamination may occur from accidental spills or leaks of hazardous materials or sewage, inadequate management of solid and liquid wastes and use of contaminated water for dust suppression. However, the quantities of hazardous materials and wastes that would be stored on site would be relatively small and therefore would not result in a major impact.

The source of the reclamation material is currently under review, although the preferred option is for the material dredged from the access channel to be re-used to reclaim land if suitable from a grain size / engineering perspective. Should the dredged access channel material be utilised, there is potential for pre-existing contamination to be dredged and disposed of to land resulting in contaminated soil that could also spread to groundwater and the marine environment. The risk of there being existing contamination within the proposed access channel is relatively low given that there are no known point source pollutants into the area, although it is currently being utilised as an access channel for vessels travelling to and from DIMC and Dubai Marina with the associated potential for small fuel leaks and spills from private vessels. Further, sediment samples collected as part of the marine baseline survey did not detect any contamination within the sediments from the access channel locations, with the exception of small exceedances to the NOAA guidelines for Nickel at three sites (although values were within Dutch Criteria) and one exceedance for Cadmium.

Should there be any contamination, it would likely be localised and in small concentrations and would be heavily diluted within the large volumes of dredged sediment and suspension water, As such, it would not be transferred in notable quantities to the reclaimed soil. However, mitigation measures and monitoring should be implemented to reduce the risk accordingly.

6.6.1.2 Groundwater Contamination

Generally, groundwater contamination occurs where there is sufficient percolation of contaminated substances through the vadose zone and into the underlying aquifer, which could then migrate with the hydraulic gradient to the adjacent marine environment. As such, potential contamination risks to soil also pose a risk to groundwater quality at the site and the down-gradient marine environment.

6.6.1.3 Soil Erosion

The primary risk of soil erosion is related to wave and current action at the interface with the zone of reclamation. The rock revetment will provide a physical barrier between the outer edges of the reclamation zone and the marine environment, where the geotextile fabric lining is expected to effectively eliminate erosion at this interface. However, the interface between the reclamation zone and the sea will be at risk of erosion, particularly during rough sea conditions. Erosion of fill material will increase the sediment load in the marine waters with elevated turbidity and suspended solids likely to generate negative impacts on the surrounding marine environment, as discussed in Section 6.7.1.

In addition to potential soil erosion impacts discussed above, the potential for soil erosion is also likely to increase in the event of placement or movement of heavy equipment in close proximity to areas where there is an identified risk of erosion (e.g. excavation sites, exposed edge, and areas of unconsolidated fill material). Further, should elevated quantities of water be utilised for dust suppression, this could cause erosion to the ground surface.

Should the dredged material not be deemed appropriate for use in reclamation, disposal of the dredged material to land may be selected. Given the water content of the material, it is likely that a settlement basin or evaporation pond would be required to remove the moisture from the dredge material. The location and logistics of this are to be confirmed, but it has the potential to result in significant erosion of soil during deposition of the material.

6.6.1.4 Summary

The impact level on soil and groundwater during Project construction phase (before implementing mitigation measures) are summarised in Table 6-16

Table 6-16 Potential unmitigated construction phase impacts on soil and groundwater

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Spread of potential pre-existing soil contamination via movement of contaminated fill / stockpiled material	Unlikely	Minor	**Low**	Terrestrial ecology	Negative
Soil contamination from using contaminated water for dust suppression	Unlikely	Minor	**Low**	Terrestrial ecology Employees and visitors on-site	Negative
Soil contamination due to handling, storage and use of hazardous materials (e.g. oil, fuel, paint and other chemicals)	Likely	Minor	**Medium**	Terrestrial ecology Employees and visitors on-site	Negative
Soil contamination from inadequate waste management (e.g. hazardous waste, sewage)	Likely	Minor	**Medium**	Terrestrial ecology Employees and visitors on-site	Negative
Placement of potentially contaminated sediments from the dredged access channel to the reclaimed land	Possible	Minor	**Low**	Soil, groundwater	Negative
Erosion of fill due to action of sea waves during reclamation process	Unlikely	Major	**Medium**	Sensitive marine receptors	Negative

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Soil erosion due to earthmoving activities (stockpiling)	Likely	Minor	**Medium**	Terrestrial ecology	Negative
Soil erosion from disposal / settlement of unsuitable dredged material (unconfirmed requirement)	Possible	Moderate	**Medium**	Soil	Negative
Groundwater contamination as a result of spill / leak of potentially hazardous material (i.e. oil, fuel, sewage, paint and other chemicals)	Unlikely	Major	**Medium**	Terrestrial flora and fauna Marine flora and fauna	Negative
Groundwater contamination as a result of inadequate waste management (e.g. hazardous waste, sewage)	Unlikely	Major	**Medium**	Terrestrial flora and fauna Marine flora and fauna	Negative

6.6.2 Operation Phase

6.6.2.1 Contamination from Landscape Maintenance

Landscaping within the Project site will require daily irrigation and frequent soil improvement measures through the application of fertilisers to aid plant growth. It is assumed that the majority of water utilised in irrigation will be TSE. The application of TSE and fertilisers presents a contamination risk to both soil and groundwater. The degree of impact is associated with the following:

- The quality of TSE used for landscaped irrigation. In the event that TSE used on-site does not meet DM effluent requirements (provided in Section 3.3.6, Table 3-13), soil and groundwater contamination is likely;
- Excessive application of fertiliser and/or herbicides and pesticides could potentially lead to soil contamination. If soil contamination occurs then this increases the potential for a range of associated / resultant environmental issues including stormwater pollution and groundwater contamination. In the case of the Project, the surrounding marine environment is also considered vulnerable to adverse impacts from the excessive fertiliser application given its immediate proximity and the high level of interchange between the coastal and groundwater resources. Elevated levels of nutrients in the marine environment can lead to Harmful Algal Blooms (HABs) and oxygen depletion with potentially fatal consequences for marine receptors in addition to closure of the beaches at the Project site and nearby;

- A large majority of pesticides are toxic. Application of pesticides in landscaping can lead to accumulation in groundwater. Given the high rate of groundwater exchange with marine waters, there is a high chance these chemical compounds would enter the marine environment with potentially severe negative impacts on the marine ecosystem;
- Inadequate ground protection measures, such as failure to use impermeable liners for landscaped zones, increases the risk of soil and groundwater contamination as a result of landscaping activities.

6.6.2.2 Contamination from Utilities

There is potential for contamination to soil and groundwater from utilities, as follows:

- Leak or overflow of untreated sewage from sewerage transfer infrastructure;
- Leachate from waste management infrastructure (e.g. waste collection centres); and
- Accidental spill or leakage from on-site bulk storage and handling of fuel and oil for utilities (e.g. substation).

With appropriate management measures in place, the risk of soil contamination resulting from the above incidents is likely to be minimal.

6.6.2.3 Soil Erosion

Dredging maintenance operations will generate waste soil material that could potentially require disposal to land. Given the water content of the material, it is likely that a settlement basin or evaporation pond would be required to remove the moisture from the dredge material. The location and logistics of this are to be confirmed, but it has the potential to result in significant erosion of soil during deposition of the material.

Given the low frequency of this requirement (approximately once every 20 years), the impact would be temporary, intermittent and would comprise relatively low volumes of material. An appropriate management plan would be prepared to address the specific impacts once further details are confirmed closer to the time, given that the activity would occur 20 years from now.

6.6.2.4 Summary

The impact level on soil and groundwater during Project operation phase (before implementing mitigation measures) are summarised in Table 6-17.

Table 6-17 Potential unmitigated operation phase impacts on soils and groundwater

Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Soil and groundwater contamination from poorly treated TSE used for irrigation	Possible	Moderate	**Medium**	Terrestrial ecology Groundwater consumer	Negative
Soil contamination due to excessive application of fertilisers, herbicides or pesticides	Possible	Minor	**Low**	Terrestrial ecology	Negative
Soil contamination due to accidental spill / leak from utilities (e.g. sewage pumps, power substation) and leachate from waste management facilities	Unlikely	Moderate	**Medium**	Terrestrial ecology	Negative
Soil erosion from disposal / settlement of dredged material from channel maintenance	Possible	Moderate	**Medium**	Soil	Negative
Groundwater and marine contamination due to excessive application of fertilisers and pesticides	Unlikely	Moderate	**Medium**	Terrestrial flora and fauna Groundwater consumer Marine flora and fauna	Negative
Groundwater contamination due to accidental spill / leak from utilities (e.g. sewage pumps, power substation) and leachate from waste management facilities	Possible	Moderate	**Medium**	Terrestrial flora and fauna Groundwater consumer Marine flora and fauna	Negative

6.7 Coastal Processes

The coastal processes in vicinity of the Project site will be gradually altered as reclamation activities progress. However, quantifying the impact throughout reclamation progression would be extremely difficult due to the transient nature of the activities. Therefore, an assessment of the existing condition versus the full operation scenario (all reclamation completed) was undertaken, which is provided under the operation phase sub-section below.

To provide land access to the Project site (specifically Logo Island) during construction, a temporary causeway has been constructed that could result in an impact to coastal processes. The impact of the causeway on coastal processes has been assessed as part of the construction phase impacts below.

6.7.1 Construction Phase

A temporary causeway has been constructed between Logo Island and the existing DIMC as part of the early works to provide land access to the site during construction activities. The causeway will potentially alter the flushing regime of surrounding enclosed water bodies.

A flushing assessment of four locations in vicinity of the Project area was undertaken by Sogreah (2017b) to predict the effect of the temporary causeway on water exchange rates. The assessment areas of JBR Beach (Figure 6-2), Mina Al Seyahi Beach (Figure 6-3), Dubai Marina (Figure 6-4) and DIMC (Figure 6-5) were evaluated for existing and during-construction conditions. The flushing criteria described in section 5.6.2.5 were adopted for this assessment.

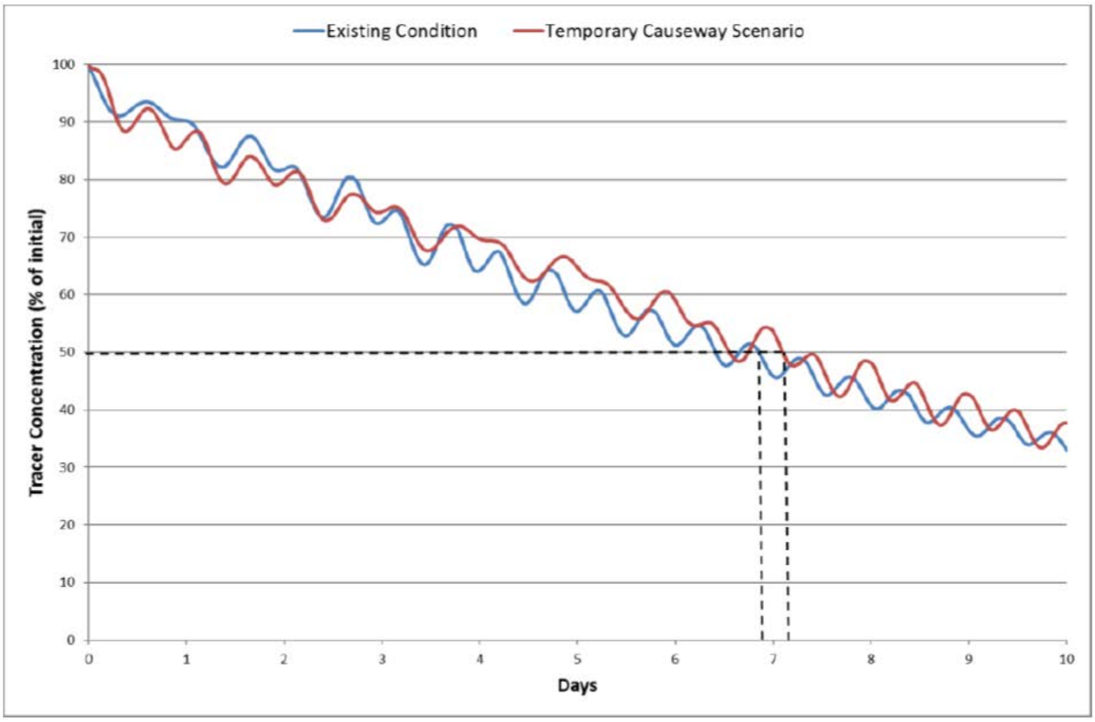


Figure 6-2 Basin-averaged tracer concentrations in the JBR Beach for exisiting conditions and with the temporary causeway

Source: Sogreah (2017b)

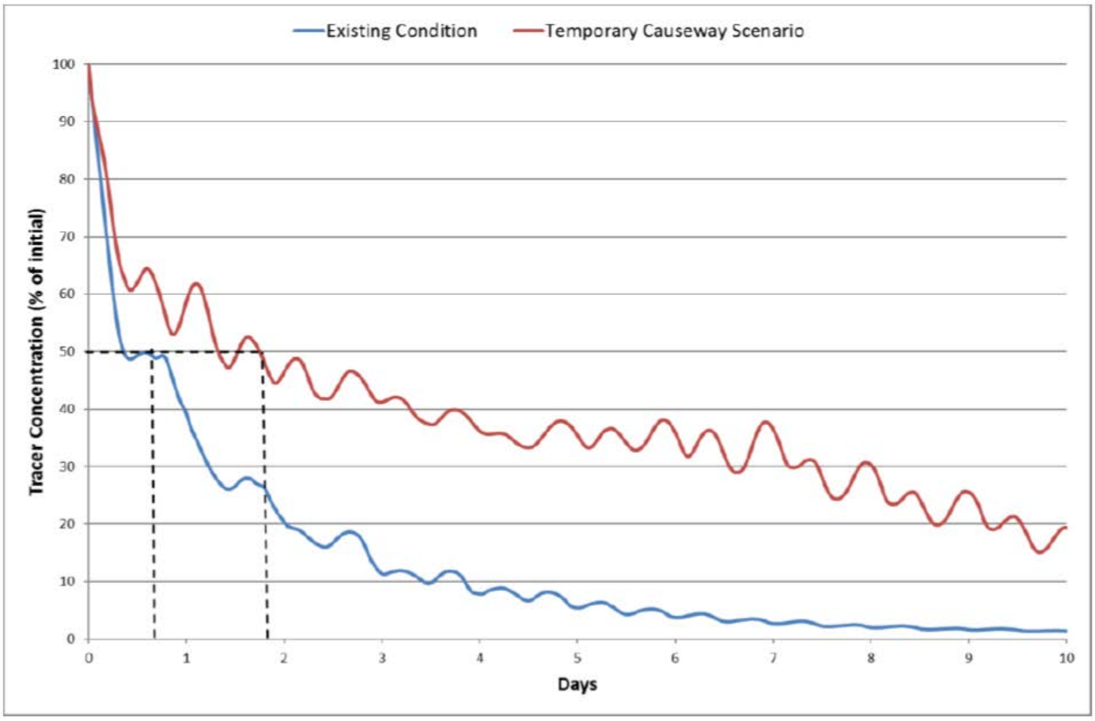


Figure 6-3 Basin-averaged tracer concentrations at Mina Al Seyahi Beach for existing conditions and with the temporary causeway

Source: Sogreah (2017b)

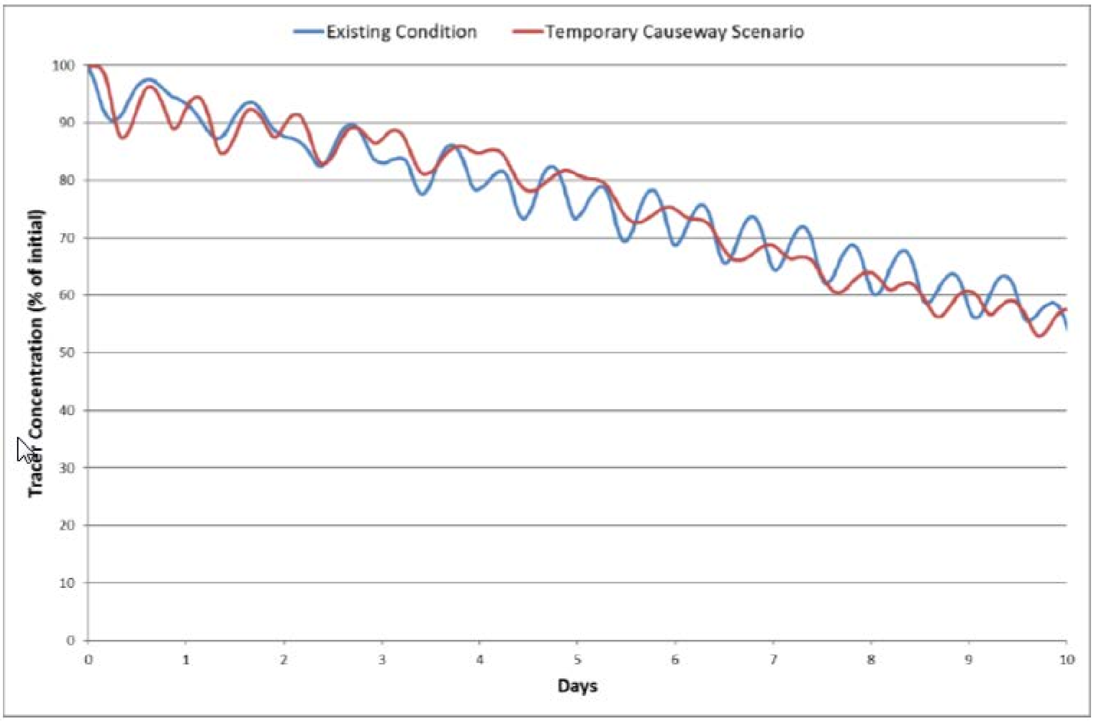


Figure 6-4 Basin-averaged tracer concentrations in Dubai Marina for existing conditions and with the temporary causeway

Source: Sogreah (2017b)

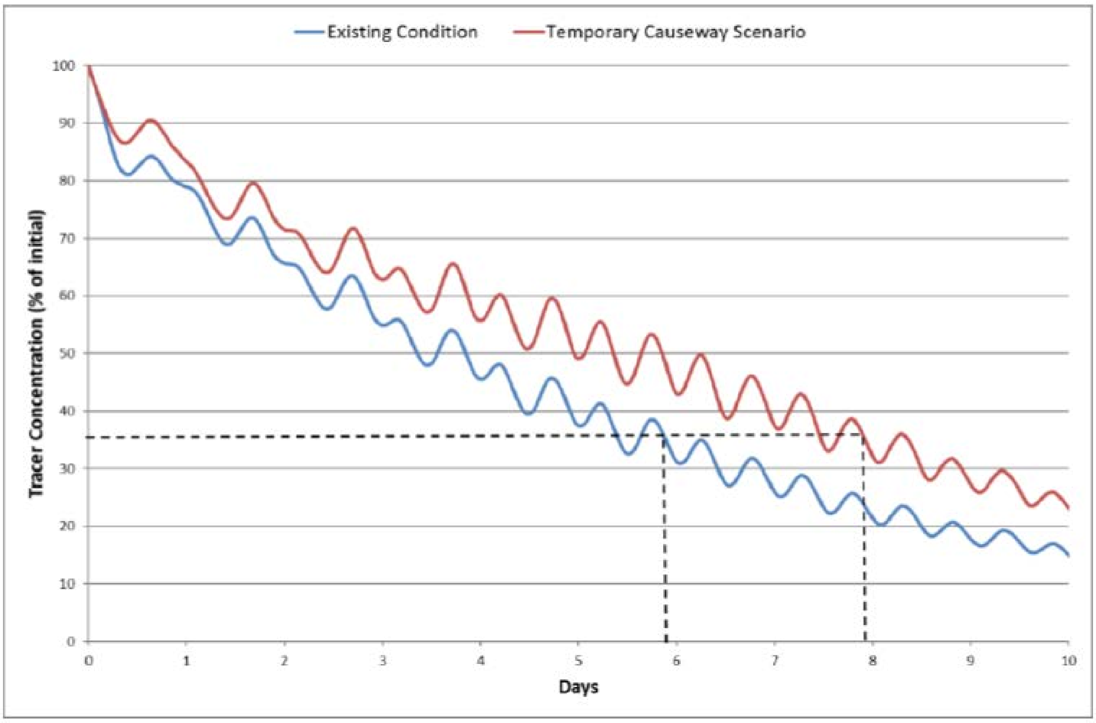


Figure 6-5 DIMC flushing assessment area for existing (left) and during construction (right)

Source: Sogreah (2017b)

The results of the existing condition compared with the temporary causeway simulations are presented in Table 6-18. Some of the areas initialised with a tracer for the flushing assessment of temporary causeway (Sogreah, 2017b) differed to the flushing assessment of the whole Project (Sogreah, 2017d), for which the existing condition results were presented in Section 5.6.2.5. As such, the existing condition results presented in Table 6-18 are slightly different.

In general, minor decreases in flushing are predicted to occur following construction as a result of the temporary causeway and all assessed areas that were not predicted to meet the flushing criteria also failed to meet these criteria for the existing condition simulations. Furthermore, there are no known existing water quality issues within these water bodies and as such, the minor decreases in flushing rates are not expected to result in any significant impacts to water quality.

Table 6-18 Summary of flushing results for the existing condition and the temporary causeway scenarios

Assessment Area	Flushing Criterion	Flushing Result – Existing Condition (Sogreah, 2017b)	Flushing Result – Temporary Causeway (Sogreah, 2017b)
JBR Beach	T_{50} < 5-7 days	T_{50} = 6.9 days	T_{50} = 7.1 days
Mina Al Seyahi Beach	T_{50} < 5-7 days	T_{50} = 0.6 days	T_{50} = 1.8 days
Dubai Marina	E > 0.18	E = 0.03	E = 0.03
	T ≤4 days	T = 14.7 days	T= 14.7 days
	Ψ > 0.1 E > 0.15 for at least 95% of basin	Ψ = 0 E > 0.15 for 10% of basin	Ψ = 0 E > 0.15 for 9% of basin
DIMC	E > 0.18	E = 0.09	E = 0.07
	T ≤4 days	T = 5.9 days	T = 7.9 days
	Ψ > 0.1 E > 0.15 for at least 95% of basin	Ψ = 0.01 E > 0.15 for 38% of basin	Ψ = 0 E > 0.15 for 32% of basin

Green cells indicate results meeting the flushing criteria and red cells indicate results not meeting the flushing criteria.

A summary of the potential unmitigated construction phase impacts is presented in Table 6-19.

Table 6-19 Potential unmitigated construction phase impacts on coastal processes

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Decreased flushing of enclosed beaches and marinas	Likely	Insignificant	Low	Swimmers at JBR and Mina Al Seyahi Beaches; Water quality within Dubai Marina and DIMC	Negative

6.7.2 Operation Phase

6.7.2.1 Changes to Local Hydrodynamics

Potential changes to local hydrodynamics (current speeds) were assessed in a numerical modelling study undertaken by Sogreah (2017c, Appendix E). Peak tidal current speeds were compared for pre- and post-construction of the Dubai Harbour. The predicted differences in peak depth-averaged current speeds are presented in Figure 6-6.

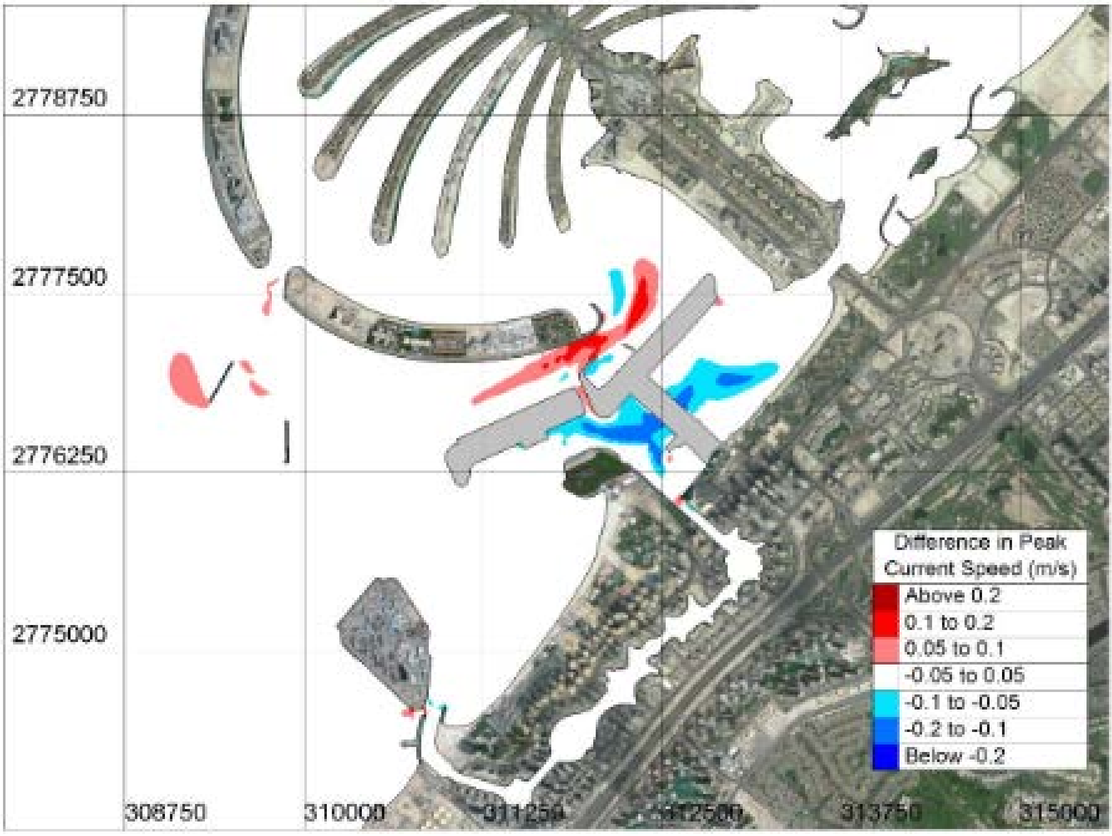


Figure 6-6 Predicted difference in peak depth-averaged tidal current speeds

Positive values indicate increased current speeds in the post-development scenario

Source: Sogreah (2017a)

Generally, peak current speeds in the post-development scenario are predicted to be within ±0.05 m/s of existing conditions. This magnitude of change is not expected to result in any significant impacts to local users (e.g. swimmers, vessel operators). However, to reduce the wave heights to within acceptable levels, two detached breakwaters are proposed to be constructed (described in Section 6.7.2.3), which result in a localised increased peak depth-averaged current speeds of up to 0.2 m/s. This magnitude increase is also expected in the channel between the southern breakwater of Palm Jumeirah and Logo Island. Furthermore, decreased peak depth-averaged current speeds of up to 0.2 m/s are predicted in the vicinity of the Marina (Zone 4).

These changes to local peak current speeds have the potential to result in localised changes to sedimentation/erosion patterns. Increased erosion of bed sediments may occur in the areas of elevated current speeds near the proposed detached breakwaters and the channel between the Palm Jumeirah and Logo Island, whereas increased rates of sediment deposition may occur in the vicinity of the Marina.

6.7.2.2 Flushing

Methodology

A flushing assessment of six locations in the vicinity of the Project area was undertaken by Sogreah (2017d, Appendix E) to predict the effect of the Project on water exchange rates. The flushing criteria described in section 5.6.2.5 were adopted for this assessment. Seven locations within and surrounding the Project site were evaluated for existing conditions (if currently built) and post-development conditions, comprising:

- JBR Beach;
- Mina Al Seyahi Beach;
- Dubai Marina;
- Palm Jumeirah;
- DIMC (existing) / Dubai Harbour Main Marina (proposed)
- Palm View Marina (proposed); and
- Bay Marina.

The other proposed marina for the Project (Cruise Marina) was not assessed as part of the flushing study. This is because the Cruise Marina is not an enclosed area and flushing conditions will be much better than in the Main Marina and therefore a separate assessment is not required.

For the proposed Dubai Harbour Main Marina, the flushing assessment results for post-construction were compared against the pre-construction DIMC flushing results, as the proposed Main Marina comprises an extension / re-configuration of the existing DIMC marina. The Palm View Marina does not have an existing condition to compare against and as such was compared against the flushing criteria.

The flushing conditions inside the Palm Jumeirah (2017o, Appendix E) were assessed through tracking of a conservative tracer (in the same manner as the other areas) and additionally by simulating the discharge at the entrance of the Palm Jumeirah for both pre- and post-development. Flushing criteria were not adopted for the Palm Jumeirah as this large area does not represent a marina or beach. Instead, an analysis of pre- and post-construction conditions was undertaken to assess potential impacts.

Results

The results of the pre- and post-development simulations for each of the assessed locations are presented in Table 6-20. The impact on flushing conditions at the Palm Jumeirah are negligible, as illustrated in Figure 6-7. For the beaches, the flushing criteria were predicted to be satisfied for the post-development scenarios, although a minor reduction in flushing efficiency was predicted for the Mina Al Seyahi beach, while a slight improvement in flushing was predicted at JBR Beach (Figure 6-8).

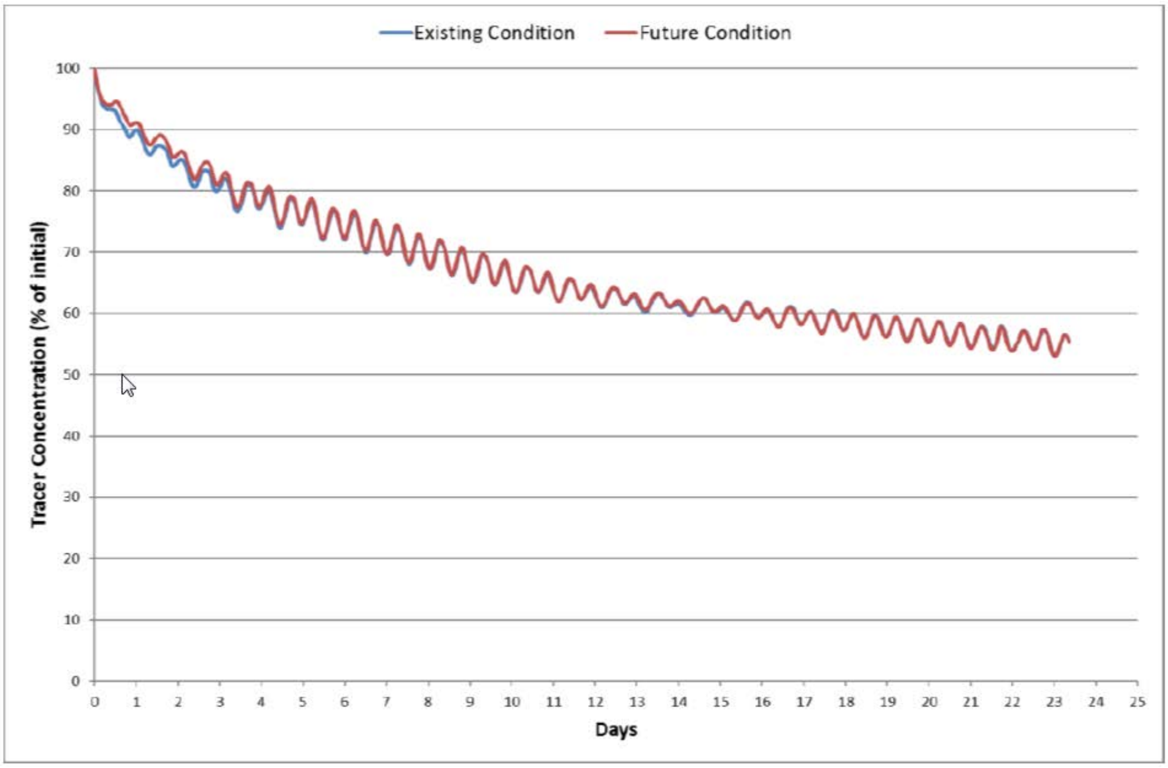
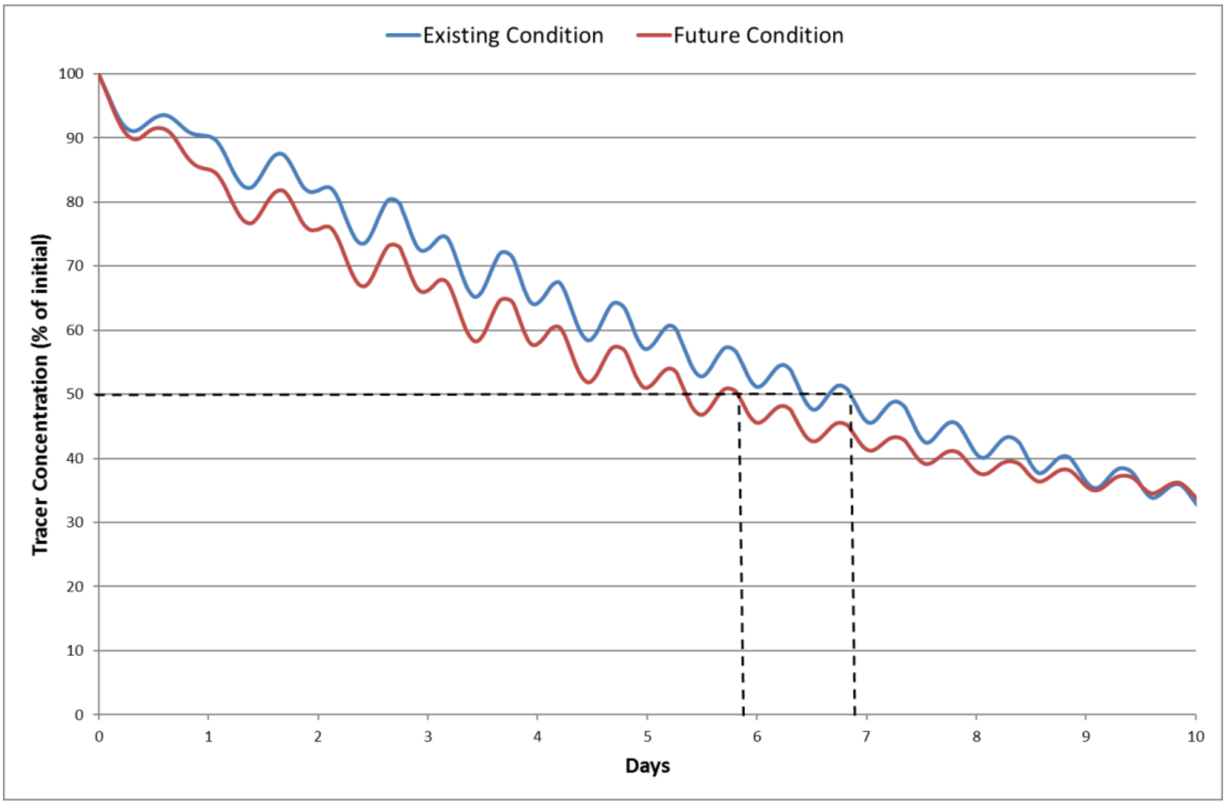


Figure 6-7 Tracer Concentration for Existing and Future Conditions at the Palm Jumeirah



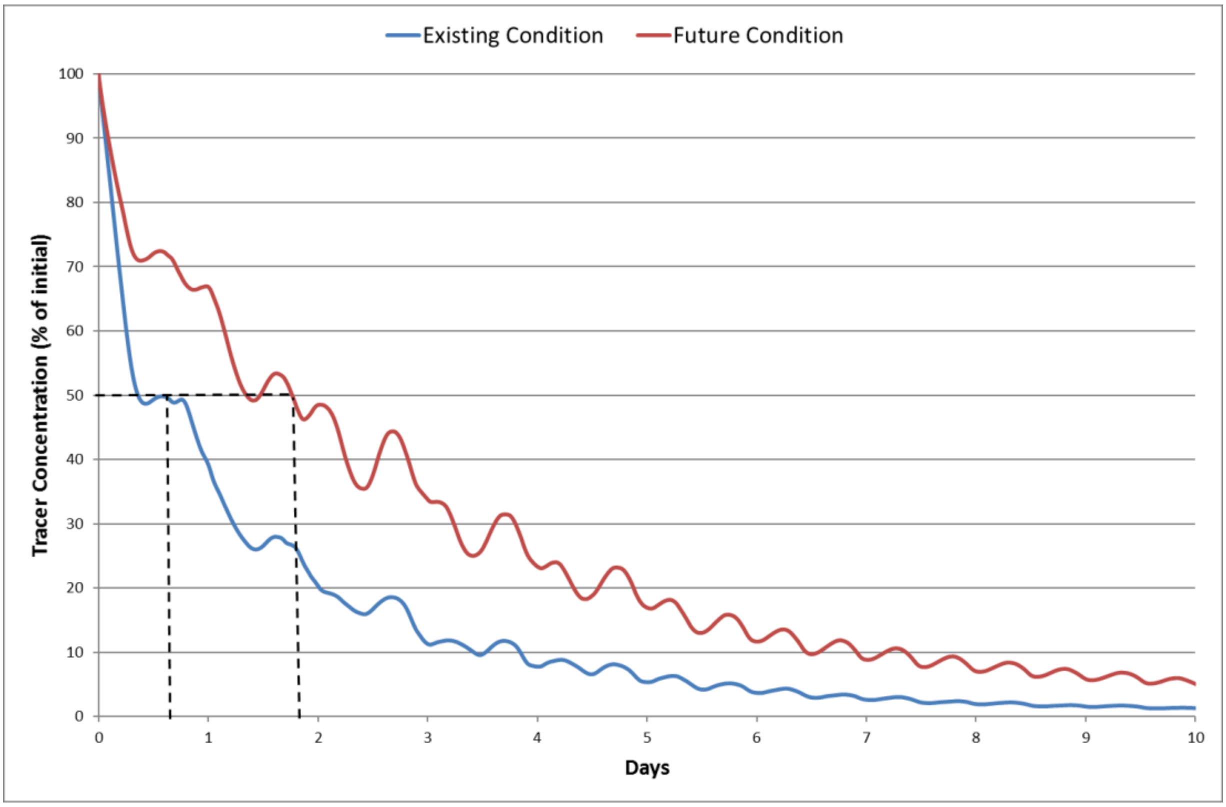


Figure 6-8 Basin-averaged Tracer Concentration for Existing and Future Conditions at JBR Beach (Top) and Mina Seyahi Beach (Bottom)

For the marinas, the following outcomes are predicted:

- A decrease in flushing is predicted for the post-development scenario at Dubai Marina, with both pre and post-development flushing modelling showing that the marina flushing criteria are not met (Figure 6-9);
- Flushing rates at the proposed Dubai Harbour Main Marina are slightly improved compared with those modelled for the existing DIMC, although the flushing criteria are still not predicted to be satisfied (Figure 6-10). There was a slight decrease in the criterion for the exchange coefficient exceeding 0.15, which was predicted to occur for 26% of the Main Marina compared with 38% of the existing DIMC. However, slight improvements were predicted for all other flushing criteria.

Marina flushing criteria are predicted to be satisfied at the new Palm View Marina, with tracer concentrations reducing to negligible concentrations (<5%) after three days (Figure 6-11). The primary risk identified by the flushing assessment is the decreased flushing capacity of the Dubai Marina following construction of the proposed development. Longer flushing times in this water body will potentially result in the generation of poor water quality, particularly if sources of pollution are introduced to these waters. Furthermore, long residence times of algae within this water body may result in the generation of anoxic conditions, leading to fish deaths within the marina. If sources of elevated nutrient concentrations are introduced, eutrophication is also a potential risk which may lead to the generation of algal blooms. It is noted however that the existing marina, for which no known water quality issues have occurred, also exceeds the adopted flushing criteria.

Flushing at the Palm Jumeirah is not predicted to undergo any significant changes following development of the Project. Negligible differences in flushing were observed between pre- and post-development simulations within day 1, with no difference discernible after day 1. Furthermore, negligible differences in the volumetric discharge through the entrance to Palm Jumeirah were predicted, indicating the exchange rate with surrounding waters will be maintained following development of the Project.

Flushing at the Cruise Terminal was not assessed through numerical modelling due to the relatively open design of this structure. Ample flushing times satisfying the various marina criteria are expected at this location.

Table 6-20 Summary of flushing results for the existing condition and the post-development condition

Assessment Area	Flushing Criterion	Flushing Result – Existing Condition (Sogreah, 2017d)	Flushing Result – Post-Development (Sogreah, 2017d)
JBR Beach	T_{50} < 5-7 days	T_{50} = 6.9 days	T_{50} = 5.9 days
Mina Al Seyahi Beach	T_{50} < 5-7 days	T_{50} = 0.6 days	T_{50} = 1.9 days
Dubai Marina	E > 0.18	E = 0.03	E = 0.02
	T ≤4 days	T = 14 days	T = >21 days
	Ψ > 0.1	Ψ = 0 E > 0.15 for 10% of basin	Ψ = 0 E > 0.15 for 3% of basin

Assessment Area	Flushing Criterion	Flushing Result – Existing Condition (Sogreah, 2017d)	Flushing Result – Post-Development (Sogreah, 2017d)
	E > 0.15 for at least 95% of basin		
DIMC / Dubai Harbour Main Marina (re-configured)	E > 0.18	E = 0.09	E = 0.10
	T ≤4 days	T = 5.9 days	T = 5.3 days
	Ψ > 0.1 E > 0.15 for at least 95% of basin	Ψ = 0.01 E > 0.15 for 38% of basin	Ψ = 0.04 E > 0.15 for 26% of basin
Palm View Marina	E > 0.18	Not Existing	E = 0.36
	T ≤4 days	Not Existing	T = 1 day
	Ψ > 0.1 E > 0.15 for at least 95% of basin	Not Existing	Ψ = 0.29 E > 0.15 for 100% of basin
Bay Marina	E > 0.18		E = 0.09
	T ≤4 days		T = 5.3 days
	Ψ > 0.1 E > 0.15 for at least 95% of basin		Ψ = 0.02 E > 0.15 for 55% of basin

Note: Green cells indicate results meeting the flushing criteria and red cells indicate results not meeting the flushing criteria.

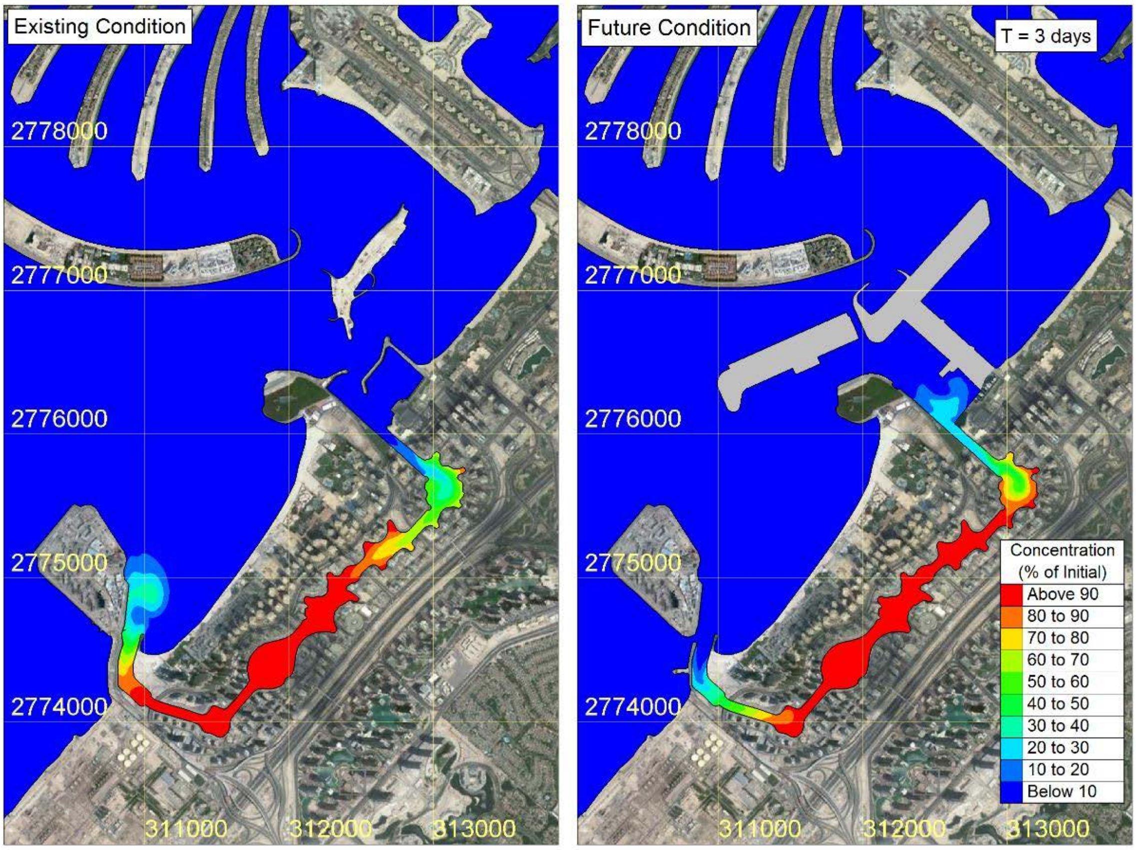


Figure 6-9 Modelled Existing and Future Condition Tracer Concentration at Dubai Marina 3 Days After Release

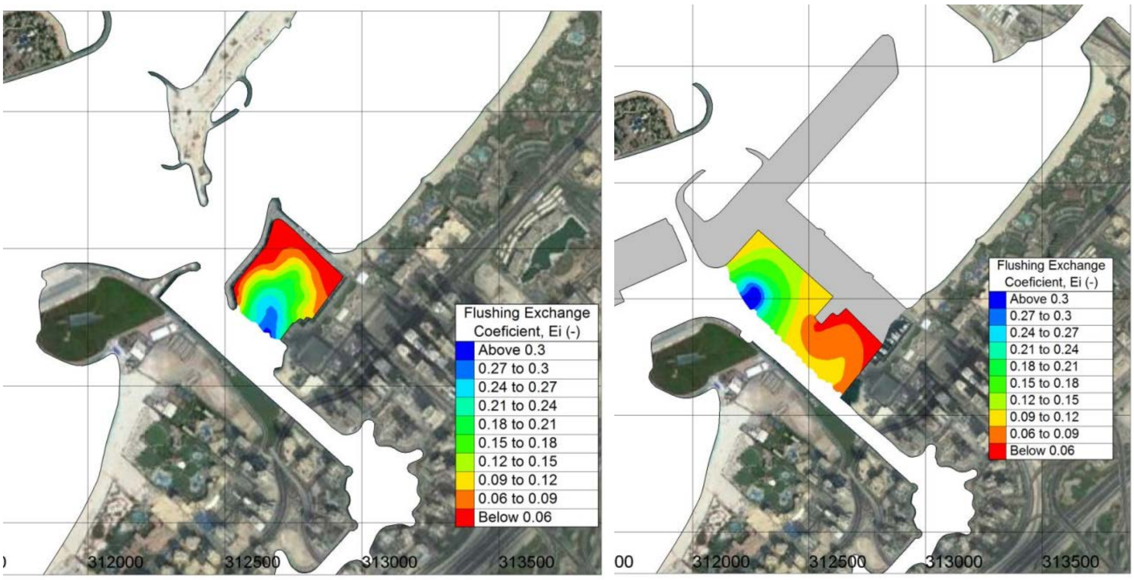


Figure 6-10 Exchange Coefficients Computed After 4 days for Existing and Post Development Scenarios

Figure 6-11 Tracer Concentrations at Palm View Marina after 1 Day (left) and 3 Days (Right)

6.7.2.3 Wave penetration at Palm View and Cruise Terminal Marinas

Wave penetration modelling has been undertaken by Sogreah (2017e, Appendix E) for the Palm View and Cruise Terminal marinas using the Danish Hydraulic Institute's MIKE21 Boussinesq Wave modelling platform. A total of eight simulations assessed extreme wave conditions for 1 and 100 year recurrence intervals and a range of offshore wave heights and directions. Peak wave heights were assessed at three berths within the Cruise Terminal Marina and one berth within the Palm View Marina as presented in Figure 6-12. Following initial assessments completed by Sogreah, it was determined that the wave heights would be too high for the marina requirements and as such, two detached breakwaters are proposed to be installed as shown in Figure 6-12. The study results below represent the findings with the proposed breakwaters in place.

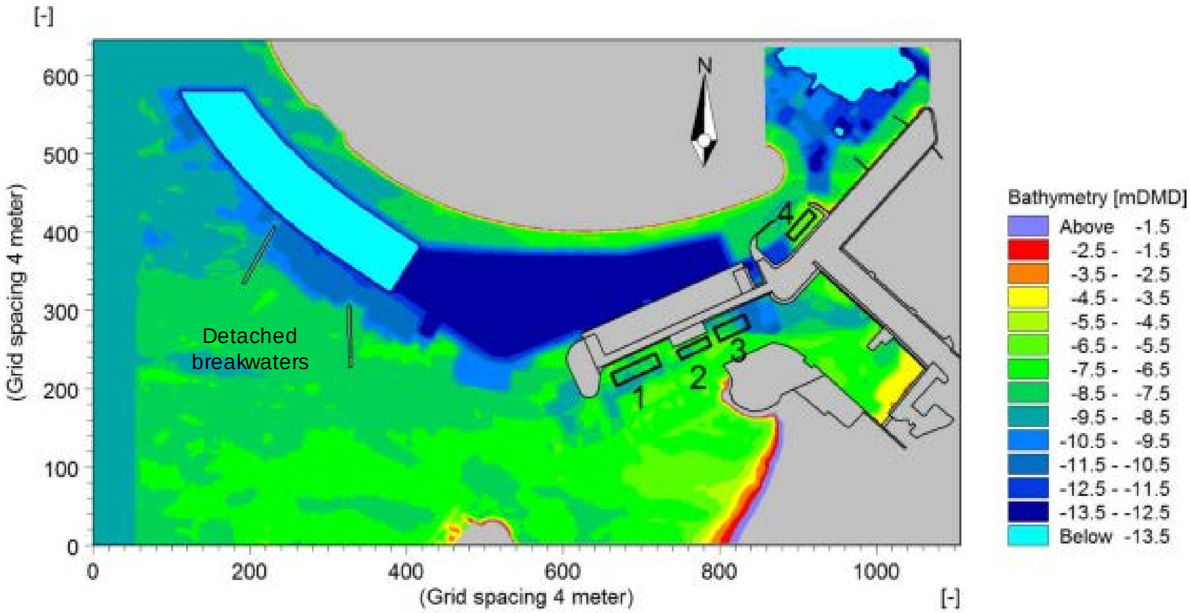


Figure 6-12 Wave height assessment areas in the Cruise Terminal Marina (areas 1-3) and the Palm View Marina (area 4)

Source: Sogreah (2017e)

An alternative layout for the lighthouse platform was also assessed by Sogreah (2017e), involving the extension of the breakwater 50 m south as presented in Figure 6-13.

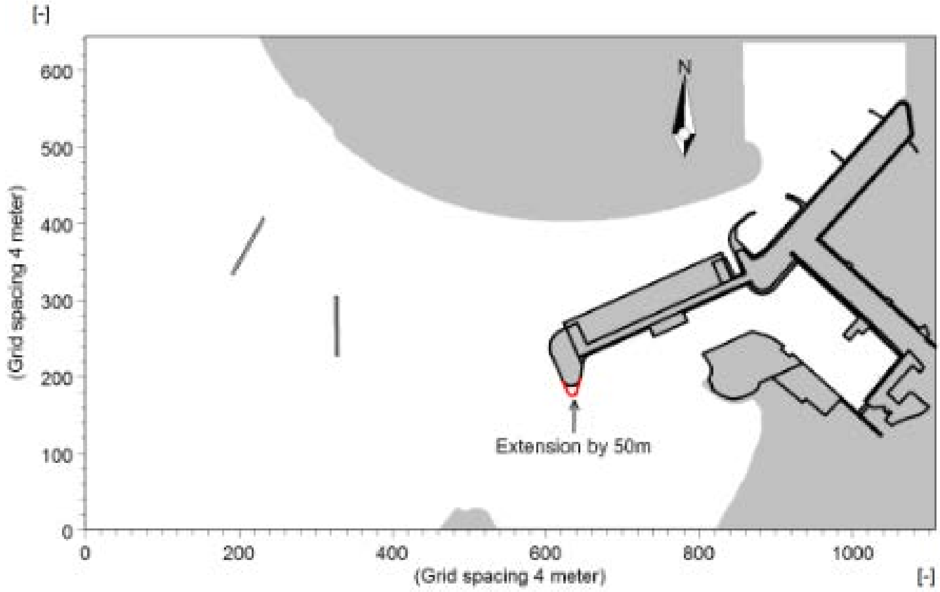


Figure 6-13 Alternative lighthouse platform layout (shown in red)

Source: Sogreah (2017e)

Wave heights within the berths were assessed against the Australian Standards for marina tranquillity based on a 'moderate' wave climate. These criteria are presented in Table 6-21. Due to the layouts of the proposed marinas, beam seas (i.e. waves approaching the side of vessels approximately at right angles) were deemed extremely unlikely to affect vessels within the berths and were not assessed. In general, simulated wave angles at area 1 were categorised as head-on to berthed ships, and oblique to berthed ships at areas 2 – 4.

Table 6-21 Australian Standards for marina tranquillity based on 'moderate' seas

Direction and Peak Period of Marina Wave	1 in 1 year Peak Wave Height standard (m)	1 in 100 year Peak Wave Height standard (m)
Head seas >2 s	<0.4	<0.75
Oblique seas >2 s	<0.4	<0.5

Wave heights at the model boundary ranged from 1.4 – 3.1 m for the 1 in 1 year recurrence conditions and 3.0 – 4.1 m for the 1 in 100 year recurrence conditions. An example of simulated wave transformation is presented in Figure 6-14 for the 1 in 1 year recurrence interval conditions. Significant reductions in wave height are predicted towards the south-east of the proposed detached breakwaters, indicating the effectiveness of this proposed structure as a mitigation measure for reducing waves within the marinas.

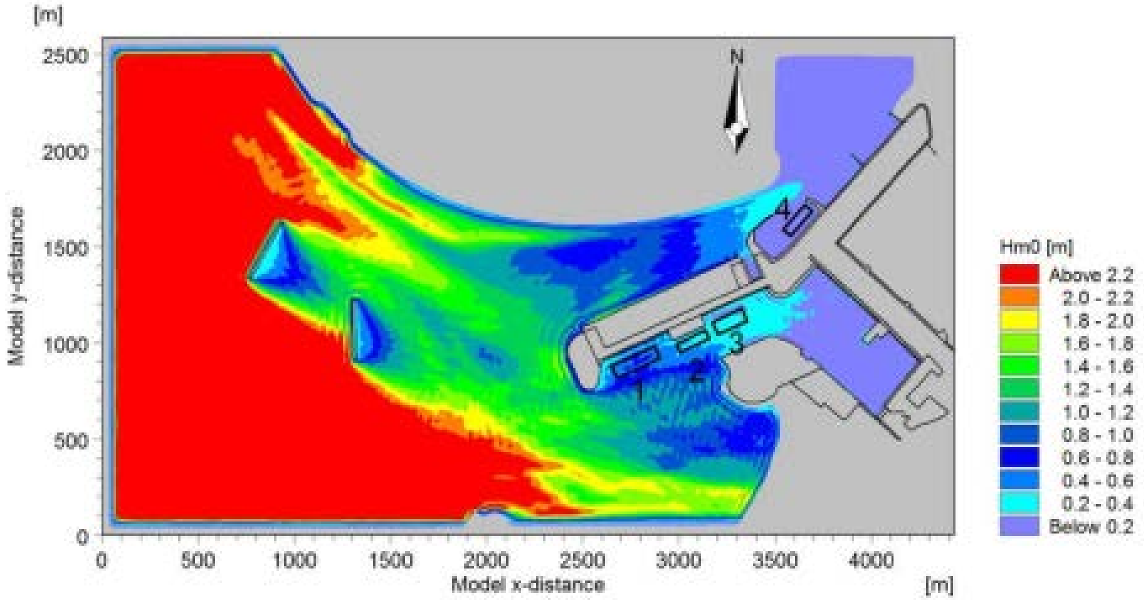


Figure 6-14 Wave transformation for 1 in 1 year recurrence interval wave conditions

Source: Sogreah (2017e)

A summary of the most severe wave conditions within the marinas predicted for the 1 and 100 year recurrence intervals is presented in Table 6-22. Significant reductions in wave height are predicted inside the marinas compared to modelled boundary conditions. Assessment area 1 (the western berth in the Cruise Terminal Marina) is predicted to be exposed to the highest wave heights in each case.

For the current marina design (i.e. no extension of the lighthouse platform), the 1 in 1 year peak wave heights were predicted to be 0.5 m in area 1, exceeding the adopted tranquillity standard of <0.4 m. The tranquillity criteria were met for areas 2 – 4, with peak wave heights of 0.3 m and below. For 1 in 100 year recurrence conditions, the tranquillity criteria were also met. Peak wave heights for these conditions were predicted to be a maximum of 0.7 m at area 1 and 0.4 m or lower at all other berths.

For the modified layout with the lighthouse platform extended south by 50 m, reductions in wave heights inside the marinas were predicted for all scenarios. The tranquillity conditions were predicted to be satisfied at all assessed areas for both the 1 and 100 year recurrence interval conditions.

Table 6-22 Summary of most severe wave conditions in the four assessment areas

Recurrence Interval	Lighthouse Platform Layout	Offshore conditions producing most severe wave heights	Assessment Area	Peak Wave Height (m)
1 in 1 year extreme conditions	Current design	Wave height = 2.8 m Period = 9 s Direction = 300 - 305°	1 2 3 4	0.5 0.3 0.2 0.1
1 in 1 year extreme conditions	Extended platform	Wave height = 2.8 m Period = 9 s Direction = 300 - 305°	1 2 3 4	0.4 0.2 0.2 0.1
1 in 100 year extreme conditions	Current design	Wave height = 4.0 m Period = 10 s Direction = 305°	1 2 3 4	0.7 0.4 0.2 0.2
1 in 100 year extreme conditions	Extended platform	Wave height = 4.0 m Period = 10 s Direction = 305°	1 2 3 4	0.6 0.3 0.2 0.2

Red entries = tranquillity conditions exceeded. Green entries = tranquillity conditions met.
Source: Sogreah (2017e)

6.7.2.4 Sedimentation

Navigation channel

Construction of the proposed Cruise Terminal will require the establishment of a dredged navigation channel and berthing basin for use by large ships. The proposed layout of the navigation channel and berthing basin is presented in Figure 6-15.

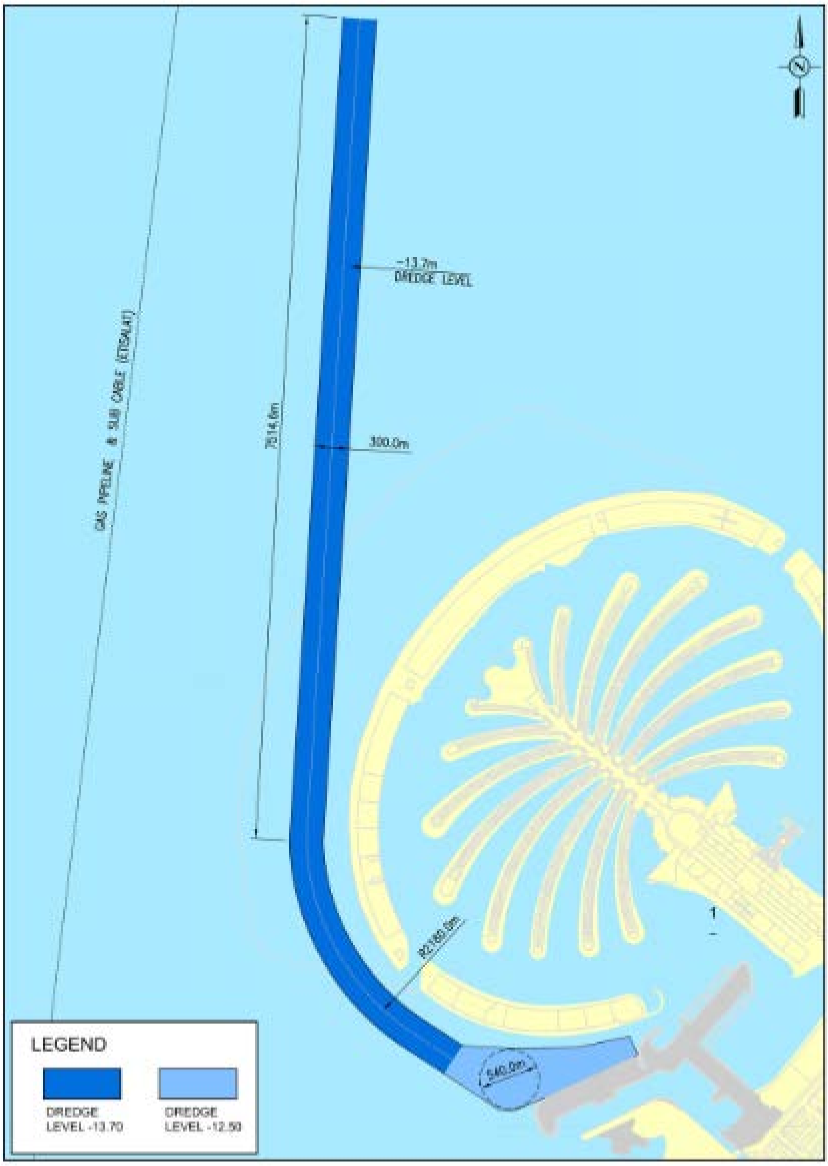


Figure 6-15 Proposed navigation channel and berthing basin layout

Source: Sogreah (2017f)

Sogreah (2017f, Appendix E) have undertaken a sedimentation assessment to predict the likely rates of infill that will occur in the dredged channel. The assessment provides insight into the potential frequency of dredging that will be required to maintain the channel and berthing basin once established. Two assessment methodologies were applied by Sogreah (2017f), comprising:

- A desktop assessment of historical sedimentation rates through comparison of historical LiDAR data;
- An empirical assessment to assess potential sediment transport utilising simulated waves and hydrodynamic conditions and bed sediment data as inputs.

An overview of the findings of each is provided below.

LiDAR Assessment

A series of trenches surrounding the Palm Jumeirah are evident in historic LiDAR imagery from 2007 (Figure 6-16) and 2013 (Figure 6-17). The trenches are of a similar depth to the proposed navigation channel and were used as an analogue of the future channel to investigate likely deposition rates. Changes in the bed level were assessed through comparison of a series of trench cross-sections taken from the various historic LiDAR elevation readings. An example cross-section comparison is presented in Figure 6-18, comprising a comparison of 2007 and 2013 LiDAR survey datasets.

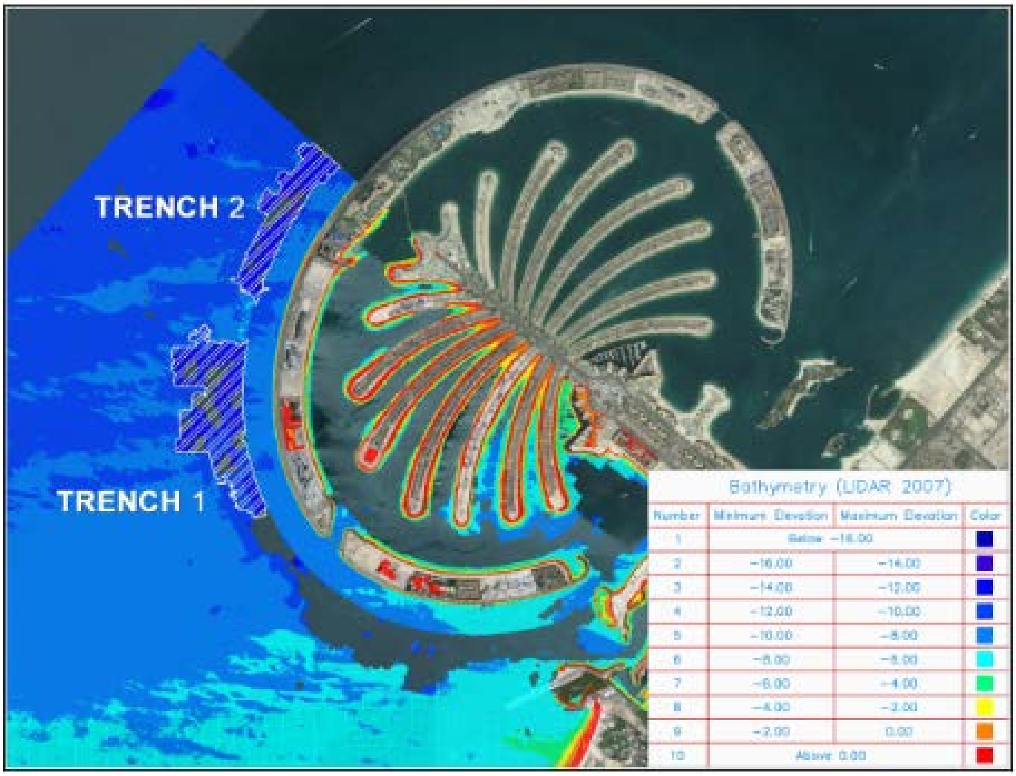


Figure 6-16 Trenches 1 and 2 identified in the 2007 LiDAR imagery

Source: Sogreah (2017f)

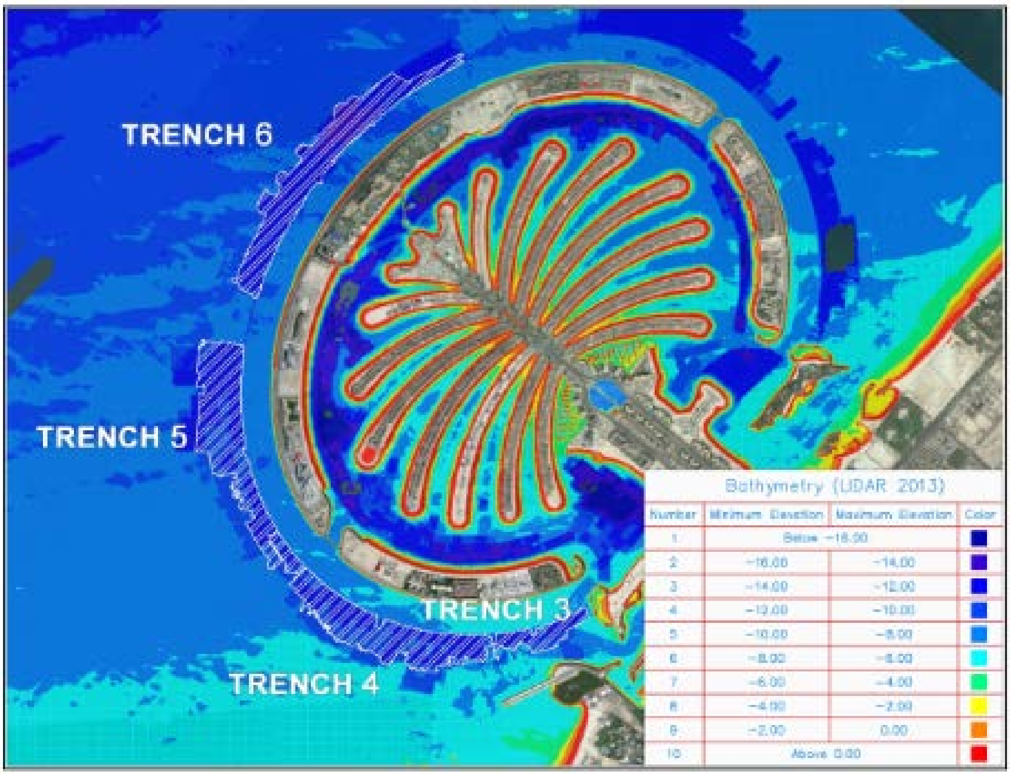


Figure 6-17 Trenches 3 – 6 identified in the 2007 LiDAR imagery

Source: Sogreah (2017f)

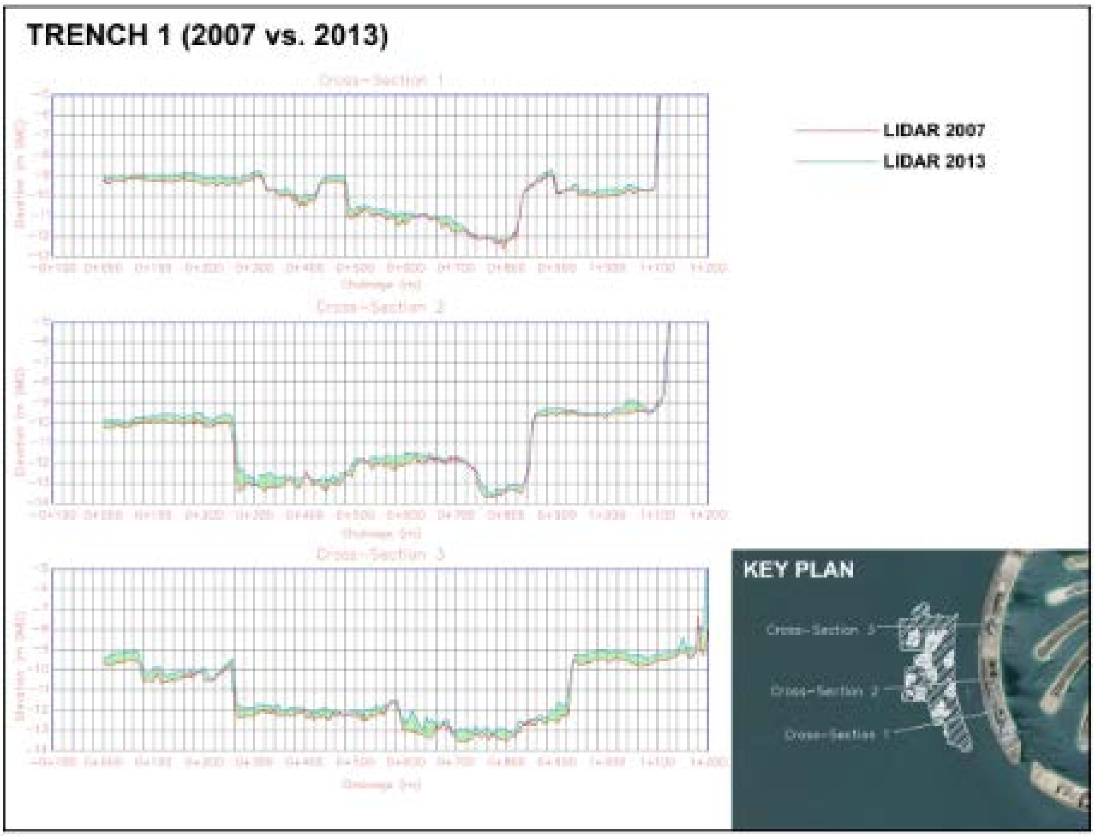


Figure 6-18 Comparison of bed levels at three cross sections – 2007 vs 2013 LiDAR

Source: Sogreah (2017f)

Assessed infill rates across the six trenches ranged from -0.02 m/year (representing erosion) to 0.06 m/year (representing deposition). The average infill rate across all assessed channels was 0.03 m/year. In some instances, evidence of slope failure was apparent in the cross section comparisons, which showed localised increases in bed level towards the edges of the trench likely due to collapse of the trench wall.

The vertical accuracy (root mean-squared error) of the LiDAR measurements is within ±15 cm. As such, comparison between two LiDAR datasets has an inherent vertical accuracy error of ±30 cm (Sogreah, 2017f). In many of the comparisons undertaken, the difference in bed level was consistently within this vertical error range (e.g. Figure 6-18) and may be largely due to measurement inaccuracies.

With these considerations in mind, the true infill rate is likely to be lower than the average of 0.03 m/year observed in the LiDAR comparison.

Empirical Assessment

The empirical infill assessment applied the Soulsby & Van-Rijn equation to estimate total sediment transport resulting from simulated currents and wave conditions. Sediment properties were estimated from recent geotechnical data from the nearby Bluewaters Island project. A total of 13 locations in the proposed navigation channel and berthing basin were assessed with the empirical equation. The annual deposition rates were estimated to be less than 0.005 m/year for all locations.

Conclusion

Given the inherent uncertainties with the assessment methods applied in this study, a conservative empirical infill rate of <0.01 m/year is adopted (i.e. over double the rate predicted by the empirical assessment). Based on this infill rate and a siltation allowance of 0.2 m, the anticipated frequency of maintenance dredging is estimated to be 20 years.

Dubai Harbour and Dubai Marina

A per the above summary of the Navigation Channel Sedimentation Assessment (Sogreah 2017f), empirical infill assessment (Soulsby & Van-Rijn) estimated the average annual channel infill rate over a period of 58 years (based on 3-hourly wave and current data).

Figure 6-19 provides the results of the net sediment infill rates in the channel. In areas A, B, C and D the infill rates are negligible due to the low currents and small wave heights. For this reason it will be impossible for sediment to be transported further landward to the leeside of Dubai Harbour and into the Duba Marina area and for this reason no significant sediment influx is expected and no increase in sedimentation due to Dubai Harbour development in the Dubai Marina canal is expected.

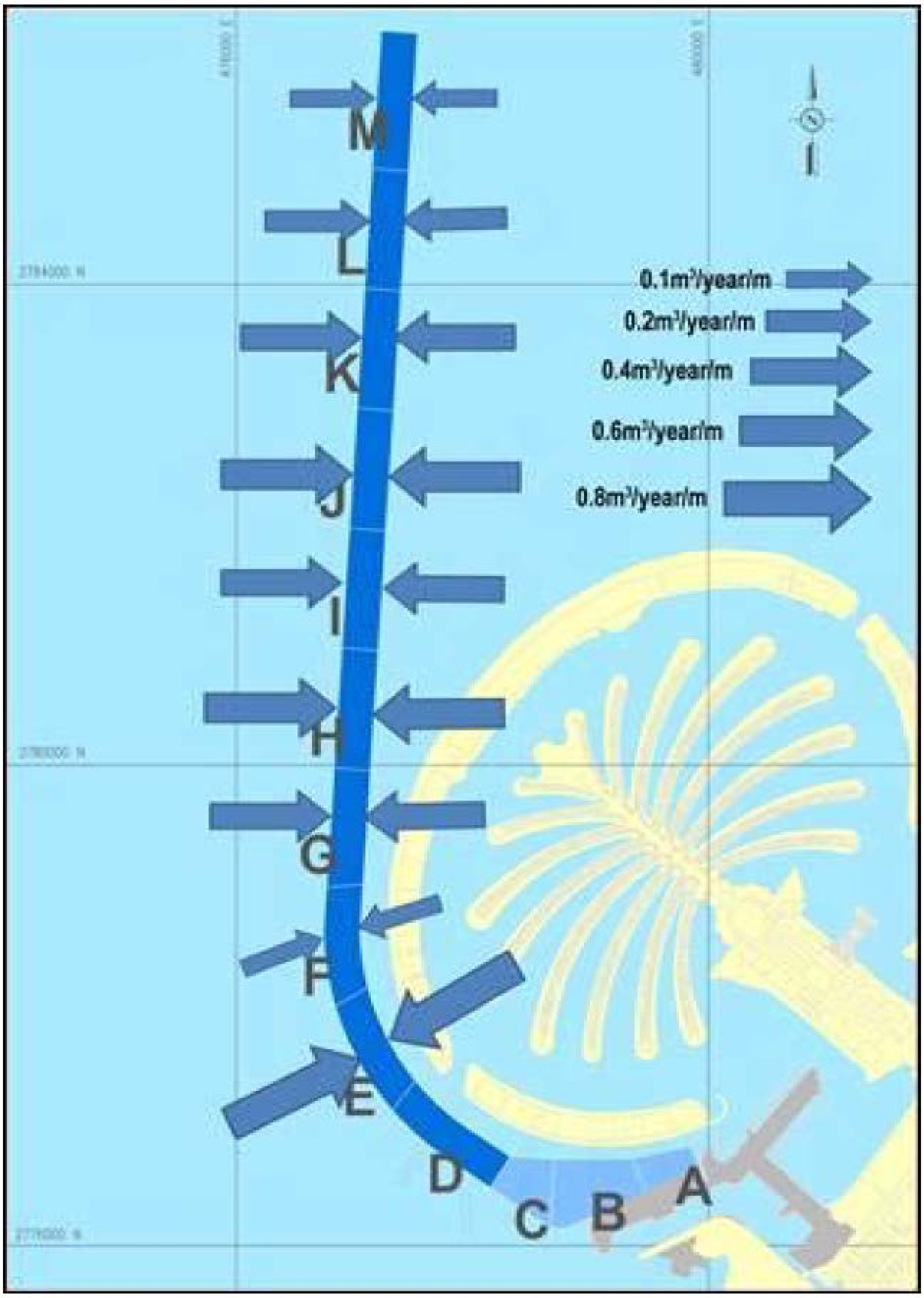


Figure 6-19 Estimated channel infill rate (Sogreah 2017f)

6.7.2.5 Beach Stability Assessment

The proposed Dubai Harbour development has the potential to locally change the wave climate, which will have an impact on the public beach of JBR. As such, a beach stability assessment was undertaken by Sogreah (2017g, Appendix E) to evaluate the potential evolution of shorelines within the Project area. The key objectives of the assessment were to:

- Determine the long-term equilibriuim alignment of JBR beach for the present conditions (pre-Dubai Harbour);
- Determine the likely impact of the Dubai Harbour Project on the equilibrium of JBR Beach;
- Assess the beach profile stability during and after storms; and
- Determine the existing and future hazard lines along JBR Beach.

Assessment of the impact of the Project on the equilibrium alignment of Bluewaters Beach and Palm Jumeirah Beach was also undertaken by Sogreah (2017g Appendix E). Furthermore, an additional beach stability modelling assessment was undertaken for North Beach (Sogreah, 2017g).

JBR Beach

Shoreline Evolution

The time-dependent shoreline evolution has been modelled by Sogreah (2017g) using the LITLINE numerical model.

JBR Beach is a natural beach that is presently not in an equilibrium alignment with the wave climate. The beach has a total length of 2.2 km and is experiencing shoreline recession along the northern beach extent and shoreline accretion along the southern beach extent.

Predicted shoreline alignment based on shoreline evolution assessment undertaken by Sogreah (2017g) over a 50-year period for the pre-development (without Project) and post-development (with Dubai Harbour Project) scenarios is provided in Table 6-23 and presented in Figure 6-20. Generally, the impact of Dubai Harbour Development on the equilibrium alignment of the JBR Beach is minor compared with the existing condition. The assessment also showed that equilibrium alignment with the Project is better for the southern end of the beach.

Table 6-23 Shoreline alignment of JBR Beach for the pre- and post-development scenarios

JBR Beach	Pre-Development (Sogreah, 2017g)	Post-Development (Sogreah, 2017g)
Northern end of the beach	Recession up to 46 m	Accretion of up to 48 m
Mid-section of the beach	Recession up to 34 m	Recession up to 38 m
Southern end of the beach	Accretion of up to 110 m	Accretion of up to 84 m

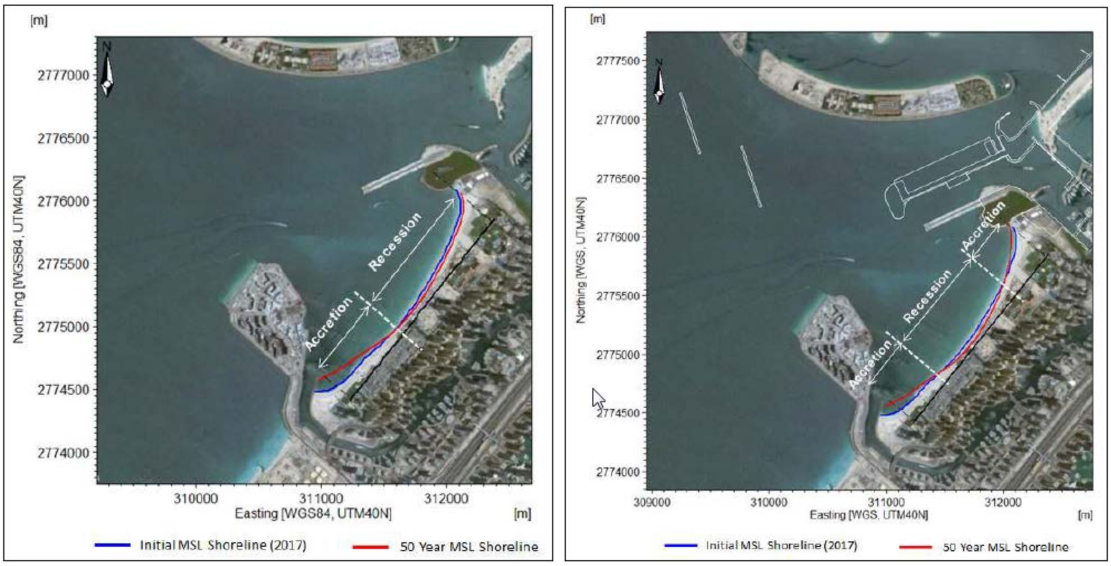


Figure 6-20 Shoreline alignment for the pre-development (left figure) and post-development (right figure) scenarios

Source: Sogreah, 2017g
Note: MSL – mean seal level

A comparison between the shoreline alignment after 50 years (equilibrium alignment) of JBR Beach for the pre and post-Dubai Harbour scenarios was undertaken and is presented in Figure 6-21.

Figure 6-21 50 year shoreline alignments for the pre and post-Dubai Harbour scenarios

Source: Sogreah, 2017g

Beach Profile Stability and Hazard Lines

Beach recession due to sea level rise was assessed by Sogreah (2017g) over a 50-year period. The modelling predicted that a sea level rise of 0.32 m is expected to result in a beach recession of approximately 7 m.

With regards to storm response, the cross-shore beach responses for the 1 in 1 year and 1 in 100 year return period event for the pre- and post-Dubai Harbour scenarios is provided in Table 6-24. Predicted erosion depths for the post-Dubai Harbour scenario are between 0 to 0.1 m less than the pre-Dubai Harbout scenario for these storm events.

Table 6-24 Summary of cross-shore beach erosion for pre- and post-development

Scenario No.	Return Period (Years)	Water level (mDMD)		Beach Recession (m)		Maximum Erosion Depth (m)	
		Pre-Dubai Harbour	Post-Dubai Harbour	Pre-Dubai Harbour	Post-Dubai Harbour	Pre-Dubai Harbour	Post-Dubai Harbour
1	1	+2.28	+2.28	43	39	2.0	2.0
2	1	+2.60	+2.60	45	42	2.0	1.9
3	100	+2.64	+2.64	49	45	2.1	2.0
4	100	+2.96	+2.96	52	52	2.0	1.9

Source: Sogreah, 2017g

Hazard Lines

The hazard lines represent the dynamic extent of shoreline movement that may be expected due to the combination of long-term shoreline changes (shoreline orientation, recession or accretion and sea level rise) and short-term shoreline erosion due to storm events (Sogreah 2017g). Based on Sogreah's (2017g) assessment, the 50-year hazard line for both pre- and post-development extends up to 59 m from the 50-year shoreline alignment. Infrastructure at the central part of the JBR Beach are the most vulnerable to coastal hazards.

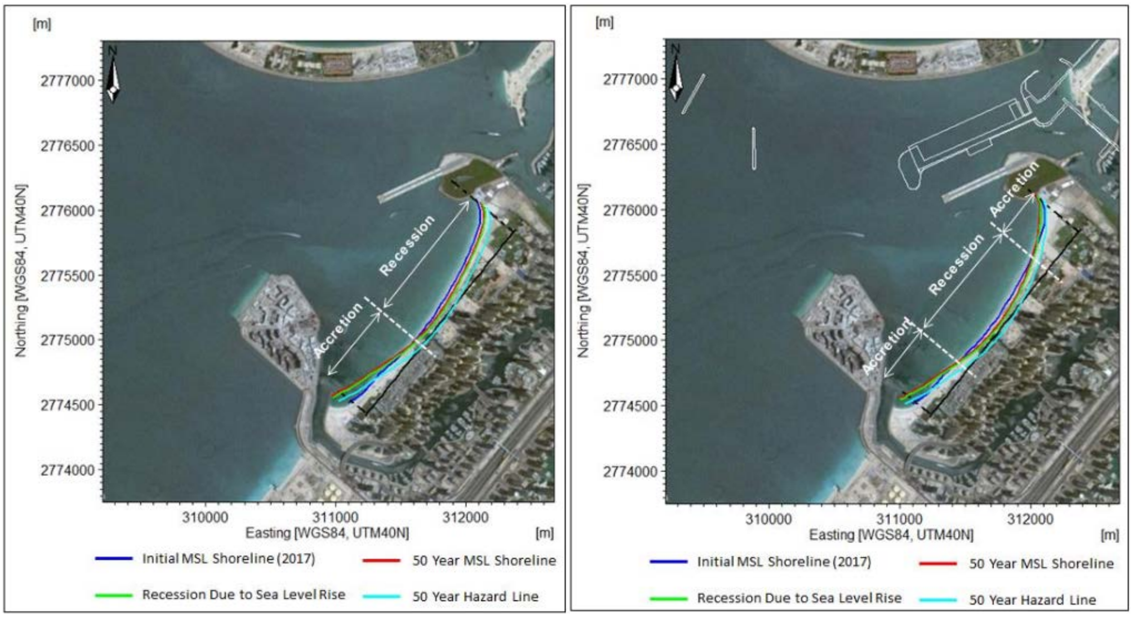


Figure 6-22 Hazard lines for pre-development (left figure) and post-development (right figure) scenarios

Source: Sogreah, 2017g

Bluewaters Beach

Bluewaters Beach is an artificial beach located along the northern extent of the Bluewaters Island and was constructed with a long-term equipibrium alignment of N308°. The long-term equilibrium alignment of Bluewaters Beach post-Dubai Harbour is approximately N302° and as such, the beach will experience a counter-clockwise rotation (Sogreah, 2017g).

Palm Jumeirah Beach

Palm Jumeirah Beach is an artificial beach located along the southern edge of the trunk of Palm Jumeirah, which is not in equilibrium alignment with the wave climate; however, the beach is well-sheltered from offshore climate and is mostly subjected to locally generated wind waves of relatively short fetch lengths. As such, the sediment transport processes are relatively minor (Sogreah, 2017g).

Sogreah (2017g) concluded that the development of Dubai Harbour will further shelter the Palm Jumeirah Beeach from offshore wave climate. Therefore, it is anticipated that the maintenance requirements for Palm Jumeirah Beach will not increase after the construction of the proposed Project.

North Beach

An artificial beach (North Beach) is proposed to be constructed along the north-eastern face of the Zone 2 development. A perched beach design will be adopted for the proposed construction. The North Beach site is exposed to a mild wave climate, however the proposed shoreline alignment is highly oblique to the prevailing wave directions (Figure 6-23) which may result in significant net shoreline transport in the long-term (Sogreah, 2017n).

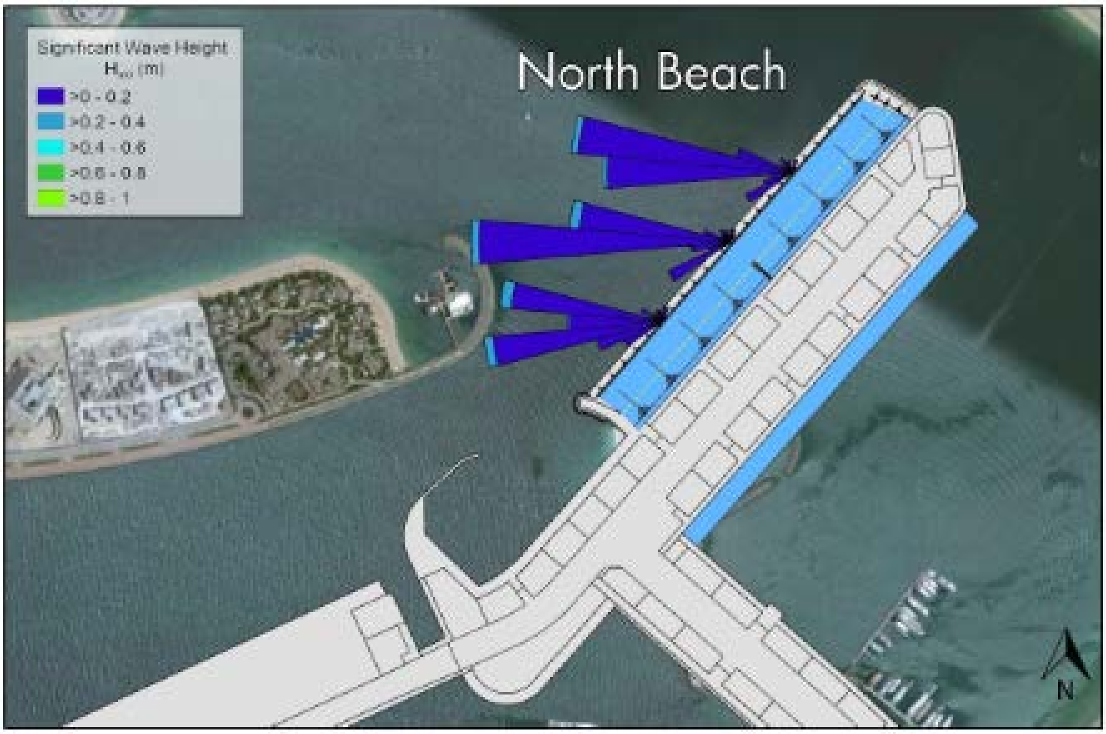


Figure 6-23 North beach alignment and 50-year wave climate roses

Source: Sogreah, 2017n

Cross-shore Storm Response

Cross-shore beach erosion was simulated by Sogreah (2017n) in the SBEACH platform for 1 in 1 year and 1 in 100 year return period storm events. The results for the present, future and Design Low Water Level (DLWL) scenarios are presented in Table 6-25. Erosion depths are predicted to be reduced by ~0.1 m for the future scenario during both 1 and 100 year return period storm events. The cross-shore profiles for the 1 in 100 year event are presented in Figure 6-24.

Table 6-25 Summary of cross-shore beach erosion

Return Period (years)	Scenario	Water Level (m DMD)	Crest Erosion (m)	Max. Erosion Depth (m)
1	Present	2.30	0	~0.4
	Future	2.62	0	~0.3
	DLWL	-0.10	0	~0.1
100	Present	2.62	0	~0.8
	Future	2.94	~3	~0.7
	DLWL	-0.10	0	~0.6

Source: Sogreah, 2017n

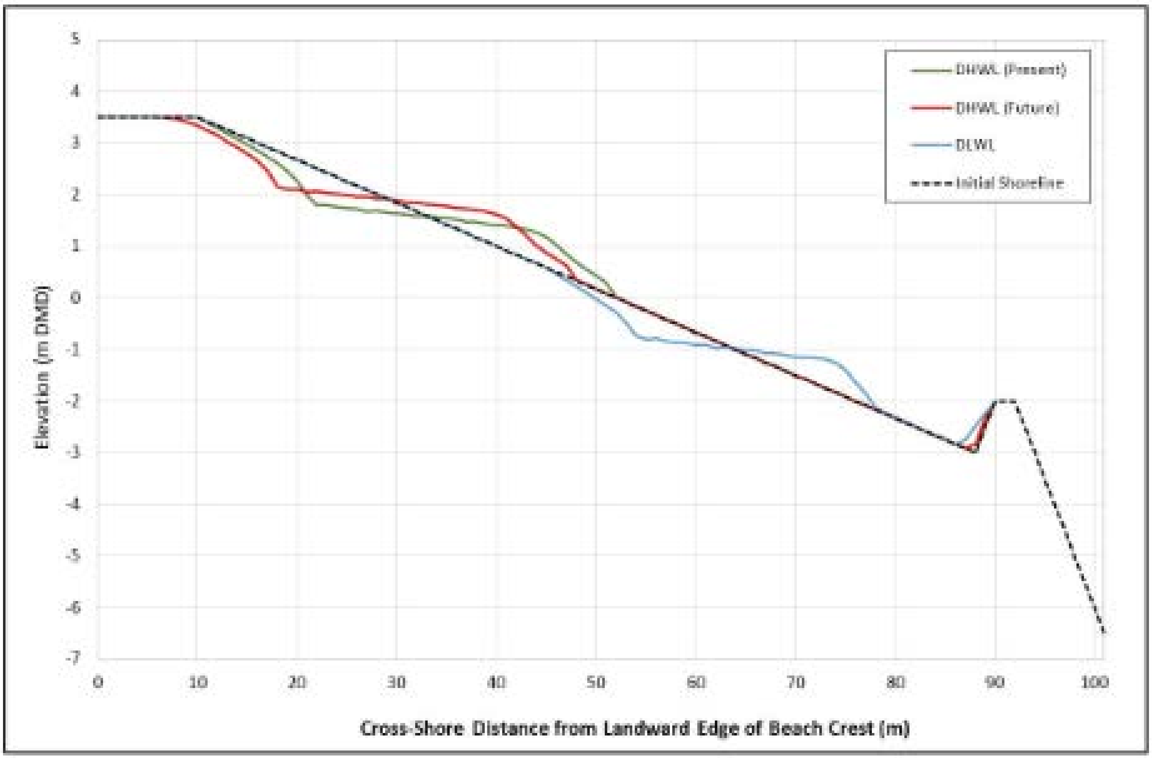


Figure 6-24 Cross-shore profiles for the 1 in 100 year return period strom event

Source: Sogreah, 2017n

Shoreline Evolution

The long-term equilibrium shoreline alignment was evaluated over a 50-year period using the LITDRIFT modelling platform (Sogreah, 2017n). The proposed design alignment of North Beach is 311° however the simulated long-term equilibrium alignment is 271°, indicating an anti-clockwise sand transport regime. This will result in sand accretion at the northern end of the beach and erosion at the southern end of the beach. The extent of this morphological change over a 5-year period is illustrated in Figure 6-25. The average annual sediment transport over this 5-year period is 1,250 m^3 (Sogreah, 2017n).

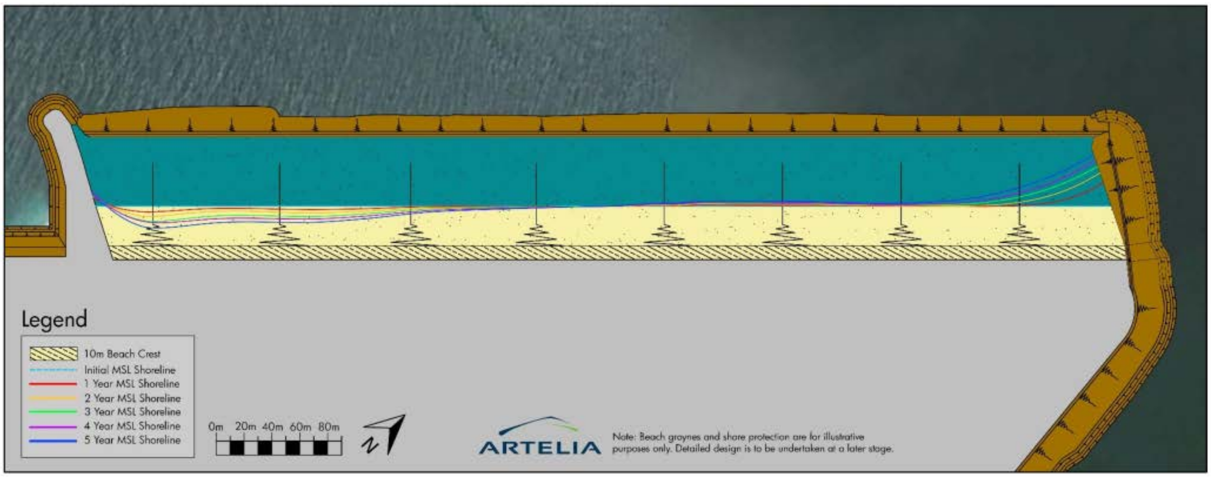


Figure 6-25 5-year shoreline evolution

Source: Sogreah, 2017n

Beach Aesthetic

Calm wave conditions can result in the settlement of fine suspended matter onto beach sediments. Over time, a layer of soft sediment will develop which feels ‘muddy’ underfoot and reduces beach aesthetic. As a general rule, a beach should be exposed to wave heights in excess of 1 m for a minimum of 12 hours each year in order to maintain good quality sediments (Sogreah, 2017n). Assessment of the simulated near-shore wave climate at North Beach indicates that the significant wave height exceeded for 12 hours each year is 0.3 m (Sogreah, 2017n). However, due to the relatively high level of sand mobility resulting from the oblique wave direction, siltation of fine particles resulting in poor beach quality is not expected to occur.

6.7.2.6 3D Physical Modelling

Three-Dimensional (3D) physical modelling of the wave climate surrounding the proposed Cruise Terminal was undertaken by Deltares (2017) as summarised by Sogreah (2017i). The primary objectives of this study were as follows:

- Assess the stability of the roundhead rock revetment at the south-western end of the marina;
- Measure wave forces at two locations on the quay wall;
- Investigate wave overtopping of the quay wall at five locations and at the roundhead revetment at two locations;
- Optimise the roundhead rock revetment cross-section; and
- Optimised/validate the offshore detached breakwaters configuration.

A 1:36 scale physical model of the western section of the quay wall and the roundhead revetment was constructed at the Deltares Delta Basin facility. Scaled waves approaching from the north-west were generated with a 100-panel wave board, allowing spatially-varied wave heights and directions to be generated. A photograph of the physical model setup in the Delta Basin facility is presented in Figure 6-26.

Figure 6-26 Physical model setup with wave board (pictured left)

Source: Deltares, 2017

A range of test wave conditions were generated at the wave board as detailed in Table 6-26. The wave conditions consider the sheltering effect of the offshore breakwaters as informed by Sogreah (2017a) nearshore wave modelling.

Table 6-26 Range of scaled wave condition simulated at the wave board

Test ID	Return Period (years)	Still Water Level (m DMD)	Maximum Wave Height (m)	Wave period (s)	Offshore Wave Direction (°N)	Marina Configuration
T0101	1	2.6	2.39	9.0	280°	As designed
T0102	100	2.96	3.21	10.0		
T0103	100	-0.1	3.21	10.0		
T0104	Overload[3]	2.96	3.85	10.0		
T0201	1	2.6	2.02	9.0	300°	As designed
T0202	100	2.96	2.69	10.0		
T0204	Overload[3]	2.96	3.23	10.0		
T0301	1	2.6	2.39	9.0	280°	Quay wall raised by 0.25 m
T0302	100	2.96	3.21	10.0		Quay wall raised by 0.5 m
T0303	100	-0.1	3.21	10.0		
T0401	1	2.6	2.39	9.0	280°	As designed, shifted measurement locations for wave overtopping
T0402	100	2.96	3.21	10.0		
T0501	1	2.6	2.39	9.0	280°	Rock revetment steepened to 1:1.5. Crest widened from 3.6 m to 8.6 m near quay wall. Recurve wall installed on quay wall.
T0502	100	2.96	3.21	10.0		
T0503	100	-0.1	3.21	10.0		
T0504	Overload[3]	2.96	3.85	10.0		
T0601	1	2.6	2.34	9.0	280°	Modified configuration of offshore detached breakwaters
T0602	100	2.96	3.16	10.0		
T0603	100	-0.1	3.16	10.0		

Adapted from: Deltares (2017) and Sogreah (2017i)

The following criteria for assessment of the marina structures were adopted:

- Wave overtopping < 1 L/s/m (EurOtop, 2016); and
- Damage parameter S = 2 represents 'start of damage' as specified in The Rock Manual (CIRIA, CUR, CETMEF, 2007).

The damage criteria for the roundhead rock armour was satisfied for all tests performed, with S = 0.8 being the maximum damage level observed.

For the original design, the wave overtopping discharge at the quay wall reached 3.6 L/s/m for 1 in 1 year conditions and 32 L/s/m for 1 in 100 year conditions, exceeding the adopted criteria. This occurred for tests with an offshore wave direction of 280°.

In order to meet the wave overtopping criteria it was found that the quay wall would need to be raised by 0.5 m, which resulted in overtopping discharges of 1 L/s/m for 1 in 1 year conditions (i.e. at the threshold) and 11.5 L/s/m for 1 in 100 year conditions (above the threshold).

Wave overtopping of 7.8 and 36.4 L/s/m for 1 and 100 year recurrence interval wave conditions was also observed at the crest of the roundhead immediately adjacent to the quay wall. As such, the crest was widened from the original design of 3.6 m to 8.6 m over the first 28 m of the roundhead. This resulted in reduced wave overtopping at this location to 0.7 L/s/m for 1 year recurring interval conditions and 13.7 L/s/m for 100 year recurrence interval conditions.

[3] Overload: Wave height is increased by 20% compared to the 100 year return interval

Installation of a recurve wall on the seaward face of the quay wall had a minimal effect in reducing wave overtopping volumes and will impact the selection of fenders.

Based on the frequency of wave heights resulting in overtopping, it was estimated by Sogreah (2017i) that a mean overtopping discharge >1 L/s/m will result in cessation of quayside operations for up to 24 hours annually if the original design of the harbour and detached breakwaters is maintained. This is considered acceptable from an operational perspective and is preferable to redesigning the cruise terminal and increasing the extent of the detached breakwaters, with associated increase in environmental impacts. Recommended mitigation measures to reduce the impact of wave overtopping during significant storm events are presented in Section 7.6.2.4.

6.7.2.7 Summary

A summary of the potential unmitigated operation phase impacts to coastal processes is presented in Table 6-27.

Table 6-27 Potential unmitigated operation phase impacts on coastal processes

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Changes to sediment depositional/erosional patterns resulting from altered current speeds. This could result in the requirement for maintenance dredging	Possible	Moderate	**Medium**	Benthic habitats	Negative
Decreased flushing at Mina Al Seyahi Beach	Likely	Insignificant	**Low**	Swimmers at Mina Al Seyahi Beach	Negative
Decreased flushing at Dubai Marina	Likely	Minor	**Medium**	Water quality within Dubai Marina	Negative
Exceedance of marina tranquillity criteria (for waves) at western berth of Cruise Terminal Marina	Likely	Minor	**Medium**	Ships berthed at the western berth during storm conditions	Negative
Sedimentation in the navigation channel and berthing basin	Likely	Minor	**Medium**	Marine environment Vessel operators (altered navigation during maintenance work)	Negative

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Improved flushing at DIMC / Dubai Harbour Main Marina	Likely	Insignificant	Low	Water quality within Dubai Harbour Marina and Dubai Harbour Marina North	Positive

6.8 Marine Ecosystem

6.8.1 Construction Phase

During the construction phase of the Project, the following activities are predicted to have the greatest risk of affecting the biodiversity and ecological values of the marine ecosystem at the Project site and in the surrounding areas:

- Deconstruction of existing breakwaters and groynes;
- Construction of revetment and placement of reclamation fill material;
- Disposal of unsuitable fill material to the marine environment (if required / approved);
- Discharge of dredged tailwater during reclamation;
- Dredging of cruise terminal basin and navigation channel;
- Beach profiling works;
- Dust deposition into the marine environment;
- Accidental oil and chemical spills both from marine construction vessels and construction works on reclaimed land.

The most significant negative impacts associated with the Project activities are likely to be associated with marine water quality, sediment deposition and marine ecology in and around the reclamation footprint. A summary of the key impacts is provided in the following sub-sections.

6.8.1.1 Habitat Loss and Modification

Proposed project works include the deconstruction of existing breakwaters and groynes, the reclamation of land and the dredging of an access channel. All of these activities will result in potential habitat loss and or modification.

Removal of Hard Substrate

In terms of the removal of breakwaters, the areas of breakwaters that would be removed are located around Logo Island, which was constructed relatively recently and is therefore predominantly comprised of a bivalve dominated fouling community. During the marine baseline survey, two sites were assessed along the Logo Island Breakwaters (sites 19 and 23), along which only one small coral was recorded (*Favia speciose*), which is common in the Gulf and listed as ‘Least Concern’ on the IUCN red list (IUCN 2017). While coral communities have high ecological value, the recorded coral cover was particularly low (0.02% cover), likely due to the relatively short period of time that the breakwaters have been in place (approximately 12 years). The loss of these corals would have a marginal impact on the diversity and value of the local marine environment, however, the addition of a larger area of breakwater will provide hard substrate for potential future colonisation of corals (refer to Section 6.8.2.2). Further, the areas of breakwater that supported the greatest density and diversity of corals (sites 1, 4, 7, 17 and

18) are located around the outside of the Palm Jumeirah, which would not be removed of modified as part of the Project.

Loss of Marine Habitat in Place of Land Reclamation

During reclamation, an area that is currently marine habitat will be lost as it will be covered with sediment to create land. A number of sample locations were located in the areas proposed for reclamation (sites 12, 13, 26, 27 and 28), which were all comprised of unconsolidated sediment with no habitat or species of significance noted during the drop down video assessment to warrant further investigations. The benthic infauna diversity was noted to be low at the majority of the sites with the exception of site 26, where a high diversity index was determined. However, this was noted to be tempered by an uneven distribution of organisms and numerical dominance by one or a few species (in both cases the Crustacean Apseudidae), suggesting a recent perturbation or sub-optimal conditions. Only two sample locations were recorded to support seagrass populations (sites 21 and 24), but both were located outside of the reclamation footprints. As such, the reclamation of land in these locations is not considered to cause a significant impact to marine habitats.

Removal of Habitat from Dredging

For the dredging activities, much of the area to be dredged has already been dredged as part of previous Projects and is therefore already highly disturbed. During the marine ecology survey, sites 2, 5, 8, 14, 16, 32 and 33 assessed the previously dredged areas and found that there was an absence of benthic organisms in the channel bed, while a bivalve dominated fouling community was recorded on the channel edges. As such, this area is considered to be of low conservation value and comprises a generally depositional, smothering environment with a limited or absent epibenthic community. However, the portion of the access channel that will be dredged further offshore has not been dredged before and currently comprises hard bottom habitat. Sample locations 34, 35 and 36 were located in this proposed offshore dredge area. At these locations, the diversity and abundance of marine flora and fauna was generally found to be low, with relatively few epibenthic species observed (a mean of eight species per site). One extremely small coral (approximately 1 cm diameter) was recorded at site 36 at the outer extent of the proposed channel, although estimated coral cover was <0.01%. As a result of the mobility of the sediment layer, neither the hard nor the soft substrate assemblages tend to develop into an especially rich community and therefore this habitat is not considered to have high conservation value.

In addition to removing any pre-existing organisms, dredging alters the substrate, depth, light penetration, hydrology and a host of other fundamental characteristics which structure the benthic community. Subsequent recolonization will be determined by the modified site conditions, although the new assemblage is unlikely to duplicate the previous community.

Summary

While the loss and modification of habitat within the Project site is considered permanent, irreversible and cumulative for the replacement of marine habitat with land, the effect on the marine community from removal of breakwaters and the dredged areas is reversible and temporary as infauna can recolonise disturbed habitats and fishes will return to the habitats once construction ceases. The patchy distribution of infauna observed in the Project area demonstrates that the recruitment and recovery of assemblages is not expected to be permanently affected by altered bathymetry.

Due to the low ecological value of the marine habitats in the areas that will be lost or modified, the impact is considered to be moderate.

6.8.1.2 Suspension and Deposition of Sediments

Dredging and reclamation activities generate plumes of suspended sediments that can remain suspended in the water column for an extended period of time. The dispersion of suspended sediments is dictated by the rate of generation of suspended sediments, particle size, ambient currents, weather conditions and mitigation measures implemented. Dust deposition from unmanaged roads and uncovered stockpiles may have similar effects on a smaller scale

The most significant risk associated with unmitigated dispersion and deposition of sediment is the potential to impact the water quality at several nearby sensitive receptors, including:

- The existing beaches to the south-west of the site (Bluewaters and JBR Beach) and to the east of the development (Barasti/Hotel Beach)
- The Dubai Marina entrance to the south-west of the development;
- Palm Jumeirah entrance to the east of the site, including the existing marina and beach in Palm Jumeirah;
- Palm Jumeirah flushing channel to the north-west of the development; and
- Local benthic habitats within the Project area.

The impact can be divided into two aspects, increased suspended sediments load in the water, which increases shading on the seabed and may have a deleterious effect on photosynthetic organisms, and sediment deposition, which can cause smothering of benthic communities. The two aspects are described in the following sub-sections.

Sogreah (2017k) have undertaken modelling of the sediment plume using a SISYPHE numerical sediment dispersion model to simulate the behaviour of passive fine sediment particles released into coastal waters as a result of reclamation and dredging for the Project. The completed modelling report is included in Appendix E. The modelling assessed the impact at nine key receptor locations, as shown in Figure 6-27. The approach adopted by Sogreah (2017k) was to simulate the first 15 days (8 to 23 September 2012) of suspended sediment generation during two project phases, representing an early construction phase (phase A) and an intermediate construction phase (phase B). This impact assessment has been undertaken on the assumption that the 15 day duration of sediment release simulated by Sogreah (2017k) was sufficiently long enough to allow establishment of a dynamic equilibrium state (whereby the long-term rate of sediment suspension at the dredge/reclamation site is balanced by the long-term rate of sediment deposition over a wider area). As such, it is assumed that no further concentration of suspended sediments will occur over the next 15 days following the Sogreah (2017k) simulations and the suspended sediment results are widely applicable for the long-term (>21 months) marine works proposed.

The bathymetries applied to the hydrodynamic model for the two phases are presented in Figure 6-28, while the four dredging scenarios that were considered across different areas of the Project are provided in Figure 6-29.

Figure 6-27 Sedimentation Assessment Areas

Source: Sogreah (2017k)

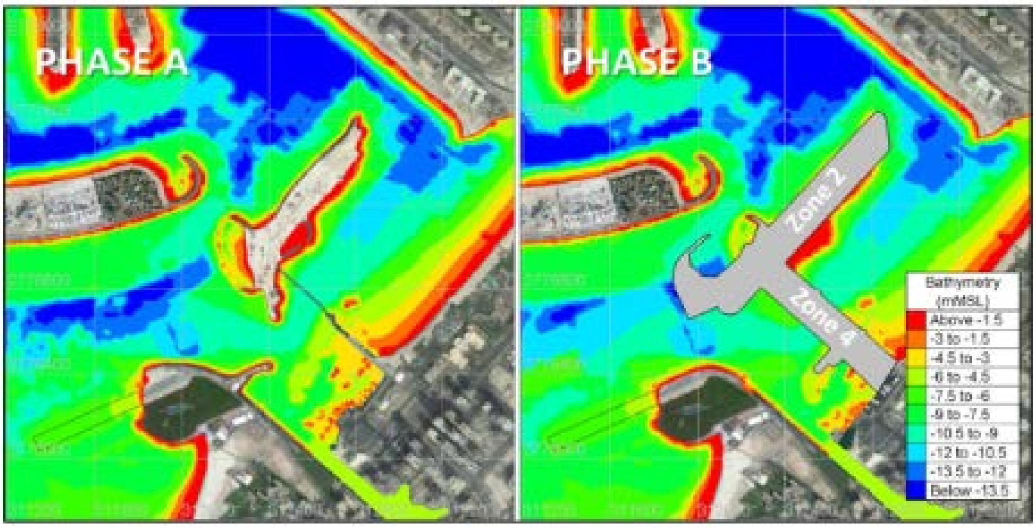


Figure 6-28 Bathymetries applied in sediment plume modelling for Phase A (left) and Phase B (right)

Source: Sogreah (2017k)

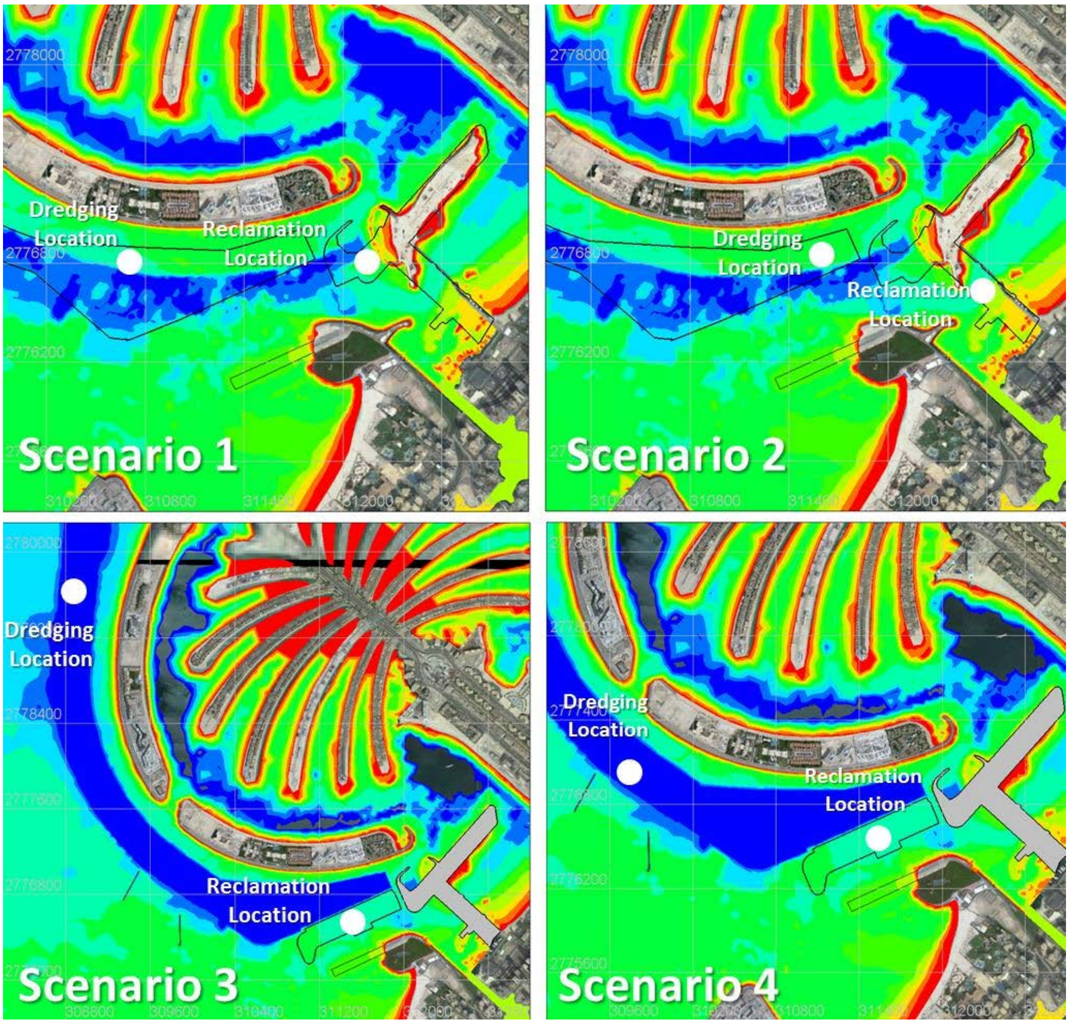


Figure 6-29 Summary of Modelling Scenarios

Sediment Suspension

Sogreah's modelling (2017k) predicts that with no mitigation measures in place (i.e. silt curtains, etc.), suspended sediments in the immediate vicinity of construction activities will exceed the DMWQO threshold, but will remain below the DMWQO guideline (< 0.025 g/L) at the assessed sensitive receptor locations. One exception comprises brief exceedances in the Palm Jumeirah Flushing Channel during Phase A under Scenario 1 during Ebb tides (Figure 6-30). Although not recorded at the specific sensitive receptor point, suspended sediments are also predicted to enter into the Palm Jumeirah under the same scenario, but during flood tides (Figure 6-30), although values are predicted to remain within guideline limits.

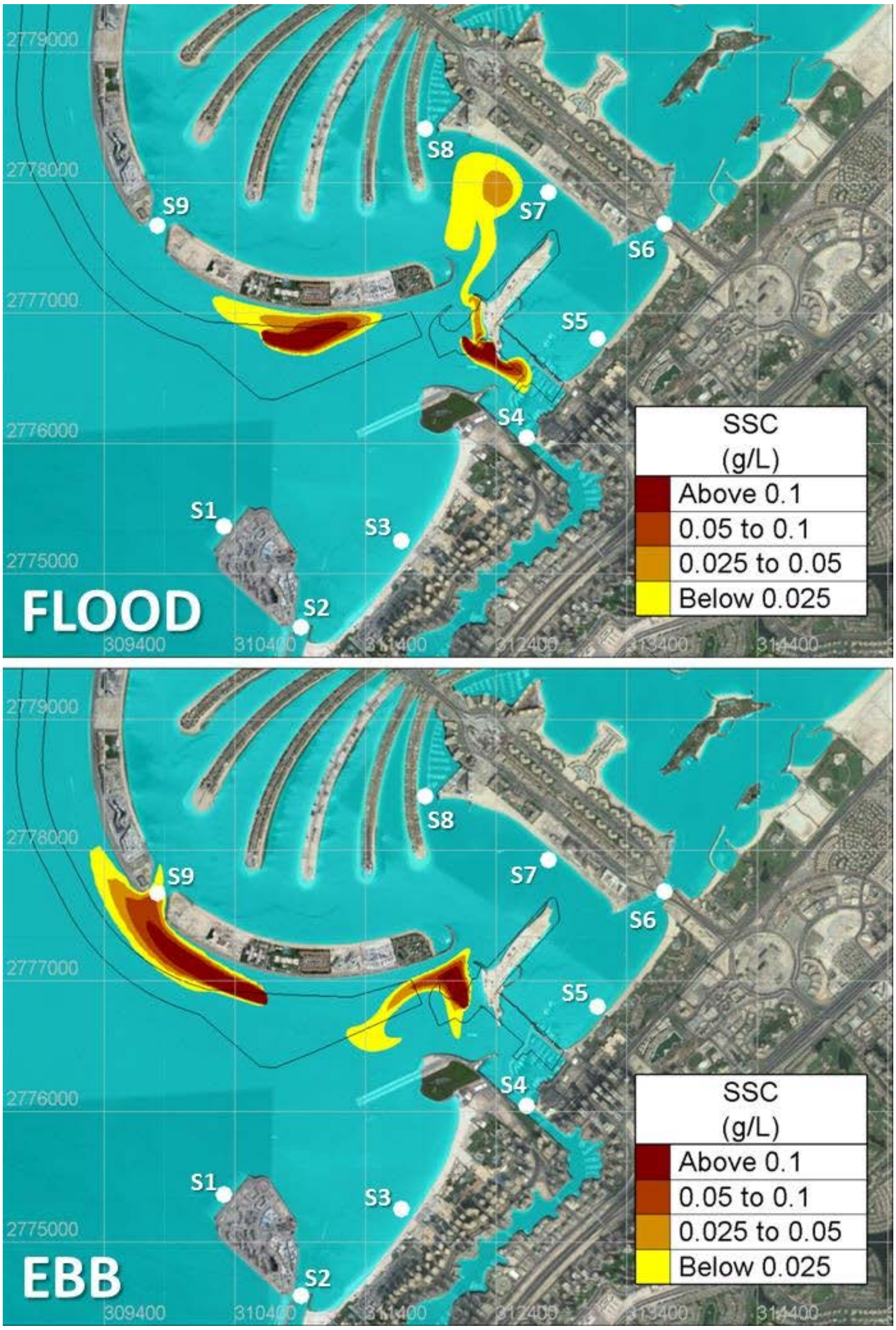


Figure 6-30 Modelled Suspended Sediment Concentrations for Phase A, Scenario 1

The majority of remaining assessed scenarios under each phase predicted that the suspended sediment plumes will disperse away from sensitive receptors and within areas that are relatively well flushed. However, under Scenario 2, Phase A, some movement into the Palm Jumeirah and Dubai Marina is predicted (Figure 6-31). While anticipated to be in low concentrations, the relatively low flushing in the Dubai Marina means that the sediments could remain in the area without being dispersed and flushed out. As such, dredging during this phase and scenario should be avoided during flood tide wherever possible.

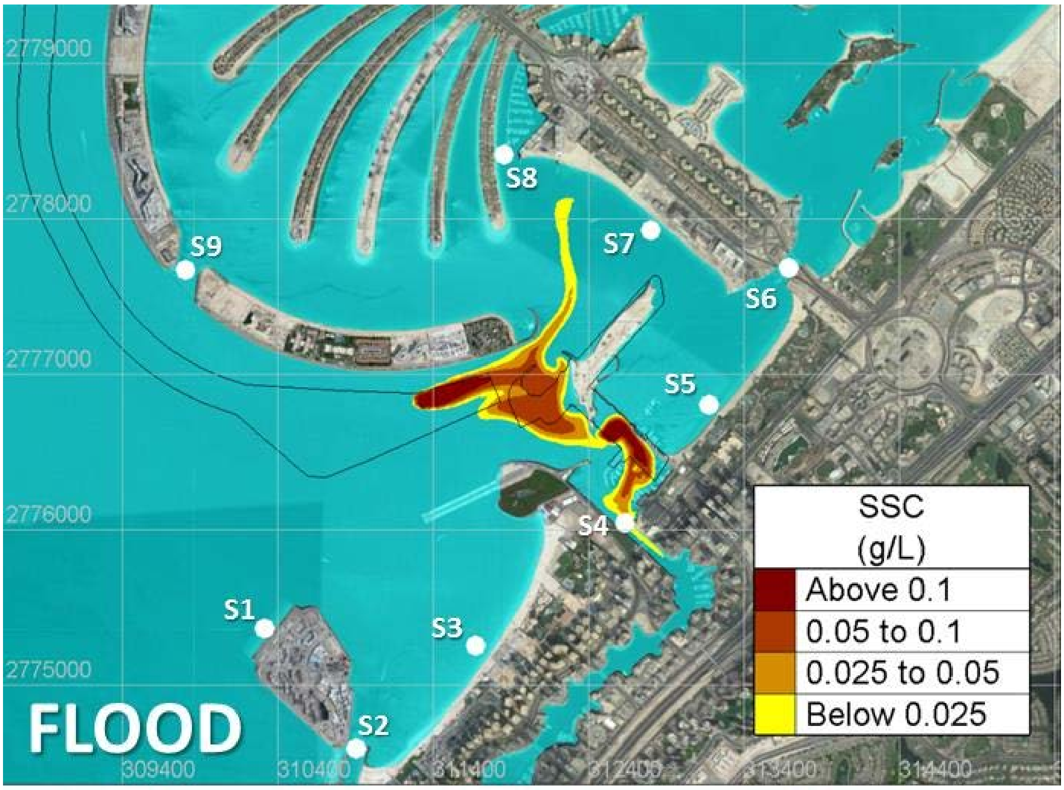


Figure 6-31 Modelled Suspended Sediment Concentrations for Phase A, Scenario 2

The maximum spatial extent of fine sediment plumes exceeding the DMWQO threshold of 0.025 g/L was predicted to be between 1.8 and 5.4 km for dredging activities and 0.2 and 1.3 km for reclamation activities. If unmitigated, these effects are likely to persist for the duration of dredging and reclamation activities, which are predicted to occur continuously over at least 21 months (Section 4.8).

An increased suspended sediments load in the water column increases shading on the seabed, which may have a deleterious effect on photosynthetic organisms. Although at low densities, the MEBS identified patches of sparse seagrass scattered across the sediment habitat around Logo Island and occasional corals on the adjacent rock revetments. Minimum light requirements for seagrasses varies by species, with thresholds usually published as a percentage of Surface Irradiance (SI), which is determined by many factors, but most notably by the sediment load and the depth of the water column. For Gulf species, *Halodule uninervis* requires between 14 and 30% of SI, while *Halophila* spp. requires between 5 and 9% of SI (Erftemeijer & Shuail, 2012). Short-term increases in turbidity are unlikely to have significant impacts on seagrasses, which may survive reductions in light intensity below these levels from four weeks to several months (Erftemeijer & Shuail, 2012), while extended periods of shading may result in temporary or permanent loss of seagrass. The suspended sediment modelling did not show dispersion of sediments towards the seagrass areas under any of the modelled phases or scenarios.

There are no published regionally specific coral mortality thresholds, although mechanisms are likely to be similarly dependant on suspended sediments load and depth.

Prolonged and elevated suspended sediment concentrations in these areas may also result in negative impacts to other benthic species, as a result of decreased light penetration for photosynthetic organisms or by clogging the filtering apparatus of filter feeding organisms. Elevated turbidity can effect photosynthesis of phytoplankton and vegetation, migratory patterns of fish and impede foraging opportunities of fish and other marine fauna.

Water quality and sediment quality outside of the reclamation zone is not expected to be significantly altered in the long-term. With appropriate implementation of mitigation measures to limit the dispersion of marine sediment and nutrients, the level of impact on marine ecology outside the reclamation footprint will be substantially reduced.

Additionally, peak suspended fine sediment plumes over the simulation period for all the 4 scenarios, are presented in Figure 6-32.

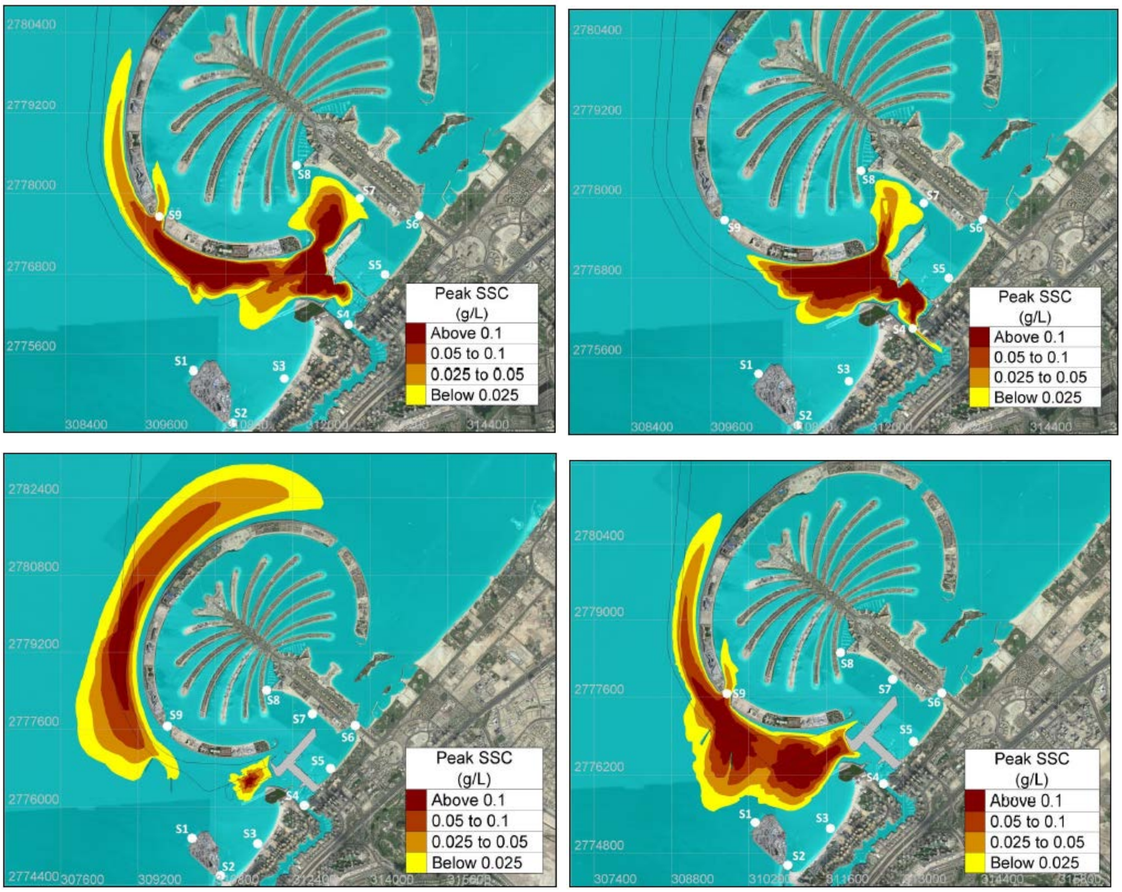


Figure 6-32 Peak suspended fine sediment over a 15-day simulation period for Scenarios 1 - 4

Sediment Deposition

The thicknesses of the deposited fine sediment layers at the end of the 15-day simulation period are shown in Figure 6-33 for the four modelling scenarios. The colour contours are truncated at a lower limit of 0.005m. Generally, dredging activities in the navigation channel results in dispersal of sediments over a wider area, compared to dredging activities in the Cruise Terminal basin. The thickness of deposited fine sediment layer due to reclamation activities does not exceed 0.1m at a distance greater than 350m from the Dubai Harbour development boundaries. For each of the four scenarios, the sediment deposition layer at all sensitive areas is less than 0.04m, but is predominantly less than 0.001 m.

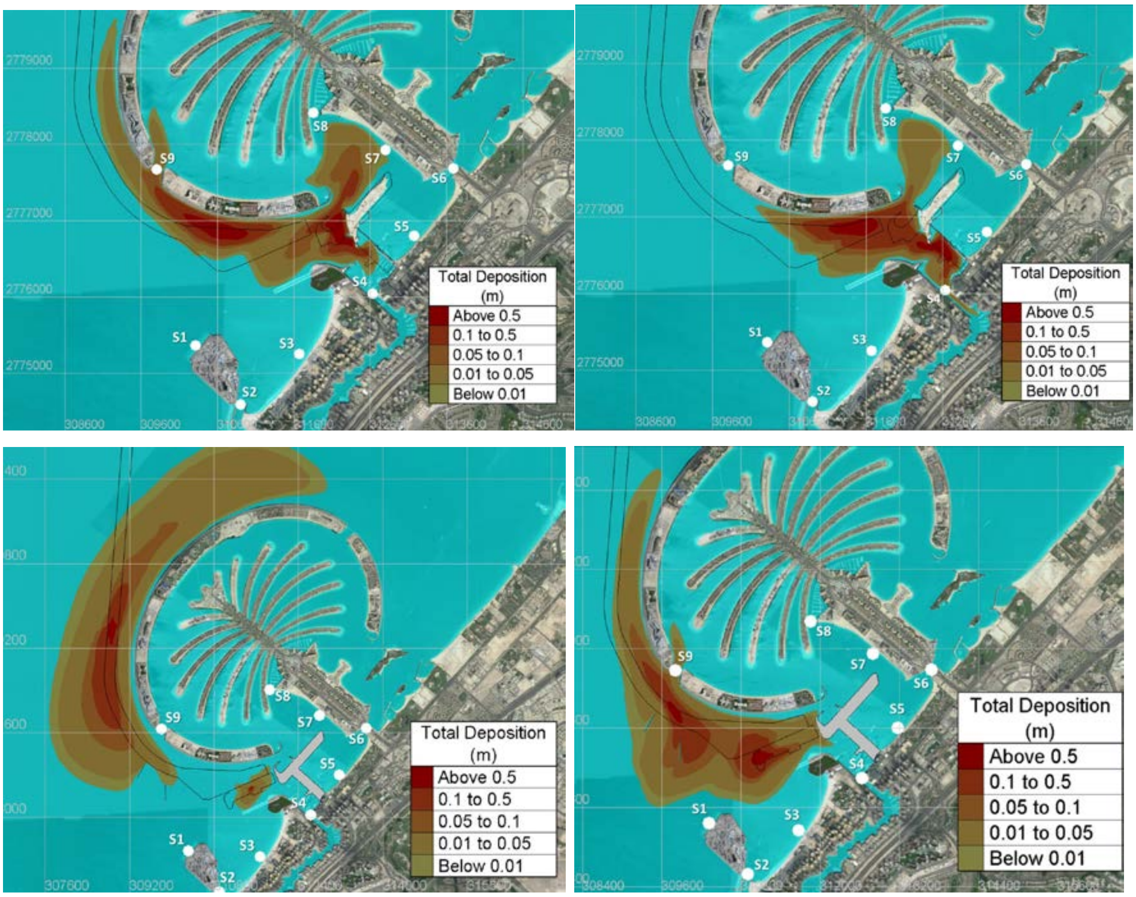


Figure 6-33 Thickness of Deposited Fine Sediment Layer After 15 Days for Scenarios 1 - 4

Sediment deposition from plumes of suspended sediment generated by marine works can potentially smother benthic habitat communities or result in poor beach quality. Seagrasses and filter feeding organisms have varying levels of tolerance to deposition. For example, large seagrass species such a *H. decipiens* can maintain substantial photosynthetic surface even after large-scale burial. Small species, such as the *Halodule* sp. or *Halophila* sp. present at the site, are often completely removed after very small sediment events. As a general rule, the maximum sedimentation threshold for seagrasses to survive in the UAE is 0.05 m per year (Erftemeijer & Shuail, 2012).

The proposed construction schedule detailed in Section 4.8 indicates that dredging and reclamation activities will last for at least seven quarters (i.e. 21 months) across the four zones of the Project. As such, it is assumed that dredging and reclamation activities in each individual zone will last approximately 5 months. Sogreah (2017k) simulated plume generation from dredging and reclamation activities over a period of 15 days (i.e. one full neap-spring tidal cycle). Furthermore, Sogreah (2017k) predicts that minimal re-suspension of fine sediments occurs following initial settling out of the generated plume, indicating that deposited sediment tends to remain deposited. Accordingly, GHD has estimated total sediment deposition thicknesses at key sensitive areas by scaling up the results presented in Sogreah (2017k) by a factor of 10 (15 days x 10 is approximately equivalent to 5 months' worth of sedimentation).

Sedimentation was assessed at the sites depicted in Figure 6-27 above. Following GHD scaling, the total sedimentation thickness at all nine sites was estimated to be <0.01 m over 5 months, with the exception of Palm Jumeirah Beach (up to 0.03 m deposited sediment) and Palm Jumeirah Flushing Channel (up to 0.4 m deposited sediment). The estimated sediment deposition at Palm Jumeirah Flushing Channel is in exceedance of the 0.05 m per year threshold for seagrass (Erftemeijer & Shuail, 2012). Furthermore, unmitigated dredging and reclamation activities are predicted to generate sediment deposition in excess of the 0.05 m threshold in the vicinity of Zone 1, Zone 4 and the Cruise Terminal Basin. Benthic species, including the occasional corals on breakwaters and scattered patches of seagrass in the surrounding sediment habitats within these areas are at risk of becoming smothered by deposited sediments if mitigation efforts are not undertaken during dredging and reclamation works.

Seagrass species that exist in the Arabian Gulf (*Halodule uninervis*, *Halophila stipulacea* and *H. ovalis*) are known to be opportunistic, pioneering species with a broad tolerance and ability to recover rapidly (Den Hartog, 1970, Duarte *et al*. 1997). A study undertaken by Sheridan (2004), measured the impact of sediment disposal from dredging on adjacent benthic habitats and showed that seagrass populations were well-established three years after dredging. Seagrasses and corals established within the near-shore coastal waters surrounding the Project experience fluctuations in physical extreme, including variable salinity, light penetration, turbidity and sediment deposition regimes. These are experienced in response to varying coastal and climatic processes that affect this area year round. Despite these factors, these sensitive communities continue to persist.

As such, short term and localised increases in turbidity associated with dredging and reclamation are considered unlikely to impact long term on the broader distribution of seagrass and other benthic communities within the Project site and surrounding areas. However, a moderate short term impact is likely.

6.8.1.3 Nutrient Enrichment and Introduced Contaminants

Marine sediment contains nutrients from both organic and inorganic sources (OzEstuaries, 2003). Reclamation activities and suspension of sediment in the water column can subsequently result in elevated nutrient (mostly nitrogen and phosphorus) or contaminant load in the water column. Further, the discharge of dewatering effluent or other wastewater during the construction phase could increase the nutrient or contaminant load. Elevated nutrient load has the potential to lead to algal blooms and oxygen depletion in the areas around the reclamation zones, which could result in a moderate impact to the marine environment, although it would likely be temporary and reversible.

As discussed above, the spread of sediment, and subsequently nutrients and contaminants, can be limited with the implementation of suitable mitigation measures. The anticipated long-term negative impacts with regard to nutrient enrichment associated with sediment loading are subsequently expected to be negligible. Mitigation measures proposed during construction are detailed in Section 7.7.1 and will also be contained in CEMP with regards to sediment suspension and dewatering / wastewater discharges.

6.8.1.4 Mobilisation of Dormant Algal Cysts

The MEBS survey identified dormant algal cysts, including those of HAB species, in sediment samples collected along the navigation channel route. Not all algal blooms are harmful, and the degree to which a bloom impacts the environment depends on the dominant species, population density and the receiving environment. For all species, including non-toxic taxa, effects may include;

- **Hypoxic conditions at the seabed**: Bacterial break-down of dead phytoplankton cells which have sunk out of the surface layers can deplete oxygen levels to hypoxic levels;
- **Hypoxia in the water column**: Despite oxygen generation during the day, respiration at night by a high biomass of phytoplankton may reduce dissolved oxygen levels to hypoxic levels detrimental to other organisms. This is exacerbated In warm waters, such as those found in the UAE, as respiration rates increase and oxygen is less soluble;
- **Reduced light penetration**: Absorption of sunlight by phytoplankton reduces or prevents through-water light penetration, limiting availability to other (benthic) species.

In addition, numerous species of phytoplankton are either physical irritants or are toxic, as described below. Harmful algal blooms are a concern for desalination plants due to the high biomass of microalgae present in ocean waters during these events, and a variety of substances that some of these algae produce (Caron et al., 2010). These compounds range from noxious substances to powerful neurotoxins that constitute significant public health risks if they are not effectively and completely removed by the plant reverse osmosis membranes. Algal blooms can cause significant operational issues that result in increased chemical consumption, increased membrane fouling rates, and in extreme cases, a temporary shut-down of the plant (Caron et al., 2010). Given this risk, the vicinity of the DEWA desalination plant should be considered for this Project.

Irritants

The sheer density of phytoplankton may cause mechanical damage to sensitive organs, however, some organisms are particularly problematic, especially certain species of Bacillariophyceae (commonly referred to as diatoms). Diatoms are a unicellular eukaryotic algae found in almost every aquatic environment and are a significant component of most phytoplanktonic communities. They are non-motile (as opposed to the motile dinoflagellates), using lipid filled vacuoles or hydrostatic morphology to change and maintain buoyancy within the water column. They consist of two overlapping protective plates which are mainly composed of silica, upon which some species, (such as those of the genus *Chaetoceros*), have defensive spines which can effect the respiratory systems of other organisms.

Toxic species

Most toxic species of phytoplankton are Dinokaryota, a large group of protists commonly called dinoflagellates. Most species are 'flagellate'; i.e. equipped with two whip-like flagella, which enable them to move within the water column and from which they derive their class name. In contrast to the silica skeleton of diatoms, dinoflagellates have protective plates of cellulose.

Dinoflagellate toxins have been implicated in the deaths of fish, marine mammals and entire ecosystems such as coral reefs (Bauman *et al.*, 2010). Bioaccumulation of certain toxins may result in an increase in concentrations as they move up the food chain, and is known to pose a threat to humans.

Triggers

HABs are usually closely associated with eutrophic conditions (elevated nutrients), although this is not the primary cause in all cases (Sellner *et al.*, 2003). While elevated levels of phosphorous and phosphate were recorded during the baseline survey, other sampled nutrients were low and corresponding indicators of eutrophication such as very low dissolved oxygen, high BOD and high turbidity were not detected. High nutrient levels tend to favour only a few very competitive phytoplankton species, so populations in eutrophic waters are usually low in diversity but very high in population density, in comparison to the high diversity and low population density typically encountered in less enriched and normally clearer waters. The ratio between nutrients, as well as total concentration, is thought to be important in determining which species thrive. However; it is not eutrophication alone that causes HABs. Circulation and meteorological events have been known triggers, although blooms of different species have been recorded throughout the year, and the abundance and distribution of the standing HAB species is also critical.

Two hundred of the approximate two thousand recognised, existing species of marine dinoflagellates are known to form resting cysts in a part of their life cycle. These cysts allow organisms to enter a low-energy dormant stage when conditions are not suitable, but ensure that they can rapidly respond and re-seed an area when conditions become favourable. Cysts of several species of dinoflagellate were identified in the project area (Section 5.7.3), including those of the genus *Prorocentrum,* which is known to cause Diarrheic shellfish poisoning, as well as other toxic species such as Coolia sp. and taxa known to form blooms associated with hypoxic fish kills (*Pyrodinium)* (Moestrup et. al,. 2009).

It has been noted that dredging can mobilise these cysts (e.g. DEPI, 2015), however, few, if any, studies have been conducted on this connection and no quantitative data is available to predict the likelihood of initiating an HAB during dredging activities. As discussed above, there are numerous other factors which influence the population dynamics of phytoplankton communities, including nutrient concentration, the ratio of key nutrients, climatic and meteorological conditions, predation pressure and standing population. However, the optimal conditions that may enable a species to bloom varies between species, meaning that the range of conditions suitable for an HAB is broad and making accurate prediction of conditions leading to HABs difficult, if not impossible.

The presence of HAB species cysts in the sediment necessitates caution during dredging, and measures should be taken to minimise the potential resuspension of sediments by selecting the appropriate dredging and sediment transport methods and by containing the sediment plume. However, in the short term little more can be done to minimise the potential of HABs occurring. In the medium-term, the removal of sediment containing algal cysts will reduce the likelihood of HABs by these species, therefore benefiting the marine environment.

While the potential consequence of a HAB is considered potentially major, the likelihood is relatively low given that the project area was not considered to be eutrophied at the time of the baseline survey and given the range of factors that influence population dynamics of phytoplankton.

6.8.1.5 Introduction of Invasive or Exotic Species

Proposed construction works have the potential to introduce marine pest species if they are carried in ballast or as biofouling associated with the dredger or other vessels. These species can threaten biodiversity as some exotic species can become invasive, spreading rapidly and out-competing native species through competition for resources (Gardner and Howarth, 2009). The introduction of invasive or exotic species is considered permanent, irreversible and cumulative and could impact marine ecology. However, the majority (if not all) of the marine equipment is locally sourced and utilised within the region. Therefore, the likelihood of invasive species introduction is low.

6.8.1.6 Accidental Oil or Chemical Spills

Oil or chemical spills from marine vessels have the potential to introduce contaminants into the marine environment, which can substantially reduce marine water quality and potentially cause injury or death of marine flora and fauna. Impacts to the marine ecosystem will likely be minor given that the quantities would be relatively small and with appropriate spill clean up, could be reversible.

6.8.1.7 Disturbance to Local Marine Fauna (Exposure to Noise Emissions)

The construction works will generate underwater noise emissions from construction activities, such as dredging and rock dumping for breakwater construction. Underwater noise can disturb or result in negative health and behavioural effects to local marine fauna including acoustic masking, hearing loss, and changes in foraging and anti-predator behaviour. Although the generated emissions are likely to be localised and intermittent, emissions could impact marine fauna within and adjacent to the Project site. Construction noise will be temporary and generally reversible once construction has ceased.

Cetaceans and other marine species that have a high dependence on acoustics for navigation, breeding and other life history traits were not observed in the Project area. Fishes that could be affected by underwater noise are predicted to move out of the construction area when disturbed by water quality and other disturbances such as vessel movements. As such, minor and temporary biodiversity displacement is predicted to occur from the generation of underwater noise and vessel disturbance.

6.8.1.8 Injury/Death to Local Fauna

Inappropriate disposal of construction waste to the marine environment could result in injury or death to local marine fauna through entanglement or ingestion of potentially lethal waste material. In addition, the presence of construction vessels introduces the risk of vessel strike, which can cause injury or death to marine fauna. Although construction will be temporary, impacts to local marine fauna could be permanent, irreversible and cumulative and can effect fauna within and adjacent to the Project site.

Moderate adverse impacts are anticipated on local marine fauna without mitigation measures to prevent waste disposal to the marine environment. However, marine fauna will likely move out of the construction area during works and there were no observations of turtles or cetaceans that are highly susceptible to impact from ingesting plastic waste material within the area.

6.8.1.9 Summary

Whilst localised negative impacts to marine ecology will occur, the site is characteristic of a disturbed marine environment of limited regional ecological significance. Impacts associated with sedimentation and land reclamation are unlikely to have a large or sustained impact on the regional population structures of benthic infauna, epifauna, demersal fish, reptiles, or marine mammals. A summary of the construction phase impacts is provided in Table 6-28.

Table 6-28 Potential unmitigated construction phase impacts on marine ecology

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Habitat loss and modification	Almost certain	Moderate	**High**	Marine flora and fauna	Negative
Suspension and deposition of sediments	Almost certain	Moderate	**High**	Marine flora and fauna, human amenity (beaches)	Negative
Nutrient enrichment and introduced contaminants	Possible	Moderate	**Medium**	Marine flora and fauna, human amenity (beaches)	Negative
Mobilisation of dormant algal cysts	Rare	Major	**Medium**	Marine ecosystem, desalination plant	Negative

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Marine pest introduction	Unlikely	Major	**Medium**	Marine flora and fauna	Negative
Accidental oil or chemical spills	Unlikely	Minor	**Low**	Marine ecosystem	Negative
Disturbance to marine fauna from vessels and underwater noise	Almost certain	Minor	**Medium**	Marine fauna	Negative
Injury / death to fauna via intake of waste	Possible	Moderate	**Medium**	Marine fauna	Negative

6.8.2 Operation Phase

The key potential impacts to marine ecology during operation of the Project are provided below.

6.8.2.1 Habitat Loss and Modification and Suspension of Sediments

Operational dredging has the potential to cause loss of sediment benthos, create suspended sediments and cause alteration and disturbance of the habitats. However, the dredging activities will be undertaken predominantly within areas that have been dredged previously and as such represent disturbed areas of low ecological value.

However, should the dredged material require ocean disposal, then potentially new areas of marine habitat and associated flora and fauna could be smothered and blocked from photosynthesising due to the suspension of sediments. Given that operational maintenance activities will be undertaken once every 20 years, the surrounding environmental conditions, rules and regulations are likely to alter and as such a specific environmental management plan should be provided prior to each dredging activity to assess the particular impacts, mitigation and management measures, particularly with regards to disposal options. Without this measure in place, a moderate to major impact could be expected, depending on the area of disposal.

6.8.2.2 Provision of Additional Hard Substrate Habitat

The use of rock revetment provides a potential positive impact for marine ecology in the Project area through the provision of a large area of hard substrate. This provides potential habitat to be colonised by a plethora of marine organisms that require a hard substrate to attach to. Diverse and abundant benthic communities have been recorded on breakwaters in Dubai and Abu Dhabi (Burt et al. 2010). The breakwaters provide substrate not only for coral assemblage development but also provide habitat for the settlement of oysters, urchins, anemones and other hard substrate taxa. In addition, the introduction of inter-tidal and sub-tidal habitat may eventually provide suitable habitat for the development of marine communities and seagrass recolonization. Therefore, moderate beneficial impacts are anticipated to marine ecology.

With potential for future communities, steps should be taken to minimise impacts to the breakwaters of the area, particularly those in more exposed locations.

6.8.2.3 Introduction of Invasive or Exotic Species

Cruise ships rely on quantities of ballast water to stabilize the vessel. Ballast water discharge has until now been the leading source of introduction of non-native or invasive species (plants, animals, viruses, and bacteria). In marine waters, invasive species can cause extensive ecological and economic damage to aquatic ecosystems, along with serious human health issues including death. However, there is no requirement to take on or discharge ballast at or near the terminal for the cruise ships and therefore the risk of introduction is negligible.

6.8.2.4 Accidental Fuel and Chemical Leaks / Spills

Marine cruise ships will require bunkering when arriving at Dubai Harbour. The main fuel types that will require bunkering include Liquefied Natural Gas (LNG), Heavy Fuel Oil 380, Marine Diesel Oil and Marine Gas Oil. Bunkering will occur via truck (LNG, Marine Diesel Oil and Marine Gas Oil) or barge (LNG, Heavy Fuel Oil 380) as required. The risk of a spill during bunkering exists, which has the potential to cause injury or death to marine flora and fauna and reduction of water and sediment quality.

Further, bilge water may contain oil or petroleum substances resulting from oil spills and leaks occurring during the use and maintenance of on-board mechanical systems. Illegal discharge of bilge/ballast water by cruise vessels in international or coastal waters, as well as oil spills resulting from collisions and groundings have been documented extensively because they represent a serious threat to pelagic and coastal marine life.

During operation of the four marinas within the Project, there is also potential for accidental spills or leaks of fuel, oil or chemicals during maintenance and refuelling of vessels. Without appropriate mitigation measures in place (e.g. oil separators, bunded areas, etc.), this could represent a moderate impact.

During a spill, a proportion of the hydrocarbons will also bind with suspended matter in the watercolumn and be deposited on the seabed or shoreline, in a process known as 'sedimentation'. The amount of sedimentation is difficult to predict, estimate or quantify, and will vary with many factors including type of fuel and environmental conditions, but this process is known to be more common in shallow waters where sediment loads tend to be greater. In addition to impacting sediment quality, sedimentation may subject biota to long term exposure.

Petroleum pollution is known to have adverse effects on coral reefs, mangroves, as well as on marine mammals, sea birds, fish, and plankton and other invertebrates associated with these ecosystems. Many species are especially vulnerable to even small quantities of hydrocarbons at low concentrations. Long-term exposure to low concentrations can be as harmful as short-term exposure to higher concentrations, especially in harbours with poor flushing action where the marine plants or animals are continuously exposed to discharges of oil and contaminated bilge products, resulting in damage to the flora and fauna in these coastal waters.

Oil Spill Modelling

Methodology

A modelling study was undertaken by Sogreah (2017l Appendix E) to simulate accidental oil spills occurring during bunkering operations. The hydrodynamic model described previously was utilised as a based for the oil spill modelling assessment, which comprised a numerical model of oil spill trajectory.

The potential volume that could be accidentally released to the surrounding waters depends on a number of factors, including:

- The location of the fuel station (Cruise Marina Fuel Station I, Cruise Marina Fuel Station II, Dubai Marina Fuel Station and Cruise Berth) presented in Figure 6-34;
- Accident type (leak or overfilling); and
- Bunkering operations and fuel oil (marine gas oil, marine diesel oil and IFO380).

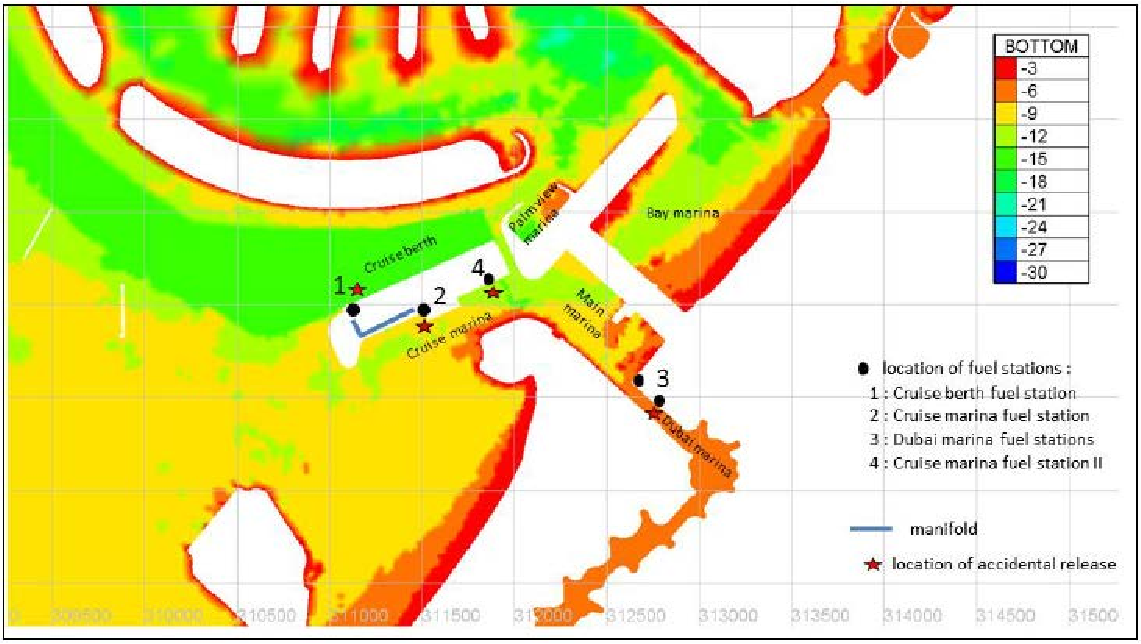


Figure 6-34 Locations of fuel stations

Source: Sogreah, 2017l

It was predicted that the potential volume released could vary from 250 L to 12,850 L in the worst case, depending on the location.

A selection of scenarios representing accidental release of oil in the harbour was simulated using the numerical model OILEF included in TELEMAC (Sogreah, 2017l). The oil slick is represented in the model as a set of particles representing oil parcels, with varying distribution in time and space varies under the processes of advection and diffusion under the effect of wind and water currents, evaporation, mechanical spreading and shoreline deposition. The resulting oil slick distribution was analysed in a short time-scale (few days) due to the rapid encountering of seashore beaches or surrounding infrastructure.

As part of the risk analysis, several causes and scenarios of discharges were investigated by Sogreah (2017l) in order to determine the range of releases, as follows:

- Hose leak;
- Overfilling; and
- Sudden disconnection of the hose at the dispensers.

The risk of collision between cruise vessels and leisure vessels in the channel and risk of collision between large yachts in the marinas was determined to be very unlikely (0.00072 yr^{-1} and 0.00049 yr^{-1} resp., Sogreah 2017h) and was therefore not modelled in the assessment. The risk of collision between small vessels inside the marina is likely and between medium size vessels is unlikely but will not generate larger leaks than the one modelled for the leaks at the fuelling stations inside the marinas and was also therefore not modelled.

At each fuel station, the scenario resulting in the highest volume of oil spill was selected to allow review of the most unfavourable situation. Three wind directions were simulated, comprising:

- N292.5°: most frequent direction tends to orientate the slick towards the coastline;
- N180°: tends to orientate the slick towards the Palm Jumeirah residential area; and
- N0°: tends to orientate the slick towards the JBR area.

Several wind intensities were tested in the case of the oil spill due to large leak / overfilling accident at the fuel station, to assess the influence of the wind magnitude. The simulated scenarios are summarised in Table 6-29.

Table 6-29 Volume spilled depending on bunkering operation at the four fuel stations

Location	Scenario	Oil type	Volume spilled (L)	Wind conditions
Cruise Marina Fuel Station	1	Diesel	950	5 m/s N292.5°
	2			5 m/s N0°
Cruise Marina Fuel Station II	3	Diesel	250	5 m/s N292.5°
	4			5 m/s N180°
Dubai Marina Fuel Station	5	Diesel	250	5 m/s N292.5°
	6			5 m/s N180°
Cruise Berth Fuel Station	7	IFO 380	12,480	5 m/s N292.5°
	8			1 m/s N180°
	9			3 m/s N180°
	10			5 m/s N180°

Source: Sogreah 2017l

Results

Oil Spill at Cruise Marina Fuel Station I

Predicted oil spill scenarios at Cruise Marina Fuel Station I is provided in Table 6-30 (Scenarios 1 and 2). The drift velocity of the oil slick is approximately 0.20 m/s. The oil slick is predicted to cover a small surface area and impacts a narrow length of the shoreline.

After 12 hours, the evaporated volume is up to 2% of the initial volume (Table 6-30: Plate 2 and Plate 4). Therefore, the final volume of oil to be cleaned up after 12 hours is almost identical to the volume initially released.

Oil Spill at Cruise Marina Fuel Station II

Table 6-30 (Scenarios 3 and 4) shows the predicted oil spill scenarios at Cruise Marina Fuel Station II. After 12 hours (Table 6-30: Plate 6 and Plate 8) the evaporated volume is 2.7% of the initial volume released.

Table 6-30 Oil Spill Scenarios at Cruise Marina Fuel Stations I and II

Oil Spill at Cruise Marina Fuel Station I		Oil Spill at Cruise Marina Fuel Station II	
Scenario 1: Oil slick reaches revetment protection at SkyDive after 0.5 hours.	Scenario 2: Oil slick reaches JBR Beach after 2.5 hours.	Scenario 3: Oil slick reaches the southern edge of the Main marina after 1.5 hours.	Scenario 4: Oil slick reaches the northern end of the Palm Jumeirah Beach after 3.5 hours.

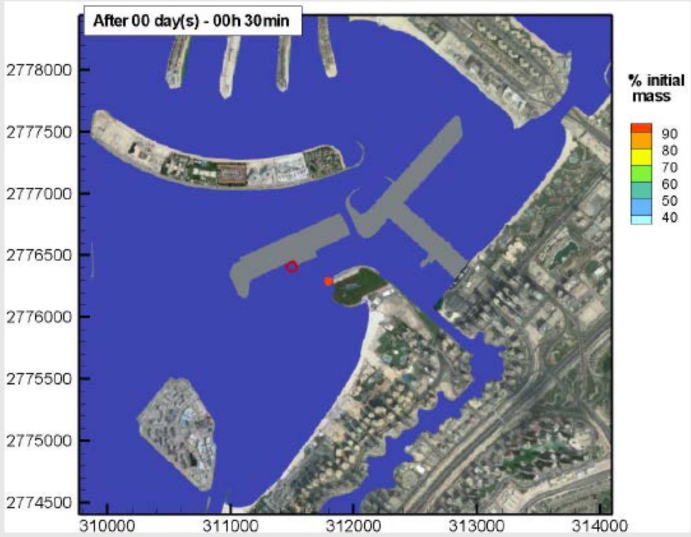
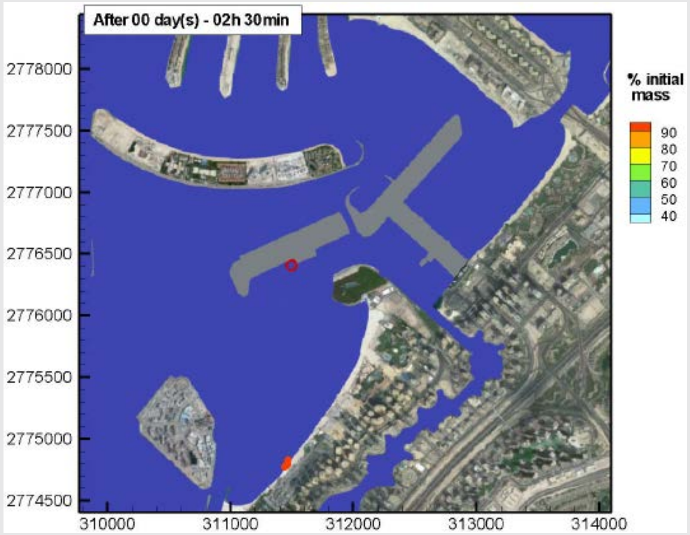
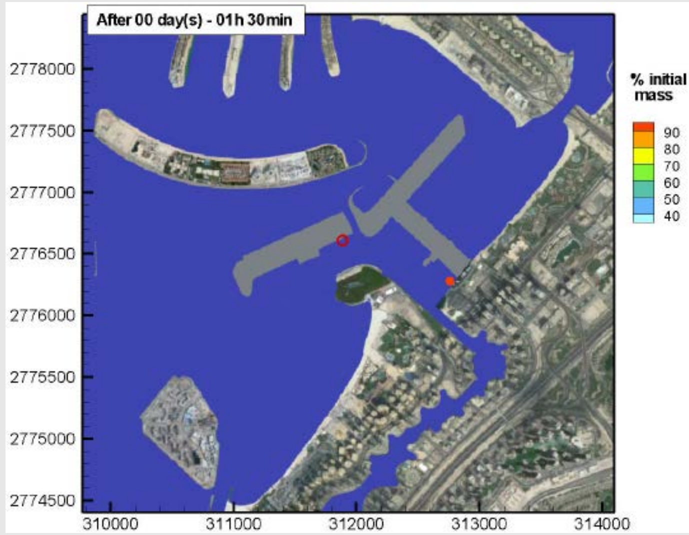
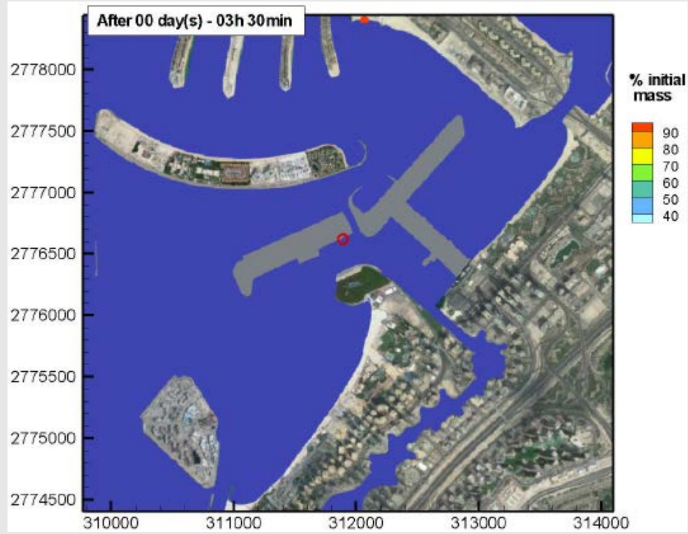

			

Plate 1 Location of oil slick after 0.5 hours	Plate 3 Location of oil slick after 2.5 hours	Plate 5 Location of oil sick after 1.5 hours	Plate 7 Location of oil slick after 3.5 hours

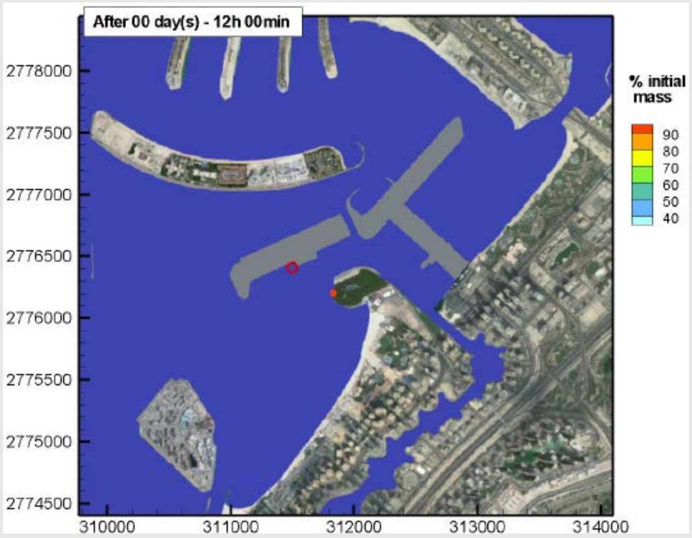
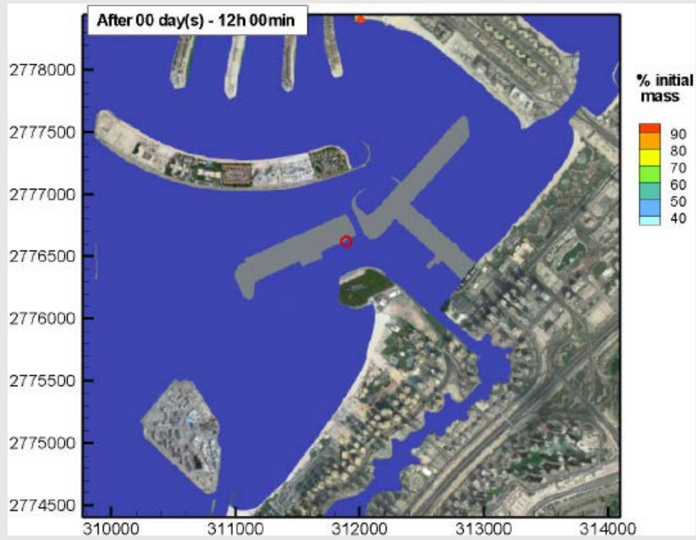

			

Plate 2 Location of oil slick after 12 hours	Plate 4 Location of oil slick after 12 hours	Plate 6 Location of oil slick after 12 hours	Plate 8 Location of oil slick after 12 hours

Note: The red circle represents the location of the initial release

Oil Spill at Dubai Marina Fuel Station

The predicted oil spill at Dubai Marina Fuel Station are provided in Table 6-31. The drifting velocity of the oil slick is approximately 0.16 m/s. After 12 hours (Table 6-31: Plate 10 and Plate 12), the evaporated volume is 2.7% of the volume initially released.

Oil Spill at the Cruise Berth

Several wind directions and intensities were tested for oil spill scenarios at the Cruise Berth. The final location of slick is shown in Table 6-32 (Scenarios 7 to 10).

After 12 hours, the evaporated volume is 1.5% from the initial volume of Scenario 7 (Plate 14) and Scenario 10 (Plate 20). The evaporated volume is 0.5% and 1.1% for Scenario 8 (Plate 16) and Scenario 9 (Plate 18), respectively. Therefore, the influence of the wind intensity does not influence significantly the volume of evaporated in the first 12 hours.

Conclusion

From the results, Sogreah (2017l) concluded the following:

- Wind direction and intensity should be taken into account in the oil clean up strategy in case of an oil spill accident, as it determines the time needed to reach the shoreline and the area where the oil can be deposited.
- A fast response is needed to reduce the impact of the oil spill as the oil slick reaches the beaches and the surrounding infrastructures in a few hours' time.

These recommendations have been included in Section 7.7.2.

Table 6-31 Oil Spill Scenarios at Dubai Marina Fuel Station

Oil Spill at Dubai Marina Fuel Station

Scenario 5: Oild slick reaches the northern end of Dubai Marina after 1 hour.

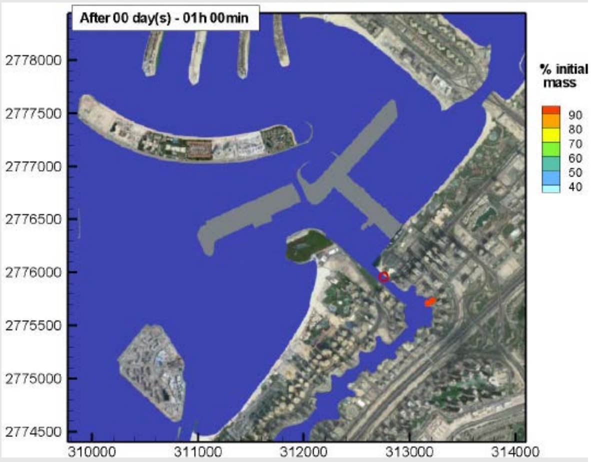


Plate 9 Location of oil slick after 1 hour

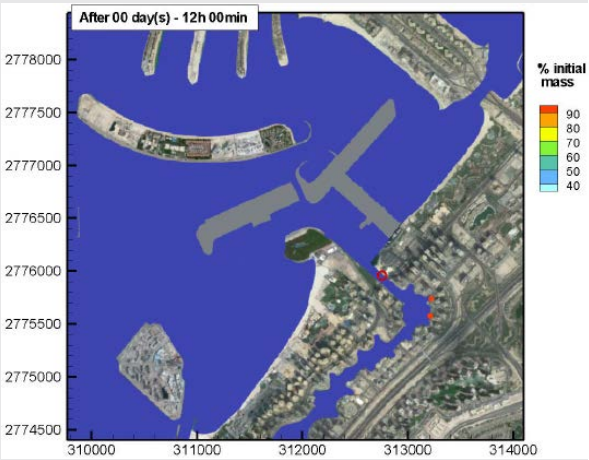


Plate 10 Location of oil slick after 12 hours

Scenario 6: Oil slick reaches the southern end of the Capitainerie and Sailor's Club platform in the Main Marina after 1 hour.

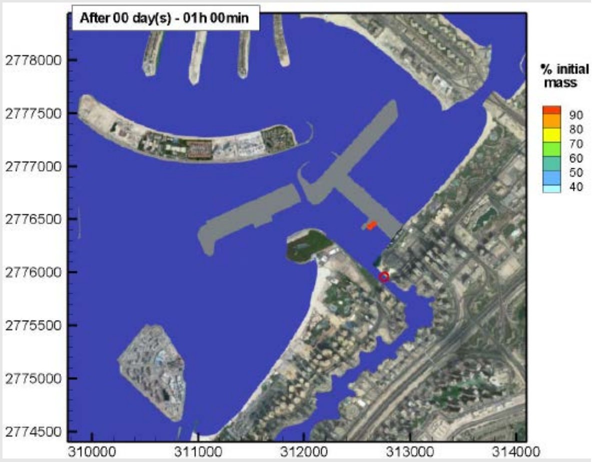


Plate 11 Location of oil slick after 1 hr

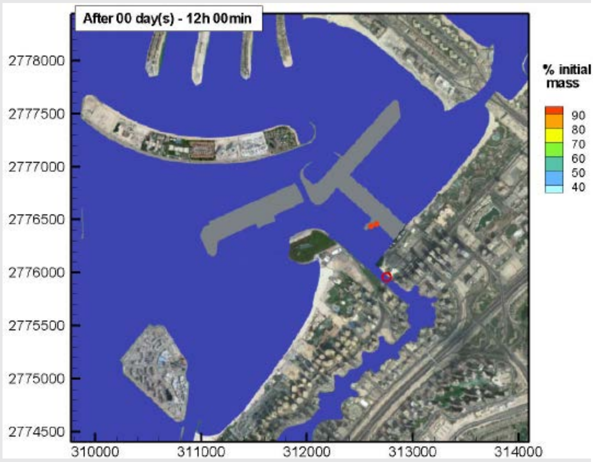


Plate 12 Location of oil slick after 12 hours

Table 6-32 Oil Spill Scenarios at Cruise Berth Fuel Station

Oil Spill at the Cruise Berth			
Scenario 7: Oil slick reaches the northern side of the Capitainerie and Sailor's Club platform in th Main Marina after 3.5 hours. The advection is south-eastward with a velocity of 0.2 m/s.	Scenario 8: The calm wind condition enhanced the oil slick dispersion under the effect of the tides. The tidal current orientate water displacement eastward and northwards alternatively. After 1 day, the particles are distributed all along the Palm Jumeirah breakwater crescent facing Palm View Marina, which forms an obstacle on the northward trajectory of the oil slick. After 1.75 days, the particles move further northward and reach the Palm Jumeirah Beach.	Scenario 9: Oil reaches the northern end of the Palm Jumeirah Beach after 10 hours. The oil slick velocity is 0.06 m/s.	Scenario 10: Oil slick reaches the northern end of the Palm Jumeirah Beach after 6 hours. The oil slick velocity is 0.14 m/s.

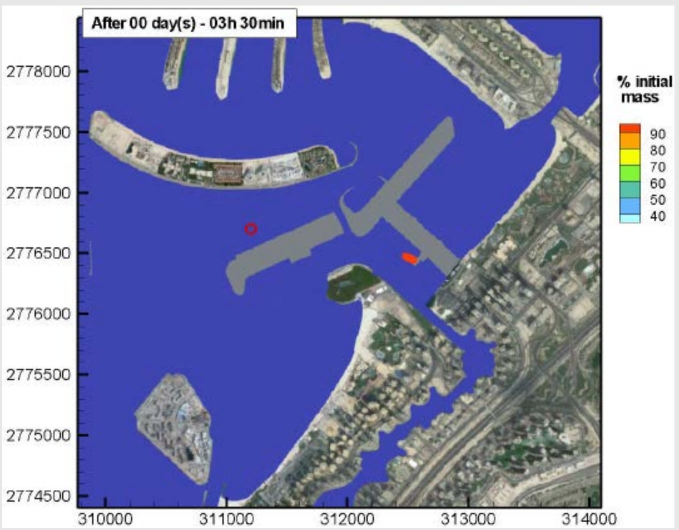


Plate 13 Location of oil slick after 3.5 hours

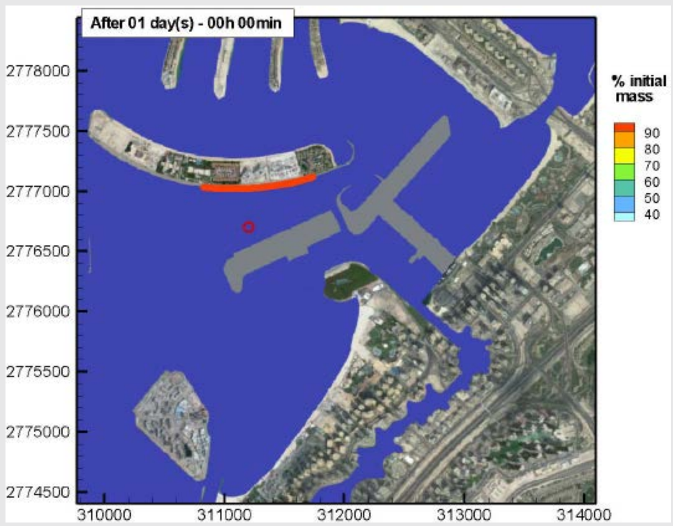


Plate 15 Location of oil slick after 1 day

Plate 17 Location of oil slick after 12 hours

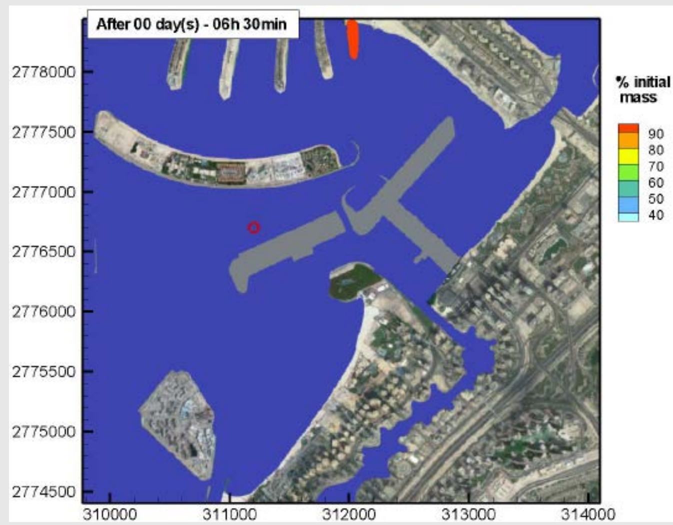


Plate 19 Location of oil slick after 6.5 hours

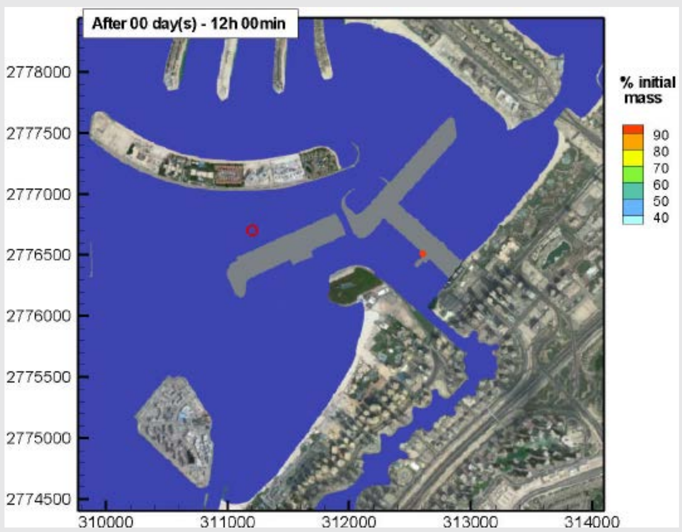


Plate 14 Location of oil slick after 12 hours

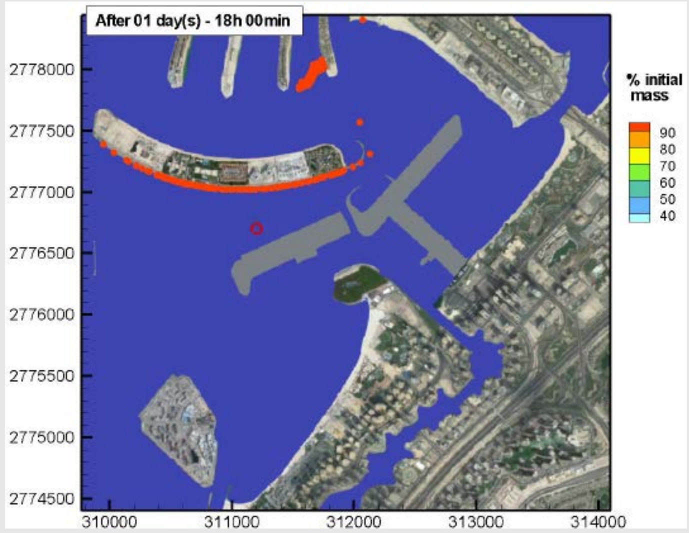


Plate 16 Location of oil slick after 1.75 days

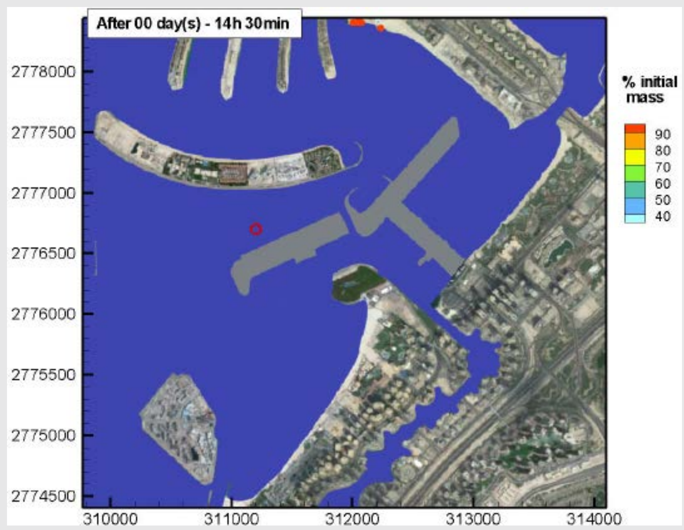


Plate 18 Location of oil slick after 14.5 hours

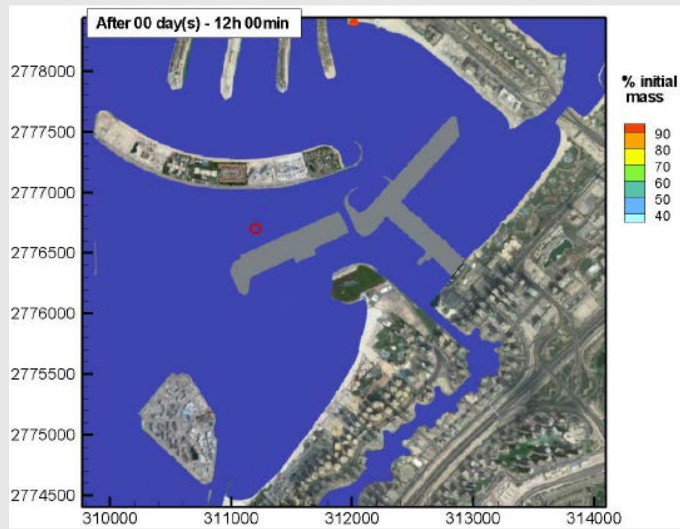


Plate 20 Location of oil slick after 12 hours

Note: The red circle represents the location of the initial release

6.8.2.5 Increased Marine Traffic

Ongoing Disturbance to Local Marine Flora and Fauna

The operation of the Project is likely to increase noise disturbances to the marine environment through the increased volume of marine traffic, including the addition of cruise ships. Species that may be sensitive to increases in marine traffic, such as turtles and dolphins, may be displaced from the Project area. No marine turtles or mammals were observed during the MEBS, although it is considered highly likely that they will occasionally frequent the Project site.

Beach nourishment is not expected to be required for the Project, therefore there will be no ongoing disturbance to established beach areas. However, maintenance dredging of the navigation channel will be required. Maintenance dredging will result in a disturbance to water quality as discussed above, potentially resulting in a significant impact during the operation phase.

Injury / Death to Local Marine Fauna

Boat strikes are a known cause of mortality for marine megafauna. An increase in vessel traffic (of all sizes) resulting from the development will proportionally increase the risk of collision with (resulting in injury or death) marine fauna, including mammals and reptiles.

The presence of operational waste may potentially result in injury or death to local marine fauna through entanglement or ingestion of potentially hazardous waste material. Impacts to local marine fauna from generated operational waste could be permanent, irreversible and cumulative and can affect fauna within and adjacent to the Project site.

6.8.2.6 Stormwater Discharge Modelling

It is proposed that seven discharge points with oil separators be installed within the Project site (see Section 4.6.4.3) for stormwater discharges. Stormwater inputs to the marine environment can cause increases in nutrients, particularly from landscaped areas, resulting in algal blooms that would affect the diversity of other flora and fauna. This impact could be cumulative if stormwater is not managed. A portion of the proposed development will be soft landscaping. In the event that appropriate landscape management measures are not implemented, there is a risk of nutrients used in fertilisers leaching into the surrounding marine environment. Stormwater quality can be influenced by various other factors, such as catchment areas, impervious cover, land use, population density, vehicle traffic, rainfall frequency and intensity. Stormwater can include contaminants such as sediments, nutrients, chemicals, pathogens and litter from a range of sources, including:

- Sediments/suspended solids – Streets, lawns, driveways, roads, construction activities,atmospheric deposition, drainage channel erosion;
- Pesticides and herbicides – Residential lawns and gardens, roadsides, utility right-ofways, commercial and industrial landscaped areas,soil wash-off;
- Organic materials – Residential lawns and gardens, commercial landscaping, animal wastes;
- Metals – Vehicles, bridges, atmospheric deposition, soil erosion, corroding metal surfaces, combustion processes;
- Oil and grease/hydrocarbons – Roads, driveways, parking lots, vehicle maintenance areas, gas stations, illicit dumping to storm drains;
- Bacteria and viruses – Lawns, roads, leaky sanitary sewer lines, sanitary sewer cross contamination, animal waste, septic systems;

- Nitrogen and phosphorus – Lawn fertilizers, atmospheric deposition, vehicle exhaust, soil erosion, animal waste, detergents.

Sogreah (2017m) were commissioned by North 25 to investigate the advection and dispersion of the proposed stormwater discharges from the seven proposed outfalls from the Project. Sogreah used a 3D numerical hydrodynamic model to assess these discharges from the points illustratrated in Figure 4-41, and the full report is included in Appendix E.

The simulated stormwater discharge rates were representative of the 1 in 5 year return period, 90-minute storm duration for each catchment area. The discharge hydrographs are presented in Figure 6-35.

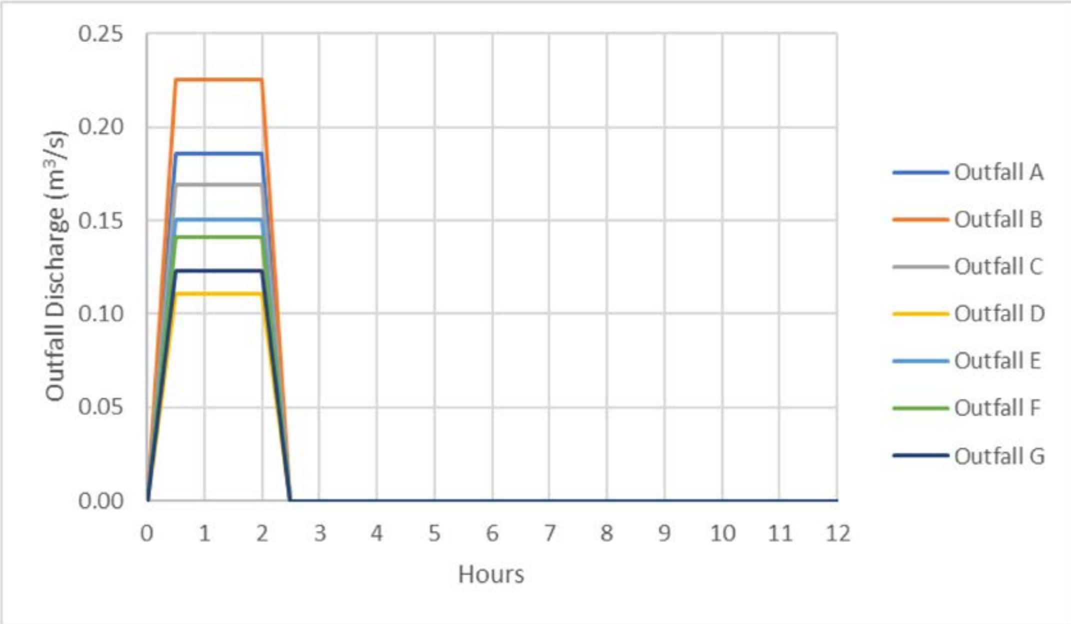


Figure 6-35 Stormwater discharge hydrographs

Source: Sogreah (2017m)

A total of eight scenarios were simulated comprising stormwater releases beginning during spring and neap tides, flooding and ebbing tides and with and without winds (2 x 2 x 2 = 8 scenarios). For the scenarios with winds, north-westerly winds of 4.7 m/s were adopted, representative of median wind speeds in this quadrant during the months of December – March (when rainfall and therefore stormwater generation is most likely to occur).

There are no known environmental guidelines for Dubai relating specifically to the discharge of stormwater to the marine environment. Local Order No. 61 of 1991 of the Environment Protection Regulations in the Emirate of Dubai sets out regulatory requirements for the discharge of 'wastewater' to the marine environment. The document suggests an initial regulatory mixing zone of 300 m from the point of release. Furthermore, it specifies a maximum decrease in salinity of 2 ppt to apply at the edge of the mixing zone. These criteria were adopted as the basis of this study.

Stormwater concentrations were assessed within the 300 m mixing zones and at the sensitive receptors of:

- Palm Jumeirah Beach;
- Mina Al Seyahi Beach;
- JBR Beach;
- North Beach; and

- South Beach.

Changes to Salinity

Across all scenarios, peak decreases in salinity at the 300 m mixing zone extent were below the adopted threshold of 2 ppt for all discharges except Outfall A. An example of the peak surface salinity is presented in Figure 6-36.

For Outfall A, salinity decreases were predicted to be above the 2 ppt threshold for a maximum period of <4 hours. Furthermore, the threshold exceedance is limited to the surface waters, with no exceedances predicted near the seabed. These infrequent, short-duration and localised decreases in salinity are not expected to impact water quality in the Dubai Harbour to any significant degree.

No significant changes to salinity were predicted to occur at the sensitive receptors for any scenarios assessed.

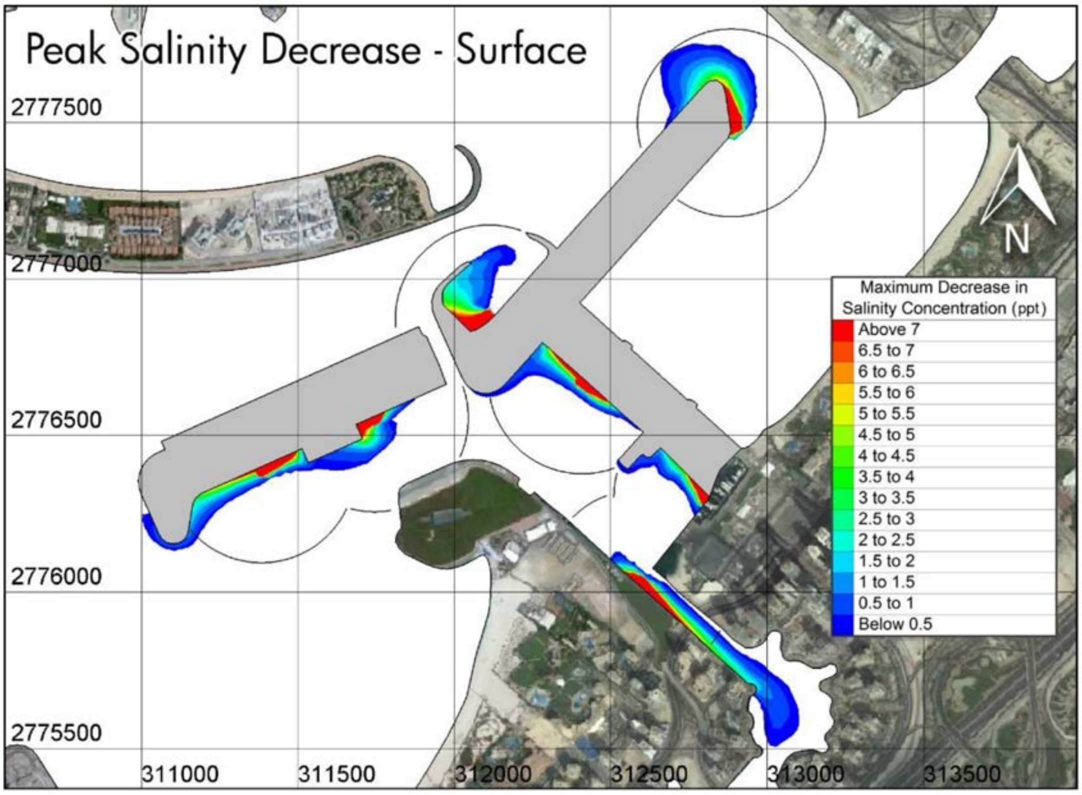


Figure 6-36 Peak salinity decrease at the sea surface for the spring flood without winds. Mixing zone boundaries are depicted as black lines.

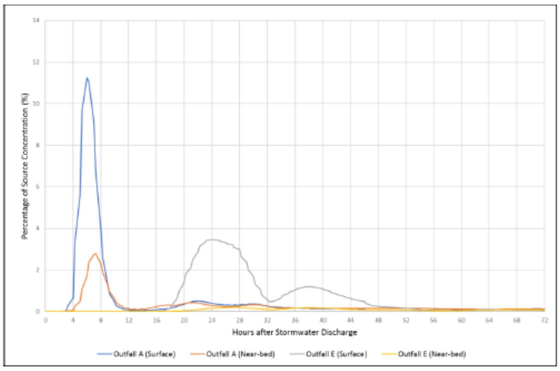
Source: Sogreah (2017m)

Passive, non-decaying tracer representing contaminants

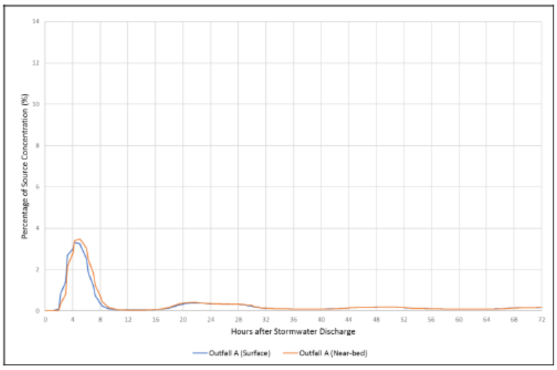
For all modelled scenarios, only Outfall A and Outfall E showed significant contaminant concentration at the 300 m radius (Table 6-33 and Figure 6-37). The time-series are presented only for the outfalls for which the peak percentage concentration exceeds 1% along the 300 m radius mixing zone. Changes in contaminant concentrations at both surface and near-bed for the remaining outfalls (e.g. Outfalls B, C, D, F, G and H) are negligible. The highest peak source concentration of the passive, non-decaying tracer is modelled to occur during neap flood without wind at Outfall A.

Table 6-33 Time-series of percentage of source contamination at the 300 m radius for Outfall A and Outfall E for all scenarios

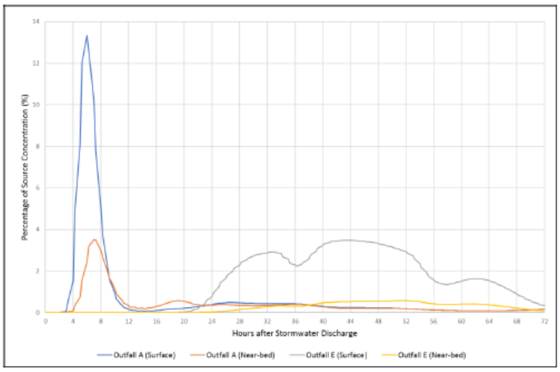
Scenario	Outfall A		Outfall E
	Surface	Near-bed	Surface
1A Spring Flood without Wind	11.5	2.8	3.5
1B Spring Flood with Wind	3.5	3.5	<1
2A Spring Ebb without Wind	1.0	1.0	<1
2B Spring Ebb with Wind	1.0	1.0	<1
3A Neap Flood without Wind	13.5	3.8	3.5
3B Neap Flood with Wind	3.0	3.0	<1
4A Neap Ebb without Wind	2.5	<1	5.5
4B Neap Ebb with Wind	<1	<1	<1



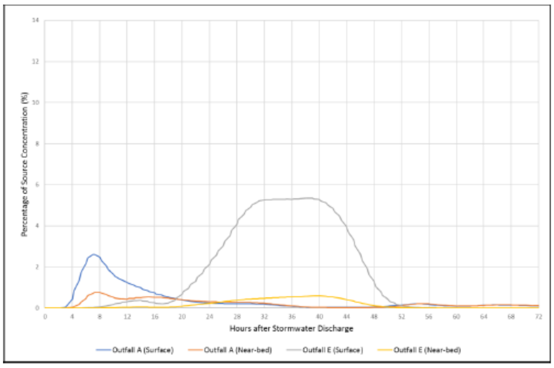
1A Spring Flood without Wind



1B Spring Flood with Wind



3A Neap Flood without Wind



4A Neeap Ebb without Wind

Figure 6-37 Time-series contaminant concentration (%) at 300 m radius

Stormwater Contaminants Dilution

In order to calculate the level of stormwater dilution required to meet the relevant marine water quality standards, an assessment was undertaken on measurements of stormwater quality at a nearby North 25 Project in Dubai (La Mer Development) as well as stormwater quality discharge at Perth's Marine Beaches.

La Mer Project

Due to the lack of available information on measured contaminant and physico-chemical parameter levels in stormwater discharge within Dubai or the wider UAE, data collected for La Mer Development has been utilised as a basis to form the predicted concentrations of pollutants and other parameters of concern at the point of discharge from the Dubai Harbour outfalls. This monitoring comprised sampling events on a forthnightly basis of a DM stormwater discharge pipe. Mean and maximum values from 10 sampling events of the stormwater discharge pipe between February and June 2017 have been collated and are provided in Table 6-34. The catchment area of the monitored outfall is the Satwa area of Dubai, which comprises a larger area than the Dubai Harbour's catchment area and includes a broader range of land uses with associated broader range of potential contaminant sources.

Table 6-34 Stormwater Quality from DM Outfall at La Mer

Parameters	Mean Values (mg/L)*	Maximum value (mg/L)	Limit/Standard (mg/L) – *DM Effluent Standards for Marine Water Discharge*
Temperature	30.43	34.37	–
Specific Conductivity (uS/cm)	69,167	95,998	–
Salinity (ppt)	48.46	69.07	–
pH	7.7	8.12	6 to 9
Turbidity (NTU)	241.62	1495	75 NTU
DO (%)	101.09	109.69	–
ODO (mg/L)	5.87	7.47	–
Total Suspended Solids (TSS)	3.27**	10.2	30
Total Dissolved Solids (TDS)	52,868.30	69,400	–
Oil & Grease	<5	<5	5
Nitrate-Nitrogen	4.13	29.8	5
Nitrite	0.063**	0.58	–
5-day Biochemical Oxygen Demand (BOD_5)	<2	<2	30
Phosphate - Phosphorus	0.58	1.6	0.1
Sulphide (S^2)	<0.02	<0.01	0.1
Chemical Oxygen Demand (COD)	16.24	18	–
Ammonia (NH_3)	<0.01	<0.01	–
Aluminium (Al)	0.095**	0.9	–
Arsenic (As)	<0.001	<0.001	0.05
Cadmium (Cd)	<0.01	<0.01	0.05
Total Chromium (Cr)	<0.01	<0.01	0.5

Parameters	Mean Values (mg/L)*	Maximum value (mg/L)	Limit/Standard (mg/L) – *DM Effluent Standards for Marine Water Discharge*
Copper (Cu)	<0.01	<0.01	0.5
Iron (Fe)	1.20**	11.9	2
Lead (Pb)	<0.01	<0.01	0.1
Mercury (Hg)	<0.001	<0.001	0.001
Nickel (Ni)	<0.01	< 0.01	0.1
Zinc (Zn)	<0.01	< 0.01	0.1
Fecal Coliforms	<1	< 1.8	100 MPN / 100 mL

*Mean values from samples taken on 14 and 28 February, 14 and 27 March, 10 and 24 April, 9 and 22 May, 7 and 20 June 2017. Red font denotes exceedances to DM guidelines
**For values that were below the Limit of Reporting (LoR), half the value of the LoR was taken for average calculations.

Results show that the mean concentration for all parameters is compliant with relevant guideline limits at the point of discharge, with the exception of phosphate and turbidity. While remaining parameters remained compliant on average, there were some exceedances during some of the monitoring events for nitrate and iron. The elevated iron levels are anticipated to be a result of a rusting pipeline, which was observed while the pipe was exposed, and which is not anticipated to be an issue for Dubai Harbour given the newer pipes being utilised. As such, this is not assessed further. With regard to the nutrients, these could originate from fertilisers utilised for landscaping, or other wastewater discharges; however, the source of nutrients and turbid waters are not confirmed.

For the majority of parameters analysed, concentrations remained within DM effluent guidelines at the point of discharge and are therefore compliant with required guidelines and no associated impact to the environment is expected. Further assessment was not completed for those parameters. However, with regard to the parameters that exceeded DM effluent guidelines at the point of discharge, an assessment of the potential concentrations using the modelled tracer concentraitons at the edge of the 300 m mixing area is provided in Table 6-35. Using the maximum recorded values, two parameters exceeded the guideline values, namely: turbidity and phosphorus. However, exceedances are only anticipated from Outfall A, during the spring flood without wind and neap flood without wind, with the exceedance limited to the surface waters, of relatively short duration (maximum 8 hours). They are not anticipated to reach any of the nearby sensitive receptors.

The nutrient Phosphorous can contribute to eutrophication. However, while the anticipated concentration slightly exceeds DM guideline levels, mean phosphate concentration recorded during the baseline survey also exceeded DM guidelines and such concentrations are commonly routinely recorded across the UAE. For example; the Environment Agency Abu Dhabi's (EAD) water quality monitoring programme recorded phosphate levels of over 0.2 mg/l at 12 of the 20 monitoring stations (including the offshore island of Bu Tinah within the Merawah Marine Protected Area) during the first quarter 2015 (EAD 2015a); and similar results are regularly recorded both in Abu Dhabi (EAD 2015b) and across Dubai (GHD records).

Table 6-35 Potential contaminant concentrations at Dubai Harbour (La Mer data, worst case)

Scenarios	Outfall A				Outfall E	
	Surface		Near-bed		Surface	
	%	Potential Concentration at the Edge of Mixing Zone (around 300 m from the outfall)	%	Potential Concentration at the Edge of Mixing Zone (around 300 m from the outfall)	%	Potential Concentration at the Edge of Mixing Zone (around 300 m from the outfall)
Turbidity	*1495 NTU**					
DM Standards	*75 NTU*					
1A Spring Flood without Wind	11.5	**171.93**	2.8	41.11	3.5	52.33
1B Spring Flood with Wind	3.5	52.33	3.5	52.33	-	-
3A Neap Flood without Wind	13.5	**201.83**	3.8	56.06	3.5	52.33
3B Neap Flood with Wind	3.0	44.85	3.0	44.85	-	
4A Neap Ebb without Wind	2.5	37.38	-	-	5.5	82.23
Nitrate-nitrogen	*29.8**					
DM Standards	*5*					
1A Spring Flood without Wind	11.5	3.43	2.8	0.82	3.5	1.04
1B Spring Flood with Wind	3.5	1.04	3.5	1.04	-	
3A Neap Flood without Wind	13.5	4.02	3.8	1.12	3.5	1.04
3B Neap Flood with Wind	3.0	0.89	3.0	0.89	-	
4A Neap Ebb without Wind	2.5	0.75	-		5.5	1.64
Phosphate-phosphorus	*1.6**					
DM Standards	*0.1*					
1A Spring Flood without Wind	11.5	**0.18**	2.8	0.04	3.5	0.06
1B Spring Flood with Wind	3.5	0.06	3.5	0.06	-	
3A Neap Flood without Wind	13.5	**0.22**	3.8	0.06	3.5	0.06
3B Neap Flood with Wind	3.0	0.05	3.0	0.05	-	
4A Neap Ebb without Wind	2.5%	0.04	-		5.5	0.09
*Iron 11.9**						

Scenarios	Outfall A				Outfall E	
	Surface		Near-bed		Surface	
	%	Potential Concentration at the Edge of Mixing Zone (around 300 m from the outfall)	%	Potential Concentration at the Edge of Mixing Zone (around 300 m from the outfall)	%	Potential Concentration at the Edge of Mixing Zone (around 300 m from the outfall)
DM Standards 2						
1A Spring Flood without Wind	11.5	1.37	2.8	0.33	3.5	0.42
1B Spring Flood with Wind	3.5	0.42	3.5	0.42	-	
3A Neap Flood without Wind	13.5	1.61	3.8	0.45	3.5	0.42
3B Neap Flood with Wind	3.0	0.36	3.0	0.36	-	
4A Neap Ebb without Wind	2.5	0.30	-		5.5	0.65

**Based on the maximum concentration recorded across 10 sampling events at La Mer for worst case scenario (refer to Table 6-34). Red font denotes exceedances to DM guidelines*

Perth Stormwater Data

Stormwater discharge data from Perth, Australia (Government of Western Australia, 2007) was also utilised as basis to form predicted concentrations of contaminant and other parameters of concern from the Projects' outfalls. The monitoring comprises sampling events of a total of 65 drains spanning 90 km of the coastline north and south of Swan River. Samples were collected from Perth stormwater drains, or, if flow had ceased, from the pools formed below the outlets. The sampling collection spanned the latter part of winter 2004 and winter of 2005 with a total of 224 drain visits with 11 samples collected per site and about 2500 samples analysed in total. Rainfall data was collected for 2005 from the Bureau of Meteorology Garden Island weather station (Figure 6-38) and from the Swanbourne weather station (Figure 6-39). Mean and maximum values from the sampling events of the stormwater drains have been collated and are provided in Table 6-36.

Dubai is hotter and dryer than Perth, however; there are some similarities in climate with mild winters and hot dry summers. Summer months are hot with an average temperature of 29 °C during the day with some days recorded to rise above 40 °C (Perth's Online Portal). The average daily temperature in Dubai in 2015 ranged between 16.5 °C to 43.3 °C (Dubai Statistical Centre, 2016).

The rainfall pattern in Perth is similar to some degree with Dubai. The mean number of days of rain (≥ 1 mm) in Perth from 1993–2017 is 80.6 days (Commonwealth of Australia, Bureau of Meteorology, 2017). The annual rainfall in Perth in 2016 is between 600 mm and 800 mm on the coastal plains and islands (Commonwealth of Australia, Bureau of Meteorology, 2017) while the total annual rainfall in Dubai was in the range of 22.8 mm to 53.7 mm (Dubai Statistical Centre, 2014).

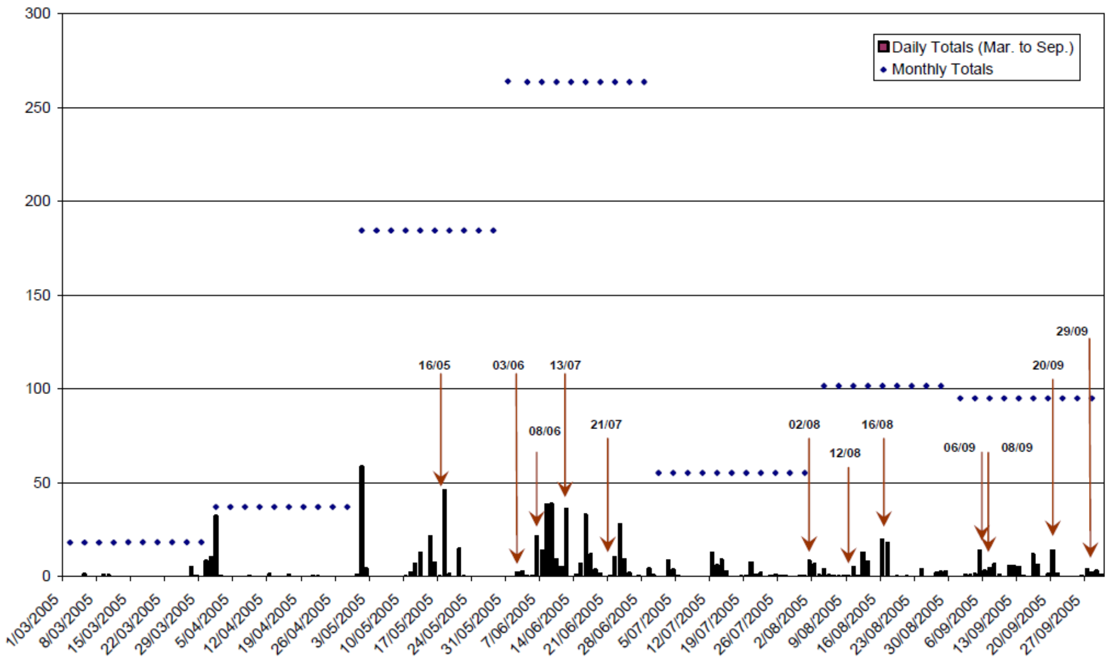


Figure 6-38 Garden Island Station: rainfall (mm) and sampling dates 2005

Source: Government of Western Australia, 2007

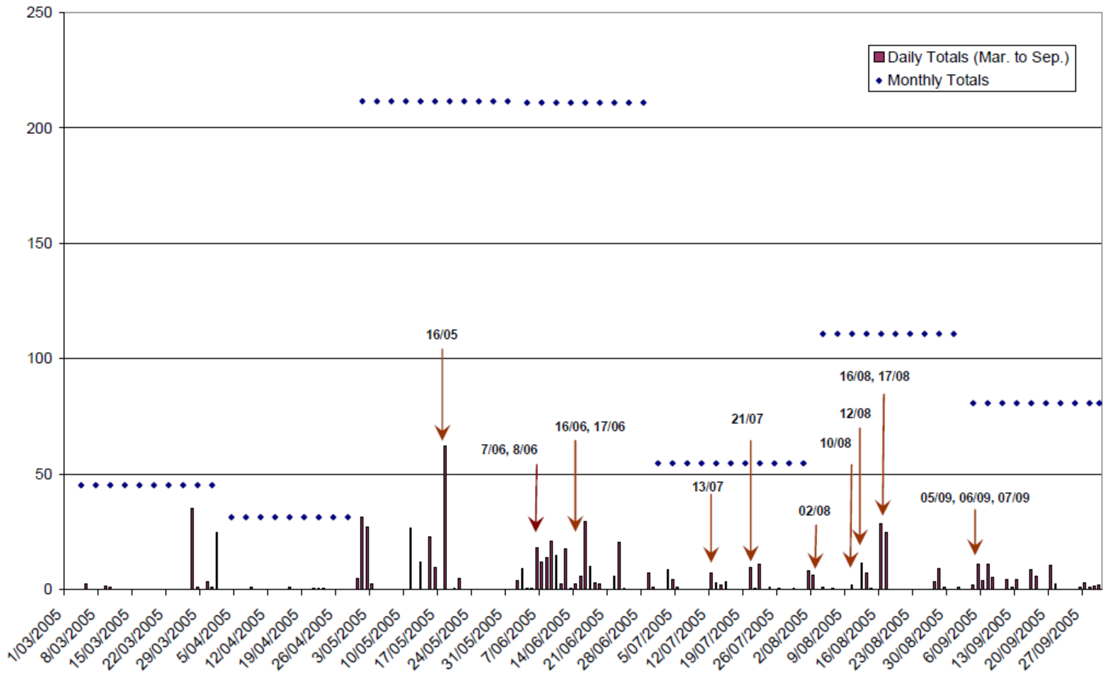


Figure 6-39 Swanbourne Station: rainfall (mm) and sampling dates 2005

Source: Government of Western Australia, 2007

Table 6-36 Stormwater Quality from Stormwater Drains, Swan Region, Perth

Contaminants		Max	Mean	DM Effluent Standards for Marine Water Discharge
Coliforms	(org / 100 mL)	120000	7197	100 MPN / 100 mL
Enterococci	(org / 100 mL)	24000	2914	-
Total Hydrocarbons	mg/L	4.4	0.08	-
BTEX	mg/L	0.055	0.00	-
Nitrogen (Sol Ox)	mg/L	4.1	0.18	-
Nitrogen (total kjel)	mg/L	14	0.69	5
Nitrogen (TN, pTN)	mg/L	15	0.86	5
Nitrogen (NH4)	mg/L	2.9	0.11	5
Phosphorus (TP, pTP)	mg/L	0.68	0.11	0.1
Phosphorus (sol react)	mg/L	0.45	0.05	-
Total Suspended Solids	mg/L	494	56	30
Aluminium	mg/L	2.3	0.64	-
Arsenic	mg/L	0	0	0.05
Cadmium	mg/L	0	0	0.05
Chromium	mg/L	0.05	0	0.5
Copper	mg/L	0.081	0.016	0.5
Iron	mg/L	2.4	0.505	2
Lead	mg/L	0.069	0.014	0.1
Manganese	mg/L	0.076	0.011	-
Mercury	mg/L	0	0	0.001
Nickel	mg/L	0	0	0.1
Zinc	mg/L	0.43	0.066	0.1

Results show that the mean concentration for all parameters is compliant with relevant guideline limits, with the exception of coliforms and total suspended solids (TSS). An assessment of the potential concentrations coliforms and TSS at the Dubai Harbour outfall discharge at 300 m from the discharge point is provided in Table 6-37. Coliform exceeded the guideline values for all scenarios at the edge of the mixing zone. However, modelled concentrations (120,000 mpn/100ml) are unrepresentative of conditions in Dubai (none were recorded in the La Mer data) and, as stated in the original Perth stormwater report (Government of Western Australia, 2007); "Faecal coliforms detected in marine waters indicate a recent pollution event"[4]. TSS exceeded for scenario 1A (spring flood without wind) and 3A (neap flood without wind). The exceedance was limited to the surface waters only, of relatively short duration (maximum 8 hours) and was not anticipated to reach any of the nearby sensitive receptors.

Pesticides, which are likely to be included in stormwater runoffs were not monitored both in DM outfall and Swan Region stormwater drains. According to the International Stormwater Database, detection rates of pesticide concentrations (trans-1, 3-Dichloropropene and bromomethane) in stormwater runoffs from residential areas in Minnesota and states of similar climate across the Unitied States were 50% or less. As such, the median was assumed to be below the detection limit (Minnesota Pollution Control Agency, 2017) and therefore this is not considered to be a risk for the Dubai Harbour outfalls.

[4] As described in the report (Government of Western Australia, 2007), "They (thermotolerant coliform) are not discussed as the new guidelines for recreational water quality describe thermotolerant coliforms as unreliable indicators (NHMRC 2005) because: a) there are no adequate studies on which to base the guidelines; b) the process incorporates and analyses organisms not faecally derived; and c) thermotolerant coliforms are not stable in seawater." (Government of Western Australia, 2007).

Table 6-37 Potential contaminant concentration at Dubai Harbour (Perth Data, worst case)

Scenarios	Outfall A				Outfall E	
	Surface		Near-bed		Surface	
	%	Potential Concentration at the Edge of Mixing Zone	%	Potential Concentration at the Edge of Mixing Zone	%	Potential Concentration at the Edge of Mixing Zone
Coliform	*120,000**					
DM Standards	*100 MPN/100 ml*					
1A Spring Flood w/o Wind	11.5	13800	2.8	3300	3.5	4200
1B Spring Flood with Wind	3.5	4200	3.5	4200	-	
3A Neap Flood w/o Wind	13.5	16200	3.8	4500	3.5	4200
3B Neap Flood with Wind	3.0	3600	3.0	3600	-	
4A Neap Ebb w/o Wind	2.5	3000	-		5.5	6600
Nitrogen (Total)	*14**					
DM Standards	*5*					
1A Spring Flood w/o Wind	11.5	1.61	2.8	0.39	3.5	0.49
1B Spring Flood with Wind	3.5	0.49	3.5	0.49	-	
3A Neap Flood w/o Wind	13.5	1.89	3.8	0.53	3.5	0.49
3B Neap Flood with Wind	3.0	0.42	3.0	0.42	-	
4A Neap Ebb w/o Wind	2.5	0.35	-		5.5	0.77
Nitrogen (TN, pTN)	*15**					
DM Standards	*5*					
1A Spring Flood w/o Wind	11.5	1.73	2.8	0.41	3.5	0.53
1B Spring Flood with Wind	3.5	0.53	3.5	0.53	-	
3A Neap Flood w/o Wind	13.5	2.03	3.8	0.56	3.5	0.53
3B Neap Flood with Wind	3.0	0.45	3.0	0.45	-	
4A Neap Ebb w/o Wind	2.5	0.38	-		5.5	0.83
Phosphorus	*0.68**					

Scenarios	Outfall A				Outfall E	
	Surface		Near-bed		Surface	
	%	Potential Concentration at the Edge of Mixing Zone	%	Potential Concentration at the Edge of Mixing Zone	%	Potential Concentration at the Edge of Mixing Zone
DM Standards	*0.1**					
1A Spring Flood w/o Wind	11.5	0.08	2.8	0.02	3.5	0.02
1B Spring Flood with Wind	3.5	0.02	3.5	0.02	-	
3A Neap Flood w/o Wind	13.5	0.09	3.8	0.03	3.5	0.02
3B Neap Flood with Wind	3.0	0.02	3.0	0.02	-	
4A Neap Ebb w/o Wind	2.5	0.02	-		5.5	0.04
Total Suspended Solids	*494**					
DM Standards	*30*					
1A Spring Flood w/o Wind	11.5	56.81	2.8	14	3.5	17
1B Spring Flood with Wind	3.5	17.29	3.5	17	-	
3A Neap Flood w/o Wind	13.5	66.69	3.8	19	3.5	17
3B Neap Flood with Wind	3.0	14.82	3.0	15	-	
4A Neap Ebb w/o Wind	2.5	12.35			5.5	27
Iron	*2.4**					
DM Standards	*2*					
1A Spring Flood w/o Wind	11.5	0.28	2.8	0.07	3.5	0.08
1B Spring Flood with Wind	3.5	0.08	3.5	0.08	-	
3A Neap Flood w/o Wind	13.5	0.32	3.8	0.09	3.5	0.08
3B Neap Flood with Wind	3.0	0.07	3.0	0.07	-	
4A Neap Ebb w/o Wind	2.5	0.06	-		5.5	0.13
Zinc	*0.43**					
DM Standards	*0.1*					
1A Spring Flood w/o Wind	11.5	0.05	2.8	0.01	3.5	0.02

Scenarios	Outfall A				Outfall E	
	Surface		Near-bed		Surface	
	%	Potential Concentration at the Edge of Mixing Zone	%	Potential Concentration at the Edge of Mixing Zone	%	Potential Concentration at the Edge of Mixing Zone
1B Spring Flood with Wind	3.5	0.02	3.5	0.02	-	
3A Neap Flood w/o Wind	13.5	0.06	3.8	0.02	3.5	0.02
3B Neap Flood with Wind	3.0	0.01	3.0	0.01	-	
4A Neap Ebb w/o Wind	2.5	0.01	-		5.5	0.02

**Based on the maximum concentration recorded at Swan Region, Perth for worst case scenario (refer to Table 6-36). Red font denots exceedances to DM guidelines.*

6.8.2.7 On-site Discharge of Sewage

Sewage from individual buildings will be discharge to the existing Dubai municipal network. Description of the sewerage network of the Project is provided in Section 4.6.4.3.

Cruise ships usually provide amenities similar to hotels such as pools, salons, restaurant, dry cleaners, etc. As such, cruise ships have the potential to generate wastes that are similar in volume and character. The Cruise Ship Discharge Assessment Report (2008) examined five primary waste streams from cruise ships including sewage, greywater, oily bilge water, solid waste and hazardous waste.

Without appropriate waste management in place, wastes from marine vessels have the potential to impact marine environment, including water quality and other marine recources, along with human health issues. However, the discharge of waste from marine vessels / cruise ships is not anticipated, apart from exceptional situations where accidental spillage occurs. Therefore, the risk of on-site discharge to the marine environment is minor. As stated in DM Technical Guideline on Disposal of Hazardous Wastes, vessel / cruise ship arriving in any port of Dubai are required to attach Advance Notification Form for Waste Delivery signed by the captain and Port Reception Facility. The Project is also required to comply with international conventions (provided in Section 3.4.4). Additional measures to avoid on-site discharge of sewage from marine vessels is provided in Section 7.7.2.

6.8.2.8 Marine Risk Assessment

A Marine Risk Assessment was undertaken by Sogreah (2017h; Appendix E) to assess the impacts of Dubai Harbour on the existing and proposed facilities as well as vessels in the area. The marine risk assessment focused on vessel traffic hazards, with the following objectives:

- Identify accidental risks linked to all vessel types (passengers, cruising, yachts) in the new harbour facility;
- Evaluate the risk of damage against harbour facilities during berthing and in case of an uncontrolled drifting vessel sailing in the area;
- Evaluate the environmental risk of loss of containment and pollution during bunkering operations (oil spill scenarios);
- Evaluate the risk of damage (impact and hooking) against existing subsea gas pipeline due to vessel activities in the area;
- Evaluate the level of risk regarding risk acceptance matrix criteria; and
- Define mitigation measures to reduce risk level.

Methodology

The typical process flowchart for undertaking the risk analysis is provided in Figure 6-40. The risk is defined by the combination of a likelihood of occurrence and severity of consequences. The likelihood and consequences estimated for each possible major incident are compared with Risk Acceptance Criteria (Table 6-38), in order to decide if additional mitigation measures must be implemented or if the risk level is acceptable.

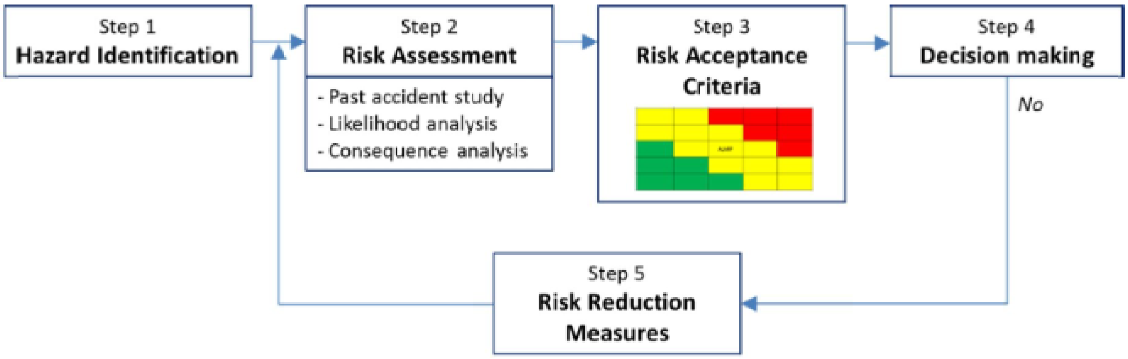


Figure 6-40 Marine Risk Assessment Methodology Flowchart

Source: Sogreah, 2017h

Table 6-38 Risk Acceptance Criteria

	Likelihood of occurrence (per year)				
Consequence Severity	Remote (E) $P<10^{-5}$	Extremely unlikely (D) $10^{-5}\leq P<10^{-4}$	Very unlikely (C) $10^{-4}\leq P<10^{-3}$	Unlikely (B) $10^{-3}\leq P<10^{-2}$	Likely (A) $10^{-2}\leq P$
Disastrous (5)	Yellow	Yellow	Red	Red	Red
Catastrophic (4)	Yellow	Yellow	Yellow	Red	Red
Severe (3)	Green	Yellow	Yellow	Yellow	Red
Significant (2)	Green	Green	Yellow	Yellow	Yellow
Minor (1)	Green	Green	Green	Yellow	Yellow
Green	Acceptable risk zone, not requiring the implementation of mitigation (reduction) measures.				
Yellow	Intermediate zone. For these scenarios, a continuous improvement approach is pertinent with a view to achieve, under economically acceptable conditions, a Risk Level as Low As Possible (ALARP).				
Red	Intolerable risk area. The implementation of reducing measures is necessary.				

Source: Sogreah, 2017h

A Hazard Identification study was carried out by Sogreah (2017h) using a 'what if' methodology to identify top hazardous events or situations linked to the Dubai Harbour project. The study objective was to define the potential causes and final consequences of hazardous events as well as identifying the prevention and protection measures in place.

At the end of hazard identification, the following accidental situations were selected that needs detailed evaluation process:

- Risk of grounding the cruise vessel (outside the channel, on the breakwaters, etc.);
- Risk of collision between ships:
  - Collision between cruise vessels and leisure vessels;

- Collision between two cruise vessels at berthing; and
- Collision between two leisure vessels.

- Risk of collisions of ships against marine infrastructure:
  - During berthing of the cruise vessels; and
  - Due to drifting of leisure vessels.
- Loss of containment and pollution during bunkering of ships; and
- Other risks (e.g. aircraft collision from SkyDive area, helipads, etc.).

Risk Assessment

The five scenarios lead to 34 hazardous situations, which were assessed in terms of frequency and severity (Table 6-39). These scenarios were plotted in the risk acceptance matrix in order to assess their acceptability in terms of human, environment, financial and operational impacts.

The summary of risk assessment is provided below:

- *Human aspects*: Eighteen (18) situations are ranked in the ALARP region while one (aircraft crash) is ranked 'unacceptable' before the implementation of additional mitigation measures.
- *Environmental aspects:* One situation is acceptable while 34 are ranked in the ALARP region.
- *Financial aspects:* One situation is acceptable while 18 are ranked in the ALARP region.
- *Operational aspects:* One situation is acceptable while 18 are ranked in the ALARP region.

Based on risk assessment undertaken by Sogreah (2017h), most situations are in the intermediate region and no situation is considered unacceptable after the implementation of additional measures. A continuous improvement approach detailed in Section 7.10.2 shall be undertaken to reduce Risk Levels to as low as reasonably possible (ALARP).

Table 6-39 Marine Risk Assessment

No.	Scenario	Description	Details		Zone	No.	Frequency per year	Human safety			Environment			Cost and Financial			Operational		
								F	S	R	F	S	R	F	S	R	F	S	R
1	Risk of grounding	Risk of grounding of cruise vessels	Ship A		Zone 1	1	1,22E-03	B	3	2	B	1	2	B	2	2	B	3	2
			Ship B		Zone 1	2	1,22E-03	B	3	2	B	1	2	B	2	2	B	3	2
		Risk of grounding of leisure vessels	Small ships		All	3	2,44E-02	A	2	2	A	1	2	A	1	2	A	2	2
			Medium ships		All	4	4,07E-03	B	2	2	B	1	2	B	1	2	B	2	2
			Large ships		All	5	1,02E-03	B	2	2	B	1	2	B	1	2	B	2	2
2	Risk of contact against harbour facilities	Risk of damage against harbour facilities from cruise vessels	Ship A		Zone 1	6	3,59E-05	D	4	2	D	3	2	D	3	2	D	3	2
			Ship B		Zone 1	7	3,59E-05	D	3	2	D	3	2	D	2	3	D	2	3
		Risk of damage against harbour facilities due to drifting of leisure vessels	Small ships		All	8	2,88E-03	B	2	2	B	2	2	B	2	2	B	2	2
			Medium ships		All	9	4,79E-04	C	2	2	C	2	2	C	2	2	C	2	2
			Large ships		All	10	1,20E-04	C	2	2	C	2	2	C	2	2	C	2	2
3	Risk of collision	Risk of collision between cruise vessels at berth	Ship A		Zone 1	11	1,43E-04	C	4	2	C	3	2	C	3	2	C	3	2
			Ship B		Zone 1	12	1,43E-04	C	4	2	C	3	2	C	3	2	C	3	2
		Risk of collision between cruise vessels and leisure vessels in the channel	Ship A		Zone 1	13	7,18E-04	C	4	2	C	3	2	C	3	2	C	3	2
			Ship B		Zone 1	14	7,18E-04	C	4	2	C	2	2	C	2	2	C	2	2
		Risk of collision between leisure vessels in the various marinas	Small ships		All	15	1,15E-02	A	2	2	A	2	2	A	2	2	A	2	2
			Medium ships		All	16	1,91E-03	B	2	2	B	2	2	B	2	2	B	2	2
			Large ships		All	17	4,78E-04	C	2	2	C	2	2	C	2	2	C	2	2
4	Oil spills	Oil spill risks during refuelling (leaisure boats)	Super yacht fuel station	Small leak	Zone 1	18	2,19E-03	B			B	1	2	B			B		
				Medium leak	Zone 1	19	2,19E-03	B			B	2	2	B			B		
				Large leak	Zone 1	20	2,19E-03	B			B	2	2	B			B		
			Canal fuel station	Small leak	All	21	9,30E-03	B			B	1	2	B			B		
				Medium leak	All	22	9,30E-03	B			B	1	2	B			B		
				Large leak	All	23	9,30E-03	B			B	2	2	B			B		
			Bay Marine fuel station	Small leak	All	24	7,75E-03	B			B	1	2	B			B		
				Medium leak	All	25	7,75E-03	B			B	1	2	B			B		
				Large leak	All	26	7,75E-03	B			B	2	2	B			B		

No.	Scenario	Description	Details		Zone	No.	Frequency per year	Human safety			Environment			Cost and Financial			Operational		
								F	S	R	F	S	R	F	S	R	F	S	R
		Oil spill risks during refuelling (cruise boats)	Truck to ship	Small leak	Zone 1	27	4,17E-04	C			C	2	2	C			C		
				Medium leak	Zone 1	28	4,17E-04	C			C	2	2	C			C		
				Large leak	Zone 1	29	4,17E-04	C			C	2	2	C			C		
			Barge to ship	Small leak	Zone 1	30	2,68E-03	B			B	2	2	B			B		
				Medium leak	Zone 1	31	2,68E-03	B			B	2	2	B			B		
				Large leak	Zone 1	32	2,68E-03	B			B	3	2	B			B		
5	Other risks	Aircraft crash			All	33	8,58E-03	B	4	1	B	1	2	B	3	2	B	2	2
		Helicopter crash			All	34	9,58E-04	C	4	2	C	1	3	C	3	2	C	2	2

Source: Sogreah, 2017h

Note:

Ship A – Oasis of the Seas

Ship B – MSC Fantasia

Small ships: 10–25 m

Medium ships: 25–50 m

Large ships: >50 m

6.8.2.9 Summary

The predicted impact levels on marine ecology during the operation phase (prior to implementing mitigation measures) are presented in Table 6-40.

Table 6-40 Potential unmitigated operation phase impacts on marine ecosystem

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Habitat loss and modification from maintenance dredging	Possible	Moderate	**Medium**	Marine flora and fauna	Negative
Provision of additional hard substrate habitat	Almost certain	Moderate	**High**	Beach users, marine fauna	Positive
Potential contamination and nutrient input from Stormwater discharge	Possible	Minor	**Low**	Marine flora and fauna	Negative
Decreased salinity resulting from stormwater discharge	Almost certain	Insignificant	**Low**	Marine ecosystem	Negative
Introduction of invasive or exotic species	Unlikely	Moderate	**Medium**	Marine ecosystem	Negative
Accidental fuel or chemical leaks / spills	Possible	Moderate	**Medium**	Marine ecosystem	Negative
Ongoing disturbance to marina fauna from increased marine traffic	Almost certain	Minor	**Medium**	Marine fauna	Negative
Damage to existing subsea gas pipeline due to vessel activities in the area	Unlikely	Moderate	**Medium**	Marine ecosystem	Negative
Reduced water quality from discharge of stormwater with potentially elevated concentrations of nutrients, pesticides and sediments.	Likely	Minor	**Medium**	Marine flora and fauna, beach users	Negative
Reduced light climate for	Possible	Minor	**Low**	Marine ecosystem	Negative

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
photosynthetic marine organisms or smothering of marine benthos in vicinity to the outfalls from TSS loads					
Reduced sediment quality	Possible	Minor	**Low**	Marine flora and fauna	Negative
Reduced visual amenity for beach users	Rare	Minor	**Negligible**	Residents of local community. Beach users	Negative
Accidental discharge of sewage from marine vessels / cruise ship	Possible	Moderate	**Medium**	Marine flora and fauna	Negative

6.9 Terrestrial Ecology

6.9.1 Construction Phase

6.9.1.1 Habitat Loss and Modification

Proposed early works include demolition of existing rock structures on Logo Island, such as revetment and breakwaters. Whilst the loss and modification of habitat within the Project site is considered permanent, irreversible and cumulative, negligible consequences are considered since Logo Island is a manmade island with low ecological significance.

The breeding colony of the Black-crowned Night Heron, likely to be located on the grounds of the Royal Mirage Hotel, will not be impacted by construction as it is located outside of the Project site (between the Dubai Marina and the stem of Palm Jumeirah).

6.9.1.2 Loss of Vegetation / Flora

Due to the relatively recent construction of Logo Island and the urban nature of the surrounding environment, ecological diversity is low. Vegetation / flora that will be lost as a result of Project construction activities includes a small area of grass associated with the Skydive Dubai area. There may be limited impact on local avifauna, however, as discussed in Section 5.8.3, the majority of avifauna utilising the area are common, opportunistic species and the area is not associated with breeding or nesting populations. The potential breeding colony associated with landscaped gardens on the mainland would not be affected by loss of habitat as this is outside of the Project area. Further, none of the migratory birds that were noted to utilise the shoreline of Logo Island for resting are considered to be of conservation significance and would likely utilised nearby alternatives during construction.

6.9.1.3 Disturbance to Local Terrestrial Fauna (Exposure to Dust Emission)

Demolition and construction works associated with the Project may generate dust emissions from the movement of vehicles and equipment that could potentially disturb or result in negative impacts to local terrestrial fauna including irritation to the eyes, nose and throat as well as respiratory illnesses. Although the generated emissions are likely to be localised and intermittent, emissions could impact terrestrial fauna, particularly avifauna, within and adjacent to the Project site. However, terrestrial fauna is in extremely low abundance and avifauna is highly mobile. Construction dust will be temporary and generally reversible once construction ceases. As such, negligible to minor adverse impacts on local terrestrial fauna are anticipated.

6.9.1.4 Disturbance to Local Terrestrial Fauna (Exposure to Noise Emission)

Noise emissions may be generated from construction activities as well as movement of vehicles and equipment that could potentially disturb or result in negative health and behavioural effects to local terrestrial fauna including acoustic masking, hearing loss, and changes in foraging and anti-predator behaviour. Construction noise and disturbance during early works and construction may deter avifauna from resting on the banks nearby, however this effect is temporary and considered negligible, as it is expected that the birds will find alternative banks to rest on. Noise disturbance is not considered significant enough to disturb fauna outside of the Project site, such as the Black-crowned Night Heron breeding colony.

Construction noise will be temporary and any negative impacts generally reversible once construction has ceased. Additionally, terrestrial fauna was generally absent during the site walkthrough. Therefore, a negligible short-term disruption is anticipated on local terrestrial fauna.

6.9.1.5 Injury / Death to Local Terrestrial Fauna

The presence of construction waste could result in injury or death to local terrestrial fauna through entanglement or ingestion of potentially lethal waste material. Although generated construction waste will be temporary, impacts to local terrestrial fauna will be permanent, irreversible and cumulative. Injury to or death of local terrestrial fauna may also be caused by machinery strike. However, due to the highly disturbed nature of the Project site and the limited presence of terrestrial fauna species within the area, this is a rare occurrence.

6.9.1.6 Summary

The impact level on terrestrial ecology during the construction phase (prior to implementing mitigation measures) is provided in Table 6-41.

Table 6-41 Potential unmitigated construction phase impacts on terrestrial ecology

Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Habitat loss and modification	Possible	Insignificant	**Negligible**	Terrestrial flora and fauna	Negative
Loss of vegetation / flora	Unlikely	Insignificant	**Negligible**	Terrestrial flora and fauna	Negative
Exposure to dust and noise emission	Almost certain	Insignificant	**Low**	Terrestrial flora and fauna	Negative
Injury / death to terrestrial fauna via intake / entanglement of waste or machinery strike	Rare	Minor	**Negligible**	Terrestrial fauna	Negative

6.9.2 Operation Phase

6.9.2.1 Increased Vegetation / Flora

Once the project is completed, the ecological value of Logo Island in terms of terrestrial fauna habitat will be similar to the existing conditions on the mainland. The site will comprise a modified habitat with planted vegetation, which will provide increased vegetation cover in a reclaimed / highly disturbed environment. These habitats are likely to provide shelter and food for local terrestrial fauna, including birds and insects and therefore will provide a beneficial impact to terrestrial ecology.

Increased vegetation / flora is considered permanent, reversible and non-cumulative, which could affect local terrestrial fauna within and adjacent to the Project site. Increased vegetation / flora can be further enhanced by maximising the use of native species, including endemic or ecologically important species for landscaping and park areas. This measure is aimed at enhancing the ecological value of the site as well as attracting and supporting native terrestrial fauna.

6.9.2.2 Introduction of Invasive or Exotic Species

Project development requires landscaping, which may potentially result in the intentional or accidental introduction of invasive or exotic (non-native) species into the beach area. This can threaten biodiversity, as some of these species can become invasive, spreading rapidly and out-competing native species through competition of resources (Gardner and Howarth, 2009).

The potential introduction of invasive or exotic species is considered permanent, reversible and cumulative and could adversely impact terrestrial ecology if not properly mitigated. However, this impact is considered negligible given the highly disturbed nature of the Project site and the general absence of vegetation / flora in addition to it being a reclaimed area. Prohibiting the use of invasive species and minimising the use of exotic species for landscaping works could eliminate the introduction of invasive species within the Project site. An experienced botanist or landscape consultant should be engaged to identify potentially invasive or exotic species.

6.9.2.3 Disturbance to Local Terrestrial Fauna (Exposure to Noise Emissions)

The proposed development will have a high-end mixed-use nature and is likely to generate increased anthropogenic disturbance and subsequent noise emissions that could potentially disturb or result in ill health and behavioural effects to local terrestrial fauna. Operational noise is likely to be permanent, irreversible and cumulative and could impact terrestrial fauna within and adjacent to the Project site. Given the limited terrestrial fauna present within the Project area, this is considered negligible.

6.9.2.4 Disturbance to Local Terrestrial Fauna (Artificial Lighting)

The operation of the Project is likely to generate increased amounts of artificial lighting, which has the potential to disturb or result in negative health and behavioural effects to local terrestrial fauna. Impacts on terrestrial fauna include disruption to biological clock, changes in foraging, prey detection, anti-predator behaviour and navigational disorientation.

Disturbance due to artificial lighting has the potential to impact terrestrial fauna within and adjacent the Project site and is considered to be permanent, reversible and cumulative. However, significant adverse impacts are not anticipated given the limited number of species present in the area and the existing artificial lighting levels in the areas adjacent to the Project site.

6.9.2.5 Injury / Death to Local Terrestrial Fauna

Improper management and disposal of operational waste may potentially result in injury or death of local terrestrial fauna due to entanglement or ingestion of potentially hazardous waste material. Impacts to local terrestrial fauna will be permanent, irreversible and cumulative; however, given the highly disturbed nature of the Project site and the limited number of terrestrial fauna, minor adverse impacts are anticipated.

6.9.2.6 Summary

The anticipated impact levels on terrestrial ecology during the operational phase (prior to implementing mitigation measures) are presented in Table 6-42.

Table 6-42 Potential unmitigated operation phase impacts on terrestrial ecology

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Increased vegetation / flora	Almost certain	Moderate	**High**	Beach users Terrestrial fauna	Positive
Introduction of invasive or exotic species	Possible	Minor	**Low**	Terrestrial flora and fauna	Negative
Exposure to increased noise	Possible	Insignificant	**Negligible**	Terrestrial fauna	Negative
Exposure to artificial lighting	Almost certain	Insignificant	**Low**	Terrestrial fauna	Negative

6.10 Waste

6.10.1 Construction Phase

A range of waste materials will be generated during the construction of the Project, which includes non-hazardous and hazardous solid and liquid wastes that are typical and inherent to construction and reclamation works.

6.10.1.1 Demolition Waste

Demolition waste will be generated during the early works, which includes demolition of concrete, excavation of pipe foundation and removal of existing breakwaters and revetments on Logo Island and mainland Zone 3. Existing rock structures that will be removed will be stockpiled and re-used for construction where practicable. However, concrete material, reinforcement bar and other existing structures that are not re-used will generate waste that will be transferred off-site for disposal to the DM waste management system.

6.10.1.2 Solid Waste

The types of solid waste materials likely to be generated during the development of the Project include:

- Spoil from earthmoving activities and excavation works;
- Concrete waste;
- Plastic waste (e.g. packaging materials, pipes);
- Metal (e.g. reinforcement bars, aluminium window panels, electrical and communication wires);
- Wood (e.g. packaging materials);
- Glass (e.g. scrap glazing);

- Ceramics (e.g. finishing materials);
- Paper (e.g. office supplies, cardboard, packaging materials);
- Food wastes; and
- General refuse.

These types of waste are generally easy to manage, with a large component either reusable on-site (e.g. excavated material to be used for backfilling, where applicable) or recyclable via an off-site facility. On the other hand, food waste and other domestic waste would require regular collection for disposal to an appropriate landfill.

6.10.1.3 Liquid Waste

The following are the key components of liquid waste anticipated during the Project construction phase:

- Domestic sewage from portable toilets;
- Concrete truck washing;
- Equipment washing; and
- Dewatered water from excavation works.

With the exception of dewatered water, all other components of wastewater will require regular collection for off-site disposal to an appropriate treatment facility. Dewatered water is anticipated to be generally similar to that of the marine water and could therefore be discharged directly into the marine environment provided that its quality complies with the DM standard parameter limits. However, in the event that dewatered water has been contaminated (e.g. with oil from equipment), dewatered water will be collected for off-site disposal by a DM-approved waste collector.

6.10.1.4 Hazardous Waste

Project construction is anticipated to generate hazardous waste, which include the following:

- Paint;
- Oil, fuel and grease;
- Batteries;
- Light bulbs;
- Adhesives;
- Solvent; and
- Containers of hazardous materials.

Contaminated soil from accidental spills or leaks of hazardous waste will also be considered and managed as hazardous waste. Hazardous waste will require segregation from non-hazardous waste. Suitable storage facilities on-site will be provided prior to collection for off-site disposal. While hazardous waste is commonly generated in much smaller quantities compared to non-hazardous waste, the environmental risk associated with its storage and disposal is considered to be significantly greater.

6.10.1.5 Construction Waste Estimate

The Environment Agency Abu Dhabi (EAD) estimates that 400 tonnes of construction waste is generated per site per day within the Emirate of Abu Dhabi (AGEDI, 2009). For the purpose of estimating the amount of construction waste generated at the Dubai Harbour Project, the 400 tonnes/day waste generation figure published by the EAD will be used. This number may be subject to significant variance in the absence of empirical figures. In terms of the composition of the waste, Table 6-43 provides general construction waste composition data taken from three international sources, since no similar data exists within the UAE. In the absence of locally suitable empirical data, there may be significant variances exhibited in the construction waste figures for the Dubai Harbour Project.

The construction period for the Project is approximately three years. A significant portion of the construction schedule consists of marine works and the development of high rise buildings, which will generate significantly less construction waste than other infrastructure. To take this into consideration, the waste generation estimate of 400 tonnes/day has been halved for one year of the program. Therefore, approximately 365,000 tonnes of construction waste is anticipated to be generated during the three-year construction phase (2018 – 2020). An estimated 322,404 tonnes (88.3%) of generated construction waste would be recyclable. As described in Sections 4.4.4 and 4.6.3.2, the total volume of dredged material is expected to be approximately 5 million m^3.

Table 6-43 Expected composition of construction waste

Waste Material	New South Wales (Australia) Percentage Composition[5] (%)	Envirowise-WRAP (UK) Percentage Composition[6] (%)	California Environmental Protection Agency, (USA) Percentage Composition[7] (%)	Adopted Percentage Composition[8] (%)	Estimated Construction Waste Quantity (tonnes/day/site) (AGEDI, 2009)
Cardboard/ Paper	3.20	4.00	8.60	5.27	21.07
Plastic	2.90	15.00	1.70	6.53	26.13
Wood/Timber	20.00	24.00	30.70	24.90	99.60
Concrete/ Masonry	22.90	32.00	17.20	24.03	96.13
Glass	0.40	0.00	0.30	0.23	0.93
Metals	5.70	6.00	3.10	4.93	19.73
Gypsum Material	3.70	6.00	18.20	9.30	37.20
Organic Waste	1.80	3.00	4.00	2.93	11.73
Non-recyclable	25.00	10.00	0.00	11.67	46.67
Clay and/or other materials	14.40	0.00	16.20	10.20	40.80
TOTAL	**100%**	**100%**	**100%**	**100%**	**400**

6.10.1.6 Environmental Impacts of Construction Waste

Without appropriate management measures, the generation, temporary storage (on-site), collection, transport and disposal of construction waste may lead to adverse environmental issues, including the following:

[5] Hyder Consulting (2011) Construction and Demolition Waste Status Report for Department of Sustainability, Environment, Water, Population and Communities (Commonwealth) and Queensland Department of Environment and Resource Management
[6] Envirowise-WRAP. 2005. Site waste management practices in construction industry in United Kingdom.
[7] California Environmental Protection Agency. 2006. Detailed characterization of construction and demolition waste.
[8] The adopted composition is an average of the construction waste composition data taken from three sources.

- Contamination of soil, groundwater and marine environment. This risk is primarily associated with the temporary storage of sewage and hazardous waste on-site that could result in spill / leaks contaminating soil. If soil contamination is not mitigated, contaminants have the potential to migrate into the groundwater. Any groundwater contamination may result in impact to the marine environment due to the close proximity and interface between the marine environment and groundwater;
- Nuisance odour due to inadequate storage of putrescible waste and leakage from portable toilets and temporary septic tanks. Such an issue is typically localised and the sensitive receptors likely to be affected are the construction workers and visitors to the site;
- Vermin infestation (e.g. rats, flies and mosquitoes). This issue is mainly related to food waste which, when left uncontrolled or not regularly collected, would likely encourage vermin infestation on-site;
- Injury or death to marine flora and fauna. When deposited into the marine environment, construction debris could potentially result in injury / harm or death of marine species (such as fish and mammals) via clogging of fish gills and entanglement. Deposition of fine waste materials (e.g. erosion of excavated materials) into the marine environment negatively impacts marine flora as it reduces light availability for photosynthesis;
- Injury or death to terrestrial fauna. Construction waste could potentially result in injury / harm or death of terrestrial fauna through entanglement or ingestion of hazardous materials; and
- Stormwater and marine pollution. Litter and other contaminants (e.g. oil and grease) associated with the construction works could enter the marine environment via wind dispersion or stormwater discharge. Although an impact may not be readily apparent at the time of the discharge, some contaminants (e.g. oil, trace metals from waste paints) can accumulate in the sediment and be released to water under favourable redox conditions, causing a delayed impact on water quality in the marine environment.

Improper management of waste also has associated health and safety risks for the general workers and visitors especially for staff involved in managing / handling the waste. Risks involved include:

- Injury due to contact with sharp scrap metals, wood, glass or plastic material;
- Injury or fatality due to fire resulting from improper storage / handling of flammable materials (e.g. waste oil); and
- Ill effects due to exposure to hazardous materials or chemicals in the event of a significant spill or prolonged exposure to volatile emissions.

Adverse impacts associated with waste management can generally be avoided via implementation of suitable mitigation measures. Where impacts cannot be avoided (e.g. soil contamination), the extent is typically localised and reversible if cleaned-up immediately.

Construction wastes from the Project will eventually generate additional strain on the existing waste management infrastructure and services in the Emirate of Dubai. Management of waste also generates GHGs such as CO_2 and CH_4. Carbon dioxide emissions are a result of fuel use for waste transport and recycling while CH_4 is generated by decomposition of waste in landfill. By forming additional loads to the existing waste management facilities in the Emirate, the Project's construction waste is considered to be a contributor to the Emirate's overall GHG emissions.

6.10.1.7 Unsuitable Dredged Material

An estimated 4.7 million m^3 of material will be generated during the dredging of the navigation channel. Material complying with the requirements detailed in the Earthworks, Dredging, Reclamation and Ground Improvement specifications will be used in reclamation, while material not meeting these standards and is considered 'unsuitable' for reclamation as the material will not be compatible to project specifications.

Geotechnical investigations along the navigation channel route (Section 5.4.3) categorised the material into four categories, with estimated volumes shown in Table 6-44. It is considered likely that rock will be suitable for reclamation, however; this can only be accurately determined following dredging, as the fines and larger particulate content varies depending on numerous factors, including rock characteristics, dredging and transportation processes. Before mitigation measures are applied, the total volume of unsuitable material may therefore range from 922,300 m^3 to 3,864,000 m^3.

Table 6-44 Expected volumes of dredged material

Dredged material	Potential Suitable Sediment (m^3)	Potential Unsuitable Sediment (m^3)	Unsuitable Sediment Volume (m^3)	Quantity of Rocks to be Dredged (m^3)
Total	882,600	332,300	922,300	2,609,400

Unsuitable dredged material may be disposed at sea (offshore disposal) and on land (onshore disposal). Potential impacts of offshore and onshore disposal are described below.

Offshore disposal has the potential to cause the following impacts:

- *Effects on water quality and pelagic organisms*. Dredged material disposal has the potential to affect the physical properties (such as turbidity) as well as the chemical characteristics (such as concentrations of pollutants) of water. Turbidity may increase during the disposal; however, the suspended solids are usually low enough to cause few, if any, detectable physical impacts on pelagic organisams (USEPA, 1989). The release of contaminants from descending dredged material is not considered threatening to the environment unless the concentrations of suspended solids are very high (USEPA, 1989).
- *Effects on benthic organisms*. Benthic organisms are mostly affected during the disposal of dredged material. In case that disposal occurs repeatedly, the original benthic infauna as well as other animals may become smothered and die of suffocation, unless these organisms are able to migrate vertically to the new surface (USEPA, 1989). Faunal recolonization usually starts very shortly after the disposal of sediment terminates (USEPA, 1989).

Disposal onshore usually requires processing the raw material in a nearshore environment, to reduce the large volume of water mixed with the solid fraction. This will have a direct impact on the land used for this process, as well as potentially releasing suspended solids into the nearshore environment (the location of many sensitive receptors and habitats). This process requires reworking and relocation of the material by earthmoving equipment, with associated emmisions and resource use impacts. Transportation from the processing area to the disposal site would be by truck, with an estimated 175,000 truck movements required to relocate the unsuitable material if rock and potentially unsuitable sediment cannot be used (approximately 3.8 million m^3). This again would have emmisions and resource use impacts, as well as considerable negative impact on local traffic. Unsuitable dredged material are usually disposed onshore via confined disposal facilities (CDF). Impacts of CDF are provided below:

- *Direct physical impacts*. Impacts may include alteration of habitat, changes in hydrological conditions (e.g. circulation patterns in surface waters and groundwater recharge), aesthetic, cultural and land use impacts (USEPA, 2004).
- *Storage Capacity.* A CDF must be designed and operated to provide adequate storage volume and surface area. Large area will be required for placing the material.
- *Contaminant pathways.* Contaminant pathways that need to be considered if onshore disposal is used include effluent discharges to surface water during filling operations and subsequent settling and dewatering, rainfall surface runoff, leachate into groundwater, volatilization to the atmosphere and direct uptake (USEPA, 2004).

A detailed discussion on disposal options as well as measures to mitigate the impacts of dredged material disposal are provided in Section 7.9.1.4.

6.10.1.8 Summary

Based on the above discussion, the potential impacts associated with construction waste generation (prior to implementing mitigation measures) is summarised in Table 6-45.

Table 6-45 Potential unmitigated construction phase impacts on waste generation

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Generation of waste that will increase strain on the waste infrastructure and result in additional quantities being deposited to landfill	Almost certain	Moderate	**High**	Dubai waste infrastructure and landfill	Negative
Potential contamination of soil, groundwater, marine and stormwater; odour; vermin infestation, injury / hazard from improper waste management	Possible	Moderate	**Medium**	Workers involved in waste handling Construction site workers and visitors Marine and terrestrial ecosystem Soil and groundwater	Negative
Potential impacts on water quality, pelagic organisms and benthic organisms, in case of offshore disposal of unsuitable dredged materials	Possible	Moderate	**Medium**	Marine flora and fauna	Negative

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Potential impacts on water quality, pelagic organisms and benthic organisms, in case of onshore reworking of unsuitable dredged materials for disposal	Possible	Moderate	**Medium**	Marine flora and fauna	Negative
Potential impacts on aesthetic, cultural and land use in case of onshore disposal of unsuitable dredged materials	Possible	Moderate	**Medium**	Community surrounding the proposed disposal site	Negative
Potential contamination of surface and groundwater quality in case of onshore disposal of unsuitable dredged material	Possible	Major	**High**	Groundwater and surface water surroundinig proposed disposal site	Negative

6.10.2 Operation Phase

A range of waste streams will be generated during the Project operation phase, which includes household / residential wastes, hotel wastes, commercial and retail waste, landscaping wastes and wastes from regional and other services (including the cruise terminal and marina).

6.10.2.1 Municipal Waste

The estimated quantity of municipal wastes to be generated during the Project operation phase is provided in Table 6-46. The estimate is based on the Abu Dhabi Urban Planning Council Estimada default waste generation factors for buildings.

As provided in Table 6-46, a significant volume of waste will be generated once the Project becomes fully occupied and operational. However, as the Project will be operational in phases, this volume would not be generated immediately but on a gradually increasing trend over time. It is also anticipated that with the implementation of proper waste management on-site (e.g. waste minimisation, reuse and recycling) the quantity of waste would be reduced significantly and waste materials requiring landfill disposal would be minimised.

Typical composition of municipal waste is anticipated from the Project; and as such, collection and disposal can be managed via the DM municipal waste collection and disposal system.

Table 6-46 Estimated Quantity of Waste to be Generated during the Operation Phase of the Project

Land Use Description		Annual Waste Generation Rate	Estimated Annual Waste Generation (m^3)
Retail / Food and Beverage	GFA: 77,659 m^2	40 $kg/m^2/yr$	3,106,378
Regional and Other Services	GFA: 60,400 m^2	40 $kg/m^2/yr$	2,416,004
Leisure and Entertainment	GFA: 41,915 m^2	40 $kg/m^2/yr$	1,676,602
Facilities	GFA: 6,492 m^2	40 $kg/m^2/yr$	259,691
Residential	46,211*	532.9 kg/person/yr	24,625,842
Hospitality (Hotel)	705**	900 kg/room/yr	634,500
Total			32,719,017

Notes:

As a conservative approach and due to lack of specific waste generation factors for Regional and Other Services, Leisure & Entertainment, and Facilities, the waste generation factor for Retail was assumed to be applicable.

GFA: Gross Floor Area

*Expected total number of residents

**Estimated total number of rooms based on parking bays

6.10.2.2 Hazardous Waste

Hazardous waste will be generated from the various land uses / components of the Project and particularly from the vessel maintenance area and marinas. These will likely include liquid waste materials such as hydrocarbon products, chemical cleaning fluids, solvents, oils and paints, as well as batteries. The quantity of hazardous waste is typically much smaller compared to other non-hazardous wastes; however, improper disposal of these types of wastes could result in environmental pollution or pose a threat to human health.

6.10.2.3 Domestic Sewage

An approximate 42,200 residents, 16, 270 employees and 73,030 visitors are anticipated when the Project becomes fully occupied and operational. As such, domestic sewage waste will be generated on a daily basis. An assessment of the impacts of domestic sewage is provided in Section 6.12.2.

6.10.2.4 Maintenance Dredging Material

Modelled infilling rates of the channel show that insignificant quantities of deposition are anticipated, at less than 1 cm per year at all locations. As a siltation allowance of 0.2 meters is being considered in the design of the navigation channel, the frequency of dredging maintenance operations is expected to be around 20 years (Sogreah 2017f). Total infill volume per year was estimated at 3,760 m^3/year (Sogreah 2017f), therefore over a 20 year period, 75,200 m^3 material would be generated.

Due to the timeframe involved (20 years), the specific method of disposal of the maintenance dredging material has not been determined, but would comprise the same impacts as discussed in Section 6.10.1.7.

6.10.2.5 Environmental Impacts of Operation Waste

Waste generated during the Project operation phase could lead to environmental issues when not managed appropriately. These issues are similar to the construction waste impacts including contamination issues, odour, vermin infestation and risk to terrestrial and marine flora and fauna.

Waste from the Project's operation would eventually form additional loads to the municipal waste collection facility and landfill sites. Further, it is considered to be a contributor to the Emirate's overall GHG emissions. The generation of waste during the operation phase is considered a long-term and permanent impact.

6.10.2.6 Summary

The Project's operational waste impacts (prior to implementing mitigation measures) is summarised in Table 6-47.

Table 6-47 Potential unmitigated operation phase impacts on waste generation*

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Additional strain on the existing waste management infrastructure and services, particularly hazardous waste management	Almost certain	Moderate	**High**	Residents, visitors and guests Workers involved in waste handling and management Terrestrial and marine ecosystem	Negative
Contamination of soil, groundwater, marine and stormwater; odour; vermin infestation, injury / hazard	Possible	Moderate	**Medium**	Residents, visitors and guests Workers involved in waste handling and management Terrestrial and marine ecosystem Soil and groundwater	Negative

*Potential impacts of the disposal of dredged material is similar with the impacts during the construction phase. Please refer to Table 6-45.

6.11 Traffic and Transport

6.11.1 Construction Phase

Transport requirements of the Project during the construction phase will comprise marine and land-based traffic for the following:

- Transport of fill materials from the borrow area to reclamation site;
- Daily transport of site workers and staff members to Project site;
- Delivery of construction materials and resources including fuel / oil;
- Delivery of site equipment and supporting utilities; and
- Collection of waste (Section 6.10.1) for off-site disposal.

An assessment of construction (vehicle) traffic has been completed and it is estimated that the volume will reach its peak in 2019. It is estimated that 860 heavy vehicles will arrive on site on daily basis during this time. Wherever feasible, construction works will be phased with the aim of minimising demands on the existing transport infrastructure. During reclamation works, the Project will require a range of marine vessels including dredgers, survey vessels, crew boats and barges. The number of marine vessels to be utilised on a daily basis will be minimal (up to 10) and are not anticipated to result in significant impact to the existing marine traffic. However, reclamation and rockwork activities will affect the movement and routes currently utilised by marine vessels, which will be required to take a detour.

Regarding land based traffic, construction transport will include a range of vehicles and equipment, most of which will use the surrounding road network. Traffic generated during the construction phase is not expected to be significant as the movements would be intermittent and undertaken outside of rush hour traffic. Consequently, traffic congestion as a result of the Project is not anticipated.

It is important to note that while the Project's increased traffic impact during construction is likely to be insignificant, road and marine traffic introduced on-site have inherent environmental issues including:

- Air quality and noise emissions, as discussed in Section 6.3.1 and Section 6.4.1, respectively; and
- Increased risk of marine contamination in the event of accidental oil spills from marine vessels. With regard to the movement of the dredger between the borrow area and the Project site, a wider potential impact area is considered, as discussed in Section 6.8.1.

Where traffic congestion may be caused as a result of the construction works, this is likely to generate significant disruption and ill feeling amongst members of the surrounding residential areas as well as tourists / visitors of commercial areas that are adjacent to the Project site. Traffic impacts during construction of the Project can be managed via appropriate site traffic management and logistical planning, measures that are discussed in Section 7.10.1. Based on the impact assessment discussed above, the potential impacts (prior to implementing mitigation measures) associated with construction traffic) are summarised is Table 6-48.

In the event that the dredged material is unsuitable for reclamation, the material would need to be transported off site for disposal. Given the large estimated quantity of dredge material (5 million m^3), this could equate to a substantial number of truck movements, depending on the proportion of unusable compared with useable material. However, it is probable that the majority of dredge material would be usable given that material from this area has previously been utilised as reclamation fill for the Palm Jumeirah. However, even disposing of 10% to land could equate to as many as 50,000 truck movements (based on an average truck size of 10 m^3). Over an approximate 21 month reclamation duration, this would equate to around 80 truck movements (one way) per day, which could result in a moderate disturbance to the traffic in the area.

Table 6-48 Potential unmitigated construction phase impacts on traffic and transport

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Increase in road and marine traffic as a result of construction materials and	Almost certain	Minor	**Medium**	Residents of local community Users (local and visitors) of the neighbouring	Negative

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
delivery to site as well as workers/staff transportation				beaches, resorts and commercial establishments	
Temporary diversion for marine traffic around the Project during construction	Likely	Minor	**Medium**	Marine traffic	Negative
Potential traffic congestion	Possible	Minor	**Low**	Residents of local community Users (local and visitors) of the neighbouring beaches, resorts and commercial establishments	Negative
Transport of dredged material to on-land disposal site in the event of unsuitability for reclamation (unconfirmed)	Possible	Moderate	**Medium**	Residents of local community	Negative

6.11.2 Operation Phase

A marked increase in road traffic at the Project site and on the surrounding road network is anticipated once development is completed and the Project becomes fully operational. In addition to the residents, an estimated 2000 to 3000 visitors per day will be attracted to the Project site. Residents and visitors travelling to and from the Project site each day will generate a large number of vehicle trips. Various modes of public transportation (e.g. connection to the monorail, tram line, metro line) are being considered for the Project, however, it is anticipated that a number of visitors will still access the site via vehicles.

The anticipated traffic increase will contribute to the cumulative strain placed on the existing road network, as the surrounding developments such as Bluewaters Island become operational. Existing large-scale property developments surrounding the proposed site include JBR and Dubai Marina.

6.11.2.1 Traffic Impact Study

A Traffic Impact Study (TIS) was undertaken by AECOM (2017) to fully assess the impact of anticipated traffic generation on the surrounding road network. The TIS was undertaken in accordance to the relevant Dubai Roads and Transport Authority (RTA) TIS Guidelines and in coordination with the RTA liaison engineers.

The Dubai Harbour TIS evaluates the transportation network, site accesses and parking supply as well as the connections to the key external strategic highway network, based on the latest approved Master Plan. The TIS was carried out based on the Project's phasing plan as follows:

- Year 2020: This year corresponds to the opening year of the development; and

- Year 2030: This year corresponds to the ultimate year with the fully built development.

The summary of findings of the Dubai Harbour TIS is provided in the following sections while the detailed study is provided in Appendix J.

Trip Generation

Based on Dubai Trip Generation and Parking Rates Manual (2013), developed by RTA, the proposed Dubai Harbour project is categorized as Level III TIS since it generates more than 1500 trips in the critical peak hour. As provided in Table 6-49, the evening peak (PM) is the critical peaek with a total of 2974 two-way vehicle trips in the year 2020 and 15,342 two-way vehicular trips in year 2030.

Table 6-49 Trip generation – 2020 and 2030

AM Peak Hour			LT Peak Hour			PM Peak Hout			PHG Peak Hour		
In	Out	2-Way	In	Out	2-Way	In	Out	2-Way	In	Out	2-Way
2020											
775	1271	2046	1213	1068	2281	1596	1378	2974	1460	1727	3187
2030											
3542	7309	10,851	6372	5278	11,650	8348	6994	15,342	7499	9367	16,866

Source: AECOM 2017

Road Network and Junction Analysis

Detailed traffic analysis has been carried out on internal and external study area junctions for the existing and future years. The evaluation was undertaken based on HCM Level of Service (LOS) criteria (Table 6-50).

Table 6-50 HCM LOS Criteria for signalised junctions

LOS	Delay (second)
A	00.0–10.0
B	10.1–20.0
C	20.1–35.0
D	35.1–55.0
E	55.1–80.0
F	≥ 80.1

Three scenarios were considered for the operational analysis of the junctions, as summarised below.

- Existing year (2017) – Junction analysis for the existing condition shows that all junctions are performing at acceptable LOS ‘D’ or better, except the two junctions that located immediately after Interchange 5. However, delays do not exceed the cycle length of these signals.
- Opening year (2020) with connectivity to the existing network – Three junctions will fail in either one or two peaks in the year 2020.

- Full development (2030):
  - Without the Dubai Harbour Project: All the junctions will perform at an acceptable LOS except for one junction, which fail in the PM peak.
  - With Dubai Harbour Project and Road Links v/c Plots: Four junctions will perform with high LOS in either one or two peaks.

Parking Requirements

Based on the Dubai Trip Generation and Parking Rates Manual (2013) and Dubai Municipality by-Laws rates, the parking demand for the proposed development is 21,083 and 19,083, respectively.

6.11.2.2 Marine Vessel Navigation Simulation Study

The first part of the navigation simulation study (Sogreah, 2017j; Appendix E) was undertaken in April 2017 to confirm the geometry and dimensions of the access channel and port basin layout, estimate wind and wave threshold, assess tug requirements and determine layout for aids to navigation. Sogreah (2017j; Appendix E) carried out a second part in June 2017 to test the results of the first part. The mathematical model used by Sogreah (2017j) to perform the simulations is based on the SIMFLEX software (v4.7.3).

Based on the conclusions and recommendations of Sogreah (2017j) during the first part of navigation simulations, a new layout has been designed during the second part. An overview of the tested layout is presented in Figure 6-41 while the detail of the harbour basin is shown in Figure 6-42.

The new layout has been designed with the following characteristics:

- A one-way navigation channel of 300 m width including a long straight section (approx. 7.5 km long – 4 nautical miles – oriented N04 towards the sea) and a curved section (turning radius Rc = 2000 m)
- Two detached breakwaters located close to the west limit of the channel in the bend
- A 540 m diameter turning circle
- A 910 m long quay (with two berths: east berth and west berth) orientated N245–N65
- The whole channel and port basin are dredged to -12.50 m DMD

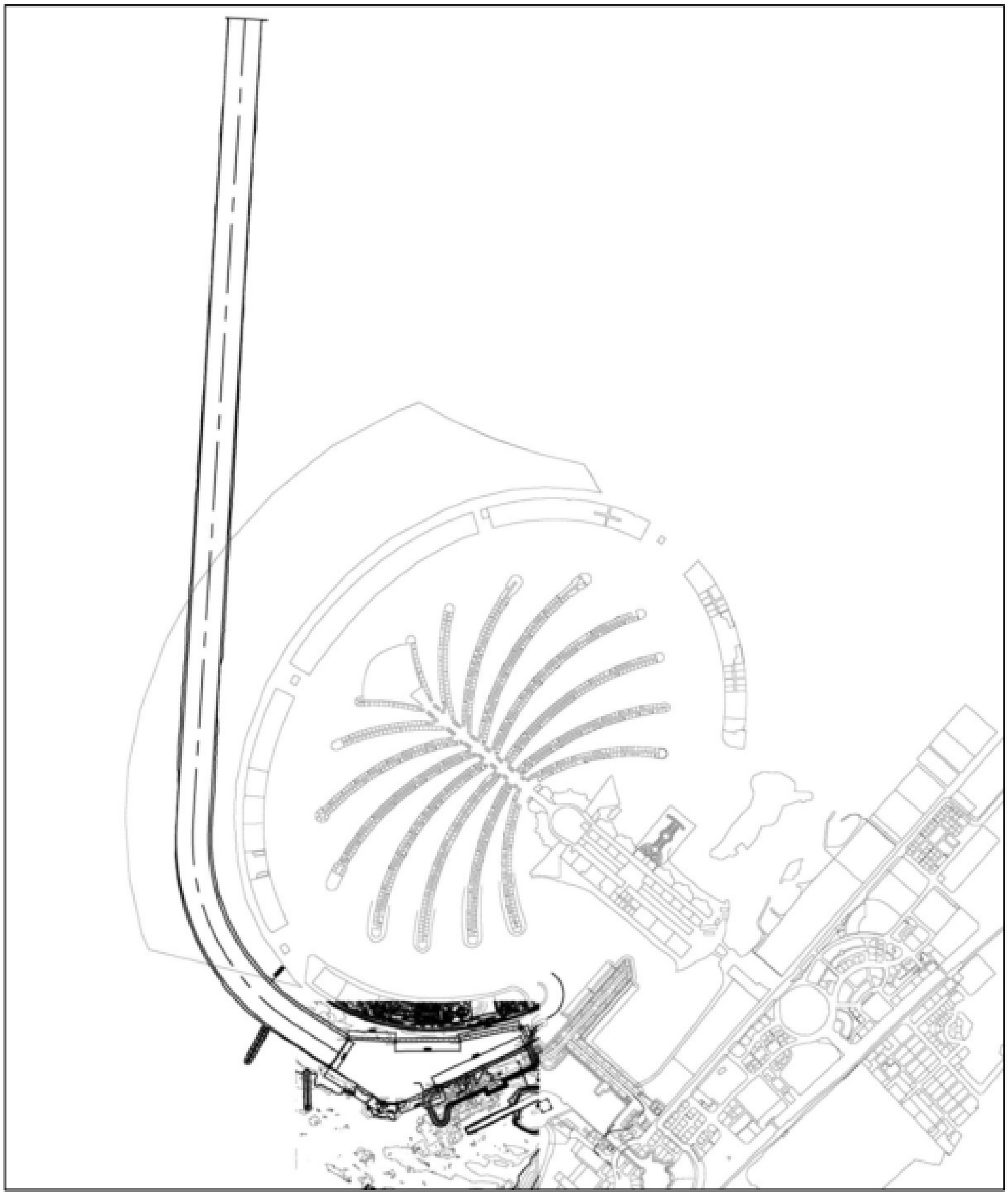


Figure 6-41 Plan view of the tested layout

Source: Sogreah, 2017j

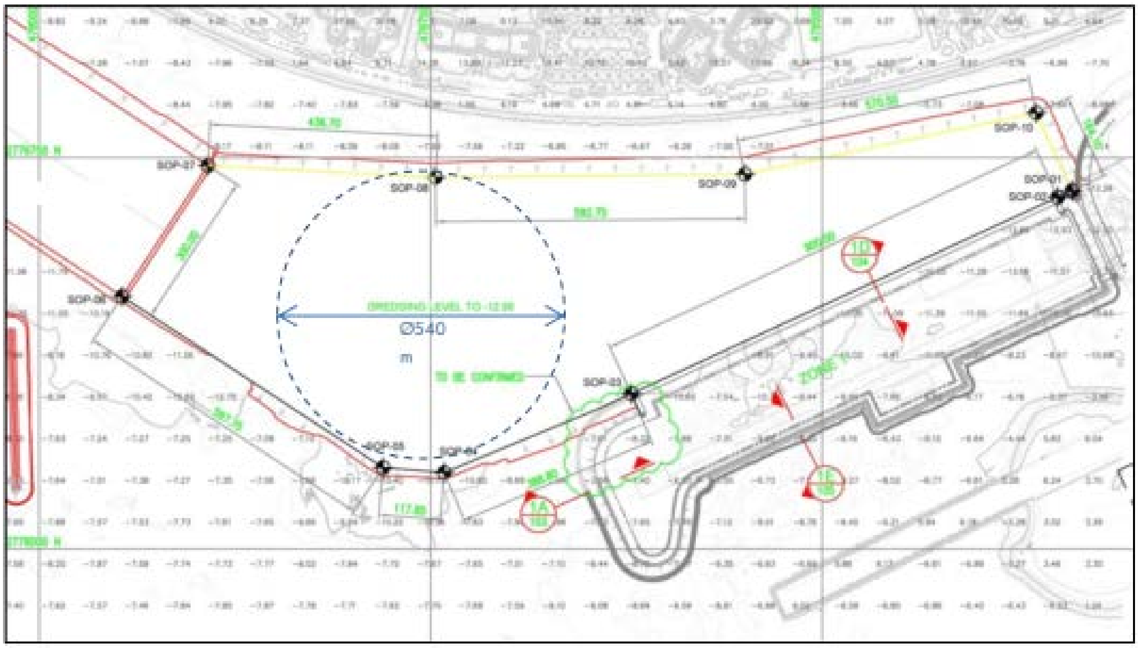


Figure 6-42 Plan view of the harbour basin

Source: Sogreah, 2017j

In some cases, the navigation simulations resulted in the ship crossing the southwest limit of the dredged area at the end of the bend and passes very close to the northern breakwater of the northeast limit of the bend (Figure 6-43). This could potentially cause the ship to cross out of the navigation channel and close to the northern breakwater, which may impact benthic habitats in areas adjacent to the dredged channel. In rare events, vessels could collide with the breakwater, which may result in damage and/or accidental leaks and spills. Therefore, in order to get higher safety margins in the bend and in the stopping zone, a widening of this part of the channel is recommended (Figure 6-44). It may be noted that the manoeuverability of the vessels was observed to improve with tug assistance, particularly during high wind conditions.

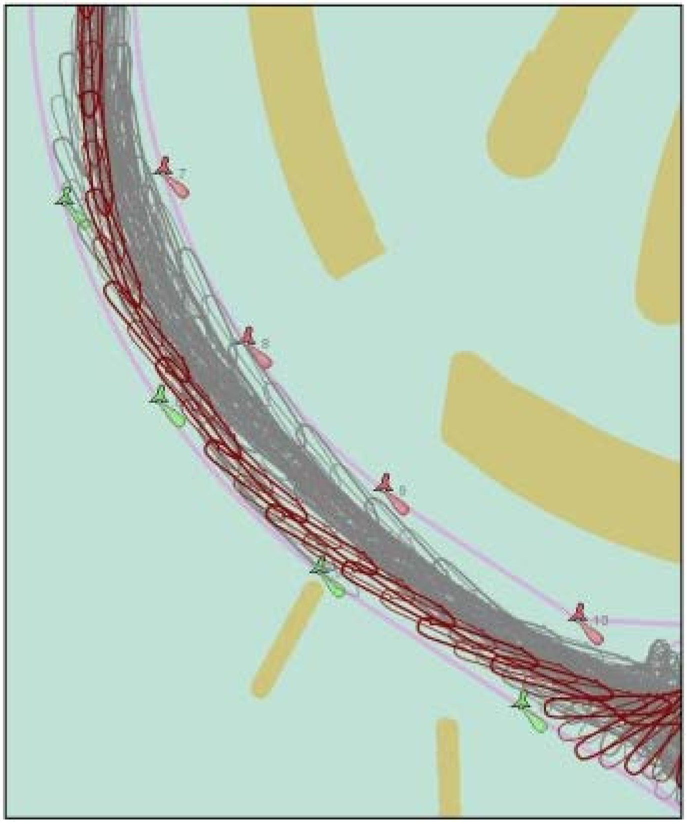


Figure 6-43 Envelope of trajectories: Oasis of the Seas in the bend (Arrivals)

Source: Sogreah, 2017j

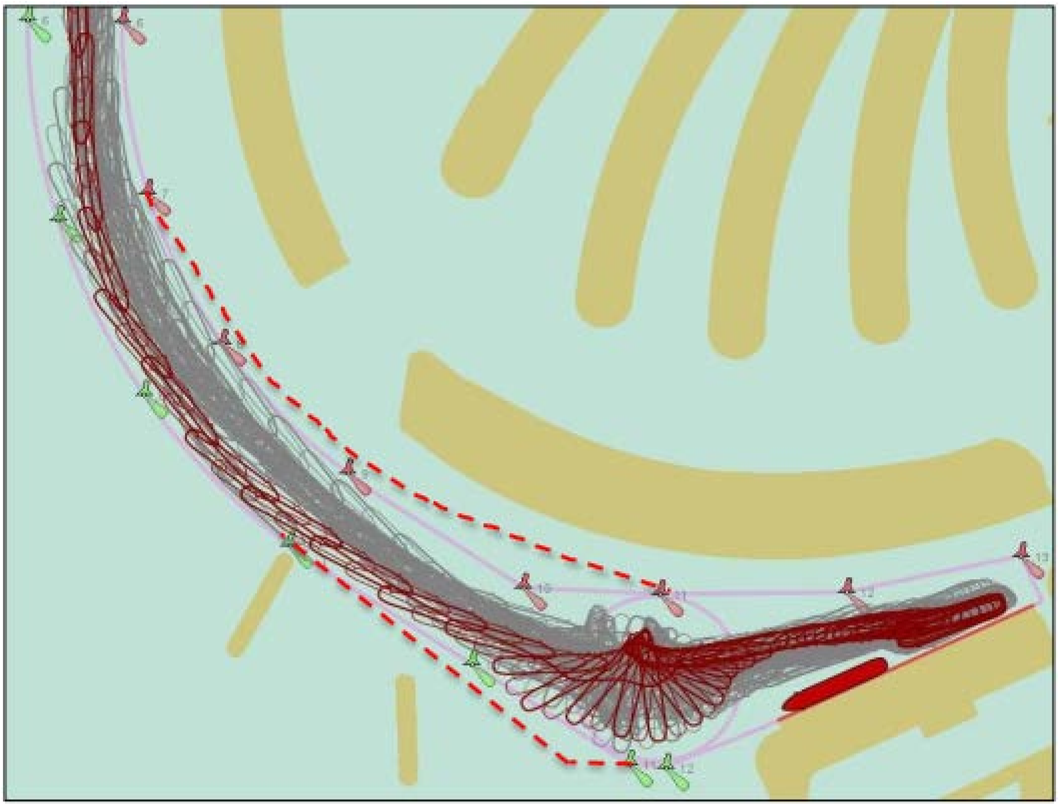


Figure 6-44 Proposed layout modifications

Source: Sogreah, 2017j

Modelled ships and tugs

Sogreah (2017j) used two cruise ship models in the simulations. The Oasis of the Seas, which is one of the largest cruise vessels envisaged to visit the terminal equipped with azipods and bos thrushers; and the MSC Fantasia, a shorter and narrower ship compared to Oasis but is representative of the largest cruise ships in service worldwide with no azipod (i.e. less manoeuverable).

All simulations have been performed for arrival to and departure from the east berth, which is the most critical berth in terms of manoeuvres. A moored ship has been placed at the westberth for all simulations. The first meteorological conditions that were tested correspond to 1 year-return period conditions (i.e. conditions expected once in one year). More extreme conditions of up to 10 year-return conditions were also input in the model (i.e. conditions expected once in 10 years). Prevailing wind directions (from west to north northwest) were tested with the associated wave conditions, whereas land winds transverst to the berth were tested with no wave.

The summary of thresholds for arrival and departure of the modelled ships are provided in Table 6-51.

Table 6-51 Typical wind and wave thresholds for arrival and departure of the modelled ships

	Arrival			Departure		
	Tug assistance	Wind (V10min)	Wave height Hs offshore	Tug assistance	Wind (V10min)	Wave height Hs offshore
Oasis of the Seas						
Channel	No	17.5 m/s	2.5–3.0 m	No	17.5 m/s	3–3.5 m
Basin	No	17.5 m/s for N270 to N330 wind direction	1–1.5 m	No	< 15 m/s	1–1.5 m
	No	15 m/s for land wind	–	Yes	15–20 m/s	1–1.5 m
MSC Fantasia						
Channel	No	17.5 m/s	2.5–3.0 m	No	17.5 m/s	3–3.5 m
Basin	No	≤ 10 m/s	1–1.5 m	2 tugs of 60–70 t BP	≤ 17.5 m/s	1–1.5 m
	2 tugs of 50 t BP	12–15 m/s	1–1.5 m			
	2 tugs of 60–70 t BP	15–17.5 m/s	1–1.5 m			

Source: Sogreah, 2017j

6.11.2.3 Summary and Conclusion

With the implementation of the recommended mitigation measures, the proposed site accesses and the adjacent roads can accommodate the expected demand with no adverse impacts on the study area. The suggested mitigation measures will enhance the grid system connectivity to Marina and JBR development thus availing more residual capacity at grade level for Dubai Harbour Traffic. The proposed mitigation measures are realistic in the context of the complexity of Interchange 5 and other constraints within the study area. It is recommended that the 2030 proposed mitigation measures should be completed by opening date of the project to avoid any negative impact on the development if mitigation considered at later stage.

The conclusions and recommendations of the navigation simulations study by Sogreah (2017j) indicated that arrival and departure manoeuvres for vessels in the navigation channel could be difficult under strong wind or strong wave conditions. As such, attention must be paid during transit in the straight and curved sections during these conditions and tug assistance must be employed to help manoeuvres. Under strong environmental conditions, docking and undocking manoeuvres will succeed provided that the power of the ship is large enough and that tugs of appropriate power are mobilized when necessary.

The summarised potential impacts (before implementing mitigation measures) associated with changes in road traffic volumes during the operation phase are presented in Table 6-52. The corresponding air and noise impacts associated with the Project related traffic impacts are assessed in Section 6.3.2 and Section 6.4.1.1, respectively.

Table 6-52 Potential unmitigated operation phase impacts on traffic and transport

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Increase in road and marine traffic as a result of journeys generated by visitors, residents, staff working on-site and contractors providing services and goods to the facilities	Almost certain	Moderate	**High**	Residents, visitors and occupants on-site Residents and visitors of nearby residential and commercial areas Local users of nearby beach	Negative
Traffic congestion	Almost certain	Moderate	**High**	Residents, visitors and occupants on-site Residents and visitors of nearby residential and commercial areas Local users of nearby beach	Negative
Impact to benthic infauna in case vessels cross out of the navigation channel	Possible	Moderate	**Medium**	Marine ecosystem	Negative

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Accidental spills or leaks due to vessel damage or collisions	Possible	Moderate	**Medium**	Marine ecosystem	Negative

6.12 Utilities

6.12.1 Construction Phase

6.12.1.1 Utility Requirements

The following temporary facilities will be provided on-site to facilitate construction of the Project:

- Power supply;
- Water supply (potable and other water requirements);
- Portable toilets; and
- Waste storage area (for hazardous and non-hazardous waste).

The operation / maintenance of temporary utilities on-site have associated environmental issues, which could potentially lead to adverse impacts. The following sections discuss the key environmental issues associated with the operation of temporary utilities on-site.

Power Supply

Power requirements for the construction site will most likely be supplied through power generating units which have the following associated environmental impacts:

- Air pollutant emissions (NO_2, SO_2, TSP, HC, CO, and O). Emissions from power units are typically localised and in low quantities; and
- Potential for oil spills and VOC emissions from the regular delivery and storage of fuel on-site. Marine contamination is also a potential impact given the close proximity.

Water Supply

Water for construction activities will be delivered via water tankers to temporary water storage tanks. Water will also be required for dust suppression purposes, although dewatering effluent is a potential resource that can be reused.

Water for construction would be sourced from desalination plants and is therefore contributing to air emissions and marine impacts associated with the production of water via desalination plants.

Domestic Sewage Facilities

Construction workers and visitors will require portable toilet and washing facilities on-site. Improper use and management of these facilities could result in the following:

- Contamination of soil and groundwater in the event of spill / leak from pipes;
- Odour nuisance or health hazards to the site workers; or
- Contamination of marine water.

The wastewater generated from toilet and washing facilities will require regular collection for off-site disposal via DM approved service providers.

Haulage of Construction Materials

Road access to the Project site is currently not available and it is likely that during the initial stages of development, transport arrangements will be by boat, barges and other marine vessels. As part of the early works activities, a temporary causeway is under construction to connect DIMC and Logo Island and will be used as access to and from the Project site.

Use of uncovered trucks for transporting building materials as well as improper storage of building materials, especially gravel, sand and cement on the construction site could lead to inadvertent dispersal of materials during heavy rains or high winds. This could have a negative impact on the marine water. Improper storage or handling of hazardous or flammable materials, including fuel, paints and solvents, could result in soil contamination and eventual leaching (or direct runoff) of these substances into the harbour waters. Further, additional strain will be placed on the surrounding transport network for the transport of construction workers, materials and equipment.

As the site development progresses, internal haul roads will be laid out to facilitate traffic movement across the site, which are often unconsolidated and can result in noise, vibration and dust suspension.

6.12.1.2 Potential Impacts on Existing Utilities and Infrastructure

The Project site is located adjacent to a built-up area where utilities and infrastructure networks are present, including power and water supply / distribution system, communication, sewerage and irrigation networks. Without suitable construction management, site works could potentially result in property damage and interruptions of service to local communities. This is particularly relevant to tie-ins to existing networks.

The risk of Project construction works resulting in utility / infrastructure damage or service interruptions is considered to be low where management measures (e.g. early communication and close coordination with utility providers) are implemented.

6.12.1.3 Summary

Environmental impacts (before implementing mitigation measures) associated with the use of construction utilities for site works are presented in Table 6-53.

Table 6-53 Potential unmitigated construction phase impacts on utilities

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Power / fuel consumption causing localised air pollution, noise emissions and risk of spill from delivery and on-site storage of fuel, potentially resulting in soil, groundwater or marine contamination	Almost certain	Minor	**Medium**	Construction site workers and visitors Residents and users of nearby residential and commercial establishments Marine flora and fauna	Negative
Water consumption, air emissions, marine and health impacts for	Almost certain	Moderate	**High**	Water supply / system infrastructure in the Emirate of Dubai	Negative

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
desalination and distribution of potable water from DEWA				Construction site workers and visitors	
Potential nuisance odour and contamination of soil, groundwater and marine water from spill / leak of sewage from portable toilets or septic tanks	Possible	Minor	**Low**	Construction site workers and visitors Residents and users of nearby residential and commercial establishments Marine flora and fauna	Negative
Additional load on the existing road traffic network	Likely	Minor	**Medium**	Local residents and users of the nearby residential and commercial establishments	Negative

6.12.2 Operation Phase

The utilities and infrastructure required during the operation and maintenance of the Dubai Harbour Project are typical to mixed-use development projects, including:

- Power network;
- Potable water network;
- Irrigation network;
- Sewage network;
- Road and transport network;
- Stormwater drainage network
- Telecommunication network; and
- Firefighting network.

6.12.2.1 Power Network

The operation of the Project will require continuous supply of power. It is planned that the site will be connected to the DEWA distribution grid with three primary substations needed to supply the Project.

The Project's power requirement may be an insignificant strain on the available electricity resource in the Emirate but can potentially have a significant loading impact on the available distribution network in the local area. Therefore, it is important to coordinate with DEWA as to the availability of service (connection) as early as the design stage and throughout the development of the Project.

Once fully developed and occupied, the Project is considered to continuously contribute to the adverse environmental impacts associated with the operation of the power plant providing for the Project's electricity demand. Key impacts of power plants include:

- Reduction in available energy as a result of fuel consumption; and

- Air pollution emissions (NO_x, SO_2, TSP, HC, CO and O_3) as well as CO_2 emissions.

6.12.2.2 Potable Water Network

The proposed potable water network will be designed to serve the residential buildings, mall and all other domestic demands for the Project along with the non-domestic requirements of the marinas. The potable water network for the Dubai Harbour will be connected to the existing DEWA distribution network.

The Project forms an additional and long-term strain on the available water supply resource in the Emirate. The total average domestic potable water demand for the Project is estimated at 23,111 m^3/day, while the total non-domestic flow for the marinas would be 170.4 L/sec. Similar to the power network, the Project's water requirement would add to the requirement for desalinated water in the Emirate and could have a significant loading impact on the available distribution network in the local area.

The Project will also contribute to adverse environmental impacts associated with the operation of the desalination plant providing for its water demand. The impacts include energy usage, air emissions and marine environmental impacts as a result of seawater intake and discharge of brine and elevation of water temperature.

6.12.2.3 Irrigation Network

The proposed landscape area will require regular irrigation. It is anticipated that the irrigation system will only make use of drip emitters or sub surface components, in addition to the use of soil amendments, such as soil additives to increase water holding capacity within planting beds and help reduce the demand for irrigation.

The estimated irrigation demand for this Project is 1,340 m^3/day of TSE water, which includes 831 m^3/day for parks and open spaces, 380 m^3/day for right of way and 129 m^3/day for leisure and entertainment (Table 6-54). It is understood that the DM limit water rates to 5 litres/m^2/day, but these units are not comparable to the Project's estimated irrigation demand due to differing units (m^2 / m^3). Further calculations will be undertaken upon finalisation of the Master Plan to ensure that the DM limits will be adhered to.

Potable water is not planned to be used for irrigation purposes for the project. DM has informed that the external TSE network will require upgrade to accommodate the project demand and Shamal has confirmed (in writing) their commitment to the cost sharing agreement proposed by DM, to ensure that adequate volumes of TSE are available and eliminate any need for potable water. Further studies and discussions are currently ongoing. Relevant correspondence is provided in Appendix K.

Table 6-54 Landscape area and irrigation demand calculations

Land use	Total area (m^2)	Landscaped area (m^2)	% of area taken up by Landscaping	Unit rate* (L/m^2/day)	Irrigation Demand (m^3/day)
Parks & Open Spaces	166,201	166,201	100%	5.00	831
Right of way	253.541	76,062	30%	5.00	380
Leisure & Entertainment	64,335	25,734	40%	5.00	129

Land use	Total area (m^2)	Landscaped area (m^2)	% of area taken up by Landscaping	Unit rate* ($L/m^2/day$)	Irrigation Demand (m^3/day)
Total	**484,077**	**267,997**			**1340**

* The irrigation unit rate demand as per latest DM regultions should be a maximum of 5 $L/m^2/day$ with reference to the combined total landscape area

The application of TSE for irrigation is a positive impact as it allows the reuse of a waste stream that would otherwise be discharged. Further, it reduces the demand on the potable water supply. However, in the event that TSE has not been treated adequately, the following potential adverse impacts could occur:

- Contamination of soil, groundwater and surrounding marine environment via stormwater flow or interface with groundwater;
- Emission of undesirable odour; and
- Health hazards to residents and guests from TSE that is not suitably treated.

The availability of TSE water will be confirmed with DM. A communication letter (ref. DXB-DHA-CIV-LTR-AAL-Y17-00038) was submitted to DM Drainage and Irrigation Department on 21 May 2017 pertaining to the TSE water requirements for the Project as well as the location of the tie-in connections to the existing DM network. On 06 July 2017, DM Drainage and Irrigation Department has replied (ref. 812/02/02/1/1705622) confirming that the existing network cannot cater for the additional TSE and will need external upgrade to accommodate Dubai Harbour flow. DM has also requested the proponent to contribute to the upgrading cost, and Shamal have confirmed their commitment to this cost sharing agreement. As of writing this EIA, discussion between DM and Shamal are ongoing.

In the event that TSE water is not available, potable water will be used for irrigation, which would increase the demand on the potable water network and reduce the opportunity to beneficially reuse TSE. The Project's water requirement may also be considered a significant strain on the available desalinated water resource in the Emirate. It will also contribute to adverse environmental impacts associated with the operation of a desalination plant providing for its water demand. These impacts include energy usage, air pollution emissions and marine environmental impacts as a result of seawater intake and discharge of brine and elevated water temperature.

6.12.2.4 Sewerage Network

A sewage collection network will be constructed as part of the Project's utilities and infrastructure services. Sewerage network design drawings are provided in Appendix K.

The average domestic sewage generated from the Project is expected to be 2,332 m^3/day by 2020, increasing up to 19,212 m^3/day by 2030. The overall sewage generated flow from the Project is 579.30 L/sec, comprising of 521.60 L/sec peak daily domestic flow and 57.70 L/sec marina sewerage flow in 2030. Due to the Project's large generated sewage flows, the existing network within the vicinity of the Project will not be able to accommodate the generated sewage flow from the Project.

The proposed sewerage network for the project area shall be connected to the external DM network on King Salman Bin Abdul-Aziz Al Saud Street. Furthermore, three lifting stations are proposed within the sewage network designed for the project, namely in Zone 1, Zone 3 and Zone 4. In addition to the on-land network, in-berth sewage pump-out stations will be incorporated within the Marina to avoid direct discharge to the marine environment.

A detailed schematic plan of the proposed sewerage network is provided in Appendix K. Three lifting stations are proposed within the sewage network designed for the project, namely in Zone 1, Zone 3 and Zone 4. The design of the sewerage network will utilize the applicable design standards, guidelines and codes of practice as per Dubai Municipality standards and specifications for various components of the network.

Currently the external sewerage network will require upgrades to accommodate Project requirements. These upgrades will be undertaken under a cost sharing agreement proposed by DM, to which Shamal have made a written commitment (relevant correspondence is provided in Appendix K. The detailed design was submitted to DM on 9 November 2017, for confirmation and approval of the proposed network and tie-in locations to the external system, and further studies and discussions are currently ongoing.

The generation of sewage during the operation of the Project will eventually form an additional load / strain on the sewage network and receiving STP. Potential impacts associated with sewage collection, such as a pipeline leak or overflow of a pumping station (if any) include nuisance odour, soil and groundwater contamination, health hazards to residents and guests, as well as marine pollution.

Cruise Ship Sewage – Black and Grey Water Discharges

Cruise ship sewage or black water generated from toilets is typically more concentrated than land based sewage and may contain bacteria, pathogens, diseases and viruses requiring treatment prior to release at sea. Grey water, which represents the largest proportion of liquid waste generated by cruise ships, includes drainage from dishwashers, showers, laundry, baths, galleys, and washbasins. It can contain pollutants such as faecal coliform, food waste, oil and grease, detergents, shampoos, cleaners, pesticides, heavy metals, and, on some vessels, medical and dental wastes. It is estimated that a typical cruise ship carrying 3,000 passengers and crew produces up to 10 gallons of black water per person per day, or 15,000 to 30,000 gallons per day, and 30 to 85 gallons of grey water per passenger per day, or 90,000 to 255,000 gallons per day.

International Maritime Organization Regulations (MARPOL 73/78 Annex IV) prohibit the discharge within three nautical miles of shore of untreated or inadequately treated sewage with a faecal coliform bacterial count greater than 200 most probable number per 100 millilitres, or total suspended solids exceeding 150 mg/100 ml. According to the industry regulations, black and grey waters are discharged only when underway and not while in Port. Sewage generated by cruise liners visiting the Project site in the operation phase will be discharged at sea, or transported off-site for treatment if required.

6.12.2.5 Road and Transport Network

The Project requires an internal road system that complements the surrounding road network. Traffic generated by the Project poses an additional strain on the existing road network in the surrounding area. Further, the road network and transport activities associated with the operation of the Project have inherent environmental issues including air and noise emissions, which have been discussed in Sections 6.3.2 and 6.4.1.1, respectively. Traffic congestion and associated social impacts (e.g. disturbance to residents) are potential issues arising from the Project, which are further discussed in Section 6.11.2.

A TIS and associated regulatory approval will be obtained for the road infrastructure of the Project (due to be submitted late June 2017). Where such approval is obtained, increased traffic impact on the surrounding transport network is considered to be acceptable.

6.12.2.6 Stormwater Drainage Network

The stormwater drainage network for the Project will transport stormwater to seven outfalls prior to discharge to the marine environment. Rainfall events in Dubai are highly seasonal and infrequent; however, they can result in high volumes of run-off in a short period of time. Stormwater discharge can include a range of pollutants depending on the land use within the respective catchment area, but generally comprise total suspended solids from lose sediments, nutrients from landscaped areas and oil and grease for car parks and roads. All stormwater outfalls will be fitted with an oil separator and flap valve in accordance with DM requirements, which will reduce the impact to the marine environment. Further discussion on the potential impacts of stormwater discharge on the marine environment is provided in Section 6.8.2.6.

6.12.2.7 Telecommunication Network

The telecommunication network will consist of fixed lines as well as a wireless mobile network. The fixed lines will tie in to an existing network adjacent to the Project, and the infrastructure required for a wireless network will be coordinated with the telecom authorities (Etisalat and DU) for their approval. The network will follow the standards and guidelines set by Etisalat and DU.

The telecommunication network for the Project is not anticipated to result in any adverse impact on the existing environment in the area.

6.12.2.8 Firefighting Network

A firefighting network will be provided for various buildings within the Project development. The source of water supply or the external fire hydrant system is the potable water network. An independent pump system, as per National Fire Protection Association and Civil Defence requirements will be designed to meet the fire demands and located on site.

The firefighting network will be designed to control a fire event for two hours, with two fire hydrants having a flow of 1,000 gallons per minute (500 each). If used, the potable water will flow through the drainage system and impacts are assessed under stormwater drainage. The firefighting network infrastructure itself is not anticipated to result in any adverse impact on the existing environment in the area.

6.12.2.9 Summary

Environmental impacts (before implementing mitigation measures) associated with the Project service and utilities demand during operation are summarised in Table 6-55.

Table 6-55 Potential unmitigated operation phase impacts on utilities

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Electricity and water consumption resulting in additional load / strain on the available power resources in the Emirate and contribution to GHG emissions associated with the operation of the power plant.	Almost certain	Moderate	**High**	Residents of the surrounding communities Operators and users of surrounding commercial establishments	Negative

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Utilisation of TSE for landscape irrigation (reuse of a waste stream)	Almost certain	Minor	Moderate	Residents of the surrounding communities Operators and users of surrounding commercial establishments	Positive
Use of TSE that has not been treated to the required standard, causing contamination to soil and groundwater and potential adverse health impacts to visitors and residents	Unlikely	Moderate	Medium	Residents of the surrounding communities Operators and users of surrounding commercial establishments	Negative
Generation of sewage requiring connection to sewerage network and consequently leading to increased load / strain on existing sewerage network and STP; associated air / noise issues	Almost certain	Moderate	High	Residents of the surrounding communities Operators and users of surrounding commercial establishments	Negative

6.13 Socio-Economic

6.13.1 Construction Phase

6.13.1.1 Generation of Employment and Business Opportunities

The generation of employment and business opportunities is considered a significant positive impact of the Project during the construction phase. During the peak of construction, the Project is anticipated to employ approximately 2000 to 5000 workers. This would comprise general construction labour and skilled trades people such as masons, carpenters and steel workers as well as Engineers, Project Managers and consultants.

This opportunity will generate income for workers and subsequently improve the standard of living for their respective families. Wages from employment will provide contribution to the local economy as a result of the multiplier effect, where the additional money earned locally will be used to purchase goods and services that may increase investment in local businesses, which may in turn provide indirect employment opportunities.

Local businesses that may positively be affected include food and accommodation establishments. Business opportunities that will be created in the construction industry, including trading of materials and equipment rental, are also expected to contribute to the overall socio-economic growth of Dubai.

6.13.1.2 Workforce Accommodation and Labour Conditions

It is expected that contractors and sub-contractors will provide accommodation camps to house the majority of the workforce. As the Project is currently in the Master Planning stage, no detail on the location of the accommodation camps is available. However, it is anticipated that buses to and from the accommodation camps will be provided to the workers. In addition to construction labour accommodation, some staff would be permanent employees or contractors who live locally.

All temporary and permanent labour accommodation is required to meet the requirements of the following standards:

- Health Requirements for the Services provided inside Labours Accommodation, Public Health and Safety Department (Doc Ref: DM-PH&SD-P7-W118); and
- Health Requirements for Permanent Labour Accommodation, Public Health and Safety Department (Doc Ref: DM-PH&SD-P7-W102).

If the above standards are adhered to, then the standard of living for the personnel working on the Project would be acceptable and will not pose a negative socio-economic impact.

6.13.1.3 Occupational Health and Safety

The workers or staff members could be exposed to various health and safety hazards during the construction phase of the Project. Specific occupational health and safety hazards inherent to construction works include exposure to heat, noise, electrical hazards, fire and explosion, chemical hazards and dust. Safe work methodologies will be required to ensure protection of workers from injuries and ill health effects of construction activities. The Proponent, through the contractors, will ensure that construction work will meet all UAE Labour Law requirements, including:

- Dubai Municipality Code of Construction Safety Practice (Latest Version);
- Provision of Local Order No. (3) of 1999 on Construction Activities Regulations in the Emirate of Dubai;
- Provision of Local Order No. (11) of 2003 on Public Health and community Safety in the Emirate of Dubai;
- Code of Construction Safety Practice (Adopted Under Local Order 61/1991); and
- UAE Fire & Life Safety Code of Practice outlined by the Civil Defence, which includes "Chapter 12 - Fire & Safety Codes during Construction and Maintenance".

6.13.1.4 Visual Amenity

The construction of the Project is anticipated to slightly reduce the amenity of the Project site's surrounding land uses (e.g. residential and commercial establishments at Dubai Marina and Palm Jumeirah) as a result of the increased land and marine traffic and associated air emissions and noise generation. This impact, will be temporary and transient.

The reclamation works are likely to generate increased sediment and nutrient loads in the water. The sediment plumes resulting from the reclamation works, if uncontrolled, may be displeasing to nearby beach users and local residents. The potential elevated nutrient load associated with the sediment in the water may also increase the risk of outbreaks of HABs, which in extreme cases can lead to beach closure. Dewatering of the reclaimed area also has the potential to generate foam and scum which if washed up onto the beach is likely to have a negative impact on neighbouring beach users. This impact would be significantly reduced if the mitigation measures for the marine ecosystem are implemented.

6.13.1.5 Disruption from Construction Activities and Traffic

The road network to access the site passes through residential and commercial (e.g. DIMC) areas with narrow streets. It is important that all construction traffic is scheduled to avoid peak traffic periods causing increased congestion and disturbance to local residents. Further, the air and noise impacts from construction activities could affect nearby sensitive receptors and cause sleep disturbance. Working hours and conditions will comply with UAE Labour Law and directives issued by the Government of Dubai and Federal Government of the United Arab Emirates.

6.13.1.6 Conflict between Local Residents and Workers

The potential influx of a large number of construction workforce can be a challenge to the local communities located close to the Project site. Some residents and tourists at the residential and commercial areas may find the behaviour of the workers a nuisance/disturbance (e.g. utilising areas in the local communities during rest breaks). Behavioural or cultural differences and misconduct (e.g. littering) by construction workforce may result in public health or safety concerns.

6.13.1.7 Summary

Socio-economic impact ratings (before implementing mitigation measures) of the Project during the construction phase is summarised in Table 6-56.

Table 6-56 Potential unmitigated construction phase impacts on socio-economic environment

Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Generation of employment and business opportunities	Almost certain	Moderate	**High**	Local residents and business owners Expatriates / foreign workers	Positive
Reduced amenity of surrounding residential and commercial areas as a result of construction traffic, air and noise emissions from traffic and construction equipment and visual impact from the construction site	Almost certain	Minor	**Moderate**	Local residents Workers and customers of retail and commercial establishments	Negative
Increased occupational health and safety risk	Almost certain	Moderate	**High**	Construction workforce and site visitors	Negative

Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Conflict between local residents and workers	Possible	Moderate	**Medium**	Local residents Workers and customers of retail and commercial establishments Workers on-site	Negative
Poor workforce accommodation and living conditions	Possible	Moderate	**Medium**	Construction workforce	Negative

6.13.2 Operation Phase

6.13.2.1 Enhancement of Tourism Industry and Generation of Employment and Business

The Project is intended primarily to enhance the tourism industry in Dubai while providing residential and retail business opportunities for the Dubai residents. It is envisaged that Dubai Harbour will play a vital role in raising Dubai's global profile as a cruise ship hub capable of accommodating 6000 passengers at one time. According to the Cruise Line International Association (cited in Arabian Business, 2017), Dubai is expected to receive 650,000 maritime travellers.

Given that tourism is a key sector that is prioritised under the Dubai's economic diversification strategy, the long-term positive impact or contribution of the Project on the Emirate's socio-economic development is considered significant. Business opportunities will be generated once hotel resorts, commercial and retail establishments as well as entertainment and leisure facilities are completed. Business opportunities will in turn generate long-term employment opportunities for expatriates and local Emiratis alike.

The long-term business and employment opportunities brought about by the Project will eventually contribute to the overall socio-economic development in the Emirate.

6.13.2.2 Change in Land Use and Improved Amenity

The Dubai Harbour Project is anticipated to enhance the amenity of the surrounding communities such as JBR, Dubai Marina and Palm Jumeirah, as it will provide a range of services and facilities including sports, recreation, food and beverage. Further, the Dubai Lighthouse is expected to provide a visual highlight for the area.

6.13.2.3 Occupational and Community Health and Safety Risk

The operation and maintenance of the different Project components have associated occupational health and safety risks, which require control measures to ensure protection of workers as mandated in the UAE Labour Law. The operators of each individual facility / service will be directly responsible for managing health and safety risks associated with the activities of their employees.

Further, the operation of the Project is considered to have potential impacts on health and safety of the future communities surrounding the site. Potential impacts relates to the:

- Generated traffic and associated road safety risk, gaseous emissions and noise; and
- Accidents / incidents from operation and maintenance of various facilities and services on-site (e.g. cruise terminal, leisure and entertainment, hotel, etc.).

6.13.2.4 Increase in Vessel Traffic and Associated Impacts

An increase in the number of vessels is anticipated, as given the capacity for 1,400 yachts at the Project site. The increase in vessel movement could result in increased chances of vessel collision.

6.13.2.5 Increase in Local Population and Associated Impacts

An increase in the local population (total of approximately 46,000) is anticipated as the Dubai Lighthouse, hotel resort and other commercial establishments start to operate, and the residential units become occupied. The increase in population would likely be gradual over time but this would be a long-term positive impact on the local community.

However, the influx of guests / visitors, employees and residents into the site has other associated social impacts including the additional strain on the locally available social and infrastructure services including security, health, education, water, power, cooling, sewerage, and municipal waste. These impacts are discussed in Section 6.12.2.

6.13.2.6 Summary

Socio-economic impact ratings (before implementing mitigation measures) of the Project during the operation phase is summarised in Table 6-57.

Table 6-57 Potential unmitigated operation phase impacts on socio-economic environment

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Enhancement of tourism activity, creating business and employment opportunities	Almost certain	Moderate	**High**	Residents of local community Expatriates / foreign workers Tourists	Positive
Change in land use and improved amenity	Almost certain	Moderate	**High**	Residents of local community Users of nearby beach, resorts, hotels and commercial establishments Tourists	Positive
Occupational / community health and safety risk and deterioration of environmental quality	Possible	Moderate	**Medium**	Residents of local community Employees and staff on-site Tourists	Negative
Increase in local population resulting in additional load / strain on existing local service utilities and infrastructure	Almost certain	Moderate	**High**	Residents of local community Expatriates / foreign workers Tourists	Negative

Potential Impact	Likelihood	Consequence	Impact Rating	Impacted Parties	Status of Impact
Increased chances of vessel collision due to increased number of vessels in the area	Possible	Moderate	**Medium**	Residents of local community Expatriates / foreign workers Tourists	Negative

7. Mitigation Measures and Enhancement Plan

This section proposes mitigation measures with of the objective of minimising and, where feasible, eliminating the key environmental impacts presented in Section 6.

7.1 Climate and Meteorology

7.1.1 Construction Phase

The GHG emissions associated with the use of fuel for the construction of the Project can be mitigated through the same management measures aimed at increasing energy efficiency, as discussed in Section 7.2.1.

7.1.2 Operation Phase

The following are measures to be implemented to mitigate GHG emissions associated with the operation of the different Project components:

- **Optimising water and power efficiency**: GHG emissions associated with the use of water and power during the operation phase of the Project could be mitigated by adopting green building design measures in accordance with the DM Green Building Regulations (Section 3.3.6). Further details on the proposed measures for increasing water and power efficiency are available in Section 7.2.1.
- **Use of sustainable building materials**: Where practical, sustainable building materials shall be used for the Project. At the minimum, the Project shall comply with the following requirements in the DM Green Building Regulations:
  - Recycled content should account for at least 5% of the total volume of materials used in the construction of new buildings;
  - Building materials available regionally should comprise at least 5% of the total volume of materials used in the construction of new buildings;
  - At least 25% by volume of timber and timber-based products used should be obtained from certified / accredited sources approved by DM;
  - The heating, ventilation, air conditioning and refrigeration equipment for new buildings should use refrigerants with zero Ozone depletion potential, or with Global Warming Potential of less than 100, with the exception of equipment containing less than 0.23 kg of refrigerant; and
  - Fire suppression systems should not contain chlorofluorocarbons, hydrochlorofluorocarbons or Halons.
- **Provision of sustainable transport infrastructure**: The Project site should be accessible by public transport and/or cycling, where possible to minimise the use of private vehicles to reduce GHG emissions.
- **Waste management**: The proposed waste management measures discussed in Section 7.9 will facilitate diversion of waste from landfill site to recycling facilities and thereby reduce GHG emissions associated with waste transport and landfill operation.
- **Incorporation of trees in landscape design**: The integration of trees (native species with low water demand) as part of the landscape design (Section 7.2.2) will also assist in reducing or offsetting the Project's contribution to climate change. Trees absorb or take up CO_2 through the natural process of photosynthesis.

Further, to mitigate against the potential for sea level rise during operation of the Project, the ground level should be raised by at least 0.32 cm (refer to Section 6.2.2) to allow for predicted sea level rise during the design lifespan.

7.2 Air Quality

7.2.1 Construction Phase

Impacts on ambient air quality resulting from the construction activities can be controlled through the implementation of the mitigation measures described below. A detailed dust and gaseous emissions control plan will also be developed as part of the construction environmental management plan for the Project.

7.2.1.1 Dust Control from General Earthmoving and Vehicle Movement

- Erect hoarding of at least 2.5 m along the site boundary and/or areas where dusty activities are performed to minimise off-site dispersion of dust;
- Locate the dust generating activities, haulage routes, stockpiles and dusty materials away from the sensitive receivers as far as possible (taking the predominant wind direction into consideration);
- Provide surfacing and / or compaction of site access roads to minimise dust generated by vehicle movements on-site;
- Provide hard surface and / or compaction of unsurfaced areas as soon as possible once earthworks are complete to minimise areas susceptible to wind erosion;
- Dusty materials on site or being transported (within and outside the site) are to be covered by impervious sheet to prevent wind erosion;
- No idling of engines and vehicles;
- Avoid using diesel or petrol powered generators, where practicable, with mains electricity or battery powered equipment to be utilised preferentially;
- Impose and signpost a maximum speed limit of 20 km/h to minimise the emission of dust on unsurfaced roads and apply designated traffic routes to reduce traffic on unsurfaced areas;
- Undertake dust suppression through water spraying on unsurfaced areas and areas where dusty work is performed (cutting, grinding and sawing);
- Undertake wheel washing at site exits to minimise dust and soil on wheels being transferred off-site;
- Minimise drop heights from conveyors, loading shovels, hoppers, loading or handling equipment and use water sprays on such equipment / work areas where possible;
- Enclose chutes and conveyors and cover skips to prevent suspension of dust;
- Suspend dusty works during periods of high wind speed; and
- Implement a construction logistic plan and construction traffic management plan to manage the sustainable deliveries of machinery, materials, workers and staff members.

7.2.1.2 Dust Control from Stockpiles

The contractor for the works should be required to excavate, transport and dispose of excavated sediments and other site materials in a manner that limits the generation of dust. Should sediment need to be temporarily stockpiled on site, the following mitigation measures will be implemented:

- Minimize stockpiles onsite (e.g. immediate removal of excavated materials requiring offsite disposal);
- Stabilize stockpiled materials with one of the following:
  – Apply water to at least 80 percent of stockpile surface areas on a daily basis when there is evidence of wind driven fugitive dust;
  – Provide impervious cover to stockpiles of all dusty materials (i.e. sand, cement); or
  – Construct a three-sided enclosure around stockpiled material with walls of no more than 50 percent porosity to the height of the stockpile.
- Limit the height and slope of stockpiles and locate away from sensitive receptors;
- Stockpiles will be located away from the Project boundary and will not be located on or near drainage lines;
- Align stockpiles along their main axis in the direction of prevailing winds to ensure minimal cross-section exposure to prevailing winds, whenever possible;
- Stockpiles within 100 meters of buildings/offices must be below two meters in height; and
- When stockpiling or unloading dusty/friable material, ensure that the loader bucket is close to the truck so that drop height is below three meters.

7.2.1.3 Control of Exhaust Gases and Particulate Emissions from Powered Equipment (including Energy Saving) and Site Activities

- Idling of equipment and vehicles will be prohibited, equipment and vehicles to be turned off when not in use to minimise gaseous emissions and fuel consumption[9].
- Use low sulphur diesel, ultra-low sulphur diesel or bio-diesel to minimise the emission of sulphur dioxide, where practical.
- Use equipment fitted with pollution control devices (e.g. diesel particulate matter filter), where possible.
- Maintain equipment and vehicles as per manufacturer recommendations and remove any malfunctioning or sub-standard equipment and vehicles from service, particularly if observed to be emitting black smoke.
- Implement a construction logistic plan and construction traffic management plan to manage the sustainable delivery of machinery, materials, workers and staff members.
- Open burning on site will be prohibited.

7.2.1.4 Control of VOC Emissions

- Storage of fuel, paints and other volatile materials:
  – Designated and well ventilated storage facilities will be provided for the storage of volatile organic materials.
  – The storage area should be located away from on-site and off-site sensitive receptors (with consideration of the predominant wind direction).
  – The quantity of volatile materials to be stored on-site should be kept to minimum and containers holding the volatile materials should be kept closed when not in use.
- An exhaust ventilation system is to be provided where volatile organic materials are stored to protect workers and staff members from exposure.

[9] US EPA (2010) reports that idling engines waste up to 1 gallon of fuel per hour.

7.2.1.5 Odour Control

- Locate toilet utilities, sewage tanks (if any) and waste storage facilities away from sensitive receptors on-site (e.g. site office, works area) and off-site (neighbouring residential villas).
- Maintain the sanitary and waste disposal facilities in good, clean conditions with any leaks fixed as soon as possible.
- Waste bins holding putrescible waste should be covered to minimise odour emission and attraction of vectors.
- Regular off-site disposal of waste should be arranged.

7.2.2 Operation Phase

Impacts on ambient air quality resulting from the operational activities can be controlled through the implementation of the following mitigation measures:

7.2.2.1 Control of Volatile Emissions

During the operations phase, the main sources of volatile emissions are likely to be from hull painting, fuel storage and cleaning chemicals. Volatile emissions from these activities should be controlled in the following ways:

- Standard fuel and chemical storage procedures should be used to minimise volatile emissions, including properly sealed and vented underground fuel tanks, covered storage areas, properly sealed containers and regular inspection of storage facilities;
- Use of cleaning solvents that are non or less hazardous for vessel cleaning and degreasing.

7.2.2.2 Control of Exhaust Emissions

Operation phase traffic emissions should be controlled in the following ways:

- **Provision of sustainable transport infrastructure**: The master plan of the proposed Project should encourage walking, jogging and cycling within the Project site with vehicle access restricted to access routes only. The Project site should be accessible by public transport (tram, metro) and/or cycling where possible to minimise the use of private vehicles;
- **Provision of adequate ventilation in the car parks**: Effective ventilation to be installed in all car parks to minimise trapped vehicle emissions;
- **Landscape by design**: Trees and vegetation to be included in the landscape master plan. Natural growth aids removal of gaseous pollutants, intercepts, traps and absorbs airborne particles, and replenishes the ambient air with oxygen (Nowak, 1998). Vegetation also helps to improve the microclimate (e.g. provide shading, reducing ambient air temperature and blocking winds) (Nowak, 1995);
- **Implement a Traffic Management Plan**: The plan should regulate the traffic routes and speeds to minimise vehicle emissions and the exposure to atmospheric pollutants contained in combustion emissions; and
- Marine vessels are required to conform to the ship pollution rules specified in the “International Convention on the Prevention of Pollution from Ships”, known as MARPOL 73/78.

7.2.2.3 Odour Control

- Maintain housekeeping and sanitary conditions at the waste management facilities, toilets and showers on the beach: Bins for putrescible waste to be covered. Waste on the beaches and marinas and at the waste management facilities to be removed from site regularly to avoid accumulation of waste.
- Leaking of sewage and TSE pipes and networks should be fixed as soon as possible to minimise the exposure of site occupants to harmful substances and odours. Where practical, pressure monitors should be installed in the sewerage and TSE transport networks to monitor for leaks within the system.
- Odour control must be considered as part of the design. Activated carbon type odour control system shall be provided which will include activated carbon filter, fan(s), demisters, dampers, ducting and all relevant instrumentation equipment. Odour control system shall comply with Section 19.14 of the DM General Specification.
- The Contractor shall submit detailed calculations for the odour control system sizing for approval.
- The equipment and plant to be supplied and installed shall be designed for use with crude sewage in the climate and conditions of Dubai.

7.3 Noise

7.3.1 Construction Phase

A detailed noise control plan with specific mitigation measures will be provided as part of the CEMP. However, impacts on noise emissions resulting from the construction activities can be controlled through the implementation of the following mitigation measures.

7.3.1.1 Erection of Noise Barrier

- Erection of hoarding / noise barrier along the site boundary and/or areas where activities emitting high noise levels are performed: Erect hoarding of at least 2.5 m to minimise noise transmitted to off-site sensitive receivers. Barriers should be installed close to noise emission sources.
- For construction works carried out in close proximity to the eastern Project boundary, and adjacent to noise sensitive receptors, erection of noise barriers made of sound absorbent materials is required. In addition, noise barriers with cantilever should be considered to divert sound waves. Achieving the maximum possible noise reduction requires careful sealing of gaps between barrier / hoarding panels and between the barrier and the ground or elevated guide way deck. The highest noise levels are predicted at noise monitoring locations N1 and N5 and as such, noise barriers should be placed between the Project boundary and these areas in particular.

7.3.1.2 Equipment Noise Control

- Piling: quiet piling methods should be identified (e.g. vibration, hydraulic insertion techniques, drilled or augured holes for cast-in-place piles).
- Selection of appropriate equipment: Quite equipment (with lower sound power level), electrical driven tools (instead of mechanical or pneumatic) and/or equipment meeting the power requirement of the tasks to be deployed for works, where possible.
- To reduce the annoyance associated with reversing alarms, consider the use of broadband reversing alarms (audible movement alarms) for all site equipment.
- Proper equipment operation:

- All plant on-site should be operated in accordance with the manufacturer's instructions;
  - Acoustic covers should be kept closed while the equipment is operational;
  - Machines to be operated at low speed or power and switched off when not being used rather than left idling for prolonged periods, where practical;
  - Silencers to be installed on equipment, where practical.
- Maintain and service the equipment at regular intervals:
  - Malfunction and sub-standard equipment should be withdrawn from service;
  - The equipment should be maintained in good order.
- Where possible, locate noise-generating utilities and equipment, parking areas and laydown areas as far away from noise sensitive receptors.
- Designate routes for materials delivery away from sensitive receptors.

7.3.1.3 Work Methods

- Where piling works are required, work is to be performed between 9:00 am and 4:00 pm. No piling work is to be conducted during early mornings, evenings and night-time.
- No noisy works permitted on Fridays or after 7:00 pm.
- Avoid the coincidence of noisy equipment working simultaneously close together and particularly when close to the site boundary.
- Deploy noise barriers: Stockpiles, temporary perimeter fence or purpose built structures to be provided to minimise off-site noise transmission, where possible.
- Staging / phasing of construction works, where possible to minimise consecutive works in the same locality.
- Avoid placement of noisy equipment / machinery at the Project boundary as far as is practicable.
- Avoid dropping materials from heights while loading and unloading of materials.
- Implement a Construction Logistic Plan and Site Traffic Management Plan: To manage the sustainable delivery of machinery, materials, workers and staff members, avoid doubling handling of materials and generating unnecessary trips.
- Occupational health and safety: Hearing protection equipment (e.g. ear plugs or mufflers) should be used by workers, staff members and visitors who are exposed to high noise levels.

7.3.1.4 Community Relations

- Contractor to provide nearby sensitive receptors in residential areas with advance notification of noisy works.
- The Contractor will provide a community liaison notification (signage) that includes a phone number and e-mail address for a permanent site contact so that noise complaints can be received and addressed in a timely manner.
- Noise complaints will be handled as soon as possible.
- Advise nearby residents of potential vibration in advance of construction activities.

7.3.2 Operation Phase

In terms of general noise mitigation measures, the most effective are noise barriers constructed adjacent to the edge of the carriage way. Acoustic barriers would typically be expected to provide a reduction of 10 dB or more at the closest receptors where the barrier ensures there is no clear line of sight between the receptor and the road or noise source. Given the dimensions of the Project and the space restrictions associated with the harbour, it is expected that the use of noise barriers will be unfeasible and largely ineffective due to the relative height of the buildings and the distance from the road edge. However, considering that the incidence of road traffic noise is expected to be unavoidable based on the current masterplan design, provision of mitigation for indoor environments through design of the buildings themselves, rather than applying costly and complex mitigation to the roads would be preferable. Increased noise protection offered by thermal glazing (double glazed windows) may prove significant when reducing the indoor noise levels within buildings in the Project area. The actual effectiveness of this measure is dependent on many factors such as the geometry and positioning of the windows within the building facade.

The Building Research Establishment Digest 379 outlines typical noise insulation rating for different types of windows as shown in Table 7-1 (BRE, 1993). Given the insulation qualities of double/thermal glazed windows (common practice in the UAE due to the climate), it is expected that sufficient mitigation of noise break-in can be achieved to allow for adequate sleep/work conditions and recreational indoor environments. As a result, it is considered likely that road traffic noise will not constitute a significant impact to the general living conditions of residences and offices built on the Dubai Harbour.

Table 7-1 Typical Noise Insulation Factors for Different Types of Window

Type of Window	Description	Single Number Insulation Rating	
		R_w – Weighted Sound Reduction Index (dB)	$R_{A(traffic)}$ – Net Acoustic Insulation Values (dB)
Open Window	Small casement window open to 45° for ventilation	± 10	± 10
Single Glazing	4 mm single glazed window	22 – 30	22 – 28
Thermal Glazing	Thermal 6-12-6 mm in a PVC-U frame	33 – 35	26 – 29
Secondary Glazing	Open-able 4-200-4 mm system with absorbent reveals	40 - 45	36 - 41

7.4 Geology, Geomorphology and Seismicity

It is anticipated that the design and construction of the Project shall be undertaken in accordance with the requirements of the DM Building Code as well as the findings of the site's geotechnical investigation. This is considered to be the most effective management measure for the seismic / earthquake risk on the Project site, along with ensuring sufficient compaction and land stability is achieved prior to commencing building and infrastructure works.

No specific measures to mitigate geology or geomorphology are considered required given that the Project will be constructed within the marine environment and on reclaimed land.

7.5 Soils and Groundwater

7.5.1 Construction Phase

7.5.1.1 Soil Erosion

The following measures should be adopted to prevent soil and sediment loss from erosion during construction:

- Site roads and tracks should be surfaced with milled asphalt or gatch to reduce suspension of dust and erosion of soil;
- The use of water for dust suppression should be controlled to ensure that the amounts applied to internal roads and tracks do not exceed the amounts required, which could cause excessive surface runoff and erosion;
- The site should undergo progressive compaction (stabilisation) immediately after earthmoving activity;
- An efficient temporary drainage system within the Project area should be provided to prevent loose soil from being scoured off by surface runoff;
- Excavation work plans should specify cut slope and maximum height to prevent erosion and to minimise the area of disturbed and unconsolidated soil; and
- Soil stockpiles should be maintained at minimum height and located on flat areas and away from stormwater flow paths.

Should the dredge material be disposed to land (disfavoured option), there is potential for erosion to the receiving soil given the high water content. Prior to commencing disposal, the receiving environment should be assessed for adequacy for the purpose, and consideration should be given to placing a liner to reduce soil erosion.

7.5.1.2 Soil and Groundwater Contamination

The following measures should be adopted to prevent soil and groundwater contamination during construction:

- Any imported fill should be clean-fill only and obtained from an approved source;
- Imported topsoil for landscaping should be obtained from an approved supplier;
- Water used for dust suppression during construction should meet municipal health standards and should not exceed the salinity levels of soil on-site;
- Toilet facilities should be provided at regular intervals within the site to allow workers ease of access during shifts;
- Effluent from site offices should be discharged directly to the municipal sewage system where feasible;
- Portable toilets or facilities with septic tanks are to be regularly checked for signs of leaks or overflow and storage tanks should be emptied when ¾ full for off-site disposed by a DM licensed waste disposal contractor;
- A program for routine checking of equipment, machinery and vehicles should be implemented to ensure there is no leakage of oil and fuel. Poorly maintained equipment should be refused entry to the site;
- Washout of concrete trucks will be prohibited outside of designated concrete wash areas, which comprise a bunded area with collection facilities for all wash water for disposal off-site; and

- There is to be no routine maintenance activities carried out at the Project site. Emergency equipment, machine and vehicle maintenance is to take place in a designated maintenance zone with covered, impermeable surfaces (such as concrete slabs) with runoff to be captured in lined drains and sumps. The collected material should be disposed of as hazardous waste by a DM licensed waste disposal contractor to appropriate waste management facilities.

The proposed management measures for hazardous materials and spill incidents discussed in the following sections will also reduce the risk of soil and groundwater contamination.

7.5.1.3 Hazardous Materials Management

The risk of soil contamination resulting from the bulk storage and use of hazardous materials on-site can be managed through the following measures:

- Where significant volumes of chemicals and hazardous materials (e.g. fuel, paints) are to be stored on-site, an appropriate bunded facility should be provided in accordance with the minimum requirements set out in the *DM EPSS Technical Guideline No. 6 – Bunding of Storage Tanks and Transfer Facilities* (June 2011). Key aspects of these requirements are provided below:
  - The gross capacity of the bunded area should be 110% of the capacity of the biggest tank, or 25% of the total capacity of all tanks within the bund, whichever is greater;
  - Bunded area for drums storage should have a capacity to hold at least the volume of 25% of the drums to be stored up to 10 Kilo litres plus 10% of any volume in excess;
  - Adequate separation distance should be maintained for incompatible materials;
  - Bunded areas which are not covered with a roof should have a minimum bund height of 150 mm;
  - Provisions for overfill control should be made available for facilities used for filling operations;
  - Stormwater collected from the bunded area should be disposed of appropriately (e.g. through a registered waste collector). The requirements (e.g. DM permit) for waste disposal as discussed in Section 7.9 may apply in this instance, and this should be coordinated with the DM Environment Department; and
  - Adequate fire precautions should be in place.
- Only authorised and trained personnel should be allowed access to areas where hazardous materials are stored or used;
- Storage areas should also be sited away from the marine environment and sensitive receptors (e.g. site office);
- Provisions for roof / shelter should be arranged where heavy rains are anticipated so as to prevent build-up of rainwater in the bund (which will otherwise be considered contaminated water requiring appropriate disposal);
- Where possible (without interrupting construction), the stock of hazardous materials to be stored on-site should be kept to the minimum;
- A register / inventory of chemical and hazardous materials stored / used on-site should be maintained and regularly updated. The inventory should be accompanied with MSDS, which are important documents that provide guidance on the management measures in cases of emergencies / spill incidents. Where possible, the register and MSDS file should be kept close to the storage area or readily accessible to relevant staff';

- Storage containers / areas should be labelled (e.g. name of the materials) and posted with conspicuous hazards warnings in order to alert employees and visitors of the contents of containers;
- The Project's site inspection program should include daily visual checks of the areas where hazardous materials are stored and / or used. The inspection will facilitate immediate detection of any spill or leak which in turn will enable undertaking of corrective actions in a timely manner;
- Staff with designated responsibilities on the use, handling and storage of hazardous materials should be provided with competency training as well as environment, health and safety training. The training program should enable the relevant staff to perform their tasks efficiently without resulting in any contamination issues, as well as knowing the appropriate actions to take in response to an emergency (e.g. fire) or spill incidents;
- Standard operating procedures should be developed, where possible for works or activities involving hazardous materials. The following could be adopted for fuel transfer / delivery:
  - Maintenance and checking for worn or faulty "O" rings in hose and connector couplings, to reduce accidental oil spills during tank loading;
  - Complete drainage of fuel from loading hoses to reduce accidental oil spills during tank loading;
  - Accurate tank level readings and loader attention to avoid negligence, helping to reduce accidental oil spills during loading;
  - Installation of spill guards, which capture small spills and overfills during fuel delivery; and
  - Refuelling activities should be undertaken at designated hardstand / bunded areas, or with the use of appropriate drip trays; and
  - Inspection should be undertaken to check for any spill / leak when refuelling has been completed.

7.5.1.4 Spill Response and Contingency

A Spill Response and Contingency Plan should be developed by the Contractor specific to the Project's risk. The Plan should be readily accessible at areas where there is an identified risk of spill. At a minimum, the following should be incorporated in the Plan:

- Appropriate response procedures;
- Requirements for the appropriate type and strategic location of spill response kits (i.e. should readily be accessible in the event of a spill);
- Delineating the responsibilities of site staff and communication requirements including an emergency contact list with site management and relevant authorities;
- Appropriate methods for disposal of spills and clean-up materials; and
- Appropriate training / drills should be undertaken to enable the relevant staff to respond appropriately to spill incidents.

7.5.2 Operation Phase

7.5.2.1 Control of Soil and Groundwater Contamination Risk from Landscape Maintenance

The proposed use of TSE for irrigation and application of fertilisers for the Project's landscape maintenance pose environmental hazards requiring appropriate management. The following are measures to be implemented to control risk of soil contamination and salinization resulting from the daily landscape irrigation:

- Installation of impermeable liners at the base of all landscaped zones to reduce or eliminate percolation of nutrient enriched irrigation leachate into the marine environment;
- As early as the Master Planning / design stage of the Project, the relevant authorities (DM) should be consulted to ensure that there is an adequate TSE resource which could be allocated to supply the Project demand;
- During the operation phase, incidents (e.g. odour) indicating poor quality of TSE should immediately be coordinated with the relevant authority (DM);
- An appropriate irrigation programme should be developed and consistently implemented with due consideration of the plant and tree species featured in the landscape design of the Project. This should include:
  - Schedule and frequency of irrigation;
  - Rate of irrigation; and
  - Method of irrigation.
- Similarly, an appropriate program for fertiliser application should be developed and consistently implemented in order to control the risk of soil contamination and the consequent stormwater pollution. The program should also include:
  - Schedule and frequency of application;
  - Rate of application; and
  - Method of application.
- Native species are not anticipated to require significant irrigation or fertiliser application; therefore, use of these species will assist in reducing the risk of soil contamination and salinization impacts associated with the irrigation and fertilisers application.
- The use of soil conditioners should be explored, as they can contribute to reduction in fertiliser and water use, and can mitigate some of the effects of soil salinity.

7.5.2.2 Control of Soil and Groundwater Contamination from Utilities

The risk of soil contamination resulting from the operation of utilities on-site (e.g. sewerage and TSE piping system and pump stations, waste management facilities, and power substations) can be prevented / mitigated via routine inspection and maintenance program. Coordination with the relevant authorities (who have direct control over the utilities) may need to be arranged, such as during incidents of spill / leak of fuel, oil, sewage or TSE.

Potential control measures that can be implemented to minimise the risk of soil and groundwater contamination related to fuel storage are identified below.

- Each storage tank must be equipped with an overfill alarm and/or appropriately sized containment basin, tank cathode protection, and a leak detection system;
- Each storage tank must be vented using a pressure relief valve or other appropriate safety device that prevents the accumulation of vapours inside the tank to levels that can rupture or otherwise damage the tank;
- Periodic preventive maintenance and testing should be conducted according to tank manufacturer's recommendations and applicable federal and local government regulations and requirements; and
- The location of storage tanks on site must be clearly identified by aboveground signs.

7.6 Coastal Processes

7.6.1 Construction Phase

Construction of the temporary causeway between Logo Island and the existing DIMC is predicted to result in slightly decreased flushing rates at JBR Beach, Mina Al Seyahi Beach and the DIMC.

No known water quality issues currently exist within these water bodies, however there is a risk that poor water quality may be generated if sources of pollution are introduced at these sites. It is therefore recommended that discharges of wastewater (e.g. dewatering effluent, stormwater runoff, sanitary wastes etc.) are directed away from these enclosed water bodies during the construction phase. Preferably, discharges should be directed to areas modelled to exhibit the highest current speeds and outside of marinas or other enclosed water bodies.

7.6.2 Operation Phase

7.6.2.1 Management of erosion/deposition zones

The primary coastal processes impact anticipated from the operational phase of the project is the change in peak current speeds at localised sites within the Project area. Altered peak current speeds may result in increased sediment deposition onto the seabed where speeds are decreased and increased erosion of sediments from the seabed where speeds are increased. Potential management and mitigation measures include:

- Periodic monitoring of the seabed level at the identified risk areas for a minimum of two years duration to ascertain if significant erosion/deposition are occurring;
- If significant erosion/deposition is occurring that may cause risks to ship navigation, these areas may need to be maintained through periodic maintenance dredging.

In the event that maintenance dredging is required, an operational environmental management plan should be prepared to address the environmental impacts and mitigation measures to be implemented during dredging. These could include the provision of silt curtains and temporary diversions for marine traffic. The disposal site should also be assessed to ensure that sediment is not deposited in an area that could smother sensitive marine benthos.

7.6.2.2 Water and sediment quality within enclosed waterbodies

Water quality

Following construction of Dubai Harbour, water exchange at the Mina Al Seyahi Beach will remain very good, and meet the required flushing criteria (despite a slight reduction); therefore, no mitigation is deemed necassary.

A reduction in the flushing rate is predicted for the Dubai Marina Canal, which has the potential to contribute to poor water quality. However, modelled water exchange in the Canal currently exceeds the flushing criteria, and there has been no recorded impact on the water quality. It therefore cannot be concluded that further reduction of the post-development water exchange will have a significant impact on the water quality within this water body.

It must be noted that specific flushing criteria for water bodies in arid regions have not been developed and empirical evidence suggests that existing guidelines (adopted from more temperate climates) may be overly stringent for the UAE. Despite currently exceeding the flushing guidelines, no known water quality issues have occurred for the existing marina. As such, provided the existing environmental management of the marina is maintained and the introduction of pollution sources (e.g. wastes from boat maintenance, sanitary wastes etc.) into or near the Dubai Marina is avoided, it is not thought that the decrease in flushing rate will lead to the generation of poor water quality. Numerous factors, such as boat traffic and wind channelling by surrounding buildings, may modify actual currents from those predicted by models, especially in an enclosed waterbody such as the Dubai Marina Canal.

Regular seawater and sediment monitoring will be undertaken in the Marina to closely monitor any changes in water quality in the area, both during construction and during operation. Should water quality deteriorate and fall significantly below DM Water Quality Objectives (Table 3-11), appropriate mitigation measures to improve water exchange will be implemented.

Various different mitigation measures have been considered. These include:

- Hydrological manipulations: altering physical structures to beneficially change water currents;
- Mechanical solutions: physically moving water to increase additional flow.

Table 7-2 shows a high-level assessment of potential mitigation measures to increase flushing in the Dubai Marina Canal, which are discussed in greater detail below. Hydrological manipulations may be of limited benefit despite requiring considerable structural changes (with associated cost and environmental impacts). Mechanical methods of increasing flushing through the Dubai Marina canal will require initial infrastructure, as well as ongoing running, maintenance and management. However, this may be more effective and cheaper than any feasible hydrological manipulation and are considered preferable to the alternative of no development of Dubai Harbour (Section 1.4).

These options are discussed in more detail below.

Option 1: Modification of Dubai Harbour design

Additional modelling was undertaken to investigate whether the predicted reduction in flushing rate in the Dubai Marina could be improved by the introduction of a 15 m wide channel through Zone 4, shown in Figure 7-1 (Sogreah, 2017d). Modelled concentrations of a tracer introduced inside Dubai Marina for the pre-development condition was compared to both post-development scenarios (with and without the channel). Basin averaged tracer concentrations for all three scenarios are displayed in Figure 7-2. The time required to reduce the conservative tracer concentration to 37% (T37) of the initial concentration (E-folding residence time) for the pre-development scenario was 14 days, while for both post-development conditions (with and without the channel) it was more than 21 days.

It was therefore concluded that the inclusion of a channel or culvert in Zone 4 did not decrease the modelled flushing time in the Dubai Marina canal and was consequently rejected as a potential mitigation measure.

Option 2: Modification of the canal entrance adjacent to Bluewaters Island

Reconfiguration of the canal entrance adjacent to Bluewaters Island was shown to have limited beneficial effect on the inflow / outflow of water to the canal. Modification will not significantly improve water exchange.

Table 7-2 Dubai Marina Canal flushing: assessment of potential mitigation measures

Options	Mitigation measure		Description	Comments	Status
1	**Hydrological manipulations**	Modification of Dubai Harbour design	15 m wide channel through Zone 4	Modelling shows no benefit to addition channel.	Rejected
2		Modification of the canal entrance adjacent to Bluewaters Island	Removal of additional length of breakwater to increase inflow into the canal	Limtied beneficial effect on water exchange.	Rejected
3	**Mechanical solutions***	Water pumps	Water pumped from the sea to the centre of the Marina Canal	Modelling shows a flow rate of 0.5 $m^3 s^{-1}$ is sufficient to keep flushing below pre-development rates. Ongoing studies are looking at optimisation.	Preferred option
4		Mechanical mixers	Large-scale horizontal flow generators deployed singly or along the length of the Dubai Marina to increase water current	Potentially large space required in the canal. Potential for health and safety issues (rotating blades), environmental impacts (e.g. sediment resuspension), social impacts (boat users) and maintenance issues.	Not likely to be suitable
5		Tidal gates	Closing the waterway at high tide, opening at low to increase outflow	Dubai Marina canal would be closed periodically closed to boat traffic, potentially for up to 12 hours per day. Likely to have minimal impact on flushing.	Rejected
6		Lift station	Water pumped up to a higher elevation to create additional head of water	Unsuitable for the configuration of the waterway. Likely to have minimal impact on flushing.	Rejected
7		Aerators	Air pumped through a diffuser near the bottom of the waterbody vertical circulation cells	Limited horizontal flow generation. Aerators would restore deficiencies of dissolved oxygen, but would not address other contaminants.	Rejected

*Mechanical solutions will only be undertaken if monitoring in the Dubai Marina Canal shows a deterioration in water quality

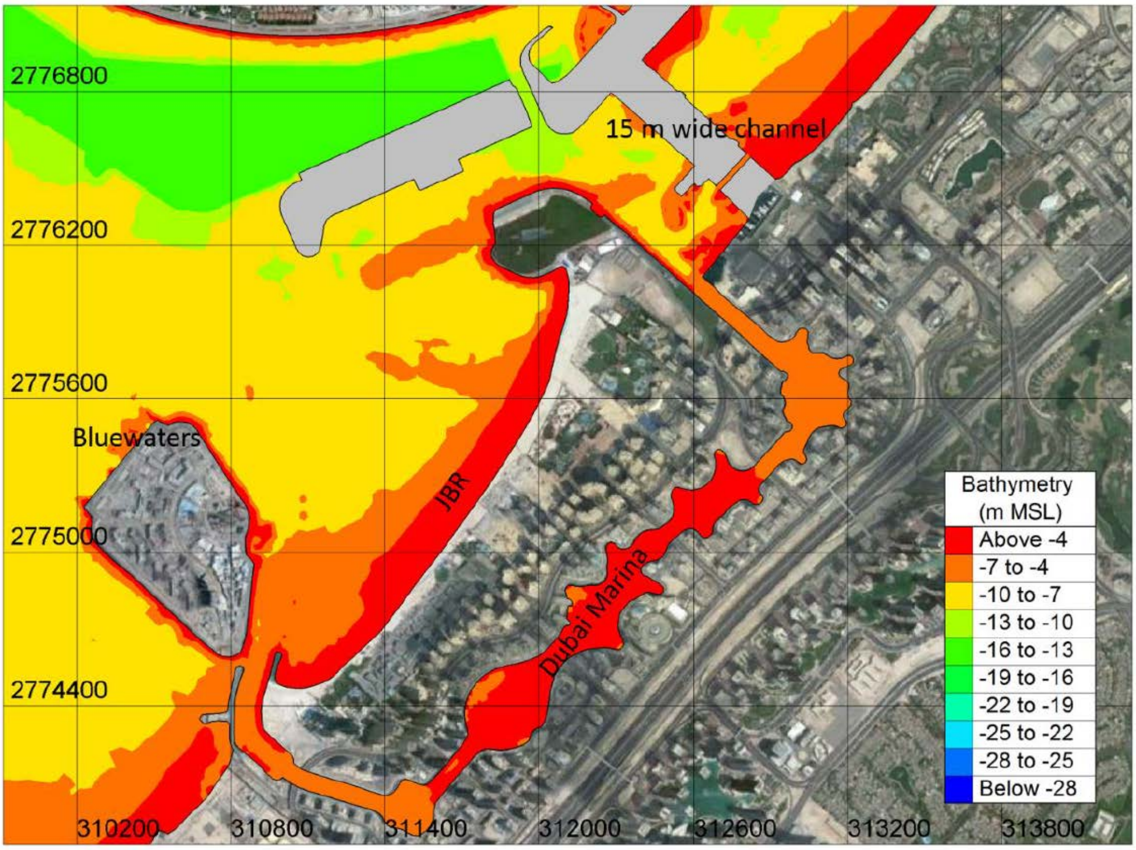


Figure 7-1 Bathymetry map showing the location of the 15 m wide modelled channel through Zone 4 (Sogreah 2017d)

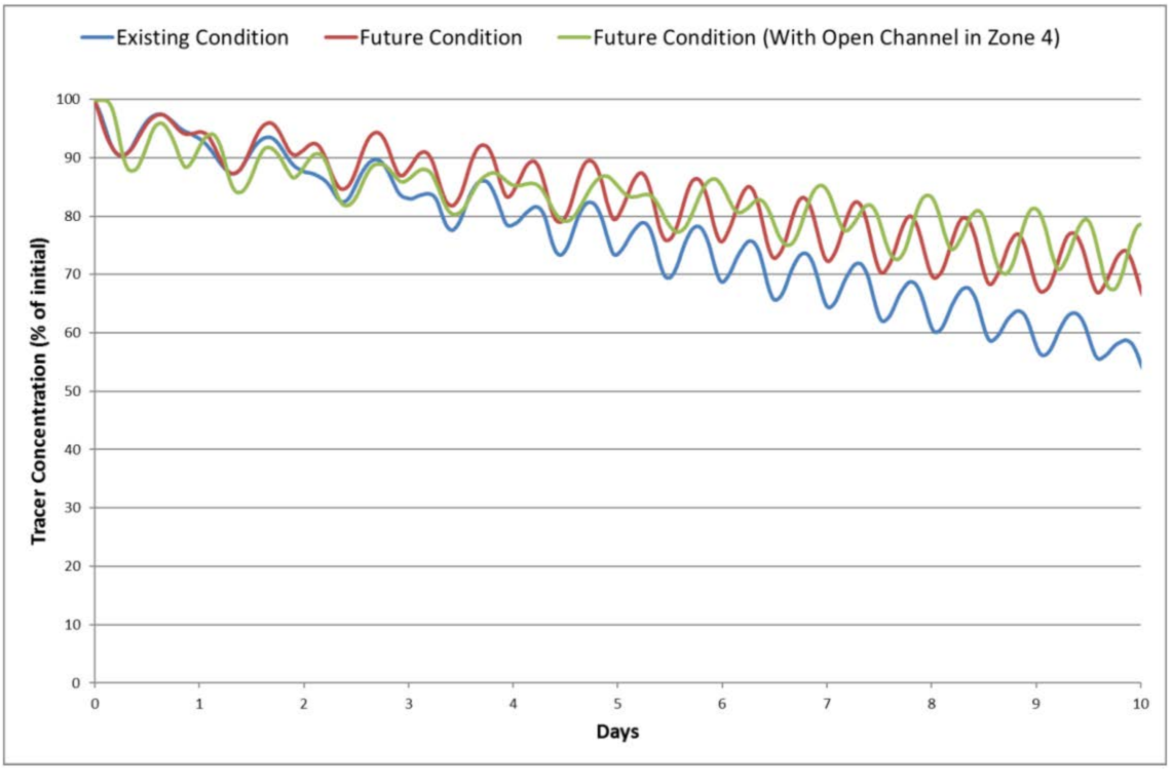


Figure 7-2 Basin-averaged tracer concentrations in Dubai Marina pre-development vs. post-development with and without a 15 m channel in Zone 4 (Sogreah 2017d)

Option 3: Water pumps

Pumping water from a seabed intake, through a pipe and into the centre of the canal would increase flow in both directions and replace canal water with 'clean' seawater. Initial modelling has shown that a pumping rate of 0.5 $m^3 s^{-1}$, post-development flushing conditions almost exactly match existing conditions (Figure 7-3). Initial evaluations suggest that this would be feasible. Ongoing modelling assessments are looking at optimising the design and further investigating cost and practicalities.

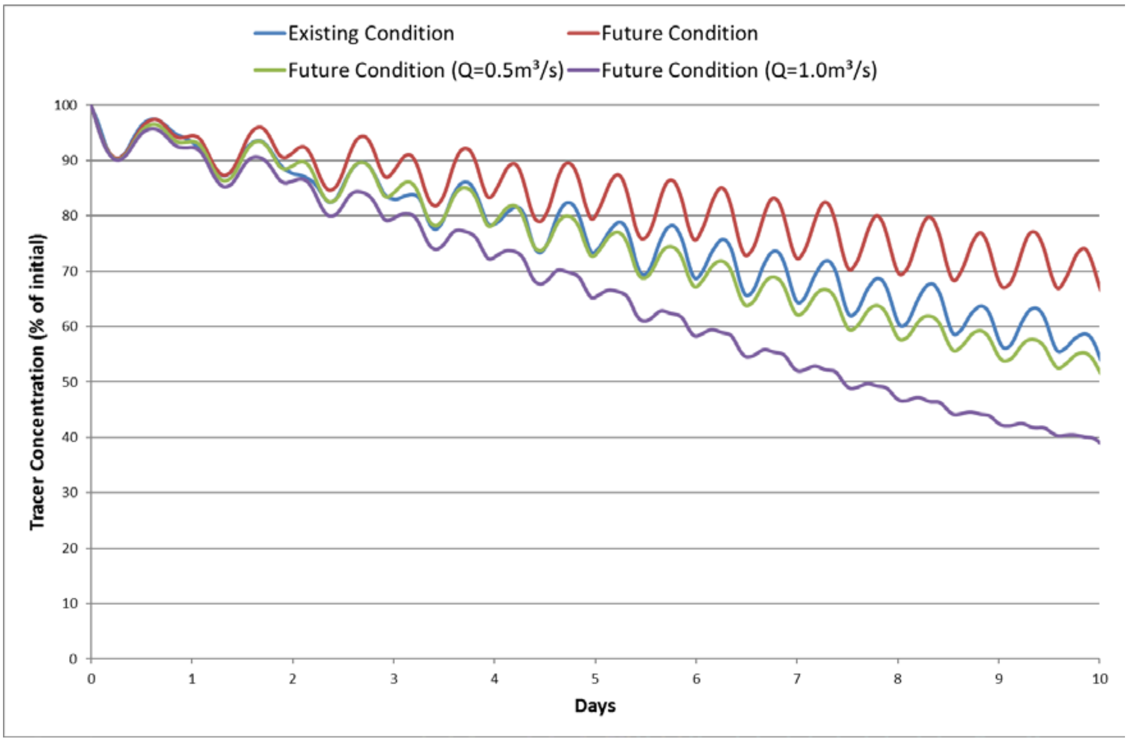


Figure 7-3 Dubai Marina flushing rate under existing conditions (blue line) and post development conditions with no mitigation (red line) and when pumping 0.5 $m^3 s^{-1}$, 1.0 $m^3 s^{-1}$ and 2.0 $m^3 s^{-1}$ water into the centre of the canal

Option 4: Mechanical mixers

Mechanical mixers, such as the large-scale horizontal flow generators commonly used in wastewater treatment plants (Figure 7-4), deployed singly or along the length may generate sufficient flow to increase flushing rates. However, initial correspondence with suppliers suggest that the required devices would be large, for example; Cyberflow® Accelerator is an open bladed mechanical flow generator with 2.75 m diameter (Invent 2017). Such equipment would have considerable space requirements with consequent impact on boat and other waterway users, health and safety issues with the rotating blades, and potential for environmental impact. If several units were required, installation cost would be significant and there is the likelihood of considerable ongoing maintenance issues and costs. While this option has the potential to increase flushing, due to the prospective issues it is not a preferred option.

Option 5, 6 and 7: Tidal gates, lift station and aerators

Mechanical engineering solutions to increase flow rates are used in both waterways management and wastewater treatment. Several potential options were rejected as unsuitable for the Dubai Marina Canal following initial assessments: tidal gates would require the canal to be close for extended periods (potentially up to 12 hours per day); the canal has neither the space nor the configurations for lift stations; aerators generate predominantly localised vertical currents and would not generate sufficient horizontal flow to increase flushing.

Preferred option

Upon completion of the ongoing assessments, a preliminary feasibility study will be submitted to DM. Shamal will issue a written commitment from to undertake the detailed mitigation (or suitable alternative, if approved by DM), should, as a result of Dubai Harbour, a significant negative impact on the water quality be observed, resulting in water quality falling below the DM Water Quality Objectives. The environmental and social impacts of any solution will be assessed prior to implementation, including consultation with key stakeholders including DM and the owner of the Dubai Marina Project Emaar. An OEMP will be developed for any selected mechanical engineering solution prior to implementation.

Sediment quality

The Navigation Channel Sedimentation Assessment (Sogreah 2017f) shows that sediment deposition in the inshore sectors of the Navigation Channel would be negligible and consequently, no significant sediment influx or increase in sedimentation due to the Dubai Harbour development is expected in the leeside of Dubai Harbour or in the Duba Marina; (Section 6.7.2.4). As such, no mitigation measures are deemed necassary.

7.6.2.3 Wave climate within Palm View and Cruise Terminal Marinas

With the addition of two detached breakwaters to the west of the Palm Jumeirah, simulated wave heights within the Palm View and Cruise Terminal marinas were predicted to satisfy the adopted marina tranquillity criteria for 1 and 100 year recurrence storms, with the exception of a predicted wave height exceedance at the western berth of the Cruise Terminal Marina. Modelling by Sogreah (2017e) indicates that extension of the lighthouse platform southwards by 50 m will provide further sheltering within this marina and reduce the likelihood of exceeding the tranquillity criteria at this location.

7.6.2.4 Mitigation of wave overtopping at the quay wall

From an operational perspective, wave overtopping at the quay wall is expected to result in a maximum annual shutdown period of 24 hours, which is acceptable. However, overtopping volumes have the potential to result in damage to the cruise terminal buildings and flooding of the area behind the terminal during extreme (i.e. 1 in 100 year recurrence) events.

To mitigate this risk, it is proposed that a vertical wall of height 0.8 to 1.0 m be constructed at the back of the quay apron (i.e. 28 m from the quay edge) and on the western edge of the quay as depicted in Figure 7-4. It is also recommended that the cruise terminal building be raised from the surrounding levels by >0.5 m (at least two steps) to lessen the risk of flooding during extreme events.

Figure 7-4 Indicative position of vertical wall (blue lines)

Source: Sogreah (2017i)

7.6.2.5 Maintenance of beach areas

JBR Beach

Consistent with the previous study findings, beach maintenance/nourishment activities will still be required on an average of 5-year regular time interval. Sand would be sourced from the northern and southern ends of the beach and placed at the mid-section of the beach. Anticipated sand volumes are in the order of 10,500 m^3/year.

Palm Jumeirah Beach

The existing Palm Jumeirah Beach undergoes relatively minor rates of sediment transport. Further sheltering from offshore waves due to the construction of the Dubai Harbour is likely to further reduce sediment transport rates and therefore the maintenance requirements for this beach are not expected to increase.

North Beach

Due to the oblique angle of approaching waves, an anti-clockwise rotation of sediments at North Beach is predicted. A number of beach monitoring and maintenance activities are recommended as detailed in Table 7-3.

Beach profile surveys should be undertaken for transects perpendicular to the beach crest at intervals of 30 m along the beach. Measurement points along the transect should be spaced a maximum of 2 m apart. Profiles should be conducted during low tide (preferable spring tide) from the coastal setback line to the depth of the Lowest Astronomical Tide (LAT). Some wading may be required to obtain measurements near LAT. The same profiles should be surveyed during each monitoring event to allow direct comparison of datasets. Surveys shall be carried out using Real Time Kinematic (RTK) GPS or similar technology with similar vertical and horizontal accuracy.

Table 7-3 Recommended beach monitoring and maintenance activities for North Beach

Activity	Recommended Frequency/Triggers
Visual walk-over inspections and photographic records	3-monthly for the first 2 years and every 6 months thereafter Following extreme events (storms, pollution incidents etc)
Beach cleaning	Daily to weekly removal of litter, flotsam etc. Minimum monthly interval for sand raking (or as required) Cleaning of sand (removal of coarse and fine material) as necessary and informed by the visual inspections
Beach profile survey	3-monthly for the first 2 years, 6 monthly thereafter Following extreme events (storms, pollution incidents etc)
Beach reshaping	Beach reshaping should be performed at a minimum 6 monthly frequency, or as informed by the beach profile surveys. Reshaping shall be triggered in the event that profile changes of more than 0.5 m vertically are observed and/or beach crest recession/accretion exceeds more than 2 m compared to as-built conditions. Importation of additional beach sand may be required should additional sand volumes be needed to restore the beach shape to as-built conditions.

7.7 Marine Ecosystem

7.7.1 Construction Phase

Mitigation measures for key construction phase impacts are provided in the following sub-sections. Mitigation is not proposed for the loss and modification of habitat as the existing habitat is considered to be of relatively low ecological value and the provision of additional hard substrate could allow re-colonisation of a range of marine organisms in the future.

Should dredge material disposal be necassary, then it is recommended that a study be undertaken of the proposed disposal methodology and location to minimise environmental impact and ensure that no sensitive habitats or species of conservation significance would be affected.

7.7.1.1 Suspension and Deposition of Sediments

One of the principal unmitigated impacts predicted during the construction phase is the dispersion and settlement of fine sediment particles during dredging and reclamation. As previously noted, the modelling results presented a worst-case scenario based on a construction methodology where fill material is placed directly into the marine environment without any mitigation measures.

To reduce the magnitude of suspended sediments within the site, a number of mitigation measures are proposed. One of the key items is to restrict the outflow of highly turbid water.

This may be achieved by containing the dredged material within designated areas, either through:

- Construction of rock revetments;
- Construction of temporary sand bunds;
- Containment of water using silt curtains.

This will significantly reduce the dispersion of fine sediments during reclamation and a greater proportion of fine particles are expected to settle within the footprint of the reclamation zone.

However, there is still anticipated to be some dispersion of sediments beyond the reclamation footprint. As such, additional control measures have been proposed with a view to further limiting the dispersion of fine particles during reclamation. The proposed mitigation measures are detailed below:

- Prior to the start of any works in the marine environment, the contractor should install low permeability silt screens to minimise the dispersion of marine sediments. Silt curtains should be placed between dredging / reclamation activities and sensitive areas, particularly Dubai Marina which exhibits poor flushing;
- Preferential use of pumping ashore over rainbowing methods for reclamation. Rainbowing should only be utilised in extreme circumstances where pumping ashore is not possible;
- No dredging or dumping/filling operations are to be carried out outside the designated dredge and reclamation footprint – the maximum total volume and width constraints of the dredging and construction area are not to be exceeded;
- Optimise dredging location(s) based on met-ocean conditions and areas of elevated TSS;
- All associated vessels to avoid sensitive areas and shallow waters to minimize turbidity due to propeller wash;
- Maintain a low water level in the reclamation area to prevent accidental run-off of silty water;
- Prevent leakage of silty water into the marine environment through monitoring and assessment of pipelines, pipeline connections and drainage channels;
- Utilise fill material of good quality with larger sediment grain size favoured wherever feasible, with a view to minimising re-suspension of fine particles;
- The water mixed with dredged sediments (dredge water) is to be separated in a controlled manner and is not to be disposed of in unauthorised onshore locations;
- Construct settlement basins where feasible to promote deposition of fine particles and decrease the TSS concentrations in the discharge effluent. The settlement basins should have the following characteristics:
  - Multiple (minimum of two) treatment stages for increased settlement of TSS with each successive stage;
  - Utilise a relatively large area for the settlement basin to improve the retention capacity and allow time for the finer particles bearing the lowest settling velocity to settle to the bottom;
  - Use adjustable weirs between the settlement basin stages to control the water level and allow only the upper water layer containing the lowest TSS concentrations to pass into the next stage;

- The overflow level of the weir boxes must be kept high enough during operations to maintain a free water surface above the newly settled sediment and prevent re-suspension;
  – Placement of weirs strategically to promote flow through a large proportion of the settlement basin (i.e. not concentrated on the shortest route between intake and weir) to promote low flow velocity and maximum retention time in the basins;
  – Maintain weir height at a minimum of 1 m above the silt bed to minimize the potential for re-suspension near the weir boxes;
  – Install multiple inlet points into the settlement basins and distribute them along the bund of each cell to spread the in-flow over the whole silt basin and reduce flow velocity, therefore encouraging settlement of particulates; and
  – Maintain a low flow velocity of the mixture pumped through the discharge pipe into the settlement basins to enable and maximise settlement of fine particles.
- Construct finger bunds, where possible, within the reclamation area to guide process water to the settlement basins; and
- Discharge any tailwater to areas that will be subsequently lost due to other construction activities and / or direct discharge away from sensitive receptors (coral area); and
- Limit the number of tailwater discharge points to achieve greater control and minimise the areal extent of suspended sediment in the marine environment.
- Optimise grain size in fill material (0.45 mm) to minimise re-suspension of fine particles during nourishment and storm events;
- Aim to undertake as much of the beach re-profiling works during low tide and calm sea conditions as is feasible.

7.7.1.2 Introduction of Contaminants

Introduction of contaminants from dewatering discharge, accidental oil or chemical spills and inappropriate waste disposal would be mitigated through the following:

- Undertake regular visual and analytical sampling of dewatering effluent prior to discharge. Discharge of effluent that does not meet required guideline levels will be prohibited;
- Implementation of appropriate hazardous material storage, hazardous waste, solid waste and wastewater management control plans will be required by all contractors and subcontractors throughout construction. Weekly inspections will be undertaken to assess for conformance. Detailed requirements will be specified within the CEMP control plans, but will include the use of bunded storage areas, segregating of wastes and maintaining waste / hazardous storage areas away from the marine environment.
- Maintenance of vessels and equipment will be prohibited on site. However, all vessels and equipment should be maintained and inspected regularly to reduce the risk of spills or leaks.
- Spills and leaks shall be cleared / cleaned up immediately to prevent migration to marine environment and to prevent spread once in the marine environment.
- Provision of spill kits and booms on all marine vessels and rapid response to any leaks or spills.

7.7.1.3 Mobilisation of Dormant Algal Cysts and Introduction of Invasive Species

Mitigation measures would include:

- **Mobilisation of dormant algal cysts:**
  - In the event an algal bloom occurs in vicinity to the Project, dredging operations would be temporarily ceased until the outbreak has ceased.
  - Implement the mitigation measures for silt control to prevent the spread of sediments, particularly in the direction of the DEWA desalination plant.
  - In the event of HABs outbreak in the vicinity of the Project, appropriate mitigation measures will be implemented.
  - Appropriate mitigation measures will be implemented in the event of HABs outbreak within the vicinity of the Project. Management and control measures that may be implemented are provided in Table 7-4.

Table 7-4 Management and control measures for the presence of HABs

Management Method	Description
Physical controls	
Aeration	Aerators operate by pumping air through a diffuser near the bottom of the waterbody, resulting in the formation of plumes that rise to the surface and create vertical circulation cells as they propagate outwards from the aerator. This method is successfully implemented in small ponds and waterbodies.
Hydrologic manipulations	Low flow conditions in water bodies can lead to stratification of the water column, which aids in cyanobacterial growth. Particularly in regulated systems, the inflow/outflow of water in the system can be manipulated to disrupt stratification. This method is easy to implement in controlled system.
Mechanical mixing (circulation)	Mechanical mixers are usually surface-mounted and pump water from the surface layer downwards or draw water up form the bottom to the surface layer. This mixing of the water column disrupts the behaviour of cyanobacteria to migrate vertically in addition to limiting accessibility of nutrient.
Reservour drawdown / dessication	In reservoirs and other controlled water bodies, can drawdown the water level to the point where cyanobacteria accummulations are exposed above the waterline. Subsequent dessication and/or scraping to remove the layer of cyanobacteria attached to sediment or rock is required, in addition to the reinjection of water into the system.
Surface skimming	Oil-spill skimmers can be used to remove cyanobacteria from the surface scums.
Ultrasound	An ultrasound device is used to control HABs be emitting ultrasonic waves of a particular frequency such that the cellular structure of cyanobacteria is destroyed by rupturing internal gas vesicles used for buoyancy control.
Chemical controls	

Management Method	Description
Algaecides	Algaecides are chemical compounds applied to a water body to kill cyanobacteria such as copper-based algaecides, potassium permanganate, chlorine and lime
Barley straw	Barley straw bales are deployed aroun the perimeter of the water body. Barley straw, when exposed to sunlight and I the presence of oxygen, produces a chemical that inhibits algae growth.
Coagulation	Coagulants are used to facilitate the sedimentation of cyanobacteria cells to the anoxic bottom layer of the water column. Unable to access light, oxygen and other critical resources, the cells do not continue to multiply and eventually die.
Flocculation	Flocculants are used to facilitate the sedimentation of nutrients to the anoxic bottom layer of the water thereby limiting nutrient levels in the water body.
Hypolimnetic oxygenation	The primary goal of this method is to increase the oxygen concentration in order to prevent or reduce the release of nutrients from the sediment while maintaining water column stratification. This serves to limit the upper level nutrient levels thereby inhibiting cyanobacterial growth. Techniques include airlift pumps, side stream oxygenation and direct oxygen injection.
Biological controls (biomanipulation)	
Increasing grazing pressure	Various measures can be introduced to encourage the growth of zooplankton, benthic fauna and other aquatic organisms that feed on cyanobacteria, thereby limiting the area of proliferation of cyanobacteria populations. Techniques include: ▪ The removal of fish that feed on zooplankton and other benthic fauna or introduction of predators to these fish, and ▪ The development of niches to encourage the growth of beneficial organisms.
Increasing resource competition	The introduction of other primary producers such as macrophytes can limit the available phosphorus and therefore limit cyanobacterial growth.

Source: US Environmental Protection Agency, 2017

- **Introduction of Invasive or Exotic Species:**
  – Vessels should be sourced from the local region to minimise chance of invasive / exotic species introduction. If vessels are sourced from outside the local area, a service history should be requested which includes treatment for biofouling (e.g. details of anti-fouling coating application).
  – Utilise vessels that have not visited locations where marine pest outbreaks are present, which have appropriate antifouling solutions in place and which practice appropriate ballast water exchange.
  – No sediments carried in ballast or dredge hoppers would be released to the local environment.

- All ships will be required to implement a ballast water management plan in compliance with international convention (see Section 3.4.4).
- Whenever possible, ballast water exchange shall be in undertaken in accordance with Dubai standard, if any, or the International Convention for the Control and Management of Ships' Ballast Water and Sediments (2004), which requires at least 200 nautical miles from the nearest land and in water at least 200 m in depth.

7.7.1.4 Disturbance or death of Marine Fauna

To reduce the potential impact of collision with marine fauna, members of the dredging and reclamation team should be familiar in the spotting of marine fauna. In the event that marine fauna is spotted within 150 m of operations, then works should temporarily cease until the area is clear. Measures for reducing the risk of contaminants introduction should also be implemented to reduce the risk of impacts to marine fauna.

7.7.2 Operation Phase

Key operational impacts are proposed to be mitigated as follows:

- **Operational Dredging** – Given that operational maintenance activities will be undertaken once every 20 years, the surrounding environmental conditions, rules and regulations are likely to alter and as such a specific environmental management plan should be provided prior to each dredging programme to assess the particular impacts, mitigation and management measures, particularly with regards to disposal options.
- **Discharge of stormwater**

  Modelling of stormwater discharges (Section 6.12.2.6) suggested that one of the stormwater outfalls (Outfall A) had the potential to contribute to elevated levels of contaminants when discharging during the unfavourable conditions (flood tide without wind). During the detailed design of the stormwater network, later in the Project, the location of Stormwater Outfall A will be reviewed to assess the potentially repositioning it in a location with greater flushing to facilitate more effective dilution of the discharge. This will be further assessed in an addendum to the EIA.

  Additional mitigative measures to be applied to the discharge of stormwater during operation include:

  - Gross pollutant traps should be utilised to remove sediment fines and waste materials prior to discharge;
  - Discharge points should be directed away from any areas of poor flushing to allow fast and efficient dispersion and dilution;
  - Strict control on discharges through the stormwater pipeline should be maintained. No other wastewater streams are to be discharged through this system from the project site.
  - Implementation of soil and sediment impacts mitigation measures, such as ensuring quality of water, fertilizers and pesticides used for landscaping activities and installation of impermeable membranes in al landscaped areas to limit run-off into the marine environment.
  - Selection of appropriate landscaping features to control run-off volumes and stormwater flow.
  - Following best practice procedures for storage and handling of hazardous materials, including appropriate cover, bunding, spill kits and emergency response.
- **Impacts associated with sewage collection** – Accidental leak and overflow of a pumping station will be mitigated by implementing the following measures:

- Frequent inspections to ensure normal functioning and identify potential problems. Inspection should include observation of pumps, motors and drives for unusual noise, vibration, heating and leakage, check of pump suction and discharge lines for valving arrangement and leakage.
- Monitoring of discharge pump rates and pump speed as well as pump suction and discharge pressure should also be undertaken regularly.
- Removal of coarse materials from the wastewater for disposal.
- Preparation of Operation and Maintenance Manual to prevent unnecessary wear and downtime. The manual should maintain an inventory of critical spare parts.

- **Introduction of invasive marine species** - The International Maritime Organisation (IMO)'s International Convention for the Control and Management of Ships' Ballast Water and Sediments will be coming into force in September 2017. This convention aims to prevent the spread of harmful aquatic organisms by establishing standards and procedures for the management and control of ships' ballast water and sediments. It will require all vessels to manage their ballast water and sediments, according to a ship-specific ballast water management plan and to carry a ballast water record book and an international ballast water management certificate (IMO, 2017). All vessels utilising the area will be required to confirm to this requirement.

- **Accidental fuel and chemical leaks from marinas, cruise terminal and maintenance activities** – An operational environmental management plan will be required to cover each of the key Project areas in detail. This would include the marinas, cruise terminal, maintenance areas, beaches, refuelling areas, utility pipelines and systems. The OEMP would include specific measures to reduce the potential for spills (include bunded, covered and shaded storage areas, oil interceptors at maintenance areas, spill trays and collection points). A detailed maintenance plan should be provided by proponent to assess for correct operation of utilities and pipeline systems. In addition, the following measures would be considered:

  - Wind direction and intensity should be taken into account in the oil clean up strategy in case of oil spill accident, as it determines the time needed to reach the shoreline and the area where the oil can be deposited.
  - A fast response is needed to reduce the impact of the oil spill as the oil slick reaches the beaches and the surrounding infrastructures in a few hours' time.
  - Following a fuel spill, the amount of oil sedimentation should be assess through analysis of sediment samples. If identified, appropriate remediation should be undertaken.

- **Accidental sewage discharge from marine vessels / cruise ships** – All marine vessels / cruise ships using the marinas and cruise terminal will be required to implement waste management plan and comply with the DM Technical Guideline on Disposal of Wastes (see Section 3.3) and applicable international conventions (Section 3.4.4). An emergency response plan will be implemented to respond to accidental sewage discharge / leaks.

- **Marine Risk**. The following control measures are proposed by Sogreah (2017h) to reduce the identified marine risks:

  - *Pilot expertise / training*: Pilots should be trained to national standards and systems. Selection of harbour pilots for cruise vessels navigation with very good knowledge of the Dubai area and weather conditions is a key point.
  - *Towing capacity*: Availability of tug boats shall be defined for normal and emergency situations. For normal operation and due to the cruise liner terminal specificity (home

port), the towing capacity (1 or 2 or more tugs) shall be determined depending on the extreme weather conditions that might happen in Dubai.

– *Weather forecast*: Strong and robust weather forecast shall be assessed in order to identify situations where the navigation of large cruise vessels is not possible within the channel nor to maintain the position of vessel berthed alongside at quan (design of storm bollards shall be eventually associated with the presence of towing emergency capacity).
– *Leading line*: Leading line assists in maintaining position in the channel to reduce risk of collision with cruise vessels.
– *Anchor deployment control*: Ensure anchors are not dragged along with vessels to prevent damage to existing pipeline and the surrounding marine environment.
– *Two side channel*: Define whether small leisure vessel can navigate in channel to reduce risk of collision with cruise vessels.
– *Implementation of IRPCS*: International Regulations for Prevention of Collision at Sea (IRPCS) should be observed at all time.
– *Notice to mariners*: Small vessels required to give clear passage to large cruise vessels in port approach. In addition large leisure vessels berthed at Zone 4 may cross the departure or arrival phase of a cruise vessel when arriving at a restricted space at the south of the Palm Jumeirah and the Zone 1.
– *Interference between leisure crafts and beach users*: Ensure that the delimitation of the swimming area at beaches considers the passge of new leisure crafts nearby presence of people at sea.
– *Reduction of aircraft crashes*: Reinforce pilots' training, define some extreme meteorological conditions where landing / taking off is forbidden and define specific landing procedures.
– *Liaison between authorities*: Liaison between Port Authorities, airstrip management and Aerial Authorities to ensure the safety level of the facilities.

7.8 Terrestrial Ecology

7.8.1 Construction Phase

Impacts on terrestrial ecology resulting from the construction of the Project can be controlled through the implementation of the following mitigation measures:

- Habitat loss and modification: Negligible impact therefore no mitigation measures required;
- Dust emissions: Implement proposed construction air quality mitigation measures (Section 7.2.1);
- Noise emissions: Implement proposed construction noise mitigation measures (Section 7.3.1);
- Waste: Develop and implement a waste management plan (Section 7.9.1) to prevent the fauna from injury or ingestion of waste (e.g. sharps);
- Injury/death to terrestrial fauna from intake/entanglement of waste or machinery strike: Negligible impact therefore no mitigation measures required.

7.8.2 Operation Phase

Impacts on terrestrial ecology resulting from the operational activities of the Project can be controlled through the implementation of the following mitigation measures:

- Native vegetation and flora: Maximise use of native species within landscaping and park areas, including endemic or ecologically important species. This is aimed at enhancing the ecological value of the site and attracting and supporting native terrestrial fauna. Native vegetation species tend to have lower water requirements, are often salt tolerant and resistant to local diseases;
- Habitat connectivity: Connect landscaped areas to create green corridors and fauna passageways, where practical;
- Invasive species: Do not use invasive species and minimise use of exotic species for landscaping and park areas. Eradicate all invasive species within the Project site as soon as possible following confirmed identification by an experienced botanist who should perform a periodic inspection of vegetation around the site;
- Noise emissions: Implement proposed operational noise mitigation measures (Section 7.3.2);
- Artificial lighting: Design a lighting system to minimise light spill and where possible limit outdoor lighting; and
- Waste: Develop and implement a waste management plan (Section 7.9.1.1) to prevent risk for injury or death of local terrestrial fauna.

The implementation of the above described mitigation measures will manage and mitigate expected impacts on terrestrial ecology caused by construction and operational activities. During construction, impacts are temporary and generally minor. Post mitigation, residual impacts to flora and fauna are considered positive, given the provision of landscaping that will increase potential terrestrial habitat.

It is considered that operational impacts are very unlikely to have any significant effect on the bird species breeding on the mainland as they are currently breeding in a highly developed anthropogenic habitat which implies that they are adapted and accustomed to human disturbance (Nautica 2017).

7.9 Waste Management

7.9.1 Construction Phase

7.9.1.1 Solid Waste Management

The following measures shall be implemented for the management of construction solid waste:

- **Waste minimisation through efficient design, procurement and material management practices:** Construction Work Methods should be developed and corresponding site instruction issued to facilitate the efficient use of construction materials and minimise waste generation;
- **Implementation of procurement policies**: Standard procedures for procurement of construction materials, consumables and equipment / plant should include, where possible:
  - Specifying the actual quantity of materials required for construction;
  - Ordering of materials in bulk, where possible, to minimise packaging waste;
  - Preference of materials with minimum packaging;
  - Arrangements with the suppliers for the return or buy-back of containers and packing materials;
  - Preference for pre-fabricated / pre-casted structures or materials; and

- Preference for environmentally friendly materials, such as those that are wholly or partly recycled;

- **Waste segregation at source**: The Dubai *Green Building Regulations and Specifications* require that waste be segregated at the minimum, into inert aggregates, metals, timber, dry recyclables and hazardous materials. Waste segregation at source will control the risk of cross-contamination as well as facilitate waste reuse on-site and recycling via DM approved recycling facilities;

- **Waste reuse and recycling**: Reuse of scrap materials for on-site works shall be considered a priority. The following specific measures should be undertaken, where practical:

  - Re-use of beach sand, where possible, for the beach re-profiling;
  - Re-use of rocks / boulders generated from the demolition of breakwaters;
  - Re-use of excavated materials for fill purposes during site development or foundation works, ensuring that materials are geotechnically suitable for purpose;
  - Use of scrap materials such as wood and metals for temporary structures on-site. Drip trays could also be made from scrap metal sheets, provided they are water-tight;
  - Recycling of concrete waste and washings. An arrangement where such waste can be sent back to the supplier / concrete batching plant for recycling shall be considered; and
  - Where possible, paper, wood, metal and plastic wastes shall be sent to suitable recycling facilities.

  In compliance with the Dubai *Green Building Regulations and Specifications*, the Project should aim to divert at least 50% of the total construction waste (with the exception of excavated soil and hazardous waste) from disposal to the landfill. The diverted waste materials shall either be reused or sent to a recycling facility;

- **Provision of appropriate waste bins for different types of waste**: Bins with lids shall be provided for food wastes to avoid vermin infestation. Sharp waste materials should be kept in sturdy waste bins. Skips and bins should also be covered to prevent littering of light-weight materials particularly during strong wind conditions, which could disperse litter off-site including to the marine environment;

- **Labelling of waste bins / containers and collection areas**: The labels should be written in English and other languages understood by the construction workers, and include the name of the waste, hazard and safety precautions. Labelling will assist workers in segregating waste properly and minimise the risk of cross contamination; and

- **Strategic location of waste bins / containers**: Areas where waste is generated (e.g. work areas, canteen) shall be provided with suitable waste bins / containers. Waste containers / storage areas shall be located away from the marine environment and stormwater flow paths.

7.9.1.2 Liquid Waste Management

Similar measures to those discussed in the solid waste management section shall be undertaken for managing the different liquid waste streams generated during the construction phase of the Project. Measures that should be implemented for managing construction liquid waste include the following:

- **Wastewater minimisation**: For washing activities on-site, use high-pressure sprays, where possible. Water efficient portable toilets will also be used, where possible / available.

- **Reuse and recycling**: Where possible, options to reuse washings and dewatered water should be considered. The following are examples of wastewater reuse that should be considered:
  – Dewatered water could be used for dust suppression on haul roads and unsurfaced areas after confirming its appropriate for use through water quality testing;
  – Concrete waste and washings can be sent to the concrete supplier / batching plant for recycling;
- **Provision of sedimentation / settling tank for dewatering water**: Dewatering effluent typically contains high concentrations of suspended solids which may require removal (e.g. settling) prior to reuse (e.g. for dust suppression) or final discharge into the marine environment. The effluent will also be checked for any other signs of contamination (e.g. oily sheen, foam or odour). When discharge to the marine environment is undertaken, the quality of the dewatering water should comply with the relevant DM standards (Section 3.3);
- **Designated bunded areas for equipment and vehicle washing**: In the event that equipment, concrete trucks and vehicles washing is undertaken on-site, a suitable and dedicated facility (e.g. a bunded area with impervious surface) should be provided, ensuring that no contaminated washings are discharged into the marine environment or on the ground. Contaminated wash water should be disposed off-site via a DM-approved waste contractor; and
- **Provision of suitable temporary sewage holding tanks**: Storage tanks shall be leak proof and of sufficient capacity. A DM approved service provider should be engaged to collect sewage for off-site disposal. Sewage should be collected on a regular basis such that volume of stored sewage on-site does not exceed 80% of the tank capacity. Sewage storage tanks shall be located away from sensitive receptors and the marine environment.

7.9.1.3 Hazardous Waste Management

Key measures that should be implemented for managing construction hazardous waste include:

- Provision of suitable bunded storage area (made with impervious material) for hazardous waste storage;
- Copies of MSDS for waste materials shall be maintained at the storage area and kept easily accessible for relevant staff in the event of an emergency (e.g. spill or fire). Handling, storage, and disposal of hazardous materials should be undertaken in accordance with the MSDS requirements;
- Contractors shall establish emergency management procedures at hazardous waste storage areas. Procedures should be developed in accordance with the MSDS requirements. Spill kits and fire extinguishers suitable to the waste stored at the area should be available where there is a risk of spill and fire, respectively;
- Materials used for containing / cleaning-up spills (e.g. absorbents, sand, hand gloves) should be treated and disposed of as hazardous waste.

7.9.1.4 Unsuitable Dredged Material

To reduce the impact of dredging materials on the environment and to limit costs, dredging volumes will be minimised and material used for reclamation maximised as much as possible. The dredging volume, which is approximately 4.7 million m^3, have been minimised by accurate planning of the navigation channel along the existing trenches adjacent to Palm Jumeirah. On the other hand, approximately 5 million m^3 of material is needed for the reclamation.

Where suitable, the dredged material will be used for reclamation. The main criterion for usability of the dredged material in the reclamation areas is compactability. For sand, this is mainly driven by the amount of fines, while compactability for dredged rock is driven by the amount and size of the large fraction and the fines produced during dredging. Requirements for suitable material are defined in the Earthworks, Dredging, Reclamation and Ground Improvement specifications.

If dredged material does not meet the criteria, the following mitigation measures may be implemented, depending on material characteristics and Project requirements:

- Using fill material with high fines content:
  - Sand with high fines content, above 10% and up to 30%, can be used at the top (above the groundwater level) and compacted using surface compaction in layers;
  - Sand with high fines content above, 10% and up to 20%, can be compacted using dynamic compaction methods;
  - Material with high fines content can be used in landscaping areas and under the beaches; or
  - Exported to other project sites.
- Reclaimed dredged rock material with higher coarse fraction
  - Application of different compaction techniques, such as dynamic compaction, which is only applicable for limited reclamation layer thickness
- Material with boulders (>200 mm)
  - Crushing to reduce the size for high content of boulders;
  - Screening for limited boulders content; and
  - Dynamic compaction and using other methods rather than CPT for QA/QC testing (geophysical / zone load tests, etc.)
- Mixing non-complying material with other material to meet Project requirement;
- Use of the material above water level with specific compaction requirement;
- Additional ground improvement measures such as stone columns or prealoading;
- Use of deep foundations to offset larger settlement;
- Use of different compaction techniques;
- Alternative project uses (for example in offshore breakwaters with non-structural requirements)
- Beneficial use in other projects – Projects surrounding the site could benefit from the dredge material, for example; use in underwater reclamation to create a shallow “Maldivian” type reef.

Should the material still be considered unsuitable for reclamation purposes, it will be disposed offsite.

The Employer, Marine consultants, Environmental consultants and Contractor are investigating options to manage the environmental impacts of dredged material disposal. During a meeting with DM’s *Coastal Zone and Waterways Management Section* (DM-CWMS) on 30th October 2017, a review of disposal options and a methodology for investigating offshore placement sites for unsuitable material was presented by the consultants. DM-CWMS agreed in principal that this approach was acceptable, although a more detailed SoW for the investigations should be submitted for approval by DM-CWMS.

This report will assess:

- High level disposal options review (onshore vs. offshore);
- Disposal methods (bottom door vs. suction pipe placement);
- Offshore placement site selection:
  - Literature review, including previous borrow pit surveys
  - Field surveys: Benthic ecology (DDV); Macrofauna (infauna grab samples); sediment Particle Size Distribution (PSD)
- Sediment plume models for the selected location(s);
- Short term fate / sediment dispersion model for the selected location(s);
- Long term fate of the dredged material;
- Opportunities for ecological enhancement.

Once completed, a report will be submitted and the results presented to DM-CWMS for review and approval. Disposal of unsuitable material will not be undertaken until the appropriate approvals and NOCs have been obtained.

Preliminary desktop investigations related to unsuitable material disposal are provided below.

Disposal Options

Should the material still be considered unsuitable for reclamation purposes, two options for disposal are considered: onshore disposal (disposal on land) and offshore disposal (disposal at sea). The impact comparison of the two options are provided in Figure 7-5.

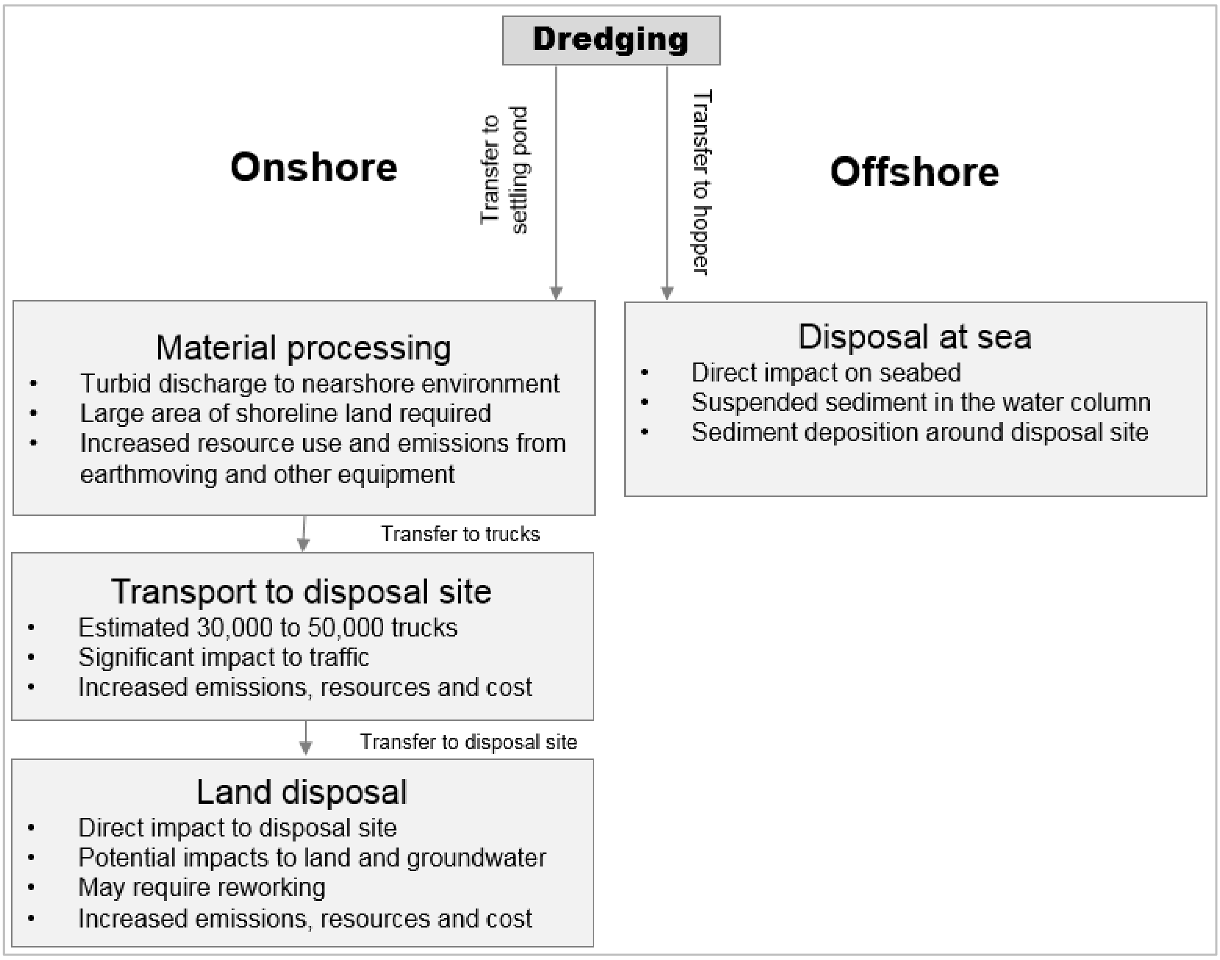


Figure 7-5 Impact comparision of onshore and offshore disposal

It was determined that onshore disposal has the following constraints:

- Large area required for placing the material (which is currently not available);
- High potential to impact sensitive nearshore marine habitats during the processing of marine sediments;
- Long time required to dry the material before rehandling is possible;
- Additional re-working of sediments;
- Huge cost and time impact on the Project;
- Between approximately 50,000 truck movements (1 million m^3), up to 175,000 truck movements (3.8 million m^3) required to transport the material;
- Generation of dust (from transportation); and
- Environmental impact on land (e.g. land use, landscape, aesthetics).

Offshore disposal impacts may include:

- Reduced water quality due to suspended sediments released during disposal or through resuspention;
- Direct smothering of seabed communities; and
- Sediment deposition around the placement site.

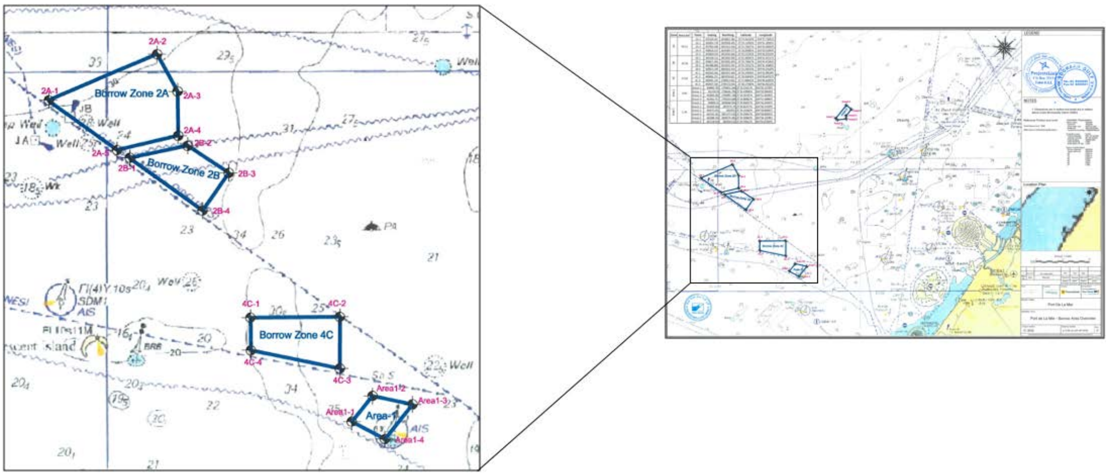
If disposal locations are carefully selected and potential impacts assessed and managed, then offshore disposal has the potential to be the most economic and environmentally feasible solution, and as such, it is the preferred option.

During a preliminary literature review, a number of sites were considered (Figure 7-6), including previous spoil dumping areas, however; two areas were identified as potentially most suitable:

- 'Zone 4' depleted offshore borrow pits, initially assessed for Dredging International and used for the La Mer Project; and
- A natural depression to the eastern side of Zone 2B, assessed for Van Oord as part of the Port De La Mer.

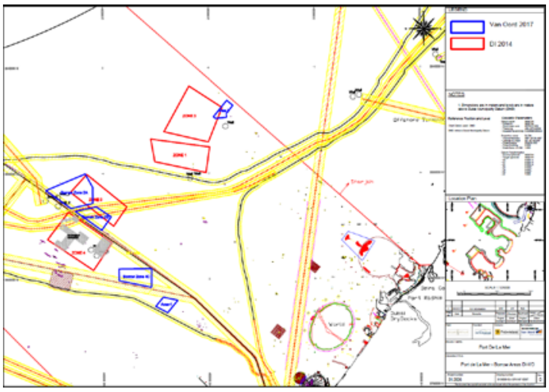
An ecological assessment of Zone 4 was undertaken in May 2015, and NOCs for extraction subsequently granted by DM for the least environmentally sensitive areas. Following extraction, the benthic community is likely to have been depleted further; however, field surveys are planned to confirm current site characteristics.

The Port De Le Mer borrow area, Zone 2B was surveyed for Van Oord in January 2017 as one of five potential borrow areas. The eastern side of this area was found to be a natural depression with a depositional environment and a fine silty substrate that supported few organisms. The characteristics and preliminary assessment of borrow area Zone 2B are provided in Table 7-5, below.

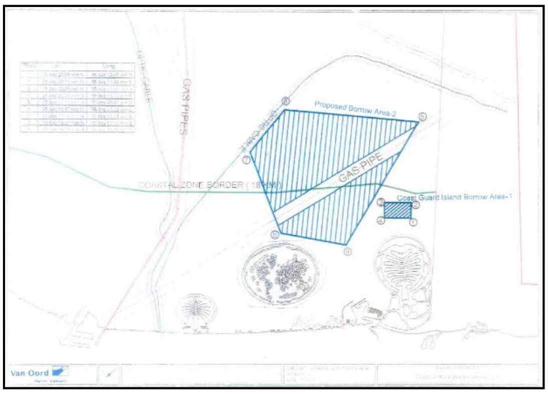


A – Port De La mer Borrow Areas

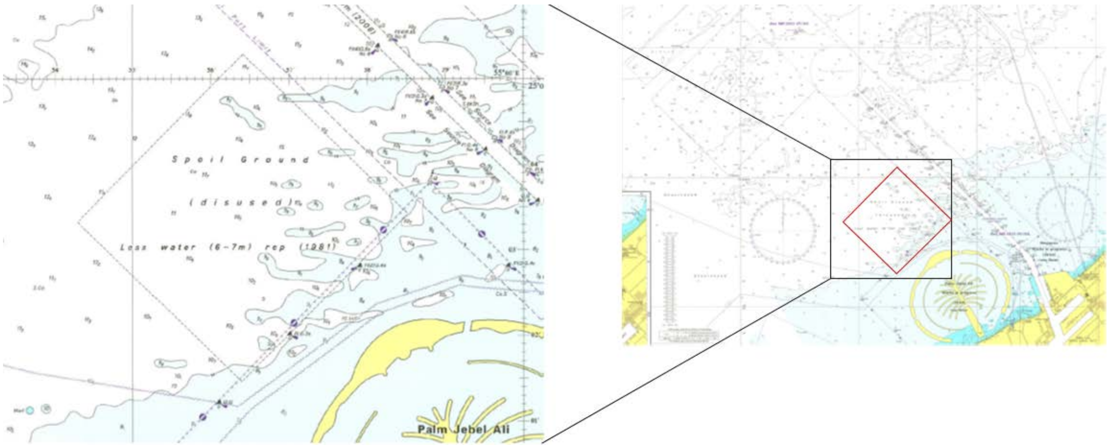
B – Zone 4, La Mer Borrow Area (Dredging International)



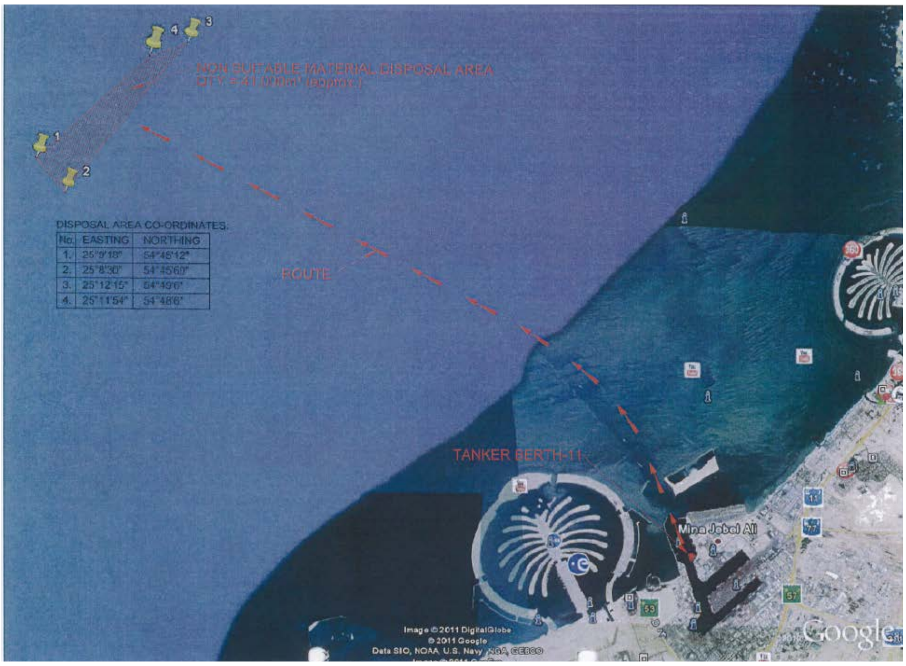
C – Van Oord and Dredging International Borrow Area



D – Island 2 Borrow Area



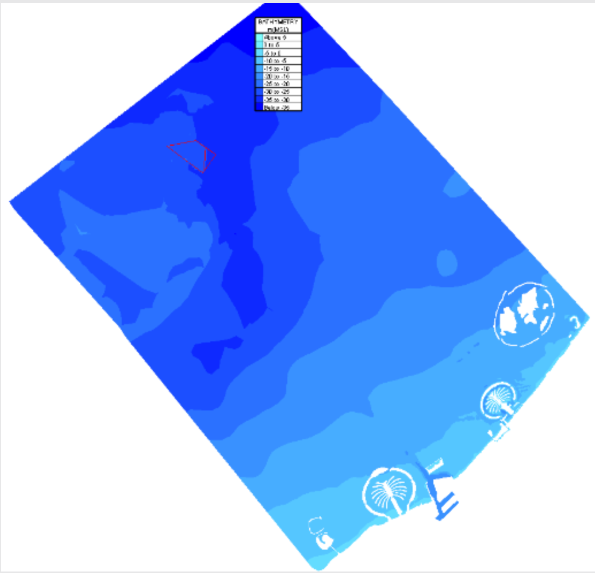
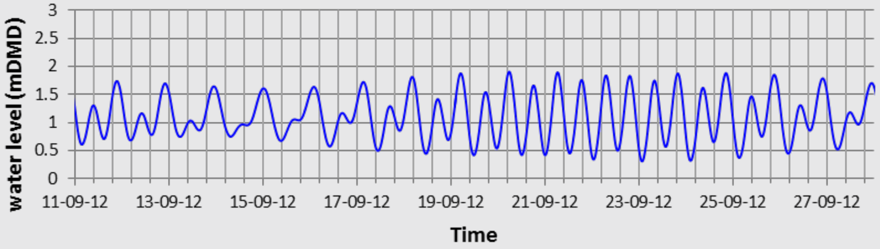
E – DP World Disposal Site



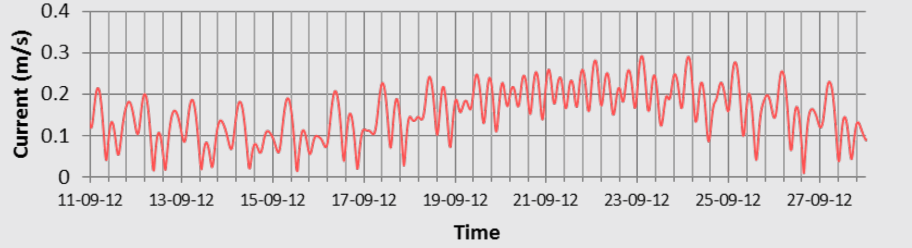
F – Gulf Refining Company Disposal Site

Figure 7-6 Previous Dredging and Disposal Sites Considered for Offshore Disposal Areas

Table 7-5 Characteristics of Port De La Mer Borrow Area

Characteristics	Description	Figure
Bathymetry	• Depleted sand source: natural pit • More than 30 m deep location • ~35 km offshore of Dubai Coast	
Volumetric capacity	• More than 2.5 Mm2 area deeper than 30 m[10] • The volumetric capacity of the proposed site is more than 1 Mm^3 (assuming 0.5 m thick layer of disposed materials)	
Hydrodynamics of Zone 2B	• Tide levels • Current speed less than 0.3 m/s	

[10] Based on Admiralty Charts and La Mer post dredging bathymetric survey

<table>
<tr><th>Characteristics</th><th>Description</th><th>Figure</th></tr>
<tr><td></td><td></td><td>
</td></tr>
<tr><td>Bottom Sediment of Zone 2B</td><td>The average Fine Content (FC) of the dredged materials* unsuitable for reclamation is lower than the FC of the Borrow Area Zone 2B
The unsuitable dredged materials from the navigation channel have finFC higher than 10%, the average GC is calculated based on all samples with FC>10%</td><td>Average Fine Content (%)
<table>
<tr><th>VCH06 - @0.0 m to 3.7m</th><th>VCH08 - @0.0m to 5.5m</th><th>Unsuitable Dredged Materials *</th></tr>
<tr><td>51%</td><td>48%</td><td>34%</td></tr>
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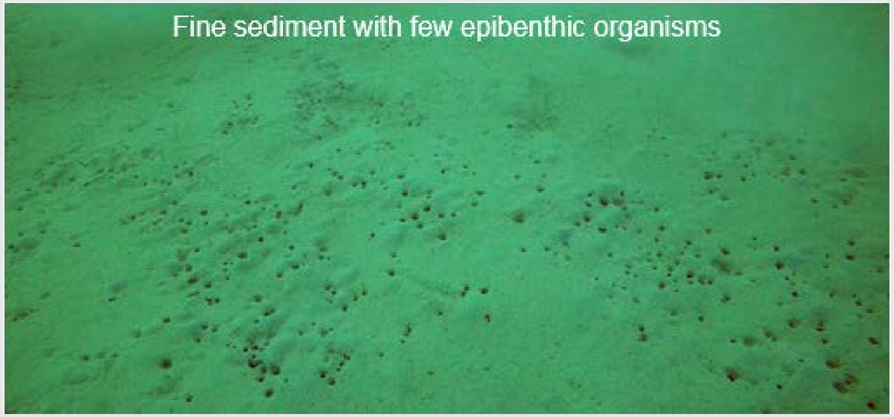
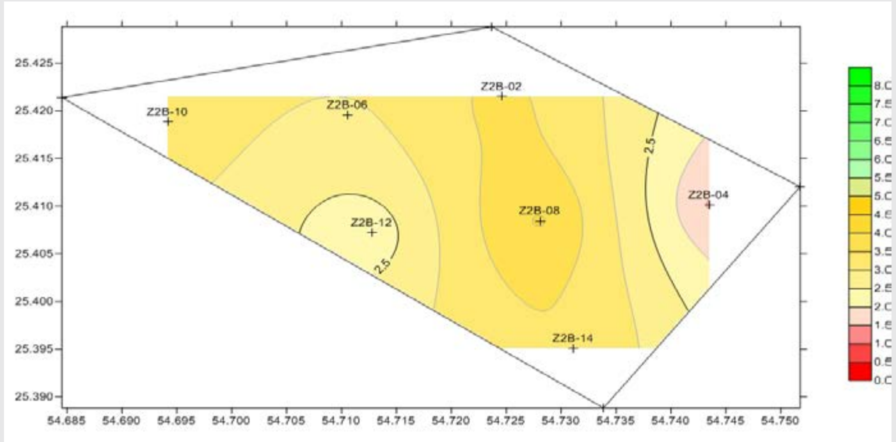
Characteristics	Description	Figure
Biological Characterization of Zone 2B	• The ecological assessment of the borrow area concluded that, “the most easterly site Zone 2B was particularly poor”.	
Zone 2B Infauna	• The infauna is diversity was similarly very low (n=2, s=2, d=1.4, H’=0.7) • Just two organisms – poorest of all samples in an assessment of five potential borrow areas	

Placement Equipment and Technique Options

Two primary placement methodologies are being considered (Figure 7-7):

- Placement via Bottom Door – Loading of Trailing Suction Hopper Dredger (TSHD) or barge by dredging with CSD and/or TSHD, sailing to the defined placement area and proceeding to aquatic placement via bottom door. Estimated 1–5% loss of fine material ((Becker et al., 2015);
- Placement via the suction pipe – Loading of TSHD, with flow reversed through the suction pipe allowing placement closer to the seabed. Estimated < 1-5% loss of fine material (Becker et al., 2015).

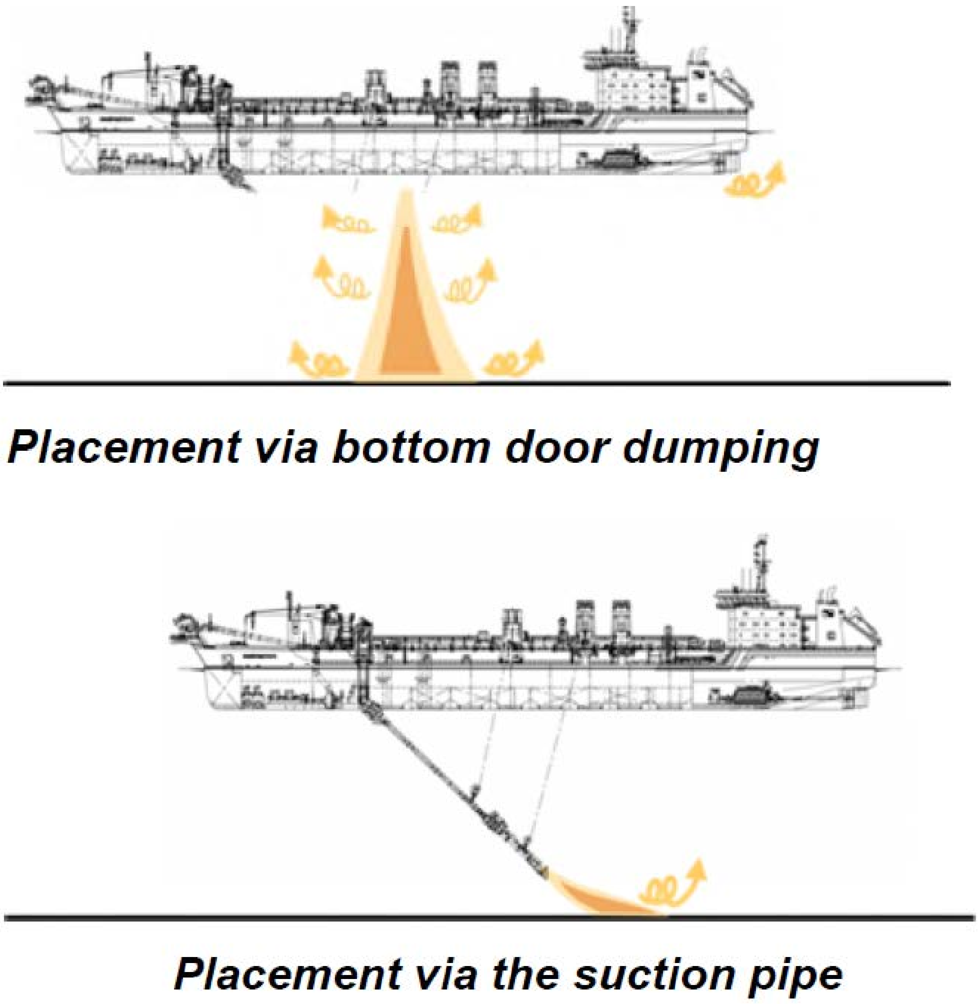
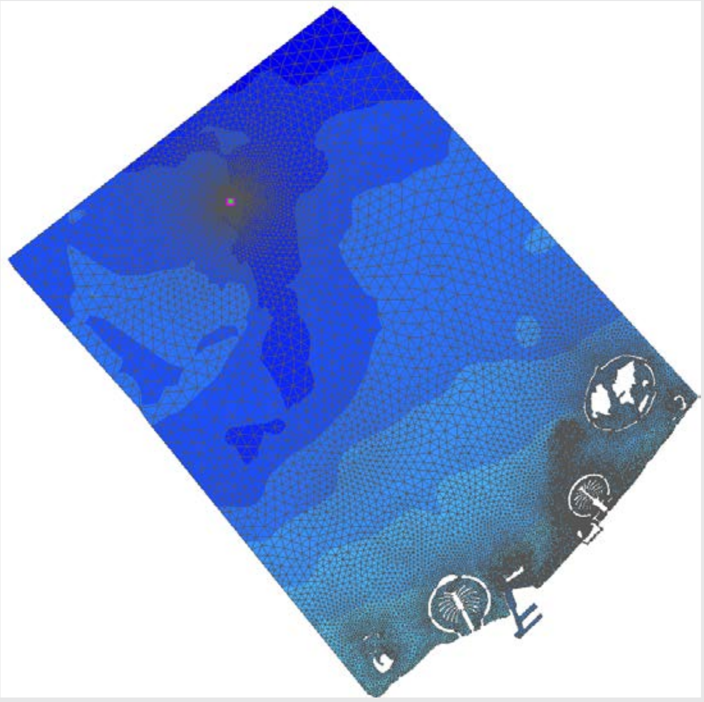


Figure 7-7 Offshore Placement options: (top) via bottom door; (bottom) via suction pipe

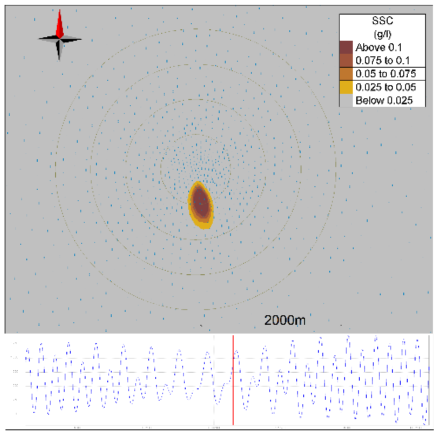
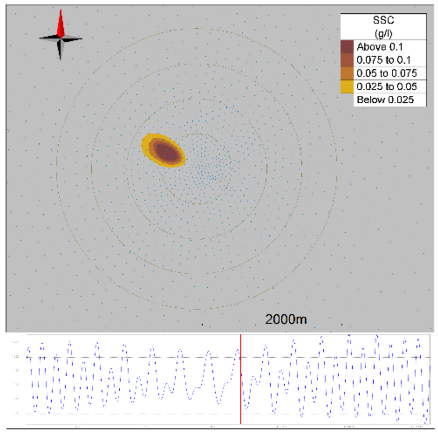
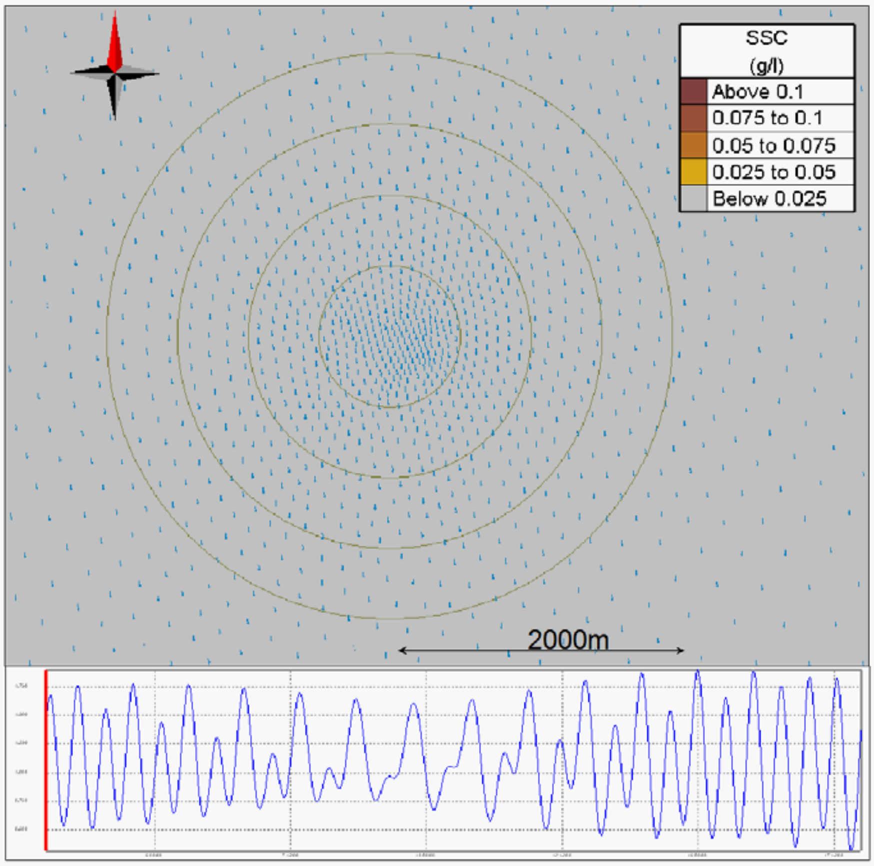
Sediment Plume Modelling

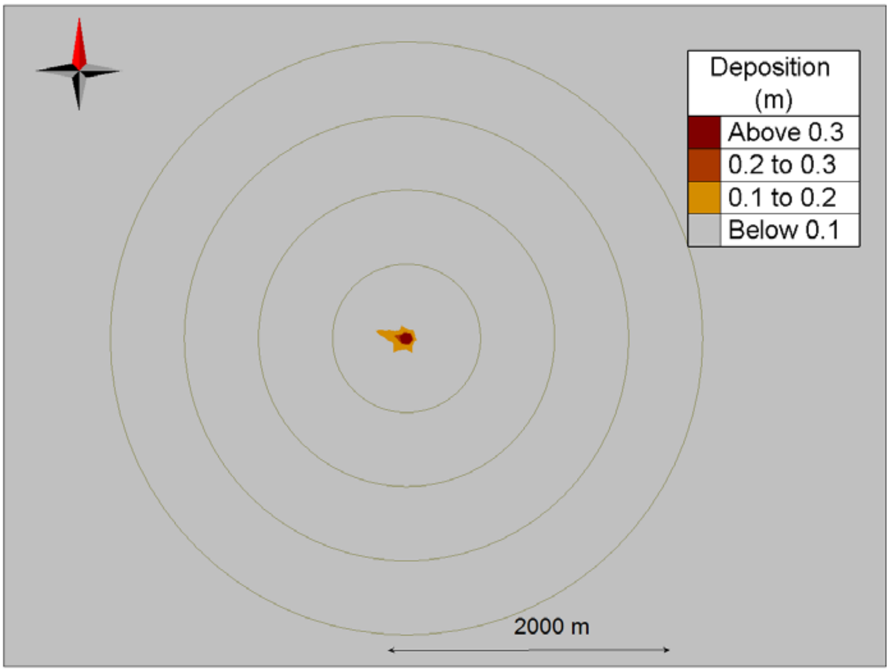
Sediment plume models will be run for selected location, as required. A preliminary sediment plume modelling was undertaken for bottom door placement of dredged material at Zone 2B. The result of the modelling study is provided in Table 7-6.

Table 7-6 Sediment Plume Modelling

Item	Description
Assumptions	• Location: Zone 2B • TSHD capacity: 200,000 m3 • TSHD sailing speed: 10 knots • Dumping method: 5 minutes • Dumping cycle 11: every 5.4 hours • Sediment release: 525,000 kg/dump • Simulation duration: 15 days (tidal cycle)
Methodology	• The numerical modelling software SISYPHE which is part of the hydrodynamic modelling system TELEMAC was used to study sediment plume • The mesh consist of 63,656 element and 34,066 nodes • Sediment transport rates are calculated at each node of the computational mesh as a function of various flow (velocity, water depth, etc.) and sediment (grain diameter, relative density, settling velocity, etc.) parameters.
Result	
Suspended Sediment Concentration	Suspended sediment plume do not extend beyond 2 km from the dumping point.

[11] Assuming 2.7 hours journey to the dumping site. It is assumed conservatively that the ime for dredging is zero corresponding to two TSHD/barges performing chain work

Item	Description
	 
Suspended Sediment Concentration Results – Animation	
Deposition Rate	All materials are settled within less than 500 m from the dumpling point

Item	Description
	

Offshore Placement Control Methods

- Containment
  - Lateral Containment:
    - Natural depression: eastern site of Zone 2B
    - Borrow pit: Zone 4
    - Underwater berms: not preferred due to additional disturbance
  - Capping: low currents / minimal sediment dispersal, once in location. This method is not preferred because it will create additional disturbance
- Uncontained Placement
  - Seascaping: underwater topography increases benthic colonisation. Studies (de Jong 2016; EcoShape 2017) showed that post-dredging landscaping of seabed result in five fold increase in infauna and four to five time more fish (variable distribution, with up to 20 time more fish in places) as shown in Figure 7-8.
  - Thin-layer placement: allows migration of macrobenthos. NODGDM (2002) reported that, 'deposition of spil in [thin] layer…facilitates benthic organisms burrowing up to the surface and imporves the rate of colonization'.

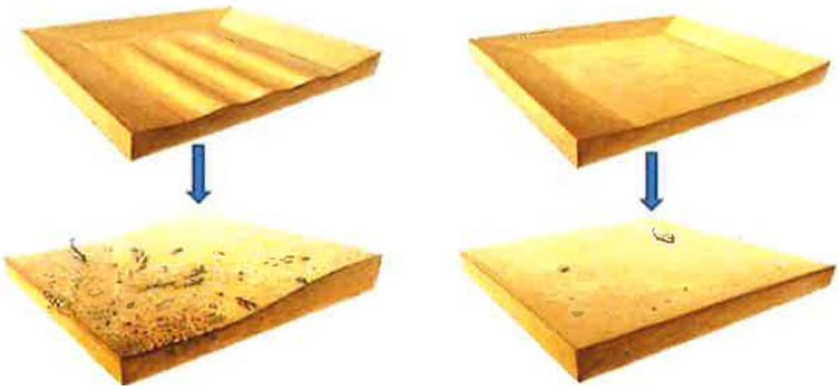


Figure 7-8 Seabed landscaping (left panel) versus traditional approach (building with nature) (right panel)

Source: EcoShape 2017

7.9.1.5 General Waste Management

The following are general measures that should be implemented as part of the Project's overall waste management program:

- **Reduce, reuse, recycle**: Establish achievable targets on the quantity of waste minimised, recycled and re-used and establish a programme for implementation and monitoring;
- **Provision of training**: All site workers shall be provided with orientation / site induction training on waste management. The training program shall be developed to provide workers with adequate awareness on the environmental, health and safety issues associated with waste management and to seek commitment in adhering to waste management practices (e.g. minimisation, reuse and segregation) on-site;

  Staff designated to handle or manage construction waste shall be provided with additional training on the proper handling, storage and disposal of waste;
- **Personal protective equipment**: Site staff involved in managing waste should be provided with and trained on the use of suitable personal protective equipment including mask, gloves, coverall and safety boots / shoes;
- **Restriction of access to waste storage areas**: Only authorised personnel shall be allowed access to waste storage areas. Restriction signs and warnings should be posted at these areas;
- **Use of DM-approved service providers**: Only DM-approved service providers shall be engaged for the collection and disposal of construction waste. Recyclable wastes should be sent only to DM licensed facilities;
- **Waste documentation**: In order to ensure that construction wastes are managed appropriately, relevant documents shall be maintained on-site including but not be limited to:
  - Waste inventory including information on the types and quantity of waste generated;
  - Service provider's licence / permit to collect / transport, recycle / process, or treat certain types of waste; and
  - Waste transfer notes or similar documents showing proof that waste had been collected and disposed of to an appropriate facility, whether a recycling / processing plant or a landfill site.

With consistent implementation of waste management measures discussed in this section, significant adverse environmental impacts are not anticipated during the development of the Project. Table 8-1 presents the residual rating of construction waste impacts where suitable management measures are implemented.

7.9.2 Operation Phase

Considering the scale of the proposed mixed use development, it is recommended that an Operation Waste Management Plan be developed for the Project. The waste management plan shall integrate the following key measures:

- **Waste minimisation**: Residents and operators (e.g. hotel, entertainment and retail) should be encouraged to develop and undertake a waste minimisation program tailored to their day-to-day activities / operations. Waste management awareness could be enhanced through information campaigns such as seminars, waste collection drive, dissemination of brochures / leaflets.
- **Waste segregation**: Waste segregation should be encouraged among residents, operators and visitors. Suitable and dedicated waste bins shall be allocated to facilitate waste segregation at-source and reduce risk of cross contamination issues.
- **Provision of suitable waste management facility**: Appropriate waste collection bins / skips and storage facilities shall be provided and strategically located such that they are an adequate distance from the marine environment and other on-site sensitive receptor areas (e.g. food establishments). The design of the waste management facility shall comply with regulatory / standard design requirements for building, villa and community waste management facilities. Adequate ventilation and housekeeping should be maintained at the facility.
- **On-shore sewage discharge**: Sewage waste should be discharged into the sewerage network. Discharge of liquid waste into marine water or connecting the discharge network to the stormwater drains will be prohibited.
- **Cruise ship sewerage:** Sewage should be treated by on-board STPs. Discharge at sea shall follow MARPOL 73/78 regulations. Sewage not discharged at sea will be transported offsite for treatment and disposal, if required.
- **Use of DM approved service providers**: The collection of waste on a regular basis shall be arranged through DM approved service providers.
- **Disposal of maintenance dredging material**: Disposal of dredging material generated during the operation and maintenance phase is not expected to be required for 20 years, with an estimated 75,200 m^3 generated over that period (Section 6.10.2.4). When undertaken, disposal and mitigation will be similar to the measures for the disposal of unsuitable dredged materials during the construction phase (Section 7.9.1.4).

With consistent implementation of waste management measures discussed above, significant adverse environmental impacts from operational wastes are not anticipated. Table 8-2 presents the residual rating of operational waste impacts where suitable management measures are implemented.

7.10 Traffic and Transport

7.10.1 Construction Phase

The following are mitigation measures which should be implemented to minimise traffic impacts during construction of the Project:

- **Site traffic management**: A construction traffic management plan should be developed with the objective of ensuring smooth traffic flow on surrounding public roads and at the Project site's entrance and exit points to reduce traffic congestion. It should include, where practical:
  – Speed limit(s);
  – Designated routes and parking areas of suitable capacity;
  – Traffic signs and control signals to direct and control traffic flow;
  – Potential for split shifts to reduce rush hour traffic; and
  – Flagmen and / or signalling equipment.
- **Arrangement for shared transport**: Shared transport of workers should be arranged where possible to minimise trips to and from the construction site; and
- **Management of delivery schedule**: Delivery of materials during rush hours should be avoided, where possible. Delivery of materials in bulk should be arranged, rather than in small batches which would require more frequent trips.

Consistent implementation of the above mitigation measures will reduce construction traffic impacts of the Project to acceptable levels, which will reduce the potential for community complaints. Table 8-1 presents the residual rating of construction traffic impacts when suitable mitigation measures are implemented.

As discussed in Section 6.11.1, there is a potential for dredged material to be disposed of to land in the event that it is unsuitable for use as reclamation material. In this scenario, the Traffic Impact Study should be revised to account for the potential significant increase in truck movements to transport the material to the disposal site. Appropriate mitigation measures should be provided within the TIS to abate traffic congestion issues.

7.10.2 Operation Phase

Vehicle Traffic

Traffic impacts of the Project can be mitigated via implementation of the following measures:

- **Traffic management plan**: Given the large scale and mixed land uses of the Project, it is recommended that a site-specific traffic management plan be developed and implemented to facilitate smooth and safe traffic flow within site as well as the surrounding road network. The traffic management plan should incorporate relevant regulatory requirements (RTA) including the following:
  – Adequate capacity and suitable location of parking areas;
  – Adequate traffic signage;
  – Requirements for speed limits;
  – Restriction to certain areas (e.g. residential areas); and
  – Safety provision (e.g. speed humps).
- **Integrated transport design**: An appropriate transport network (road, metro, tram, cycling and marine) should be designed and built specific to the requirements of the Project as determined in the TIS. The design should maximise the potential for use of public transport (metro and tram) as well as providing cycle and pedestrian access. All designs should be in accordance with RTA requirements and be able to accommodate peak flows without resulting in congestion issues within the Project site and / or at the surrounding areas;

- **RTA consultation**: Early consultation with RTA would assist in identifying existing and future opportunities and constraints that will impact the Project's transport infrastructures. Where possible, an improved or increased public transport to the Project area (for example, more regular services, closer drop-off points and possibly new routes) could be negotiated with the RTA.
- **Traffic Impact Study**: Based on the TIS undertaken by AECOM (2017), the following mitigations are proposed:
  - 2020: Dubai Harbour will be connected directly to King Salman Road via a grade signal. Regardless of the low 2020 traffic related to the development, it is recommended that the 2030 proposed mitigations should be completed by the opening date of the project.
  - 2030: The preferred mitigation measures consist of the implementation of 2X2 lanes bridge along King Salman Road on the north-south direction. The new bridge will enhance the grid system and connectivity from/to Marina and JBR and will separate the background traffic from the Dubai Harbour Project traffic, which will have access through an at-grade level.
  - 2030 Optional Mitigation Measures: Alternative optional mitigation measures to ensure all junctions perform at acceptable LOS 'D' or better are as follows:
    - One lane bridge in the southbound direction along King Salman Road on the section in from of JBR. This bridge will provide a bypass route for the southbound traffic approaching Interchange (5 ½) on King Salman Road. The ROW is very limited on the aforementioned area, thus minor reductions of the existing lane width may be required to accommodate the via duct bridge.
    - Al Falak Street vs. Al Naseem Street junction – converting the existing three phases signal to two phases signal by grade separating the very heavy southbound left turn movement and the northbound left turn movement. This mitigation will require providing alternative routes to the heavy southbound left turn movement (the outbound traffic from TECOM area) by providing a directional ramp from Al Falak Street towards IC#5 or enhance the connectivity towards Sheikh Zayed Road.

Given the large scale and strategic developments ongoing and proposed in the area, it is anticipated that the Dubai government, particularly RTA, will undertake integrated transport planning that includes assessment of traffic impacts and transport requirements associated with developments along Dubai's coastal zone. Increased traffic is considered an unavoidable impact of the Project: however, with implementation of suitable traffic management measures, the impact could be reduced to an acceptable level such that congestion issues in the surrounding road network are minimal. Table 8-1 presents the residual rating of operational traffic impacts when management measures discussed above are implemented.

Vessel Traffic

The navigation simulation study indicated that arrival and departure manoeuvres for vessels in the navigation channel could be difficult under strong wind or strong wave conditions. This could potentially cause vessels to cross out of the navigation channel close to the northern breakwater in such conditions, which could consequently impact the benthic habitat and marine fauna in the area in case of collisions and accidental spills. As such, the following mitigation measures are recommended:

- Usage of tug assistance, particularly during high wind conditions, to facilitate manoeuverability of the vessels.
- Ensuring that tugs of appropriate power are mobilized when necessary.

7.11 Utilities

7.11.1 Construction Phase

Contractors will be required to provide suitable service utilities and ensure they are maintained in good operating conditions. Relevant regulatory NOCs shall be obtained for the temporary utilities to be used on-site.

Other proposed measures for managing environmental issues associated with the operation of temporary utilities on-site include:

- **Optimising energy efficiency:** The proposed measures (Section 7.2.1 and 7.3.1) for increasing energy efficiency will minimise the demand for non-renewable energy;
- **Reduce electricity use:** Energy use can be reduced at site offices by employing energy efficient practises such as switching off lights when not in use, using automatic or timed light systems, using energy efficient light bulbs (CFL or LED), switching off equipment when not in use and adjusting temperature set points where possible in site offices;
- **Water conservation measures:** The use of water on-site shall be minimised through the use of water efficient devices and practises, where feasible. Potential water conservation measures include:
  - Use of high-pressure water spray for equipment cleaning;
  - When cleaning small tools and equipment use buckets as opposed to running water;
  - Utilise auto-shut off taps and ensure water supply is able to be switched off at the point of use;
  - Use closed-loop systems for plant and equipment;
  - Site inspections for water leaks and wastage are to be carried out frequently;
  - Use of water efficient bathroom products and taps in site offices;
  - When concreting, use water from settled concrete wash out area to clean equipment;
  - Limit dust suppression to what is necessary (avoid over watering); and
  - Provide employee training on site water use behaviour and best practise procedures.

Potential adverse environmental impacts associated with the operation of construction utilities could generally be avoided or reduced to acceptable levels via consistent implementation of mitigation measures discussed above. Table 8-1 presents the residual rating of construction utilities impacts assuming that suitable management measures are implemented.

7.11.2 Operation Phase

The relevant authorities / agencies are being consulted with regards to the availability of required service utilities and the respective connection points. Early engagement of the authorities / service providers will enable the Project Proponent to identify any constraints. Similarly, this provides an opportunity for the authorities to assess the available resources and capacity of infrastructure against the current and future demands of the Emirate in general.

The environmental issues associated with the Project's additional load to the existing service utilities can be addressed via the following measures:

- **Optimising energy efficiency**: The design of the Project's building components shall comply with the requirements of the *Green Building Regulations and Specifications in the Emirate of Dubai* with regard to energy efficiency, where appropriate;
- **Optimising water efficiency**: Water efficiency measures shall be adopted as early as the design phase and on an ongoing basis during the operation phase of the Project. This

is particularly important given that potable water is scarce in Dubai and the UAE. Measures would include:

- The design of the Project's building components shall comply with the requirements of the Dubai Green Building Regulations, where appropriate.
- Xeriscaping should be considered. Plant species to be used for landscaping shall consist of native species tolerant to the dry and arid conditions in the Emirate and should require minimal water application. The *Green Building Regulations and Specifications in the Emirate of Dubai* requires that 'a minimum of 25% of the total planted area of a building plot must utilise plant and tree species indigenous or adapted to Dubai's climate and region';
- As part of the xeriscaping, a drip irrigation system should be considered rather than the overhead water sprinkler or conventional spray method. Drip irrigation is considered more efficient (Loehrlein, 2013) in that it ensures water goes directly into the roots zone and not the surrounding soil, thereby reducing unnecessary water loss by evaporation;
- Where feasible, the irrigation program shall include undertaking irrigation early in the morning or late in the afternoon when temperature is relatively low, in order to avoid unnecessary water losses due to evaporation; and

- **Stormwater drainage**: management measures for stormwater drainage are discussed in Section 7.7.2.

Table 8-2 presents the residual impact of operational utilities impacts when suitable management measures are implemented.

7.12 Socio-cultural Environment

7.12.1 Construction Phase

7.12.1.1 Enhancement Measures for Positive Socio-economic Impacts

In order to optimise the benefits from employment and business opportunities, the following enhancement measures shall be implemented:

- **Priority given to local workforce**: Local workers, who are currently and presently available in Dubai, will be prioritised instead of hiring workers outside of the UAE. This measure will minimise impacts associated with the influx of migrant workers;
- **Priority given to local companies**: During procurement of construction materials and services required for the Project, priority shall be given to local suppliers and service companies. This will optimise the economic benefits to the Emirate as well as the UAE in general;
- **Just and fair compensation to workers**: All parties involved in the Project (e.g. contractors and sub-contractors) shall comply with the UAE Labour Code provisions on the minimum salary, working hours and working conditions (e.g. occupational health and safety);
- **Workers' protection**: Employees of the Project Proponent, contractor and sub-contractors will have freedom of association and have the right to collective bargaining. All forms of forced or compulsory labour will be prohibited.

7.12.1.2 Mitigation Measures for Potential Adverse Socio-economic Impacts

Potential adverse impacts of the Project during its construction phase should be mitigated through the implementation of the following mitigation measures:

- **Appointment of Community Liaison Officer (or similar)**: The Proponent or the principal contractor shall appoint a Community Liaison Officer (or similar) to maintain a good relationship with the local communities or other stakeholder groups who may potentially be affected by the construction work. Where possible, regular project updates should be disseminated to the stakeholders via Proponent's website, newsletter and / or posters onsite;
- **Grievance management procedure**: A grievance management procedure should be developed to ensure that all complaints are addressed promptly. Signage should be provided at the Project site boundary providing contact information for potential complains and grievances. Any complaints received with regard to the Project should be logged through a Complaints Register. Any feedback, both positive and negative, received will be considered by management, registered, investigated, and addressed through appropriate mitigation measures;
- **Environmental management measures**: With consistent implementation of environmental management measures described throughout this Section, potential nuisance / disturbance / adverse impacts (e.g. dust, noise, traffic) of the Project to nearby communities can be avoided. Similarly, any reduced amenity impacts in the surrounding areas will be minimised;
- **Construction health and safety risks:** The site layout, construction logistics and method should consider the potential environmental, health and safety risk to the local communities.
- **Induction training**: The induction training provided to foreign workers should include understanding and respecting culture and religion of the UAE and the Emirate, life style and preferences of the local community residents, rules and practices to be observed in order to ensure the harmony between local communities and foreign workforce.

7.12.2 Operation Phase

7.12.2.1 Enhancement Measures for Socio-economic Impacts

The following are proposed measures to enhance socio-economic benefits of the Project:

- **Use of locally available work force**: In support to the UAE's Emiratisation Policy, Emiratis shall be given priority when sourcing staff and employees;
- **Fair compensation to staff and employees**: Similar to the construction phase, the operation of the Project in general shall comply with the UAE Labour Code provisions on the minimum salary, working hours and working conditions (e.g. occupational health and safety).

7.12.2.2 Mitigation Measures for Potential Adverse Impacts

The following measures are proposed to mitigate potential adverse socio-economic impacts of the Project:

- The operation of the Project will require increase the population which will place additional strain on the social and utilities infrastructure, such as schools, hospitals and the water and electricity supply. To ensure that this strain will not significantly affect or reduce the available resources and services in the local area, consultation with the relevant service providers (including DM, DEWA, etc.) must be undertaken in order to determine what services are readily available for the Project as well as what utilities will need to be provided by the Project;

- A traffic management plan should be in place to maximise the use of public transport, cycling or running and minimise congestion, traffic noise and air pollution;
- A marine traffic risk assessment will be prepared to reduce the impact of increased marine traffic and potential collisions during operation;
- Good housekeeping of facilities on site (e.g. waste storage areas, pest control) should be maintained to minimise nuisance, health and safety risk to the neighbouring areas. Malfunctioning facilities (e.g. leaked sewage pipes) should be fixed promptly.

8. Environmental Impacts Summary

The environmental and social impact levels before and after the implementation of mitigation measures during the construction and operation phases of the project area consolidated in Table 8-1 and Table 8-2, respectively.

Table 8-1 Environmental and Social Impacts Ratings Before and After Mitigation – Construction Phase

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Climate and Meteorology								
GHG emissions from use of fuel for the operation of equipment, plant, tools and utilities (e.g. power plant)	Almost certain	Insignificant	Low	Workers and occupants on-site Surrounding communities	Optimising energy efficiency as proposed for mitigation of air quality impacts.	Almost Certain	Insignificant	Low
GHG emissions associated with construction waste transport and disposal to landfill	Almost certain	Insignificant	Low	Workers and occupants on-site Surrounding communities Occupants along the route for the waste transport and nearby landfill site	Waste minimisation and reuse measures	Almost Certain	Insignificant	Low
Use of construction / building materials with embodied energy	Likely	Minor	Medium	Workers and occupants on-site	Use of sustainable construction materials (e.g. recycled materials)	Likely	Insignificant	Low

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Air Quality								
Fugitive dust emission from site development / earthmoving works and wind erosion on unpaved surfaces	Almost certain	Moderate	**High**	Workers / staff and visitors on-site Occupants of surrounding residential and commercial areas	Dust control including erection of hoarding, site planning with dust generating activities / sources located away from sensitive receivers, phasing of earthmoving works, stabilisation / compaction of unsurfaced areas. Detailed list provided in Section 7.2.1.1 and 7.2.1.2.	Likely	Minor	**Medium**
Deposition of dust to the marine environment	Almost certain	Minor	**Medium**	Marine community	Dust control measures as discussed above.	Possible	Minor	**Low**
Emission of exhaust gases from the operation of equipment, vessels, plant, tools and utilities using fuel	Almost certain	Insignificant	**Low**	Workers / staff and visitors on-site Occupants of surrounding residential and commercial areas	Banning of open burning on site. Use of cleaner fuel. Use of equipment fitted with pollution control devices (e.g. diesel particulate matter filter), where possible. Maintain the equipment and vehicles as per the manufacturer's instructions. Implementing a Construction Logistic Plan and Construction Traffic Management Plan. No idling of equipment and vehicles.	Almost Certain	Insignificant	**Low**
VOC emissions	Likely	Insignificant	**Low**	Workers / staff and visitors on-site	Provision of a well-ventilated storage facility for fuel, paints and other volatile materials.	Possible	Insignificant	**Negligible**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
				Occupants of surrounding residential and commercial areas	Storage areas to be located away from sensitive receptor areas. Quantity of volatile materials to be stored on-site shall be kept to minimum.			
Odour emission from sanitary and waste disposal facilities, and poor quality dredged material	Likely	Insignificant	Low	Workers / staff and visitors on-site Occupants of surrounding residential and commercial areas	Locate toilet utilities, sewage tanks (if any) and waste storage facilities away from sensitive receptors. Sanitary and waste disposal facility to be kept in good condition at all times. Implement appropriate waste management measures, ensuring proper waste storage and regular waste collection for off-site disposal.	Possible	Insignificant	**Negligible**
Noise								
Sleep disturbance	Almost certain	Moderate	High	Residents and occupants of surrounding communities	Erection of hoarding / noise barrier along the site boundary and / or noisy areas	Possible	Moderate	Medium
Annoyance	Almost certain	Moderate	High	Residents and occupants of surrounding communities	Equipment noise control: • Quiet piling methods • Selection of appropriate equipment • Proper equipment operation • Maintain and service the equipment at regular intervals	Likely	Minor	Medium
Hearing impairment	Possible	Moderate	Medium	Workers on Project site Residential receptors in close proximity		Unlikely	Minor	Low

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
				to construction site	• Usage of broadband reversing alarms (audible movement alarms) for all site equipment • Acoustic covers should be kept closed during equipment use • Silencers to be installed on equipment Work methods including phasing, scheduling noisy activities during day time and minimising consecutive noisy activities. For full list refer to Section 7.3.1.3.			
Geology, Geomorphology and Seismicity								
Seismic tremor causing collapse of infrastructure, that is under construction and not yet able to withstand earthquake tremors	Rare	Catastrophic	**Medium**	Workers and visitors of the site during construction	Design and construct the Project in accordance with the requirements of the DM Building Code and the findings of the site's geotechnical investigation. Ensure sufficient compaction and land stability is achieved prior to commencing building and infrastructure works.	Rare	Moderate	**Low**
Soils and Groundwater								

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Spread of potential pre-existing soil contamination via movement of contaminated fill / stockpiled material	Unlikely	Minor	Low	Terrestrial ecology	Any imported fill should be clean-fill only and obtained from an approved source. Imported topsoil for landscaping should be from an approved supplier.	Rare	Minor	**Negligible**
Soil contamination from using contaminated water for dust suppression	Unlikely	Minor	Low	Terrestrial ecology Employees and visitors on-site	Water used for dust suppression should meet municipal health standards and should not exceed the salinity levels of soil on-site.	Rare	Minor	**Negligible**
Soil contamination due to handling, storage and use of hazardous materials (e.g. oil, fuel, paint and other chemicals)	Likely	Minor	**Medium**	Terrestrial ecology Employees and visitors on-site	Hazardous materials management ensuring the following are provided: • Appropriate storage facilities (suitably bunded). • Siting the storage facility away from marine environment and sensitive areas. • Spill and fire response procedure and equipment. • Materials inventory / register and MSDS files. • Labelling of containers and areas. Labels to include name of chemical, hazard and precautionary measures.	Possible	Minor	Low

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
					• Standard operating procedures for materials handling. • Access restrictions at storage areas. • Relevant staff to be provided with training and PPE.			
Soil contamination from inadequate waste management (e.g. hazardous waste, sewage)	Likely	Minor	**Medium**	Terrestrial ecology Employees and visitors on-site	Implementation of appropriate waste management measures, ensuring provision of suitable collection and storage facilities (e.g. bund systems) Toilet facilities located at regular intervals within site for workers ease of access. Direct discharge of site offices effluent to the municipal sewage system where feasible. Portable toilets or facilities with septic tanks to be regularly checked for signs of leaks or overflow. Storage tanks to be emptied when ¾ full. Routine checking of equipment, machinery and vehicles to ensure no leakage of oil and fuel. Washout of concrete trucks only in designated and fully bunded concrete wash areas. No routine maintenance activities to be carried out at the Project site. Emergency maintenance only in	Possible	Minor	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
					designated maintenance zones with impermeable surfaces (such as concrete slabs).			
Soil erosion from disposal / settlement of unsuitable dredged material (unconfirmed requirement)	Possible	Minor	Low	Soil, groundwater	Prior to commencing disposal, the receiving environment should be assessed for adequacy for the purpose, and consideration should be given to placing a liner to reduce soil erosion.	Unlikely	Minor	Low
Erosion of fill due to action of sea waves during reclamation process	Unlikely	Major	Medium	Sensitive marine receptors	Containment of dredged material within designated areas, either through construction of rock revetments, temporary sand bunds or containment of water using silt curtains. Construct beach toe revetment prior to the start of sediment deposition for beach profiling works.	Unlikely	Minor	Low
Soil erosion due to earthmoving activities (stockpiling)	Likely	Minor	Medium	Terrestrial ecology	The site should undergo progressive compaction (stabilisation) immediately after earthmoving activity. Site roads and tracks should be surfaced with milled asphalt or gatch to reduce suspension of dust and erosion of soil. An efficient temporary drainage system within the Project area should be provided to prevent loose soil from being scoured off by surface runoff. Excavation work plans should specify cut slope and maximum height to	Possible	Minor	Low

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
					prevent erosion and to minimise the area of disturbed and unconsolidated soil. Soil stockpiles should be maintained at minimum height and located on flat areas and away from stormwater flow paths.			
Groundwater contamination as a result of spill / leak of potentially hazardous material (i.e. oil, fuel, sewage, paint and other chemicals)	Unlikely	Major	**Medium**	Terrestrial flora and fauna Marine flora and fauna	Implementation of mitigation measures for soil contamination impacts.	Unlikely	Minor	**Low**
Groundwater contamination as a result of inadequate waste management (e.g. hazardous waste, sewage)	Unlikely	Major	**Medium**	Terrestrial flora and fauna Marine flora and fauna	Implementation of mitigation measures for soil contamination impacts.	Unlikely	Minor	**Low**
Coastal Processes								
Decreased flushing of enclosed beaches and marinas	Likely	Insignificant	**Low**	Swimmers at JBR and Mina Al Seyahi Beaches; Water quality within Dubai	Wastewater discharges (e.g. dewatering effluent, stormwater runoff, sanitary wastes etc.) to be directed away from enclosed water bodies, preferably to areas modelled to exhibit the highest current speeds and outside of marinas or other enclosed water bodies.	Likely	Insignificant	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
				Marina and DIMC	Regular marine monitoring during construction phase to check water quality in the area. Aeration, mechanical mixing and hydrological manipulation measures will be implemented if water quality deteriorates.			
Marine Ecosystem								
Habitat loss and modification	Almost certain	Moderate	**High**	Marine flora and fauna	Mitigation is not proposed for the loss and modification of habitat as the existing habitat is considered to be of relatively low ecological value and the provision of additional hard substrate could allow re-colonisation of a range of marine organisms in the future.	Almost certain	Moderate	**High**
Suspension and deposition of sediments	Almost certain	Moderate	**High**	Marine flora and fauna, human amenity (beaches)	Prepare a detailed silt control plan as part of the CEMP, which would include the following measures as a minimum: - Containment of fine material within designated reclamation areas, either through construction of rock revetments, temporary sand bunds and / or installation of low permeability silt screens between dredging / reclamation activities and sensitive areas - Careful management of dredging and reclamation activities and mitigation measures to control suspended sediment load, taking into account met-	Possible	Moderate	**Medium**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
					ocean conditions (currents and tides) and areas of elevated TSS - Aim to undertake as much of the beach re-profiling works during low tide and calm sea conditions as is feasible.			
Nutrient enrichment and introduced contaminants including accidental oil spill	Possible	Moderate	**Medium**	Marine flora and fauna, human amenity (beaches)	- Undertake regular visual and analytical sampling of dewatering effluent prior to discharge - Implement appropriate hazardous material storage, hazardous waste, solid waste and wastewater management control plans - Maintenance of vessels and equipment will be prohibited on site. - Spills and leaks shall be cleared / cleaned up immediately - Provision of spill kits and booms on all marine vessels and rapid response to any leaks or spills.	Possible	Minor	**Low**
Mobilisation of dormant algal cysts	Rare	Major	**Medium**	Marine ecosystem, desalination plant	In the event an algal bloom occurs in vicinity to the Project, dredging operations would be temporarily ceased until the outbreak has ceased. Implement the mitigation measures for silt control to prevent the spread of sediments, particularly in the direction of the DEWA desalination plant.	Rare	Moderate	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Marine pest introduction	Unlikely	Major	**Medium**	Marine flora and fauna	- Vessels should be sourced from the local region to minimise chance of invasive / exotic species introduction. - Utilise vessels that have not visited locations where marine pest outbreaks are present, which have appropriate antifouling solutions in place and which practice appropriate ballast water exchange. - No sediments carried in ballast or dredge hoppers would be released to the local environment.	Rare	Moderate	**Low**
Disturbance to marine fauna from vessels and underwater noise	Almost certain	Minor	Medium	Marine fauna	Members of the dredging and reclamation team should be familiar in the spotting of marine fauna. In the event that marine fauna is spotted within 150 m of operations, then works should temporarily cease until the area is clear. Measures for reducing the risk of contaminants introduction should also be implemented to reduce the risk of impacts to marine fauna.	Possible	Minor	**Low**
Terrestrial Ecology								
Habitat loss and modification	Possible	Insignificant	**Negligible**	Terrestrial flora and fauna	Negligible impact therefore no mitigation measures required.	Possible	Insignificant	**Negligible**
Loss of vegetation / flora	Unlikely	Insignificant	**Negligible**	Terrestrial flora and fauna	Negligible impact therefore no mitigation measures required.	Unlikely	Insignificant	**Negligible**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Exposure to dust and noise emission	Almost certain	Insignificant	**Low**	Terrestrial flora and fauna	Implement proposed construction air quality and noise mitigation measures	Likely	Insignificant	**Low**
Injury / death to terrestrial fauna via intake / entanglement of waste or machinery strike	Rare	Minor	**Negligible**	Terrestrial fauna	Negligible impact therefore no mitigation measures required.	Rare	Minor	**Negligible**
Waste								
Generation of waste that will increase strain on the waste infrastructure and result in additional quantities being deposited to landfill	Almost certain	Moderate	**High**	Dubai waste infrastructure and landfill	• Implementation of waste minimisation, reuse and recycling programs (including setting achievable targets for waste minimised, recycled and reused). • Implementation of waste minimisation, segregation (at source), reuse and recycling programs. • Provision of appropriate and suitably labelled waste bins and collection areas at strategic locations. • Designated bunded areas for equipment and vehicle washing. • Provision of a suitable temporary sewage holding tank on-site. • Provision of suitably bunded storage area for hazardous waste.	Almost certain	Minor	**Medium**
Potential contamination of soil, groundwater, marine and stormwater; odour; vermin infestation, injury / hazard from improper waste management	Possible	Moderate	**Medium**	Workers involved in waste handling Construction site workers and visitors Marine and terrestrial ecosystem		Possible	Minor	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
				Soil and groundwater	• Keeping records of MSDS and compliance with their requirements. • Emergency management plan / procedures to be established for hazardous waste storage area. • Provision of staff awareness / induction training on waste management. • Staff involved in waste management to be provided with PPE. • Restriction of access to waste storage areas. • Use of DM-approved service providers. • Waste documentation.			
Potential impacts on water quality, pelagic organisms and benthic organisms, in case of offshore disposal of unsuitable dredged materials	Possible	Moderate	**Medium**	Marine flora and fauna	Where feasible, maximise use of dredged material by: • Mixing unsuitable materials with suitable materials to meet Project requirement • Alternative project uses, such as offshore breakwaters • Beneficial use in other projects surrounding the Dubai Harbour Conduct investigation of various options to dispose dredged materials without	Possible	Minor	**Low**
Potential impacts on water quality, pelagic organisms and benthic	Possible	Moderate	**Medium**	Marine flora and fauna		Possible	Minor	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
organisms, in case of onshore reworking of unsuitable dredged materials for disposal					causing significant environmental impacts (e.g. disposal at previous dredging and existing disposal sites; conduct baseline assessment of potential disposal sites and select disposal site with the least impact; conduct modelling studies, etc.).			
Potential impacts on aesthetic, cultural and land use in case of onshore disposal of unsuitable dredged materials	Possible	Moderate	**Medium**	Community surrounding the proposed disposal site	Mitigation may include: • Planned disposal of unsuitable material during slack tide to limit the extent of sediment plumes • Apply the most suitable placement technique to limit the sediment plume, such as placement in bulk (bottom door opening) or placement directly on the seabed (by pumping through draghead) • Pumping material from the top of the water column to be avoided.	Possible	Minor	**Low**
Potential contamination of surface and groundwater quality in case of onshore disposal of unsuitable dredged material	Possible	Major	**High**	Groundwater and surface water surroundinig proposed disposal site		Possible	Minor	**Low**
Traffic and Transport								
Increase in road and marine traffic as a result of construction materials and delivery to site as well as workers/staff transportation	Almost certain	Minor	**Medium**	Residents of local community Users (local and visitors) of the neighbouring beaches, resorts and commercial establishments	• Development of construction traffic management plan to ensure smooth traffic flow and reduce traffic congestion. • Arrangement for shared transport where possible to minimise trips.	Possible	Minor	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
					• Management of material delivery schedule and avoidance during rush hours. Delivery of materials in bulk should be arranged to reduce trip frequency.			
Temporary diversion for marine traffic around the Project during construction	Likely	Minor	**Medium**	Marine traffic	Development of marine traffic management plan to minimise diversion of marine traffic as much as possible.	Possible	Minor	**Low**
Potential traffic congestion	Possible	Minor	**Low**	Residents of local community Users (local and visitors) of the neighbouring beaches, resorts and commercial establishments	Development of construction traffic management plan to ensure smooth traffic flow and reduce traffic congestion.	Unlikely	Minor	**Low**
Transport of dredged material to on-land disposal site in the event of unsuitability for reclamation (unconfirmed)	Possible	Moderate	**Medium**	Residents of local community	Appropriate mitigation measures should be provided within the Traffic Impact Study to abate traffic congestion issues in this scenario.	Possible	Moderate	**Medium**
Utilities								

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Power / fuel consumption causing localised air pollution, noise emissions and risk of spill from delivery and on-site storage of fuel, potentially resulting in soil, groundwater or marine contamination	Almost certain	Minor	**Medium**	Construction site workers and visitors Residents and users of nearby residential and commercial establishments Marine flora and fauna	Optimise energy efficiency. Oil spill preventive and contingency management plan / procedure to be established.	Almost certain	Insignificant	**Low**
Water consumption, air emissions, marine and health impacts for desalination and distribution of potable water from DEWA	Almost certain	Moderate	**High**	Water supply / system infrastructure in the Emirate of Dubai Construction site workers and visitors	Implementation of water conservation measures. Re-use of water.	Almost certain	Minor	**Medium**
Potential nuisance odour and contamination of soil, groundwater and marine water from spill / leak of sewage from portable toilets or septic tanks	Possible	Minor	**Low**	Construction site workers and visitors Residents and users of nearby residential and commercial establishments Marine flora and fauna	Implementation of mitigation measures for soil / groundwater and waste management impacts.	Unlikely	Insignificant	**Negligible**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Additional load on the existing road traffic network	Likely	Minor	**Medium**	Local residents and users of the nearby residential and commercial establishments	Implementation of mitigation measures for traffic management impacts.	Possible	Minor	**Low**
Socio-economic								
Generation of employment and business opportunities	Almost certain	Minor	**Medium (Positive)**	Local residents and business owners Expatriates / foreign workers	• Priority given to local companies. • Support in the UAE's Emiratisation policy. • Just and fair compensation to workers.	Almost certain	Moderate	**High (Positive)**
Reduced amenity of surrounding residential and commercial areas as a result of construction traffic, air and noise emissions from traffic and construction equipment and visual impact from the construction site	Almost certain	Minor	**Medium**	Local residents Workers and customers of retail and commercial establishments	• Environmental management measures. • Complaints register and management including the appointment of a community liaison officer. • Construction health and safety risk mitigation	Possible	Minor	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Increased occupational health and safety risk	Almost certain	Moderate	High	Construction workforce and site visitors	The site layout, construction logistics and method should consider the potential environmental, health and safety risk to the workers, visitors and local communities.	Possible	Moderate	Medium
Conflict between local residents and workers	Possible	Moderate	Medium	Local residents Workers and customers of retail and commercial establishments Workers on-site	Provision of induction training to foreign workers to understand and respect culture and religion of the UAE and the Emirate.	Unlikely	Minor	Low
Poor workforce accommodation and living conditions	Possible	Moderate	Medium	Construction workforce	All temporary and permanent labour accommodation is required to meet the requirements of the following standards: - Health Requirements for the Services provided inside Labours Accommodation, Public Health and Safety Department (Doc Ref: DM-PH&SD-P7-W118); and - Health Requirements for Permanent Labour Accommodation, Public Health and Safety Department (Doc Ref: DM-PH&SD-P7-W102).	Unlikely	Minor	Low

Table 8-2 Environmental and Social Impacts Ratings Before and After Mitigation – Operation Phase

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Climate and Meteorology								
GHG emissions (indirect) as a result of electricity and water consumption	Almost certain	Moderate	**High**	Contribution to global climate change causing potential sea level rise.	Optimising water and electricity efficiency / green building design Incorporation of trees in the landscape design	Almost Certain	Minor	**Medium**
Use of materials for operation and maintenance with embodied energy	Likely	Minor	**Medium**	Residents and occupants on site and in vicinity to the relative material production, manufacturing and transport	Use of sustainable building materials in line with the Green Building Regulations and Specifications in the Emirate of Dubai	Likely	Insignificant	**Low**
GHG emissions from use of fuel for vehicles	Almost certain	Minor	**Medium**	Workers and occupants on-site Surrounding communities	Provision of sustainable transport infrastructure such as public transport and/or cycling	Almost certain	Insignificant	**Low**
GHG emissions from use of fuel for marine vessels	Almost certain	Insignificant	**Low**	Workers and occupants on-site Surrounding communities	Use of sustainable fuel alternatives and optimising fuel efficiency of marine vessels. Ensure marine vessels conform to ship pollution rules specified in the “International Convention on the Prevention of Pollution from Ships”, MARPOL 73/78.	Likely	Insignificant	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
GHG emissions associated with waste transport and disposal to landfill	Almost certain	Minor	**Medium**	Workers and occupants on-site Surrounding communities Occupants along the route for the waste transport and nearby landfill site	Implementation of proposed waste management measures (Section 7.9) will facilitate diversion of waste from landfill site to recycling facilities.	Almost Certain	Insignificant	**Low**
Air Quality								
Exhaust gases and particulates emitted from road and marine traffic	Almost certain	Minor	**Medium**	Residents, visitors and occupants of the Project site and surrounding residential and commercial areas	Provision of sustainable transport infrastructure. Landscape by design. Implementation of Traffic Management Plan.	Almost certain	Insignificant	**Low**
Oil mist emitted from catering kitchens	Almost certain	Minor	**Medium**	Residents, visitors and occupants on the Project site and surrounding residential and commercial areas	Install kitchen emission control system.	Possible	Minor	**Low**
Odour emission from leaked	Likely	Minor	**Medium**	Residents, visitors and	Monitors to be installed in the sewerage and TSE networks to monitor for leaks.	Possible	Minor	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
sewage pipes and waste management facilities				occupants on the Project site	Leaks from sewage and TSE pipes to be fixed as soon as possible. Maintain housekeeping and sanitarily conditions of the site.			
Use of chlorinated solvent vapour degreasers	Unlikely	Minor	**Low**	Residents, visitors and occupants on the Project site	Proper installation and operation of a retrofitted enclosure on an open-topped degreaser.	Unlikely	Insignificant	**Negligible**
Noise								
Annoyance	Likely	Minor	**Medium**	Residents, tourists and occupants within the Project site and surrounding areas	Provision of mitigation for indoor environments through building design. Thermal glazing (double glazed windows) to reduce indoor noise levels within buildings in the Project area.	Possible	Minor	**Low**
Hearing impairment	Possible	Minor	**Low**	Residents, tourists and occupants within the Project site and surrounding areas	It is considered unlikely that road traffic noise will constitute a significant impact to the residences and offices built on the Dubai Harbour.	Possible	Minor	**Low**
Soils and Groundwater								
Soil and groundwater contamination from poorly treated TSE used for irrigation	Possible	Moderate	**Medium**	Terrestrial ecology Groundwater consumer	Installation of impermeable liners at the base of all landscaped zones. Only the TSE supplied by DM's TSE network to be used for irrigation. Should other TSE sources are used,	Unlikely	Minor	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
					the TSE quality should meet DM's requirement. Incidents (e.g. odour) indicating poor quality of TSE to be coordinated with the relevant authority.			
Soil contamination due to excessive application of fertilisers, herbicides or pesticides	Possible	Minor	**Low**	Terrestrial ecology	Implementation of an appropriate fertilisers application programme. The feasibility of using soil conditioners to reduce fertiliser application requirements shall be explored. The landscape management plan should include the appropriate demand on fertilisers, herbicides or pesticides; and shall be implemented. No introduction of invasive or exotics flora and fauna on site or species requiring extensive application of fertilisers, herbicides and pesticides.	Unlikely	Insignificant	**Negligible**
Groundwater and marine contamination due to excessive application of fertilisers and pesticides	Unlikely	Moderate	**Medium**	Terrestrial flora and fauna Groundwater consumer Marine flora and fauna		Unlikely	Minor	**Low**
Soil contamination due to accidental spill / leak from utilities (e.g. sewage pumps, power substation) and leachate from waste management facilities	Unlikely	Moderate	**Medium**	Terrestrial ecology	Implementation of routine inspection and maintenance program for the utility and waste management facilities.	Rare	Moderate	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Soil erosion from disposal / settlement of dredged material from channel maintenance (unconfirmed)	Possible	Moderate	**Medium**	Soil	Prior to commencing disposal, the receiving environment should be assessed for adequacy for the purpose, and consideration should be given to placing a liner to reduce soil erosion.	Unlikely	Minor	**Low**
Groundwater contamination due to accidental spill / leak from utilities (e.g. sewage pumps, power substation) and leachate from waste management facilities	Possible	Moderate	**Medium**	Terrestrial flora and fauna Groundwater consumer Marine flora and fauna	Monitor to be installed at the underground network (e.g. sewage, TSE) to monitor for leaks. Regular preventive maintenance and testing to be undertaken. Location of storage tanks should be clearly identified by aboveground signs.	Unlikely	Minor	**Low**
Coastal Processes								
Changes to sediment depositional/erosional patterns resulting from altered current speeds. This could result in the requirement for maintenance dredging	Possible	Moderate	**Medium**	Benthic habitats	Periodic monitoring of the seabed level to ascertain erosion / deposition rates. Development of an operational environmental management plan in case maintenance dredging is required.	Possible	Moderate	**Medium**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Decreased flushing at Mina Al Seyahi Beach	Likely	Insignificant	**Low**	Swimmers at Mina Al Seyahi Beach	Ongoing monitoring of water quality to determine whether water quality has deteriorated. If poor water quality is recorded, use mechanical (installation of water pumps) to increase water exchange.	Likely	Insignificant	**Low**
Decreased flushing at Dubai Marina	Likely	Minor	**Medium**	Water quality within Dubai Marina		Likely	Insignificant	**Low**
Exceedance of marina tranquillity criteria (for waves) at the western berth of Cruise Terminal Marina	Likely	Minor	**Medium**	Ships berthed at the western berth during storm conditions	Install two detached breakwaters to the west of the Palm Jumeirah to reduce wave heights entering the Project area. Extension of the lighthouse platform southwards by 50 m to provide further sheltering within this marina and reduce the likelihood of exceeding the tranquillity criteria at this location.	Unlikely	Minor	**Low**
Sedimentation in the navigation channel and berthing basin	Likely	Minor	**Medium**	Marine environment Vessel operators (altered navigation during maintenance work)	An allowance for siltation has been integrated into the dredge level of the navigation channel to limit the frequency of maintenance dredging. Navigation channel sedimentation report suggests very low required frequency of dredging (20 years). Undertake periodic maintenance dredging	Possible	Minor	**Low**
Improved flushing at DIMC / Dubai Harbour Main Marina	Likely	Insignificant	**Low (Positive)**	Water quality within Dubai Harbour Main Marina	N/A	Likely	Insignificant	**Low (Positive)**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Marine Ecosystem								
Habitat loss and modification from maintenance dredging	Possible	Moderate	**Medium**	Marine flora and fauna	Mitigation is not proposed for the loss and modification of habitat as the existing habitat is considered to be of relatively low ecological value and the provision of additional hard substrate could allow re-colonisation of a range of marine organisms in the future (see below).	Almost certain	Moderate	**Medium**
Provision of additional hard substrate habitat	Almost certain	Moderate	**High (Positive)**	Marine flora and fauna	N/A	Almost certain	Moderate	**High (Positive)**
Potential contamination and nutrient input from stormwater discharge	Possible	Moderate	**Medium**	Marine flora and fauna Beach users	Gross pollutant traps should be utilised to remove sediment fines and waste materials prior to discharge Discharge points should be directed away from any areas of poor flushing to allow fast and efficient dispersion and dilution Strict control on discharges through the stormwater pipeline should be maintained. No other wastewater streams are to be discharged through this system from the project site.	Unlikely	Minor	**Low**
Introduction of invasive or exotic species	Possible	Moderate	**Medium**	Marine ecosystem	Enforce applicable ballast water management regulations for all ships entering the Project site.	Rare	Moderate	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
					Undertake ballast water exchange in accordance with local and international standards. If possible, source vessels from the local reagion; if vessels are from outside, service history should be requested which include treatment of biofouling. Utilise vessels that have not visited locations where marine pest outbreaks are present			
Accidental fuel or chemical leaks / spills from fuel storage, sanitary pumps and lifting stations	Possible	Moderate	**Medium**	Marine ecosystem	Ensure all fuels and chemicals are stored in appropriately bunded and sealed areas and drip / spill trays are utilised. Spill kits and spill response plans will be prepared for operational implementation. Specific OEMP to be prepared to address these aspects. Frequent inspections and preventive maintenance	Possible	Minor	**Low**
Ongoing disturbance to marina fauna from increased marine traffic	Almost certain	Minor	**Medium**	Marine fauna	Enforce speed limits in proximity to the Project site and implement a marine traffic management plan during operation.	Possible	Minor	**Low**
Damage to existing subsea gas pipeline due to vessel activities in the area	Possible	Moderate	**Medium**	Marine ecosystem	Ensure anchors are not dragged along with vessels to prevent damage to existing pipeline and marine environment	Possible	Minor	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Reduced water quality from discharge of stormwater with potentially elevated concentrations of nutrients, pesticides and sediments	Likely	Minor	**Medium**	Marine flora and fauna, beach users	Install oil and silt separators and undertake maintenance as required Control nutrient load from the Project's landscaping Implement appropriate fertilizers and pesticide program on the area to limit any run off into the marine environment	Unlikely	Minor	**Low**
Reduced light climate for photosynthetic marine organisms or smothering of marine benthos in vicinity to the outfalls fromTSS loads	Possible	Minor	**Low**	Marine ecosystem	Install silt separators and undertake maintenance as required	Rare	Minor	**Negligible**
Reduced sediment quality	Possible	Minor	**Low**	Marine flora and fauna	Install oil separators and undertake maintenance as required Control nutrient load from the Project's landscaping	Rare	Minor	**Negligible**
Reduced visual amenity for beach users	Rare	Minor	**Negligible**	Residents of local community. Beach users	N/A	Rare	Minor	**Negligible**
Accidental discharge of sewage from	Possible	Moderate	**Medium**	Marine flora and fauna	Ensure all marine vessels / cruise ship implement waste management plan and comply with relevant local and international guidelines and regulations.	Possible	Minor	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
marine vessels / cruise ship					Implement emergency response plan to address accidental sewage discharge / leak.			
Terrestrial Ecology								
Increased vegetation / flora	Almost certain	Moderate	**High (Positive)**	Beach users Terrestrial fauna	Maintain the landscape in accordance with the approved landscape plan.	Almost certain	Moderate	**High (Positive)**
Introduction of invasive or exotic species	Possible	Minor	**Low**	Terrestrial flora and fauna	All landscaped areas are to be planted with native, salt tolerant plants where possible and the use of invasive species will be prohibited.	Rare	Minor	**Negligible**
Exposure to increased noise	Possible	Insignificant	**Negligible**	Terrestrial fauna	Implement proposed operational noise mitigation measures.	Unlikely	Insignificant	**Negligible**
Exposure to artificial lighting	Almost certain	Insignificant	**Low**	Terrestrial fauna	Design the lighting system to minimise light spill to areas of potential habitat for terrestrial ecology. This includes potential nesting areas for marine avifauna.	Possible	Insignificant	**Negligible**
Waste								
Additional strain on the existing waste management infrastructure and services, particularly hazardous waste management	Almost certain	Moderate	**High**	Residents, visitors and guests Workers involved in waste handling and management	Residents and operators (e.g. hotel, entertainment and retail) should be encouraged to develop and undertake a waste minimisation program tailored to their day-to-day activities / operations.	Almost certain	Minor	**Medium**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
				Terrestrial and marine ecosystem				
Contamination of soil, groundwater, marine and stormwater; odour; vermin infestation, injury / hazard	Possible	Moderate	**Medium**	Residents, visitors and guests Workers involved in waste handling and management Terrestrial and marine ecosystem Soil and groundwater	Development and implementation of an integrated waste management plan including the following key management measures: • Waste minimisation • Waste segregation • Provision of suitable waste management facility • Use of DM approved service providers • Segregation and special collection drive for household hazardous waste • Waste management awareness program	Almost certain	Minor	**Medium**
Potential contamination due to disposal of maintenance dredging materials	Possible	Moderate	**Medium**	Marine flora and fauna	Same as mitigation measures during the construction phase (Table 8-1)	Possible	Minor	**Low**
Traffic and Transport								

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Increase in road and marine traffic as a result of journeys generated by visitors, residents, staff w orking on-site and contractors providing services and goods to the facilities	Almost certain	Moderate	**High**	Residents, visitors and occupants on-site Residents and visitors of nearby residential and commercial areas Local users of nearby beach	Promote use of public transport to access the Project Site through provision of efficient linkages. Development and implementation of an appropriate site traffic management plan. Appropriate design of road and marine transport infrastructure, ensuring that traffic peak flow s can be accommodated. RTA consultation to identify transport opportunities and constraints relevant to the Project. Spill contingency plan (for marine) in place.	Likely	Minor	**Medium**
Traffic congestion	Almost certain	Moderate	**High**	Residents, visitors and occupants on-site Residents and visitors of nearby residential and commercial areas Local users of nearby beach	Development and implementation of site traffic management, ensuring smooth traffic flow at site entry and exit points. Appropriate design of road and marine transport infrastructure, ensuring that traffic peak flow s can be accommodated.	Unlikely	Moderate	**Medium**
Impact to benthic infauna in case vessels cross out	Possible	Moderate	**Medium**	Marine ecosystem	Facilitate vessel maoeuverability by tug assistance during arrvivals and	Unlikely	Minor	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
of the navigation channel					departures, particularly during high wind conditions.			
Accidental spills or leaks due to vessel damage or collisions	Possible	Moderate	**Medium**	Marine ecosystem	Facilitate vessel maoeuverability by tug assistance during arrvivals and departures, particularly during high wind conditions.	Unlikely	Minor	**Low**
Utilities								
Electricity and water consumption resulting in additional load / strain on the available power resources in the Emirate and contribution to GHG emissions associated with the operation of the power plant.	Almost certain	Moderate	**High**	Residents of the surrounding communities Operators and users of surrounding commercial establishments	Incorporate energy efficient measures during design of building. Ensure compliance with the Green Building Regulations and Specifications in the Emirate of Dubai. Coordinate with the relevant authority to ensure availability for connection to an existing power supply network.	Almost certain	Moderate	**High**
Utilisation of TSE for landscape irrigation (reuse of a waste stream)	Almost certain	Minor	**Moderate (Positive)**	Residents of the surrounding communities Operators and users of surrounding commercial establishments	Coordinate with the relevant authority to ensure availability for connection to an existing irrigation water supply and distribution network.	Almost certain	Minor	**Moderate (Positive)**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Use of TSE that has not been treated to the required standard, causing contamination to soil and groundwater and potential adverse health impacts to visitors and residents	Unlikely	Moderate	**Medium**	Residents of the surrounding communities Operators and users of surrounding commercial establishments	Ensure treatment procedures for TSE are compliant with applicable standards	Unlikely	Minor	**Low**
Generation of sewage requiring connection to sewerage network and consequently leading to increased load / strain on existing sewerage network and STP; associated air / noise issues	Almost certain	Moderate	**High**	Residents of the surrounding communities Operators and users of surrounding commercial establishments	Coordinate with the relevant authority to ensure availability for connection to an existing sewerage network. Minimise the interior water usage.	Almost certain	Moderate	**High**
Socio-economic								
Enhancement of tourism activity, creating business and employment opportunities	Almost certain	Moderate	**High (Positive)**	Residents of local community Expatriates / foreign workers Tourists	Priority given to local companies. Support in the UAE's Emiratisation policy. Just and fair compensation to workers.	Almost certain	Major	**High (Positive)**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
Change in land use and improved amenity	Almost certain	Moderate	**High (Positive)**	Residents of local community Users of nearby beach, resorts, hotels and commercial establishments Tourists	Implementation of appropriate environmental management measures.	Almost certain	Moderate	**High (Positive)**
Occupational / community health and safety risk and deterioration of environmental quality	Possible	Moderate	**Medium**	Residents of local community Employees and staff on-site Tourists	Good housekeeping of facilities on site (e.g. waste storage areas, pest control) to minimise nuisance, health and safety risk to the neighbouring areas. Malfunctioning facilities (e.g. leaking sewage pipes) should be fixed promptly. Regular monitoring of utility infrastructure should be undertaken.	Possible	Minor	**Low**
Increase in local population resulting in additional load / strain on existing local service utilities and infrastructure	Almost certain	Moderate	**High**	Residents of local community Expatriates / foreign workers Tourists	Ensure provision of adequate service utilities and infrastructure on-site and / or via government / public service. Consultation with the relevant service providers (including DM, DEWA) for utility planning and management.	Almost certain	Minor	**Medium**
Increased chances of vessel collision due to increased number of vessels in the area	Possible	Moderate	**Medium**	Residents of local community Expatriates / foreign workers	Marine traffic risk assessment and development of marine traffic management plans to reduce the impact of increased marine traffic and potential collisions during operation.	Unlikely	Moderate	**Low**

Project Impact	Initial Impact (before implementing mitigation measures)				Mitigation Measures	Residual Impact (after implementing mitigation measures)		
	Likelihood	Consequence	Impact Rating	Impacted Parties		Likelihood	Consequence	Impact Rating
				Tourists				

9. Stakeholder Consultation

9.1 Overview

Stakeholder consultation is an important component of how the Proponent conduct its businesses and is an integral part of any EIA process. Stakeholder engagement enables project teams and management to identify, monitor and address issues as they pertain to a Project. It also provides opportunities for stakeholders (e.g. regulatory authorities, interest groups, local community and the general public) to provide commentary on the Project and its real and perceived adverse impacts and benefits. Engagement requires not only dialogical processes but also the use of transparent issues management. It is a two-way process of disseminating and receiving information.

This section describes the stakeholder consultation activities undertaken for the Project to date.

9.2 Stakeholder Engagement Activities

9.2.1 Government and Statutory Stakeholders

Government, statutory and service providers were consulted for the Dubai Harbour Development. Consultation includes presentation of the proposed Project and submission of requirements in order to obtain the necessary permits for the construction and operation of the proposed Dubai Harbour development. Further consultation with the government authorities will be carried out. A summary of the consultation activites that has been undertane is provided in Table 9-1.

9.2.2 The Local Community and Wider Public

The concept of the project was announced in January 2017. The general public was informed of the project via media releases including the following:

- Arabian Business – 02 January 2017
- The National – 02 January 2017
- Time Out Dubai – 02 January 2017
- Design MENA – 03 January 2017
- What's On – 05 January 2017

The North 25 company website provides a description of the proposed Project and location. This website also provides the following routes for contacting the proponent regarding the Dubai Harbour Project and any of its projects.

- Postal address
- Telephone and facsimile number (800-637227)
- Email address
- Instant messaging

Table 9-1 Stakeholder engagement with government and statutory stakeholders

Authority		Comments from Authority (if any)	Status	Action by	Response
Dubai Electric and Water Authority (DEWA)	Electricity	DEWA requested for additional detailes of micro-tunnelling required for the 132kV corridor. DEWA requested for expedited issuance of the Affection Plans for the Primary substations. DEWA issued several technical comments to be addressed on the nexct desig nstage.	Master Plan (MP) SOS Approval obtained for power Master Plan	AECOM	Further Detailed Design development under preparation
	Water	No comment	MP SOS Approval obtained for water demand and connection	AECOM	Further Detailed Design development under preparation
Dubai Civil Defense		Consultation meeting held during project planning. Submission of the MP yet to be made.	In Progress	AECOM	–
Dubai Civil Aviation Authority (DCAA) and SkyDive Dubai		Extensive consultation with SkyDive were undertaken throughout the development of the Master Plan. DCAA were always present during the consultations. Several mitigation strategies are under discussion to assure ongoing and undisturbed operations of SkyDive Dubai.	In Progress	AECOM	Once the consultations with SkyDive are completed, the sibmission of the MP to the DCAA will proceed.

Authority		Comments from Authority (if any)	Status	Action by	Response
Dubai Municipality (DM)	Planning Department	DM comments on CMP were implemented and DM accepted the MP. The SOS was issued on 22 June 2017. Revised SOS issued on 08 August 2017.	In Progress	AECOM	Final approval by DM once all SOS signatures are collected.
	Drainage and Irrigation Department	DM sent a letter confirming that the existing network cannot cater for the additional sewerage and accordingly will need external upgrade.	MP SOS Approval obtained	AECOM	Further Detailed Design development under preparation
		DM sent a letter confirming that the existing network cannot cater for the additional TSE and accordingly will need external upgrade. North 25 has been requested to contribute to the upgrading costs. North 25 sent a response to DM confirming their commitment to abide by the regulations and associated cost. (Appendix K).	MP SOS Approval obtained.	North 25 / Shamal	Further Detailed Design development under preparation by AECOM
	Environmental Department	Environmental studies ongoing by GHD and Sogreah	In Progress	GHD / Sogreah	–
Roads and Traffic Authority (RTA)	Traffic	RTA has reviewed and approved the Methodology Report and the Modelling Report for the Traffic Impact Study (TIS). AECOM is frequently communicating with the RTA to assure that all requirements are incorporated. RTA has requested that Cruise Terminal baselines are introduced to the TIS, which	The TIS report has been submitted to the RTA on the 14 August 2017.	RTA / AECOM	–

Authority		Comments from Authority (if any)	Status	Action by	Response
		was done based on the various Cruise Termianls traffic data, including the Port Rashir Terminal.			
	Public Transport	RTA was approached to discuss the Public Transport Strategy for the Dubai Harbour. RTA suggested that they will support the implementation of Public Transport preferred option. AECOM has prepared a seperate Public Transport Strategy Report, which supplements the TIS, for review and approval of the RTA. RTA recommended public 2020 and 2030 bus route options to be tested from feasible and traffic impact perspectives	In Progress	AECOM	The final SOS of the RTA will require approval of the TIS at first
	Roads	–	–	–	–
	Right of Way (ROW)	–	–	–	–
	Marine Transportation	RTA Marine were consulted and provided requirements for the Marine Transprtation Routes and Water Taxi Requirements to be incorporated into the MP and other informaiton required.	In Progress	AECOM	The final SOS of the RTA will require approval of the TIS at first
Dubai Police		All requirements made by Dubai Police during the meetings at the early MP	In Progress	AECOM	–

Authority		Comments from Authority (if any)	Status	Action by	Response
Dubai Maritime City Authority (DMCA)		development stage were implemented into the Master Plan. MP submission was made to Dubai Police on 24 July 2017. Further meeting is planned to address any comment the Dubai Police May have.	Sogreah/Artelia is obtaining approvals from DMCA for marine works	Sogreah / Artelia	–
Telecommunication	Etisalat and DU	–	MP SOS Approval obtained for telecommunication network.	–	Further Detailed Design development under preparation by AECOM
EMPOWER / District Cooling		North 25 has investigated the possibility of providing District Cooling to the Development. Meetings with Empower and other providers were held. Currently no District Cooling is envisioned for the Master Plan.	–	–	–
Nakheel		A meeting between Nakheel and North 25 was held to discuss Dubai Harbour and potential relocation of the DIMC Marina to Palm Jebel Ali Area. This relocation plan has later been abandoned.	–	North 25	–

10. Environmental Management and Monitoring Program

10.1 Introduction

The framework Environmental Management and Monitoring Plan (EMMP) forms part of this EIA report to provide a mechanism for the development and implementation of mitigation measures against potential adverse environmental impacts from the Project construction and operational activities. It also incorporates actions necessary for the monitoring, reporting and auditing of the Project's environmental performance in line with DM standard requirements.

This framework EMMP is a guidance document to be referred to when developing the more comprehensive and site specific Construction and Operational EMPs, which are stand-alone documents that may need to be submitted to DM post EIA.

10.2 Objectives

The objectives of this framework EMMP are outlined below:

- To provide guidance for the development of the more comprehensive Construction and Operation EMPs;
- To outline mitigation measures and management procedures to be implemented in order to ensure that the Project is designed, constructed and operated in accordance with the requirements of all relevant environmental legislation, policy and guidelines;
- To provide a mechanism for monitoring and reporting of the various environmental undertakings of the Project, which will include routine liaison with DM environmental regulatory authorities;
- To define environmental roles, responsibilities and accountabilities of parties and individuals, ensuring that all entities involved in the Project understand and adhere to the environmental management requirements relevant to their line of work;
- To set the requirements for environmental induction and training program; and
- To ensure continuous improvement of the Project's overall environmental performance through a continual review of specific EMPs and audit of the Project's compliance to EMPs requirements.

10.3 Implementation

This framework EMMP should be employed as a guideline for the design, construction and operation of the Project. Specific components of this EMMP will be finalised as separate management plans for each stage of the construction and operation phases of the Project. Specific management measures will also be incorporated, where relevant, in the Contractors' work method statements.

Managers and supervisors are responsible for providing assurance that their work unit complies with the requirements in this framework EMMP as translated to Construction and Operation EMPs. This can be done via conducting regular inspections, monitoring and audits of the Project management system and / or specific EMPs.

Audits can be undertaken as regular internal or end of phase ‘milestone’ checks against regulatory guidelines by internal staff or independent external auditors. A documented auditable trail should be established for verification purposes.

10.4 Responsibilities

As the developer, North 25 has the overall responsibility of ensuring that adequate environmental management measures are continuously implemented throughout the Project development and operation. However, the construction and operation of the Project will involve a number of parties and individuals, which will have direct and indirect contribution to, and consequently influence on the overall environmental performance of the Project.

In order to ensure effective implementation of this EMMP, specific duties and responsibilities are delegated as outlined in Table 10-1.

Table 10-1 Roles and Responsibilities in the Implementation of EMMP

Party	Responsibilities
Developer	
North 25	o Ensure that all relevant parties comply with the environmental management and monitoring requirements of this CEMP. o Ensure that all contractors and their sub-contractors receive, and adhere to, relevant environmental instructions in relation to the CEMP. This can be done by incorporating environmental clauses in work instructions and service contracts. o Ensure that all contractors and their sub-contractors, supervisory and management staff are competent and committed to their responsibilities in accordance with this CEMP. o Ensure that appropriate and adequate resources are allocated to allow for the effective implementation of the environmental management and monitoring requirements of this CEMP. o Ensure that periodic reviews of the Project’s environmental performance are conducted. o Report to DM any major environmental incidents that may have significant impact on the environment both within the Project boundaries and / or the surrounding areas. o Ensure that corrective actions, where required, are undertaken in order to safeguard the environment, public health and safety. o According to the Project scope and when required, appoint a DM-accredited third party consultant to conduct periodic environmental site audits to check compliance with Overarching CEMP, and to submit the audit report to DM. o Appoint a dedicated Project environment personnel (or engage environment consultant) that manage construction activities on site and management compliance with the CEMP. o Review and approve the Contractor’s specific method statement and proposed control measures for the Project’s construction activities not covered in the Overarching CEMP prior to Contractor submission to DM.

	o Ensure that the Overarching CEMP is reviewed / updated when changes occur; review and approve the proposed update; and provide the updated information to DM. o Deal with the environmental complaints an working with the Contractors in environmental compliant investigation(s).
Lead Consultant	
AECOM	o Responsible for managing the overall construction works and activities, including other contractors and sub-contractors working under its management and supervision. o Provide a logistics plan to North 25 clearly defining the detailed arrangements of the lay down area. o Provide an organizational chart showing the key personnel and Contractors in managing the construction project. o Provide measures ensuring Contractors / Subcontractors compliance with the Overarching CEMP and specific method statements. o According to the Project scope and when required, carry out environmental inspection, field monitoring and internal environmental performance audit. o Deliver environmental site induction and training to their staff members and to the Contractors / Subcontractors.
Marine Engineering Consultant	
Sogreah	o Provides input for the development of the detailed project plan to the Project proponent. o Ensures that site activities are executed as per Project plan and in compliance with relevant environmental instructions in relation to the CEMP. o Ensure the compliance of the contractors / sub-contractors to the requirements set out in this CEMP. o Ensure that corrective actions, where required, are undertaken in order to safeguard the environment, public health and safety. o Ensure that all equipment is maintained in appropriate condition to minimise the risk of environmental incidents.
Contractors and Subcontractors	
Van Oord: Marine Works Majestic: Pontoon Demolition Goldine: Demolition Contractor Energo Project: Substation Contractor	o Be aware of and understand the environmental management and monitoring requirements relevant to their scope of work. o Carry out all works in a manner that will have the least impact on the environment. o Establish an Environmental Management Team (typically integrated into Environment, Health and Safety Management Team) and designate competent personnel (Site Environmental Engineer) to oversee the day-to-day environmental undertakings on-site.

S&B Fencing: Site Hoarding Arif & Bintoak: Fit-out Design and Supervision Other Contractors and Subcontractors	o Ensure all personnel, including subcontractors, and site visitors adhere to the requirements of the EIA. Where necessary, work method statements should be developed incorporating appropriate environmental controls. o Ensure that all site workers are competent to undertake their designated works. o Ensure that adequate environmental training is provided to all personnel, including subcontractors, involved in the construction works. o Make sure that environmental safeguards and precautions are developed and implemented throughout the construction. Regular site inspections, monitoring and audits should be undertaken and documented through formal periodic reports. o Report to North 25 all environmental incidents as soon as practicable. o Ensure that corrective actions, where required, are undertaken in order to safeguard the environment and public health and safety.
Environmental Consultant	
GHD Global Pty Ltd	o Perform the following tasks: – Environmental monitoring activities – Weekly inspections of the contractors to assess compliance with the EIA and CEMP o Investigate and report environmental incidents and non-conformances to the Project proponent and contractor manager along with required corrective actions. o Process environmental monitoring data and consolidate contractors' monthly environmental reports to be submitted to the DM on a monthly and quarterly basis o GHD has been appointed as the Environmental Consultant for the Project. As such, with the approval of North 25, GHD is responsible for: – Communicating with DM on environmental matters; – Arranging adequate and appropriate resources to implement the CEMP specifically the conduct monitoring activities; – Reporting environmental performance of the Project to EAD at the time interval as required; – Communicating with Contractos on environmental matters.

10.5 Organizational Structure

The implementation of this Framework EMMP during the construction phase of the Project will be in accordance to the organizational structure shown in Figure 10-1. A number of main contractors will likely be engaged for the construction of different Project components. Similar structure will be adopted during the operation phase of the Project.

As the developer, North 25 is primarily responsible in ensuring that the construction and operation of Project are undertaken in accordance with the requirements of this Framework EMMP.

10.6 Resources

North 25 shall ensure that all appropriate resources are readily available to facilitate the effective implementation of environmental mitigation and monitoring measures proposed in this EIA. During the construction phase, North 25 can delegate this task to the main contractor(s). Examples of the resources required include:

- Competent and experienced personnel appointed to manage environmental issues;
- Provision of environmental training;
- Adequate time and budget allocated for personnel to manage environmental issues (e.g. environmental monitoring, training);
- Provision of suitable documentation including environmental monitoring records, incident reports and corrective action plans; and
- Purchase of appropriate devices and equipment for pollution control and monitoring.

10.7 Induction and Training

North 25 should ensure that all entities involved in the construction and operation of the Project receive adequate environmental induction or orientation. Environmental induction and trainings should be undertaken to provide awareness, delegate responsibilities and seek commitment among key environmental players involved in the Project.

Induction and trainings should be developed to provide all relevant entities a clear understanding of the following:

- The requirements and importance of complying with environmental standards, regulations, laws and policies;
- The environmental aspects of their activities and the benefits of improved personal environmental performance;
- Specific roles and responsibilities in implementing environmental management measures and monitoring;
- The environmental management and monitoring programs developed for the Project / relevant to their line / scope of work; and
- The potential consequences of non-compliance with the environmental management and monitoring activities.

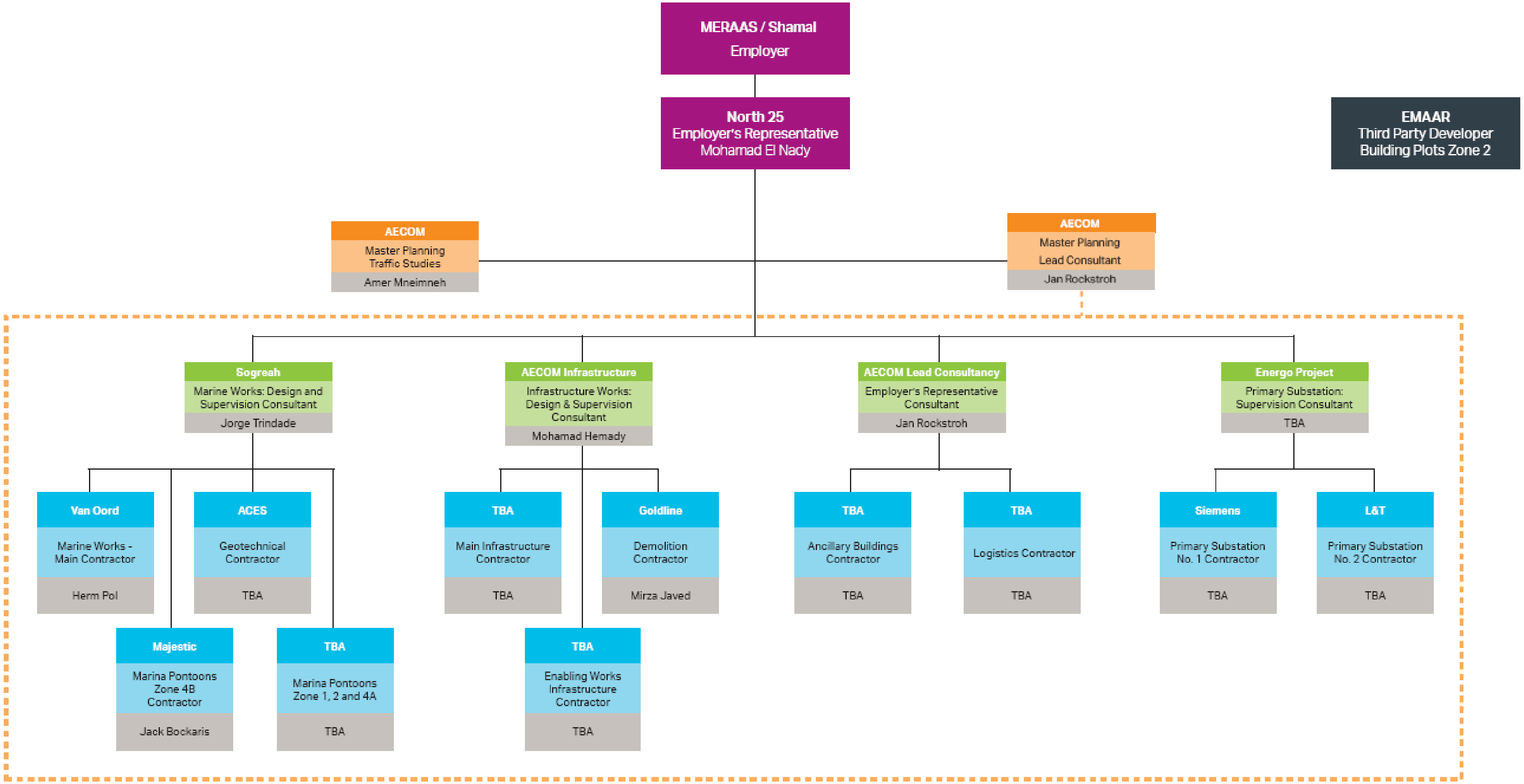


Figure 10-1 Environmental Management Organization Structure during Construction Phase

10.8 Monitoring and Record Management

Environmental monitoring will be required throughout the Project lifecycle and should be developed according to the following objectives:

- Ensure that the proposed mitigation measures are consistently implemented;
- Assess whether the mitigation measures in place are adequate and identify any requirement for additional measures to ensure that impacts are minimised, where possible and reduced to acceptable level; and
- Assess Project's compliance to the relevant environmental regulatory requirements / standards.

Ultimately, the program will facilitate continuous improvement of the Project's overall environmental performance. The environmental monitoring plan is provided in Section 10.9.

An Environmental Monitoring Program Register should be maintained to facilitate a well-documented and accurate assessment of the Project's overall environmental performance. The register should include, but not be limited to, the following information / documents:

- Daily site inspection checklist;
- Environmental monitoring results (e.g. water quality, noise) and compliance status with environmental standards specified by Federal Law and/or DM;
- Audit reports;
- Incident reports including corrective actions;
- Non-compliance reports including corrective actions; and
- Complaint register and management reports.

The documents listed above shall prove useful in providing compliance evidence during environmental audits.

10.9 Environmental Management Plans

A project wide CEMP has been developed (Ref: 76106664-CEMP-33567, Rev 0), based on the construction method statements provided by the appointed contractor(s). This document was submitted on 18th October 2017 and is under currently review by DM. The CEMP will be revised and updated as necassary, based on the findings and recommendations of this EIA report and / or any comments received from DM. An OEMP will be developed based on the findings and recommendations of this EIA report.

An NOC was received from DM-ED for early works, including demolition, site preparation and preliminary construction. As part of the conditions, a CEMP was developed by the contractor, based on the construction method statements for these activities, in line with the NOC. As the Project has progressed, additional activities have been added to the NOC and consequently the Early Works CEMP has been revised and updated to reflect current site conditions and planned activities. The early works CEMP (Ref: DHM-HSE-002) is currently on Revision 7; included activities are detailed in Section 4.6.2. Should any further activities be approved as part of the Early Works NOC, additional CEMP revisions will be developed.

For any construction activity, the CEMP should be approved and relevant NOCs secured prior to commencement of construction.

The OEMP should be prepared at least three months prior to operation commencement for the Project to ensure that all parties can prepare for the required monitoring and environmental management requirements. Further details on the CEMP and OEMP requirements are provided in the following sub-sections.

10.9.1 Construction Environmental Management Plan

The CEMP will contain only applicable project components as stipulated in the approved EIA and will contain the following items as a minimum:

- **Introduction –** Introduce the Project and the CEMP including the objectives and structure;
- **Overview of the Project Development –** Provide an overview of the Project including any changes / updates since completion of this EIA Report. The overview should include details of sensitive receptors, project phases, quantities to be dredged / reclaimed, information on temporary construction-phase utilities, laydown areas, offices and other ancillary facilities;
- **Construction Methodology –** Detailed information on the construction methods to be employed, including workforce, schedule and equipment;
- **Identified Environmental Aspects and Impacts –** Summary of the key environmental impacts of the Project, as identified within this report;
- **Mitigation Measures –** The measures to be implemented to mitigate the key impacts of the project;
- **Environmental Monitoring Plan –** A detailed monitoring plan based on the construction impacts and areas. The monitoring plan should include the exact locations, duration, frequency, method and comparison criteria for each component to be monitored;
- **Incident/Emergency Preparedness and Response –** Provide the emergency response plan for key potential emergencies. This should include the protocol, required training, drills, responsible personnel and appropriate contact numbers;
- **Data Management and Reporting –** Details on how the monitoring (and other environmental data) will be managed and reported on;
- **Statement of Responsibilities –** List of which personnel / companies will be responsible for each aspect of the environmental management / mitigation. Training requirements should also be included.

Further, specific environmental control plans will be provided as an appendix that can be provided to relevant personnel. The control plans will include the monitoring requirements, responsibilities and environmental management measures to be implemented in the form of specific detailed instructions. Control plans will be prepared for the following as a minimum:

- Dust control
- Gaseous emissions
- Reclamation and sedimentation
- Noise and vibration
- Waste management
- Wastewater management

- Hazardous materials management.

Further, a specific traffic management plan and complaints and grievance mechanisms will be prepared.

10.9.2 Operational Environmental Management Plan

The OEMP will contain only applicable project components as stipulated in the approved EIA and will contain the following items as a minimum:

- **Introduction –** Introduce the Project and the OEMP including the objectives and structure;
- **Overview of the Project Development –** Provide an overview of the Project including any changes / updates since completion of this EIA Report. The overview should include details on potential emissions to air and noise sources, expected traffic numbers, wastewater discharges from the cruise terminal, marinas, stormwater outfalls, restaurants, and other hotel facilities, landscaping, beach nourishment requirements, maintenance and fuelling facilities and maintenance dredging requirements;
- **Identified Environmental Aspects and Impacts –** Summary of the key environmental impacts of the Project, as identified within this report;
- **Mitigation Measures –** The measures to be implemented to mitigate the key impacts of the project;
- **Environmental Monitoring Plan –** A detailed monitoring plan based on the operational impacts and areas. The monitoring plan should include the exact locations, duration, frequency, method and comparison criteria for each component to be monitored;
- **Incident/Emergency Preparedness and Response –** Provide the emergency response plan for key potential emergencies. This should include the protocol, required training, drills, responsible personnel and appropriate contact numbers;
- **Data Management and Reporting –** Details on how the monitoring (and other environmental data) will be managed and reported on;
- **Statement of Responsibilities –** List of which personnel / companies will be responsible for each aspect of the environmental management / mitigation. Training requirements should also be included.

As appendices to the OEMP, a specific management plan should be provided for each of the key areas / facilities of the Project, including but not limited to:

- Cruise terminal;
- Marinas (including all maintenance and fuelling facilities);
- Beaches;
- Dredged access channel;
- Utilities and connections (water, power, stormwater).

The management plan would provide details on maintenance requirements, environmental management and monitoring and responsibilities.

10.10 Environmental Monitoring Plan

The proposed environmental monitoring programme for the construction and operation phases of the Project is presented in Table 10-2 and Table 10-3, respectively. A final monitoring plan with monitoring locations will be provided in the Project CEMP, which will be developed for the remaining activities associated with the development.

Table 10-2 Environmental Monitoring Program for Construction Works

Particular	Air Quality	Noise	Marine Water					Weather	Marine Sediment	Dewatering Effluent	Benthic Infauna	Reclamation Fill Material	Marine fauna and avifauna
			Analytical	Daily *in-situ*	Continuous	Water Movement	Tide						
Monitoring Parameter	Dust: • PM_{10} (1-hr) • PM_{10} (24-hr)	• L_{Aeq} • L_{A10} • L_{A50} • L_{A90} • L_{Amax} • L_{Amin}	• TSS • TDS • pH • Metals (Al, As, Cd, Cr, Cu, Ni, Pb, Zn, Hg, Fe) • Bacteriological (E. coli, faecal coliform • Conductivity • BOD • COD • Chlorides • Chlorine • Detergents • Nutrients (nitrite, nitrate, phosphate, phosphorus, ammonia) • Pesticides (non-chlorinated) • Petroleum hydrocarbons • Phenols • Sulphide • Chlorophyll-a • Oil & grease	• pH • Dissolved oxygen • Turbidity • Temperature	• Turbidity • Dissolved oxygen • pH • Temperature	• Current speed and direction • Waste speed and direction	• Sea level	• Wind speed • Wind direction • Precipitation • Pressure	• Sulphide • BTEX • m&p Xylene • VPH C5-C10 • EPH C10-C40 • PAH • Phenols • PCBs • Organics (tributylin, dibutylin, monobutyltin) • Total nitrogen • Total phosphorus • TOC • Enterococci • E. coli • Streptococci • Metals (Al, As, Cd, Cu, Pb, Hg, Ni, Zn) • PSD	• pH • Salinity • Turbidity • Suspended Solids • Nitrate-Nitrogen • Sulphides • BOD_5 • COD • Phosphate-Phosphorus • Ammonia • Hydrocarbons • Metals (Cu, Pb, Cd, Ni, Co, Zn) • Faecal coliform	• Benthic infauna taxonomic identification	• Sulphide • Metals (Al, As, Cd, Cu, Ni, Pb, Zn, Hg) • Total Petroleum hydrocarbons (C_6-C_{10}, C_{10}-C_{16}, C_{16}-C_{34} and C_{34}-C_{40}) • BTEX • TOC • PAH • Phenols	• Incidental observation of marine fauna (mammal and reptile) and avifauna

Particular	Air Quality	Noise	Marine Water					Weather	Marine Sediment	Dewatering Effluent	Benthic Infauna	Reclamation Fill Material	Marine fauna and avifauna
			Analytical	Daily *in-situ*	Continuous	Water Movement	Tide						
Monitoring Location	Two locations at the border of the site next to sensitive receptors: • AN1 • AN2	Two locations at the border of the site next to sensitive receptors: • AN1 • AN2	Buoys 1–5 Outside active reclamation discharge points Two locations in Dubai Marina	Buoys 1–5 25 and 50 m from silt curtains 100 m / 200 m from silt curtain if turbidity exceeds 10 NTU Reclamation discharge point and outside discharge silt curtain Two locations in the Dubai Marina	Five monitoring locations: • Buoy 1 (25.09656 N, 55.14722 E) • Buoy 2 (25.10329 N, 55.13914 E) • Buoy 3 (25.10537 N, 55.11600 E) • Buoy 4 (25.08280 N, 55.13139 E) • Buoy 5 (25.08794 N, 55.14362 E)	Two stations: • Buoy 4 (25.08280 N, 55.13139 E) • Buoy 5 (25.08794 N, 55.14362 E)	To be determined	Deployed with air and noise station AN1	Twelve locations covering key impact areas, including two Dubai Marina sites and one reference site.	Two dewatering tanks to assess quality prior to discharge	Five locations covering key impact areas, plus one reference site.	Dredge material prior to placement at one or various locations.	Project site

Particular	Air Quality	Noise	Marine Water					Weather	Marine Sediment	Dewatering Effluent	Benthic Infauna	Reclamation Fill Material	Marine fauna and avifauna
			Analytical	Daily *in-situ*	Continuous	Water Movement	Tide						
Frequency and Duration of Monitoring	Twice a week (when construction work is carried out): • One measurement on a weekday; and • One measurement on a weekend day. On each monitoring, event, the following will be undertaken: • PM_{10} sampling / monitoring for a period of 1 hour; • PM_{10} sampling / monitoring for a period of 24 hours; and • TSP sampling / monitoring for a period of 24 hours.	Four measurements a week (when construction work is carried out): • One measurement on a weekday during day time • One measurement on a weekday during night time (if construction work is carried out) • One measurement on a weekend day during day time • One measurement on a weekend day during night time (if construction work is carried out) Measurement shall last 15 minutes.	The frequency of sampling will be determined at the Project CEMP. Samples will be taken at two depts.: • 1 m below surface • 1 m above seabed	Continuous during in-water construction activities Real-time/Continuous turbidity monitoring through fixed stations.	Continuous with real time data transfer throughout all in-water works	Continuous with real time data transfer throughout all in-water works	Continuous with real time data transfer throughout all in-water works	Continuous with real time data transfer	Quarterly	As per the NOC to discharge groundwater. In the event that frequency is not indicated in the NOC, sampling and testing will be undertaken on a monthly basis.	Annual	Monthly testing of dredge fill material prior to placement. Where routine visual and olfactory checking indicates potential contamination of fill materials.	Continuous (incidental observation)

Particular		Monitoring Method	Equipment
Air Quality		Light scattering – integrating nephelometer method or Particulate matter – impinged matter – directional dust gauge method or Particulate matter – TSP – high volume sampler method Particulate matter – PM10 – high volume sampler with size-selective inlet	Osiris Monitor or Topas Monitor or equivalent High-volume sampler or equivalent
Noise		ISO 1996-1: 2003, Acoustics – Description, measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures	Sound Level Meter and Sound Calibrator (Type 1 or above)
Marine Water	Analytical	Water sampling will be carried out using a 4.2 litre Beta Water Sampler (or similar). Samples will be collected from mid-depth in the water column. Samples will be stored in refrigerated conditions before transfer to DAC approved analytical laboratory for analysis.	4.2 litre Beta Water Sampler (or similar); Grab sample collected in a sample container made of material comply with APHA recommendation (or equivalent) followed by laboratory testing; and YSI 6920 V2 Multi-Parameter Intelligent Logger (or similar)
	Daily *in-situ*	Parameters will be measured using a hand-held calibrated YSI Exo-2 Multi Parameter Probe (or similar) deployed from the survey vessel	YSI 6920 V2 Multi-Parameter Intelligent Logger (or similar)
	Continuous	Water quality monitoring stations will use YSI Exo2 multiparameter sondes (or similar) mounted in custom built solar powered buoys with real-time data transfer Measurements will be taken at the top of the water column.	YSI Exo2 multiparameter sondes mounted in custom built solar powered buoys with real-time data transfer
	Water Movement	Acoustic Doppler Current Profiler (ADCP) with real time data transfer	Acoustic Doppler Current Profiler (ADCP) with real time data transfer
	Tide	Use of tidal gauge	Tidal gauge
Weather		Use of weather station	Weather station
Marine Sediment		Sampling and laboratory testing by DAC approved laboratory	Van Veen grab
Dewatering Effluent		Sampling and laboratory testing by DAC approved laboratory	Grab sample collected in a sample container made of material which complies with APHA recommendation (or equivalent) followed by laboratory testing; and YSI 6920 V2 Multi-Parameter Intelligent Logger (or similar)
Benthic Infauna		Sampling and identification by appropriately qualified marine biologist	Van Veen grab 0.5 mm mesh sieve. 10% formaldehyde solution
Reclamation Fill Material		Sampling and laboratory testing by DAC approved laboratory	Composite sample collected from dredged material from each borrow area filled directly into a sanitised glass sample container followed by laboratory testing
Marine fauna and avifauna		Incidental observation	Binocular

Particular	Air Quality	Noise	Marine Water					Weather	Marine Sediment	Dewatering Effluent	Benthic Infauna	Reclamation Fill Material	Marine fauna and avifauna
			Analytical	Daily *in-situ*	Continuous	Water Movement	Tide						
Trigger Level for Corrective Actions	• Federal ambient air quality standard for PM_{10}: - 150 $\mu g/Nm^3$ (24-hr) • DM ambient air quality standard: PM_{10} - 300 $\mu g/Nm^3$ (1-hr) - 150 $\mu g/Nm^3$ (24-hr) TSP - 250 $\mu g/Nm^3$ (24-hr) • Visible dust emission • Community complaints	Federal Allowable Noise Limits for *Residential areas with some workshops and commercial near highways*, plus the Incremental allowable noise level (Table 6-9 and Table 6-10): - 60dB(A) (daytime) - 50 dB(A) (night time) • Community complaints	• DM Water Quality Objectives (Table 3-11)	• DM Water Quality Objectives (Table 3-11)	• Automated alerts for turbidity equivalent to 25 mg/l TSS • [10 NTU until relationship with TSS is established]	• NA	• NA	• NA	• The Australian New Zealand Guidelines for Fresh and Marine Water and Sediment Quality (2000) (Table 3-9); and • The National Oceanographic and Atmospheric Administration (NOAA) sediment quality guidelines (1999).	DM Effluent Standards for Marine Water Discharge (Table 3-6)	N/A	The National Assessment Guideline for Dredging (NAGD) will be used for assessment of marine sediment fill materials (Table 3-10)	NA
Actions to be taken in the event that the Trigger Level is exceeded	• The activities carried out on the construction site and in the vicinity of the monitoring location during monitoring (via reviewing the field record sheet) shall be reviewed to determine if exceedances are associated with the Project construction activities on site. • If the exceedance is associated with the Project, cease the construction activity causing the exceedance, identify cause and implement appropriate corrective actions. • If the exceedance is not associated with the Project construction activities, actions are not required.									• Contaminated dewatering effluent shall not be discharged into the sea or reused on site. • Offsite disposal via DM approved waste contractors should be considered.	N/A	• Contaminated fill materials shall not be used onsite. • Alternative borrow areas should be identified.	• N/A

Table 10-3 Environmental Monitoring Program for Operational Works

Particular	Noise	Marine Water Quality	Treated Sewage Effluent (TSE)
Monitoring Parameter	L_{Aeq}, L_{A10}, L_{A50}, L_{A90}, L_{Amax}, L_{Amin}	• pH • Conductivity • Dissolved oxygen • Turbidity • Temperature • Salinity • TSS • Metals (aluminium, cadmium, chromium, copper, nickel, lead, zinc, mercury, arsenic, iron) • BOD • Nutrients • Oil & grease • TDS • Faecal coliform	As per DM Accepted Limits of Treated Wastewater for Restricted and Unrestricted Irrigation (Table 3-13).
Monitoring Location	Noise impact area where there is a complaint.	Four within the marinas (one location within each marina) Two locations around the development Two locations within Dubai Marina	Point of TSE supply (one location).
Frequency and Duration of Monitoring	Noise monitoring should be undertaken in the event that a complaint is received from sensitive receptor. Measurement shall last 30 minutes with data to be logged at 5-min intervals.	Quarterly for the first year. Frequency will be reviewed after one year pending the results of the analysis. Quarterly monitoring of Dubai Marina ongoing through operation phase	Quarterly
Monitoring Method	ISO 1996-1: 2003, Acoustics – Description, measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures	In-situ parameters will be assessed using a YSI Exo-2 multiparameter probe (or similar). Water sampling will be carried out using a 4.2 litre Beta Water Sampler (or similar). Samples will be collected from mid-depth in the water column. Samples will be stored in refrigerated conditions before transfer to DAC approved analytical laboratory for analysis.	Sampling: a grab sample to be collected in sample container(s). Laboratory testing: APHA or equivalent. *Note: The material of the sample container(s) and holding time of the samples shall be reference to APHA or equivalent.*
Equipment	Sound Level Meter and Sound Calibrator (Type 1 or above).	4.2 litre Beta Water Sampler (or similar); Grab sample collected in a sample container made of material comply with APHA recommendation (or equivalent) followed by laboratory testing; and YSI Exo-2 Multi-Parameter Intelligent Logger (or similar).	Grab sample collected in a sample container made of material comply with APHA recommendation (or equivalent) followed by laboratory testing; and YSI 6920 V2 Multi-Parameter Intelligent Logger (or similar).
Trigger Level for Corrective Actions	Federal Allowable Noise Limits for *Residential areas with some workshops and commercial near highways*: • 60dB(A) (daytime) • 50 dB(A) (night time) Community complaints	DM Water Quality Objectives	As per DM Accepted Limits of Treated Wastewater for Restricted and Unrestricted Irrigation (Table 3-13).
Actions to be taken in the event that the Trigger Level is exceeded	• If the exceedance is associated with the Project operational activities: actions shall be identified and implemented to rectify the situation. • If the exceedance is not associated with the Project operational activities: actions are not required.		Liaise with the TSE supplier to identify the reasons for the exceedance and identify mitigation measures.

11. Conclusions

It is anticipated that relatively minor environmental impacts will be generated on climate, geology, soil and groundwater, terrestrial ecology, waste management and socio-economics. The major potential impacts identified in the EIA for the construction and operational phases of the proposed development are summarised below.

11.1 Construction Phase

Major environmental impacts during the construction phase would be associated with:

- **Disposal of unsuitable dredged material from the proposed navigation channel -** As such, it would be preferable to re-use as much as possible of the dredged material as reclamation fill. This reduces the requirement to obtain fill from a new borrow area, which decreases the area of impact. Further, it reduces the requirement to dispose of the dredge material to ocean or land, both of which would result in significant impacts. The impacts from off shore disposal include potential smothering of benthos, creation of sediment plumes thus, reducing light availability to marine fauna. The impacts from land disposal include soil erosion, change of land use / habitat in the area required to settle the fines as well as the significant increase in traffic associated with transporting the dredged material to the disposal site (with corresponding air and noise impacts).
- **Suspension and deposition of fine sediments during dredging and reclamation -** Dredging and reclamation activities will generate plumes of suspended sediments that can remain suspended in the water column for an extended period of time, resulting in increased shading of the seabed with corresponding deleterious effects on photosynthetic organisms and sediment deposition, which can cause smothering of benthic communities. Prepare a detailed silt control plan as part of the CEMP, including measures to containment fine material within designated reclamation areas through the construction of rock revetments, temporary sand bunds and / or installation of silt screens will significantly reduce this impact.
- **Increase in dust levels –** Construction activities such as earthworks, grinding and stockpiling have inherent risk of producing elevated dust concentrations, particularly in the Middle East where the surface comprises sand and dust material. Elevated dust emissions can cause irritation to the eyes and throat for both human and animal receptors, in addition to increasing the likelihood of respiratory diseases such as asthma. While the baseline values were within the guidelines, dust levels vary seasonally and depend on prevailing winds and sand storm occurrences. Impact on air quality from construction activities can be controlled through strict implementation of dust control measures.
- **Increase in noise levels -** Increase in noise levels could result in detrimental impacts such as sleep disturbance and potential minor hearing loss for nearby sensitive receivers and workers within the construction site. Although the noise levels varied between stations, the levels recorded during baseline were generally above ambient guidelines, particularly at night. The increased noise levels from construction activities can be controlled through the erection of noise barriers, control of equipment noise and work methods.
- **Reduction in amenity of the Project site's surrounding land uses -** This would include the visual impact of construction (cranes and equipment blocking the existing views), an increase in dust and noise levels, increased traffic and congestion from construction vehicles and an influx of migrant workers to the area. While the residents of

Dubai are accustomed to these impacts to a degree, this could result in complaints from the community and local business owners. Should mitigation measures be implemented appropriately, then impact is expected to be acceptable.

11.2 Operation Phase

The major environmental impacts during the operation phase would be associated with:

- **Altered hydrodynamics and flushing.** The addition of the Dubai Harbour structures and reclaimed land will alter the existing coastal processes and flushing in the surrounding area. Generally, peak current speeds in the post-development scenario are predicted to be within ±0.05 m/s of existing conditions, although increases and decreases above this value are also predicted in localised areas. These alterations could result in increased erosion and sedimentation respectively, with associated impacts to the surrounding marine ecology. With regards to flushing, the proposed Project is predicted to improve conditions at the existing DIMC marina through reconfiguration into a more open marina. Further, flushing conditions at JBR beach are predicted to be improved. However, reduced flushing is anticipated at Dubai Marina, which has the potential to contribute to poor water quality. Models of feasible modifications to the design of Dubai Harbour or the southern entrance to the marina showed negligible beneficial effect. Pumping seawater into the channel will be undertaken as a mitigation measure, should a decrease in water quality be detected in the Marina during ongoing monitoring through the construction and operation phases.
- **Increase in vehicle and marine traffic**. Given the large scale and strategic developments ongoing and proposed in the area, increased traffic is considered an unavoidable impact of the Project; however, effective access to the Project via public transport such as the Dubai Metro and Tram will reduce traffic congestion and associated noise and GHG emissions. The Traffic Impact Study, along with other design information, will be submitted to the RTA for approval.
- **Additional strain on utilities**. The operational phase of the Project will result in an increased demand for utilities including power, potable water and sewage networks. The additional strain on the available resources will contribute to an increase in GHG emissions associated with the operation of the power plants and the impact to the marine environment from desalination of water and stormwater discharges.
- **Socio-economic**. The Project will greatly enhance tourism in Dubai while playing a vital role in raising Dubai’s global profile as a cruise ship hub capable of accommodating 6000 passengers at one time. The Project is also anticipated to enhance the amenity of the surrounding communities such as JBR, Dubai Marina and Palm Jumeirah, as it will provide a range of services and facilities including sports, recreation, food and beverage. Further, the Dubai Lighthouse is expected to provide a visual highlight for the area. The long term positive impact of the Project on the Emirate’s socio-economic development is considered significant, as business and employment opportunities will be generated once hotel resorts, commercial and retail establishments as well as entertainment and leisure facilities are completed.

Specific operation environmental management plans will be developed for each of the key areas / facilities of the Project (e.g. cruise terminal, marinas) to ensure that appropriate measures specific to each facility type are in place, including monitoring and maintenance requirements.

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Appendices

Appendix A – Scope of Work Approval and DM Correspondence

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Appendix I – Noise Modelling Report

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Appendix M – Construction Schedule

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