kV	kilovolt
m	metre
m^2	square metre
mbar	millibar
MW	megawatt

Chemicals

NO_x	Oxides of Nitrogen

Definitions

OWNER	Marubeni
EPC CONTRACTOR	Means the entity, corporation or partnership to which the Engineering, Procurement and Construction (EPC) phase for this project has been awarded.
VENDOR	Any person, firm, partnership, OWNER, corporation or combination thereof to which the CONTRACTOR has sent the QUOTATION REQUEST or placed the PURCHASE ORDER.
PROJECT	Means the Fujairah 3 (F3) Power Generation Plant, being executed by OWNER or its affiliates.

Executive Summary

WKC Environment Consultancy (WKC) has undertaken an environmental noise modelling assessment for the Fujairah 3 (F3) Power Generation Plant, hereafter referred to as the 'Project'. This project is located in Qidfa City in the Emirate of Fujairah, in the United Arab Emirates (UAE) and will consist of a standalone independent power plant (IPP) with a net power capacity of 2,000 – 2,400 MW in order to meet present and future demand for power in the Emirate of Fujairah. The Project is located adjacent to the existing Fujairah 1 (F1) independent water and power plant (IWPP) and Fujairah 2 (F2) IWPP.

A baseline noise study was conducted from the 22nd to the 23rd of January 2020. This was done in order to determine the environmental noise characteristics at seven locations around the F3 power plant. A NL-52 Rion Cirrus Type 1 sound level meter, together with a NC-75 Rion acoustic field calibrator, was utilised for all measurements and were undertaken in accordance with best practice.

Results from the baseline study indicated one of the seven locations exceeded the night-time limit at sensitive receptor 3 (SR3). The exceedance could be attributed to the close proximity of SR3 to the existing F1 and F2 IWPPs (SR3 is located 210 m and 479 m from F1 and F2 respectively). All other results were in compliance with the Projects noise limits for both the daytime and night-time periods.

Noise emissions from construction activities have been assessed in accordance with the methodology presented in British Standard (BS) 5228:2014 [1] and the construction noise guidelines of the Department of Environment and Climate Change New South Wales (NSW) [2]. In line with a conservative assessment methodology, construction noise was assessed by assuming construction activities occur at the unit boundary nearest to the closest receptors.

The Project is located within close proximity to residential zones, with the closest residences being approximately 170 m (SR3) and 561 m (SR8) from the nearest unit boundary where construction will take place. The predicted noise levels generated by general construction activities for daytime and night-time periods are anticipated to fall below the construction noise thresholds for all locations with the exception of SR3 and SR8 [2]. Based on the cumulative results, the results show that during the day, the predicted impacts from the project are in the range of "slight" with the exception of SR3 and SR8 where a "high" impact is predicted. In terms of night-time noise levels, the predicted impacts are in the range of "slight" to "high" with majority of the SRs having a "low" impact severity. However, this represents a reasonable worst-case scenario, where all items in the general construction equipment list have been assumed to be operating concurrently at a single location.

In order to estimate the operational noise levels, the internationally recognised noise modelling software 'SoundPLAN' has been utilised. The propagation methodology adopted within the SoundPLAN model was the International Organisation for Standardisation (ISO) 9613 [3].

An assessment of the noise contribution of the Project in conjunction with the F1 and F2 IWPPs has been conducted. A total of 151 continuous noise generating equipment items were modelled for normal operations, this excluded all equipment items that were identified as ‘spare’. The noise from the project is dominated by a mixture of turbines, generators, pumps, compressors, fans/blowers and transformers.

The site boundary assessment considered all noise sources within the Project. The project requirements specify that the noise level should not exceed a L_{Aeq} of 70 dB(A) at the property boundary for daytime and 65 dB(A) for night-time conditions. The results showed that during normal operations, the predicted cumulative site boundary noise levels will be below the daytime limit of 70 dB(A) L_{Aeq} at all 42 boundary assessment points with the exception of point B30. The cumulative night-time limit is exceeded at locations B1, B2, B11, B12, B27-B36 and B42 on the northern, western and eastern boundary (Figure 7-1). These exceedances could be attributed to the close proximity of some of the equipment items to the boundary, particularly the pumps located at the Eastern boundary between boundary receptors B30 and B33, combined with a lower night-time noise limit which contributes to the number of exceedances.

An assessment of the noise contribution of the Project has been conducted at various SRs identified in close proximity to the Project site. The predicted noise levels from project contributions are below the Federal and International Finance Corporation (IFC) daytime guideline noise levels at all locations. However, when assessing against the Federal night-time guideline noise levels for the residential locations, the assessment predicted an exceedance at receptor, SR3. The baseline noise level recorded at SR3 indicates that the Federal night-time limit of 50 dB(A) is already being exceeded, however the proposed project should not significantly contribute further to this exceedance. The exceedance at SR3 can be attributed to the close proximity of the proposed project site to the existing receptor in the area and the cumulative noise level from noisy equipment items identified for this project.

A cumulative noise impact assessment was performed in order to determine the severity of the impact of the project at the nearest SR locations in the context of existing ambient noise levels. The results show that during the day, the impacts from the project have either “no effect” or “slight” with the exception of SR3 where a “low” impact is predicted. In terms of night-time noise levels, the predicted impacts are largely “slight”, with the exception of SR3 where a “low” impact is also predicted. An assessment of the cumulative noise from the project and baseline levels was undertaken. The results of the assessment (Table 7-6) shows that cumulative noise levels are anticipated to exceed the noise limits (SR5 exceeded the daytime noise limit whereas SR2, SR3, SR6, SR7 and SR9 exceeded the night-time noise limit); this is primarily due to the high baseline noise levels.

It is recommended that a detailed noise assessment should be conducted during the Engineering, Procurement and Construction (EPC) stage of the project, once vendor equipment data sheets are available and the applicable preventive measures indicated in the individual unit’s occupational noise studies are applied.

1 Introduction

WKC Environment Consultancy (WKC) has undertaken an environmental noise modelling assessment for the Fujairah 3 (F3) Power Generation Plant, hereafter referred to as the ‘Project’. This project is located in Qidfa City in the Emirate of Fujairah, in the United Arab Emirates (UAE) and will consist of a standalone independent power plant (IPP) with a net power capacity of 2,000 – 2,400 MW in order to meet present and future demand for power in the Emirate of Fujairah.

1.1 Project Site

The proposed project site is located on the Gulf of Oman coast approximately 20 km north of the City of Fujairah and approximately 280 km north east of Abu Dhabi. The Project is located adjacent to the existing Fujairah 1 (F1) independent water and power plant (IWPP) (760 MW net power capacity) and Fujairah 2 (F2) IWPP (2,000 MW net power capacity). The F1 plant was commissioned in 2004 while the F2 plant was commissioned in 2011. The site location within the UAE is illustrated in Figure 1-1. Figure 1-2 presents the project in a local context.

WKC

Figure 1-1 – Project Location (Regional Context)

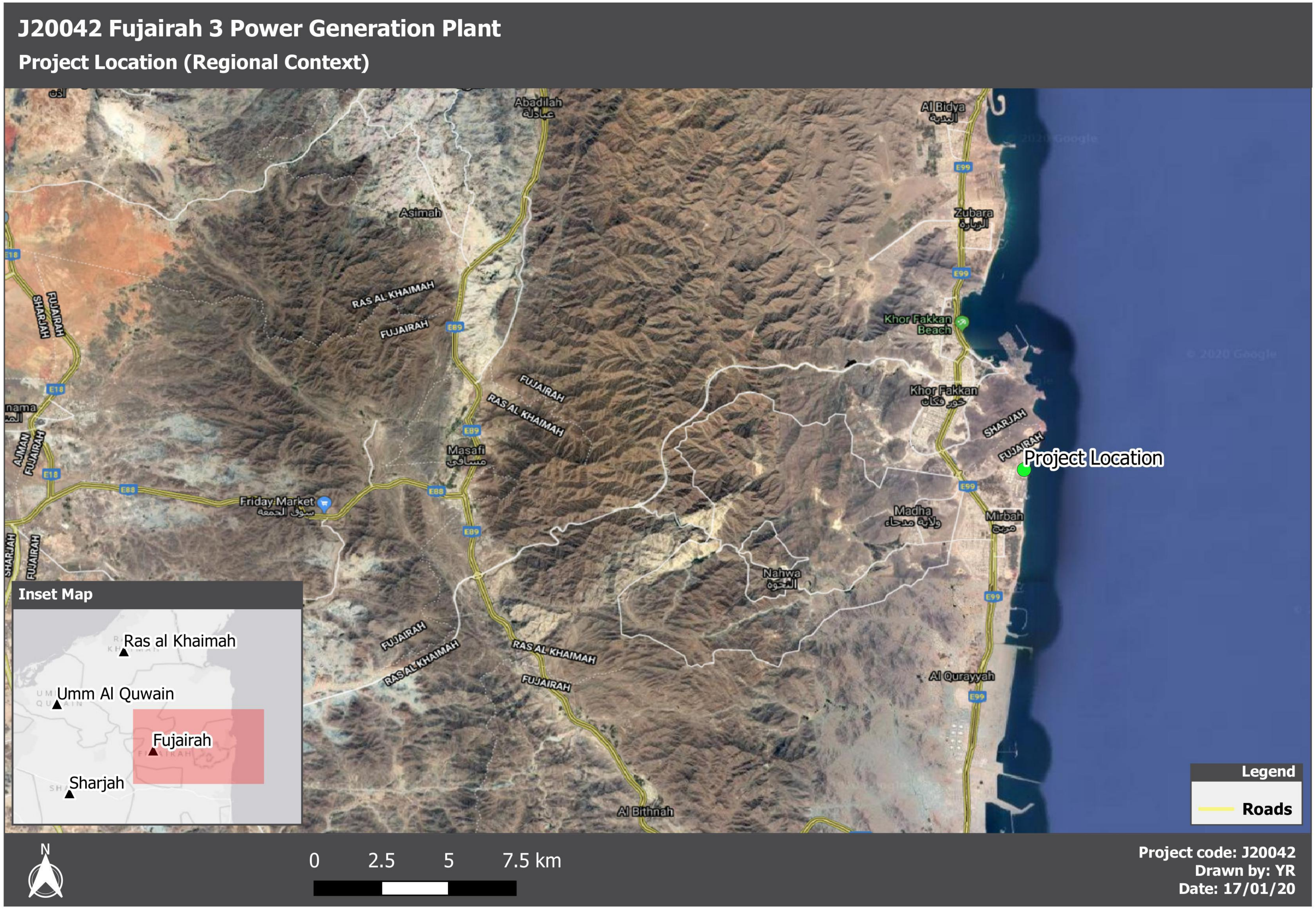


Figure 1-2 – Project Location (Local Context)

1.2 About This Report

This report presents the findings of an environmental noise modelling study for the F3 Power Generation Plant. The assessment considered the current noise created by the existing F1 and F2 IWPPs in the form of baseline noise measurements taken on the boundary and at nearby sensitive receptors (SRs), and the noise contribution from new equipment items associated with the proposed project. Through a review of equipment lists, plot plans and the noisy equipment list prepared by contractor's project team, potentially noisy equipment items have been identified and modelled using SoundPLAN 8.1. Predicted noise levels have then been compared directly to those noise limit specifications described in Section 2.

A series of noise contour plots have been produced detailing the overall project noise levels, with these being assessed in accordance with the environmental noise standards detailed in Section 2.

1.3 Project Description

The project will be developed on a brownfield site located at Qidfa city in the Emirate of Fujairah on the Gulf of Oman, approximately 5 km south of Khor Fakkan, 20 km north of the city of Fujairah and approximately 280 km north east of the city of Abu Dhabi in the UAE. The proposed site was formally used for a power and desalination plant that was developed by the Federal Electricity and Water Authority (FEWA) and is located adjacent to the existing F1 IWPP (owned by Emirate Sembcorp Water and Power Company (ESWPC)) and F2 IWPP (owned by Fujairah Asia Power Company (FAPCO)), as shown in Figure 1-3.

The F3 IPP project will be structured as a standalone independent power producer and will be developed on a build, own and operate basis by the F3 Project Company, which will be established as a joint stock company under the laws of the UAE and the Emirate of Abu Dhabi.

The F3 plant will be dual firing, with natural gas being the primary fuel and diesel oil acting as the secondary fuel. Gas will be transported to the site via a new pipeline from the existing Fujairah Receiving Facility operated by DEL.

In accordance with the requirements of the F3 power purchase agreement (PPA), the F3 Project Company shall provide a facility that offers the phased introduction of Net Dependable Power Capacity in discrete blocks, as follows:

Table 1-1 – Net Dependable Power Capacity in Discrete Blocks

	Scheduled Commercial Operation Date	Contracted Capacity (MW)
Early Contract Period 1 (gas turbine (GT) 11)	28th April 2022	520
Early Contract Period 2 (GT 11 and GT 12)	29th April 2022	1,040
Early Contract Period 3 (GT 11 or GT 12/GT 21 and steam turbine (ST) 20)	30th April 2022	1,200
Group 1 (GT 11, GT 12, and ST 10)	1st March 2023	1,600
Project Commercial Operation Date (Group 1 and Group 2)	30th April 2023	2,400

The proposed configuration of the F3 plant comprises the following main items of equipment or systems:

Group 1 (two GT on one ST):

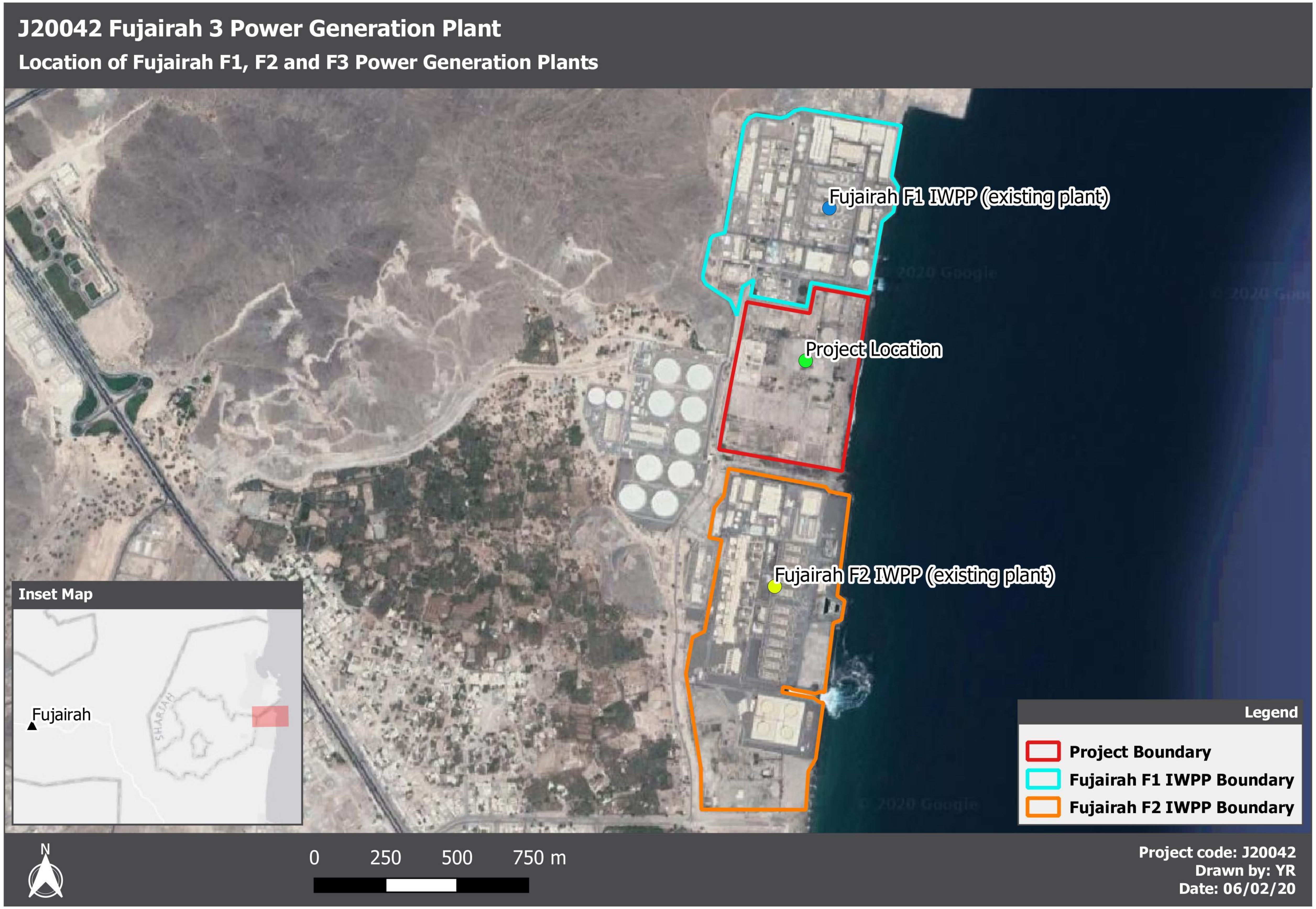
- Two Mitsubishi M701JAC GTs;
- Two triple pressure with reheat unfired heat recovery steam generators (HRSGs);
- One Mitsubishi-Hitachi reheat and condensing ST with combined high-pressure (HP) and intermediate-pressure (IP) sections and two double flow type low-pressure (LP) sections; and,
- Three main transformers exporting power at 400 kV.

Group 2 (one GT on one ST):

- One Mitsubishi M701JAC GTs;
- One triple pressure with reheat HRSG with supplementary fired burners;
- One Mitsubishi-Hitachi reheat and condensing ST with combined HP and IP sections and one double flow type LP section; and,
- Two main transformers exporting power at 400 kV.

In addition, the project will be largely financed by international lenders and private financing institutions, many of whom are signatories to or follow the Equator Principles (EPs) or require projects to which they provide financing to comply with International Finance Corporation (IFC) Performance Standards and World Bank Guidelines.

Figure 1-3 – Location of Fujairah F1, F2 and F3 Power Generation Plants



2 Environmental Noise Standards and Guidance

Noise generated as a result of activities associated with the Project is a potential issue during construction and operation of the new plant.

This section presents the national and international standards, guidance and project specifications applicable to the assessment.

2.1 Project Environmental Noise Standards

2.1.1 National Legislation

Federal Law 12 of 2006 sets out permissible ambient noise levels for specific types of land use, as shown in Table 2-1. A project cannot emit noise levels that cause exceedance of these limits.

Table 2-1 – Allowable Limits for Noise (dB(A))

Classification of Receptor	**Allowable Limits for Noise Levels (L_{Aeq} dB(A))**	
	Daytime (7:00 – 22:00)	**Night-Time (22:00 – 7:00)**
Residential - Light Traffic	40-50	30-40
Residential - Downtown	45-55	35-45
Mixed Residential/Commercial Residential Near Highway	50-60	40-50
Commercial	55-65	45-55
Industrial	60-70	50-60

The UAE federal regulations are consistent with the guidelines of the World Health Organisation (WHO) and those of the World Bank as presented in Table 2-2.

2.1.2 International Guidelines

The international standards/guidelines that have been applied to the Project are the IFC General Environmental, Health and Safety (EHS) Guidelines [4]. The EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP).

IFC refers to guidance from the WHO on establishing community noise levels [5]. The guidance indicates that noise levels at receptors should not exceed the levels presented in Table 2-2, or result in a maximum increase in background levels of 3 dB(A) at the nearest receptor location off-site [4].

Table 2-2 – Maximum Permissible Noise Levels for General Environment [4]

Classification of Receptor	Allowable Limits for Noise Levels (L_{Aeq} dB(A))	
	Daytime (7:00 to 22:00)	Night-Time (22:00 to 07:00)
Residential, Institutional/Educational	55	45
Industrial or Commercial	70	70

A summary of the most stringent limits from both standards is presented in Table 2-3 below.

Table 2-3 – Most Stringent Noise Levels for General Environment [6] [7]

Receptor (Outdoors)	Allowable Limits for Noise Levels (dBA)	
	Daytime	Night-Time
Residential - Light Traffic	50 (Federal)	40 (Federal)
Residential - Downtown	55 (Federal & IFC)	45 (Federal & IFC)
Institutional/Educational	55 (IFC)	45 (IFC)
Mixed Residential/Commercial Residential Near Highway	60 (Federal)	50 (Federal)
Commercial	65 (Federal)	55 (Federal)
Industrial	70 (Federal & IFC)	60 (Federal)

2.2 Construction Noise Assessment Methodology

2.2.1 Calculation of Construction Noise

The calculation of construction noise has been carried out in accordance with BS5228:2014 'Noise and Vibration Control on Construction and Open Sites' [1]. The standard provides a comprehensive construction equipment inventory with associated noise levels, a construction noise calculation method, practical information on noise reduction measures, and promotes 'Best Practice Means' approach to control noise emissions during construction.

2.2.2 Construction Noise Impact Assessment Criteria

In the absence of national construction noise limits, the construction noise assessment has been carried out in accordance with internationally recognised construction noise guidelines of the Department of Environment and Climate Change New South Wales (NSW) [2]. The interim construction noise guidelines define a construction noise threshold margin of 10 dB(A) above the background noise levels with a 75 dB(A) upper limit for construction operations during standard hours. A construction noise threshold margin of 5 dB(A) above the background noise levels is defined for construction operations outside recommended standard hours. This is due to the temporary/short-term and transient nature of construction noise, as opposed to operational noise levels or conditions that are long-term (and therefore considered more significant). A noise level of L_{Aeq} 75 dB(A) represents the point above which there may be strong community reaction to noise and indicates a need to consider other feasible and reasonable ways to reduce noise, such as restricting the times of very noisy works to provide respite to affected residences.

Table 2-4 presents the impact assessment matrix relating to the contributed noise level from the construction phase. Given the duration of construction for this project, a conservative approach has been taken, adopting the most stringent (> 6 months duration) long term criteria.

Table 2-4 – Construction Noise Impact Severity Assessment Criteria

Impact Severity	Normal Working Hours (Daytime)		Abnormal Working Hours (Night-time)	
	Incremental Change in Ambient Noise Level	Description of Impact	Incremental Change in Ambient Noise Level	Description of Impact
No Change	0 dB(A)	Not discernible.	N/A	See below
Slight	0.1 – 2.9 dB(A)	Not discernible – Marginal changes in noise levels of less than 3 dB(A) in residential areas, or outdoor recreational areas in close proximity to main roads.	0 - 1 dB(A)	Not discernible however impulsive and tonal sounds from construction activities may be audible at night.
Low	3 – 4.9 dB(A)	Noticeable adverse – Noise levels of 3-5 dB(A) in residential areas, or at outdoor recreational areas.	1 – 2.9 dB(A)	Marginal changes in noise levels of less than 3 dB(A) in residential areas, or outdoor recreational areas in close proximity to main roads.
Medium	5 – <10 dB(A)	Considerable adverse – Noise levels warrant mitigation of residential properties on a widespread basis in a community, or for outdoor recreation areas.	3 – 4.9 dB(A)	Considerable adverse – Noise levels warrant mitigation of residential properties on a widespread basis in a community, or for outdoor recreation areas.
High	10 dB(A) or in excess of 75 dBA	Major adverse – Noise increases to a level where continued residential use of individual properties is inappropriate, or where the use of a community building could be inappropriate.	5 dB(A) or in excess of 75 dB(A)	Major adverse – Noise increases to a level where continued residential use of individual properties is inappropriate, or where the use of a community building could be inappropriate.

2.3 Operational Noise Assessment Methodology

2.3.1 Calculation of Operational Noise

International Organisation for Standardisation (ISO) 9613 'Acoustics – Attenuation of Sound during Propagation Outdoors' [3] specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level (L_{Aeq}) under meteorological conditions favourable to propagation from sources of known sound emission. SoundPLAN adopts ISO 9613 as its model protocol.

2.3.2 Operational Noise Assessment Criteria

The criteria for the assessment of change in noise levels arising at noise SRs from the operation of the Project have been adapted from the joint Institute of Environmental Management and Assessment (IEMA) and the

Institute of Acoustics (IoA) guidelines for noise and vibration impact assessment categories and are given in Table 2-5.

Table 2-5 – Operational Noise Impact Severity Assessment Criteria

Impact Severity	Incremental Change in Ambient Noise Level	Description of Impact
No Effect	0 dB (A)	Not Discernible
Slight	0.1 – 2.9 dB(A)	Not Discernible – Marginal changes in noise levels of less than 3 dB(A) in residential areas, or outdoor recreational.
Low	3 – 4.9 dB(A)	Noticeable Adverse – Noise levels of 3-5 dB(A) in residential areas, or at outdoor recreational areas.
Medium	5 – < 10 dB(A)	Considerable Adverse – Noise levels warrant mitigation of residential properties on a widespread basis in a community, or for outdoor recreation areas.
High	10 dB(A) or more	Major Adverse – Noise increases to a level where continued residential use of individual properties is inappropriate, or where the use of a community building could be inappropriate.

2.4 Other International Guidance

2.4.1 Baseline Noise Monitoring

ISO 1996-1-3 'Description and Measurement of Environmental Noise' [8] defines the basic quantities to be used for the description of noise in community environments and the basic procedures for the determination of these quantities. It also includes the methods for acquisition of data that enable specific noise situations to be checked for compliance with given noise limits.

3 Baseline

3.1 Noise Baseline Monitoring

Short-term and long-term baseline noise surveys were undertaken by Anthesis. The measurements were taken for 15 minutes (short-term) and 24-hour (long-term) periods at seven different locations.

3.2 Equipment and Calibration

A NL-52 Rion Cirrus Type 1 sound level meter, together with an NC-75 Rion acoustic field calibrator, were utilised for all measurements. The selected sound level meter automatically logs environmental noise measurement parameters including L_{Aeq}, L_{Aeq10}, L_{Aeq90}, L_{Amax} and L_{Amin}.

The sound level meter was calibrated regularly before and after each measurement using the field calibrator, subsequently ensuring any potential drift is attributed to each measurement location rather than all locations throughout the survey period. In addition, the sound level meter and field calibrator are factory calibrated by the certified bodies on an annual basis. A copy of the latest calibration certificates can be found in Appendix C of this report.

3.3 Noise Measurement Locations

Short-term and long-term baseline noise studies were conducted from the 22nd to the 23rd of January 2020. This was carried out in order to determine the environmental noise characteristics at several key representative locations. Details of the measurement locations are summarised in Table 3-1, and the measurement locations are shown in Figure 3-1 below. These locations were selected based on site inspection to ensure that the equipment was deployed in locations that would be characteristic of the surrounding areas anticipated noise conditions.

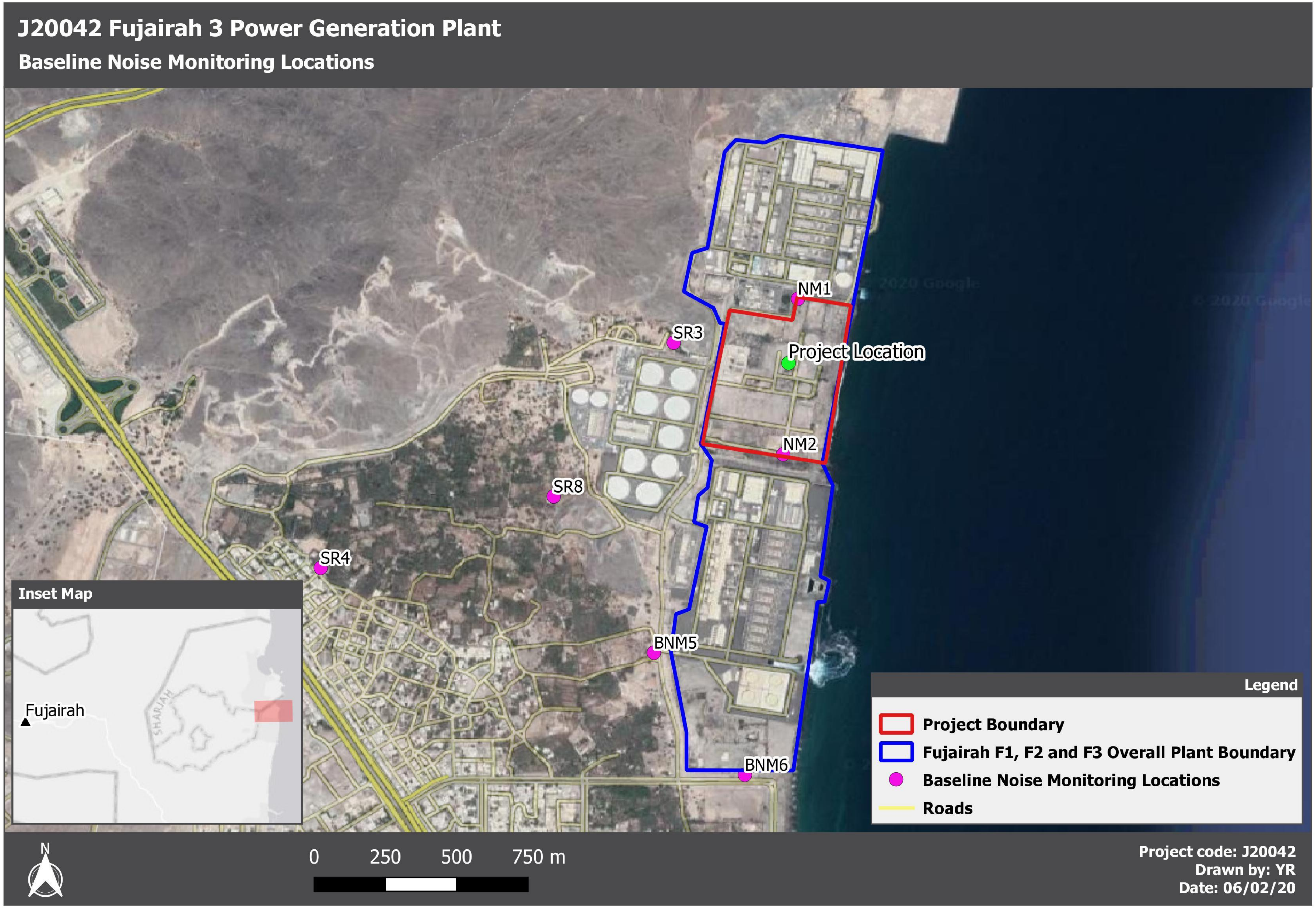
In order to carry out the cumulative noise assessments, baseline monitoring was conducted to include the following locations:

- The Project Boundary (F3);
- The boundary encompassing the F1, F2 and F3 plants; and,
- SRs.

Table 3-1 – Noise Measurement Locations

Receptor	Site Description	Site Classification	Universal Transverse Mercator (UTM) Coordinates	
			m E	m N
Short-Term Measurements (15 minutes)				
BNM5	Noise measurement at overall plant boundary.	Industrial	436,389	2,798,231
BNM6	Noise measurement at overall plant boundary.	Industrial	436,707	2,797,759
SR3	Residential properties immediately west of the F3 site.	Mixed Residential	436,464	2,799,428
Long-Term Measurements (24 hours)				
NM1	Noise measurement at F3 plant boundary.	Industrial	436,901	2,799,596
NM2	Noise measurement at F3 plant boundary.	Industrial	436,846	2,798,996
SR4	Northern outskirts of Qidfa.	Mixed Residential	435,221	2,798,564
SR8	Dwellings approximately 550 m south west of the F3 site.	Mixed Residential	436,040	2,798,836

Figure 3-1 – Baseline Noise Measurement Locations



3.4 Survey Timing, Frequency and Duration

The following short-term and long-term measurements were taken at each location identified above in the noise measurement location section. The date and start and end time of each measurement is detailed in Table 3-2.

Table 3-2 – Survey Timing and Schedule

Receptor	Site Classification	Daytime Measurements			Night-Time Measurements		
		Date	Start Time [hh:mm]	End Time [hh:mm]	Date	Start Time [hh:mm]	End Time [hh:mm]
Short-Term Measurements (15 minutes)							
BNM5	Industrial	22/01/2020	15:56	16:12	22/01/2020	20:23	20:39
BNM6	Industrial	22/01/2020	15:33	15:49	22/01/2020	20:44	21:00
SR3	Mixed Residential	22/01/2020	16:25	16:43	22/01/2020	20:00	20:16
Long-Term Measurements (24 hours)							
NM1 – Day 1	Industrial	21/01/2020	11:56	20:00	21/01/2020	20:00	23:59
NM1 – Day 2	Industrial	22/01/2020	07:00	11:35	22/01/2020	00:00	06:59
NM2 – Day 1	Industrial	21/01/2020	11:38	19:59	21/01/2020	20:00	23:59
NM2 – Day 2	Industrial	22/01/2020	07:00	11:16	22/01/2020	00:00	06:59
SR4 – Day 1	Mixed Residential	22/01/2020	12:05	19:59	22/01/2020	20:00	23:59
SR4 – Day 2	Mixed Residential	23/01/2020	07:00	12:50	23/01/2020	00:00	06:59
SR8 – Day 1	Mixed Residential	22/01/2020	11:54	19:59	22/01/2020	20:00	23:59
SR8 – Day 2	Mixed Residential	23/01/2020	07:00	07:43	23/01/2020	00:00	06:59

3.5 Results and Analysis

The ambient noise measurements recorded at all locations are summarised below in Table 3-3 (daytime noise survey results) and Table 3-4 (night-time noise survey results).

Table 3-3 – Ambient Noise Survey Results: Daytime Noise Levels

Receptor	Land Use Type	Most Stringent Noise Limit L_{Aeq} (dB(A))	Recorded Noise Level L_{Aeq} (dB(A))	Limit Exceeded
Short-Term Measurements (15 minutes)				
BNM5	Industrial	70 (Federal & IFC)	61.1	No
BNM6	Industrial	70 (Federal & IFC)	58.6	No
SR3	Mixed Residential	60 (Federal)	54.6	No

Receptor	Land Use Type	Most Stringent Noise Limit L_{Aeq} (dB(A))	Recorded Noise Level L_{Aeq} (dB(A))	Limit Exceeded
Long-Term Average Measurements (24 hours)				
NM1	Industrial	70 (Federal & IFC)	46.7	No
NM2	Industrial	70 (Federal & IFC)	52.5	No
SR4	Mixed Residential	60 (Federal)	49.1	No
SR8	Mixed Residential	60 (Federal)	44.8	No

Table 3-4 – Ambient Noise Survey Results: Night-Time Noise Levels

Receptor	Land Use Type	Most Stringent Noise Limit L_{Aeq} (dB(A))	Recorded Noise Level L_{Aeq} (dB(A))	Limit Exceeded
Short-Term Measurements (15 minutes)				
BNM5	Industrial	60 (Federal)	49.3	No
BNM6	Industrial	60 (Federal)	53.3	No
SR3	Mixed Residential	50 (Federal)	52.8	Yes
Long-Term Average Measurements (24 hours)				
NM1	Industrial	60 (Federal)	49.3	No
NM2	Industrial	60 (Federal)	56.3	No
SR4	Mixed Residential	50 (Federal)	46.1	No
SR8	Mixed Residential	50 (Federal)	45.4	No

There were no daytime exceedances of the Project noise limits. In terms of the most stringent night-time limits, there was one exceedance at SR3, having a level 2.8 dB(A) above the federal night-time noise limit of 50 dB(A). The exceedance could be attributed to the close proximity of SR3 to the existing F1 and F2 IWPPs (SR3 is located 210 m and 479 m from F1 and F2 respectively). All of the remaining survey locations (BNM5, BNM6, NM1, NM2, SR4 and SR8) have recorded noise levels that are below the applicable noise limits.

4 Construction Noise Assessment

An assessment of predicted noise emissions from construction activities in the area surrounding the Project site was carried out in accordance with BS5228 [1].

4.1 Equipment Inventory

The construction equipment list is detailed in Table 4-1 below. The equipment inventory was based on Client provided equipment numbers for the construction of the Project Facilities.

Table 4-1 – Assumed Construction Equipment Inventory

Plant/Activity	Equipment Total	Sound Pressure Level @ 10 m, L_{Aeq} (dB(A))	Reference[1]
General Construction			
Crawler Crane (1,000 ton)	1	66,00	No. 50 C4
Crawler Crane (300 tons)	2	73,01	No. 52 C5
Hydro Crane (200 tons)	3	75,77	No. 37 C5
Hydro Crane (120 tons)	3	75,77	No. 37 C5
Hydro Crane (100 tons)	4	77,02	No. 37 C5
RT Crane (100 tons)	1	65,00	No. 30 C3
Hydraulic Gantry Lift	1	63,00	No. 61 C4
Excavator	5	78,99	No. 2 C2
Wheel Loader	5	80,99	No. 26 C2
Barge	6	66,78	No. 42 C4
Dump Truck	10	84,00	No. 30 C2
Stone Columns Equipment	3	88,77	No. 1 C3
Tower Crane (25 tons)	2	74,01	No. 48 C4

1. References from are from Annex C of BS5228 [1]

4.2 Assumptions

The following assumptions were applied when conducting the construction impact assessment:

- Construction activities occur at the boundary nearest to the receptor;

- All equipment items were assumed to be operating for 100% of the construction hours (daytime and night-time); and,
- All equipment items are operating at a single location concurrently.

4.3 Construction Noise Impact Assessment

Noise emissions from construction activities have been outlined in Table 4-2 in accordance with the methodology presented in BS5228:2014 [1]. It is not possible to identify an exact location from which to measure the edge of the construction site, as a result, construction noise was assessed by assuming construction activities occur at the unit boundary nearest to the closest receptor (Figure 3-1) and reported as such below.

To represent a reasonable worst-case scenario, all items in the general construction equipment list have been assumed to be operating concurrently at a single location.

The construction noise thresholds are based on the internationally recognised construction noise guidelines of the Department of Environment and Climate Change NSW [2]. In terms of the construction phase assessment, the study considers the noisiest activities for general construction. The predicted noise levels in the area surrounding the Project site are detailed in the tables below and have been evaluated against the standards detailed in Section 2. Table 4-2 presents the predicted noise levels at specific intervals from 50 m to 1,000 m.

Table 4-2 – Predicted Construction Noise Emissions at Sensitive Receptors

Distance from Project Boundary (m)	General Construction (dB(A))
50	77.5
100	71.4
150	67.9
200	65.4
500	57.5
1,000	51.4

Table 4-3 details the assessment of predicted daytime noise levels at the SRs in terms of the calculated construction noise threshold level (i.e. background noise level + 10 dB) [2].

Table 4-4 details the assessment of predicted night-time noise levels at the SRs in terms of the calculated construction noise threshold level (i.e. background noise level + 5 dB) [2].

Table 4-3 – Daytime Noise Levels and Limits at Baseline Locations

Baseline Locations[1]	Distance from Unit Boundary (m)	Baseline Noise at Sensitive Receptor	Highest Construction Noise Level at Receptors (dB(A))	Noise Limit at Receptor as per Construction Guideline Threshold[2] (dB(A)) [2]	Guideline Threshold Exceeded	Cumulative Noise Level (dB(A))	Maximum Change in Noise Level at Receptor (dB(A))	Impact Severity
SR1	2,274	49.1[3]	44.3	59.1	No	50.3	1.2	Slight
SR2	1,433	54.6[3]	48.3	64.6	No	55.5	0.9	Slight
SR3	170	54.6	66.8	64.6	Yes	67.1	12.5	High
SR4	1,424	49.1	48.4	59.1	No	51.8	2.7	Slight
SR5	1,030	61.1[3]	51.2	71.1	No	61.5	0.4	Slight
SR6	2,218	49.1[3]	44.5	59.1	No	50.4	1.3	Slight
SR7	742	54.6[3]	54.0	64.6	No	57.3	2.7	Slight
SR8	561	44.8	56.5	54.8	Yes	56.8	12.0	High
SR9	1,543	58.6[3]	47.7	68.6	No	58.9	0.3	Slight
SR10	3,915	49.1[3]	39.6	59.1	No	49.6	0.5	Slight

[1] Note that baseline locations are the same as those defined in the baseline section, Table 3-1, and have the same ID

[2] Threshold calculated based on background daytime noise level and NSW interim construction noise guidelines (i.e. background noise level + 10 dB)

[3] Baseline values were assigned based on the closest monitored receptor

Table 4-4 – Night-time Noise Levels and Limits at Baseline Locations

Baseline Locations[1]	Distance from Unit Boundary (m)	Baseline Noise at Sensitive Receptor	Highest Construction Noise Level at Receptors (dB(A))	Noise Limit at Receptor as per Construction Guideline Threshold[2] (dB(A)) [2]	Guideline Threshold Exceeded	Cumulative Noise Level (dB(A))	Maximum Change in Noise Level at Receptor (dB(A))	Impact Severity
SR1	2,274	46.1[3]	44.3	51.1	No	48.3	2.2	Low
SR2	1,433	52.8[3]	48.3	57.8	No	54.1	1.3	Low
SR3	170	52.8	66.8	57.8	Yes	67.0	14.2	High
SR4	1,424	46.1	48.4	51.1	No	50.4	4.3	Medium
SR5	1,030	49.3[3]	51.2	54.3	No	53.4	4.1	Medium
SR6	2,218	46.1[3]	44.5	51.1	No	48.4	2.3	Low
SR7	742	52.8[3]	54.0	57.8	No	56.5	3.7	Medium
SR8	561	45.4	56.5	50.4	Yes	56.8	11.4	High
SR9	1,543	53.3[3]	47.7	58.3	No	54.4	1.1	Low
SR10	3,915	46.1[3]	39.6	51.1	No	47.0	0.9	Slight

[1] Note that baseline locations are the same as those defined in the baseline section, Table 3-1, and have the same ID

[2] Threshold calculated based on background night-time noise level and NSW interim construction noise guidelines (i.e. background noise level + 5 dB)

[3] Baseline values were assigned based on the closest monitored receptor

The facility is located within close proximity to residential zones, with the closest residences being approximately 170 m (SR3) and 561 m (SR8) from the nearest unit boundary where construction will take place. As can be seen from the above tables, the predicted noise levels generated by general construction activities for daytime and night-time periods are anticipated to be below the construction noise thresholds for all locations with the exception of SR3 and SR8 [2]. Based on the cumulative results shown above, the severity in the change of noise levels at the SRs due to the project construction can be quantified. The results show that during the day, the predicted impacts from the project are in the range of "slight" with the exception of SR3 and SR8 where a "high" impact is predicted. In terms of night-time noise levels, the predicted impacts are in the range of "slight" to "high" with majority of the SRs having a "low" impact severity. However, this represents a reasonable worst-case scenario, where all items in the general construction equipment list have been assumed to be operating concurrently at a single location. Additionally, it can be noted that SR8 might have substantial screening due to the large tanks located between the receptor and the Project boundary which has not been accounted for in the noise model.

4.3.1 Potential Mitigation Measures for Construction Noise

The noise predictions presented in Table 4-3 and Table 4-4 are for activities with all items in the inventory operating at a single location concurrently, therefore, this can be considered a 'worst case' scenario.

Noise and vibration from construction activities can be controlled through the Health, Safety and Environmental (HSE) Management Plans, such as the Construction Environmental Management Plan (CEMP). Due to the potential of exceedances at locations within close proximity to the project site the following general mitigation measures should be considered and commitments to good site practices should be incorporated into the CEMP:

- Site inductions to cover the importance of noise control and available noise reduction measures;
- Construction contractors should be required to use equipment that is in good working order, is properly maintained according to the equipment's manufacturer requirements and that meets current best practice noise emission levels. This should be achieved by making it a component of contractual agreements with the construction contractions;
- As far as reasonably practicable, sources of significant noise should be enclosed. The extent to which this can be done depends on the nature of the machines to be enclosed and their ventilations requirements;
- All mobile or fixed noise-producing equipment used on the project, which is regulated for noise output by a local, state, or federal agency, shall comply with such regulation while in the course of project activity;
- Electrically powered equipment instead of pneumatic or internal combustion powered equipment shall be used, where feasible;
- Construction site speed limits shall be established and enforced during the construction period;
- A gradual start to noisy activities and as far as it is feasible, establish a schedule for noisy activities to reduce overlapping of works;
- The on-site construction supervisor shall have the responsibility and authority to receive and resolve noise complaints. A clear appeal process to the owner shall be established prior to construction commencement that will allow for resolution of noise problems that cannot be immediately solved by the site supervisor;

- The Engineering, Procurement and Construction (EPC) contractor shall develop a project construction noise control plan, which shall be approved and implemented prior to commencement of any construction activity;
- The EPC contractor shall limit the hours of operation for specific equipment or construction activities; and,
- Contract incentives may be offered to the construction contractor to minimise or eliminate noise complaints resulting from project activities where project construction would result in significant noise impacts.

5 Operations Phase Noise Model

In order to estimate the operational noise levels, the internationally recognised noise modelling software ‘SoundPLAN’ has been utilised.

The propagation methodology adopted within the SoundPLAN model was the ISO 9613 [3]. This document can be referred to for an in-depth description of the methodology SoundPLAN utilises for attenuation of sound and propagation outdoors.

ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level (L_{Aeq}) under meteorological conditions favourable to propagation from sources of known sound emission. The source (or sources) may be moving or stationary and takes account of the following physical effects:

- Geometrical Divergence;
- Atmospheric Absorption;
- Ground Effect;
- Reflection from Surfaces; and,
- Screening by Obstacles.

This method is applicable in practice to a variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning: industrial noise sources, road or rail traffic and many other ground-based noise sources.

5.1 Propagation of Sound

The variables which affect sound propagation over ground away from a source have been the subject of much detailed investigation over the years. The principal factors influencing sound attenuation with distance from the source are:

- Geometrical spreading (this is the standard spherical wave divergence term which gives 6 dB reduction in noise level for each doubling of distance from point source e.g. small motor, 3 dB for a line source e.g. piping) [9];
- Source Directivity (angle of the emission source);
- Atmospheric (molecular) Absorption;

- Ground Effects (different for hard/soft ground, and type of ground cover);
- Atmospheric Wind Temperature Gradients (refraction);
- Source Height;
- Atmospheric Turbulence; and,
- Barrier Effects (diffraction).

The total attenuation due to all these factors except geometrical spreading and directivity is generally referred to as 'excess attenuation' and will vary with frequency. Because of these effects, a significant noise source may not be significant at, and beyond, the boundary and vice-versa.

A noise source dominated by low frequency noise (with a long wavelength) is likely to travel a greater distance under the same excess attenuation factors to that of a noise source dominated with high frequency noise (with a shorter wavelength).

5.2 Meteorological and Ground Conditions

The most influential environmental condition on noise propagation is distance, the greater the distance between the noise source and the receiver, the greater the noise reduction achieved. Typically for stationary sources (such as a power station), a reduction of 6 dB(A) per doubling of distance is considered the norm [10].

The type of ground cover also influences noise propagation. Soft ground such as sand or agricultural land absorbs sound energy shortening the propagation path whereas hard ground such as compact soil or tarmac (paving, concrete etc.) reflects the sound energy and thereby noise travels further. It has been assumed for this assessment that the ground cover will be hard between the project area and the property boundary.

For noise propagation over short distances, climatic conditions do not have a significant effect; however over longer distances over 50 m, wind becomes more influential. Downwind the level may increase by a few dB, depending on wind speed whereas on the upwind or side-wind the level can drop by 10 dB.

Temperature gradients create effects similar to those of wind gradients, except that they are uniform in all directions from the source. On a sunny day with no wind, temperature decreases with altitude, giving a noise shadow (the result is the noise is taken up and away from the source and the ground). On a clear night, temperature may increase with altitude (temperature inversion) focusing sound towards the ground surface.

Ambient conditions incorporated into the SoundPLAN model for the design and performance of the F3 power generation plant are shown in Table 5-1 below:

Table 5-1 – Ambient Conditions [11]

Reference Site Condition (RSC)	Unit	Data
Ambient Air Temperature	°C	46
Relative Humidity	%	40
Ambient Air Temperature	mbar	1,013

5.3 Modelled Equipment

Equipment items/noise sources have been integrated into the noise model as either a point, area or block source (referred to in SoundPLAN as “Industrial Buildings” which are cube shaped objects with noise emitting façades), depending on the size and function of the item of equipment. Stacks, pumps, blowers, agitators and transformers were modelled as point sources. Fans were modelled as area sources. Generators, turbines, filter houses and compressors were modelled as block sources with noise emitting façades.

5.4 Modelling Assumptions

The following assumptions have been made for the modelling assessment, and wherever possible, a conservative approach has been taken:

- Normal operations scenario of the facility has been modelled;
- The model includes only continuously operating noise sources that would be running under normal operating conditions. Equipment items identified as spare have been excluded from the assessment;
- Equipment elevations have been based upon data provided or determined from plot plans;
- Equipment locations were determined from the plot plans provided;
- Noise sources have been modelled as point, area or block sources;
- Calculations have been performed in the eight octave bands centred between 63 Hz and 8 kHz;
- The model does not incorporate features which might provide partial screening (e.g., columns, pipe racks, structural steelwork, and small equipment), this is to maintain a conservative approach;
- Ground absorption has been modelled as hard (having an absorption coefficient of 0.6) to maintain a conservative assessment;
- The topography between noise source and the site boundary 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. A temperature of 46 ˚C and humidity of 40% was used based on the specified design conditions;
- Objects that are deemed to be of significant influence on the screening of noise (including large tanks and buildings) have been included in the noise model. Object dimensions have been based upon Plot Plans provided;
- All equipment dimensions have been approximated from plot plans;
- Building heights have conservatively been assumed at 6 m;
- Data provided states that all noise sources will be operating at < 85 dB(A), noise sources have therefore been modelled at a conservative value of 85 dB(A) at 1m (unless otherwise stated in the noise log);
- Where exact equipment locations could not be identified, equipment items were represented as area sources; and,

- Equipment noise spectrums have been estimated in accordance with the methods of Engineering Noise Control [9].

6 Equipment Review and Noise Control

6.1 Equipment Included in Study

Overall, 151 noise sources were identified within the project boundary for inclusion in the noise model; this excluded all equipment items that were identified as 'spare'. Full details of all modelled equipment items can be found within the 'Equipment Noise Data Log' in Appendix B.

6.2 Noise Estimation Methodology

Noise prediction modelling requires various input data. The main parameters required for calculating noise levels within the Project model domain are the specific equipment noise data. The accuracy of the noise calculations is completely reliant on the quality of the source input data. As a result, it is recommended that the noise study is updated in the EPC phase of the Project.

The various modelled noise sources which make up the various components of a working project site are reliant on the following factors:

- Sound Power Level of noise source given in octave bands from 63 Hz to 8 kHz;
- Source type estimation of the wave-front of the source, modelled as either a point, line, block or area source; and,
- Location of source in terms of co-ordinate plane x, y and z; matching the real-world location of the modelled source with the noise model.

Other data types which improves source accuracy includes:

- Source directivity; and,
- Operational duty cycles Hz.

Therefore, in order to produce a noise model which can aid the project assessment and engineering process, the accuracy of the noise input data is most critical. Sound power level data for noisy equipment is considered from the following source:

- Vendor provided noise data sheets; and,
- Calculated noise levels based on equipment specification.

Vendor data sheets weren't available at this phase of the project; therefore, equipment noise levels have been conservatively assumed to be within equipment limits of 85 dB(A) at 1m.

6.3 Major Noise Sources

Major noise sources identified as part of this study include:

- Generators;
- Turbines;
- Stacks;
- Pumps;
- Compressors;
- Fans;
- Blowers;
- Agitators; and,
- Transformers.

A detailed log of all the modelled noise sources and their associated noise levels is attached as Appendix B of this report.

7 Operational Noise Assessment

Calculations have been carried out under normal operating conditions to determine the level of compliance with the environmental noise requirements.

A series of noise contour maps have been produced to predict the noise levels in plant areas and across the project site. Noise contour maps are detailed in Appendix A.

Project in isolation:

- Figure A - 2 – Overall - Noise Contour Plot;
- Figure A - 3 – Group 1 - Noise Contour Plot; and,
- Figure A - 4 – Group 2 - Noise Contour Plot.

7.1 Normal Operation

A total of 151 continuous noise generating equipment items were modelled for normal operations. The noise from the project is dominated by a mixture of generators, turbines, stacks, pumps, compressors, air coolers/fans, blowers and transformers. A full list of sources considered are presented in Section 6 and the equipment noise data log is presented in Appendix B.

7.2 Site Boundary Noise Contribution

The site boundary assessment considers all noise sources within the Project. The project requirements specify that the noise level should not exceed a L_{Aeq} of 70 dB(A) at the property boundary for daytime and 65 dB(A) for night-time conditions. For the purposes of the assessment and modelling, point receptors were set up on the boundary fence of the site. Figure 7-1 details the locations of these point receptors, where several points are named as a reference. An average daytime baseline level of 49.6 dB(A) and a night-time average baseline noise level of 52.8 dB(A) was applied at the boundary based on the noise measurements taken at the property boundary.

Figure 7-1 – Site Boundary Point Receiver Locations

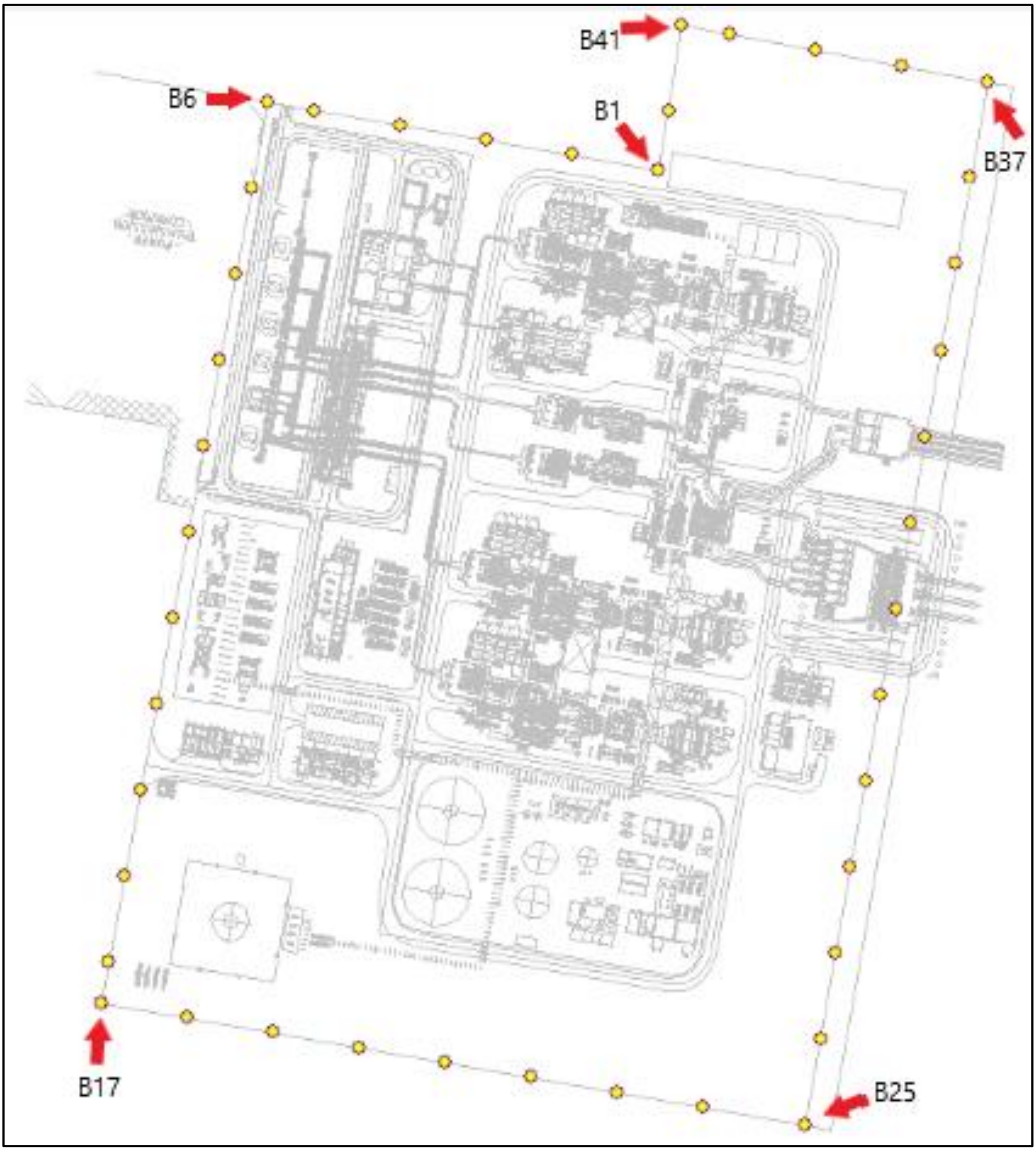


Table 7-1 and Table 7-2 detail the modelled noise contribution of the proposed project equipment items, as well as the estimated cumulative noise at the predefined receptors on the boundary of the site. Table 7-1 presents the cumulative noise in terms of daytime baseline noise, and Table 7-2 presents the corresponding night-time noise results.

Table 7-1 – Cumulative Daytime Boundary Contribution from Project Noisy Equipment for Normal Operations

Boundary Receptor	Boundary Noise Contribution (dB(A))	Baseline Noise (dB(A))	Cumulative Noise (dB(A))	70 dB(A) Limit Exceeded
B1	69.0	49.6	69.0	No
B2	66.4	49.6	66.5	No
B3	64.3	49.6	64.4	No
B4	62.0	49.6	62.2	No
B5	60.0	49.6	60.4	No
B6	59.2	49.6	59.7	No
B7	59.9	49.6	60.3	No
B8	60.4	49.6	60.7	No
B9	62.3	49.6	62.5	No
B10	64.0	49.6	64.2	No
B11	66.4	49.6	66.5	No
B12	67.3	49.6	67.4	No
B13	64.7	49.6	64.8	No
B14	57.3	49.6	58.0	No
B15	57.9	49.6	58.5	No
B16	56.6	49.6	57.4	No
B17	55.8	49.6	56.7	No
B18	56.9	49.6	57.6	No
B19	57.6	49.6	58.2	No
B20	59.4	49.6	59.8	No
B21	61.6	49.6	61.9	No
B22	61.9	49.6	62.1	No
B23	60.9	49.6	61.2	No
B24	61.5	49.6	61.8	No
B25	61.5	49.6	61.8	No
B26	63.8	49.6	64.0	No
B27	66.4	49.6	66.5	No
B28	68.7	49.6	68.8	No
B29	69.8	49.6	69.8	No
B30	70.3	49.6	70.3	Yes
B31	69.9	49.6	69.9	No
B32	69.5	49.6	69.5	No
B33	69.2	49.6	69.2	No

Boundary Receptor	Boundary Noise Contribution (dB(A))	Baseline Noise (dB(A))	Cumulative Noise (dB(A))	70 dB(A) Limit Exceeded
B34	68.4	49.6	68.5	No
B35	68.3	49.6	68.4	No
B36	66.0	49.6	66.1	No
B37	63.2	49.6	63.4	No
B38	64.0	49.6	64.2	No
B39	64.1	49.6	64.3	No
B40	64.0	49.6	64.2	No
B41	63.3	49.6	63.5	No
B42	66.2	49.6	66.3	No

Table 7-2 – Cumulative Night-Time Boundary Contribution from Project Noisy Equipment for Normal Operations

Boundary Receptor	Boundary Noise Contribution (dB(A))	Baseline Noise (dB(A))	Cumulative Noise (dB(A))	65 dB(A) Limit Exceeded
B1	69.0	52.8	69.1	Yes
B2	66.4	52.8	66.6	Yes
B3	64.3	52.8	64.6	No
B4	62.0	52.8	62.5	No
B5	60.0	52.8	60.8	No
B6	59.2	52.8	60.1	No
B7	59.9	52.8	60.7	No
B8	60.4	52.8	61.1	No
B9	62.3	52.8	62.8	No
B10	64.0	52.8	64.3	No
B11	66.4	52.8	66.6	Yes
B12	67.3	52.8	67.5	Yes
B13	64.7	52.8	65.0	No
B14	57.3	52.8	58.6	No
B15	57.9	52.8	59.1	No
B16	56.6	52.8	58.1	No
B17	55.8	52.8	57.6	No
B18	56.9	52.8	58.3	No
B19	57.6	52.8	58.8	No
B20	59.4	52.8	60.3	No

Boundary Receptor	Boundary Noise Contribution (dB(A))	Baseline Noise (dB(A))	Cumulative Noise (dB(A))	65 dB(A) Limit Exceeded
B21	61.6	52.8	62.1	No
B22	61.9	52.8	62.4	No
B23	60.9	52.8	61.5	No
B24	61.5	52.8	62.0	No
B25	61.5	52.8	62.0	No
B26	63.8	52.8	64.1	No
B27	66.4	52.8	66.6	Yes
B28	68.7	52.8	68.8	Yes
B29	69.8	52.8	69.9	Yes
B30	70.3	52.8	70.4	Yes
B31	69.9	52.8	70.0	Yes
B32	69.5	52.8	69.6	Yes
B33	69.2	52.8	69.3	Yes
B34	68.4	52.8	68.5	Yes
B35	68.3	52.8	68.4	Yes
B36	66.0	52.8	66.2	Yes
B37	63.2	52.8	63.6	No
B38	64.0	52.8	64.3	No
B39	64.1	52.8	64.4	No
B40	64.0	52.8	64.3	No
B41	63.3	52.8	63.7	No
B42	66.2	52.8	66.4	Yes

The results presented in Table 7-1 and Table 7-2 show that during normal operations, the predicted cumulative site boundary noise levels will be below the daytime limit of 70 dB(A) L_{Aeq} at all 42 boundary assessment points with the exception of point B30. The predicted cumulative night-time noise levels are above the night-time noise limit at locations B1, B2, B11, B12, B27-B36 and B42 on the northern, western and eastern boundary. These exceedances could be attributed to the close proximity of some of the equipment items to the boundary, particularly the pumps on the Eastern boundary between boundary receptors B30 and B33, combined with a lower night-time noise limit which contributes to the number of exceedances. It must also be noted that the assumption that all equipment items are operating at a noise level of 85 dB(A) at 1m is the most conservative assumption, in practice it is expected that a number of equipment items will be operating at lower noise levels. It is therefore recommended that an update to the model is completed once vendor data and more complete plots plans are available in order to verify if these predicted exceedances are still present.

7.3 Environmental Noise Assessment

An assessment of the noise contribution of the proposed plant has been conducted at various SRs identified in close proximity to the Project site. These include residences, schools and a beach. The predicted noise levels have been compared to the most stringent limits defined in the Federal standards and the IFC guideline noise levels. The locations of these SRs in relation to the project are illustrated in Figure 7-2. A contour plot for the normal operations of the facility is provided in Figure 7-3.

Figure 7-2 – Sensitive Receptor Locations

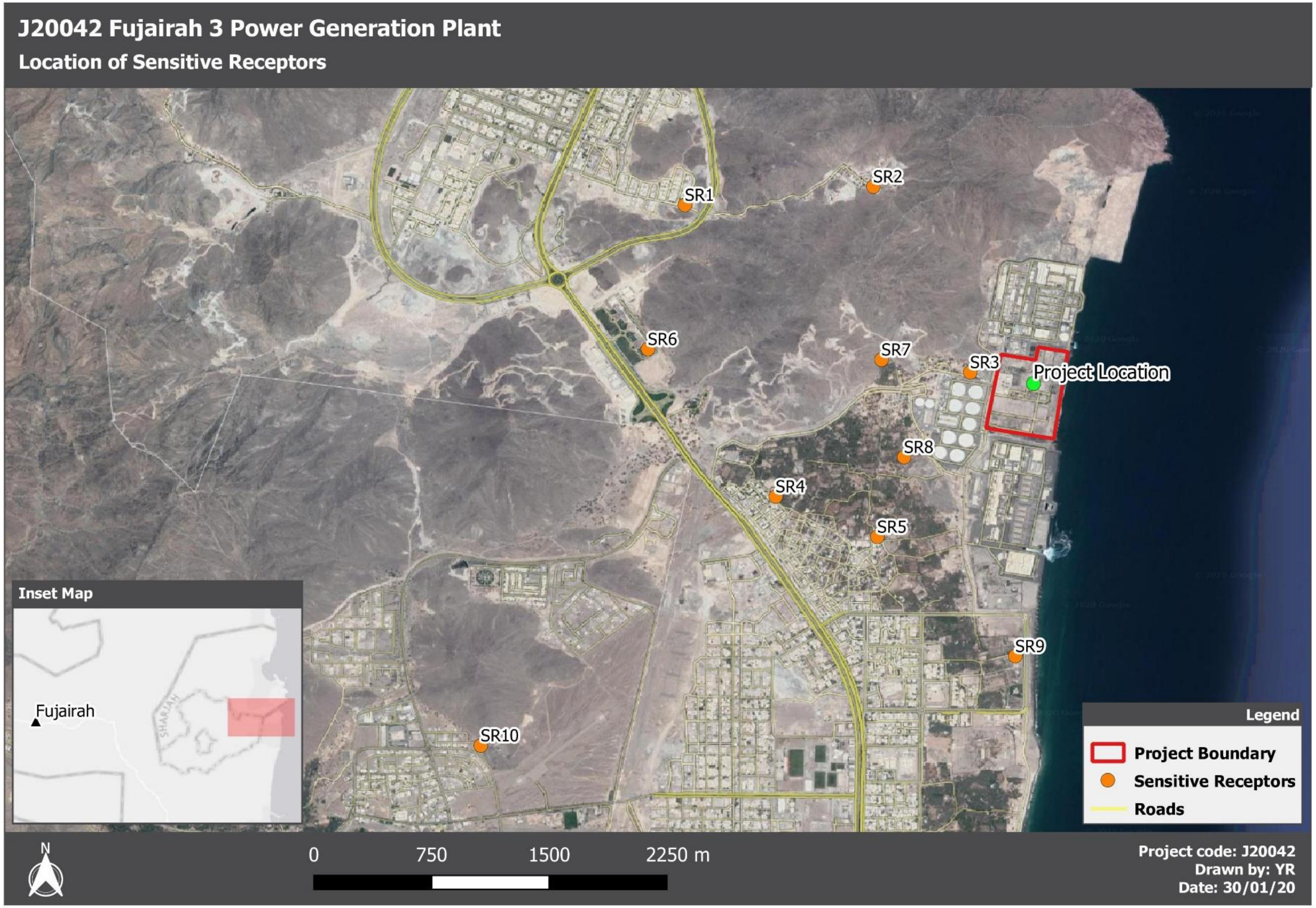
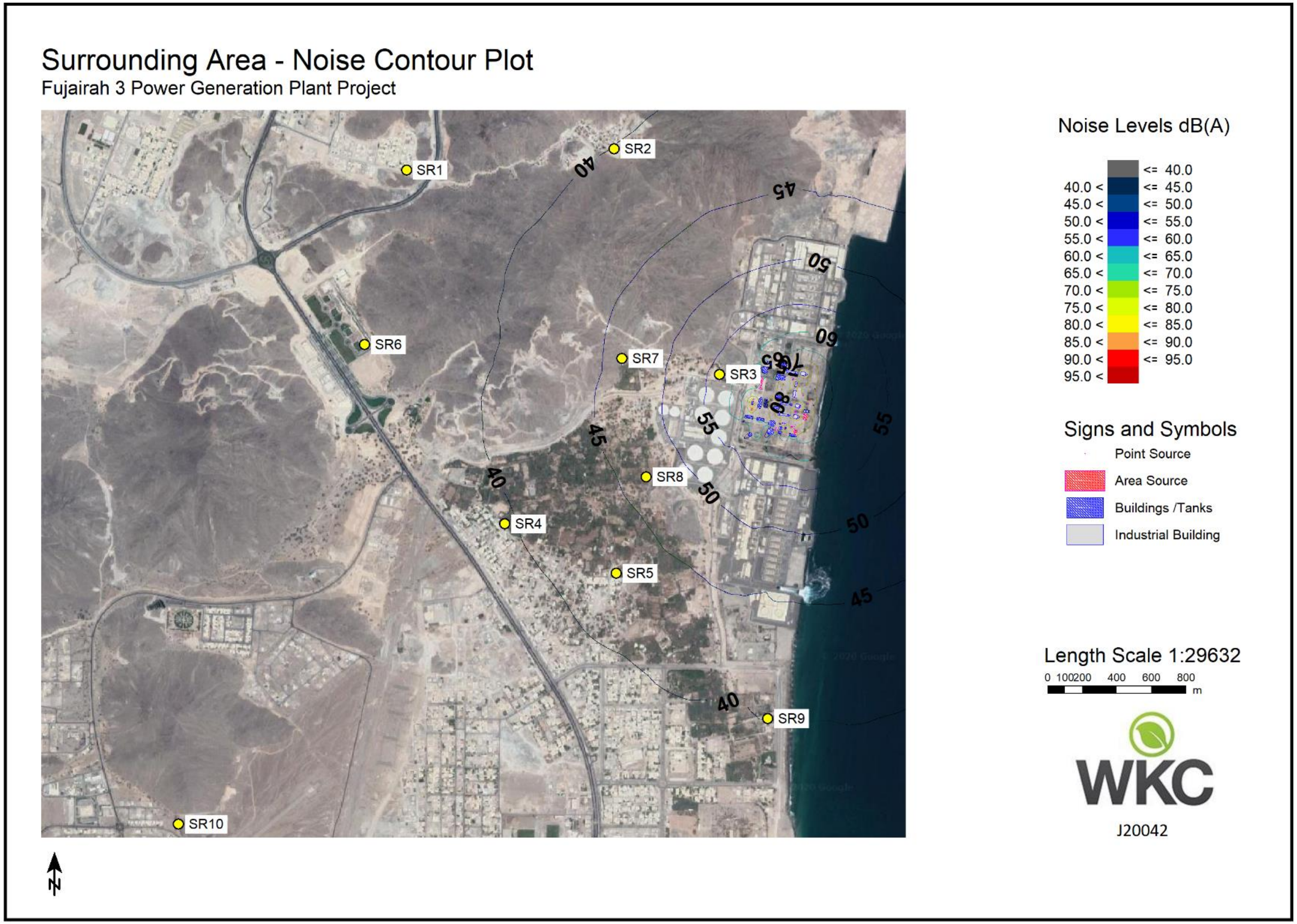


Figure 7-3 – Surrounding Area - Noise Contour Plot



The details of the SRs assessed, including receptor ID, classification and the coordinates are summarised in Table 7-3 below.

Table 7-3 – Sensitive Receptor Details

ID	Site Description	Site Classification	UTM Coordinates	
			m E	m N
SR1	Outskirts of Khawr Fakkan	Mixed Residential	434,653	2,800,609
SR2	Village south east of Khor Fakkan	Mixed Residential	435,853	2,800,732
SR3	Residential properties immediately west of the F3 site	Mixed Residential	436,464	2,799,428
SR4	Northern outskirts of Qidfa	Mixed Residential	435,221	2,798,564
SR5	North east outskirts of Qidfa	Mixed Residential	435,867	2,798,278
SR6	University of Sharjah	Institutional/Educational	434,412	2,799,600
SR7	Dwellings approximately 750 m west of the F3 site	Mixed Residential	435,899	2,799,519
SR8	Dwellings approximately 550 m south west of the F3 site	Mixed Residential	436,040	2,798,836
SR9	Qidfa beach	Mixed Residential	436,742	2,797,438
SR10	Madha residential area	Mixed Residential	433,334	2,796,828

7.3.1 Environmental Noise Assessment – Project Contribution in Isolation

The results of the predicted Project noise contributions at the SR locations in isolation are shown in Table 7-4 below.

Table 7-4 – Contributed Noise Levels at Selected Sensitive Receptors

ID.	Description	Most Stringent Noise Limits (dB(A))		Modelled Results (dB(A))	Value above Daytime Limit dB(A)	Value above Night-Time Limit (dB(A))
		Daytime	Night-Time			
SR1	Mixed Residential	60 (Federal)	50 (Federal)	36.2	-	-
SR2	Mixed Residential	60 (Federal)	50 (Federal)	38.3	-	-
SR3	Mixed Residential	60 (Federal)	50 (Federal)	55.0	-	5.0
SR4	Mixed Residential	60 (Federal)	50 (Federal)	38.0	-	-
SR5	Mixed Residential	60 (Federal)	50 (Federal)	40.4	-	-
SR6	Institutional/Educational	55 (IFC)	45 (IFC)	33.7	-	-
SR7	Mixed Residential	60 (Federal)	50 (Federal)	43.6	-	-
SR8	Mixed Residential	60 (Federal)	50 (Federal)	44.6	-	-
SR9	Mixed Residential	60 (Federal)	50 (Federal)	38.8	-	-
SR10	Mixed Residential	60 (Federal)	50 (Federal)	29.3	-	-

Table 7-4 shows the predicted noise levels from project contributions are below the Federal and IFC most stringent daytime and night-time limits at all locations with the exception of point SR3.

The highest modelled noise result of 55 dB(A) belonged to SR3, which is 170 m from the Project boundary. The result shows exceedance with the night-time limit of 50 dB(A) by 5.0 dB(A). The high noise level at SR3 can be attributed to the close proximity of the proposed project site to the existing receptors in the area and the cumulative noise level from noisy equipment items identified for this project. No single item has a major contribution that can be solely attributed to the exceedances, but rather a cumulative effect. A summary of noise control measures that could be applied are detailed in Section 8.

7.3.2 Environmental Noise Assessment – Cumulative Impact Assessment

A cumulative noise impact assessment was performed in order to determine the severity of the impact of the project at the nearest SR locations in the context of existing ambient noise levels. The results of the Project noise contribution and resulting cumulative noise and impacts at the identified SR's is presented in Table 7-5 for both daytime and night-time operations.

Table 7-5 – Operational Impact Assessment

ID.	Description	Project Noise Contribution (dB(A))	Baseline Noise Level (dB(A))	Cumulative Noise Level (dB(A))	Maximum Change in Noise Level at Receptor (dB(A))	Impact Severity
Daytime Operational Impact Assessment						
SR1	Mixed Residential	36.2	49.1[1]	49.3	0.2	Slight
SR2	Mixed Residential	38.3	54.6[1]	54.7	0.1	Slight
SR3	Mixed Residential	55.0	54.6	57.8	3.2	Low
SR4	Mixed Residential	38.0	49.1	49.4	0.3	Slight
SR5	Mixed Residential	40.4	61.1[1]	61.1	0.0	No Effect
SR6	Institutional/ Educational	33.7	49.1[1]	49.2	0.1	Slight
SR7	Mixed Residential	43.6	54.6[1]	54.9	0.3	Slight
SR8	Mixed Residential	44.6	44.8	47.7	2.9	Slight
SR9	Mixed Residential	38.8	58.6[1]	58.6	0.0	No Effect
SR10	Mixed Residential	29.3	49.1[1]	49.1	0.0	No Effect
Night-time Operational Impact Assessment						
SR1	Mixed Residential	36.2	46.1[1]	46.5	0.4	Slight
SR2	Mixed Residential	38.3	52.8[1]	53.0	0.2	Slight
SR3	Mixed Residential	55.0	52.8	57.0	4.2	Low
SR4	Mixed Residential	38.0	46.1	46.7	0.6	Slight
SR5	Mixed Residential	40.4	49.3[1]	49.8	0.5	Slight
SR6	Institutional/Educational	33.7	46.1[1]	46.3	0.2	Slight
SR7	Mixed Residential	43.6	52.8[1]	53.3	0.5	Slight

ID.	Description	Project Noise Contribution (dB(A))	Baseline Noise Level (dB(A))	Cumulative Noise Level (dB(A))	Maximum Change in Noise Level at Receptor (dB(A))	Impact Severity
SR8	Mixed Residential	44.6	45.4	48.0	2.6	Slight
SR9	Mixed Residential	38.8	53.3[1]	53.5	0.2	Slight
SR10	Mixed Residential	29.3	46.1[1]	46.2	0.1	Slight

Note 1: Baseline values were assigned based on the closest monitored receptor

Based on the cumulative results shown above, the severity in the change of noise levels at the SRs due to the project operation can be quantified. The results show that during the day, the predicted impacts from the project are in the range of “no effect” to “slight” with the exception of SR3 where a “low” impact is predicted. In terms of night-time noise levels, the predicted impacts are largely “slight”, with the exception of SR3 where a “low” impact is also predicted. It should also be noted that the increase in noise levels at SR3 (day and night) is predicted to be in excess of the IFC guideline, which states that the project should not result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

The following table shows the cumulative values of the project contribution and recorded baseline values at the SR locations. The cumulative values have been compared against the most stringent limits (Table 2-3).

Table 7-6 – Project Noise Limit Assessment

ID.	Description	Most Stringent Noise Limits (dB(A))	Modelled Results (dB(A))	Baseline Noise (dB(A))	Cumulative Noise Level (dB(A))	Limit Exceeded?	Cumulative Value above Limit dB(A)
Daytime Cumulative Noise levels at SR's							
SR1	Mixed Residential	60 (Federal)	36.2	49.1[1]	49.3	No	-
SR2	Mixed Residential	60 (Federal)	38.3	54.6[1]	54.7	No	-
SR3	Mixed Residential	60 (Federal)	55.0	54.6	57.8	No	-
SR4	Mixed Residential	60 (Federal)	38.0	49.1	49.4	No	-
SR5	Mixed Residential	60 (Federal)	40.4	61.1[1]	61.1	Yes	1.1
SR6	Institutional/ Educational	55 (IFC)	33.7	49.1[1]	49.2	No	-
SR7	Mixed Residential	60 (Federal)	43.6	54.6[1]	54.9	No	-
SR8	Mixed Residential	60 (Federal)	44.6	44.8	47.7	No	-
SR9	Mixed Residential	60 (Federal)	38.8	58.6[1]	58.6	No	-
SR10	Mixed Residential	60 (Federal)	29.3	49.1[1]	49.1	No	-
Night-time Cumulative Noise levels at SR's							
SR1	Mixed Residential	50 (Federal)	36.2	46.1[1]	46.5	No	-
SR2	Mixed Residential	50 (Federal)	38.3	52.8[1]	53.0	Yes	3.0
SR3	Mixed Residential	50 (Federal)	55.0	52.8	57.0	Yes	7.0
SR4	Mixed Residential	50 (Federal)	38.0	46.1	46.7	No	-
SR5	Mixed Residential	50 (Federal)	40.4	49.3[1]	49.8	No	-

ID.	Description	Most Stringent Noise Limits (dB(A))	Modelled Results (dB(A))	Baseline Noise (dB(A))	Cumulative Noise Level (dB(A))	Limit Exceeded?	Cumulative Value above Limit dB(A)
SR6	Institutional/ Educational	45 (IFC)	33.7	46.1[1]	46.3	Yes	1.3
SR7	Mixed Residential	50 (Federal)	43.6	52.8[1]	53.3	Yes	3.3
SR8	Mixed Residential	50 (Federal)	44.6	45.4	48.0	No	-
SR9	Mixed Residential	50 (Federal)	38.8	53.3[1]	53.5	Yes	3.5
SR10	Mixed Residential	50 (Federal)	29.3	46.1[1]	46.2	No	-

Note 1: Baseline values were assigned based on the closest monitored receptor

As can be seen from Table 7-6 several of the cumulative noise levels at the SR's are in exceedance of the most stringent noise limits defined in Table 2-3. With the exception of SR3, these exceedances can be entirely attributed to the relatively high baseline noise levels recorded in these areas, which are already exceeding the limits before the project contribution is added. SR3 already also has a baseline level that is above the limit however the project should not contribute noise that can significantly contribute further to this exceedance. Again, this relatively high project contribution at SR3 could be attributed to the close proximity of the receptor to this industrial site (170 m) and the conservative nature of the modelling assessment.

8 Noise Control

Noise control is required when the predicted noise levels from a project have the potential to exceed the relevant noise levels at SRs. The common practice for controlling noise levels from stationary sources is to implement noise control measures at the source, these methods depend on the type of source and the proximity of the receptors to the noise. Noise mitigation measures, proposed in the IFC General EHS Guidelines [4], that should be considered include but are not limited to:

- Selecting equipment with lower sound power levels;
- Installing silencers for fans;
- Installing suitable mufflers on engine exhausts and compressor components;
- Installing acoustic enclosures for equipment casing radiating noise;
- Improving the acoustic performance of constructed buildings, apply sound insulation;
- Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective;
- Installing vibration isolation for mechanical equipment;
- Developing a project noise control plan during the EPC phase;
- Limiting the hours of operation for specific pieces of equipment or operations;
- Re-locating noise sources to less sensitive areas to take advantage of distance and shielding;
- Siting permanent facilities away from community areas if possible;
- Taking advantage of the natural topography as a noise buffer during facility design; and,
- Developing a mechanism to record and respond to complaints.

Due to fact that the conservative nature of the modelling could be a factor in the predicted exceedances, it is recommended that a detailed assessment should be conducted during the EPC stage of the project, once vendor equipment data sheets and more complete plot plans are available.

9 Conclusion

An environmental noise modelling assessment has been conducted for the F3 Power Generation Plant. The project is located in Qidfa in the Emirate of Fujairah.

9.1 Construction phase

The assessment of noise impacts due to construction equipment was carried out in accordance with the methodology outlined in BS5228, [1] and the construction noise guidelines of the Department of Environment and Climate Change NSW [2]. The predicted noise levels generated by general construction activities for daytime and night-time periods are anticipated to fall below the construction noise thresholds for all locations with the exception of SR3 and SR8 [2]. Based on the cumulative results, the results show that during the day, the predicted impacts from the project are in the range of “slight” with the exception of SR3 and SR8 where a “high” impact is predicted. In terms of night-time noise levels, the predicted impacts are in the range of “slight” to “high” with majority of the SRs having a “low” impact severity. However, this represents a reasonable worst-case scenario, where all items in the general construction equipment list have been assumed to be operating concurrently at a single location. Additionally, it can be noted that SR8 might have substantial screening due to the large tanks located between the receptor and the Project boundary which has not been accounted for in the noise model.

Due to the transient nature of construction noise, it is advised that ‘best practice’ measures be implemented in respect of noise control, wherever possible. A variety of possible noise management measures have been suggested, which if implemented effectively, could lead to reduction in impacts for the onsite receptors which are affected by construction noise and therefore should be implemented through HSE management plans (‘Noise Control Plan’ during construction).

9.2 Operations Phase

The aim of the operations phase noise assessment was to establish project compliance with environmental noise standards. This report presents the findings of a noise modelling analysis of high noise-emitting equipment items associated with the project.

Potentially noisy equipment items of plant that included turbines, generators, pumps, blowers, compressors, and other equipment items were modelled using the internationally recognised SoundPLAN model and a series of noise contour maps produced (Appendix A).

The assessment of the predicted environmental noise levels arising from the Project was carried out by means of a site boundary noise assessment, as well as an assessment of discrete SRs in the adjacent community area.

9.2.1 Boundary Noise Assessment

The site boundary noise assessment predicted noise levels in isolation ranging from 55.8 dB(A) to 70.3 dB(A). During normal operations, the predicted cumulative site boundary noise levels were found to be below the daytime limit of 70 dB(A) L_{Aeq} at all 42 boundary assessment points with the exception of point B30. When comparing the cumulative noise levels against night-time limit of 65 dB(A), the limit was estimated to be exceeded at locations B1, B2, B11, B12, B27-B36 and B42 on the northern, western and eastern boundary. These exceedances could be attributed to the close proximity of some of the equipment items to the boundary, particularly the pumps located at the eastern boundary between boundary receptors B30 and B33, combined with a lower night-time noise limit which contributes to the number of exceedances.

9.2.2 Environmental Noise Assessment – Project Contribution in Isolation

The assessment of the project contributions at the SRs predicted one exceedance of the applicable limits. For mixed residential locations, the most stringent limit is defined by the Federal law and therefore was used to assess these locations. The assessment predicted no exceedances at the residential locations of the daytime limits, however when assessing against the night-time limits, there is one exceedance predicted at SR3. The baseline noise level recorded at SR3 indicates that the Federal night-time limit of 50 dB(A) is already being exceeded, however in accordance with the assessment methodology the proposed project should not significantly contribute further to this exceedance (impact severity of Low). It should however be noted that the increase in noise levels at SR3 (day and night) is predicted to be in excess of the IFC guideline, which states that the project should not result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

The exceedance at SR3 can be attributed to the close proximity of the Project site to the existing receptor and the cumulative equipment noise levels. No single item has a major contribution that can be solely attributed to the exceedances, but rather a cumulative effect from a large number of items. It is recommended that these receptors are reassessed once vendor data is available.

9.2.3 Environmental Noise Assessment – Cumulative Impact Assessment

A cumulative assessment was also conducted in order to estimate the potential increase in ambient noise levels at SRs as a result of Project noise contribution. The results of this assessment indicate that for daytime periods, the projects noise contribution is likely to range from “no effect” to “slight” with the exception of SR3 where a “low” impact is predicted. Slight impacts are marginal changes to the noise level and are not discernible.

For night-time periods, the cumulative assessment largely predicted “slight” impacts with the exception of SR3. SR3 is predicted to have an increase of approximately 4.2 dB(A) having a “low” impact and, therefore, having a noticeable adverse impact.

In addition to the assessment of change in ambient noise, an assessment of the cumulative noise levels at SRs was carried out in terms of the most stringent noise limits defined in Table 2-3. The results of the assessment (Table 7-6) shows that cumulative noise levels are anticipated to exceed the most stringent noise limits (SR5 exceeded the daytime noise limit whereas SR2, SR3, SR6, SR7 and SR9 exceeded the night-time noise limit); this is primarily due to the high baseline noise levels. Whilst the project does have contributions that exceed the limits at some points, they are largely “slight” based on the change in ambient noise assessment results presented in Table 7-5.

It is recommended that a detailed assessment should be conducted during the EPC stage of the project, once vendor equipment data sheets are available. The overall noise levels produced by the project are anticipated to decrease marginally once vendor data is available as it is unlikely that all equipment will be operating at a noise level of 85 dB(A) at 1 m.

9.2.4 Recommendation

It must also be noted that the assumption that all equipment items are operating at a noise level of 85 dB(A) at 1m is the most conservative assumption. It is therefore recommended that an update to the model is completed once vendor data and more complete plots plans are available in order to verify if these predicted exceedances are still present.

10 References

[1] British Standards Institute (BSI), BS5228 - Noise and Vibration Control on Construction and Open Sites, London: BSI, 2014.

[2] Department of Environmental & Climate Change NSW, Interim Construction Noise Guideline, Sydney, 2009.

[3] International Organisation for Standardisation (ISO), "ISO 1613-2 'Acoustics - Attenuation of Sound during Propogation Outdoors'," 1993.

[4] International Finance Corporation, *General Environment, Health and Safety (EHS),* International Finance Corporation (IFC), 2007.

[5] World Health Organisation (WHO), "Guidelines for Community Noise," WHO, Geneva, 1995.

[6] Official Government Gazette 4597, *Instructions for Reduction and Prevention of Noise (2003),* Hashemite Kingdom of Jordan, 15/05/2003, p. 2335.

[7] International Finance Corporation (IFC), *General Environment, Health and Safety (EHS) Guidelines for Mining,* International Finance Corporation (IFC), 2007.

[8] International Organisation for Standardisation (ISO), "ISO 1996-1-3 'Description and Measurement for Environmental Noise'," 2016.

[9] D. Bies and C. Hansen, Engineering Noise Control, 4th Ed, Theory and Practice, Spon Press, 2009.

[10] I. Sharland, "Woods Practical Guide to Noise Control," Woods of Colchester Limited, 1979.

[11] EWEC, "General Technical Specifications".

11 Glossary

dB - Decibel: dB is a logarithmic unit of measurement that expresses the magnitude of a physical quantity (usually power or intensity) relative to a specified or implied reference level. Since it expresses a ratio of two quantities with the same unit, it is a dimensionless unit.

dB(A): The 'A' weighting network is very similar to the way in which the human ear responds to variations in sound pressure level as it places higher attenuation on the lower frequencies than on the mid to upper frequencies. It is applied to the decibel scale in order to account for how the human ear responds to changes in sound levels.

L_{A90}: The noise level exceeded for 10% of the measurement period with A weighting.

L_{A90}: The noise level exceeded for 90% of the measurement period with A weighting.

L_{Amin}: The minimum sound level with A weighting.

L_{Amax}: The maximum sound level with A weighting.

L_{Aeq} T: This is the continuous equivalent sound level. It is a widely used noise parameter that calculates a constant level of noise with the same energy content as the varying acoustic noise signal being measured. The letter "A" denotes that the A-weighting has been included and "eq" indicates that an equivalent level has been calculated. Hence, L_{Aeq} is the A-weighted equivalent continuous noise level. A-weighting is a filter incorporated into a sound level meter which when measuring noise replicates the sensitivity of human hearing.

L_{ASN}, T percentile levels: The level of A-weighted noise exceeded for N% of the measurement time. L_{AS90}, T is often used as a measure of background noise in many standards and guidelines. The L_{AS90}, T parameter would therefore represent the level exceeded for 90% of the measurement period, T. Likewise the L_{AS10}, T would indicate the level exceeded for 10% of the measurement period, T indicating the higher noise levels measured.

L_p - Sound Pressure Level: An acoustic measurement for the ratios of sound energy. Rated in decibels.

L_w - Sound Power Level: The L_w is a measure of the total airborne acoustic power generated by a noise source, expressed on a decibel scale referenced to a common standard (10-12 watts).

Octave Band Analysis: To identify frequency components of a sound, there is octave band analysis in which frequencies are segmented into proportionate widths (octave bands) and analysed. The sound pressure level of a single octave band is called the "octave band level", while that analysed for 1/3 of the octave band is called a "1/3 octave band level". The frequency band in the octave band and 1/3 octave band is expressed as the centre frequency of that band. Using f1 and f2 as the upper and lower end frequencies of the band.

Appendix A – Noise Contours

- Figure A-2 – Overall - Noise Contour Plot;
- Figure A-3 – Group 1 - Noise Contour Plot; and,
- Figure A-4 – Group 2 - Noise Contour Plot.

Refer to the plot plan in Figure A - 1 indicating ‘Group 1’ and ‘Group 2’ equipment items/systems.

Figure A - 1 – Plot Plan Indicating Group 1 and Group 2 Equipment Items

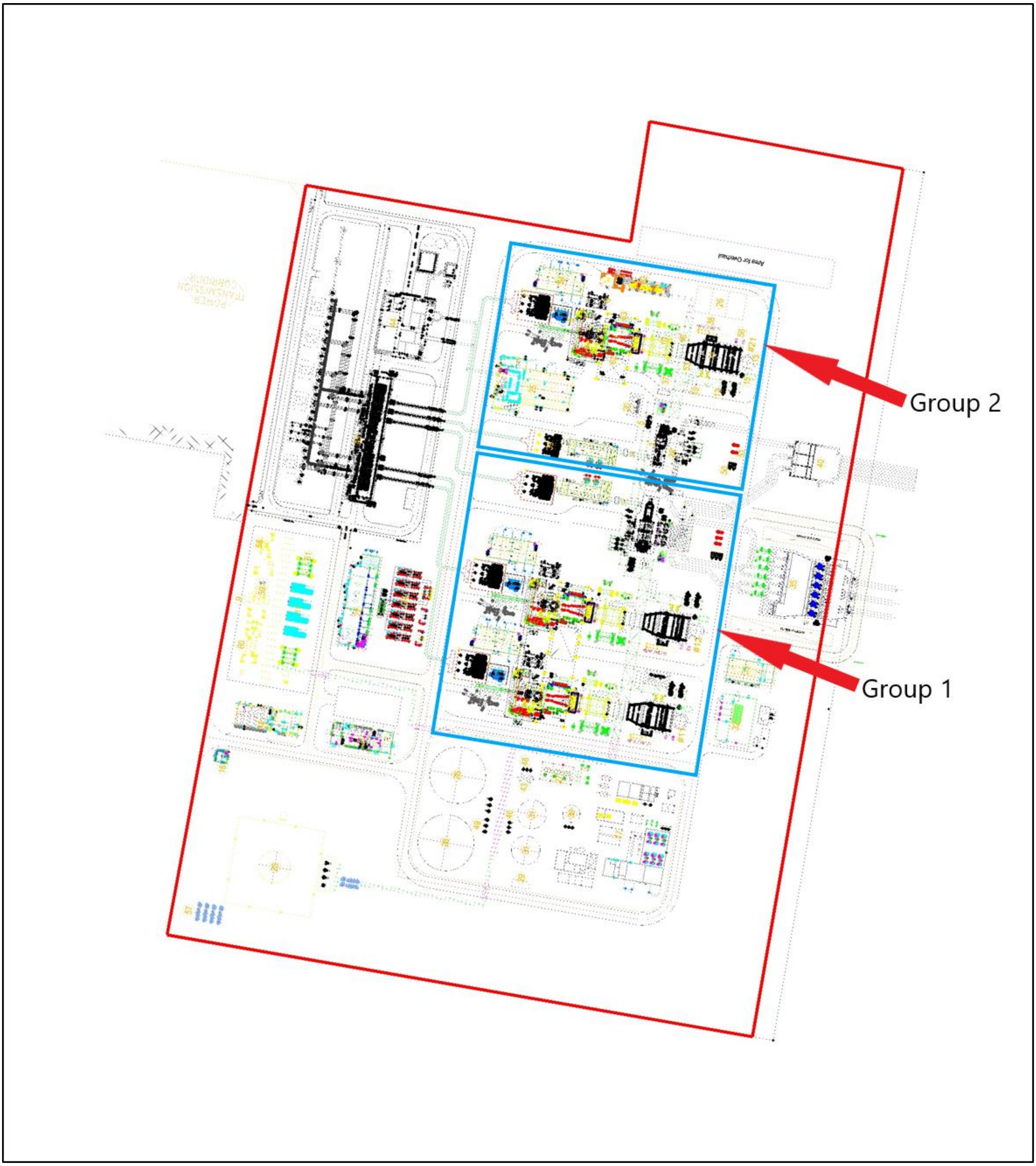


Figure A - 2 – Overall - Noise Contour Plot

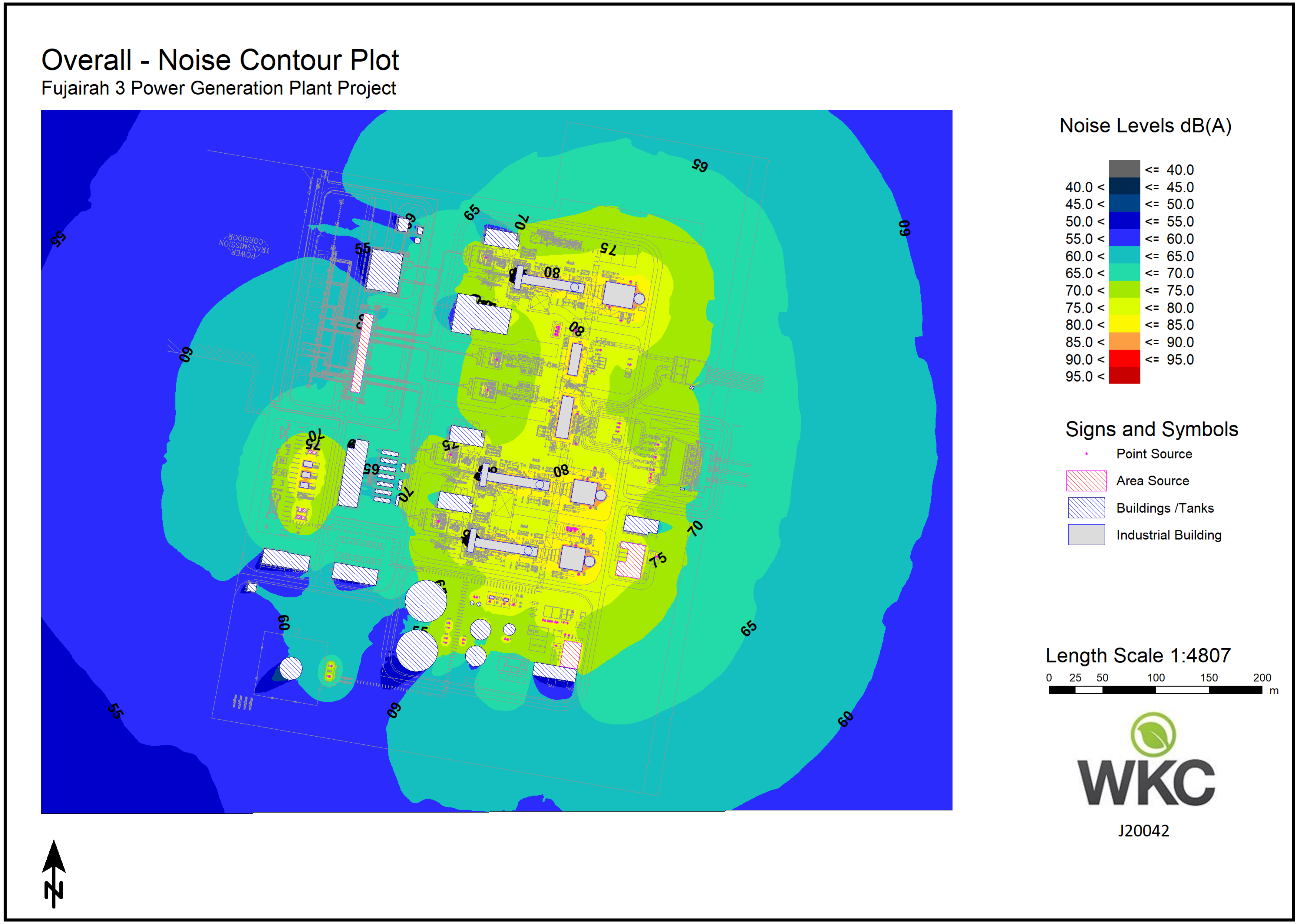


Figure A - 3 – Group 1 - Noise Contour Plot

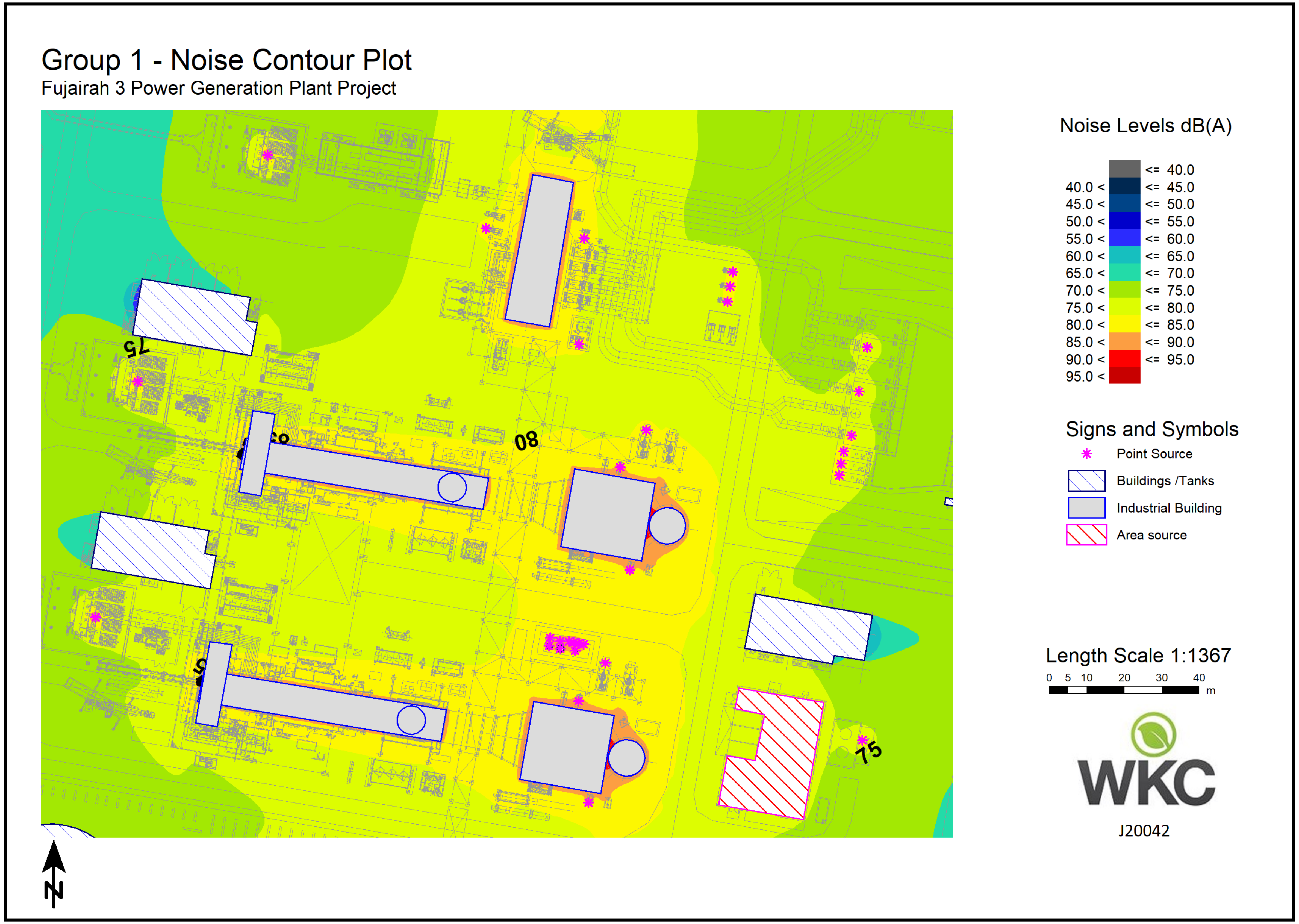


Figure A - 4 – Group 2 - Noise Contour Plot

Appendix B – Equipment Noise Data Log

Table B - 1 – Equipment Noise Log

Unit/System/ Package	Equip Type	Equipment Description	No. of Items	Source Type	Lp (dB(A)) @ 1m	Single Octave Frequency Band, Hz, Sound Power Levels (dB(A))									Overall Sound Power (Lw) dB(A)	Comment
						31.5	63	125	250	500	1k	2k	4k	8k		
Gas Turbine Generator (GTG) and Auxiliaries	Generator	GTG	3	Block[1]	85	75,0	87,1	95,6	101,0	104,2	105,4	105,2	103,1	75,0	111,2	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Turbine	GT	3	Block[1]	85	75,0	87,1	95,6	101,0	104,2	105,4	105,2	103,1	75,0	111,2	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Filter House	GT Inlet Filter House	3	Block[1]	85	89,4	94,4	98,5	99,6	100,2	98,5	96,1	92,1	89,4	106,3	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Steam Turbine Generator (STG) and Auxiliaries	Generator	STG (Large)	1	Block[1]	85	109,8	79,4	90,5	98,0	103,4	104,6	103,8	100,6	93,5	109,8	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Turbine	ST (Large)	1	Block[1]	85	109,8	79,4	90,5	98,0	103,4	104,6	103,8	100,6	93,5	109,8	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Generator	STG (Small)	1	Block[1]	85	107,9	77,5	88,6	96,1	101,5	102,7	101,9	98,7	91,6	107,9	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Turbine	ST (Small)	1	Block[1]	85	107,9	77,5	88,6	96,1	101,5	102,7	101,9	98,7	91,6	107,9	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Diverter Damper and Bypass Stack	Stack	Bypass Stack	3	Point	124.4	84,8	89,8	93,9	95,0	95,6	93,9	91,5	87,5	84,8	101,7	Given < 124.4 dB(A) at 1m, Spectrum from ENC Ch11
HRSG	Generator	HRSG	3	Block[1]	85	79,1	90,2	97,7	103,1	104,3	103,5	100,3	93,2	79,1	109,5	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Pump	Cycles per Hour (CPH) Recirculation Pump	3	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Stack	HRSG Main Stack	3	Point	85	86,3	91,3	95,4	96,5	97,1	95,4	93,0	89,0	86,3	103.2	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Condensate System	Pump	Condensate Extraction Pump	2	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Feedwater System	Pump	Boiler Feedwater Pump	3	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Natural Gas System	Compressor	Fuel Gas Compressor	3	Block[1]	85	67,5	78,6	82,1	87,5	92,7	97,9	96,7	90,6	67,5	101.7	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Fan	Fuel Gas Compressor Air Cooler	3	Area	85	67,9	76,0	85,5	90,9	93,1	91,3	86,1	82,0	67,9	97.5	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Fuel Oil System	Pump	Fuel Oil Forwarding Pump	2	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Intake Facility and Circulating Water (CW) System	Pump	CW Pump	3	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Pump	Desalination Feed Pump	1	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Pump	Auxiliary CW Pump	2	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Condenser Air Removal System	Pump	Condenser Vacuum Pump	2	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Pump	Waterbox Priming Pump	2	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Closed Cooling Water (CCW) System	Pump	CCW Pump	4	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Potable Water System	Pump	Potable Water Delivery Pump	2	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Service Water System	Pump	Service Water Delivery Pump	2	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11

Unit/System/ Package	Equip Type	Equipment Description	No. of Items	Source Type	Lp (dB(A)) @ 1m	Single Octave Frequency Band, Hz, Sound Power Levels (dB(A))									Overall Sound Power (Lw) dB(A)	Comment
						31.5	63	125	250	500	1k	2k	4k	8k		
	Pump	Demineralized Water Supply Pump	4	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Pump	Grease Trap De-NOx Water Supply Pump	2	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Pump	Desalinated Water Supply Pump	2	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Pump	Remineralization System Feed Pump	1	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Instrument Air System	Compressor	Air Compressor	2	Block[1]	85	63,9	75,0	78,5	83,9	89,1	94,3	93,1	87,0	63,9	98.1	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Fan	Air Dryer	1	Point	85	67,9	76,0	85,5	90,9	93,1	91,3	86,1	82,0	67,9	97.5	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Desalination and Demineralized Water System	Pump	HP Feed Pump	3	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Pump	Pumps (Desalination)	9	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Compressor	Dissolved Air Flotation (DAF) Air Compressor	1	Block[1]	85	57,2	68,3	71,8	77,2	82,4	87,6	86,4	80,3	57,2	91.4	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Blower	Blowers for Water Treatment System	2	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Wastewater Treatment System	Pump	Pumps for Wastewater Treatment System	7	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Blower	Mixing Air Blower	2	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Chemical Feed System	Agitator	Chemical Storage Tank Agitator	6	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Pump	Chemical Dosing Pump	9	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
Electro-Chlorination System	Pump	Pumps for Electro-Chlorination System	8	Area	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Blower	Dilution Air Blowers	1	Point	85	57,2	68,3	77,8	83,2	89,4	87,6	83,4	75,3	57,2	93.0	Given < 85 dB(A) at 1m, Spectrum from ENC Ch11
	Transformer	Transformer	3	Area	70	-	-	-	78,0	-	-	-	-	-	78	Assumed 70 dB(A) at 1 m, Assumed Central Frequency at 500 Hz
Generator Step-up Transformer	Transformer	Step-up Transformer for GTG	3	Area	70	-	-	-	99,2	-	-	-	-	-	99.2	Assumed 70 dB(A) at 1 m, Assumed Central Frequency at 500 Hz
	Transformer	Step-up Transformer for STG (Large)	1	Point	70	-	-	-	99,2	-	-	-	-	-	99.2	Assumed 70 dB(A) at 1 m, Assumed Central Frequency at 500 Hz
	Transformer	Step-up Transformer for STG (Small)	1	Point	70	-	-	-	99,1	-	-	-	-	-	99.1	Assumed 70 dB(A) at 1 m, Assumed Central Frequency at 500 Hz
Unit Auxiliary Transformer (UAT) and Service Transformer	Transformer	UAT	3	Area	70	78,0	-	-	-	78,0	-	-	-	-	78,0	Assumed 70 dB(A) at 1 m, Assumed Central Frequency at 500 Hz
	Transformer	Station Service Transformer	24	Area	70	78,0	-	-	-	78,0	-	-	-	-	78,0	Assumed 70 dB(A) at 1 m, Assumed Central Frequency at 500 Hz

Note 1: The sound power levels for block sources are presented in Lw/m^2 of source façade area

Appendix C – Baseline Detailed Information

MEASUREMENT SYSTEMS

CERTIFICATE OF CONFORMANCE

Date of Issue	**01 April 2019**
Customer	**Anthesis Middle East**
Certificate Number	**CONF041902**

	Manufacturer	Type	Serial
Sound Level Meter	Rion	NL-52	00197695
Preamplifier	Rion	NH-25	87904
Microphone	Rion	UC-59	14643

This is to certify that the instrument was tested and calibrated at the Manufacturer's factory according to their specification and that the product satisfied all the relevant requirements of the following Standards:

IEC 61672-1:2013 Class 1.

The instrument also received a functional check by ANV Measurement Systems prior to despatch in the UK, in accordance with our standard procedures.

Signed. Amrat C. Patel .. Position. Calibration Technician Date. 01 April 2019

A C Patel

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MEASUREMENT SYSTEMS

CERTIFICATE OF CONFORMANCE

Date of Issue	**01 April 2019**
Customer	**Anthesis Middle East**
Certificate Number	**CONF041901**

	Manufacturer	Type	Serial Number
Acoustic Calibrator	Rion	NC-75	34291327

This is to certify that the instrument was tested and calibrated at the Manufacturer's factory according to their specification and that the product satisfied all the relevant requirements of the following Standards:

IEC 60942:2003 Class 1 (Electroacoustics - Sound Calibrators)

The instrument also received a functional check by ANV Measurement Systems prior to despatch in the UK, in accordance with our standard procedures.

Signed Amrat C. Patel	Position	Date
A C Patel	Calibration Technician	01-Apr-19

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Appendix 2-4 – Hydrodynamic Modelling Report

Anthesis

Fujairah 3 Independent Power Plant (F3-IPP)

Marine Modelling Assessment

Prepared for: Anthesis

Ref.: J20042-R-03

Date: 11-02-2020

Report Approval & Revision Record

Project:		Fujairah 3 Independent Power Plant (F3-IPP)		
Document Title:		Marine Modelling Assessment		
Client:		Anthesis		
Report Number:		J20042-R-03		
Rev	Date	Prepared	Reviewed	Approved
00	11-02-2020	Ravel Barnard Environmental Engineer	Greg Ashcroft Partner	Greg Ashcroft Partner

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Acronyms

2D	Two-dimensional
3D	Three-dimensional
°C	Degrees Celsius
AD	Advection and Dispersion
AWQS	Ambient Marine Water Quality Standards
BCG	Boundary Conditions Generator
CFSR	Climate Forecast System Reanalysis
CSIRO	Commonwealth Scientific and Industrial Research Organisation
E	Efficiency Coefficient
EAD	Environment Abu Dhabi
EPDD	Environmental Protection and Development Department
ESIA	Environmental and Social Impact Assessment
EWEC	Emirates Water and Electricity Company
FM	Flow Model
HD	Hydrodynamic
HYCOM	Hybrid Coordinate Ocean Model
IFC	International Finance Corporation
IOA	Index of Agreement
IPP	Independent Power Plant
km	kilometre
LAT	Lowest Astronomical Tide
m	metre
MDL	Minimum Detection Limit
mg/l	milligrams per litre
m^3/s	cubic metres per second
MAE	Mean Absolute Error
mg/l	milligrams per litre
MSL	Mean Sea Level
MWQO	Marine Water Quality Objectives
NASA	The National Aeronautics and Space Administrations
NCEP	National Centres for Environmental Prediction
NOPP	National Ocean Partnership Program
ppt	parts per thousand
PSU	Practical Salinity Unit
RMSE	Root Mean Square Error
RMZ	Regulatory Mixing Zone
SWRO	Salt Water Reverse Osmosis

TDS	Total Dissolved Solids
TR	Transport Module
UAE	United Arab Emirates
UKHO	United Kingdom Hydrographic Office
WKC	WKC Environment Consultancy

1 Introduction

1.1 Background

WKC Environment Consultancy (WKC) have been contracted by Anthesis to conduct a hydrodynamic and thermal plume study for the effluent outfalls associated with the proposed Independent Power Plant (IPP), known as Fujairah-3 (F3). The proposed F3 site is located in between to the existing Fujairah 1 (F1) and Fujairah 2 (F2) IPP, on the coast of Fujairah, United Arab Emirates (UAE).

Marubeni Corporation (Marubeni) have been awarded the opportunity to submit their design proposal to Emirates Water and Electricity Company (EWEC) for the proposed F3 project and the scope of works outlined within this report were conducted in order to aid in an Environmental and Social Impact Assessment (ESIA) which the client has been awarded to prepare for submission for evaluation by Fujairah Municipality Environmental Protection and Development Department (FM-EPDD), International Finance corporation (IFC) and Japan Bank for International Cooperation. .

The proposed F3 project is the third power facility at this location and will be situated in between these two existing IPPs (F1 & F2). Note F1 has also been expanded to include a Sea Water Reverse Osmosis plant (F1 SWRO) being located to the north-east of F1. The F3 project will require the supply sea water for cooling purposes throughout the design life of the project.

Below in Figure 1-1 shows the project location in a local context.

Figure 1-1 - Fujairah F3 IPP - Local Context

1.2 Study Objectives

The objectives of the hydrodynamic modelling assessment were to provide technical support in aid of the impact assessments contained within the ESIA. These objectives can be summarised as follows:

- Simulation of hydrodynamics to feed into subsequent dispersion assessments;
- Simulations to determine the mixing zone of the thermal plume (and other parameters of concern) discharged from F3 and cumulative contribution from F1 and F2;
- Analysis to determine whether cooling water re-circulation is observed; and
- Assess whether regulatory compliance is met with regards to effluent discharge temperatures, salinities and residual chlorine.

2 Project Standards

2.1 Legal Context

This section describes the environmental regulatory framework in Fujairah and the UAE, including relevant guidelines, protocols and standards that will be applicable to the Project. The regulatory framework and project requirements and standards are detailed below:

- Fujairah Municipality (FM) Environment Protection and Development Department (EPDD) guidelines and procedures;
- UAE Federal environmental legislation and policies [1];
- International Finance Corporation's (IFC) General Environmental, Health and Safety (EHS) guidelines [2]; and
- EWEC environmental parameters for effluent discharges as stipulated in the PPA.

2.1.1 Fujairah Municipality

With regards to this assessment, the FM-EPDD follows the legislation as set out within Federal Law No. (24) of 1999, Protection and Development of Environment as described below.

2.1.2 UAE Federal Regulations

Federal Law No. (24) of 1999, Protection and Development of Environment is the key environmental law within the UAE. This law broadly outlines environmental protection across different environmental aspects (such as marine pollution, chemical materials, hazardous wastes and air pollution) and outlines the requirement for adequate environmental impact assessments of projects.

The principal law which is subject to this assessment is that set forth in the Council of Ministers Decree No. 37 of 2001 – Regulation for the Protection of the Maritime Environment [1]. The principle requirements of Chapter 3 of this regulation, pertaining to this scope of works, are as follows:

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

In accordance with the Council of Ministers' Decision No 37 – 2001 – Protection of the Marine Environment, the following non-degradable pollutants / Illegal compounds listed in Table 2-1 below, are not to be discharged into marine environment:

Table 2-1 – UAE Federal Discharge Banned Substances [3]

Organ phosphorus Pesticides	Polychlorinated Biphenyls
Dimethoate	PCBs
Malathion	Aroclor
Organochlorine Pesticides	Tetrachlorobiphenyl
Aldrin	Trichlorobiphenyl
Dieldrino	Polynuclear Aromatic Hydrocarbons (PAH)
DDT	Benzo (a) pyrene and Naphthalene

Note that the cooling water will not contain any of the above banned substances under any conditions. Therefore, the Federal Regulations are not considered further within this assessment.

The full text of the Regulation should be referred to for further details. Specific discharge standards contained within the regulation are presented in Table 2-2.

Table 2-2 – Treated Industrial Wastewater Standards for Discharge to Sea from Land-based Sources

Parameter	**Symbol**	**Unit**	**Suggested Limit**
Physical Properties			
Total Suspended Solids	TSS	mg/L	50
Total Dissolved Solids	TDS	mg/L	1,500
pH		pH Units	6-9
Floating Particles		mg/m^2	None
Temperature Rise (above ambient)	T	°C	5
Turbidity		NTU	75
Inorganic Chemical Properties			
Total Ammonia (as N)	NH^{4+}	mg/L	2
Nitrate	$NO^{3-}N$	mg/L	40
Chlorine Residual	Cl^-	mg/L	1
Cyanide	CN^-	mg/L	0.05
Dissolved Oxygen	DO	mg/L	>3
Fluoride	F^-	mg/L	20
Sulphide	S^{-2}	mg/L	0.1
Biochemical Oxygen Demand	BOD_{5-20}	mg/L	50
Total Kieldahl Nitrogen (as N)	TKN	mg/L	10
Total Phosphorous (as P)	PO_4^{-3}	mg/L	2
Chemical Oxygen Demand	COD	mg/L	100

Parameter	Symbol	Unit	Suggested Limit
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	Cr^{+6}	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			
Halogenated Hydrocarbons & Pesticides		mg/L	Nil
Hydrocarbons	HC	mg/L	15
Oil & Grease		mg/L	10
Phenols		mg/L	0.1
Solvents		mg/L	Nil
Total Organic Carbon	TOC	mg/L	75
Biological Properties			
Total Coliform		MPN/100mL	1,000
Faecal Coliform Bacteria		Cells/100mL	1,000
Colon Group		No./100cm^2	5,000
Egg Parasites			None
Worm Parasites			None

The standards and limits for Pollution to Air and Marine Environments which the Emirate of Fujairah have adopted are those set forth by the Environment Agency for Abu Dhabi (EAD). The recommended Ambient Marine Water Quality Standards (AWQS) described by EAD are presented in Table 2-3 below.

Table 2-3 – Adopted Ambient Marine Water Quality Objectives (EAD AWQS) [4]

Parameter		Proposed Maximum Concentration	Unit of Measurement
I Physical Indicators			
1	Floating Particles/Floatable/debris	Nil	mg/m^3
2	Temperature	+/-3	Δ °C of ambient water temperature
3	Turbidity	10	NTU
4	Transparency / Clarity	>=10	Meter of Secchi Depth
5	Salinity	<5	% of background concentration
6	BOD5	4	mg/l (5day at 20°C Annual Average)
7	Odour	Not Objectionable	Not Objectionable
8	Colour	No Change from Background	No Change from Background
II Chemical Indicators			
9	Ammonia (Free as N) or Ammonia (NH_3-N)	0.004	mg/l
10	Arsenic (As)	0.005	mg/l
11	Cadmium (Cd)	0.001	mg/l
12	Chlorine Residual (Cl_2)	0.01	mg/l
13	Chromium (Cr)	0.01	mg/l
14	Copper (Cu)	0.01	mg/l
15	Cyanide (Cn)	0.004	mg/l
16	Lead (Pb)	0.01	mg/l
17	Mercury (Hg)	*No Specified Limit*	
18	Oil and Grease	Not Visible	mg/l
19	Petroleum Hydrocarbons	5	ppm or mg/l
20	Dissolved Oxygen (DO)	>4	mg/l
21	Total Suspended Solids (TSS)	<33	mg/l
22	Si-SiO_3	890	µg/l
23	PH	6.5 – 8.5	mg/l
24	Phenols	0.001	mg/l
25	Phosphorous Total as (P)	0.001	mg/l
26	Phosphate (PO_4)	34	µg/l
27	Sulphides (S)	0.004	mg/l
28	Total Organic Carbon (TOC)	2.5	mg/l

Parameter		Proposed Maximum Concentration	Unit of Measurement
29	Zinc (Zn)	0.01	mg/l
30	Nickel (Ni)	20	µg/l
31	Iron (Fe)	0.3	mg/l
32	Vanadium (V)	9.4	µg/l
33	Nitrate (NO_3-N)	95	µg/l
34	NO_2	34	µg/l
III Biological Indicators			
35	Total Coliform	70	MPN/100ml

2.1.3 IFC General (EHS) Guidelines

The IFC General EHS Guidelines for Environmental Wastewater and Ambient Air Quality [2], with regards to General Liquid Effluent Quality, the discharge to surface water state: *"should not result in contaminant concentrations in excess of local ambient water quality criteria or, in the absence of local criteria, other sources of ambient water quality."*

Furthermore, the IFC General EHS guidelines for Thermal Power Plants state: *"Temperature of wastewater prior to discharge does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use and assimilative capacity among other considerations."*

The IFC EHS Guidelines goes on to state: *"In general, thermal discharge should be designed to ensure that discharge water temperature does not result in exceeding relevant ambient water quality temperature standards outside a scientifically established mixing zone. The mixing zone is typically defined as the zone where initial dilution of a discharge takes place within which relevant water quality temperature standards are allowed to exceed and takes into account cumulative impact of seasonal variations, ambient water quality, receiving water use, potential receptors and assimilative capacity among other considerations."*

2.1.4 EWEC Environmental Parameters

EWEC have specified within their Request for Proposal (RFP) conditions that a range of environmental parameters are met. These are presented as follows.

EWEC have confirmed that the following standards shall be applied:

- European Union Standards (for requirements not covered by those listed below);
- Standards and requirements as stated in the PPA and applicable in the UAE; and
- Other national requirements, consents and licenses.

The permissible effluent limits discharged to the marine environment are listed in Table 2-4 below.

Table 2-4 – EWEC Effluent Discharge Limits

Parameter		Proposed Maximum Concentration	Unit of Measurement
1	Ammoniacal Nitrogen	0.5	mg/l
2	Arsenic (Ar)	0.05	mg/l
3	Bio-chemical Oxygen Demand (BOD)	30	mg/l
4	Cadmium (Cd)	0.1	mg/l
5	Residual Chlorine	0.15	mg/l
6	Total Chromium (Cr)	0.5	mg/l
7	Copper (Cu)	0.5	mg/l
8	Chemical Oxygen Demand (COD)	100	mg/l
9	Cyanide (CN)	0.1	mg/l
10	Oil	10	mg/l
11	Total Iron (Fe)	1	mg/l
12	Lead (Pb)	0.1	mg/l
13	Manganese (Mn)	1	mg/l
14	Mercury (Hg)	0.001	mg/l
15	Nickle (Ni)	0.5	mg/l
16	pH	6.5 - 8.5	mg/l
17	Phenols	0.1	mg/l
18	Phosphate (Total as P)	2.0	mg/l
19	Selenium (Se)	0.05	mg/l
20	Silver (Ag)	0.1	mg/l
21	Sulphide	0.2	mg/l
22	Suspended Solids	30	mg/l
23	Vanadium	1.0	mg/l
24	Zinc (Zn)	0.5	mg/l
25	Total Dissolved Solids (TDS) above receiving water at the edge of the mixing zone (100m from point of discharge)	< 5	% from background concentration
26	Max. cooling seawater temperature rise at edge of mixing zone (100m from point of discharge)	3	Degrees Celsius

1) The limit refers to continuous chlorination. In case of shock chlorination (according to WB limit), the maximum value is 2 mg/l for up to 2 hours, not to be repeated more frequently than once in 24 hours, within a 24hours average of 0.2 mg/l.
2) The provided values shall be verified from Fujairah Municipality and other local authorities as necessary, and the values which are more stringent shall be used.

2.2 Summary

A review of relevant regulations suggests that the target marine water quality objectives for temperature and excess chlorine produced within a 100m Regulatory Mixing Zone (RMZ) from point of discharge is Δ3°C and 0.01 mg/L respectively. Furthermore, regarding salinity discharges within the RMZ, the maximum allowable increase in salinity is 5% from the ambient (background) salinity levels.

3 Modelling Systems

The modelling study has been carried out utilising the MIKE software package (developed by DHI). The MIKE software package is a powerful and versatile tool for simulating physical, chemical, biological and ecological processes in coastal and marine areas. The package utilises multiple modules for various simulation, prediction and forecast applications; the modules utilised within this scope of works are summarised further below.

3.1 MIKE3 Hydrodynamic Flow Model

The MIKE3 Hydrodynamic (HD) Flow Model (FM) is a numerical modelling system for the simulation of water level variations and their associated flows. The model is able to run, in both two-dimensional (2D) and three-dimensional (3D) modes, using multiple simulation engines, including single grid, multiple grid and flexible mesh application. The MIKE HD FM modules are the 'base' module for the software suite, the outputs of which are used as input for various other modules of differing applications.

The 3D, baroclinic module MIKE3 FM HD, is a general non-hydrostatic numerical modelling system which simulates unsteady, 3D flows in fluids when presented with the bathymetry and other relevant ambient conditions (e.g. bed resistance, wind forcing, hydrographic boundary conditions, and atmospheric influence). MIKE3 FM HD is applicable to areas where stratification cannot be discounted, or where simulation requires the assessment of effluent with a positive or negative density differential. The fully baroclinic nature of the module enables density currents caused by this differential density to be simulated accurately, in conjunction with other dispersal effects associated tide and wind driven flows and atmospheric effects (such as surface cooling).

The software also incorporates near-field simulations which can accurately simulate the 'jet' phase of an effluent discharge (where the effluent momentum influences trajectory and mixing behaviour). These near-field simulations are linked within the MIKE3 FM HD module, enabling the influence of ambient currents on 'jet' behaviour to be simulated at the same temporal and spatial resolution as the hydrodynamic model.

3.2 MIKE2 Advection Dispersion/Transport Model

The MIKE2 Advection Dispersion (AD)/Transport (TR) module uses the associated MIKE3 FM HD results to simulate the spreading and fate of dissolved or suspended substances in an aquatic environment under the influence of the fluid transport and associated dispersion processes. The HD AD/TR module can be applied for both barotropic or baroclinic flows and in the latter case, the effect of variable density on the flow is included by solving the transport equations for salinity and temperature. The viscosities or diffusivities in the HD module are described either as simple or constant or calculated using complex turbulence models.

The solution of the transport equations is closely linked to the solution of the hydrodynamic conditions with the spatial discretization of the primitive equations being performed using cell-centred finite volume method. The spatial domain is discretised by subdivision of the continuum into non-overlapping elements/cells.

Besides the input data required for the HD model, the necessary input data to the AD/TR module are;

- Component Type;
- Dispersion coefficients;
- Decay Information;
- Initial Conditions; and,
- Boundary Conditions.

Additional scientific documentation on MIKE TR/AD can be provided on request.

4 Methodology

4.1 Overview

Due to the likely stratified nature of the environment after the introduction of the heated effluent plumes from all three of the IPP discharges as well as the rejected brine effluent from the F1 SWRO plant, the MIKE3 HD FM (Flow Module) (3D software) was utilised for the study utilising 10 vertical layers. The hydrodynamics of the area were simulated for a baseline case (Scenario 0) (i.e. without the introduction of the intakes and outfalls associated with any of the existing or proposed power plants) in order that a hypothetical temperature differential could be calculated. Scenario 0 is also used for validation and calibration purposes. Two ‘operational’ scenarios were simulated; a pre-development scenario (Scenario 1), which included the effluent discharges from the existing F1 and F2 facilities only, and a post-development scenario (Scenario 2) which included the effluent discharges from the existing F1 and F2 facilities with the addition of the proposed F3 facility.

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

- Hydrodynamic and Thermal Plume Assessment (MIKE3 HD FM);
  - Scenario 0 - Baseline case (i.e. no outfalls or intakes);
  - Scenario 1 – Pre-development (i.e. before completion F3); and
  - Scenario 2 – Post-development (i.e. after completion of F3);
- Residual Chlorine Assessment (MIKE3 AD/TR) – Simulated within Scenario 2 listed above

4.2 Hydrodynamic Modelling

4.2.1 Overview

The hydrodynamics of the project area were simulated utilising the MIKE3 HD FM model, driven by tidal initial conditions which were generated using a combination of data sourced from the Global Hybrid Coordinate Ocean Model (HYCOM) [5] and the DTU10 global ocean tide model [6]. MIKE Boundary Conditions Generator (BCG), utilises this data and generates initial and boundary conditions for temperature, salinity and tidal variation at each water node along the boundaries in order to ‘force’ the subsequent tidal and current variations within MIKE3D HD FM model domain.

Meteorological data, such as Air Pressure, Wind Speeds, Relative Humidity, and Clearness, was sourced from the National Centres for Environmental Prediction (NCEP) [7], which provides MIKE3 HD FM with the necessary ambient data over the entire domain, which varies in time and space. MIKE3 HD FM also takes into account heat transfer calculations during the simulation period. The data sourced from NCEP has been validated against measured data where relevant in order to verify its accuracy and usefulness within the project location. An overview of the hydrodynamic modelling approach is presented in Table 4-1.

Table 4-1 – Summary of Hydrodynamic Modelling Approach

Task	Hydrodynamic Modelling
Model	MIKE3 HD FM
Model Features	3-dimensional Horizontal and vertical planes σ-coordinate vertical layering scheme
Tidal Data	HYCOM Data at 1/12° resolution [5].
Meteorological Data	NCEP supported CFSR data at ≈0.2° spatial and hourly temporal resolution. [7]
Period Modelled	One baseline simulation (without inclusion of any intakes or discharges) used for validation purposes (July 2018) known as Option 0 Thermal plume assessments for the area were simulated for a baseline case (without any intakes and outfalls associated with the Fujairah power plants) for a representative summer (July 2018) period. Two operational scenarios, pre & post-development (before and after the introduction of the outfalls and intakes of the proposed F3 plant) were simulated for a representative summer (July 2018) period known as Option 1 and Option 2 respectively. Summarised as follows: Baseline - Option 0 (No intake or outfalls for validation purposes) 2x Operational Scenarios Option 1 and Option 2 - (with and without Intakes and Outfalls of F3)
Bathymetry	Simulations were conducted utilising bathymetric data collected by Middle East Survey Engineering [8] as well as from digitized admiralty charts sourced from digitised British Admiralty Charts [9].
Model Verification	Verification was conducted against predicted water level variations at Khawr Fakkan tidal station.
Horizontal Resolution	Flexible mesh, variable element size from a maximum area of 121,500 m^2 (equivalent to approx. 590 m horizonal resolution) to an area of 1500 m^2 (equivalent to approx. 58 m horizontal resolution).
Vertical Resolution	10 vertical layers (variable σ-coordinate vertical layering scheme)
Initial Conditions **(HYCOM & DTU10)**	Surface level (variable in domain) Velocity (static in domain) Temperature (variable in domain) Salinity (variable in domain)
Boundary Conditions (HYCOM & DTU10)	Surface Level (varying in time and along boundary) Velocity (varying in time and along boundary) Temperature (varying in time and along boundary) Salinity (varying in time and along boundary)

General Information	Maximum time step – 30s Flood and dry – included Horizontal turbulence model – Smagorinsky Vertical turbulence model – k-ε Bed friction – constant in domain (0.01m) Wind friction – Varying with wind speed Up to 4 m/s - (0.001255) Up to 18 m/s – (0.002425) Density – salinity and temperature dependent Coriolis forcing – included Atmospheric forcing – included Precipitation and evaporation – excluded Critical CFL value – 0.8

4.2.2 Model Grids and Bathymetry

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

- Digitised Admiralty Bathymetric Charts 3709 [9] , sourced from C-MAP; and
- Bathymetric survey data conducted by MES in the vicinity of the project was received from the client [8].

The coverage and resolution of the modelling domain were decided based on knowledge of the project area, and the outcomes of a number of modelling iterations carried out during the validation/calibration process. The final modelling domain mesh and bathymetry are provided below in Figure 4-1, Figure 4-2 and Figure 4-3.

Figure 4-1 – Fujairah F3 – Model Bathymetry

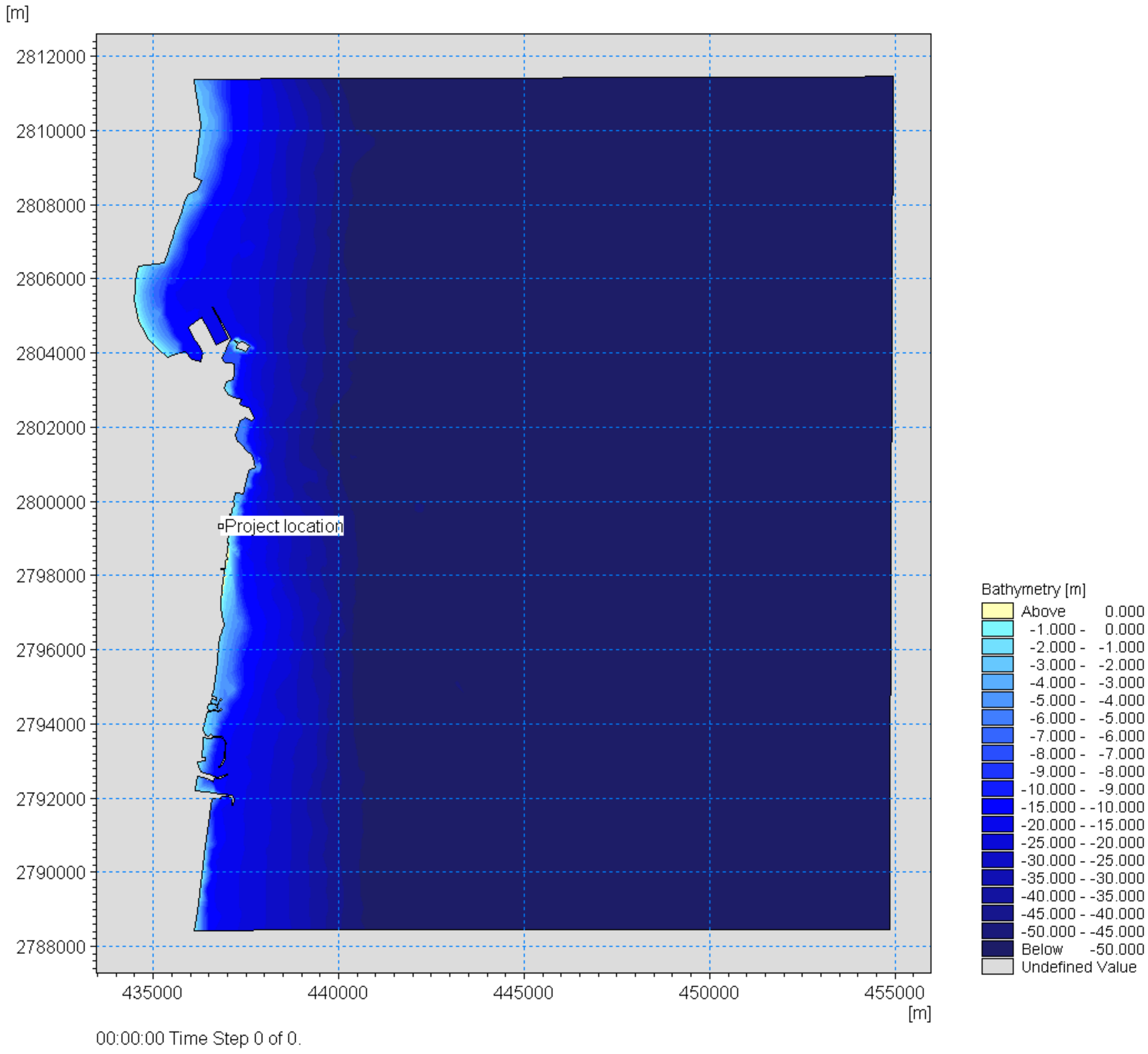


Figure 4-2 – Fujairah F3 – Model Mesh

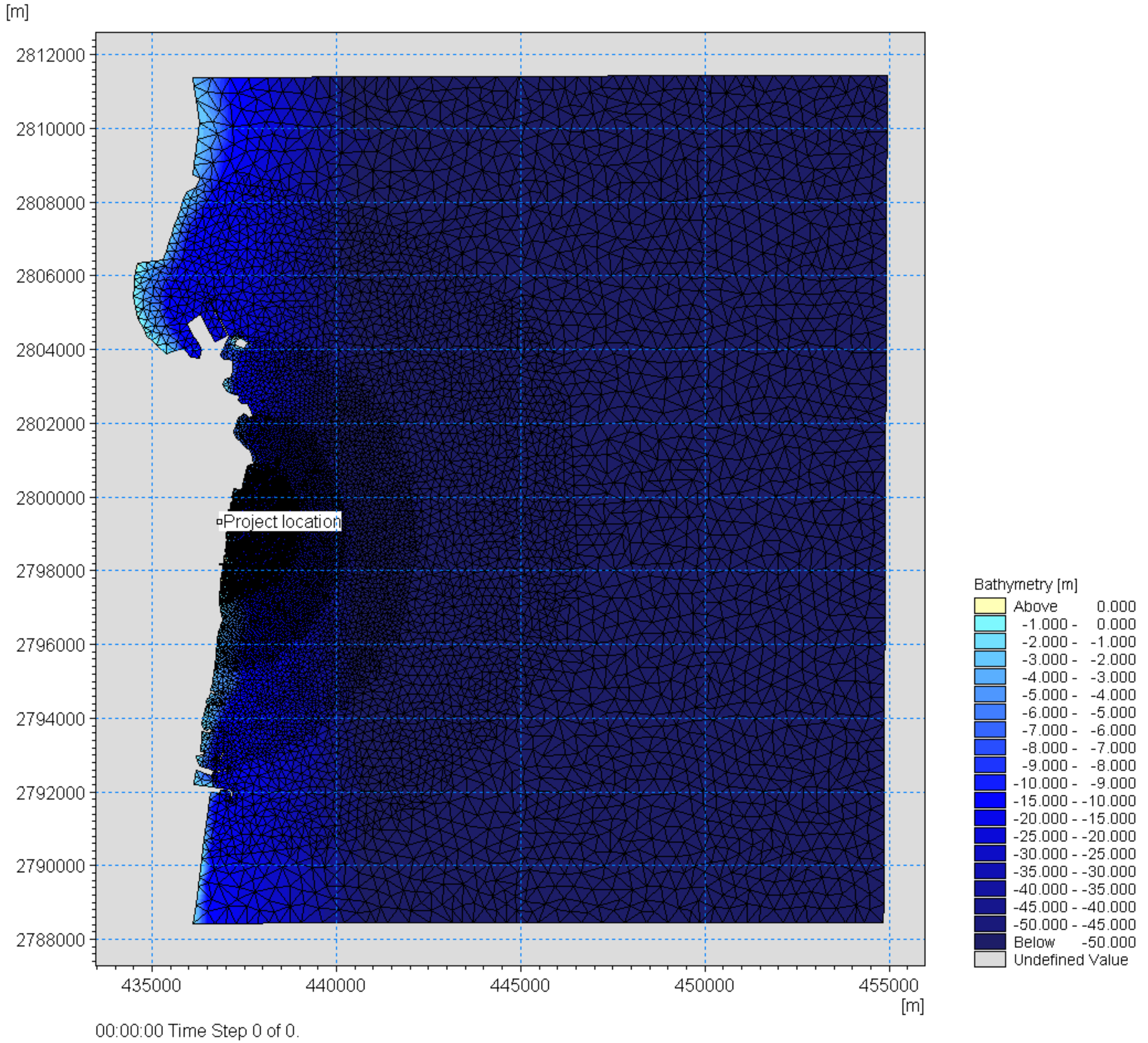
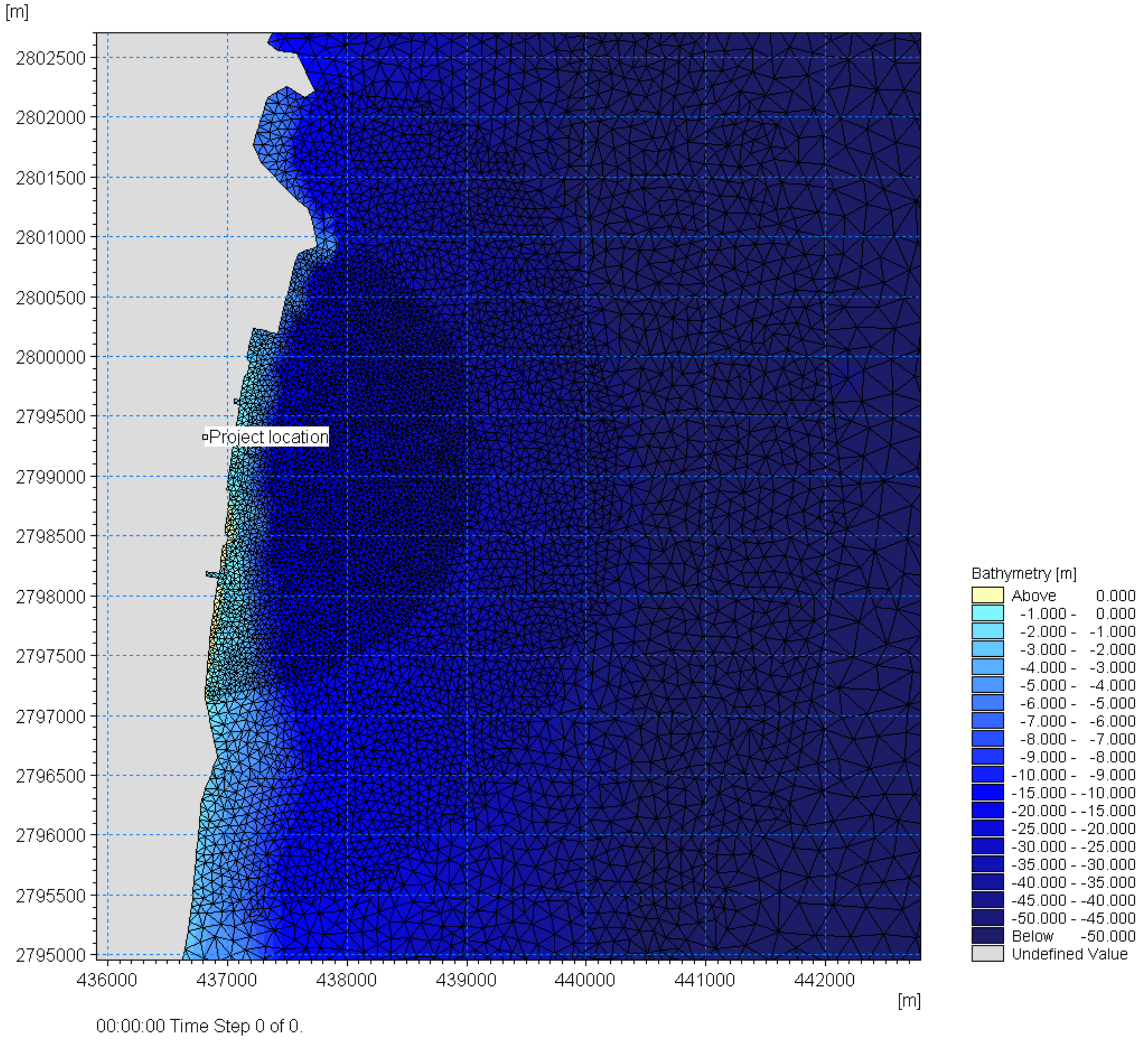


Figure 4-3 – Fujairah F3 – Model Mesh – Zoomed in View



4.2.3 Winds

Meteorological data such as wind speed and direction data was sourced from the Climate Forecast Reanalysis (CFSR) which is a global reanalysed forecast data centre and was used in the MIKE3 HD FM simulations. [7] The CFSR routinely operates a suite of numerical weather prediction models at a range of spatial and temporal resolutions.

Wind roses generated from model output data for the July month of 2018 at the project location are provided within Figure 4-4, additionally for the annual 2018 period Figure 4-5 below displays the wind rose generated at the project location. The winds are as expected for this time of year and are dominated by south-easterlies.

Figure 4-4 – Wind Rose (CFSR) at Project Location (July 2018)

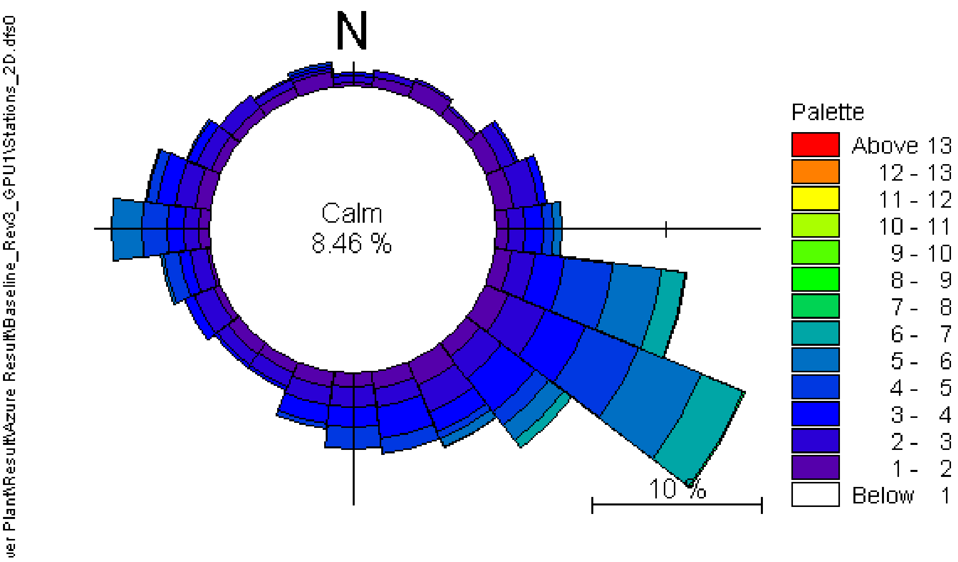
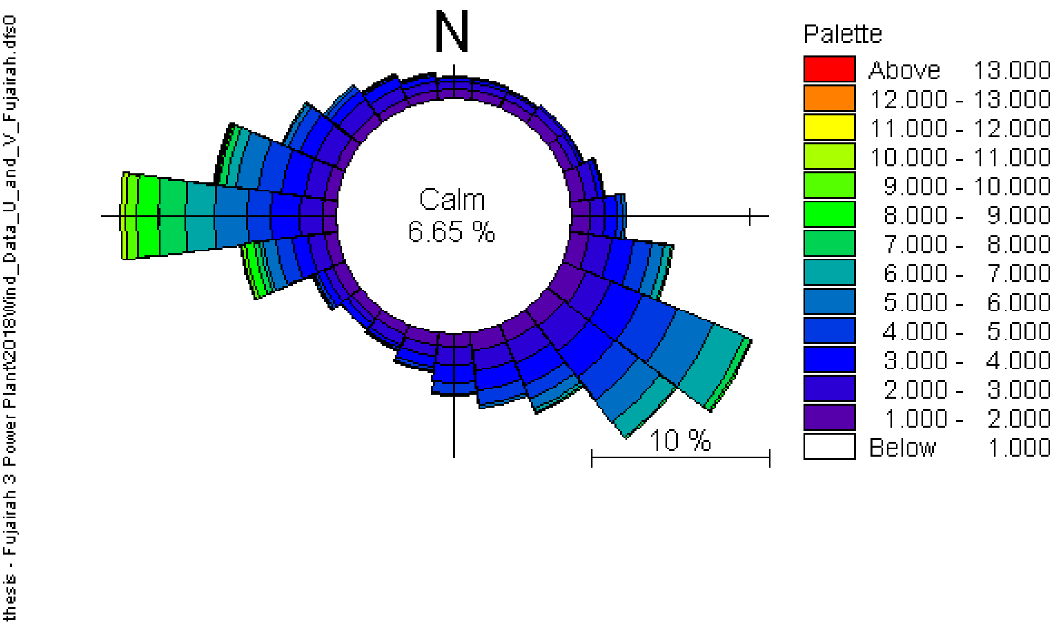


Figure 4-5 - Wind Rose (CFSR) at Project Location - Annual Period (2018)



4.2.4 Boundary Conditions

In order to accurately simulate the propagation of the tides to the project area within the modelling domain, tidal boundary and initial conditions (such as water level and initial velocity) were sourced from a combination of HYCOM [5] and DTU10 [6] tidal constituents data. The data is pre-processed in order to be recognised by MIKE and provides the user with 3D model boundary data and initial conditions at each open water boundary in order to allow MIKE3 HD FM to simulate the tidal and current variations within the project domain.

4.2.5 Tides

Tidal variations at the coast of Fujairah are dominated by diurnal tidal variations and in order to accurately simulate the propagation of the tides to the project area within the modelling domain, tidal boundary conditions were sourced from HYCOM global ocean tide model and DTU10 global ocean models' tidal constituents data.

The amplitude and phase of the two dominant tidal constituents, the principal lunar semidiurnal (M_2) and the principal solar semidiurnal (S_2) constituents for the DTU10 global ocean tide model are presented within Figure 4-6 and Figure 4-7 below.

Figure 4-6 - Amplitude and Phase of Principal Lunar Semidiurnal Constituent

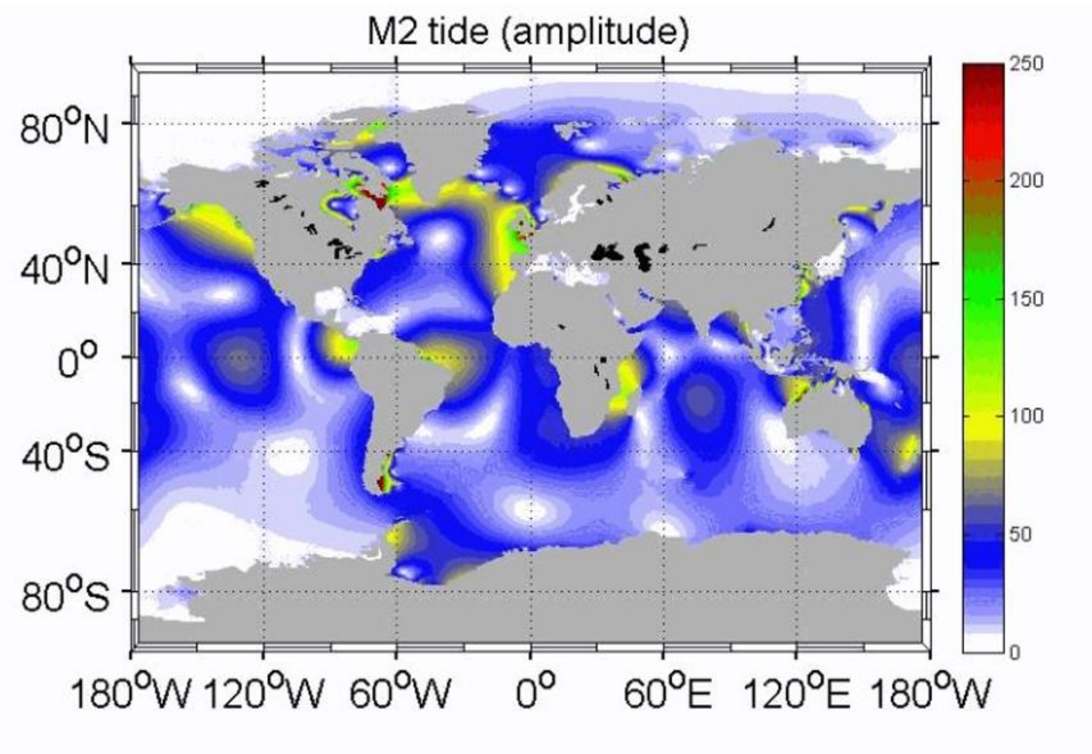
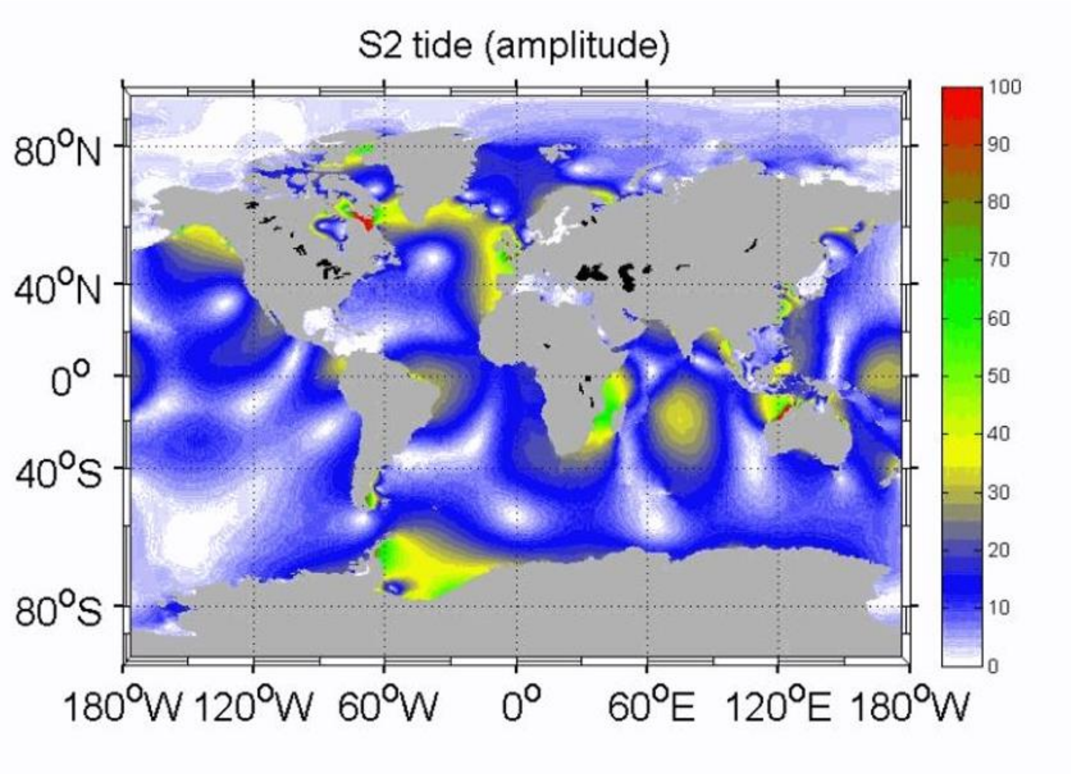
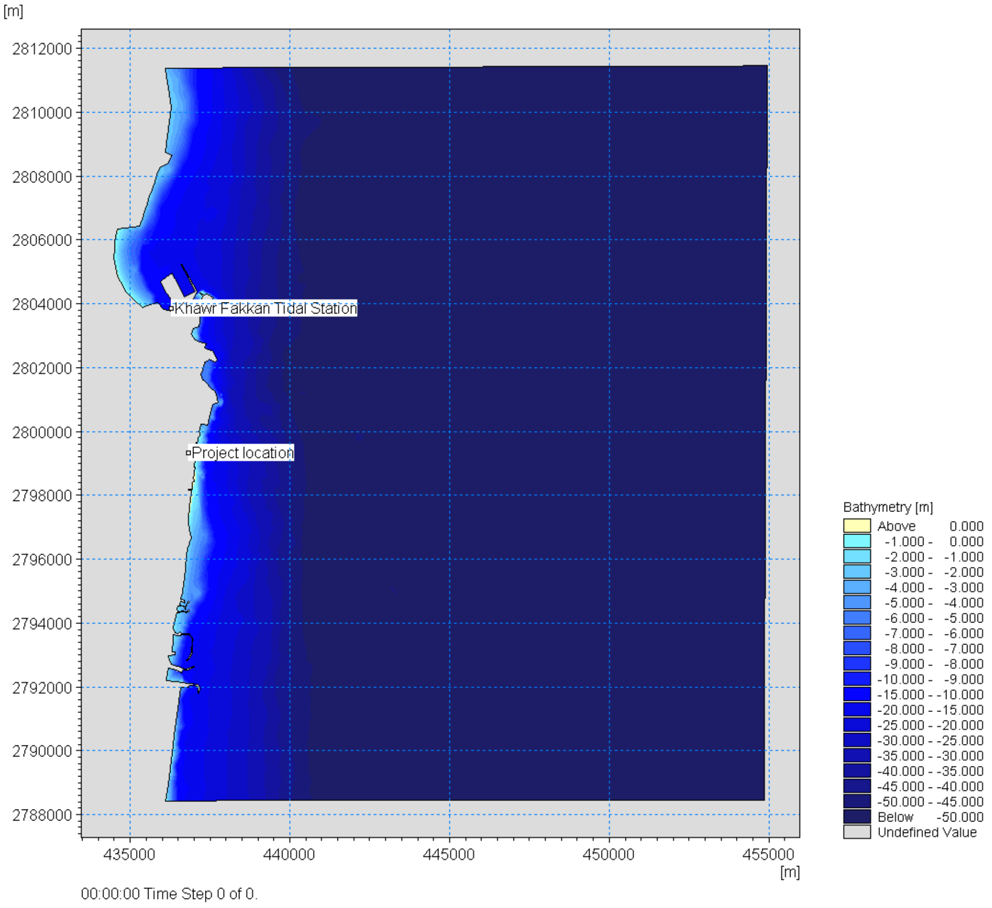


Figure 4-7 - Amplitude and Phase of Principal Solar Semidiurnal Constituent



The data is pre-processed in order to be recognised by MIKE and provides the user with 2D model boundary data at each open water boundary in order to allow MIKE3 HD FM to simulate the tidal and current variations within the project domain. The modelled tidal variations were checked against data predicted tidal variations obtained from Khawr Fakkan tidal station as shown in Figure 4-8 below.

Figure 4-8 - Khawr Fakkan Tidal Station



The tidal planes at Fujairah Harbour are shown in Table 4-2 below.

Table 4-2 – Tidal Levels at Fujairah Harbour

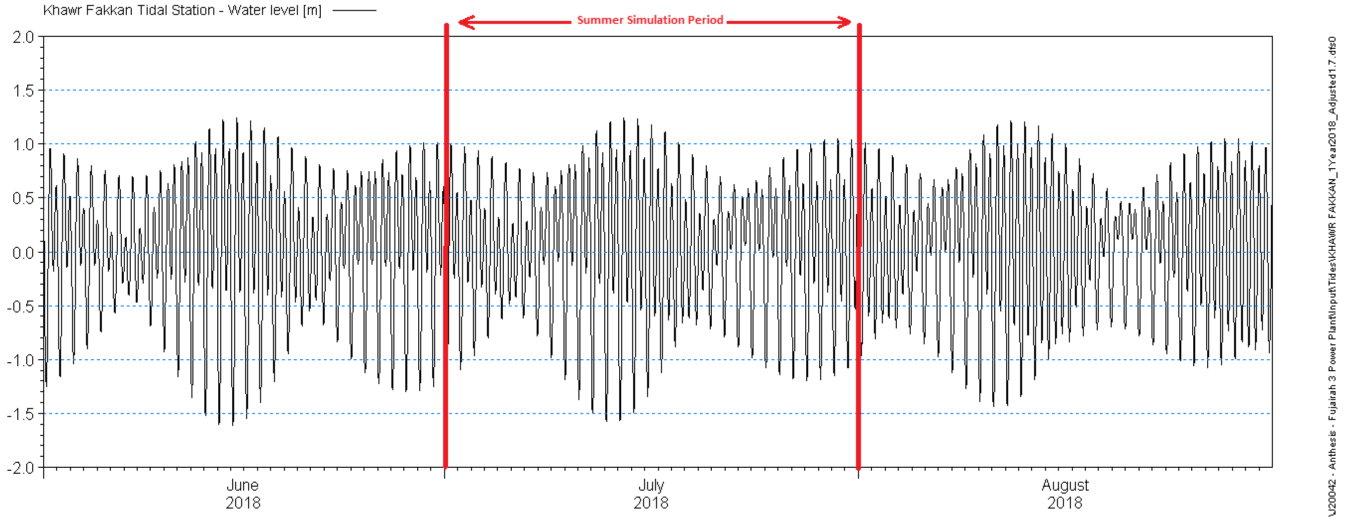
Water Level	Abbreviation	Water Level*
Extreme High Water	EHW	3.14
Highest Astronomical Tide	HAT	2.8
Mean Higher High Water	MHHW	2.6
Mean Lower High Water	MLHW	2.3
Mean Sea Level	MSL	1.7
Mean Higher Low Water	MHLW	1.4
Mean Lower Low Water	MLLW	0.2
Lowest Astronomical Tide	LAT	-0.1

NOTE*: All levels in meters above Fujairah Harbour Datum

4.2.6 Simulation Period

The hydrodynamic model was used to simulate the thermal, saline and excess chlorine plume assessments over a full summer month (July 2018) in order to fully capture spring and neap tides. In a report conducted by HR Wallingford for EWEC, *"F3 IPP Dispersion and recirculation Study"* of 2019, the summer period is likely to be the most critical period in terms of thermal dispersion and recirculation [10]. This period is illustrated in Figure 4-9 below.

Figure 4-9 – Summer Simulation Period



4.3 Simulation of Effluent Discharges

4.3.1 Overview

The F3 project will utilise seawater, from an intake structure placed approximately 450m offshore from the project, which will be utilised in heat rejection by the plant. The rejected volume of heated effluent will be returned to the marine environment via four outfall pipelines ending in four diffusers in a staggered arrangement, , with the first pipelines' diffuser structure starting at approximately 1.2km offshore.

The purpose of the modelling study is to simulate the dispersion of the rejected heated effluent and to assess the residual chlorine concentration levels in order to aid an assessment of potential impacts to the environment in support of an ESIA preparation. A secondary objective is to determine whether there is any potential for recirculation of the thermal plume at the seawater intake location.

The heated effluent from F3, at the point of discharge, will be significantly less dense than the ambient environment, however, the effluent discharges from F1, F1-SWRO and F2 will be more dense that the ambient receiving waters and will tend to sink to the bottom of the ocean floor. It is therefore necessary to simulate the discharge in 3D to ensure that any potential for stratification is captured. This density gradient has the potential to impact upon ambient currents due to the possibility of baroclinic gravity flows, therefore the simulations of the heated saline effluent dispersion were carried out within the MIKE HD FM module.

The outfall constituents of concern are differential temperature, differential salinity as well as residual chlorine within the F3 effluent discharge. In addition to simulating the thermal change due to the discharge of cooling water, the simulations were also used to predict the dispersion of the residual chlorine and salinity excess. The residual chlorine levels within the discharge were simulated using an additional MIKE AD/TR module to predict the dispersal and dispersion of the chlorine contained within the plume.

The mixing and dilution of reject waters from a marine outfall can be considered in two distinct spatial zones; the near-field and far-field. Both zones must be simulated accurately in order to reliably represent the mixing behaviour of an effluent. The near field can be defined as the zone where mixing behaviour is influenced by the momentum and buoyancy (influenced by discharge design and effluent characteristics). Far-field mixing, and dilution rely on the ambient conditions of the receiving waters (tidal and wind driven currents, wave induced turbulence and baroclinic gradients) to induce horizontal and vertical mixing. MIKE3 HD FM is capable of accurately simulating, and linking, both mixing fields in a single software suite.

An overview of the approach to modelling is presented in Table 4-3, with additional information provided in the following sections.

Table 4-3 – Plume and Residual Chlorine Discharge Modelling Overview

Stage	Plume and Residual Chlorine Modelling
Model	MIKE3 HD FM & MIKE3 AD/TR
Task Pre-requisite	MIKE3 HD FM baseline condition validation
Scenarios	Thermal plume assessments for the area were simulated for a baseline case (without any intakes and outfalls associated with any of the IPP's) for a representative summer (July 2018) period known as Option 0. Two operational conditions (before and after the introduction of the F3 outfalls and intakes) were simulated for a representative summer (July 2018) period known as Option 1 and Option 2 respectively. Summarised as follows: Scenario 0 – (No intake or outfalls) 2x Operational Scenarios (Pre & Post Development) Scenario 1 (before introduction of F3 intake and outfalls)) Scenario 2 (after introduction of F3 intake and outfalls)
No. of Sources	40 individual diffuser 'jets'
No. of Intakes	1
Parameters Simulated	Differential Temperature, differential salinity & residual chlorine concentration levels

4.3.2 Modelling Scenarios

Scenario 0 (Without any intakes or outfalls)

A baseline case, known as Scenario 0, was simulated without the introduction of any intakes or outfalls within the project area which is primarily used for validation and calibration purposes.

Scenario 1 (Without F3 IPP Intake & Outfalls)

The project area currently has two intakes and three outfall structures in operation by the F1 plant, the F1-SWRO plant (Which shares a common intake with F1) and the F2 plant. This was simulated as Scenario 1 (without and intake/outfall structures for F3) to formulate the baseline environmental conditions that currently exist and is depicted in Figure 4-10 below.

Scenario 2 (With proposed F3 Intake & Outfalls)

Scenario 2 (with the intake/outfall structures for F3) depicted below Figure 4-11, was used to assess whether the proposed F3 project would meet the environmental criteria as outlined in Section 2.2 and this Post-Development simulation was also used to assess the recirculation potential at the Fujairah F1, F2 and F3 seawater intake locations as shown below in Figure 4-11.

Figure 4-10 – Scenario 1 - Pre-Development

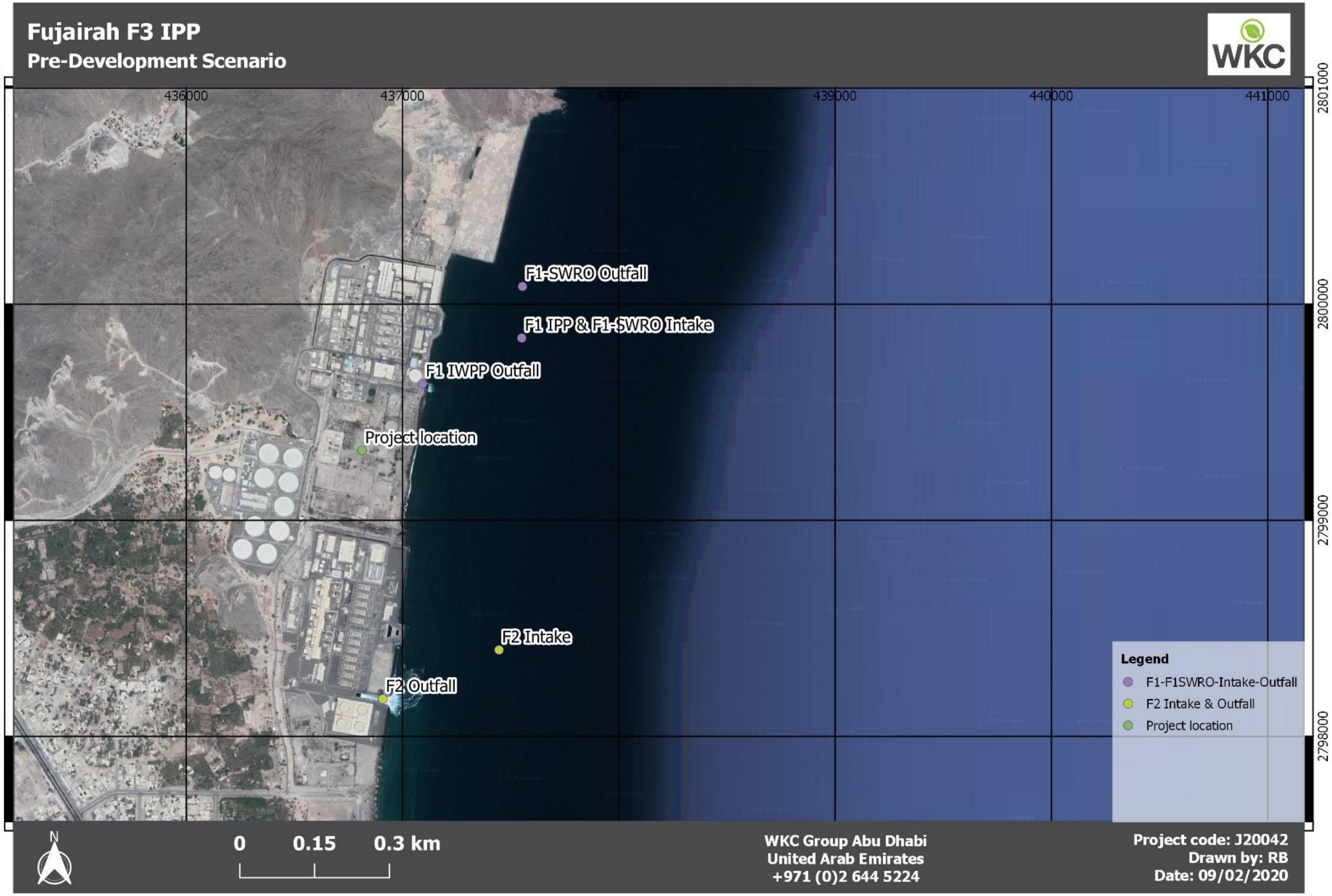
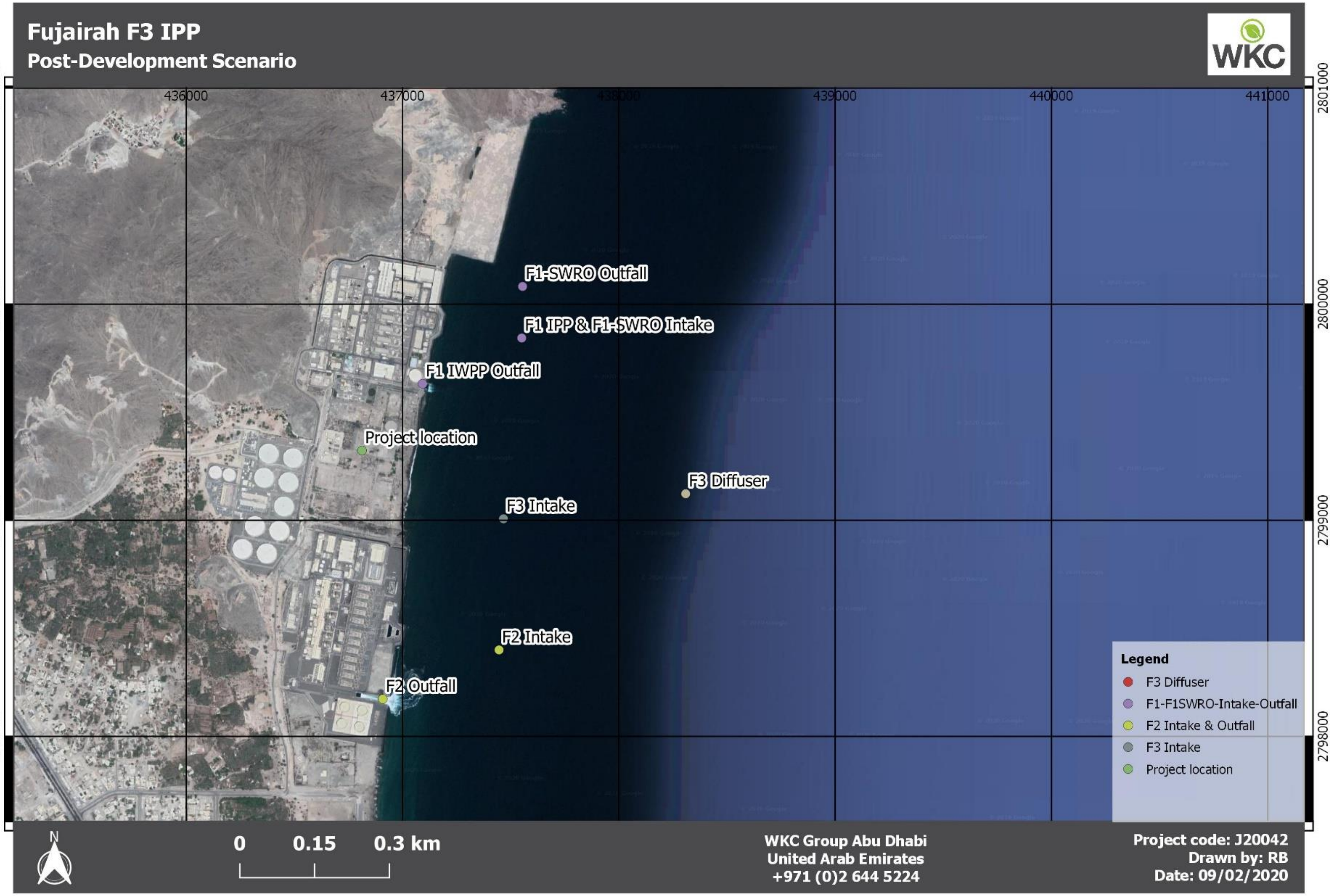


Figure 4-11 – Scenario 2 - Post-Development



4.3.3 Effluent Parameters

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

An additional parameter to consider, other than the temperature and salinity of the heated effluent, is the residual chlorine concentration present in the discharge due to the use of the biocide sodium hypochlorite.

The biocide proposed for use within the cooling water system is sodium hypochlorite (which results in residual chlorine once dissolved in seawater).

The term free chlorine refers to Cl_2, HOCl and hypochlorite ion (OCl^-) in equilibrium. The relative amounts of these chemical species are dependent on pH, temperature and ionic strength. In addition, chlorine reacts readily with nitrogenous substances such as ammonia to form chlorinated compounds. These compounds are more persistent in the marine environment than free chlorine and are known as combined chlorine. The sum of combined and free chlorine is referred to as total residual chlorine [11].

Research into the behaviour of residual chlorine once it has entered the marine environment would lead to a better understanding of possible decay or breakdown. Specific studies on the decay rate of residual chlorine within seawater cooling systems have been conducted and under laboratory conditions where the decay rate was shown to be highly dependent on seawater salinity and temperatures (increasing decay with elevated temperatures and salinities of the receiving marine water). The residual chlorine levels were found to decrease rapidly over the first 20 minutes and the tests show that the total percentage of decay, before reaching a steady state concentration equilibrium, increases with a reduction in initial dosing concentration. [12]

Table 4-4 – Approximate decay rates of residual chlorine [12]

Initial Dosing Concentration (mg/l)	Concentration Remaining at Equilibrium (mg/l)	Percentage of Initial Dosage Remaining at Equilibrium (%)
5.90	2.50	42%
4.74	1.80	38%
3.53	1.20	34%
2.35	0.40	17%
1.23	<0.01	<1%

Effluent parameter concentration data regarding the expected residual chlorine levels expected in the effluent discharge was supplied by Marubeni and the planned initial dosage of biocide used within the cooling water intake is proposed at 0.2mg/l for normal operations (to control macro fouling) with intermittent shock dosing of 2.0 mg/l (to control micro fouling), the latter of which will not be repeated in a 24hour cycle. Although the decay rate of residual chlorine depend on multiple variables, such as temperature, sunlight, salinity and Biological Oxygen Demand (BOD), for the purposes of this assessment a conservative decay rate has been assumed which results in 10% of the initial concentration remaining after 20 minutes of discharge, after which it is conservatively assumed that the residual chlorine concentration remaining in the effluent discharge reaches equilibrium and does not undergo any further chemical decay. A summary of the effluent parameters for F3, F2, F1 and F1-SWRO plants are provided below within Table 4-5.

Table 4-5 - Summary of effluent parameters

Power Plant	Effluent Flow Rate m3/h	Effluent Δ Temperature Δ°C	Effluent Δ Salinity PSU	Effluent Residual Chlorine Concentration mg/l	Approximate Δ Density (Δ kg/m3)	Source
F1	33, 000	9.0	10.0	0	+4.03	F3 IPP Scoping Report by Mott MacDonald [13]
F1-SWRO	2, 400	4.8	28.7	0	+19.75	F3 IPP Scoping Report by Mott MacDonald [13]
F2	21, 600	8.0	4.6	0	+0.41	F3 IPP Scoping Report by Mott MacDonald [13]
F3	61, 000	5.0	0.1	0.2	-1.84	Marubeni response to data request

4.3.4 Ambient Parameters

Hydrodynamic parameters, such current velocity, current direction, tidal variation etc. are obtained from the hydrodynamic modelling domain set-up (Section 4.2). MIKE3D HD uses these parameters within the conservation of mass, energy and momentum equations to accurately simulate flow conditions, using numerical methods, within the modelling domain. Ambient parameters which have a significant effect on flow conditions are tidal variations, temperature, salinity, wind speed & direction.

The residual chlorine levels measured in the Marine Environmental Baseline Survey (MEBS) conducted by WKC stated that the residual chlorine levels measured across multiple points around the project area were less than 0.02mg/l (the minimum detection limit (MDL) of the marine water ex-situ laboratory analysis).

Considering the fact that the MDL limit, listed in the WKC MEBS report for the F3 project, is above the regulatory limit for residual chlorine as outlined in the EAD-MWQS, the ambient residual chlorine level is assumed to be 0.001 mg/l based on past experience and knowledge of the project [14].

Note, this assumption is required in order for each dilution of the plume with ambient water to influence a reduction in concentration. With the lab MDL being above the EAD-MWQS limit (Table 2-3), it would not be possible to meet the criteria if this lab MDL value is assumed as the ambient concentration. Based on past experience, the value is also considered to be in excess of what would be expected for a coastal area in Fujairah Emirate with relatively un-polluted receiving waters.

For reference purposes, a summary of the measured (observed) ambient parameters is provided in Table 4-6, however please note that within the simulations, seawater temperature, salinity, atmospheric pressure and density are spatially and temporally variable based on simulated inputs.

Table 4-6 – Summary of Summer Ambient Parameters

Parameter	Units	Value	Source
Ambient Seawater	°C	33.0 (Maximum)	Port of Fujairah website [15]
Ambient Salinity	ppt	39.0	Previous marine studies [16], [17]
Atmospheric Pressure (average)	hPa	1015.93	National Oceanographic Data Centre [7]
Ambient Residual Chlorine	mg/l	0.001	Assumption based on MEBS MDL
Ambient Density	kg/m^3	1023.66	Fundamentals of seawater desalination [18]

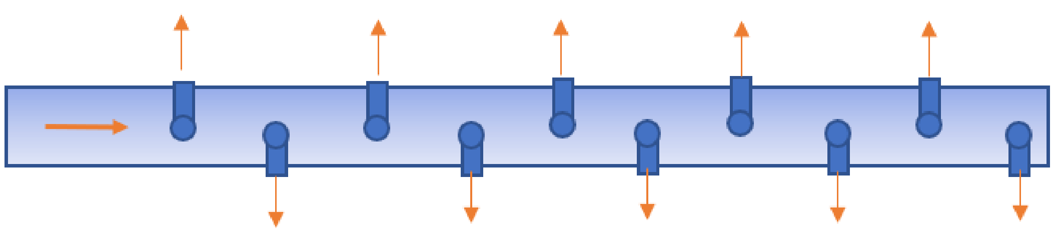
4.3.5 Diffuser/Outfall Design

The F1 and F2 power plants make use of open channel outfall structures located on the coastline in proximity to each IPP. In the absence of data from the current operators of the F1 and F2 facilities, the outfall channel widths were approximated via satellite imagery (37m and 35m for F1 and F2 respectively) and the channel depths were assumed to be at 1m referenced to lowest astronomical tide (LAT) for both F1 and F2. The F1 and F2 outfalls were simulated as standard sources which, mathematically, considers the sources' contribution to both the continuity and momentum equations (i.e. an initial velocity is considered).

At the time of the study, information regarding the F1-SWRO plant diffuser design was not available and as a conservative approach, the F1-SWRO plant outfall was simulated as a simple source which, mathematically, only considers the sources' contribution to the continuity equations. This is a conservative approach due to the model not simulating any initial velocity.

The proposed F3 outfall pipeline configuration will comprise of four outfall pipelines, each starting at the coast with the first outfall pipe's diffuser starting at approximately 1.2km offshore. Each pipeline will have a 45m long diffuser with 10 discharge ports orientated (in an alternating design) with the exit flow from the ports being orientated normal to the direct of flow within the outfall pipeline as depicted below Figure 4-12. Each port has a diameter of 0.75m and is orientated 30 ° vertically upwards and will have an exit velocity of approximately 2.16m/s in a direction that opposes the prevailing current direction of flow.

Figure 4-12 – F3 Diffuser Arrangement



Diffuser Design Summary

The outfall design parameters of the diffusers are summarised below in Table 4-7.

Table 4-7 – Summary of Outfall Design Parameters

Parameter	Units	Value				Source
		F1	F1-SWRO	F2	F3	
Outfall Co-Ordinates (UTM)	m	E – 437093 N – 2799629	E – 437554 N – 2800083	E – 436908 N – 2798173	E – 438211.83 N – 2799148.20	F1 & F2 Previous marine studies [16] F3 - Marubeni
Intake Co-Ordinates (UTM)	m	E – 437550 N – 2799842	E – 437550 N – 2799842	E – 437446 N – 2798399	E – 437466 N – 2799007	F1 & F2 Previous marine studies [16] F3 - Marubeni
Depth	M	-1	-12.5	-1	-22.61 to -25.65	F1&F2 – Assumed Channel Depth F1-SWRO & F3 -Based on Bathymetry of Model
Outfall Length	m	-	-	-	45.0	Marubeni
Outfall Width		37	-	35	-	Satellite Imagery
Number of Outfall Pipes	-	-	-	-	4	Marubeni
Port Number	-	-	-	-	10	Marubeni
Max Discharge Velocity	m/s	0.33	-	0.22	2.16	Marubeni
Outfall Pipe Velocity[1]	m/s	-	-	-	15.34	Marubeni
Distance Between Risers	m	-	-	-	5	Marubeni
Distance Between Outfall Pipes	m	-	-	-	3	Marubeni
Port Diameter	m	-	-	-	0.75	Marubeni
Horizontal Angle of Ports[2]	°	-	-	-	+90 & -90	Marubeni
Vertical Angle of Ports[3]	°	-	-	-	+30	Marubeni

Note 1: Based on assumed channel depth
Note 2: Relative to seabed
Note 3: Relative to diffuser orientation

4.4 Assumptions and Limitations

The movement of coastal ocean is controlled by the principles of mass, energy and momentum conservation. Numerical hydrodynamic modelling attempts to solve complex flow situations using empirical approximations and derivations of these principles. All numerical models make approximations to solve these principles and therefore have inherent limitations [19].

In addition to these inherent limitations, numerical modelling requires that input data be selected which itself has inherent limitations, and where input data is unavailable educated assumptions must be made. The following section highlights the limitations of the input data and assumptions which have been selected. Note, these assumptions and limitations do not invalidate the conclusions of the modelling study and the best-known source of data available within the confines of the project scope of work have been selected where possible.

The modelling assessment has been carried out utilising the most accurate data available at this time, however a number of assumptions/calculations were used to fill data gaps. Where selected methodologies or data gaps limit the assessment, these are summarised below:

4.4.1 Hydrodynamic Modelling

- Meteorological input data derived from a third-generation reanalysis product, NCEP/CFSR model data, is a high resolution reanalysed global meteorological conditions data set collected over a period stretching more than 31 years. However, as a global meteorological model, it can result in a 'smoothing' of localised and peak conditions. Note however, that this is the best readily available source of gridded meteorological data available for use within the MIKE modelling software.

- Boundary conditions sourced from the DHI boundary conditions generator (BCG) are based largely from the HYCOM Global Ocean Model. The HYCOM model is a global model that has been extensively validated and calibrated, however being a global model, particular local influences may be excluded. However, note that HYCOM is used to 'drive' the model and the domain boundaries. One of the benefits of modelling at a local scale using software such as MIKE is to accurately simulate these local particulars.

- Tidal forcing is based on tidal constituent amplitudes and phases from the DTU10 global tidal model. These data have proved to be very reliable in the central regions of the Arabian Gulf, but, due to the observed tidal prediction data only taking into account astronomical effects (it does not account for any meteorological effects such as wind, temperature, relative humidity and pressure), variations between simulated and predicted tidal variations data is expected.

- The bathymetric data was collected from a combination of bathymetry points obtained through digitisation of historic navigation charts and bathymetry data sourced from a survey conducted by MES. Bathymetry obtained from the navigational charts were used for most of the surrounding areas within the modelling domain whilst the accurate survey data was used specifically around the Project Location. The ocean floor is a dynamic and constantly changing environment, therefore it is possible that certain bathymetric data used, some variation between modelled bathymetry and actual bathymetry may exist. It is however not expected that this variation is significant enough to change the outcomes of this assessment.

4.4.2 Plume Simulations

- Based on laboratory studies regarding the decay of residual chlorine in ocean water, a decay factor was applied which results in 10% of the initial dosing concentration remains present in the discharge effluent. Thereafter, residual chlorine was modelled as a conservative pollutant which does not decay or combine chemically or biologically to any other constituents.

- Considering the fact that the MDL limit, listed in the WKC MEBS report for the F3 project, is also considered the limit for residual chlorine as outlined in the EAD-MWQS, the ambient residual chlorine level that is assumed to be present was, as listed above, is 0.001 mg/l [14].
- At the time of the study, no excess chlorine levels were available for F1 & F2 power plants. They were assumed to have zero excess chlorine present in their discharges.
- Details of the design of the diffuser for the F1-SWRO was unavailable at the time study commencement which meant that the F1-SWRO discharge was modelled as a simple source which mathematically only takes the continuity equations into account and not momentum.
- Exact dimensions of the cooling water outfall channels for the F1 and F2 facilities were not available, therefore initial momentum was calculated based on assumed channel dimensions.

5 Results

5.1 Hydrodynamic Modelling

5.1.1 Overview

In order to provide simulation data which captured a full tidal cycle and achieved steady state equilibrium, MIKE3 HD FM was run for one month (31 days) for the month of July 2018 in order to represent the predicted worst case scenario with regards to the lowest cooling capacity of the power plant receiving warmer ocean water during the summer period. This was corroborated in the F3 recirculation study conducted by HR Wallingford for EWEC [10].

The ambient currents generally flow in-line with the coast in a north-south direction with the prevailing South-Easterly winds likely to be the main contributing factor to the current speeds and directions within the project area.

Current speeds within the area are generally slow (<0.4 m/s), with a depth average speed of <0.12m/s. A video of current speeds and directions for the entire simulated period for Scenario 2 can be found within Appendix A.

Tidal phase and amplitude are generally of a mixed diurnal and semi-diurnal nature. The current velocities, at all vertical sea levels, within the project area are dominated by the flood and ebb tidal events, but are generally low, resulting in significant wind influence near sea surface.

Figure 5-1 and Figure 5-2 shows the mean and maximum current speeds for scenario 2 within the project area modelled during a representative summer month.

Figure 5-1 - Mean Current Speeds in Project Area – Scenario 2

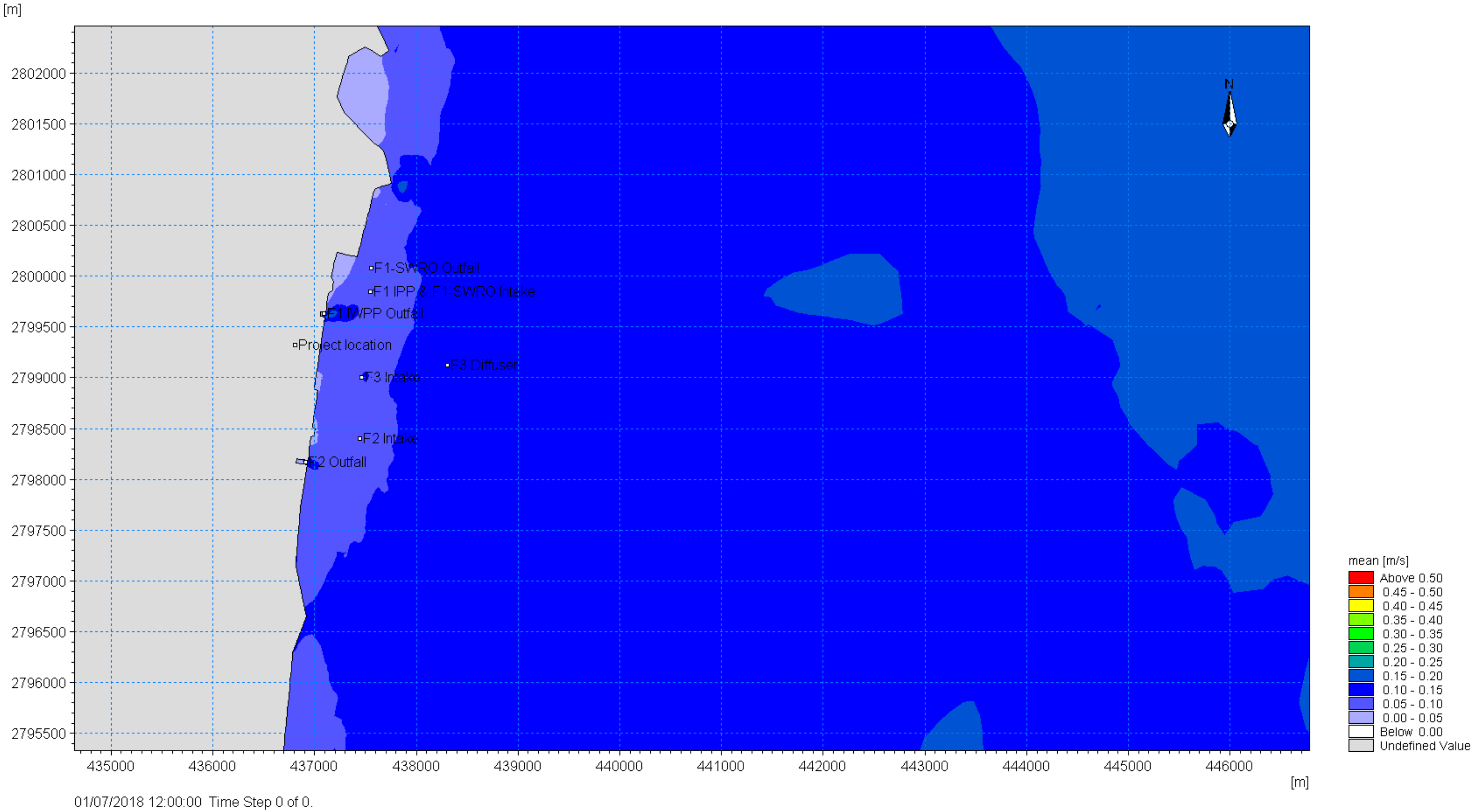
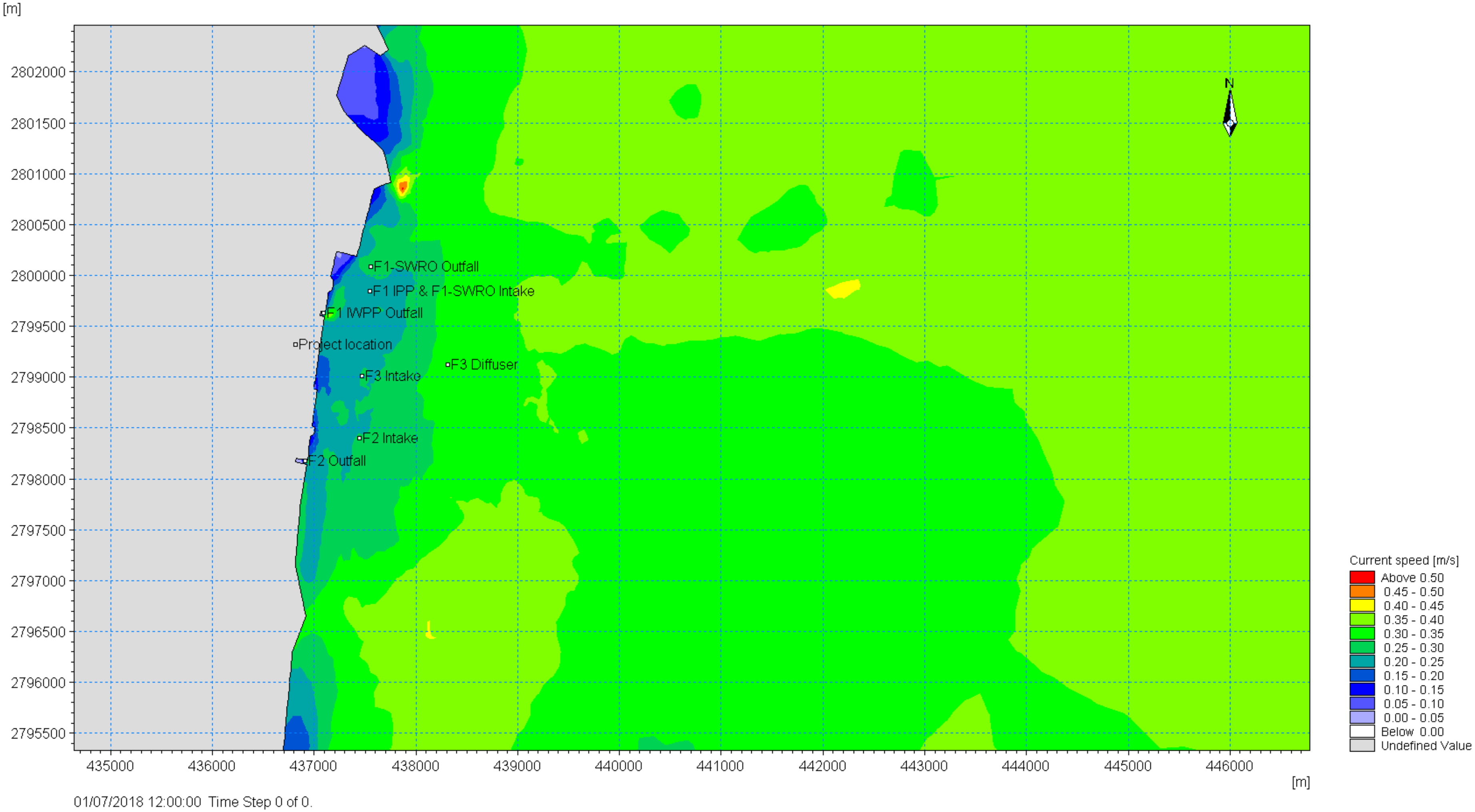


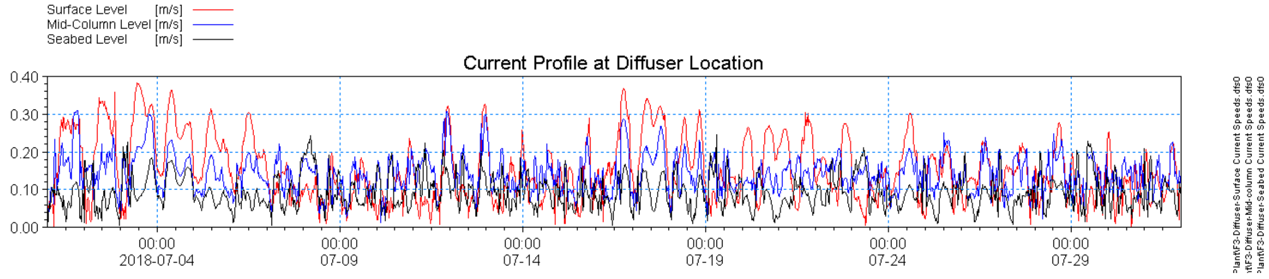
Figure 5-2 – Maximum Current Speeds in Project Area – Scenario 2



5.1.2 Depth Variation

MIKE3 HD FM is a sigma coordinate system (meaning that the depth of the vertical layers will vary depending on actual water depth), however, at the F3 diffuser location, the near seabed, mid-column and surface readings correspond to a simulated depth of –25.7, -13.7m and -1.7m (relative to LAT). Below in Figure 5-3 shows the current profile throughout the water column at the F3 diffuser location which shows the predicted current speeds throughout the water column. Due to the vertical layering scheme the actual thickness and depth of the layers will vary due to the rise and fall of tidal waters.

Figure 5-3 - Current profile at F3 diffuser location

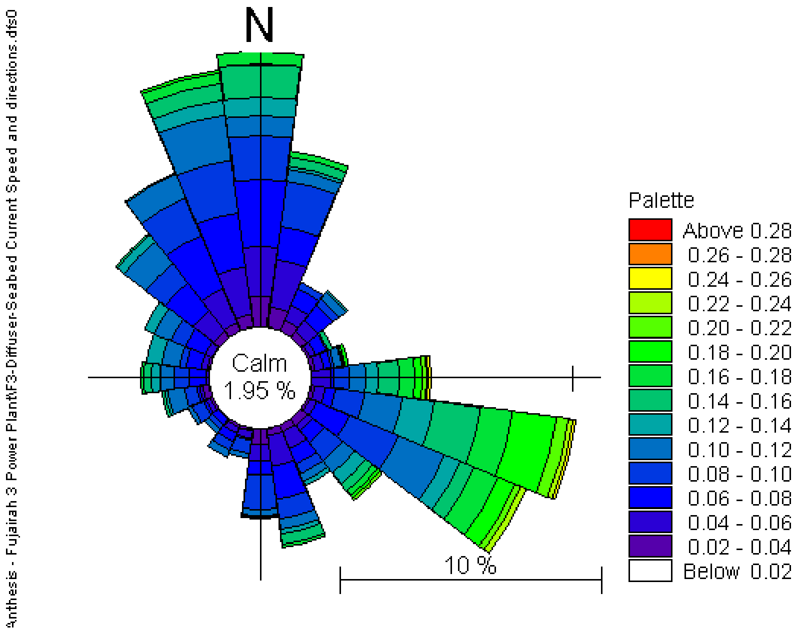


Current speeds are generally stronger on the sea surface than compared to mid-column or seabed speeds to due to the increase influence of wind and reduced influence of bottom friction.

5.1.3 Directional Variation

Currents within the project area (specifically at the F3 diffuser location) are dominated by tidal factors and by the alignment of the coast resulting in currents flowing in a north-south direction. These currents are also influenced from the predominant wind direction displayed in Figure 4-4.

Figure 5-4 - Current Rose at F3 Diffuser Location



5.1.4 Verification of Tide and Current Predictions

The tidal water level variations utilised within the assessment were simulated for representative summer (July) scenarios for 2018. The verification of tidal variations provides a good indication of how accurately MIKE3 HD

FM is simulating the ocean physics. The location of Khawr Fakkan tidal station is shown in Figure 4-8. Note however, the project schedule did not allow for the deployment of any instrumentation (e.g. acoustic doppler current profilers ADCPs) which would have allowed verification of current speeds and directions.

To statistically analyse model performance, the Index of Agreement (IOA) is calculated through comparison between observed (Tidal prediction data) and simulated model data and is compared to the semantic scale presented in Table 5-1. The statistical agreement and analysis of the data has been conducted which is presented in Table 5-1 below with explanation of the various metrics and indices given in the text that follows:

Table 5-1 – Indices of Agreement Score Qualifications

Range	Qualification
0.8 < x < 1.0	Excellent
0.6 < x < 0.8	Good
0.3 < x < 0.6	Reasonable
0.0 < x < 0.3	Poor
x < 0.0	Bad

Presented below in Table 5-2 presents the mean absolute error (MAE) root-mean-square error (RMSE), the coefficient of efficiency (E) and the IOA, for water level variations along with the ideal score.

The RMSE can be described as the standard deviation of the difference for predicted and observed pairing at the tidal station location. The RMSE is a quadratic scoring rule which measures the average magnitude of the error. The RMSE is a good measure of model performance, but since large errors are weighted heavily, its value can be distorted. The MEA is a measure of comparison similar to the RMSE but puts less emphasis on the largest errors. RMSE and MEA are equal to the unit of the values being analysed.

E can range from negative infinity to 1 with larger values indicating a better fit. E measures the one to one relationship between the observed and simulated values and hence is sensitive to bias and proportional effects.

The IOA [20] can take a value between 0 and 1, with 1 indicating perfect agreement. The IOA is the ratio of the total RMSE to the sum of two differences, the difference between each prediction and the observed mean, and the difference between each observation and the observed mean. Therefore, the IOA is a measure of the match between departure of each prediction from the observed mean and the departure of each observation from the observed mean.

Table 5-2 – Statistical Performance of MIKE3D HD FM for Ocean Characteristics – Water Levels

	MAE	RMSE	E	IOA
Ideal Score	0	0	1	1
Water Levels – July 2018 – Khawr Fakkan	0.28	0.30	0.77	0.94

The statistical analysis of the simulated and observed water levels, the simulated tidal variations (water levels) show an excellent correlation to the measured tidal data for the summer season of the 2018 data period. This suggests that the physical tidal variations within the model domain are well represented by the simulation.

Below in Figure 5-5 and Figure 5-6 are the time series comparison and scatter plots of the simulated versus observed water level variations for the Summer month of 2018.

Figure 5-5 – Water Level Comparison – Khawr Fakkan (C-Map) – Summer (July) 2018

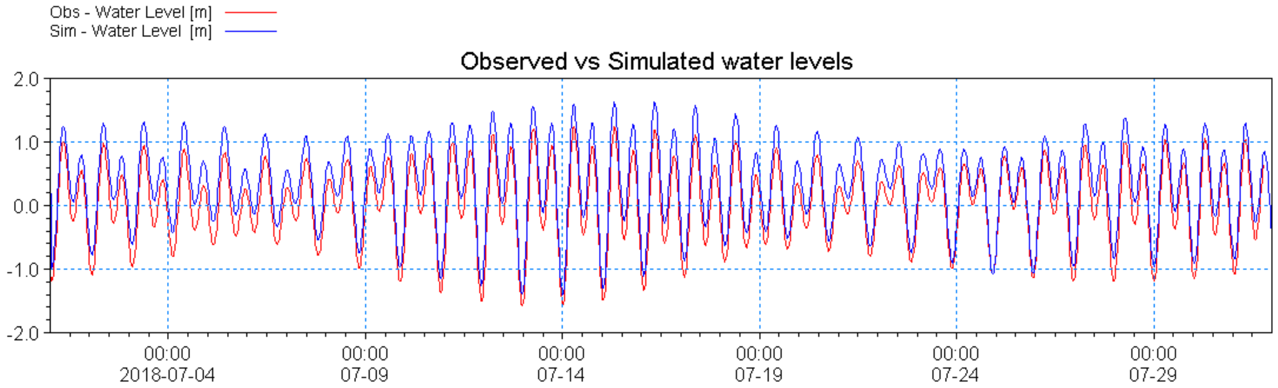
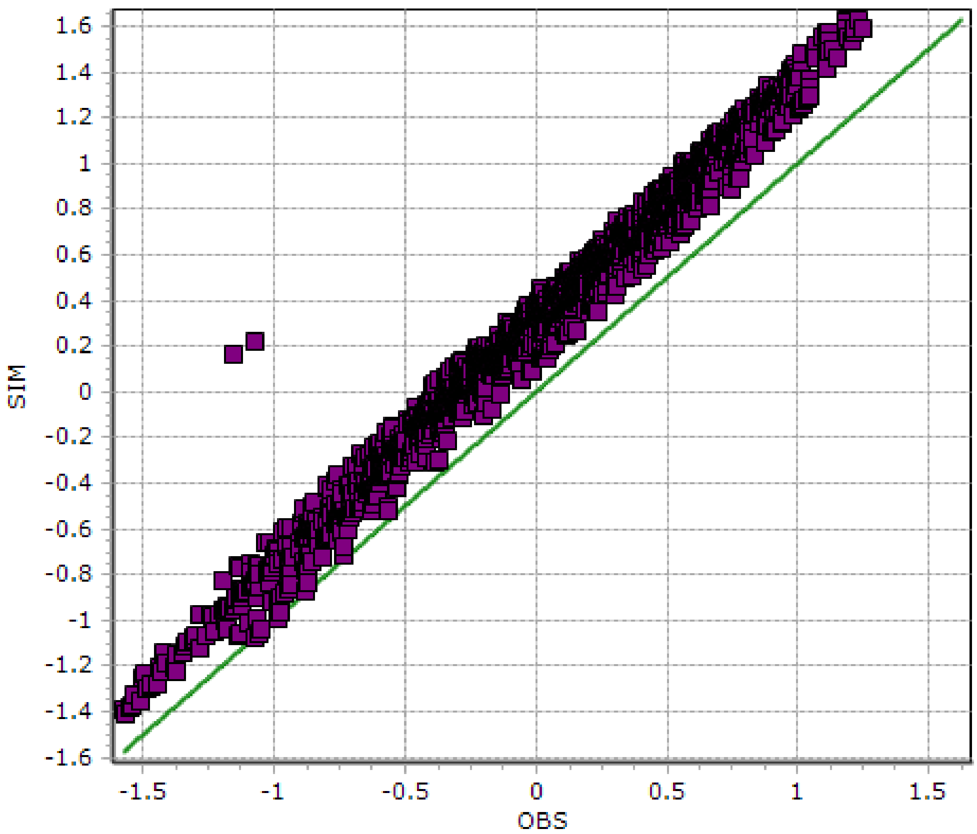


Figure 5-6 – Water Level Comparison – Scatter Plot – Khawr Fakkan (C-Map) – Summer (July) 2018



5.2 Simulation of Thermal Plume Discharges

5.2.1 Overview

The cooling water effluent, rejected from the diffusers, will be warmer than the ambient environment. Due to various processes within each of the facilities, the salinity of the cooling water from each facility will also be higher than the ambient (to varying degrees depending on the facility). Due to these variations in temperature and salinity, the discharges will be more or less dense than the ambient environment, and therefore may influence baroclinic flows. Due to this potential to influencee baroclinic flows, the effluent discharge was simulated within MIKE3 HD FM, which is capable of simulating these density currents.

MIKE3 HD FM simulates both the near-field mixing zone, where the effluent acts under its own momentum and can be described as 'jet-like', and the far-field mixing zone, where the effluent acts under influence from the ambient environment. The linkage of between these two numerical modelling schemes is dynamic, therefore the jet trajectory and momentum are dependent on ambient currents speeds, and the point at which the far-field commences is dependent on the trajectory of the jet phase.

The intake 'sink' is dynamically linked with the diffuser 'source', meaning that any variation in ambient conditions at the intake location is fed back to influence the characteristics of the effluent discharged from the diffuser.

5.2.2 Temperature

Scenario 1

Scenario 1 includes cooling water discharges from both F1 and F2 only (i.e. without influence from the proposed F3 facility). This scenario was simulated to determine the existing extent of the mixing zone to assist in comparison as to how the proposed F3 facility is likely to influence the existing conditions and/or cause additional exceedance or environmental impact.

Figure 5-7 to Figure 5-9 present the simulated mean differential temperature at near-surface, mid-column and near-seabed for Scenario 1. Figure 5-13 to Figure 5-15 present the 95th percentile (below which 95% of simulation can be found) differential temperature, also for near-surface, mid-column and near-seabed for Scenario 1.

The F1 and F2 facilities discharge approximately 33,000 m^3/hr and 21,600 m^3/hr of cooling water respectively at a differential temperature of 9°C for F1 and 8°C for F2. In addition to the main cooling water outfalls, the F1 SWRO also currently discharges approximately 2,400 m^3/hr of rejected brine at a differential temperature of 4.8°C. The F1 and F2 discharges are via simple open channel structure on the coast in the vicinity of each of the IPP plants, whereas the F1 SWRO discharges via a diffuser structure approximately 175m from the shore (measured to the closest land point).

Open channel discharges generally do not promote good near-field mixing behaviour, with the effluent being discharged at relatively low velocities into shallow coastal environments. The mixing processes from the channels will therefore be dominated by slower far-field processes such as passive diffusion and buoyant spreading, further slowed by damping of vertical exchange in stratified conditions. All effluents (both cooling water and brine) are anticipated to be more dense than the surrounding environment, which results in the plumes causing stratification, with higher temperatures being experiences near the seabed, despite the elevated temperature differential. A density current is created, with the plumes moving down the seabed slope under the influence of gravity (see Figure 5-15).

Under these unfavourable mixing conditions, exceedance of the regulatory criteria (2°C) is predicted under certain conditions (see Figure 5-15) up to 1.2 km southwards along the coast and 600 m offshore from the F2 discharge. The F1 outfall is similarly anticipated to result in exceedances of the ambient criteria up to 1 km north-east of the outfall location under certain conditions (see Figure 5-15).

Scenario 2

Scenario 2 considers all existing outfalls from F1 and F2 and add the proposed new outfall from the F2 facility. The F3 facility will discharge approximately 61,000 m^3/h of cooling water, at a differential temperature of 5°C from four diffuser structures approximately 1.2 km offshore.

Figure 5-10 to Figure 5-12 present the simulated mean differential temperature at near-surface, mid-column and near-seabed for Scenario 2. Figure 5-16 to Figure 5-18 present the 95th percentile (below which 95% of simulation can be found) differential temperature, also for near-surface, mid-column and near-seabed for Scenario 2.

The four diffuser structures, located at a depth of approximately 12 m, will discharge the cooling water from alternately arranged ports at a vertical angle of 30°. The salinity of the cooling water rejected from the F3 plant will not significantly differ compared to the ambient environment, meaning that buoyancy will be dominated by the increased temperature, resulting in a positively buoyant plume. The near-field, 'jet' phase of the plume will rise through the water column, losing momentum on interaction with the sea surface, and thereafter drifting with the current within the far-field mixing zone.

The diffuser structure is predicted to efficiently induce good near-field mixing behaviour to a degree that the plume is anticipated to meet regulatory criteria within a short time frame (and likely within metres of the diffuser structure). The good mixing behaviour is will be aided by a relatively deep water column and increased current speeds at the discharge location offshore (when compared to the coastal discharges of F1 and F2) increasing total momentum and buoyancy flux.

The cooling water outfall from F3 is not anticipated to cause any exceedance to the regulatory criteria (2°C) within or outside the regulatory mixing zone of 100m. However, the addition of the F3 cooling water will increase the overall area of influence of the combined F1, F2 and F3 outfalls, however this increase in overall temperature is likely to be less than 0.2°C.

A video of differential temperature over the entire simulated period for Scenario 2 can be found within Appendix A.

5.2.3 Salinity

Scenario 1

The F1 and F2 cooling water discharges are more saline than the ambient by 10 PSU and 4.6 PSU respectively. In addition to the cooling water discharges, the F1 SWRO extension discharges rejected brine at a differential salinity of 28.7 PSU.

Figure 5-19 to Figure 5-21 present the simulated mean differential salinity at near-surface, mid-column and near-seabed for Scenario 1. Figure 5-25 to Figure 5-27 present the 95th percentile (below which 95% of simulation can be found) differential salinity, also for near-surface, mid-column and near-seabed for Scenario 1.

The plumes associated with the F1 and F2 facilities are all anticipated to be negatively buoyant due to the elevated differential salinity, therefore the plumes will tend to sink to the seabed and movement will be influence by gravity flows on the seabed as well as by tide and wind driven currents.

The relatively poor mixing near-field mixing characteristics and large volumes of the F1 and F2 cooling water outfalls result in these outfalls significantly influencing the overall area of regulatory exceedance (differential of 5%). The F1 facility (including the F1 SWRO outfall) is predicted to contribute to regulatory exceedance at up to 2 km offshore of the outfall location, whereas exceedance for the F2 facility is likely to be limited to 1 km offshore.

Scenario 2

The outfall for the F3 facility will discharge a larger volume than either the F1 or F2 facility, however the differential salinity is anticipated to be only 0.1 PSU greater than ambient.

Figure 5-22 to Figure 5-24 present the simulated mean differential salinity at near-surface, mid-column and near-seabed for Scenario 2. Figure 5-28 to Figure 5-30 present the 95th percentile (below which 95% of simulation can be found) differential salinity, also for near-surface, mid-column and near-seabed for Scenario 2.

The outfall for F3 is anticipated to meet regulatory requirements for salinity under all simulated conditions. In addition, the additional differential salinity from the F3 facility will not significantly affect the overall area of influence when considering cumulative contributions with the F1 and F2 facilities.

A video of differential salinity over the entire simulated period for Scenario 2 can be found within Appendix B.

5.2.4 Residual Chlorine

Scenario 1

The dosing and residual (at the point of discharge) concentration for biocide in the form on residual chlorine was not available for the F1 and F2 facility at the time of this study. The cumulative contribution from the existing facilities has therefore been excluded from this assessment.

Scenario 2

The proposed F3 facility will dose the cooling water with sodium hypochlorite for biofouling control purposes. The continuous dose (to control macro-fouling) will result in a residual chlorine concentration within the cooling water of 0.2 mg/l. The cooling water will also be shock dosed once per 24-hour period (to control micro-fouling) at a concentration of 2.0 mg/l. As the shock dosing will be instantaneous, only the continuous dosing concentration has been simulated within this assessment.

Figure 5-31 to Figure 5-33present the simulated mean residual chlorine concentration at near-surface, mid-column and near-seabed for Scenario 2. Figure 5-34 to Figure 5-36 present the 95th percentile (below which 95% of simulation can be found) residual chlorine concentration, also for near-surface, mid-column and near-seabed for Scenario 2.

As detailed within Section 4.3.3, biocide in the form of residual chlorine, decays within seawater. The rate of decay is highly dependent on a combination of temperature, salinity, exposure to sunlight and BOD of the receiving environment. The point at which equilibrium is met (i.e. the point at which no further chemical decay occurs) is also highly dependent on the initial dosing concentration, with a lower fraction of total chlorine remaining at equilibrium remaining at smaller initial doses. It is therefore difficult, in the absence of laboratory experiments specific to site conditions, to accurately predict the rate of decay and equilibrium point of residual chlorine. For the purposes of this study, it has therefore been conservatively assumed, based on the low initial dose of 0.2 mg/l, that 10% of the initial dosing concentration will remain at equilibrium after 20 minutes exposure to seawater.

The F3 facilities cooling water will be discharged via a relatively complex diffuser which has been demonstrated within this study to optimise near-field mixing. It is therefore predicted that residual concentrations of chlorine will be reduced to levels below the regulatory criteria (0.01 g/l) within a relatively short distance. The simulations predict that the regulatory criteria for chlorine will not be exceeded during continuous dosing conditions.

A video of differential residual chlorine concentration over the entire simulated period for Scenario 2 can be found within Appendix C.

Figure 5-7 - Scenario 1 - Mean Temperature Differential - Surface

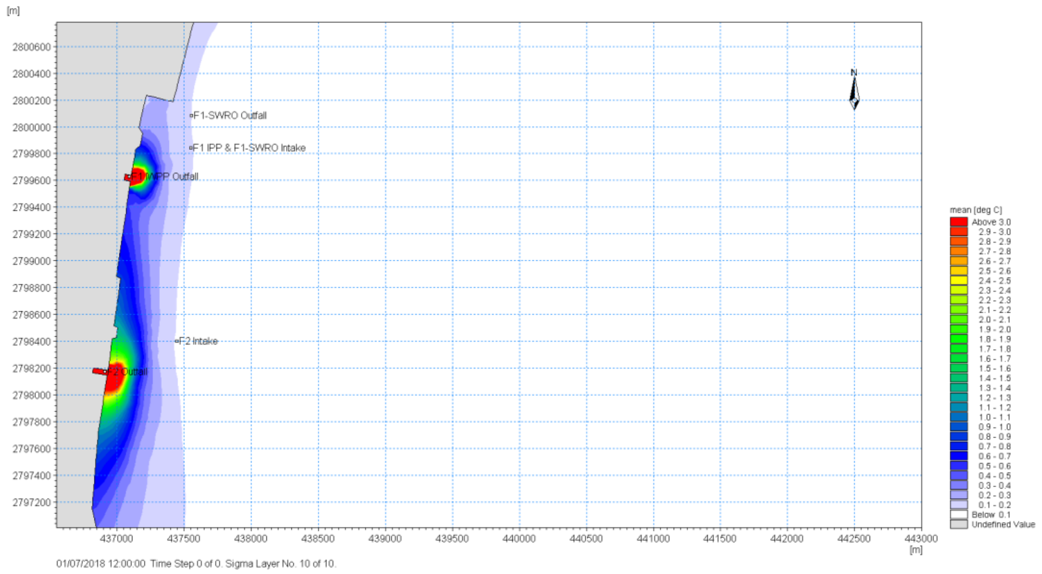


Figure 5-8 - Scenario 1 - Mean Temperature Differential – Mid-column

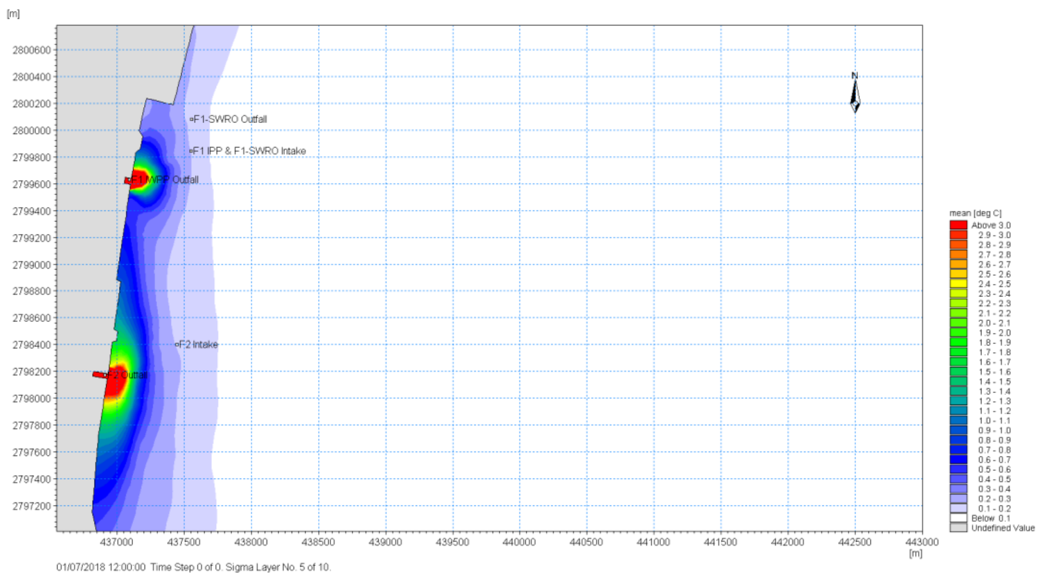


Figure 5-9 - Scenario 1 - Mean Temperature Differential - Seabed

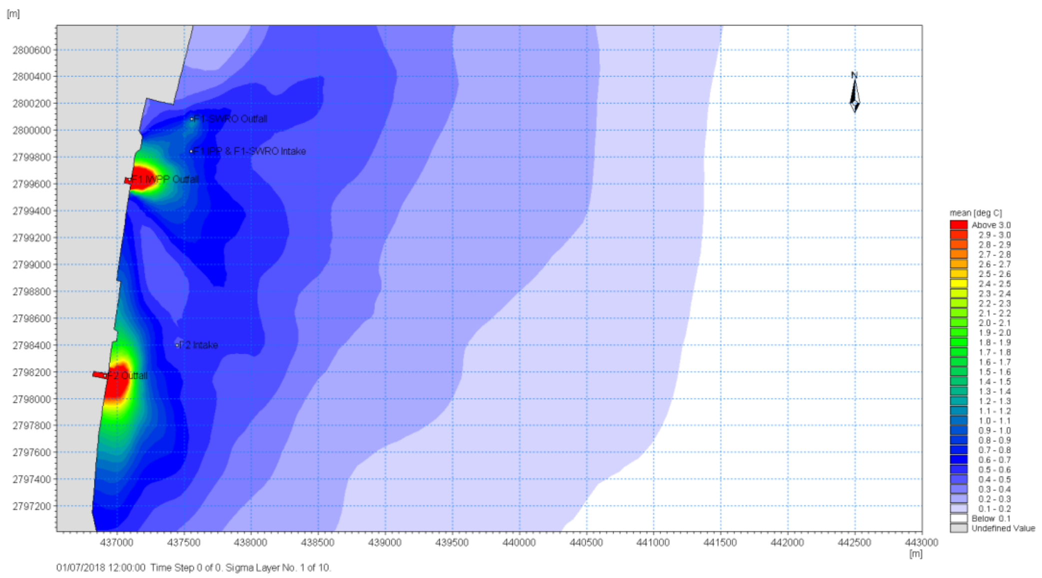


Figure 5-10 - Scenario 2 - Mean Temperature Differential - Surface

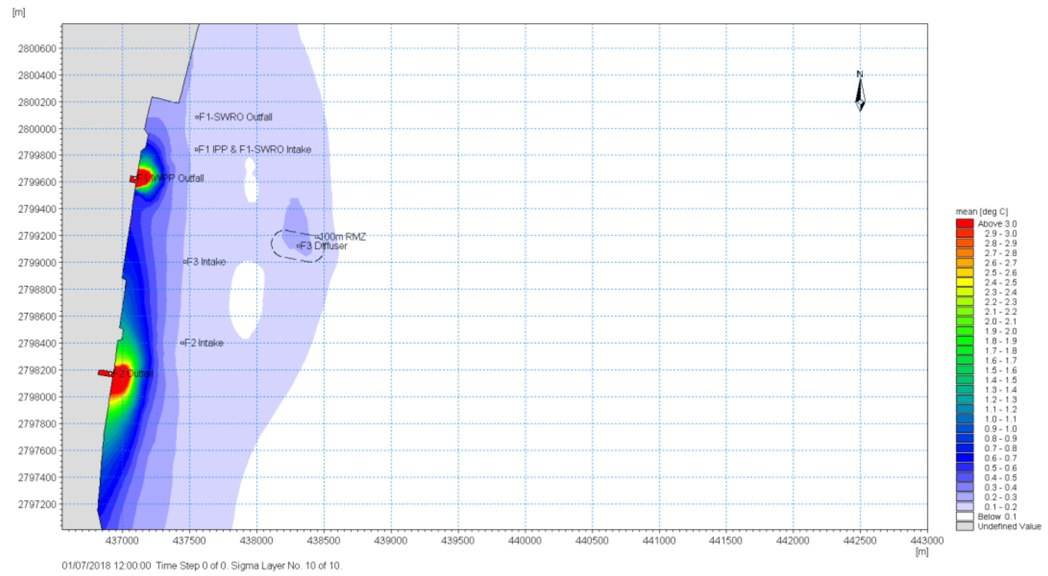


Figure 5-11 - Scenario 2 - Mean Temperature Differential - Mid-column

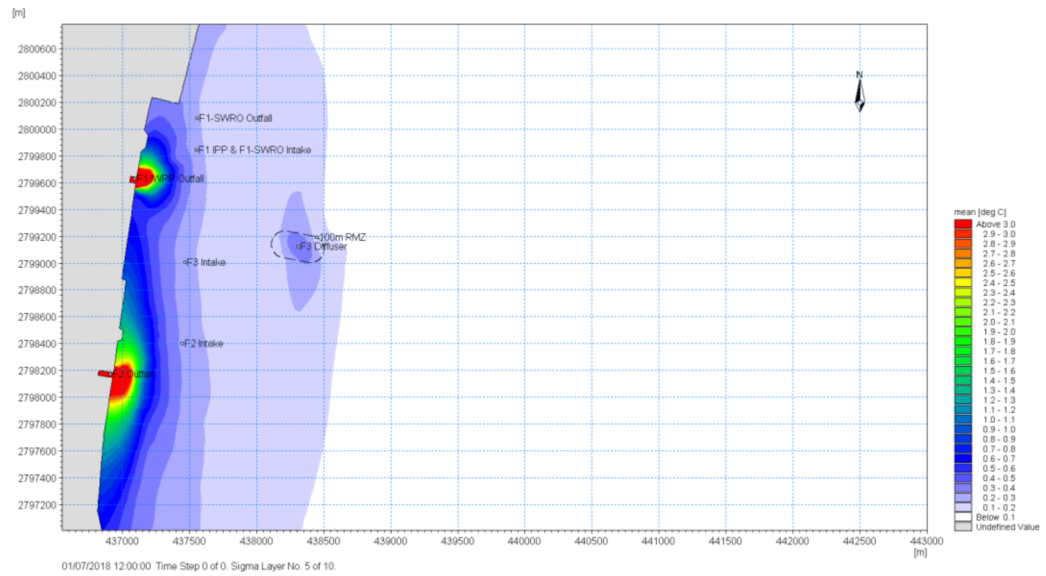


Figure 5-12 - Scenario 2 - Mean Temperature Differential - Seabed

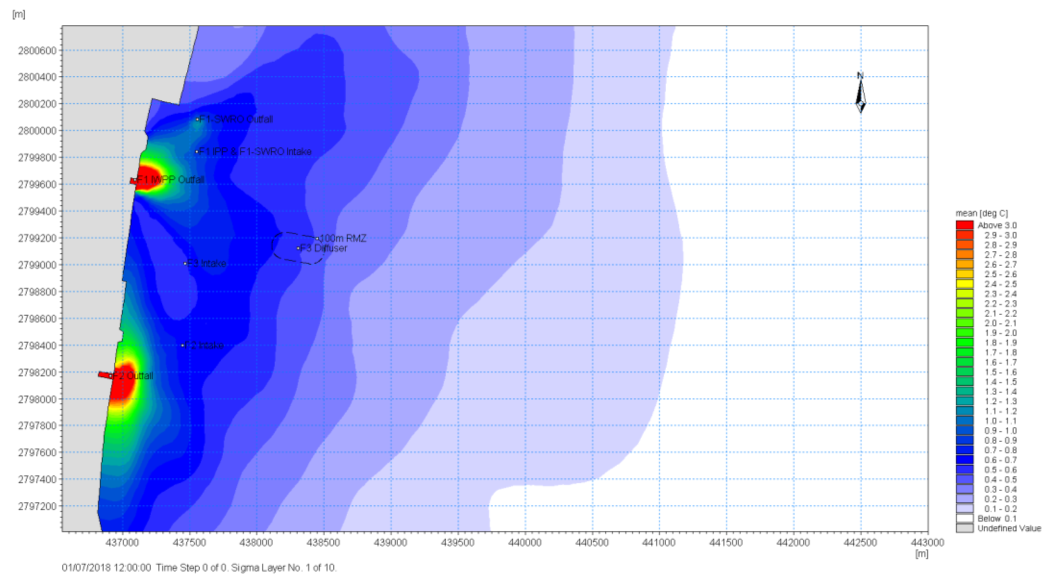


Figure 5-13 - Scenario 1 - 95th Percentile Temperature Differential - Surface

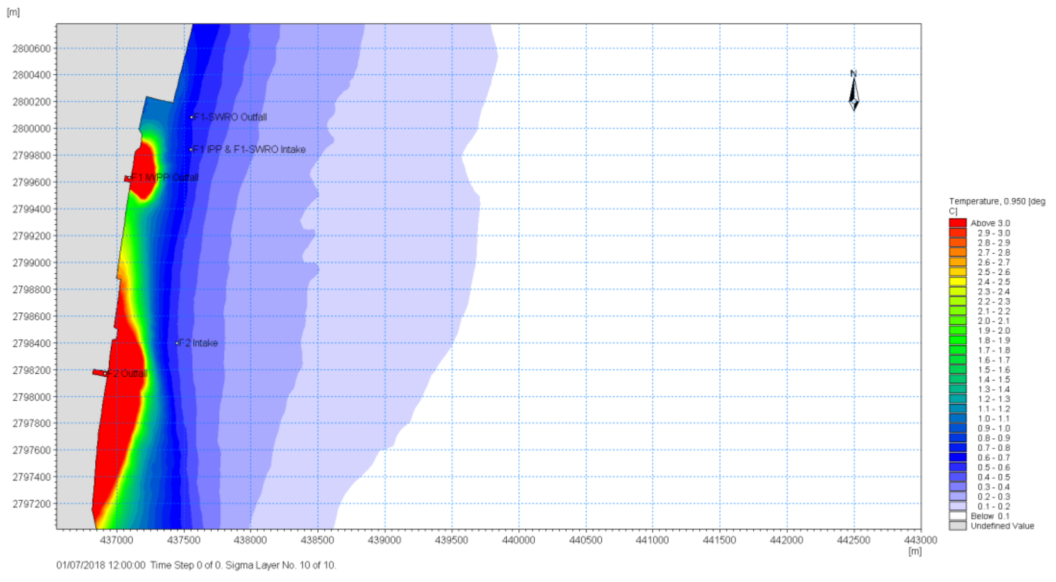


Figure 5-16 - Scenario 2 - 95th Percentile Temperature Differential - Surface

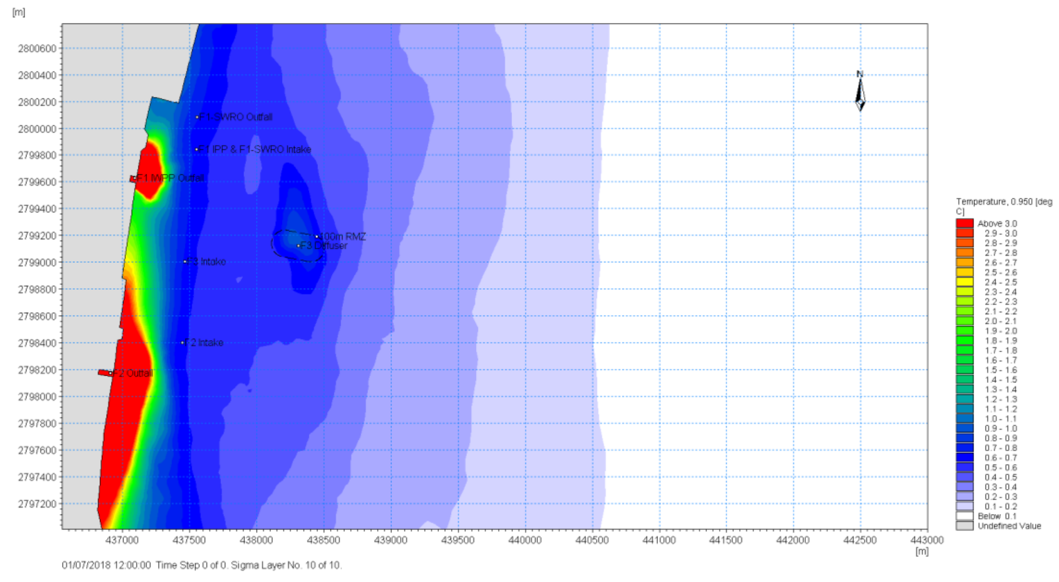


Figure 5-14 - Scenario 1 – 95th Percentile Temperature Differential - Mid-column

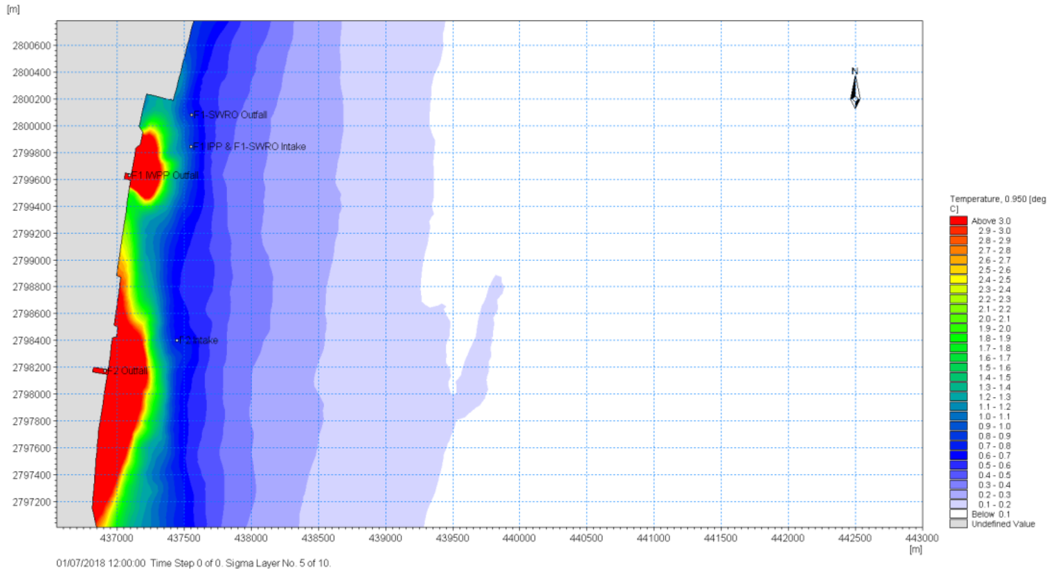


Figure 5-17 - Scenario 2 - 95th Percentile Temperature Differential - Mid-column

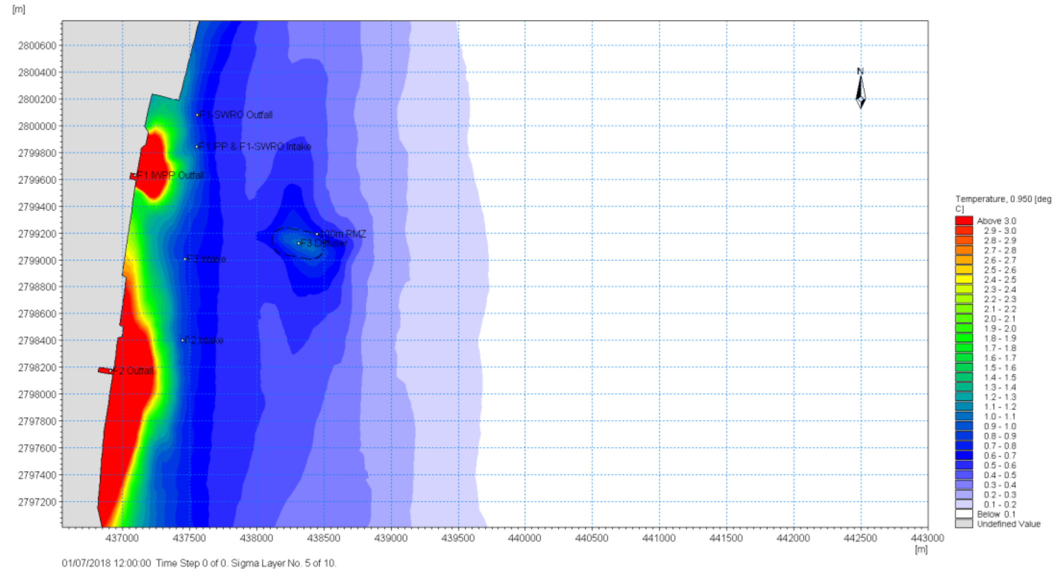


Figure 5-15 - Scenario 1 - 95th Percentile Temperature Differential - Seabed

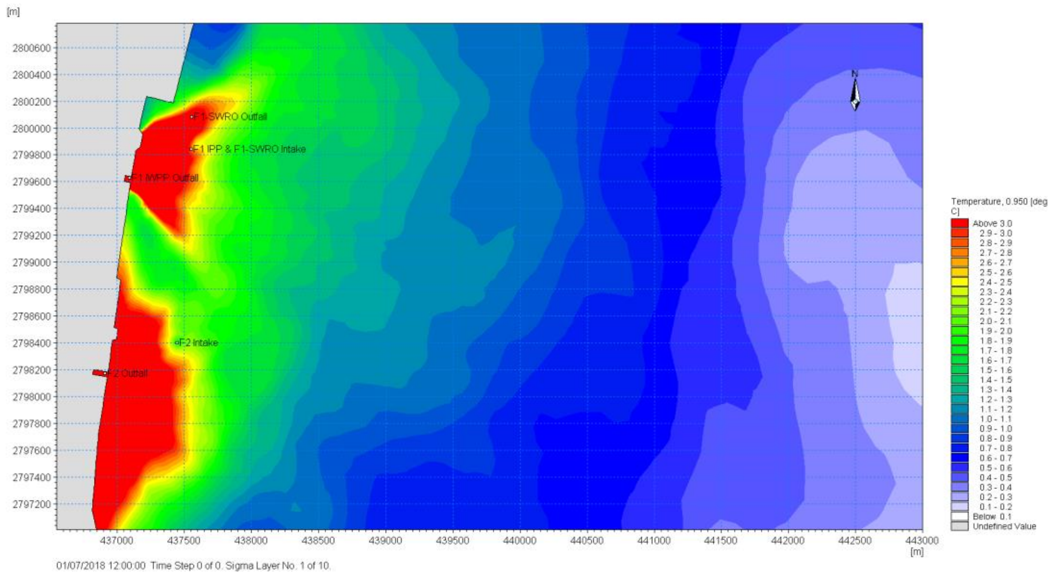


Figure 5-18 - Scenario 2 - 95th Percentile Temperature Differential - Seabed

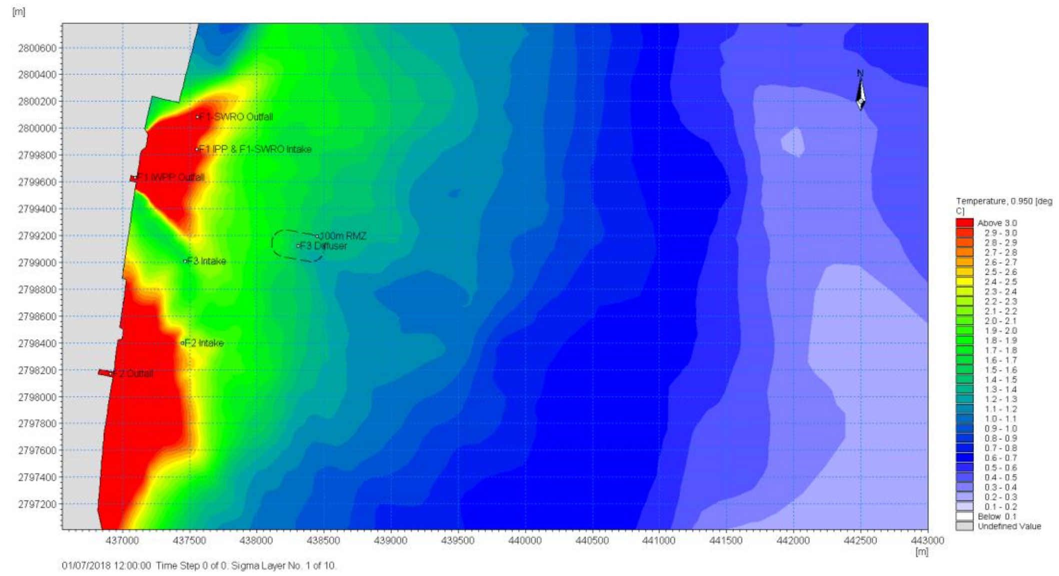


Figure 5-19 - Scenario 1 - Mean Salinity Differential - Surface

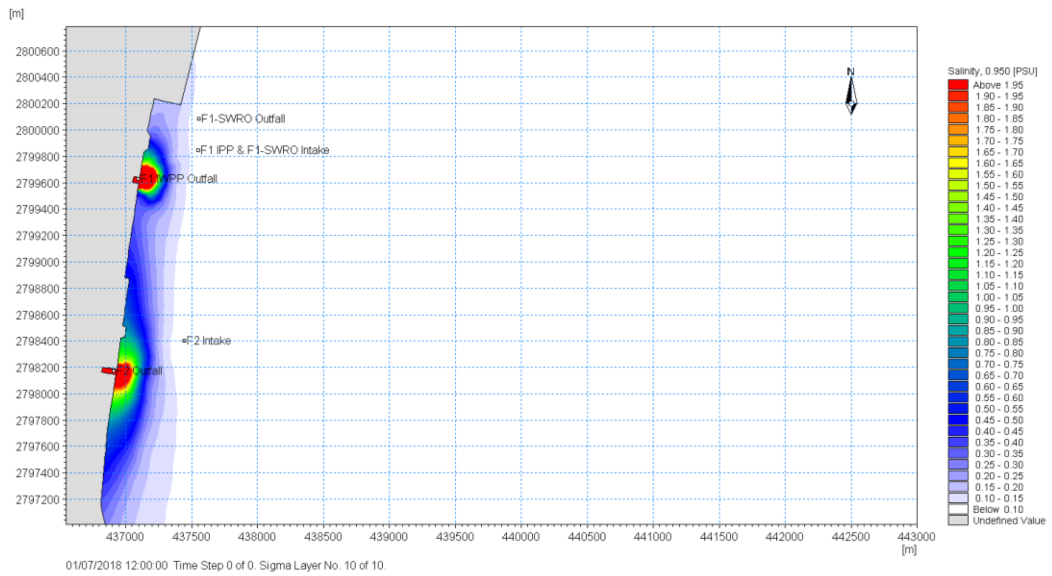


Figure 5-22 - Scenario 2 - Mean Salinity Differential - Surface

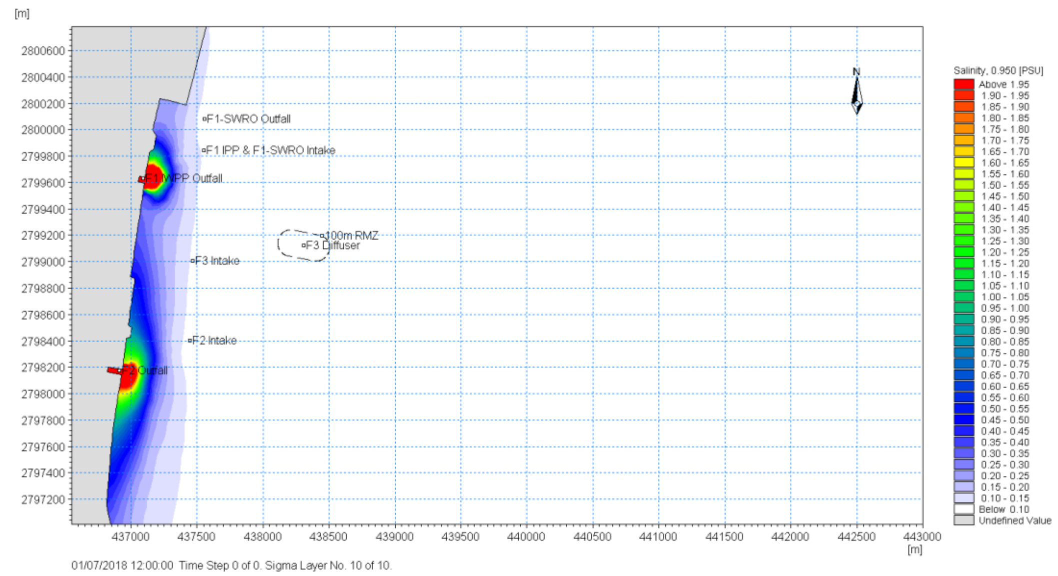


Figure 5-20 - Scenario 1 - Mean Salinity Differential – Mid-column

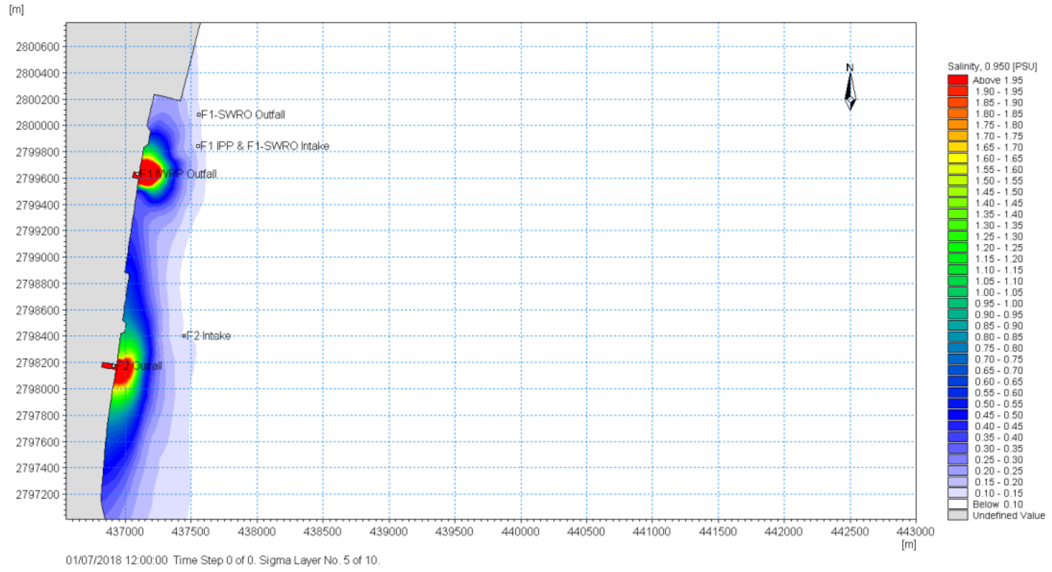


Figure 5-23 - Scenario 2 - Mean Salinity Differential - Mid-column

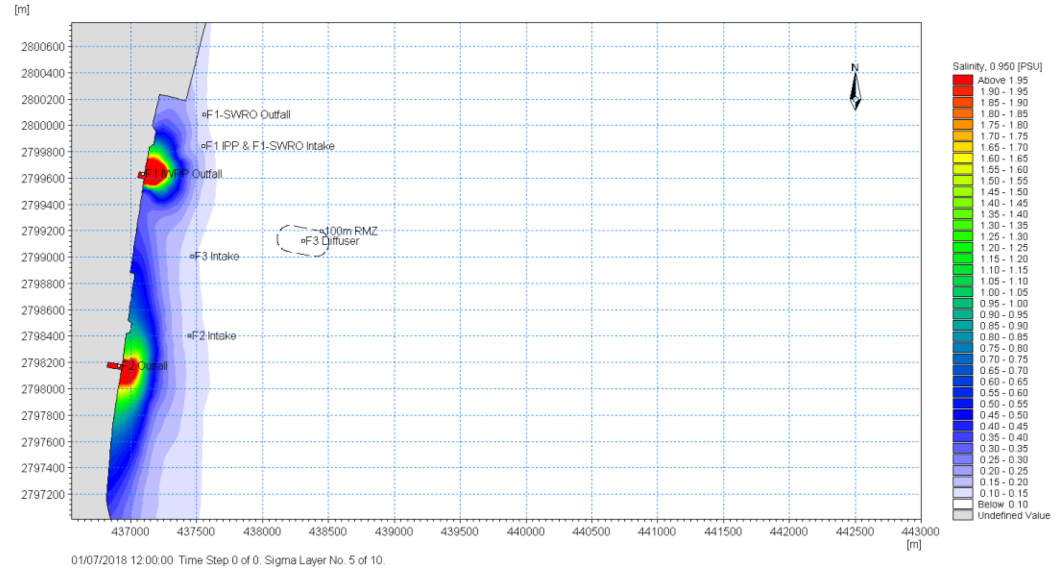


Figure 5-21 - Scenario 1 - Mean Salinity Differential - Seabed

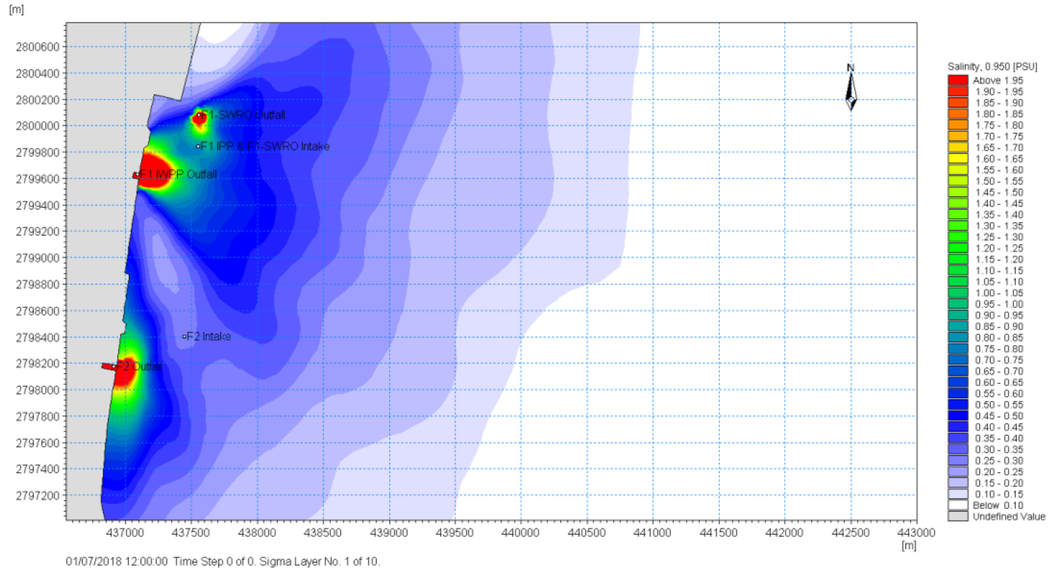


Figure 5-24 - Scenario 2 - Mean Salinity Differential - Seabed

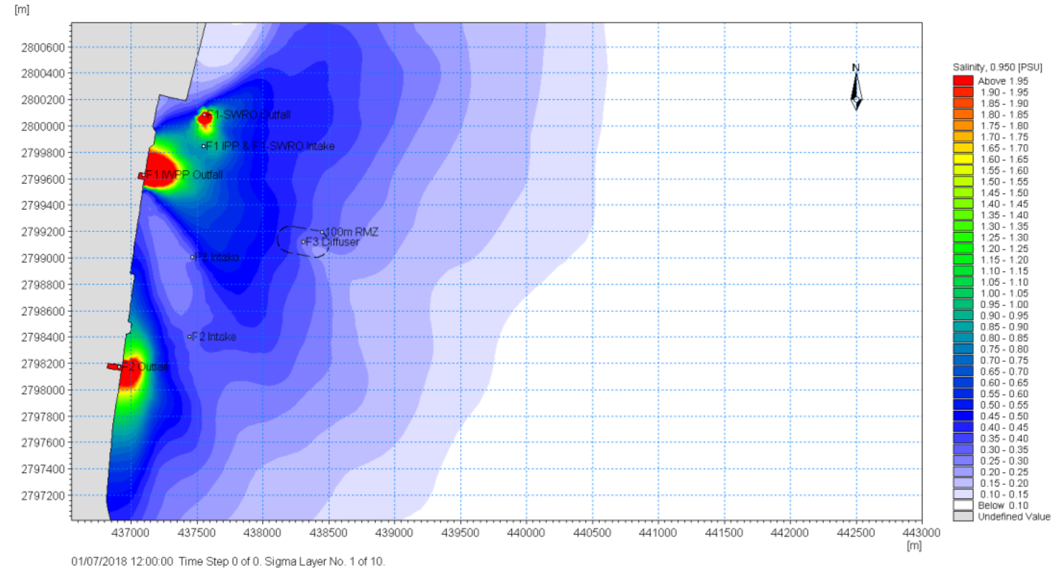


Figure 5-25 - Scenario 1 - 95th Percentile Salinity Differential - Surface

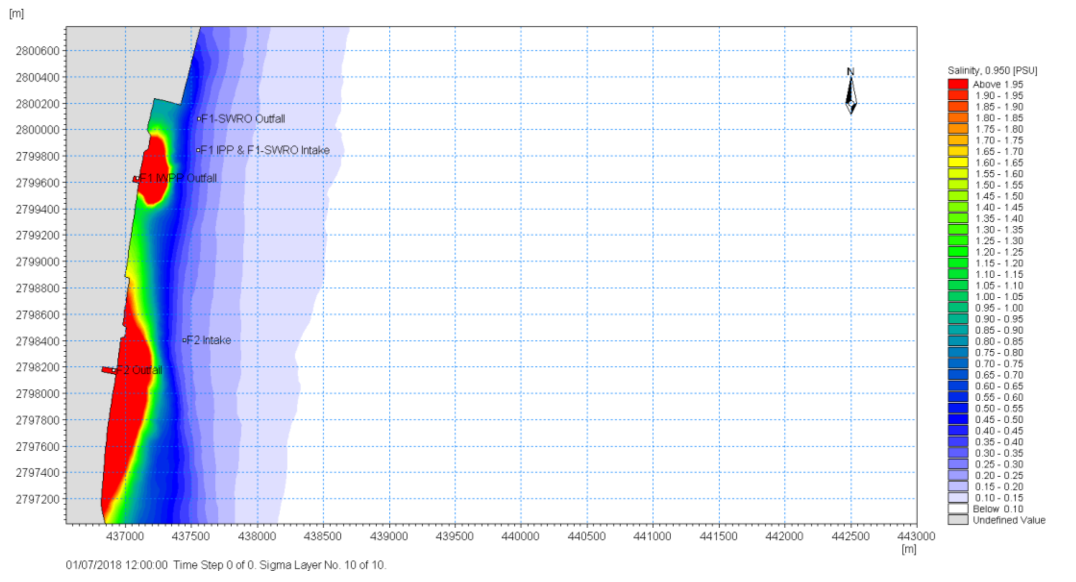


Figure 5-26 - Scenario 1 – 95th Percentile Salinity Differential - Mid-column

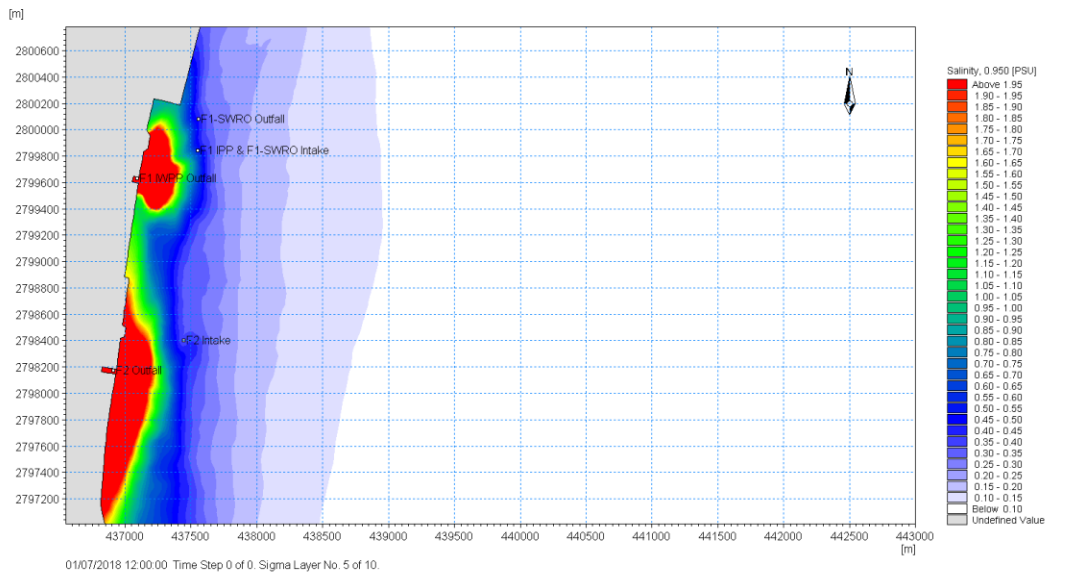


Figure 5-27 - Scenario 1 - 95th Percentile Salinity Differential - Seabed

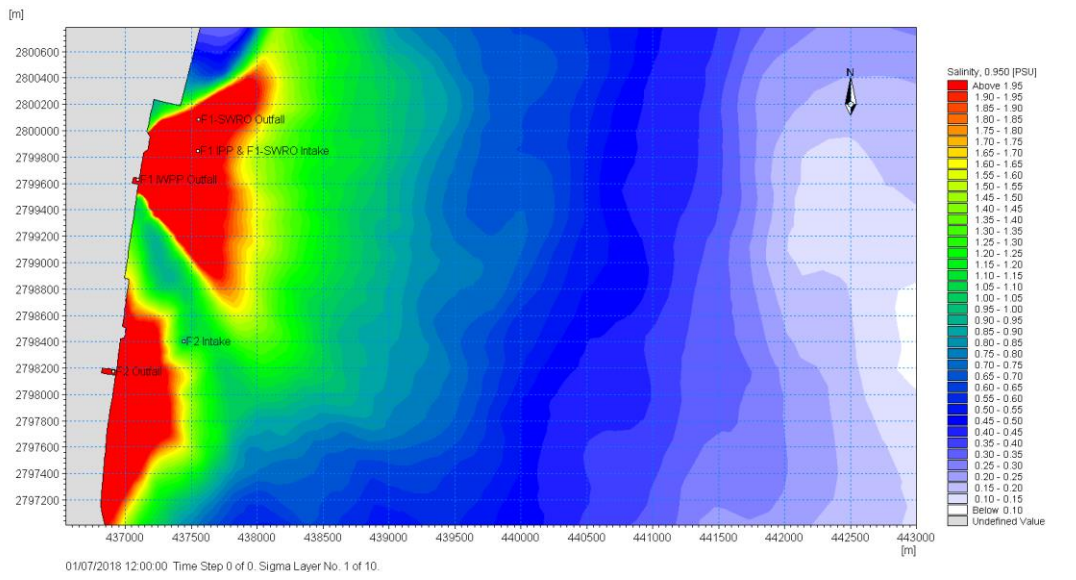


Figure 5-28 - Scenario 2 - 95th Percentile Salinity Differential - Surface

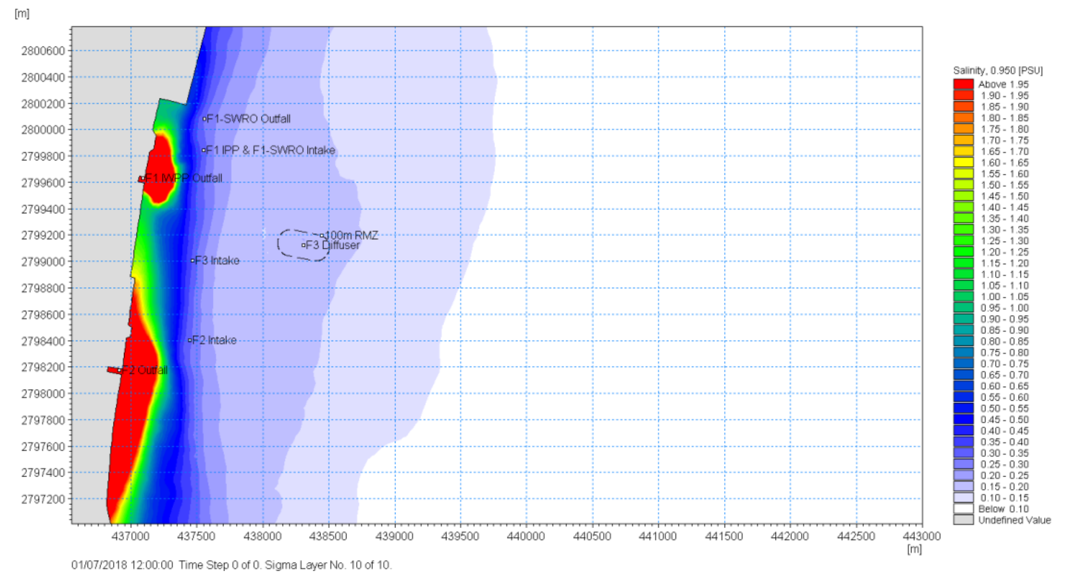


Figure 5-29 - Scenario 2 - 95th Percentile Salinity Differential - Mid-column

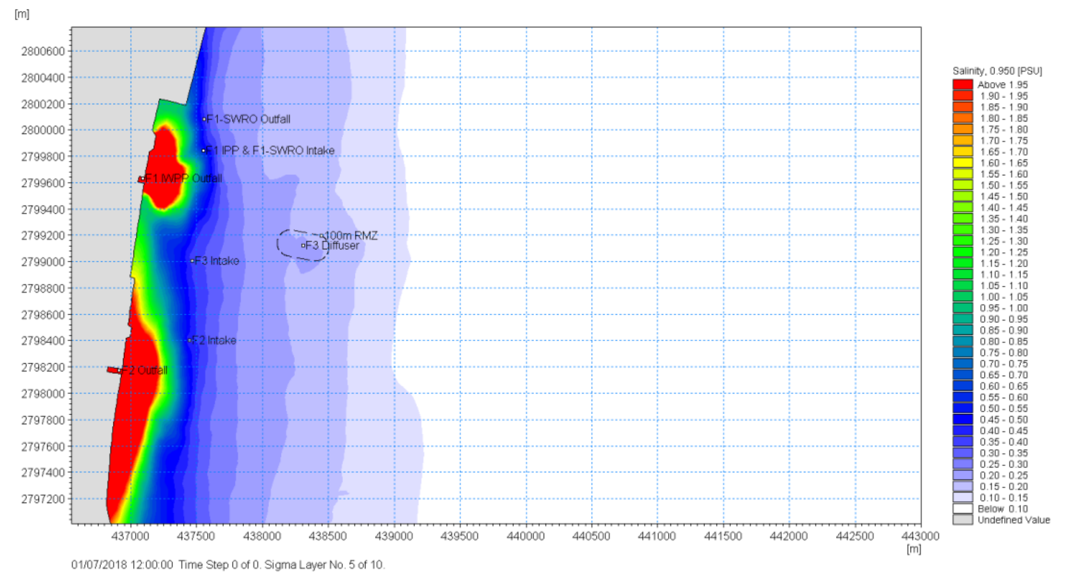


Figure 5-30 - Scenario 2 - 95th Percentile Salinity Differential - Seabed

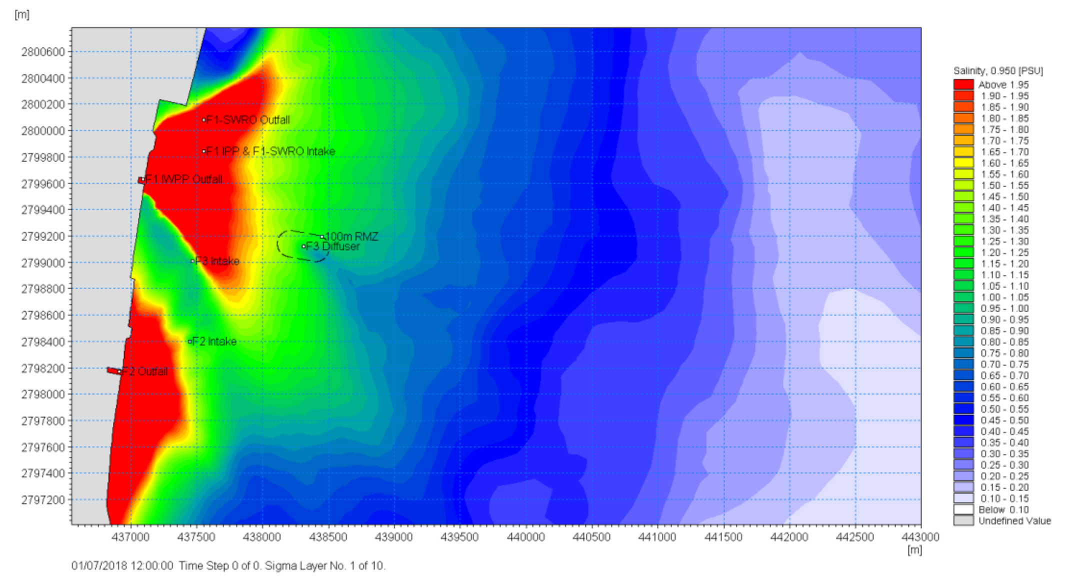


Figure 5-31 - Scenario 2 - Mean Percentile Excess Chlorine - Surface

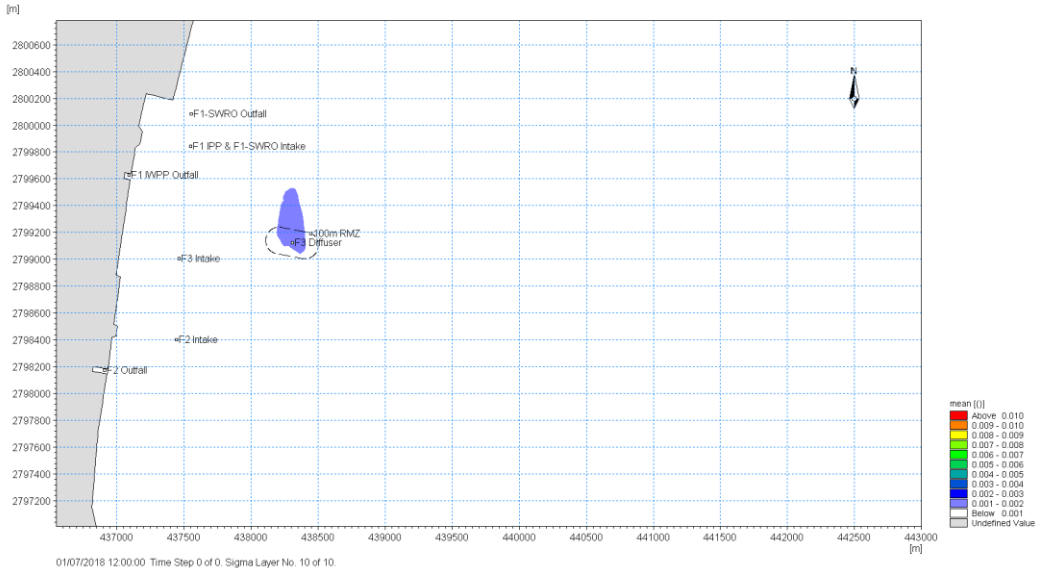


Figure 5-32 - Scenario 2 – Mean Percentile Excess Chlorine - Mid-column

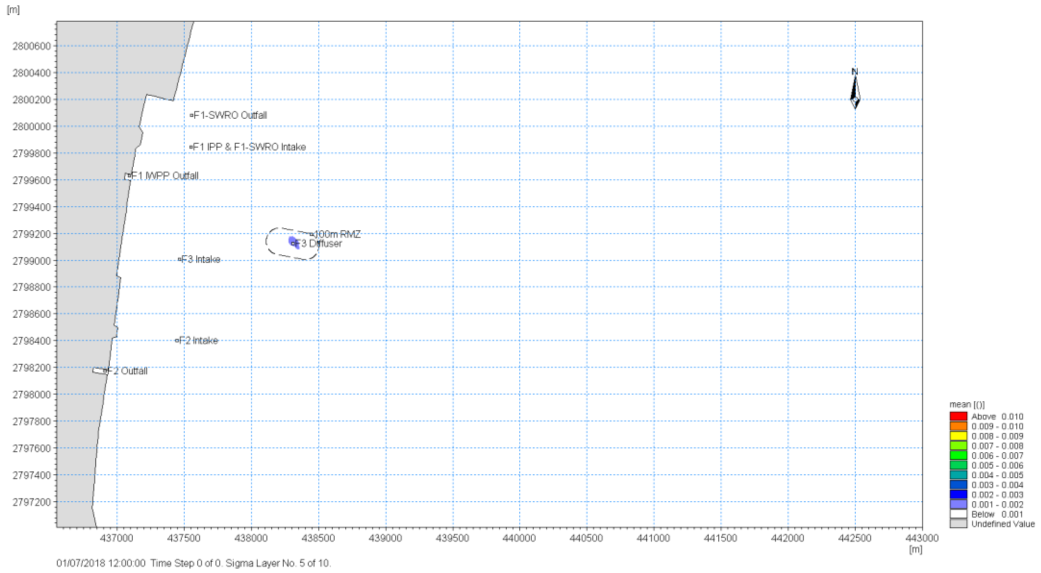


Figure 5-33 - Scenario 2 - Mean Percentile Excess Chlorine - Seabed

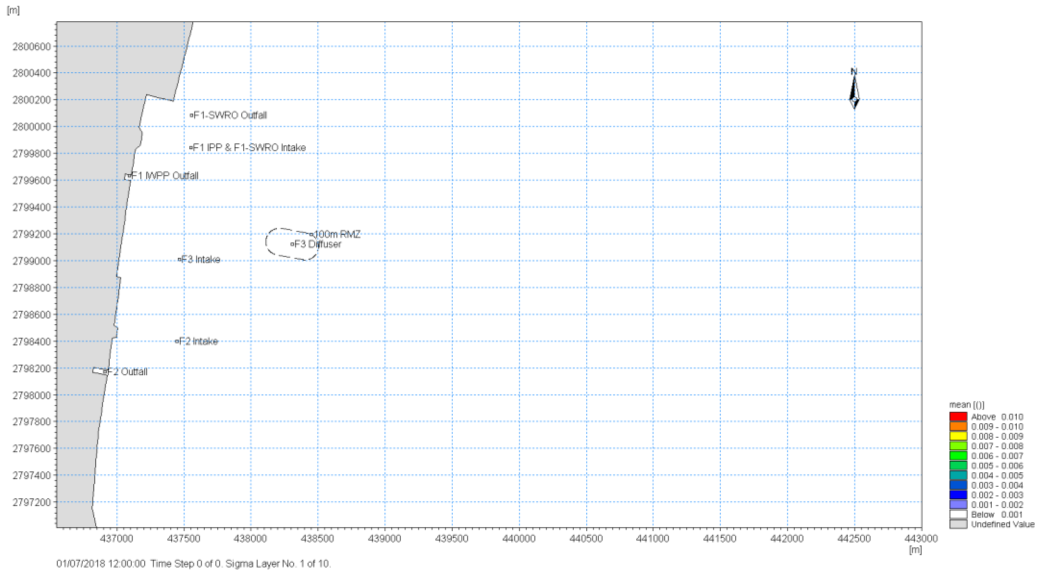


Figure 5-34 - Scenario 2 - 95th Percentile Excess Chlorine - Surface

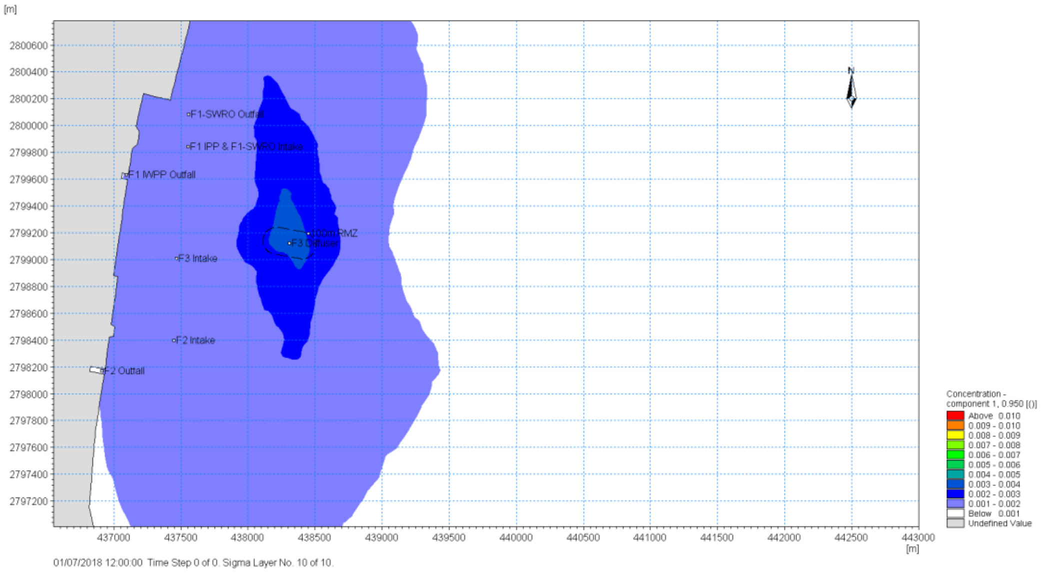


Figure 5-35 - Scenario 2 – 95th Percentile Excess Chlorine - Mid-column

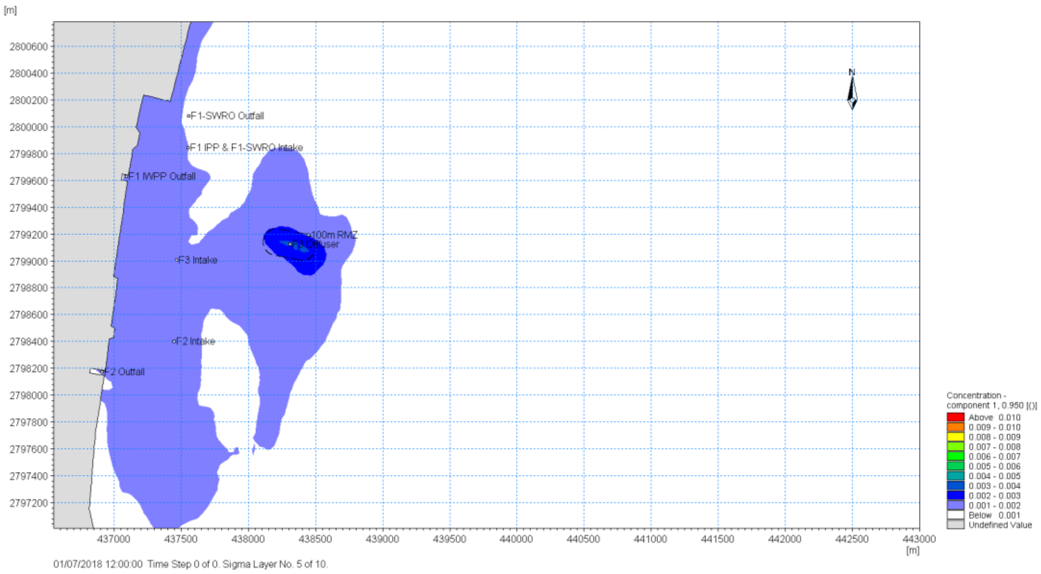
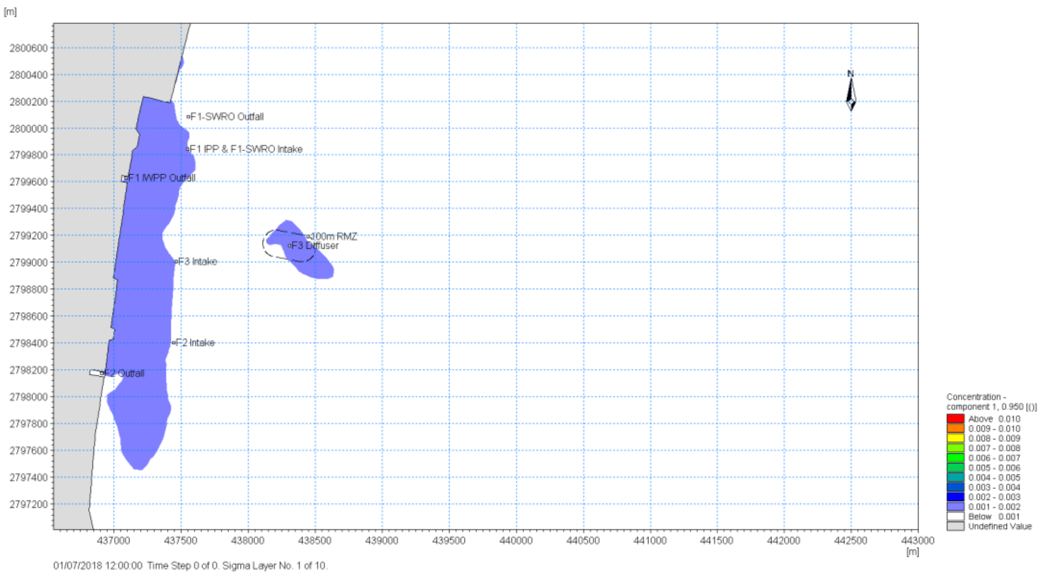


Figure 5-36 - Scenario 2 - 95th Percentile Excess Chlorine - Seabed



5.2.5 Recirculation Potential

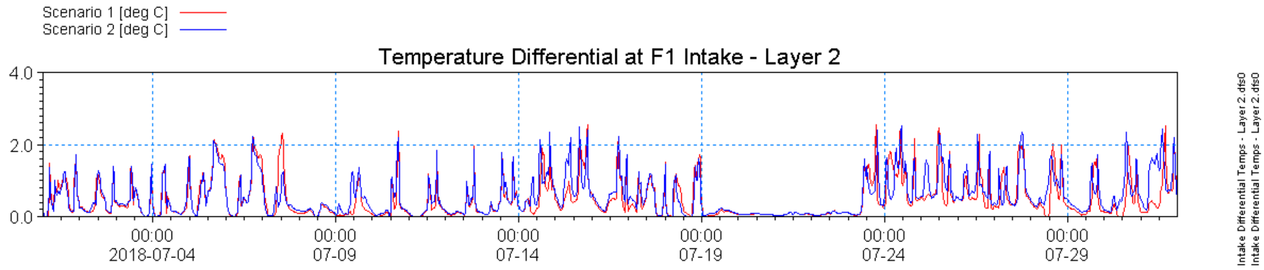
Impact to Existing Intakes

The F1 and F2 facilities utilise open channel discharges along the coastline within the vicinity of each of the facilities, with intake pipeline running offshore at a distance of 150 m and 450 m from the nearest shoreline respectively. The intention of placing the intake structure offshore would have been to allow sufficient distance between the outfall and intake to minimise the chances of recirculation.

It is possible that the intake for the F1 and F2 projects have a specified differential temperature threshold defined by the operators at which cooling efficiency of the plant is not adversely impacted, and also potentially an allowable period for which this threshold can be exceeded. At present, it is not known whether and what the defined operational threshold for temperature exceedance is, however it is possible to analyse through interpretation of the modelling results whether the proposed F3 facility is likely to significantly impact upon existing re-circulation potential.

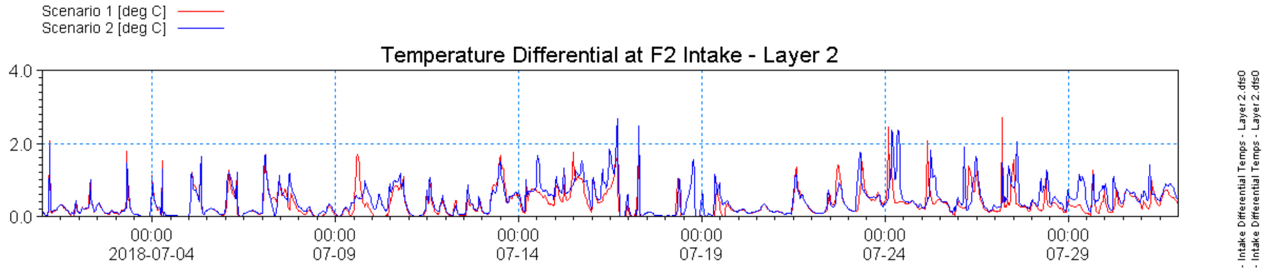
The modelling results indicate that the temperature differential at the intake of F1 (when compared to the overall ambient) is likely to exceed 2°C on a regular basis. In addition, a differential temperature of 1°C is anticipated to be exceeded at least once for the majority of tidal periods (approximately 24 hours). This indicates that under certain tidal conditions a certain amount of re-circulation of cooling waters is expected. Figure 5-37 compares the temperature differential predicted at the F1 intake for Scenario 1 (existing conditions) and Scenario 2 (post-development conditions) at a depth of approximately -10m (assuming the intake structure is near seabed) at the F1 intake location. The difference in overall temperature and the time at which temperature peaks occur is not predicted to differ significantly with the addition of the F3 facility, therefore it is predicted that the F3 outfall is unlikely to increase the potential for re-circulation at the F1 intake location.

Figure 5-37 - Temperature Differential Variation at F1 Intake



Simulations demonstrate that the potential for re-circulation at the F2 intake is less than that of the F1 intake, however peaks above a differential of 1°C are still predicted but at a lower frequency (possibly at up to every second tidal period). Figure 5-38 presents a comparison of simulated differential temperature for Scenario 1 (existing conditions) and Scenario 2 (post F3 development) at the F2 intake location at a depth of approximately -12.5m (assuming a near seabed intake). Again, the simulations predict that the overall temperature and the time at which temperature peaks occur is not predicted to differ significantly with the addition of the F3 facility, therefore it is predicted that the F3 outfall is unlikely to increase the potential for re-circulation at the F2 intake location.

Figure 5-38 - Temperature Differential Variation at F2 Intake



Potential for Re-circulation at the F3 Intake

The potential for re-circulation at the F3 intake has also been considered. Any re-circulation of previously discharged heated plumes into the cooling water system have the potential to reduce efficiency. A larger volume of warmer water would be required to have the same cooling effect on the IPP components. This larger volume would then be release at a greater temperature (equal differential temperature) which would increase the potential for recirculation within a positive feedback loop. It is therefore important to minimise the order and frequency that the intake location exceeds defined operational thresholds.

Figure 5-39, Figure 5-40 and Figure 5-41 summarise the temperature at the F3 intake location for a hypothetical Scenario 0 (i.e. no outfalls) and Scenario 2 (outfalls from F1, F2 and F3 all included) as well as the temperature differential between the two. Three depths have been provided to determine whether significant stratification occurs at this location, which may aid in defining the intake structure depth.

It is understood that the temperature threshold for the F3 IPP is 18 – 35°C. The summer simulations do not anticipate that that a temperature of 35°C will be exceeded under normal operating conditions, however it is feasible that under certain extreme conditions temperature may exceed 35°C momentarily in extreme cases.

Simulations for Scenario 2 (post development) predict that peaks in differential temperature are more pronounced at the seabed. This indicates that the majority of excess temperature influence at this location is from the existing F1 and F2 facilities, as the plume from these facilities is more dense than the ambient and tends to sink to the seabed.

Momentary differential temperature peaks in excess temperature above 1°C again occur regularly near the seabed, with maximum peaks occurring infrequently above 2°C. The frequency and magnitude of these peaks decrease sequentially for both mid column and near sea surface results. The model results do not indicate that any significant problem with circulation will occur, however the influence from the existing F1 and F2 outfalls may be in excess of the risk thresholds applied by the operator.

Figure 5-39 - F3 Intake Temperature - Surface Level

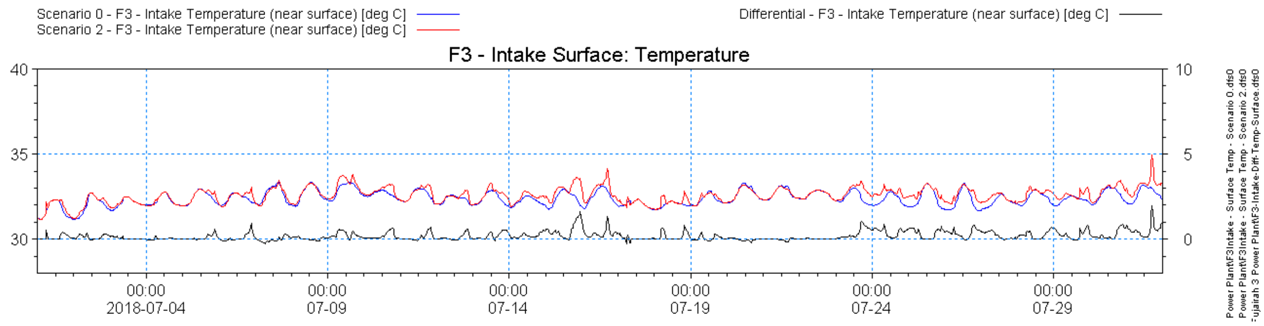


Figure 5-40 - F3 Intake Temperature - Mid-Column Level

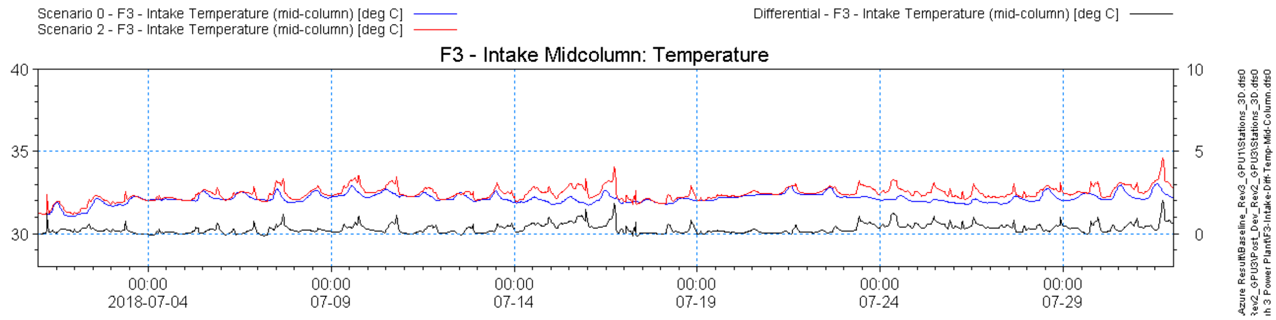
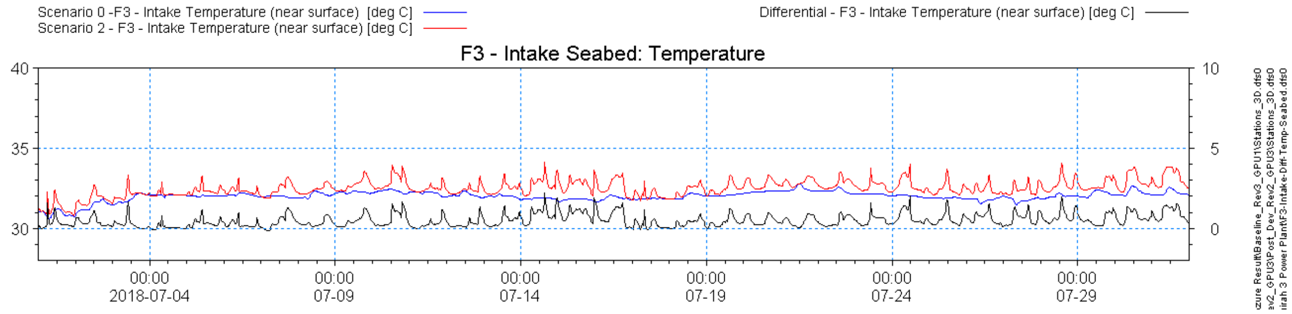


Figure 5-41 - F3 Intake Temperature - Seabed Level



6 Summary and Conclusions

WKC have been contracted by Anthesis to conduct a hydrodynamic and thermal plume study for the effluent outfalls associated with the proposed Independent Power Plant (IPP), known as Fujairah-3 (F3). The proposed F3 site is located in between to the existing Fujairah 1 (F1) and Fujairah 2 (F2) IPP, on the coast of Fujairah, United Arab Emirates (UAE).

The objectives of the study were to provide technical support in aid of the impact assessments contained within the ESIA, including; the simulation of hydrodynamics and thermal plumes (and other parameters of concern), analysis to determine whether cooling water re-circulation is a concern, and to assess whether regulatory compliance is met with regards to effluent discharge temperatures, salinities and residual chlorine.

The proposed F3 project is the third power facility at this location and will be situated in between these two IPPs (F1 & F2). Note F1 has also been expanded to include a Sea Water Reverse Osmosis plant (F1 SWRO) being located to the north-east of F1. The F3 project will require the supply sea water for cooling purposes throughout the design life of the project.

The hydrodynamics of the project area, the thermal plume discharges and residual chlorine concentrations have been simulated utilising DHI's MIKE modelling suite. Due to the likely stratified nature of the environment after the introduction of variable density plumes from IPP effluent discharges, the MIKE3 HD FM 3D module was utilised for the study.

Simulation were conducted for a hypothetical baseline case (Scenario 0) (i.e. without the introduction of the intakes and outfalls from any source), a pre-development (existing) case (Scenario 1) (which included the intake and outfalls for the F1 and F2 IPPs, and a post -development case (Scenario 2) (i.e. after the introduction of the outfalls and intakes associated with the proposed F3 IPP).

The principal constituents of concern within the rejected effluent discharge are differential temperature, salinity and residual chlorine concentrations. A review of relevant regulations suggests that the target marine water quality objectives for temperature and excess chlorine produced within a 100m Regulatory Mixing Zone (RMZ) from point of discharge is Δ3°C and 0.01 mg/L respectively. Furthermore, regarding salinity discharges within the RMZ, the maximum allowable increase in salinity is 5% from the ambient (background) salinity levels.

Cooling water from the F1 and F2 facility (Scenario 1) are discharged under unfavourable mixing conditions, exceedance of the regulatory criteria (2°C) is predicted under certain conditions up to 1.2 km southwards along the coast and 600 m offshore from the F2 discharge. The F1 outfall is similarly anticipated to result in exceedances of the ambient criteria up to 1 km north-east of the outfall location under certain conditions. Regulatory criteria for differential salinity (5%) are similarly anticipated to be exceeded over a significant area (up to 2 km offshore of the F2 outfall).

The diffuser structure of the proposed F3 IPP (Scenario 2) is predicted to efficiently induce good near-field mixing behaviour to a degree that the plume is anticipated to meet regulatory criteria for differential temperature and salinity within a short time frame (and likely within metres of the diffuser structure). The cooling water outfall from F3 is not anticipated to cause any exceedance to the regulatory criteria (2°C) within or outside the regulatory mixing zone of 100m. However, the addition of the F3 cooling water will increase the overall area of influence of the combined F1, F2 and F3 outfalls, however this increase in overall temperature is likely to be less than 0.2°C. The F3 outfall is not anticipated to contribute significantly to existing salinity levels considering the existing area of influence from the F1 and F2 outfalls.

It is also predicted that residual concentrations of chlorine (sourced from the hypochlorite biocide dosing) will be reduced to levels below the regulatory criteria (0.01 g/l) within a relatively short distance. The simulations predict that the regulatory criteria for chlorine will not be exceeded during continuous dosing conditions.

The addition of the F3 IPP cooling water outfall is not predicted to significantly increase re-circulation potential at the existing F1 and F2 intakes. In addition, a significant risk of re-circulation was not anticipated at the proposed F3 intake, however some influence from the existing F1 and F2 IPP facility outfalls may exceed the risk thresholds applied by the operator.

6.1 Recommendations

The proposed design is anticipated to meet the regulatory requirements as set out within Section 2.2 for temperature variation, salinity differential and residual chlorine. However, it is possible that during shock dosing, exceedance of the regulatory criteria may occur momentarily outside of the regulatory mixing zone. It is not currently recommended that this dosing be reduced, as this dose is approaching the low of the effective range to control micro-fouling. It is however recommended that shock dosing be limited to 10 minutes within every 24-hour period. Shock dosing for these durations has been shown to be sufficient to adequately control microfouling communities within cooling water systems [21].

In addition, although a significant potential for re-circulation at the intake of the F3 IPP facility has not been predicted, the thermal influence from the existing F1 and F2 facilities is approaching the threshold of what would be considered a potential risk. It is therefore recommended that the design consider moving the F3 intake further offshore, to areas less influenced by the F1 and F2 outfalls. In addition, it is recommended that long term, continuous monitoring of seasonal temperature be conducted throughout the water column to ensure the intake is placed at a depth outside the zone of influence of the dense F1 and F2 outfalls.

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Appendix A – Temp. Diff Video (Sc. 2)

Appendix B – Sal. Diff. Video (Sc. 2)

Appendix C – Chlorine Diff Video (Sc. 2)

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Appendix 4 – ESIA Terms of Reference

Appendix 4.1 – ESIA Terms of Reference

Fujairah 3 Independent Power Project (IPP)

Environmental & Social Impact Assessment Terms of Reference

Prepared for Fujairah Municipality and Japan Bank for International Cooperation (JBIC)

QUALITY ASSURANCE

Version	**V00**		
Project Reference:	1116		
Document Reference:	200208-KM-SP-AB-ESIA ToR-V00		
Date:	8th February 2020		
Originator:	Karl McMullan		
Signature			
Approval:	Simon Pickup		
Signature			

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ABBREVIATIONS

Abbreviation	Definition
ADM	Air Dispersion Modelling
AIMS	Australian Institute of Marine Science
AQMS	Air Quality Monitoring Stations
CBD	Convention on Biological Diversity
CEMS	Continuous Emissions Monitoring Systems
CESMP	Construction Environment and Social Management Plan
CGRFA	The International Treaty on Plant Genetic Resources for Food and Agriculture
CITES	Convention on International Trade in Endangered Species of wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species of Wild Animals
DDV	Drop Down Video
DIV	Dutch Intervention Values
EAD	Environment Agency Abu Dhabi
EHS	Environmental Health and Safety Guidelines
ESIAC	Emirates International Accreditation Centre
ESIA	Environmental and Social Impact Assessment
EWEC	Emirates Water and Electricity Company
F1	Fujairah 1
F2	Fujairah 2
F3	Fujairah 3
FM	Fujairah Municipality
EPDD	Environment Protection & Development Department
EPFI	Equator Principal Financial Institutions
GCC	Gulf Cooperation Council
GIIP	Good International Industry Practice
GT	Gas Turbine
HP	High Pressure

Abbreviation	Definition
HRSG	Heat Recovery Steam Generators
HVAC	Heating, Ventilation, Air Conditioning System
IFC	International Finance Corporation
IP	Intermediate Pressure
IPP	Independent Power Project
JBIC	Japan Bank for International Cooperation
LP	Low Pressure
MOOPAM	Manual of oceanographic observations and pollutant analyses methods
MW	Mega Watt
NOC	Non-Objection Certificate
OESMP	Operation Environment and Social Management Plan
RDF	Refuse Derived Fuel
RFP	Request for Proposal
ROPME	Regional Organization for the Protection of the Marine Environment
SCR	Selective Catalytic Reduction
TDS	Total Dissolved Solids
ToR	Terms of Reference
UAE	United Arab Emirates

GLOSSARY OF TERMS

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

1. EXECUTIVE SUMMARY

1.1. Project Description

The Project is planned as a gas-powered combined cycle facility with a net power capacity of 2,400 MW. The Project is located within Qidfah city in Fujairah Emirate in the United Arab Emirates (UAE). The Project will be situated on a vacant, disturbed site between the existing Fujairah F1 and Fujairah F2 power and water plants. The Fujairah F1 Plant was commissioned in 2004 and is owned by Emirates Sembcorp Water and Power Company. The Fujairah F2 Plant was commissioned in 2011 and is owned by Fujairah Asia Power Company.

The gas turbines and the supplementary fired HRSG operate with natural gas as the primary fuel during operation and only in the event of natural gas interruption, natural gas non-conforming quality or for testing purposes will the plant operate on a diesel back-up fuel.

Marine water will be obtained from the sea for the circulating water system to transfer cooling seawater from the seawater intake facility to steam surface condensers and seal water heat exchanger of vacuum pumps for each group and return it back into the sea.

Three (3) intake pipelines will supply the intake basin with seawater via gravity flow. These pipelines extend into the Gulf of Oman and collect seawater. Each pipeline is buried underneath the seafloor from the shoreline out to its respective intake head.

1.2. Current Project Site and Surrounding Conditions

The Project site was previously developed as a former power plant. Most of these facilities have now been removed although a number of the former facilities remain, including:

- Some abandoned buildings previously used for operations;
- Abandoned mosque;
- Infrastructure such as roads and paved areas;
- Military security station at Project site entrance;
- Abandoned materials and operational waste (e.g. batteries admin equipment); and
- One fuel storage tank.

There are no identified sensitive receptors located on the Project site. The closest sensitive receptors are farming residents located approximately 300m west of the Project site.

Schools and mosques are located approximately 2km south-west of the Project site.

1.3. Proposed Baseline Investigations

Baseline investigations will be undertaken to understand baseline conditions. The following primary data will be undertaken and/or collected on or surrounding the Project site:

- Four years of air quality data from four Fujairah Municipality AQMS;
- Noise monitoring data from seven locations;
- Terrestrial ecology site survey;
- Marine Ecology survey;

- Marine water and sediment analysis; and
- Six soil and groundwater and samples from three locations within the Project site.

All findings will be included within the finalised ESIA document with appropriate environmental impacts and follow-up mitigation measures.

1.4. Proposed Impact Assessments

A range of detailed impact assessments will be undertaken as part of the ESIA, which includes the following:

- Modelling of emissions to air from the Project using CALPUFF;
- Modelling of noise emissions using SoundPLAN;
- Assessment of soil and groundwater impacts;
- Assessment of terrestrial ecology impacts;
- Terrestrial ecology site survey;
- Marine modelling using the MIKE software package;
- Assessment of waste impacts;
- Assessment of social impacts;
- Assessment of terrestrial ecology impacts; and
- Assessment of archaeology and cultural heritage impacts.

2. INTRODUCTION

2.1. Project Title and Project Proponent

The Fujairah 3 Independent Power Project (IPP) Project will be referred to as ‘the Project’ throughout this report. The Project is planned as a gas-powered combined cycle facility with a net power capacity of 2,400 MW located in Fujairah Emirate, adjacent to the existing Fujairah 1 (F1), with a capacity of 760 MW net, and the existing Fujairah 2 (F2), with a capacity of 2,000 MW net.

The Project Proponent, **Emirates Water and Electricity Company *(‘EWEC’)***, have appointed ***Marubeni Corporation (‘Marubeni’)*** as first-ranked shortlisted bidder in relation to the F3 Project to develop, design, finance, engineer, procure, construct, commission, insure, test, own, operate and maintain the F3 plant, together with ***Samsung C&T (“Samsung”)*** as EPC Contractor.

The main contact details are as follows:

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Project Type		Power Project
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	Mobile:	+81 70 4192 4007

2.2. ESIA Consultants

Anthesis has been appointed as the independent Environmental Consultant by Marubeni to prepare environmental studies in accordance with the requirements of Fujairah Municipality Environmental Protection and Development Department (FM-EPDD), International Finance Corporation (IFC) and Japan Bank for International Cooperation (JBIC).

This document is the first stage of the ESIA process, which sets out the Terms of Reference / Scope of Work (referred to as a ‘ToR’) for the subsequent ESIA study and has been developed for submission to FM-EPDD.

The contact details for Anthesis are as follows:

Environmental Consultancy Company		**Anthesis Consulting (UK) Limited (Dubai Branch)**
	Contact Person:	Simon Pickup
		Managing Director
	Address:	1605 Metropolis Tower, Business Bay, Dubai, P.O. Box 392563
	Email:	Simon.Pickup@anthesisgroup.com
	Telephone:	+971 4 277 8007
	Fax:	+971 4 277 8006

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

Table 2-1: ESIA ToR technical team members

Team Member	Company	Role / Expertise	Project Involvement
Simon Pickup	Anthesis	Project Director	Technical review
Apolline Boudier	Anthesis	Project Manager	ESIA management, technical review and ESIA reporting
Karl McMullan	Anthesis	Project Team Support	Phase I survey, baseline noise monitoring survey and soil, surface water and groundwater ESIA chapter reporting

3. PROJECT DESCRIPTION

3.1. Statement of Need

The Project will support the Ministry of Energy Strategic Plan 2017 – 2021 and the UAE Energy Strategy 2050 by compensating the limitations of the existing and future solar photovoltaic projects within the UAE. Furthermore, the Project will allow the following:

- Meet the future UAE energy demand;
- Provide power flexibility;
- Provide a cost-effective power source; and
- Provide an efficient power capacity.

This ESIA present the significant impacts and proposed mitigation and monitoring measures to be implemented by the Project with regard to the following environmental aspects:

- Ambient air quality;
- Ambient noise;
- Soil, surface water and groundwater;
- Terrestrial ecology;
- Marine ecology;
- Marine water and sediment;
- Waste;
- Socio-economy; and
- Archaeology and cultural heritage.

All identified sensitive receptors in regard to the above environmental aspects are fully presented in **Section 7.10.2: Site Description and Surrounding Areas**.

3.1.1. Project Location and Site Overview

The Project is planned as a gas-powered combined cycle facility with a net power capacity of 2,400 MW. The Project is located within Qidfah city in Fujairah Emirate in the United Arab Emirates, as shown in Figure 3-1 and Figure 3-2 below.

The Project will be situated on a vacant site between the existing Fujairah F1 and Fujairah F2 power and water plants as illustrated in Figure 3-3 below. The Fujairah F1 Plant was commissioned in 2004 and is owned by Emirates Sembcorp Water and Power Company. The Fujairah F2 Plant was commissioned in 2011 and is owned by Fujairah Asia Power Company.

The Project site has been previously developed within a former power plant. Most of these facilities have now been removed although a number of the former facilities remain, including:

- Some abandoned buildings previously used for operations;
- Abandoned mosque;
- Infrastructure such as roads and paved areas;

- Military security station at Project site entrance;
- Abandoned materials and operational waste (e.g. batteries admin equipment); and
- One fuel storage tank.

Anthesis undertook a site visit of the Project site on 22nd January 2020 in order to understand current conditions within and surround the Project site. Please note, photographs were not allowed to be captured during the Project site visit due to security restrictions issued by the onsite military personnel. As a result, no Project site photographs have been provided within this report.

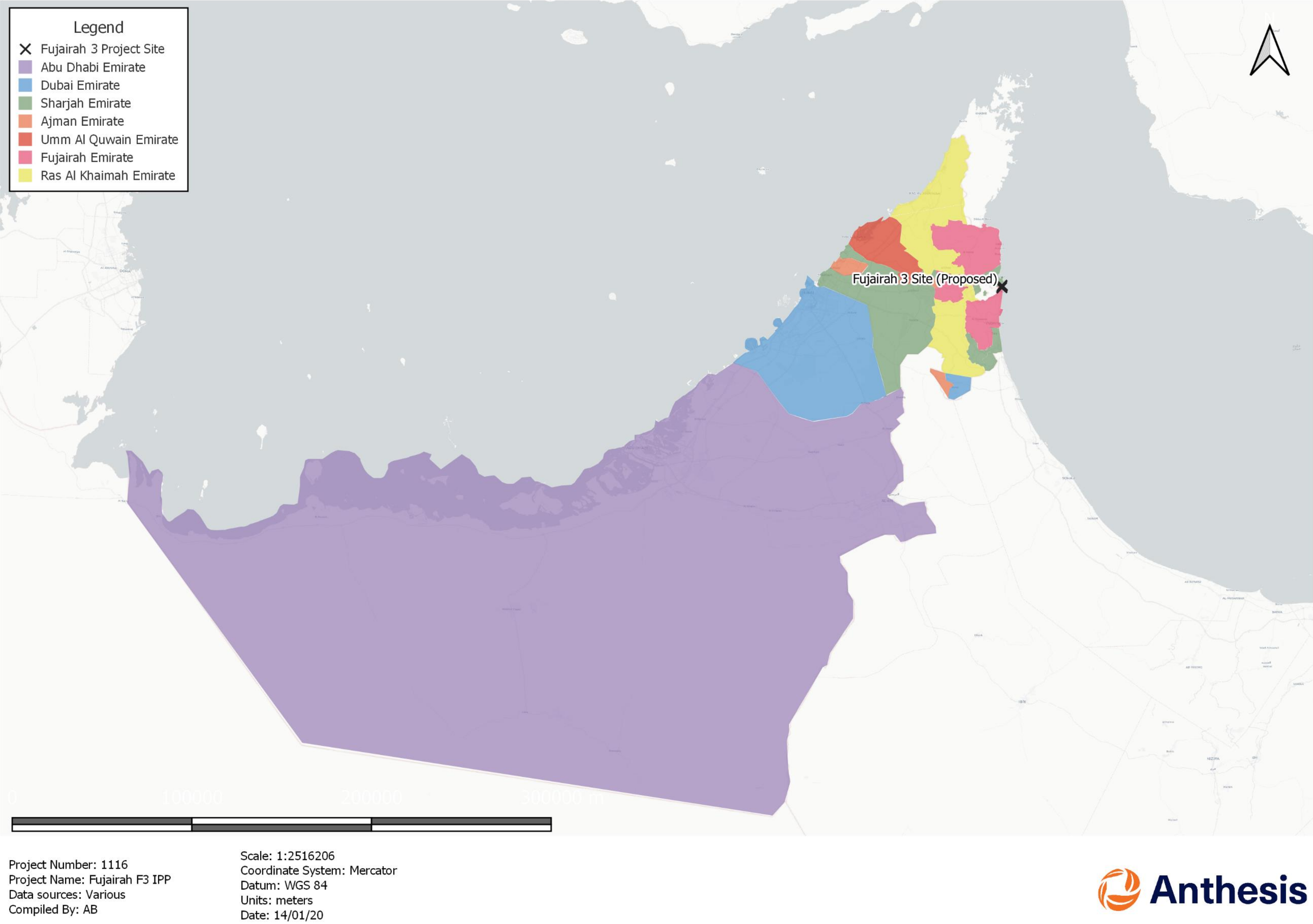


Figure 3-1: Overview of the Project site within the UAE

Project Number: 1116
Project Name: Fujairah F3 IPP
Data sources: Various
Compiled By: AB

Scale: 1:13306
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 19/01/20

Anthesis

Figure 3-2: Project site location

Project Number: 1116
Project Name: Fujairah F3 IPP
Data sources: Various
Compiled By: AB

Scale: 1:3929.207
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 19/01/20

Anthesis

Figure 3-3: Project Site

3.1.2. Project Design Overview

The Project is planned as a gas powered combined cycle facility with a net power capacity of 2,400 MW located in Fujairah Emirate, adjacent to the existing Fujairah 1 (F1), with a capacity of 760 MW net, and the existing Fujairah 2 (F2), with a capacity of 2,000 MW net. An overview of the Project design is shown in Figure 3-4 and Figure 3-5 below.

The below sections will provide details on the Project Design.

3.1.2.1. Power Generation

All the gas turbines and the supplementary fired Heat Recovery Steam Generators (HRSGs) operate with natural gas as the primary fuel and only in the event of natural gas interruption, natural gas non-conforming quality or for testing purposes will the plant operate on a back-up liquid fuel, which is diesel. The power generation units will comprise the following:

- **Group 1 Power Unit:**
  - two Mitsubishi Hitachi Power Systems M701JAC gas turbines;
  - two triple pressure with reheat unfired HRSGs;
  - one reheat and condensing steam turbine with combined high pressure (HP) and intermediate pressure (IP) sections;
  - two double flow type low pressure (LP) sections; and
  - three main transformers exporting power at 400 kV.

- **Group 2 Power Unit:**
  - one Mitsubishi Hitachi Power Systems M701JAC gas turbine;
  - one triple pressure with reheat HRSG with supplementary fired burners;
  - one reheat and condensing steam turbine with combined HP and IP sections and one double flow type LP section; and
  - two main transformers exporting power at 400 kV.

Each Power Group will include both Main Stacks (for combined cycle operation) and Bypass Stacks (for simple cycle operation) together with:

- Environmental control systems such as Selective Catalytic Reduction (SCR); and
- Continuous Emissions Monitoring Systems (CEMS).

3.1.2.2. Seawater Intake and Outfall

Three (3) intake pipelines supply the intake basin with seawater via gravity flow. These pipelines extend into the Gulf of Oman and collect seawater, as shown in Figure 3-4 below. Pipelines are rested or are buried in the seafloor from the shoreline out to its respective intake head.

The seawater intake system filters debris from the circulating water system upstream of the circulating water pumps and auxiliary cooling water pumps. The system consists of bar screens, travelling type trash rake, center flow type travelling band screens, and stop logs to isolate the pump bays, spray wash pump, level measuring equipment. Pumps and intake facilities will be maintained by mobile crane.

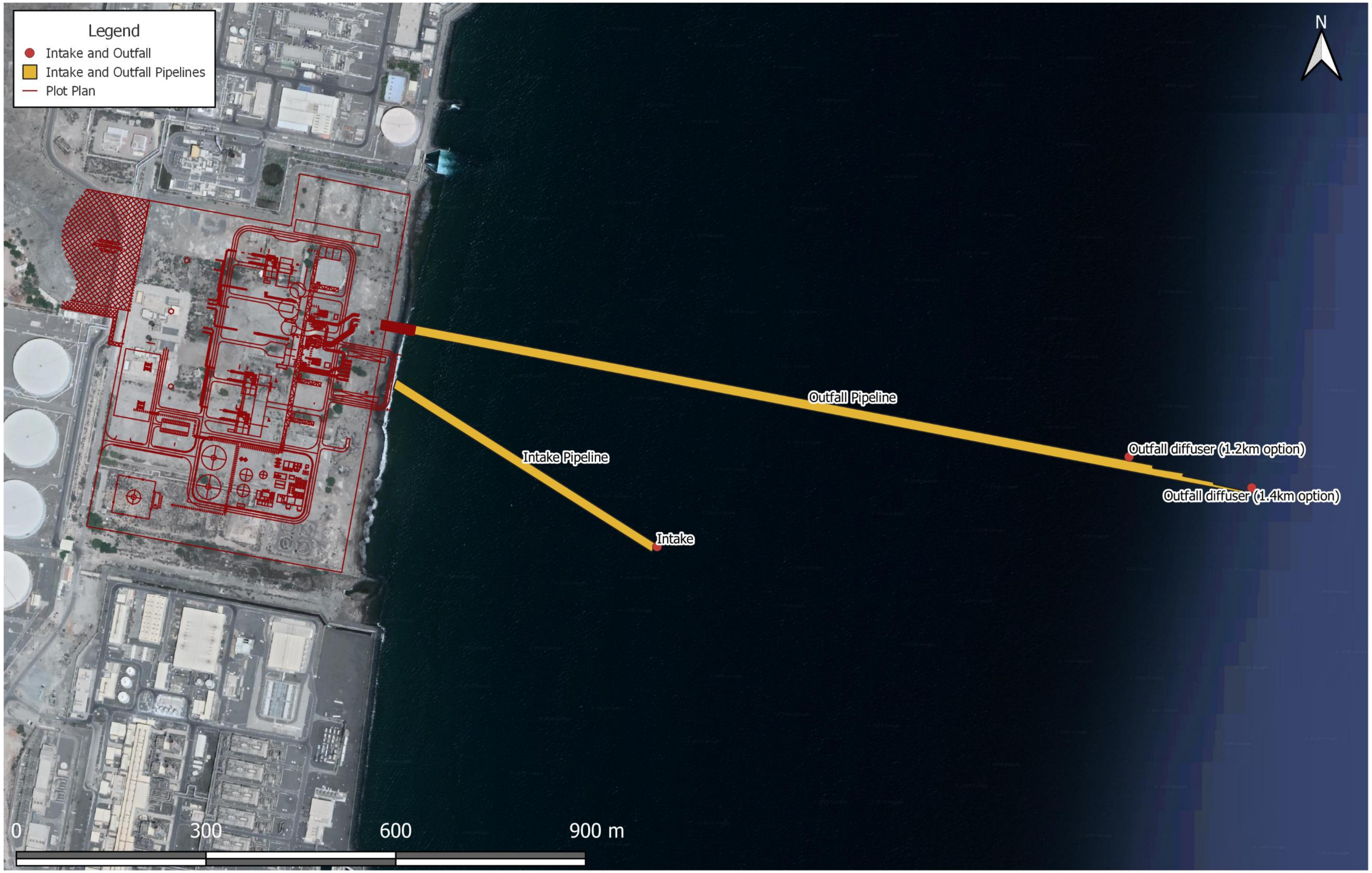
The proposed outfall pipeline system currently includes four parallel outfall pipes from the shore and discharge diffusers. The diffuser sections will be staggered to distribute the cooling water across the main direction of ambient flow. With the first diffuser section starting about 1.2km from the shore, this means the longest of the outfall pipes extends nearly 1.4km offshore. As with the intake, pipelines are rested or are buried in the seafloor to the discharge diffuser.

3.1.2.3. Other Components

- Fuel Gas Supply System;
- Fuel Oil Transfer & Forwarding system;
- Demineralized Water Distribution Systems;
- Service Water Distribution System;
- Potable Water Distribution system;
- Compressed Air System;
- Miscellaneous Gas Systems;
- Electro chlorination system for prevention of biofouling at intake pipelines;
- Water Treatment systems (reverse osmosis) for all operational systems, service water and potable water;
- Wastewater treatment system;
- Heating, Ventilation, Air Conditioning (HVAC) systems; and
- Fire alarm and detection, fire protection and firefighting systems.

3.1.2.4. Grid Connections

Transco's 400 kV network in Fujairah will be exporting power from F1, F2 and F3 which is 7,500 MVA, and is of adequate capacity for the installed generating units at F1 and F2 and the planned capacity to be installed at F3.



Project Number: 1116
Project Name: Fujairah F3 IPP
Data sources: Various
Compiled By: AB

Scale: 1:7409.279
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 19/01/20

Anthesis

Figure 3-4: Project layout and intake and outfall pipeline locations

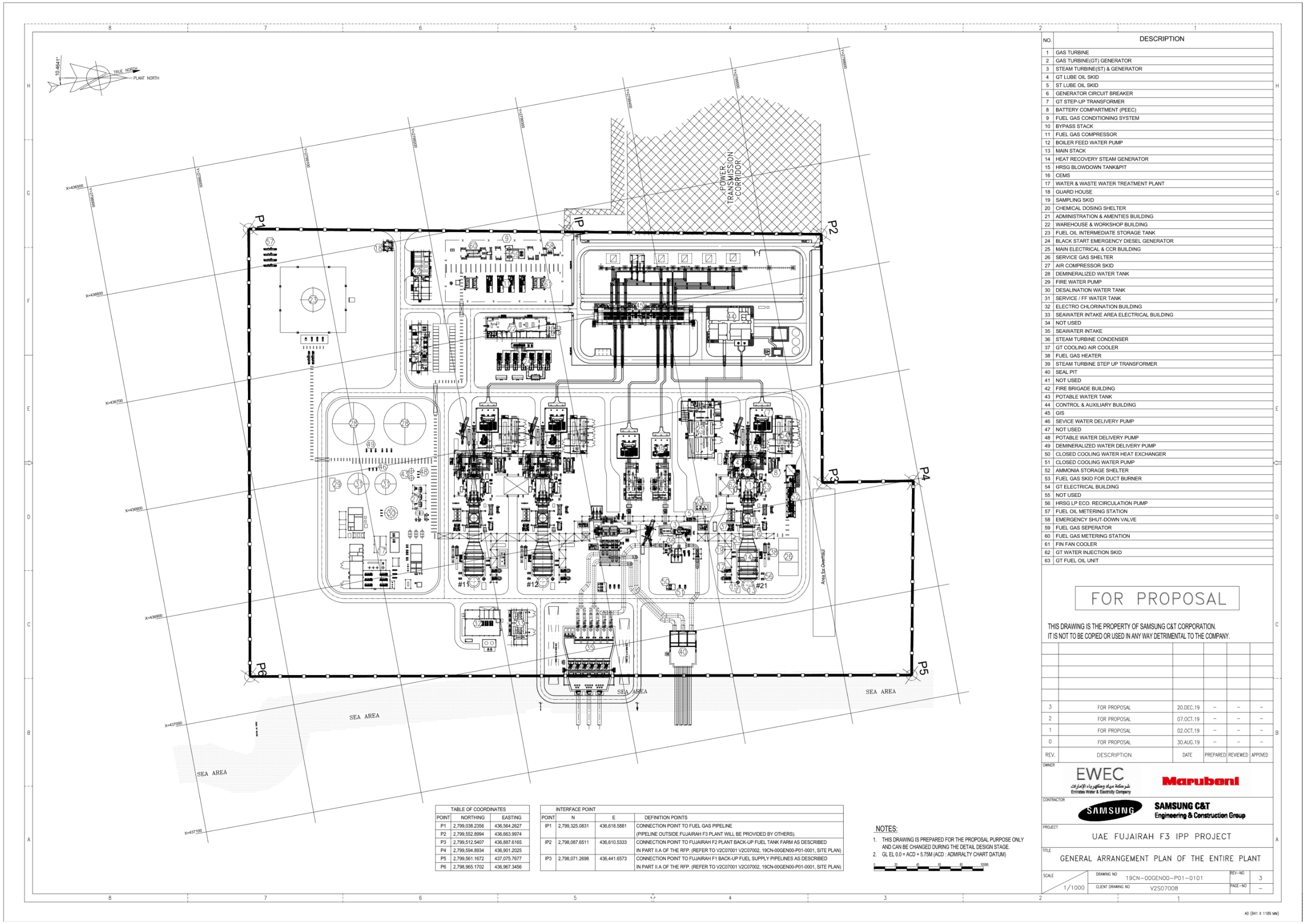


Figure 3-5: Project layout detail

3.1.3. Project Scheduling / Phases

The Project phases and schedule is detailed in Table 3-1 below.

Table 3-1: Project scheduling and phases

Phase / Stage	Details	Start Date	End Date
Design and Construction Phase	The design and construction schedule is expected to last 39 months. Construction is expected to start in April 2020.	10th February 2020	29th April 2023
Operation Phase:	The F3 Project Company agreed to	30th April 2023	29th April 2048
Early Contract Period 1:	One GT in open cycle operation: 520 MW	28th April 2022	29th April 2022
Early Contract Period 2:	Two GTs in open cycle operation: 1,040 MW	29th April 2022	30th April 2022
Early Contract Period 3:	One GT in open cycle and one on one block in combined cycle operation: 1,200 MW	30th April 2022	31st October 2022
Group 1:	Two GTs on one ST in combined cycle operation: 1,600 MW	1st March 2023	30th April 2023
Entire F3 Plant (Group 1 & Group 2):	Entire F3 Plant (Group 1 & 2) in combined cycle operation: 2,400 MW	30th April 2023	29th April 2048
Decommissioning	Decommissioning of the Project	Information not confirmed at this stage	Information not confirmed at this stage

3.2. Project Status

The Project is currently at the planning stage as Marubeni has been recently appointed by EWEC on the 30th January 2020. Therefore, design is in the process and no works have been undertaken to date.

As a result, no approvals have been requested at this stage. Table 3-2 below details the future expected approvals for the Project.

Table 3-2: Project approvals

Phase	Approval	Applicant	Authority Approval
Design Phase	Approval of the Project ESIA Scope of Work	Anthesis acting as Environmental Consultant on behalf of Marubeni and Samsung C&T	FM-EPDD
	Approval of the Project ESIA	Anthesis acting as Environmental Consultant on behalf of Marubeni and Samsung C&T	FM-EPDD
Construction Phase including Demolition and Enabling Works	Approval of the Project Construction Environment and Social Management Plan (CESMP) undertaken by the construction contractor, Samsung C&T, in order to receive an environmental NOC prior to the start of the Project Construction	Samsung C&T	FM-EPDD
	Renewal approval of the Project CESMP	Samsung C&T	FM-EPDD
	During construction, all required approvals with other authorities will be obtained	Samsung C&T	Other Authorities
Operation	Approval of the Project Operation Environment and Social Management Plan (OESMP) undertaken by the future F3 Operator, in order to receive an environmental NOC for the Project Operation	Future F3 Operator	FM-EPDD
	Renewal approval of the Project OESMP	Future F3 Operator	FM-EPDD
	During operation, all required approvals with other authorities will be received	Future F3 Operator	Other Authorities
Decommissioning	Approval of the decommissioning plan and other required decommissioning approvals	Future F3 Operator	FM-EPDD & other authorities

4. SITE DESCRIPTION AND SURROUNDING AREAS

4.1. Site Description

As previously stated, photographs were not allowed to be captured during the Project site visit undertaken by Anthesis due to security restrictions issued by the CICPA personnel. As a result, no Project site photographs have been provided within this report.

The Project site, as shown in Figure 3-2 above, covers an area approximately 0.24km^2 along the eastern coast of Fujairah. The Project site has been previously developed as a power plant but was subsequently decommissioned and largely demolished between 2013 and 2017, although some components remain.

The Project site currently contains large amount of concrete rubble and waste, generated from the decommissioning of the previous power plant, as highlighted in Figure 4-1 below. This waste is heaped in areas around the centre of the Project site as well as flattened along the eastern section closest to the coast. Some concrete buildings remain standing, generally in the centre of the Project site which were previously used as battery storage units and administration offices based upon signage that remains on the existing buildings. A concrete underground seawater network exists within the centre of the Project site, connecting these two existing buildings as well as extending throughout large parts of the site. Additionally, an abandoned mosque remains in the centre of the Project site.

Flattened concrete rubble remains in large concentrations around the external areas of the Project site. Much of these areas support a light coverage of vegetation with vegetation in the area being composed of some exotic remnants of landscaping, ruderal weeds and limited recolonization by indigenous species in some areas. Additionally, approximately five Ghaf trees are located within the Project site, two located in the central area, east of the concrete buildings, and three located in the southern edge of the Project site, adjacent to the site entrance.

Large amounts of wooden, metal and plastic waste previously used within the operations of the Project site exist in several heaps throughout the eastern half of the Project site. This waste generally takes the form of wooden pallets, lengths of fiberglass pipe and metal rebar.

Approximately 15 sheets of asbestos concrete sheeting were located stacked near the southern perimeter of the Project site. Additionally, the eastern perimeter of the Project site contains a significant amount of coastal waste which has been deposited over time. This waste generally contains plastic and wooden debris.

The northern area of the Project site contains an oil storage facility which remains existing from the decommissioned plant as well as areas of flattened rubble.

The perimeter of the Project site is guarded with a high-security which has broken gaps along the eastern, coastal side.

Project Number: 1116
Project Name: Fujairah 3
Data Sources: Various
Compiled By: AB

Scale: 1:3108
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 02/02/20

Figure 4-1: Project site conditions

4.2. Surrounding Areas

As mentioned previously, the future Project is located directly adjacent to the F1 & F2 power facilities. To access the Project site, vehicles use the E99 highway, then join the Qidfa Power Station Street to The Station Street. No photos were allowed around the Fujairah plants area; however, a representation of the site visit findings is illustrated in Figure 4-2 to Figure 4-10 below.

Regarding other industrial sites, except F1 and F2, the Project site is also located adjacent to a number of oil storage tanks, containing approximately 26,000 m^3 of oil. These tanks are understood to be used by the adjacent F1 and F2 plants.

Other land uses surrounding the Project site include agricultural areas and residential areas. F1, F2 and the Project are located directly adjacent to a farming area which is comprised of several residential housing units.

The residential areas near the Project comprise the population of Mirbah and Qidfah towns which include shops, mosques, houses, residential towers, parks and governmental buildings. Approximately 300m to 1km to the south of F2 are located in Mirbah city several schools and a kindergarten.

Figure 4-2: Farms with residential housings

Figure 4-3: Alshahad Kindergarten

Figure 4-4: Saif bin Hamad Alsharqi School

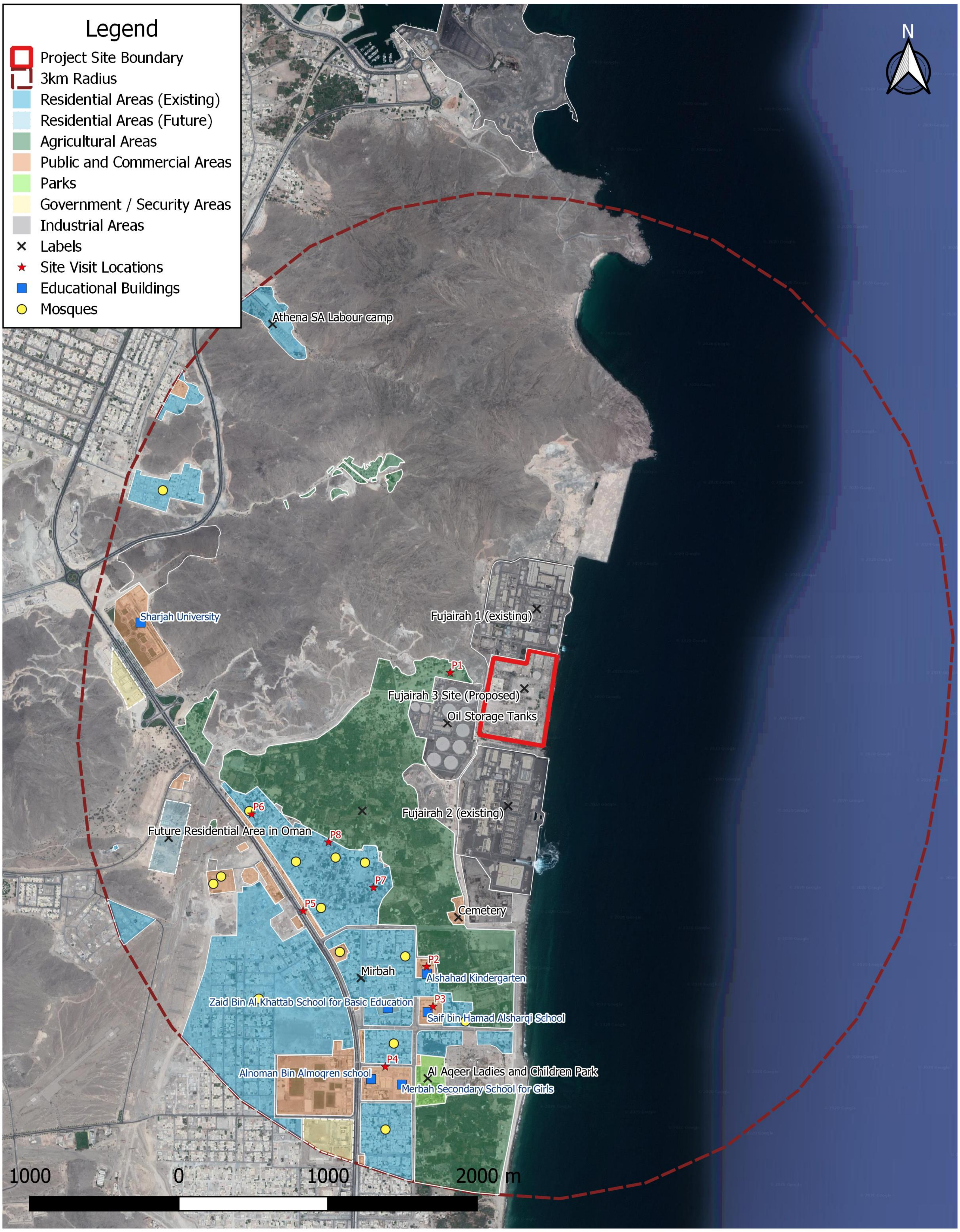
Figure 4-5: Sport Hall of Alnoman bin Almoqren School and Merbah Secondary School for Girls

Figure 4-6: Commercial areas adjacent to E99

Figure 4-7: Example of a mosque

Figure 4-8: Example of residential houses

Figure 4-9: Example of a residential house



Project Number: 1116
Project Name: Fujairah 3
Data Sources: Various
Compiled By: AB

Scale: 1:31287
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 02/02/20

Anthesis

Figure 4-10: Overview of the Project surroundings

5. LEGAL FRAMEWORK

5.1. Legislation

5.1.1. Regulatory Framework in the United Arab Emirates

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

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

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

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

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

a) Any environmental impact on the ecological system that might be affected by the project / activity; and

b) *Any impact on an Area/Place/or building that has an archaeological, amusement, architectural, cultural, historical, scientific, or social values, or has other environmental characteristics that form a value for the existing or future generations."*

Table 5-1 below details additional Federal laws, which are of potential relevance to the Project.

Table 5-1: UAE laws & standards

Legislation	Scope
Federal Law Number 7, 1993 Establishment of FEA and its amendments	Articles establishing the Federal Environmental Agency as a legal entity.
Federal Law Number 23, 1999 Protection and Development of Marine Resources	Governs exploitation, protection and development of marine biological resources.
Federal Law Number 9, 1983 UAE Hunting Law	Law regulating the hunting of birds and animals (mammals and reptiles).
Federal Law Number 11, 2002 Regulation and Control of Trade in Endangered Species and Wild Fauna and Flora and its Executive Order	Controls trade in internationally recognized endangered species and wild flora and fauna.
Law No 1, 2002 and its amendment by the Federal Law No 20, 1996 regarding the Regulation and Control of the use of Radioactive Sources and Protection against their Hazards	This law aims to control the use of radioactive sources in the UAE and control associated hazards. The law stipulates the establishment of the Federal Environment Agency which coordinates, controls and develop emergency plans at a country level for radioactive sources and potential environmental impacts. * Note, no radioactive materials will be used during the construction phase of the project.
Ministerial Order (12) 2006, pertaining to the protection of Air Quality.	Establishes the relevant Ambient Quality Standards in the UAE for: Sulphur dioxide, Nitrogen dioxide, Ozone and Particulate matter less than 10m.
UAE standards EMS 477 / 2006	The standard composition of the new diesel has been approved by the Emirates Standardization and Metrology Agency (EMS 477/2006).
Ministerial Order Number 12 and the Federal Environment Agency's Noise Emission limit values.	Establishes limits for noise levels within residential areas with light traffic, residential areas downtown, industrial areas, commercial areas, and residential areas which include some workshops, commercial business or residential areas near the highways.
Ministerial Decision 42 of 2008	This Ministerial Decision is to ensure that any structure that is to undergo demolition must be free of Asbestos Containing Materials prior to demolition.
Ministerial Decision No 32, 1982	This law is concerned with the protection of Health and Safety of workers, it contains provisions to ensure that employers take the necessary measures to prevent employees being exposed to risks from work related accidents and diseases.
Law No. (4), 1989	Concerning the establishment of the National Avian Research Centre.
Law No. (2) 1999	Pertaining to the protection of environment against abuse of the use of insecticides, pesticides and chemical fertilisers.

5.1.2. Regulatory Framework in Fujairah

The Competent Authority for environmental affairs in Fujairah is Fujairah Municipality (FM) Environment Protection & Development Department (EPDD). Fujairah adopts the legislation as set out within Federal Law No. (24) of 1999, Protection and Development of Environment (refer to **Section 5.1.1**) and additional Emirate level environmental standards are not in place.

Table 5-2 below presents the EPDD ESIA report format, as set out within the EP&DD Standard ESIA Report format, Guidelines for ESIA Report, Format for the Submission of Environmental Impact Assessment Reports). This ESIA Report has been developed to be consistent with the required structure.

Table 5-2: Fujairah Municipality ESIA Structure

EPDD Standard ESIA Report Format		
General	The report should include; (i) Title Page, (ii) Table of Contents, (iii) List of tables, (iv) List of Figures, (v) List of Pictures, (vi) List of Maps and (vii) Table of Abbreviations, which should be kept to a minimum within the body of the report.	
Chapter No.	**Title**	**Contents**
1-	**Executive Summary**	Project Description. Findings
2-	**Introduction**	(2.1) Project Title and Project Proponent. (2.2) ESIA Consultants (2.3) Project Rationale (2.4) Referenced Documents
3-	**Legal Framework**	List legislation (Federal, local) as well as international Conventions and Treaties, which may apply to the Project.
4-	**Project Description**	(4.1) Statement of Need (4.2) Concept and Phases (4.3) Location, Scale and Scheduling of Activities (4.4) Project Status (4.5) Waste Streams and Emissions
5-	**Description of the Environment**	(5.1) Baseline Conditions (5.2) Components Likely To-Be-Affected.
6-	**Impact Prediction and Evaluation**	(6.1) The Most Important Environmental Impacts (6.2) The ESIA Matrix (6.3) Impact Assessment
7-	**Mitigation Measures**	(7.1) Recommendations

EPDD Standard ESIA Report Format		
		(7.2) Additional Mitigation Measures (7.3) Residual Impacts (7.4) EMPs/Statement of Commitments
8-	**Alternatives**	Enlist alternatives to the main technology/philosophy used in the project. All assumptions must be clearly stated in all of the alternatives considered.
9-	**Monitoring Program**	(9.1) Monitoring Program for Compliance of Monitoring Measures. (9.2) Monitoring Program for Residual Impacts.
Annexes		
Annex 1	**Data on Existing Environment**	Detailed relevant description of the Environment
Annex 2	**Methodologies and Data Analysis**	Detailed methodologies; not only references.
Annex 3	**List of References**	-
Annex 4	**TOR and Consultation Activities**	TOR for ESIA Consultants List of consultation held. Details of involvement of key stakeholders (how, when, who). Quality of relevant background documents. Quality assurance of data presented. Reliability of data sources.

5.2. Environmental Regulations & Standards

5.2.1. Air Quality

5.2.1.1. Ambient Air Quality

Cabinet Decree 12 of 2006, pertaining to the protection of air quality sets out ambient air quality standards sets out ambient air quality standards which are presented within Table 5-3 below. It should be noted that the Project is required to adopt more stringent 1-hour standards for NO_2 and SO_2 of 200 μg/m^3 specified by EWEC, as described in **Section 5.7.2**.

Table 5-3: Ambient air quality standards

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

5.2.1.2. Emissions Standards

Cabinet Decree 12 of 2006, pertaining to the protection of air quality sets out ambient air quality standards sets out maximum allowable emission limits of air pollutants emitted from stationary sources and emitted from hydrocarbon fuel combustion sources (Annex 1 & Annex 2) which apply at the Federal level. These are set out within Table 5-4 and Table 5-5 below. It should be noted that the Project is required to adopt more stringent emissions standards for NO_x and CO specified by EWEC, as described in **Section 5.7.3**.

Table 5-4: Maximum allowable emission limits of air pollutants emitted from stationary sources for the UAE (Annex 1)

Substance	Symbol	Sources	Emission Limits (mg/Nm^3)
Visible Emissions	-	Combustion sources Other sources	250 none
Carbon Monoxide	CO	All sources	500
Nitrogen Oxides (expressed as nitrogen dioxide)	NO_x	Combustion sources Material producing industries Other sources	*Refer to Annex (2) (*Table 5-5 *below)* 1500 200
Sulphur Dioxide	SO_2	Combustion sources Material producing industries Other sources	500 2000

Substance	Symbol	Sources	Emission Limits (mg/Nm^3)
			1000
Sulphur Trioxide Including Sulphuric Acid Mist (expressed as Sulphur Trioxide)	SO_3	Material producing industries Other sources	150 50
Total Suspended Particles	TSP	Combustion sources Cement industry Other sources	250 15 150
Ammonia and Ammonium Compounds (expressed as ammonia)	NH_3	Material producing industries Other sources	50 10
Benzene	C_6H_6	All sources	5
Iron	Fe	Iron & steel foundries	100
Zinc and its compounds (expressed as Zinc)	Zn	Electroplating/Galvanizing Industries	10
Lead and its Compounds (expressed as lead)	Pb	All sources	5
Antimony and its Compounds (expressed as antimony)	Sb	Material producing industries Other sources	5 1
Arsenic and its Compounds (expressed as arsenic)	As	All sources	1
Cadmium and its Compounds (expressed as cadmium)	Cd	All sources	1
Mercury and its Compounds (expressed as mercury)	Hg	All sources	0.5
Nickel and its Compounds (expressed as nickel)	Ni	All sources	1
Copper and its Compounds (expressed as copper)	Cu	All sources	5
Hydrogen Sulphide	H2S	All sources	5
Chloride	Cl^-	Chlorine works Other sources	200 10
Hydrogen Chloride	HCl	Chlorine works Other sources	200 20
Hydrogen Fluoride	HF	All sources	2
Silicon Fluoride	SiF4	All sources	10

Substance	Symbol	Sources	Emission Limits (mg/Nm^3)
Fluoride and its Compounds Including HF & SiF4 (expressed as fluoride)	F^-	Aluminum smelters Other sources	20 50
Formaldehyde	CH2O	Material producing industries Other sources	20 2
Carbon	C	Odes production Waste incineration	250 50
Total Volatile Organic Compounds (expressed as total organic carbon (TOC))	VOC	All sources	20
Dioxins & Furans		All sources	1 (ng TEQ/m^3)

Notes:

- The concentration of any substance specified in the first column emitted from any source specified in the third column shall not at any point before admixture with air, smoke or other gases, exceed the limits specified in the fourth column.
- ‘‘mg’’ means milligram.
- ‘‘ng’’ means nanogram.
- ‘‘Nm^3’’ means normal cubic meter, being that amount of gas which when dry, occupies a cubic meter at a temperature of 25 degree Centigrade and at an absolute pressure of 760 millimeters of mercury (1 atm).
- The limit of “Visible Emission” does not apply to emission of water vapor and a reasonable period for cold start-up, shutdown or emergency operation.
- The measurement for “Total Suspended Particles (TSP)” emitted from combustion sources should be @ 12% reference CO_2.
- The total concentration of the heavy metals (Pb, Cd, Ni, Hg, Cu, As & Sb) must not exceed 5 mg/Nm^3.
- VOC limit is for unburned hydrocarbons (uncontrolled).
- The emission limits for all the substances exclude “Dioxins and Furans” are conducted as a daily average value.
- “Dioxins and Furans”: Average values shall be measured over a sample period of a minimum of 6 hours and a maximum of 8 hours. The emission limit value refers to the total concentration of dioxins and furans are calculated using the concept of toxic equivalence in accordance with *Annex 5.*

Table 5-5: Maximum allowable emission limits of air pollutants emitted from stationary sources for the UAE (Annex 2)

Substance	Symbol	Sources	Maximum Allowable Emission Limits (mg/Nm^3)
Visible Emissions	-	All sources	250
Nitrogen Oxides [expressed as Nitrogen Dioxide (NO_2)]	NOx	Fuel Combustion Units – having a gross heat input above 100,000 MJ excluding glass furnaces: – Gas Fuel – Liquid Fuel Turbine Units: – Gas Fuel – Liquid Fuel	350 500 70 150
Sulfur Dioxide	SO_2	All sources	500
Total Suspended Particles	TSP	All sources	250
Carbon Monoxide	CO	All sources	500

Notes:

- The concentration of any substance specified in the first column emitted from any source specified in the third column shall not at any point before admixture with air, smoke or other gases, exceed the limits specified in the fourth column.
- ''mg'' means milligram.
- ''Nm^3'' means normal cubic meter, being that amount of gas which when dry, occupies a cubic meter at a temperature of 25 degree Centigrade and at an absolute pressure of 760 millimetres of mercury (1 atm).
- The limit of "Visible Emission" does not apply to emission of water vapor and a reasonable period for cold start-up, shutdown or emergency operation.
- The "NOx" emission limit of any existing turbine units operated by gas fuel, prior to the issuance and adoption of this regulation will be 125 mg/Nm^3.
- The measurement for "Total Suspended Particles (TSP)" emitted from combustion sources should be @ 12% reference CO_2.

5.2.2. Noise

5.2.2.1. National Legislation

Federal Law 12 of 2006 sets out permissible ambient noise levels for specific types of land use, as shown in Table 5-6 below. A project cannot emit noise levels that cause exceedance of these limits.

Table 5-6: Allowable limits for noise (dB(A))

Classification of Receptor	Allowable Limits for Noise Levels (L_{Aeq} dB(A))	
	Daytime (7:00 – 22:00)	Night-Time (22:00 – 7:00)
Residential - Light Traffic	40-50	30-40
Residential - Downtown	45-55	35-45
Mixed Residential/Commercial Residential Near Highway	50-60	40-50
Commercial	55-65	45-55
Industrial	60-70	50-60

The United Arab Emirates (UAE) federal regulations are consistent with the guidelines of the World Health Organisation (WHO) and those of the World Bank.

5.2.2.2. International Guidelines

The international standards/guidelines that have been applied to the Project are the International Finance Corporation (IFC) General Environmental, Health and Safety (EHS) Guidelines (1). The EHS Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP).

IFC refers to guidance from the WHO on establishing community noise levels (2). The guidance indicates that noise levels at receptors should not exceed the levels presented in Table 5-7Table 5-7: , or result in a maximum increase in background levels of 3 dB(A) at the nearest receptor location off-site (1).

Table 5-7: Maximum permissible noise levels for general environment (1)

Classification of Receptor	Allowable Limits for Noise Levels (LAeq dB(A))	
	Daytime (7:00 to 22:00)	Night-Time (22:00 to 07:00)
Residential, Institutional/Educational	55	45
Industrial or Commercial	70	70

A summary of the most stringent limits from both standards is presented in Table 5-8 below.

Table 5-8: Most stringent noise levels for general environment (3) (4)

Receptor (Outdoors)	Allowable Limits for Noise Levels (dBA)	
	Daytime	Night-Time
Residential - Light Traffic	50 (Federal)	40 (Federal)
Residential - Downtown	55 (Federal & IFC)	45 (Federal & IFC)
Institutional/Educational	55 (IFC)	45 (IFC)
Mixed Residential/Commercial Residential Near Highway	60 (Federal)	50 (Federal)
Commercial	65 (Federal)	55 (Federal)
Industrial	70 (Federal & IFC)	60 (Federal)

5.2.3. Marine Environment

5.2.3.1. Marine Water and Sediments

5.2.3.1.1. Federal Standards

Protection of the marine environment is regulated under the 'Regulation for the Protection of Maritime Environment', UAE Cabinet (5). The principle requirements of Chapter 3 of this regulation, pertaining to this scope of works, are as follows:

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

In accordance with the Council of Ministers' Decision No 37 – 2001 – Protection of the Marine Environment, the non-degradable pollutants / Illegal compounds to be discharged into marine environment are presented in Table 5-9 below.

Table 5-9: Prohibited substances for discharge to marine environment (5)

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

5.2.3.1.2. Fujairah Standards

No marine standards are in place within Fujairah. Nevertheless, it is understood that as part of the development of the Environment and Social Scoping Report prepared by Mott MacDonald (12th September 2019), Fujairah Municipality confirmed during a consultation meeting with Mott MacDonald, that the project shall comply with Abu Dhabi environmental standards and guidelines. These have therefore been referred to in **Section 5.2.3.1.3** below.

Separately, the Project is required to adopt effluent discharge limits specified by EWEC, as described in **Section 5.7.4**.

5.2.3.1.3. Adopted Abu Dhabi Guidelines

The EAD Technical Guidance Document Standards and Limits for Pollution to Air and Marine Environments includes Recommended Ambient Marine Water Quality Standards as presented in Table 5-10 below.

Table 5-10: Recommended Ambient Marine Water Quality Objectives (EAD AWQS)

Parameters	Maximum Concentration	Units
Physical Indicators		
Floating Particles / Floatable / Debris	Nil	mg/m^2
Temperature	+/- 3	ºC of background
Turbidity	10	NTU
Transparency	≥10	Meter of Secchi Depth
Salinity	≤5	% background concentration
BOD	5	mg/l
Odour	Not objectionable	-
Colour	No change from background	-
Chemical Indicators		
Ammonia	0.004	mg/L
Arsenic	0.005	mg/L
Cadmium	0.001	mg/L
Chorine Residual	0.01	mg/L
Chromium	0.01	mg/L
Copper	0.01	mg/L
Cyanide	0.004	mg/L
Lead	0.01	mg/L
Mercury	Not given	Not given
Oil and grease	Not visible	mg/L
Petroleum Hydrocarbon	5	mg/L
Dissolved Oxygen	≥4	mg/L
Total Suspended Solids	≤33	mg/L
pH	6.5 – 8.5	mg/L

Parameters	Maximum Concentration	Units
Phenols	0.001	mg/L
Phosphorus Total	0.001	mg/L
Phosphate	34	Microgram/L
Sulphides	0.004	mg/L
Total Organic Carbon	2.5	mg/L
Zinc	0.01	mg/L
Nickel	20	Microgram/L
Iron	0.3	mg/L
Vanadium	9.4	Microgram/L
NO_3	95	Microgram/L
NO_2	34	Microgram/L

Furthermore, the Abu Dhabi Specification (ADS) for Ambient Marine Water and Sediments Specifications are also in place. which are presented in Table 5-11 and Table 5-12 below.

Table 5-11: Maximum allowable concentrations for ambient marine water (ADS)

Parameter	Unit	General Use Areas	Marine Protected Use Areas
Cadmium	µg/l	0.7	0.3
Chromium	µg/l	0.2	0.2
Copper	µg/l	3.0	3.0
Lead	µg/l	2.2	2.2
Mercury	µg/l	0.1	0.1
Nickel	µg/l	7.0	3.0
Zinc	µg/l	15.0	15.0
Total Petroleum Hydrocarbons (TPH)	µg/l	7.0	7.0
Total Polychlorinated Biphenyls (PCBs)	µg/l	0.03	0.03

Parameter	Unit	General Use Areas	Marine Protected Use Areas
Chlorophyll (a)	µg/l	1.0	0.7
DO*	mg/l	4.0	4.0
Enterococci	CFU or MPN/100 ml	35	35
Note: µg/l: micrograms per liter; mg/l: milligram per liter; CFU: Colony Forming Unit; MPN: Most Probable Number; **: minimum allowable concentration*			

Table 5-12: Maximum allowable concentrations for ambient marine sediments (ADS)

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

5.2.3.2. Marine Ecology

Federal Law No. (24) of 1999 Protection and Development of the Environment sets out control measures with respect to the development of natural resources and conservation of biological diversity in the region.

5.2.4. Waste Management

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

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

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

5.2.5. Soil & Groundwater

There are no soil or groundwater standards which have been adopted within Fujairah. it is therefore proposed to adopt the Dutch Intervention Values (2009) for soil, which are presented within Table 5-13 below and target and intervention values for groundwater, which are presented in Table 5-14 below.

Table 5-13: Dutch intervention values for soils (2009)

Parameter	Dutch Intervention Values (mg/kg)
Metals	
Antimony	22
Aluminium	-
Arsenic	76
Barium	(1)
Cadmium	13
Chromium Hexavalent (Cr6+)	78
Chromium Trivalent (Cr3+)	180
Copper	190
Lead	530
Nickel	100
Zinc	720
Molybdenum	190
Pesticides	
Chlorodane (sum)	4
DDT (sum)	1.7
DDE (sum)	2.3

Parameter	Dutch Intervention Values (mg/kg)
DDD (sum)	34
Aldrin	0.32
Drins (sum)	4
α-endosulphan	4
α-HCH	17
β-HCH	1.6
γ-HCH (lindane)	1.2
Heptachlor	4
Heptachlor epoxide (sum)	4
Organotin compounds (sum)	2.5
MCPA	4
Atrazine	0.71
Carbaryl	0.45
Carbofuran	0.017
Other Inorganic Compounds	
Cyanide (free)	20
Cyanide (complex)	50
Phenols	14
Cresols (sum)	13
Polynuclear Aromatic Hydrocarbons (PAH)	
PAH (total)	40(2)
Chlorinated Hydrocarbons	
Monochloroethene (Vinylchloride)	0.1
Dichloromethane	3.9
1,1-dichloroethane	15
1,1-dichloroethane	6.4
1,1-dichloroethane	0.3
1,2-dichloroethene (sum)	1
Dichloropropanes (sum)	2
Trichloromethane (chloroform)	5.6
1,1,1-trichloroethane	15
1,1,2-trichloroethane	10
Trichloroethene (Tri)	2.5

Parameter	Dutch Intervention Values (mg/kg)
Tetrachloromethane (Tetra)	0.7
Tetrachloroethene (Per)	8.8
Monochlorobenzene	15
Dichlorobenzenes (sum)	19
Trichlorobenzenes (sum)	11
Tetrachlorobenzenes (sum)	2.2
Pentachlorobenzenes	6.7
Hexachlorobenzene	2.0
Monochlorophenols (Sum)	5.4
Dichlorophenols (Sum)	22
Trichlorophenols (Sum)	22
Pentachlorophenol	21
PCBs (sum 7)	12
BTEX Compounds	
Benzene	1.1
Ethylbenzene	110
Toluene	32
Total Xylenes	17
Other Substances	
Monochloroanilines (sum)	50
Dioxin (sum I-TEQ)	0.00018
Chloronaphthalene (sum)	23
Asbestos	100
Cyclohexanone	150
Dimethyl phthalate	82
Diethyl phthalate	53
Di-isobutyl phthalate	17
Dibutyl phthalate	36
Butyl benzyl phthalate	48
Dihexyl phthalate	220
Di(2-ethylhexyl)phthalate	60
Mineral oil	5,000
Pyridine	11

Parameter	Dutch Intervention Values (mg/kg)
Tetrahydrofuran	7
Tetrahydrothiophene	8.8
Tribromomethane (bromoform)	75

(1) The barium standard has been repealed because the intervention value for barium proved to be lower than the concentration naturally occurring in the soil. In the case of increased barium concentrations compared to the natural background due to an anthropogenic source, this concentration can be assessed on the basis of the former intervention value for barium of 920 mg/kg d.s. This former intervention value is substantiated in the same manner as the intervention values for most of the other metals, and for barium it includes a natural background concentration of 190 mg/kg d.s.

(2) Based on the sum of 10 individual PAH species.

(3) Original Guidelines for specific values

Table 5-14: Dutch target and intervention values for groundwater (2009)

Parameters	Groundwater (µg/L in solution)	
	Target value for shallow groundwater (<10m bgl)	Intervention value
I - Metals		
Antimony	-	20
Arsenic	10	60
Barium	50	625
Cadmium	0.4	6
Chromium	1	30
Cobalt	20	100
Copper	15	75
Mercury	0.05	0.3
Lead	15	75
Molybdenum	5	300
Nickel	15	75
Zinc	65	800
II - Inorganic compounds		
Cyanides-free	5	1500
Cyanides-complex (pH<5)	10	1500
Cyanides-complex (pH >5)	10	1500
Thiocyanates (sum)	-	1500
Bromide (mg Br/l)	0.3mg/L[2]	-

Parameters	Groundwater (µg/L in solution)	
	Target value for shallow groundwater (<10m bgl)	Intervention value
Chloride (mg Cl/l)	100mg/L[2]	-
Fluoride (mg F/l)	0.5mg/L[2]	-
III - Aromatic compounds		
Benzene	0.2	30
Ethyl benzene	4	150
Toluene	7	1000
Xylenes	0.2	70
Styrene (vinyl benzene)	6	300
Phenol	0.2	2000
Cresols (sum)	0.2	200
Catechol(o-dihydroxybenzene)	0.2	1250
Resorcinol(m-dihydroxybenzene)	0.2	600
Hydroquinone(p-dihydroxybenzene)	0.2	800
IV - Polycyclic aromatic hydrocarbons (PAH)		
PAH (sum 10)	-	-
Naphthalene	0.01	70
Anthracene	0.0007	5
Phenatrene	0.003	5
Fluoranthene	0.003	1
Benzo(a)anthracene	0.0001	0.5
Chrysene	0.003	0.2
Benzo(a)pyrene	0.0005	0.05
Benzo(ghi)perylene	0.0003	0.05
Benzo(k)fluoranthene	0.0004	0.05
Indeno(1,2,3-cd)pyrene	0.0004	0.05
V - Chlorinated hydrocarbons		
Vinyl Chloride	0.01	5
Dichloromethane	0.01	1000
1,1-dichloroethane	7	900
1,2-dichloroethane	7	400
1,1-dichloroethene	0.01	10
1,2-dichloroethene (cis and trans)	0.01	20

Parameters	Groundwater (µg/L in solution)	
	Target value for shallow groundwater (<10m bgl)	Intervention value
Dichloropropane	0.8	80
Trichloromethane (chloroform)	6	400
1,1,1-trichloroethane	0.01	300
1,1,2-trichloroethane	0.01	130
Trichloroethene (Tri)	24	500
Tetrachloromethane (Tetra)	0.01	10
Tetrachloroethene (Per)	0.01	40
Chlorobenzenes (sum)	-	-
Monochlorobenzene	7	180
Dichlorobenzenes	3	50
Trichlorobenzenes	0.01	10
Tetrachlorobenzenes	0.01	2.5
Pentachlorobenzene	0.003	1
Hexachlorobenzene	0.00009	0.5
Chlorophenols (sum)	-	-
Monochlorophenols (sum)	0.3	100
Dichlorophenols	0.2	30
Trichlorophenols	0.03	10
Tetrachlorophenols	0.01	10
Pentachlorophenol	0.04	3
Chloronaphthalene	-	6
Monochloroaniline	-	30
Polychlorobiphenyls (sum 7)	0.01	0.01
VI - Pesticides		
DDT/DDE/DDD	0.004ng/L	0.01
Drins (sum)	-	0.1
Aldrin	0.009ng/L	
Dieldrin	0.1ng/L	
Endrin	0.04ng/L	
HCH-compounds	0.05	1
α-Hch	33ng/L	

Parameters	Groundwater (µg/L in solution)	
	Target value for shallow groundwater (<10m bgl)	Intervention value
β-Hch	8ng/L	
γ-Hch	9ng/L	
Atrazine	29ng/L	150
Carbaryl	2ng/L	50
Carbofuran	9ng/L	100
Chlorodane	0.02ng/L	0.2
Endosulfan	0.2ng/L	5
Heptachloro	0.005ng/L	0.3
Heptachloro-epoxide	0.005ng/L	3
Maneb	0.05ng/L	0.1
Mcpa	0.02	50
Organotin compounds	0.05*-16ng/L	0.7
VII - Other contaminants		
Cyclohexanone	0.5	15000
Phthalates (sum)	0.5	5
Mineral oil	50	600
Pyridine	0.5	30
Tetrahydrofuran	0.5	300
Tetrahydrothiophene	0.5	5000
Tribromomethane	-	630
VIII - Aromatic compounds		
Dodecylbenzene	-	0.02
Aromatic solvents	-	150
IX - Chlorinated hydrocarbons		
Dichloroaniline	-	100
Trichloroaniline	-	10
Tetrachloroaniline	-	10
Pentachloroaniline	-	1
4-chloromethylphenols	-	350
Dioxin	-	0.00 1ng/L
X - Pesticides		
Azinphos-methyl	0.1* ng/L	2

Parameters	Groundwater (µg/L in solution)	
	Target value for shallow groundwater (<10m bgl)	Intervention value
XI - Other contaminants		
Acrylonitrile	0.08	5
Butanol	-	5600
1,2-butylacetate	-	6300
Ethylacetate	-	15000
Diethylene glycol	-	13000
Ethylene glycol	-	5500
Formaldehyde	-	50
Isopropanol	-	31000
Methanol	-	24000
Methyl-tetra-butyl ether (MTBE)	-	9200
Methylethylketone	-	6000

5.2.6. Terrestrial Ecology

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

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

5.2.7. Cultural Heritage

5.2.7.1. Overview

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

5.2.7.2. Legal Definition of Antiquities

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

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

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

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

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

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

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

5.2.7.3. Protection, preservation and education as legal aims

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

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

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

5.2.7.4. Requirement for development projects

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

5.2.7.5. Regulations on the violation of the Antiquities Law

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

5.3. International Treaties

The UAE is party to a number of regional and international treaties and conventions related to the environment as presented in Table 5-15.

Table 5-15: International conventions related to the environment in the UAE

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

Convention Name	Status: Approval, Acceptance, Accession, Succession or Ratification	Date of Approval, Acceptance, Accession, Succession or Ratification	Globally Date of Agreement
Cartagena Protocol on Biosafety	Ratified	23/07/2014	Montreal, 29/01/2000
Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their use	Ratified	23/07/2014	Nagoya, 29/10/2010
Intergovernmental Platform on Biodiversity and Ecosystem services	Ratified	11/01/2015	Panama City, 01/04/2012
Stockholm Convention on Persistent Organic Pollutants	Ratified	11/07/ 2002	Stockholm, 22/ May/ 2001
Convention on Wetlands of International Importance - Ramsar	Ratified	29/12/2007	Australia, 08/05/1974
United Nations Framework Convention on Climate Change (UNFCCC)	Ratified	20/11/1995	New York, 09/05/1992
Kyoto Protocol to the United Nations Framework Convention on Climate Change	Ratified	29/12/2004	Kyoto, 11/12/1997
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	Ratified	11/08/2002	Rotterdam, 10/10/1998)
Regional Organization for the Protection of the Marine Environment (ROPME)	Ratified	01/04/1979	Kuwait, 24/04/1978
Protocol Concerning Regional Cooperation In Combating Pollution By Oil And Other Harmful Substances In Cases Of Emergency	Ratified	01/04/1979	Kuwait, 24/April/1978
Protocol Concerning Marine Pollution resulting from Exploration of the Continental Shelf	Ratified	16/07/1990	Kuwait, 1/03/1989
Protocol for the protection of the Marine Environment against Pollution from Land - Based Source	Acceptance	21/02/1990	Kuwait, 1/02/1990
Convention on the sanitary and phytosanitary (SPS)	Accession	10/04/1996)	Kuwait, 1/01/1995
International Plant Protection Convention	Accession	02/10/2005	Rome, 6/12/1951
Minamata Convention on Mercury	Ratified	25/03/2015	Kumamoto, 10/10/2013
Agreement on Agriculture	Accession	10/04/1996	Kuwait, 1/January/1995
Convention on the Conservation of Migratory Species of Wild Animals (CMS)	Ratified	01/05/2016	Bonn, 23/06/1979

Convention Name	Status: Approval, Acceptance, Accession, Succession or Ratification	Date of Approval, Acceptance, Accession, Succession or Ratification	Globally Date of Agreement
Convention on Conservation of Wildlife and its Natural Habitats in the GCC	Ratified	2003	Kuwait, 2001
Paris Agreement on Climate Change	Acceptance	22/04/2016	Paris, 12/12/2015
The International Treaty on Plant Genetic Resources for Food and Agriculture (CGRFA)	Ratified	9/05/1990	Washington, D.C, 3/03/1973

5.4. World Bank / International Finance Corporation

5.4.1. Overview

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

5.4.2. Performance Standards

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

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

5.4.3. IFC Environmental Health & Safety Guidelines

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

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

- General EHS Guidelines (2007): The General EHS Guidelines covers four main subjects which include environment, occupational health and safety, community health and safety and construction and decommissioning; and
- EHS Guidelines for Thermal Power Plants (2007): The Thermal Power Guidelines are applicable to combustion processes fuelled by gaseous, liquid and solid fossil fuels and biomass and designed to deliver electrical or mechanical power, steam, heat, or any combination of these, regardless of the fuel type (except for solid waste).

5.5. Equator Principles

In October 2002, the IFC convened a meeting of banks in London to discuss environmental and social issues in project finance. It was decided to try to develop a banking industry framework for addressing environmental and social risks in project financing which led to the drafting of the Equator Principles (EPs). The EPs apply globally to all industry sectors and to four financial products; 1) Project Finance Advisory Services 2) Project Finance 3) Project-Related Corporate Loans and 4) Bridge Loans.

On June 4th, 2003, 10 banks from seven countries signed up to the Equator Principles (EPs), a voluntary set of guidelines for assessing and managing environmental and social risks in project financing. To date, 94 Equator Principles Financial Institutions (EPFIs) operating in 37 countries worldwide have adopted the Equator Principles. EPFIs commit to implementing the EPs in their internal environmental and social policies, procedures and standards for financing projects and will not provide Project Finance or Project-Related Corporate Loans to projects where the client will not, or is unable to, comply with the EPs.

The EPs present ten key principles:

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

5.6. Japanese Bank for International Cooperation

5.6.1. Overview

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

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

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

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

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

JBIC ascertains whether a project complies with environmental laws and standards of the host national and local governments concerned, as well as whether it conforms to their environmental policies and plans. JBIC also ascertains whether a project meets the relevant aspects of World Bank Safeguard Policy regarding environmental and social considerations. On the other hand, for private sector limited or non-recourse project finance cases, or where appropriate, JBIC ascertains whether the project meets the relevant aspects of International Finance Corporation Performance Standards (which are discussed in **Section 5.4** above).

5.6.2. JBIC Project Categorisation

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

An illustrative list of sensitive sectors, characteristics and areas is provided within the Guidelines. Within this list Thermal Power is included as Point 12. Given the fact that the Project could result in significant environmental impacts and that these impacts could extend beyond the sites or facilities subject to physical construction, for the purposes of this ESIA it is assumed that the Project would be classified as Category A. On this basis, the ESIA has adopted the conditions set out within the JBIC Guidelines for ESIA Reports for Category A Projects.

5.6.3. JBIC ESIA Requirements

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

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

5.6.4. Disclosure

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

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

5.7. EWEC Requirements

5.7.1. Overview

EWEC have specified within their Request for Proposal (RFP) conditions that a range of environmental parameters are met. These are presented within the following sections.

EWEC have confirmed that the following standards shall be applied:

- European Union standards (for requirements not covered by those listed below);
- Standards and requirements as stated in the PPA and applicable in the UAE; and
- Other national requirements, consents and licenses.

5.7.2. Ambient Air Quality

5.7.2.1. RFP Requirements

For the F3 Plant, the maximum permissible air pollutant concentration at ground level and within a reference period of one hour (1-hour average) shall be as follows:

- Nitrogen dioxide NO_2 200 µg/m^3; and
- Sulphur dioxide SO_2 200 µg/m^3.

Note that this is more stringent than that required within Ministerial Order (12) 2006, pertaining to the protection of Air Quality, which sets standards of 400 µg/m^3 for NO_2 and 350 µg/m^3 for SO_2 (refer to **Section 5.2.1**). These more stringent standards have therefore been adopted within the assessment conducted as part of this ESIA.

5.7.2.2. European Union (EU) Legislation

The EU has established the following legislation, which defines ambient air quality limits as summarised in Table 5-16 below:

- **Directive 2008/50/EC** on ambient air quality and cleaner air for Europe including the following elements:

- The merging of most of existing legislation into a single directive (except for the Fourth Daughter Directive) with no change to existing air quality objectives;
- New air quality objectives for $PM_{2.5}$ (fine particles) including the limit value and exposure related objectives;
- The possibility to discount natural sources of pollution when assessing compliance against limit values;
- The possibility for time extensions of three years (PM_{10}) or up to five years (NO_2, benzene) for complying with limit values;

- **Directive 2004/107/EC** of the European Parliament and of the Council relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air (Fourth Daughter Directive);
- **Directive 2015/1480/EC of** 28 August 2015 amending several annexes to Directives 2004/107/EC and 2008/50/EC of the European Parliament and of the Council laying down the rules concerning reference methods, data validation and location of sampling points for the assessment of ambient air quality; and
- **Commission Implementing Decision 2011/850/EU:** Commission Implementing Decision of 12 December 2011 laying down rules for Directives 2004/107/EC and 2008/50/EC of the European Parliament and of the Council as regards the reciprocal exchange of information and reporting on ambient air quality (notified under document C(2011) 9068).

Table 5-16: EU Air Quality Standards

Pollutant	Concentration	Average Period	Permitted Exceedences each year
Fine Particles ($PM_{2.5}$)	25 µg/m³	1-year	N/A
Sulphur dioxide (SO_2)	350 µg/m³	1-hour	24
	125 µg/m³	24-hour	3
Nitrogen dioxide (NO_2)	200 µg/m³	1-hour	18
	40 µg/m³	1-year	N/A
PM_{10}	50 µg/m³	24-hour	35
	40 µg/m³	1-year	N/A
Lead (Pb)	0.5 µg/m3	1-year	N/A
Carbon Monoxide (CO)	10 mg/m3	Maximum daily 8-hour mean	N/A
Benzene	5 µg/m³	1-year	N/A
Ozone	120 µg/m³	Maximum daily 8-hour mean	25 days averaged over 3 years
Arsenic (As)	6 ng/m3	1-year	N/A
Cadmium (Cd)	5 ng/m3	1-year	N/A

Pollutant	Concentration	Average Period	Permitted Exceedences each year
Nickel (Ni)	20 ng/m3	1-year	N/A
Polycyclic Aromatic Hydrocarbons	1 ng/m3 (expressed as concentration of Benzo(a)pyrene)	1-year	N/A

5.7.3. Emissions to Air

The maximum permissible air emission levels, which are to be met within the specified temperature range between minimum stable load (which is expected at about 30% load) and maximum continuous rating of each gas turbine including supplementary firing are shown in the table below.

Table 5-17: Maximum Permissible Air Emission Levels

Emission	Unit	Simple Cycle (at Bypass stack)		Combined Cycle (at HRSG stack)	
		NG 3)	FO	NG 3)	FO
NOx (as NO_2)	mg/Nm^3	50	120 1)	20	120 1)
CO	mg/Nm^3	50	50	50	50
SO_2	mg/Nm^3	2)	2)	2)	2)
Smoke number	Bacharach	2	2	2	2
Ammonia Slip	ppm	-	-	5	-
Reference – O_2	Vol. %	15	15	15	15

Notes:

1) NOx emissions for Back-up Fuel (FO) are based on maximum fuel bound nitrogen content of 0.015 % by weight.

2) according to sulphur content in the fuel.

3) Emission guarantees are given for a daily average and for steady state operation and normal loading and deloading transients. Emissions guarantees will not apply to grid code compliance or frequency following transients.

For the stacks of the HRSGs, the RFP also specifies the following:

- The main stack height above ground level shall be a minimum of 60m;
- The bypass stacks height above ground level shall be a minimum of 30m; and
- A flue gas dispersion study is to be performed by the Bidder as part of the Environmental Impact Assessment.

The following mitigation measures are also required to implemented:

- For the limitation of NOx when burning natural gas in turbines, such turbines shall be equipped with dry low NOx combustion. When burning fuel oil in gas turbines, the NOx emission shall be controlled by water injection if required;
- For the limitation of NOx when burning natural gas in supplementary fired HRSGs, such steam generators shall be equipped with low NOx burners;
- HRSGs shall be equipped with a SCR system with ammonia injection to meet NOx emission limits.
- For the limitation of particulates, CO and unburnt hydrocarbons, the steam generators shall be equipped with modern burner management systems and satisfactory burner design;
- Determination of final stack height shall be based on calculations mentioned above; and
- The plant shall be equipped to continuously monitor and record NOx, SO_2, CO and O_2 emissions.

5.7.4. Marine Discharges

Permissible effluent limits for aqueous discharges into the sea as mandated by EWEC are shown in Table 5-18 below.

Table 5-18: Permissible effluent limits

Constituents	Maximum Limits (mg/1)
Ammoniacal nitrogen	0.5
Arsenic (As)	0.05
Bio-chemical oxygen demand (BOD)	30
Cadmium (Cd)	0.1
Chlorine (residual) [1)]	0.15
Chromium, total (Cr)	0.5
Copper (Cu)	0.5
COD	100
Cyanide (CN)	0.1
Oil	10
Iron, total (Fe)	1.0
Lead (Pb)	0.1
Manganese (Mn)	1.0
Mercury (Hg)	0.001
Nickel (Ni)	0.5
pH	6.5 - 8.5

Constituents	Maximum Limits (mg/1)
Phenols	0.1
Phosphate (total as P)	2.0
Selenium (Se)	0.05
Silver (Ag)	0.1
Sulphide	0.2
Suspended solids	30
Vanadium	1.0
Zinc (Zn)	0.5
TDS above receiving water at the edge of the mixing zone (100 m from point of discharge point)	< 5%
Max. cooling seawater temperature rise at edge of mixing zone (100 m from point of discharge point)	3 K
1) The limit refers to continuous chlorination. In case of shock chlorination (according to WB limit), the maximum value is 2 mg/l for up to 2 hours, not to be repeated more frequently than once in 24 hours, within a 24 hours average of 0.2 mg/l. 2) The provided values shall be verified from Fujairah Municipality and other local authorities as necessary, and the values which are more stringent shall be used.	

The RFP requires that a seawater recirculation study, based on the proposed F3 Plant design and configuration, is undertaken which shall determine the dispersion patterns for the cooling water and desalination plant effluent discharged from the F3 Plant, in addition to the existing conditions due to F1 and F2 Plant thermal discharges. This has been undertaken as part of this ESIA and is presented within **Section 7.7: Marine Water & Sediment.**

5.7.5. Soil Contamination

The F3 Plant shall be designed, operated and maintained in an adequate way to prevent any soil contamination.

5.7.6. Permissible Noise Levels

The design of the facility must ensure compliance with the following noise pressure levels, as set out within the RFP:

- At 1 meter outside the F3 Plant, when all equipment is in operation: max. 60 dB (A);
- At 1 meter distance of open air installations or turbine buildings: max. 85 dB (A);
- At 1 meter distance of each equipment inside turbine buildings: max. 90dB (A);
- Within the central control room: max. 50 dB (A); and
- Within other machine rooms and workshops: max. 85 dB (A).

6. ESIA APPROACH AND METHODOLOGY

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

6.1. Methodology

The standard approach to the assessment of impacts within this ESIA is presented in Figure 6-1 below. A detailed methodology for conducting baseline studies and impact assessments for each environmental aspect is presented within each respective technical chapter.

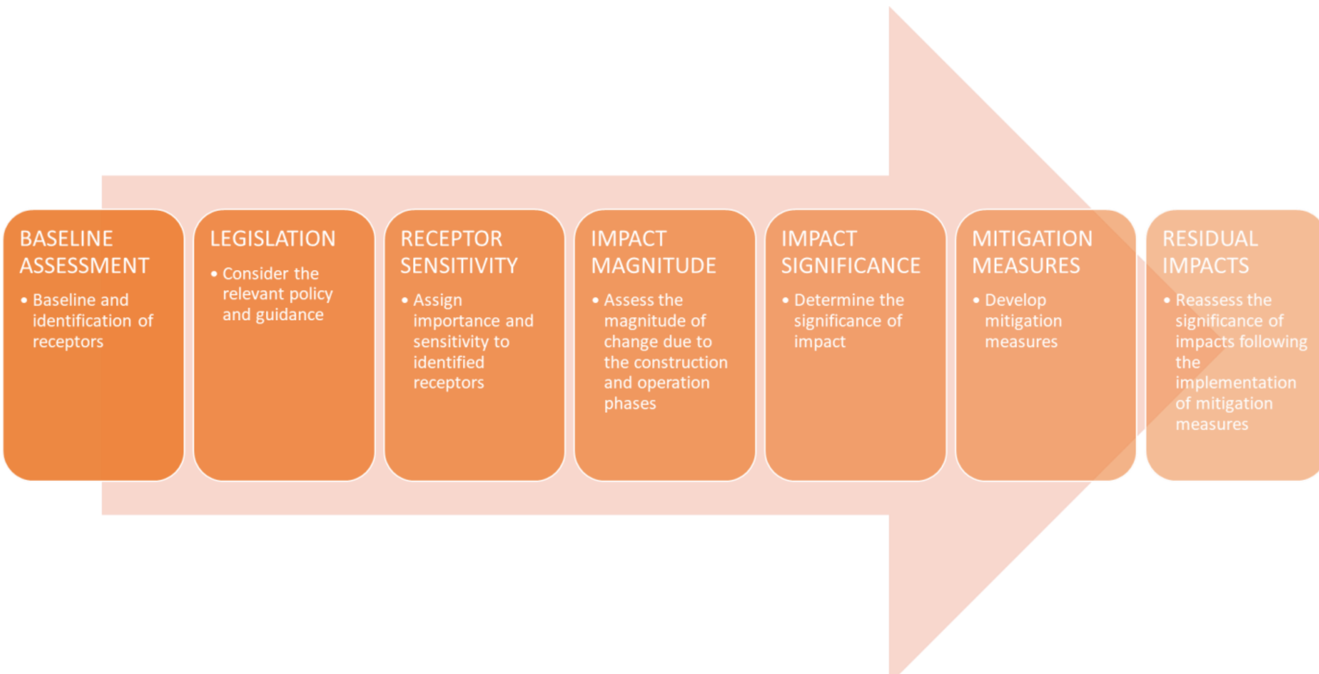


Figure 6-1: ESIA process flow chart

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

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

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

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

6.2. Sensitivity and Importance of Receptors

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

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

6.3. Description of Impact

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

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

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

6.4. Significance of Impacts

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

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

- **Impact Magnitude:** the magnitude of the change that is induced (i.e. the percentage of a resource that is lost);
- **Impact Duration:** the time period over which the impact will last;
- **Impact Extent:** the geographical extent of the induced change;
- **Likelihood:** the likelihood that the event will occur during the project lifecycle; and

- **Regulations, Standards and Guidelines**: the status of the impact in relation to regulations (e.g. discharge limits), standards (e.g. environmental quality criteria) and guidelines.

Table 6-1 to Table 6-4 below outline the impact criteria used within the assessment of the proposed Project.

Table 6-1: Definition of impact type

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

Table 6-2: Impact assessment terminology

Impact Severity	Definition
Impact Magnitude	
Magnitude	Estimate the size of the impact (e.g. the size of the area damaged or impacted the % of a resource that is lost or affected etc.)
Impact Nature	
Negative impact	An impact that is considered to represent an adverse change from the baseline or introduces a new undesirable factor.
Positive impact	An impact that is considered to represent an improvement on the baseline or introduces a new desirable factor.
Neutral impact	An impact that is considered to represent neither an improvement nor deterioration in baseline conditions.
Impact Duration	
Temporary	Impacts are predicted to be of a short duration and intermittent / occasional in nature.
Short-term	Impacts that are predicted to last only for a limited period but will cease on completion of the activity, or as a result of mitigation / reinstatement measures and natural recovery.
Long-term	Impacts that will continue over an extended period but cease when the project stops operating. These will include impacts that may be intermittent or repeated rather than continuous if they occur over an extended period of time.
Permanent	Impacts that occur once on development of the project and cause a permanent change in the affected receptor or resources that endures substantially beyond the project lifetime.

Impact Severity	Definition
Impact Extent	
Local	Impacts are on a local scale (e.g. restricted to the vicinity of the facility etc).
Regional	Impacts are on a national scale (effects well beyond the immediate vicinity of the project and affect an entire region).
Global	Impacts are on a global scale (e.g. global warming, depletion of the ozone layer).

Table 6-3: Impact severity criteria

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

Table 6-4: Likelihood categories

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

6.5. Evaluation of Impacts

The significance of each impact (Table 6-6) is determined by comparing the impact severity against the sensitivity of the receptor in the impact significance matrix provided below in Table 6-5.

Table 6-5: Determining the significance of impacts

Impact Severity	Sensitivity of Receptor				
	Low	Low-medium	Medium	Medium High	High
No Change	Negligible	Negligible	Negligible	Negligible	Negligible
Slight	Negligible	Negligible	Negligible	Minor	Minor
Low	Negligible	Negligible	Minor	Minor	Moderate
Medium	Negligible	Minor	Minor	Moderate	Major [1]
High	Minor	Moderate	Moderate	Major [1]	Major [1]

Table 6-6: Definition of each impact significance

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

The Critical Impact designation indicated in Table 6-6 above will be allocated in place of a Major Impact when mitigation for the Major Impact is not possible and the impact takes on a Critical Impact status where alternatives must then be considered.

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

6.6. Mitigation, Enhancement and Assessment of Residual Impacts

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

Such measures will need to be implemented during the construction phase or the operational phases or the Project by adopting the control hierarchy principles as illustrated by Figure 6-2.

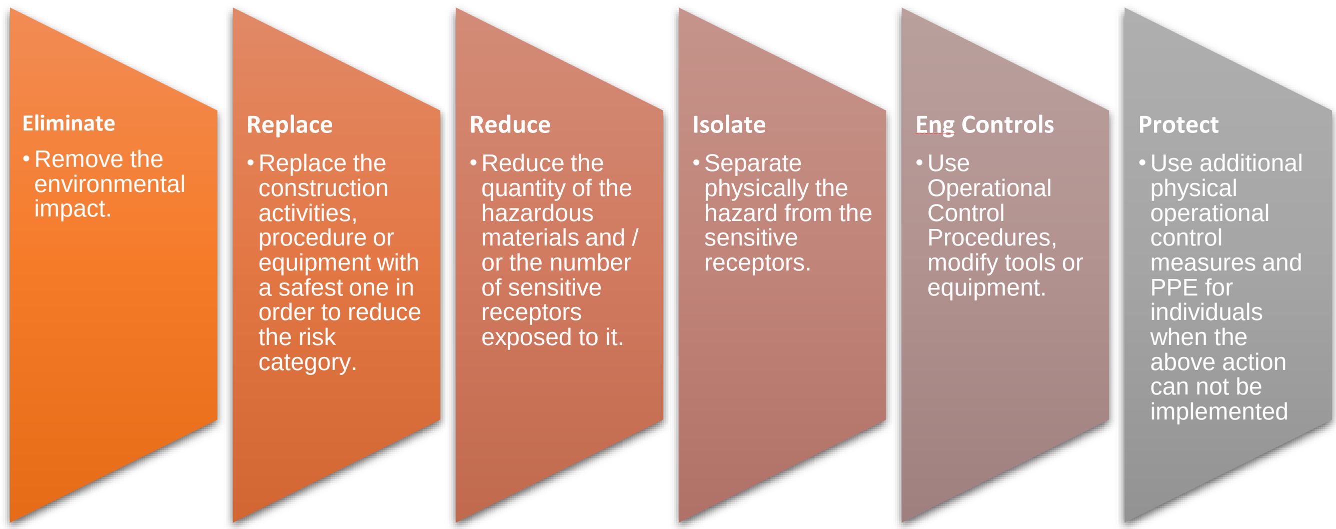


Figure 6-2: Control hierarchy principles

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

6.7. Cumulative Impacts

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

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

6.8. Mitigation Measures

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

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

7. APPROACH TO THE TECHNICAL ASSESSMENTS

7.1. Overview

A range of environmental and social impact assessments will be undertaken as part of the ESIA, including:

- Air Quality;
- Noise;
- Soil, Surface Water and Groundwater;
- Terrestrial Ecology;
- Marine Ecology;
- Marine Water and Sediment;
- Waste;
- Socio-Economic; and
- Archaeology and Cultural Heritage.

The approach for each is set out in the following sections.

7.2. Air Quality

7.2.1. Baseline Methodology

Existing air quality baseline data will be collected from Fujairah Municipality (FM) if made available, which will include one year of data, from some of the existing FM operated Air Quality Monitoring Stations (AQMS), as shown in Figure 7-1 below:

- City Centre;
- Al Qurrayah;
- Qidfa'; and
- Sakamkam School.

If made available, the following parameters will be collected:

- NO_2;
- CO;
- PM_{10};
- $PM_{2.5}$; and
- Wind speed and direction.

Project Number: 1116
Project Name: Fujairah 3 IPP
Data Sources: Various
Compiled By: KM

Scale: 1:10316
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 04/02/20

Anthesis

Figure 7-1: Location of FM Air Quality Monitoring Stations (AQMS)

7.2.2. Impact Assessment Methodology

7.2.2.1. Construction

A qualitative assessment of impacts during construction of the Project will be undertaken. It is currently anticipated that the key impacts upon air quality during the construction phase of the Project will be as follows:

- Dust/particulates emissions from Project construction activities including soil movement and construction activities; and
- Gaseous emissions from construction vehicles, plant and other equipment.

7.2.2.2. Operation

The project will use natural gas, an existing regionally abundant fuel stream to generate electricity. The use of natural gas offers a number of environmental benefits over other sources of energy, particularly other fossil fuels. For example, coal and oil have a much higher carbon ratio and higher nitrogen and sulphur contents. This means that when combusted, coal and oil release higher levels of harmful emissions, including a higher ratio of carbon emissions, NOx and sulphur dioxide (SO_2), in addition to particulate matter. The combustion of natural gas, on the other hand, releases negligible quantities of sulphur dioxides, virtually no ash or particulate matter, and lower levels of CO. Notwithstanding the above, the following pollutants will be considered in this assessment, when considered relevant in the modelling scenarios:

- NO_2;
- CO;
- $SO_{2;}$
- PM_{10}; and
- $PM_{2.5.}$

In order to predict the likely impact to ambient air quality from the implementation of the project, an air dispersion modelling assessment is proposed to be undertaken utilising the CALPUFF Modelling System. From a technical standpoint, CALPUFF is preferred over AERMOD given the Project's location (both adjacent to the Gulf of Oman, and within an area of complex topography). The CALPUFF model has particular effectiveness in coastal areas where complex meteorological effects (such as coastal fumigation and recirculation) are known to occur. It also performs better than AERMOD in areas with complex terrain / significant topographical features (such as the coastline of Fujairah).

The modelling will consider the following scenarios as detailed in Table 7-1 below.

Table 7-1: Proposed modelling scenarios

Scenario	Description	Fuel Type	Pollutants of Concern
1	Baseline Case - normal operation of existing power stations F1 and F2	Natural Gas	NO_2, CO*
2A	F3 in isolation -normal operations with the Selective Catalytic Reduction (SCR) Unit. The NOx emission limit for this scenario is 20 mg/Nm^3.	Natural Gas	NO_2, CO and PM
2B	Cumulative assessment -normal operations of all three power plants (F1, F2 and F3) with the F3 turbines operating with a SCR Unit. The F3 NOx emission limit for this scenario is 20 mg/Nm^3.	Natural Gas	NO_2, CO and PM
3A	F3 in isolation- normal operations of F3 with the F3 turbines operating without SCR Unit. The NOx emission limit for this scenario is 50 mg/Nm^3.	Natural Gas	NO_2, CO and PM
3B	Cumulative assessment -normal operations of all three power plants (F1, F2 and F3) with the F3 turbines operating without a SCR Unit. The F3 NOx emission limit for this scenario is 50 mg/Nm^3.	Natural Gas	NO_2,.CO and PM
4	Alternate fuel operations Short TermF3 turbines operating on diesel), with a 10ppm sulphur content (20 hours per year).	Diesel	NO_2, SO_2, CO and PM

**The baseline case data obtained from previous studies did not include SO_2 or PM as these pollutants were screened out based on the fuel gas specification* (6).

7.3. Noise

7.3.1. Baseline Methodology

A noise baseline investigation will be conducted as follows:

- Measurements of baseline noise will be taken from four locations for a period of 24-hours at each location, as identified within Figure 7-2 below; and
- This will be supplemented by three 15-minute monitoring location during both daytime and night-time periods, the location of which is provided within Figure 7-2 below.

Coordinates for the noise monitoring locations are provided within Table 7-2 below.

Table 7-2: Noise monitoring locations

Borehole	Easting (m)	Northing (m)
24-hour Noise Monitoring		
NM1	436901.36	2799595.84
NM2	436846.46	2798995.92
SR4	435221.40	2798564.07
SR8	436050.41	2798825.82
15-minute Noise Monitoring		
SR3	436453.63	2799426.67
BNM5	436389.04	2798231.46
BNM6	436706.63	2797758.54

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Compiled By: KM

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Figure 7-2: Location of noise monitoring

7.3.2. Impact Assessment Methodology

7.3.2.1. Construction

It is considered that the key impacts associated with potential noise emissions would be from Project construction activities, including from construction vehicles, plant and other equipment which could cause nuisance and impacts. Impacts would be received by existing nearby residential areas e.g. sensitive receptors located nearby the Project site.

The calculation of construction noise will be carried out in accordance with the British Standard BS5228:2014 'Noise and Vibration Control on Construction and Open Sites' (7). The standard provides a comprehensive construction equipment inventory with associated noise levels, a construction noise calculation method, practical information on noise reduction measures, and promotes 'Best Practice Means' approach to control noise emissions during construction.

The construction noise thresholds will be based on the internationally recognised construction noise guidelines of the Department of Environment & Climate Change NSW (8). In terms of the construction phase assessment, the study will consider the noisiest activities for general construction.

7.3.2.2. Operation

During operation, impacts are expected as a result of noise emissions from the power generation facilities. An assessment is proposed to be undertaken for the operational scenario to determine the magnitude of impacts on nearby noise-sensitive receptors, which will be undertaken using the internationally recognised noise modelling software package SoundPLAN©. Version 8.1 of SoundPLAN, which applies in-built noise propagation standards such as ISO 9613 and CONCAWE, will be used to model the facility.

SoundPLAN is a graphics-orientated package that will allow the production of noise contour maps for assessing the project's performance against the specified noise standards. SoundPLAN enables a 3-dimensional model to be produced by defining the relative and absolute heights of the local ground surfaces, noise sources and any obstacles which may provide noise screening. Noise screening calculations may need to be processed, for example, where there are tanks, bunds and buildings present.

For the noise impact assessment, we will compare Project (Fujairah III) noise level contributions in isolation to the environmental noise limits, as well as look at the potential increase in noise levels as a result of the project cumulatively (i.e. baseline + project contribution). As the baseline will essentially account for existing facilities, this methodology should be adequate to contextualise the Project's impact in isolation and cumulatively.

7.4. Soil, Surface Water and Groundwater

7.4.1. Baseline Methodology

7.4.1.1. Phase I Investigation

A Phase I non-intrusive investigation of the Project site will be conducted to determine initial conditions in advance of detailed investigations. This comprised a visual investigation of the Project site taking site notes. The primary aim of the Phase I assessment was to establish the historical use and existing potential contamination sources on site, potential pathways and sensitive receptors as defined and illustrated in Figure 7-3 below. The assessment included the identification of:

- Potential soil and/or surface water contamination;

- Potential sources of contamination such as:
  - Storage areas or illegal dumping areas of hazardous and non-hazardous waste;
  - Storage areas of chemicals of potential concern such as fuel/oil drums, tanks etc.;
  - Utilities, industrial and/or commercial activities that can cause potential contamination; and
  - Existing buildings on-site which may contain asbestos;
- Potential pathways;
- Groundwater abstraction; and
- Overall site surroundings, in order to identify potential sensitive human and environmental receptors.

Figure 7-3: Contamination risk assessment pollution linkage

7.4.1.2. Soil and Groundwater Sampling

As part of the Project baseline investigations, a total of six soil and six groundwater samples will be collected from three locations within the Project site, to provide details of existing baseline geo-environmental conditions and to understand if there are any issues of contamination migrating into the Project site. The sample locations are shown in Figure 7-4 below, with coordinates listed in Table 7-3.

Table 7-3: Sample Locations

Borehole	Easting (m)	Northing (m)
BH-05	436905.11	2799046.92
BH-10	436888.21	2799477.28
BH-13	436649.33	2799198.16

7.4.1.2.1. Soil

Soil sampling will be conducted to ascertain current baseline conditions and to highlight any areas of contamination. For each location, due to the well-drained nature of the soils (predominantly sand and gravels), one composite surface soil sample to a maximum depth of 0.5m as well as one composite sample from a depth ranging from 50 cm to 1.0m per location will be collected. The samples will be analysed by an ESIAC accredited laboratory. In the absence of soil regulations within the emirate of Fujairah, it is proposed to adopt the Dutch Intervention Values (2009), which will be considered as reference values as they are not compulsory threshold standards.

7.4.1.2.2. Groundwater

Six groundwater samples from three existing boreholes located within the Project site will be collected for analysis. The samples will be analysed by an ESIAC accredited laboratory. In the absence of groundwater regulations within the emirate of Fujairah, it is proposed to adopt the Dutch Intervention Values (2009), which will be considered as reference values.

7.4.1.2.3. Testing Parameters

As these are no applicable Emirate or Federal limits for the limits of soil or groundwater analysis, the Dutch Intervention Value (DIV) limits have been adopted. Table 7-4 below details the soil testing parameters and Table 7-5 below details the groundwater testing parameters.

Table 7-4: Soil testing parameters and DIV limits

No.	Parameter	Unit of Measurement	Dutch Intervention Value (2009) Limits (9)	
			Standard Value	Corrected Value
Physical Parameters				
1.	pH	-	-	
2.	Soil Texture	USDA Classification	-	
3.	Asbestos	g/10kg	-	
Heavy Metals:				
4.	Zinc	mg/kg	720 *	258
5.	Manganese	mg/kg	-	-
6.	Iron	mg/kg	-	-
7.	Copper	mg/kg	90 *	80
8.	Selenium	mg/kg	100	-
9.	Cadmium	mg/kg	13 *	7
10.	Lead	mg/kg	530 *	313
11.	Arsenic	mg/kg	76 *	39
12.	Chromium	mg/kg	-	-
13.	Nickel	mg/kg	100 *	29
14.	Mercury	mg/kg	-	-
Note: - Value in (*) are based on a standard soil of 10% organic matter and 25% clay. In the case of this Project, the soil value has been corrected in the 'corrected value' column				

No.	Parameter	Unit of Measurement	Dutch Intervention Value (2009) Limits (9)	
			Standard Value	Corrected Value
- The sign '-'significates that this is not applicable, or this parameter is not listed in the Dutch Intervention Value.				

Table 7-5: Groundwater testing parameters and DIV limits

No.	Parameter	Unit of Measurement	Dutch Intervention Value (2009) limits (9)
Physical Parameters			
1.	pH	-	-
2.	Electrical Conductivity (EC)	MicroS/cm	-
3.	Total Dissolved Solids (TDS)	mg/L	-
Inorganic Parameters			
4.	Sodium	mg/L	-
5.	Potassium	mg/L	-
6.	Calcium	mg/L	-
7.	Magnesium	mg/L	-
8.	Sulphate	mg/L	-
9.	Nitrate	mg/L	-
10.	Total Nitrogen	mg/L	-
11.	Chloride	mg/L	-
12.	Arsenic	µg/L	60
13.	Cadmium	µg/L	6
14.	Chromium	µg/L	30
15.	Copper	µg/L	75
16.	Iron	µg/L	-
17.	Lead	µg/L	75
18.	Molybdenum	µg/L	300
19.	Boron	µg/L	-
20.	Barium	µg/L	-

No.	Parameter	Unit of Measurement	Dutch Intervention Value (2009) limits (9)
21.	Beryllium	µg/L	-
22.	Manganese	µg/L	-
23.	Zinc	µg/L	800
Miscellaneous Parameters			
24.	Phenols	mg/L	2
25.	Benzene	mg/L	0.03
26.	1, 2 dichloroethane	mg/L	0.4
27.	Dichloromethane	mg/L	1
Note: The sign '-'significates that this is not applicable, or this parameter is not listed in the Dutch Intervention Value.			

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Project Name: Fujairah 3
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Figure 7-4: Location of soil and groundwater sample locations

7.4.2. Impact Assessment Methodology

An assessment of the potential risks associated with contamination would be undertaken or both the construction and operational phases of the Project, based upon the activities proposed.

7.5. Terrestrial Ecology

7.5.1. Baseline Methodology

A literature review will be conducted as per the IFC Performance Standard 6. Due to the very degraded nature of the study area a single site visit will be conducted by an experienced ecologist, which will include the collection of data for the following:

- General ecological status of the site;
- Plant species presence;
- Avifauna species presence;
- Mammal species presence; and
- Reptile species presence.

7.5.2. Impact Assessment Methodology

As part of the ESIA, the results of the terrestrial ecology survey will be used to undertake an Ecological Impact Assessment which will be used to determine the following:

- The presence of protected species of conservation concern and the extent of impact;
- Identification of the potential impacts (local, national and regional) associated with the proposed construction works and operational activities; and
- Determination of the impacts significance prior and following mitigation measures.

7.6. Marine Ecology

7.6.1. Baseline Methodology

The methodologies used to conduct the marine survey for qualitative and quantitative data collection will be based on the following survey standards:

- Australian Institute of Marine Science (AIMS): Survey Manual for Tropical Marine Resources; and
- Regional Organization for the Protection of the Marine Environment (ROPME): Manual of oceanographic observations and pollutant analyses methods.

The following sections describe the sampling and survey methodologies utilised for the marine baseline survey.

7.6.1.1. Survey Locations

The sampling programme will involve the analysis of marine ecology assessment through Drop-Down Video (DDV) and dive transects.

Each sample point location and the type of samples to be collected at the sample point are presented in Figure 7-5 and Figure 7-6 below for DDV and diver-based surveys respectively.

The survey is designed to maximise coverage surrounding the Project site. Sampling locations have been selected to allow for the likely spatial distribution of marine habitats and to provide a comprehensive overview of the ecological conditions surrounding the Project site.

7.6.1.2. Drop Down Video

DDV transects will be conducted to assess the habitats present within the proposed intake and outfall pipeline corridors. Three towed transects will be conducted for each pipeline corridor, a total of 6 tows. The DDV will be deployed at the start of the transect and towed at low speed using the boat to direct the transect along the proposed corridor. The location of the start and end of each transect will be marked with a Garmin GPS. Footage from the DDV will be continuously monitored during the deployment and later analysed to identify habitat types, fauna and flora recorded.

7.6.1.3. Diver-based survey

A total of 10 transect dives will be conducted to assess the most common habitat type identified during the DDV's. The dived transects will also be conducted in shallow areas as these areas are more likely to provide habitat to sensitive species like corals and seagrass. At each transect a 50m line will be marked with a tape measure perpendicular to the shoreline extending seawards. The 50m transect will be recorded and a 1m x 1m quadrat will be photographed at each 10m interval including the beginning and end of the transect (10 quadrats/transect).

Species will be recorded along the transect or during the dive. Quadrat data will be analysed to indicate diversity and abundance of benthic species.

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Figure 7-5: Proposed Drop Down Video (DDV) locations

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Figure 7-6: Proposed diver based survey locations

7.6.2. Impact Assessment Methodology

The baseline investigations will identify levels of marine terrestrial ecology as well as areas of habitat which are of ecological significance. Once findings are presents, construction and operational impacts can be determined.

As part of the ESIA, the results of the marine ecology surveys will be used to determine the following:

- The presence of protected marine species and habitats of conservation concern and the extent of impact;
- Identification of the potential impacts; and
- Determination of the impacts significance prior and following mitigation measures.

7.7. Marine Water & Sediment

7.7.1. Baseline Methodology

The methodologies used to conduct the marine water survey for qualitative and quantitative data collection will be based on the following survey standards:

- Australian Institute of Marine Science (AIMS): Survey Manual for Tropical Marine Resources; and
- Regional Organization for the Protection of the Marine Environment (ROPME): Manual of oceanographic observations and pollutant analyses methods.

The following sections describe the sampling and survey methodologies utilised for the marine baseline survey.

7.7.1.1. Survey Locations

The sampling programme will involve the analysis of seawater quality (in situ and ex situ) and sediment quality. Each sample point location and the type of samples to be collected at the sample point are presented in Figure 7-7 below.

The survey is designed to maximise coverage throughout the Project site. Sampling locations have been selected to allow for the likely variation of the marine water and sediment conditions surrounding the Project site

7.7.1.2. In situ Seawater Quality

Physical parameters will be measured in situ through the use of a calibrated Aquaread AP-5000 multi-parameter water quality probe. The following physical water quality parameters will be measured in situ:

- Conductivity (μS/cm);
- Dissolved oxygen (mg/L and %);
- pH;
- Salinity (PSU);
- Total Dissolved Solids (mg/L);
- Turbidity (NTU);
- Temperature (°C);
- Redox Potential (mV); and
- Clarity via Secchi Disc.

7.7.1.3. Ex Situ Seawater Quality

Samples for ex situ laboratory analysis will be collected using a horizontal 2.2 litre Van Dorn water sampler with messenger release mechanism. The samples will be transferred directly into the laboratory sample receptacles, sealed and cold stored before transit to an accredited laboratory.

Results of the water quality analysis will be compared against the standards set out in **Section 5.2.3: Marine Environment.**

7.7.1.4. Sediment Quality

A total of 5 sediment samples will collected at the same locations as water quality, as indicated in Figure 7-7 above. Parameters analysed will be compared against the standards specified as set out in **Section 5.2.3: Marine Environment.**

Sediment quality samples will be collected using a 0.025m^3 Van Veen grab deployed from the survey vessel and collection techniques will be undertaken utilising best practice (MOOPAM) sediment sampling procedures. Due to the degeneration rates of certain parameters being tested, samples will be cold stored immediately after collection to maintain sample integrity.

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Compiled By: KM

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Date: 04/02/20

Figure 7-7: Proposed marine water sampling locations

7.7.2. Impact Assessment Methodology

The Baseline investigations will identify marine water and sediment quality when compared to standards specified as set out in **Section 5.2.3: Marine Environment.**

Hydrodynamic modelling will be carried out utilising the MIKE software package (developed by DHI). The MIKE3 Flow Model (FM) Hydrodynamic Module (HD) will be used to simulate water level variations and their associated flows taking into account seabed resistance, wind forcing, baroclinic forcing, hydrographic boundary conditions and atmospheric influence (e.g. pressure and temperature). A 'baseline' simulation will be carried out for validation / calibration purposes which will include natural tidal and wind influences only (i.e. no outfalls).

Effluent plumes from the facility will be simulated within the MIKE FM HD module. The MIKE FM HD module is deal for simulating the advection and dispersion behaviour of effluents which are released at a different density to the ambient environment. The fully baroclinic nature of the software enables density currents caused by this differential density to be simulated accurately, in conjunction with other dispersal effects associated with dispersion, tide and wind driven flows and atmospheric effects (such as surface cooling). The software also incorporates near-field simulations which can accurately simulate the 'jet' phase of the effluent (where the effluent momentum influences trajectory and mixing behaviour). These near-field simulations are linked with the MIKE3 FM HD module, enabling the influence of ambient currents on 'jet' behaviour to be simulated at the same temporal and spatial resolution as the hydrodynamic model.

7.8. Waste

7.8.1. Baseline Methodology

A desk-based data collection exercise has been undertaken in the first instance to identify the current waste management framework within the Emirate of Fujairah to identify current waste management opportunities and constraints, based upon publicly available information. This desk-based research will be supplemented by site visits undertaken in 2020 to gain an overall understanding of any existing waste management issues at the Project site.

7.8.2. Impact Assessment Methodology

During construction works it is anticipated that significant amounts non-hazardous wastes will be produced together with smaller amounts of hazardous solid wastes. If these wastes are not handled and stored appropriately, contamination of soils and groundwater could occur.

During the operational phase, it is anticipated that a high volume of industrial solid waste and potentially hazardous waste would be generated, which would be further assessed as part of the ESIA and the Project's waste management plan.

The assessment of potential waste impacts during construction and operation will be undertaken within the ESIA will include the following:

- A desktop baseline study will be undertaken based on the current data and information on existing and proposed waste management facilities and quantities in Fujairah Emirate;
- An estimation of waste types and potential quantities associated with proposed construction activities;
- An estimation of likely waste types and potential quantities associated with operational activities; and
- The development of appropriate and specific control measures, for the avoidance, re-use, recycling and disposal of various waste streams.

7.9. Socio-Economy

7.9.1. Baseline Methodology

A desk-based socio-economic baseline study will be conducted, although this excludes any community engagement. The survey will include a desktop survey followed by a site visit in order to determine the existing following components:

- Land use and Livelihoods;
- Communities;
- Current and planned infrastructure;
- Population and demographics; and
- Landscape and visual aesthetics.

7.9.2. Impact Assessment Methodology

It is anticipated that the key significant impacts associated with the socio-economic aspects of the Project are as follows:

- Construction:

– Positive impacts
  - – Enhancement of the local economy through generation of revenue from the influx of workers and creation of jobs;

– Negative Impacts
  - – Potential impacts including nuisance to, and loss of amenity for, sensitive receptors. These will include but not be limited to nearby residents, business owners and visitors as a result of construction activities such as the generation of noise, dust and traffic congestion;
  - – The influx of a large population of expatriate workers which may cause social problems or unrest;
  - – Damage and/or loss of any buried archaeological artefacts of cultural and historical significance which have not previously been identified; and
  - – Reduction in visual amenity for the surrounding land uses and their associated sensitive receptors, since construction activities and associated equipment are likely to result in a temporary decline in the quality of the surrounding landscape.

- Operation:

– Positive impacts
  - – Creation of skilled Jobs in local area; and
  - – Provision of increased energy supply for the growth of the local economy.

– Negative impacts
  - – Potential impacts of surround noise and air quality levels.

7.10. Archaeology and Cultural Heritage

7.10.1. Baseline Methodology

Due to the significant level of disturbance to the existing site and the previous level of development that was undertaken prior to demolition, no archaeological artefacts are expected to be located within the Project site. No Project site investigations for archaeological finds will be undertaken.

7.10.2. Impact Assessment Methodology

7.10.2.1. Construction phase

No impacts to archaeological finds are expected within the Project site. However, there is the potential for chance finds to be located on the adjacent Murbah Beach.

7.10.2.2. Operational Phase

No impacts to archaeological finds are expected within the Project site during the operational phase.

8. ESIA REPORTING STRUCTURE

The ESIA Reporting Structure will be in accordance with the FM EPDD Standard for ESIA Report format as presented in **Section 5.1.2** which will be as follows, modified for compliance with IFC / Equator Principles:

- Front Pages:
  - Title Page;
  - Table of Contents;
  - List of Tables;
  - List of Figures;
  - Table of Abbreviations and definitions
- Executive Summary:
  - Project Description
  - Findings
- Introduction:
  - Project Title and Project Proponent
  - ESIA Consultants
  - Project Rationale
  - Reference Documents
- Legal Framework:
  - List of legislation (Federal, local) as well as international Conventions and Treaties, which may apply to the Project
  - List of applicable IFC Guidelines and Equator Principles
- Project Description:
  - Statement of Need
  - Concept and Phases
  - Location, Scale and Scheduling of Activities
  - Project Status
  - Waste Streams & Emissions
- Description of the Environment:
  - Baseline Conditions for Air Quality, Noise, Soil and Groundwater, Marine Environment, Waste, Socio-Economic, Terrestrial Ecology
  - Components Likely to be Affected
- Impact Prediction and Evaluation:
  - Impact Assessment for Air Quality, Noise, Soil and Groundwater, Marine Environment, Waste, Socio-Economic, Terrestrial Ecology
  - ESIA Impact Matrix
- Mitigation Measures:
  - Recommendations
  - Additional Mitigation Measures

- Residual Impacts
- EMPs / Statement of Commitments

- Alternatives
  - Alternatives to the main technology / philosophy used in the project

- Environmental & Social Monitoring Program
  - Monitoring Program for Compliance of Mitigation Measures
  - Monitoring Program for Residual Impacts.

- Appendices

REFERENCES

1. **International Finance Corporation.** General Environment, Health and Safety (EHS) . s.l. : International Finance Corporation (IFC), 2007.

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5. **UAE Cabinet.** Decree No 37 of 2001 - Regulations for the Protection of the Marine Environment. Abu Dhabi : s.n., 2001.

6. **Mott MacDonald.** *Fujairah F3 Independent Power Plant Air Quality Feasibility Study.* 2019.

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8. **Department of Environmental & Climate Change NSW.** *Interim Construction Noise Guideline.* Sydney : s.n., 2009.

9. **Dutch Government.** *Soil Remediation Circular.* 2009.

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Appendix 4.2 – Fujairah Municipality ToR Comments

Anthesis

23/02/2020

Environmental Studies Review Report

Project Name: Fujairah 3 Independent Power Project (IPP)
Project Proponent: Emirates Water & Electricity Company
Env. Consultant: Anthesis Middle East
Subject: Environmental Social Impact Assessment (ToR)
Statement: Approved with remarks

EPS Comments:-

Environment Protection Section has no objection on the Term of Reference, and you may proceed with the EIA study of the project.

The project proponent/ Environmental consultant should clarify the following points within the ESIA report :

1- Provide detailed description about Reverse osmoses unit to be used and associated waste generation (RO membranes , Ro sludge) and disposal.
2- Intake Outfall studies and surveys have been conducted to identify the ideal locations must be submitted, including hydrodynamic studies.
In addition to cumulative impact on the marine environment should be considered.
3- Flue gas dispersion study and stack height calculation must be attached.
4- Construction works of both intake and outfall does it require dredging works (if yes , this should be considered as a part of impact assessment ,marine environment.
5- CEMP must include both land and marine works/activities.

Engr/ Sharifa Ali

Head of Environment Protection Section

Reviewed by:
Engr/ Mohamed Ateeg
Date: 23/02/2020

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