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شركة البترول الوطنية الكويتية
KNPC

KNPC Clean Fuels Project (CFP) 2020 FEED Update Phase

Environmental Impact Statement (EIS)

Report, Rev 2

Report for KNPC
prepared by DNV
Fluor Document No. P6000CFP-000-10R-106_A
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MANAGING RISK

KNPC Clean Fuels Project (CFP) 2020
Feed Update Phase
Environmental Impact Statement EIS (Rev 2)
for

KNPC

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NON- TECHNICAL SUMMARY

BACKGROUND

Kuwait contains an estimated 101.5 billion barrels (bbl) of proven oil reserves, roughly 8% of the world total, and around 1,600 producing oil wells. Currently, Kuwait produces about 2.6 million bbl/d of crude oil. Overall, around two thirds of Kuwaiti oil production comes from the southeast of the country, with about one-fifth from northern Kuwait and about one-tenth from the west.

Kuwait's three domestic refineries currently have a combined capacity of 936,000 bbl/d. The country's largest refinery is Mina Al Ahmadi (MAA), with a capacity of 466,000 bbl/d. The other refineries are Mina Al Abdullah (MAB) (270,500 bbl/d) and Shuaiba (SHU) (200,000 bbl/d). In the long term, total refining capacity is expected to be 1.4 million bbl/d.

Kuwait National Petroleum Company (KNPC), in its continuing commitment to meet changing (and more stringent) environmental requirements and to meet the increased need for clean fuels, is embarking upon an ambitious project, the Clean Fuels Project 2020 (hereafter referred to as CFP), to upgrade and modernize the three existing refineries. CFP will involve major upgrades at Mina Al Ahmadi refinery (MAA) and Mina Abdullah refinery (MAB), while the old processing facilities at Shuaiba refinery (SHU) will be retired.

The Front End Engineering Design (FEED) Phase of the project was completed in June 2008. During FEED, an Environmental Impact Statement (EIS) was submitted by KNPC to the Kuwait Environmental Public Authority (K-EPA).The project is currently under the FEED Update Phase which is intended to meet the new marketing requirements of the Project. Thus, the EIS submitted and presented to K-EPA in 2008 needs to be updated to reflect the new scope of the facilities as per Feed Update Phase requirements. This EIS is an update of the original EIS and covers an assessment of the FEED Update Phase scope of facilities.

THE ENVIRONMENTAL IMPACT STATEMENT

In accordance with the regulatory requirements promulgated by Kuwait's principal environmental regulatory authority, the Kuwait Environment Public Authority (K-EPA), and international 'best practice', Det Norske Veritas (DNV) conducted a full independent EIA process in 2008 for the proposed CFP, following an Initial EIA submitted by Fluor to K-EPA in August 2007. EIA is a process undertaken for certain types of major projects, which are judged likely to have potentially significant environmental effects, it assesses the environmental consequences of a proposed development in advance, with emphasis on the prevention of unacceptable impacts.

The output of the EIA process was an Environmental Impact Statement (EIS), which was prepared by DNV on behalf of Fluor, in accordance with the State of Kuwait Regulations Implemented under Law No. 21 of 1995 as Amended by Law No. 16 of 1996. The EIS also fulfilled KNPC's regulatory and internal procedural (EIA Study procedure SHE-ESHU-03-1407) requirements, as well as the statutory requirements *of K-EPA. This FEED Update Phase EIS has also been prepared in accordance with the above requirements and procedures.*

This updated EIS sets out DNV's 3rd-party assessment of the potential environmental effects during the construction, subsequent operation and final decommissioning of the CFP. It is supported by an Environmental Baseline Study (EBS) conducted by DNV in conjunction with two Kuwaiti technical providers, Kuwait Institute for Scientific Research (KISR) and Wataniya Environmental Services (WES) in 2007. The EBS provides an existing environmental 'baseline' of the CFP site and its surroundings allowing DNV to assess any potential impacts posed by the project. WES also provided some assistance with the development of part of this EIS. Public consultation was not within the scope of the CFP EIA.

PROJECT DESCRIPTION

CFP involves modifications at KNPC's three (3) existing refineries: MAA, MAB, and SHU. The MAA and MAB refineries will undergo major upgrades whilst the processing facilities at SHU will be retired. The outcome of this will be the integration of the KNPC Refining System into one merchant Refining Complex with Full Conversion operation with highest Light Ends Products Yields and minimum Fuel Oil production.

The CFP, which is currently under the Front-End Engineering and Design (FEED) Update stage managed by Fluor, will result in a reduction in the overall refining capacity of the three refineries from the current operating levels of 936,000 bbl/d to 800,000 bbl/d. The changes are expected to reduce impact on the environment from the refinery activities. The project will integrate the new and existing process units along with storage, infrastructure, oil movement and shipping. A variety of new Utilities and Offsite (U&O) facilities will be provided.

Environmental Measures Incorporated in CFP

KNPC's objective is that the CFP 2020 will incorporate best environmental practices such as Best Available Control Technologies (BACT) and environmental mitigation measures deemed necessary, so as to meet or exceed all relevant K-EPA emissions criteria. The CFP has been designed to mitigate all environmental impacts, and numerous environmental measures / BACT have been incorporated. BACT is incorporated into the following areas:

- *Noise control and abatement*
- *Air emissions abatement*
- *Solid waste management*
- *Management of hazardous chemicals*
- *Wastewater treatment and disposal*
- *Environmental monitoring*

Assessment of Alternative Sites

It is a requirement of the EIA process to consider alternative site locations when assessing a proposed development. CFP will, however, be based at the existing KNPC refineries and not in a grassroots location and thus evaluating alternative site "locations" is not possible. Thus this EIS examined alternatives to the project itself.

Constructing and operating the new petroleum refining and support facilities within the available space at the existing MAA and MAB refineries was considered the most suitable alternative. This is because it is economically viable, will improve regional air quality by providing low sulphur fuels, and will upgrade current refining capabilities, thus enhancing KNPC's competitive standing within the industry

CFP will not only provide Kuwait and export customers with cleaner burning fuels but will also enhance the safety and environmental performance of the MAA and MAB refineries through modernization and incorporation of current best environmental practice, while the older SHU refinery processing units will be decommissioned.

ENVIRONMENTAL BASELINE STUDY

In support of the EIA process, DNV conducted an Environmental Baseline Study (EBS). The EBS was completed to provide a baseline of the existing environment in order to properly assess any potential impacts posed by this project. The EBS field work was undertaken by two specialist local consultants, WES and KISR.

DNV, WES and KISR conducted the following specialized studies as part of the background studies:

- *Soil characteristics*
- *Ambient air quality*
- *Noise*
- *Land use*
- *Demography and socioeconomic aspects*
- *Geology and seismology*
- *Surface Water, groundwater and water use*
- *Terrestrial and aquatic ecology*
- *Meteorology*

The majority of the EBS work was carried out between March 2007 and August 2007. The main environmental issue identified was that existing air quality in the study area often exceeds criteria.

NOISE

The main purpose of the Noise study was to evaluate the potential community noise impact due to the noise emissions from CFP.

This noise assessment considered noise impacts based on available information at this early stage in the design process, and drew the following findings:

- *There are no exceedences of relevant K-EPA standard predicted at any receptor during daytime due to CFP for both construction and operation.*
- *For the construction phase, night time noise levels will not be affected, since construction activities are not performed during the night hours except under very exceptional situations.*
- *For the operations phase, night time noise levels are expected to exceed the relevant K-EPA standards at several locations.*

Based on the above, the following recommendations are made:

- *Construction activities generating significant noise levels should not be carried out during the night time except under very exceptional situations. This is particularly relevant near the beach chalets to the south east of MAB refinery.*
- *In order to fully comply with K-EPA community noise standards, additional noise attenuation using acoustic enclosures should be considered for significant noise emitting sources located close to the fence lines, particularly for CFP works near the eastern part of the CFP at MAB refinery. Details are provided within the body of the report.*
- *Noise monitoring will be necessary during both construction and operation to ensure no significant impact upon receptors.*

AIR QUALITY

Air modelling was conducted to evaluate the impact of the CFP upon the existing poor air quality in the study area. The air modelling results indicate that the air quality impacts associated with the CFP are acceptable for the following reasons:

- *The CFP will decommission the majority of air emission point sources from the SHU refinery (as well as some units at MAA and MAB refineries), most of which have large atmospheric pollutant emission rates. This will help reduce the total pollutants emitted to atmosphere, hence improving the air quality in the area.*
- *After the completion of CFP, the vast majority of long and short term NO_2, SO_2 and TSP concentrations should improve. This is mainly due to the fact that pollutant emissions from sources that are to be decommissioned far exceed the emissions associated with new CFP sources.*
- *Although, air quality in the study area improves as a result of the CFP, air quality criteria are still breached in some areas for some parameters.*
- *Fugitive emissions on site from the tank farms areas satisfy relevant criteria.*
- *CFP emissions during Sulphur Recovery Unit (SRU) emergency upset conditions satisfy relevant criteria.*
- *Based on the design data available, the air modelling results for the emergency scenarios associated with new CFP Flares indicated that all scenarios satisfy the occupational exposure standard for SO_2, apart from the new acid gas flare at MAB (Unit 146).*

  In the absence of any guidelines or criteria from the Kuwaiti regulator for this type of emergency event beyond the refinery fence-lines, the CFP compared maximum ground level concentrations against more stringent US air quality criteria. Maximum ground level sulphur dioxide concentrations beyond the refinery fence-lines generally meet this more stringent criteria (US AEGL-2) apart from emergency scenarios for the flares associated with Units 162, 167, 146, 149 (High Pressure) and Total Power Failure (TPF). The acid gas flare at MAB (Unit 146) will also exceed the US ERPG-2 criterion for sulphur dioxide.

Sensitivity analysis was thus conducted by increasing the flare stack heights for these Units. The revised results indicate that all relevant criteria are met for all cases except the new acid gas flares at MAA and MAB (Units 167 & 146), as well as the TPF Case, which still exceed the AEGL-2 criterion.

Additional, preliminary sensitivity analysis on the aforementioned flare units indicates that with the emission rate of sulphur dioxide halved, the resulting peak ground level concentrations will reduce proportionally. This would result in MAA Unit 167 and the TPF Case meeting the AEGL-2 criterion. MAB Unit 146 would still not meet the AEGL-2 criterion (in order to meet AEGL-2 criterion, the emission rate of sulphur dioxide should be reduced to around 35-40% of its current value).

Consequently, it is recommended that KNPC implement design changes during the EPC phase to reduce the relief loads for the flare systems which have the highest potential impact on the receptors located outside the refinery boundaries.

SOLID WASTE

CFP will produce a variety of solid wastes (hazardous and non-hazardous) during both construction and operational activities. In order to manage waste properly and comply with local and globally recognized waste management practices, a Waste Management Plan (WMP) will be developed by each EPC Contractor in accordance with KNPC policies / procedures as well as K-EPA requirements. Specifically, the WMP will comply with the existing KNPC Procedure for Solid Waste Management (SHE-ESHU-03-1406).

As part of the WMP, a number of mitigating measures will be implemented. These will have the effect of reducing both the amount of waste generated, and the associated impacts on the environment. The greatest potential impact to the environment relates to the storage of hazardous wastes. The impact of the generation, storage, transportation and disposal of non-hazardous and hazardous solid waste during the operation of the CFP facilities is considered to be of small to moderate negative significance. During construction it is considered to be of small negative significance. This is due to the quantities and the nature of the material, the implementation of an Environmental Management System (EMS) and WMP, and the full implementation of all control measures by the EPC contractors as recommended in this report.

HAZARDOUS MATERIALS

The new and modified CFP facilities will handle and / or store a variety of potentially hazardous materials, including finished products, raw materials and catalysts. Hazardous materials being used within the various systems that comprise the CFP will include: water treatment chemicals such as hydrochloric acid, sulphuric acid, caustic, chlorine, catalysts, and water conditioning chemicals such as corrosion inhibitors and oxygen scavengers.

During construction, all hazardous material will be stored and managed in a central location located within each EPC Contractor controlled area. Materials within these *areas will be stored according to compatibility and all flammable materials will be segregated and stored in a flame protected area. All hazardous materials will be contained within temporary or permanent bunding in order to prevent a release to soil and / or groundwater.*

Hazardous materials storage during operation of CFP facilities will either be in fixed tanks (at various bunded locations on the site), in a compressed gas cylinder storage area, or in the new MAB Chemical Storage Warehouse / Catalyst Storage Area. Material Safety Data Sheets (MSDS's) will be made available at the guardhouse, administration building and control room buildings for the refineries. In addition, MSDS's will be accessible at the new chemical storage warehouse building and catalyst storage facility at the MAB refinery for the materials stored in those buildings.

The impact from the storage, use, transportation and disposal of hazardous materials is considered to be of "small negative" significance during construction and of "moderate negative" significance during operation provided that all recommended management measures are followed. It is important that the management systems will, as proposed, comply with K-EPA requirements for the handling, storage and disposal of hazardous materials. Storage of hazardous chemicals will be in accordance with the provisions in Article 30 of the K-EPA regulations.

WASTEWATER

The CFP development will require large volumes of water for cooling tower, boiler feedwater (BFW) make-up, process water, potable water, sanitation and other refinery services. KNPC plan for as much of the CFP's water demand to be met by wastewater recycling and reuse as possible.

There will be two new Wastewater Treatment (WWT) Systems provided as part of CFP:

- *New Wastewater Treatment System at MAB – Unit 156*
- *New Wastewater Treatment System at MAA – Unit 163.*

DNV has assessed the environmental impacts from the collection, treatment and reuse of process and sanitary wastewater effluents generated during both construction and operational phases as having a 'Small Negative Impact'. Overall, it is concluded that the planned new CFP wastewater collection and treatment facilities are state of the art, and constitute best practice and apply a considerable number of BACT elements. The CFP wastewater facilities will be designed, built and operated in such a way as to meet best practice and the applicable K-EPA environmental criteria.

In order to augment the robust approach to addressing and mitigating environmental impacts during the CFP's construction and subsequent operations, this study makes the following additional recommendations:

- *The wastewater discharge monitoring results should be audited by an independent party on a regular basis.*
- *The wastewater, storm water and sanitary wastewater collection / treatment facilities should be made available at the earliest stage possible during construction, and it is recommended that each EPC contractor make this an early priority for the CFP construction.*

TRAFFIC

A preliminary Traffic Impact Assessment (TIA) was conducted in the FEED Stage EIA in 2008. It has not been updated as part of this report because a detailed TIA will be conducted for the Ministry of Interior in the near future prior to the start of construction activities.

The 2008 TIA indicated that the CFP could have a significant impact on local traffic conditions during the construction phase, in particular during the seven month period of peak construction activities. The impact on traffic during operation of CFP facilities was found to be acceptable although the overall volume of traffic is expected to increase.

The long term impact should be positive for traffic around the SHU Refinery due to a substantial reduction in the number of employees at the start of the CFP operational phase.

It is recommended that a comprehensive TIA be conducted during the EPC phase to further study local traffic patterns with the objective of determining the current status of local roadways relative to their design carrying capacity. This information should be used as the basis for development of a comprehensive CFP Traffic Management Plan to ensure impacts are managed acceptably via detailed traffic control measures.

MISCELLANEOUS ISSUES

Socio-economics

The proposed CFP will have positive benefits on the regional employment market and local economy, due to the recruitment of approximately 33,000 construction workers (at peak) and approximately 1,500 additional operational staff. In addition, there are anticipated to be positive benefits due to the effects of supply, maintenance and service contracts to local businesses.

There will be some potential negative social impacts from CFP construction staff. The main concerns relate to the impact of the very large construction employees when not working, with some potential impact upon local residential areas owing to cultural differences, and increased strain upon local facilities, and it is recommended that the EPC contractor should develop a plan to handle the potential negative social impacts from such a large influx of construction workers. To counter this, there will also be potential positive impacts upon the local community via local businesses benefiting from increased trade and commerce.

KNPC's Safety, Health and Environmental practice will likely be enhanced through the upgrading / replacing of aging units. This will generally make the KNPC refineries and their surroundings a safer and cleaner place to live and work.

Assessment of Landscape and Visual Impacts

There are no significant landscape impacts from installation of the CFP facilities and receptors at long distances will consider the refinery in context with the existing industrial developments adjacent to the site. Local observers will be visually impacted by the CFP development, especially on the south-eastern edge of the project and mitigation measures have been proposed to minimise visual impacts, in the form of hording or earth bunds. The impact of the CFP development is minimised due to the development being incorporated within the refinery boundaries.

Groundwater Monitoring and Contaminated Land

In the EBS, it was observed that there was no significant soil contamination identified at MAA and MAB, however, soil hydrocarbon levels were higher at SHU where contamination was identified at one location. The soil in this location will need to be carefully removed and disposed of correctly. It is recommended that an independent Environmental Advisor is regularly on site during construction whilst soil excavations are taking place to ensure that the soil is excavated and disposed of in the correct manner, and to help identify other areas of contamination, if any.

KNPC recently commissioned a comprehensive Groundwater Study, which involved the establishment of 47 groundwater wells around the three existing refineries; the report identified a degree of groundwater contamination below the refineries.

DNV recommend that regular checks for fugitive emissions to ground/groundwater from CFP refinery plant and tanks are included as part of the EMS, and that systematic groundwater monitoring is conducted around the CFP facilities and in the vicinity of the tank farms, and analysed against agreed criteria). The CFP will need to provide a groundwater monitoring well system to detect any groundwater contamination from areas where oil or other hazardous materials are normally handled or stored.

It is additionally recommended that soil and groundwater identified as contaminated in the KISR report and overlapping with the CFP location will require remediation prior to the start of CFP construction.

EMERGENCY RESPONSE

The three KNPC refineries, MAA, MAB and SHU, process, store and distribute large quantities of flammable and toxic materials. An incident, such as fire, explosion or gas release occurring within the CFP facilities may have serious consequences, affecting not only the site and the local environment, but also other industries and the public outside the site boundaries.

KNPC is committed to the safety of its employees, installations and the general public. All applicable safety standards, procedures and best practices are followed during process selection, design, construction and operation. However, even with the best safe working practices, it is recognized that emergency incidents may and do still occur. KNPC has developed and implemented a Major Incident Procedure Plan (MIPP) for its existing refineries. Since the CFP is being constructed and *operated within KNPC's refineries' boundaries, the MIPP will apply to CFP. The MIPP provides a procedural framework for responding to emergency incidents such as fire and flammable / toxic releases, and has been approved by the appropriate Kuwaiti authorities.*

DECOMMISSIONING AND CLOSURE MANAGEMENT PLAN

At some stage in the future, the CFP will reach the end of its operational life. The future decommissioning and closure of the CFP will be a complex process, especially in ensuring that the sites are rehabilitated to K-EPA's requirements such that the sites can either be handed back to government control, or sold for another private sector use.

KNPC will develop a conceptual Decommissioning and Closure Management Plan (DCMP) for the CFP (which will involve consultation with K-EPA) as closure planning progresses. The DCMP will address all the project stages that CFP decommissioning will include, which are likely to be: pre-decommissioning consents and contracts; decommissioning activity obligations; and post-decommissioning responsibilities.

Specific environmental related decommissioning and closure objectives associated with the CFP are predicated around meeting all Kuwaiti legal and regulatory requirements (including K-EPA criteria), and mitigating any impacts (environmental, public health, safety, social) within the 'impact vicinity' of the site.

The final goal of a successful eventual decommissioning of the CFP should be to ensure that the need for post-closure site maintenance is minimised, and any long-term environmental activities are mitigated.

ENVIRONMENTAL MANAGEMENT SYSTEM (EMS)

KNPC has developed and implemented a company wide EMS in line with the requirements of the ISO14001:2004 Standard – Apex Manual for Environmental Management System (SHE-ESHU-04-1401). Since the CFP facilities are within KNPC refinery boundaries, this EMS will also apply to them, ensuring a structured approach to the management of project-related environmental issues.

The implementation of the EMS will commence during the initial stages of construction and will develop as the CFP becomes fully operational.

1.0 Introduction

1.1 Background

Kuwait contains an estimated 101.5 billion barrels (bbl) of proven oil reserves, roughly 8 % of the world total, and around 1,600 producing oil wells. Currently, Kuwait produces about 2.6 million barrels/d of crude oil. Overall, around two thirds of Kuwaiti oil production comes from the southeast of the country, with about one-fifth from northern Kuwait and about one-tenth from the west.

Kuwait's three domestic refineries have a combined capacity of roughly 936,000 bbl/d. The country's largest refinery is Mina Al Ahmadi, with a capacity of 466,000 bbl/d. The other refineries are Mina Al Abdullah (270,500 bbl/d) and Shuaiba (200,000 bbl/d). Kuwait National Petroleum Company (KNPC) continues to plan significant expansion of its production capacity aiming to reach a long-term total refining capacity of 1.4 million barrels/d.

KNPC, in its continuing commitment to meet changing (and more stringent) environmental requirements and to meet the increased need for clean fuels, is embarking upon an ambitious project, the Clean Fuels Project 2020 or CFP, to upgrade the three existing refineries. These requirements will be implemented by the year 2015.

1.2 Outline of Clean Fuels Project 2020

The CFP involves modifications at KNPC's three (3) existing refineries: Mina Al Ahmadi (MAA), Mina Abdullah (MAB), and Shuaiba (SHU). The MAA and MAB refineries will undergo major upgrades while the processing facilities at SHU will be retired. The outcome of this will be the integration of the KNPC Refining System into one merchant Refining Complex with Full Conversion operation with highest Light Ends Products Yields and minimum Fuel Oil production.

The CFP will result in a reduction in the overall refining capacity of the three refineries from the current operating levels of 936,000 bbl/d to 800,000 bbl/d. The changes are expected to reduce impact on the environment from the refinery activities. The CFP will integrate the new and existing process units along with storage, infrastructure, oil movement and shipping. A variety of new Utilities and Offsite (U&O) facilities will be provided.

The Front End Engineering Design (FEED) Phase of the project was completed in June 2008. During the latter stages of FEED Phase development, a variety of changes surfaced as a result revised marketing parameters which necessitated further Front End Engineering Design development under a new FEED Update Phase. The project is currently under the FEED Update Phase which is intended to meet the new marketing requirements, demands and specifications for transport fuels while integrating the operating capability of the MAA and MAB refineries with optimum utilization of KNPC's existing infrastructure.

1.3 Environmental Impact Assessment

In accordance with the regulatory requirements promulgated by Kuwait's principal environmental regulatory authority, the Kuwait Environment Public Authority (K-EPA), and international 'best practice', Det Norske Veritas (DNV) conducted a full independent Environmental Impact Assessment (EIA) process for the proposed CFP during FEED in 2008. An Initial EIA was completed by Fluor (the CFP Project Management Consultant contractor) in August 2007. EIA is a process undertaken for certain types of major projects which are judged likely to have potentially significant environmental effects. It assesses the environmental consequences of a proposed development in advance, with emphasis on the prevention of unacceptable impacts. The output of the EIA process was an Environmental Impact Statement (EIS), which was prepared by DNV on behalf of Fluor.

The project is currently under the FEED Update Phase which provides changes to the FEED Phase engineering design intended to meet the new marketing requirements of the Project. Thus, the EIS submitted and presented to K-EPA in 2008 needs to be updated to reflect the new scope of the facilities as per Feed Update Phase requirements. This EIS is an update of the original EIS (June 2008) which encompasses the FEED Update Phase scope of facilities.

The EIS was prepared in accordance with the State of Kuwait Regulations Implemented under Law No. 21 of 1995 as Amended by Law No. 16 of 1996. The EIS also fulfilled KNPC's regulatory and internal procedural (EIA Study procedure SHE-ESHU-03-1407) requirements, as well as the statutory requirements of K-EPA.

The EIS sets out DNV's 3rd-party assessment of the potential environmental effects during the construction and subsequent operation of the CFP, and also provides a framework for a decommissioning, closure, clean-up and reinstatement plan.

This EIS is supported by an Environmental Baseline Study (EBS) conducted in 2007/8 by DNV in conjunction with two Kuwaiti technical providers, Kuwait Institute for Scientific Research (KISR) and Wataniya Environmental Services (WES). The EBS provides an existing environmental 'baseline' of the CFP site and its surroundings allowing DNV to assess any potential impacts posed by the project. WES also assisted with the development of part of this EIS. Public consultation was not within the scope of the CFP EIA.

1.4 Key Objectives

The key objectives of this EIA process include:

- Establishing and reviewing the existing environmental conditions pertaining to the CFP site and surrounding area;
- Identifying and assessing the potential environmental impacts of the proposed CFP development which might arise during construction and operation, and providing a framework for a CFP decommissioning plan;
- Assessing KNPC planned measures to mitigate any adverse environmental impacts;

- Assessing the provision of measuring, monitoring and sampling and associated capabilities to ensure that the CFP operates a robust system of environmental management and controls;
- Making additional recommendations, as appropriate, on what further measures could be taken to address such impacts, such that environmental impacts are reduced, managed and considered acceptable.

1.5 Principal Environmental Impacts

The potential environmental impacts associated with the CFP include both short-term environmental impacts, which will generally result from various construction activities, and potential longer-term environmental impacts associated with operation of the CFP facilities. Both types of environmental impacts are examined within the body of this report.

KNPC intends that the CFP will incorporate the optimum level of Best Available Control Technologies (BACT) and associated environmental mitigation measures deemed necessary, so as to meet or exceed all relevant K-EPA emissions criteria. In particular, BACT will be incorporated to address the following:

- air emissions abatement;
- wastewater collection, treatment, reuse and disposal;
- solid waste management, minimization and disposal;
- noise control and abatement;
- odour abatement
- protection of Kuwait's coastal and marine environment; and
- environmental monitoring.

1.6 Environmental Impact Statement (EIS): Structure

This EIS is a comprehensive and detailed document which describes the potential environmental impacts, associated with the CFP's construction and operation, and takes into consideration the baseline environmental conditions (via the EBS) at the project site. It also describes the key facilities for the CFP, including the principal emissions and discharge points, plus the management and control systems, which will be implemented to mitigate any adverse environmental impacts. This EIS also provides a framework for the decommissioning of the CFP.

In summary, the EIS is set out for maximum clarity according to the following structure:

- Non-Technical Summary: an outline of the CFP, the EIA process, the EIS, and findings;
- Description of the CFP: including both its construction, design, principal processes and associated facilities;
- Environmental Measures incorporated in the CFP Design: a summary of all the appropriate BACT and environmental mitigation measures deemed necessary, so as to meet or exceed all relevant K-EPA emissions criteria;

- Assessment of Project Alternatives: it is a requirement of the EIA process to consider alternatives and their respective environmental impacts / benefits, including the 'no development' option;
- Environmental Baseline Study: in support of the EIA process, the EBS provides a baseline of the existing environment at the site and surrounding area in order to assess any potential impacts;
- Impact Assessment Methodology: applying DNV's EIA 'impact matrix' methodology to the CFP, to assess potentially significant environmental impacts during construction and operation;
- Noise: including environmental noise predictions, and reduction measures, for the CFP;
- Air Quality during Construction: focusing on air quality and associated air pollutant emissions from the CFP during its construction;
- Air Quality during Operation: focusing on ambient air quality and associated air pollutant emissions from the CFP once operational.
- Waste: focusing on solid waste generated during the CFP's construction and operations, and setting out the Solid Waste Management Plan;
- Chemical Hazards Management: covers the use and management of potentially hazardous materials;
- Wastewater: including process / industrial, sanitary wastewater and stormwater generation, an evaluation of wastewater minimization / reuse / treatment and recycling, and assessment of final discharges;
- Preliminary Traffic Impact Assessment: describes the effects of vehicles related to CFP construction and operation on traffic in the surrounding area. It should be noted that the figures and data used in this Chapter are from the FEED Phase. A comprehensive Traffic Impact Assessment to address the design requirements and scope of facilities for FEED Update will be undertaken during the EPC/Detailed Design Phase of the CFP.
- Miscellaneous Issues: covering socio-economic issues, landscape & visual impacts, groundwater contamination and contaminated land issues;
- Emergency Response Plan: setting out KNPC's Major Incident Procedure Plan (MIPP) which will be similarly adopted as the Emergency Response Plan for the CFP;
- Decommissioning and Closure Management Plan Framework: providing the structure for developing a decommissioning, closure, clean-up and reinstatement plan for the CFP site;
- Environmental Management System: KNPC's company-wide EMS, which will be implemented for the CFP facilities;
- Recommendations.

In support, Appendix I (VOC Storage Tank Data) is attached.

2.0 Description of Clean Fuels Project

2.1 General Description of Clean Fuels Project

CFP will provide a major upgrade and expansion of both the MAA and MAB refineries. Accompanying this expansion, KNPC will retire a number of existing inefficient operating units at MAA, MAB and SHU.

A refinery is an organized co-ordinated arrangement of manufacturing processes, which are designed to provide physical and chemical changes of petroleum crude to convert it into useful products. The finished products for CFP include:

Table 2.1 Finished Products of CFP

Local Market Mogas	MAA
Local Market Gas Oil (10 ppm Sulfur)	MAA
Export Mogas	MAA
Petrochemical Naphtha	MAA & MAB
Local Market ATK	MAA
Local Market DPK	MAA
Export ATK	MAA & MAB
Export DPK	MAB
Export JP 5	MAB
Export Gas Oil (10 ppm Sulfur)	MAA & MAB
Fuel Oil Bunker 380	MAA & MAB
Fuel Oil Bunker 180	MAA & MAB
PIC Aromatic Plant Naphtha	MAB
Gas Oil MEW (500 ppm Sulfur)	MAA
Gas Oil Bunker (10 ppm Sulfur)	MAA & MAB
Petrochemical Coke	MAA & MAB
Sulfur	MAA & MAB

The CFP will provide major upgrades to the MAA and MAB refineries and integration of the KNPC Refining System into one merchant Refining Complex with Full Conversion operation with highest Light Ends Products Yields and minimum Fuel Oil production.

The CFP will integrate new and existing process units along with storage, infrastructure, oil movement and shipping leading to the integrated operating capability of MAA and MAB with optimum utilization of existing infrastructure. A variety of new utilities and offsite facilities will be provided. SHU will continue to operate as a tank farm, product storage and export shipping facility, while its old and less environmentally friendly processing units will be retired.

2.2 Key Environmental Issues Typically Associated with Refineries

Refineries are very large and complex sites that manage large amounts of raw materials and products; they are also demanding consumers of energy and water. In their storage and refining processes, refineries generate emissions to the atmosphere, effluents to water bodies, noise and solid waste, all of which may result in impact to the environment. Typical refinery emissions to the environment include:

- **Air emissions:** Air emissions are often the most important environmental issue for oil refineries. Oxides of carbon (CO), nitrogen (NOx) and sulphur (SOx), particulates and volatile organic carbons (VOCs) are the main air pollutants generated.

- **Wastewater:** Water is used extensively in a refinery as process water and for cooling purposes. Its use often contaminates the water with oil products. The main water contaminants are hydrocarbons, sulphides, ammonia, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), phenol, suspended solids and some metals.

- **Waste:** In the context of the large amount of raw material they process, refineries do not typically generate substantial quantities of waste. Wastes generated by refineries are dominated by sludges, non-specific refinery waste (domestic, demolition, etc.), and spent chemicals such as acids, amines and catalysts.

- **Noise:** Noise from equipment is another typical emission to the environment. Although not generally a problem, noise levels during construction and operation can be high, but controllable.

Minimizing Impacts

The following methods are usually the most effective methods to minimize the key environmental impacts from refinery operations:

- ***Reduce sulphur oxides (SOx) emissions***: typically generated via combustion of fuels (containing sulphur compounds), amine treating, sour water strippers, tail gas treating units and flares. High efficiency sulphur recovery units significantly reduce the sulphur content of fuels, thus minimizing SOx emissions.

- ***Reduce nitrogen oxides (NOx) emissions***: typically a key environmental issue, particularly from specific processes and activities, notably from energy generation (e.g. furnaces and boilers). Choosing low NOx burners as well as selecting gaseous fuels over liquid fuels with higher nitrogen content are important steps in minimizing the NOx emissions.

- ***Increase refinery energy efficiency***: the principal benefit of improved energy efficiency is a reduction in the emissions of all air pollutants. Techniques to increase energy efficiency within refineries include increasing the energy efficiency of the various processes/activities and enhancing energy integration throughout the refinery.

- ***Reduce VOC emissions***: VOC emissions from refineries come from fugitive sources such as storage tanks, transfer / loading / unloading operations and equipment components. Use of floating roof tanks for volatile products, nitrogen blanketing for equipment, provision of mechanical seals and implementation of a Leak Detection and Repair (LDAR) program are recognized as very effective methods to minimize VOC emissions.

- ***Reduce water contamination:*** Because refineries are extensive consumers of water, they can also generate large quantities of contaminated wastewater. Recycling and reuse of water (such as for utility use and irrigation) reduces water consumption requirements. Wastewater treating facilities are imperative to site operations before discharge.

2.3 CFP Process Description and Key Environmental Emissions

KNPC is currently finalizing the FEED Update stage for the CFP, which will decrease the cumulative capacity of the three refineries from 936 KBPD to 800 KBPD. This is expected to reduce impact on the environment in surrounding areas.

There will be twenty new process units, four revamped process units, twenty new Utilities & Offsite (U&O) units and nine revamped U&O units currently planned at the MAA refinery. Similarly, there will be nineteen new process units, two revamped process units, nineteen new U&O units and six revamped U&O units at the MAB refinery. To balance this, all processing facilities and most utility support units (including utility boilers) at the SHU Refinery will be decommissioned in parallel. Additionally, a Crude Distillation Unit (CDU-3) and Merox Unit (Unit 94) at MAA, as well as a Crude Unit (Unit 01), RCD Unibon Unit (Unit 02) and Hydrogen Unit (Unit 03) at MAB will be retired.

The CFP is being designed, engineered and constructed to assure safety, environmental compliance, reliability, efficient manpower utilization, operability and maintainability.

Figure 2.A, Figure 2.B and Figure 2.C show the preliminary site layout of the CFP within the three refineries. The CFP process flow diagrams for the refineries are illustrated in Figure 2.D and Figure 2.E.

Figure 2.A: MAA Refinery Site Plan (preliminary)

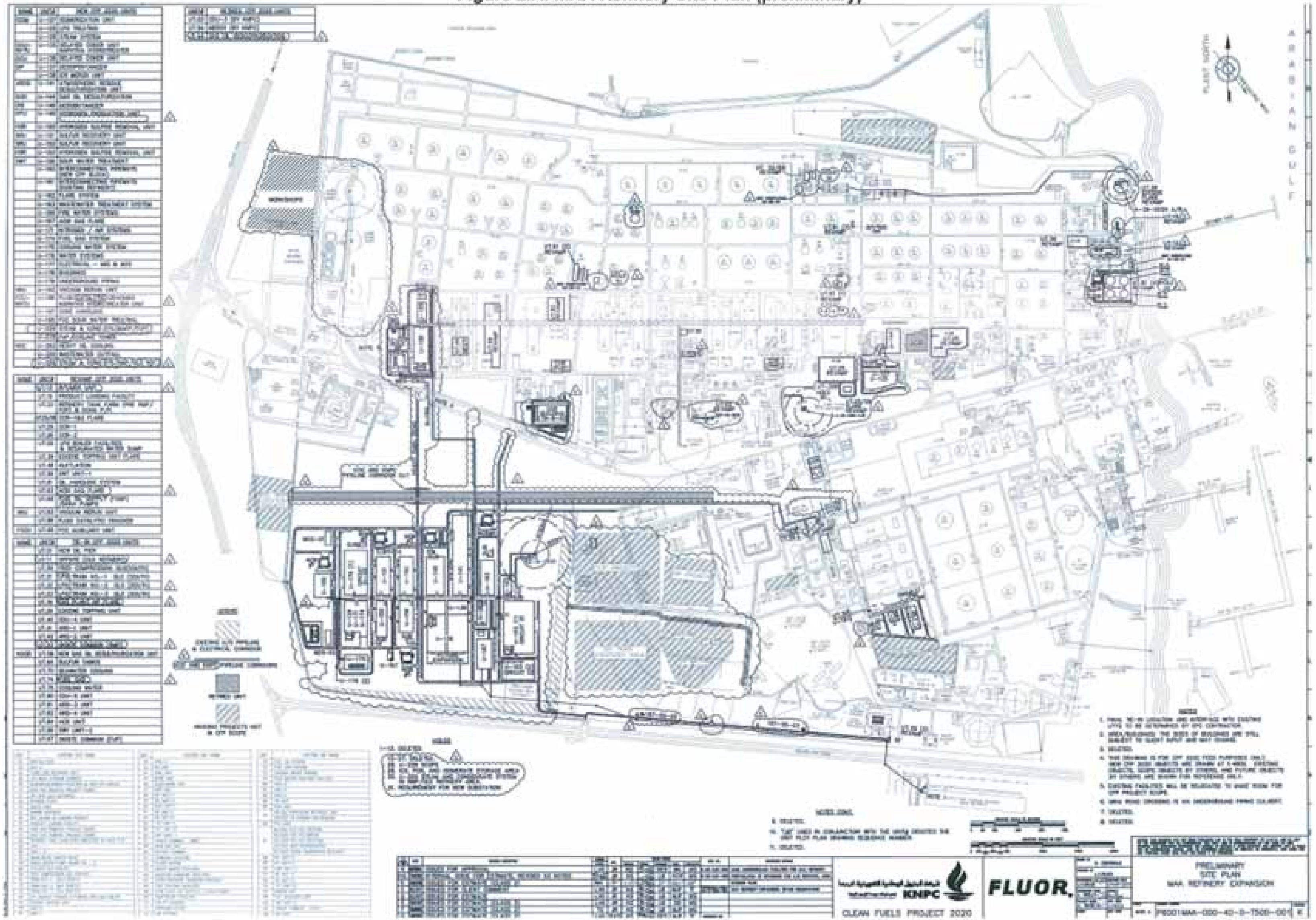


Figure 2.B: MAB Refinery Site Plan (preliminary)

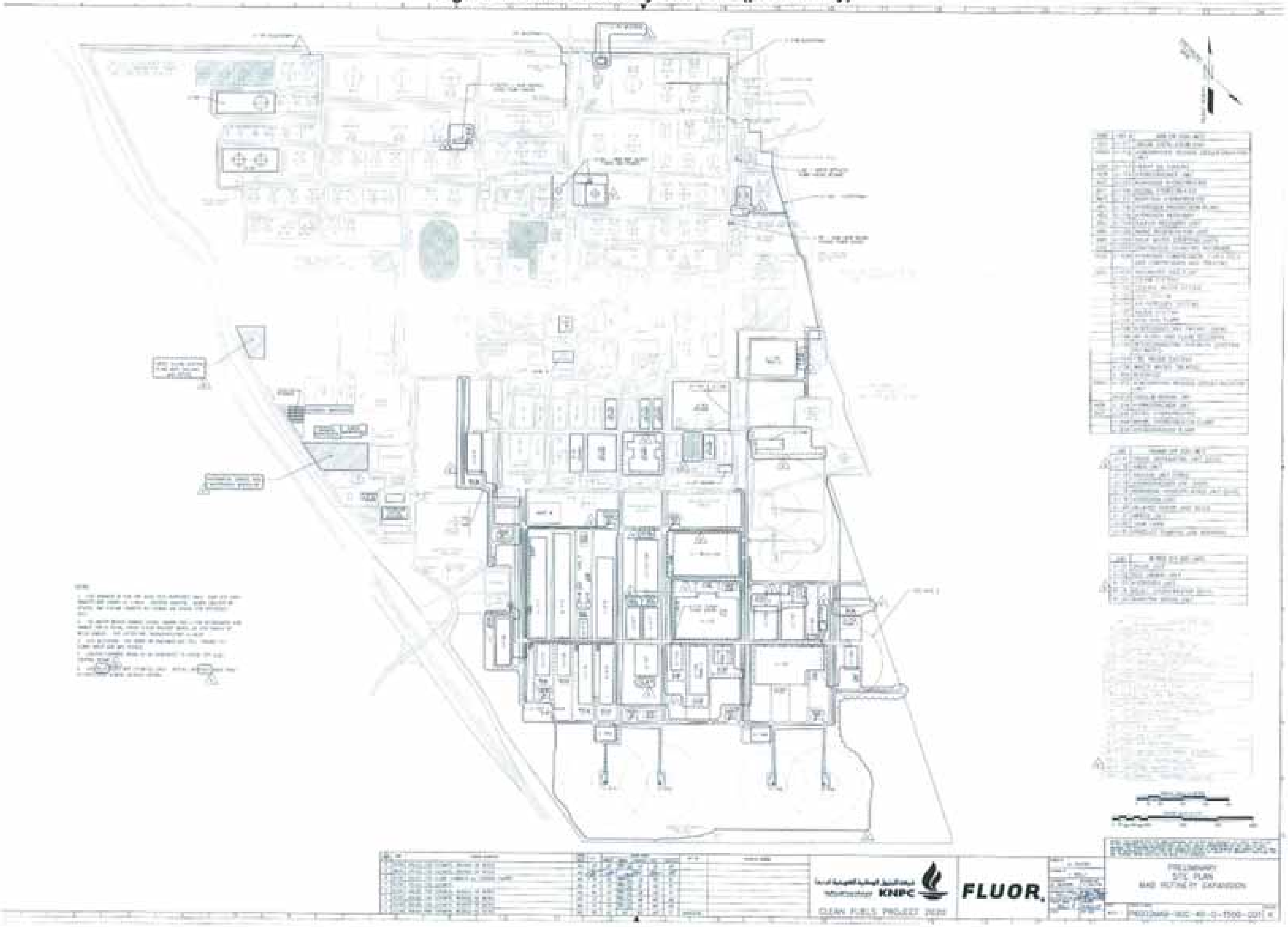


Figure 2.C: SHU Refinery Site Plan (preliminary)

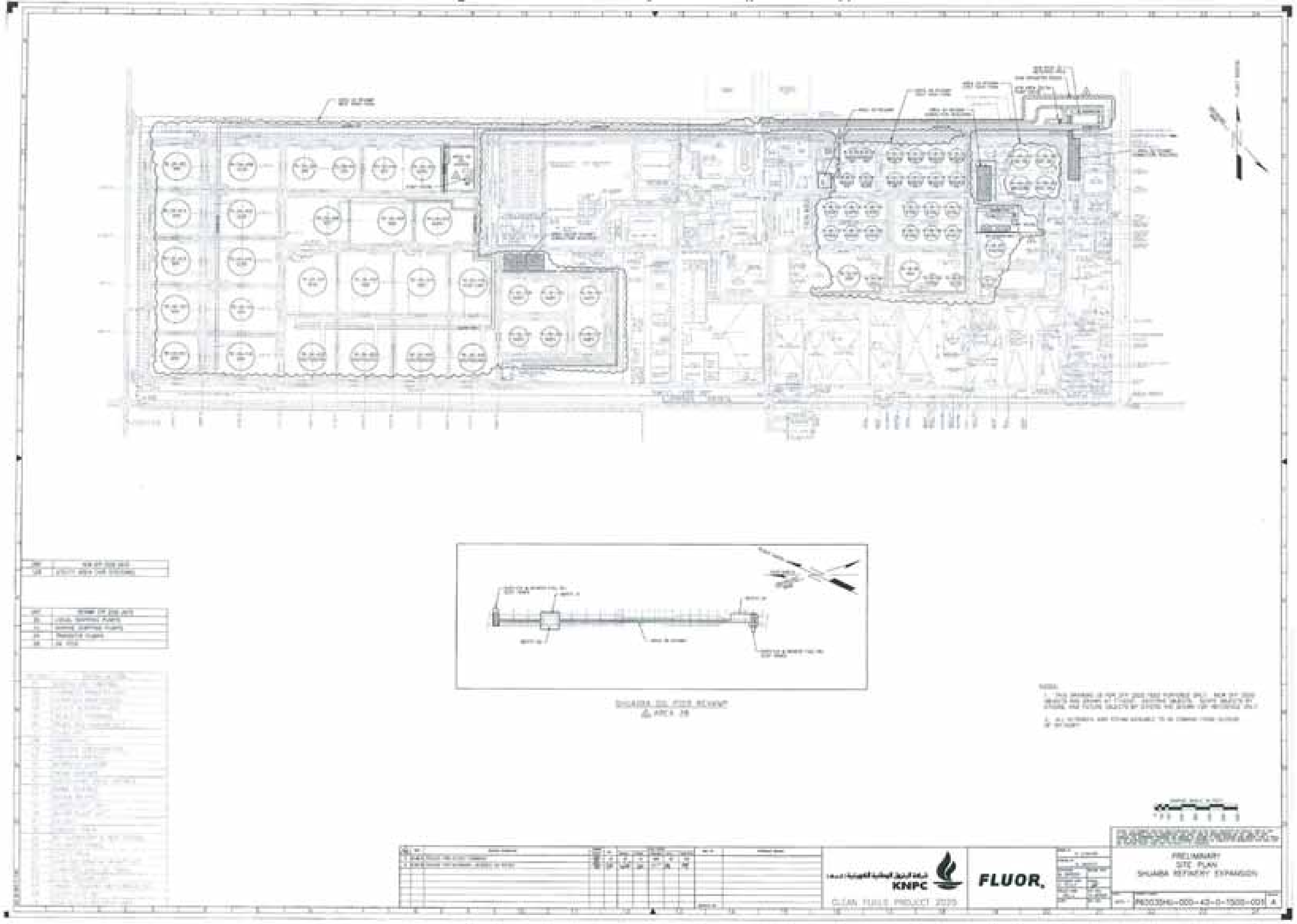


Figure 2.D: MAA Refinery Overall Block Flow Diagram (preliminary)

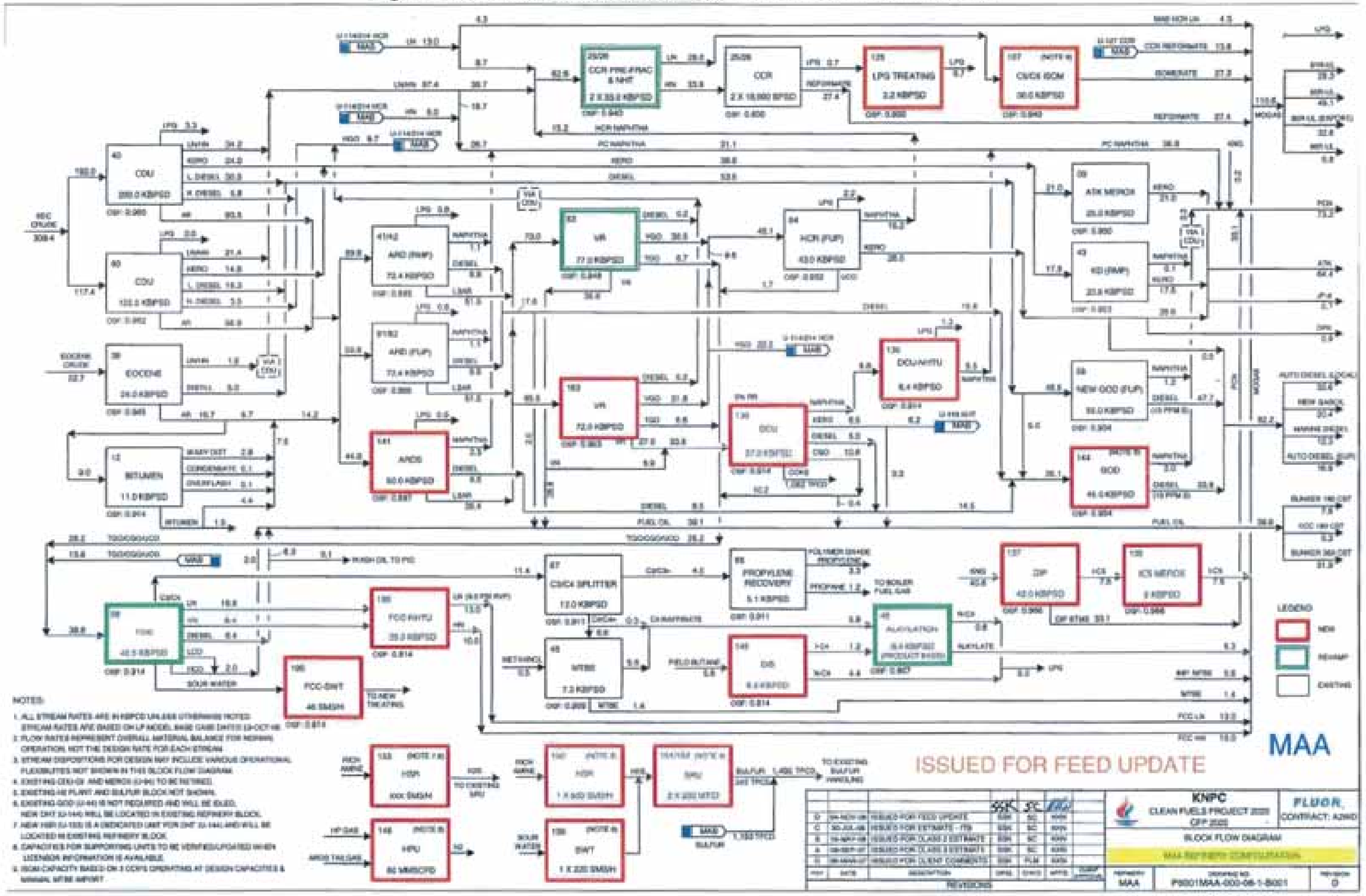
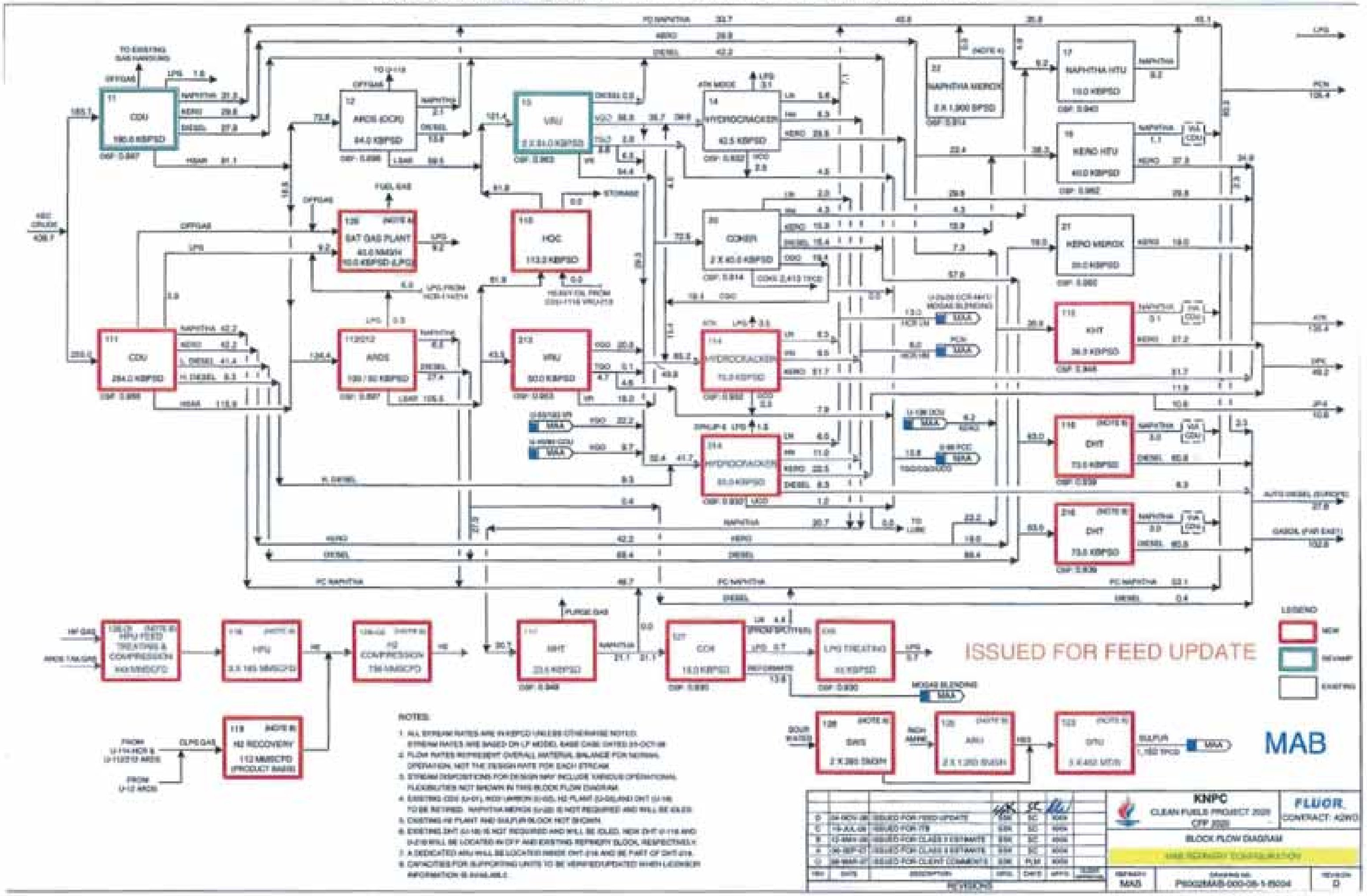


Figure 2.E: MAB Refinery Overall Block Flow Diagram (preliminary)



A brief description of CFP process units is given below. At the end of each unit description, the typical key environmental issues related to each process unit are highlighted.

Note that noise sources (pumps, compressors, forced draft fans, etc.) are typically located throughout a plant and are not highlighted individually in this Chapter, but are considered in detail in Chapter 7. Similarly, fugitive emissions take place from many units and only the key emitters (e.g. large storage tanks) are highlighted here. These volatile emissions are considered in detail in Chapter 9.

2.3.1 MAA Refinery

Twenty new process units are planned for the MAA refinery:

1	Tail Gas Treating Unit (i.e. SCOT Unit)	TGT, Unit 99
2	Isomerisation Unit	ISOM, Unit 107
3	LPG Treating Unit	LPG TU 125
4	Delayed Coker Unit - Naphtha Hydrotreating Unit	DCU-NHTU, Unit 135
5	Delayed Coker Unit	DCU, Unit 136
6	Deisopentanizer	DIP, Unit 137
7	Isopentane IC5 Merox Unit	IC5 Unit 138
8	Atmospheric Residue Desulphurization	ARDS, Unit 141
9	Gas Oil Desulfurization Unit	GOD, Unit 144
10	Deisobutanizer	DIB, Unit 146
11	Hydrogen Production Unit	HPU, Unit 148
12	Hydrogen Sulfide Removal	HSR, Unit 150
13	Sulphur Recovery Unit	SRU, Unit 151
14	Sulphur Recovery Unit	SRU, Unit 152
15	Hydrogen Sulfide Removal	HSR, Unit 153
16	Sour Water Treatment Unit	SWT, Unit 156
17	Vacuum Rerun Unit	VRU, Unit 183
18	Fluid Catalytic Cracking – Naphtha Hydrotreater	FCC-NHTU, Unit 186
19	FCC Sour Water Treating	FCC–SWT, Unit 195
20	Heavy Oil Cooling	HOC, Unit 283

Four revamped process units are planned for the MAA refinery:

1	CCR 1 & 2	Unit 25/26
2	Alkylation	Alky, Unit 46
3	Vacuum Rerun	VR, Unit 83
4	Fluid Catalytic Cracker Unit	FCU, Unit 86

Two process units are planned for retirement at the MAA refinery:

1	Crude Distillation Unit	CDU-3, Unit 03
2	Merox Unit	Unit 94

Twenty new U&O Units are planned for the MAA refinery:

1	Incoming HV Power Supply	Unit 111
2	Site Prep/Roads/Paving/Fencing/Temp Facilities & Electrical	Unit 113
3	Steam System	Unit 129
4	Integrated Control & Safety System (ICSS)/ Enterprise Integration & Communication Systems (EICS)	Unit 159
5	Interconnecting Pipeways (New CFP Block)	Unit 160
6	Interconnecting Pipeways (Existing Refinery)	Unit 161
7	Flare System (hydrocarbon flare)	Unit 162
8	Wastewater Treatment System	WWT, Unit 163
9	Fire Water Systems	Unit 166
10	Acid Gas Flare	Unit 167
11	Nitrogen/Air Systems	Unit 171
12	Fuel Gas System	Unit 174
13	Cooling Water System	Unit 175
14	Water Systems	Unit 176
15	Electrical	Unit 177
16	Buildings	Unit 178
17	Underground Piping	Unit 179
18	Coke Handling	Unit 187
19	Steam and Condensate	Unit 229
20	FUP Cooling Tower	Unit 275

Nine revamped U&O Units are planned for MAA refinery:

1	Product Loading Facility	Unit 19
2	Refinery Tank Farm (pre-RMP/FUP) and DOHA P/H	Unit 22
3	CCR 1&2 Flare	Unit 25/26
4	Eocene Topping Unit Flare	Unit 39
5	Onsite Common (RMP – Interconnecting Piping)	Unit 57
6	Oil Handling System	Unit 61
7	Acid Gas Flare	Unit 62
8	Fuel Oil Supply(FOSP)/DOHA Pumps	Unit 68
9	Onsite Common (Further Upgrade Project)	Unit 97

A number of existing MAA Units will also have tie-in with the CFP, or minor equipment modifications. However, these will not have any significant environmental impact.

2.3.1.1 New MAA Refinery Process Units

Tail Gas Treating Unit (TGT, Unit 99)

A new Shell Claus Offgas Treating (i.e. SCOT) Unit will be provided to reduce the sulphur content of waste gas streams generated by two existing sulphur recovery units (Unit 91 and Unit 92) before these streams are routed to an existing tail gas incinerator. The new SCOT Unit will not generate new air emissions, wastewater effluents or solid waste, but rather, will significantly reduce the concentration of sulphur compounds routed to the existing tail gas incinerator, and thus reduce SO_2 emissions.

Isomerisation Unit (ISOM, Unit 107)

A new C5/C6 Isomerization Unit 107 will process light naphtha from existing CCR Unit 25/26 NHT Section, and will produce isomerate product for the gasoline pool. In the current operation, the light naphtha feed streams are routed to Petrochemical Naphtha (PCN). In the CFP scope, these streams will be routed to the ISOM unit. The new ISOM will be designed to treat 30,000 BPSD of light naphtha and produce isomerate. Key environmental emissions include atmospheric emissions from two fired heaters, and spent caustic waste.

LPG Treating (Unit 125)

The LPG Treating Unit will treat the LPG liquid product from the existing CCRs. Treatment in this unit will reduce the olefins in the LPG liquid product to avoid plugging issues with the gas plant. The design capacity of the LPG Treating Unit is based on the combined LPG production from CCR Unit 25/26 and will be 2,264 BPSD.

Delayed Coker Unit - Naphtha Hydrotreating Unit (DCU-NHTU, Unit 135)

The DCU-NHTU (Unit 135) will be located on the same plot as the DCU Unit 136 and will be integrated with the DCU. The Hydrotreater will process the unstabilized full range naphtha (FRN) stream coming from the Wet Gas Compressor 2nd Stage After-Cooler Surge Drum to meet the Petrochemical Naphtha (PCN) specifications.

Any sour water streams generated by the DCU-NHTU will be integrated with that from the DCU Unit 136 and routed to the Sour Water Treatment Unit (SWT, Unit 156) in the CFP block.

Key environmental emissions from the DCU-NHTU will include:

- Atmospheric emissions from the single gas-fired heater.
- Sour wastewater, which will integrate with that from the DCU Unit 136 and be routed to the SWT (Unit 156) in the CFP block.
- Solid waste (i.e. spent catalyst).

Delayed Coker Unit (DCU, Unit 136)

Delayed Coking is a process by which heavier crude oil fractions are thermally decomposed under conditions of elevated temperature and pressure to produce a mixture of lighter oils. These lighter oils can then be processed further to produce more valuable products and petroleum coke that can be used either as a fuel or in other applications such as the manufacturing of steel or aluminum.

The DCU will have Chemical Injection Systems for anti-foam, polysulfides and antioxidants.

Key environmental emissions from the DCU will include:

- Atmospheric emissions from two gas-fired heaters.
- Particulate emissions and hydrocarbon emissions, which will be released in a batch type process during the removal of coke from the four coke drums (Note: hydrocarbon vapors will be condensed and the liquid pumped to the slop oil system).
- Sour wastewater which will be routed to the new Sour Water Treatment Unit (Unit 156) or Sour Water Stripper.
- Wastewater generated during coke cutting operations which will be recycled back to the coke cutting water tank within the unit where a hydroclone is used to separate coke fines from cutting water.

Deisopentanizer (DIP, Unit 137)

The DIP Unit will treat the Kuwait Natural Gasoline (KNG) stream produced by the MAA Refinery Gas Plant Trains to produce both normal-Pentane (n-Pentane) and Isopentane (IC5).

The DIP Unit relief systems will be routed to the existing Gas Plant HP Flare System. Key environmental emissions from the DIP will include sour water streams, which will be routed to the closest Sour Water Treatment Unit within the MAA Refinery.

There is a fired reboiler heater in this unit which will produce atmospheric emissions.

Isopentane IC5 Merox Unit (IC5, Unit 138)

The IC5 Merox Unit is needed to meet the Sulphur content requirements for the Isopentane product from the DIP Unit (Unit 137). The IC5 Merox unit will remove mercaptans sulphur from the Isopentane product to meet the 2020 Sulphur Specification of 10 ppmw before it is sent to Mogas blending. The new Unit 138 will be a single 100% capacity unit and will include sulphur extraction and caustic regeneration sections. There is no fired equipment in Unit 138. Disulfide separator vent gas will be routed to the DIP Reboiler Heater.

Key environmental emissions from the IC5 Merox Unit will include:

- Steam Condensate, which will be sent to the Wastewater Treatment Unit (Unit 163) via the ODS drain system.
- Spent Caustic, which is handled by the Spent Caustic Disposal System.
- Approximately 250 cubic feet of sand (non-hazardous solid waste from disulfide filter) every five years, which requires landfill disposal.

Atmospheric Residue Desulphurization (ARDS, Unit 141)

CFP will provide a new ARDS Unit at the MAA Refinery, which will be capable of processing 100% Atmospheric Residuum (AR) from the existing crude distillation units and existing Eocene Unit. The process removes sulphur from the hydrocarbon feed stream by treating the feed with hydrogen gas over a noble metal alloy catalyst on a fixed bed reactor.

The primary product of the ARDS Unit is a hydrotreated LSAR with 0.5 wt% sulphur. Other major products are diesel, stabilized naphtha and sour Liquefied Petroleum Gas (LPG).

Key environmental emissions from the ARDS Unit will include:

- Atmospheric emissions from the reactor feed furnace and fractionation feed furnace.
- Sour water which will be sent to a new SWT Unit (Unit 156).
- Solid waste stream (i.e. spent catalyst).

Gas Oil Desulfurisation Unit (GOD, Unit 144)

MAA has two existing GOD Units, GOD-44 (processing heavier diesel stocks) and NGOD-58 (processing predominately straight-run light diesel). GOD-44 cannot meet the CFP processing objectives and will therefore be idled upon completion of CFP. The New Gas Oil Desulphurization Unit (GOD-144) will be capable of producing Ultra Low Sulfur Diesel fuel for export. GOD-144 will process diesel from ARDS-41/42/81/82, ARDS-141, Delayed Coker Unit (DCU) 136, and light diesel from CDU 4 and 5. Heavy diesel from CDU-4 and 5 will be processed in the Hydrocracker (HCR-84). The design capacity of GOD-144 will be 45,000 BPSD.

The primary product of GOD-144 will be Ultra Low Sulfur Diesel (ULSD). The unit also produces Wild Slops (un-stabilized naphtha and kerosene) as a secondary product.

Key environmental emissions from the revamped GOD Unit will include:

- Atmospheric emissions from the reactor charge heater.
- Sour water.
- Solid waste (i.e. various spent catalysts including Nickel-Molybdenum and Cobalt-Molybdenum).

Deisobutanizer (DIB, Unit 146)

The existing DIB at MAA cannot produce the required amount of make-up Isobutane because it cannot handle the necessary feed rate of Field Butane. The current Field Butane feed to the DIB is 2,400 BPSD, but 6,450 BPSD is needed to produce the required amount of make-up Isobutane, and thus a new DIB unit will be installed to operate in parallel with the current DIB unit. The new DIB will be sized to handle 6,800 BPSD.

The main purpose for providing a full-sized DIB is to allow flexibility to operate the Alky Unit when the existing DIB is down for maintenance, or to provide additional Isobutane as required.

Key environmental emissions from the DIB will include:

- Liquid Blow Down routed to storage
- Oily Water Sewer routed to storage (wet slops)

Hydrogen Production Unit (HPU, Unit 148)

The total hydrogen requirement for the new hydroprocessing units is provided from the new HPU, which will provide up to 60 MMSCFD of hydrogen product. The HPU will produce hydrogen from the treatment and compression of high pressure fuel gas and ARDS tail gas. A common feed gas compression/ H_2S scrubbing unit will be provided upstream of the new HPU. The new HPU will utilize steam reforming to generate hydrogen.

The only fired equipment item within the new HPU will be the Reforming Furnace. A variety of catalysts will be required.

Key environmental emissions from the HPU will include:

- Atmospheric emissions from the Reforming Furnace.
- Solid waste (i.e. spent catalysts).
- Liquids collected in the HPU flare knockout drum, which will be routed to the MAA Refinery Wet Slop Oil Header.

Hydrogen Sulfide Removal (HSR, Unit 150)

H_2S is stripped out of Rich Amine (circulating solvent that removes H_2S from refinery gas and product streams) in the HSR and is sent as a concentrated acid gas stream (Lean Amine) to the Sulphur Recovery Unit and Tail Gas Treating Unit. Absorbers in the MAA Refinery will use an aqueous solution containing Methyl-Diethanol Amine (MDEA) to remove H_2S from refinery gas and product streams.

There will be two new HSR Units at the CFP: HSR 150 and HSR 153 (see next page for HSR 153). HSR 150 will have two (2) 60% capacity trains with a design capacity of 250 standard m^3/hour of rich Amine.

Acid gas will be stripped out of the amine solution using kettle reboilers with low pressure steam. The H_2S overhead stream is piped to the SRU (Units 151/152). The Amine Regenerator Overhead System will require a water purge to the Sour Water Stripper (Unit 156).

Key environmental emissions from the HSR will include:

- Oily water (ODS will be provided to collect any oily water generated during steam out of vessels and other equipment during shutdown).
- Solid waste (i.e. spent activated carbon and filter cartridges).

Sulphur Recovery Units (SRUs, Units 151 & 152)

H_2S will be recovered and sent to the new SRUs where it will be converted into elemental Sulphur and exported as a refinery byproduct. Two identical SRUs will be provided. The new SRUs will be designed to process acid gas streams from the new HSR, ARU, SWS and SWT Units. The SRUs will recover at least 99.9 weight percent sulphur from the acid gas feed streams, incinerate the ammonia, and oxidize the residual sulphur to sulphur dioxide before venting it to the atmosphere.

Each SRU train will have a Tail Gas Incinerator, including waste heat recovery for steam optimization and utilization within the unit and for steam export. A dedicated incinerator stack will also be provided for each train.

Key environmental emissions from the SRU will include:

- Atmospheric emissions, primarily SO_2 from the Tail Gas Incinerator within each SRU.
- Solid waste (i.e. spent catalyst, ceramic balls, and filter cartridges)

Hydrogen Sulfide Removal (HSR, Unit 153)

MAA has two existing HSR Units which run at near capacity to support the existing refinery H_2S removal requirements. There is no spare capacity to support new units installed as part of the CFP so two new HSR Units will be provided: HSR 150 and HSR 153.

HSR 153 will service new users in the existing block and will utilize DIPA for compatibility with the existing refinery. It will strip the absorbed H_2S from the rich amine stream from GOD 144, regenerating the amine prior to recirculation. The stripped H_2S is sent as a concentrated acid gas stream to the Sulfur Recovery Unit where it is converted to elemental sulfur to be disposed of as a refinery byproduct. The stripped rich amine is returned as lean amine to the amine absorber in GOD-144.

HSR 153 will have sufficient capacity to process GOD 144 LP sour offgas in addition to 5 MMSCFD of sour gas from the existing refinery.

Key environmental emissions from the HSR will include:

- Oily water (ODS will be provided to collect any oily water generated during steam out of vessels and other equipment during shutdown).
- Solid waste (i.e. spent activated carbon and filter cartridges).

Sour Water Treatment (SWT, Unit 156)

Sour water containing appreciable concentrations of Hydrogen Sulfide (H_2S) and Ammonia (NH_3) is produced from several units. The sour water will be steam stripped in the new SWT to suitable levels of H_2S and NH_3 for additional treatment in the CFP Wastewater Treating Unit (Unit 163).

The SWT will be designed to separate gas, light hydrocarbons, and oil emulsions from the sour water feed before steam stripping to remove the bulk of the H_2S and NH_3 (maximum 20 ppmw and 50 ppmw, respectively). A Caustic Injection System is provided to introduce caustic (NaOH) solution into the Stripper Column as required.

Sour water may also contain phenols, cyanides, chlorides and carbon dioxide. The treated sour water from the Stripper Column will be routed into two headers. One header is for refinery reuse and the other for discharge to the Wastewater Treating (WWT) Unit.

Key environmental emissions from the SWT will include:

- Treated sour water, which is sent to the WWT Unit for additional treatment.
- The H_2S and NH_3 rich acid gas from the Stripper Column, which will be sent to the SRUs (Units 151/152) where H_2S is converted to elemental sulphur.

Vacuum Rerun Unit (VRU, Unit 183)

The VR Unit will have a capacity to process approximately 50,000 BPSD of Low Sulphur Atmospheric Residuum (LSAR) from the ARDS units to yield a variety of products, including DFO, VGO, TGO and VR.

The only fired equipment item within the new VR Unit is the Vacuum Charge Heater.

Key environmental emissions from the VR Unit will include:

- Atmospheric emissions from the gas-fired Vacuum Charge Heater.
- Off-gas from the Ejector System will be routed through an MDEA scrubber prior to being disposed of by burning in the Vacuum Charge Heater.
- Sour water collected in the condensate drums and routed to the SWS Unit.
- Slop oil, which will be collected in the condensate drums.

Fluid Catalytic Cracking – Naphtha Hydrotreater Unit (FCC NHTU, Unit 186)

The new FCC-NHTU will process high sulphur light naphtha (LN) and high sulphur heavy naphtha (HN) streams from the revamped FCC (Unit 86) to produce low sulphur light and heavy naphtha streams with a maximum sulphur content of 10 ppmw. These product streams will then be used as blending components of the gasoline pool. The FCC-NHTU will consist of two major sections: Selective Hydrogenation (SH) Unit and Splitter, and Hydrodesulphurization (HDS).

Key environmental emissions from the FCC NHTU will include:

- Atmospheric emissions from two HDS Reactor Heaters.
- Sour water which will be piped to the existing Sour Water Stripper Unit.
- Solid waste (i.e. spent catalysts generated in both the SH and HDS sections of this unit).

FCC Sour Water Treating Unit (SWT, Unit 195)

A new sour water treatment unit (SWT, Unit 195) will be installed to meet the higher sour water rate based on the revamp of some existing units and the addition of new processing units. It will be designed for 125% of the normal sour water flow rate from FCC Unit 86. The capacity of this unit is 202.5 gpm.

The proposed location of this unit is north of FCC-NHT Unit 186. The existing SWT Unit 95, which is used to treat Unit 86 phenolic sour water, will be made available to process non-phenolic sour water from both the RMP & FUP blocks of process units.

Flexibility will be provided to divert some non-phenolic sour water to SWT Unit 195 via a flow control valve, during times of excess non-phenolic sour water generation.

Key environmental emissions from the SWT will include:

- Stripped Sour water which will be sent to the WWT plant
- Gaseous discharges (Nitrogen and traces of H_2S) from the sour water storage tank

Heavy Oil Cooling Unit (HOC, Unit 283)

HOC Unit 283 will use a tempered diesel recirculation system to cool heavy oil products from the new Vacuum Rerun Unit 183 to an acceptable operating temperature before transfer to storage. In addition, this system will include the capability to cool hot LSAR from the new ARDS Unit 141 before being routed to storage in the event that Unit 183 is shut down.

Apart from slops, there are no major environmental emissions from the HOC Unit.

2.3.1.2 Revamped MAA Refinery Process Units

CCR 1&2 (NHT, Units 25 & 26)

Existing Units 25 & 26 are two identical units that each consist of two major sections: Naphtha Hydrotreater (NHT) and Continuous Catalytic Reformer (CCR). Hydrotreated naphtha is separated into light naphtha and heavy naphtha in a splitter column located in each of the NHTs. The heavy naphtha product from NHT is fed to CCR, as per the existing configuration. The light naphtha product will be rerouted as feed to the new Isomerisation unit 107.

These units have atmospheric emissions from the two existing charge heaters and generate solid waste in the form of spent catalyst. However, the revamp work will not result in any additional emissions impacts.

Alkylation (Alky, Unit 46)

CFP will revamp (i.e. increase capacity of) the existing Alkylation Unit to handle a revised composition and higher feed rate of Methyl Tertiary Butyl Ether (MTBE) C4 Raffinate stream. This revamp will increase Alkylate production required for Mogas blending. A new Deisobutanizer (DIB) Column will be added to increase overall DIB capacity.

CFP will increase capacity of the LPG plants to handle the C_3/C_4 streams from the new and revamped units. Therefore, the amount of Isobutane used as feed to this unit has to be increased in order to meet the required Alkylate specification. The Alkylate produced will be sent to the Mogas pool as an important blending stock which can improve the octane and reduce the consumption of imported MTBE.

Key environmental emissions from the revamped Alky Unit will include:

- Spent acid
- Spent caustic

Vacuum Rerun Unit (VRU, Unit 83).

The existing VRU is an open arts unit that was constructed in 1986 with a design capacity of 77,000 BPSD. The feed for this unit is Low Sulphur Atmospheric Residue (LSAR) with a maximum Sulphur content of 0.7%.

In the pre-revamp operation, the main products of Unit 83 are VGO and VR. The components of VGO are drawn off separately from the column and are only mixed after the heat of the HVGO product has been utilized to preheat the feed to the column. The vacuum residue product that is recovered from the bottom of Unit 83 is used for the production of low sulphur fuel oil.

Unit 83 includes one existing gas fired charge heater (H-83-001). The revamp work will not add any new fired equipment nor will it change the existing fired equipment. There will be no impact to the amount or type of effluents generated including atmospheric emissions as a result of the revamp activities. No solid waste is generated by this unit. Ejector condensate (i.e. sour water) is routed to the Sour Water Stripper and ejector slop oil (i.e. dry slops) is processed by the Dry Slops System.

Fluid Catalytic Cracking Unit (FCC Unit 86)

The existing FCC Unit at the MAA Refinery was initially designed in 1984 for a feed rate of 30,000 BPSD of hydrotreated VGO. The unit was revamped in 1997 to increase capacity to 40,000 BPSD. However, parts of the recommended scope on the unit revamp for the reactor, spent catalyst stripper, and feed distributor system were not implemented.

The revamp scope consists of the following work:

- Upgrade of regenerator system to cold wall design,
- Replacement of the feed distribution system with UOP Optimix device,
- Installation of new fluffing air rings and compressor,
- Upgrade of reactor cyclones,
- Upgrade of the spent catalyst stripper to state of the art technology,
- Any additional equipment upgrades identified during scoping study by UOP.

The revamped design will allow the FCC Unit to handle 42,500 BPSD of a heavier feed blend containing VGO and TGO (Trim Gas Oil), CGO and Unconverted Oil (UCO) from various new and existing process units.

A new electrostatic precipitator (ESP) will be installed to reduce particulate emissions from the existing FCC Unit (Unit 86) at MAA under a separate project, which will result in environmental improvement.

Key environmental emissions from the revamped FCC Unit will include:

- Atmospheric emissions from the existing fired heater.
- Suspended particulates (dust particles) emitted from the FCCU to atmosphere.
- Solid waste (i.e. spent catalyst).

2.3.1.3 Retired MAA Refinery Process Units

Crude Distillation Unit (CDU Unit 03)

The CDU is the first important processing step in a refinery. In this unit, crude oil is heated to elevated temperatures and then it is distilled and various fractions are separated according to their boiling ranges. MAA KEC crude that is currently processed by Unit 03 will be routed to the remaining CDUs (CDU Unit 40 and CDU Unit 80). The retirement of this unit will result in a decrease in atmospheric emissions.

Merox Unit 94

The Merox Unit reduces the sulphur content of kerosene feed from CDUs and is currently treating refinery gasoline product. It does not have any fired equipment or solid waste. Once Unit 94 has been retired, the gasoline product will be treated in the new FCC-NHTU Unit 186. The retirement of this unit will result in a decrease in noise.

2.3.1.4 New MAA Refinery Utility & Offsite Units

Many of these facilities will have minimal environmental impact, as they are not process units, and other than the Steam System, do not have continuously operating fired equipment. Impact during their construction is dealt with in relevant chapters. Below, focus is given to those facilities with potential for impacting the environment.

It is noted that material containing Polychlorinated Biphenyls (PCBs) will not be used in equipment provided by the CFP.

Steam System (Unit 129)

The Steam System will be designed to produce steam and boiler feed water (BFW) to support continuous operation of the new CFP refinery units. The steam is used for driving steam turbines, as a process reactant in the production of Hydrogen, and for heating.

Key environmental emissions from the Steam System will include:

- Oily water, which will be routed via gravity drains to the Accidentally Oil Contaminated (AOC) sewer for appropriate treatment and/or disposal.
- Atmospheric emissions from three Utility Steam Boilers.
- Boiler Blowdown.

Hydrocarbon Flare System (HFS, Unit 162)

The Hydrocarbon Flare System (HFS) represents one of the key safety systems in the CFP. It serves as the final line of protection against catastrophic failure resulting from overpressure of equipment and interconnecting piping. The purpose of the HFS is to provide the means for the safe relief and combustion of potentially explosive and/or toxic fluids. These gases and liquids, which are present as feeds, products, or intermediate streams within the refinery processes, must be flared under unplanned upset conditions.

New CFP flares will all be elevated flares.

A single Flare Gas Recovery Unit (FGRU) will be provided. Functionally, a single FGRU will take suction from the flare header at a point located between the Main KO Drum and Water Seal Pot. The FGRU is designed to recover the combined purge/vent flow from each flare header.

Additionally, under typical refinery operations, gases may be vented or liquids blown down to the flare to maintain a required process operating pressure. It is also common practice to start-up or shutdown a process unit by temporarily venting hydrocarbon gases to the flare until the unit can be properly lined out (start-up) or de-pressured and purged (shutdown). However, for the CFP, refinery operations will implement suitable sequencing of unit startups and shutdown to minimize simultaneous planned flaring from different process units.

The key environmental emissions from the Hydrocarbon Flare System will include:

- Gaseous Emissions – SO_2, CO, NO_2 and Hydrocarbons
- Wet slops

Wastewater Treatment System (WWT, Unit 163)

A new WWT plant will be provided to collect, convey and treat wastewater from the MAA CFP block according to the K-EPA requirements prior to any discharge. Process wastewater streams from the CFP units as well as fire fighting water and rainwater runoff from paved process areas are the main streams treated in the WWT Unit.

The new CFP facilities will incorporate state of the art design to complement upgrades to the existing MAB effluent treatment facility under a separate project (KNPC Effluent Treatment Facility Revamp project). The CFP design will incorporate best environmental engineering practices such as 'Best Available Control Technology' (BACT) to avoid, prevent or mitigate the discharge of harmful emissions so as to meet (or exceed) applicable K-EPA environmental standards.

The main wastewater streams treated in the WWT units are process wastewater streams from the CFP units, such as surplus Stripped Sour Water (SSW), Cooling Tower (CT) blowdown, boiler blowdown, as well as fire fighting water and storm water runoff from paved process areas. Storm water runoff from areas and roadways outside paved process areas is collected in an oil catcher and pumped to the Gulf.

The effluent streams generated and collected from the new CFP process units are segregated at the source and collected in one of following seven drainage systems. Effluents segregated and collected in these drainage systems receive different treatment, depending on the source, type and level of contamination.

- Accidentally Oil Contaminated (AOC)

- Oily Drips System (ODS)
- Chemical Collection and Drainage System
- Dry Slops System
- Outside Battery Limits (OSBL) and Roadway Storm Water Drainage System
- Sanitary and Gray Water Collection
- Sludge Collection and Treatment

The key environmental emission from the WWT System will be the treated wastewater discharge to the Gulf.

Fire Water Systems (Unit 166)

The firewater system facilities include the following major unit components:

- Firewater Tanks, pumps and drivers.
- Biocide Injection Systems.
- Ring-Main System.
- Hydrants, Monitors, Post-Indicating Valves, Hose Reels.
- Foam Extinguishing and Storage Systems.
- Water Spray Systems.
- Sprinkler Systems.

Freshwater is supplied for initial make-up of the firewater tanks. Treated effluent water (utility water) from the waste water treatment plant will be used for normal make-up of firewater tank level.

There are no major environmental emissions from the Fire Water Systems, except in an emergency (contaminated firewater) or when fire water pump drivers (diesel engines) are periodically tested.

Acid Gas Flare (Unit 167)

The new elevated Acid Flare System represents one of the key safety systems in the CFP. It serves as the final line of protection against catastrophic failure resulting from overpressure of equipment and interconnecting piping. The purpose of the Acid Flare System is to provide the means for the safe relief and combustion of potentially explosive and/or toxic fluids containing H_2S. These gases and liquids, which are present as feed products, or intermediate streams within the refinery processes, must be flared under unplanned upset conditions.

Additionally, under typical refinery operations, gases may be vented or liquids blown down to the Acid flare to maintain a required process operating pressure. It is also common practice to start-up or shutdown a process unit by temporarily venting gases to the Acid Gas Flare until the unit can be properly lined out (start-up) or de-pressured and purged (shutdown). However, for the CFP, refinery operations will implement suitable sequencing of unit startups and shutdown to minimize simultaneous planned flaring from different process units.

Key environmental emissions from the Acid Gas Flare will include:

- Gaseous Emissions: SO_2, CO, Hydrocarbon, NO_2.
- Sour water from the flare KO drum pumps.

Nitrogen/Air Systems (Unit 171)

The Nitrogen/Air Systems must supply sufficient compressed air to meet the demands of Instrument Air and Plant Air.

Key environmental emissions from the Nitrogen/Air systems will include:

- Water and oily water from air compressors and air dryer package.
- Solid waste (i.e. spent Desiccant Activated Alumina from air dryer packages).

Fuel Gas System (FGS, Unit 174)

Refinery Fuel Gas for the CFP units is supplied primarily by the Coker. When the Coker is down, imported fuel gas will be the primary makeup source.

The main objectives of the FGS are to:

- Remove H_2S from imported fuel gas and ARDS Fractionator off gas with Fuel Gas Scrubber.
- Collect fuel gas from the refinery off gas and treated imported fuel gas, and distribute to various fired heaters and steam generators throughout the MAA facilities.

Key environmental emissions from the FGS will include:

- Oil drips.
- Solid waste (i.e. cartridges from Amine Sump Filter).

Cooling Water System (CWS, Unit 175)

The objective of the Cooling Water System is to maintain the cooling water circulation rate and temperature in order to remove heat from the process and utility units in the new CFP Units at the MAA Refinery.

The Cooling Water System is a closed circuit water system. The major equipment consists of a cooling tower and cooling water pumps. The cooling water is pumped from the cooling tower basin to various process and utility units to remove the heat loads from the units. The hot returning cooling water then enters the cooling tower where the heat is dissipated to the atmosphere.

A small stream of cooling water is directed to blow-down to control the concentration of dissolved solids in the circulating cooling water. Desalinated water is used as make up to the cooling tower basin to replenish the water losses primarily due to evaporation and blow-down. Fresh water is used as back up to the desalinated water. Chemical feed systems are provided to condition the cooling water quality for proper operation.

Key environmental emissions from the Cooling Water System will include:

- Blowdown from cooling water pumps.
- Backwash from side stream filter.

Coke Handling Unit (Unit 187)

A new Coke Handling Unit (Unit 187) in the MAA plant will be provided to transport the coke from the new Delayed Coker Unit (Unit 136) to the existing Coke Storage Building (BD-72-101). In the event of a downstream upset or if the existing Coke Storage Building is full, the Coke Handling Unit can divert the coke to a new Emergency Coke Storage Building which is part of Unit 187.

The new Coke Handling Unit begins at the first coke conveyor inside the new Delayed Coker Unit and extends to the existing Coke Storage Building, BD-72-101, physically tied-in at the existing conveyor BT-72-101. Unit 187 consists of a covered belt conveyance system, ventilation system, deluge system, spray water system, dust collection system, and coke emergency storage and reclaim system.

Key environmental emissions from the Coke Handling Unit will include:

- Dust - To minimize the amount of dust during the transfer of coke, each conveyor transfer chute has a water spray system to suppress the air born dust. The sprayers are switched on automatically when the belts are loaded. Flow rates for each sprayer can be manually adjusted by the operator to meet dust suppression needs. There are also ventilation systems consisting of two inlet air filters and two fans; one fan is operating while the other is on standby. The fans are designed to optimize the air flow for the proper ventilation and displace sufficient volumetric flow to maintain a negative pressure inside the galleries. The negative pressure will prevent any dust emissions from exiting the galleries and transfer towers and entering the surrounding environment.
- Contaminated Water (i.e. water containing coke fines) - Drainage sumps are provided for each transfer tower. These sumps collect the dirty water drains from the coke while being transported or stored and from the spray water system at each tower. The dirty water collected in the sumps is pumped back to the DCU for use as coke cutting water.

2.3.1.5 Revamped MAA Refinery Utilities and Offsite Units

Many of these facilities will have minimal environmental impact, as they are not process units. Impact during their construction is dealt with in relevant chapters. Below, focus is given to those facilities with potential for impacting the environment during operation.

Refinery Tank Farm (pre-refinery Modernization Project RMP, Unit 22)

The tankage facilities will include the following:

- Intermediate product storage.
- Product blending.
- Pumping.
- Finished product storage.

- Product transfer and ship loading.
- Inter-Refinery Transfer (IRT).

Finished and intermediate products are transferred from the processing units to the storage facilities. From storage, intermediate products are pumped to other processing units for finishing or sent to product blenders. Finished products are pumped to the New Oil Pier for ship loading, sent to the local market, or transferred to MAB or SHU. Tankage provides continuous feed capacity to processing units and storage of products/intermediates during unit shutdowns.

Existing storage facilities and pumps will be re-aligned to the operating philosophy for the CFP.

Key environmental impacts will include VOC emissions from the storage, filling and emptying of hydrocarbon tankage.

CCR-1&2 Flare (Units 25/26)

The existing Units 25 & 26 are two identical units each consisting of two major sections: Naphtha Hydrotreater (NHT) and Continuous Catalytic Reformer (CCR). Hydrotreated naphtha is separated into light naphtha and heavy naphtha in a splitter column located in each of the NHTs. The heavy naphtha product from NHT is fed to CCR, as per the existing configuration. A study done in 2008, confirms that the existing major equipment are suitable for the revamp operating conditions and for providing feed definition for the downstream C5/C6 Isom unit. Existing Flare Units 25/26 will be revamped to serve the Units.

Key environmental impacts from the flares will include atmospheric emissions.

Eocene Topping Unit Flare (Unit 39)

The purpose of the revamped elevated Flare Unit 39 is to provide the means for the safe relief and combustion of potentially explosive and/or toxic fluids - it represents one of the key safety systems in the KNPC Clean Fuels Project 2020 (CFP-2020). Additionally, under typical refinery operation, gases may be vented or liquids blown down to the flare system to maintain a required process operating pressure or liquid level.

The flare is designed to receive the relief loads from the Eocene Topping Unit 39, the Bitumen Plant Unit 12 and the new Storage Facilities Unit 61. For design purposes, a liquid rate equivalent to 5 wt% of the gas stream is assumed for sizing the knock-out drum and pump.

Key environmental impacts will include atmospheric emissions.

Flare (Unit 62)

Elevated Flare Unit 62 is to be revamped under the CFP. Key environmental emissions from the flare will include atmospheric emissions during emergency relief. Emissions are expected to be minimal during normal refinery operations.

2.3.2 MAB Refinery

Nineteen new process units are planned for the MAB refinery:

1	Crude Distillation Unit	CDU, Unit 111
2	Atmospheric Residue Desulphurization	ARDS, Unit 112
3	Atmospheric Residue Desulphurization	ARDS, Unit 212
4	Heavy Oil Cooling	HOC, Unit 113
5	Hydrocracker Unit	HCR, Unit 114
6	Kerosene Hydrotreater Unit	KHT, Unit 115
7	Diesel Hydrotreater Unit	DHT, Unit 116
8	Naptha Hydrotreater Unit	NHT, Unit 117
9	Hydrogen Plant	H2 Plant, Unit 118
10	Hydrogen Recovery	HR, Unit 119
11	Sulphur Recovery Unit	SRU, Unit 123
12	Amine Regeneration Unit	ARU, Unit 125
13	Sour Water Stripping Unit	SWS, Unit 126
14	Continuous Catalytic Reformer	CCR, Unit 127
15	Hydrogen Production Unit (HPU) Feed Treating & Compression	HR Unit 128-01 & 128-02
16	Saturates Gas Plant	SGP, Unit 129
17	Vacuum Rerun Unit	VRU, Unit 213
18	Hydrocracker Unit	HCR, Unit 214
19	Diesel Hydrotreater Unit	DHT, Unit 216

Two revamped process units are planned for the MAB refinery:

1	Crude Distillation Unit	CDU, Unit 11
2	Vacuum Unit	VU, Unit 13

Three process units are planned for retirement at the MAB refinery:

1	Crude Distillation Unit	CDU, Unit 01
2	RCD Unibon Unit	Unit 02
3	Hydrogen Unit	H2 Plant, Unit 03

Nineteen new U&O Units are planned for the MAB refinery:

1	Steam System	Unit 131
2	Cooling Water System	Unit 132
3	Fuel System	Unit 133
4	Nitrogen/Air Systems	Unit 134
5	Electrical	Unit 136
6	Water Systems	Unit 137
7	Acid Gas Flare	Unit 146
8	Interconnecting Pipeways (New CFP Block)	Unit 148

9	Hydrocarbon Flare	Unit 149
10	Interconnecting Pipeways (Existing Refinery)	Unit 150
11	Incoming HV Power Supply	Unit 152
12	Fire Water Systems	Unit 154
13	Wastewater Treatment System	Unit 156
14	Integrated Control & Safety System (ICSS)/ Enterprise Integration & Communication Systems (EICS)	Unit 159
15	Buildings	Unit 165
16	Site Prep/Roads/Paving/Fencing/Temp Facilities & Electrical	Unit 166
17	Underground Piping	Unit 179
18	DHT Flare	Unit 249
19	HCR Flare	Unit 314

Six revamped U&O Units are planned for MAB refinery:

1	Utilities and Offsites	Unit 06
2	Interconnecting Pipeways	Unit 48
3	Tank Farm	Unit 50
4	Product Pumping & Blending	Unit 51
5	Pre-RMP Tank Farm	Unit 52
6	Inter Refinery Transfer Lines	Unit 53

A number of existing MAB Units will also have tie-in with the CFP, or minor equipment modifications. However, these will not have any significant environmental impact.

2.3.2.1 New MAB Refinery Process Units

Crude Distillation Unit (CDU, Unit 111)

The new CDU will have a capacity to process 264,000 BPSD of KEC feed, while the remaining 190,000 BPSD of KEC is fed to the existing CDU (Unit 11, which will be revamped under this project). The new CDU will have two main sections: the Crude Tower Section and the Naphtha Stabilizer Section.

Unit 111 produces medium and low pressure off-gases, LPG, Naphtha, Kerosene, Light and Heavy Diesel, and Atmospheric Residue. The Naphtha is a finished product, while all the other streams undergo further processing.

Key environmental emissions from the CDU will include:

- Atmospheric emissions from the two crude heaters.
- Sour waste water which will be routed to the SWS Unit for treatment.
- Desalter Effluent Water, which will be routed to WWT (Unit 156).

Atmospheric Residue Desulphurization (ARDS, Unit 112 & Unit 212)

CFP will provide two new ARDS Units at the MAB Refinery, which will be designed to process 100% High Sulphur Atmospheric Residuum (HSAR) from the new CDU (Unit 111). The process removes sulphur from the hydrocarbon feed stream by treating the feed with hydrogen gas over a noble metal alloy catalyst of a fixed bed reactor. Unit 112 will consist of two identical trains. Unit 212 will have a single train. The primary product of the ARDS Units is a hydrotreated LSAR with 0.5 wt% sulphur. Other major products are diesel, stabilized naphtha and sour Liquefied Petroleum Gas (LPG).

This process and associated emissions are further described in the process unit in MAA (ARDS, Unit 141).

Key environmental emissions from each ARDS Unit will include:

- Atmospheric emissions from the reactor feed furnace(s) and fractionation feed furnace.
- Sour water sent to centralized Sour Water Treating (SWT) unit
- Solid waste stream (i.e. spent catalyst).

Heavy Oil Cooling (HOC, Unit 113)

Apart from slops, there are no major environmental emissions from the HOC Unit.

Hydrocracker (HCR, Unit 114)

A new HCR Unit will be provided to convert VGO, TGO, and CGO to lighter products. It will produce sour LPG light naphtha, heavy naphtha, kerosene, diesel (when operating in Distillate mode), and a small amount of unconverted oil (UCO). Kerosene is the primary intended product.

Key environmental emissions will include:

- Atmospheric emissions from three gas fired heaters.
- Solid waste (i.e. spent catalyst)
- Sour water will be sent to the new Sour Water Stripping Unit (Unit 126).

Kerosene Hydrotreater (KHT, Unit 115)

The new KHT will be fuel-gas fired and will produce Dual Purpose Kerosene (DPK). The unit will be designed to process a flow of straight run (SR) kerosene and coker kerosene. The MAB Refinery currently has an existing 100 ppmw Sulphur Kerosene Hydrotreater (KHTU-15). The specification for hydrotreated kerosene from the new KHT will be a maximum of 7 ppmw sulphur as required for blending into the Ultra Low Sulphur Diesel (ULSD) pool.

The new KHT will consist of two sections: a Reactor Section and a Product Stripper Section. The KHT feedstock will be reacted over a catalyst bed in a Hydrogen-rich environment at elevated temperature. The process reduces the Sulphur content and improves the smoke point as required to meet ATF specifications.

Key environmental emissions from the CDU will include:

- Atmospheric emissions from one gas fired charge heater.
- Sour water, which will be sent for treatment to the new SWS (Unit 126).
- Solid waste (i.e. spent catalyst).

Diesel Hydrotreater (DHT, Unit 116 & Unit 216)

As part of the CFP-2020, two new DHT Units (Unit 116 and Unit 216) will be installed capable of processing 73 KBPSD and producing Ultra Low Sulfur Diesel (ULSD) fuel for export. Unit 116 will be retained within the new CFP Refinery Block whereas Unit 216 will be located within the existing MAB Refinery area to allow for the continued production of ULSD during CFP shutdowns.

Both Units will be designed to process an identical feed slate consisting of light straight (SR) diesel, ARDS diesel and coker diesel to satisfy ULSD Product Quality Specifications while also meeting a minimum catalyst run length of 30 months. All unit feedstocks are derived from 100% KEC. Unit-216 will be provided with a dedicated amine regeneration unit to minimize impact to the existing refinery facilities.

Key environmental emissions from each DHT will include:

- Atmospheric emissions from gas fired charge heater.
- Sour wastewater, which will be sent for treatment to a SWS.
- Solid waste (i.e. spent catalyst).

Naphtha Hydrotreater (NHT, Unit 117)

A new NHT will be provided to produce hydrotreated/desulphurized full range Naphtha. The new NHT will be directly coupled to a new downstream CCR.

The quality of the hydrotreated naphtha product from the new NHT contains a maximum sulphur level of <0.5 ppmw, a maximum nitrogen level of <0.5 ppmw, and have a bromine index < 100 (nil olefins).

The NHT feedstock will be reacted over a catalyst bed in a Hydrogen-rich environment at elevated temperature. The process will de-sulphurize the heavy Naphtha to meet CFP specifications.

Key environmental emissions from the NHT will include:

- Atmospheric emission from one gas fired charge heater.
- Sour wastewater, which will be sent for treatment to the new SWS.
- Solid waste (i.e. spent catalyst).

Hydrogen Plant (H2 Plant, Unit 118)

CFP will include a new H2 Plant to provide the Hydrogen required for the new hydroprocessing units in the refinery. The new Hydrogen Plant will consist of three Hydrogen Production Trains.

The new H2 Plant will utilize steam reforming to generate Hydrogen. The Reformer Furnace will normally be fired using H2 Plant PSA tail gas. This fuel will be supplemented by refinery fuel gas when necessary.

Key environmental emissions from the H2 Plant will include:

- Oily water generated during steam-out of vessels and other equipment during shutdown which will be collected by an Oil Drip Sewer (ODS).
- Atmospheric emissions from three tubular reformer furnaces.
- Solid waste (i.e. spent catalyst)

Hydrogen Recovery (HR, Unit 119)

The Cold Low Pressure Separator (CLPS) off-gas streams from the ARDS (Units 112 and 212) and HCR (Unit 114) contain sufficient Hydrogen to justify recovery through Hydrogen Recovery. The recycle gas purges from the KHT, DHT and HCR will also be fed to HR for Hydrogen recovery.

The new HR will have two main sections: the Amine System and the PSA Unit. The Amine System will be composed of two absorbers; the first one removes Ammonia from the feed gas using wash water, and the second removes H_2S from the feed gas using Amine solution (45% MDEA)

Key environmental emissions from the HR Unit will include:

- Sour water from water wash knock-out.
- Solid waste (i.e. sieve packing).

Sulphur Recovery Unit (SRU, Unit 123)

H_2S will be recovered and sent to the new SRU where it will be converted into elemental Sulphur and exported as a refinery byproduct. Unit 123 will be designed to process acid gas streams from the new Amine Regeneration Units and the new Sour Water Stripper Units. It will recover at least 99.9 weight percent sulphur from the acid gas feed streams, incinerate the ammonia, and oxidize the residual sulphur to sulphur dioxide before venting it to the atmosphere.

Unit 123 will be comprised of three 450 MT/day trains. The three plants will be designed as 3-35% units. Normally all three plants will be in operation. Each train will have a Tail Gas Incinerator, including waste heat recovery for steam optimization and utilization within the unit and for steam export. A dedicated incinerator stack will also be provided for each train.

Key environmental emissions from the SRU will include:

- Atmospheric emissions, primarily SO_2 from the Tail Gas Incinerator within each SRU.
- Solid waste (i.e. spent catalyst, ceramic balls, and filter cartridges)

Amine Regeneration Unit (ARU, Unit 125)

A new ARU will be provided to strip H_2S from the amine solution. The ARU will consist of two 70% trains, each with a design capacity of 1100 m^3/hour. These trains will receive rich amine and supply lean amine to the new Amine Absorbers/Contactors. The H_2S that is stripped out will be sent as a concentrated acid gas stream to the SRU.

The ARU design will include provision for injecting corrosion inhibitor into the Amine System.

Key environmental emissions from the ARU will include:

- Liquid hydrocarbons (i.e. wet slops from Flare KO Drum).
- Solid waste (i.e. mechanical filter cartridges and spent activated carbon filters).
- H2S acid gas stream (to SRU)

Sour Water Stripper (SWS, Unit 126)

Sour water containing appreciable concentrations of H_2S and NH_3 is produced from several units. The sour water is steam stripped to suitable levels of H_2S and NH_3 for additional treatment in the WWT Unit (Unit 156). A significant volume of stripped water will be reused in the CDU and ARDS Units, with smaller volumes required by the KHT, DHT and NHT.

The SWS will consist of two plants, each with a design capacity of 300 m^3/hour. Each plant provides 75% of the needed flow rate and both plants will normally be operated simultaneously.

The SWS will be designed to separate non-aqueous gas, light hydrocarbons, and oil emulsions from the sour water feed before steam stripping to remove the bulk of the H_2S and NH_3. Sour water may also contain phenols, cyanides, and carbon dioxide.

Key environmental emissions from the SWS will include:

- Oily water drains: collected liquid hydrocarbons in the Sour Water Feed Drum will be separated and pumped to the Hydrocarbon Flare KO Drum.
- Stripped sour water to wastewater treatment (WWT Unit 156).

Continuous Catalytic Reformer (CCR, Unit 127)

A new CCR will be provided and coupled with the new NHT (Unit 117) to process a flow rate of up to 18,000 BPSD of hydrotreated Full Range Naphtha (FRN) from the NHT. The CCR will include a Naphtha Splitter Section followed by a Reformer Section.

Products from the CCR include Reformate, Light Naphtha, LPG and Net Gas Byproducts. The byproducts include Debutanizer overhead gas, which will be sent to the Fuel Gas System and spent Caustic from catalyst regeneration, which will be sent to the Water Treatment Unit for neutralization.

Hydrogen required for start-up of the new CCR will be sourced from the new HPU (Unit 118), new HRU (Unit 119), and the new membrane unit, which treats the Hydrogen-rich ARDS purge stream.

Key environmental emissions from the CCR will include:

- Atmospheric emission from five gas fired heaters (two stacks).
- Solid waste (i.e. spent CCR catalyst).
- Spent caustic (to WWT plant)

Hydrogen Production Unit Feed Treating & Compression (HPU, Unit 128-01)

CFP will include a new HPU Feed Treating & Compression Unit to treat / remove H_2S, as well as CO_2 and NH_3 from the feed gas stream in an Amine Absorber.

Key environmental emissions from the HPU Feed Treating and Compression will include sour water, which will be sent for treatment to the new SWS (Unit 126).

Hydrogen Compression (HC, Unit 128-02)

CFP will include a new HC Unit to provide the Hydrogen required for the new hydroprocessing units in the refinery. The total Hydrogen product will be compressed in the new, centralized HC facility to supply the requirements of the hydrotreating units. The major components of the new HC will include multi-stage reciprocating Hydrogen Compressors, various suction drums and discharge coolers.

Key environmental emissions from the HC may include generation of intermittent liquid wastewater stream consisting of hydrocarbons with sour water, from the suction drums.

Saturates Gas Plant (SGP, Unit 129)

The new SGP will process the off-gas streams produced in the new CDU and the planned New Refinery Project hydroprocessing units; the sour LPG produced in the new ARDS, the new Hydrocracker, and the new CDU; as well as sweet LPG produced by the new CCR. The SGP will have a capacity to process 35 MMSCFD of off-gas and 12,000 BPSD of LPG.

The SGP will produce treated refinery off-gas (100 ppmv H_2S maximum; 50 ppmv per design basis) and an LPG-rich stream (less than 20 ppmw H_2S).

Lean Amine solution will be used in two separate Amine Scrubbers: a Refinery Off-gas Amine Scrubber and an LPG Amine Contactor. These will remove H_2S from the refinery off-gas and the sour LPG liquid.

Key environmental emissions from the SGP will include:

- Water Wash Coalescer - supplier to recommend disposal options during EPC.
- Rich Amine Filter

Vacuum Rerun Unit (VRU, Unit 213)

The VR Unit will process Low Sulphur Atmospheric Residuum (LSAR) from the ARDS units to yield a variety of products, including DFO, VGO, TGO and VR.

The only fired equipment item within the new VR Unit will be the Vacuum Charge Heater. Off-gas from the Ejector System will be routed through an MDEA scrubber prior to being disposed of by burning in the Vacuum Charge Heater.

Key environmental emissions from the VR Unit will include:

- Atmospheric emissions from the gas-fired Vacuum Charge Heater.
- Sour water collected in the condensate drums and routed to SWS Unit.
- Slop oil, which will be collected in the condensate drums.

Hydrocracker Unit (HCR, Unit 214)

The main objective of the HCR Unit 214, a 50,000 BPSD Unit, is to convert heavy vacuum gas oil (VGO), trim gas oil (TGO), and heavy SR diesel to lighter products meeting specifications of LPG, naphtha, kerosene and diesel. Unconverted Oil (UCO) will also be produced as by-product or as lube oil base stock (LOBS). The feed to the unit can be supplied directly from the upstream Vacuum Rerun (VRU), Crude Distillation (CDU), and Delayed Coker (DCU) units for maximum hot feed available, and supplemented with cold feed from storage.

Unit 214 shall consist of two stages, with a common fractionation system, to separate the products. Each stage is provided with independent feed/effluent heat exchanges, feed heaters, product separators, and a gas recycle system. The unit shall be able to operate with the first or second stage online, while the other stage is down.

Key environmental emissions will include:

- Atmospheric emissions from three gas fired heaters.
- Solid waste (i.e. spent catalyst)
- Sour water will be sent to the new Sour Water Stripping Unit (Unit 126).

Diesel Hydrotreating Unit (DHT, Unit 216)

See details for Unit 116 above.

2.3.2.2 Revamped MAB Refinery Process Units

Crude Distillation Unit (CDU, Unit 11)

For CFP, the existing CDU (Unit 11) will continue to process Kuwait Export Crude (KEC) in parallel with the new CDU (Unit 111). The capacity of the existing CDU will remain at 190,000 BPSD, however the unit will be upgraded to produce a heavier diesel cut and improve the reliability and safety of the unit.

Heater firing for the CDU Charge Heater will be 100% fuel gas with back-up from the fuel oil system. CFP will provide the following modifications and enhancements:

- New Heavy Diesel Side Stripper,
- Spare Flashed Crude Pump,
- Crude Tower Modifications,
- Kerosene Product Water Cooler Modifications,
- ATM Residue / Flashed Crude Exchanger Modifications, and
- New Temperature Control Station.

The revamp works will not change or impact emissions. Key environmental emissions from the revamped CDU will remain as:

- Atmospheric emissions from heater
- Sour water which will be routed to the SWS
- Desalter effluent which is routed to the WWT
- Dry and wet slops which are collected and routed to storage

Vacuum Unit (VU, Unit 13)

The existing VU consists of two trains originally designed to process Low-Sulphur Atmospheric Residue (LSAR). The products from the VU are Light Vacuum Gas Oil (LVGO), Heavy Vacuum Gas Oil (HVGO), and Vacuum Residue (VR).

The CFP revamp will decrease the throughput of each of the two existing trains in order to maximize the overall gas oil product yield.

Key environmental emissions from the revamped VRU will not change with the revamp. The revamp work will not impact the two existing gas fired heaters. There is no solid waste generated by this unit. Sour water is collected in the condensate drums and routed to the SWS.

2.3.2.3 Retired MAB Refinery Process Units

Retirement of some MAB refinery process units will result in environmental benefit, as the following will cease:

- Atmospheric emissions from the crude heaters and furnace.
- Solid waste (i.e. spent catalysts).
- Liquids collected in the HPU flare knockout drum.

2.3.2.4 New MAB Refinery Utility and Offsite Units

Nineteen new U&O Units are planned for the MAB refinery. Many of these facilities will have minimal environmental impact, as many are not process units. Impact during their construction is dealt with in relevant chapters. Below, focus is given to those facilities with potential for impacting the environment during operation.

Steam System (Unit 131)

The Steam System will be designed to produce steam and Boiler Feed Water (BFW) to support continuous operation of the new CFP refinery units. The steam is used for driving steam turbines, as a process reactant in the production of Hydrogen, and for heating.

Key environmental emissions from the Steam System will include:

- Oily water, which will be routed via gravity drains to the Accidentally Oil Contaminated (AOC) sewer for appropriate treatment and/or disposal.
- Atmospheric emissions from six Utility Steam Boilers.
- Boiler Blowdown.

Cooling Water System (Unit 132)

The objective of the Cooling Water System is to maintain the cooling water circulation rate and temperature in order to remove heat from the process and utility units in the new CFP Units at the MAB Refinery.

The Cooling Water System is a closed circuit water system. The major equipment consists of a cooling tower and cooling water pumps. The cooling water is pumped from the cooling tower basin to various process and utility units to remove the heat loads from the units. The hot returning cooling water then enters the cooling tower where the heat is dissipated to the atmosphere.

A small stream of cooling water is directed to blow-down to control the concentration of dissolved solids in the circulating cooling water. Desalinated water is used as make up to the cooling tower basin to replenish the water losses primarily due to evaporation and blow-down. Fresh water is used as back up to the desalinated water. Chemical feed systems are provided to condition the cooling water quality for proper operation.

Key environmental emissions from the Cooling Water System will include:

- Blowdown from cooling water pumps.
- Backwash from side stream filter.

Fuel Gas System (Unit 133)

Refinery Fuel Gas for the CFP units is supplied primarily by the Coker. When the Coker is down, imported fuel gas will be the primary makeup source.

The main objectives of the FGS are to:

- Remove H_2S from imported fuel gas and ARDS Fractionator off gas with Fuel Gas Scrubber.
- Collect fuel gas from refinery off gas and treated imported fuel gas, and distribute to various fired heaters and steam generators throughout MAB.

Key environmental emissions from the FGS will include:

- Oil drips.
- Solid waste (i.e. cartridges from Amine Sump Filter).

Nitrogen/Air Systems (Unit 134)

The Nitrogen/Air Systems must supply sufficient compressed air to meet the demands of Instrument Air and Plant Air.

Key environmental emissions from the Nitrogen/Air systems will include:

- Water and oily water from air compressors and air dryer package.
- Solid waste (i.e. spent Desiccant Activated Alumina from air dryer packages).

Unit 137 Water Systems

There are a number of new water systems onsite, such as desalinated water, potable water, fresh water, demineralised water and cooling water. These new systems will have a number of environmental issues associated with them such as:

- Noise from pumps etc
- Waste generated(e.g. resins)
- Resource use

Acid Gas Flare (Unit 146)

The Acid Gas Flare Unit 146 is a new elevated flare and represents one of the key safety systems in the CFP. It serves as the final line of protection against catastrophic failure resulting from overpressure of equipment and interconnecting piping. The purpose of the Acid Gas Flare is to provide the means for the safe relief and combustion of potentially explosive and/or toxic fluids containing H2S. These gases and liquids, which are present as feeds, products, or intermediate streams within the refinery processes, must be flared under unplanned upset conditions.

Additionally, under typical refinery operations, gases may be vented or liquids blown down to the Acid Gas Flare to maintain a required process operating pressure. It is also common practice to start-up or shutdown a process unit by temporarily venting gases to the Acid Gas Flare until the unit can be properly lined out (start-up) or de-pressured and purged (shutdown). However, for the CFP, refinery operations will implement suitable sequencing of unit startups and shutdown to minimize simultaneous planned flaring from different process units.

Key environmental emissions from the Acid Gas Flare will include:

- Gaseous emissions: SO_2, CO, Hydrocarbon, NO_2.
- Sour water from the flare KO drum pumps.

Hydrocarbon Flare System (HFS, Unit 149)

The Hydrocarbon Flare System (HFS) represents one of the key safety systems in the CFP. It serves as the final line of protection against catastrophic failure resulting from overpressure of equipment and interconnecting piping. The purpose of the HFS is to provide the means for the safe relief and combustion of potentially explosive and/or toxic fluids. These gases and liquids, which are present as feeds, products, or intermediate streams within the refinery processes, must be flared under unplanned upset conditions.

All CFP flares are elevated flares. The new hydrocarbon flare system for MAB includes a High Pressure HP Flare and a Low Pressure LP Flare.

A single Flare Gas Recovery Unit (FGRU) will be provided. Functionally, a single FGRU will take suction from the flare header at a point located between the Main KO

Drum and Water Seal Pot. The FGRU is designed to recover the combined purge/vent flow from each flare header.

Additionally, under typical refinery operations, gases may be vented or liquids blown down to the flare to maintain a required process operating pressure. It is also common practice to start-up or shutdown a process unit by temporarily venting hydrocarbon gases to the flare until the unit can be properly lined out (start-up) or de-pressured and purged (shutdown). However, for the CFP, refinery operations will implement suitable sequencing of unit startups and shutdown to minimize simultaneous planned flaring from different process units.

Key environmental emissions from the Hydrocarbon Flare System will include:

- Gaseous emissions – SO_2, CO, NO_2 and Hydrocarbons
- Wet slops

Fire Water Systems (Unit 154)

The firewater system facilities include the following major unit components:

- Firewater Tanks, pumps and drivers.
- Biocide Injection Systems.
- Ring-Main System.
- Hydrants, Monitors, Post-Indicating Valves, Hose Reels.
- Foam Extinguishing and Storage Systems.
- Water Spray Systems.
- Sprinkler Systems.

Freshwater is supplied for initial make-up of the firewater tanks. Treated effluent water (utility water) from the waste water treatment plant will be used for normal make-up of firewater tank level.

There are no major environmental emissions from the Fire Water Systems, except in an emergency or when fire water pump drivers (two diesel engines) are periodically tested.

Wastewater Treatment System (WWT, Unit 156)

A new WWT System will be provided to collect, convey and treat wastewater from the MAB CFP block according to the K-EPA requirements prior to any discharge. Process wastewater streams from the CFP units as well as fire fighting water and rainwater runoff from paved process areas are the main streams treated in the WWT Unit.

The new CFP facilities will incorporate state of the art design to complement upgrades to the existing MAB effluent treatment facility under a separate project (KNPC Effluent Treatment Facility Revamp project). The CFP design will incorporate best environmental engineering practices such as 'Best Available Control Technology' (BACT) to avoid, prevent or mitigate the discharge of harmful emissions so as to meet (or exceed) applicable K-EPA environmental standards.

The main wastewater streams treated in the WWT units are process wastewater streams from the CFP units, such as surplus Stripped Sour Water (SSW), Cooling Tower (CT) blowdown, boiler blowdown, as well as fire fighting water and storm water runoff from paved process areas. Storm water runoff from areas and roadways outside paved process areas is collected in an oil catcher and pumped to the Gulf.

The effluent streams generated and collected from the new CFP process units are segregated at the source and collected in one of following seven drainage systems. Effluents segregated and collected in these drainage systems receive different treatment, depending on the source, type and level of contamination.

- Accidentally Oil Contaminated (AOC) drainage system
- Oil Drips System (ODS) Drainage and Biological Treatment System
- Chemical Collection and Drainage System (DCH)
- Dry Slops System (DS)
- Outside Battery Limit (OSBL) and Roadway Rainwater Drainage System
- Sanitary and Grey Water Collection System
- Sludge Collection and Treatment System

Oily solids from the oil separators in the CFP ODS System will be routed to the oily sludge centrifuges for dewatering, and the resulting dewatered cake will be incinerated in a fluidized bed incinerator. This incinerator will be designed with adequate capacity to also incinerate oily sludge streams from the rest of the MAB Refinery, MAA Refinery and open market.

Key environmental emissions from the WWT System will be:

- Treated wastewater discharge
- Incinerator ash (disposed to landfill).
- Atmospheric discharges from sludge incinerator stack

DHT Flare (Unit 249) & HCR Flares (Unit 314)

New elevated flare units will also be provided at Units 249 and 314 (High Pressure and Low Pressure).

They will serve as the final line of protection against catastrophic failure resulting from overpressure of equipment and interconnecting piping. Under normal operating conditions, emissions from the flares are not significant, consisting only combustion products from pilot gas and purge gas.

Miscellaneous New Uitlities & Offsite Units

New Utility and Offsite Units are also provided at Units 136, 148, 150, 159, 165 and 166, although they do not have significant environmental aspects associated with them.

2.3.2.5 Revamped MAB Refinery Utilities & Offsite Units

Many of these facilities will have minimal environmental impact, as they are not process units. Impact during their construction is dealt with in relevant chapters. Below, focus is given to those facilities with potential for impacting the environment during operation.

Tank Farm (Unit 50)

The existing Tank Farm at the MAB Refinery receives, stores, blends and transfers feed, intermediate, product and finished product streams from source units and sends them to the process units, ship loading facilities or to pipelines. For CFP, existing tankage will be reallocated to meet distribution requirements.

Key environmental impacts will include VOC emissions from the storage, filling and emptying of hydrocarbon tankage.

Pre-RMP Tank Farm (Unit 52)

There are three types of residual stocks held in dedicated storage for the refinery. They include Sour Atmospheric Residual (SAR), Low Sulphur Atmospheric Residue (LSAR) and Low Sulphur Fuel Oil (LSFO). Dedicated storage tanks and piping are maintained for each of the three commodities although residual storage tanks can be used interchangeably depending on the current mode of refinery operation.

Key environmental emissions from the Pre-RMP Tank Farm will include VOC emissions.

2.3.3 SHU Refinery

The process units planned for retirement at SHU are:

1	Burgan Gas Treating	Unit 01
2	Hydrogen Manufacturing	Unit 02
3	Hydrogen Compression	Unit 03
4	Sulphur Recovery	Unit 04
5	Catalytic Reformer	Unit 05
6	Crude and Vacuum	Unit 06
7	H-Oil	Unit 07
8	Isomax	Unit 08
9	Naphtha Fractionation	Unit 09
10	Naphtha Unifier	Unit 10
11	Kerosene Unifier	Unit 11
12	Diesel Unifier	Unit 12
13	Light / Heavy Defile Unifier	Unit 13
14	Amine Treating	Unit 14
15	Merox Treating	Unit 17
16	Acid Gas Removal Plant	Unit 61
17	Hydrogen Manufacturing Train	Unit 62
18	H-Oil Vacuum	Unit 63
19	Hydrocracking Exp. C. Water Sys.	Unit 64
20	Isocracker	Unit 68
21	New Sulphur Recovery	Unit 74

In addition, the utility steam boilers at SHU will be decommissioned. Although the retirement of these SHU facilities are not part of the CFP scope, their decommissioning will be conducted in parallel with the commissioning of the CFP facilities. The retirements of these units will significantly improve environmental conditions in the area surrounding the SHU refinery, because they are some of KNPC's oldest and least efficient operating facilities.

Six Retained/Revamped Tank Farm Units are planned for SHU:

1	Local Ship Pumps	Unit 30
2	Marine Shipping Pumps	Unit 32
3	Shuaiba Harbor	Unit 33
4	Transfer Pumps	Unit 34
5	Shuaiba Oil Pier	Unit 38
6	Inter Refinery Transfer Pipe	Unit 65

One new U&O Units are planned for the SHU refinery:

1	Utility Area Air System	Unit 129

2.4 CFP Construction

The CFP will have ten EPC contractors: three EPC Contractors at MAA, five EPC Contractors at MAB, one EPC Contractor for SHU and one EPC buildings Contractor (responsible for both MAA and MAB).

There will be three other major contracts: a high voltage contract and two early works contractors (one in MAA and one in MAB). The buildings and high voltage contractors will have activity in both MAA & MAB.

The overall construction window for the CFP is 45 months with the preparatory works being 10 months long and the effective construction duration being 35 months.

2.4.1 Preparatory works

The initial preparatory works at the CFP will involve the following:

- Demolition of buildings
- Removal of existing utilities
- Clearing/grubbing
- Cut and fill
- Installation of major underground headers in the E-W pipe rack corridors
- Installation of main permanent roads
- Installation of construction roads
- Installation of gates and fencing
- Installation of site support buildings (guardhouses, visitor centre, central medical facility, site office at MAB, etc).

At the same time, a full range of temporary utilities will need to be provided throughout the construction phase – i.e. power, water, sanitation, telecoms etc. such as:

- *Construction power supply*: It is estimated that 6.25MW will be required at MAA for construction purposes. 11.8 MW will be required at MAB, and 6 MW will be required at SHU.
- *CFP site lighting*: Area lighting will be installed at the construction entrances.
- *Water supply*: Site temporary water will be provided to the EPC contractors via a water tie-in point. EPC's will be responsible for routing the water to their networks.
- *Sanitary system*: Specific details on the collection of sanitary waste were not available at the time of writing of this EIA, however each EPC Contractor is responsible to adhere to Project and Regulatory Requirements.
- *Temporary site drainage*: to ensure efficient construction, the CFP site will need to be effectively drained. Conceptually, the EPC contractor will contain storm water on site using existing drainage channels/ditches.

Water Quality will be monitored by the EPC Contractor and, if it meets K-EPA water quality standards, it will be discharged via existing storm water discharge outlets at MAA or MAB. If the water quality does not meet K-EPA standards, it will be treated, by the EPC contractor, prior to discharge. There will be no new discharge outlets provided during construction. Existing refinery wastewater treatment facilities will not be used for treatment of construction drainage.

The site will be rough graded and sloped to allow the controlled runoff of surface water. Engineering has optimized the site elevation to balance the cut and fill requirements and thus the current estimated excess material is minimal. It is estimated that there with be 129,106 m^3 of stripped topsoil at MAA and 259,028 m^3 at MAB. The net, after balancing cut and fill, will be -6,500 m^3 of cut at MAA (shortage) and 67,000 m^3 of cut at MAB (surplus).

2.4.2 Construction

Impacts during construction are discussed in the various chapters in this report. The construction lay down areas are shown in Figure 13B in Chapter 13.

The following two figures 2.F and 2.G provide:

- a provisional master schedule for the CFP construction which demonstrates how the various CFP construction activities, from contracts being awarded to commissioning and start-up, fit together
- Two curves showing planned progress and manpower from June 2010 to May 2015.

Figure 2.F: Provisional Master Construction Schedule

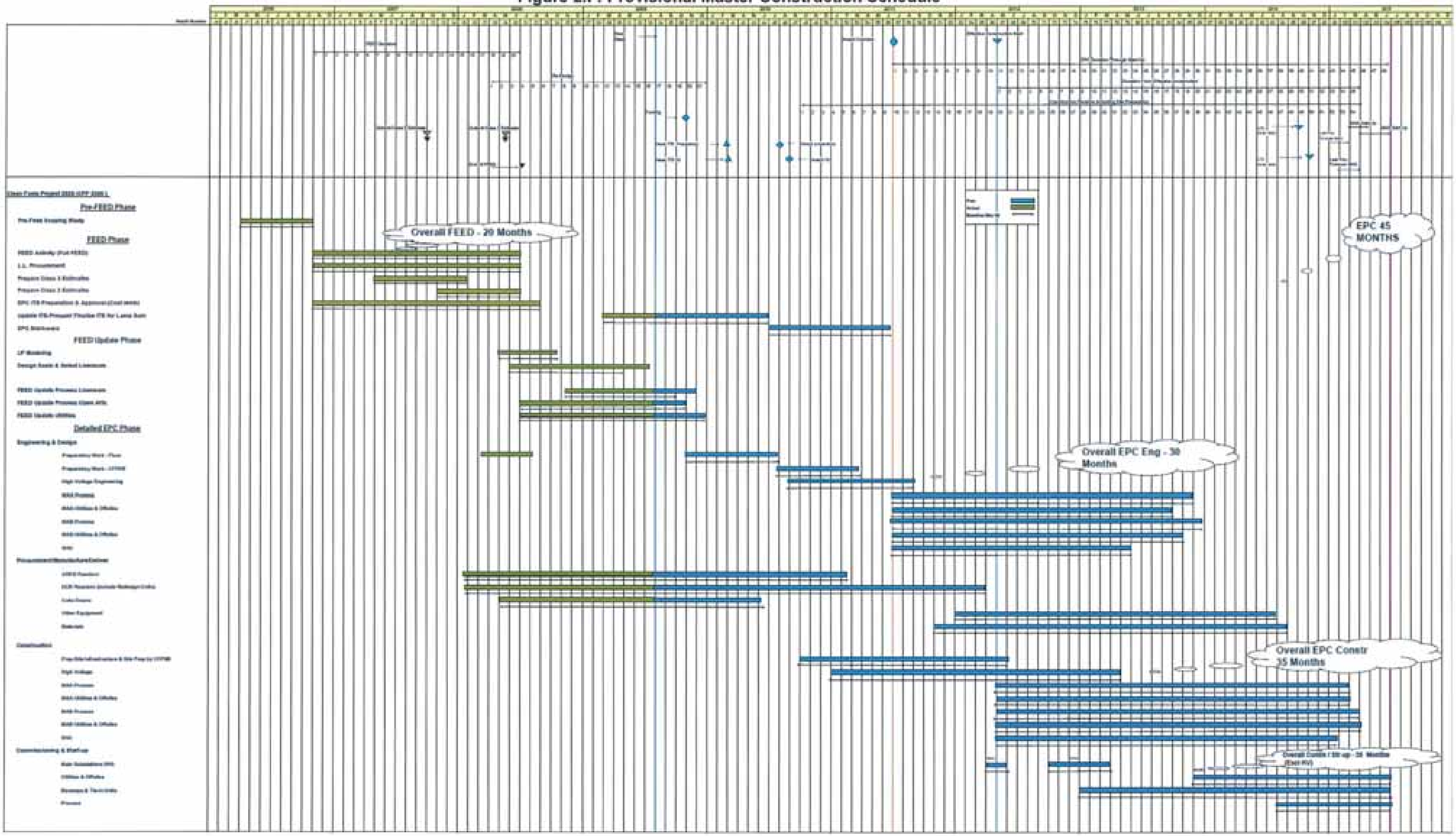
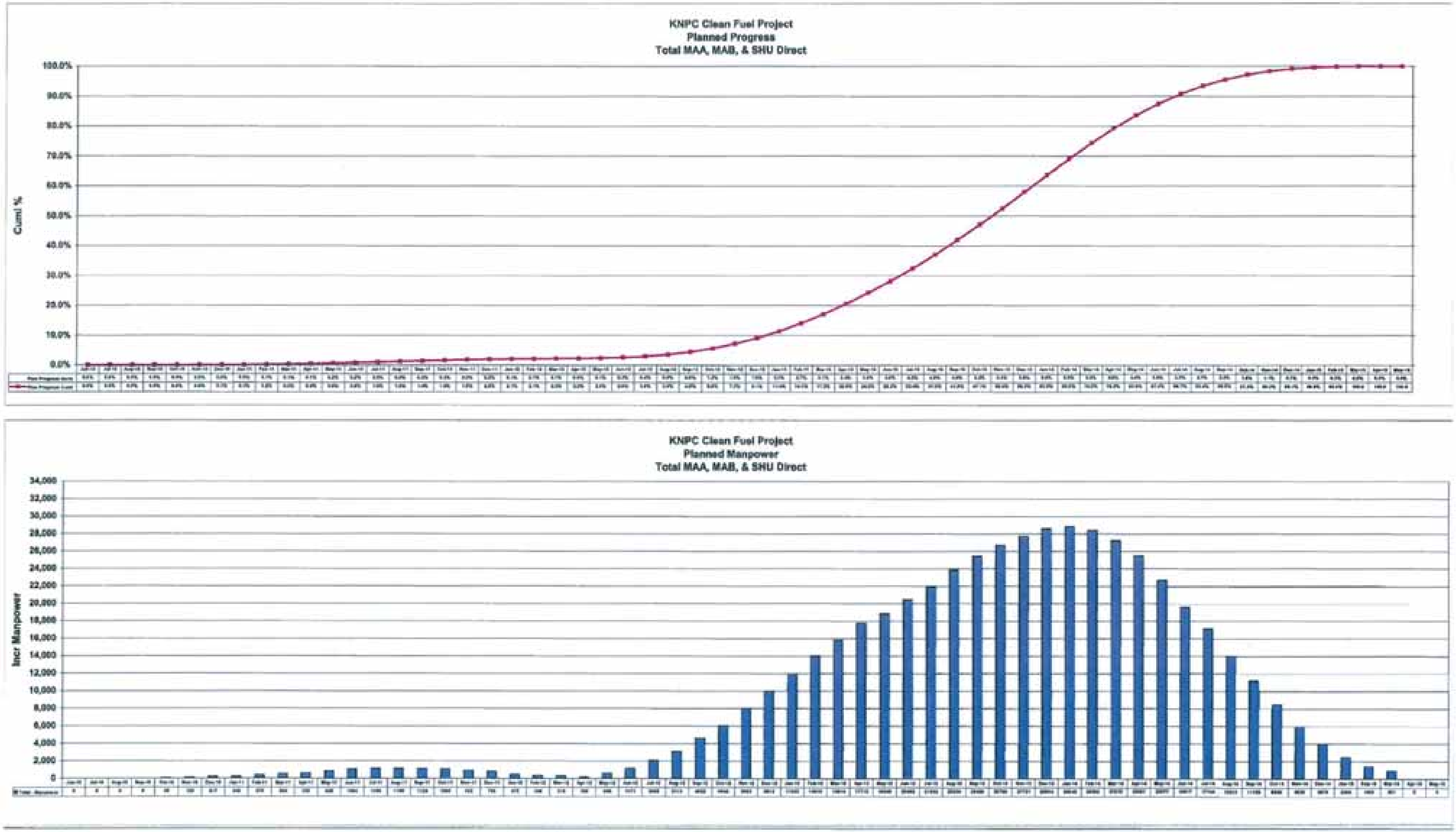


Figure 2.G: Total MAA, MAB & SHU Direct Progress and Manpower



3.0 Environmental Measures Incorporated within CFP Design

The CFP is a project that involves modifications at KNPC's three existing refineries and is not in grass root locations. There will thus be a dual approach to the environmental design philosophy of the CFP as it is not always possible to treat both new and revamped facilities in the same way with respect to environmental management. Existing facilities undergoing revamp are already being managed in accordance with their design and existing KNPC HSE Practices and Procedures. New facilities will be subject to current state of the art practices in environmental design which will be at least as stringent and protective as the practices now in place for the facilities being revamped. All three of the refineries have been certified to the ISO 14001 Environmental Management System (EMS) and thus the facilities will be designed and operated in accordance with the EMS of these refineries.

KNPC's objective is that the CFP will incorporate appropriate Best Available Control Technologies (BACT) and environmental mitigation measures deemed necessary, so as to meet or exceed all relevant K-EPA regulatory criteria. The CFP has been designed to mitigate environmental impact, and numerous 'environmental best practice measures' / BACT have been incorporated. These are discussed within the relevant parts of this EIS but are summarized below for ease of reference. It should be noted that for each chapter of this report, after assessment of impacts has been conducted, additional recommendations are presented, as appropriate, to further mitigate impacts.

3.1 Air Emissions Abatement

CFP will have both point and fugitive sources of air contaminants emitting to the atmosphere. The point sources are primarily combustion equipment items consisting of process heaters/furnaces/boilers, incineration systems and flare systems. The fugitive emission sources include storage tanks, equipment components, sulfur handling operations, coke handling operations and wastewater treatment facilities.

Principal environmental measures regarding point source emissions at the CFP will include:

- BACT to limit Oxides of Nitrogen (NOx) emissions: all boilers, heater and furnaces of 100 MMBtu heat capacity or greater will be equipped with Low NOx Burners (LNB) to reduce NOx emissions.
- BACT for Oxides of Sulphur (SOx) emissions: burning of treated refinery fuel gas (not more than 100 ppm H_2S), LPG or low sulfur fuel oil (less than 1.0 weight % sulfur). The Tail Gas Treating Units (TGTUs) will ensure that the SO_2 emissions from the incinerator stack do not exceed 250ppm. SO_2 emissions will be controlled by incorporation of techniques including feedstock hydrodesulphurization.
- A new TGTU (Unit 99) to substantially reduce existing sulphur dioxide emissions from the MAA refinery.
- BACT for stack height: minimum stack height of 61 metres for discharge of air contaminants from equipment located within process units and having a fired duty of 100 MMBtu/hr or greater. Minimum stack height of 65 metres for utility steam boilers. For natural draft heaters, the maximum stack gas

velocity will be 7.6 meters per second and for balanced draft heaters it will be 15.0 meters per second.

- BACT for venting: vents to the atmosphere that may contain hydrocarbons will be flared to remove the hydrocarbon portion to the extent practical.
- New hydrocarbon flare systems incorporating flare gas recovery to minimize flaring activities.
- A new Electrostatic Precipitator (ESP) to reduce the suspended catalyst particles in the flue gas from the regenerator of the existing FCCU (Unit 86) at MAA.

Principal environmental measures to control fugitive emissions from the CFP facilities will include:

- A Leak Detection and Repair Programme (LDAR) will be in place during operation of the facilities.
- BACT for H_2S emissions: all sour water streams will be treated to ensure compliance with applicable K-EPA discharge criteria. All process vents having hazardous concentrations of sour gas will be routed to either a recovery system or a control device. Ambient H_2S monitors will be placed in those areas of the CFP having the greatest potential for H_2S fugitive emissions.
- BACT for Suspended Particulate Matter (SPM) emissions: the coke handling systems will be designed to minimize and control suspended particulate emissions. The coke handling system will be enclosed and the air extraction vents will be filtered.
- BACT for VOC emissions: the following techniques will be included:
  - Relief valves routed to flare
  - Open-ended valves equipped with cap, plug, blind flange or second valve
  - Pumps incorporating double mechanical seals
  - Reciprocating compressors designed with cylinder packing case venting to flare system
  - Centrifugal compressors provided with dry gas seals and nitrogen buffer gas venting to flare system
  - Closed process drains and effluent sumps. Vents to atmosphere will be via an appropriate control device
  - Unless otherwise specified or directed by K-EPA regulation, Shell DEP or KNPC Procedure, US EPA'S Petroleum Refinery Wastewater Systems Rule (40 CFR 60, Subpart QQQ) will be used as a design guideline for controlling VOC emissions from wastewater treatment systems, which will be enclosed where equipment is in contact with hydrocarbons or odorous compounds, where feasible.
  - Liquid sample points will be designed to minimize hydrocarbon or product loss to the drainage system.
  - Closed loop sampling will be used wherever practical to minimize operator exposure and minimize emissions during sample purging.
- Controlling storage tank emissions via measures including: double seals or vapor recovery systems and pole wipers for floating roof tanks.

3.2 Wastewater Treatment / Reuse / Disposal

CFP will require large volumes of water for cooling, boiler feedwater (BFW) make-up, process water, potable water, sanitation and other refinery services. KNPC's planned approach is to reduce the CFP's water demand requirements by wastewater recycling and reuse to the extent possible.

Minimization of wastewater generation at the source and by reuse, as well as segregation, collection and treatment of similar wastewater streams are the main principles used in the design of the cost effective and environmentally friendly wastewater treatment system. The new Wastewater Treatment systems will collect, convey and treat wastewater according to the K-EPA requirements prior to any discharge.

There will be two new Wastewater Treatment (WWT) Systems provided as part of the CFP:

- New Wastewater Treatment System at MAB – Unit 156
- New Wastewater Treatment System at MAA – Unit 163.

These new CFP facilities will incorporate state of the art design to complement upgrades to the existing MAB effluent treatment facility under a separate project (KNPC Effluent Treatment Facility Revamp project). The CFP design will incorporate best environmental engineering practices such as BACT to avoid, prevent or mitigate the release of all harmful discharges so as to meet (or exceed) applicable K-EPA environmental standards.

3.3 Hazardous Materials Management

Principal environmental measures regarding the management of Hazardous Materials at the CFP include:

- Collecting and maintaining MSDS forms for all hazardous materials intended for use during operation of the CFP.
- Appropriate labelling of hazardous material storage containers.
- Secondary containment for all new storage tanks in hazardous materials service.
- A system for leak detection will be in place serving the new hydrocarbon and hazardous materials storage tanks whose contents are liquid at ambient conditions.
- Fenced off designated hazardous material storage areas with spill containment systems and limited controlled access.
- Surface impoundments in the Wastewater Treatment System used to hold or store hazardous materials will incorporate appropriate secondary containment and leak detection systems.

3.4 Solid Waste Management

Principal environmental measures regarding solid waste generation at the CFP will include:

- Minimizing waste generation through optimizing operations, ensuring reclamation, recycling, and recovery of precious metals from spent catalysts.
- Analyzing, categorizing and segregating solid wastes.
- A Waste Transport Manifest requirement for all waste transported offsite for treatment or disposal. All landfill sites used will be designed and licensed to accept the specific hazardous and non-hazardous type wastes.
- Designated areas for temporary storage of all solid waste generated with waste being stored in appropriate containers.
- Installation of equipment for the handling, treatment and minimization of industrial sludge generation.
- Handling of spent catalysts as hazardous waste unless analyzed to be non-hazardous in accordance with K-EPA criteria.

3.5 Noise Control and Abatement

Principal environmental measures regarding noise abatement for the CFP facilities include:

- Using mufflers/silencers on process vents and steam generation system vents, where feasible.
- Providing high noise sources with sound-reducing enclosures, acoustical insulation, silencers or other engineering methods to minimize noise where necessary.
- Applying noise limits in indoor areas.
- Optimization of high velocity fluid flow in process piping.
- Designing systems with flow velocity no greater than 100 times (in feet per second) the square root of the specific volume of the fluid (cubic feet per pound), where appropriate.
- Use of soft bends and longer pipe length between valves to minimize turbulence at pipe bends and in between valves, where appropriate.
- An absolute work area noise limit of 115 dB(A) and a work area noise limit/equipment noise limit of 85 dB(A).
- The use of permanent warning signs at boundaries of noise restricted areas to indicate mandatory use of hearing protection.

3.6 Odour Abatement

KNPC has embarked upon an Odour Management System with a mission to be "Odour free" in all its operations. Principal environmental measures regarding odour abatement at the CFP include:

- Double mechanical seals for hydrocarbon pumps
- Closed loop sampling systems
- Flare gas recovery unit
- Appropriate sequencing during unit startups to minimize flaring
- Vapor recovery systems or floating roofs with double seal, pole wipers and fittings
- Installing carbon canisters for odour mitigation from tank vents of fixed roof storage tanks, and from drain vents of some oily wastewater vents.
- Provision of procedures for proper regeneration and passivation to reduce odour during catalyst dumping
- Routing water seal on flare drums to a sour water system via wet slop tanks
- Provision of ISO tanks for chemical unloading
- Providing floating skimmers at lagoons
- Ensuring adequate sparing of equipment such as pumps to avoid overflow of sumps.

3.7 Environmental Stewardship

The principal environmental stewardship measures for the CFP facilities include:

- Ensuring compliance with applicable international treaties / protocols
- Avoiding the use of ozone-depleting substances where practical, and prohibiting asbestos containing materials (ACMs) and the use of equipment containing polychlorinated biphenyls (PCBs).
- Operating the CFP with energy efficiency measures to minimize emissions of Green House Gases (GHGs); for example, CO_2.
- Ensuring no chromium-based corrosion inhibitors are used for cooling water treatment
- EMS certification to ISO14001 as soon as possible following start-up.

3.8 Monitoring

Principal environmental monitoring measures covering air, water, groundwater and noise, include:

- Implementation of a fully automated Environmental Information Management System (EIMS), the 100% browser-based *Essential Suite™ EHS and Crisis Management system.* Essential Suite™ facilitates the use of EHS and crisis management data in support of regulatory reporting and performance monitoring, as well as demonstrating how KNPC is exercising its corporate social responsibility. Essential Suite™ is also a core component of KNPC's project action plan to address its long-term sustainability.

- Installing groundwater monitoring wells at both up-gradient and down-gradient locations around process units where oil or other hazardous materials are handled/stored.
- Continuous and intermittent monitoring for various air emission sources (providing readouts in the control room) including:
    - Area/Ambient monitoring
    - Flare system monitoring
    - Continuous emission monitoring (Continuous Emissions Monitoring System - CEMS - installed for new dual-fired or oil-fired combustion sources). CEMS will continuously measure NOx, SOx and Oxygen.
- Monitoring of wastewater effluent flow and quality from the wastewater treatment system.
- An automatic composite sampling package to collect liquid effluent samples prior to discharge.
- Effluent monitoring at the point of discharge from the Wastewater Treatment Systems.
- Periodic noise monitoring from process and utility areas to ensure that K-EPA criteria is met for both the workplace and at the fence line.

4.0 Environmental Comparison of Project Alternatives

It is a requirement of the EIA process to consider alternative site locations when assessing a proposed development. CFP will be constructed at the existing KNPC refineries and not in grass root locations, therefore, evaluating specific alternative site "locations" is not possible. This chapter will instead examine alternatives to the project itself.

The project alternatives currently available are:

1) Do not construct and operate new petroleum refining and support facilities (i.e. no project)
2) Construct and operate new petroleum refining and support facilities in a location outside the existing MAA and MAB refineries
3) Construct and operate new petroleum refining and support facilities within the available space at the existing MAA and MAB refineries

4.1 Alternative 1

As previously described, CFP will expand and upgrade the MAA and MAB refineries by increasing their capacities and increasing conversion of LSFO to higher end products through Bottom of Barrel (BOB) processing utilizing ARDS / Coker / HC technologies. The project is intended to provide the industrial and private sectors of Kuwait and export customers with cleaner burning fuels than those currently available in Kuwait. If the project is not constructed, KNPC will be unable to meet the future market demands for cleaner burning fuels both in Kuwait and abroad and improvements in air quality throughout the region (such as lower ambient SO_2 concentrations) will not progress.

This alternative is considered unacceptable for the following reasons:

- CFP has the key objective of providing low sulphur fuels that will meet the specifications and demands mandated for their continued use in Kuwait in the Year 2020, by the Year 2015. Currently, sulphur dioxide concentrations exceed K-EPA ambient air quality criteria in various locations and regions throughout Kuwait. The availability of low sulphur fuels from CFP will substantially reduce the impacts of sulphur dioxide pollution on public health and the ecology of Kuwait. The production of low sulphur diesel fuels will permit the installation and use of catalytic converters on diesel-powered equipment and vehicles to reduce NOx and CO emissions.
- A significant number of existing petroleum refining units currently being operated by KNPC at MAA, MAB and SHU are inefficient and outdated/obsolete by current industry standards. CFP will optimize conversion capacity by upgrading and modernizing many existing facilities to state-of-the-art design, while retiring obsolete units. New refining units will be provided that fully comply with applicable K-EPA environmental criteria. The project will further allow KNPC to remain competitive within the industry by developing refining operations into an export oriented

integrated merchant refining complex to meet diversified market requirements.

- If the project were not implemented, the following environmental upgrades would not be available:
  - a new Tail Gas Treating Unit (Unit 99) to substantially reduce existing sulphur dioxide emissions from the MAA refinery;
  - a new oily sludge incinerator at MAB that will process and reduce the volume of solid waste from both MAA and MAB;
  - a new electrostatic precipitator to reduce particulate emissions from the existing MAA FCCU (Unit 86).

4.2 Alternative 2

The adoption of Alternative 2, constructing and operating new petroleum refining and support facilities in a location outside the existing MAA and MAB refineries, will:

- Increase costs and jeopardize the project's economic viability. New land acquisitions will be required for both onshore and offshore facilities. Connectivity (i.e. pipelines, cables etc) with existing refining and support units at MAA and MAB will be over longer distances and may be impractical resulting in the need to construct and operate additional units (such as storage, blending shipping facilities).
- Require local infrastructure, which depending upon the selected location may include, but is not limited to roads, marine port facilities, and available support services for construction contractors and KNPC operating personnel.
- Increase environmental impacts to previously undeveloped areas or areas without a strong, existing industrial base. Impacts would be generated by the need to construct and operate additional infrastructure and support units such as storage, blending and shipping facilities. Impacts may include both terrestrial and marine ecological communities and destruction of habitat. When considering alternative locations for the project, consideration must be given to geology, seismic risk, coastal characteristics and available space among other criteria. Marine port facilities are the only available option in Kuwait for loading and unloading sulphur and for export of petroleum products, regardless of whether the refining facilities are located inland or along the coastline.

4.3 Alternative 3

CFP will not only provide Kuwait and export customers with cleaner burning fuels, but will also enhance the safety and environmental performance of the MAA and MAB refineries through modernization and incorporation of current best environmental practices.

Existing air quality for the Shuaiba Industrial Area is currently of concern and pollutant levels at times are known to exceed K-EPA air quality criteria. CFP will employ best environmental practices, including BACT, to control emissions. There will be some additional load placed on the environment due to the construction of new units and expansions of existing facilities at the MAA and MAB refineries.

However, much of this load on the region is expected to be offset to a significant extent by the retirement of all process units at the SHU refinery as well as by the retirement of some process units at MAA and MAB.

Hence, the overall environmental impact of the new and modified CFP facilities is expected to be acceptable to K-EPA.

Alternative 3 is the selected alternative for CFP. Utilizing existing space within the MAA and MAB refineries for construction and operation of new petroleum refining units has clear cut advantages over Alternative 2 that include:

- Minimizing project costs and economic viability. Adequate space is available within the MAA and MAB refineries for construction of the planned CFP facilities. There is no requirement for new land acquisitions. Distances for connections (pipelines, cables etc.) between new and existing units including existing tankage is minimized. Costs are also minimized by the ability of the project to utilize existing infrastructure as well as storage, blending and shipping facilities.
- Taking advantage of existing local infrastructure including but not limited to roads, port facilities (no new port facilities are required for this alternative), and available support services for construction contractors and KNPC operating personnel.
- Minimizing environmental impacts by constructing and operating the project within an area that is designated for industrial development. Since infrastructure as well as storage, blending and shipping facilities are available to be utilized for CFP; the need for similar new facilities and their associated environmental impacts is minimized or eliminated. Existing waste treatment and disposal facilities are located within relatively close proximity of MAA and MAB minimizing the distance over which such wastes need to be handled and transported.

Alternative 3 is selected because it is economically viable, will improve regional air quality by providing low sulphur fuels, and will upgrade current refining capabilities, thus enhancing KNPC's competitive standing within the industry.

5.0 Environmental Baseline Study

In support of the EIA process, DNV was commissioned by Fluor to conduct an Environmental Baseline Study (EBS). The EBS work at the CFP site was conducted in accordance with the requirements and standards for the State of Kuwait promulgated as Regulations Implemented under Law No. 21 of 1995 as Amended by Law No. 16 of 1996.

The EBS was conducted during 2007 for the purpose of providing a baseline of the existing environment in order to properly assess any potential impacts posed by this project.

As an independent foundation operating worldwide, DNV is committed to involving local specialists to ensure that they will benefit from any developments in their own country and to draw on their experience of local environments and conditions. As a result, a large part of the EBS work was subcontracted out to two local technical specialists, Kuwait Institute for Scientific Research (KISR) and Wataniya Environmental Services (WES). This, along with the execution plan, was agreed upon with KNPC prior to the commencement of the EBS.

DNV, KISR and WES conducted the following specialized studies as part of the background investigation for the EBS, which were then used to develop the EIS:

- Soil Characteristics
- Ambient Air Quality
- Noise
- Land Use
- Demography and Socioeconomic Aspects
- Geology and Seismology
- Surface Water, Groundwater and Water Use
- Terrestrial and Aquatic Ecology
- Meteorology

The majority of the EBS work was carried out between March and August 2007, and all EBS reports are supported by suitable and accurate maps and graphics wherever possible.

The full KNPC CFP EBS report is provided in a separate report. Additional information from a separate KNPC groundwater study is summarised in Chapter 14.

A summary of the key issues identified in the EBS are highlighted below:

- The project sites for the CFP are in developed zones, and the major CFP upgrades and expansions occur within the existing refineries' industrial site boundaries. The immediate surrounding areas are a mix of industrial, residential and open land.
- Thirty-nine soil samples were collected around the perimeter and near the centre of the study area, and analysed. Results generally indicate no contamination problems, although minor TPH contamination was identified at

MAA and MAB; hydrocarbon levels were higher at SHU, where TPH contamination was identified at sampling location S39.

- KNPC groundwater study (2009) indicates that groundwater onsite is contaminated in some areas with parameters such as TPH, phenol and coliforms.
- KNPC HSE air monitoring data was analysed in conjunction with the air monitoring data collected by the EBS Study Team, and results indicate the following:
    - Results often exceed K-EPA / Ministry of Oil air quality criteria for NO_2, NMHC and suspended particulate matter (SPM).
    - Fewer violations were also observed for SO_2, O_3 and PM_{10} (compared with SPM, NO_2 and NMHC).
    - There are very infrequent exceedences of the K-EPA/MO criteria for NH_3 and H_2S at some locations.
- Twenty noise sampling sites were located at various points throughout the study area. All locations meet daytime K-EPA noise criteria, although some of the locations exceed night time criteria (depending on which K-EPA criteria is used in the comparison).
- A review of existing KNPC HSE Noise Monitoring Data showed that some measurements onsite exceeded 85 dB (A), the permissible exposure limit. In areas where limits were exceeded, however, special measures are implemented to ensure proper hearing protection of personnel.
- There is no significant seismic activity currently reported in the area.
- The topography of the study area is flat and sandy with the soils having high porosity and permeability.
- The sites show a negligible existence and distribution of natural drainage systems and there are no important natural reserves/natural sensitive areas in the vicinity.
- The coastline is sandy and muddy and has been altered by man in the study area. Sea water quality is reported to be relatively poor owing to the many industrial activities in the area.
- There is no suitable habitat to encourage a wide diversity of flora and fauna in the area.
- Kuwait has two main seasons, summer and winter. The seasonal temperatures vary widely, with summer temperatures often reach above 45°C during July and August, while temperatures during winter can drop to below 3°C during the night. The rainy season extends from October to May. The long term average annual rainfall for the whole country was approximately 176 mm, but in recent years rainfall has decreased to an average of between 106 - 134 mm/year. Dust and sandstorms are common throughout the year. The wind generally blows from the northwest.

6.0 Environmental Assessment Methodology

This section outlines DNV's *Matrix for Assessment of Non-Quantifiable Impacts* methodology, which is applied across the sections of this EIA that are not quantifiable. Where impacts are quantifiable, results of assessment are, in general, simply compared against relevant numerical criteria to establish significance.

DNV's *Matrix for Assessment of Non-Quantifiable Impacts* methodology meets World Bank requirements, and has been successfully applied to similar types of projects in various parts of the world including the KNPC New Refinery Project. This approach avoids the EIA becoming an over-documented report, and produces deliverables which distinguish the important aspects and are easier to understand.

Environmental aspects that cannot be quantified are described and subjected to a technical evaluation of the type of effect, its scope, and its consequences, and the environmental significance is then simply illustrated.

The main objective of the 'Matrix for Assessment of Non-Quantifiable Impacts', is to distinguish those critical impacts from those that are less important. This is done by considering the effect of an impact in the area in which it is occurring (i.e. its 'value' or 'sensitivity'), and combining it with the 'scope of the effect', to arrive at the 'total impact'.

The assessment methodology applies DNV's EIA matrix together with Impact Assessment Forms (see Figure 6A overleaf) to summarise the scale of an environmental impact. In outline, the methodology is as follows:

Step	Procedure
1	**General description of the area (situation and characteristics):** *Evaluation of the value / sensitivity*: Step 1 is categorising the area being assessed in terms of 'value' or 'sensitivity'. This is, so far as possible, based on official data or statements: e.g. 'this area is of relative low importance to national fisheries compared with other areas," etc and information compiled in the Environmental Baseline Study (EBS).
2	**Description of the extent of effect:** *Evaluation of extent:* The extent of effect from the planned activity should be based on scientific documentation, or, if not available, based on expert and objective evaluation (based on knowledge/experience of the type of projects/activities and similar environments, and technology). The scale of this effect is then evaluated objectively, ranging from very negative to very positive.
3	**Establishing total impact per 'category' (e.g. Environment)** By combining Steps 1 and 2 in the impact matrix (see Figure 6A overleaf), the total impact can be identified. This gives a relatively narrow area indicating the magnitude of the impact. *Total (environmental) impact*: Combining the outputs from Steps 1 and 2, provides a graphical view of the total impact: This ranges from a very large negative impact to a very positive impact.

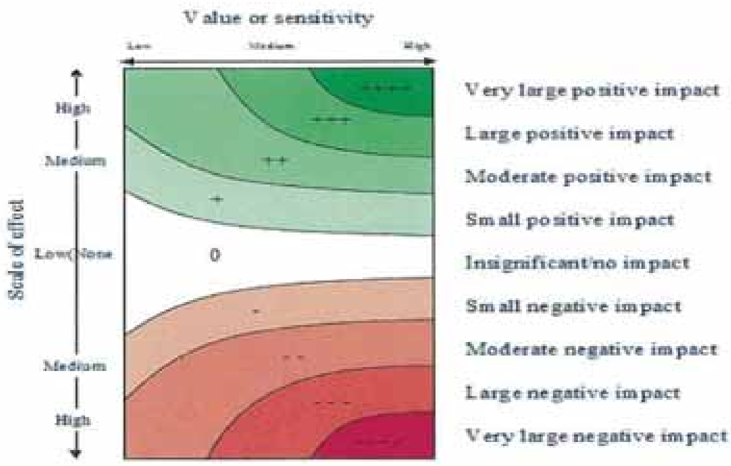
The same magnitude of effect may then result in a different impact depending on the value or sensitivity of the impacted environmental component. This is considered a sound basis for assessing and presenting the environmental impacts associated with the CFP. Each impact is then assessed and documented according to the above system. The results of this exercise are extracted and presented in this EIS report, enabling focus on the most important impacts.

The process also ensures transparency, because it is simple to go backwards and identify why the impact was assessed as it was, and to study the premises and assumptions on which its assessment was based. It also gives the flexibility to change one factor, if new information arrives, and so provides a simple clear methodology to assess any updated impacts.

Figure 6A Impact Assessment Form

Impact Assessment Form

Category: [e.g. ENVIRONMENT or SOCIETY] **Consequence evaluation for:** [issue: e.g. wastewater management during NRP operations]	
1. General description of the area (situation and characteristics):	
Description of the basis for evaluating 'value' or 'sensitivity' of an area. What are the facts, literature sources or statements this is based upon?. Indicate further factors considered more important than other arriving at this conclusion. **Evaluation of the value:** Small Medium Large |X-------------|-------------|	
2. Description of the extent of effect	**3. Total (environmental) impact**
Description of the scientific information and data that the assessment is based on. Describe further how it is interpreted in this context. Describe what has been given highest priority, and why? Document why the assessment conclude on the extent of effect. **Evaluation of extent:** Very neg. Medium neg. Little/no Medium pos. Very pos. |----------------|----------------X--|----------------|----------------|	Combine 1) and 2) in the impact matrix. The total impact is then identified and stated here. E.g. 'Small Negative Impact'



7.0 Noise

7.1 Introduction

7.1.1 General Approach

A noise impact assessment study for CFP has been carried out as part of the EIA. The main purpose of this study is to evaluate the potential community noise impact due to the noise emissions from the activities associated with the CFP. Toward this, predictive computational modelling is used to quantitatively estimate the sound pressure level (SPL) at various discrete receptors located near the ground level, especially including the sensitive noise receptors identified in the Environmental Baseline Study EBS.

Considering that CFP facilities are located at three geographically distinct sites, *viz.*, Mina Al-Ahmadi (MAA), Mina Al-Abdullah (MAB) and Shuaiba (SHU), separate modelling runs were performed for each site. Similarly, since the noise emission sources are distinctly different for each phase of the project, separate modelling runs were performed for the Construction Phase and the Operations Phase at each site.

The background values (existing noise levels) were added to the predicted SPL values and the net values were compared with regulatory standards for community noise levels issued by K-EPA.

7.1.2 Model Description

Predictor Type 7810 Ver 6.20 software developed by Brüel & Kjær is used for noise modelling in this study. Predictor is one of the most efficient multi-purpose Windows-based software packages available for calculating environmental noise. Predictor complies with the European Union's (EU) Environmental Noise Directive (2002/49/EC) and is in accordance with Guidelines on Revised Interim Computation Methods (2003/613/EC) and the European Commission's Assessment of Exposure to Noise Working Group's Good Practice. Among the various algorithms available, the modelling algorithm conforming to the international standard ISO 9613 is used in this study, including the following:

- ISO 9613-1 Acoustics - Attenuation of sound during propagation outdoors. Part 1: Calculation of the absorption of sound by the atmosphere
- ISO 9613-2 Acoustics - Attenuation of sound during propagation outdoors. Part 2: General method of calculation
- VDI 2571 Schallabstrahlung von industriebauten: German method used to calculate the directivity of point sources for noise emitting facades and roofs
- Commission Recommendation 6 August 2003: 2003/613/EC "Guidelines on the revised interim computation methods for industrial noise, aircraft noise and railway noise, and related emission data"

The following inputs to the model are required:

- Noise Sources: Noise sources can be either point sources or line sources. Line sources are basically a series of point sources. For each point source, the required input data include its identification, location coordinates, height above the ground level, directivity of noise, sound power level (SWL_o) in 1 octave or 1/3 octave in the units of dB(A), working hours and any user defined attenuation.

- Noise Receptors: The receiver points can be input as individual discrete points or grid points. For each point the required input data include its identification, location coordinates and height above the ground level.
- Barriers: Barriers are basically the screens and walls that exist between a source point and a receptor point. They are graphically entered into the model as a polyline. For each barrier, the required input data include its identification, end point location coordinates, height above the ground level, surface reflection factor (0 for no reflection to 1 for total reflection) and profile correction (ISO method recommends zero correction) .
- Buildings: Buildings are modelled as polygons with uniform height, and graphically entered into the model. They can be linked to one or more sources. For each building, the required input data include its identification, end point location coordinates, height above the ground level, surface reflection factor (0 for no reflection to 1 for total reflection) and profile correction (ISO method recommends zero correction) .
- Terrain Features: The terrain can be uniformly flat or undulating. For undulating terrain, the terrain height with reference to the mean sea level at each receptor point can be input numerically or using a digitised contour map.
- Topographical Features: The topography can be simple ground region (with specified ground absorption factor ranging from 0 for soft surface to 1 for hard surface), housing region (for heavily urbanised areas), industrial site (for industrial areas) or foliage region (for very dense plantations).
- Meteorological Parameters: Ambient air temperature, relative humidity and barometric pressure. These parameters are used for calculating noise attenuation by the air absorption. Wind speed, wind direction and atmospheric stability are not considered in the ISO method.
- Time Averaging: The hourly SPL values can be time averaged for up to four user specified periods (day, night, evening, other) and day-night (24 hour) average.

For each combination of a source point and a receptor point, the model calculates the SPL value at the receptor point using the following equation as per ISO method, as shown below.

$$SPL_r = SWL_o - C_t - C_m - D_c - A_{div} - A_{atm} - A_{gr} - A_{bar} - A_{bld}$$

SPL_r = Sound pressure level at a receptor	A_{div} = Attenuation due to geometric divergence
SWL_o = Sound power level at a point source	A_{atm} = Attenuation due to atmospheric absorption
C_t = Active time correction	A_{gr} = Attenuation due to ground absorption
C_m = Meteorological correction	A_{bar} = Attenuation due to barriers
D_c = Directivity correction	A_{bld} = Attenuation due to buildings

The model uses subroutines to calculate the various attenuations and corrections. The attenuation levels for each source-receiver combination can be viewed to evaluate the quality of the calculations and as a help to determine how to reduce noise levels. The model calculates the overall SPL value for a given receptor point by logarithmically adding the individual SPL values for each contributing source.

7.1.3 Impact Assessment Criteria

K-EPA community noise standards are used for the purpose of community noise impact assessment. If the predicted noise levels are within the applicable limits, then it is assumed that there would be no adverse impact on the community. K-EPA community noise standards are summarised in the following table:

Table 7.1: K-EPA Community Noise Standards

Area Classification	Main Source/ Cause of Community Noise	Maximum Permissible Time Weighted Noise Level (L_{eq}) in		
		Day Time - dB(A) (7am-2pm)	Evening- dB(A) (2pm-10pm)	Night Time- dB(A) (10pm-4am)
Ideal Residential Area (Villa Areas and Suburbs)	Industrial activity	50	45	45
	Traffic movement	55	55	50
Urban Residential Areas	Industrial activity	55	50	45
	Traffic movement	62	60	55
Urban Residential Areas (with some commercial activities and workshops)	Industrial activity	60	55	50
	Traffic movement	65	65	60
Industrial Commercial Areas	Industrial activity	70	70	65
	Traffic movement	70	65	60

Notes: There are no specifications for the time period of 4am-7am. The community receptors near the CFP sites fall under the classification of 'Urban Residential Areas (with some commercial activities and workshops)'.

7.2 Site Description

7.2.1 MAA Refinery Site

As shown in the plot plan (Figure 2A) MAA Refinery Site is about 2750m by 3600m in area. However, most new plant facilities proposed to be installed as part of CFP will be located within a smaller area of around 750m by 1100m (referred to as the CFP Block) within the southwest quadrant of MAA Refinery Site.

As part of CFP, some existing plant equipment in MAA Refinery will be revamped. The revamp equipment are well scattered over the remaining MAA Refinery Site.

Adjacent to and toward east of the CFP Block, three new projects are being developed. These are the Fourth Gas Train Project (FGTP) and the Ethane Recovery Plant (ERP) and proposed area for the 5th Train. These three projects are not included in the scope of this study, since there are being designed and engineered by third parties and detailed information on these projects is not available.

The environmental features of the MAA Refinery Site and the surrounding areas have been discussed in the Environmental Baseline Study. From community noise viewpoint, the significant receptors are the large urban settlements located in Fahaheel area, about 150m distance from the Tank Farm boundary and about a 1600m distance from the CFP Block toward the north. There are no other settlements in the vicinity toward east, south or west directions of MAA Refinery Site.

7.2.2 MAB Refinery Site

As shown in the plot plan (Figure 2C), MAB Refinery Site is about 3000m by 3500m in area. However, the new plant facilities proposed to be installed as part of CFP will be located within a smaller area of around 1250m by 1500m (referred to as the CFP Block within the south / southeast quadrant of MAB Refinery Site).

As part of CFP, some existing plant equipment in the MAB Refinery will be revamped. The revamp equipment are scattered over the northeast and northwest quadrants of the MAB Refinery Site.

The environmental features of MAB Refinery Site and surrounding areas have been discussed in the Environmental Baseline Study. From a community noise viewpoint, the significant receptors are a few villas located along the coastline about 500m distance from MAB Refinery New Plant Site toward the (south) east. There are no other settlements in the vicinity toward the north, west or south directions of the MAB Refinery Site.

7.2.3 Shuiaba Refinery Site

As shown in the plot plan (Figure 2E), Shuaiba Refinery Site is about 2900m by 850m in area. No new process plant facilities are proposed to be installed as part of CFP at Shuaiba Refinery Site. The existing process facilities will be decommissioned while some offsites facilities such as the tank farm will be integrated with operations at MAA and MAB.

The environmental features of Shuaiba Refinery Site and the surrounding areas have been discussed in the Environmental Baseline Study. From a community noise viewpoint, there are no human settlements located in the vicinity of Shuaiba Refinery

Site in any direction. The areas surrounding Shuaiba Refinery are designated as industrial areas.

7.2.4 Construction Footprint

The construction activities at the MAA CFP Block (about 750m by 1100m) and MAB CFP Block (about 1250m by 1500m) do not cover the entire site area at any given time due to the staggering of the construction activities. With regard to the early construction activities (Site Preparation and Earthworks), the maximum worked over area at any given time will be two adjacent sections each of about 200m by 250m area. Therefore all the early construction activities at any give time will be concentrated within approximately one quarter of the total area of each CFP Block. As discussed later in Section 7.4.1.2, the Site Preparation and Earthworks phase represents the worst case of the overall Construction Phase with regard to the environmental noise impact. No pile driving is envisaged for the foundation work needed for the CFP.

7.3 Background Noise Levels

As part of Environmental Baseline Study for CFP noise monitoring was conducted in 2007 at twenty offsite locations around MAA and MAB sites. The noise monitoring was primarily intended to determine the background noise levels existing prior to the construction and operation of CFP facilities. The noise monitoring sites were located primarily around the perimeter of the planned MAA and MAB Refinery expansion sites, and some were located within 100m of residential areas in the vicinity. In addition, two noise monitoring sites were located outside the MAA and MAB Refinery sites. No noise monitoring sites were located around SHU Refinery Site because noise levels there will be reduced as a result of CFP operations due to the decommissioning of all existing process plant facilities. The locations where the noise was monitored are shown in Figure 7A (offsite), Figure 7B (MAA) and Figure 7C (for MAB).

The details of the background noise monitoring locations and the results are summarised in the following table. The noise measurements are presented as time weighted SPL (L_{eq}) for both day time and night time.

Table 7.2: Background Noise Levels[1]

Location ID	Location Description	UTM Coordinates		Area Classification	L_{eq} in dB(A)	
		Northing (m)	Easting (m)		Day	Night
N1 (MAA)	Near Busy Road	3,212,969	813,703	Residential (affected by traffic)	55	52
N2 (MAA)	Near Main-gate, Car Park & Flare	3,212,058	812,229	Industrial	62	61
N3 (MAA)	Near Flare/Road	3,212,334	812,152	Industrial	66	66

[1] Reference: EBS Report (2007)

Location ID	Location Description	UTM Coordinates		Area Classification	L_{eq} in dB(A)	
		Northing (m)	Easting (m)		Day	Night
N4 (MAA)	Near Busy Road / Flare Sound in Background	3,211,616	812,180	Industrial	52	55
N5 (MAA)	Near Flare (Continuous & Strong Flare Sound)	3,212,551	812,135	Industrial	69	68
N6 (Offsite)	Close to Major Highway & Mosque (Continuous Traffic Noise)	3,213,975	810,919	Residential (affected by traffic)	51	51
N7 (MAA)	Near Busy Road (Traffic Signal & Highway), Workshops & Working Machinery	3,213,126	812,204	Residential (affected by traffic)	60	57
N8 (MAA)	Lamp Post Opposite to Tank 758	3,213,102	814,437	Residential	53	60
N9 (MAA)	Near Road	3,211,040	812,369	Industrial	53	55
N10 (Offsite)	Near Busy Road (Working Machinery)	3,213,642	813,609	Residential (affected by traffic)	54	53
N11 (MAB)	Near KNPC Units (Background Noise from Birds)	3,206,897	818,294	Residential	50	50
N12 (MAB)	Near Road	3,206,588	816,142	Industrial	53	55
N13 (MAB)	Near KNPC Units (Construction Work)	3,207,235	818,120	Residential	55	55
N14 (MAB)	Near KNPC Units	3,206,510	818,504	Residential	45	45
N15 (MAB)	Near Busy Road and Working KNPC Units	3,206,234	816,499	Industrial	57	56
N16 (MAB)	Near Villas (Birds & Knocking Sounds in the Background)	3,206,010	818,763	Residential	46	49
N17 (MAB)	Near Busy Road (Garage and Working Crane)	3,207,385	815,234	Industrial	54	56
N18 (MAB)	Near Busy Road and Working KNPC Units (Aeroplane Flying in the Background)	3,207,872	814,821	Industrial	54	58
N19 (MAB)	Near Busy Road (Cranes Working Nearside)	3,208,726	814,067	Industrial	57	58
N20 (MAB)	Far from Working KNPC Units	3,206,043	817,190	Industrial	44	49

Of the above locations, the residential locations are N1, N6, N7, N8, N10, N11, N13, N14 and N16. All these locations fall under the category of "urban residential areas with some commercial activities and workshops". Out of these locations, N1, N6, N7 and N10 are also affected by noise from road traffic, and at these locations the maximum permissible limits for community noise are 65 dB(A) for the day time and 60 dB(A) for the night time. For the residential locations N8, N11, N13, N14 and N16, where road traffic is not significant, the maximum permissible limits for community noise are 60 dB(A) for the day time and 50 dB(A) for the night time. The remaining locations (N2, N3, N4, N5, N9, N12, N15, N17, N18, N19 and N20) are industrial locations, where the permissible limit for community noise is 70 dB(A) for the day time and 65 dB(A) for the night time.

As seen from the table above, while the day time noise levels at all locations are currently well within the relevant maximum permissible limits, the night time noise levels at two industrial locations (N3 & N5) – due to flare noise, and three residential locations (N8, N11 & N13) have either reached or exceeded the relevant maximum permissible limits. The locations where the baseline (current) noise levels exceed the permissible limits are highlighted in red in the table above and can be identified in Figures 7A, 7B and 7C below.

Figure 7A: Soil, Noise & Air sampling sites Offsite

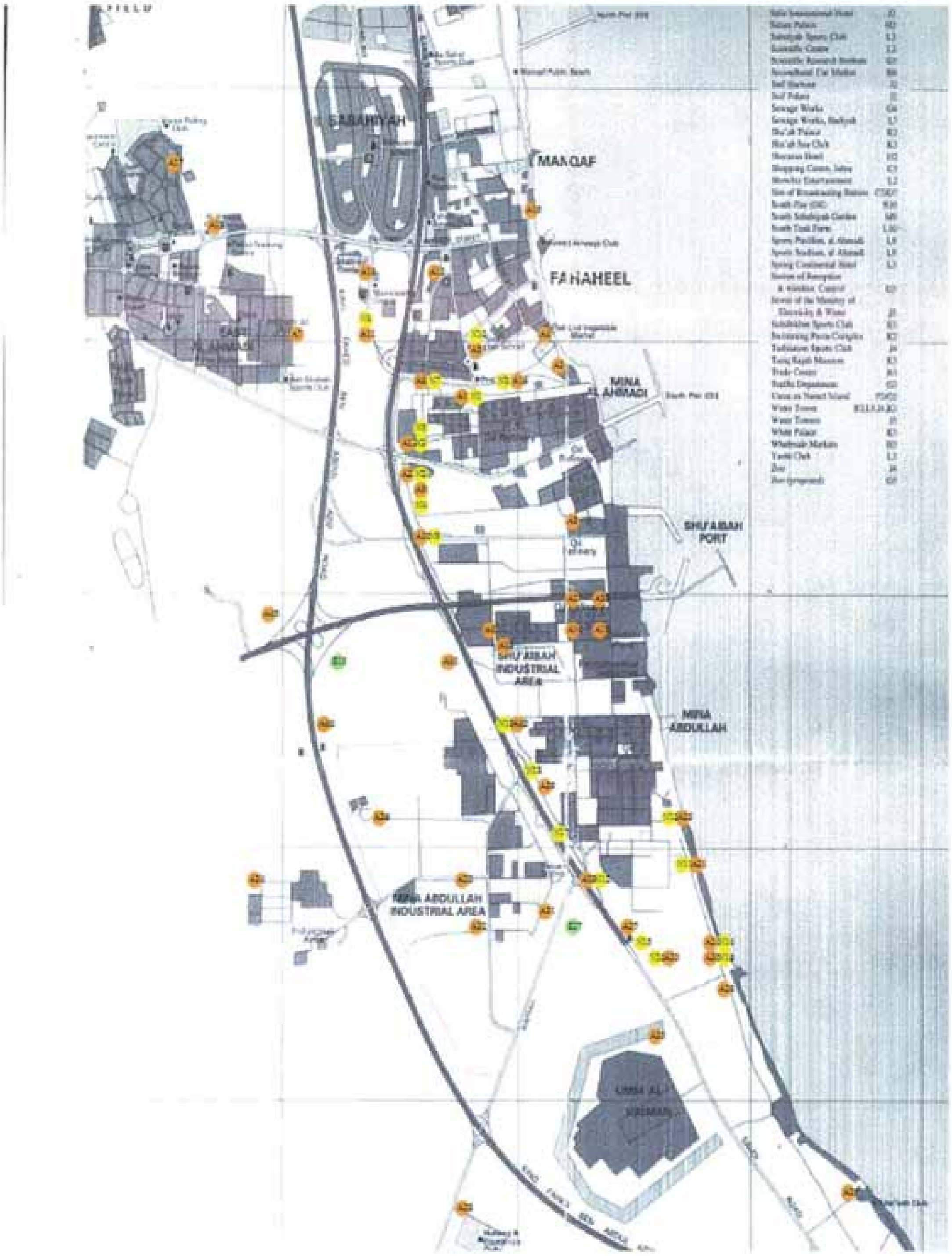


Figure 7B: Soil, Noise & Air sampling sites at MAA

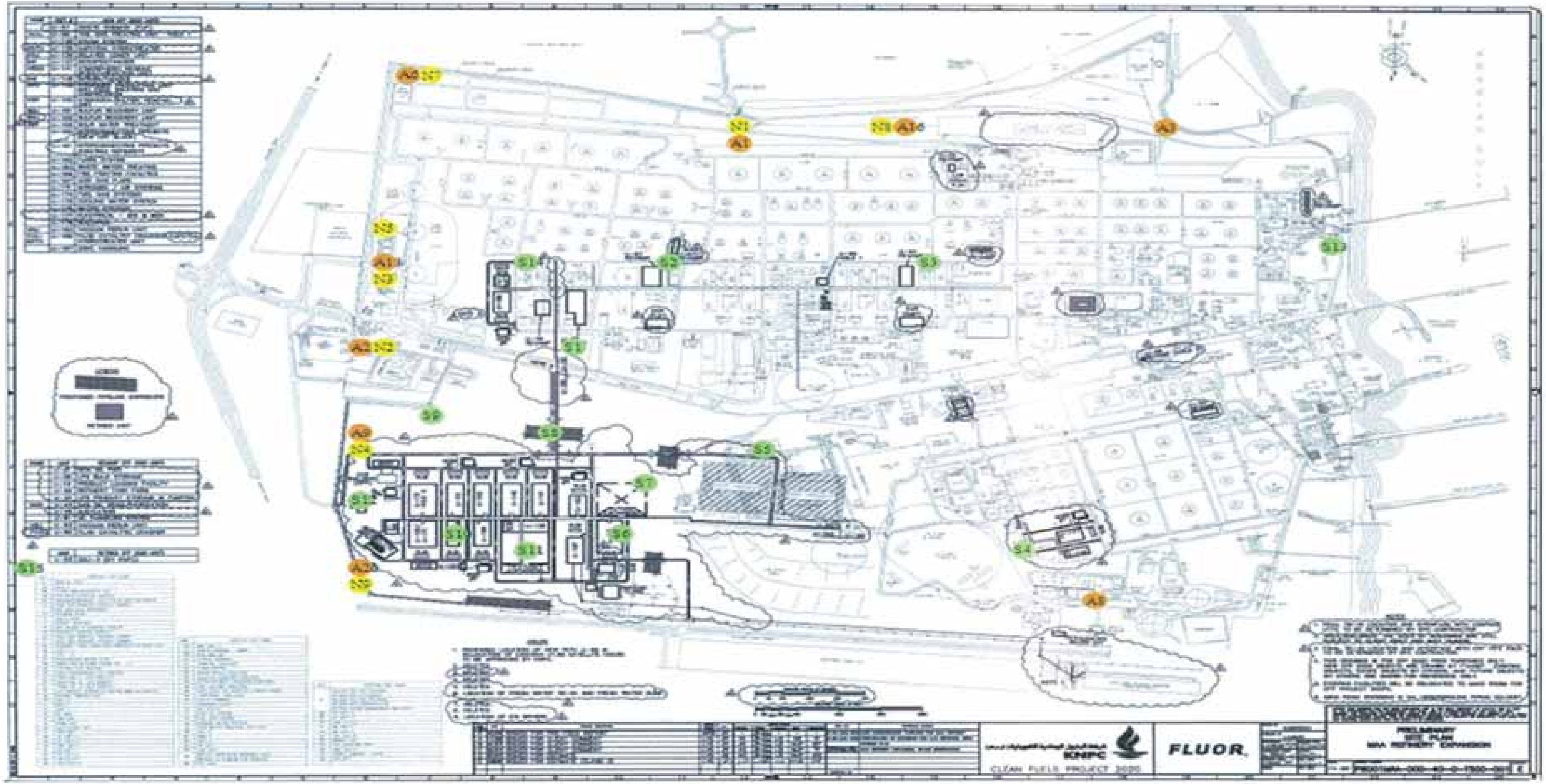
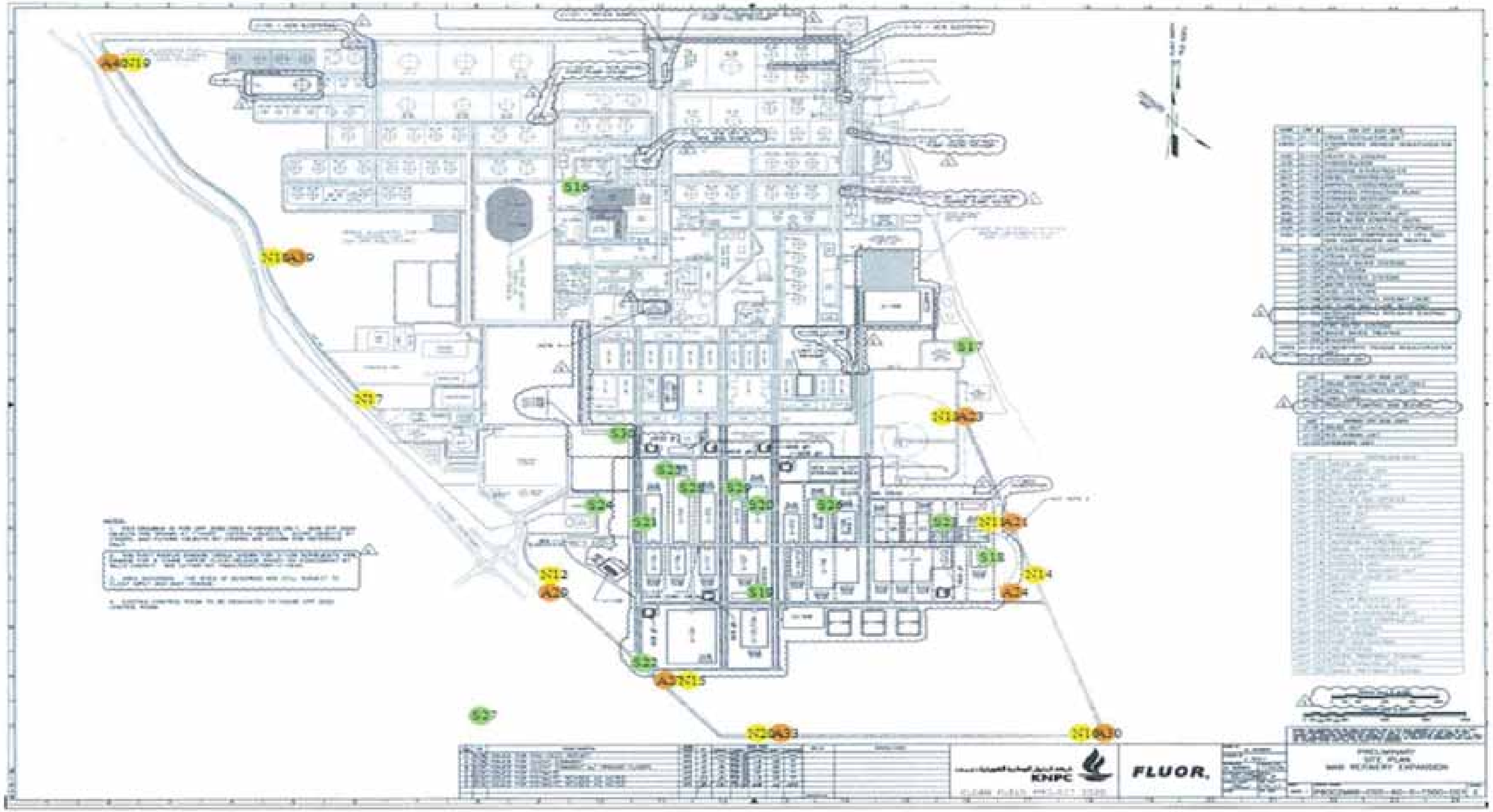


Figure 7C: Soil, Noise & Air sampling sites at MAB



7.4 Significant Noise Sources & Source Noise Levels

7.4.1 General

7.4.1.1 Construction Activities

The Construction Phase of CFP uses fewer noise generation sources (construction machinery and equipment) compared to the Operations Phase. The nature and the type of construction will be similar at both the MAA and MAB Refinery Sites. The Construction Phase consists of three distinct sub-phases: Site Preparation and Earthworks; Erection of Plant Equipment and Buildings; and Commissioning and Testing of Equipment.

From a noise impact viewpoint, the early Construction Phase, viz., Site Preparation and Earthworks Phase is the most significant due to the use of relatively high noise generating construction machinery and equipment. Therefore, the Site Preparation and Earthworks Phase represents the worst case of environmental noise impact of the construction use phase at both the MAA and MAB Refinery Sites.

The significant noise generating sources present during the Site Preparation and Earthworks Phase include bull dozers, dump trucks, wheel loaders, excavators, graders, roller compactors, asphalt machines and rollers. Intermittent and transient noise sources are not considered as significant sources of community noise, since their contribution to L_{eq} values (time weighted average) will be negligible.

7.4.1.2 Operations Activities

Almost all plant equipment generate noise of varying degrees, with SWL ranging from as low as 40 dB(A) to as high as 130 dB(A). At both MAA and MAB sites, there are several hundred such sources of noise generation. For the purpose of noise impact prediction, it is necessary to identify those sources that are significant. Since SWL is represented on a logarithmic scale[2], when there are sources with high SWL, the sources with low SWL can be disregarded without causing any noticeable error in the overall impact prediction. In this study, only those sources with 60 dB(A) or higher SWL are considered in noise impact modelling.

The significant noise sources include turbines, compressors, pumps, motors, fans, blowers, coolers, heaters, furnaces, boilers, heat exchangers, ejectors, crushers, collectors, separators, conveyors, flares and high flow pipelines.

Intermittent and transient noise sources like pressure safety valves and emergency diesel generators are not included.

There are currently numerous noise sources (i.e. existing plant equipment items) located at the MAA, MAB and SHU Refinery Sites. The net noise impact from these sources (as well as any existing external sources) is reflected in the current baseline noise levels (also known as the background noise levels). Therefore, it is not necessary to include the existing noise sources in any of these sites (MAA, MAB and SHU) in the current noise impact prediction modelling study.

[2] Sound power level, SWL is proportional to log [sound power]

Only the new sources (i.e. the new CFP plant equipment items) that will be installed at these sites are considered in this study. As noted in Sections 7.2.1 and 7.2.2, the new sources are mostly located within the CFP Blocks at MAA and MAB refineries.

It is also noted in Sections 7.2.1 and 7.2.2 that the CFP scope also involves the replacement or revamping some existing plant equipment in both the MAA and MAB refineries. Such equipment is well dispersed within MAA and MAB sites. In all likelihood, the source noise level of equipment being revamped or replaced will be either lower or similar to that of the existing equipment. Therefore it is expected that the net impact on environmental noise from replacement or revamping of existing equipment at MAA and MAB sites will be more or less neutral. As a result, the noise sources from replacement/revamping activity are not included in this modelling study.

With reference to the SHU Refinery Site, as noted in Section 7.2.3, KNPC plans to decommission all of the existing processing facilities. Therefore, many major sources of noise generation will be removed, resulting in a significant reduction in the environmental noise in the vicinity of Shuaiba site. As a result, SHU is excluded from the scope of work in this modelling study.

7.4.1.3 Decommissioning Activities

It is recognised that the decommissioning of the existing facilities in the SHU Refinery can generate some noise due to the associated civil and mechanical work. However, decommissioning of facilities at SHU is not part of the CFP scope and will need to be addressed in a separate EIA study for KNPC.

7.4.2 Source Noise Levels at MAA Refinery Site

7.4.2.1 Construction Phase

As discussed earlier in Section 7.4.1.1, the early Construction Phase activities (i.e. Site Preparation and Earthworks) are considered for the worst case noise impact during the Construction Phase. The significant noise generating sources present during the early Construction Phase have also been identified in Section 7.4.1.1. The estimated SWL value for each of these sources is shown in the following table, along with other details.

Table 7.3: Characterisation of Significant Noise Sources in CFP Block at MAA Refinery Site: Construction Phase

Name of Construction Equipment	Number of Units (Individual Noise Sources)	Spacing between Individual Units (m)	Height[a] of Noise Emission Source (m)	SWL_{total} [dB(A)] – Each Source
Bulldozer	5	75	1	109
Dumper Truck	25 (as clusters of 5)	100 (for clusters)	1	103
Wheel Loader	4	75	1	104
Excavator	5	75	1	109
Grader	3	75	1	109
Roller Compactor	5	75	1	104

Name of Construction Equipment	Number of Units (Individual Noise Sources)	Spacing between Individual Units (m)	Height[a] of Noise Emission Source (m)	SWL_{total} [dB(A)] – Each Source
Asphalt Machine & Roller	1	None	1	104

Note: [a]. Emission height with reference to the site ground level at the lowest elevation.

All the sources are assumed to be continuous noise emission sources with 360° directivity. It is also assumed that SWL of any source does not show any variance with time, either diurnal or seasonal.

7.4.2.2 Operations Phase

Based on the discussion presented in Section 7.4.1, only those equipment items located within the CFP Block with SWL above 60 dB(A) are considered as significant noise sources in the model input. Each new unit within the MAA CFP Block consists of a number of equipment items with varying SWL values. Using the preliminary technical information (provided by Fluor, the FEED contractor) for each major individual equipment item, the SWL value is estimated based on the equipment type and its electrical power rating, as well as using DNV's noise data bank. DNV's internal noise data bank for typical plant equipment is based on DNV's experience from real onsite monitoring at various industrial locations combined with empirical correlations.

After estimating the SWL values for each piece of major equipment within each unit, the total SWL value (SWL_{total}) for the unit is calculated by logarithmic addition of the individual SWL values. Thus, each unit is modelled as a single virtual point source with its SWL value equal to the logarithmic total. The location coordinates of this virtual point source correspond to the actual location coordinates of the real point source with the highest individual SWL value in that unit.

This simplification is made in order to conserve the runstream time (due to the presence of several hundred individual point sources in each site) and due to dynamic memory limitations of the model. Trial runs showed that this simplification does not lead to any noticeable error with regard to the SPL values at receptors outside the fence line.

Pipelines with high fluid velocity (>3m/s) are considered as significant noise sources and hence included in the model. These are modelled as line sources. The calculated SWL_{total} value for each unit in the MAA CFP Block is shown in the following table.

Table 7.4: Characterisation of Significant Noise Sources in CFP Block in MAA Refinery Site: Operations Phase[a]

Name of Unit	Source ID	Number of Significant Sources in Process Unit	Height[b] of Noise Emission (m)	SWL_{total}[dB (A)]
Isomerisation Unit	U-107	12	13.5	111.6
LPG Treatment Unit	U-125	9	13.5	114.1
Steam System	U-129	7	33.1	108.6
Naphtha Hydrotreater	U-135	6	30.2	103.3
Delayed Coker Unit	U-136	19	30.2	113.7
Deisopentanizer	U-137	18	13.5	108.4
ICS Merox Unit	U-138	8	12.5	104.2
Atmospheric Residue Desulfurization Unit	U-141	25	30.2	112.7
Gas Oil Desulphurisation Unit	U-144	24	13.5	114.8
Deisobutanizer	U-146	19	13.5	109.8
Hydrogen Production Unit	U-148	13	30.2	112.4
Hydrogen Sulphide Removal Unit	U-150	4	33.1	104.6
Sulphur Recovery Unit	U-151	10	33.1	110.1
Sulphur Recovery Unit	U-152	10	33,1	110.1
Hydrogen Sulphide Removal Unit	U-153	6	17.8	105.8
Sour Water Treatment	U-156	3	33.1	94.5
Interconnecting Pipeways	U-160	Line source	variable	78.0
Interconnecting Pipeways	U-161	Line source	variable	78.0
Hydrocarbon Flare	U-162	4	27.6 134.1	88.5[c] 145.0[d]
Waste Water Treating	U-163	17	27.6	112.6
Fire Fighting Facilities	U-166	-	34.8	110.0
Acid Gas Flare	U-167	3	33.1 132.6	82.8[c] 135.0[d]
Nitrogen / Air Systems	U-171	3	33.1	103.0
Fuel Gas Systems	U-174	2	33.1	90.5
Cooling Water System	U-175	4	34.8	107.7
Water Systems (1st partition)	U-176	13	32.1	97.7
Water Systems (2nd partition)	U-176	1	34.8	77.0
Vacuum Rerun Unit	U-183	13	27.6	108.5
Fluid Catalyst Cracking Naphtha Hydrotreater Unit	U-186	4	33.1	107.6
Coke Handling	U-187	7	28.6	114.1

FCC Sour Water Treating	U-195	9	33.1	97.5
Cooling Water System	U-275	2	32.1	103.1
Heavy Oil Cooling	U-283	3	26.6	103.3

Notes:

[a] Some existing units will be retired; the subsequent benefit via a reduction of noise has not been considered in this assessment..

[b]. Noise emission height with reference to the site ground level at the lowest elevation.

[c]. At normal plant operation with minimal continuous flaring.

[d]. At plant upset condition with maximum flaring at the design rating.

All the sources are continuous noise emission sources with 360° directivity. It is assumed that SWL of any source does not show any variance with time, either diurnal or seasonal. For flares, under normal plant operation, there will be minimal flaring and the SWL will be relatively low.

7.4.3 Source Noise Levels at MAB Refinery Site

7.4.3.1 Construction Phase

The significant noise sources for the MAB construction activities, their relative locations, and their SWL values are identical to those presented in Section 7.4.2.1 for the CFP Block in MAA site. However, since the scope of work at the MAB site is much larger than that at MAA site, it is conservatively assumed that the number of equipment items present at MAB site is double that at the MAA site.

The estimated SWL value for each of these sources is shown in the following table, along with other details.

Table 7.5: Characterisation of Significant Noise Sources in CFP Block in MAB Refinery Site: Construction Phase

Name of Construction Equipment	Number of Units (Individual Noise Sources)	Spacing between Individual Units (m)	Height[a] of Noise Emission Source (m)	SWL_{total} [dB(A)] – Each Source
Bulldozer	10	75	1	109
Dumper Truck	50 (as clusters of 5)	100 (for clusters)	1	103
Wheel Loader	8	75	1	104
Excavator	10	75	1	109
Grader	6	75	1	109
Roller Compactor	10	75	1	104
Asphalt Machines & Roller	2	100	1	104

Note: [a]. Emission height with reference to the site ground level at the lowest elevation.

7.4.3.2 Operations Phase

Each new unit within the CFP Block in MAB consists of a number of equipment items with varying SWL values. As discussed in Section 7.4.2.2, each unit is modelled as a single virtual point source. The calculated SWL_{total} value for each unit in the MAB CFP Block is shown in the following table.

Table 7.6: Characterisation of Significant Noise Sources in CFP Block in MAB Refinery Site: Operations Phase

Name of Process Unit	Source ID	Number Significant Sources in Process Unit	Height[a] of Noise Emission (m)	SWL_{total} [dB(A)]
Crude Distillation Unit	U-111	19	22.2	114.3
Atmospheric Residue Desulfurization Unit	U-112	22	22.2	118.3
Heavy Oil Cooling	U-113	3	22.2	106.6
Hydrocracker	U-114	16	22.2	115.2
Kerosene Hydrotreater	U-115	7	22.2	112.3
Diesel Hydrotreater	U-116	9	22.2	115.1
Naphtha Hydrotreater	U-117	5	19.0	106.9
Hydrogen Production Plant	U-118	12	17.0	114.3
Hydrogen Recovery Unit	U-119	4	16.0	103.4
Sulfur Recovery Unit	U-123	9	13.9	112.0
Amine Regeneration Unit	U-125	4	13.9	109.9
Sour Water Stripping Units	U-126	4	12.4	108.1
Continuous Catalytic Reformer	U-127	13	20.0	112.7
Train 1 - HPU Feed Treatment & Compression	U-128/1	3	17.0	107.3
Train 2 - Hydrogen Compression	U-128/2	6	17.0	115.9
Saturated Gas Plant	U-129	3	10.9	106.8
Steam Systems	U-131	11	20.0	112.0
Cooling Water Systems	U-132	7	27.8	109.1
Fuel System	U-133	1	16.0	77.0
Air / Nitrogen Systems	U-134	1	19.5	108.0
Water Systems	U-137	18	16.0	103.3
Acid Gas Flare	U-146	2	13.4 132.4	85[b] 138.0[c]
Interconnecting Pipeway	U-148	Line source	Variable	78.0
HC Flare and Flare Recovery System[b]	U-149	3	17.3 77.3 / 80.3	90[c] 143.0[d]
Interconnecting Pipeway	U-150	Line Source	Variable	78.0

Name of Process Unit	Source ID	Number Significant Sources in Process Unit	Height[a] of Noise Emission (m)	SWL$_{total}$ [dB(A)]
Fire Water System	U-154	1	16.0	110.0
Waste Water Treating	U-156	17	9.9	114.1
Atmospheric Residue Desulfurization Unit	U-212	15	23.2	116.3
Vacuum Unit	U-213	1	19.0	108.5
Hydrocracker Unit	U-214	21	23.2	116.1
Diesel Hydrotreater	U-216	24	24.3	116.5
Diesel Hydrotreater Flare	U-249	2	13.9 89.4	101.0[c] 140.0[d]
Hydrocracker Flare	U-314	2	107.7 123.7	140.0[c] 140.0[d]

Notes: [a] Noise emission height with reference to the site ground level. [b] The HC Flare and Flare Recovery System consists of a flare recovery unit (U-149/a) and two HC flares (U-149/b/c) with each HC flare consisting of two stacks of same height. [c] At normal plant operation with minimal continuous flaring. [d] At plant upset condition with maximum flaring at the design rating.

All the sources are continuous noise emission sources with 360° directivity. It is assumed that the SWL of any source does not show any variance with time, either diurnal or seasonal. For flares, under normal plant operation, there will be minimal flaring and the SWL will be relatively low.

7.4.4 Source Noise Levels at SHU Refinery Site

As discussed in Section 7.4.1, noise impact modelling is not considered necessary at the SHU Refinery site. Noise levels at SHU will decrease because the process units (and some utility units) within that refinery will be decommissioned. This is regarded as a positive impact for CFP.

7.5 Model Set Up

7.5.1 Model Options and Assumptions

The description of the noise model used in this study and the input requirements are presented in Section 7.1.2. The model options used and the assumption made in this study are described in the following table.

Table 7.7: Model Options and Assumptions

Parameter	Option Used
Noise Sources	• All sources, except pipelines are considered as point sources. Pipelines with high fluid velocity are considered to be high noise generating sources and, therefore, included in the model. These are modelled as line sources. • The source location coordinates are determined from

Parameter	Option Used
	the plot plans and the source heights are determined from the equipment specification datasheets. • SWL values are entered using 1 octave option for the frequency bands 62.5, 125, 250, 500, 1000, 2000, 4000 and 8000Hz[3]. In the absence of any vendor information, the SWL values are estimated based on the equipment specifications (equipment type and electrical power rating) and using DNV's noise data bank. • Considering that there are several hundred pieces of equipment with some noise generation, only the equipment with SWL above 60 dB(A) are considered as significant noise source. This assumption does not lead to any noticeable error, since SPL is added on a logarithmic scale. For instance, the net SPL from a 60 dB source and an 80 dB source is 80.04 dB. • Each Process Unit is modelled as a single virtual point source. The total SWL of the virtual source is calculated by logarithmic addition of the various individual point sources (up to over 20 for each Unit). This simplification is made to conserve the runstream time and due to dynamic memory limitations. • For each source, the directivity is assumed to be 360°. Similarly, the working (operating) period is assumed to be 24 hours. Both are conservative assumptions, representing the worst case.
User Defined Attenuation	• User defined attenuation takes into consideration the reduction in source noise level achieved by providing acoustic enclosures and barriers around high noise generating sources. • In this modelling study, the user defined attenuation is taken as zero (worst case) for all sources except for the following sources as detailed below. • For flares at both MAA and MAB sites, 15 dB(A) attenuation is assumed. In compliance with the KNPC noise specifications, the flares are designed in such a way that SPL outside the enclosure will not exceed 115 dB(A).
Noise Receptors	• Uniform rectangular grid of 50m spacing is used for the receptor points. • Additional discrete receptors at locations, where background noise levels are available from the Environmental Baseline Study, are also used. • All receptors are placed at 1.8m above the local ground level, representing the average hearing height of human receptor.
Barriers	• No barriers are used, since none are present at the project sites. This in any case is a conservative assumption.
Buildings	• Buildings details are input into the model based on the plot plans. • All buildings are assumed to have totally reflective

[3] As per ISO 9613 method, the frequency band 31Hz is not entered.

Parameter	Option Used
	surfaces (no absorption) as well as vertical surfaces (no profile correction). This is a conservative assumption.
Terrain	• Terrain is assumed to be flat, as recommended in the ISO method. • It is recognised that there is about 10-20m drop in the elevation across the plant site for each refinery. However there are no valleys and peaks that act as sound barriers.
Topography	• The topography is assumed to be a simple ground region with hard surface (zero ground absorption). This is a reasonable assumption as well as being conservative
Meteorological Conditions	• Based on two years of meteorological data recorded at the project site, the worst case meteorological parameters are used for calculating noise attenuation by the air absorption. • As noted earlier, wind speed, wind direction and atmospheric stability are not considered in ISO method.
Time Averaging	• Since none of the input parameters has any time dependence, there is no need for selecting different time averaging periods.
Time-of-the-day Compensation	• As a standard default, the model output returns L_{den} value, which is a time weighted average value of SPL in which a penalty of +5 dB and +10 dB is applied for the evening and night hours respectively. • This option is not used in this study because such penalties are already applied in the K-EPA's ambient noise standards (refer Table 7.1). Consequently, the model output returns the 'uncompensated' SPL values.

7.5.2 Modelling Scenarios

Considering that the noise sources are different for the Construction Phase and the Operations Phase, for each site (MAA and MAB), separate model runs were performed. Within the Operations Phase, two different scenarios were considered – normal operation and plant upset condition. The difference is that the flaring will be at the design rating under plant upset condition, while flaring will be minimal under normal plant operation.

The following scenarios were considered for noise modelling:

Scenario MAA 1: Operations Phase (Normal Plant Operation) – MAA Site

Scenario MAA 2: Operations Phase (Plant Upset Condition) – MAA Site

Scenario MAA 3: Construction Phase – MAA Site

Scenario MAB 4: Operations Phase (Normal Plant Operation) – MAB Site

Scenario MAB 5: Operations Phase (Plant Upset Condition) – MAB Site

Scenario MAB 6: Construction Phase – MAB Site

7.5.3 Layout of Noise Sources and Buildings

Using the plot plans for the MAA and MAB sites, the virtual point noise sources and the buildings between the sources and the receptors were entered into the Predictor model. The screen shots taken from the model software after entering the above input data for both the sites for the Operations and Construction Phases are shown in Figures 7D through 7G. It should be noted that the sources and buildings, and their locations for the Operations Phase remain the same under normal operation and upset condition.

Figure 7D: Screen Shot Showing Layout of Noise Sources in MAA CFP Block – Construction Phase

(Note: The construction footprint progresses from one end to the other within the CFP)

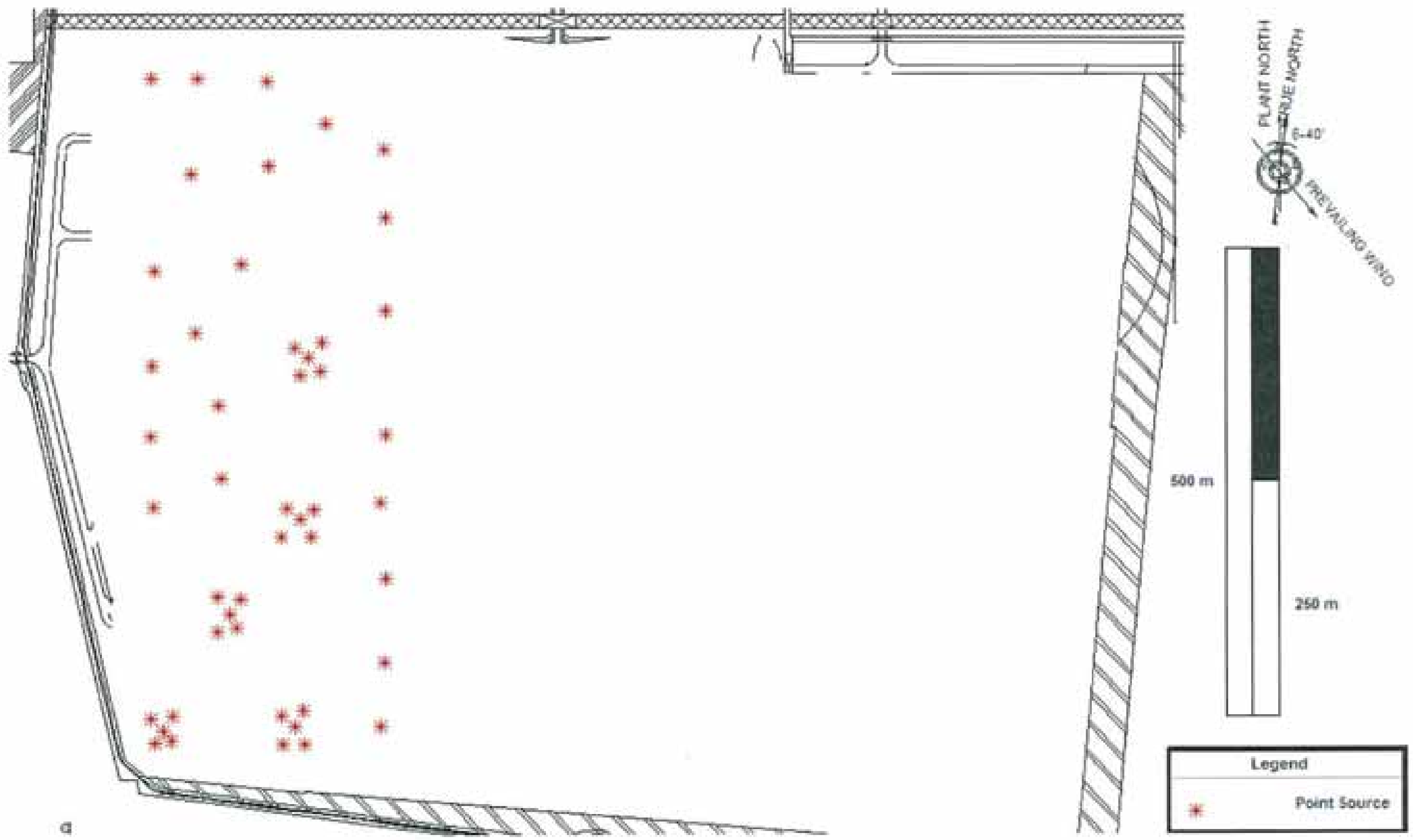


Figure 7E: Screen Shot Showing Layout of Noise Sources and Buildings in MAA CFP Block – Operations Phase

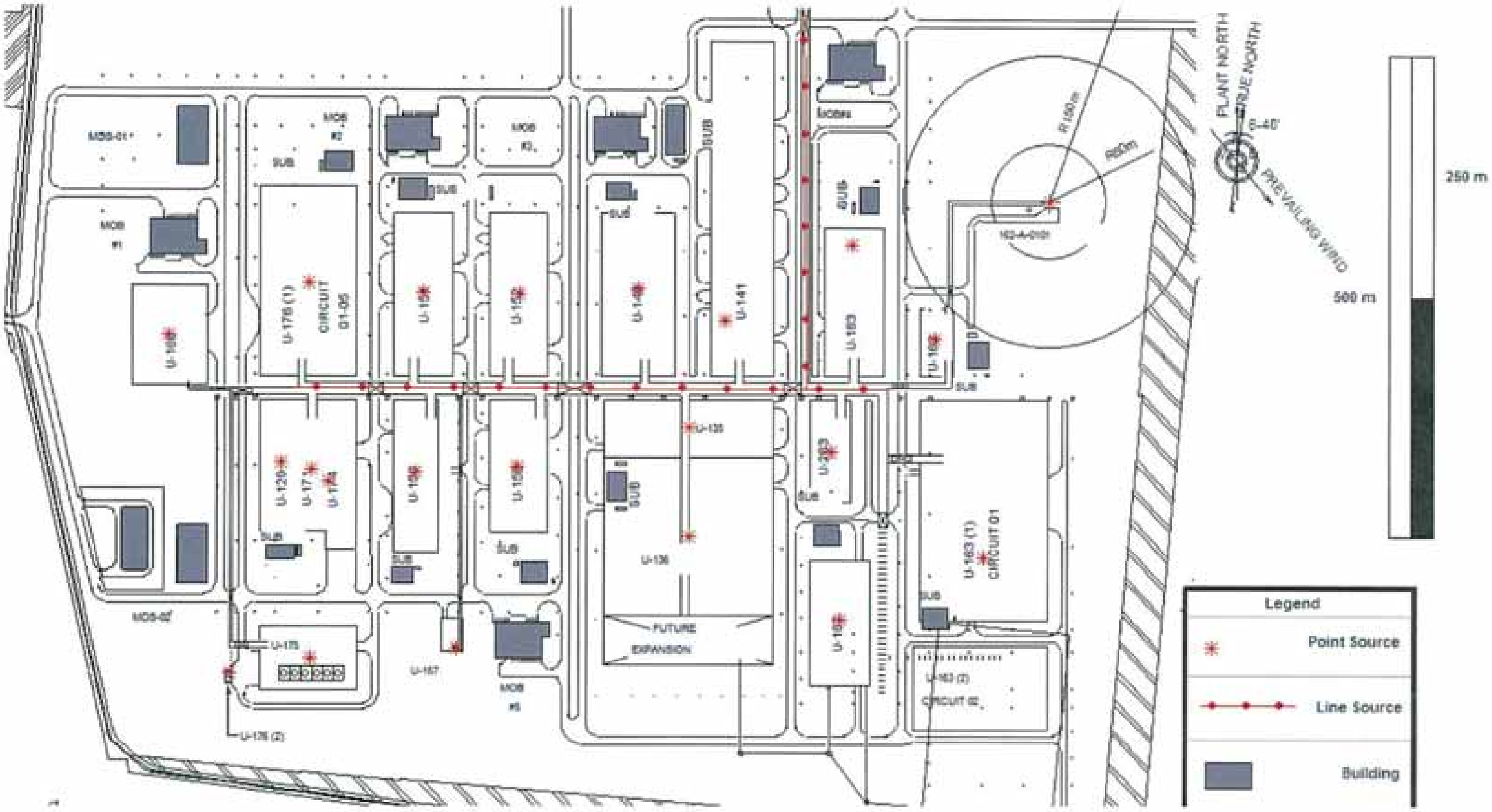


Figure 7F: Screen Shot Showing Layout of Noise Sources in MAB CFP Block – Construction Phase
(Note: The construction footprint progresses from one end to the other within the CFP Block.)

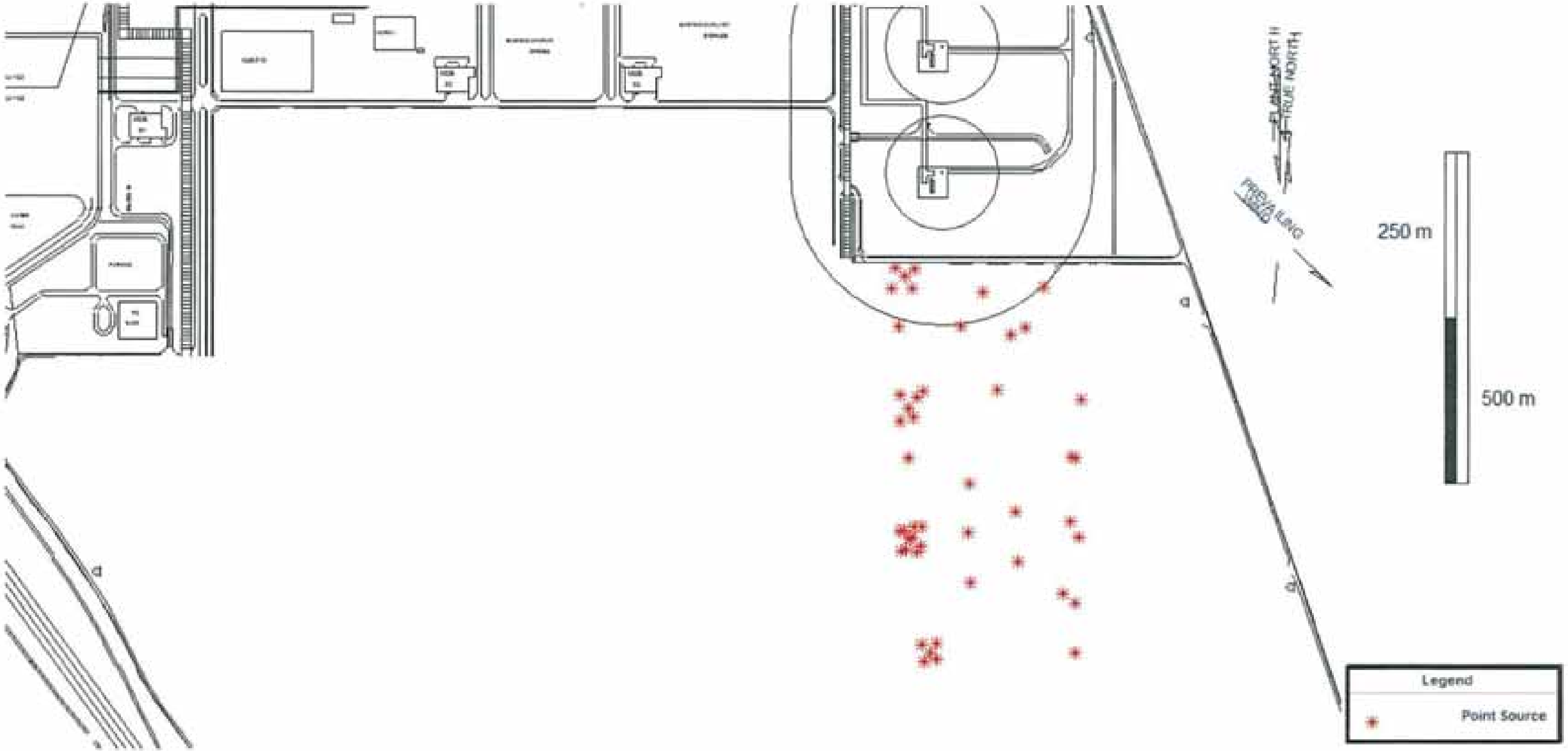
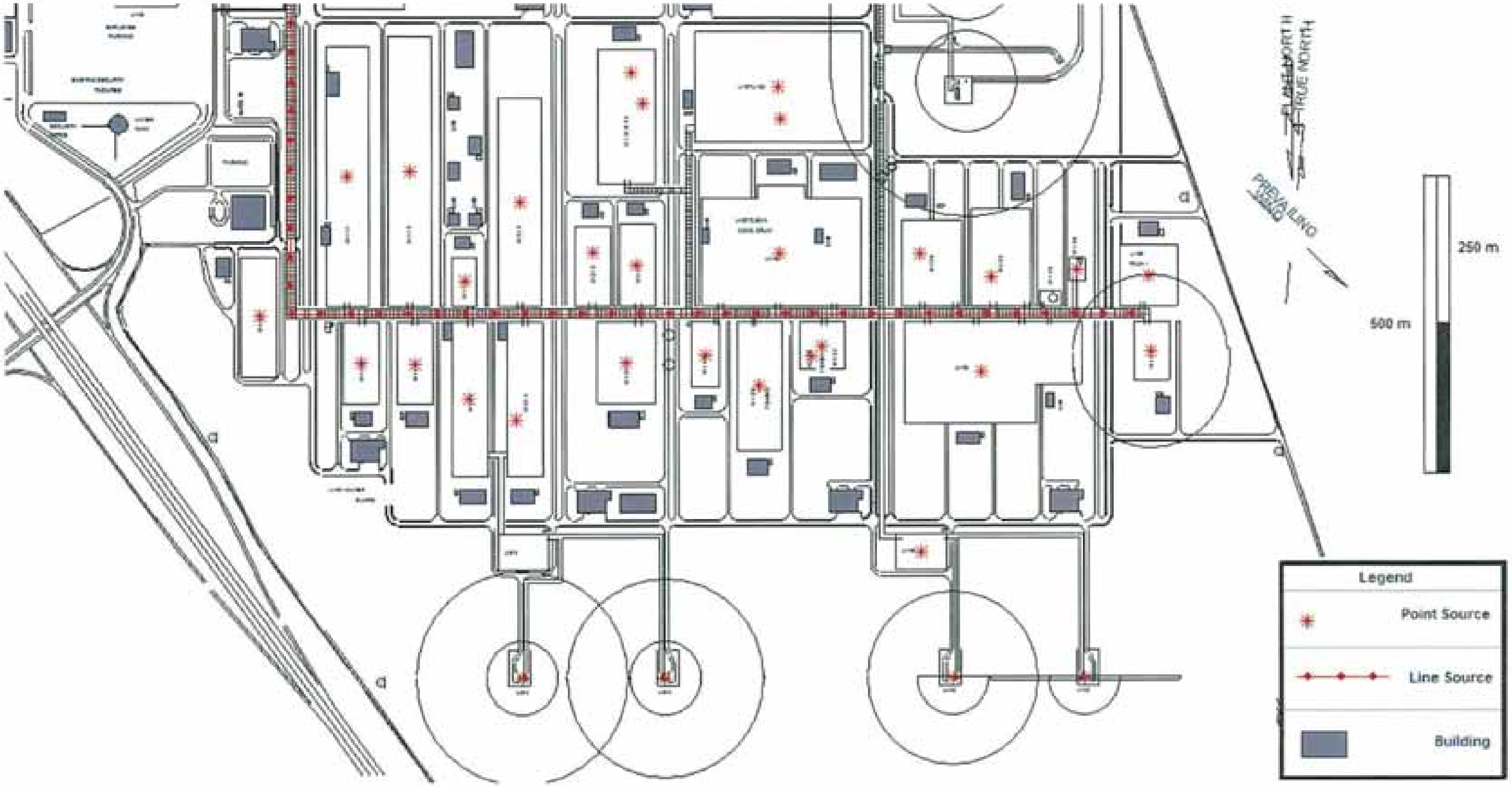


Figure 7G: Screen Shot Showing Layout of Noise Sources and Buildings for MAB CFP Block – Operations Phase



7.6 Model Set Up

7.6.1 General

For each of the scenarios listed in Section 7.5.2, noise modelling was performed as discussed in Section 7.5.1. The results are presented graphically as noise contours, which are overlain on the plot plans. Additionally, the results are also shown in tables, including a few selected receptors. The selected receptors include the fence line points and residential sites (where background noise levels were monitored as part of environmental baseline monitoring).

Also as discussed in Table 7.7, L_{den} values are not used; hence no penalties are applied for the evening and night hours.

7.6.2 MAA Refinery Site

The predicted noise contours for Scenarios MAA 1 (Operations Phase - Normal Plant Operation), MAA 2 (Operations Phase - Plant Upset Condition) and MAA 3 (Construction Phase) are shown in the following figures. It shall be noted that the noise values shown are for any time of the day, expressed as SPL in dB(A) and do not include the background noise levels. The effect of the background noise levels on the predicted values is discussed later in Section 7.7.1.

Figure 7H: Predicted Noise Levels for Construction Phase (Site Preparation & Earthworks) - within MAA CFP Block

(Note: Background noise levels are not included. Site Preparation & Earthworks stage represents the worst case with respect to noise generation during the Construction Phase)

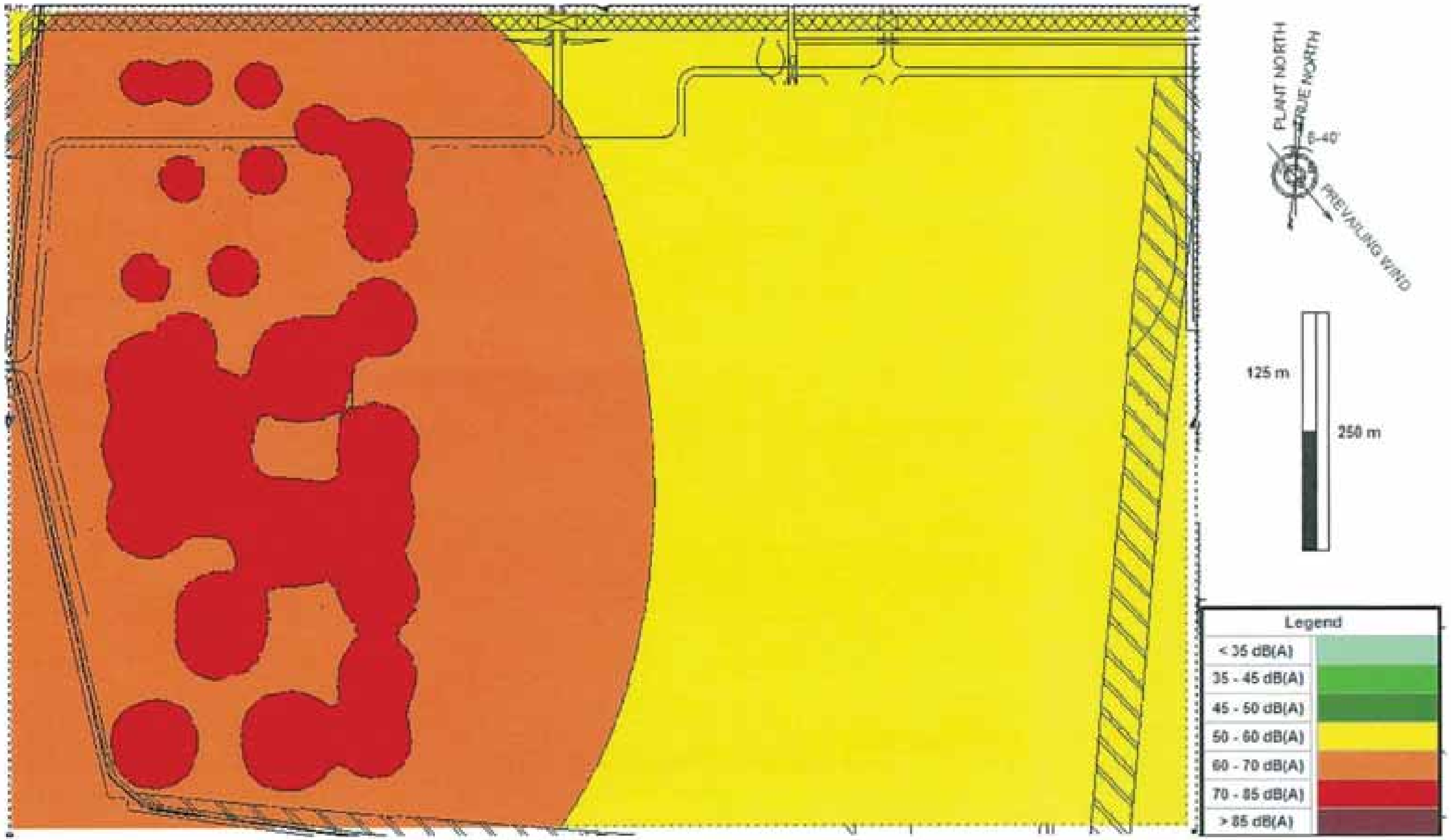


Figure 7l: Predicted Noise Levels for Construction Phase (Site Preparation & Earthworks) – Within MAA Refinery Site

(Note: Background noise levels are not included. Site Preparation & Earthworks stage represents the worst case with respect to noise generation during the Construction Phase)

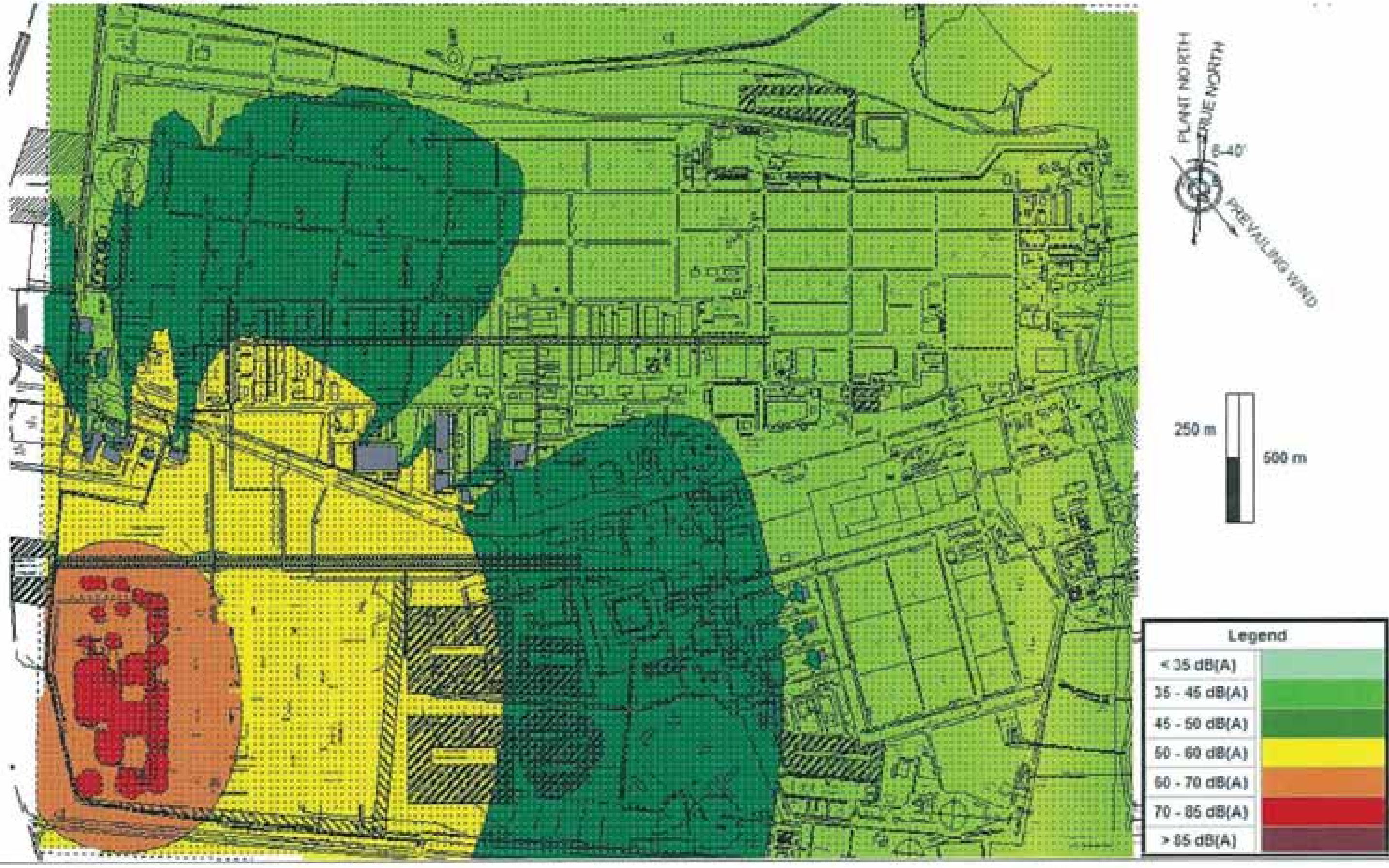


Figure 7J: Predicted Noise Levels for Construction Phase (Site Preparation & Earthworks) – Within MAA Area

(Note: Background noise levels are not included. Site Preparation & Earthworks stage represents the worst case with respect to noise generation during the Construction Phase)

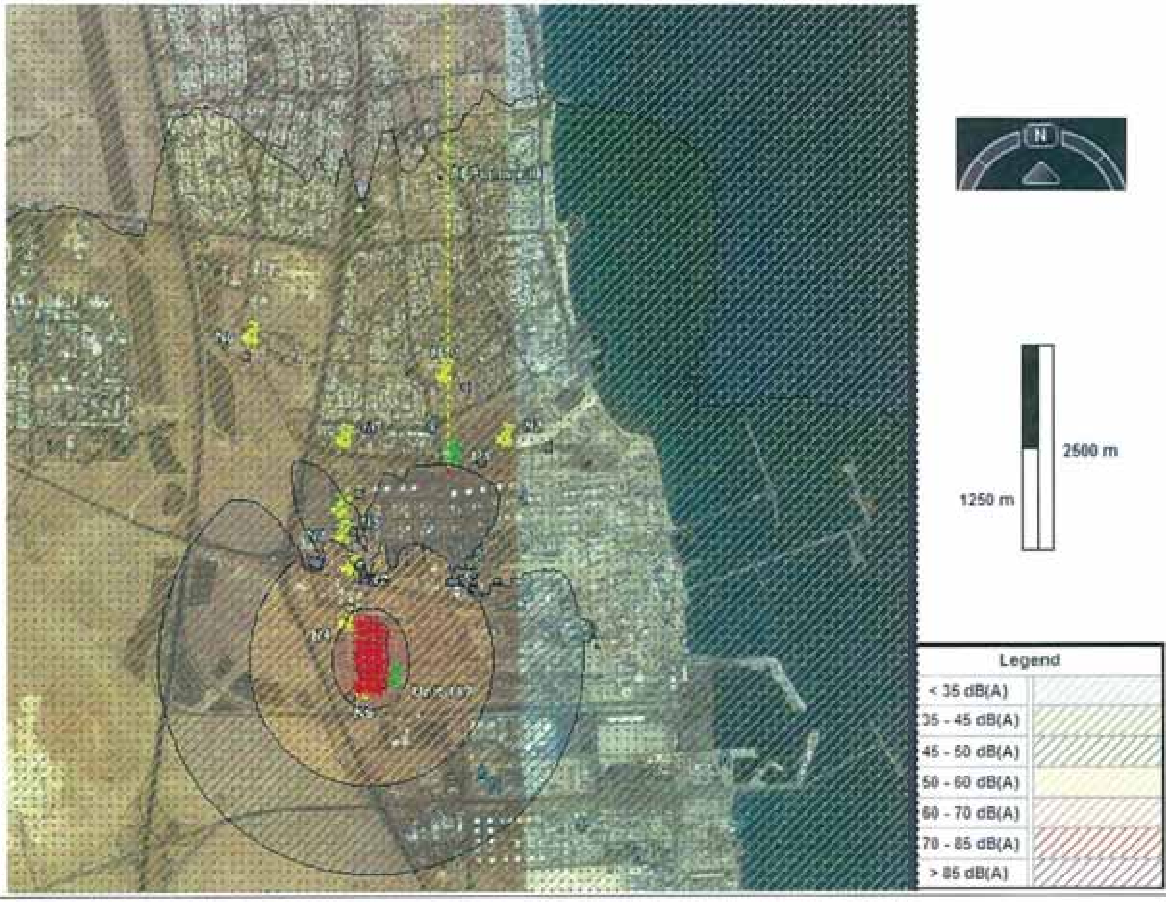


Figure 7K: Predicted Noise Levels for Operations Phase (Normal Plant Operation) - within MAA CFP Block

(Note: Background noise levels are not included. Under normal plant operation, flaring is at the minimal and flare noise is at the lowest.)

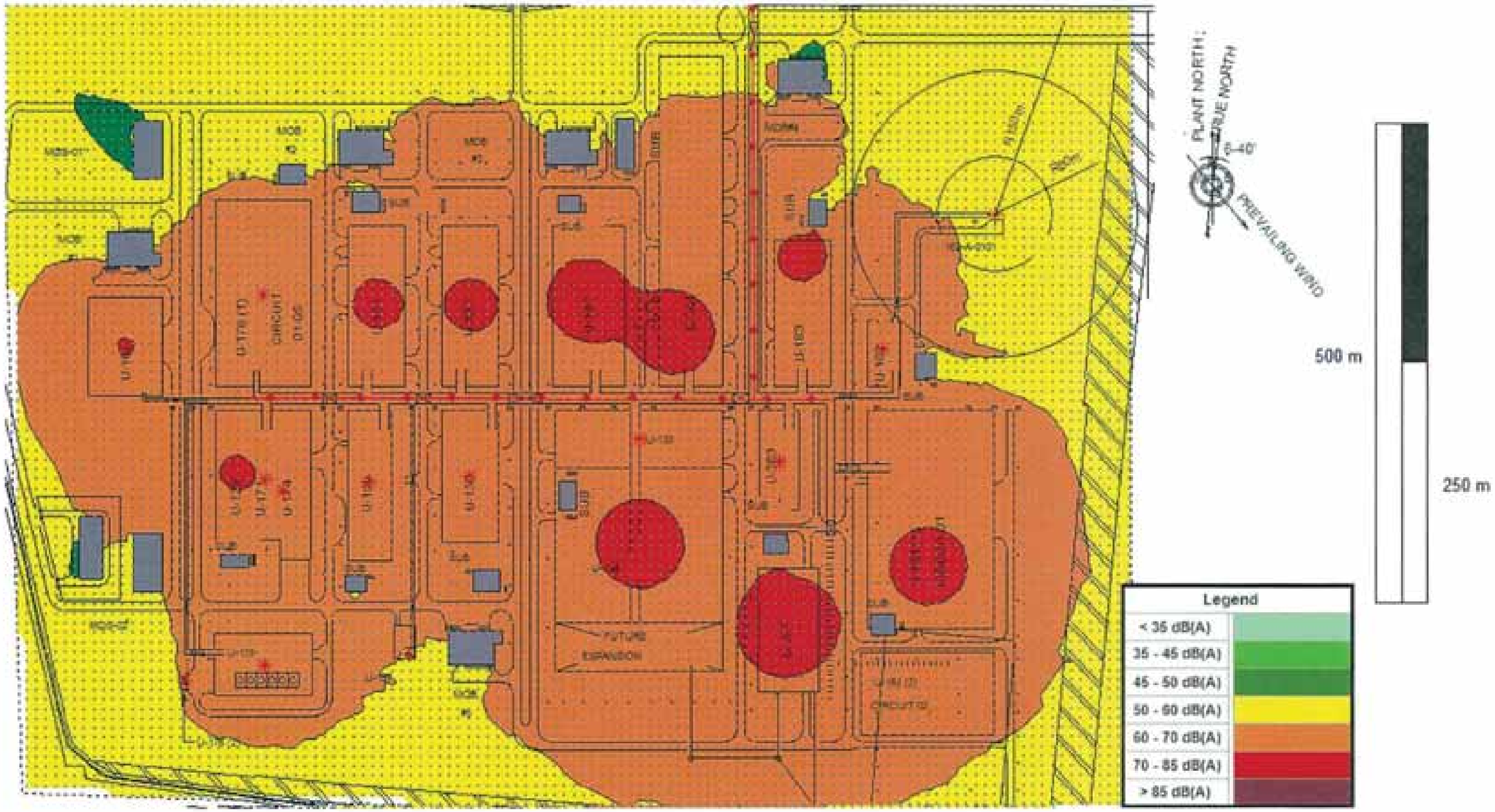


Figure 7L: Predicted Noise Levels for Operations Phase (Normal Plant Operation) - within MAA Refinery Site

(Note: Background noise levels are not included. Under normal plant operation, flaring is at the minimal and flare noise is at the lowest.)

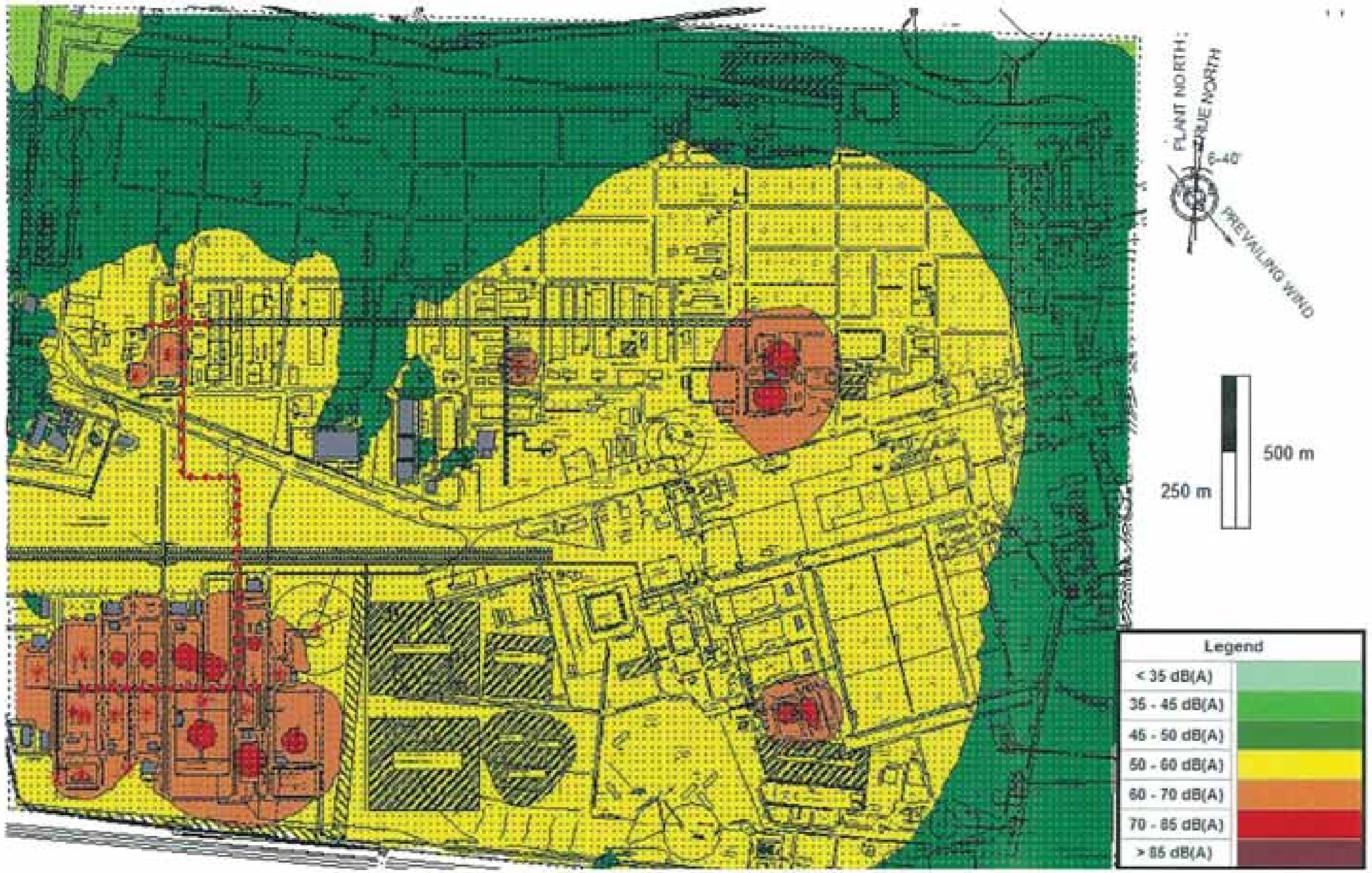


Figure 7M: Predicted Noise Levels for Operations Phase (Normal Plant Operation) - within MAA Area

(Note: Background noise levels are not included. Under plant upset condition, flaring is at the maximum at design rating and flare noise is at the highest.)

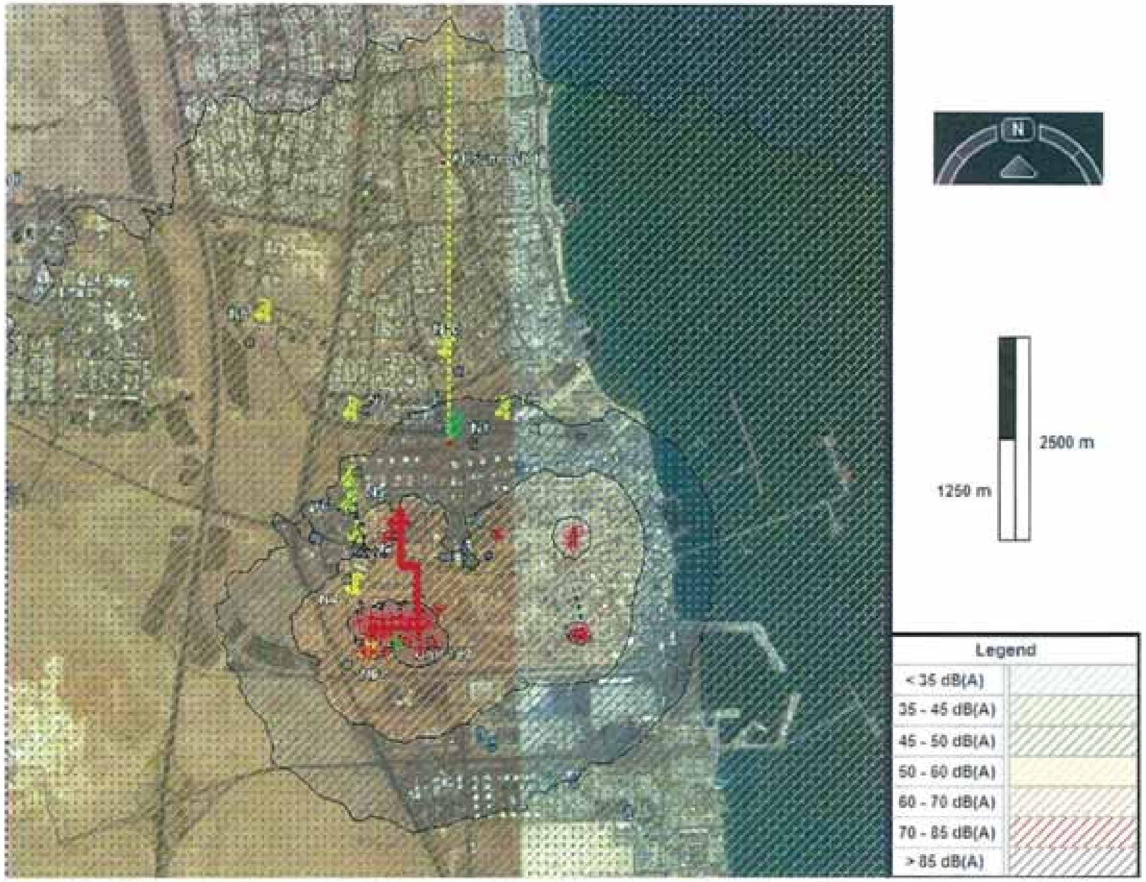


Figure 7N: Predicted Noise Levels for Operations Phase (Plant Upset Condition) – within MAA CFP Block

(Note: Background noise levels are not included. Under plant upset condition, flaring is at the maximum at design rating and flare noise is at the highest.)

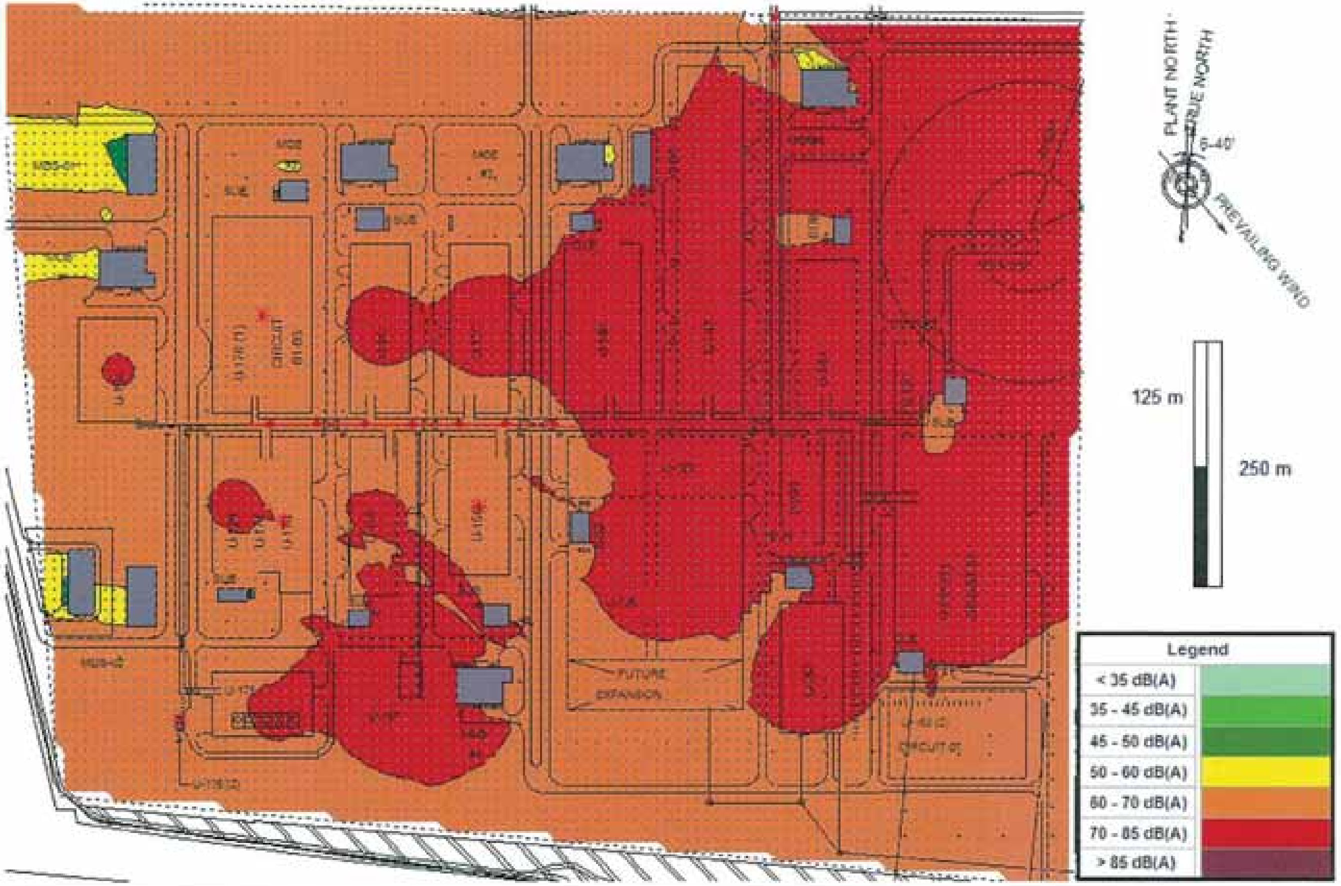


Figure 7O: Predicted Noise Levels for Operations Phase (Plant Upset Condition) – within MAA Refinery Site

(Note: Background noise levels are not included. Under plant upset condition, flaring is at the maximum at design rating and flare noise is at the highest.)

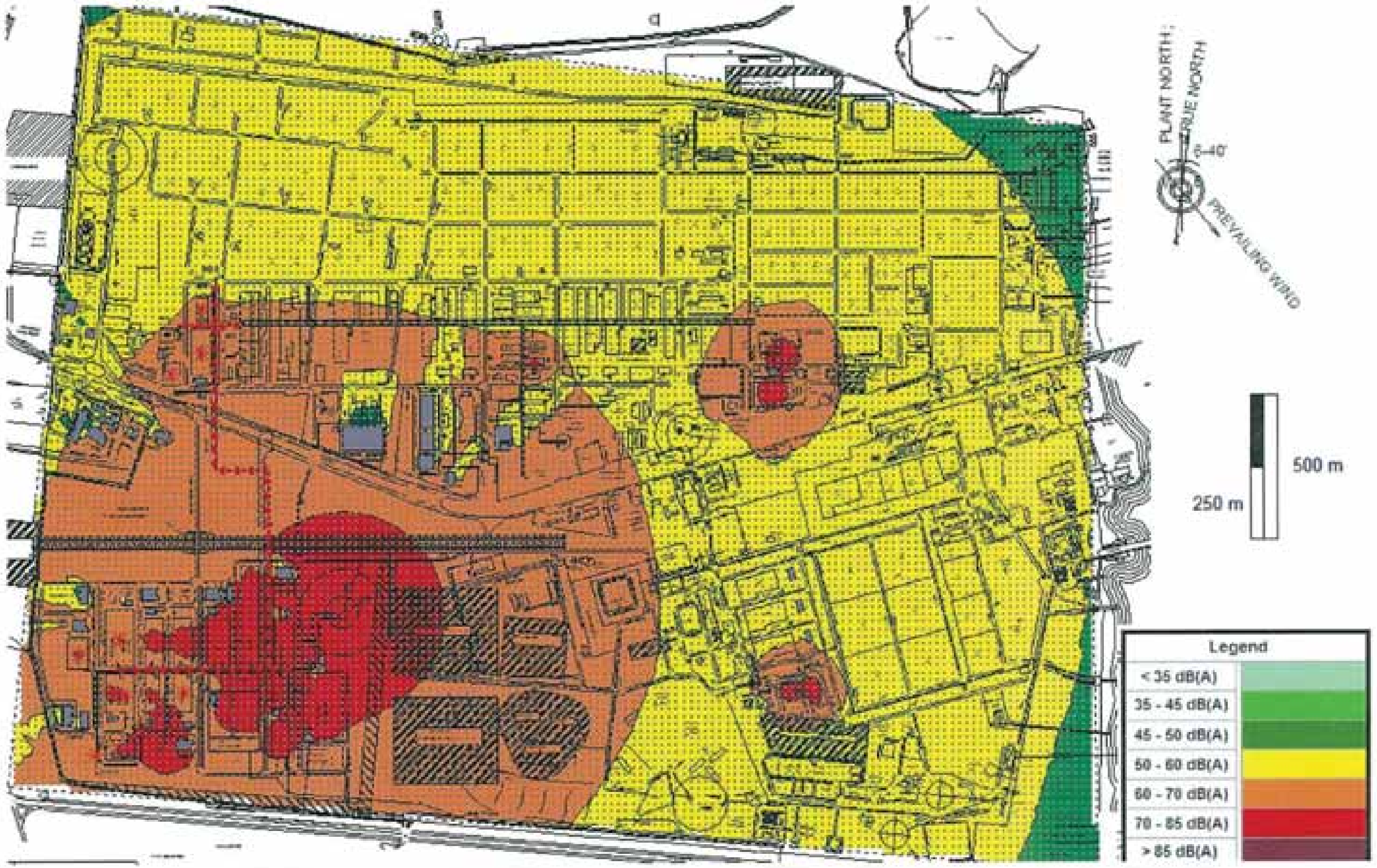
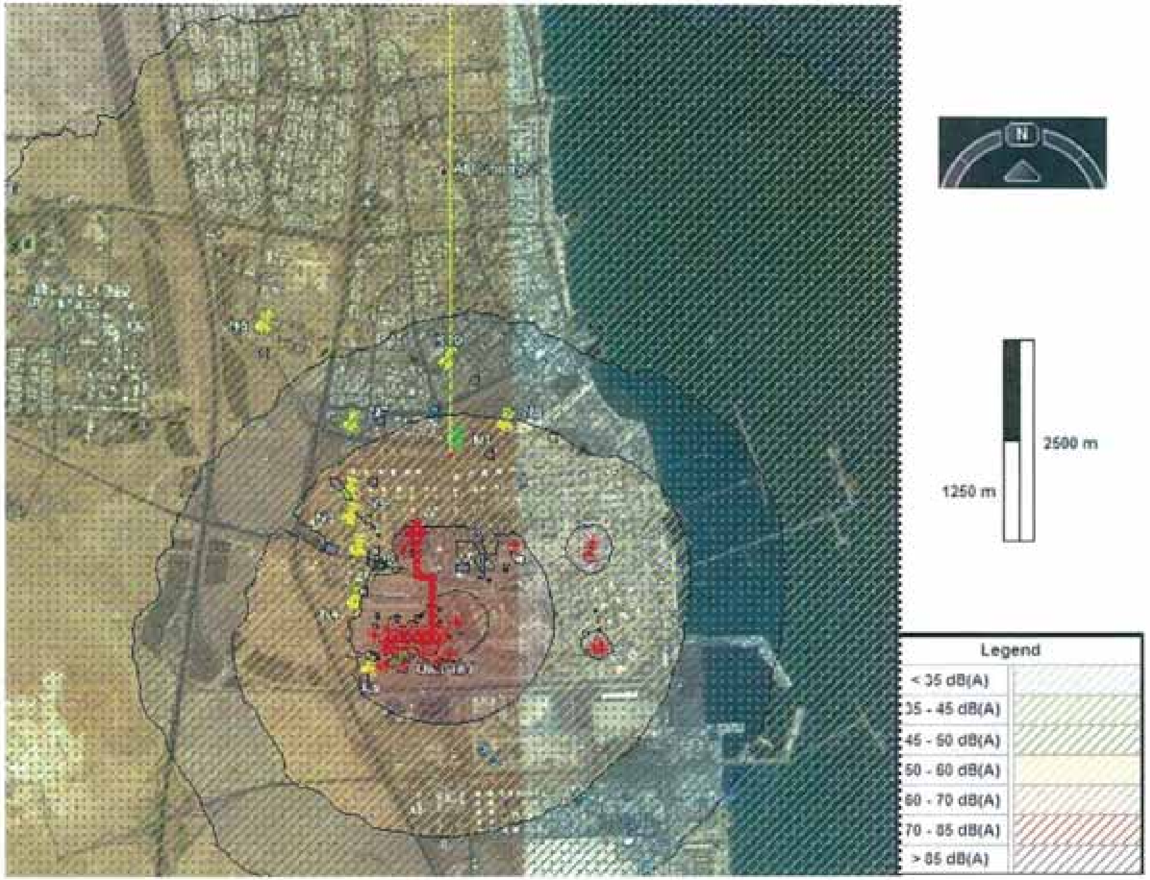


Figure 7P: Predicted Noise Levels for Operations Phase (Plant Upset Condition) - within MAA Area

(Note: Background noise levels are not included. Under plant upset condition, flaring is at the maximum at design rating and flare noise is at the highest.)



Based on the noise contours presented in Figure 7H through to Figure 7P, the maximum distances from the MAA CFP Block to various noise contour levels are identified and summarised in the following table.

Table 7.8: Noise Impact Prediction for MAA CFP

Predicted Noise Level[#] (Leq)	Maximum Distance from Fence Line of MAA CFP Block		
	Construction Phase (Site Preparation and Earthworks)	Operations Phase (Normal Plant Operation)	Operations Phase (Plant Upset Condition)
70 dB(A)	0 m	0 m	0 m
65 dB(A)	56 m [West]	0 m	70 m [South]
60 dB(A)	187 m [West]	0 m	440 m [South]
55 dB(A)	513 m [West]	230 m [South]	930 m [South]
50 dB(A)	1090 m [West]	865 m [South]	1690 m [South]
45 dB(A)	2068 m [West]	1780 m [South]	2910 m [South]

[#] Not including the existing background noise levels.

As seen from the above table, the most stringent community noise level of 45 dB(A) for night time L_{eq} in the ideal residential area will be reached at a maximum distance of 2910 m from the fence line of MAA CFP Block under the worst scenario (Operations Phase – Plant Upset Condition).

The predicted noise levels at selected receptors where background noise levels were monitored as part of baseline study are summarised in the following table (excluding baseline conditions)

Table 7.9: Predicted Noise Levels at Selected Receptors in MAA Area

Location ID	Location Description	Area Classification	Predicted L_{eq} in dB(A)		
			Construction Phase (Site Preparation and Earthworks)	Operations Phase (Normal Plant Operation)	Operations Phase (Plant Upset Condition)
N1 (MAA)	Near Busy Road	Residential (affected by traffic)	44.5	46.7	52.3
N2 (MAA)	Near Main-gate, Car Park & Flare	Industrial	46.3	50.3	58.9
N3 (MAA)	Near Flare/Road	Industrial	45.9	47.1	52.9
N4 (MAA)	Near Busy Road / Flare Sound in Background	Industrial	58.0	51.5	59.9

Location ID	Location Description	Area Classification	Predicted L_{eq} in dB(A)		
			Construction Phase (Site Preparation and Earthworks)	Operations Phase (Normal Plant Operation)	Operations Phase (Plant Upset Condition)
N5 (MAA)	Near Flare (Continuous & Strong Flare Sound)	Industrial	42.1	45.8	53.5
N6 (Offsite)	Close to Major Highway & Mosque (Continuous Traffic Noise)	Residential (affected by traffic)	40.2	38.8	43.3
N7 (MAA)	Near Busy Road (Traffic Signal & Highway), Workshops & Working Machinery	Residential (affected by traffic)	41.6	42.9	48.8
N8 (MAA)	Lamp Post Opposite to Tank 758	Residential	41.9	46.5	50.4
N9 (MAA)	Near Road	Industrial	63.5	55.4	62.0
N10 (Offsite)	Near Busy Road (Working Machinery)	Residential (affected by traffic)	41.9	43.9	48.0

Note: The results presented for the Construction Phase represent the case where the construction footprint within the CFP Block is located closest to the sensitive community receptors.

7.6.3 MAB Refinery Site

The predicted noise contours for Scenarios MAB 1 (Operations Phase - Normal Plant Operation), MAB 2 (Operations Phase - Plant Upset Condition) and MAB 3 (Construction Phase) are shown in the following figures. It should be noted that the noise values shown are for any time of the day, expressed as SPL in dB(A) and do not include the background noise levels. The effect of the background noise levels on the predicted values is discussed later in Section 7.7.1.

Figure 7Q: Predicted Noise Levels for Construction Phase (Site Preparation & Earthworks) – within MAB CFP Block

(Note: Background noise levels are not included. Site Preparation & Earthworks stage represents the worst case with respect to noise generation during the Construction Phase.)

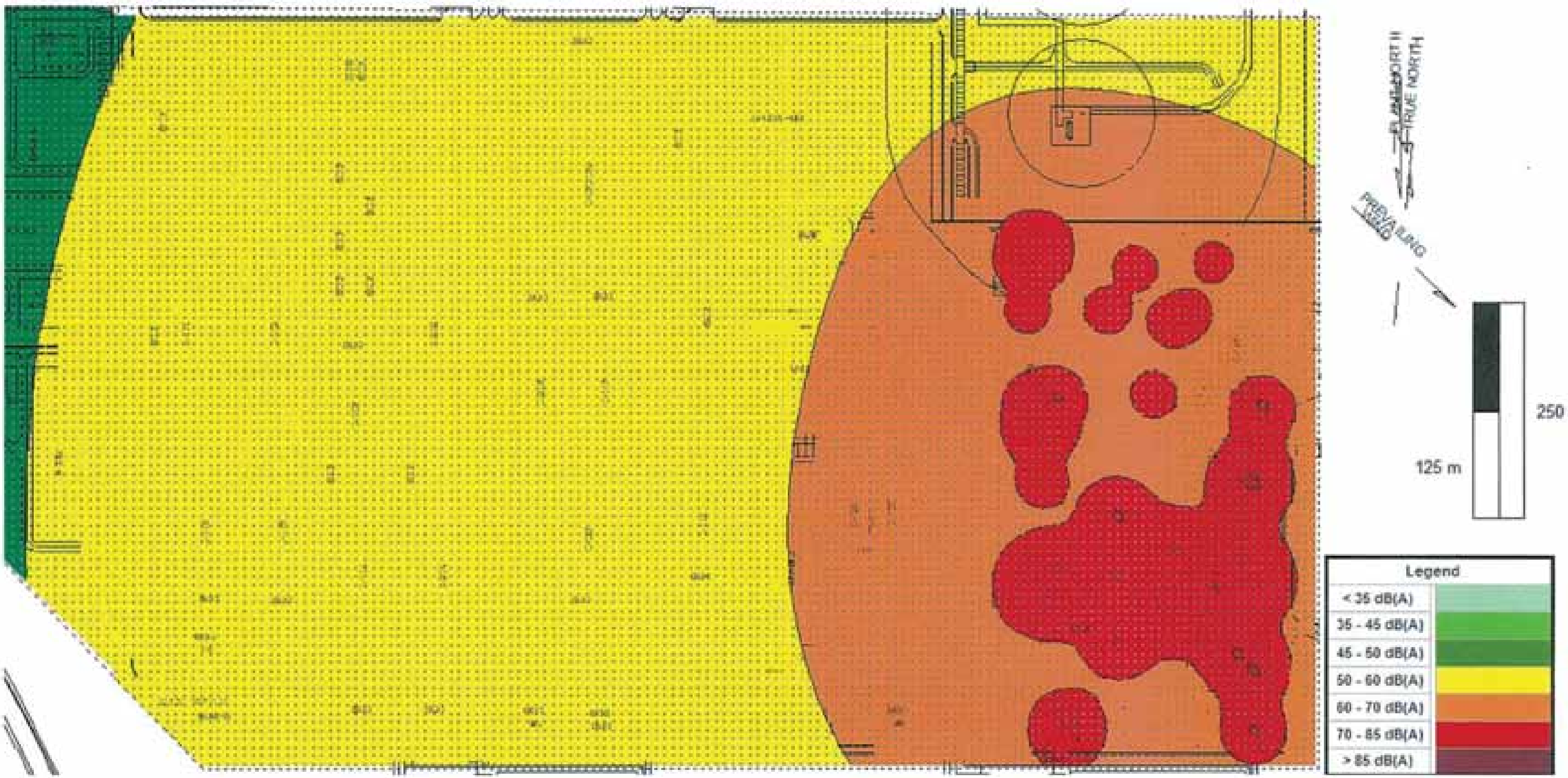


Figure 7R: Predicted Noise Levels for Construction Phase (Site Preparation & Earthworks) – within MAB Refinery Site

(Note: Background noise levels are not included. Site Preparation & Earthworks stage represents the worst case with respect to noise generation during the Construction Phase.)

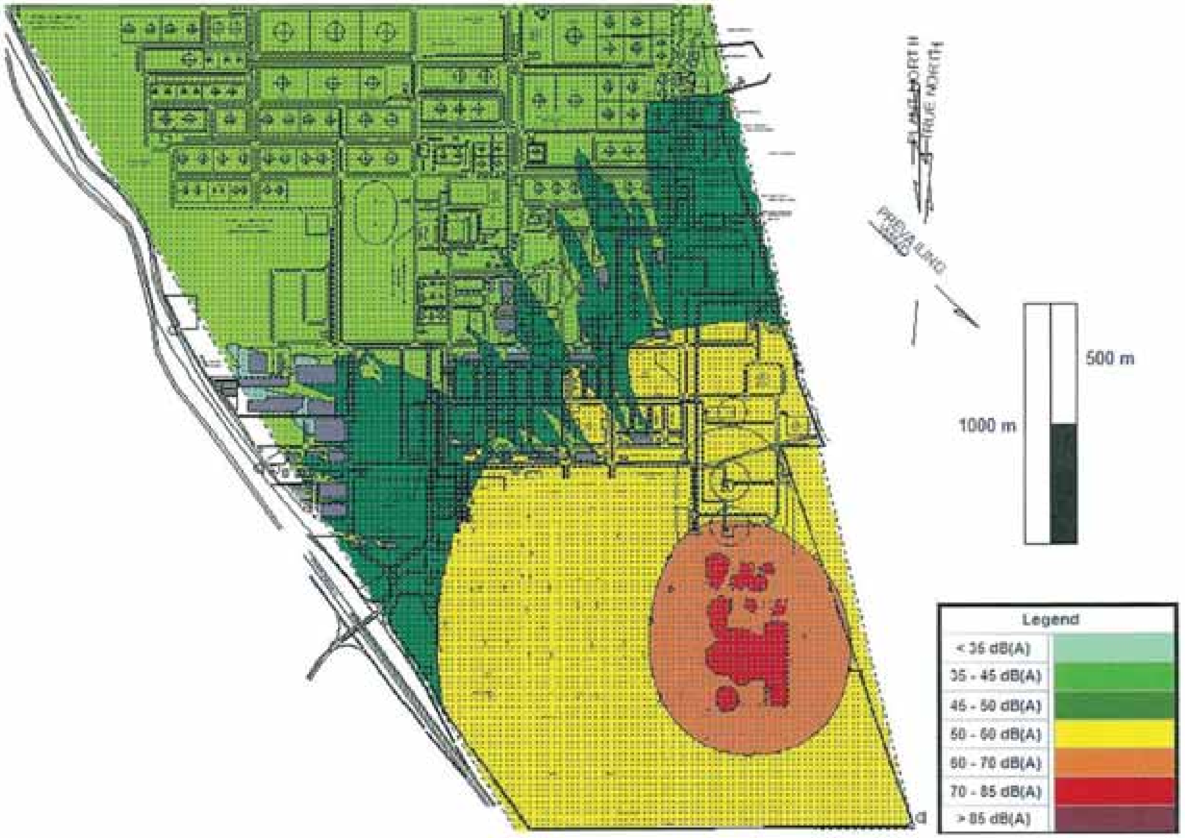


Figure 7S: Predicted Noise Levels for Construction Phase (Site Preparation & Earthworks) – within MAB Area

(Note: Background noise levels are not included. Site Preparation & Earthworks stage represents the worst case with respect to noise generation during the Construction Phase.)

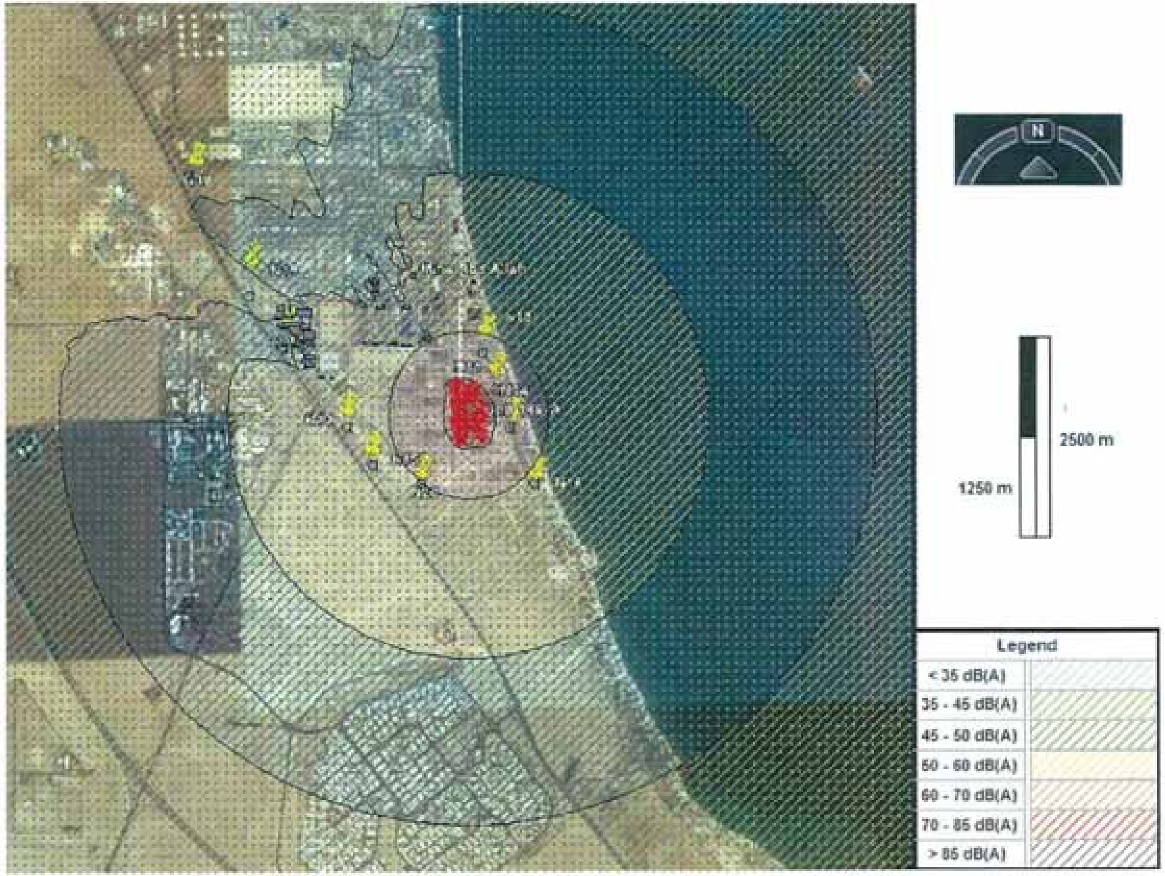


Figure 7T: Predicted Noise Levels for Operations Phase (Normal Plant Operation) – within MAB CFP Block

(Note: Background noise levels are not included. Under normal plant operation, flaring is at the minimal and flare noise is at the lowest.)

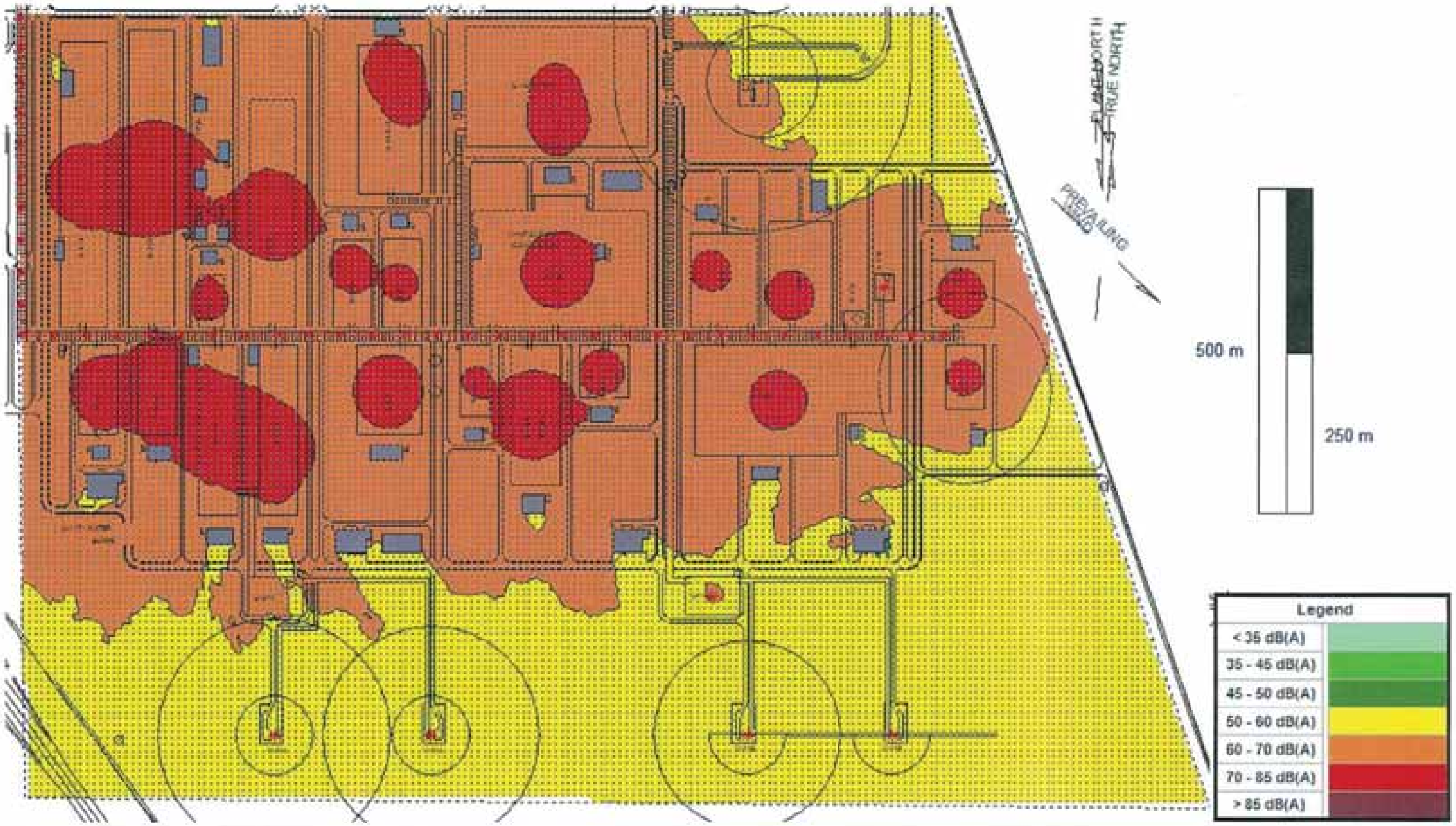


Figure 7U: Predicted Noise Levels for Operations Phase (Normal Plant Operation) – within MAB Refinery Site

(Note: Background noise levels are not included. Under normal plant operation, flaring is at the minimal and flare noise is at the lowest.)

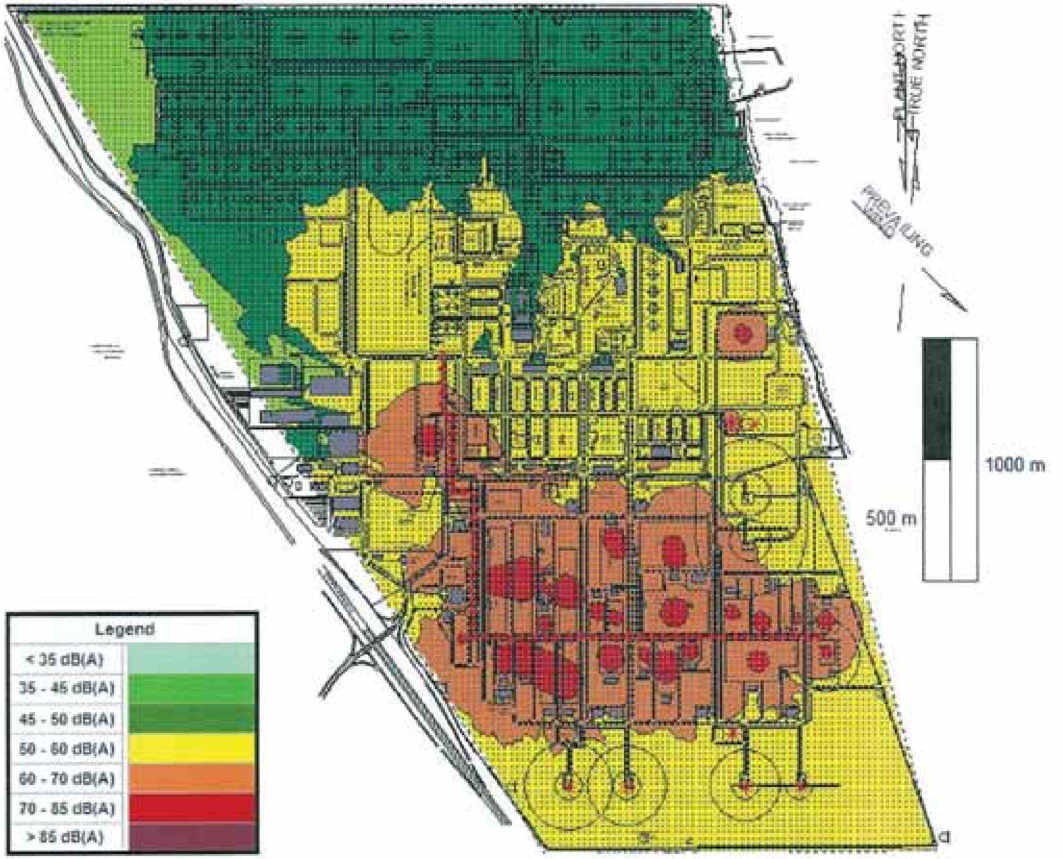


Figure 7V: Predicted Noise Levels for Operations Phase (Normal Plant Operation) – within MAB Area

(Note: Background noise levels are not included. Under normal plant operation, flaring is at the minimal and flare noise is at the lowest.)

Figure 7W: Predicted Noise Levels for Operations Phase (Plant Upset Condition) – within MAB CFP Block

(Note: Background noise levels are not included. Under plant upset condition, flaring is at the maximum at design rating and flare noise is at the highest.)

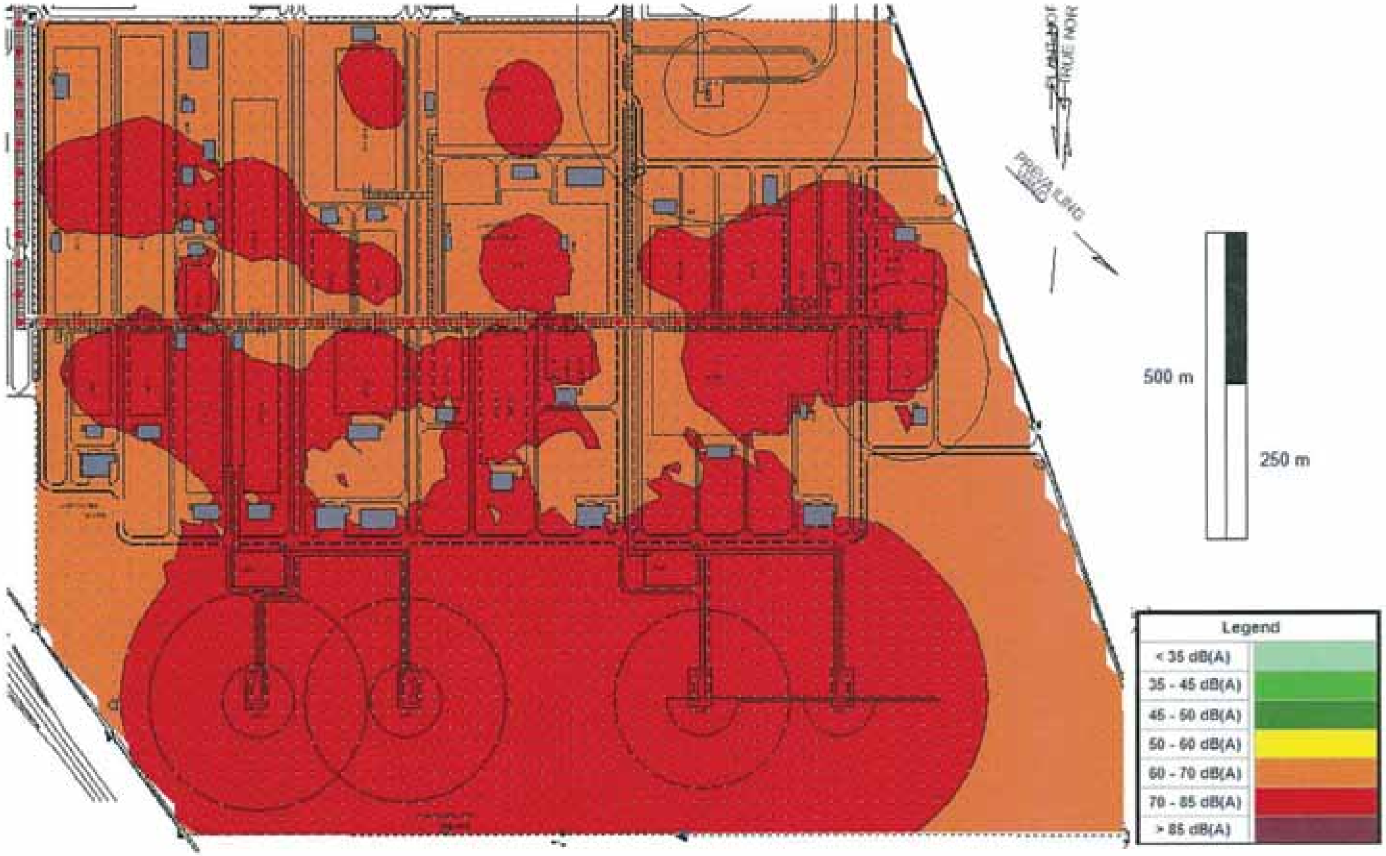


Figure 7X: Predicted Noise Levels for Operations Phase (Plant Upset Condition) – within MAB Refinery Site

(Note: Background noise levels are not included. Under plant upset condition, flaring is at the maximum at design rating and flare noise is at the highest.)

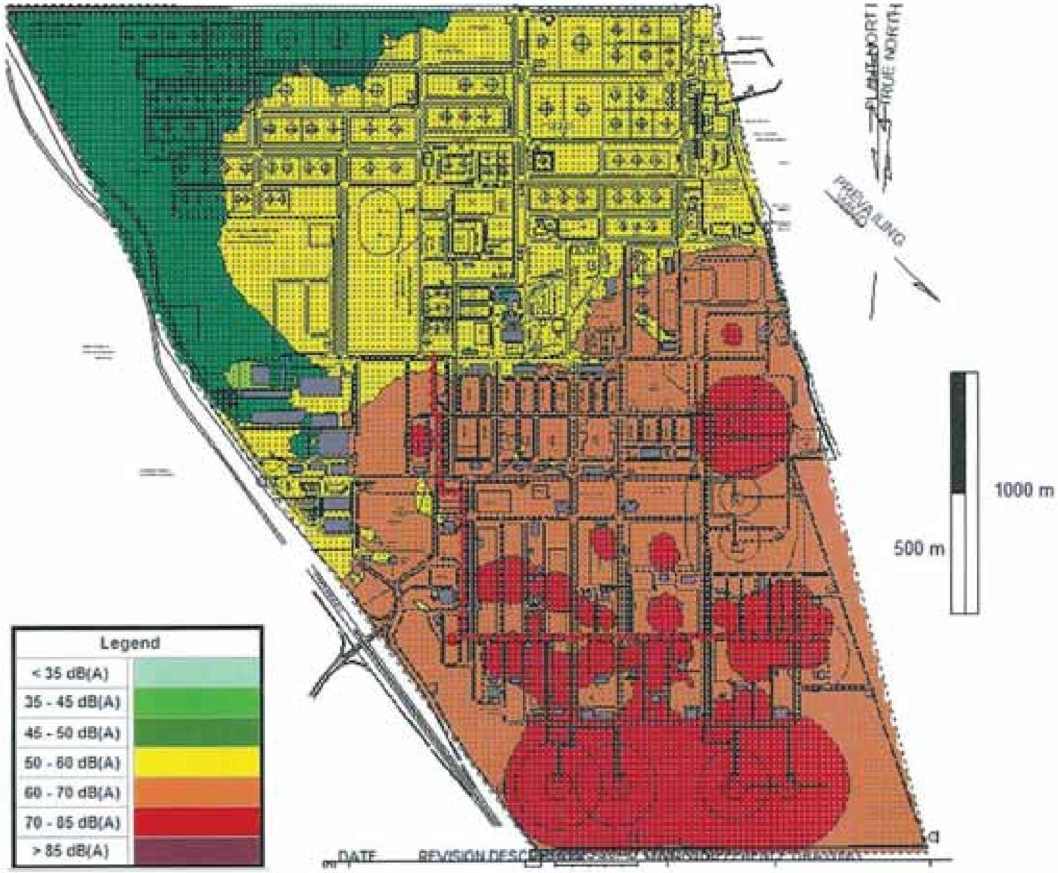


Figure 7Y: Predicted Noise Levels for Operations Phase (Plant Upset Condition) – within MAB Area

(Note: Background noise levels are not included. Under plant upset condition, flaring is at the maximum at design rating and flare noise is at the highest.)

Based on the contour maps shown in Figure 7Q, 7R, 7S, the maximum distances from the fence line of CFP Block in MAB to various noise contour levels are identified as summarised in the following table.

Table 7.10: Noise Impact Prediction for MAB CFP

Predicted Noise Level[#] (Leq)	Maximum Distance from Fence Line of CFP Block in MAB		
	Construction Phase (Site Preparation and Earthworks)	Operations Phase (Normal Plant Operation)	Operations Phase (Plant Upset Condition)
70 dB(A)	0 m	0 m	42 m [South]
65 dB(A)	0 m [East]	0 m	345 m [South]
60 dB(A)	30 m [East]	0 m	680 m [South]
55 dB(A)	380 m [East]	460 m [West]	1215 m [South]
50 dB(A)	950 m [East]	1200 m [South West]	2090 m [East]
45 dB(A)	1980 m [East]	2460 m [South West]	3500 m [South]

[#] Not including the existing background noise levels.

As seen from the above table, the most stringent community noise level of 45 dB(A) for night time L_{eq} in the ideal residential area will be reached at a maximum distance of 3500 m from the fence line of CFP Block under the worst scenario (Plant Upset Condition).

The predicted noise levels at selected receptors where background noise levels were monitored as part of baseline study are summarised in the following table (excluding baseline conditions).

Table 7.11: Predicted Noise Levels at Selected Receptors in MAB Area

Location ID	Location Description	Area Classification	Predicted L_{eq} in dB(A)		
			Construction Phase (Site Preparation and Earthworks)	Operations Phase (Normal Plant Operation)	Operations Phase (Plant Upset Condition)
N11 (MAB)	Near KNPC Units (Background Noise from Birds)	Residential	60.0	60.9	68.8
N12 (MAB)	Near Road	Industrial	48.9	61.9	65.0
N13 (MAB)	Near KNPC Units (Construction Work)	Residential	55.4	55.5	67.1

Location ID	Location Description	Area Classification	Predicted L_{eq} in dB(A)		
			Construction Phase (Site Preparation and Earthworks)	Operations Phase (Normal Plant Operation)	Operations Phase (Plant Upset Condition)
N14 (MAB)	Near KNPC Units	Residential	58.5	55.5	66.5
N15 (MAB)	Near Busy Road and Working KNPC Units	Industrial	49.9	56.7	70.0
N16 (MAB)	Near Villas (Birds & Knocking Sounds in the Background)	Residential	51.9	50.9	62.9
N17 (MAB)	Near Busy Road (Garage and Working Crane)	Industrial	39.7	49.6	53.6
N18 (MAB)	Near Busy Road and Working KNPC Units (Aeroplane Flying in the Background)	Industrial	35.8	43.6	48.7
N19 (MAB)	Near Busy Road (Cranes Working Nearside)	Industrial	37.3	42.3	45.5
N20 (MAB)	Far from Working KNPC Units	Industrial	52.5	54.5	71.4

Note: The results presented for the Construction Phase represent the case where the construction footprint within the CFP Block is located closest to the community receptors.

7.6.4 SHU Refinery Site

As discussed in Sections 7.4.1 and 7.4.4, noise modelling was not performed for the SHU Refinery Site, since following construction of the CFP facilities, the existing noise levels in this location will be reduced. The impact is, therefore positive (beneficial).

7.7 Noise Impact Evaluation

7.7.1 Predicted Impact from CFP Construction & Operation

The noise levels predicted through modelling for all of the scenarios considered in this study (refer Sections 7.6.2 and 7.6.3) do not include the existing background noise levels. Data on existing background noise levels are available at 20 selected locations of community interest (refer to Table 7.2). In order to determine the impact of community noise due to the noise generated from CFP construction and operation, the background noise levels are superposed on the predicted noise levels, and overall noise levels are determined and as discussed in the following sections.

Construction Phase

The predicted community noise impact for the Construction Phase is presented in the following table. It is to be noted that, there will normally be no night time impacts during the Construction Phase since the considered construction activities (Site

Preparation and Earthworks Phase) will not be performed during the night time expect under exceptional situations.

Table 7.12: Predicted Community Noise Impact at MAA and MAB Areas – Construction Phase

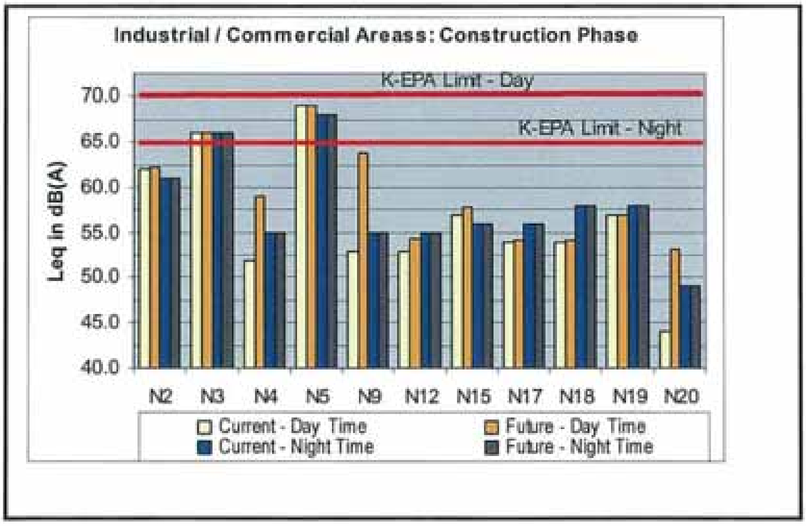
Location ID	Area Classification	Maximum Permissible Noise Levels in dB(A) (K-EPA Standards)	Worst Case L_{eq} in dB(A)				
			Predicted Noise Level due to CFP (Day)	Current Background Level (Measured)		Predicted Future Noise Level (Overall)	
				Day	Night	Day	Night
N1 (MAA)	Residential (affected by traffic)	Day: 65 Night: 60	44.5	55	52	55.4	No change
N2 (MAA)	Industrial	Day: 70 Night: 65	46.3	62	61	62.1	No change
N3 (MAA)	Industrial	Day: 70 Night: 65	45.9	66	66	66.0	No change
N4 (MAA)	Industrial	Day: 70 Night: 65	58	52	55	59.0	No change
N5 (MAA)	Industrial	Day: 70 Night: 65	42.1	69	68	69.0	No change
N6 (Offsite)	Residential (affected by traffic)	Day: 65 Night: 60	40.2	51	51	51.3	No change
N7 (MAA)	Residential (affected by traffic)	Day: 65 Night: 60	41.6	60	57	60.1	No change
N8 (MAA)	Residential	Day: 60 Night: 50	41.9	53	50	53.3	No change
N9 (MAA)	Industrial	Day: 70 Night: 65	63.5	53	55	63.9	No change
N10 (Offsite)	Residential (affected by traffic)	Day: 65 Night: 60	41.9	54	53	54.3	No change
N11 (MAB)	Residential	Day: 60 Night: 50	60	50	50	60.4	No change
N12 (MAB)	Industrial	Day: 70 Night: 65	48.9	53	55	54.4	No change
N13 (MAB)	Residential	Day: 60 Night: 50	55.4	55	55	58.2	No change
N14 (MAB)	Residential	Day: 60 Night: 50	58.5	45	45	58.7	No change
N15 (MAB)	Industrial	Day: 70 Night: 65	49.9	57	56	57.8	No change
N16 (MAB)	Residential	Day: 60 Night: 50	51.9	46	49	52.9	No change

Location ID	Area Classification	Maximum Permissible Noise Levels in dB(A) (K-EPA Standards)	Worst Case L_{eq} in dB(A)				
			Predicted Noise Level due to CFP (Day)	Current Background Level (Measured)		Predicted Future Noise Level (Overall)	
				Day	Night	Day	Night
N17 (MAB)	Industrial	Day: 70 Night: 65	39.7	54	56	54.2	No change
N18 (MAB)	Industrial	Day: 70 Night: 65	35.8	54	58	54.1	No change
N19 (MAB)	Industrial	Day: 70 Night: 65	37.3	57	58	57.0	No change
N20 (MAB)	Industrial	Day: 70 Night: 65	52.5	44	49	53.1	No change

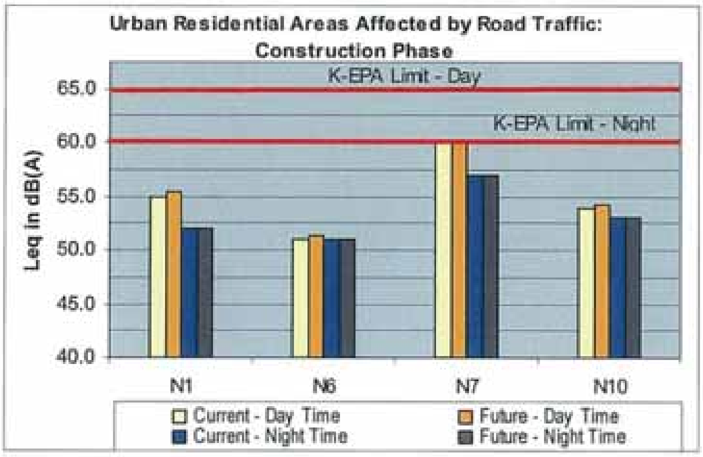
Note: The values exceeding the relevant K-EPA community noise standards (refer Table 7.1.) are highlighted in orange for the baseline noise levels and in red for the predicted future noise levels.

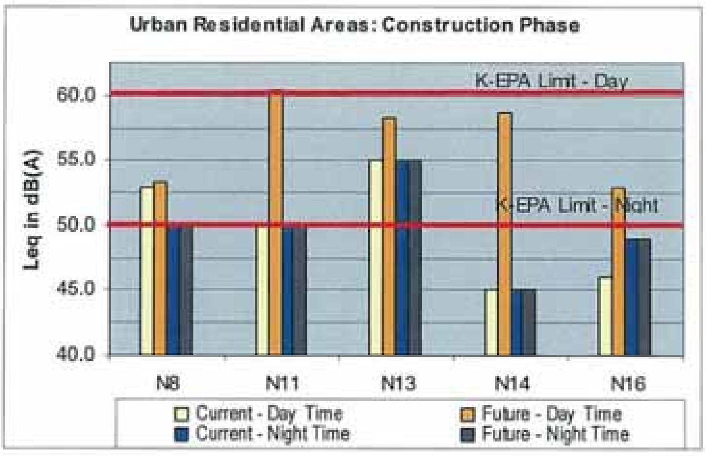
The above results are graphically presented in the following figure.

Figure 7Za: Predicted Community Noise Impact at MAA and MAB Areas – Construction Phase



MANAGING RISK





As seen from the above table, the current (baseline) noise levels have already reached or exceeded the relevant K-EPA standards during the night time at two industrial receptors (N3 and N5) and at three residential receptors (N8, N11 and N13), although no exceedence is observed during the day time at any receptor.

With regard to the future noise levels, a minor exceedence of the relevant K-EPA standard is predicted during the day time for N11 (60.4 dB(A)). Moreover, daytime noise levels do increase at sensitive residential receptors N4, N9, N11, N14, N16 and N20 as a result of CFP construction, but do not exceed the K-EPA relevant standard.

The night time noise levels remain unaffected during the Construction Phase since the considered type of construction activities will not be carried out during the night time, except under exceptional situations.

Operations Phase (Normal Plant Operation)

The predicted community impact for the Operations Phase under normal plant operation is presented in the following table. Under normal operation, the flaring will be minimal and consequently the noise generated from the flares will also be minimal.

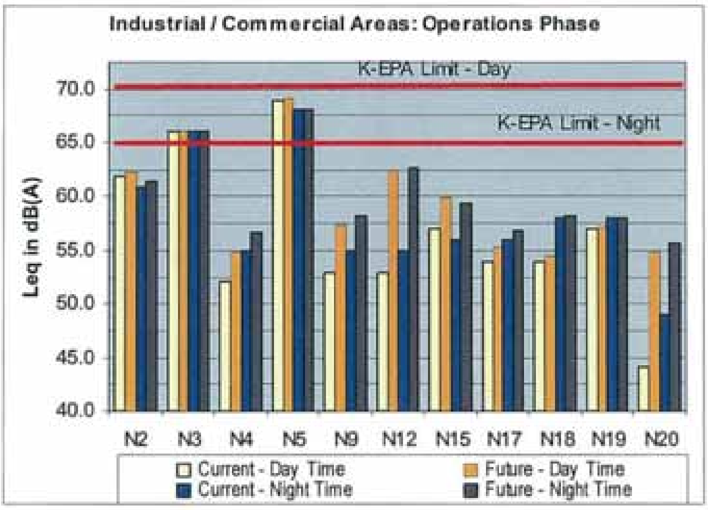
Table 7.13: Predicted Community Noise Impact in MAA & MAB Areas Operations Phase (Normal Plant Operation)

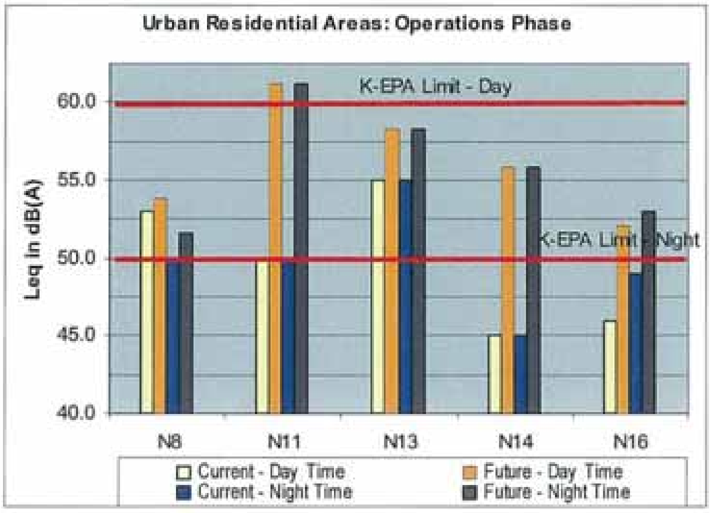
Location ID	Area Classification	Maximum Permissible Noise Levels in dB(A) (K-EPA Standards)	L_{eq} in dB(A)				
			Predicted Noise Level due to CFP (Day or Night)	Current Background Level (Measured)		Predicted Future Noise Level (Overall)	
				Day	Night	Day	Night
N1 (MAA)	Residential (affected by traffic)	Day: 65 Night: 60	46.7	55	52	55.6	53.1
N2 (MAA)	Industrial	Day: 70 Night: 65	50.3	62	61	62.3	61.4
N3 (MAA)	Industrial	Day: 70 Night: 65	47.1	66	66	66.1	66.1
N4 (MAA)	Industrial	Day: 70 Night: 65	51.5	52	55	54.8	56.6
N5 (MAA)	Industrial	Day: 70 Night: 65	45.8	69	68	69.0	68.0
N6 (Offsite)	Residential (affected by traffic)	Day: 65 Night: 60	38.8	51	51	51.3	51.3
N7 (MAA)	Residential (affected by traffic)	Day: 65 Night: 60	42.9	60	57	60.1	57.2
N8 (MAA)	Residential	Day: 60 Night: 50	46.5	53	50	53.9	51.6
N9 (MAA)	Industrial	Day: 70 Night: 65	55.4	53	55	57.4	58.2
N10 (Offsite)	Residential (affected by traffic)	Day: 65 Night: 60	43.9	54	53	54.4	53.5
N11 (MAB)	Residential	Day: 60 Night: 50	60.9	50	50	61.2	61.2
N12 (MAB)	Industrial	Day: 70 Night: 65	61.9	53	55	62.4	62.7
N13 (MAB)	Residential	Day: 60 Night: 50	55.5	55	55	58.3	58.3
N14 (MAB)	Residential	Day: 60 Night: 50	55.5	45	45	55.9	55.9
N15 (MAB)	Industrial	Day: 70 Night: 65	56.7	57	56	59.9	59.4

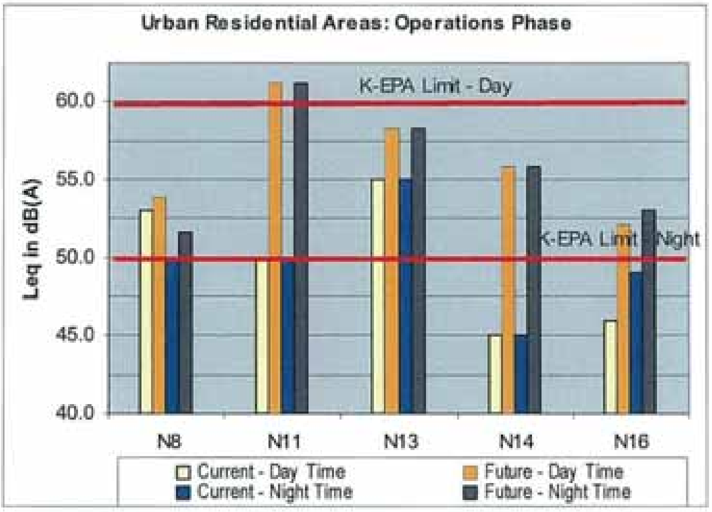
Location ID	Area Classification	Maximum Permissible Noise Levels in dB(A) (K-EPA Standards)	L_{eq} in dB(A)				
			Predicted Noise Level due to CFP (Day or Night)	Current Background Level (Measured)		Predicted Future Noise Level (Overall)	
				Day	Night	Day	Night
N16 (MAB)	Residential	Day: 60 Night: 50	50.9	46	49	52.1	53.1
N17 (MAB)	Industrial	Day: 70 Night: 65	49.6	54	56	55.3	56.9
N18 (MAB)	Industrial	Day: 70 Night: 65	43.6	54	58	54.4	58.2
N19 (MAB)	Industrial	Day: 70 Night: 65	42.3	57	58	57.1	58.1
N20 (MAB)	Industrial	Day: 70 Night: 65	54.5	44	49	54.9	55.6

Note: The values exceeding the relevant K-EPA community noise standards (refer Table 7.1) are highlighted in orange for the baseline noise levels and in red for the predicted future noise levels.

Figure 7Zb: Predicted Community Noise Impact at MAA and MAB Areas – Operation







As noted earlier, the current (baseline) noise levels already reach or exceed relevant K-EPA standards during the night time at two industrial receptors (N3 & N5) and at three residential receptors (N8, N11 and N13), although no exceedence is observed during the daytime at any receptor.

With regard to the future noise levels, as seen from the above figure, minor exceedence of the relevant K-EPA standard is predicted during the day time at N11 (61.2 dB(A)) under normal plant operation. Moreover daytime noise levels do increase at some key sensitive residential receptors, N9, N11, N12, N14, N16 and N20 as a result of CFP operation.

For the night time noise however, minor to significant exceedences are predicted at five residential receptors (N8, N11, N13, N14 and N16) and two industrial receptors (N3 and N5).

The following points are noteworthy:

- At all the receptors where exceedence is predicted, the predicted night time noise levels are more or less the same as the predicted day time noise levels. (This is due to the fact that the baseline noise levels are more or less the same during the day and night at these receptors. This implies that community noise levels at these receptors are strongly influenced by the nearby industrial sources which hardly show any diurnal variation.)
- All receptors except N8 are located within 1000 m distance from the respective CFP site fence[4], while N8 which is about 1900 m away.
- Of all receptors where exceedence of criteria is predicted, at four receptors (N11, N13, N14 and N16) the exceedence is noticeable, that is the increase is more than 3 dB(A)[5].
- At the two industrial receptors where night time exceedence is predicted (N3 and N5), the current (baseline) night time noise levels have already exceeded the applicable community noise standard [65 dB(A)], apparently due to the noise from existing sources. The incremental rise due to the new noise sources is marginal.

Operations Phase (Plant Upset Condition)

The predicted noise levels without considering the baseline levels have been presented in Table 7.9 (for receptors N1 to N10) and in Table 7.11 (for receptors N11 to N20) for the Operations Phase under plant upset conditions. Under the plant upset operation, it is assumed that flaring will be at the maximum design flow rate resulting in the maximum SWL at source, while all other major plant equipment (the significant noise sources) would continue to operate as usual. Under such conditions, the predicted noise levels increase significantly (with reference to the normal plant operation) at receptors close to the flares – a maximum of 8.6 dB(A) at N2 receptor for MAA site and a maximum of 16.9 dB(A) at N20 receptor for MAB site.

However, this rise will not make any significant impact on the future noise level when the baseline noise levels are superposed, for the following reasons:

- The assumption that all process units continue to operate as usual during emergency flaring is overly conservative. During the power failure (which leads to emergency flaring), most of the process units will be shutdown and there is trade off between more flare noise and less process noise. Therefore in reality, there may not be any net rise in the noise levels at the receptors during emergency flaring.
- Emergency flaring occurs for only a short duration (an hour or less) for each occurrence, which will be followed by a period of several hours of virtually no noise from the process units and the flares. Since the community noise level is time-weighted over a period of 7 hours (7am to 2pm) for the day time and 6 hours (10pm to 4am) for the night time, any change in the time-weighted noise level at any receptor in reality would be negligibly small.

[4] For locations N1 to N10, the referred distance is with respect to the fence line of the CFP Block in MAA. For locations N11 to N20, the referred distance is with respect to the fence line of the CFP Block in MAB.
[5] Study's have shown that a change of less than 3 dB(A) in noise level is hardly noticed by most people, while a change of 6 dB(A) and above is quite obvious. A change of 10 dB(A) is considered significant.

7.7.2 Cumulative Impact from Concurrent External Projects

The cumulative impacts on the community noise from projects that are being developed concurrently are discussed in this section. With regard to the MAA Refinery Site, as discussed in Section 7.2.1, adjacent to and east of the CFP Block, three new projects FGTP, ERP and the proposed are for the 5th Train are being developed. No new projects were identified for consideration during the time of this writing at the MAB Refinery Site.

Since these projects are being designed and engineered by third parties, detailed information on these projects is not available. Consequently, based on limited information provided by KNPC, the following observations are made:

- The construction periods (particularly the civil works phase) of FGTP and ERP projects are not expected to coincide with that of the CFP. Therefore, no additional impact on community noise will occur.
- The noise contours for FGTP and ERP projects during the normal Operations Phase are not available. However, considering that these project sites are located farther from the community receptors when compared to the CFP Block of the MAA Refinery Site, it is likely that their impact will be marginal (<3 dB(A)).

7.8 Conclusions and Recommendations

7.8.1 Conclusions

Predicated on the results obtained from noise modelling based ISO 9613 method, the following conclusions are made with regard to the impact on community noise of CFP construction and operation at MAA and MAB sites:

(a) The contribution to community noise from CFP activities at both MAA and MAB is higher for the Construction Phase compared to the Operations Phase. The impact from construction activities is more at MAB than at MAA due to larger construction scope and footprint at MAB.

(b) The noise contour for 70 dB(A), which corresponds to maximum permissible day time community noise level in 'Industrial / Commercial Areas' ,will remain within the fence lines of CFP Block at both sites (MAA and MAB) and for both phases (construction and operations - not considering upset conditions).

(c) The noise contour for 60 dB(A), which corresponds to maximum permissible day time community noise level in 'Urban Residential Areas with Some Commercial Activities and Workshops, will remain within 680m distance from the fence lines of CFP Blocks at both sites and for both phases, when background noise is disregarded.

(d) The noise contour for 50 dB(A), which corresponds to maximum permissible day time community noise level in 'Ideal Residential Areas', will remain within 1610m distance from the fence lines of CFP Blocks at both sites and for both phases, when background noise is disregarded.

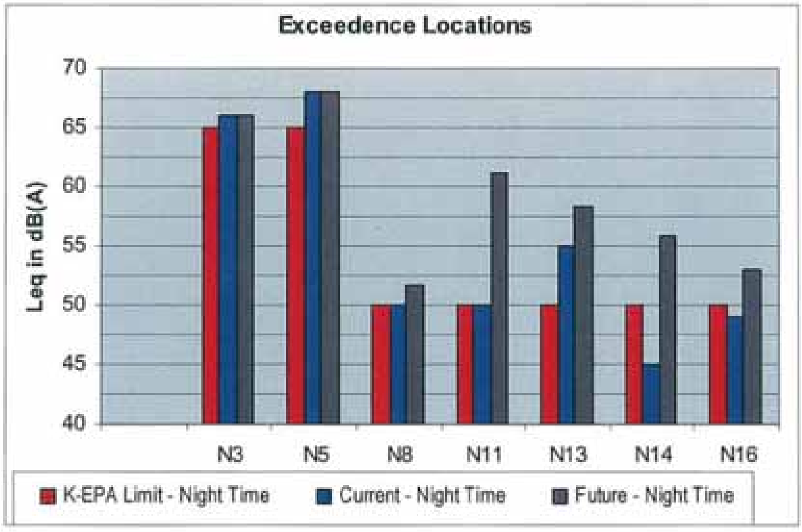
Out of the twenty receptors where the current (baseline) noise levels were measured, the night time levels have either reached or exceeded the relevant K-EPA standards at two industrial receptors (N3 and N5) and at three residential receptors (N8, N11 and N13). However, no exceedence is observed during the day time at any receptor.

When the current background noise levels are superposed on the predicted noise levels from the CFP construction and operation, the following conclusions are made:

(e) One case with minor exceedence with respect to the relevant K-EPA standard is predicted at N11 during the daytime. Moreover, there are noticeable noise increases at sensitive residential receivers N4, N9, N11, N12 N14, N16 and N20 and N20 during both CFP construction and operation during daytime.

(f) For the Construction Phase, night time noise levels will not be affected, since construction activities are not performed during the night hours except under very exceptional situations.

(g) For the Operations Phase, the night time noise levels are expected to exceed the relevant K-EPA standards at five residential receptors (N8, N11, N13, N14 and N16) and two industrial receptors (N3 and N5) as illustrated in the figure below.



(h) Of all receptors where exceedence of night time criteria is expected, at four receptors (N11, N13, N14 and N16) the exceedence is noticeable, that is the increase is more than 3 dB(A)

(i) At the 2 industrial receptors where night time exceedence is predicted (N3 & N5), the current night time background noise levels have already exceeded the applicable community noise standard [65 dB(A)] due to noise from existing sources (flares). The incremental rise due to the new CFP noise sources is marginal, and not deemed significant because there are no noise sensitive receivers at this area.

(j) All receptors except N8 are located within 1000 m distance from the respective site fence[6]. Receptor N8 which is about 1900m away from the respective site fence, and at this receptor the current noise level has already reached the maximum limit.

[6] For locations N1 to N10, the referred distance is with respect to the fence line of the CFP Site in MAA. For locations N11 to N20, the referred distance is with respect to the fence line of the CFP Site in MAB.

7.8.2 Recommendations

Based on the above, the following recommendations are made:

(a) Construction activities generating significant noise levels should not be carried out during the night time except under very exceptional situations. Otherwise, night time community noise levels may significantly breach the relevant K-EPA standards at residential locations close to the CFP sites.

(b) In order to fully comply with K-EPA community noise standards, additional noise attenuation using acoustic enclosures should be considered for significant noise emitting sources located close to the fence lines, particularly for CFP works near the eastern part of the CFP at MAB refinery.

(c) The process units where additional attenuation should be considered are U-123, U-125, U-129, U-146, U-149 and U-156. All these units are located in MAB CFP Block and they are close to the residential receptors N11, N13, N14 and N16 on the east side of the site. The additional attenuation required would be about 5 dB(A).

(d) Noise monitoring will be necessary during both construction and operation to ensure no significant impact upon receptors.

Observations:

(a) In the absence of vendor specifications for the SWL values for the equipment items, conservative values based on past experience were used in this study. Consequently, the predicted impacts are likely to be higher than actual. Therefore, noise modelling should be repeated after detailed equipment specifications are provided by the vendors in order to evaluate the need for further noise attenuation as indicated above.

(b) The results obtained from this study should not be used for the demarcation of noise hazard areas within the fence lines (workplace areas). In this study the numerous noise sources (i.e. equipment items) located within each individual unit at the CFP Block Sites are approximated to a single virtual point source. The consequence of this approximation is that the total area where SPL exceeds 85 dB(A)[7] is over-estimated. This approximation will however cause little error with regard to the community noise prediction.

[7] This is K-EPA's maximum permissible limit within workplace without ear protection.

8.0 Air Quality During Construction

8.1 Introduction

The most significant air contaminant potentially emitted during the construction phase of the CFP is dust (i.e. particulate matter). The US Environmental Protection Agency (EPA) describes dust as follows:

'Significant atmospheric dust arises from the mechanical disturbance of granular material exposed to the air. Dust generated from these open sources is termed "fugitive" because it is not discharged to the atmosphere in a confined flow stream. Common sources of fugitive dust include unpaved roads...aggregate storage piles, and heavy construction operations.

For the above sources of fugitive dust, the dust-generation process is caused by two basic physical phenomena:

- *pulverization and abrasion of surface materials by application of mechanical force through implements (wheels, blades, etc.)*
- *entrainment of dust particles by the action of turbulent air currents, such as wind erosion of an exposed surface by wind speeds over 19 km/h'.*

There will also be other air contaminants emitted during the construction phase of the CFP from activities such as cutting, welding, grinding and sand/shot blasting. The impacts of these are likely to be significantly less in comparison to dust, but they should still be considered.

This section provides an overview discussion of the potential issues associated with air pollutants released during the construction phase, with main focus on dust. It provides common sources of dust released typical to construction projects such as the CFP and details typical mitigation methods. This Chapter commits the CFP EPC contractors to develop Air Quality Management Plans during Construction.

8.2 Health Risks

Dust is a general name for minute solid particles with diameters less than 500 micrometers. The principal pollutant of interest in dust is PM10, particulate matter (PM) with no greater than 10 micrometers in aerodynamic diameter (µmA). Particulate Matter is a health risk, especially when small PM - e.g. PM10 – is inhaled.

Many studies have been conducted on the health risks of PM10. Larger particles are generally filtered in the nose and throat and do not cause problems, but particulate matter smaller than about 10 micrometres, can settle in the bronchi and lungs and cause health problems such as the exacerbation of chronic respiratory diseases e.g. asthma and bronchitis. If the dust is contaminated - e.g. dust released from demolition or the clean-up of contaminated land - the risk is significantly greater and can include lung cancer and cardiovascular issues.

However, the EBS suggests that any dust released from activities related to the CFP during its construction is generally not contaminated, apart from in isolated areas (these areas are addressed in Chapter 14).

8.3 Regulation in Kuwait

K-EPA'S Dust Pollution Division performs the following tasks:

- Monitoring and studying the daily and monthly rates of dust fall.
- Continuously monitoring air pollution and the different volatile organics in the residential, industrial and commercial areas, and other areas.
- Defining the sources of air pollutants, and assessing quantities.
- Suggesting control methodologies for each source of dust and volatile organics.
- Formulating necessary recommendations and regulations to protect humans from exposure to dangers of dust fall and suspended particulates.
- Preparing standard criteria & guidelines for air quality, and so specifying rates of emission from the different sources.
- Preparing monthly & annual reports about sources & rates of air pollution from dust & volatile particles.
- Preparing suggestions & plans in order to develop technology used in monitoring & measuring, as well as controlling, the air pollution of dust and volatile organic particles.

8.4 Sources and Control / Mitigation

There are several potential sources of fugitive dust releases during the construction phase of the CFP. They include the following:

- paved, and unpaved roads;
- cement mixing & batching;
- heavy construction operations;
- aggregate handling and storage piles.

Each of these sources is considered in the table below, with examples of control measures being provided. 'Best Available Control Techniques' (BACT) for specific sources cannot be provided at this stage of the project as control techniques will depend on the exact characteristics, extent and nature of the dust source. BACT will however, be used in the Air Quality Management Plan for managing specific sources of dust.

The CFP EPC contractors will each develop an Air Quality Management Plan using basic 'source - pathway – target' (i.e. receptor) methodology prior to and during the construction phase. This plan will be in accordance with any applicable K-EPA criteria and approved by KNPC.

Reducing the potential for dust to arise at source - i.e. preventative controls - should be employed as the most effective control and monitoring of dust at the site boundary and offsite should be an integral part of the plan.

The Air Quality Management Plan should also include control of other sources of air pollution during construction, including the use of the large numbers of Diesel Generator (DG) sets employed for welding, which have potential for creating low level air pollution.

Table 8.1 - Potential Sources of Air Pollutants and Various Control Techniques

	Source	Control
Paved roads	Particulate emissions occur whenever vehicles travel over a paved surface such as a road or parking area. They are due to: • direct emissions from vehicles in the form of exhaust emissions, • brake wear and tyre wear emissions, and • the re-suspension of loose material on the road surface. In general terms, re-suspended particulate emissions originate from, and result in the depletion of, loose material present on the surface. Surface loading of material is replenished by spillage of material and material carried from unpaved roads which could also be an issue on surrounding public roads.	Control techniques for paved roads attempt either to prevent material from being deposited onto the surface (*preventive controls*) in the first place, or the removal from the road of any material that has been deposited (*mitigation*). • *Preventative*: Covering loads in trucks, and paving of access areas to unpaved areas or construction sites. • *Mitigation*: Vacuum cleaning / sweeping, water-flushing, and broom-sweeping and under-chassis and wheel washing. The actual control efficiencies by any of these techniques vary.
Unpaved roads	The force of the wheels of vehicles travelling on unpaved roads causes pulverisation of surface material. Particles are lifted and dropped from the rolling wheels, and the road surface is exposed to strong air currents. The turbulent wake behind the vehicle continues to act on the road surface after the vehicle has passed. The main factor in the amount of particles released is particle size & moisture content. In arid regions such as the CFP site, moisture content of the underlying road surface is likely to be very low. Therefore the risk of significant dust release from unpaved roads is likely to be high.	A variety of options exist to control emissions from unpaved roads. These options fall into the following three groupings: • vehicle restrictions that limit the speed, weight or number of vehicles on the road; • surface improvements by measures such as (a) paving or (b) adding gravel or slag to a dirt road; • surface treatments such as watering or treatment with chemical dust suppressants.
Heavy Construction Operations	Heavy construction is a source of dust emissions that may have substantial temporary impact on local air quality. Building and road construction are two examples of construction activities with high emissions potential. Emissions during the construction of a project such as the CFP can be associated with: • land-clearing, • drilling, • ground excavation,	Each phase of construction can be broken down into specific stages which have a differing potential for dust generation and associated control measures: I. Demolition / debris removal II. Site preparation III. General Construction (earth moving) Control methods can be made suitable for each stage – for example: • Phase I - a combination of paved roads, and wet / chemical

	Source	Control
	• cut and fill operations (i.e. earth moving), and • the construction of a particular facility itself. Dust emissions can vary substantially from day to day, depending on the level of activity, specific operations, and prevailing meteorological conditions. The temporary nature of construction differentiates it from other fugitive dust sources as to estimation and control of emissions. Construction consists of a series of different operations, each with its own duration and potential for dust generation. However, in general, the quantity of dust emissions from construction operations is proportional to the area of land being worked and to the level of construction activity.	suppression could be used; • Phase II - as above but with the stockpiles covered with tarpaulins / wind reduction techniques to reduce wind blown dust (see below). In addition, the boundary fence could be designed to reduce windflow over the site and thus reduce the potential for wind-blown dust. During construction activities, water used as a dust suppressant will be applied, as necessary, in the construction area during grading, excavation, and earth-moving activities to control or reduce fugitive dust emissions. Application of water significantly reduces emissions.
Aggregate handling and storage piles	Construction activities on site are likely to use aggregates stored in outdoor storage piles. Storage piles are usually left uncovered, partially because of the need for frequent material transfer into or out of storage. Dust emissions can occur at several points in the storage cycle, such as: • material loading onto the pile, • disturbances by strong wind currents, and • loading trucks from the pile. The quantity of dust emissions from aggregate storage operations varies according to the volume of aggregate passing through the storage cycle. Emissions also depend on three storage pile condition parameters: • age of the pile, • moisture content, and • proportion of aggregate fines.	Watering and the use of chemical wetting agents are the principal means for control of aggregate storage pile emissions. However, in regions with high evaporation, construction site enclosure or covering of inactive piles to reduce wind erosion can also reduce emissions. Watering / chemical wetting agents are useful mainly to reduce emissions from vehicle traffic in the storage pile area. The use of water on the storage piles themselves typically has only a very temporary effect on total emissions. A much more effective technique, is to apply chemical agents (such as surfactants) that permit more extensive wetting. Continuous chemical treating of material loaded onto piles, coupled with watering or treatment of roadways can reduce total particulate emissions from aggregate storage operations by up to 90%.
Cutting, welding, grinding & blasting	General construction activities such as cutting, welding, blasting and grinding will have the potential to create low level air pollution from diesel generators. This pollution will likely be negligible in comparison to the dust pollution on site.	The control of this low level air pollution will be covered in the contractor Air Quality Management Plan. Control measures will include keeping diesel generator usage to a minimum.

8.5 Air Quality Management Plan / Risk Assessment

The potential impact of construction dust and other air pollution upon the surrounding environment was assessed using the matrix approach of DNV's impact assessment methodology (as discussed in Chapter 6). Figure 8A below displays the impact assessment and concludes that, provided a solid Air Quality Management Plan is developed by the EPC contractor and implemented, impacts from construction dust will be managed at a moderate negative impact. The Air Quality Management Plan will typically apply the sort of mitigation methods discussed for the various dust sources likely to occur. The Air Quality Management Plan will also include the control of other sources of air pollution during construction.

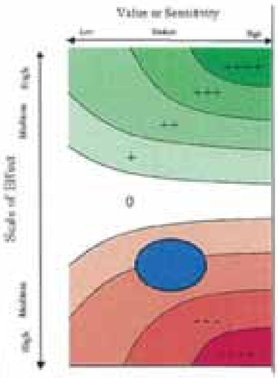
Figure 8A: Impact Matrix for Air Quality during Construction

<table>
<tr><td colspan="2">Category: Environment
Consequence evaluation for: Air Quality During Construction</td></tr>
<tr><td colspan="2">1. General description of the area (situation and characteristics)</td></tr>
<tr><td colspan="2">Note: This section describes the sensitivity of the area in question. Following a review of existing information regarding the site's sensitivity, a sensitivity rating or value is given.

There are some residential communities potentially downwind of the CFP site. There will also be a large construction workforce who will be susceptible to construction dust impacts. As the workforce shall be provided with protective equipment, the sensitivity is deemed Medium.

Low Medium High
|-- ---------X------------|</td></tr>
<tr><td>2. Description of the extent of effect</td><td>3. Total impact on environment</td></tr>
<tr><td>Evaluation of extent:

There is high potential for very negative effects as a result of construction dust if it is not managed in a strict and structured manner. This EIA commits EPC contractors to produce a solid Air Quality Management Plan based on the key elements set out in this chapter. Provided these are implemented, it is considered that the extent of construction dust effect will be managed at a medium negative effect.

Very neg. Medium neg. Little/no Medium pos. Very pos.
|---------------X---------------|---------------|------------------|</td><td>"Moderate negative impact"
</td></tr>
</table>

8.6 Conclusions

Based on available information, it is believed that dust released from activities related to the CFP during its construction will not be contaminated. Naturally occurring dust storms occur periodically and are expected to pose a greater threat to the health and safety of the workforce and local residents.

Most sources of dust which may be generated during the construction phase can readily be addressed by standard control measures. These control measures need to be **strictly** implemented for the impacts to be managed to a satisfactory level.

A strong Air Quality Management Plan, key elements of which have been set out above, will need to be implemented by the EPC contractors during the construction phase of the CFP in order to limit impacts to "medium negative impact". This plan will also need to cover other ambient air pollution sources during construction such as cutting, welding, grinding and blasting and control measures for these sources will be laid out in the Plan.

8.7 Recommendations

Provided the following recommendations are adopted, impacts upon air quality during construction can be managed satisfactorily.

It is recommended that:

- A rigorous Air Quality Management Plan be provided by the EPC contractors and be put into action.
- The Air Quality Management Plan should include some early commitment to provide temporary construction roads as soon as practicable to minimise dust releases.
- The EPC contractors ensure that appropriate mitigation measures are applied, both by themselves and their sub-contractors.
- The EPC contractors conduct ongoing monitoring for generation of dust across the CFP site throughout the construction phase.
- The EPC contractors ensure that appropriate mitigation measures are applied, both by themselves and their sub-contractors, for other sources of air pollution during construction such as welding, cutting, grinding and blasting.
- An experienced independent environmental professional should visit the site at least twice a week to ensure that these measures (and all other environmental management measures recommended in this EIS report) are being applied by EPC contractors.

9.0 Air Quality During Operation

9.1 Introduction

The operation of the CFP Project will "remove" significant quantities of air contaminants from the atmosphere primarily owing to the decommissioning of SHU Refinery, as well as generate air contaminant emissions to atmosphere from the new facilities at MAA and MAB refineries. The focus in this Chapter is on air quality and associated air emissions during CFP Operations Phase only. The key objective of this Chapter is to evaluate the overall effect that this project has on the air quality, and whether the resulting concentrations of various pollutants meet K-EPA / Ministry of Oil (*MOO*) criteria.

All the conclusions drawn in this Chapter assume that SHU is decommissioned at the same time as CFP new facilities are commissioned.

For construction-related air quality impacts, refer to Chapter 8 of this report.

The structure of this chapter includes:

- Discussion of baseline ambient air quality at the CFP site and its adjacent vicinity, both now and in the future (Section 9.2).
- Process releases during operations are discussed – point source, fugitive, emergency emissions, upset condition emissions and maintenance scenarios (Section 9.3).
- Discussion and information concerning the atmospheric dispersion modelling conducted by DNV, together with analysis of the results, and comparison against K-EPA / MOO criteria (Section 9.4)
- Analysis of VOC fugitive emissions (Section 9.4.6.7).
- Discussion on monitoring and sampling, which will be crucial in ensuring that the CFP's operations are conducted in compliance with K-EPA / MOO criteria (Section 9.5).
- Conclusions (Section 9.7).

Following start-up of the CFP's operations, point source emissions will primarily be generated by combustion-related equipment such as process heaters / furnaces / boilers, incineration systems, and flare systems (during emergency). In addition, the decommissioned point sources (primarily at the SHU refinery) will also impact the resulting air quality, both within the CFP's boundaries as well as the adjacent area of the site. The approach in this report is to combine the 'negative' effect of the new sources with the beneficial effect (in terms of air quality) of the decommissioned sources to obtain a representative estimate of the future air quality in the area after the completion of the CFP Project.

Fugitive emission sources will mainly include storage tanks, equipment components (such as valves, pumps, flanges, drains and compressors), port loading operations, sulphur-handling operations and wastewater treatment facilities.

The CFP incorporates good engineering practices, 'Best Available Control Technology' (BACT) and Environmental Management System (EMS) mechanisms that minimize or eliminate (where practical) atmospheric emissions, in compliance with K-EPA, and MOO air quality criteria (see Table 9.1, below):

Table 9.1: K-EPA air pollutant emissions standards from fixed sources

Source	Pollutant	Maximum allowed emissions
1. Industrial installations (all):		
1.1: All sources of emission	Suspended particulates	Smut (i.e. soot) must not exceed max. 20%
	Asbestos	No emissions allowed
1.2: Product piles	Suspended particulates	Smut (i.e. soot) must not exceed max. 20%
1.3: Chimneys	Suspended particulates	115 mg/m³
	Opacity	Must not exceed max. 20%
2. Combustion facilities:		
Boilers and furnaces operated by mine fuel: thermal capacity >30MW (100 MBTU / hr)	Suspended particulates	43 ng/Joule
	SO_2	512 ng/Joule
	NOx	86 ng/Joule (for natural gas burning facilities)
	NOx	130 ng/Joule (for oil burning facilities)
	Opacity	Must not exceed max. 20%
3. Oil refineries:		
3.1 Burning systems or boilers used with FCCU	Suspended particulates	1 kg/tonne of charcoal to be burnt
	SO_2	9.8 kg/tonne of charcoal to be burnt
	CO	500 ppm
	Opacity	30% (except 6 minutes per hour)
3.2 Gas fuel burning operations	H_2S	230 mg/m³ (dry)
3.3 Claus sulphur retrieval units (> 20 tonnes / day capacity)	SO_2	250 ppm for oxidization, reduction and burning activities
4. Liquid petroleum / organic volatile liquids storage tanks:		
4.1 Petroleum liquids tanks (1000 barrel capacity)	VOCs	Liquid at steam pressure ranging between 78/570mm Hg can be kept in tanks having floating or fixed ceilings (with internal floating cover or steam recall system). Emissions rate must remain at 95% or its equivalence.
4-2 Tanks of volatile organic liquids, including petroleum liquids tanks of > 1000 barrel capacity (where actual steam pressure is between 39-570 mm Hg), or of 500 barrels capacity (where steam pressure is between 207-570 mm Hg).	VOCs	Tanks must be provided with recall systems and steam must be relieved, so that emission rate should be 95% or its equivalence.
4-3 Fuel tanks of more than 500 barrel capacity (and steam pressure > 570 mm Hg).	VOCs	Tanks must be provided with fixed ceilings having floating internal cover, or it must be provided with floating ceilings of close ventilation. Further, tanks must be supplied with a system for relieving steam so that emissions must be reduced by 95% minimum or equivalence.
4-4 Fuel tanks >1000 barrel capacity (& steam pressure <24 mm Hg), or 500 barrel capacity (& steam pressure > 116 mm Hg).	VOCs	Tanks must be provided with closed ventilation system to relieve steam pressure, so that emissions must be reduced by 95% minimum.

Note: Source Appendix No.20. K-EPA

Stack height will be based upon good engineering practices to ensure optimal dispersion of air contaminants. For the majority of the new units installed as part of the CFP, a stack height of 61 m has been initially assumed, based on the data provided by Fluor and KNPC.

The CFP will provide fired equipment in MAB Units 111 (CDU), 112 (ARDS), 212 (ARDS) and 131 (Steam Generation) that will have dual fuel firing capability. In order to ensure compliance with the relevant K-EPA point source emission rate criteria, the fired equipment in these units will burn either fuel gas only or a mixture of fuel oil and fuel gas not to exceed more than 15% fuel oil.

9.2 Baseline Ambient Air Quality

The baseline air quality data provided in this section is based on the following information sources:

- KNPC HSE Ambient Air Monitoring Data for the period November 2005 to November 2006 for a selection of monitoring points at various refinery site boundaries (Section 5.2 of the Environmental Baseline Study for the KNPC CFP 2020, EBS Final Report, DNV No. 32317425 / Fluor Doc. No. P6000CFP.000.10R.02, Rev3, 5th June 2008)
- KISR measurements from baseline studies (Section 5.3 of the EBS report for the CFP Project)

As the air quality data have been presented, discussed and analysed in Section 5 (and associated appendices) of the CFP Project EBS Report, as referenced above, this section simply summarises the locations and ambient air quality data used for the purposes of the air modelling, from both sets of data available. Any exceedances, against the K-EPA / Ministry of Oil criteria, from these monitoring points are summarised at the end of this section.

The data for each monitoring point of interest will be combined with the predicted ADMS ground level concentrations at each point, to obtain an estimate of the resulting air quality at these sites after the CFP project is completed.

It should be noted that the existing background air quality does not currently meet the relevant K-EPA / MOO air quality criteria (e.g. for SO_2, TSP, etc).

9.2.1 Existing KNPC HSE Ambient Air Monitoring Data

As detailed in Section 5.2 of the CFP Project EBS report (DNV No. 32317425 / Fluor Doc. No. P6000CFP.000.10R.02), two sets of ambient air quality data were collected by KNPC HSE department at MAA, MAB and SHU refineries for monthly periods between November 2005 and November 2006. Monitoring took place for 24 hours a day, for a period of one month at ten different locations (see Table 5.1 from the CFP EBS Report). The locations of these monitoring points are indicated in Figures 9.1 to 9.3, for MAA, MAB and SHU refineries.

The KNPC HSE data monitoring locations are both onsite (locations A, B, E, G, I, J) and at the refinery boundary (C, D, F. H). The locations at the refinery boundary are required to meet K-EPA / MOO air quality criteria, hence the data provided for these four monitoring points have been averaged (for the total number of months for which data have been provided for each point) and converted to annual and 99.7%ile 1-hour average concentrations for the pollutants of interest, namely NO_2, SO_2, CO, H_2S and TSP (see Table 9.2). It was assumed that the monthly averages could be directly compared to the annual average criteria, whereas the daily average measurements for each location have been converted to equivalent 1-hour average concentrations using the factors (1.11 for this case) provided in the *Workbook of Atmospheric Dispersion Estimates, D. Bruce Turner, 2nd Edition, 1994.*

The resulting concentrations for these monitoring points have then been compared against the K-EPA / MOO criteria (Table 9.16) for each pollutant examined. The results from this comparison, along with the average concentrations at each monitoring point of interest, are presented and discussed in Section 9.2.3.

Figure 9.1: KNPC Ambient Air Monitoring Point Locations at MAA Refinery

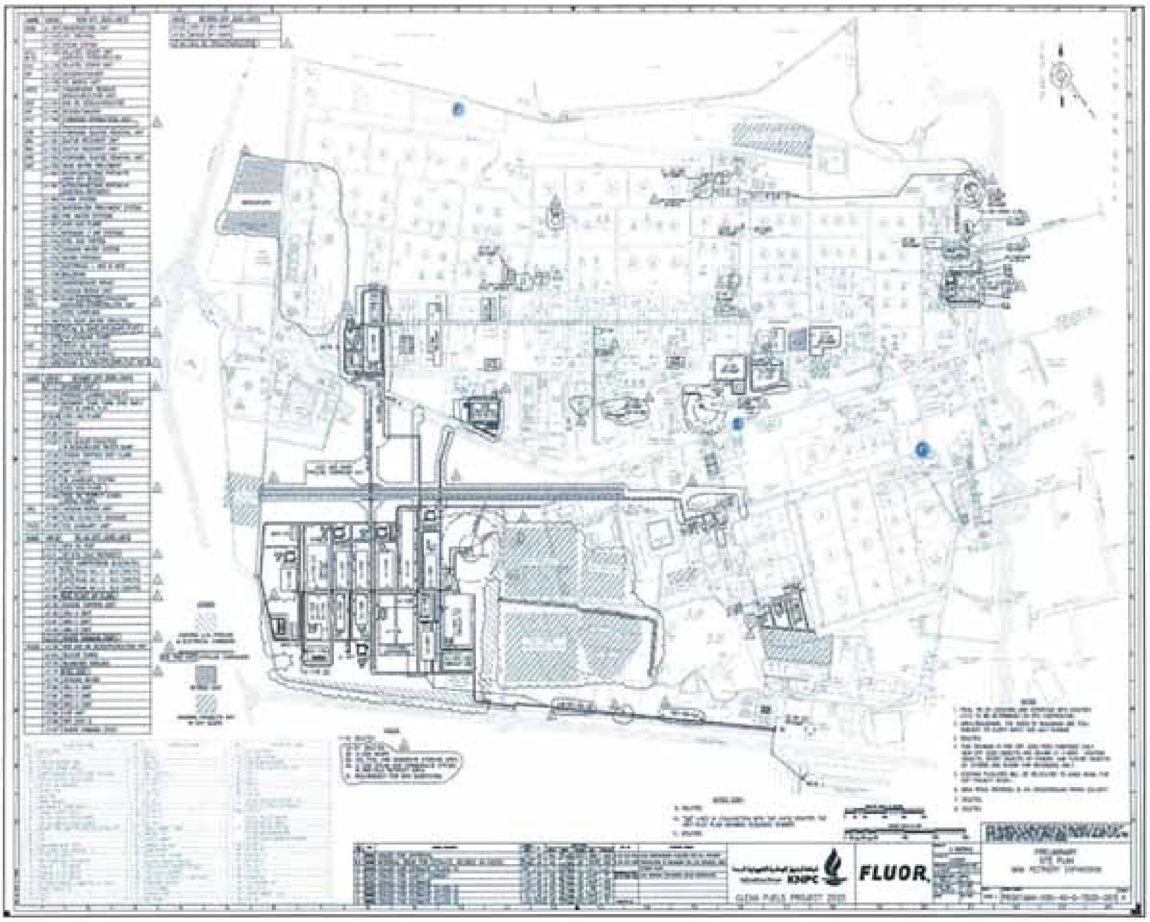


Figure 9.2: KNPC Ambient Air Monitoring Point Locations at MAB Refinery

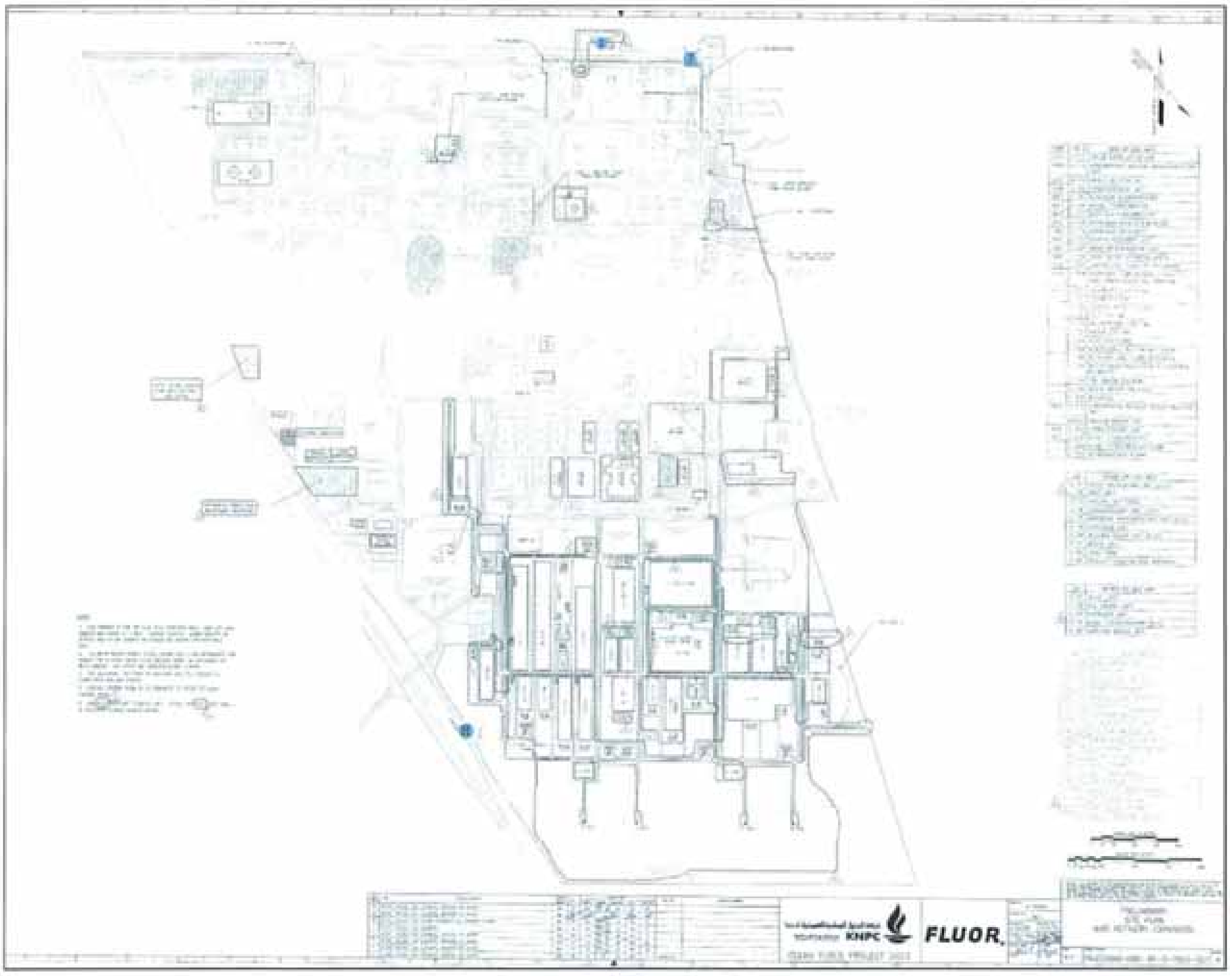
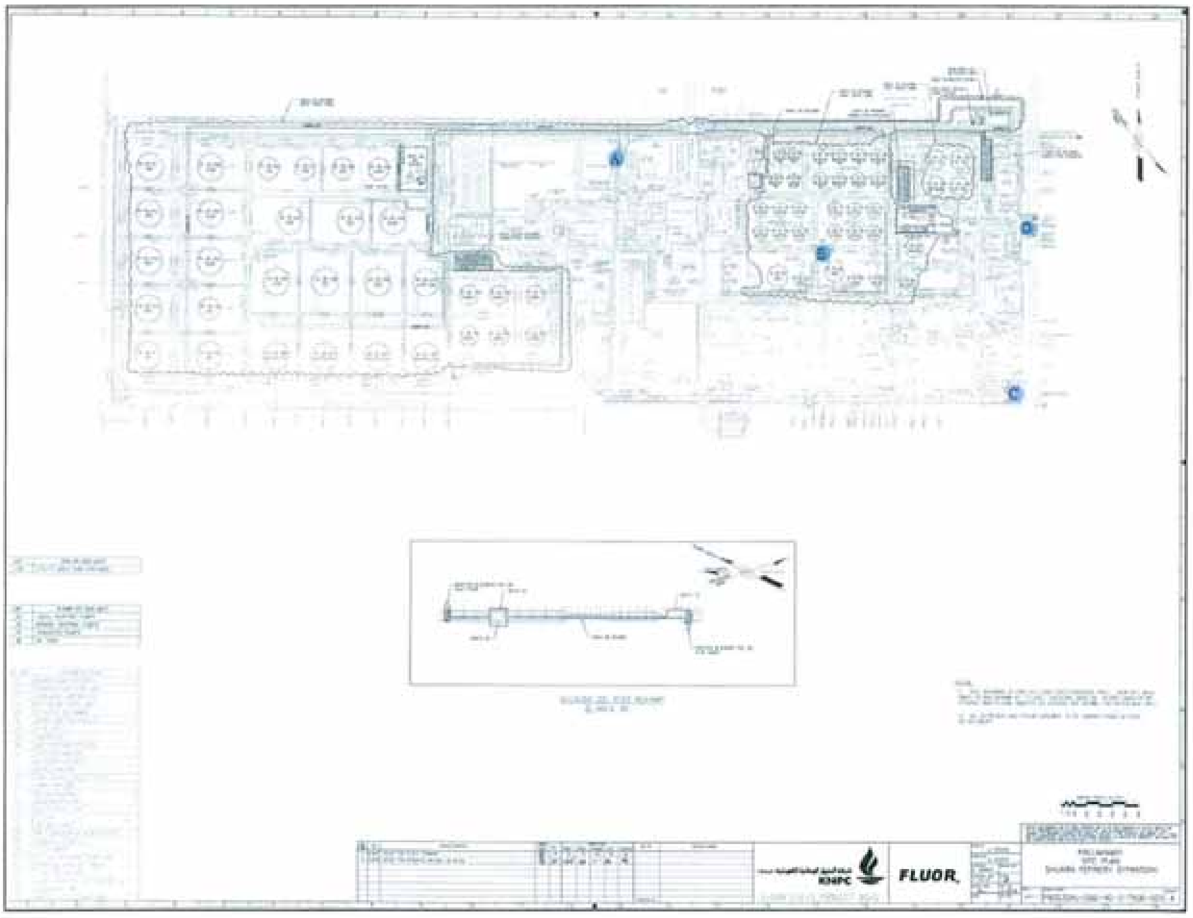


Figure 9.3: KNPC Ambient Air Monitoring Point Locations at SHU Refinery



9.2.2 Environmental Baseline Results 2007

As described in the Environmental Baseline Study (EBS) report (DNV No. 32317425 / Fluor Doc. No. P6000CFP.000.10R.02 - Chapter 5 and associated appendices), ambient air quality monitoring was also conducted at 45 monitoring sites (A1 to A45) within the CFP Project study area, extending to some distance outward from the site. Air sampling locations for the baseline survey covered a number of locations at each refinery (MAA, MAB and SHU), the adjacent coastal area, the nearby residential and industrial areas, as well as locations upwind and downwind of the refinery sites.

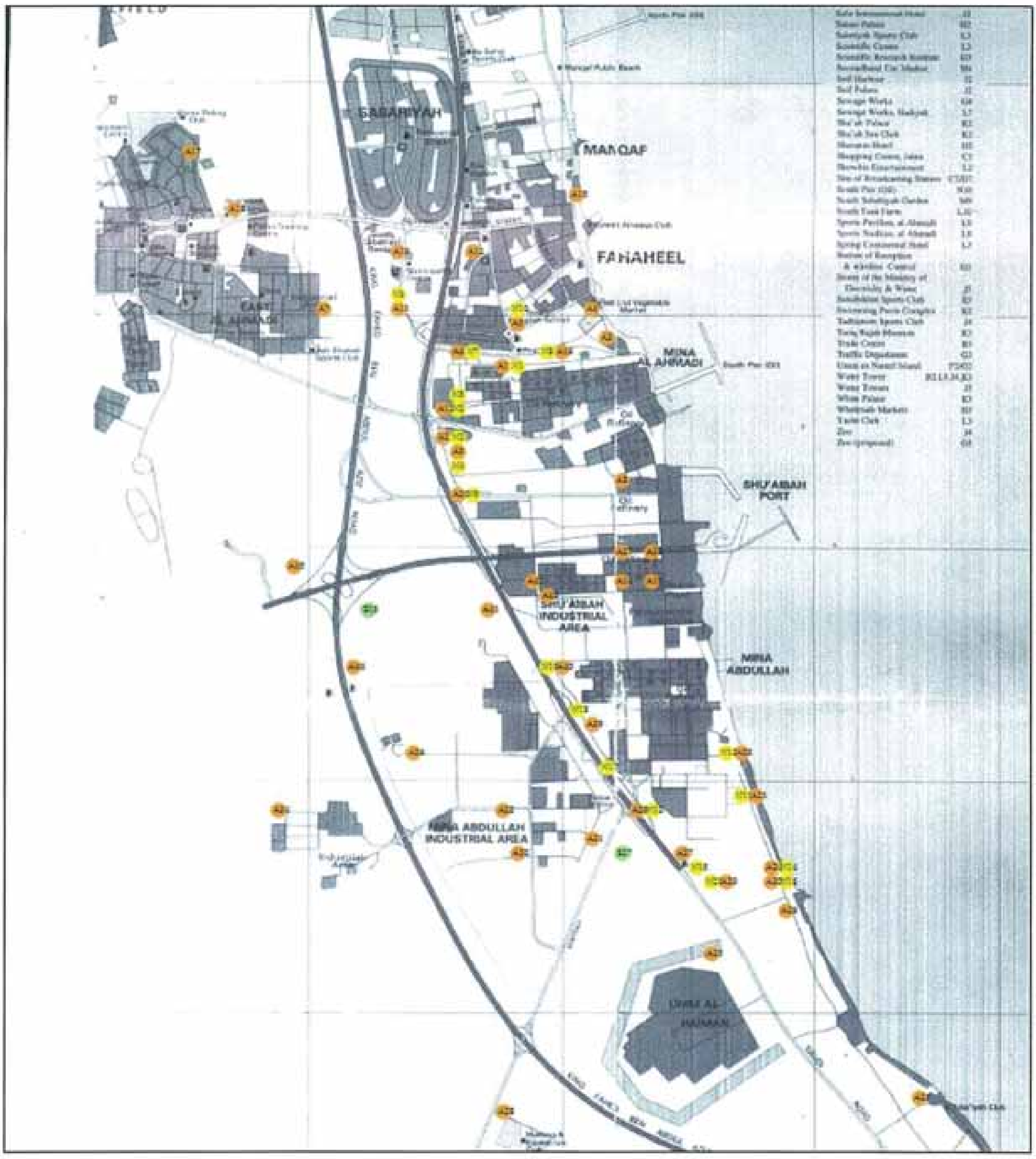
As Section 5.3 of the CFP Project EBS report covers the analysis and interpretation of the collected air monitoring data, this section simply summarises the selected data to be used for comparison against the applicable criteria. The locations of these monitoring points are indicated in Figure 9.4.

The data for all 45 monitoring points are used for the purposes of this study, and are compared to the applicable criteria in order to summarise any exceedances. The Diffusive Passive Sampler (DPS) data (for a sampling period of one month) for each point have been assumed to correspond to the annual average concentrations, whereas these monthly average measurements for each location have been converted to equivalent 1-hour average concentrations (99.7%ile) using the factors (1.25 for this case) provided in the *Workbook of Atmospheric Dispersion Estimates, D. Bruce Turner, 2nd Edition, 1994.* This approach was followed for NO_2, SO_2 and H_2S.

For the case of TSP, the results from the continuous air sampler were used. A daily averaging period was used when collecting the TSP samples at each location. The same method for converting these to results that can be compared against applicable, hourly-averaged, criteria has been used as for the existing KNPC HSE ambient air quality data (see Section 9.2.1 of this report). It is noted here that the annual average concentration value used for TSP is the actual data collected by the continuous air sample, making the comparison slightly conservative. Monitoring for TSP was only conducted for locations inside the three refineries.

The resulting concentrations for these monitoring points have been compared against the K-EPA / MOO criteria (Table 9.16) for each pollutant examined. The results from this comparison, along with the average concentrations at each monitoring point of interest, are presented in Section 9.2.3.

Figure 9.4: Ambient Air Quality Monitoring Point Locations (orange)



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9.2.3 Ambient Air Quality Data against Criteria

This section summarises the results of the ambient air quality data, also highlighting any exceedances against the applicable criteria from K-EPA / MOO.

Firstly, the ambient air quality concentrations of interest, i.e. annual (long term) and 99.7%ile 1-hour (short term) average, for each monitoring point location are presented, followed by identification of areas of exceedance of criteria for any of the pollutants of interest.

These baseline concentrations of interest for each pollutant will later be combined with the ADMS modelling results at these particular monitoring point locations, in order to provide an indication of the air quality after the CFP project has been completed.

Table 9.2 summarises the baseline concentrations of interest for each pollutant at the monitoring points locations, whereas Table 9.3 indicates exceedances against the various pollutant criteria outlined in Table 9.16, by evaluating the ratio of the concentration at each monitoring point against the relevant criterion (exceedances highlighted in red, with the locations of the monitoring points indicated in Figures 9.1 to 9.4).

Table 9.2: Concentrations of pollutants at KNPC HSE & KISR Monitoring Points

Averaging Period	Annual					99.7%ile 1-hour Average				
	Pollutant									
Monitoring Location	NO2 µg/m³	SO2 µg/m³	H2S µg/m³	CO* µg/m³	TSP µg/m³	NO2 µg/m³	SO2 µg/m³	H2S µg/m³	CO µg/m³	TSP µg/m³
A1	20	32.5	6	-	570	25.0	40.6	7.5	N/A	632.7
A2	13	38	5	-	280	16.3	47.5	6.3	N/A	310.8
A3	13	18	5.8	-	180	16.3	22.5	7.3	N/A	199.8
A4	6.5	25.5	4.8	-	N/A	8.1	31.9	6	N/A	N/A
A5	15.5	19	5.7	-	N/A	19.4	23.8	7.1	N/A	N/A
A6	21.2	32.5	5.7	-	290	26.5	40.6	7.1	N/A	321.9
A7	11.5	30	5.5	-	N/A	14.4	37.5	6.9	N/A	N/A
A8	15.1	98	8.4	-	215	18.9	122.5	10.5	N/A	238.7
A9	14.5	40	8	-	175	18.125	50	10	N/A	194.3
A10	16.5	21	4.4	-	N/A	20.6	26.3	5.5	N/A	N/A
A11	14	23	5.2	-	N/A	17.5	28.8	6.5	N/A	N/A
A12	19.5	22	5.8	-	N/A	24.4	27.5	7.3	N/A	N/A
A13	13	40	4.3	-	195	16.3	50.0	5.4	N/A	216.5
A14	24.5	95	9.8	-	1010	30.6	118.8	12.3	N/A	1121.1
A15	15.5	13	5.9	-	N/A	19.4	16.3	7.4	N/A	N/A
A16	14.8	23	6.9	-	390	18.5	28.8	8.6	N/A	432.9
A17	10.1	24	4.3	-	N/A	12.6	30.0	5.4	N/A	N/A
A18	8.5	21	5.7	-	N/A	10.6	26.3	7.1	N/A	N/A
A19	15.5	119	8.1	-	190	19.4	148.8	10.1	N/A	210.9
A20	15.8	40	6.9	-	165	19.8	50.0	8.6	N/A	183.2
A21	19	85	7.4	-	720	23.8	106.3	9.3	N/A	799.2
A22	10.5	32.5	6.1	-	N/A	13.1	40.6	7.6	N/A	N/A
A23	20	85	10.7	-	430	25.0	106.3	13.4	N/A	477.3
A24	20	82	6.9	-	330	25.0	102.5	8.6	N/A	366.3
A25	9.8	30	5.8	-	N/A	12.3	37.5	7.3	N/A	N/A

Averaging Period	Annual					99.7%ile 1-hour Average				
	Pollutant									
Monitoring Location	NO2	SO2	H2S	CO*	TSP	NO2	SO2	H2S	CO	TSP
	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
A26	11.5	43	7.4	-	N/A	14.4	53.8	9.3	N/A	N/A
A27	15	32.5	6.8	-	1103	18.8	40.6	8.5	N/A	1224.3
A28	10.2	23	0	-	N/A	12.8	28.8	0.0	N/A	N/A
A29	14.2	40	6.3	-	286	17.8	50.0	7.9	N/A	317.5
A30	16.5	68	6.5	-	460	20.6	85.0	8.1	N/A	510.6
A31	15	36	6.9	-	N/A	18.8	45.0	8.6	N/A	N/A
A32	10.5	32	7.2	-	N/A	13.1	40.0	9.0	N/A	N/A
A33	12	42.1	7.9	-	215	15.0	52.6	9.9	N/A	238.7
A34	5.8	10	14.5	-	N/A	7.3	12.5	18.1	N/A	N/A
A35	10.5	29	8.7	-	N/A	13.1	36.3	10.9	N/A	N/A
A36	10	35	6.7	-	N/A	12.5	43.8	8.4	N/A	N/A
A37	19	95	9.9	-	700	23.8	118.8	12.4	N/A	777.0
A38	16	110	9.6	-	205	20.0	137.5	12.0	N/A	227.6
A39	17	42.1	7.3	-	720	21.3	52.6	9.1	N/A	799.2
A40	15.2	16	5.7	-	605	19.0	20.0	7.1	N/A	671.6
A41	16	39	6.7	-	N/A	20.0	48.8	8.4	N/A	N/A
A42	10	36.5	6.6	-	995	12.5	45.6	8.3	N/A	1104.5
A43	13.5	45	6.1	-	220	16.9	56.3	7.6	N/A	244.2
A44	12	37	7.6	-	N/A	15.0	46.3	9.5	N/A	N/A
A45	16	36.5	7.5	-	N/A	20.0	45.6	9.4	N/A	N/A
KNPC C	156.6	31.0	16.0	-	1046.3	287.7	263.2	132.8	5825.5	3556.4
KNPC D	45.2	48.3	24.7	-	316.8	74.3	127.4	57.3	N/A	1386.3
KNPC F	69.0	21.2	5.4	-	526.4	184.0	183.3	29.5	2944.1	2024.2
KNPC H	53.1	29.9	3.7	-	201.5	92.7	86.2	13.0	N/A	589.5

* Long term (i.e. annual) concentrations are not applicable for Carbon Monoxide.

Table 9.3: Exceedances of Criteria for Ambient Air Quality

Averaging Period	Annual					99.7%ile 1-hour Average					99.7%ile 1-hour Average
	Ratio against Residential & Industrial Criteria (only Residential for SO2)										Ratio against Industrial Criteria
Monitoring Location	NO2	SO2	H2S	CO*	TSP	NO2	SO2	H2S	CO	TSP	SO2
A1	0.30	0.41	0.75	-	[illegible]	0.11	0.09	0.19	N/A	[illegible]	0.05
A2	0.19	0.48	0.63	-	3.73	0.07	0.11	0.16	N/A	0.98	0.06
A3	0.19	0.23	0.73	-	2.40	0.07	0.05	0.18	N/A	0.63	0.03
A4	0.10	0.32	0.60	-	N/A	0.04	0.07	0.15	N/A	N/A	0.04
A5	0.23	0.24	0.71	-	N/A	0.09	0.05	0.18	N/A	N/A	0.03
A6	0.32	0.41	0.71	-	3.37	0.12	0.09	0.18	N/A	[illegible]	0.05
A7	0.17	0.38	0.69	-	N/A	0.06	0.08	0.17	N/A	N/A	0.05
A8	0.23	1.23	1.00	-	2.87	0.08	0.28	0.26	N/A	0.75	0.16
A9	0.22	0.50	1.00	-	2.33	0.08	0.11	0.25	N/A	0.61	0.06
A10	0.25	0.26	0.55	-	N/A	0.09	0.06	0.14	N/A	N/A	0.03
A11	0.21	0.29	0.65	-	N/A	0.08	0.06	0.16	N/A	N/A	0.04

Averaging Period	Annual					99.7%ile 1-hour Average					99.7%ile 1-hour Average
	Ratio against Residential & Industrial Criteria (only Residential for SO2)										Ratio against Industrial Criteria
Monitoring Location	NO2	SO2	H2S	CO*	TSP	NO2	SO2	H2S	CO	TSP	SO2
A12	0.29	0.28	0.73	-	N/A	0.11	0.06	0.18	N/A	N/A	0.04
A13	0.19	0.50	0.54	-	[illegible]	0.07	0.11	0.13	N/A	0.68	0.06
A14	0.37	[illegible]	[illegible]	-	13.47	0.14	0.27	0.31	N/A	[illegible]	0.15
A15	0.23	0.16	0.74	-	N/A	0.09	0.04	0.18	N/A	N/A	0.02
A16	0.22	0.29	0.86	-	[illegible]	0.08	0.06	0.22	N/A	[illegible]	0.04
A17	0.15	0.30	0.54	-	N/A	0.06	0.07	0.13	N/A	N/A	0.04
A18	0.13	0.26	0.71	-	N/A	0.05	0.06	0.18	N/A	N/A	0.03
A19	0.23	[illegible]	[illegible]	-	[illegible]	0.09	0.34	0.25	N/A	0.66	0.19
A20	0.24	0.50	0.86	-	[illegible]	0.09	0.11	0.22	N/A	0.58	0.06
A21	0.28	[illegible]	0.93	-	[illegible]	0.11	0.24	0.23	N/A	[illegible]	0.14
A22	0.16	0.41	0.76	-	N/A	0.06	0.09	0.19	N/A	N/A	0.05
A23	0.30	[illegible]	[illegible]	-	[illegible]	0.11	0.24	0.33	N/A	[illegible]	0.14
A24	0.30	[illegible]	0.86	-	[illegible]	0.11	0.23	0.22	N/A	[illegible]	0.13
A25	0.15	0.38	0.73	-	N/A	0.05	0.08	0.18	N/A	N/A	0.05
A26	0.17	0.54	0.93	-	N/A	0.06	0.12	0.23	N/A	N/A	0.07
A27	0.22	0.41	0.85	-	[illegible]	0.08	0.09	0.21	N/A	[illegible]	0.05
A28	0.15	0.29	0.00	-	N/A	0.06	0.06	0.00	N/A	N/A	0.04
A29	0.21	0.50	0.79	-	[illegible]	0.08	0.11	0.20	N/A	[illegible]	0.06
A30	0.25	0.85	0.81	-	[illegible]	0.09	0.19	0.20	N/A	[illegible]	0.11
A31	0.22	0.45	0.86	-	N/A	0.08	0.10	0.22	N/A	N/A	0.06
A32	0.16	0.40	0.90	-	N/A	0.06	0.09	0.23	N/A	N/A	0.05
A33	0.18	0.53	0.99	-	[illegible]	0.07	0.12	0.25	N/A	0.75	0.07
A34	0.09	0.13	[illegible]	-	N/A	0.03	0.03	0.45	N/A	N/A	0.02
A35	0.16	0.36	[illegible]	-	N/A	0.06	0.08	0.27	N/A	N/A	0.05
A36	0.15	0.44	0.84	-	N/A	0.06	0.10	0.21	N/A	N/A	0.06
A37	0.28	[illegible]	[illegible]	-	[illegible]	0.11	0.27	0.31	N/A	[illegible]	0.15
A38	0.24	[illegible]	[illegible]	-	[illegible]	0.09	0.31	0.30	N/A	0.72	0.18
A39	0.25	0.53	0.91	-	[illegible]	0.09	0.12	0.23	N/A	[illegible]	0.07
A40	0.23	0.20	0.71	-	[illegible]	0.08	0.05	0.18	N/A	[illegible]	0.03
A41	0.24	0.49	0.84	-	N/A	0.09	0.11	0.21	N/A	N/A	0.06
A42	0.15	0.46	0.83	-	[illegible]	0.06	0.10	0.21	N/A	[illegible]	0.06
A43	0.20	0.56	0.76	-	[illegible]	0.08	0.13	0.19	N/A	0.77	0.07
A44	0.18	0.46	0.95	-	N/A	0.07	0.10	0.24	N/A	N/A	0.06
A45	0.24	0.46	0.94	-	N/A	0.09	0.10	0.23	N/A	N/A	0.06
KNPC C	[illegible]	0.39	[illegible]	-	[illegible]	[illegible]	0.59	[illegible]	0.17	[illegible]	0.34
KNPC D	0.67	0.60	[illegible]	-	[illegible]	0.33	0.29	[illegible]	N/A	[illegible]	0.16
KNPC F	[illegible]	0.26	0.67	-	[illegible]	0.82	0.41	0.74	0.09	[illegible]	0.23
KNPC H	0.79	0.37	0.46	-	[illegible]	0.41	0.19	0.32	N/A	[illegible]	0.11

Note: The red highlighted cells indicate exceedance against K-EPA / MOO criteria.
* Long term (i.e. annual) concentrations are not applicable for CO.

9.3 Process Releases During Operation & Their Control

9.3.1 Point Source Emissions

Point source emissions generated by the CFP as by-products of combustion, will include NO_x, SO_2, CO, H_2S, suspended particulate matter (SPM), and unburned hydrocarbons (UHC), plus significant volumes of CO_2 (a greenhouse gas). In addition to the new point sources, several units from the three refineries (most of them located at SHU) will be decommissioned as part of the project. The removal of these emissions will help to improve the air quality in the area.

A summary list of air emission point sources is provided in Table 9.4 for the new sources installed as part of the CFP, whereas Table 9.5 summarises the sources that are to be decommissioned. Note these lists only include new (or revamped) and decommissioned sources that result in air pollutant emissions. Flare emission sources are not included in the new CFP sources summary table, as these will only be used intermittently (i.e. during emergencies which are discussed in Section 9.3.4).

Table 9.4: List of CFP New Fired Equipment air emission sources

Refinery	Source Name / Description	No. of sources	No. of stacks
MAA	Unit 135 DCU-NHTU	1	1
	Unit 136 DCU*	2	1
	Unit 183 VRU	1	1
	Unit 137 DIP	1	1
	Unit 186 FCC-NHTU HDS	2	2
	Unit 141 ARDS	2	2
	Unit 148 HPU	1	1
	Unit 129 Steam Boilers	3	3
	Unit 151 MAA - SRUs	1	1
	Unit 152 MAA - SRUs	1	1
	Unit 187 - Coke Handling	19	19
	Unit 25/26 NHT	2	2
	Unit 107 Isomerization	2	2
	Unit 144 – GOD	1	1
MAB	Unit 123 MAB - SRUs	3	3
	Unit 213	1	1
	Unit 117 NHT	1	1
	Unit 111 CDU*	2	1
	Unit 118 NHT TB / H2 RF	2	2
	Unit 115 KHT	1	1
	Unit 116 DHT	1	1
	Unit 112 ARDS	3	3
	Unit 212 ARDS	2	2
	Unit 114 HC	3	3
	Unit 127 CCR*	4	1
	Unit 127 CCR Stabilizer	1	1
	Unit 156 WWT	1	1
	Unit 11 CDU	1	1
	Unit 131 Steam Boilers	6	6

Refinery	Source Name / Description	No. of sources	No. of stacks
	Unit 214 Hydrocracker*	3	1
	Unit 216- DHT	1	1
	Unit 118 – H2 Plant	1	1

* For Unit 136 (2 heaters), Unit 111 (2 heaters), Unit 127 (4 reactor feed furnace), Unit 214 (3 HC heater),the emissions are combined.

(List does not include diesel engine drivers for emergency generators and firewater pumps which are used only intermittently)

Table 9.5: List of CFP Air Emission Sources for Planned Decommissioned Units

Refinery	Source Name / Description	No. of sources	No. of stacks
SHU	Unit 02 - Hydrogen manufacturing	1	4
	Unit 06 – Crude & Vacuum	1	7
	Unit 07 - Hot Oil	1	6
	Unit 08 - Isomax	1	2
	Unit 09 - Naphtha Fractionation	1	1
	Unit 11 - Kero Unifiner	1	6
	Unit 12 - Diesel Unifiner	1	4
	Unit 13 - Heavy Diesel Unifiner	1	2
	Unit 63 - Hot Oil Vacuum	1	1
	Unit 68 - Isocracker	1	4
	Unit 62 - Hydrogen manufacturing	1	2
	Unit 20 - Boilers	1	4
	Unit 05 - Catalytic Reformer	1	3
	Unit 10 - Naphtha Unifiner	1	2
	Unit 04 and Unit 74 SRUs[1]	2	2
MAB	Unit 01-Crude	1	9
	Unit 02-RCD Unibon	1	3
	Unit 03-Hydrogen Plant	1	1
MAA	Unit 99 TGTU[2]	1	1
	ESP on Unit 86[3]	1	1
	Unit 03-CDU # 3	1	1

1. Tail gas from these units (which are not decommissioned) is routed to TGTU 75 before discharge to atmosphere as a common stream after treatment.
2. Unit 99 is not a "decommissioned" unit, but a new pollution control unit (SCOT Unit) that will be commissioned to improve emissions from the existing MAA SRU. As such, it will be an improvement to the air quality, and consequently has been grouped together with the "Decommissioned" Units.
3. Similarly, Unit 86 ESP is a new pollution control facility which will improve particulate emissions from the existing plant, and as such has also been grouped with the "Decommissioned" Units.

Control of point source emissions such as these can be accomplished by various methods including pre-combustion techniques, combustion techniques and post-combustion techniques. Pre-combustion control techniques entail the careful selection and treatment of fuel which, based on the type and composition of crude oil from which it is derived, may contain significant amounts of sulphur / sulphur compounds and / or nitrogen: these in turn give rise to SO_2 and NO_x emissions during combustion.

The CFP will also incorporate combustion techniques to minimise the generation of air emissions, including management practices to ensure efficient operation of equipment as well as engineered emission control systems. Process heaters, furnaces and boilers will be equipped with low NOx burners ('LNBs').

In keeping with KNPC's commitment to environmental stewardship, a substantial financial investment is being made in providing reliable and highly efficient facilities to recover sulphur from process streams while ensuring SO_2 emissions are minimized. As part of the CFP project three new SRU units are provided, two at MAA (Units 151 and 152 - two trains) and one at the MAB (Unit 123 – three trains) refinery. The SRU unit at SHU Refinery is to be decommissioned (Unit 74 – two trains).

The Sulphur Recovery Unit/Tail Gas Treating Units will be comprised of four parallel plants, each comprising:

- One Claus section
- One SCOT section
- One degassing section
- One incineration section

The SCOT tail gas (or Claus tail gas in case the SCOT section is bypassed) and the vent gas from the sulphur storage contain residual H_2S and other sulphur compounds which are thermally incinerated to convert the H_2S and sulphur compounds into SO_2. NOx formation from the burner is reduced by limiting the primary air flow rate to 80% of the amount required for stoichiometric combustion of the fuel gas. Vent gas from the incinerator stack is expected to contain < 10ppmv H_2S and < 250 ppmv SO_2 on a dry and zero excess oxygen basis.

Units 151 and 152 at MAA are identical, and each consists of a single train. Normally, both units will be in operation. At MAB, Unit 123 consists of three identical trains, which will all normally be in operation.

Suspended particulate matter (SPM) emissions are primarily a result of construction activities (see Chapter 8). The Electrostatic Precipitator (ESP) currently being installed on Unit 86 (FCCU) at MAA has been accounted for the purposes of this study.

9.3.2 Fugitive Emissions

Fugitive emissions generated by the CFP during its operations will potentially arise from valves, flanges, pumps as well as from pressure-relief valves during abnormal and/or emergency situations. Fugitive emissions at the CFP may include suspended particulate matter (SPM), hydrogen sulphide (H_2S) and VOCs, as follows:

Fugitive SPM:
The new Coke Handling Unit at MAA (Unit 187) will incorporate covered conveyor systems to minimize the potential generation of wind blown particulate matter as well as particulate control systems at each of the nineteen transfer towers.

Fugitive H_2S:

- Potentially released from both ISBL and OSBL areas of the CFP where sour-gas or sour liquids are handled, processed or stored.
- Low-leak seals will be provided for equipment components in sour-gas or sour-liquid service as appropriate, and will be monitored on a regular basis as part of the CFP's overall Leak Detection and Repair (LDAR) programme.

- Ambient H_2S monitors will be sited in those areas with the greatest potential for H_2S fugitive emissions; should H_2S concentrations exceed the established alert threshold level, an alarm in the local control room will notify operators of a leak and need to immediately initiate appropriate response and repair actions.

Fugitive VOCs:
- Potentially released from both ISBL and OSBL areas of the CFP where equipment is in hydrocarbon service, including process and treatment units and storage tanks. VOC emissions will be minimized through efficient design, application of engineering controls and EMS procedures.
- Control techniques will include: relief valves routed to flare, open-ended valves equipped with cap, plug, blind flange or second valve, pumps incorporating double mechanical seals, reciprocating compressors designed with cylinder packing case venting to flare system, centrifugal compressors provided with dry gas seals and nitrogen buffer gas-venting to flare system, and closed process drains and effluent sumps.

Regarding the CFP's new Wastewater Treatment Unit (Unit 163 at MAA and Unit 156 at MAB), treatment systems in contact with hydrocarbons or odorous compounds will be enclosed where feasible. In addition:
- CFP Wastewater plant equipment components in VOC service including valves / pumps / flanges etc will be incorporated in the existing refineries' Leak Detection and Repair (LDAR) Programme, requiring the identification of affected components and regular inspections of those components. An equipment leak definition of 10,000 ppmv VOC will be used as a guideline;
- Monitoring frequency will be monthly on a rotation basis for the wastewater treatment facilities, storage tank areas and process units / work environment area. A protocol will be developed for responding and making repairs to leaking components.
- Liquid sample points will be designed to minimize hydrocarbon or product loss to the drainage system, and closed-loop sampling will be used wherever possible to minimize operator exposure and emissions during sample purging.

Storage tanks in VOC service will meet all applicable K-EPA / MOO air emissions criteria:
- Regulatory control requirements include: use of primary seals, secondary seals (external floating roof tanks) for various compounds subject to specified vapour pressure and storage tank design criteria;
- Pole wipers will be provided for floating roof tanks, and automatic bleeder vents (vacuum breaker vents) will be kept closed at all times except when the roof is being floated off or landed on the roof leg supports;
- All gauging and sampling devices will be kept vapour tight except when those activities are in progress.
- The CFP facilities will be incorporated within the existing MAA and MAB refineries EMS. The EMS will be updated to include a protocol and schedule for inspection of seals on floating roof storage tanks (VOC emissions from storage tanks are typically estimated using the latest version of U.S. EPA's TANKS programme, which is based upon AP-42 emission factors).

CFP will not modify or increase the number of loading arms currently in use at refinery port facilities. Therefore, VOC emissions resulting from transfer operations at the port have not been included in this analysis.

It is noted that the CFP will not implement any new HSE programmes. The new CFP facilities will be incorporated in into existing refineries programmes in order to ensure they are properly monitored, inspected and maintained to minimise potential environmental impacts.

9.3.3 Hazardous and Deleterious Air Pollutants

Kuwait is a signatory to the Montreal Protocol and its subsequent amendments for the protection of stratospheric ozone. As such, the CFP will seek to avoid the use of ozone-depleting substances (ODSs) such as chlorofluorocarbons (CFCs) and halons, wherever acceptable (i.e. environmentally-friendly) substitutes are available.

Preference will be given to chemicals which are regarded as acceptable substitutes to those chemicals that have the greatest deleterious impact on stratospheric ozone. Some acceptable substitutes for the most deleterious chemicals – e.g. HCFC-22 as a substitute for R-502 (already phased out of production) in industrial process refrigeration systems – are also scheduled for phase-out in 2020. Engineering design will take into account all ODSs that are to be phased out during the CFP's operating life.

No asbestos products will be used in either the construction or operation of the CFP, nor will chromium-based corrosion inhibitors be used for cooling water treatment.

9.3.4 Emergency Emissions

Flares

The Flare system for CFP serves as the final line of protection against catastrophic failure resulting from overpressure of equipment and interconnecting piping. Its' purpose is to provide the means for the safe relief and combustion of potentially explosive and/or toxic fluids. These fluids, which are present as feeds, products, or intermediate streams within the refinery processes, must be flared under *unplanned* upset conditions. These streams will be collected through a closed system and directed to the flares after phase separation via 'knock-out' (KO) drums.

Additionally, under typical refinery operation, gases may be vented or liquids blown down to the flare to maintain a required process operating pressure. It is also common practice to start-up or shutdown a process unit by temporarily venting hydrocarbon gases to the flare until the unit can be properly lined out (start-up) or de-pressured and purged (shutdown). However, for the CFP, refinery operations will implement suitable sequencing of unit start-ups and shutdowns to minimize simultaneous planned flaring from different process units.

A Flare Gas Recovery Unit (FGRU) will be installed in the future to permit the recovery of gases which would normally be flared, and then return them back to the processing units.

The CFP's Relief and Flare System will meet all KNPC design guidelines for smokeless flame operation, noise limits, radiation limits, and dispersion levels as well as the applicable K-EPA / MOO criteria. Flaring will be reduced by selecting relief valves and control valves designed to keep internal leaks to a minimum.

CFP will include both a hydrocarbon flare system and an Acid Gas Flare (AGF) System at each of MAA and MAB refineries. All new flares at the two refineries will be elevated.

In addition to the new CFP flare systems, some of the existing flare systems at MAA refinery will have tie-ins with relief valves in CFP process units, hence adding to the existing flare load. These reliefs have also been considered when assessing the air quality both within and beyond the fence-line of the refineries.

The flare systems considered in the scope of this study are summarised in Table 9.6. The scenarios considered are discussed in more detail in Section 9.4.

Key environmental emissions from the flares will constitute significant atmospheric emissions during emergency relief. However, emissions are expected to be minimal during normal refinery operations.

Table 9.6 – Flares Emission Modelling Scenarios

Refinery	Flare System / New or Existing	Description / Notes
MAA	Unit 167 Acid Gas – New	New acid gas flare system at MAA.
	Unit 162 Hydrocarbon – New	New hydrocarbon flare system at MAA.
	Unit 25/26 CCR 1 & 2 – Existing	Revamped flare system for catalytic cracking unit at MAA.
	Unit 39 Eocene – Existing	Revamped Eocene flare system at MAA.
	Unit 62 Acid Gas – Existing	Revamped acid gas flare system at MAA.
MAB	Unit 146 Acid Gas - New	New acid gas flare system at MAB.
	Unit 149 HP Hydrocarbon – New	New high pressure hydrocarbon flare system at MAB.
	Unit 149 LP Hydrocarbon – New	New low pressure hydrocarbon flare system at MAB.
	Unit 249 DHT – New	New flare system for diesel hydrotreater unit at MAB.
	Unit 314 HP HCR – New	New high pressure flare system for hydrocracker unit at MAB.
	Unit 314 LP HCR - New	New low pressure flare system for hydrocracker unit at MAB.

Sulphur Recovery and Handling System

In keeping with KNPC's commitment to environmental stewardship, a substantial financial investment is being made in providing reliable and highly efficient (99.9+%) facilities to recover sulphur from process streams while ensuring SO_2 emissions are minimized. As part of the CFP project three new SRU units are provided, two at MAA (Units 151 and 152 - two trains) and one at the MAB (Unit 123 – three trains) refinery. Additionally, the SRU unit (Unit 74 – two trains) at SHU Refinery will be decommissioned.

The SRU/TGTU design provides a very high degree of reliability. However, there are two emergency case scenarios for each of the units at MAA and MAB, both rare and of short duration which if were to occur, would result in significantly higher than normal emissions of SO_2 and/or H_2S:

1. SRU operating SCOT sections are bypassed (SRUs "Case 2")
2. SRU operating when SCOT sections are bypassed, and the incinerator is not operating (SRUs "Case 3")

Four (4) cases have been considered / modelled in total, as it has been assumed that emergency events will not occur simultaneously at the two refineries (MAA and MAB):

- For SRUs Case 2 at MAA, one of the two trains at MAA (Units 151 and 152) is modelled under emergency conditions.
- For SRU Case 2 at MAB, one of the three trains at MAB (Unit 123) is modelled assuming under emergency conditions.
- Similarly, for SRUs Case 3 at MAA, only one of the two trains at MAA (Units 151 and 152) is modelled under emergency conditions.
- For SRU Case 3 at MAB one of the three trains at MAB (Unit 123) is modelled under emergency conditions.

As mentioned above, this is to account for the fact that it is highly unlikely that more than one SCOT unit at either refinery will be bypassed at the same time.

The scenarios are outlined in Table 9.13. It is also noted here that it is unlikely that the incinerator will ever be out of service during its operational life.

These scenarios are not typical of normal refinery operations. However, they have been evaluated through an air dispersion modelling analysis as an emergency release case(s) for which the results are presented in Section 9.4.6.3.

9.3.5 Maintenance /Shutdown Scenarios

Two maintenance events (at the RMP and CFP block) are anticipated to occur once every four to five years at MAA, and expected to last for up to 30 days. This would result in higher than normal emissions of SO_2 from Unit 107 and Unit 137, as the fired heaters would only be operated on sour fuel gas, because sweet refinery fuel would not be available during the shutdown. During these maintenance events other units will also be shutdown, and this is incorporated in the air dispersion modelling. It is not expected that shutdowns of the CFP and RMP blocks will occur simultaneously.

Table 9.7 – Maintenance /Shutdown Emissions Modelling Scenarios

Maintenance Scenario	Refinery Unit	Status	Name
Maintenance 1 RMP Block Shutdown	MAA New	Running on sour fuel gas	Unit 107
	MAA New	Shutdown	Unit 144
	MAA Existing	Shutdown	KD Unit
	MAA Existing	Shutdown	ARDS 1
	MAA Existing	Shutdown	ARDS2
	MAA Existing	Shutdown	HP-1
	MAA Existing	Shutdown	HP-2
	MAA Existing	Shutdown	SR/TGT
Maintenance 2 CFP Block Shutdown	MAA New	Running on sour fuel gas	Unit 137
	MAA New	Shutdown	Unit 129
	MAA New	Shutdown	Unit 135
	MAA New	Shutdown	Unit 136
	MAA New	Shutdown	Unit 141
	MAA New	Shutdown	Unit 148
	MAA New	Shutdown	Unit 151
	MAA New	Shutdown	Unit 152
	MAA New	Shutdown	Unit 183

Table 9.7 outlines the two maintenance cases. Both cases are modelled with "Normal Emissions" and combined with the Decommissioned Units. The results are presented in Section 9.4.6.8.

9.4 Modelling

9.4.1 Atmospheric Dispersion Modelling

As part of identifying and assessing the major sources of emissions to air from the CFP Project, including both major continuous emission sources such as those from boilers, heaters, furnaces, flares and incinerators, and fugitive emissions (e.g. VOCs), DNV has subjected the most significant ones to air quality modelling and assessment, using the Atmospheric Dispersion Modelling Software / Version 4.1 ('ADMS 4'). The ADMS software was presented to K-EPA during the previous FEED Phase EIS. K-EPA has approved the ADMS software for conducting the study.

The dispersion model ADMS 4 is currently used in many countries worldwide, with users including:

- over 130 individual company licence holders in the UK
- regulatory authorities, including the UK's Health and Safety Executive (HSE)
- the Environment Agency in England and Wales and the Scottish Environmental Protection Agency (SEPA)
- the Environment and Heritage Service in Northern Ireland
- government organisations including the Food Standards Agency (UK)
- users in other European countries, Asia, Australia and the Middle East.

ADMS 4 can be used to assess the effect of emissions from a wide range of industrial / process types such as power plant, boilers, heaters, furnaces, flares and incinerators, and a number of industrial source types:

- Point source: e.g. emissions from a stack or vent;
- Area source: e.g. evaporative emissions from a tank;
- Volume source: e.g. fugitive emissions;
- Jet (directional releases): e.g. emissions from a ruptured pipe.

The maximum number of sources that can be modelled in ADMS 4 is 300, depending on the source type, and it is typically applied to major continuous emissions (e.g. NO_2, SO_2 etc). The model uses relevant input parameters such as local meteorological data, terrain, significant buildings and ground cover, in order to assess ground level concentrations of pollutants both on and off-site for the relevant averaging periods (e.g. 1 hour average, annual average etc) as specified by K-EPA air quality standards.

All the monitoring point locations discussed in Section 9.2 (KNPC C, D, F and H, A1 to A45) have been included as specific points of interest in the various ADMS models examined, in order to estimate the ground level concentrations after the completion of the CFP project.

9.4.2 Modelling Approach

There are two alternative approaches in examining the effects of the CFP and decommissioning of SHU on the overall air quality in the area:

(1) Model all KNPC air pollutant emission sources that will exist in the future, post-CFP (i.e. model new/revamped CFP sources in addition to the existing refinery emission sources (but excluding any existing refinery sources that will be decommissioned as part of the CFP project).

(2) Model only the new CFP emission sources (i.e. new/revamped sources) plus additionally, negatively model the existing sources that will be decommissioned as part of the CFP project. This data can then be combined with the current baseline air quality from the monitoring data that KNPC HSE provided for the CFP EBS development.

Approach (2) has been followed to estimate the effects of the CFP on the overall quality, as it has the significant advantage that modelling results can be combined with the extensive EBS baseline air quality monitoring data available to provide adequate representation of the future ambient air quality (resulting from all sources, both KNPC and non-KNPC) in the surrounding environment post-CFP. This can then be compared against relevant K-EPA / MOO air criteria.

9.4.3 Modelling Scenarios & Source Data

Based on information available at this stage, the following scenarios have been modelled:

- The **"Base Case"** Scenario: This combines the negative environmental impact of the 'Normal' emissions from the new CFP Units/Sources at MAA and MAB refineries with the positive contribution to the environment as a result of decommissioning events at the 3 refineries. The decommissioning at each of the three refineries, with the vast majority of these located at the SHU Refinery, is treated as an improvement to air quality.
- The **"Maximum Emission"** Scenario: This combines the negative environmental impact of the 'Maximum" emissions from the new CFP Units/Sources at MAA and MAB refineries with the positive contribution to the environment as a result of decommissioning events at the 3 refineries. The decommissioning at each of the three refineries, with the vast majority of these located at the SHU Refinery, is treated as an improvement to air quality. Note that for some units, Normal and Maximum emissions are the same, but in general emissions are significantly less for the Normal scenario.
- **Emergency Flare** Scenarios – Various emergency flare scenarios have been considered, which are discussed in Section 9.3.4, and summarised in Table 9.11 and Table 9.12. The emergency flare scenario results for each flare are not combined with either the "Normal Emission" or the Decommissioned scenarios, as these pollutant emissions will be negligible in comparison to the flare emissions. With the exception of the Total Power Failure (TPF) case, each flare scenario is modelled individually. The TPF case is modelled assuming all

emergency flaring occurs simultaneously at both MAA and MAB refineries, for all relevant flares.

An exit velocity of 40 m/s has been assumed for the purposes of each flare scenario considered (consistent with applicable guidelines for flare modelling). Based on this assumption, an effective diameter for the flare point source was estimated for input to ADMS. Complete combustion of the flare destruction stream (with 20% excess air) has been assumed. Since the hot plume emission begins at the top of the flame, the height corresponding to the flame height / length has been estimated based on ADMS guidelines (i.e. the flame height / length is a function of the heat release rate and effective diameter, i.e. the flame diameter, and the density, heat capacity and temperature of ambient air). The flame height is then added to the flare stack height, resulting to the effective release height required as an input to ADMS.

- **Emergency SRU** Scenarios - The SRUs upset conditions considered are outlined below (see also Section 9.3.4):

  1. SRU operating while SCOT sections are bypassed (SRUs "Case 2")
  2. SRU operating while SCOT sections are bypassed, and the tail gas incinerator is not operating (SRUs "Case 3")

  These scenarios are combined with the **"Normal Emission"** Scenario. The emergency case results are not combined with the decommissioned scenario results, as the effect of them on the predicted concentrations will be minimal.

- **VOC Fugitive Emissions** from storage tanks in hydrocarbon service (see Section 9.4.6.7).

- Two **Maintenance Event scenarios** are considered as outlined below (see Section 9.4.6.8) and are modelled with "Normal Emissions" and combined with "Decommissioned Units" emissions.

  1. RMP Block shutdown resulting in Unit 107 (two fired heaters) receiving sour gas fuel. This would result in increased SO_2 emissions but the fired equipment in RMP block will not emit any SO_2 during this period, hence it will offset the emissions from Unit 107.
  2. CFP block shutdown resulting in Unit 137 (one fired heater) receiving sour gas fuel. This would result in increased SO_2 emissions but the fired equipment in CFP block will not emit any SO_2 during this period, hence it will offset the emissions from Unit 137.

The parameters NOx, SO_2, CO have been modelled for the Decommissioned, Normal and Maximum scenarios, as these are the key parameters of concern to K-EPA and the Kuwait Ministry of Oil. Additionally, Total Suspended Particles (TSP) have been modelled for the Decommissioned and Normal scenarios, with H_2S modelled only for the new CFP sources at MAA and MAB refineries (i.e. Normal and Maximum Emission Scenarios).

Buildings have not been taken into account during modelling, because the main building structures are at a significant distance from the stacks/chimneys, which are also significantly higher than the buildings. Consequently the effect of buildings upon dispersion is considered minimal.

The source data are summarised in Table 9.8 to Table 9.14, for the Normal, Maximum and Decommissioned emission scenarios, Flare and SRUs emergency and upset scenarios and the two maintenance scenarios respectively.

Additionally Table 9.15 compares the emissions of different pollutants (NO_x and SO_2) for the new CFP sources for Normal operating conditions against the equivalent emissions decommissioned at Shuiaba. It is clear that overall atmospheric emissions of pollutants will decrease.

The storage tanks modelled for fugitive emissions are discussed in Sections 9.3.2 and 9.4.6.7, and summarised in Appendix I.

Figure 9.5 and Figure 9.6 illustrate the location of the ADMS point source input emission sources for the Decommissioned and New CFP-Sources of the Clean Fuels Project respectively. The red line in these figures represents the site boundary for all three (MAA, MAB, and SHU) refineries. Figure 9.7 illustrates the location of the flares considered for emergency flaring events.

Figure 9.5: Location of ADMS Input Point Sources for Decommissioned Units

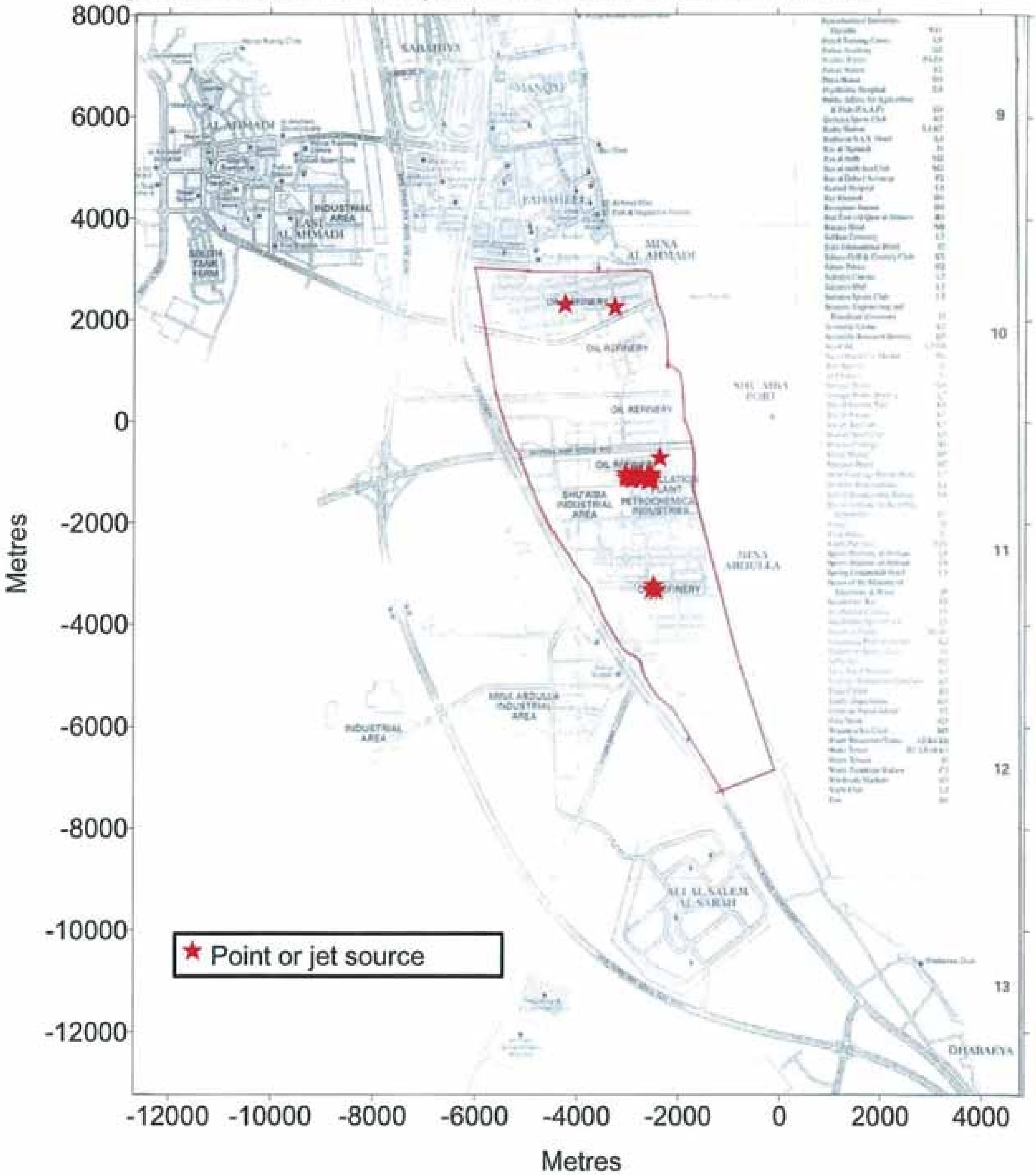

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Figure 9.6: Location of ADMS Input Point Sources for New CFP Units

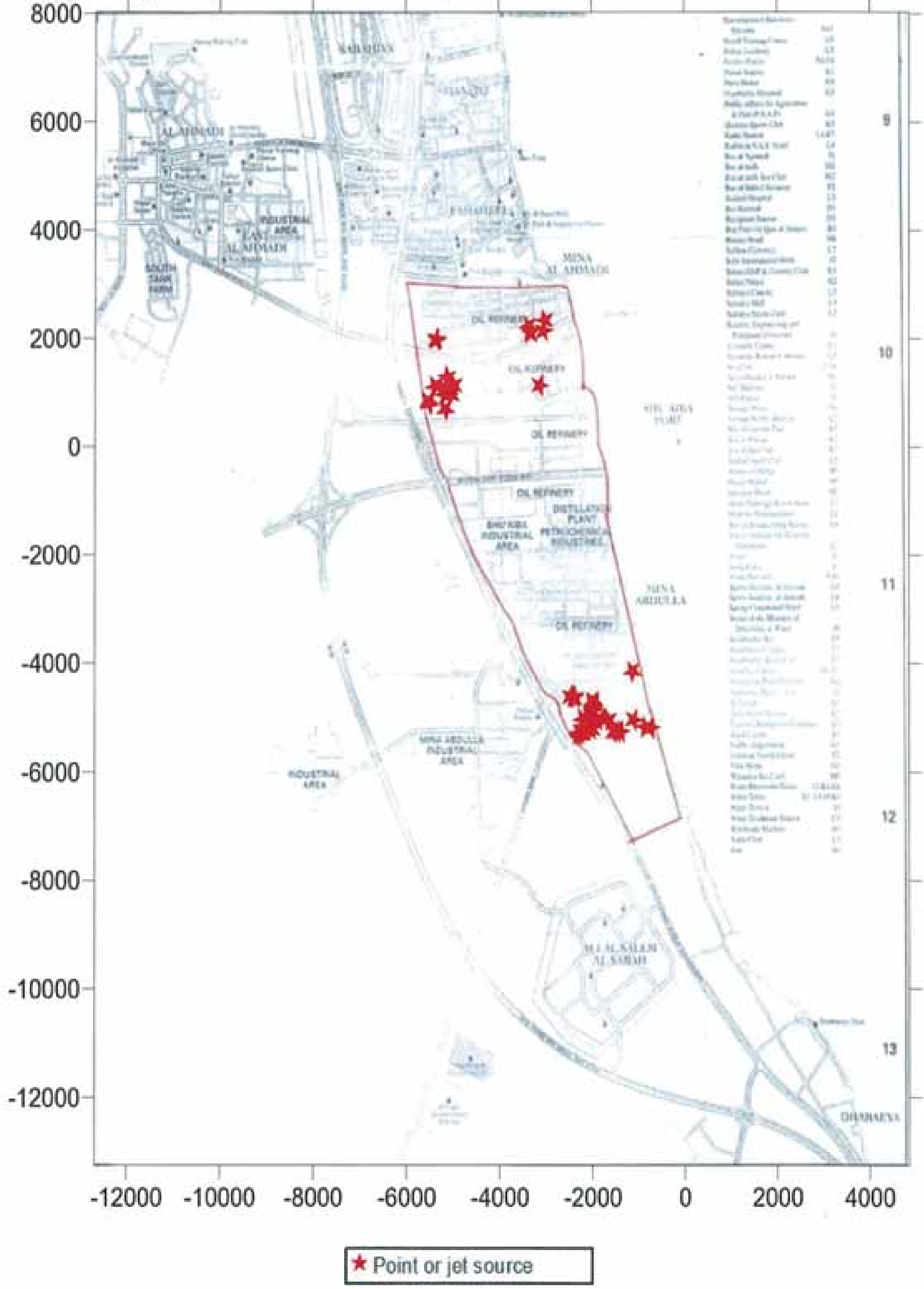

Figure 9.7: Location of ADMS Input Point Sources for Flare Systems Considered

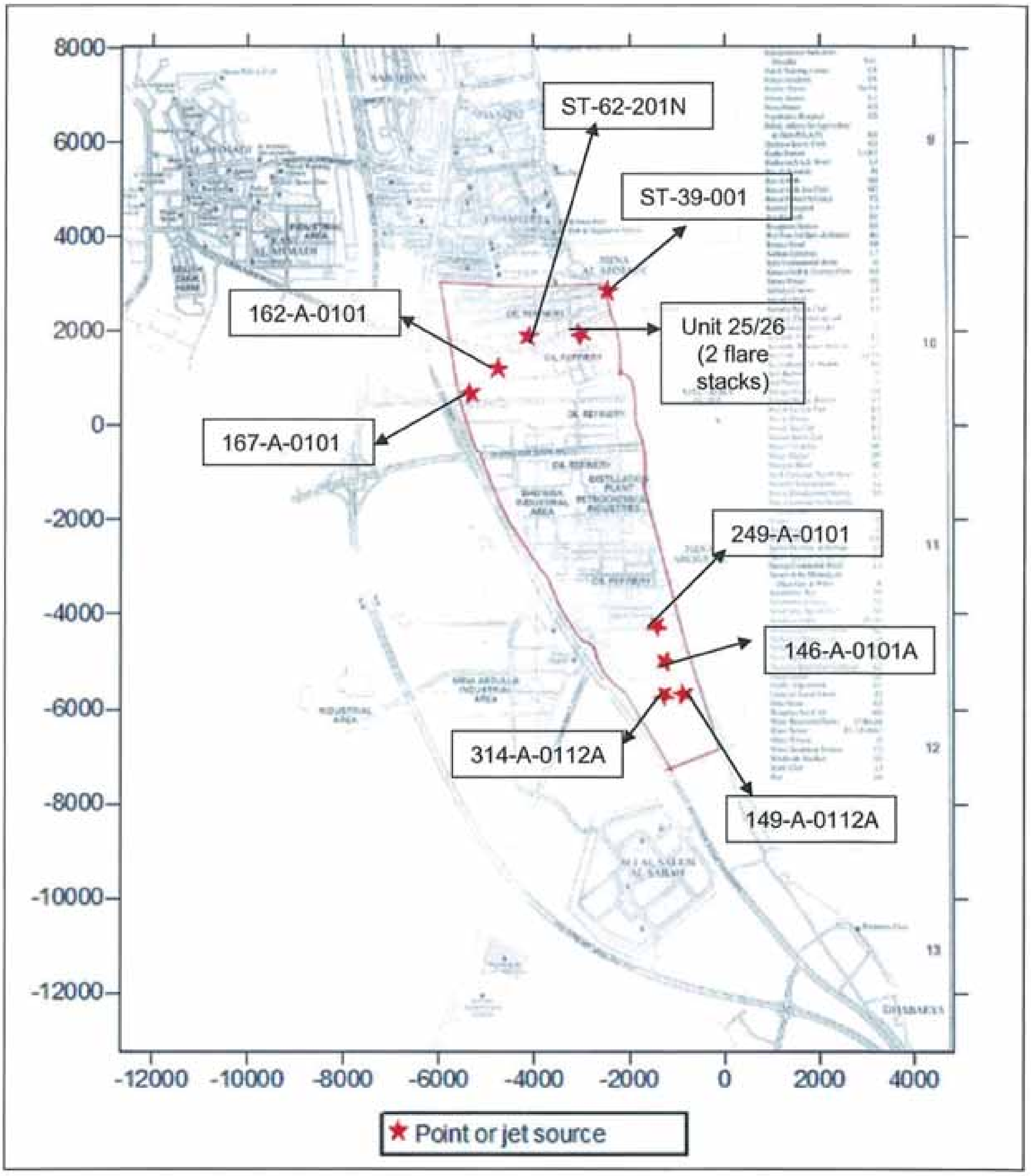

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Table 9.8: Point Emission Sources and Emission Levels (Normal Case for New Sources)

Refinery	Name	Unit (Tag No.)	NOx g/s	SO2 g/s	CO g/s	H2S g/s	TSP g/s	Height above gl (m)	Exit Velocity (m/s)	Exit Temp. (°C)	Exit Diameter (m)
MAA	Unit 135 DCU-NHTU	135-F-0101	0.06	0.01	0.11	-	-	61	7.6	321	0.5
	Unit 136 DCU[2]	136-F-0201A/B	4.51	0.28	2.71	-	-	61	4.7	150	3.3
	Unit 137 DIP Reboiler Heater	137-F-0101	2.65	0.17	1.59	-	-	61	6.8	182	2.3
	Unit 141 ARDS	141-F-0201	0.94	0.13	0.57	-	-	65	7.4	150	1.5
		141-F-0401	1.11	0.17	0.67	-	-	65	7.4	150	1.5
	Unit 148 HPU	148-F-0301	3.51	0.03	4.68	-	-	61	10.3	154	2.8
	Unit 129 Steam Boilers[1]	129-F-0201A	5.40	0.30	3.24	-	-	65	5.3	293	4.1
		129-F-0201B	5.40	0.30	3.24	-	-	65	5.3	293	4.1
		129-F-0201C	5.40	0.30	3.24	-	-	65	5.3	293	4.1
	Unit 151/152 TGTU	151-F-0132	0.76	0.67	0.03	0.06	-	61	14*	270	1.4
	Unit 151/152 TGTU	152-F-0132	0.76	0.67	0.03	0.06	-	61	14*	270	1.4
	Unit 183 VRU	183-F-0101	2.53	0.16	1.52	-	-	61	5.7	204	2.1
	Unit 186 FCC-NHTU HDS	186-F-0201	0.10	0.02	0.17	-	-	65	6.3	363	1.0
		186-F-0202	0.13	0.02	0.22	-	-	65	6.3	372	1.1
	Unit 25/26 NHT Charge Heater (revamp existing)[5]	H25-101	0.18	0.03	0.31	-	-	31.6	3.2	316	1.3
		H26-101	0.18	0.03	0.31	-	-	31.6	3.2	316	1.3
	Unit 107 Isomerization	107-F-0101	0.37	0.06	0.61	-	-	61	4.2	293	1.8
		107-F-0102	4.59	0.29	2.76	-	-	61	4.3	188	3.5
	Unit 144 GOD	144-F-0101	0.24	0.04	0.40	-	-	61	7.0	329	1.2
MAB	Unit 111 Crude Distillation - 2 Heaters[2]	111-F-0101A/B	6.87	0.43	4.12	-	-	61	4.4	177	4.5
	Unit 112 ARDS Reactor Feed Furnace Train 1	112-F-0101	1.19	0.16	0.71	-	-	65	7.6	150	1.5
	Unit 112 ARDS Reactor Feed Furnace Train 2	112-F-0201	1.19	0.16	0.71	-	-	65	7.6	150	1.5
	Unit 112 ARDS Atmospheric Fractionator Feed Furnace	112-F-0401	2.28	0.31	1.39	-	-	65	7.4	150	2.2
	Unit 212 ARDS Reactor	212-F-0101	1.19	0.16	0.71	-	-	65	7.6	150	1.5

Refinery	Name	Unit (Tag No.)	NOx g/s	SO2 g/s	CO g/s	H2S g/s	TSP g/s	Height above gl (m)	Exit Velocity (m/s)	Exit Temp. (°C)	Exit Diameter (m)
	Feed Furnace										
	Unit 212 ARDS Atmospheric Fractionator Feed Furnace	212-F-0401	1.14	0.17	0.69	-	-	65	7.3	150	1.6
	Unit 114 Hydrocracker 1st Stage Gas Heater	114-F-0101	0.27	0.05	0.45	-	-	61	5.1	159	1.6
	Unit 114 Hydrocracker 2nd Stage Gas Heater	114-F-0102	0.37	0.06	0.61	-	-	61	5.2	159	1.7
	Unit 114 Hydrocracker Product Fractionator Feed Furnace	114-F-0103	4.47	0.28	2.68	-	-	61	10.1	159	4.0
	Unit 115 KHT Reactor Feed Furnace	115-F-0101	0.09	0.02	0.14	-	-	61	7.6	413	1.3
	Unit 116 DHT Reactor Feed Furnace	116-F-0101	0.49	0.09	0.83	-	-	61	10	216	1.8
	Unit 117 NHT Reactor Feed Furnace	117-F-0101	0.03	0.01	0.05	-	-	61	7.6	397	0.5
	Unit 118 H2 Plant Tubular Reformer Furnace (Train 1)	118-F-0101	10.09	1.19	11.41	-	-	61	9.7	155	5.0
	Unit 118 H2 Plant Tubular Reformer Furnace (Train 2)	118-F-0201	10.09	1.19	11.41	-	-	61	9.7	155	5.0
	Unit 123 SRU-TGTU Tail Gas Incinerator	123-F-0132	1.67	1.47	0.14	0.25	-	61	15*	270	1.7
	Unit 123 SRU-TGTU Tail Gas Incinerator	123-F-0232	1.67	1.47	0.14	0.25	-	61	15*	270	1.7
	Unit 123 SRU-TGTU Tail Gas Incinerator[6]	123-F-0332	1.67	1.47	0.14	0.25	-	61	15*	270	1.7
	Unit 127 CCR Reactor Feed Furnace [2]	127-F-0101, 0102, 0103, 0104	1.14	0.20	1.92	-	-	61	10.8	193	2.6
	Unit 127 CCR Stabilizer Reboiler	127-F-0105	0.10	0.02	0.16	-	-	61	10.5	283	0.9
	Unit 213 VRU Vacuum	213-F-0101	1.97	0.12	1.18	-	-	61	5.7	204	2.2

Refinery	Name	Unit (Tag No.)	NOx g/s	SO2 g/s	CO g/s	H2S g/s	TSP g/s	Height above gl (m)	Exit Velocity (m/s)	Exit Temp. (°C)	Exit Diameter (m)
	Charge Heater										
	Unit 11 CDU Fired Heater (existing) [4,5]	H-11-101	4.86	0.30	2.92	-	-	70	13.0	185	2.5
	Unit 131 Steam System Utility Boiler	131-F-0201A	2.80	0.18	1.68	-	-	65	5.3	175	2.2
		131-F-0201B	2.80	0.18	1.68	-	-	65	5.3	175	2.2
		131-F-0201C	2.80	0.18	1.68	-	-	65	5.3	175	2.2
		131-F-0201D	2.80	0.18	1.68	-	-	65	5.3	175	2.2
		131-F-0201E	2.80	0.18	1.68	-	-	65	5.3	175	2.2
		131-F-0201F	2.80	0.18	1.68	-	-	65	5.3	175	2.2
	Unit 156 WWT Oily Sludge Incinerator	156-A-0209-F01	0.06	0.01	0.09	-	-	20	6.8	950	0.9
	Unit 214 Hydrocracker - 3 Heaters Combined [2]	214-F-0101/0102/0103	4.68	0.36	3.44	-	-	61	4.3	136	3.7
	Unit 216 DHT Reactor Feed Furnace	216-F-0101	0.59	0.10	1.00	-	-	61	6.9	177	1.6
	Unit 118 H2 Plant Tubular Reformer Furnace (Train 3)	118-F-0301	10.09	1.19	11.41	-	-	61	10.2	155	4.9
MAA	Unit 187 - Coke Handling	19 point sources	0.06	0.01	0.11	-	-	Varied from 3 to 17	2	1.6	50
Emission Total			**123.9**	**15.7**	**94.9**	**0.9**	**0.0**	**N/A**	**N/A**	**N/A**	**N/A**

* Denotes Normal Temperature and Pressure Conditions (NTP: 0°C and 1.013 bara)

Notes: 1. For the normal operating case all boilers are assumed to burn gaseous fuel.
2. The emissions for Unit 136 (MAA) & Unit 111 (at MAB) correspond to the combined emissions from two stacks.
3. The emissions from Unit 156 (at MAB) correspond to the flue gas after treatment and are based on two shifts per day.
4. The emissions from Unit 11 are dual fired (gas & liquid), for normal emissions it is assumed to burn gaseous fuel.
5. For unit 25/26 and Unit 11 which are existing revamped units, 20% of the emissions provided are modelled as part of the CFP as this is the incremental increase.

Table 9.9: Point Emission Sources and Emission Levels (Maximum Case for New Sources)

Refinery	Name	Unit (Tag No.)	NOx g/s	SO2 g/s	CO g/s	H2S g/s	TSP g/s	Height above gl (m)	Exit Velocity (m/s)	Exit Temp. (°C)	Exit Diameter (m)
MAA	Unit 135 DCU-NHTU	135-F-0101	0.1	0.00001	0.1	-	-	61	9.1	321	0.5
	Unit 136 DCU[2]	136-F-0201A/B	5.4	0.3	3.2	-	-	61	5.0	180	3.3
	Unit 137 DIP Reboiler Heater	137-F-0101	3.2	0.2	1.9	-	-	61	8.2	218	2.3
	Unit 141 ARDS	141-F-0201	1.3	0.2	0.8	-	-	65	7.4	150	1.5
		141-F-0401	1.4	0.2	0.8	-	-	65	7.4	150	1.5
	Unit 148 HPU	148-F-0301	9.6	0.04	5.7	-	-	61	10.3	154	2.8
	Unit 129 Steam Boilers[1]	129-F-0201A	7.7	0.48	4.64	-	-	65	7.6	293	4.1
		129-F-0201B	7.7	0.48	4.64	-	-	65	7.6	293	4.1
		129-F-0201C	7.7	0.48	4.64	-	-	65	7.6	293	4.1
	Unit 151/152 TGTU	151-F-0132	1.2	3.2	0.03	0.06	-	61	14*	270	1.4
	Unit 151/152 TGTU	152-F-0132	1.2	3.2	0.03	0.06	-	61	14*	270	1.4
	Unit 183 VRU	183-F-0101	3.0	0.2	1.8	-	-	61	6.8	204	2.1
	Unit 186 FCC-NHTU HDS	186-F-0201	0.1	0.03	0.2	-	-	65	6.3	363	1.0
		186-F-0202	0.2	0.03	0.3	-	-	65	6.3	372	1.1
	Unit 25/26 NHT Charge Heater (revamp existing) [4]	H25-101	0.2	-	0.3	-	-	31.6	1.3	329	1.3
		H26-101	0.2	-	0.3	-	-	31.6	1.3	329	1.3
	Unit 107 Isomerization	107-F-0101	0.4	0.1	0.7	-	-	61	5.1	293	1.8
		107-F-0102	5.5	0.3	3.3	-	-	61	5.1	188	3.5
	Unit 144 GOD	144-F-0101	0.3	0.1	0.5	-	-	61	8.2	329	1.2
MAB	Unit 111 Crude Distillation - 2 Heaters[2]	111-F-0101A/B	11.0	11.3	4.6	-	0.9	61	5.3	177	4.5
	Unit 112 ARDS Reactor Feed Furnace Train 1	112-F-0101	1.5	0.2	0.9	-	-	65	7.6	150	1.5
	Unit 112 ARDS Reactor Feed Furnace Train 2	112-F-0201	1.5	0.2	0.9	-	-	65	7.6	150	1.5
	Unit 112 ARDS Atmospheric Fractionator Feed Furnace	112-F-0401	3.7	3.8	1.6		0.3	65	7.4	150	2.2

Refinery	Name	Unit (Tag No.)	NOx	SO2	CO	H2S	TSP	Height above gl (m)	Exit Velocity (m/s)	Exit Temp. (°C)	Exit Diameter (m)
			g/s	g/s	g/s	g/s	g/s				
	Unit 212 ARDS Reactor Feed Furnace	212-F-0101	1.5	0.2	0.9	-	-	65	7.6	150	1.5
	Unit 212 ARDS Atmospheric Fractionator Feed Furnace	212-F-0401	1.1	1.9	0.8	-	0.2	65	7.4	150	1.6
	Unit 114 Hydrocracker 1st Stage Gas Heater	114-F-0101	0.3	0.1	0.5	-	-	61	5.1	159	1.6
	Unit 114 Hydrocracker 2nd Stage Gas Heater	114-F-0102	0.4	0.1	0.7	-	-	61	5.2	159	1.7
	Unit 114 Hydrocracker Product Fractionator Feed Furnace	114-F-0103	5.4	0.3	3.2	-	-	61	10.1	159	4.0
	Unit 115 KHT Reactor Feed Furnace	115-F-0101	0.1	0.03	0.2	-	-	61	7.6	413	1.3
	Unit 116 DHT Reactor Feed Furnace	116-F-0101	1.7	0.1	1.0	-	-	61	15	216	1.8
	Unit 117 NHT Reactor Feed Furnace	117-F-0101	0.03	0.00001	0.1	-	-	61	7.6	397	0.5
	Unit 118 H2 Plant Tubular Reformer Furnace (Train 1)	118-F-0101	12.1	1.4	13.7	-	-	61	11.6	155	5.0
	Unit 118 H2 Plant Tubular Reformer Furnace (Train 2)	118-F-0201	12.1	1.4	13.7	-	-	61	11.6	155	5.0
	Unit 123 SRU-TGTU Tail Gas Incinerator	123-F-0132	2.4	7.08	2.2	1.22	-	61	15*	270	1.7
	Unit 123 SRU-TGTU Tail Gas Incinerator	123-F-0232	2.4	7.08	2.2	1.22	-	61	15*	270	1.7
	Unit 123 SRU-TGTU Tail Gas Incinerator	123-F-0332	2.4	7.08	2.2	1.22	-	61	15*	270	1.7
	Unit 127 CCR Reactor Feed Furnace [2]	127-F-0101, 0102, 0103, 0104	1.4	0.2	2.3	-	-	61	10.8	193	2.6
	Unit 127 CCR Stabilizer Reboiler	127-F-0105	0.1	0.03	0.2	-	-	61	10.5	283	0.9

Refinery	Name	Unit (Tag No.)	NOx	SO2	CO	H2S	TSP	Height above gl (m)	Exit Velocity (m/s)	Exit Temp. (°C)	Exit Diameter (m)
			g/s	g/s	g/s	g/s	g/s				
	Unit 213 VRU Vacuum Charge Heater	213-F-0101	2.4	0.1	1.4	-	-	61	5.7	204	2.2
	Unit 11 CDU Fired Heater (existing) [4]	H-11-101	18.7	59.9	2.0	-	4.0	70	16.2	184.4	2.5
	Unit 131 Steam System Utility Boiler	131-F-0201A	4.0	4.1	1.7	-	0.3	65	7.6	293	2.6
		131-F-0201B	4.0	4.1	1.7	-	0.3	65	7.6	293	2.6
		131-F-0201C	4.0	4.1	1.7	-	0.3	65	7.6	293	2.6
		131-F-0201D	4.0	4.1	1.7	-	0.3	65	7.6	293	2.6
		131-F-0201E	4.0	4.1	1.7	-	0.3	65	7.6	293	2.6
		131-F-0201F	4.0	4.1	1.7	-	0.3	65	7.6	293	2.6
	Unit 156 WWT Oily Sludge Incinerator	156-A-0209-F01	0.1	-	0.1	-	-	20	7.6	950	0.9
	Unit 214 Hydrocracker - 3 Heaters Combined [2]	214-F-0101/0102/0103	5.6	0.4	4.1	-	-	61	5.1	136	3.7
	Unit 116 DHT Reactor Feed Furnace	116-F-0101	2.0	0.1	1.2	-	-	61	8.2	177	1.6
	Unit 118 H2 Plant Tubular Reformer Furnace (Train 3)	118-F-0301	12.1	1.4	13.7	-	-	61	12.2	155	4.9
MAA	Unit 187 - Coke Handling	19 point sources	-	-	-	-	0.003122	Varied from 3-17	2	1.6	50
Emission Total			**182.4**	**112.1**	**118.4**	**0.5**	**7.2**	**N/A**	**N/A**	**N/A**	**N/A**

*Denotes Normal Temperature and Pressure Conditions (NTP: 0°C and 1.013 bara)

Note: The SRU releases for the maximum case (Unit 151/152 & Unit 123) are based on SRU emergency case 1 for SO_2 emissions.

Notes:

1. For the maximum operating case, the fired duty for the Unit 129 boilers (at MAA) is increased by 20% (from the normal operating case).
2. For the boilers at Unit 131 (at MAB Fired equipment has dual fuel capability. For contingency/maximum case it is assumed that equipment item is fired 85% on fuel gas and 15% on fuel oil. This ratio is intended to ensure compliance with applicable Kuwait EPA point source emission limits.
3. The emissions for Unit 111, Unit 127, Unit 214 (at MAB) and Unit 136 (at MAA) correspond to the combined emissions from two stacks.
4. For Unit 25/26 and Unit 11 which are existing revamped units, 20% of the emissions provided are modelled as part of the CFP as this is the incremental increase.

Table 9.10: Point Emission Sources and Emission Levels (Decommissioned Sources)

Refinery	Name	Unit (Tag No.)	NOx	SO2	CO	TSP	Height above gl (m)	Exit Velocity (m/s)	Exit Temp. (°C)	Exit Diameter (m)
			g/s	g/s	g/s	g/s				
SHU	Hydrogen manufacturing	H-02-01N	7.55	3.66	0.11	-	52.21	8.87	427	3.66
		H-02-01S	7.21	3.91	0	-	52.21	8.87	427	3.66
		H-02-51N	7.21	4.15	0	-	52.21	8.87	427	3.66
		H-02-51S	10.3	3.91	0	-	52.21	8.87	427	3.66
	Crude & Vacuum	H-06-01N	2.05	0.3	0	-	40.54	11.6	465	1.45
		H-06-01S	0.8	2.18	0	-	40.54	11.6	465	1.45
		H-06-02N	1.55	1.2	0.154	-	40.54	11.6	465	1.45
		H-06-02S	0.8	1.22	0	-	40.54	11.6	465	1.45
		H-06-03N	3.23	1.68	0	-	45.03	7.94	425	2.27
		H-06-03S	3.51	0.93	0	-	45.03	7.94	425	2.27
		H-06-04	1.62	0.06	0	-	26.09	9.3	525	1.71
	Hot Oil	H-07-01A	1.281	0.038	0	-	27.43	11	698	1.3
		H-07-02AN	1.53	0.131	0.114	-	28.96	10.3	652	1.75
		H-07-02AS	1.74	0.07	0.03	-	28.96	10.3	652	1.75
		H-07-01B	1.03	0.04	0.017	-	27.43	10.9	694	1.3
		H-07-02BN	1.06	0.061	0	-	28.96	9.6	593	1.75
		H-07-02BS	1.31	0.122	0	-	28.96	9.6	593	1.75
	Isomax	H-08-01	0.482	0.03	0	-	35.36	9.6	737	1.22
		H-08-02	5.02	0.265	0	-	40.39	10.8	654	2.44
	Naphtha Fractionation	H-09-01	4.48	0.942	0	-	40.39	11	688	2.44
	Kero Unifiner	H-11-02	2.08	0.05	0.044	-	32.92	9.27	567	1.62
		H-11-03	1.19	0.038	0.065	-	30.48	9.6	603	1.37
		H-11-04	2.57	0.07	0	-	33.83	12	733	1.68
		H-11-05	2.12	0.162	0	-	35.05	10	733	1.98
		H-11-06	1.02	0.036	0	-	31.39	9.29	558	1.37
	Diesel Unifiner	H-12-01	1.48	0.194	0.022	-	30.48	6	629	1.98

Refinery	Name	Unit (Tag No.)	NOx	SO2	CO	TSP	Height above gl (m)	Exit Velocity (m/s)	Exit Temp. (°C)	Exit Diameter (m)
			g/s	g/s	g/s	g/s				
		H-12-04	0.907	0.093	0	-	27.89	7.6	624	1.4
	Heavy Diesel Unifiner	H-13-01	1.35	0.156	0	-	30.48	12.7	624	1.22
		H-13-03	0.874	0.067	0	-	30.48	8.6	504	1.37
	Hot Oil Vacuum	H-63-01	0.381	37.84	5.2	-	66.45	5.84	233	1.75
	Isocracker	H-68-02W	0.94	0.0372	0.05	-	49.07	5.88	372	1.75
		H-68-02E	1.08	0.0372	0.065	-	49.07	5.88	372	1.75
	Hydrogen manufacturing	H-62-01aN	15.44	6.1	0	-	52.21	8.87	427	3.66
		H-62-01aS	17.73	4.88	0	-	52.21	8.87	427	3.66
	Boilers	B-20-01A	11.02	9.4	0	-	18.29	16.18	407.4	2.97
		B-20-01B	15.7	13.52	0	-	18.29	16.18	407.4	2.97
		B-20-01C	17.36	20.27	0	-	18.29	16.18	407.4	2.97
		B-20-01D	17.17	22.62	1.672	-	18.29	16.18	407.4	2.97
	Catalytic Reformer	H-05-01W	6.04	0	0	-	24.69	14.67	815.71	3.05
		H-05-01M	1.51	0	0	-	24.69	14.67	815.71	1.52
		H-05-01E	3.1	0.1002	0	-	24.69	14.67	815.71	1.83
	Naphtha Unifiner	H-10-01	1.53	0.1043	0	-	30.78	11	749.04	1.52
	Diesel Unifiner	H-12-02	1.43	0.2421	0	-	30.48	6	627	1.98
		H-12-03	0.914	0.1547	0	-	28.5	8	626.82	1.37
	Isocracker	H-68-01W	0.94	0.0372	0.05	-	33.83	5.52	468.48	1.52
		H-68-01E	1.08	0.0372	0.065	-	33.83	5.52	468.48	1.52
MAA	MAA-CDU # 3	H-03-070	2.922	0.142	0	-	62.48	7.42	261	3.05
MAB	MAB-Crude	H-01-101	1.012	0.611	0.0713	-	21	8.53	483	1.53
		H-01-102	0.993	0.652	1.59	-	21	8.53	483	1.53
		H-01-104	1.452	0.326	0.0713	-	21	8.53	483	1.53
		H-01-105	0.382	0.326	0.0713	-	21	8.53	483	1.53
		H-01-106	1.051	1.386	0.321	-	21	8.53	483	1.53
		H-01-107	1.146	0.652	0.1783	-	21	8.53	483	1.53

Refinery	Name	Unit (Tag No.)	NOx	SO2	CO	TSP	Height above gl (m)	Exit Velocity (m/s)	Exit Temp. (°C)	Exit Diameter (m)
			g/s	g/s	g/s	g/s				
		H-01-108	1.051	1.306	0.1605	-	21	8.53	483	1.53
		H-01-109	1.719	0.163	0	-	21	8.53	483	1.53
		H-01-110	1.528	0.937	0	-	21	8.53	483	1.53
	MAB-RCD Unibon	H-02-101A	0.264	0.01	0.009	-	20	0.95	511	2.29
		H-02-101B	0.259	0.01	0.0045	-	20	0.95	511	2.29
		H-02-102	0.317	0.01	0.0086	-	20	0.91	511	2.29
	MAB-Hydrogen Plant	H-03-101	1.377	0.132	0.2455	-	43.1	2.13	288	2.75
SHU	Unit 74 SHU	H-74-001	2.17	118	24.31	-	61	7.04*	270	1.4
		H-74-002	2.38	70.35	41.25	-	61	7.04*	270	1.4
MAA	Unit 99 MAA	ST-93-001	0	173.9	0	-	61	7.55*	270	1.7
	ESP on Unit 86	ST-86-301	0	0	0	19.1	73.15	9.07*	285	2.44
Emission Total			**210.7**	**510.1**	**75.9**	**19.1**	**N/A**	**N/A**	**N/A**	**N/A**

* Denotes Normal Temperature and Pressure Conditions (NTP: 0°C and 1.013 bara)

Table 9.11: Flare Emissions during Emergency

Refinery / Flare	Tag No.	Emergency Scenario/Governing Case	NOx	SO2	Height above ground (m)	Effective Height (m)	Exit Velocity (metres/sec)	Exit Temp. (°C)	Effective Exit Diameter (m)
			g/s	g/s					
MAA Unit 162	162-A-0101	Case 2	0.15	2061	108	118	40	1000	1.06
MAA Unit 167	167-A-0101	Case 2	-	8163	91	108	40	1000	2.04
MAA Unit 25/26	-	Case 2	-	420	144	269.2	40	1000	22.18
MAA Unit 39	ST-39-001	Case 1	-	522	67.1	108.7	40	1000	5.34
		Case 2	-	433	67.1	77.1	40	1000	0.85
		Case 4	-	1.25	67.1	110.3	40	1000	5.51
		Case 5	4.9	44	67.1	69.6	40	1000	0.22
MAB Unit 146	146-A-0101A	Case 2	-	28247	36.6	64.1	40	1000	3.84
MAB Unit 149 HP HC	149-A-0112A	Case 2	0.15	1237	61	69.3	40	1000	0.85
MAB Unit 149 LP HC	149-A-0102A	Case 2	1.4	1774	64	141.7	40	1000	11.74
MAB Unit 249	249-A-0101	Case 2	146	10293	77	162.7	40	1000	14.08
MAB Unit 314 HP HCR	314-A-0112A	Case 3	3.31	439	85	131.2	40	1000	6.37

Notes:

1. Each emergency flare case is modelled separately.
2. Each flare emergency case is modelled without taking into account the contribution from new or decommissioned sources, as their contribution will be negligible compared to the actual flare emission.
3. All flares have been modelled as single stacks.
4. The emergency flare scenario numbering and data are based on information provided by Fluor.
5. The CFP project scope includes the flare for MAB Unit 314 (LP HCR flare), but as it does not have any hydrogen sulphide in its feed it has not been considered for air quality purposes.

Table 9.12: Total Power Failure Flare Emissions

Refinery / Flare	Tag No.	Emergency Scenario/Governing Case	NOx	SO2	Height above ground (m)	Effective Height (m)	Exit Velocity (metres/sec)	Exit Temp. (°C)	Effective Exit Diameter (m)
			g/s	g/s					
MAA Unit 162	162-A-0101	Case 1 - TPF	5.63	985	108	216.2	40	1000	16.4
MAA Unit 167	167-A-0101	Case 1 – TPF	-	628	91	96.9	40	1000	0.89
MAA Unit 25/26	-	Case 1 – TPF	-	219	144	244.9	40	1000	16.57
MAA Unit 39	ST-39-001	Case 3 – TPF	-	523	67.1	108.7	40	1000	5.15
MAA Unit 62	ST-62-201N	Case 1 – TPF	2910	27074	110	140.2	40	1000	4.57
MAB Unit 146	146-A-0101A	Case 1 – TPF	-	2112	36.6	46	40	1000	1.64
MAB Unit 149 HP HC	149-A-0112A	Case 1 – TPF	25	20849	61	167.4	40	1000	18.63
MAB Unit 249	249-A-0101	Case 1 – TPF	4.9	412	77	110.7	40	1000	4.06
MAB Unit 314 HP HCR	314-A-0112A	Case 1 - TPF	-	14754	85	217.7	40	1000	23.41

Notes:
1. The Total Power Failure (TPF) scenario incorporates all the emergency flaring events from each refinery (i.e. all TPF cases are modelled together at both MAA and MAB).
2. The TPF case is modelled without taking into account the contribution from new or decommissioned sources, as their contribution will be negligible compared to the actual flare emission.
3. All flares have been modelled as single stacks, with the exception of MAA Unit 25/26, where two identical flare stacks have been assumed. Note that parameters indicated in the table are per stack.
4. The emergency flaring data are based on information provided by Fluor.
5. The CFP project scope includes the flare for MAB Unit 314 (LP HCR flare), but as it does not have any hydrogen sulphide in its feed it has not been considered for air quality purposes (for the Total Power Failure Case).

Table 9.13: SRU Emissions during Upset conditions

Upset Condition	Refinery	Name	Unit (Tag No.)	NOx g/s	SO2 g/s	H2S g/s	Height above gl (m)	Exit Velocity (m/s)	Exit Temp. (°C)	Exit Diameter (m)
Upset 1	MAA	Unit 151 MAA	151-A-0131	1.16	204.72	0.11	61	14*	270	1.4
(SRU Case 2)			152-A-0131	0.78	0.68	0.06	61	14*	270	1.4
	MAB	Unit 123 MAB	123-A-0131	2.36	461.7	0.25	61	15*	270	1.7
			123-A-0231	1.67	1.472	0.25	61	15*	270	1.7
			123-A-0331	1.67	1.472	0.25	61	15*	270	1.7
Upset 2	MAA	Unit 151 MAA	151-A-0131	0.03	80.56	86.39	61	14*	150**	1.4
(SRU Case 3)			152-A-0131	0.78	0.68	0.06	61	14*	150**	1.4
	MAB	Unit 123 MAB	123-A-0131	0.0	178.67	190.92	61	15*	150**	1.7
			123-A-0231	1.67	1.472	0.25	61	15*	150**	1.7
			123-A-0331	1.67	1.472	0.25	61	15*	150**	1.7

* Denotes Normal Temperature and Pressure Conditions (NTP: 0°C and 1.013 bara)

** Denotes for Case 3, temperature change from 270 °C to 150 °C due to shutdown of TGTU.

Note

1. The results for each SRU upset scenario are combined with the normal emission case scenario for the CFP sources, but not the decommissioned modelling scenario.
2. Data is based on Rev D data provided by Fluor.
3. Modelling scenarios assume that only one SCOT (Case 2) or one SCOT and one TGTU (Case 3) at either refinery is out of operation at any given point in time (i.e. for other units normal emission data have been used).

Table 9.14 –Maintenance/Shutdown Emissions Scenario at MAA

Maintenance Scenario	Refinery	Status	Name	Unit (Tag No.)	SO2 g/s
Maintenance 1	MAA CFP	Running	Unit 107	107-F-0101	1.2777
RMP Block Shutdown				107-F-0102	5.7222
	MAA CFP	Shutdown	Unit 144	144-F-0101	0.04
	MAA Existing	Shutdown	KD Unit	H-40-001	0.3801
	MAA Existing	Shutdown		H-43-001	0.0194
	MAA Existing	Shutdown	ARDS 1	41-H001	0.0210
	MAA Existing	Shutdown		41-H-002	0.0410
	MAA Existing	Shutdown		41-H-003	0.0175
	MAA Existing	Shutdown	ARDS2	42-H001	0.000
	MAA Existing	Shutdown		42-H001	0.0410
	MAA Existing	Shutdown	HP-1	H-48-001	0.0957
	MAA Existing	Shutdown	HP-2	H-49-001	0.0957
	MAA Existing	Shutdown	SR/TGT	ST-54-001	48
Maintenance 2	MAA CFP	Running	Unit 137	137-F-0101	3.3055
CFP Block Shutdown	MAA CFP	Shutdown	Unit 129	129-F-0201A	0.3
	MAA CFP	Shutdown		129-F-0201B	0.3
	MAA CFP	Shutdown		129-F-0201C	0.3
	MAA CFP	Shutdown	Unit 135	135F-0101	0.01
	MAA CFP	Shutdown	Unit 136	136-F-0201A/B/C	0.28
	MAA CFP	Shutdown	Unit 141	141-F-0201	0.13
	MAA CFP	Shutdown		141-F-0301	0.17
	MAA CFP	Shutdown	Unit 148	148-F-0301	0.03
	MAA CFP	Shutdown	Unit 151	151-F-0132	0.67
	MAA CFP	Shutdown	Unit 152	152-F-0132	0.67
	MAA CFP	Shutdown	Unit 183	183-F-0101	0.16

Note: The units with a shutdown status have been modelled as decommissioned units.

Table 9.15 - Comparison of Total Pollutant Emissions from New CFP Sources (Normal Case) against Decommissioned Sources

Case / Sources	Total Pollutant Emission (g/s)	
	NOx	SO2
New CFP Sources (Normal Case)	123.9	15.7
Decommissioned Sources	210.7	510.1
Total *Reduction* Post CFP (g/s)	86.8	494.4

Total emissions from decommissioned units are far greater than the overall emissions for the new CFP units, particularly for SO_2. These differences are primarily due to the decommissioned boilers, as well as improvements at Unit 99 TGTU (due to new pollution control SCOT Unit that will be commissioned to improve SO_2 emissions from existing MAA SRU).

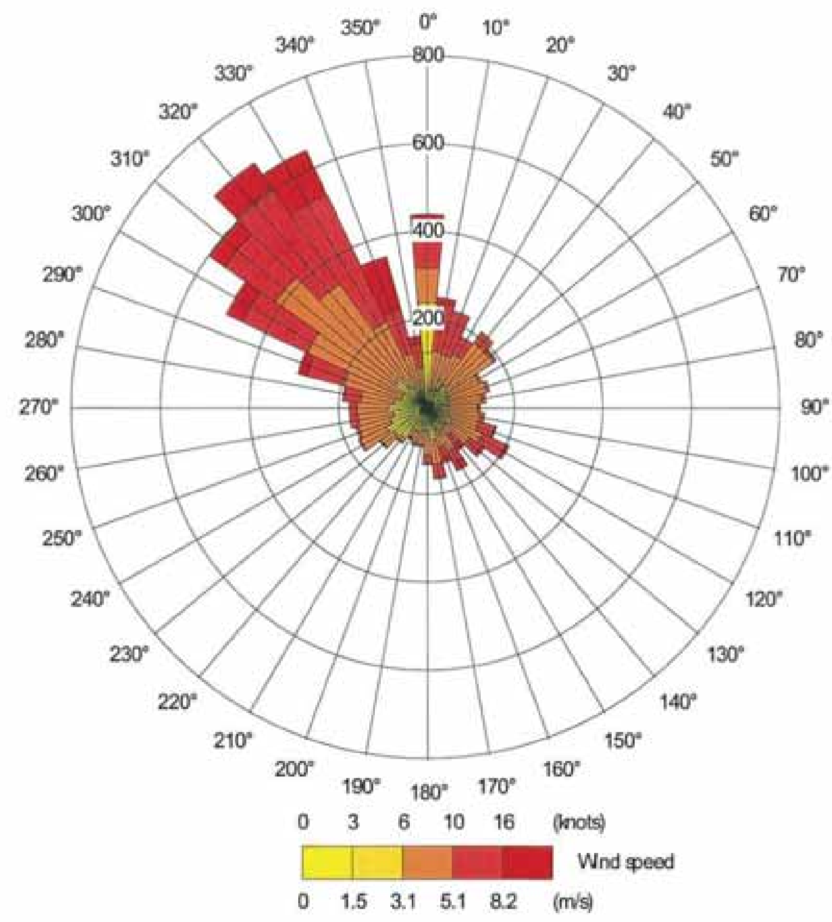
Overall, it is clear that air quality in the area should generally improve as a result of the CFP project.

9.4.4 Meteorological Data

Meteorological data provided by KISR/KNPC (as hourly sequential data), for a period of two years (2005 and 2006), from a measuring station located in the Umm Al Haiman area (south of the MAB refinery) has been used in the modelling. Sequential meteorological data from 2005 have been used to conduct the air modelling (more complete data-set than 2006).

These data were imported into ADMS 4 to produce the wind rose displayed in the figure below. The wind rose shows the predominant directions from which the wind blows. It can be seen that the wind typically blows from the North-West.

Figure 9.8: Wind Rose



9.4.5 K-EPA and Kuwait Ministry of Oil Criteria

The criteria used in the assessment are presented in Appendix C of the CFP Project EBS Report (DNV No. 32317425 / Fluor Doc. No. P6000CFP.000.10R.02), while Table 9.16 summarises the key parameters under investigation in this study, i.e. the long term and short term industrial and residential criteria for NO_2, SO_2, H_2S, CO and TSP. It is noted here that the results were compared against the most stringent criteria from the K-EPA and Ministry of Oil criteria.

Table 9.16: Maximum Permitted Ground Level Concentrations for Pollutants Based on K-EPA / MOO Criteria

Pollutant	Industrial ST (99.7%ile 1-hour average)	Industrial LT (Annual)	Residential ST (99.7%ile 1-hour average)	Residential LT (Annual)	On-Site Occ Exp Short Term[1]	On- site Occ Exp Long Term [1]
	µg/m³	µg/m³	µg/m³	µg/m³	ppm	ppm
NO_2	225	67	225	67	5** (9345)	-
SO_2	782.5	80	444	80	5* (13000)	2 *(5000)
H_2S	40	8	40	8	15* (20720)	10* (14000)
CO	34000	-	34000	-	-	-
TSP	317.5#	75	317.5#	75	-	-

1 Numbers in brackets are the equivalent µg/m³ concentrations.
* Occupational health levels are based on KNPC HSE Exposure standards for short term (15-minutes) and long term (8-hour) exposure (SHE-TSOH-04-4301).Limits are the identical to K-EPA Appendix No. 3(1).
** No limit is provided by KNPC HSE; hence the applicable short term exposure limit (15-minutes) from ACGIH (American Conference of Industrial Hygienists) has been used for the purposes of this study.
# The short term industrial and residential limits for the 1-hour average concentration averages have been converted from daily averaged concentrations.

9.4.6 Modelling Results

The primary objective for this part of the study is to examine the impact of the CFP Project on the air quality in the area. The sources that are to be decommissioned as part of the project will have a "negative" effect on the ambient air quality (i.e. air quality will improve), whereas the new units added will have a "positive" effect. The results of the "Decommissioned Emission" Scenario are combined with the "Normal Emission" / "Maximum Emission" Scenarios. The estimated, combined ADMS ground level concentrations for the various pollutants at the monitoring point locations are combined with the ambient baseline data concentrations (see Section 9.2.3), and then compared to the relevant criteria (refer to Table 9.16).

Details of the scenarios run, and the results of the "Decommissioned Emission", "Normal Emission" and "Maximum Emission" Scenarios are presented below.

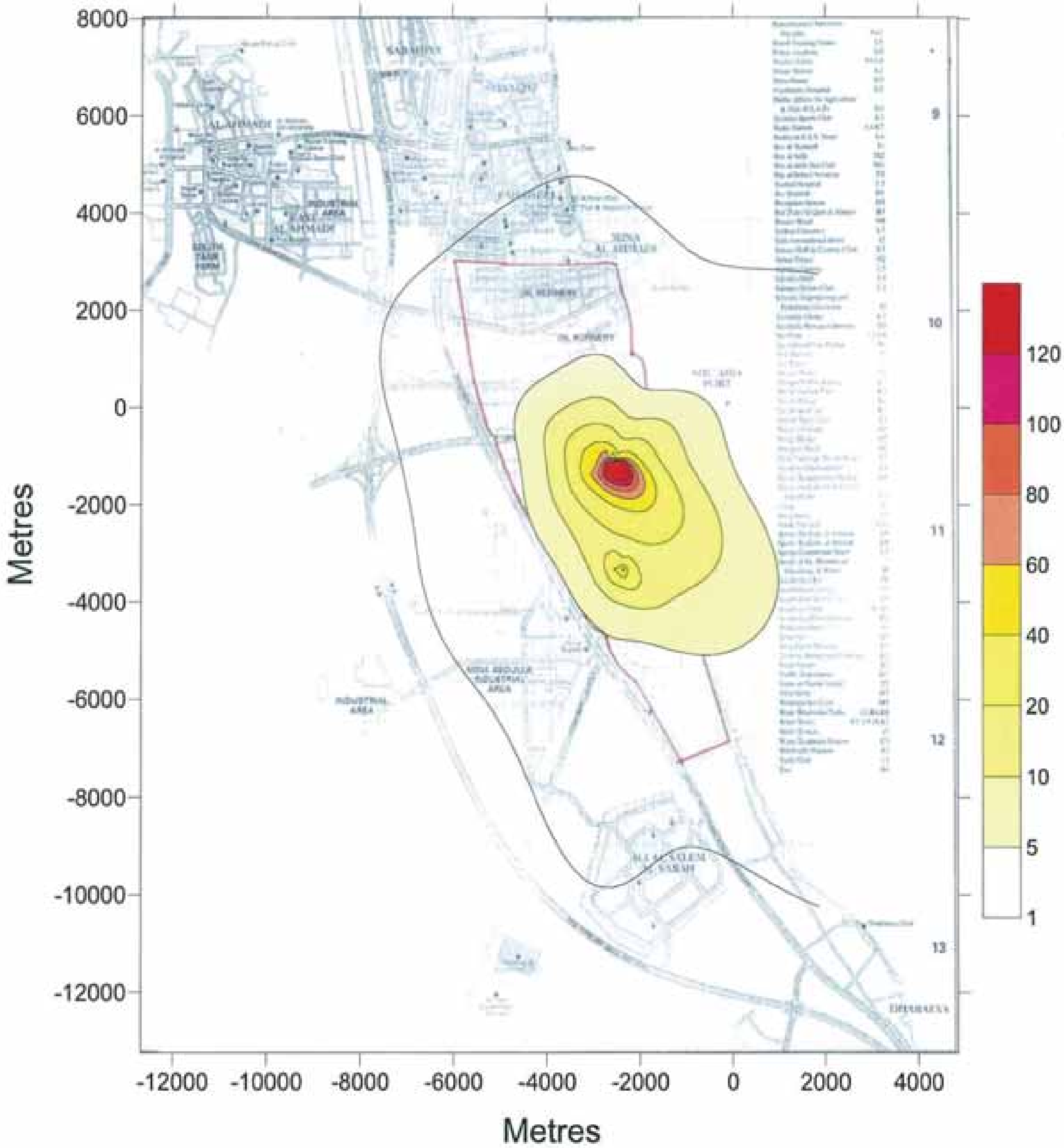
9.4.6.1 Combined "Normal Emission" + "Decommissioned Emission" Scenario

This will be the "Base Case" after the completion of the project, and reflects the overall project normal operating conditions for the refineries after the CFP is operating and SHU process units,along with other process units at MAA and MAB (refer to Table 9.5), are decommissioned. It has been modelled as follows:

- New "Normal Emission" model (sources from Table 9.8) combined with the "Decommissioned Emission" model (sources from Table 9.10) to produce the ground level concentration contours for the various pollutants
- The combined, predicted ADMS concentrations at the monitoring point locations are combined with the baseline air quality data, in order to obtain an estimated of the future air quality in the area, and then compared against the relevant K-EPA / MOO criteria.

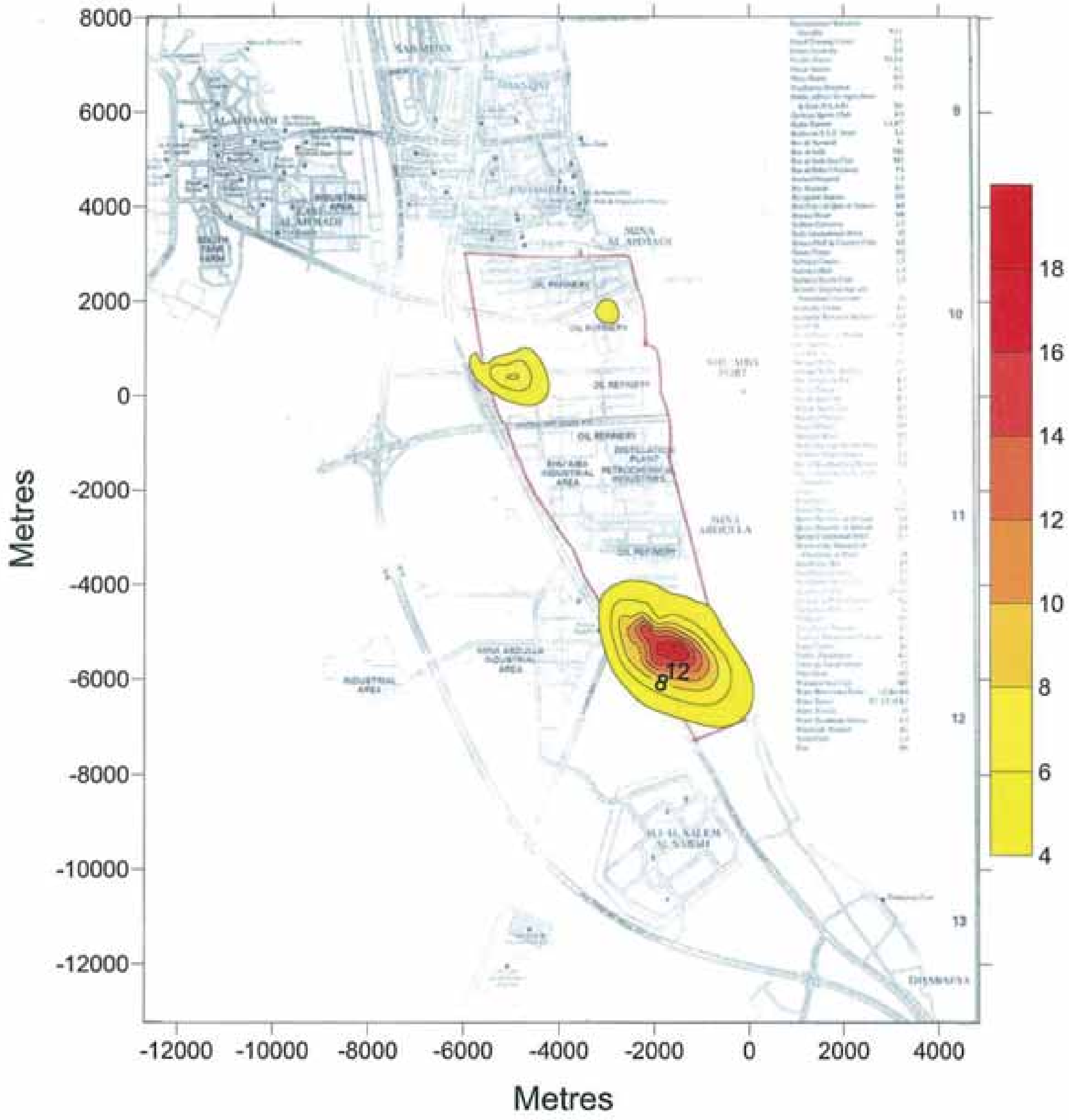
The long term (annual average) and short term (99.7%ile 1-hour average) results dispersion contours are presented in the figures that follow for NO_x, SO_2, H_2S and TSP. All results are presented in $\mu g/m^3$. The contour plots do not include the background concentration data. For the NO_x case, contours are presented for the "Decommissioned Emission" and "Normal Emission" Scenarios, as well as the combined plot. For the other pollutants only the combined plots are provided for simplicity. It is noted here that the NO_2 concentrations are assumed to correspond to 10% of the overall NO_x concentration.

Figure 9.9: NO_x Annual Average Data ("Decommissioned Case")



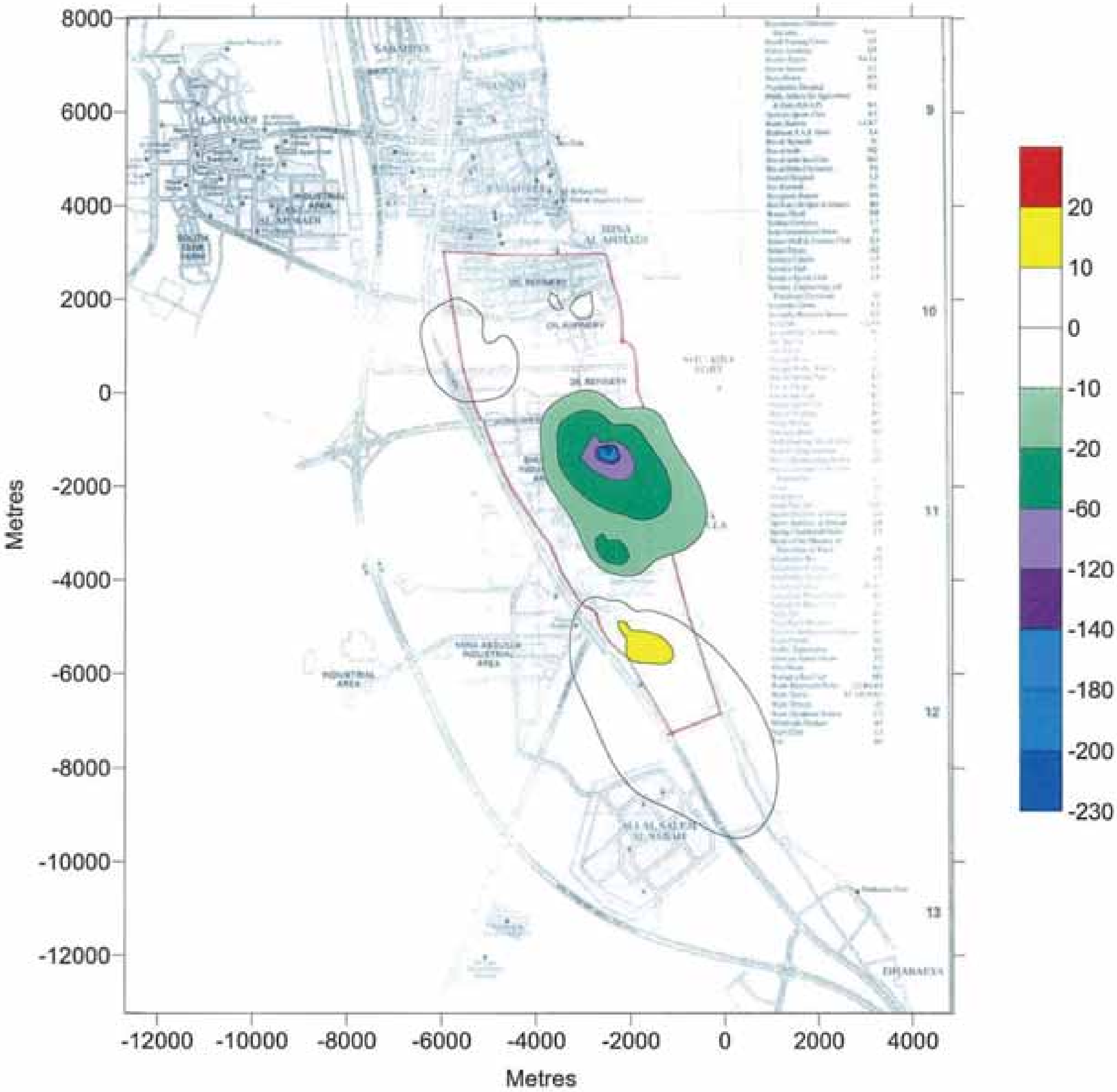
Note: The contours represent improvement in the air quality.
All results are presented in $\mu g/m^3$.

Figure 9.10: NO_x Annual Average Data ("New Normal Case")



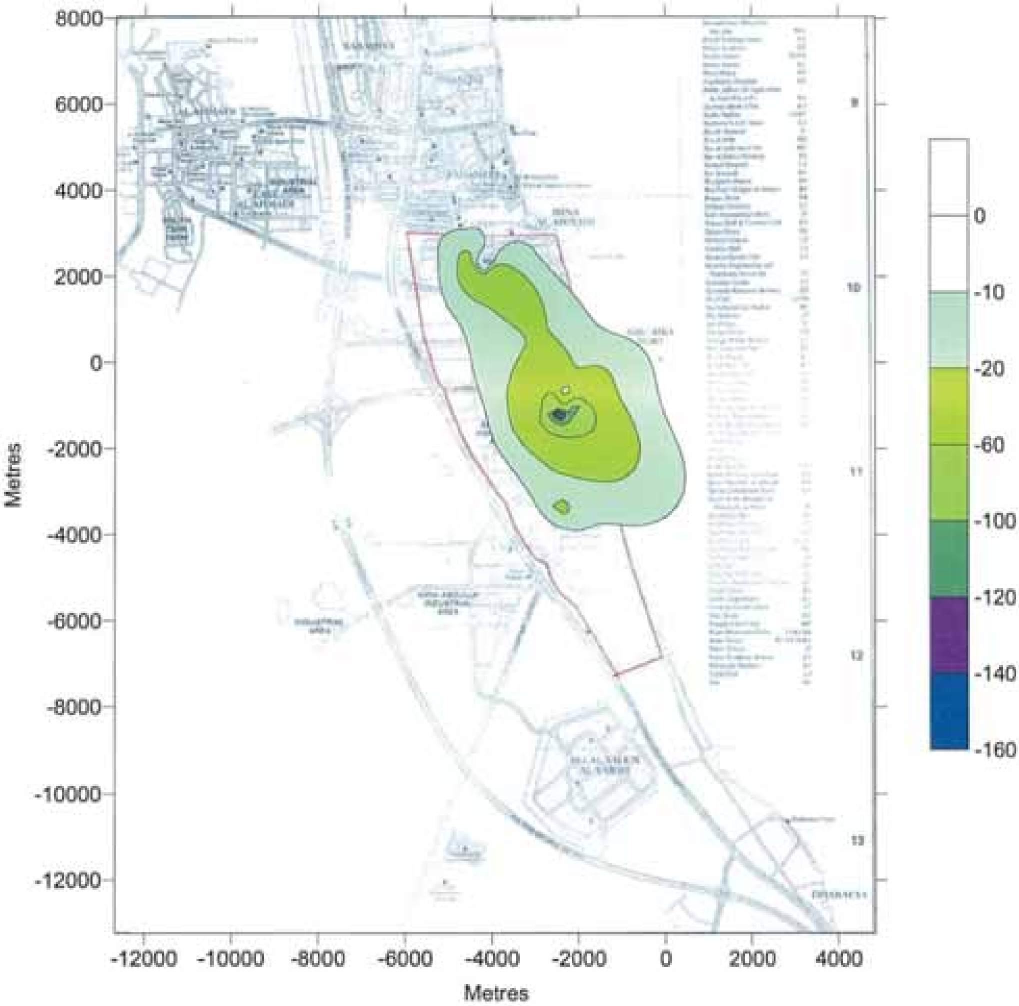
Note: The contours represent deterioration in the air quality.
All results are presented in $\mu g/m^3$.

Figure 9.11: NO_x Annual Average Data (Combined - "Base Case")



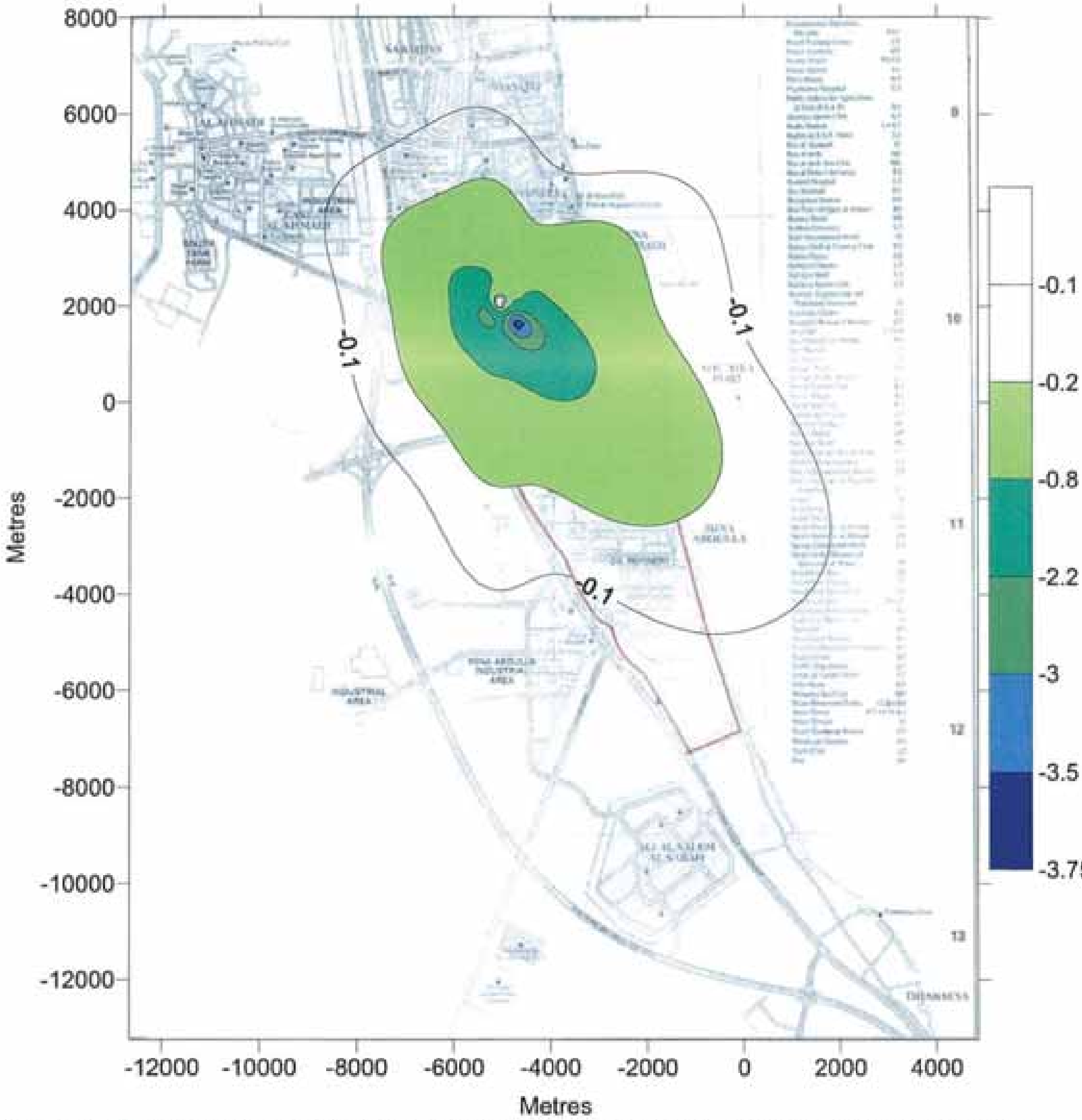
Note: The contours show both improvement and deterioration in the air quality.
All results are presented in µg/m^3.

Figure 9.12: SO_2 Annual Average Data (Combined - "Base Case")



Note: The contours show improvement in the air quality. All results are presented in µg/m^3.

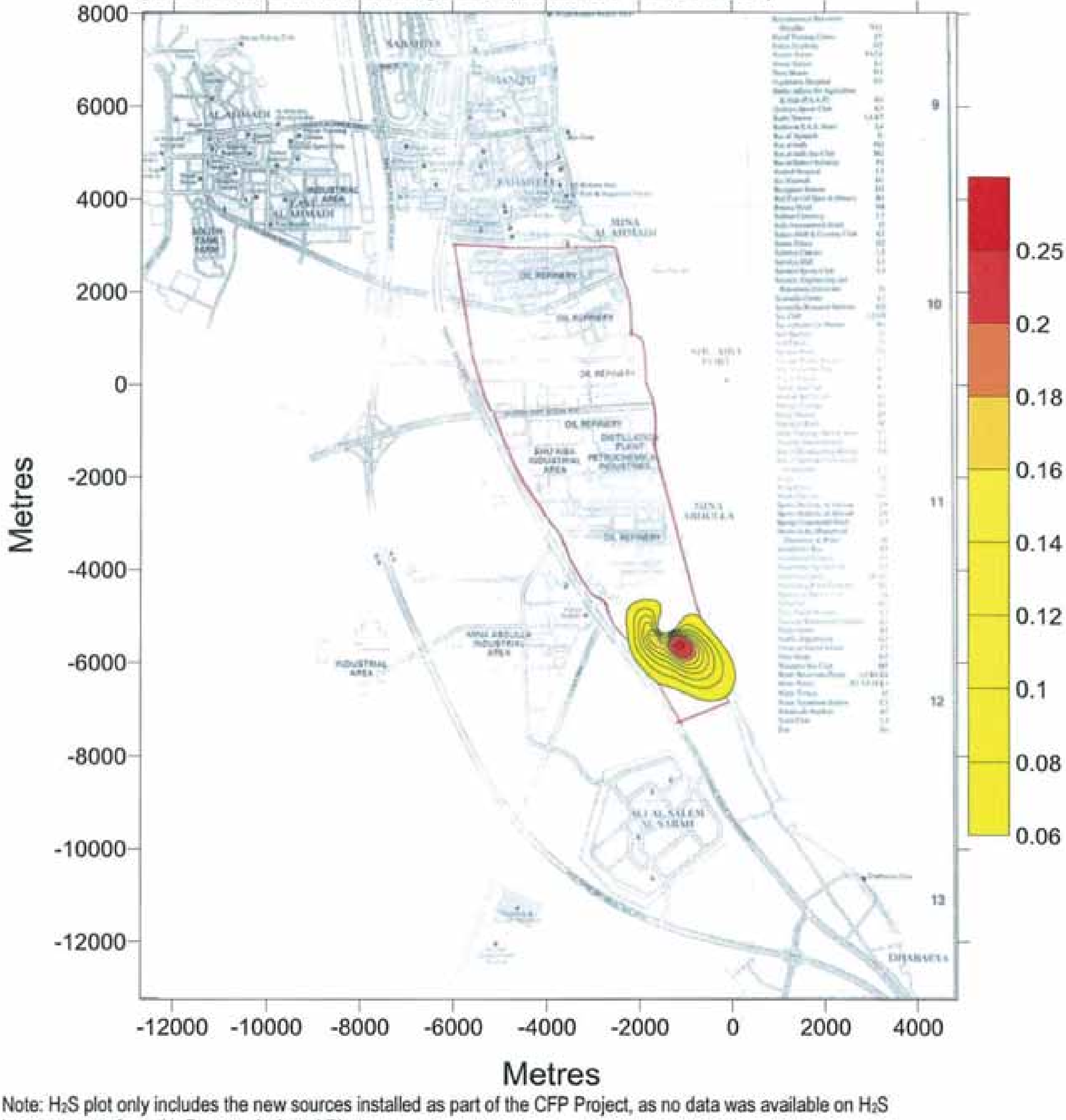
Figure 9.13: TSP Annual Average Data (Combined - "Base Case")



Note: Under normal operating conditions all fired CFP equipment will use gaseous fuel which is not a significant source of particulate emissions. The new coke handling facility at MAA (Unit 187) has the potential for significant particulate emissions but it will be tightly controlled, hence there will only be an overall improvement in the TSP levels which is reflected in the above figure, as the model also incorporates the installation of an ESP within the FCCU at MAA.

All results are presented in $\mu g/m^3$.

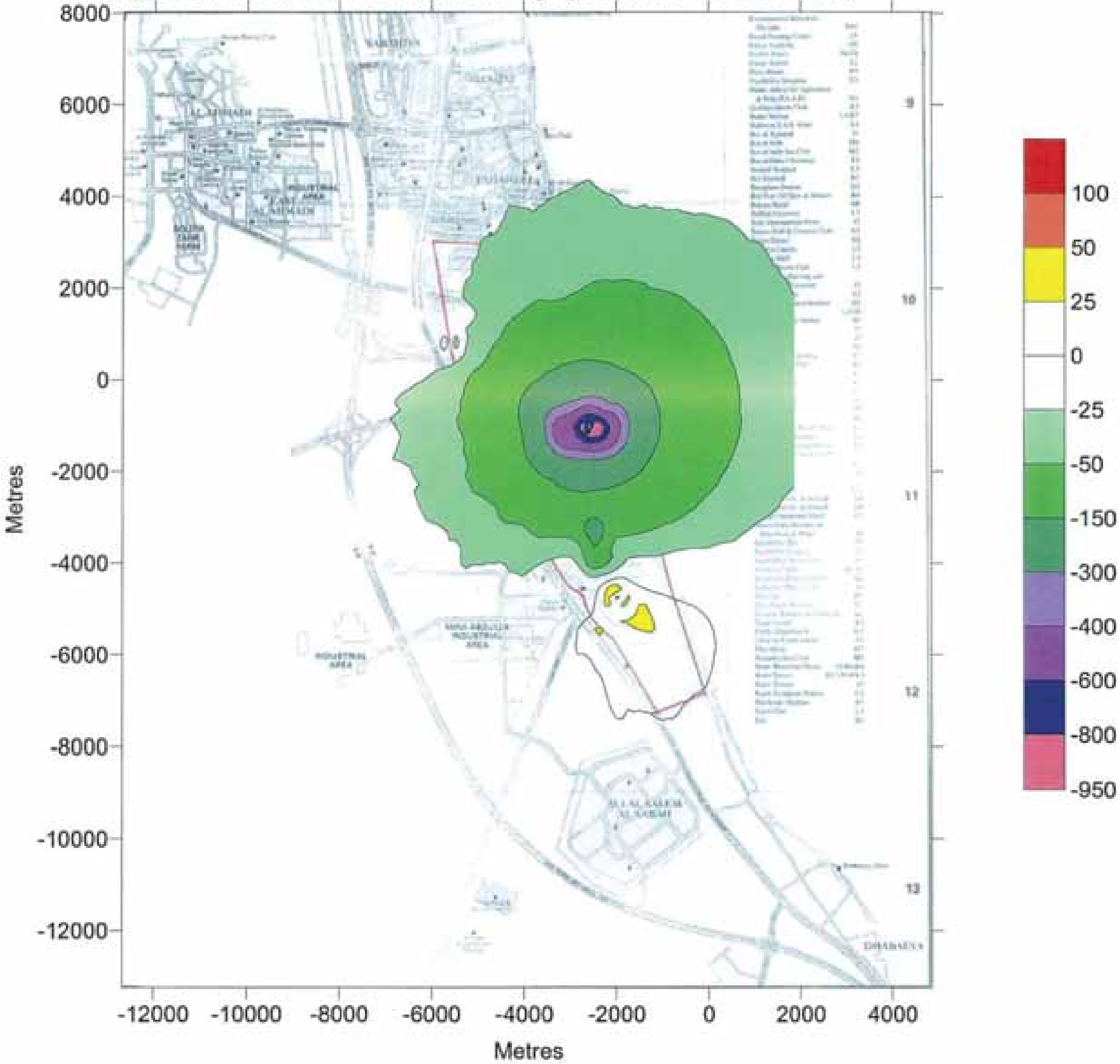
Figure 9.14: H_2S Annual Average Data (Combined - "Base Case")



Note: H_2S plot only includes the new sources installed as part of the CFP Project, as no data was available on H_2S improvements from the Decommissioned Plant.

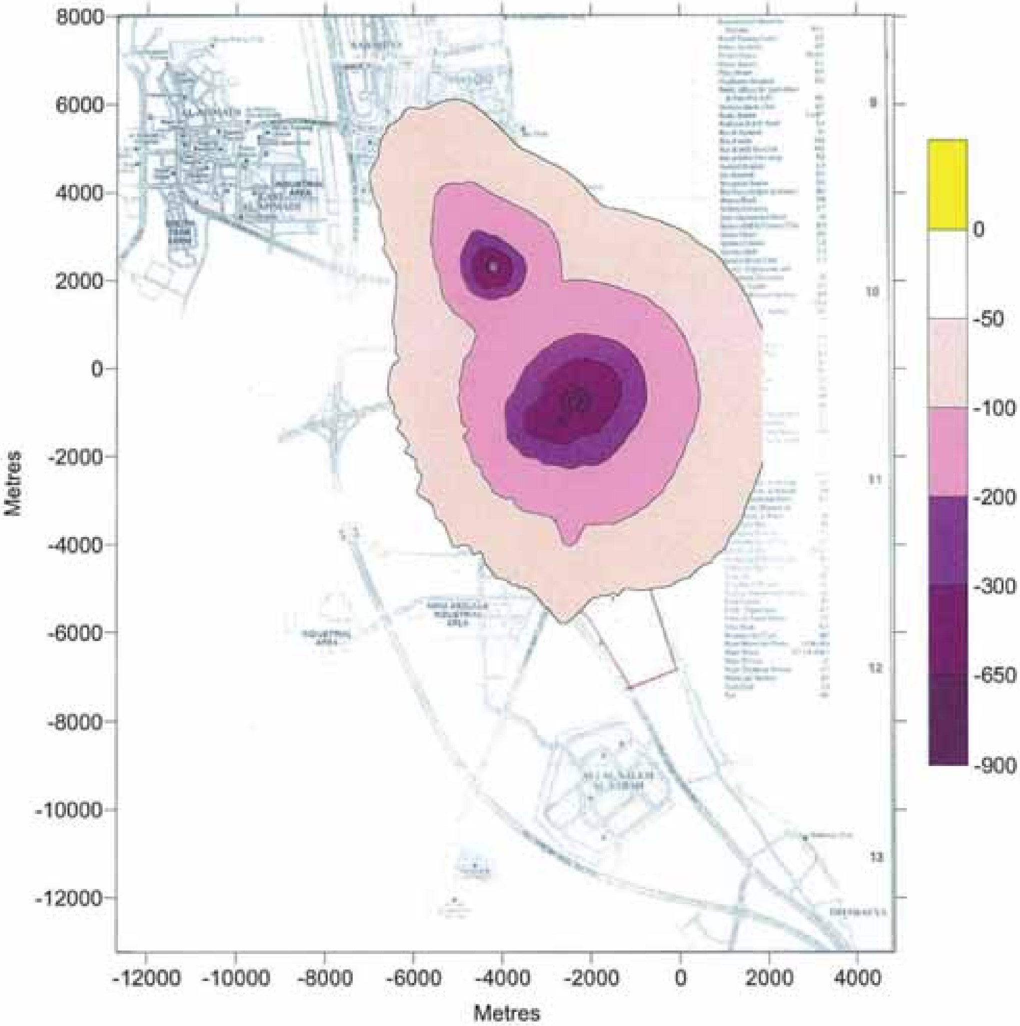
Note: The contours represent deterioration in the air quality. All results are presented in $\mu g/m^3$.

Figure 9.15: NO_x 99.7%ile 1-hour Average (Combined - "Base Case")



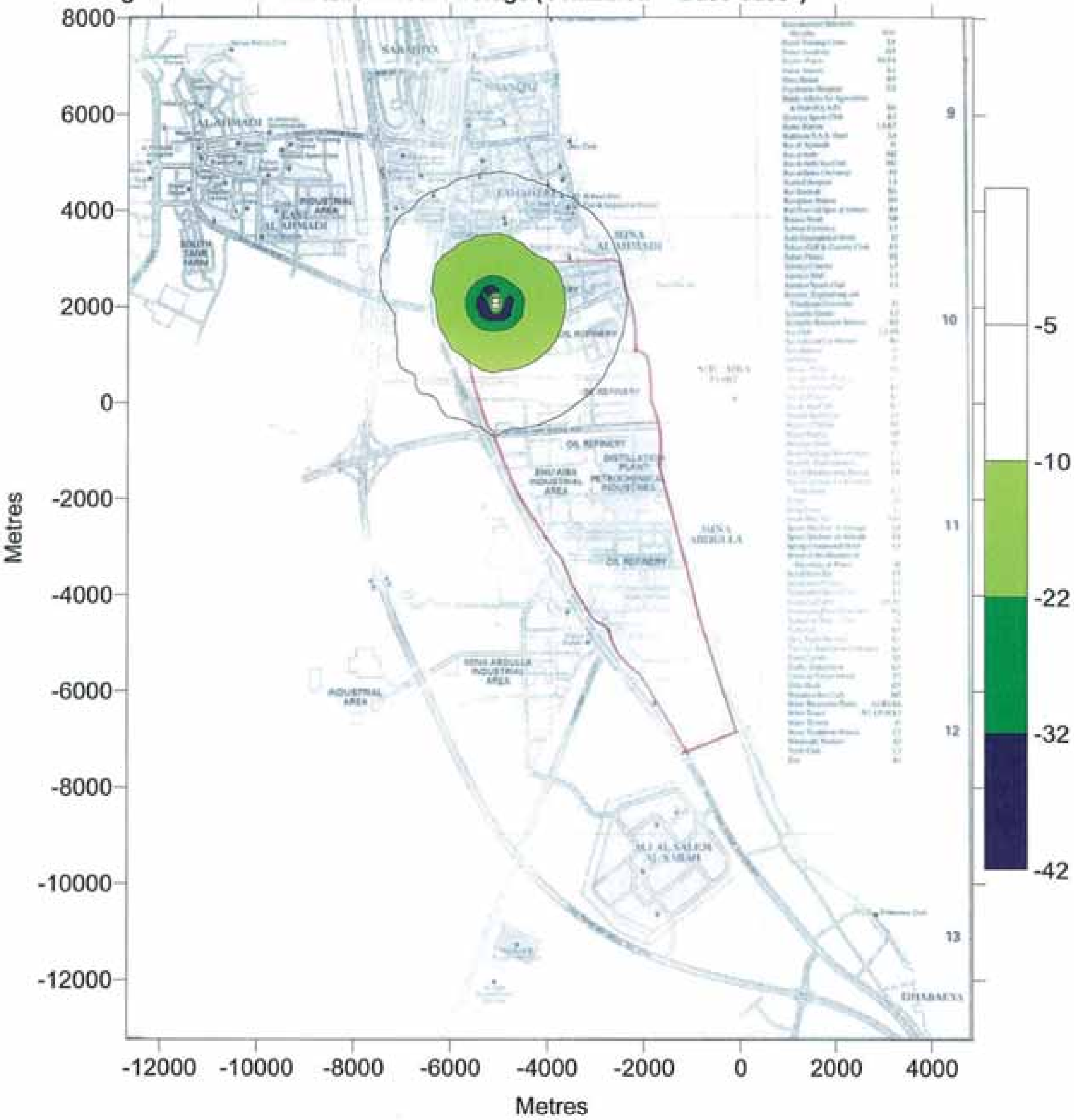
Note: The contours show both improvement and deterioration in the air quality.
All results are presented in $\mu g/m^3$.

Figure 9.16: SO_2 99.7%ile 1-hour Average (Combined - "Base Case")



Note: The contours show improvement in the air quality. All results are presented in $\mu g/m^3$.

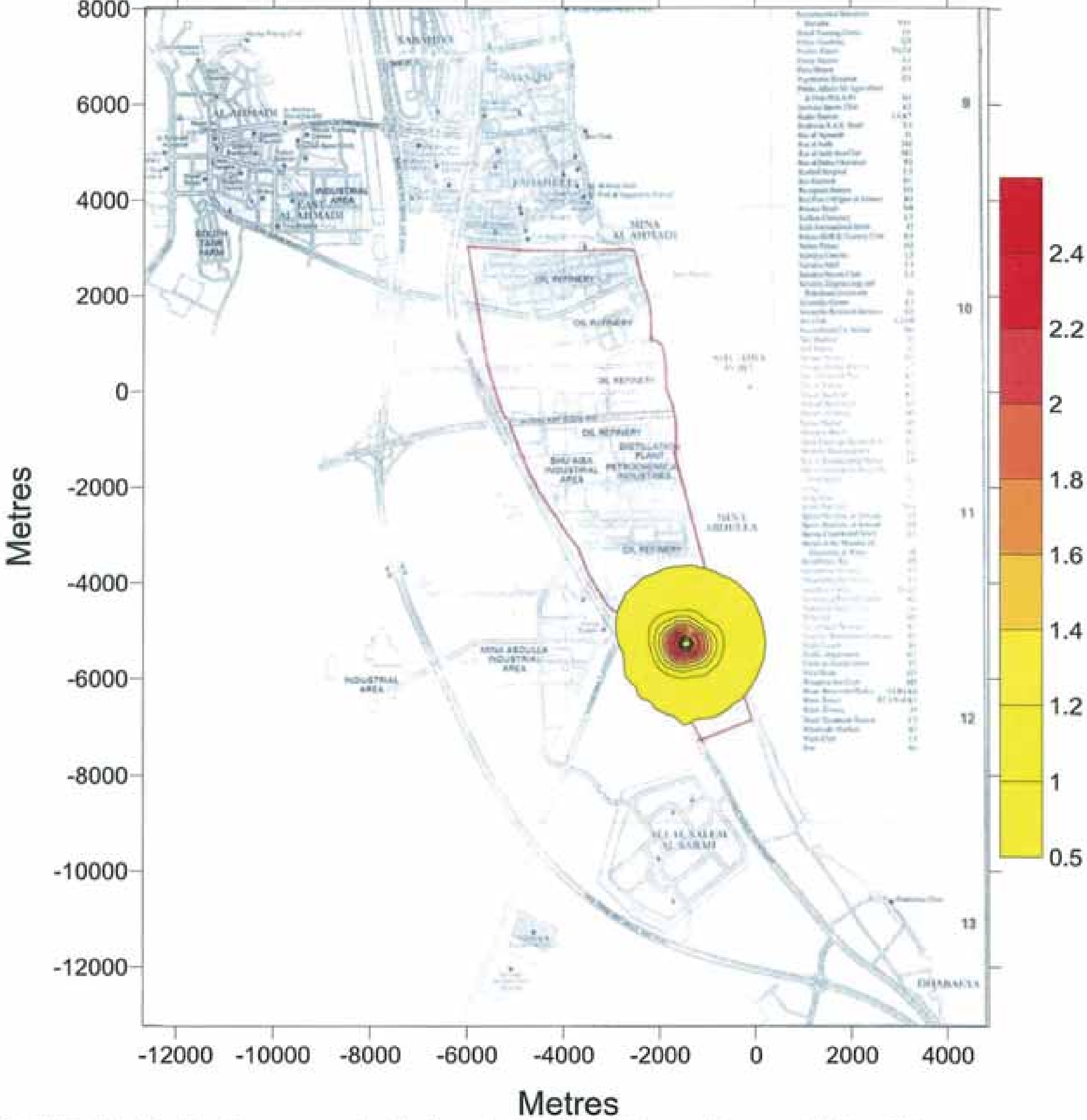
Figure 9.17: TSP 99.7%ile 1-hour Average (Combined - "Base Case")



Note: Under normal operating conditions all fired CFP equipment will use gaseous fuel which is not a significant source of particulate emissions. The new coke handling facility at MAA (Unit 187) has the potential for significant particulate emissions but it will be tightly controlled, hence there will only be an overall improvement in the TSP levels which is reflected in the above figure, as the model also incorporates the installation of an ESP at the FCCU unit at MAA.

All results are presented in μg/m³.

Figure 9.18: H_2S 99.7%ile 1-hour Average (Combined - "Base Case")



Note: H_2S plot only includes the new sources installed as part of the CFP Project, as no data was available on H_2S improvements from the Decommissioned Plant.

Note: The contours represent deterioration in the air quality. All results are presented in $\mu g/m^3$.

From the results presented in the above figures, it can be seen that air quality is significantly improved especially at SHU and areas in its immediate vicinity for all the pollutants considered. This excludes H_2S as no data were available for emissions from sources that are to be decommissioned.

As mentioned previously, the contour results presented do not include the background concentration data for the various monitoring point locations. In order to make a comprehensive comparison against the relevant criteria of the resulting air quality in the area after the CFP project has been completed, the predicted ADMS concentrations at these locations are combined with the background concentrations presented in Table 9.2. The resulting concentrations at each location are then compared against the K-EPA / MOO criteria, in order to identify the areas where exceedances are observed. Furthermore, the resulting concentrations were compared to the actual background data concentrations at each location in order to identify the overall impact of the CFP project on the air quality (i.e. whether the air quality has generally improved or not at these specific points).

Table 9.17 summarises the various pollutant concentrations at all the monitoring point locations. Note that the NO_2 concentrations correspond to 10% of the predicted ADMS NO_x concentrations.

Table 9.17: Pollutant Concentrations at Monitoring Points for "Base Case" Post-CFP, including existing Baseline Data.

Monitoring Point	Annual Average (μg/m³)					99.7%ile 1-hour average (μg/m³)				
	NO2	SO2	H2S	CO*	TSP	NO2	SO2	H2S	CO	TSP
A1	19.9	20.6	6.0	N/A	569.4	22.8	0.0	7.6	0.0	621.0
A2	13.0	32.8	5.0	N/A	278.6	17.0	0.0	6.4	0.0	294.0
A3	12.9	11.1	5.8	N/A	179.6	12.9	0.0	7.3	0.0	193.8
A4	15.1	11.2	5.7	N/A	604.8	16.4	0.0	7.2	0.0	669.2
A5	15.5	14.4	5.7	N/A	N/A	18.1	0.0	7.2	0.0	N/A
A6	21.2	27.5	5.7	N/A	289.4	25.0	0.0	7.2	0.0	311.6
A7	11.5	28.6	5.5	N/A	N/A	14.6	3.3	6.9	0.0	N/A
A8	14.7	80.4	8.4	N/A	214.3	9.7	0.0	10.6	0.0	233.2
A9	14.6	35.1	8.0	N/A	174.0	17.7	0.0	10.2	0.0	184.1
A10	16.5	19.5	4.4	N/A	N/A	19.6	0.0	5.5	0.0	N/A
A11	14.0	21.1	5.2	N/A	N/A	16.7	1.2	6.6	0.0	N/A
A12	19.5	19.8	5.8	N/A	N/A	23.4	0.0	7.3	0.0	N/A
A13	13.0	34.8	4.3	N/A	193.8	16.5	0.0	5.5	0.0	200.0
A14	15.1	16.0	9.8	N/A	1009.7	0.0	0.0	12.4	0.0	1118.5
A15	15.5	11.5	5.9	N/A	N/A	18.2	0.0	7.4	0.0	N/A
A16	14.8	14.9	6.9	N/A	389.6	17.6	0.0	8.7	0.0	427.7
A17	10.1	23.5	4.3	N/A	N/A	12.7	22.0	5.4	0.0	N/A
A18	8.5	20.3	5.7	N/A	N/A	10.8	11.9	7.2	0.0	N/A
A19	0.0	0.0	8.1	N/A	189.8	0.0	0.0	10.2	0.0	209.2
A20	16.1	35.4	6.9	N/A	164.5	18.9	0.0	8.8	0.0	177.0
A21	19.0	80.2	7.4	N/A	719.9	24.9	68.9	10.2	0.0	798.2
A22	10.4	30.7	6.1	N/A	N/A	10.9	0.0	7.7	0.0	N/A
A23	19.7	78.7	10.7	N/A	429.9	24.1	57.3	14.1	0.0	476.2
A24	20.5	78.9	7.0	N/A	329.9	26.9	76.4	9.9	0.0	365.4

Monitoring Point	Annual Average (μg/m³)					99.7%ile 1-hour average (μg/m³)				
	NO2	SO2	H2S	CO*	TSP	NO2	SO2	H2S	CO	TSP
A25	9.8	28.7	5.8	N/A	N/A	11.9	24.4	7.3	0.0	N/A
A26	11.7	41.2	7.4	N/A	N/A	14.8	36.4	9.6	0.0	N/A
A27	15.7	31.2	6.8	N/A	1102.9	22.9	16.8	9.0	0.0	1222.3
A28	10.2	22.5	0.0	N/A	N/A	13.0	23.7	0.0	0.0	N/A
A29	14.5	36.7	6.3	N/A	285.9	17.6	0.0	8.4	0.0	317.1
A30	17.0	66.2	6.6	N/A	459.9	22.0	63.7	8.8	0.0	509.8
A31	15.0	34.2	6.9	N/A	N/A	19.8	27.4	8.8	0.0	N/A
A32	10.5	30.6	7.2	N/A	N/A	11.8	10.4	9.1	0.0	N/A
A33	12.7	40.4	8.0	N/A	214.9	16.8	22.5	10.7	0.0	238.1
A34	5.8	9.2	14.5	N/A	N/A	5.8	0.0	18.2	0.0	N/A
A35	10.6	27.7	8.7	N/A	N/A	13.8	19.1	11.1	0.0	N/A
A36	9.9	33.7	6.7	N/A	N/A	10.9	15.3	8.4	0.0	N/A
A37	15.4	44.7	9.9	N/A	699.7	0.0	0.0	12.5	0.0	774.7
A38	13.1	85.0	9.6	N/A	204.8	0.0	0.0	12.1	0.0	226.5
A39	16.7	37.4	7.3	N/A	719.9	17.7	0.0	9.3	0.0	798.7
A40	15.6	33.1	6.7	N/A	N/A	14.2	0.0	8.5	0.0	N/A
A41	9.9	33.2	6.6	N/A	994.8	7.9	0.0	8.3	0.0	1101.7
A42	13.1	36.3	6.1	N/A	219.7	6.8	0.0	7.7	0.0	242.0
A43	11.5	28.2	7.6	N/A	N/A	1.0	0.0	9.6	0.0	N/A
A44	16.0	35.3	7.5	N/A	N/A	18.4	15.7	9.4	0.0	N/A
A45	6.5	24.4	4.8	N/A	N/A	6.5	2.0	6.0	0.0	N/A
KNPC C	144.1	0.0	16.0	N/A	1046.1	219.6	0.0	132.9	5656.6	3555.0
KNPC D	41.4	25.3	24.7	N/A	316.6	23.1	0.0	57.4	0	1385.3
KNPC F	69.0	12.9	5.4	N/A	525.8	181.6	82.7	29.5	2933.6	2011.0
KNPC H	53.5	27.1	3.7	N/A	201.4	94.2	38.0	13.5	0	589.2

Notes:

1. CO concentrations do not include background data (only for KNPC C and F).
2. A concentration of 0 indicates that the predicted cumulative concentration is negative.

* Long term (i.e. annual) concentrations are not applicable for CO.

The above predicted concentrations at each monitoring point, after the completion of the CFP project, were compared against the applicable criteria. Table 9.18, illustrates the ratios of the predicted concentration (including existing baseline) against the relevant criterion, with exceedances highlighted in red font. Furthermore, for the monitoring points where exceedances are observed, the way the pollutant concentration has changed, compared to the background data information, after completion of the CFP is also indicated ("✓" indicates improvement in air quality, "×" deterioration in air quality, and "-" no change in air quality).

Finally, in order to summarise the overall contribution of the CFP project, the background concentrations at each monitoring point (see Table 9.2) were compared to the predicted concentrations after the CFP completion (the "Base Case"). Table 9.19 summarises the changes in the various pollutant concentrations at each monitoring point.

Table 9.18: Exceedances of Criteria for Ambient Air Quality for "Base Case" Post-CFP, including existing Baseline Data.

Averaging Period	Annual					99.7%ile 1-hour Average					99.7%ile 1-hour Average
	Ratio against Residential & Industrial Criteria (only Residential for SO2)										Ratio against Industrial Criteria
Monitoring Location	NO2	SO2	H2S#	CO*	TSP	NO2	SO2	H2S#	CO	TSP	SO2
A1	0.3	0.3	0.8	-	[illegible]	0.1	0.0	0.2	0.0	[illegible]	0.0
A2	0.2	0.4	0.6	-	3.7 (✓)	0.1	0.0	0.2	0.0	0.9	0.0
A3	0.2	0.1	0.7	-	[illegible]	0.1	0.0	0.2	0.0	0.6	0.0
A4	0.2	0.1	0.7	-	N/A	0.1	0.0	0.2	0.0	N/A	0.0
A5	0.2	0.2	0.7	-	N/A	0.1	0.0	0.2	0.0	N/A	0.0
A6	0.3	0.3	0.7	-	[illegible]	0.1	0.0	0.2	0.0	[illegible]	0.0
A7	0.2	0.4	0.7	-	N/A	0.1	0.0	0.2	0.0	N/A	0.0
A8	0.2	1.0 (✓)	1.2	-	[illegible]	0.0	0.0	0.3	0.0	0.7	0.0
A9	0.2	0.4	1.0	-	[illegible]	0.1	0.0	0.3	0.0	0.6	0.0
A10	0.2	0.2	0.6	-	N/A	0.1	0.0	0.1	0.0	N/A	0.0
A11	0.2	0.3	0.7	-	N/A	0.1	0.0	0.2	0.0	N/A	0.0
A12	0.3	0.2	0.7	-	N/A	0.1	0.0	0.2	0.0	N/A	0.0
A13	0.2	0.4	0.5	-	2.8 (✓)	0.1	0.0	0.1	0.0	0.6	0.0
A14	0.2	0.2	1.2	-	[illegible]	0.0	0.0	0.3	0.0	[illegible]	0.1
A15	0.2	0.1	0.7	-	N/A	0.1	0.0	0.2	0.0	N/A	0.0
A16	0.2	0.2	0.9	-	4.2 (✓)	0.1	0.0	0.2	0.0	[illegible]	0.1
A17	0.2	0.3	0.5	-	N/A	0.1	0.0	0.1	0.0	N/A	0.1
A18	0.1	0.3	0.7	-	N/A	0.0	0.0	0.2	0.0	N/A	0.0
A19	0.0	.0.0	1.0	-	2.5 (✓)	0.0	0.0	0.3	0.0	0.7	0.0
A20	0.2	0.4	0.9	-	3.2 (✓)	0.1	0.0	0.2	0.0	0.6	0.0
A21	0.3	1.0 (✓)	0.9	-	[illegible]	0.1	0.2	0.3	0.0	[illegible]	0.0
A22	0.2	0.4	0.8	-	N/A	0.0	0.0	0.2	0.0	N/A	0.0
A23	0.3	[illegible]	[illegible]	-	[illegible]	0.1	0.1	0.4	0.0	[illegible]	0.0
A24	0.3	[illegible]	0.9	-	[illegible]	0.1	0.2	0.2	0.0	[illegible]	0.1
A25	0.1	0.4	0.7	-	N/A	0.1	0.1	0.2	0.0	N/A	0.0
A26	0.2	0.5	0.9	-	N/A	0.1	0.1	0.2	0.0	N/A	0.0
A27	0.2	0.4	0.9	-	14.7 (✓)	0.1	0.0	0.2	0.0	[illegible]	0.0
A28	0.2	0.3	0.0	-	N/A	0.1	0.1	0.0	0.0	N/A	0.0
A29	0.2	0.5	0.8	-	3.8 (✓)	0.1	0.0	0.2	0.0	[illegible]	0.0
A30	0.3	0.8	0.8	-	6.1 (✓)	0.1	0.1	0.2	0.0	1.6 (✓)	0.0
A31	0.2	0.4	0.9	-	N/A	0.1	0.1	0.2	0.0	N/A	0.0
A32	0.2	0.4	0.9	-	N/A	0.1	0.0	0.2	0.0	N/A	0.0
A33	0.2	0.5	1.0	-	[illegible]	0.1	0.1	0.3	0.0	0.8	0.0
A34	0.1	0.1	1.6	-	N/A	0.0	0.0	0.5	0.0	N/A	0.0
A35	0.2	0.3	1.1	-	N/A	0.1	0.0	0.3	0.0	N/A	0.0
A36	0.1	0.4	0.8	-	N/A	0.0	0.0	0.2	0.0	N/A	0.0
A37	0.2	0.6	1.2	-	[illegible]	0.0	0.0	0.3	0.0	[illegible]	0.0
A38	0.2	[illegible]	1.2	-	[illegible]	0.0	0.0	0.3	0.0	0.7	0.0

Averaging Period	Annual					99.7%ile 1-hour Average					99.7%ile 1-hour Average
	Ratio against Residential & Industrial Criteria (only Residential for SO2)										Ratio against Industrial Criteria
Monitoring Location	NO2	SO2	H2S#	CO*	TSP	NO2	SO2	H2S#	CO	TSP	SO2
A39	0.2	0.5	0.9	-	8.8 (✓)	0.1	0.0	0.2	0.0	2.5 (✓)	0.0
A40	0.2	0.4	0.8	-	6.1 (✓)	0.1	0.0	0.2	0.0	2.1 (✓)	0.0
A41	0.1	0.4	0.8	-	N/A	0.0	0.0	0.2	0.0	N/A	0.0
A42	0.2	0.5	0.8	-	13.3 (✓)	0.0	0.0	0.2	0.0	2.5 (✓)	0.0
A43	0.2	0.4	1.6	-	3.9 (✓)	0.0	0.0	0.2	0.0	0.8	0.0
A44	0.2	0.4	0.9	-	N/A	0.1	0.0	0.2	0.0	N/A	0.0
A45	0.1	0.3	0.6	-	N/A	0.0	0.0	0.2	0.0	N/A	0.0
KNPC C	2.0 (✓)	0.0	2.6	-	10.9 (✓)	1.9 (✓)	0.0	3.3	0.2	11.2 (✓)	0.0
KNPC D	0.6	0.3	5.1	-	8.2 (✓)	0.1	0.0	3.8	0.0	4.4 (✓)	0.0
KNPC F	1.0 (✓)	0.2	0.7	-	7.5 (✓)	0.8	0.2	0.7	0.1	3.3 (✓)	0.1
KNPC H	0.8	0.3	0.5	-	2.7 (✓)	0.4	0.1	0.3	0.0	1.9 (✓)	0.0

Note: All negative ratios have been rounded to 0.
Key: Red highlighted cells indicate exceedance against K-EPA / MOO criteria.
✓: Pollutant Concentration reduced after CFP Project Completion.
×: Pollutant Concentration increased after CFP Project Completion.
-: Pollutant Concentration not changed after CFP Project Completion.
N/A: Not Applicable
* Long term (i.e. annual) concentrations are not applicable for CO.
# No hydrogen sulphide emission data were available for decommissioned units, hence determination whether resulting H2S concentrations have got worse or better cannot be made.

Table 9.19: Changes in Monitoring Point Concentrations ("Base Case") Post-CFP, including existing Baseline Data.

Monitoring Point	Annual Average Concentrations					99.7%ile 1-hour average Concentrations				
	NO2	SO2	H2S	CO	TSP	NO2	SO2	H2S	CO	TSP
A1	✓	✓	-	-	✓	✓	✓	×	N/A	✓
A2	×	✓	-	-	✓	×	✓	×	N/A	✓
A3	✓	✓	-	-	✓	✓	✓	-	N/A	✓
A4	✓	✓	×	-	N/A	✓	✓	×	N/A	×
A5	✓	✓	-	-	N/A	✓	✓	×	N/A	×
A6	✓	✓	-	-	✓	✓	✓	×	N/A	✓
A7	✓	✓	-	-	N/A	×	✓	×	N/A	N/A
A8	✓	✓	-	-	✓	✓	✓	×	N/A	✓
A9	×	✓	-	-	✓	✓	✓	×	N/A	✓
A10	✓	✓	-	-	N/A	✓	✓	×	N/A	N/A
A11	✓	✓	-	-	N/A	✓	✓	×	N/A	N/A
A12	✓	✓	-	-	N/A	✓	✓	-	N/A	N/A
A13	×	✓	-	-	✓	×	✓	×	N/A	✓
A14	✓	✓	-	-	✓	✓	✓	×	N/A	✓
A15	✓	✓	-	-	N/A	✓	✓	×	N/A	N/A

Monitoring Point	Annual Average Concentrations					99.7%ile 1-hour average Concentrations				
	NO2	SO2	H2S	CO	TSP	NO2	SO2	H2S	CO	TSP
A16	✓	✓	-	-	✓	✓	✓	×	N/A	✓
A17	✓	✓	-	-	N/A	×	✓	×	N/A	N/A
A18	✓	✓	-	-	N/A	×	✓	×	N/A	N/A
A19	✓	✓	-	-	✓	✓	✓	×	N/A	✓
A20	×	✓	-	-	✓	✓	✓	×	N/A	✓
A21	×	✓	-	-	✓	×	✓	×	N/A	✓
A22	✓	✓	-	-	N/A	✓	✓	×	N/A	N/A
A23	✓	✓	-	-	✓	✓	✓	×	N/A	✓
A24	×	✓	×	-	✓	×	✓	×	N/A	✓
A25	✓	✓	-	-	N/A	✓	✓	×	N/A	N/A
A26	×	✓	-	-	N/A	×	✓	×	N/A	N/A
A27	×	✓	-	-	✓	×	✓	×	N/A	✓
A28	✓	✓	-	-	N/A	×	✓	×	N/A	N/A
A29	×	✓	-	-	✓	✓	✓	×	N/A	✓
A30	×	✓	×	-	✓	×	✓	×	N/A	✓
A31	✓	✓	×	-	N/A	×	✓	×	N/A	N/A
A32	✓	✓	-	-	N/A	✓	✓	×	N/A	N/A
A33	×	✓	-	-	✓	×	✓	×	N/A	✓
A34	✓	✓	×	-	N/A	✓	✓	×	N/A	N/A
A35	×	✓	×	-	N/A	×	✓	×	N/A	N/A
A36	✓	✓	×	-	N/A	✓	✓	×	N/A	N/A
A37	✓	✓	×	-	✓	✓	✓	×	N/A	✓
A38	✓	✓	×	-	✓	✓	✓	×	N/A	✓
A39	✓	✓	×	-	✓	✓	✓	×	N/A	✓
A40	✓	✓	×	-	N/A	✓	✓	×	N/A	N/A
A41	✓	✓	×	-	N/A	✓	✓	×	N/A	N/A
A42	✓	✓	×	-	✓	✓	✓	×	N/A	✓
A43	✓	✓	×	-	N/A	✓	✓	×	N/A	N/A
A44	✓	✓	×	-	N/A	✓	✓	×	N/A	N/A
A45	✓	✓	×	-	N/A	✓	✓	×	N/A	N/A
KNPC C	✓	✓	×	-	✓	✓	✓	×	✓	✓
KNPC D	✓	✓	×	-	✓	✓	✓	×	N/A	✓
KNPC F	✓	✓	-	-	✓	✓	✓	×	✓	✓
KNPC H	×	✓	-	-	✓	×	✓	×	N/A	✓

Key:

✓	Concentration reduced after CFP Project Completion
×	Concentration increased after CFP Project Completion
-	Concentration not changed after CFP Project Completion
N/A	Not Applicable

As shown in Table 9.18, there remains a number of exceedances of criteria for various pollutants, after the completion of the CFP project (for normal operating conditions). It is noted here that for the case of H_2S, a direct conclusion cannot be drawn, as for the purposes of modelling no information was available for H_2S emissions from the decommissioned sources. Only H_2S emissions related to the new sources were included in the model and as seen from their resulting dispersion contours (see Figure 9.14 and Figure 9.18) the overall effect to resulting air quality is insignificant (< 0.5 $\mu g/m^3$ deterioration for short term concentrations outside the site boundary).

There is an improvement to the TSP concentrations at all locations, despite the large number of exceedances at most monitoring points. Despite the large improvement in particulate emissions because of the installation of the electrostatic precipitator on Unit 86 of MAA, the improvement on ground level concentrations is relatively small because of the large height of the installation (> 70 m).

There are a few exceedances for both short and long term NO_2 and SO_2 concentrations at various monitoring points, but an overall improvement of these is observed, compared to the existing baseline concentrations. The most serious case of exceedance for the aforementioned pollutants is observed at monitoring points KNPC C, at SHU Refinery. It can be argued that the location of this point can be considered onsite, rather than at the site boundary, given its proximity to the main CFP Block.

As indicated in Table 9.19, in the vast majority of cases the CFP project results in an overall reduction to both the long and short term concentrations of NO_2, SO_2 and TSP at the various monitoring points considered in this study. Some long and short term NO_2 concentrations are slightly increased after the completion of the CFP (e.g. at monitoring locations A2, A9, A13,A20,A21,A35,KNPC H etc), but all of these comply with the applicable K-EPA / MOO criteria.

As mentioned previously, a meaningful conclusion with regards to H_2S concentrations can not be made, as only details of new emissions have been made available at this stage for this pollutant. No information on decommissioned H_2S emissions was included in the air modelling conducted. Based on the results, only small increases in the long and short term concentrations of H_2S have been observed. The few observed exceedances are mainly due to the existing background concentrations at these monitoring points. The most serious exceedances are observed at monitoring points KNPC C and D, located at the boundary fence of SHU Refinery.

In conclusion, CFP normal operations will result in improved air quality in most of the study area. The concentrations of the various pollutants are reduced in the majority of the monitoring points considered. Exceedances will still occur, although such exceedances will be smaller than existing exceedances as a result of the CFP. In general, it can be said that there will be significant improvements in the air quality for all the monitoring point locations that currently exceed K-EPA / MOO air quality criteria.

9.4.6.2 Combined "Maximum Emission" + "Decommissioned Emission" Scenario

The approach followed for this case is similar to the "Base Case", and has been modelled as follows:

- New Maximum Emissions model (sources from Table 9.9) combined with the Decommissioned Emissions model (sources from Table 9.10) to produce the ground level concentration contours for the various pollutants

- The combined, predicted ADMS concentrations at the monitoring point locations are combined with existing baseline air quality data, in order to estimate the future air quality in the area, and then compared against the relevant K-EPA / MOO criteria.

The results for the "maximum" case are presented in the form of tables summarising the exceedances against the relevant K-EPA / MOO criteria, whilst also comparing the predicted, combined concentrations to the actual background data at each location, in order to identify the overall impact of the CFP project on the air quality.

Table 9.20 below summarises the various resulting pollutant concentrations at each monitoring point for the "maximum" case.

Table 9.20: Pollutant Concentrations at Monitoring Points for "Maximum Case" Post-CFP, including existing Baseline Data.

Monitoring Point	Annual Average (μg/m³)				99.7%ile 1-hour average (μg/m³)			
	NO2	SO2	H2S	CO*	NO2	SO2	H2S	CO
A1	20.0	21.2	6.0	N/A	23.3	0.0	7.6	0.0
A2	13.1	33.3	5.0	N/A	17.9	6.5	6.5	8.4
A3	12.9	11.5	5.8	N/A	13.2	0.0	7.4	0.0
A4	15.1	11.6	5.7	N/A	16.6	0.0	7.3	0.0
A5	15.5	14.7	5.7	N/A	18.4	0.0	7.2	0.0
A6	21.2	27.9	5.7	N/A	25.5	0.0	7.3	4.6
A7	11.5	28.8	5.5	N/A	14.9	6.2	7.0	4.2
A8	14.8	81.4	8.4	N/A	10.2	0.0	10.7	0.0
A9	14.7	36.0	8.0	N/A	18.9	0.0	10.2	10.1
A10	16.5	19.6	4.4	N/A	19.8	0.0	5.6	1.7
A11	14.0	21.3	5.2	N/A	17.0	0.0	6.6	3.7
A12	19.5	19.9	5.8	N/A	23.6	0.0	7.3	0.0
A13	13.1	35.2	4.3	N/A	17.3	0.0	5.6	9.5
A14	15.2	16.7	9.8	N/A	0.0	0.0	12.6	0.0
A15	15.5	11.6	5.9	N/A	18.3	0.0	7.5	0.0
A16	14.8	15.4	6.9	N/A	18.0	0.0	8.8	0.0
A17	10.1	23.6	4.3	N/A	12.8	23.9	5.4	3.1
A18	8.5	20.4	5.7	N/A	10.9	13.9	7.2	3.4
A19	0.0	0.0	8.1	N/A	0.0	0.0	10.5	0.0
A20	16.3	36.4	6.9	N/A	20.7	0.0	8.8	27.0
A21	19.1	83.5	7.5	N/A	25.5	99.8	12.1	46.2
A22	10.5	31.0	6.1	N/A	11.1	6.6	8.0	1.5
A23	19.8	81.3	10.8	N/A	24.6	88.5	15.5	29.7
A24	20.6	84.0	7.1	N/A	27.5	106.8	12.3	44.9
A25	9.8	29.2	5.8	N/A	12.0	28.4	7.5	3.7
A26	11.7	43.3	7.5	N/A	15.1	50.4	10.2	16.9
A27	15.8	35.2	6.9	N/A	22.9	45.4	10.2	50.9
A28	10.2	22.6	0.0	N/A	13.0	26.8	0.1	3.6
A29	14.6	41.2	6.4	N/A	17.9	25.5	9.3	38.2
A30	17.1	71.2	6.9	N/A	22.5	90.4	10.2	31.5
A31	15.0	35.0	6.9	N/A	20.0	39.9	9.2	16.6
A32	10.5	30.9	7.2	N/A	12.1	18.7	9.3	3.9
A33	12.8	45.2	8.1	N/A	17.3	44.9	12.3	31.8

Monitoring Point	Annual Average (µg/m³)				99.7%ile 1-hour average (µg/m³)			
	NO2	SO2	H2S	CO*	NO2	SO2	H2S	CO
A34	5.8	9.3	14.5	N/A	5.9	0.0	18.3	0.0
A35	10.6	28.7	8.8	N/A	14.1	30.8	11.7	13.2
A36	10.0	34.0	6.7	N/A	11.1	21.6	8.6	1.5
A37	15.5	45.4	9.9	N/A	0.0	0.0	12.7	0.0
A38	13.2	85.7	9.6	N/A	0.0	0.0	12.3	0.0
A39	16.8	38.5	7.3	N/A	18.2	0.0	9.8	3.6
A40	15.7	33.7	6.7	N/A	14.5	0.0	8.8	0.0
A41	9.9	33.6	6.6	N/A	8.3	2.0	8.5	0.0
A42	13.2	37.0	6.1	N/A	7.4	0.0	7.9	0.0
A43	11.6	28.8	7.6	N/A	1.4	0.0	9.8	0.0
A44	16.0	35.5	7.5	N/A	18.5	19.8	9.5	0.0
A45	6.5	24.6	4.8	N/A	6.7	5.0	6.1	0.0
KNPC C	144.2	0.0	16.0	N/A	219.8	0.0	133.1	5668.8
KNPC D	41.5	25.9	24.7	N/A	23.3	0.0	57.7	0.0
KNPC F	69.0	13.3	5.4	N/A	182.1	86.5	29.6	2943.7
KNPC H	53.5	31.1	3.8	N/A	94.3	66.6	14.5	47.2

Notes:

1. CO concentrations do not include background data (only for KNPC C and F).
2. A concentration of 0 indicates that the predicted cumulative concentration is negative.

* Long term (i.e. annual) concentrations are not applicable for CO.

Table 9.21 summarises the various pollutant concentrations at all the monitoring point locations against the criteria, whereas Table 9.22 indicates the difference in the concentrations of various pollutants at each monitoring case after the completion of the CFP project (for the "maximum" case). Note that the NO_2 concentrations correspond to 10% of the predicted ADMS NO_x concentrations.

Table 9.21: Exceedances of Criteria for Ambient Air Quality for "Maximum Case" Post-CFP, including existing Baseline Data.

Averaging Period	Annual				99.7%ile 1-hour Average				99.7%ile 1-hour Average
	Ratio against Residential & Industrial Criteria (only Residential for SO2)								Ratio against Industrial Criteria
Monitoring Location	NO2	SO2	H2S#	CO*	NO2	SO2	H2S#	CO	SO2
A1	0.3	0.3	0.8	-	0.1	0.0	0.2	0.0	0.0
A2	0.2	0.4	0.6	-	0.1	0.0	0.2	0.0	0.0
A3	0.2	0.1	0.7	-	0.1	0.0	0.2	0.0	0.0
A4	0.2	0.1	0.7	-	0.1	0.0	0.2	0.0	0.0
A5	0.2	0.2	0.7	-	0.1	0.0	0.2	0.0	0.0
A6	0.3	0.3	0.7	-	0.1	0.0	0.2	0.0	0.0
A7	0.2	0.4	0.7	-	0.1	0.0	0.2	0.0	0.0
A8	0.2	[illegible]	[illegible]	-	0.0	0.0	0.3	0.0	0.0
A9	0.2	0.5	[illegible]	-	0.1	0.0	0.3	0.0	0.0

Averaging Period	Annual				99.7%ile 1-hour Average				99.7%ile 1-hour Average
	Ratio against Residential & Industrial Criteria (only Residential for SO2)								Ratio against Industrial Criteria
Monitoring Location	NO2	SO2	H2S#	CO'	NO2	SO2	H2S#	CO	SO2
A10	0.2	0.2	0.6	-	0.1	0.0	0.1	0.0	0.0
A11	0.2	0.3	0.7	-	0.1	0.0	0.2	0.0	0.0
A12	0.3	0.2	0.7	-	0.1	0.0	0.2	0.0	0.0
A13	0.2	0.4	0.5	-	0.1	0.0	0.1	0.0	0.0
A14	0.2	0.2	[illegible]	-	0.0	0.0	0.3	0.0	0.0
A15	0.2	0.1	0.7	-	0.1	0.0	0.2	0.0	0.0
A16	0.2	0.2	0.9	-	0.1	0.0	0.2	0.0	0.0
A17	0.2	0.3	0.5	-	0.1	0.1	0.1	0.0	0.0
A18	0.1	0.3	0.7	-	0.0	0.0	0.2	0.0	0.0
A19	0.0	0.0	[illegible]	-	0.0	0.0	0.3	0.0	0.0
A20	0.2	0.5	0.9	-	0.1	0.0	0.2	0.0	0.0
A21	0.3	[illegible]	0.9	-	0.1	0.2	0.3	0.0	0.1
A22	0.2	0.4	0.8	-	0.0	0.0	0.2	0.0	0.0
A23	0.3	[illegible]	[illegible]	-	0.1	0.2	0.4	0.0	0.1
A24	0.3	[illegible]	0.9	-	0.1	0.2	0.3	0.0	0.1
A25	0.1	0.4	0.7	-	0.1	0.1	0.2	0.0	0.0
A26	0.2	0.5	0.9	-	0.1	0.1	0.3	0.0	0.1
A27	0.2	0.4	0.9	-	0.1	0.1	0.3	0.0	0.1
A28	0.2	0.3	0.0	-	0.1	0.1	0.0	0.0	0.0
A29	0.2	0.5	0.8	-	0.1	0.1	0.2	0.0	0.0
A30	0.3	0.9	0.9	-	0.1	0.2	0.3	0.0	0.0
A31	0.2	0.4	0.9	-	0.1	0.1	0.2	0.0	0.1
A32	0.2	0.4	0.9	-	0.1	0.0	0.2	0.0	0.1
A33	0.2	0.6	[illegible]	-	0.1	0.1	0.3	0.0	0.0
A34	0.1	0.1	[illegible]	-	0.0	0.0	0.5	0.0	0.1
A35	0.2	0.4	[illegible]	-	0.1	0.1	0.3	0.0	0.0
A36	0.1	0.4	0.8	-	0.0	0.0	0.2	0.0	0.0
A37	0.2	0.6	[illegible]	-	0.0	0.0	0.3	0.0	0.0
A38	0.2	[illegible]	[illegible]	-	0.0	0.0	0.3	0.0	0.0
A39	0.3	0.5	0.9	-	0.1	0.0	0.2	0.0	0.0
A40	0.2	0.4	0.8	-	0.1	0.0	0.2	0.0	0.0
A41	0.1	0.4	0.8	-	0.0	0.0	0.2	0.0	0.0
A42	0.2	0.5	0.8	-	0.0	0.0	0.2	0.0	0.0
A43	0.2	0.4	[illegible]	-	0.0	0.0	0.2	0.0	0.0
A44	0.2	0.4	0.9	-	0.1	0.0	0.2	0.0	0.0
A45	0.1	0.3	0.6	-	0.0	0.0	0.2	0.0	0.0
KNPC C	[illegible]	0.0	[illegible]	-	1.0(V1)	0.0	[illegible]	0.2	0.0
KNPC D	0.6	0.3	[illegible]	-	0.1	0.0	[illegible]	0.0	0.0
KNPC F	[illegible]	0.2	0.7	-	0.8	0.2	0.7	0.1	0.1
KNPC H	0.8	0.4	0.5	-	0.4	0.1	0.4	0.0	0.1

Note: All negative values have been rounded to 0.

Key: Red highlighted cells indicate exceedance against K-EPA / MOO criteria.

Averaging Period	Annual				99.7%ile 1-hour Average				99.7%ile 1-hour Average
	Ratio against Residential & Industrial Criteria (only Residential for SO2)								Ratio against Industrial Criteria
Monitoring Location	NO2	SO2	H2S#	CO*	NO2	SO2	H2S#	CO	SO2

✓: Pollutant Concentration reduced after CFP Project Completion.
×: Pollutant Concentration increased after CFP Project Completion.
-: Pollutant Concentration not changed after CFP Project Completion.
* Long term (i.e. annual) concentrations are not applicable for CO.
# No hydrogen sulphide emission data were available for the decommissioned units, hence a comparison cannot be made.

Table 9.22: Change in Monitoring Point Concentrations ("Maximum Case") Post-CFP, including existing Baseline Data.

	Annual Average Concentrations				99.7%ile 1-hour average Concentrations			
Monitoring Point	NO2	SO2	H2S	CO*	NO2	SO2	H2S	CO
A1	✓	✓	-	-	✓	✓	×	N/A
A2	×	✓	-	-	×	✓	×	N/A
A3	✓	✓	-	-	✓	✓	×	N/A
A4	✓	✓	-	-	✓	✓	×	N/A
A5	✓	✓	-	-	✓	✓	×	N/A
A6	✓	✓	-	-	✓	✓	×	N/A
A7	×	✓	-	-	×	✓	×	N/A
A8	✓	✓	-	-	✓	✓	×	N/A
A9	×	✓	-	-	×	✓	×	N/A
A10	✓	✓	-	-	✓	✓	×	N/A
A11	✓	✓	-	-	✓	✓	×	N/A
A12	✓	✓	-	-	✓	✓	×	N/A
A13	×	✓	-	-	×	✓	×	N/A
A14	✓	✓	-	-	✓	✓	×	N/A
A15	✓	✓	-	-	✓	✓	×	N/A
A16	✓	✓	-	-	✓	✓	×	N/A
A17	✓	✓	-	-	×	✓	×	N/A
A18	✓	✓	-	-	×	✓	×	N/A
A19	✓	✓	-	-	✓	✓	×	N/A
A20	×	✓	-	-	×	✓	×	N/A
A21	×	✓	×	-	×	✓	×	N/A
A22	✓	✓	-	-	✓	✓	×	N/A
A23	✓	✓	-	-	✓	✓	×	N/A
A24	×	×	×	-	×	×	×	N/A
A25	✓	✓	-	-	✓	✓	×	N/A
A26	×	×	×	-	×	✓	×	N/A
A27	×	×	×	-	×	×	×	N/A
A28	×	✓	-	-	×	✓	×	N/A
A29	×	×	×	-	×	✓	×	N/A
A30	×	×	×	-	×	×	×	N/A
A31	×	✓	-	-	×	✓	×	N/A
A32	✓	✓	-	-	✓	✓	×	N/A

	Annual Average Concentrations				99.7%ile 1-hour average Concentrations			
Monitoring Point	NO2	SO2	H2S	CO*	NO2	SO2	H2S	CO
A33	×	×	×	-	×	✓	×	N/A
A34	✓	✓	-	-	✓	✓	×	N/A
A35	×	✓	×	-	×	✓	×	N/A
A36	✓	✓	-	-	✓	✓	×	N/A
A37	✓	✓	-	-	✓	✓	×	N/A
A38	✓	✓	-	-	✓	✓	×	N/A
A39	✓	✓	-	-	✓	✓	×	N/A
A40	✓	✓	-	-	✓	✓	×	N/A
A41	✓	✓	-	-	✓	✓	×	N/A
A42	✓	✓	-	-	✓	✓	×	N/A
A43	✓	✓	-	-	✓	✓	×	N/A
A44	✓	✓	-	-	✓	✓	×	N/A
A45	✓	✓	-	-	✓	✓	×	N/A
KNPC C	✓	✓	-	-	✓	✓	×	✓
KNPC D	✓	✓	-	-	✓	✓	×	N/A
KNPC F	✓	✓	-	-	✓	✓	×	✓
KNPC H	×	×	×	-	×	✓	×	N/A

Key:
✓ Concentration reduced after CFP Project Completion
× Concentration increased after CFP Project Completion
- Concentration not changed after CFP Project Completion

* Long term (i.e. annual) concentrations are not applicable for CO.

As shown in Table 9.21, there are a number of exceedances of criteria for NO_2, SO_2 and H_2S, after the completion of the CFP project (for maximum operating conditions). It is noted here that for the case of H_2S, as for the "Normal Emission" scenario, a direct conclusion cannot be drawn, as for the purposes of modelling no information was available for H_2S emissions from the decommissioned sources, and as before, H_2S impact due to new CFP sources is insignificant.

There are a few exceedances when compared to K-EPA/ MOO criteria for both short and long term NO_2 and SO_2 concentrations at various monitoring points, but an overall improvement of these is observed, compared to what the concentrations were prior to CFP completion. The exception to this is monitoring point A24, which is located at the MAB adjacent coastal area, where a slight increase in the long term sulphur dioxide concentration is observed (around 2 $\mu g/m^3$). The largest exceedance for NO_2 is observed at monitoring point KNPC C at SHU Refinery, but the implementation of the CFP improves the current situation. Also, it can be argued that the location of this point can be considered onsite, rather than at the site boundary, given its proximity to the main CFP Block.

As indicated in Table 9.22, in the majority of locations, the CFP project results in an overall improvement for both the long and short term concentrations of NO_2 and SO_2 at the various monitoring points as compared to baseline data. Some long and short term NO_2 and SO_2 concentrations have increased after the completion of the CFP (e.g. at monitoring locations A2, A7, A24,A26,A27,A29,A30,A33, and KNPC H etc), but all of them comply with the applicable K-EPA / MOO criteria. Note that the increase in concentration is observed at fewer monitoring point locations when considering sulphur dioxide rather than nitrogen dioxide.

In general, there will be improvements in the air quality for many of the monitoring point locations that currently exceed K-EPA / MOO air quality criteria.

9.4.6.3 SRU Upset Case Modelling

The following two SRU upset conditions have been modelled (note that typical SRU emissions are included with the "Normal Emission" Scenario):

> **Upset 1:** SCOT sections are bypassed. This scenario is not intended for continuous sustained operation, and it results in high SO_2 emissions. Note that the SCOT Unit is designed for 99%+ reliability.
>
> **Upset 2:** SCOT sections are bypassed; incinerator is not in operation, and is cold with no combustion air. As for the other SRU upset condition, this scenario is not intended for continuous sustained operation, and it results in high H_2S and SO_2 emissions. Note that the failure rate for a SRU/TGTU incinerator is low.

The emission data for the SRU upset scenarios are provided in Table 9.13.

Normal Case (see Section 9.4.3 and Table 9.8) emissions have been modelled together with each of the two upset conditions

Results from the modelling (short term concentrations only), shown below, are compared only against applicable occupational exposure standards for relevant pollutants, as upset conditions are short term emergency events. It is also noted that to make a meaningful comparison with typical occupational exposure limits, which are provided for 15-minute exposure and 8 hour exposure period (see Table 9.16), the maximum predicted short term, 100%ile, 1-hour concentration (for the relevant pollutant) anywhere within the CFP boundary and the adjacent area was converted to the equivalent 15-minute and 8 hour average concentration using one of the factors provided (1.07 and 0.95 respectively for this case) in the *Workbook of Atmospheric Dispersion Estimates, D. Bruce Turner, 2nd Edition, 1994.* The 99.7%ile results are also provided for information.

SRU Upset 1

The ground level maximum concentrations for MAA and MAB predicted anywhere for SO_2 are summarised in the table below. Note that the decommissioned results have not been taken into account, as they are negligible compared against these emergency emissions.

Table 9.23: Maximum Ground Level Concentrations for SO_2 Anywhere

SO_2(µg/m³)	100 %ile			99.7%ile		
	1 hr	15 min avg	8 hr avg	1 hr	15 min avg	8 hr avg
MAA	1250	1338	1187	726	777	690
MAB	2230	2386	2119	1330	1423	1264

The following table summarises the results as a comparison to the occupational exposure limits, as shown in Table 9.16.

Table 9.24: Maximum Ground Level Concentrations for SO_2 as Percentage of the Criteria

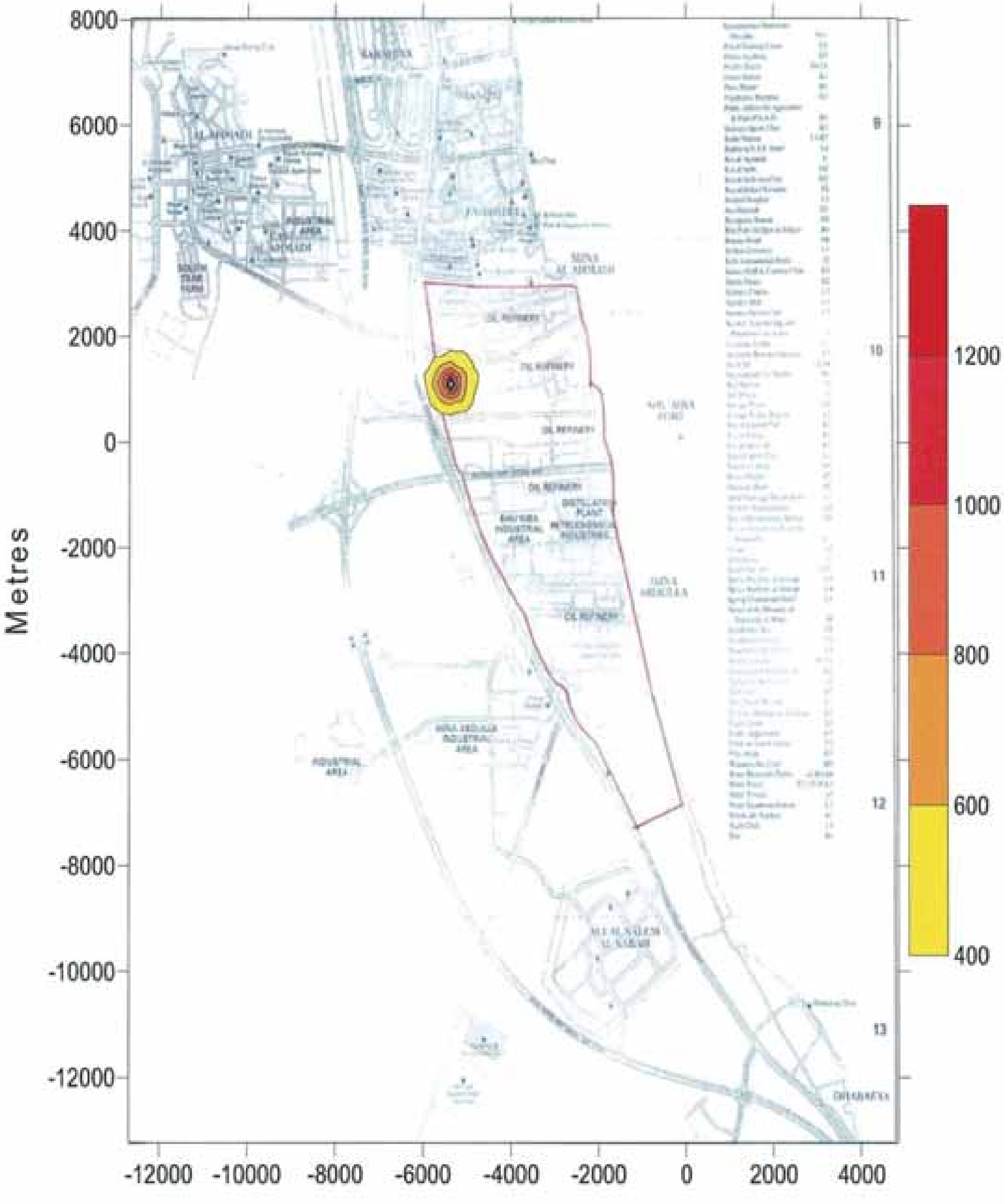
SO_2 (% against the Limit)	15 min avg (ST) 100th %ile	15 min avg (ST) 99.7th %ile	8 hr avg (LT) 100th %ile	8 hr avg (LT) 99.7th %ile
MAA	10%	6%	24%	14%
MAB	18%	11%	42%	25%

It can be seen that SO_2 levels satisfy the occupational exposure limits for 15 minutes OEL and 8 hour OEL, as this is a short term upset event, and concentrations of SO_2 will be considerably within criteria.

SO_2 concentrations also satisfy emergency response criteria at the site boundary.

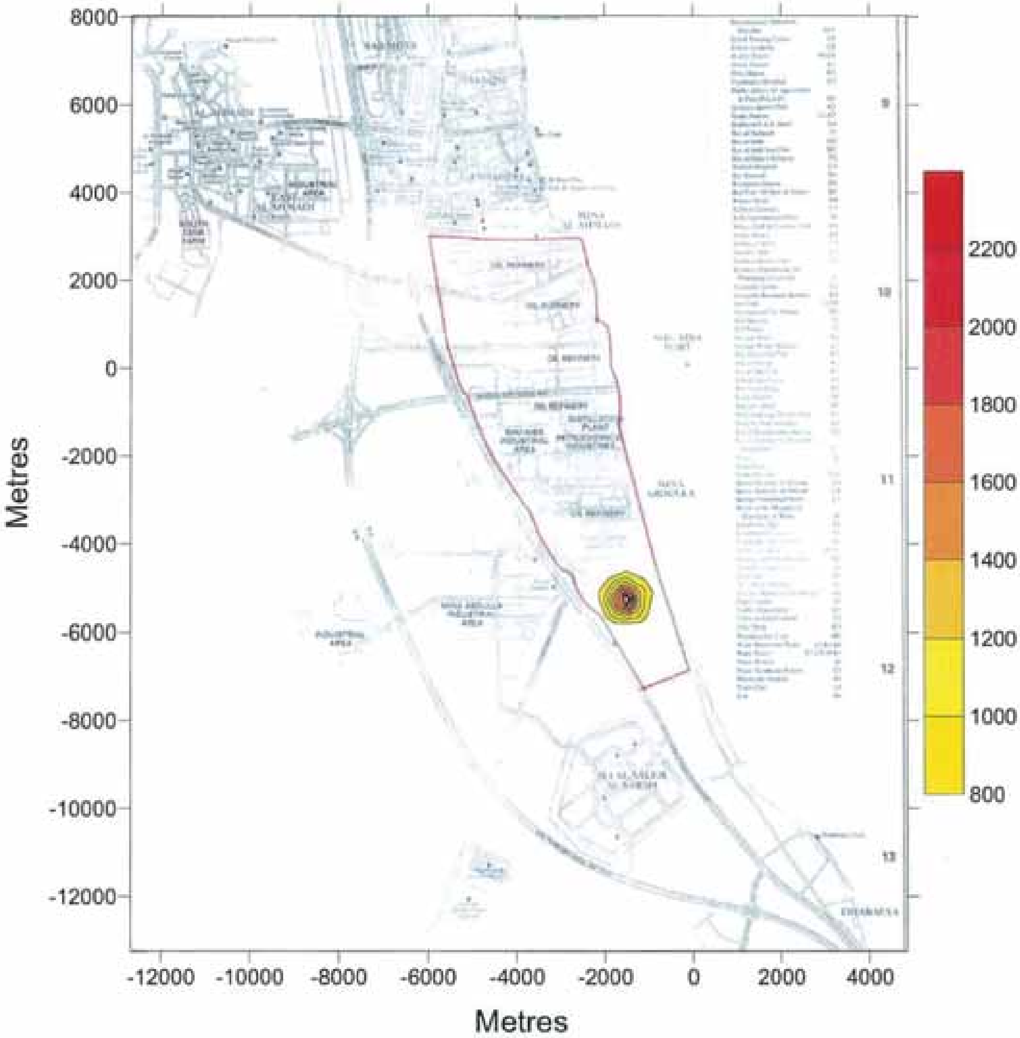
It is concluded that for SRU Upset Case 1, K-EPA / MOO criteria are satisfied. The short term dispersion contours (for SO_2) are presented in Figures 9-19 and 9-20. Note that the contours correspond to the 1-hour average concentrations, and do not include decommissioned scenario emissions. All concentrations are given in $\mu g/m^3$.

Figure 9.19: SO_2 100% percentile (SRU Upset Case 1- MAA)



All concentrations are given in µg/m³

Figure 9.20: SO_2 100% percentile (SRU Upset Case 1- MAB)



All concentrations are given in µg/m^3

SRU Upset 2

The ground level maximum concentrations predicted anywhere for SO_2 and H_2S are summarised in Table 9.25 for MAA and MAB. Note that the decommissioned results have not been taken into account, as they are negligible compared against these emergency emissions.

Table 9.25: Maximum Ground Level Concentrations for H_2S and SO_2 Anywhere

All in µg/m³		100th %ile			99.7th %ile		
		1 hr	15 min avg	8 hr avg	1 hr	15 min avg	8 hr avg
MAA	SO_2	624	666	593	371	397	352
	H_2S	668	715	635	394	422	374
MAB	SO_2	1150	1231	1093	704	753	669
	H_2S	1220	1305	1159	745	797	708

Ground Level Concentrations of SO_2 satisfy occupational exposure criteria on site, as do H_2S levels (H_2S 1 hour occupational exposure criterion is approximately 20720 µg/m³).

Comparison against the occupational exposure criteria outlined in Table 9.16 is provided in the table below:

Table 9.26: Maximum Ground Level Concentrations Anywhere for H_2S and SO_2 as Percentage of the Criteria

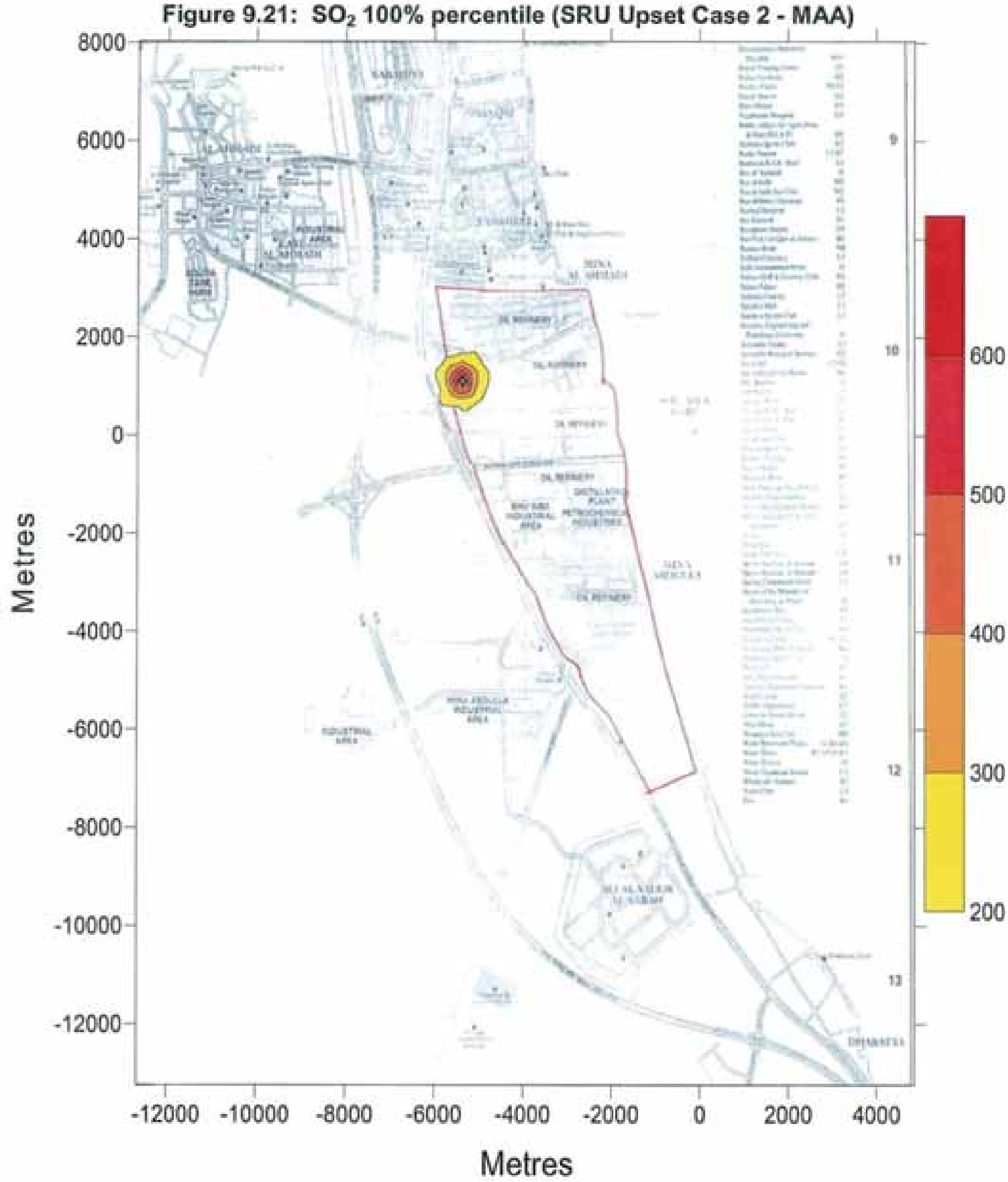
	% against the Limit	15 min avg (ST) 100th %ile	15 min avg (ST) 99.7th %ile	8 hr avg (LT) 100th %ile	8 hr avg (LT) 99.7th %ile
MAA	SO_2	5%	3%	12%	7%
	H_2S	3%	2%	5%	3%
MAB	SO_2	9%	6%	22%	13%
	H_2S	6%	4%	8%	5%

It can be seen that SO_2 and H_2S levels satisfy the occupational exposure limits, which are the appropriate ones for comparison as this is a short term upset event and concentrations of SO_2 and H_2S will be considerably within relevant K-EPA / MOO criteria.

SO_2 and H_2S concentrations also satisfy emergency response criteria at the site boundary.

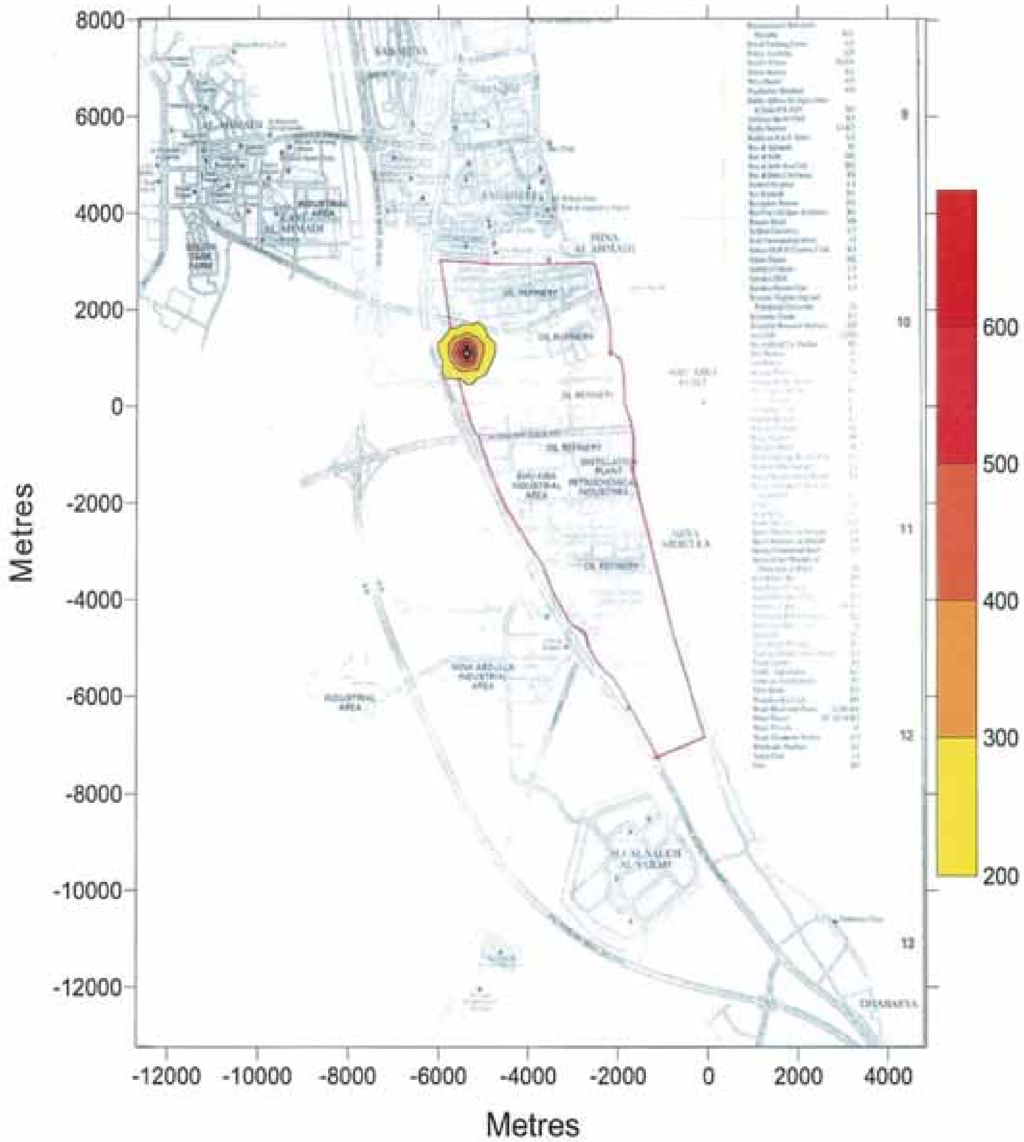
It is concluded that during an SRU Upset Case 2, impacts are managed satisfactorily. The short term dispersion contours are presented in Figures 9-21 through 9-24 below (100%ile) for both SO_2 and H_2S. Note that the contours correspond to the 1-hour average concentrations, and do not include decommissioned scenario emissions. All concentrations are given in µg/m³.

Figure 9.21: SO_2 100% percentile (SRU Upset Case 2 - MAA)



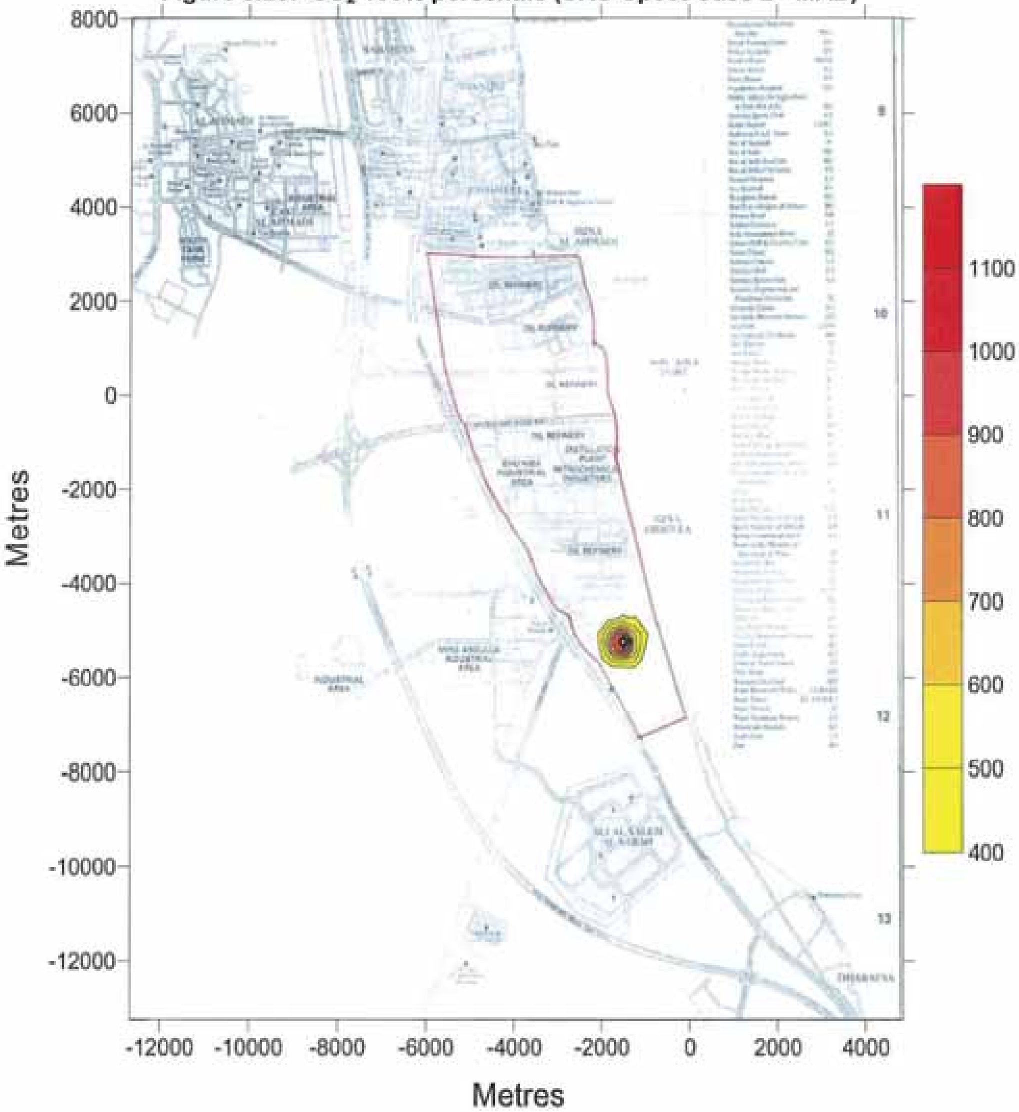
All concentrations are given in μg/m³

Figure 9.22: H_2S 100% percentile (SRU Upset Case 2 - MAA)



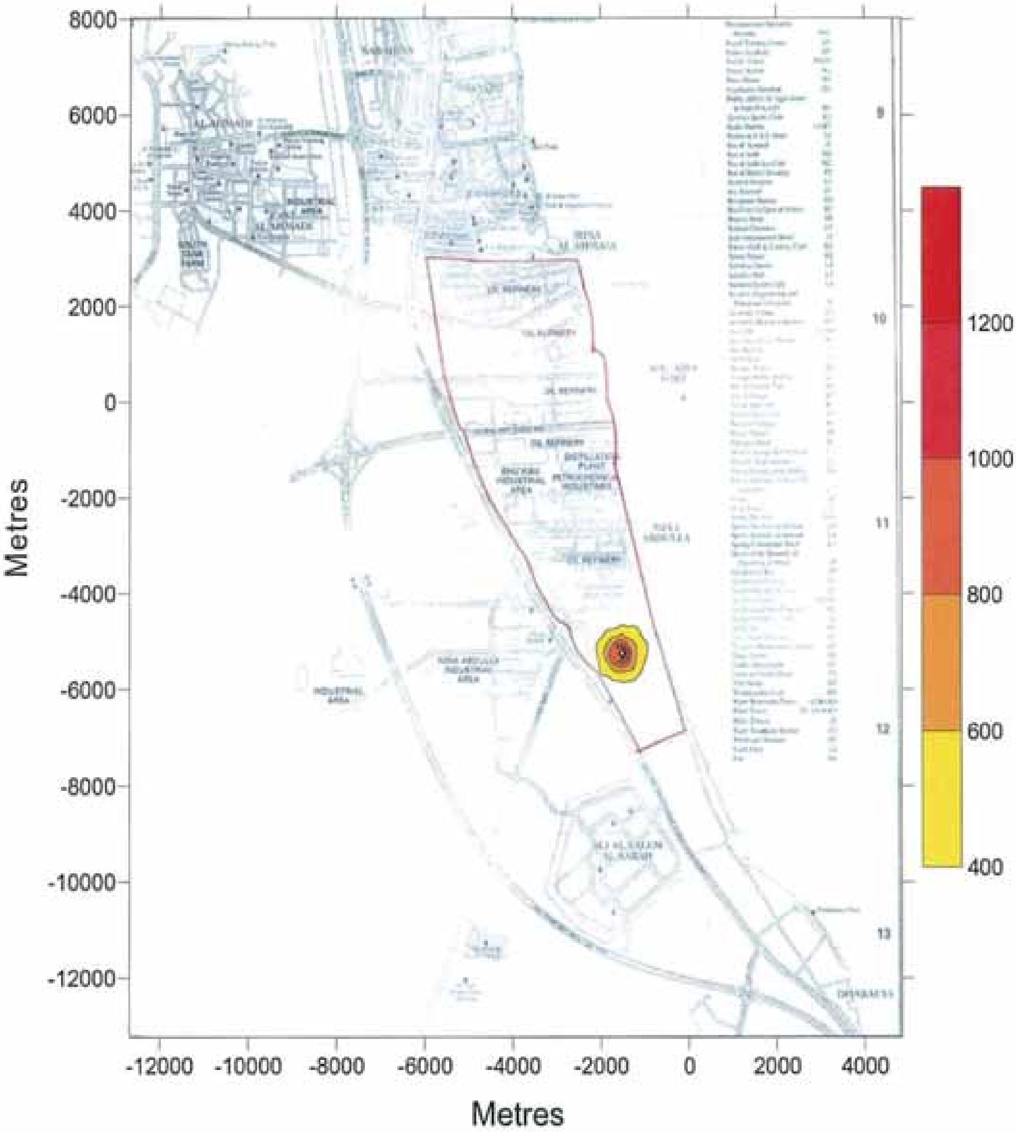
All concentrations are given in $\mu g/m^3$

Figure 9.23: SO_2 100% percentile (SRU Upset Case 2 - MAB)



All concentrations are given in $\mu g/m^3$

Figure 9.24: H_2S 100% percentile (SRU Upset Case 2 - MAB)



All concentrations are given in $\mu g/m^3$

9.4.6.4 Emergency Flare Modelling

Significant flare emissions only take place during emergencies or upset conditions (such as power failure or upset scenarios at specific units). Emissions from emergency flaring have been modelled for both the new MAA and MAB acid and hydrocarbon gas flares, as well as the revamped flare systems at the MAA refinery. The emission data for the various scenarios considered are summarised in Table 9.11 and Table 9.12.

The key assumptions for deriving the necessary emission parameters are outlined in Section 9.4.3, and are briefly described below:

- Total combustion of the released stream (including 20% excess air)
- An exit velocity of 40 m/s (consistent with flare modelling guidelines)
- Calculating the flame height, which is included in the effective release height

The emergency flaring scenarios do not include the normal emissions from sources that will continue to operate during the emergency flaring event, or the decommissioned units' emissions. The pollutant contributions from these sources will be negligible in comparison to the emissions from the emergency flaring event.

Results from the emergency flaring scenarios modelled are presented in Table 9.27 for the converted maximum 15-minute average short-term concentrations of SO_2, for the 100^{th} and 99.7^{th} percentile (see Section 9.4.6.3 regarding methodology used for converting concentrations). The 100^{th} percentile is the concentration that is compared to the occupational exposure standards, whereas the 99.7^{th} percentile concentrations are provided for information only. Note that as for the SRU upset scenarios (see Section 9.4.6.3), the reported concentrations (100% and 99.7%ile for information only) are the factored (i.e. converting the 1-hour average to 15-minute average concentrations) maximum estimated, and do not include any normal emission or the decommissioned modelling results, as they are negligible in comparison.

Table 9.27 also includes the peak 100^{th} percentile 1-hour average short-term concentration of SO_2.

NO_2 modelling results are not indicated in the table, as they result in negligible Ground Level Concentrations (GLC) in relation to the relevant criteria.

Table 9.27: Maximum Concentrations for SO_2 Anywhere for Emergency Flaring Scenarios

Refinery / Flare	Tag No.	Emergency Scenario/Governing Case	Pollutant	Maximum GLC Concentration (1-hour average) (µg/m³)	Maximum GLC Concentration (Converted 15-minute averages) (µg/m³)	
				100%ile	100%ile	99.7%ile
MAA Unit 162	162-A-0101	Case 2	SO_2	1967	2105	1287
MAA Unit 167	167-A-0101	Case 2	SO_2	3675	3932	3485
MAA Unit 25/26	-	Case 2	SO_2	8.4	9	8
MAA Unit 39	ST-39-001	Case 1	SO_2	190	203	180
		Case 2	SO_2	870	931	669
		Case 4	SO_2	0.47	0.5	0.4
		Case 5	SO_2	547	585	294
MAB Unit 146	146-A-0101A	Case 2	SO_2	16727	17900	16326
MAB Unit 149 HP HC	149-A-0112A	Case 2	SO_2	2680	2866	2205
MAB Unit 149 LP HC	149-A-0102A	Case 2	SO_2	163.6	175	159
MAB Unit 249	249-A-0101	Case 2	SO_2	641	686	621
MAB Unit 314 HP HCR	314-A-0112A	Case 3	SO_2	108.4	116	102
MAA and MAB	TPF for all flares (Table 9.12)	TPF Combination	SO_2	4805	5141	4495

These results are then compared to the relevant occupational exposure limits, as set out in Table 9.16, to assess whether the maximum ground level concentrations (converted from 1-hour average to 15-minure average concentrations) estimated comply with OEL criteria. Table 9.28 summarises the ratios of the estimated concentration against the relevant occupational exposure limit. Exceedances are highlighted in red.

Table 9.28: Maximum Ground Level Concentrations Anywhere for SO_2 against Criteria (Flaring Scenarios)

Refinery / Flare	Tag No.	Emergency Scenario/Governing Case	Pollutant	Ratio of Concentration Against Criteria	
				100%ile	99.7%ile
MAA Unit 162	162-A-0101	Case 2	SO_2	0.16	0.10
MAA Unit 167	167-A-0101	Case 2	SO_2	0.30	0.27
MAA Unit 25/26	-	Case 2	SO_2	0.0007	0.0006
MAA Unit 39	ST-39-001	Case 1	SO_2	0.02	0.01
		Case 2	SO_2	0.07	0.05
		Case 4	SO_2	-	-
		Case 5	SO_2	0.05	0.02
MAB Unit 146	146-A-0101A	Case 2	SO_2	[illegible]	[illegible]
MAB Unit 149 HP HC	149-A-0112A	Case 2	SO_2	0.22	0.17
MAB Unit 149 LP HC	149-A-0102A	Case 2	SO_2	0.01	0.01
MAB Unit 249	249-A-0101	Case 2	SO_2	0.05	0.05
MAB Unit 314 HP HCR	314-A-0112A	Case 3	SO_2	0.01	0.01
MAA and MAB	TPF for all flares (Table 9.12)	TPF Combination	SO_2	0.40	0.35

Note: 1. The cells highlighted in red indicated exceedance against the applicable K-EPA / MOO criteria.
2. The ground level concentrations of NO_2 are not included in the table, as they result in < 5% of criterion.

As shown in Table 9.28 the occupational exposure standards for SO_2 are exceeded for the acid gas flare at MAB (Unit 146). Closer investigation of the results indicates that the occupational exposure standard for sulphur dioxide is exceeded both within and beyond the refinery boundary.

All other cases satisfy the occupational exposure standard for SO_2, although significant ground level concentrations are still experienced off-site, beyond the refineries boundary, particularly for the flares associated with Units 162 and 167 at MAA refinery, Units 146 and 149 HP HC at MAB refinery, as well as the Total Power Failure flaring case.

The ground level, offsite concentrations of sulphur dioxide are discussed in the context of the ERPG-2 and AEGL-2 criteria in the section that follows.

9.4.6.5 Off-site Exposure

Despite the fact that the occupational exposure criteria for sulphur dioxide are satisfied on-site (with the exception of the acid gas flare at MAB, Unit 146), some consideration has to be given for the resulting ground level pollutant concentrations beyond the fence-line of the refineries. This is particularly relevant for the residential area South-East of MAB which is very near the fence line of the refinery.

There is a relative conservatism in the emergency flaring modelling, where the scenarios have been modelled as continuous releases, when in fact they are expected to last less than an hour, and will occur only during emergencies and very infrequently (as per Fluor / KNPC information). The relevant K-EPA criteria for off-site air quality are applicable to the 99.7%ile ground level sulphur dioxide concentration. This allows for 26 exceedances per year, hence it can be said that since these emergency flaring events are anticipated to occur less than once a year, the K-EPA off-site air quality requirements are also satisfied.

On the other hand, it is important to acknowledge the fact that concentrations beyond the refinery fence-lines will exceed (particularly for the flares associated with Units 162, 167, 146, 149 HP HC and the Total Power Failure Case based on the current design flare load and stack height) the US AEGL-2 (Acute Exposure Guideline Levels) criterion for sulphur dioxide.

The acid gas flare at MAB (Unit 146) will also exceed the US ERPG-2 (US Emergency Response Planning Guidelines) criterion for sulphur dioxide.

These criteria, which in the absence of any guidelines / criteria from K-EPA / MOO are deemed to be the more appropriate ones to be used beyond the refinery fence-line for this kind of emergency events, are briefly explained below:

- ERPG values intend to provide estimates of the concentrations at which most people will begin to experience health effects if they are exposed to a toxic chemical for one (1) hour. Note that sensitive members of the public such as old, sick, or very young people are not covered by these guidelines and they may experience adverse effects at concentrations below the ERPG values. The ERPG-

2 value is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

- The US Acute Exposure Guideline Levels (AEGL) have been developed primarily to provide guidance in situations were there can be a rare, typically accidental exposure to a particular chemical that can involve the general public. AEGL-2 is the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

The ERPG-2 and AEGL-2 criteria for sulphur dioxide are summarised in the table below.

Table 9.29: ERPG-2 and AEGL-2 Criteria for Sulphur Dioxide

Pollutant	ERPG-2 Criterion ppm ($\mu g/m^3$)	AEGL-2 Criterion ppm ($\mu g/m^3$)
SO_2	3 (7600)	0.75 (1900)

Assumes an ambient air temperature of 35°C

As a result the effects on population would be significant (if generally reversible) for the worst flare emergency scenarios (Units 162, 167, 146, 149 HP HC and the Total Power Failure Case), where the AEGL-2 criterion is exceeded.

Additional modelling was conducted for the emergency scenario involving the MAB refinery flares associated with Units 146 and 149 HP HC, as well as MAA refinery flares at Units 162 and 167. The total power failure case was also revised to account for the change in stack heights for the aforementioned flare units. In addition to that, the total power failure case considered an additional sensitivity with the stack height of the flare associated with Unit 62, as it has the highest release rate of sulphur dioxide (see Table 9.12).

The additional modelling (i.e. sensitivity cases) is discussed in the section that follows.

9.4.6.6 Emergency Flare Sensitivity Modelling

The aim of the sensitivity analysis is to examine the effect of increasing the stack height for the flaring events that currently exceed the AEGL-2 (and ERPG-2 for Unit 146) criterion for sulphur dioxide. Note that this refers to the peak 100th percentile 1-hour average short-term concentration of SO_2.

The following sensitivity cases were considered:

- For MAA Unit 162 the flare stack height has been increased to 128 m (from 108 m).
- For MAA Unit 167 the flare stack height has been increased to 141 m (from 91 m).
- For MAB Unit 146 the flare stack height has been increased to 141 m (from 36.6 m). Note that this flaring scenario currently exceeds the OEL standards on-site as

well as off-site, and significantly exceeds both the ERPG-2 and AEGL-2 criteria for SO_2 off-site.

- For MAB Unit 149 HP HC the flare stack height has been increased to 110 m (from 61 m).
- The total power failure case was revised to account for the flare stack heights mentioned above, and with the stack height for Unit 62 increased to 150 m, as opposed to the current height of 110 m. The flare associated with Unit 62 has the highest release rate of sulphur dioxide (see Table 9.12). (Note that the stack height used for Unit 149 HP HC was 100 m).

Only the stack height (and hence the effective height) of the flare is changed for these sensitivities, with the rest of the modelling parameters remaining the same (see Table 9.11 and Table 9.12).

Results from the sensitivity analysis are presented in Table 9.30 for the maximum 1-hour average short-term concentrations of SO_2 (i.e. 100th percentile). The 100th percentile is the concentration that should be compared to the ERPG-2 and AEGL-2 standards. The reported concentrations do not include any normal emissions or the decommissioned modelling results, as they are negligible in comparison.

Table 9.30: Maximum Concentration Levels for SO_2 Anywhere - Sensitivity Analysis

Refinery / Flare	Tag No.	Flare Stack Height (m)	Emergency Scenario	Pollutant	Maximum GLC Concentration (1-hr average) (μg/m^3)
MAA Unit 162	162-A-0101	128	Case 2	SO_2	1907
MAA Unit 167	167-A-0101	141	Case 2	SO_2	2640
MAB Unit 146	146-A-0101A	141	Case 2	SO_2	4386
MAB Unit 149 HP HC	149-A-0112A	110	Case 2	SO_2	1425
MAA and MAB	TPF for all flares (Table 9.12)	As for base case, with Unit 162 stack height set at 128 m, Unit 167 at 141 m, Unit 149 HP HC 100 m, for Unit 146 at 141 m, and for Unit 62 at 150 m.	TPF Combination	SO_2	3530

The sensitivity analysis results indicate that:

- The maximum ground level concentration of sulphur dioxide for all flare emission scenarios, including the TPF case, now meet the OEL criterion.
- The maximum ground level concentration of sulphur dioxide for all flare emission scenarios, including the TPF case, now meet the ERPG-2 criterion.
- Flare emissions Units 162 and 149 HP HC satisfy the stricter AEGL-2 criterion for sulphur dioxide.
- For the new acid gas flares at MAA (Unit 167) and MAB (Unit 146), the AEGL-2 criterion for sulphur dioxide will be exceeded beyond the refineries fence-line, even at the revised height 141 m.
- The revised combined TPF case, when accounting for the different stack heights of flares at MAA and MAB, improves from the base case, with the resulting sulphur dioxide ground level concentration still exceeding the AEGL-2 criterion. Unit 62 is the main contributor of sulphur dioxide emissions to the TPF case.

The key outcome from the sensitivity analysis is that further work should be conducted in order to investigate the peak ground level sulphur dioxide concentrations from Units 146, 167 and 62 (associated with the TPF case only). The peak concentration results for these units currently exceed the AEGL-2 criterion for sulphur dioxide beyond the refineries boundary.

Detailed modelling of the emergency flare scenarios should be conducted during the detailed design / EPC stages of the project, as these results are based only on preliminary data available.

Additional sensitivity analysis was conducted on the emergency flaring scenarios that currently exceed the AEGL-2 criterion for sulphur dioxide (i.e. Case 2 for MAB Unit 146 and MAA Unit 167, as well as the TPF case). The parameter investigated was the emission rate of sulphur dioxide: Three (3) additional flaring preliminary sensitivity cases were considered for the aforementioned emergency cases, assuming that the current SO_2 emission rates were halved, and all other modelling parameters remain the same. Note that for the TPF case, only the SO_2 emission rate from the flare associated with existing MAA Unit 62 was halved (Unit 62 contributes the highest SO_2 emission rate to the TPF scenario), with the emission rates for all other flares remaining as indicated in Table 9.12. The flare stack heights for TPF, MAB Unit 146 and MAA Unit 167 remain as indicated in Table 9.30.

The results indicate that with the emission rate of sulphur dioxide halved, the resulting peak ground level concentrations will reduce proportionally. This would result in MAA Unit 167 Case 2 and the TPF case meeting the AEGL-2 criterion. MAB Unit 146 Case 2 would still not meet the AEGL-2 criterion. In order for this case to meet the AEGL-2 criterion, the emission rate of sulphur dioxide should be reduced to approximately 35-40% of its current value.

9.4.6.7 VOC Fugitive Emissions

This section summarizes the modeling of VOC fugitive emissions from storage tanks in hydrocarbon service (see Appendix I), as part of the CFP project. A total of 250 tanks were modelled across all three refineries.

The breakdown of tanks from each refinery is as follows:

- 101 from MAA
- 83 from MAB
- 66 from SHU

VOC fugitive emissions from the tanks were modelled using the TANKS program (version 4.09). The program was designed by the U.S. Environmental Protection Agency's (EPA) Office of Air Quality Planning (OAQPS) for use in estimating air emissions from organic liquids in storage tanks. The OAQPS develops and maintains emission estimating tools to support public (Federal, State and Local Agencies) and private sector (industry) institutions in the estimation of air emissions. The underlying theory behind the emissions estimating equations that form the basis of the tanks software program were developed by the American Petroleum Institute (API) and can be found in AP-42 "Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources" Section 7.1, Organic Liquid Storage Tanks.

The TANKS program generates an emission report based on user specified information about each storage tank. The report generated can include monthly or annual estimates for each chemical or mixture of chemicals stored in each tank. The input required includes but is not limited to

- Tank type (structural type, dimensions, paint condition),
- Liquid contents (chemical composition) and the
- Geographical location of each tank (ambient temperature, solar insulation factor, wind speed)

The program relies on a database that includes physical & chemical data on various chemicals which include organic liquids, petroleum distillates & crude oils. The database also contains meteorological information on over 175 US cities (Arizona was used to represent Kuwait in this study).

The results of the VOC fugitive emissions on an annual basis are outlined and discussed below, and are based on the total emissions from all tanks and the total area occupied by the tanks within a specific location. The tanks were separated into four (4) different areas of interest across the refineries. Figure 9.25 to Figure 9.27 show the locations of the relevant areas on the refinery plot plans.

Figure 9.25: Tank Area 1 – MAA Refinery

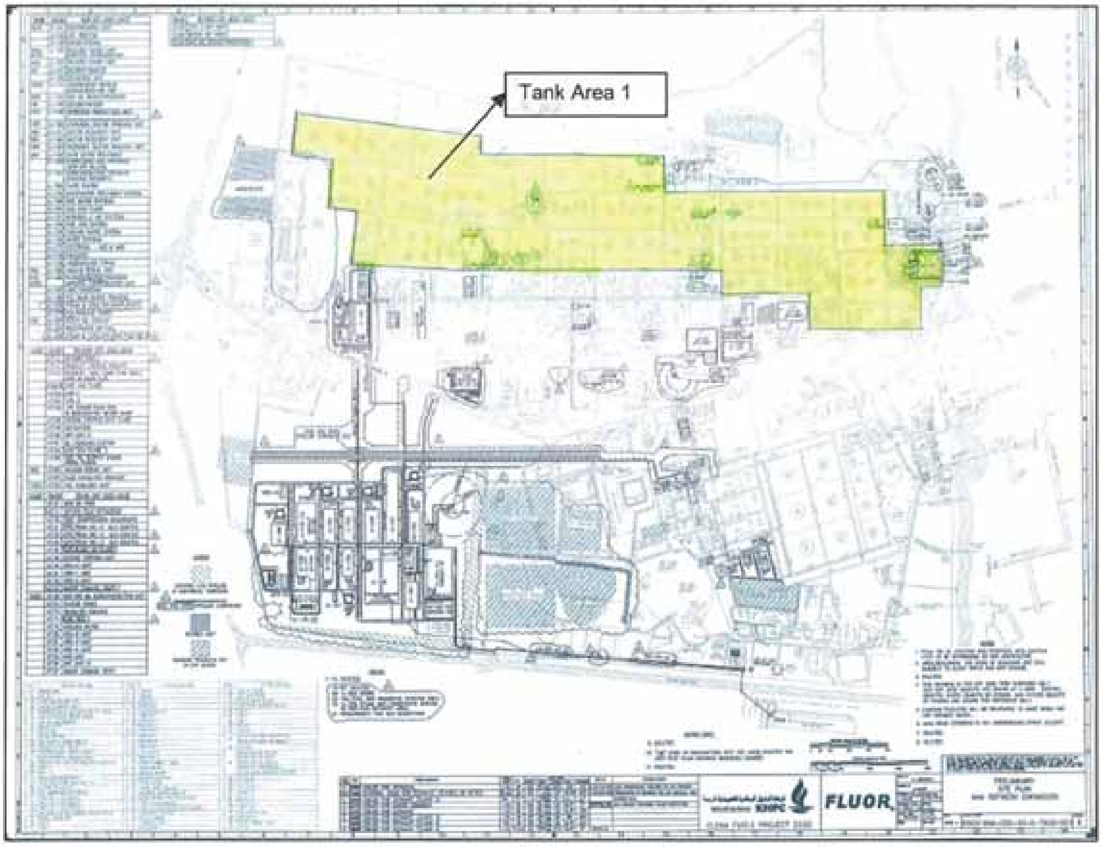


Figure 9.26: Tank Area 2 – MAB Refinery

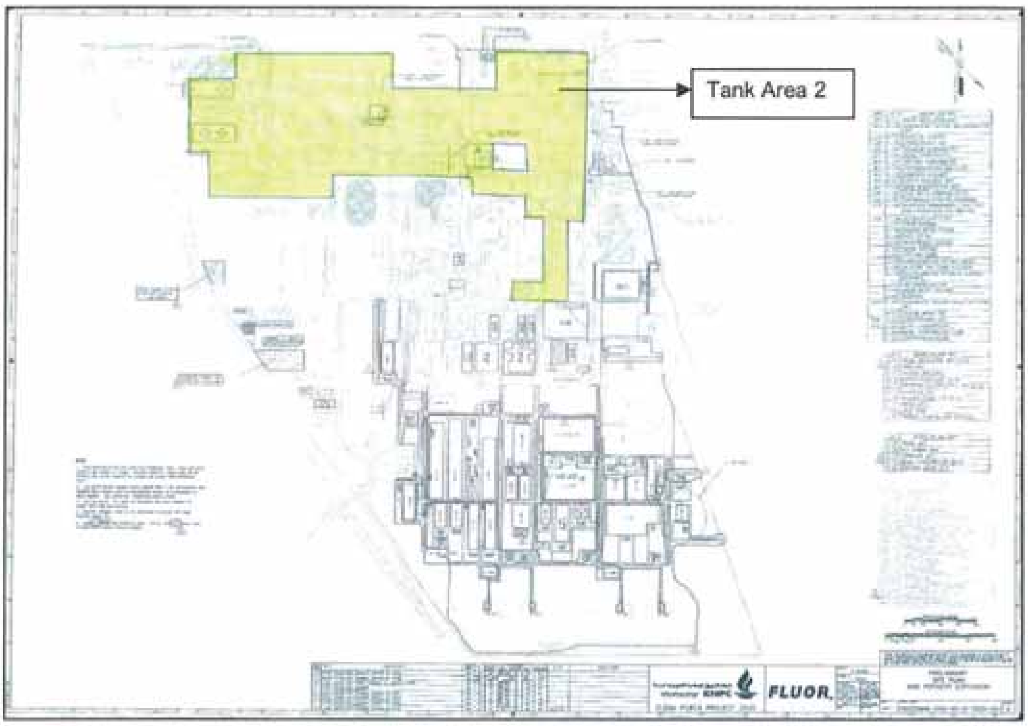
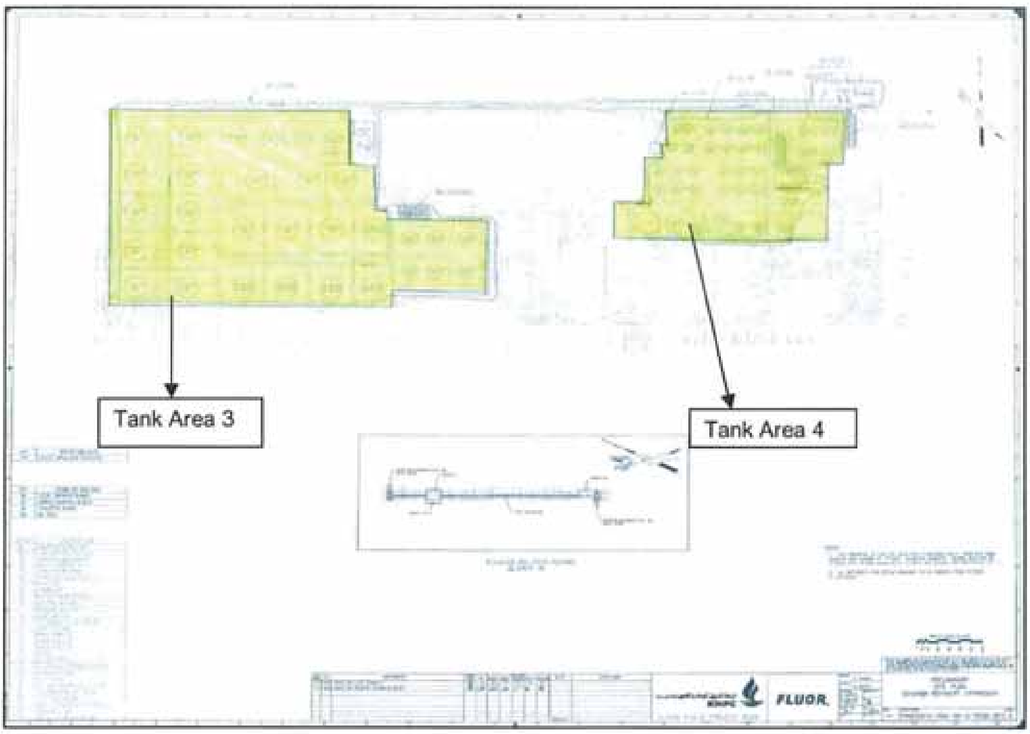


Figure 9.27: Tank Areas 3 & 4 – SHU Refinery



The key assumptions made for modeling purposes are summarised below:

- In the absence of detailed meteorological data for Kuwait in the TANKS program, Arizona was used because of the high similarity in meteorological conditions with Kuwait.
- The tank volume used to estimate the amount of VOC emissions was evaluated based on the actual dimensions of each tank. This was necessary to ensure consistency between the dimensions and volume of the tank.
- The chemical database in the TANKS program, though exhaustive, does not contain data on every single chemical substance. In instances where the material stored in the tanks was not available in the TANKS database, the material modelled in TANKS was selected using the following assumptions;
    - If Relative Vapour Pressure (RVP) data was provided for the material, a material with a similar RVP in TANKS was used
    - If no RVP data was available, the material that most closely matched the description was selected. For example "Jet kerosene" was used to model "Kerosene"
- Tank TK-34-342 at Shuaiba (SHU) refinery has been conservatively included as a vertical fixed roof tank, with the turnover data provided (it is actually an external floating roof tank but no turnover data were available).
- Tanks TK-52-109N/110N, TK-50-159 and TK-52-170/174, indicated as external floating roof tanks in the supplied data, have not been included in the modeling, because of the limited data available.
- Tanks 61-T-0103/0104 at MAA refinery have not been included in the modeling as they are not atmospheric tanks (as per Fluor supplied information these tanks are pressurised and only vent to atmosphere in case of fire).

The modelling results for the tank VOC fugitive emissions are divided over the relevant tank areas to obtain the area emission rate, for input in ADMS. Table 9.31 summarises the total emissions per unit area based on the relative tank areas defined above.

Table 9.31: Tank Grouping, Areas Covered, VOC Emission Rates & Concentrations

Area[1]	No. Of Tanks	Location	Total Emission[2] (g/s)	Total Estimated Tank Area (m^2)	Emission Rate ($g/m^2/s$)
1	101	MAA	22.5	1,790,000	1.26E-05
2	83	MAB	7.3	1,185,000	6.16E-06
3	31	SHU	4.3	690,700	6.23E-06
4	35	SHU	4.7	222,000	2.12E-05

Notes: 1. See Figures 9-26 to 9-28.
2. The total emission by tank area is based on *yearly* emissions report from TANKS.

The above emission data were entered in ADMS in order to determined resulting VOC ground level concentrations anywhere on facilities and the surrounding areas. The height for all tank areas considered is estimated to be 60 ft (approximately 18m), with the temperature of the release assumed to be 40°C. The default molecular weight of around 29 is assumed for the releases (note that tank emissions will not be pure VOC vapour).

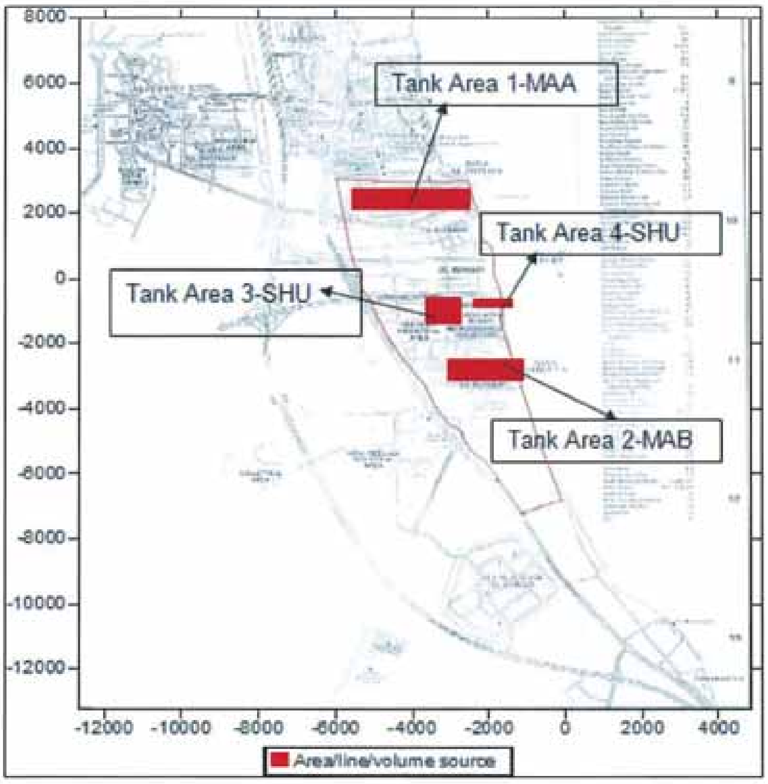
The four different tank areas identified have been entered in ADMS as area sources, and are approximated as rectangles of the equivalent area. The areas are illustrated in Figure 9.28.

Three models were considered in ADMS, namely:

- Specifying the exit velocity directly for each tank area identified, and assuming values of 0.2 and 0.001 m/s (i.e. two separate cases). The latter exit velocity value is referenced by the US EPA.
- Additionally, a conservative exit velocity of 0 m/s was considered, though the actual exit velocity for these VOC emissions will be negligible. Hence the dispersion of pollutants will be driven by the weather (rather than the initial effects of the exit velocity).

It is also noted that statistical meteorological data were used to run the ADMS model.

Figure 9.28: Location of AMDS Area Sources for Tank VOC Model



The ground level, maximum, 100%ile, 1-hour average and annual average VOC concentrations predicted for the three ADMS runs considered anywhere within the facilities and their surrounding areas are summarised in Table 9.32:

Table 9.32: Maximum Ground Level Concentrations of VOCs Anywhere

Model / Case	Pollutant	ST Concentration µg/m³ (100th %ile)	LT Concentration µg/m³
Specified Exit Velocity (0 m/s)	VOC	67	20
Specified Exit Velocity (0.2 m/s)		6	3.5
Specified Exit Velocity (0.001 m/s)		63.2	19

K-EPA and MOO criteria for non-methane hydrocarbons are as follows:

- 1/10 from specified rate in works environment (TLV's). This is considered to be 10% of the occupational exposure limit, which would equate to 0.05ppm for benzene (equivalent to 158 µg/m³)
- 0.24ppm for 3 hours 6-9am (equivalent to 780 µg/m³)
- 100ppb (1 hour average) (equivalent to 324 µg/m³)

Given the results from the modeling, it is clear that the highest estimated 100%ile, 1-hour average VOC concentration anywhere is significantly below (just over 40%) the most stringent VOC criterion for non-methane hydrocarbons specified above (158 µg/m³).

Based on these results it can be concluded that VOC emissions from the tanks associated with this project satisfy all the relevant K-EPA / MOO criteria.

Since fugitive emissions from hydrocarbon storage tanks are essentially averages over long periods of time (e.g. annually, monthly) a comparison was made of the long term VOC modeling results (i.e. annual) against relevant long term criteria. In the absence of long term K-EPA VOC criteria, a comparison was made against incoming EU long term human health criteria (annual, no exceedances allowed) for benzene for 2010 of 5 µg/m³. Maximum concentrations exceed criteria, though it should be noted that benzene constitutes a negligible part of the overall VOC emissions.

However, the USEPA IRIS Reference Concentration (RfC) of 30 µg/m³, which is the concentration at which a lifetime's exposure is not expected to have an adverse effect, is met by the KNPC refinery tank emissions (daily inhalation exposure). Note that the RfC concentration is an estimate associated with large uncertainty.

However, in addition to the emissions from storage tanks shown above, fugitive emissions from process equipment (flanges, valves, pump seals etc) represent another substantial source of VOC's emitted to the atmosphere from the refinery and can frequently account for 50% of the total emissions from a refinery (IPPC Reference Document on BAT for Mineral Oil and Gas Refineries, February 2003). Therefore, the total VOC emissions estimated from the tanks may only represent 50% of the total emissions from the refinery, although fugitive emissions from process plant will not necessarily take place in the same physical area as the tanks.

KNPC have committed to a Leak Detection and Repair (LDAR) Programme, as well as an Odour Management System (OMS) to minimize VOC emissions. These are further discussed in subsequent sections of this EIS. The new CFP facilities will be incorporated within the existing refineries LDAR Programme and OMS System.

9.4.6.8 RMP and CFP Block Maintenance Scenarios

The following two maintenance events scenarios for MAA have been modelled with "Normal Emissions" and combined with emissions from the Decommissioned units:

Maintenance 1: Shutdown of RMP Block would result in only sour fuel gas to be available to MAA Isomerization Unit 107 (two fired heaters). Consequently there would be an increase in SO_2 emissions during operation of CFP 2020 facilities. However, fired equipment within the RMP block will not operate, partially offsetting the increased SO_2 emissions from Unit 107.

Maintenance 2: Shutdown of CFP Block would result in only sour fuel gas to be available to MAA Deisopentanizer Unit 137 (one fired heater) that would result in increased SO_2 emissions. Fired equipment within the CFP block will not operate partially offsetting the increased SO_2 emissions from Unit 137.

Both these events are anticipated to last for up to 30 days, and occur once every four to five years. During the maintenance period, the concentration of H_2S in the fuel gas being consumed by the fired equipment in either Unit 107 or Unit 137 (approximately 1500 mg/dry m^3 at normal conditions) will exceed K-EPA Appendix 20 criteria (230 mg/dry m^3) However, the SO_2 emission rate will still be well below the applicable K-EPA limit (512 ng/J). The potential impacts of the 'above normal' SO_2 emissions for the two maintenance cases were evaluated by air dispersion modelling analysis in consideration of the applicable K-EPA / MOO ambient air quality criteria. For air dispersion modelling purposes, the emissions were assumed to be steady state. It is unlikely that the two maintenance events will occur simultaneously.

The emission data for the maintenance scenario are provided in Table 9.14. Normal case emission with decommissioned units emissions have been modelled together with each of the maintenance scenarios.

It is noted here that NO_2 and H_2S modelling results are not indicated in the tables as their emissions are minimal during these maintenance scenarios.

Maintenance 1: Shutdown RMP Block

During the RMP block shutdown, the specific fired equipment that would be shutdown is listed in Table 9.14 (i.e. one new unit and ten existing units in MAA). The locations of the 10 existing units in MAA were approximated for ADMS input.

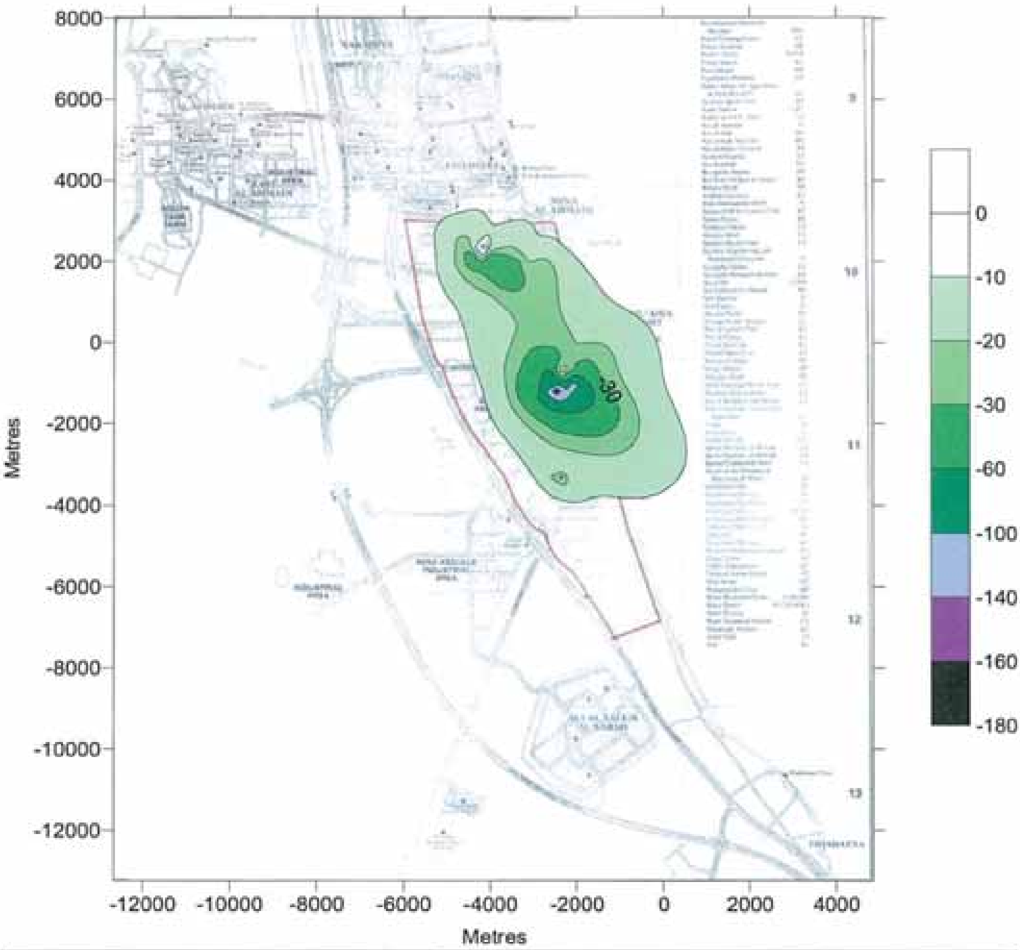
The long term (annual average) and short term (99.7%ile 1 hour average) SO_2 ground level concentration contours results are presented in Figure 9.29 and

Figure 9.30 respectively.

It can be seen that the resulting ground level concentration contour plots for sulphur dioxide are very similar to the Normal Base Case contour plots. Hence it is expected that post-CFP air quality would generally improve in the area.

In conclusion, during RMP block maintenance, the resulting ambient SO_2 concentrations would be within the K-EPA / MOO air quality criteria.

Figure 9.29: SO2 Annual average (Combined – Base Case) – Maintenance 1



All concentrations are given in $\mu g/m^3$.

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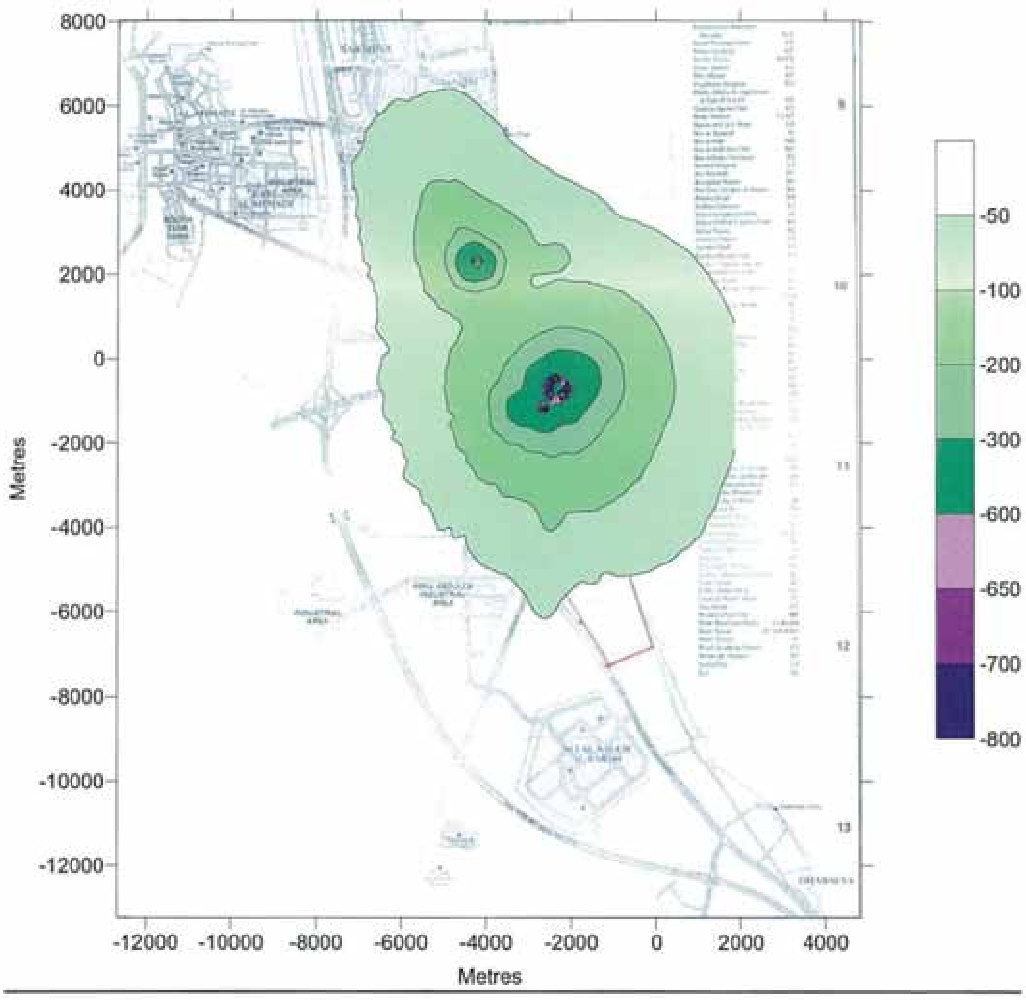
Figure 9.30: SO_2 99.7%ile 1-hour average (Combined – Base Case) – Maintenance 1



All concentrations are given in $\mu g/m^3$.

Maintenance 2: Shutdown of CFP Block

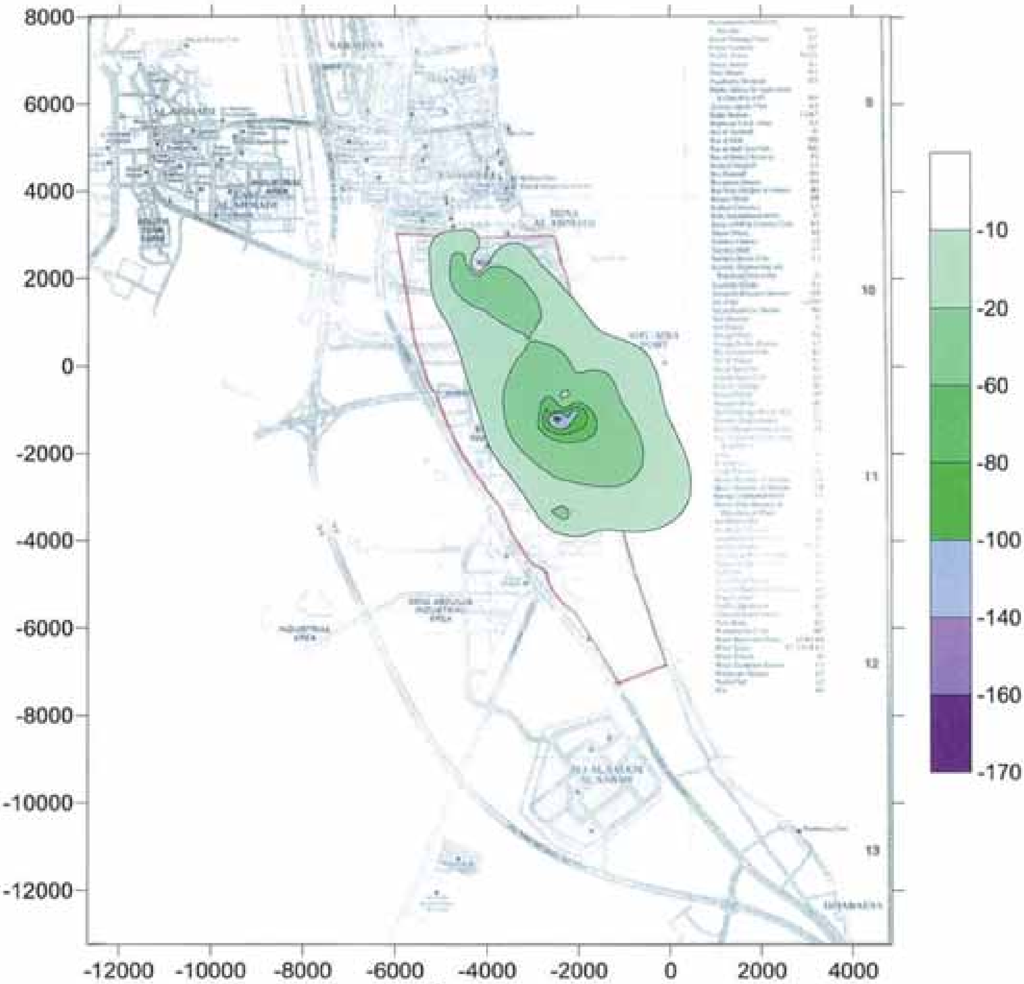
During the CFP block shutdown, the specific fired equipment items that would be shutdown are listed in Table 9.14 (eleven new units in MAA.)

The long term (annual average) and short term (99.7%ile 1 hour average) SO_2 ground level concentration contours results are presented in Figure 9.31 and Figure 9.32.

It can be seen that the resulting ground level concentration contour plots for sulphur dioxide are very similar to the Normal Base Case contour plots. Hence it is expected that post-CFP air quality would generally improve in the area.

In conclusion, during CFP block maintenance, the SO_2 concentrations currently are within the K-EPA / MOO air quality criteria.

Figure 9.31: SO_2 Annual average (Combined – Base Case) – Maintenance 2



All concentrations are given in $\mu g/m^3$.

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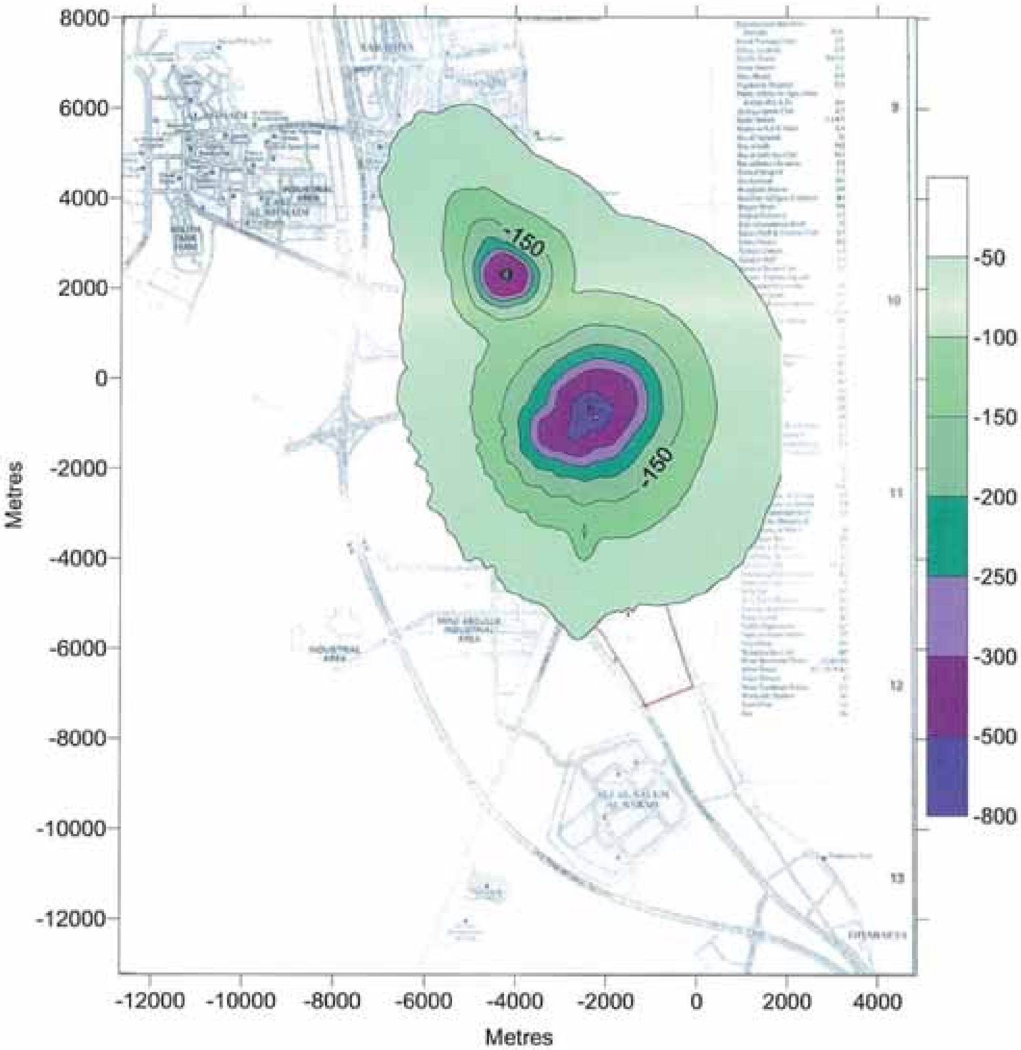
Figure 9.32: SO_2 99.7%ile 1- hour Average (Combined – Base Case) – Maintenance 2



All concentrations are given in $\mu g/m^3$.

9.5 Monitoring

The CFP's EMS will include a schedule for periodic monitoring (i.e., performance testing) of emissions from large fired equipment sources such as steam-generating boilers and process unit heaters. Stack sampling ports and fixed access platforms will be provided for all affected sources. A sampling protocol will be developed, in accordance with international methodologies, to include requirements for reporting and record keeping.

In addition, KNPC will periodically monitor the efficacy of vapour control equipment used to minimize loss of VOCs generated during loading operations at the port.

9.5.1 Continuous and Non-Continuous Emissions Monitoring (CEMS and Non-CEMS)

CFP 2020 will have both continuous and intermittent monitoring for the various air emission sources. These monitoring systems shall include area monitoring, fence line monitoring and in-stack monitoring of flue gases:

- **Point Source Monitoring:** stacks associated with large fired equipment sources that require monitoring will be equipped with sampling ports adequate to support stack gas performance testing.

- **Flare System Monitoring:** the flow rate for waste streams routed to each flare system shall be continuously monitored, displayed and recorded in the DCS control room.

- **Continuous and Periodic Emission Monitoring:** CEMS shall be installed for new dual-fired or oil-fired combustion sources with firing rates greater than 100 MMBTU/hr (~30 MW) and steam generators. It shall continuously measure and record NOx and SOx from each oil-fired heater/furnace/boiler; and Oxygen emissions for all furnace stacks where NOx and SOx are continuously measured. The CFP requirements for periodic and continuous emission monitoring shall be in accordance with KNPC's Procedure on Air Pollution Monitoring and Control.

- **Area/Ambient Monitoring:** CCTV Systems shall be used to monitor refinery operations such as flue gas stacks and pilots on flare systems. Thermocouples shall detect presence of a flare pilot flame. A Combustible Gas Detection System shall be in place to collect and summarize information regarding the ambient concentration of combustible gases such as hydrocarbons and hydrogen. Transmitters and alarms shall also be installed to detect flammable gas/vapours. A H_2S Gas Detection System will be used to monitor strategic areas where sour gas or sour liquids will be handled, processed or stored and a NH_3 Gas Detection System will be used to monitor strategic areas where ammonia may be present in either process or waste streams being handled, processed or stored. Appropriate equipment for monitoring the flow of process vent streams will be provided in the main header of flare systems. The requirement for AAQM at the fence line shall be reviewed vis-à-vis existing provisions and monitoring beyond the fence line shall be assessed subject to conditions specified by K-EPA for environmental approval of the project. A weather monitoring system shall continuously measure, record and read out various meteorological elements.

The monitoring methods used for all of the above shall be as specified by K-EPA otherwise they shall be in accordance with US EPA criteria. Data collection and management systems shall be consistent with those currently implemented for existing KNPC refineries.

9.5.2 Fugitive Emissions Management & LDAR

CFP will establish a programme for prevention, detection and control of fugitive emissions. A description of this programme is outlined below.

VOC emissions come mainly from fugitive emissions. Fugitive emissions are one of the largest sources of refinery hydrocarbon emissions. The aim in all refineries should be to prevent or minimise the release of VOCs. Control of fugitive emissions involve minimising leaks and spills through equipment changes, procedure changes and improved monitoring, good housekeeping and maintenance practices.

The only real option for process component fugitive release is the implementation of a permanent on – going Leak Detection and Repair (LDAR) programme. This consists of using a portable VOC detecting instrument to detect leaks during regularly scheduled inspections of valves, flanges and pump seals. Leaks are then repaired immediately or as scheduled for repair as quickly as possible. An LDAR programme could reduce fugitive emissions 40 to 60 percent, depending on the frequency of inspections.

A typical LDAR programme contains following elements:

- Type of measurement (e.g. detection limit of 500 ppm for valves and flanges, against the interface of the flange)
- Frequency (e.g. twice a year)
- Type of components to be checked (e.g. pumps, control valves, heat exchangers, connectors, flanges)
- Type of compound lines (e.g. exclude lines that contain liquids with a vapour pressure above 13kPa)
- What leaks should be repaired and how fast the action should be taken

The principle of fugitive loss is well known and their minimising has been the subject of much investigation and action, mainly led by operators subject to extremely tight regulations. Some techniques to consider are:

- An essential first step of any programme is to establish a fugitive release inventory for the refinery. This normally involves a combination of sampling, measurements, environmental, monitoring, dispersion modelling and estimates based on emission factors

- Identify all potential sources of VOC releases, by establishing population counts of equipment components in line with up to date P& I drawings for processes. This survey should cover gas, vapour and light liquid duties
- Quantifying of the VOC releases, initially as "baseline" estimates, and subsequently to more refined levels.
- A strategy to reduce VOC emissions: efficient seals and valves, good maintenance programmes, minimising number of flanged connections on pipelines and use of high specification joining materials, use of canned pumps or double seals on conventional pumps, use of end caps or plugs on open ended lines install maintenance drain – out system to eliminate open discharges.

9.5.3 KNPC Odour Management System

Odour management is a sensitive and challenging issue. Odours are difficult to measure and surrounding communities are sensitive receptors. As KNPC would like to remain a "Good Neighbour", a 5-year Odour Management System (OMS) has been built into the KNPC EMS with a common approach across all its sites, and is summarised in Figure 9.33. This is in line with the KNPC HSE standards. After 5 years, it will be managed as a regular activity.

Figure 9.33: Summary of KNPC OMS

OMS Mission

To be "odour-free"

OMS Vision

Be a role model among peers in running our business "odour-free" by adopting the best strategies for odour elimination.

Objectives:

1. Develop an OMS to eliminate odour from routine activities, eliminate odour from non-routing activities and minimise odor during emergencies.
2. Develop and action plan for the implementation of OMS

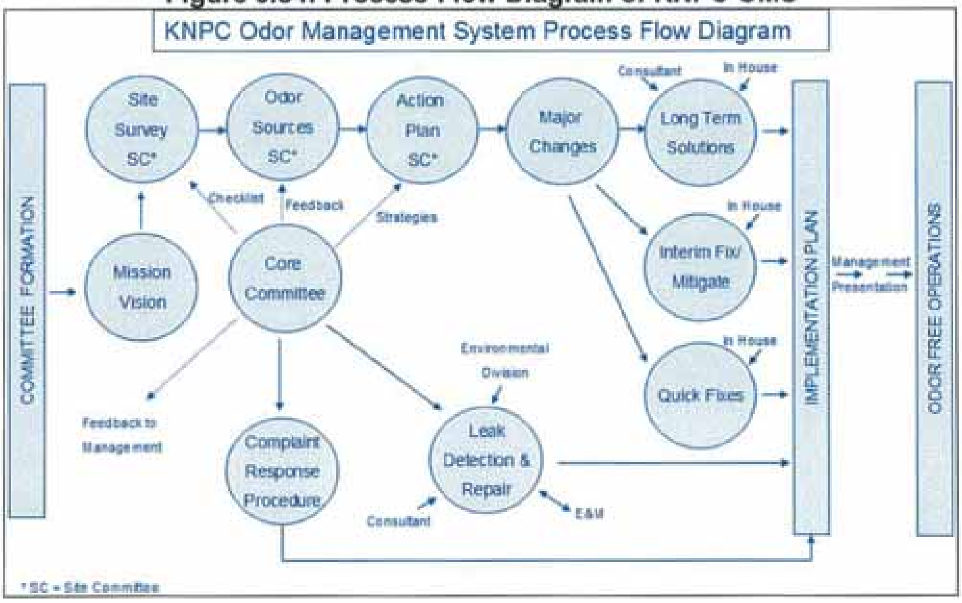
The KNPC OMS, is a proactive system that ensures continual improvement and, additionally:

- Improves overall environmental performance through fugitive emission monitoring, control and elimination.
- Enhances KNPC's ability to demonstrate a responsible environmental attitude which can dramatically improve its image thus foster a better relationship with the company's stake holders.
- Provides early detection of emissions from various sources thus reducing pollution incidents and associated expenses of recovery.
- Helps in early awareness of problems, which would offer the best opportunities for an efficient resolution.
- Reduces loses, improving the overall profit.

- Improves working environment and enhances Health and Safety standards resulting in an improved efficiency of the workforce.
- Creates a foundation for the next level of improvement.
- Demonstrates the organisations' proactive approach towards pollution prevention.
- Provides an effective structure for handling environmental complaints from the community as well as personnel working at KNPC.
- Exhibits a transparent image of the organisation by providing feedback to the complainant on KNPC's response.
- Enhances the quality of life outside, as well as inside KNPC by minimising the odour nuisance.
- Provides a structured approach for considering and addressing potential odour sources early in the project.

A process flow diagram describing the KNPC OMS is shown in Figure 9.34, and is briefly summarised in the section that follows.

Figure 9.34: Process Flow Diagram of KNPC OMS



Core Committee

This committee was formed to give direction to the Program and to provide feedback to management. It is comprised of members from all KNPC sites.

Site Committee

This committee was formed to coordinate activities at each site. They perform odour surveys to detect, identify and quantify odours, as well as locate their source.

Leak Detection and Repair

This program is designed to routinely monitor equipment for leaks, and to fix any equipment found leaking. The leak detection part of the Program will be carried out by a contractor using Optical IR cameras supplied by KNPC for identifying

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Hydrocarbon leaks. PID/FID meters will be used to measure the concentration at the point of leak. The contractor will use hand-held gas analysers and check pre-identified non-hydrocarbon components to identify non-hydrocarbon leaks. The leaks will be repaired through existing KNPC work processes.

Complaint Recording and Tracking System
The purpose of this system is to receive, log, react to stop their occurrence and track all environmental complaints (both internal and external) associated with all KNPC activities. The source of these complaints will be identified and integrated into the list of odour stressors.

Odour Control Measures
Proposed control measures were identified by the Site Committees in consultation with Process, Operations and E&M representatives. The Core Committee, in consultation with Chevron, selected the best common solutions. The solutions were classified as:

- Quick fixes (short term)
- Long term capital upgrades
- Work process/Practice improvements, Procedural changes, LDA

9.5.4 Monitoring Methodologies

KNPC's procedures include the following main elements:

- air pollution control equipment will be maintained / operated to K-EPA / MOO criteria;
- measurements will be gaseous samples (lab) analysis or by continuous monitoring;
- monitoring the various parameters will be according to K-EPA / MOO requirements.
- responsibilities under the air monitoring procedures are also specified.

Monitoring methods will be as specified by K-EPA / MOO, otherwise they will be in accordance with USEPA criteria per 40 CFR Part 50, 40 CFR Part 53 for ambient air quality and 40 CFR Part 60 for stack emissions. Monitoring sampling system equipment will be based on monitoring the following parameters:

- Oxygen: via paramagnetic sampling;
- CO and SOx: via infrared absorption;
- NOx : via chemi-luminescence or UV fluorescence;
- SOx: via infrared absorption / UV fluorescence;
- Hydrocarbons: via photo / flame ionization.

CO emissions are monitored indirectly by oxygen sensors provided for combustion sources such as boilers and incinerators. Reporting and recordkeeping requirements for the CFP will be consistent with those currently implemented at the three existing KNPC refineries.

9.5.5 Communications, Calibration and Testing

CEMS sets out a number of communication requirements including: local data acquisition system (DAS); hardcopy environmental reporting will not be acceptable. DAS will be capable of handling data from multiple CEMS units (about 20), appropriate alarms (specified) must be in place, plus the minimum features for Integrated DAS.

All sampling and monitoring equipment will be calibrated and validated, including daily auto-validation (e.g. on high and low calibration gas) and manual calibration by technician intervention. Both a 'Factory Acceptance Test' (FAT) procedure for testing via contractors' own instrumentation, and a 'Site Acceptance Test' (SAT) will be undertaken after equipment is installed. Training for the KNPC engineering, maintenance and HSE personnel will be provided at the manufacturer's facilities as necessary.

9.6 CO_2 Emissions from the CFP

9.6.1 Introduction

This section provides an estimate of the Carbon Dioxide (CO_2) emissions that will result from CFP, which are then compared against current KNPC refinery annual CO_2 emissions to examine if CO_2 emissions will increase or decrease overall as a result of the CFP.

CO_2 is a greenhouse gas, which contributes to the phenomena of global warming. Although CO_2 has a low greenhouse warming potential relative to other greenhouse gases (i.e. methane, nitrous oxide, hydrofluorocarbons), it is produced in far greater quantities by refining operations.

The CO_2 calculations relate only to activities associated with combustion of fossil fuels at the refineries and do not include:

- Process related emissions (assumed similar before and after CFP).
- CO_2 emissions related to transport.
- CO_2 emissions from electricity consumption.
- CO_2 emissions related to flaring (assumed similar before and after CFP).

As such, this study is indicative only and is not in accordance to EU emissions trading scheme methodology.

This section also discusses KNPC's CO_2 reduction strategy document, KPC Corporate HSE: Management of energy and resources (Document 18).

9.6.2 Approach

The approach was to calculate the amount of net CO_2 emissions post-CFP by:

- Adding the 2007 CO_2 emissions associated with current refinery operations (pre-CFP) to the CO_2 emissions due to new fired CFP process facilities;
- Subtracting the CO_2 emissions that will be associated with the fuel burning process units at MAA, MAB and SHU that will be decommissioned.

The conclusions assume that SHU Refinery, as well as some process units at MAA and MAB, are decommissioned in parallel with the commissioning of the new CFP process units.

9.6.3 CO2 Emission Data

KNPC and Fluor provided the following CO_2 emission data (data not verified by DNV):

Table 9.33: 2007 CO_2 Emissions for MAA, MAB and SHU

Refinery	Tonnes CO_2 /yr
MAA	4,714,602
MAB	2,325,956
SHU*	2,408,984

**Note SHU data was based on 11 months data and pro rated for 12 months*

Table 9.34: 2007 CO_2 Emissions for Decommissioned Units at MAA, MAB and SHU

Refinery	Units retired	Tonnes CO_2 /yr
MAA	CDU-03	216,624
	H-44-001	36,089
MAB	CDU-01	167,448
	RCD U-03	37,032
	H2 U-03	199,860
	H-16-101	14,916
SHU	All units	2,408,984
All units		3,080,953

Data was also provided for normal fired–duties of new CFP units at MAA and MAB (see Table 9.35 and Table 9.36), which are then converted into CO_2 emissions using appropriate factors, as described below.

9.6.4 Calculation of CO_2 Emissions for New CFP Process Units

All CFP fired equipment will burn refinery fuel gas with the exception of two utility steam boilers at MAB which will burn fuel oil. Normal fired–duties of these new CFP units at MAA & MAB are provided in Table 9.35 and Table 9.36.

To calculate CO_2 emissions, the normal fired duty of the process units is multiplied by an Emission Factor, which were sourced from:

- UK Department of Environment Food & Rural Affairs : *Guidelines to Defra's greenhouse gas (GHG) conversion factors for company reporting June 2007* (www.defra.gov.uk)
- US Department of Energy: *Units conversion, emissions factors, and other reference data (Nov 2004).*

Table 9.35: List of New CFP 2020 Fired Equipment Air Emission Point Sources at MAA

(List does not include diesel engine drivers for emergency generators & fire water pumps, as they are only used intermittently)

MAA Refinery					
Unit Number	**Point Source Description**[1]	**Equipment Tag Number**	**Fuel Type**	**Fired Duty**	**Normal Fired Duty**[1]
				MMBtu/hr	(kW)
	PROCESS UNITS				
135	DCU-NHTU Fired Heater	135-F-0101	Gas	10.0	2929
136	DCU - 2 Coke Heaters (Common Stack)	136-F-0201A/B	Gas	255.1	74743
137	Deisopentanizer - DIP Reboiler Heater	137-F-0101	Gas	177.9	52124
141	ARDS Reactor Feed Furnace	141-F-0201	Gas	55.0	16114
141	ARDS Fractionation Feed Furnace	141-F-0401	Gas	75.9	22238
148	HPU Reforming Furnace	148-F-0301	Gas	464.2	136000
151/152	TGTU Tail Gas Incinerator	151-F-0132	Gas	22.4	6574
151/152	TGTU Tail Gas Incinerator	152-F-0132	Gas	22.4	6574
183	VRU Vacuum Charge Heater	183-F-0101	Gas	170.0	49809
186	FCC-NHTU HDS Reactor Heater	186-F-0201	Gas	16.0	4673
186	FCC-NHTU HDS Reactor Heater	186-F-0202	Gas	20.5	5994
25/26	NHT Charge Heater (revamp existing)	H25-101	Gas	29.0	8491
25/26	NHT Charge Heater (revamp existing)	H26-101	Gas	29.0	8491
	U&O UNITS				
129	Steam System Utility Boiler (data is per boiler; total of 3)	129-F-0201A	Gas	362.3	106152
129	Steam System Utility Boiler (data is per boiler; total of 3)	129-F-0201B	Gas	362.3	106152

(List does not include diesel engine drivers for emergency generators & fire water pumps, as they are only used intermittently)					
MAA Refinery					
Unit Number	**Point Source Description[1]**	**Equipment Tag Number**	**Fuel Type**	**Fired Duty**	**Normal Fired Duty[1]**
				MMBtu/hr	(kW)
	PROCESS UNITS				
129	Steam System Utility Boiler (data is per boiler; total of 3)	129-F-0201C	Gas	362.3	106152
187	Coke Handling (No Fired Equipment)	---	---		0
	NEW FEED UPDATE PROCESS UNITS				0
107	Isomerization	107-F-0101	Gas	57.8	16943
107	Isomerization	107-F-0102	Gas	259.7	76095
144	GOD	144-F-0101	Gas	38.0	11133
	TOTAL			**2789.8**	**817392**

[1] Conversion 1kW/mmBTU/h 0.003413

Table 9.36: List of New CFP 2020 Fired Equipment Air Emission Point Sources at MAB

Unit Number	Point Source Description[1]	Equipment Tag Number	Fuel Type	Fired Duty	Normal Fired Duty[1]
(List does not include diesel engine drivers for emergency generators & fire water pumps,as they are only used intermittently)					
MAB Refinery					
				MMBtu/hr	(kW)
	PROCESS UNITS				
111	Crude Distillation - 2 Heaters (Common Stack)	111-F-0101A/B	Gas	467.6	137005
112	ARDS Reactor Feed Furnace Train 1	112-F-0101	Gas	68.6	20099
112	ARDS Reactor Feed Furnace Train 2	112-F-0201	Gas	68.6	20099
112	ARDS Atmospheric Fractionator Feed Furnace	112-F-0401	Gas	160.5	47026
212	ARDS Reactor Feed Furnace	212-F-0101	Gas	68.6	20099
212	ARDS Atmospheric Fractionator Feed Furnace	212-F-0401	Gas	80.3	23527
114	Hydrocracker 1st Stage Gas Heater	114-F-0101	Gas	51.3	15030
114	Hydrocracker 2nd Stage Gas Heater	114-F-0102	Gas	69.7	20421
114	Hydrocracker Product Fractionator Feed Furnace	114-F-0103	Gas	304.1	89100
115	KHT Reactor Feed Furnace	115-F-0101	Gas	16.4	4805
116	DHT Reactor Feed Furnace	116-F-0101	Gas	93.9	27521
117	NHT Reactor Feed Furnace	117-F-0101	Gas	6.1	1787
118	H2 Plant Tubular Reformer Furnace (Train 1)	118-F-0101	Gas	1335.0	391151
118	H2 Plant Tubular Reformer Furnace (Train 2)	118-F-0201	Gas	1335.0	391151
123	SRU-TGTU Tail Gas Incinerator	123-F-0132	Gas	48.9	14327
123	SRU-TGTU Tail Gas Incinerator	123-F-0232	Gas	48.9	14327
123	SRU-TGTU Tail Gas Incinerator	123-F-0332	Gas	48.9	14327
127	CCR Reactor Feed Furnace (common stack)	127-F-0101/0102/0103/0104	Gas	218.1	63902

(List does not include diesel engine drivers for emergency generators & fire water pumps,as they are only used intermittently)

MAB Refinery

Unit Number	Point Source Description[1]	Equipment Tag Number	Fuel Type	Fired Duty	Normal Fired Duty[1]
				MMBtu/hr	(kW)
	PROCESS UNITS				
127	CCR Stabilizer Reboiler	127-F-015	Gas	18.2	5332
213	VRU Vacuum Charge Heater	213-F-0101	Gas	134.2	39320
11	CDU Fired Heater (existing)	H-11-101	Dual (Gas)	391.0	114562
			Dual (Liquid)		0
	U&O UNITS				
131	Steam System Utility Boiler (data is per boiler; total of 6)	131-F-0201A	Dual (Gas)	190.9	55923
			Dual (liquid)		0
131	Steam System Utility Boiler	131-F-0201B	Dual (Gas)	190.9	55923
131	Steam System Utility Boiler	131-F-0201C	Dual (Gas)	190.9	55923
131	Steam System Utility Boiler	131-F-0201D	Dual (Gas)	190.9	55923
131	Steam System Utility Boiler	131-F-0201E	Dual (Gas)	190.9	55923
131	Steam System Utility Boiler	131-F-0201F	Dual (Gas)	190.9	55923
156	WWT Oily Sludge Incinerator	156-A-0209-F01	Gas	8.9	2607
	NEW FEED UPDATE PROCESS UNITS				
214	Hydrocracker - 3 Heaters Combined (Common Stack)	214-F-0101/0102/0103	Gas	324.2	94989
216	DHT Reactor Feed Furnace	216-F-0101	Gas	93.9	27521
118	H2 Plant Tubular Reformer Furnace (Train 3)	118-F-0301	Gas	1335.0	391151
	TOTAL			**7941.2**	**2326738**

[1] Conversion 1kW/mmBTU/h 0.003413

Using data from Table 9.35 and Table 9.36, Table 9.37 provides the calculated CO_2 emissions for the new CFP project using UK Government guidelines.

Table 9.37: Conversion of CFP Fired Equipment Duty to CO_2 Emissions

				Guidelines to Defra's GHG conversion factors for company reporting		
				DEFRA		
				Natural Gas	Fuel Oil	
				kgCO2/kWh		**tonnesCO2/kg CO2h**
				Gross CV	Gross CV	
				0.185	0.267	1.00E-03
				KgCO2h		Tonnes Co2 /h
MAA	Refinery fuel gas	MMBtu/hr	2,790			
		kW	817,392	151,218		**151**
MAA : Total tonnes CO2/yr						**1,324,645**
MAB	Refinery fuel gas	MMBtu/hr	7,941			
		kW	2,326,738	430,447		**430**
MAB: Total tonnes CO2/yr						**3,770,654**

Note: When using data from supplied by US Department of Energy, emissions only vary by approximately 2%.
CV = Calorific Value

The following assumptions were made when estimating CO_2 emissions:

- When using reference data from DEFRA, the gross calorific value was used as advised by guidelines.
- Emission factor data for refinery fuel gas (20 – 50% hydrogen) was calculated by applying the natural gas emission factor multiplied by a factor of 1.07% (this is equivalent to Exxon refining group factor for refinery fuel gas)
- CO_2 emissions were calculated based on plant running 24 hrs for 365 days per annum.

9.6.5 Conclusions

Table 9.38 summarises the post-CFP CO_2 emissions provided SHU Refinery is decommissioned. It can be seen that there will be an estimated 18% increase in CO_2 emissions as a result of commissioning the CFP, which is a negative impact, although the decommissioned units at SHU, MAA & MAB offset approximately 60% of the new CFP facilities CO_2 emissions.

Table 9.38: Summary of CO_2 Emissions Pre & Post-CFP

	2007 Annual CO2 emissions	Annual CO2 emissions for the Retired Units post CFP			Annual CO2 emissions from CFP		Total annual CO2 emissions post CFP	
	tonnes/yr	Units	tonnes/mth	tonnes/yr	tonnes/yr	tonnes/yr		
					Defra	US Dept of energy	Defra	US Dept of energy
MAA	4,714,602	CDU-03	18,052	216,624	1,324,645	1,290,179		
		H-44-001	3,007	36,089				
MAB	2,325,956	CDU-01	13,954	167,448	3,770,654	3,672,544		
		RCD U-02	3,086	37,032				
		H2 U-03	16,655	199,860				
		H-16-101	1,243	14,916				
SHU	2,408,984	SHU		2,408,984				
Total	**9,449,542**			**3,080,953**	**5,095,299**	**4,962,723**	11,463,888	11,331,312
Increase in CO2 emissions							**18%**	**17%**

There will be opportunities for reducing CO_2 emissions as KNPC has outlined their energy conservation strategy to help preserve non-renewable resources for future generations in the KPC Corporate HSE: Management of Energy & Resources (Document 18).

KNPC has a policy in place to ensure all energy will be managed to best engineering environmental principles and within regulatory requirements (including international requirements) at all times. It commits to institute a written energy efficiency programme wherever energy is generated with clear objectives overseen by a competent person managing this programme. To ensure the programme is effective, audits will be conducted and adequate training of staff will be conducted. This will be part of the Environmental Management System (EMS) ISO14001.

9.7 Conclusions

- Air quality in the vicinity of the existing KNPC refineries generally improves as a result of the Clean Fuels Project:
- On commissioning the CFP, KNPC will decommission all significant air emission point sources at the SHU Refinery (as well as some units at MAA and MAB refineries), many of which have large emission rates. This will help reduce the pollutants emitted to atmosphere, hence improving the air quality in the area, because the new CFP sources that will be commissioned will emit significantly less than the decommissioned units.
- Overall, particularly for the "normal" CFP operating scenario, there will be improvements in the air quality for the vast majority of the monitoring point locations that currently do not meet criteria (i.e. where background data currently indicate that criteria are exceeded).
- This is mainly due to the fact that pollutant emission load from sources to be decommissioned far exceed the emissions associated with new CFP sources. For example, the total decommissioned source emissions for NO_x and SO_2 are approximately 211 g/s and 510 g/s, whereas for "normal" operation of the new CFP sources, the corresponding total NO_x and SO_2 emissions will be 124 g/s and 16 g/s respectively. Hence the resulting significant improvement.
- After the completion of CFP, the majority of long and short term NO_2 and SO_2 concentrations at the monitoring point locations are reduced for the "normal" emissions case. The TSP concentrations improve at all the monitoring point locations.
- For the "maximum" emission case, the CFP project results in a general overall improvement for both the long and short term concentrations of NO_2 and SO_2 at the various monitoring points as compared to baseline data. It should be noted though that in a number of monitoring point locations the long and short term NO_2 and SO_2 concentrations have increased after the completion of the CFP, but all comply with the applicable K-EPA / MOO criteria.
- There is only one case where, whilst exceeding the K-EPA / MOO relevant criteria, the pollutant concentration has been increased at a monitoring point (for the "maximum" case). This relates to the long term SO_2 concentration at location A24 (coastal area adjacent to MAB refinery), where the actual increase to the background long term concentration is around 2 $\mu g/m^3$.
- The CFP will increase KNPC's CO_2 emissions as a result of commissioning the CFP. Note that the decommissioned units at SHU, MAA & MAB offset approximately 60% of the new CFP facilities CO_2 emissions.
- CFP emissions during upset SRU emergency conditions (SRU Upset Scenarios 1 & 2) satisfy the relevant criteria.
- For the two maintenance scenarios (shutdown of RMP and CFP blocks), the resulting ambient air quality SO_2 concentrations will generally improve air quality compared against current conditions. However, it should be noted that during these shutdown maintenance events, sweet fuel gas will not be available. Instead, fired equipment in MAA Unit 107 and MAA Unit 137 will temporarily consume imported fuel gas that exceeds the H_2S limits specified in K-EPA Appendix 20 until maintenance work to facilities within the RMP block (for increased SO_2 emissions from Unit 107) and CFP block (for increased SO_2 emissions from Unit 137) is completed.

- Fugitive emissions on site from the tank farms areas satisfy relevant K-EPA criteria, after dispersion of the emissions is factored in. It should be noted that the total VOC emissions from the tanks are estimated to only represent approximately 50% of the total VOC emissions from the refineries, although other VOC fugitive emissions (process plant emissions) will not necessarily take place in the same physical area as the tanks.

  It may also be appropriate to compare the long term VOC modeling results (i.e. annual) against relevant criteria (such as EU criteria as there is no relevant K-EPA / MOO criteria), because the fugitive emissions from tanks are essentially averages over long periods of time (e.g. annually, monthly). The long term annual EU criterion for benzene is $5\mu g/m^3$, and this is exceeded by the KNPC emissions, though it should be noted that:
    - Benzene would only constitute a very small part of the overall VOC emissions.
    - The USEPA IRIS Reference Concentration (RfC) of 30 $\mu g/m^3$ (the concentration at which a lifetime's exposure is expected to have no adverse effect) is met by KNPC refinery emissions, although the RfC concentration is an estimate with significant uncertainty.
- Although, air quality in the study area improves as a result of the CFP, air quality criteria are still breached in some areas for some parameters.
- No conclusion can be drawn on the effect that the CFP has on the ambient H_2S concentrations, as no information was available for the decommissioned sources contribution related to this pollutant. Only information for new H_2S source emissions were included in the modelling conducted, and the resulting impact of these H_2S emissions from the new CFP sources is small (i.e. they do not significantly affect the ambient air quality). Therefore, any decommissioned units which has significant hydrogen sulphide emissions will improve the air quality in the refineries and the surrounding area.

- *Emergency Flare modelling*: The initial results for the emergency flaring scenarios indicate that the occupational exposure standards for SO_2 are exceeded, both within and beyond the refinery boundary, for the new acid gas flare at MAB (Unit 146). All other cases satisfy the occupational exposure standard for SO_2.

  Despite the fact that the occupational exposure criteria for sulphur dioxide are satisfied (with the exception of the new acid gas flare at MAB, Unit 146), some consideration has to be given for the resulting ground level pollutant concentrations beyond the fence-line of the refineries.

  In the absence of any guidelines or criteria from K-EPA/MOO for this type of emergency event beyond the refinery fence-lines, the CFP compared maximum ground level concentrations against more stringent US air quality criterion.

  Maximum ground level sulphur dioxide concentrations beyond the refinery fence-lines will exceed (for the flares associated with Units 162, 167, 146, 149 HP HC and the Total Power Failure Case based on the current design flare load and stack height) the US AEGL-2 (Acute Exposure Guideline Levels) criterion for sulphur dioxide.

  The acid gas flare at MAB (Unit 146) will also exceed the US ERPG-2 (US Emergency Response Planning Guidelines) criterion for sulphur dioxide.

As a result, sensitivity analysis was conducted with increased flare heights. This indicated that:

- The maximum ground level concentration of sulphur dioxide for all flare emission scenarios, including the TPF case, now meet the OEL criterion.
- The maximum ground level concentration of sulphur dioxide for all flare emission scenarios, including the TPF case, now meet the ERPG-2 criterion.
- Flare emissions Units 162 and 149 HP HC satisfy the stricter AEGL-2 criterion for sulphur dioxide.
- For the acid gas flares at MAA (Unit 167) and MAB (Unit 146), the AEGL-2 criterion for sulphur dioxide will be exceeded beyond the refineries fence-line, even at the revised height of 141 m.
- The revised combined TPF case, when accounting for the different stack heights for the revised heights of flares at MAA and MAB, improves from the base case, with the resulting sulphur dioxide ground level concentration still exceeding the AEGL-2 criterion. Unit 62 is the main contributor of sulphur dioxide emissions to the TPF case.

The key outcome from the sensitivity analysis is that further work should be conducted in order to investigate the peak ground level sulphur dioxide concentrations from Units 146, 167 and 62 (associated with the TPF case only). The peak concentration results for these units currently exceed the AEGL-2 criterion for sulphur dioxide beyond the refineries boundary.

Preliminary sensitivity analysis on the aforementioned flare units indicates that with the emission rate of sulphur dioxide halved, the resulting peak ground level concentrations will reduce proportionally. This would result in MAA Unit 167 Case 2 and the TPF case meeting the AEGL-2 criterion. MAB Unit 146 Case 2 would still not meet the AEGL-2 criterion. In order for this case to meet the AEGL-2 criterion, the emission rate of sulphur dioxide should be reduced to around 35-40% of its current value.

Consequently, KNPC will implement design changes during the EPC phase to reduce the relief loads for the flare systems which have the highest potential impact on the receptors located outside the refinery boundaries.

Note that the CFP flare systems have been modelled conservatively, as it has been assumed that:

- Emissions will be steady-state, whereas in reality releases associated with emergency flaring are anticipated to last for around 15 minutes to 1 hour.
- Based on operating experience from the KNPC refineries, it is unlikely that all flares will be emitting under emergency at the same time at both the MAA and MAB refineries (as modelled for the Total Power Failure scenario).
- It is noted that the beach houses located to the south-east of MAB refinery may not be occupied on a continuous, year-round basis.

9.8 Recommendations

It is recommended that:

- KNPC implement design changes during the EPC phase in order to reduce the relief loads to the flare systems, particularly for the flare systems that have the highest potential impact on sensitive receptors outside the refinery boundaries (Units 146, 167 and 62. Note that Unit 62 is associated with the Total Power Failure case).
- More detailed air dispersion modelling of the emergency flare scenarios should then be conducted during the detailed design / EPC stages of the project, to verify compliance with applicable criteria.
- Currently, the MIPP provides procedures for responding to gas release incidents. These should be expanded to include details for major emergency flaring events, and appropriate actions defined (e.g. warning residents).
- The CFP clearly improves air quality in the study area on a day-to-day basis, although exceedences for some parameters are still observed. It is recommended that scope for additional air quality improvements at the existing refineries be examined under KNPC's ongoing commitment to continuously improve environmental performance.
- It is important that a strict Leak Detection and Repair (LDAR) programme is implemented and enforced onsite to control VOC emissions. The new CFP facilities will be incorporated in the existing refineries LDAR programme.
- The Environmental Management System for the Clean Fuels Project should include a continuous performance improvement process for evaluating and maintaining the efficacy of emissions control equipment, and energy efficiency. The CFP facilities will be incorporated in the existing refineries' EMS.

10.0 Waste

10.1 CFP Waste Management

The CFP will generate a variety of solid wastes that are both hazardous and non-hazardous. All solid waste shall be termed either hazardous or non-hazardous in accordance with K-EPA criteria depending on its nature and/or the presence of contaminants.

As defined by Article No. 19 of the K-EPA regulations, hazardous wastes are *"any wastes posing potential direct hazards to man or animal's health or the environment in general, resulting from industrial, commercial and agricultural activities and from the household wastes, which are identifiable by any of the disciplines stated in Appendix No. 11-1 and classified in Appendix No. 11-2 hereof and, thus, require carrying out the toxicity tests, analyzing the waste filtrate to check the permissible limits stated in Appendix No. 11-3 hereof".* Hazardous wastes may generally include any solid, semi-solid, liquid or contained gaseous waste, or combination of such wastes, which may because of its quantity, concentration, physical or chemical characteristics, pose a hazard or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of or otherwise managed. These wastes include chemical wastes identified as discarded commercial chemical products, off-specification products/chemicals, container residues and spill residues."

Kuwait is a signatory to and has ratified the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes. This Convention imposes a number of obligations upon the signatory parties including appropriate measures to:

a. Ensure that the generation of hazardous wastes and other wastes within it are reduced to a minimum, taking into account social, technological and economic aspects;
b. Ensure the availability of adequate disposal facilities, for the environmentally sound management of hazardous wastes and other wastes, that shall be located, to the extent possible, within it, whatever the place of their disposal;
c. Ensure that persons involved in the management of hazardous wastes or other wastes within it take such steps as are necessary to prevent pollution due to hazardous wastes and other wastes arising from such management and, if such pollution occurs, to minimize the consequences thereof for human health and the environment.

K-EPA has adopted the definitions and characteristics for hazardous wastes developed under this convention. As such, the classification of hazardous characteristics for wastes generated by the CFP will be performed in accordance with the UN Class and Code as provided per the Basel Convention (refer to K-EPA Appendix No. 11-1). These hazardous characteristics are as follows:

- Explosive Substances;
- Flammable Liquids;
- Flammable Solid Substances;
- Substances or Wastes Liable to Spontaneous Combustion;
- Substances or Wastes Emitting Inflammable Gases when Contacting Water;
- Oxidizing Substances;
- Organic Peroxides;
- Poisonous Substances (acute);

- Infectious Substances;
- Corrosive Substances;
- Liberation of Toxic Gases in Contact with Air or Water;
- Toxic (delayed or chronic);
- Ecotoxic;
- Substances, which are capable, by any means, after disposal, of yielding another material, e.g. leachate, which possesses any of the characteristics listed above.

Among the categories of waste streams to be controlled under Annex III of the Basel Convention (K-EPA Appendix No. 11-2) which are expected to be generated by the CFP are:

- Category Y6 – Wastes from the production, formulation and use of organic solvents.
- Category Y9 – Waste oil / water, hydrocarbons / water mixtures, emulsions.
- Category Y11 – Waste tarry residues arising from refining, distillation and any pyrolytic treatment.
- Category Y12 – Wastes resulting from the production, formulation and use of inks, polish, colouring substances, paints lacquers and varnish.
- Category Y13 – Wastes resulting from the production, formulation and use of resins, plasticizers, glues and adhesive substances.

Other categories of wastes include non-hazardous industrial waste, municipal waste and inert waste.

- Non-hazardous industrial wastes include solid, liquid and semi-liquid wastes.
- Municipal wastes include garbage, refuse, food waste, office waste etc.
- Inert wastes are those wastes which are not biologically or chemically active in the natural environment, such as glass, concrete, brick, broken clay etc.

10.2 Waste Management Procedures

The management of both non-hazardous and hazardous liquid or solid wastes on site will be undertaken using the existing KNPC Procedure for Solid Waste Management (SHE-ENVP-03-006). The procedure ensures that solid wastes generated from all KNPC sites are managed in a systematic, controllable and accountable manner in order to reduce associated environmental risks to an acceptable level. The procedure also ensures compliance with applicable K-EPA requirements as well as international regulations and guidelines. The procedure involves the following:

10.2.1 Waste Segregation

- Different types of wastes shall be sorted and segregated for effective waste management;
- Incompatible waste shall be managed so as to minimise cross-reaction or chemical incompatibility. This prevents mixing of waste in a manner that will produce dangerous or harmful effects e.g. oxidizing acids must be kept away from organic acid and flammable and combustible materials'. A list of incompatible wastes is found in Annexure 2D of KNPC's Waste Management Procedures.

10.2.2 Screening and Identification of Hazard Characteristics

- Waste shall be categorized by using a common list of wastes generated at KNPC (Annexure 2E of SHE-ESHU-03-1406: Procedure for Solid Waste Management). This shall be done by the Environmental Division in consultation with the Waste Generating Department (WGD) and Technical Services Department;
- Wastes not listed in the common list will be characterised on the basis of chemical, physical and environmental characteristics as outlined in Annexure 3A (Categories of wastes to be controlled according to Basel Agreement), 3B (List of hazardous characteristics as per Basel Agreement), 3C (Toxicity Characteristic Leaching Procedure or TCLP test for hazardous characteristics) & 3D (limits allowed for hazardous pollutants concentration that leachate produce);
- If any waste is categorised in Annexure 3A and exhibits any one of the characteristics mentioned in Annexure 3B, the waste will be categorised as "Hazardous Waste". If the waste does not fall in any category of Annexure 3A, the waste shall be declared as "Non-Hazardous Waste";
- As part of the screening process, the waste needs to undergo TCLP testing and if any of the parameters stated in Annexure 3D is found in the waste in excess of the limit prescribed by K-EPA, the waste shall be declared as "Hazardous Waste".

10.2.3 Waste Profile Sheet

The Environment Division shall create a physical, chemical and environmental hazard profile for each type of waste in consultation with the WGD and Technical Services Department-Refineries/Technical Services Division-LM/Engineering Division-LM.

- The waste shall be allocated a unique 'WPS number', which refers to the Waste Profile Sheet for that given waste. The WPS Number of each waste is given in Annexure 2E The WPS number is extremely important as it:
    - Facilitates safe handling and disposal of wastes;
    - Acts as a data reference in case of emergencies such as spillage or uncontrolled release of the waste;
    - Is a requirement of K-EPA for off-site disposal of waste;
- Is a requirement of PAI in National Cleaning Company (NCC) Waste Transportation Manifest.

10.2.4 Labelling

- To facilitate safe identification of hazardous waste stored at the CFP for subsequent off-site management and disposal; standard waste identification and 'hazard warning' labels will be put on each hazardous waste container (e.g. U.S. Department of Transportation 'DOT' labels are already widely used in Kuwait);
- The Waste Handling Department (WHD) will be responsible for ensuring that comprehensive and accurate identification labelling is in place before any transfer of custody of the hazardous waste to any other receiver or storage facility;
- Each truckload of hazardous waste shall be 'safety placarded' (i.e. Transport Road Emergency 'TREM' card plus 'DOT' labelling or National Fire Protection Association 'NFPA' fire safety hazard warning labelling indicating basic material data and hazard properties) to ensure that emergency response crews arriving in the case of a road spillage or similar accident can be aware of immediate risks during response;
- If the hazardous waste is being transported onto public highways, it shall be required that TREM/DOT/NFPA road safety placard is used;

- Re-used containers shall be decontaminated and have previous labels and markings removed.

10.2.5 Temporary storage

- The storage of waste is only acceptable as an interim measure to permit time for the collection of sufficient volumes for cost effective transport to a recycler or disposal facility;
- Wastes will, where possible, be temporarily stored in original containers or in containers (sound, sealable and not damaged) that are designed to contain a specific waste (hazardous or non-hazardous):
- Bulk wastes will be placed in good quality steel or plastic drums which will be labelled. The container must be of the correct size for its volume, must have a 5cm gap for expansion, must always be closed and must be sealed when full;
- Containers will be protected from weather and physical damage in secure, paved and shaded areas with controlled access to trained persons only. The area shall be equipped with a communication facility, portable fire extinguishers, spill control and decontamination equipment, water at adequate volume and pressure and Personal Protective Equipment (PPE);
- Wastes shall be stored to prevent spills from entering the sewer system;
- Wastes shall be kept segregated and stored in a manner consistent with information on the label, on the MSDS, and prudent practices.

10.2.6 Waste Tracking

- An internal manifest (Annexure 5A) system will be implemented for all internal waste movement at the CFP such as oily sludge movement from all sites including MAB to Oily Sludge Handling & Treatment Facility and spent catalyst transfer to MAA catalyst yard from SHU/MAA etc;
- All wastes transported from the CFP for disposal, whether by flatbed vehicle containers (drums, bags, bottles, intermediate bulk container, gas cylinder, pallet load etc.) or in bulk (tipper trailer or dump truck for solids and semi-solids or vacuum tanker for liquids and sludge); shall be manifested.
  - Hazardous Waste: A Waste Transportation Manifest (WTM) will be completed and carried along with the waste for each vehicle load.
  - Non-Hazardous Waste: A single WTM may be completed for the entire load (several truck loads), if the entire load is being moved out on the same day. If necessary, transporters and their details may be endorsed in a separate sheet appended to the manifest. (Annexure 5B)
- The WTM will include adequate information of all wastes carried by the vehicle such as their hazard characteristics (hazardous or non-hazardous) chemical names and/or KNPC 'Waste Profile Numbers.
- The Environment Division shall supply blank manifest sets as needed and record the manifest number given to any department. WGD/WHD shall keep record of all manifests issued for environmental auditing.
- For recovery / re-use in close-loop system inside the refinery, the "Internal Waste Transportation Manifest System" needs to be followed e.g. reprocessing of slop oil etc. (single manifest for any number trip in a day).

10.2.7 Transportation, Treatment and Disposal

- Waste generated from the CFP should be recycled/re-used/recovered in the first instance.
- Once the waste is identified, characterised and labelled, it shall be disposed to the appropriate waste disposal site by waste transporters
- Transporters shall have their capabilities reviewed by KNPC and shall be forwarded to K-EPA for registration.
- All precautions should be taken and relevant safety procedures should be followed while handling hazardous wastes.
- WGD should promptly contact the Environment Division if any waste requires urgent management action or input to prevent environmental degradation.
- Controlled disposal of hazardous wastes shall take priority over the disposal of inert wastes to minimise exposure to hazard risks and maximise effectiveness of wastes management resources.
- The waste receiver shall acknowledge the WTM for all hazardous wastes. Copies must be forwarded to appropriate authorities.
- Pre-treatment shall be done by the Waste Receiver to render selected hazardous wastes into inert/stable and innocuous; prior to land filling.
- WHD shall ensure that the Waste Receiver acknowledges that all hazardous wastes have been received and will be disposed of in compliance with accepted environmental standards and K-EPA regulations. This acknowledgement shall be called as a Waste Disposal Ticket (WDT) and shall have a cross reference to each waste taken from KNPC.

10.2.8 Recording and Reporting

- In order to have an auditable waste management system, necessary records of documents shall be maintained by WHD & WGD for a minimum period of 3 years.

10.3 Solid Waste Management during Construction

Construction and modification of the CFP facilities will produce a variety of solid wastes. Bearing in mind that the number of construction staff (direct plus indirect at peak manpower) is approximately 36,000, waste quantities are expected to be significant.

However, it should be noted that any waste generated as a result of decommissioning activities during the construction phase of CFP is not covered as part of this EIA. Decommissioning waste will be discussed and evaluated in a separate document.

Wastes likely to be generated during construction of CFP are listed below:

- Spoil from excavation works for foundations
- Scrap steel and off-cuts, including weld mesh, conduit, pipe-work, nuts, bolts, concrete reinforcing rods
- Timber waste from formwork and shipping crates
- Concrete, plaster board and cement sheeting
- Insulation materials
- Plastics from conduit and pipe-work
- Paints & solvents
- Transformer oils

- Chemical Cleaning products and neutralised chemical cleaning solutions
- Spent lube oils
- Oily wastes from construction vehicles and oily/contaminated rags
- Miscellaneous wastes from a range of construction activities including general office waste, paper, food scraps, food containers and wrappings
- Packaging materials from equipment, material store and spare parts
- Sanitary waste (sanitary and liquid effluent is considered in Wastewater Management, Chapter 12).

During construction, management of solid waste in work areas and camps will be the responsibility of each EPC contractor. Each EPC contractor will manage wastes in accordance with a KNPC-approved Waste Management Plan (WMP) which will comply with the existing KNPC Procedure for Solid Waste Management (SHE-ESHU-03-1406).

Each EPC contractor will develop their WMP once more detailed information on construction waste is available. The WMP will describe how wastes will be managed during the construction, commissioning and start-up phases of the project, taking into account the existing waste infrastructure within KNPC. The WMP will also include the provision of waste skips in a central collection point within the EPC contractor's area and the marking of skip bays in order to segregate waste prior to removal from site. Waste containers will be periodically collected and disposed of in a manner consistent with the waste management system.

The WMP will require:

- The recycling and re-use of solid wastes wherever possible;
- All waste to be appropriately segregated;
- The temporary storage of waste to be carried out according to type (e.g. inert, non-hazardous and hazardous – ignitable, corrosive, reactive, toxic, radioactive, bio-hazardous, etc.);
- Wastes to be stored in suitable containers clearly marked according to contents. Hazardous wastes will be stored in a safe secure area where storage containers can be inspected for leaks or deterioration;
- Municipal waste to be collected and sent to either a local municipality for treatment or to the existing refinery treatment facility;
- Hazardous waste (such as oily wastes from vehicles) will be transported to an approved site;
- Adoption of the existing KNPC Waste manifest system for the transfer of waste materials; and is discussed below;
- Auditing of the EPC contractors is recommended. This should be conducted at regular intervals throughout construction, commissioning and start-up phases of the project by an independent consultant. This will ensure that that EPC contractors are in compliance with the WMP;
- Construction debris will be removed on a regular basis to prevent build-up and will be disposed of at the solid waste disposal site. Construction waste will not be mixed with domestic waste.

The generation of solid waste during construction is unavoidable. However, all wastes will be sorted, segregated and then screened for identification of hazardous characteristics, before they are moved offsite, to maximise re-use and recycling opportunities. An action plan for managing waste generated during CFP decommissioning activities should be developed by KNPC and submitted to K-EPA for review and approval prior to start of decommissioning activities.

A significant portion of construction materials can be recycled, for example:

- Wood Products will be recovered and reused
- Scrap steel and offcuts will be recycled
- Plastics will be recycled where practicable

Construction activities are unlikely to give rise to many hazardous wastes with the exception of oily wastes. All oily wastes will be stored in bunded tanks on impermeable flooring and will be disposed of in accordance with regulatory requirements using appropriately licensed waste disposal contractors. All temporary bunds will slope to sumps, which require suction cleaning (and have no bund drain down outlets) on a regular basis in order to maintain their effectiveness. Bunds will enclose all ancillary equipment (e.g. fill and draw off facilities, vent pipes, taps, valves, etc) and will be inspected on a regular basis.

10.4 Solid Waste Management during Operation

Both the new and modified CFP facilities will operate under the KNPC Procedure for Solid Waste Management (KNPC Procedure Number SHE-ESHU-03-1406) during operations.

The purpose of the waste management plan is to ensure that appropriate waste management practices are followed in accordance with relevant prevailing national laws, regulations, and requirements regarding the protection and preservation of the environment. In addition, the waste management plan will require that personnel working where waste is generated within the area of the CFP, periodically review operations and evaluate available methodologies for reducing or eliminating the CFP wastes.

Both onsite and offsite units and utilities provided by this project shall be designed to minimise the production of solid waste as required by Article No. 26 of the K-EPA regulations. Typically during refinery operation solid and semi-solid wastes will be generated from several various sources, including administration and support buildings as well as process units.

The solid wastes generated from above-mentioned sources include, but are not limited to:

- Spent catalysts/unusable catalysts
- Oily sludge and other hydrocarbons
- Coke fines
- Contaminated sulphur and other inorganic chemical waste
- Used resins
- Spent oil, lubricants and grease
- Waste activated carbons
- Filter media
- Contaminated soil
- Tyres from plant services and refinery workshops
- Batteries
- Scrap metals
- General packaging and containers
- General process waste;
- Electrical equipment
- Spilled and lost product
- Laboratory waste

- Food waste
- Fluorescent tubes
- Waste paper

The two tables below outline the amounts of the key process solid waste streams likely to be produced by each new and each revamped unit during CFP operation in each of the refineries, MAA and MAB. Both hazardous and non-hazardous solid waste will be generated; it can be seen that the bulk of solid wastes produced are spent catalyst generated at intervals, and these are generally hazardous waste. The CFP facilities at SHU are not expected to generate any hazardous wastes and the amount of non-hazardous solid waste is not expected to be significant.

Table 10.1 Preliminary Amounts of Process Hazardous and Non Hazardous Waste from New and Revamped CFP Units at MAA

Unit	Waste	Quantity	Hazardous Waste (Yes/No)	Hazardous Characteristics	Replacement Frequency	Disposal
25/26	Spent hydrotreating catalyst	47.1 MT	Yes	Ignitibility Toxicity	Every 4 years	Regeneration or hazardous waste landfill
46	None					
83	None					
86	None					
99	None					
107	Dry Slops	Variable	Yes	Flammable	Intermittent	Routed to Storage
	Wet Slops	Variable	Yes	Flammable	Intermittent	Routed to Storage
	Spent Catalyst	Unknown	Yes	Metals	6 years	Landfill and metals recovery
	Gas drier Mol Sieve	Unknown	No	n/a	3 years	Landfill
	Feed Drier Mol Sieve	Unknown	No	n/a	3 years	Landfill
	Methanation Catalyst	Unknown	Yes	Metals	3 years	Landfill and metals recovery
	Sulfur Absorption	Unknown	Yes	Metals	3 years	Landfill and metals recovery
	Sulfur Absorption	Unknown	Yes	Metals	3 years	Landfill and metals recovery
113	Miscellaneous construction waste	Variable	No	n/a	Continuous	Landfill
125	Wet Slops	Variable	Yes	Hydrocarbons	Intermittent	Routed to Storage
	Spent Catalyst	789kg	Yes	Metals	4 years	Landfill & Metals Recovery
	Spent Sulfur Absorbent	4240kg	No	n/a	6 months	Landfill
	Spent Chloride	41390kg	No	n/a	6 months	Landfill
129	Amine and Oxygen Scavenger	66.7m3/hr	Yes	Toxic	Intermittent	Cooling water return or AOC Sewer
135	Spent Catalyst	1668kg	Yes	Metals	5 years	Vendor Reclamation
	Spent Catalyst	1356kg	No	n/a	5 years	Landfill
	Spent Catalyst	16045kg	Yes	Metals	5 years	Vendor Reclamation
	Spent Catalyst	24700kg	Yes	Metals	5 years	Vendor Reclamation
	Sour Water	4.73 m^3/hr	No	n/a	Intermittent	To SWS
136	Sour Water	13330 kg/hr	Unknown at this stage.			
	Sour Water	120000kg				
	Light Slop	100 kg/hr				
137	Hydrocarbon	11.4m^3/h	Yes	Flammable	Intermittent	Routed to Storage (Wet Slops)
	Water & Hydrocarbon	22.7m^3/h	Yes	Flammable	Intermittent	Routed to Storage (Wet

Unit	Waste	Quantity	Hazardous Waste (Yes/No)	Hazardous Characteristics	Replacement Frequency	Disposal
						Slops)
138	Disulfide Separator Vent Gas	0.367 ft3/s			Continuous	To DIP Reboiler Heater
	Disulfide Oil with Wash Oil	~1gpm			Continuous	To DIP Flare Knockout Drum
	Spent Caustic	~3gpm			Daily batches	To spent Caustic Disposal System
	Extraction Spent Caustic				As required	To Spent Caustic Degassing Drum
	Steam Condensate	0.1gpm			Continuous	To WWT via Oily Process Water Sewer
	Sand from Sand Filter	256 ft3			Intermittent	Landfill
141	Spent Catalyst	1,004,233 kg	Yes	Metals	1 Per yr	Landfill & Metals recovery
	Fresh Catalyst fines	1,000 kg	Yes	Metals	1 Per yr	Landfill
	Hydrodrilling Water	650m^3	Yes	Dissolved Metals	1/year	Will not be treated with other refinery water
	Soda Ash Solution	Unknown	No	n/a	Intermittent	Unknown
144	Spent Catalyst and Grading Material		Yes	Metals	Every 30 months	Returned to manufacturer for metals recovery
	Filter Sludge	TBD				
146	Oily Water	23 m^3/h	Yes	Flammable	Intermittent	Routed to Storage (Slops Tanks)
148	Spent Catalyst	8,832 kg	Yes	Metals	Every 5 years	Landfill
	Spent Catalyst	41,984 kg	No	Metals	Every 5 years	Landfill
	Spent Catalyst	6,144 kg	Yes	Metals	Every 5 years	Landfill
	Spent Catalyst	7,744 kg	Yes	Metals	Every 5 years	Landfill
	Spent Catalyst	19,072 kg	Yes	Metals	Every 5 years	Vendor Reclamation
150	Spent Carbon	46 m3/yr	Yes	Toxic	Once Per Yr	Secure Landfill
	Filter Cartridge	4 Cartridges	Yes	Toxic	Once Per Yr	Secure Landfill
	Filter Cartridge	4 Cartridges	Yes	Toxic	Once Per Yr	Secure Landfill
	Filter Cartridge	1 Cartridge	Yes	Toxic	Once Per Yr	Secure Landfill
	Spent Amine	330m^3/yr	Yes	Toxic	Intermittent	As per std refinery practice
	Amine Carbon Filters	15m^3/yr	Yes	Toxic	Once Per Yr	As per std refinery practice
	Caustic Wash	N/A	Yes	Caustic	Intermittent	As per std refinery practice
	Chemical Cleaning	N/A	Yes	Toxic	Intermittent	As per std refinery practice

Unit	Waste	Quantity	Hazardous Waste (Yes/No)	Hazardous Characteristics	Replacement Frequency	Disposal
151 - 152	Spent Catalyst	23,500 kg	No	n/a	5 Yrs	Landfill
	Ceramic balls	9,500 kg	No	n/a	5 Yrs	Landfill
	Spent Catalyst	21,100 kg	No	n/a	5 Yrs	Landfill
	Ceramic balls	9,500 kg	No	n/a	5 Yrs	Landfill
	Spent Catalyst	15,000 kg	Yes	Toxic	5 Yrs	Vendor Reclamation
	Ceramic balls	8,400 kg	No	n/a	5 Yrs	Landfill
	Activated carbon	1,000 kg	No	n/a	2 Per yr	Landfill
	Filter Cartridge	Each	Yes	Toxic	2 Per yr	Secure Landfill
	Filter Cartridge	Each	Yes	Toxic	6 Per yr	Secure Landfill
	Filter Cartridge	Each	No	n/a	6 Per yr	Landfill
	Filter Cartridge	Each	Yes	Toxic	1 Per yr	Secure Landfill
153	Active Carbon	2.1 ft^3	No	n/a	3 yrs	Landfill
	Filter Sludge	TBD				
156	Stripped Sour Water	168 m^3/h	No			To process units WWT-163
162	Wet Slops	34 m^3/hr	No	n/a	Continuous	To wet slops system
163	Dry Slops	3,180 m^3	No	n/a	6,360 m3 Per Month	To Oil Drips System
	Spent Diesel, Dry Slops	3,180 m^3	No	n/a	6,360 m3 Per Month	To Oil Drips System
	Wet Slops	954 m^3	No	n/a	4,000 m3 Per Month	To Oil Drips System
166	None					
167	Sour Water	11 m^3/hr	No	n/a	Continuous	To Sour Water Treatment Unit
171	Activated Alumina	13,800 kg	No	n/a	3-5 years	Landfill
174	Slops	5.0 m^3/hr	Yes	Toxic	Intermittent	To Oil Drips System

Unit	Waste	Quantity	Hazardous Waste (Yes/No)	Hazardous Characteristics	Replacement Frequency	Disposal
175	Blowdown of Cooling Water	55,800 kg/h	No	n/a	Continuous	Flow to AOC
	Backwash of SSF	2,49,400 kg/h	No	n/a	Intermittent	Flow to AOC
	Spent Filter Sand	15.6 m^3	No	n/a	Once every 10 yrs	Landfill
	Spent Filter Gravel	15.6m^3	No	n/a	Once every 10 years	Landfill
176	Activated Carbon	1.0 m^3	No	n/a	3 yrs	Landfill
	Spent Polish Cation Resin	13.5 m^3	No	n/a	5 yrs	Landfill
	Spent polish Anion Resin	13.5 m^3	No	n/a	4 yrs	Landfill
	Spent Demin Cation Resin	20.0 m^3	No	n/a	5 yrs	Landfill
	Spent Demin Anion Resin	29.9 m^3	No	n/a	4 yrs	Landfill
	Spent Filter Anthracite	21.0 m^3	No	n/a	10 yrs	Landfill
	Spent Filter Sand	21.0 m^3	No	n/a	10 yrs	Landfill
	Spent Filter Gravel	5.4 m^3	No	n/a	10 yrs	Landfill
177	None					
178	Miscellaneous municipal waste	Variable	No	n/a	Continuous	Landfill
183	None					
186	Spent Catalyst	32 m^3	Yes	Metals	4 years	Vendor Reclamation
	Spent Catalyst	5 m^3	No	n/a	4 years	Landfill
	Spent Catalyst	115 m^3	Yes	Metals	4 years	Vendor Reclamation
187	None					
195	Stripped sour water	170 gpm	No	n/a	Continuous	To WWT Plant
283	None					

Table 10.2 Preliminary Amounts of Process Hazardous and Non Hazardous Waste from New and Revamped CFP Units at MAB

Unit	Waste	Quantity	Hazardous Waste	Hazardous Characteristics	Replacement Frequency	Disposal
11	Coke Fines	Indeterminate	Yes	Metals	5 Years	Secure Landfill
	Sour Water	87gpm	Yes	Toxic	Intermittent	Sour Water Stripper
	Desalter Effluent	366 gpm	Yes	Toxic	Intermittent	Waste Water Treatment
	Dry Slops	1901 gpm	Yes	Flammable	Intermittent	Storage
	Wet Slops	127 gpm	Yes	Flammable	Intermittent	Storage
13	None					
50	None					
54	None					
111	Coke Fines	6,000 kg	Yes	Metals	6 Years	Secure Landfill
	Sour Water	51gpm	Yes	Toxic	Intermittent	Sour Water Stripper
	Desalter Effluent	176 gpm	Yes	Toxic	Intermittent	Waste Water Treatment
	Dry Slops	120 gpm	Yes	Flammable	Intermittent	Storage
	Wet Slops	20 gpm	Yes	Flammable	Intermittent	Storage
112	Spent Catalyst	1,005,782 kg	Yes	Metals	2/year	Landfill & Metals Recovery
	Fresh Catalyst Fines	1,000 kg	Yes	Metals	2/year	Landfill
	Hydrodrilling Water	650m^3 per batch	Yes	Dissolved Metals	2 years	Will not be treated with other refinery water
	Soda Ash Solution	Unknown	No	n/a	Intermittent	Unknown
113	None					
114	Spent Catalyst	39,500 kg	Yes	Metals	2 years	Vendor Reclamation
	Spent Catalyst	378,500 kg	Yes	Metals	2 years	Vendor Reclamation
	Spent Catalyst	906,000 kg	No	n/a	2 years	Landfill
	Broken Ceramic Balls	15,100 kg	No	n/a	2 years	Landfill
115	Spent Catalyst	4,367 kg	No	n/a	2.5 years	Landfill
	Spent Catalyst	2,708 kg	Yes	Metals	2.5 years	Vendor Reclamation
	Spent Catalyst	6,770 kg	Yes	Metals	2.5 years	Vendor Reclamation
	Spent Catalyst	56,284 kg	Yes	Metals	2.5 years	Vendor Reclamation
	Spent Catalyst	212,081 kg	Yes	Metals	2.5 years	Vendor Reclamation
	Spent Catalyst	29,928 kg	Yes	Metals	2.5 years	Vendor Reclamation
116	Spent Catalyst	590 m^3	Yes	Metals	2.5 years	Vendor Reclamation
	Spent Catalyst	142 m^3	Yes	Metals	2.5 years	Vendor Reclamation

Unit	Waste	Quantity	Hazardous Waste	Hazardous Characteristics	Replacement Frequency	Disposal
	Ceramic Balls	23.8 m^3	No	n/a	2.5 years	Landfill
117	Spent Catalyst	2,673 kg	No	n/a	2 years	Landfill
	Spent Catalyst	2,986 kg	Yes	Metals	2 years	Vendor Reclamation
	Spent Catalyst	26,493 kg	Yes	Metals	2 years	Vendor Reclamation
	Spent Catalyst	16,310 kg	Yes	Metals	2 years	Vendor Reclamation
	Spent Catalyst	1,361 kg	Yes	Metals	2 years	Vendor Reclamation
	Spent Catalyst	43,222 kg	Yes	Metals	2 years	Vendor Reclamation
118	Spent Catalyst	60,544 kg	Yes	Metals	every 6 years	Vendor Reclamation
	Spent Absorber	263,168 kg	No	n/a	every 1 year	Landfill
	Spent Catalyst	41,344 kg	Yes	Metals	every 6 years	Vendor Reclamation
	Spent Catalyst	43,264 kg	Yes	Metals	every 6 years	Vendor Reclamation
	Spent Catalyst	19,840 kg	Yes	Metals	every 6 years	Vendor Reclamation
	Spent Catalyst	153,344 kg	Yes	Metals	every 6 years	Vendor Reclamation
119	Sour Water	6.9 m^3/hr	No	n/a	Continuous	Sour Water Header
	Mole Sieve Packing	To be completed by EPC contractor once PSA vendor selected.				
	PSA Adsorbant					
123	Spent Catalyst	51,000 kg	No	n/a	5 years	Landfill
	Ceramic balls	9,500 kg	No	n/a	5 years	Landfill
	Spent Catalyst	47,000 kg	No	n/a	5 years	Landfill
	Ceramic balls	9,500 kg	No	n/a	5 years	Landfill
	Spent Catalyst	31,400 kg	Yes	Metals	5 years	Vendor Reclamation
	Ceramic balls	19,600 kg	No	n/a	5 years	Landfill
	Activated Carbon	2,120 kg	No	n/a	6 mo.	Landfill
	Filter cartridge	1	Yes	Metals	6 mo.	Secure Landfill
	Filter cartridge	1	Yes	Metals	2 mo.	Secure Landfill
	Filter cartridge	1	No	n/a	2 mo.	Landfill
	Filter cartridge	1	Yes	Metals	1 year	Secure Landfill
125	Spent Carbon	46 m^3	Yes	Toxic	1 year	Secure Landfill
	Filter Cartridges	2	Yes	Toxic	1 year	Secure Landfill
	Filter Cartridges	2	Yes	Toxic	1 year	Secure Landfill
	Filter Cartridges	1	Yes	Toxic	1 year	Secure Landfill
	Spent Amine	890 m^3/yr	Yes	Toxic	1 year	As per std refinery practice
	Amine Carbon filters	25 m^3/yr	Yes	Toxic	1 year	As per std refinery practice
	Caustic Wash	N/A	Yes	Caustic	Intermittent	As per std refinery practice

Unit	Waste	Quantity	Hazardous Waste	Hazardous Characteristics	Replacement Frequency	Disposal
	Chemical Cleaning	N/A	Yes	Toxic	Intermittent	As per std refinery practice
126	Stripped Sour Water	214 m^3/hr	No	n/a	Continuous	To various process units & WWT-156
127	Spent Catalyst Fines	0.1 kg/hr	No	n/a	Continuous	Vendor Reclamation
	Spent Catalyst Fines	0.1 kg/hr	No	n/a	Continuous	Vendor Reclamation
	Caustic	0.18 m^3/hr	No	n/a	Continuous	To unit Chemical Drain
128-01	None					
128-02	None					
129	Coalescing Element		Yes	Particulates	1 per yr	TBD
	Cartridge element		Yes	Particulates	1 per yr	TBD
131	Amine and oxygen scavenger	76.8 m^3/h	Yes	Toxic	Intermittent	Cooling water return or AOC Sewer
	Amine and oxygen scavenger	76.8 m^3/h	Yes	Toxic	Continuous	Cooling water return or AOC Sewer
	De-aerator overflow	88.8 m^3/h	No	n/a	Intermittent	AOC Sewer
132	Blowdown of cooling water	188060 kg/h	No	n/a	Continuous	Flow to AOC
	Backwash of SSF	596400 kg/h	No	n/a	Daily	Flow to AOC
	Spent Media	50 m^3	No	n/a	10 yrs	Landfill
	Spent Gravel	52.5 m^3	No	n/a	10 yrs	Landfill
133	Water, hydrocarbons and H2S mixture	5 m3/h	Yes	Toxic		Routed to oil drips system
	Water, hydrocarbons and H2S mixture	6.7 m^3/h	Yes	Toxic		Flare
	Water, hydrocarbons and H2S mixture	0.23 m^3/h	Yes	Toxic	Continuous	LP contaminated condensate system
134	Activated Alumina	22,000 kg	No	n/a	3-5 years	Landfill
137	Activated Carbon	2.0 m^3	No	n/a	3 yrs	Landfill
	Spent Resin	27.0 m^3	No	n/a	5 yrs	Landfill
	Spent Resin	27.0 m^3	No	n/a	4 yrs	Landfill
	Spent Resin	40.0 m^3	No	n/a	5 yrs	Landfill
	Spent Resin	59.9 m^3	No	n/a	4 yrs	Landfill
	Spent Anthracite	42.0 m^3	No	n/a	10 yrs	Landfill
	Spent Sand	42.0 m^3	No	n/a	10 yrs	Landfill
	Spent Gravel	10.8 m^3	No	n/a	10 yrs	Landfill

Unit	Waste	Quantity	Hazardous Waste	Hazardous Characteristics	Replacement Frequency	Disposal
146	Sour Water	11 m^3/hr	No	n/a	Continuous	To Sour Water Treatment Unit
149	Wet Slops	34 m^3/hr	No	n/a	Continuous	To wet slops system
156	Sludge	1,900 m^3	Yes	Metals	per month	Incinerated-ash sent to secure landfill
	Dry Slops	3,200 m^3	No	n/a	Continuous	Incinerated-ash sent to secure landfill
	Spent Diesel, Dry Slops	3,200 m^3	No	n/a	Continuous	Incinerated-ash sent to secure landfill
	Wet Slops	950 m^3	No	n/a	Continuous	Incinerated-ash sent to secure landfill
	Biological Sludge	Variable	No	n/a	Continuous	Transported to NCC (National Cleaning Company)
165	Miscellaneous municipal waste (paper, plastics)	Variable	No	n/a	Continuous	Landfill
166	Miscellaneous Construction Waste (plastic, metal, wood, concrete, etc.)	Variable	No	n/a	Continuous	Landfill
186	Spent Catalyst	Unknown	No	n/a	TBD	
	Spent Catalyst	Unknown	No	n/a	TBD	
	Spent Catalyst	Unknown	No	n/a	TBD	
212	Spent Catalyst	1,005,782 kg	Yes	Metals	1/year	Landfill & Metals Recovery
	Fresh Catalyst Fines	1,000 kg	Yes	Metals	1/year	Landfill
	Hydrodrilling Water	650m^3 per batch	Yes	Dissolved Metals	1/year	Will not be treated with other refinery water
	Soda Ash Solution	Unknown	No	n/a	Intermittent	Unknown
213	Sour Water	38.5 m^3/h	No	n/a	Continuous	Routed to U-126 Sour Water Stripping Unit
	Dry Slops	10 m^3/h	No	n/a	Continuous	Routed to Dry Slops
214	Spent Guard Bed Catalyst	4.93 MT	Yes	Ignitibility, Toxicity	Every 2 years	Hazardous Waste Landfill
	Spent hydrotreating Catalyst	208.5 MT	Yes	Ignitibility, Toxicity	Every 2 years	Catalyst regeneration Company or Hazardous Waste Landfill
	Spent Hydrocracking Catalyst	610.7 MT	No	n/a	Every 2 years	Catalyst regeneration Company

Unit	Waste	Quantity	Hazardous Waste	Hazardous Characteristics	Replacement Frequency	Disposal
	Broken inert Ceramic Balls	7 MT	No	n/a	Every 2 years	Industrial Landfill
216	All liquid discharges are collected and routed to other units for re-processing					
	Spent Catalyst	821.01 m^3	Yes	Metals	Continuous	Returned to the catalyst supplier for regeneration or metals recovery
	Filter Sludge	Minor quantities	No	n/a	As required	Incineration
249	Wet Slops	55 m^3/h	No	n/a	Intermittent	To Wet Slops System
	Utilty water	0.125	No	n/a	Intermittent	Drain to ODS Based on e evaporation losses
314	Wet Slops	58m^3/h	No	n/a	Continuous	To wet slops systems
	Wet Slops	58m^3/h	No	n/a	Continuous	To wet slops systems

10.4.1 Non-Hazardous Solid Waste Generation, Handling & Disposal

If existing areas for the temporary storage of non-hazardous wastes at the refineries are inadequate for the additional volume of waste produced by the CFP, additional facilities may be provided. No design work has been done during the FEED Phase for such an area, however non-Hazardous waste will be managed according to the KPC Corporate HSE Standard for Management of Waste Minimization and Disposal (Document 13.) Permanent waste disposal will be undertaken by K-EPA approved third parties located outside the refinery site.

Non-hazardous solid wastes will be generated during construction and operation of the CFP. Tables 10.1 and 10.2 above identify the likely non-hazardous solid wastes to be generated during operation at the new and revamped CFP units at MAA and MAB. Non-hazardous wastes likely to be generated during construction include but are not limited to:

- Spoil from excavation works for foundations
- Scrap steel and offcuts, including weldmesh, conduit, pipework, nuts, bolts, concrete reinforcing rods
- Timber waste from formwork and shipping crates
- Concrete, plaster board and cement sheeting
- Insulation materials
- Plastics from conduit and pipework
- Miscellaneous wastes e.g office waste, paper, food scraps, food containers and wrappings
- Packaging materials from equipment, material store and spare parts

Those handling and disposing of non-hazardous solid waste during the CFP will follow the following criteria:

1. Containers for storing various non-hazardous wastes will be selected for the specific service intended and shall be equipped with tightly fitting lids (except those used for inert non-blowing wastes). Lightweight plastic or paper bags will not be used alone, but may be utilized as liners for metal or plastic containers.

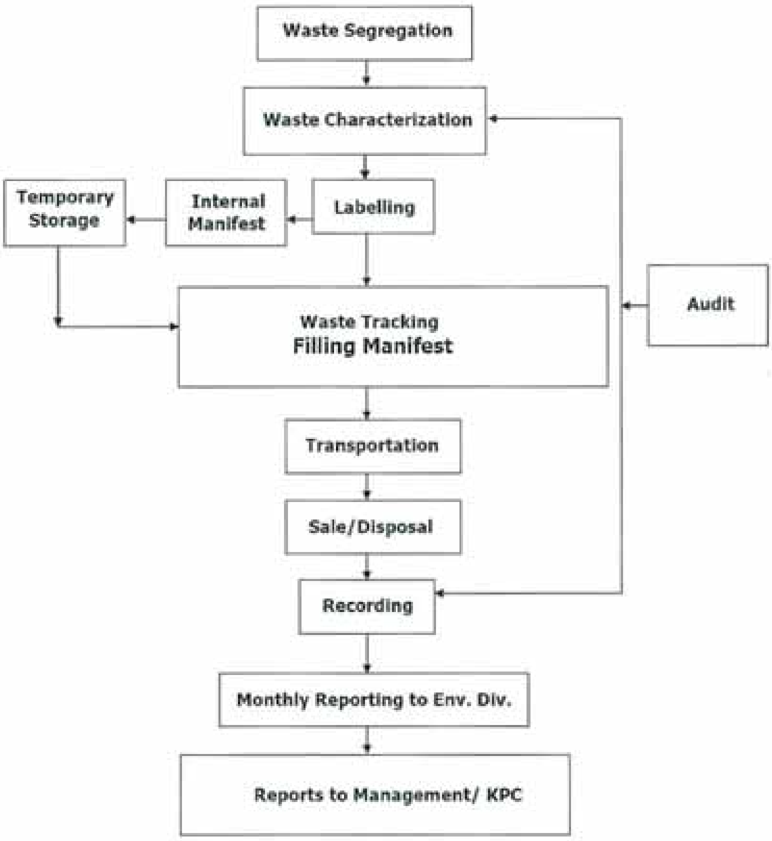
2. Refuse chutes and receiving areas will be designed to prevent the spread of fire or discharge of airborne pollutants or odours. The chutes and storage areas will be kept free of debris, and shall be cleaned and disinfected on a regular basis. Bulk containers will be readily accessible to collection vehicles.

3. Construction debris will not be allowed to accumulate and thus present a safety hazard for workers, or detract from the aesthetic values of the community. This material will be removed to the solid waste disposal site at the earliest opportunity and as the material is produced. This material will not be mixed with domestic type wastes.

4. Clean sand will not be mixed with construction debris.

Figure 10A below outlines the existing KNPC approach to Non-Hazardous Waste Management. This process is outlined in the current KNPC procedure for Solid Waste Management SHE-ESHU-03-1406.

Figure 10A - Non-Hazardous Waste Management Flowchart



10.4.2 Hazardous Waste Generation, Storage, Handling & Disposal

As a generator of hazardous wastes, the CFP will be required by Article No. 26 of the K-EPA regulations to obtain their identification number from K-EPA and to comply with the following K-EPA stipulations, as applicable:

- The waste production rate shall be reduced in quantity and quality by following clean technology and choosing alternatives of the product or raw materials that are less dangerous to the environment and public health e.g. selection of non-ozone depleting substances in refrigerant and fire protection systems; use of non-asbestos containing materials for insulation/gaskets; and use of non-PCB containing transformer oils. Waste reduction techniques include return of spent catalysts to suppliers for precious metals recovery.
- Transfer of waste outside the site will only be conducted by waste carriers with the appropriate K-EPA identification number and necessary licences from concerned authorities.

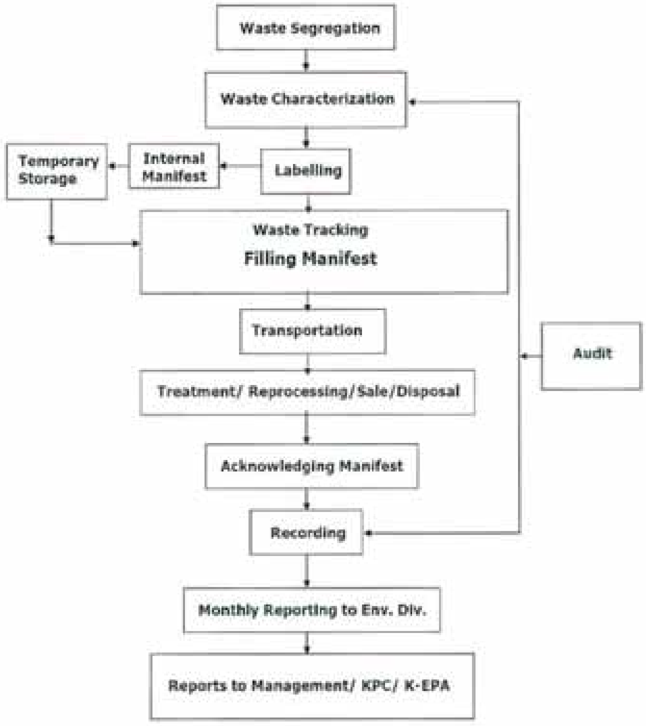
The CFP will include facilities for the temporary storage of hazardous wastes. The conditions for storing hazardous waste are stated in Article No. 30 of the K-EPA regulations as follows, and will be followed by KNPC:

(1) Separate substances either by isolating them in a separate facility or separate them in the same building by using insulated fireproof walls, or by leaving enough space or placing fireproof inert substances in between.
(2) Isolate the storage area away from buildings and other installations by erecting a proper fence, and forbid entry to everyone except to persons working in the area. Substances must be stored far from the fence area and in a well-organized way, by leaving enough space for easy movement between the stored materials. Open storage areas must be used to store secure substances only. Covering flammable waste must be done without flammable material covers to the extent practical.
(3) Storage sites must be in dry and ventilated areas.
(4) Waste must be stored in containers with edges to prevent any spillage.
(5) Storage areas must be emptied of flammable sources. Separate storage must be provided for liquid waste with a flash point less that 32°C. Highly flammable waste should be stored in refrigerators and cold storages.
(6) Substances should be classified according to their nature. Clear labelling with large letters so that substances can be distinguished.
(7) Labels should be place on stored containers so that flammable, oxidized or poisonous material can be easily distinguished. Labels should indicate the nature of substances, degree of toxicity and the right way of dealing with the substances in case of accidents or spillage. Labels should indicate the chemicals name as well as the commercial name and proper storage indicators.
(8) Separate oxidized waste from waste that it can react with. It must be stored in dry areas clear of flammable or acidic material.
(9) Unstable chemical substances that are easily solvent (i.e. highly volatile) must be stored in airtight containers and be kept cool and dark (i.e. temperature and humidity controlled). Large quantities of these substances must be stored in separate, non-confined areas to prevent damage by vapour cloud
(10) Gas cylinders must be stored away from flammable materials and heat sources.
(11) Waste must be stored in protected containers not prone to breakage or damage. Containers should be closed with covers that do not allow gas leakage and should be made easy to open.
(12) Glass containers that contain highly hazardous waste must be placed inside bigger containers, which will not react to the stored material.
(13) Contaminated stores or containers should be cleaned when closed.
(14) It is necessary to install an alarm system that will operate during emergencies. The alarm sound must be recognized and staff working in the stores must handle its mode of operation. It is necessary to supply the facility with a fire fighting system and necessary fire fighting equipment to resist fire or spillage.
(15) Daily record of stored substances must be supplied where the kind, quantity and area of storage must be recorded.

Hazardous wastes will be stored in secure areas that are paved, covered and curbed to contain any leakages or spills. Tanks containing hazardous materials or hazardous wastes that are liquid at standard conditions will be provided with secondary containment systems.

Figure 10B outlines the existing KNPC approach to Hazardous Waste Management that will be adopted at CFP. This process is outlined in the KNPC procedure for Solid Waste Management SHE-ESHU-03-1406.

Figure 10B - Hazardous Waste Management Flowchart



As part of the CFP project two new wastewater treatment systems (WWT) will be installed. One will be located at MAA Unit 163 and the other at MAB Unit 156.

These new facilities will incorporate state of the art design to complement upgrades to the existing MAB effluent treatment facility under a separate project (KNPC Effluent Treatment Facility Revamp project). The CFP design will incorporate best environmental engineering practices such as 'Best Available Control Technology' (BACT) to avoid, prevent or mitigate the discharge of all harmful emissions so as to meet (or exceed) applicable K-EPA environmental standards.

Both industrial and biological sludge will be generated from the CFP facilities. K-EPA Article No. 57 categorizes industrial sludge as follows:

- Oily sludge,
- Toxic sludge, and
- Chemical sludge.

The sludge collection and treatment system will collect and store sludge from the various pieces of WWT equipment.

For the MAB Refinery, biological treatment of wastewater from the CFP block will be carried out in the effluent treatment facilities (ETF) provided by a separate KNPC project. Waste activated sludge resulting from this treatment will be dewatered in the Sludge Dewatering facility which is also part of the separate ETF project and then shipped off-site to the NCC for disposal. Oily solids from the corrugated plate interceptor (CPI) and dissolved air flotation (DAF) separators, after removal of oil and water by centrifuging will be routed to the new CFP oil sludge incineration system at MAB (Unit 156).

At MAA, the collected sludge's are transferred appropriately into segregated storage tanks. The oily sludge collection systems will also be equipped with a vacuum truck disposal connection. The contents of each storage tank are treated in separate centrifuges to remove water and oil. The 25% solid content cakes generated by the centrifuges are loaded in roll-off boxes and transported to the appropriate sludge treatment and disposal facilities (i.e. biological sludge shipped to NCC and oily sludge routed to the new CFP oil sludge incineration system at MAB (Unit 156).

After dewatering, the oily sludge cake created at both MAB and MAA WWT facilities will be routed to a new CFP fluidised bed incinerator located at the MAB Refinery. Incinerator ash will be disposed in local landfills. A detailed description of the new WWT facilities is provided in Section 12 of this report.

10.5 Potential Impacts

The potential impacts on the surrounding environment from the generation, storage, handling, transportation and disposal of construction and operational non-hazardous and hazardous wastes have been identified by applying the impact assessment and matrix approach. The potential impacts and resulting significance are outlined in the figures below.

Figure 10C Impact Assessment Form and Matrix – Construction

Category: Environment **Consequence evaluation for: Solid Waste During Construction**

1. General description of the area (situation and characteristics)

Note: This section describes the sensitivity of the area in question. Following a review of existing information regarding the site's sensitivity, a sensitivity rating or value is given.

CFP will require new and modified facilities at the three KNPC Refineries and the use of a section of adjacent undeveloped land. The existing refineries, their surrounding areas/land and the section of adjacent undeveloped land are not considered to be highly sensitive areas.

In setting a sensitivity value relative to waste management during construction, the primary consideration is the integrity of the disposal sites for the construction waste. Construction wastes are likely to include:

- The generation of uncontaminated spoil which, if compatible, will be used as fill material within the CFP blocks. The sensitivity of the surrounding area to receiving such material will be negligible. Incompatible spoil will be transferred to an approved offsite landfill.
- Hazardous wastes and non hazardous wastes will only be disposed of at appropriate K-EPA approved facilities.

The potential impact following a release of hazardous waste also needs to be considered and the sensitivity of the area becomes relevant following failure of the prevention, control and mitigation barriers on site.

In assessing the sensitivity of the area, the relatively close proximity of the CFP to local populations (closest population approximately 2 km) needs to be evaluated along with what is considered to be a lack of adequate groundwater resources within this area. Based on this the sensitivity is deemed to be **Medium**.

Low Medium High
|---------X------------|

2. Description of the extent of effect

Evaluation of extent:

The main impact from the creation and storage of waste is the potential for a release to the surrounding environment. However, all hazardous waste will be properly bunded during the construction phase and adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge. All hazardous and non-hazardous wastes will be disposed of at appropriate waste management facilities.

The development of a waste management plan and waste procedures (by each EPC contractor) will reduce waste quantities, and continually improve re-use and recycling of construction waste. A central collection point will be allocated at the site to ensure segregation and maximise re-use and recycling.

The hazardous and non-hazardous solid waste produced as a result of the construction phase is likely to be of **small negative significance.** This evaluation is based on the effects being short-term, the fact that most of the wastes will be non hazardous, and the implementation of adequate management measures as discussed in this report.

Very neg. Medium neg. Little/no Medium pos. Very pos.
|---------------|--------------X--|----------------|------------------|

3. Total impact on environment

"small negative impact""

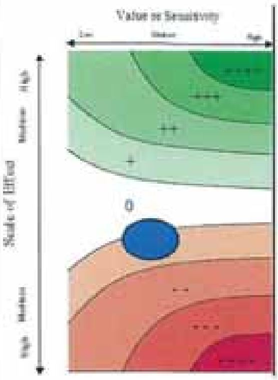


Figure 10D Impact Assessment Form and Matrix - Operations

Category: Environment **Consequence evaluation for: Solid Waste During Operation**

1. General description of the area (situation and characteristics)

Note: This section describes the sensitivity of the area in question. Following a review of existing information regarding the site's sensitivity, a sensitivity rating or value is given.

In setting a sensitivity value relative to waste management during operation, the integrity of the disposal sites for the wastes is considered.

- Much of the hazardous wastes (spent catalysts) will be recycled prior to disposal by third party at appropriate licensed disposal facilities; facilities should only accept wastes if capable of treatment.
- Hazardous and Non-hazardous wastes will only be disposed of at appropriate K-EPA approved facilities.

An additional concern is the potential for a release of hazardous waste materials through spillages (e.g. oily wastes) to the surrounding environment.

As identified above for the construction phase the most important requirement is to ensure that measures are in place to properly manage hazardous waste. The sensitivity of the area only becomes relevant if these measures fail and spillages occur.

In assessing the sensitivity of the area, the relatively close proximity of the CFP to local populations (closest population approximately 2 km) needs to be evaluated along with what is considered to be a lack of adequate groundwater resources within this area. Based on this the sensitivity is deemed to be **Medium.**

Low Medium High
|---------X------------|

2. Description of the extent of effect

Evaluation of extent:

All hazardous waste from CFP facilities will be bunded and adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge.

The impact on the environment will be mitigated by the implementation of robust waste management procedures that will reduce the impact on the environment caused by the generation of waste through operational activities at CFP facilities.

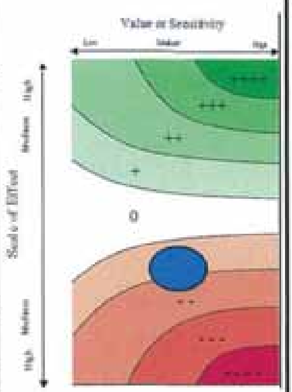
The hazardous and non-hazardous solid waste produced as a result of the CFP operation is likely to be of **small to moderate negative significance.**

This evaluation is based on the cumulative effects of waste disposal at appropriate licensed landfill sites (hazardous, non-hazardous), potential effects following incineration of hazardous waste and abnormal activities at the refinery such as spillage, and the implementation of all the management measures as recommended in this report.

Very neg. Medium neg. Little/no Medium pos. Very pos.
|-----------------|-----X-------------|----------------|-------------------|

3. Total environmental impact

"Small to moderate Negative"



10.6 Mitigation Measures

10.6.1 Construction

A Waste Management Plan (WMP) will be developed as part of the construction phase of the CFP. The WMP will require all hazardous and non-hazardous waste to be tracked, segregated, as well as re-used and recycled where feasible to do so. The quantities of solid waste generated during construction is likely to be significant, however, the impact will be temporary.

Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge.

10.6.2 Operation

The CFP will operate under an EMS, which will include a WMP. The WMP will incorporate the existing KNPC waste management procedures and practices (as described in section 10.4 above).

As defined in procedure SHE-ESHU-03-1406 on Solid Waste Management, a number of mitigating measures for the control of solid waste during the operational life of the CFP facilities will be implemented, the main ones being:

- All waste will be segregated, re-used and/or recycled wherever possible;
- Waste storage areas are required to be designed and built to meet K-EPA requirements
- Periodic waste reviews of operations will take place to identify how waste can be minimized further or eliminated in some cases;
- Facilities and equipment provided by this project will be designed to minimize the production of solid waste
- All hazardous waste will be stored in bunded or curbed areas with impermeable flooring. The waste manifest system will ensure correct categorization of hazardous solid waste, correct labeling, transportation, disposal and documentation;
- Non-hazardous solid waste will be segregated as much as possible in order to optimize the amount of material that can be reused or recycled.
- Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge.

10.7 Conclusions and Recommendations

The CFP will generate a variety of wastes that are both hazardous and non-hazardous. For the purposes of this report the impacts of wastes generated through construction and operation phases of the project are considered separately.

The construction of the CFP will produce a variety of solid wastes (hazardous and non-hazardous). Similar waste types will be generated during the operational phase. In order to manage waste properly and comply with local and globally recognized waste management practices, a WMP will be developed by each EPC Contractor in accordance with KNPC policies/procedures as well as K-EPA requirements. Specifically, the WMP will comply with the existing KNPC Procedure for Solid Waste Management (SHE-ESHU-03-1406). The WMP will be developed as part of KNPC's existing EMS which will be extended to cover the CFP facilities.

As part of the WMP, a number of mitigating measures will be implemented. These will have the effect of reducing both the amount of waste generated, and the associated impacts on the environment.

An action plan for managing waste generated during CFP decommissioning activities should be developed by KNPC and submitted to K-EPA for review and approval prior to start of decommissioning activities.

In summary, the impact of the generation, storage, transportation and disposal of non hazardous and hazardous solid waste during construction is considered to be of **small** negative significance. This is due to temporary nature of the impact, the generation of a WMP and the full implementation of control measures as recommended in this report.

The impact of the generation, storage, transportation and disposal of non hazardous and hazardous solid waste during the operation of the CFP is considered to be of **small to moderate** negative significance. This is due to the quantities and nature of material, the presence of an EMS and WMP, and the full implementation of all control measures as recommended in this report.

11.0 Chemical Hazards Management

11.1 Chemicals Management

The new and modified CFP facilities will handle and/or store a variety of chemicals. KNPC's policy is to control chemical hazards and prevent exposure based on conformance to high standards of safety, health and personal hygiene, environmental protection and compliance to legislation and standards.

It is important to note that any decommissioning work carried out as a result of CFP will be discussed and evaluated in a separate document and is, therefore excluded from this EIS.

Materials being used within the various systems that comprise the CFP will include a variety of chemicals such as DMDS (Dimethyl Disulfide), sulphuric acid, caustic, chlorine and others, which if improperly managed can pose potential hazards to living organisms and/or the environment. These same chemicals, however, are currently being stored and used successfully within the existing refineries.

Hazardous materials may be solids, semi-solids, liquids, or gases and have one or more of the following characteristics:

- flammable
- corrosive
- reactive
- toxic
- radioactive
- dangerous to the environment
- potential biohazard.

The chemicals and facilities provided by the CFP will fall under the requirements of the KNPC Chemical Hazard Management Program (KNPC DDHE Procedure No.SHE-TSOH-04-1358) as well as KPC Corporate HSE Standard for Chemical Handling (Document 19). This program provides critical information for those working with chemicals including guidelines for:

- Specification, ordering, purchase, handling, storage, use, transportation, emergencies and disposal;
- Control of hazards; and
- Hazard communication.

The Material Safety Data Sheets (MSDS's) of all chemicals have to be approved (including paints, thinners etc) by the HSE Department before being used on site. During the operations phase, MSDS's will be made available at the guardhouse, administration building and control room buildings for the refineries. In addition, MSDS's will be accessible at the new chemical storage warehouse building and catalyst storage facility at the MAB refinery for the materials stored in those buildings. Employees will be appropriately trained in the handling of chemicals and will have access to the MSDS's. Labels and warning signs will be displayed as per K-EPA Hazmat labelling.

The categories of chemical hazards are defined in Appendix No. 10 of the K-EPA regulations. The categories include:

- Category 1 – Explosives. This category is further subdivided with respect to the nature of the explosive material.
- Category 2 – Compressed, liquefied gases or gases dissolved under pressure. This category is further subdivided into flammable gases, non-flammable and non-poisonous gases, and poisonous gases.
- Category 3 – Flammable Liquids.
- Category 4 – Solid flammable materials and materials exposed to automatic ignition and materials which when in contact with water emit flammable materials. This category is further subdivided into solid flammable materials, materials that are self-reacting and react with associated materials, and desensitized explosives.
- Category 5 – Oxidizing Factors and Organic Peroxides. Oxidizing materials and organic peroxides are treated as separate categories for the purpose of marking containers and packages and transport vehicles and for the purpose of separating the packages and transport.
- Category 6 - Poisonous and Contagious Materials.
- Category 7 - Radioactive Materials. This category includes the materials or set of materials which are automatically radioactive.
- Category 8 – Corroding Materials.
- Category 9 – Other Dangerous Materials.

Table 11.1 and Table 11.2 provide preliminary lists of chemicals that will require special management attention within the CFP facilities at MAA and MAB, respectively.

Table 11.1 Preliminary List of Chemicals Used in CFP Facilities that can potentially Create Chemical Hazards MAA Refinery*

Unit [1]	Chemical Name [2]	Composition % weight	Quantity	Physical State
46	Caustic		3,500 gallons	Liquid
99		None.		
107	Penex Reactor Catalyst		$244.1m^3/hr$	
	Puraspec 2443M		$7.6m^3/hr$	
	HPG-429		$78.8m^3/hr$	
	GB-217		$5.7m^3/hr$	
	ADS-12		$17.30m^3/hr$	
	Perchloroethylene		$77.32m^3/hr$	
	Caustic	50 wt% Caustic	14,672kg	
	Anhydrous HCL		5,002kg	
	Nitrogen		$42354Nm^3$	
125	CLR-204		41390 kg	
	GB-217		8480 kg	
	H-14271		196 kg	
129	Oxygen Scavenger		$7\ m^3$	
	Amine		$13\ m^3$	
135	DMDS		3,212 kg	
136	Ammonium Polysulfide	100 wt% Ammonium Polysulfide	2 Totes	Liquid
	Anti-Foam Agent		22,280 kg	
	Corrosion Inhibitor		20,093 kg	
	Deemulsifier		1,900 kg	
	Anti-Oxidant		7,000 kg	
137	Caustic Solution	20 wt% Sodium Hydroxide	Not Specified	Liquid
138	Caustic	20° Baumè Caustic	$22\ ft^3$	

Unit [(1)]	Chemical Name [(2)]	Composition % weight	Quantity	Physical State
	Caustic Prewash	10° Baumè Caustic	141 ft^3	
	Caustic Regeneration	20° Baumè Caustic	866 ft^3	
141	Catalyst		1,004,234 kg	
	DMDS		78,047 kg	
	Anti Foaming Agent		As needed	
	Corrosion Inhibitor		As needed	
144	DMDS	100% Dimethyl Sulphide		
	Lubricity Additive			
	Anti-Foaming Agent			
	CPD Additives			
	Seal Oil			
	DN-3531 Catalyst	<30% Molybdenum <6% Nickel Oxide	398.6m^3	Solid
	SDD-800 Catalyst	0-0.7% Nickel Oxide	45.2m^3	Solid
	OptiTrap (MacroRing) Catalyst	68-82% Aluminium oxide 10-19% Molybdenum oxide 5-8% Phosphorous pentoxide 1-5% Nickel oxide	5.9m^3	Solid
	OptiTrap (Ring) Catalyst	68-82% Aluminium oxide 10-19% Molybdenum oxide 5-8% Phosphorous pentoxide 1-5% Nickel oxide	5.9m^3	Solid
	MaXTrap(Si) Catalyst	balance 5-10% Molybdenum oxide < 5% Nickel oxide	14.0m^3	Solid
	855MD "Medallions"	40% Alpha Alumina 60% Silicon dioxide	2.9m^3	Solid
	1,1 iminobis-2-propanol	100% 1,1 iminobis-2-propanol		liquid
146	None			
148	1" Ceramic Balls		8.75 m^3	
	½ " Ceramic Balls		0.8 m^3	

Unit [(1)]	Chemical Name [(2)]	Composition % weight	Quantity	Physical State
	1" Alumina Balls		1.67 m^3	
	½ " Alumina Balls		0.42 m^3	
	Hydro processing catalyst		13.8 m^3	
	Sulphur absorption catalyst		65.6 m^3	
	Steam reforming catalyst		21.7 m^3	
	Shift catalyst		7.4 m^3	
	Phosphate		450 kg	
	Morpholine		1400 kg	
150	MDEA	100% MDEA	1,445 m^3	
	Anti-Foam Chemical		2 m^3	
151-152	Ammonia	100 % Ammonia	Not Specified	Gas
	Phosphoric Acid	100 % Phosphoric Acid	15 kg	Liquid
	Anti-Foam Agent		0.4 m^3	
	Activated Carbon		2.4 m^3	
153	Anti-Foam Agent			
	Activated Carbon		2.1 m^3	
156	20% Caustic	20 wt% Sodium Hydroxide	1 m3	Liquid
163	Sulfuric Acid	98% Sulfuric Acid	306,294 kg	Liquid
	Methanol	100% Methanol	416,900 kg	Liquid
	Phosphoric Acid	Concentrated Phosphoric Acid	170,095 kg	Liquid
	Caustic	20% Sodium Hydroxide	16,134,030 kg	Liquid
166	Biocide		8,400 kg	
171	Activated Alumina		20,700 kg	
174	Amine Antifoam		240 kg	
175	Chlorine Gas	100% Chlorine	16,700 kg	Gas
	20% Caustic Solution	20 wt% Sodium Hydroxide	72,500 (14) kg	Liquid
176	Caustic (50%)	50% Caustic Solution	289,260 kg	Liquid
	Sulfuric Acid (98%)	98% Sulfuric Acid	120,330 kg	Liquid
	Chlorine	100% Chlorine	13 kg	Gas

Unit [1]	Chemical Name [2]	Composition % weight	Quantity	Physical State
183	Antifoam Emulsion		385 kg	
186	DMDS	100% DiMethyldiSulfide	17,053 kg	Liquid
195	20% Caustic	20% Sodium Hydroxide	208 ft^3	Liquid
283	None			

(1) Units were selected from MAA Refinery Work Breakdown Structure (WBS), P6001MAA-000.10.10.002_Rev.N. New Licensed and Open Arts process Units and new Utility and Offsites Units were included.

(2) Chemical properties and special handling requirements are provided in Material Safety Data Sheets (MSDSs).

* CFP facilities will handle and store a variety of proprietary catalysts which are not listed here. The handling and disposal of spent catalyst material is discussed in Chapter 10 (Solid Waste).

Table 11.2 Preliminary List of Chemicals Used in CFP Facilities that can potentially Create Chemical Hazards MAB Refinery*

Unit [1]	Chemical Name [2]	Composition % weight	Quantity	Physical State
11	Caustic Solution	Sodium Hydroxide Solution	30 - 40 gallons/hr	liquid
16	DMDS	100% DimethylDisulfide	118,912 liters	liquid
111	Caustic Solution	20 wt% Sodium Hydroxide	0.0053 m3/hr	liquid
	Ammonia Solution	5 wt% NH4OH	0.014 m3/hr	liquid
112	DMDS	100% DimethylDisulfide	154,253 kg	liquid
	Anti-Foaming Agent		As needed	
113	None			
114	DMDS	100% DimethylDisulfide	195,000 kg	liquid
115	DMDS	DimethylDisulfide	56,839 kg	liquid
116	DMDS	DimethylDisulfide	100 tonnes	liquid
	Anti-Foaming Agent			
117	DMDS	100% DiMethylDiSulfide	17,053 kg	liquid
118	Phosphate		1,400 kg	
	Morpholine		48,000 kg	
119	Amine Antifoam		770 kg	
	PSA Adsorbant			
123	Ammonia	100% Ammonia	5 cylinders	gas
	Phosphoric Acid	100% Phosphoric Acid	133 kg	liquid
	Anti-Foaming Agent		90 m^3	
	Activated Carbon		5.3 m^3	
125	MDEA	100% MDEA	3, 500 m^3	
	Activated Carbon		91 m^3	
126	Caustic solution	20% Sodium Hydroxide	400 m^3	liquid
128	Amine Antifoam		1, 172 kg	
129	Amine		1.43 litres/hour	
131	Oxygen Scavenger		18 m^3/yr	
	Amine		38 m^3/yr	
132	Biodispersant		6,100 kg	

Unit [1]	Chemical Name [2]	Composition % weight	Quantity	Physical State
	Chlorine Gas		43,300 kg	
	Caustic Solution	20% Caustic Solution	165,100 kg	
134	Activated Alumina		36,900 kg	
137	Caustic (50%)	50% Caustic Solution	578,520 kg	liquid
	Sulfuric Acid (98%)	98% Sulfuric Acid	240,660 kg	liquid
	Chlorine	100% Chlorine	26 kg	gas
154	Biocide		8,400 kg	
156	Sulfuric Acid	98% Sulfuric Acid	3,400 kg	liquid
	Caustic Solution	20 wt% Sodium Hydroxide	1,220,000 kg	liquid
	Ferric Chloride		152,100 kg	
	Chlorine	100% Chlorine	220 kg	gas
	Sodium Biocarbonate		370,000 kg	
	Activated Carbon		6,200 kg	
212	DMDS	100% DimethylDisulfide	77,127 kg	liquid
	Anti-Foaming Agent		As needed	
213	Antifoam Emulsion		385 kg	
214	DMDS	100% DimethylDisulfide	119,850 kg	liquid
	Soda Ash	Na_2CO_3	14,430 kg	
	Sodium Nitrate	$NaN0_3$	2405 kg	
216	DMDS	100% DimethylDisulfide	150 tonnes	
	Anti-Foaming Agent		TBD	
	Activated Carbon		2.4 m^3	

(1) Units were selected from MAA Refinery Work Breakdown Structure (WBS), P6001MAA-000.10.10.002_Rev.N. New Licensed and Open Arts process Units and new Utility and Offsites Units were included.

(2) Chemical properties and special handling requirements are provided in Material Safety Data Sheets (MSDSs).

* CFP facilities will handle and store a variety of proprietary catalysts which are not listed here. The handling and disposal of spent catalyst material is discussed in Chapter 10 (Solid Waste).

11.2 Chemical Handling and Storage

Potentially hazardous chemical materials will be handled, treated, stored and disposed of in the manner that is consistent with KNPC SHE Criteria during CFP construction and operations. The appropriate handling and danger placards will be displayed wherever hazardous chemical materials are handled, transported or stored. Storage will be in accordance with the provisions of Article No. 30 of the K-EPA regulations.

11.2.1 Construction

Construction of the CFP will require the use of numerous chemicals and materials including but not limited to:

- Paints
- Thinners
- Acids
- Solvents
- Lubricating oils
- Diesel for generators
- Compressed gases
- Pest control chemicals
- Cleaning fluids
- Corrosives

Only zero VOC paints will be used during construction of the CFP. Formaldehyde containing paints/ varnishes will not be used and care will be taken not to mix potentially incompatible materials. The temporary storage area (discussed below) will be required to comply with all local regulations. Fire fighting, safety and spill control equipment will be readily available should an accidental materials hazard occur. Personnel training will be provided regarding the proper use and upkeep of all emergency response equipment.

During construction, all hazardous material will be stored and managed in a central location located within each EPC Contractor controlled area. Materials within these areas will be stored according to compatibility and all flammable materials will be segregated and stored in a flame protected area. All hazardous materials will be contained within temporary or permanent bunding in order to prevent a release to soil and/or groundwater.

11.2.2 Operation

Potentially hazardous materials storage during operation of CFP facilities will either be in fixed tanks (at various bunded locations on the site), in a compressed gas cylinder storage area, or in the new MAB Chemical Storage Warehouse/ Catalyst Storage Area.

These facilities may contain hazardous materials in bottles, pails, drums, bags, or other containers. The design, construction and operation of these facilities will be in accordance with K-EPA licensing requirements as specified under Article No. 18 and the United Nations Classification System for separation of hazardous chemical materials. In addition, storage requirements and handling procedures will be in accordance with the requirements of KNPC's Chemical Hazard Management Procedure. Category 1 explosive materials are not envisaged for the CFP.

Chemical Storage Warehouse (Figure 11A)

- Two single story buildings
- Reinforced concrete slab and foundation
- Firewalls to separate materials that are combustible, flammable, corrosive or toxic, including acids and alkalis.
- Chemical resistant coating such as an epoxy on floor
- Curbing will be used to provide secondary containment where needed

Catalyst Storage Area (Figure 11B)

Fresh catalysts are typically not hazardous when properly handled. They are composed of alumina and silica substrates which contain oxides of molybdenum, cobalt, nickel and possibly other active metals such as platinum or palladium. The metal oxides and substrates are stable compounds under ambient conditions. After catalysts become spent, they are classified as hazardous waste because the metal oxides are converted to sulfides and other metals such as vanadium are accumulated within the catalyst structure. The metal sulfides, in the presence of hydrocarbons, can be pyrophoric under certain circumstances.

A new Catalyst Storage Area will be provided for fresh catalysts. It will consist of:

- Five single story, covered metal sheds
- Reinforced concrete slab and foundation
- Floor epoxy finish coating
- Steel pallet rack system finished with factory applied heavy duty corrosion resistant coating system
- Will contain catalyst packed in super sacks placed on pallets
- Catalysts in 55 gallon drums will be stored in the open yard.

Figure 11A – Chemical Warehouse Building Conceptual Site (drawing is preliminary and subject to change)

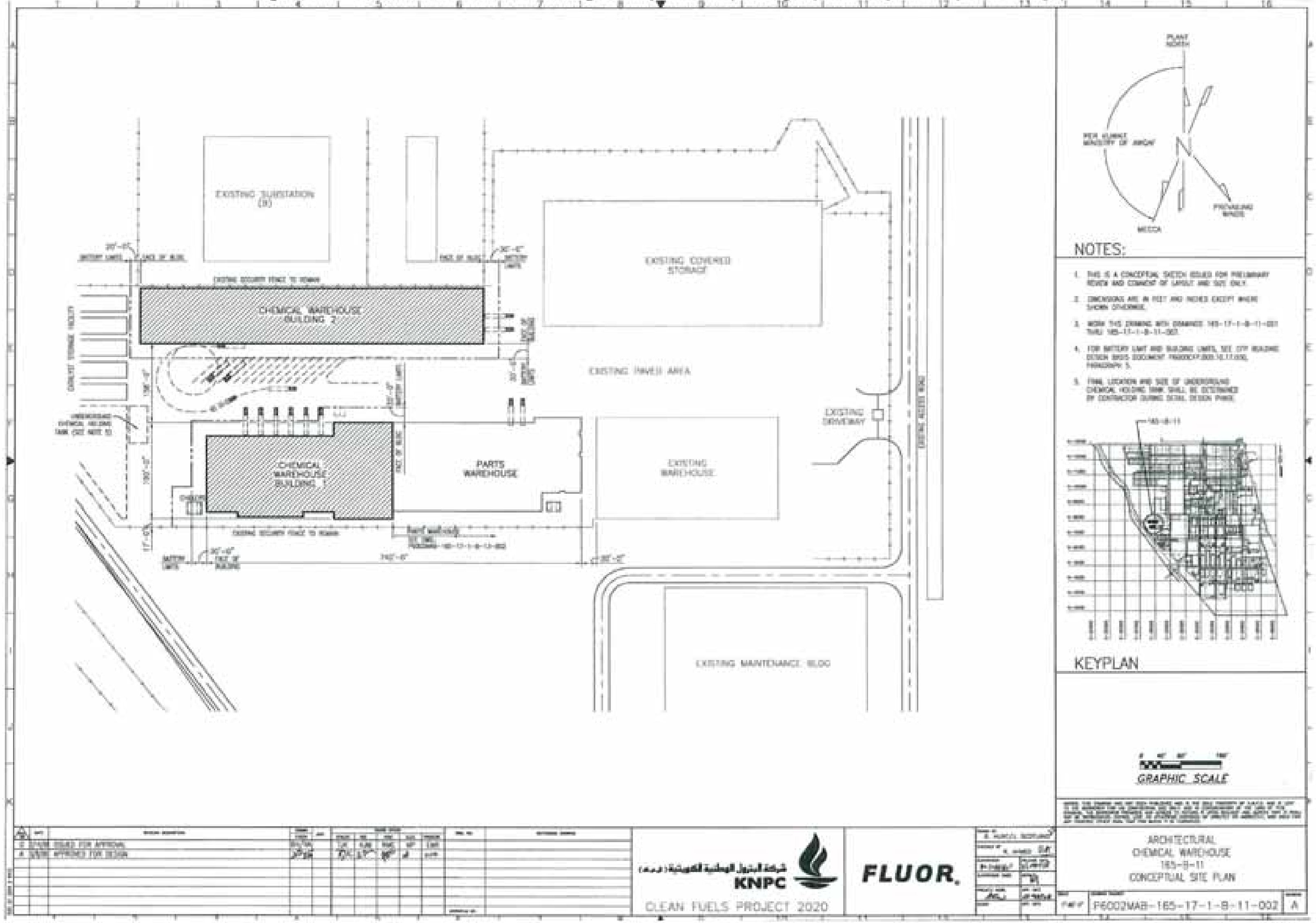
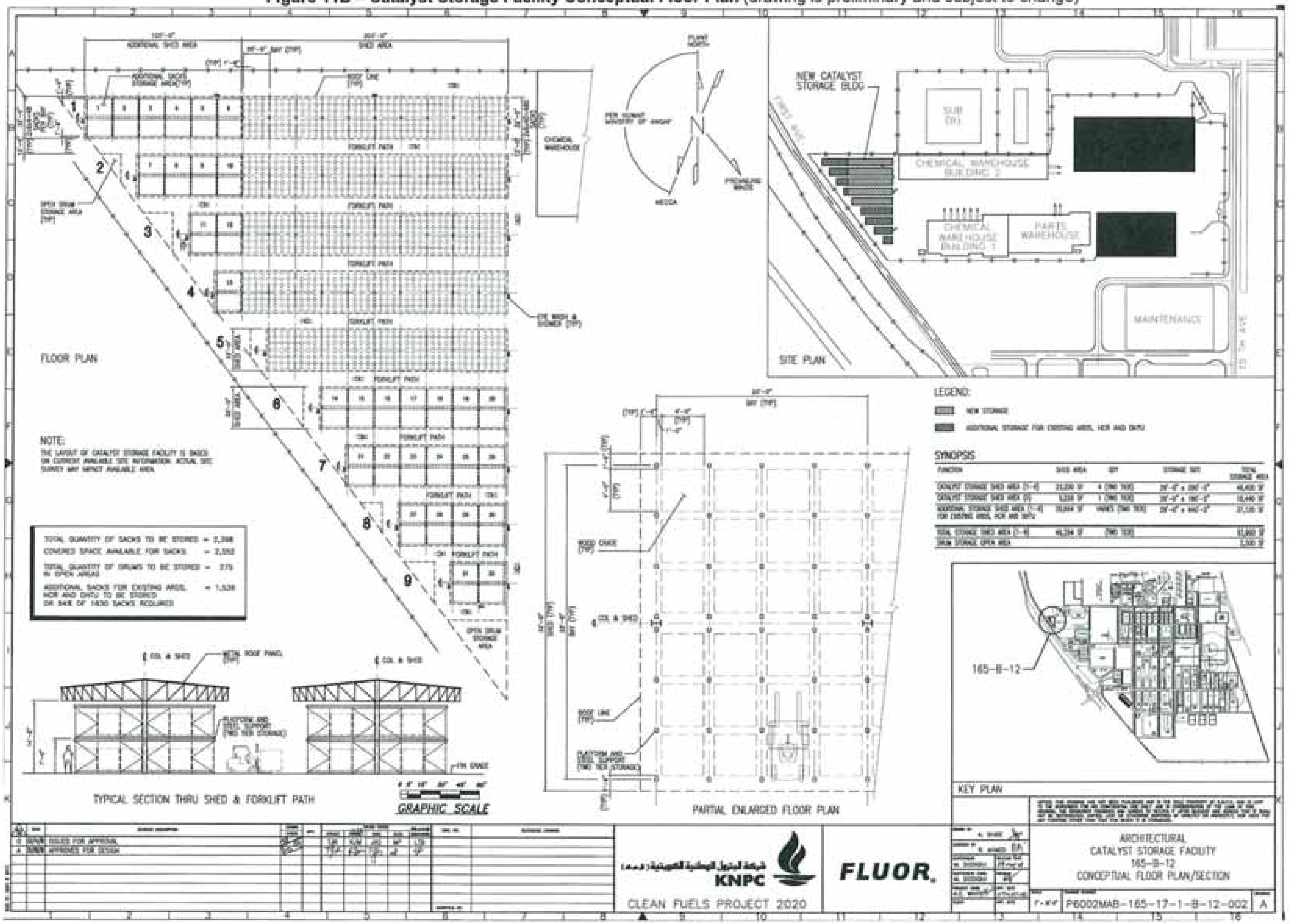


Figure 11B – Catalyst Storage Facility Conceptual Floor Plan (drawing is preliminary and subject to change)



KNPC will implement the following procedures for handling and storage of hazardous materials:

- Areas for storage of hazardous materials in any form (tanks, drums, solids, etc.) will have a spill containment system for collecting and holding spills, leaks, and precipitation;
- Any hazardous waste generated will be placed in sealed plastic or metallic drums with an inner polybag liner prior to being transported to an approved disposal site in accordance with applicable K-EPA criteria;
- Any container holding a hazardous material or hazardous waste will be kept closed during storage;
- Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge of hazardous materials;
- Written documentation for storage, handling, transportation, and disposal of hazardous materials and hazardous wastes will be maintained at the MAA and MAB refineries including a record of quantities, hazardous characteristics, and MSDS's;
- Access to any hazardous material storage area will be controlled to prevent entry of unauthorized persons or vehicles;
- Incompatible materials will not be placed in common containment areas or in the same containers in accordance with the requirements of K-EPA Article No. 18;
- Source monitoring systems will be provided in appropriate areas of the MAA and MAB refineries for detection of combustible gas.

11.3 Storage and Handling Design Basis

11.3.1 Secondary Containment

All new CFP vessels for handling or storing hazardous materials will be constructed of appropriate materials for the contents they hold and will have epoxy or similar lining as necessary to prevent corrosion and /or leaks. All new tanks in hydrocarbon and/or hazardous material service will have dike walls around the tank as well as provision of secondary containment below the tank. Secondary containment and storage requirements for hazardous materials will be in accordance with K-EPA Article No. 30 and accepted international criteria.

New or modified process vessels containing hazardous materials will be located above a concrete pad that is curbed to contain any potential spills or leaks.

A pump out system (either a permanent installation or a temporary/portable system) will be provided for draining more than 10m^3 of hydrocarbons resulting from an accidental leak or spill. Spilled oil or chemicals will be collected to the extent practical by vacuum truck and then taken to the waste water treatment system. Any remaining oil or chemicals will be washed down into a sump that is part of the Oil Drips System (ODS). The ODS is an underground, gravity drain which leads to a central sump feeding into the CFP wastewater treatment facilities.

In addition, a groundwater monitoring well system will be installed and located so that representative samples of the groundwater that may be impacted by operation of the proposed facility can be obtained. A total of three up gradient and five down gradient groundwater monitoring well systems will be placed around each CFP process block within MAA and MAB refineries. The groundwater monitoring well systems will be capable of measuring background water quality and intercepting/measuring plumes of contamination, if any, from the facility operations. Groundwater monitoring well placement will be based upon hydrogeological data for the refinery sites taking into account both the direction of groundwater flow and the planned location of facilities/equipment where oil and other potentially hazardous materials will be stored.

A chlorine gas feed system is currently used to treat cooling water within the existing refineries. The new cooling water systems for the new and modified CFP facilities will also use chlorine however the chlorine gas cylinders will be stored within enclosed buildings. Enclosure of the cylinders within specifically designed buildings will ensure containment in the event of a release. There are two chlorine system enclosures planned for MAA and two planned for MAB. They will all include leak detection systems/alarms and caustic scrubbers. Chlorine will not be used during the construction phase. Chlorine modelling should be conducted in order to ensure that any safety issues are adequately addressed.

11.3.2 Transportation of Hazardous Chemical Materials

Where transportation of hazardous materials or hazardous waste is required for disposal outside the CFP, this will be conducted in accordance with K-EPA criteria (Article Nos. 31 through 34) and good environmental operating practices. On-site collection system containers and storage areas will be kept well segregated in order to prevent the creation of health and fire hazards. The transportation of hazardous waste is discussed in detail in Chapter 10 (Solid Waste Management).

11.3.3 Underground Storage of Hazardous Chemical Materials

The CFP scope does not currently include any plans for underground storage tanks. However, there will be a number of underground piping, vessels (such as drains and sumps) as part of the various wastewater collection systems for CFP. All underground piping will be hydro-tested before operation commences.

11.3.4 Spill / Release Control and Contingency Planning

KNPC is committed to the safety of its employees, installations and the society. All applicable safety standards, procedures and best practices are followed during process selection, design, construction and operation of the various facilities. However, even with the best safe working practices, emergency incidents may occur. Therefore, as part of its overall EMS, KNPC has developed procedures for emergency response. The design and operation of CFP facilities are incorporated into KNPC's existing emergency preparedness and contingency planning procedures. These procedures include descriptions of the specific requirements for handling and disposal of hazardous materials, and emergency response. This is discussed in Chapter 15.

11.4 Potential Impacts

The potential impacts on the surrounding environment from the storage, use, handling and transportation of potentially hazardous materials have been identified by applying the impact assessment and matrix approach. The potential impacts and resulting significance are outlined in Figures 11C and 11D below.

Figure 11C Impact Assessment Form and Matrix - Construction

Category: Environment

Consequence evaluation for: Hazardous Material Management during Construction

1. General description of the area (situation and characteristics)

Note: This section describes the sensitivity of the area in question. Following a review of existing information regarding the site's sensitivity, a sensitivity rating or value is given.

CFP will require new and modified facilities at the three KNPC Refineries (MAA/MAB/SHU) and the use of a section of adjacent undeveloped land. The existing refineries, their surrounding areas/land and the section of adjacent undeveloped land are not considered to be highly sensitive areas.

It is important to note the decommissioning phase of the project is not included as part of this EIA and its impact in relation to hazardous material management has therefore not been evaluated.

It is difficult to apply a sensitivity value (using this matrix) to hazardous material management during either construction or operation, as the important issue is to ensure that measures are in place to properly manage hazardous materials. The sensitivity of the area only really becomes relevant if these measures fail and spillages occur.

In assessing the sensitivity of the area the relatively close proximity of the CFP to local populations (closest population approximately 2 km) needs to be evaluated along with what is considered to be a lack of adequate groundwater resources within this area. Based on this the sensitivity is deemed to be **Medium**.

Low Medium High
|---------X-----------|

2. Description of the extent of effect

Evaluation of extent:

The main impact from the storage of hazardous material is the potential for a release to the surrounding environment. However all hazardous materials will be properly bunded and contained and adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge.

Hazardous material management procedures will be implemented and therefore help to prevent and minimise any potential effects.

The quantities of hazardous material likely to be stored and used on site during the construction phase are likely to be relatively small. The extent of the effect is assessed to be of **Little significance** provided recommended measures are followed.

Very neg. Medium neg. Little/no Medium pos. Very pos.
|---------------|--------------X--|----------------|-------------------|

3. Total (environmental) impact

"small negative impact"

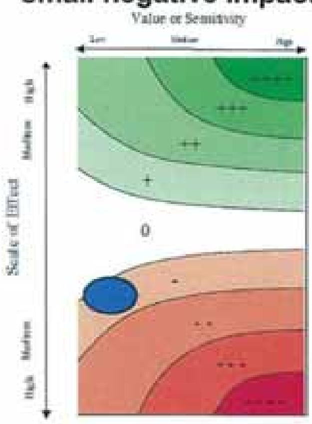


Figure 11D Impact Assessment Form and Matrix - Operations

Category: Environment

Consequence evaluation for: Hazardous Material Management during Operation

1. General description of the area (situation and characteristics)

Note: This section describes the sensitivity of the area in question. Following a review of existing information regarding the site's sensitivity, a sensitivity rating or value is given.

As identified above for the construction phase the most important requirement is to ensure that measures are in place to properly manage hazardous materials. The sensitivity of the area only really becomes relevant if these measures fail and spillages occur.

In assessing the sensitivity of the area the relatively close proximity of the CFP to local populations (closest population approximately 2 km) needs to be evaluated along with what is considered to be a lack of adequate groundwater resources within this area. Based on this the sensitivity is deemed to be **Medium.**

Low Medium High
|---------X-----------|

2. Description of the extent of effect

Evaluation of extent:

The CFP project will use and store significantly large quantities of finished product, chemicals and catalyst during its operation. The biggest risk to the environmental is likely to result from an on-site release of large quantities of hazardous material.

A large number of mitigation measures will be implemented at the site and these need to be taken into account in this evaluation:

The large quantities of hazardous material will be bunded and an impermeable lining/membrane will be present under the hydrocarbon tanks (although areas extending outwards from the sides of tanks will not be impermeable). Chlorine gas cylinders will be stored in enclosed buildings which include leak detection systems/alarms and caustics scrubbers

Hazardous material management procedures will be in place in order to prevent and minimise any potential effects and the approach to hazardous waste materials management during operation is prevent, minimisation, re-use, recycle.

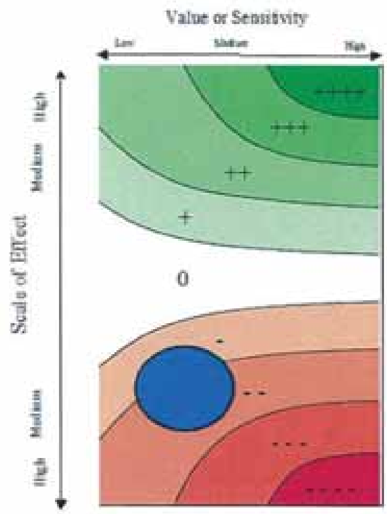
Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge of hazardous materials.

Provided the management measures advised are taken, this issue is assessed as having **Medium negative significance**

Very neg. Medium neg. Little/no Medium pos. Very pos.
|---------------|-----X-----------------|---------------|------------------|

3. Total (environmental) impact

"Medium negative impact"



11.5 Mitigation Measures

11.5.1 Construction

- A central location will be defined within each EPC Contractor storage controlled area for the storage and management of all hazardous material during construction.
- All materials will be stored according to their compatibility and will be contained within temporary or permanent bunding to prevent the release to soil and/or groundwater. All flammable material will be segregated and stored in flame proof areas.
- Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge.
- Any hazardous waste generated during construction will be disposed of according to the WMP (refer to Chapter 10).

11.5.2 Operation

A number of mitigating measures for the control of hazardous materials during operation of the CFP facilities are proposed, the main ones being:

- A groundwater monitoring well system will be installed. These wells will be installed based upon hydro-geological data for the refinery sites taking into account both the direction of groundwater flow and the planned location of facilities /equipment where oil and other potentially hazardous materials will be stored. The groundwater monitoring well system will be capable of measuring background water quality and intercepting/measuring plumes of contamination, if any occur from the refineries operations;
- Storage of hazardous chemicals will be in accordance with the provisions of Article 30 of the K-EPA regulations ensuring that the storage and handling of materials are properly managed;
- A Chemical Storage Warehouse will be built at the MAB Refinery. It will consist of two buildings both of which will be unoccupied. The warehouse will store all chemicals used at the MAB refinery and will be designed to include firewalls to separate materials that are combustible, flammable, corrosive or toxic including acids and alkalis; A new Chemical Warehouse is not planned for the MAA Refinery.
- A Catalyst Storage Area will be constructed at MAB, which will consists of five single story covered metal sheds and an open yard area for drum storage; A new Catalyst Storage Area is not planned for the MAA Refinery.
- Curbs, floor drains, sumps and trench drains with grating will be provided in the storage areas for spill control and containment of liquids and water discharge from sprinkler systems and emergency shower eyewash. The floor drains and sumps in curbed areas and floor trenches at doors will be connected by chemical resistant piping to drain to an underground collecting/holding tank. The holding tank will be adequately sized to contain releases;
- Areas for storage of hazardous materials in any form (tanks, drums, solids, etc.) will have a spill containment system for collecting and holding spills, leaks, and precipitation. All tanks containing hydrocarbons and/or hazardous material will be bunded and lined with an impermeable membrane;
- A leak detection system will be in place serving the new hydrocarbon and hazardous material storage (whose contents are in a liquid state at ambient conditions) tanks. For areas other

than that directly below storage tanks, leak detection will be accomplished through regularly scheduled visual inspection of the tank exterior and connecting piping;

- Any hazardous waste generated will be placed in sealed plastic or metallic drums with an inner polybag liner prior to being transported to an approved disposal site in accordance with applicable K-EPA criteria;
- Any container holding a hazardous material or hazardous waste will be kept closed during storage;
- Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge of hazardous materials;
- Written documentation for storage, handling, transportation, and disposal of hazardous materials and hazardous wastes will be maintained including a record of quantities, hazardous characteristics, and MSDSs;
- Access to any hazardous material storage area will be controlled to prevent entry of unauthorized persons or vehicles;
- Incompatible materials will not be placed in common containment areas or in the same containers in accordance with the requirements of K-EPA Article No. 18;
- Source monitoring systems will be provided in appropriate areas of the CFP project for detection of combustible gas;
- The chlorine system enclosures will all include leak detection systems/alarms and caustic scrubbers.
- Adequate fire fighting, safety and spill control equipment will be readily available in case of an accidental discharge;
- Disposal of hazardous waste will be in accordance with the requirements of the EMS.

11.6 Conclusions and Recommendations

The CFP facilities will store and/or handle a variety of potentially hazardous materials, including materials similar to what currently exist at the three refineries. The hazardous materials to be used on the site (the majority of which are identified above) will be potentially toxic, corrosive, flammable etc.

The impact from the storage, use, transportation and disposal of hazardous materials is considered to be "little negative" significance during construction and of "medium negative" significance during operation provided that all recommended management measures are followed.

It is important that the management systems comply with K-EPA requirements for the handling, storage and disposal of hazardous materials. Storage of hazardous chemicals will be in accordance with the provisions in Article 30 of the K-EPA regulations.

During construction and operation, hazardous material will be controlled by appropriate management procedures. Mitigation measures will be introduced during construction and operation that will ensure containment of materials either via temporary bunding during construction or permanently via the specifically designed MAB Chemical Warehouse.

12.0 WASTEWATER GENERATION, TREATMENT AND REUSE

12.1 Introduction

The CFP development will require large volumes of water for cooling tower, boiler feedwater (BFW) make-up, process water, potable water, sanitation and other refinery services. KNPC plans for the CFP's water demand to be met by wastewater recycling and reuse as much as possible.

Minimization of wastewater generation at the source and by reuse, as well as segregation, collection and treatment of similar wastewater streams are the main principles used in the design of the cost effective and environmentally friendly wastewater treatment. The new Wastewater Treatment (WWT) Systems will collect, convey and treat wastewater according to the K-EPA requirements prior to any discharge.

There will be two new WWT Systems provided as part of the CFP:
- New Wastewater Treatment System at MAA – Unit 163
- New Wastewater Treatment System at MAB – Unit 156.

These new CFP facilities will incorporate state of the art design to complement upgrades to the existing MAB effluent treatment facility under a separate project (KNPC Effluent Treatment Facility Revamp project). The CFP design will incorporate best environmental engineering practices such as 'Best Available Control Technology' (BACT) to avoid, prevent or mitigate the discharge of all harmful emissions so as to meet (or exceed) applicable K-EPA environmental standards.

The objectives of the WWT Systems are:

- Compliance with K-EPA Regulations for effluent discharges to the sea
- Simplify treatment and reduce cost of wastewater treatment by segregation, collection, and treatment of similar types of wastewater
- Uninterrupted treatment of incoming wastewater using equipment redundancy and WWT system flexibility
- Minimize Volatile Organic Carbon (VOC) emissions and reduce odour
- Reuse treated effluent water for fire water make-up and utility hose stations.

The focus on this wastewater section is on the following areas:
- Explain the details of the new WWT Systems
- Identify wastewater streams
- Identify wastewater minimization, reuse, treatment and recycling
- Assess the impact of discharges during both CFP construction and operation.

12.2 Wastewater (Construction)

It is expected that an overall peak workforce of approximately 36,000 (divided into separate EPC contractor camps) will be required at the peak of construction activities for the CFP. The workers will be housed in the local community, existing camps and potentially new camp facilities to support the project.

In all cases, plans for handling site drainage and wastewater discharge are currently not well defined. It can be stated that KNPC, and the EPC contractors, are committed that all discharges will meet regulatory requirements during construction. This is particularly important bearing in mind that groundwater onsite is currently contaminated with coliforms in some locations.

Wastewater effluents will be generated on a short-term basis as a result of the various construction activities associated with the CFP, and its scheduled start-up and maintenance activities. These will include sanitary wastewater, wash-down water, storm water, and wastewater from hydrostatic testing activities (i.e. from asset-integrity testing of pipelines and storage tanks etc). The EPC contractors will be required to develop a hydrostatic testing procedure which must be approved by KNPC and Fluor (as PMC). All hydrostatic test water must meet all applicable K-EPA criteria, such as pH, before being discharged.

Specific wastewater collection and treatment elements during the CFP's construction phase will include:

- Sanitary wastewater collection/treatment: The current basis for treating the construction sanitary wastewater is not well developed. It may involve the utilization of temporary facilities such as portacabins and holding tanks to collect and contain sanitary wastewater. Wastewater would then be periodically removed from the site via vacuum tanker trucks to an approved existing government-owned wastewater treatment facility. KNPC and the EPC contractors are committed that all discharges will meet regulatory requirements during construction. This is particularly important bearing in mind that groundwater on the refinery sites is currently contaminated with coliforms in some locations.

- Storm water from the CFP construction site and groundwater from groundwater pumpout activities will be contained and collected onsite and tested to meet K-EPA requirements before discharge via existing storm water discharge outlets at MAA or MAB. If the water quality is not acceptable, the EPC contractor will need to provide means for treating the water prior to discharge (existing refinery wastewater treatment facilities will not be used for treatment of construction drainage). No new discharge outlets will be provided during construction.

  During the early stages of construction, the volume of storm water to be collected at the CFP construction site is expected to be minimal. However, there will be a gradual increase in storm water collection over time as the amount of paved area within the CFP site increases. Specific plans and details for handling site drainage during construction are currently not well defined at this stage, although each EPC Contractors is responsible to adhere to Project and Regulatory Requirements.

K-EPA requires that all treated effluent discharges to sea be 500m or more offshore. A new outfall pipeline will be provided from the CFP wastewater treatment facilities at MAA in accordance with this requirement. This outfall will not however exist during the early construction phase. It is KNPC's policy that throughout the construction period no wastewater effluents will be discharged to the environment (either to land or sea) without first having been analyzed to verify compliance with all applicable K-EPA discharge criteria. If sample analysis indicates that the water in the retention pond(s) is not of acceptable quality for discharge it will be pumped back to the packaged wastewater treatment or collected via vacuum truck for transport to an appropriate wastewater treatment facility.

Before any storm water, groundwater and treated effluent is permitted to exit from the collection areas, it will be sampled and analyzed for compliance with the applicable regulatory criteria. Only water that is equal to or of better quality than that of the natural occurring drainage will be released. The flow of clean water from the collection areas will be gradual and normally low in volume. In the case of a large rainfall event, the collection areas may be pumped down rapidly to avoid flooding the CFP construction site and surrounding area.

Each EPC Contractor will be required to submit, for KNPC approval, a Water Conservation and Wastewater Management Plan that will detail their prescribed methods toward minimizing the generation of wastewater effluents, and wastewater management including sewage, wastewater and storm water.

12.3 Wastewater (Operation)

12.3.1 Overview of Wastewater Treatment Facilities

The main wastewater streams treated in the WWT units are process wastewater streams from the CFP units, such as surplus Stripped Sour Water (SSW), Cooling Tower (CT) blowdown, Boiler blowdown, as well as fire fighting water and storm water runoff from paved process areas.

Clean CFP storm water from MAA (OSBL) is released into an existing concrete lined ditch along the south side of MAA and winds through the refinery to make its way to a wadi near the southeast corner of MAA. KNPC currently use this wadi to receive clean storm water from existing areas of MAA. Storm water runoff from MAB areas and roadways outside paved process areas is collected in an oil catcher and pumped to the Gulf.

The effluent streams generated and collected from the new CFP process units are segregated at the source and collected in one of following seven drainage systems as discussed further in Section 12.3.3. Effluents segregated and collected in these drainage systems receive different treatment, depending on the source, type and level of contamination.

- Accidentally Oil Contaminated (AOC)
- Oily Drips System (ODS)
- Chemical Collection and Drainage System
- Dry Slops System
- Outside Battery Limits (OSBL) and Roadway Storm Water Drainage System
- Sanitary and Gray Water Collection
- Sludge Collection and Treatment

These new CFP WWT facilities will incorporate state of the art design. The CFP design will incorporate best environmental engineering practices such as 'Best Available Control Technology' (BACT) to avoid, prevent or mitigate the discharge of all harmful substances so as to meet (or exceed) applicable K-EPA environmental standards.

The new CFP WWT plants will treat wastewater streams from various CFP process areas. At MAA, treatment will include oil-water separation via CPI (Corrugated Plate Interceptor), and DAF (Dissolved Air Floatation) oil removal processes, and biological treatment for destruction of dissolved organics. At MAB, treatment will include oil-water separation via CPI and DAF, with biological treatment being provided by an existing MAB effluent treatment facility, which is currently being upgraded as part of a separate project (KNPC MAB Effluent Treatment Facility or ETF Revamp Project). The ETF is part of a separate

EIA process. The WWT facilities at MAB will also include incineration of oily sludge that is generated both at MAA and MAB.

Figures 12A and 12B provide overall block flow diagrams of the two CFP WWT plants for the CFP at MAA and MAB refineries respectively. The CFP WWT plants have significant similarities and include:

- Wastewater collection and storage in the AOC and ODS systems
- OSBL and Roadway storm water collection and drainage system discharging to the Gulf via oil catchers (for MAB) and to existing concrete lined ditch along MAA south side (for MAA).
- Oil and suspended solids removal with Corrugated Plate Interceptor (CPI) and Dissolved Air Flotation (DAF) units
- Hydrogen Sulfide removal by aeration (a new CFP unit is provided at MAA; treatment is provided by the revamped KNPC MAB ETF at MAB)
- Biological Activated Sludge Treatment (BIOX) with Nitrification/Denitrification steps for destruction of soluble organics and removal of Nitrogen, and Activated Sludge removal by clarification (a new CFP unit is provided at MAA; treatment is provided by the revamped KNPC MAB ETF at MAB)
- An Observation Basin at MAA for retention and analyzing treated effluent and clean water before discharge to the Gulf.
- Mixing Basin (existing) at MAB for mixing, retention and analyzing treated effluent and clean water before discharge to the Gulf. Some treated effluent from the existing revamped ETF facilities will be diverted to an observation basin (part of the new WWT Unit 156) for reuse in meeting utility water demands.
- Waste Activated Sludge and Oily Sludge Dewatering and Deoiling by centrifuges to obtain biosludge suitable for disposal by National Cleaning Company (NCC) and oily sludge for incineration in the MAB Oily Sludge Incinerator.
- A new wastewater outfall pipeline will be provided for the treated CFP wastewater effluent generated at MAA which will extend outward from the coastline along the New Oil Pier a distance of 500 meters from the low mean water mark for subsurface discharge. No dredging is required because the outfall will adjoin the new oil pier. CFP wastewater at MAB will be routed to the revamp of the Effluent Treatment Facility (ETF project, by others) for biological treatment and then discharged to the existing Treated and Clean Water Mixing Basin.
- Chemical Feed Systems
- Sanitary and gray wastewater at MAA will be pumped offsite for treatment at an existing Municipal Waste Treatment Facility. Sanitary and gray wastewater at MAB will be treated in the new CFP Sanitary Wastewater Treatment Plant at MAB.

This project will implement technologies and operating practices to achieve water conservation and effluent reduction. Toward this intent, KNPC will endeavour to reduce wastewater generation and recycle/reuse all treated wastewater to the extent practical. Potential uses include:

- Treated sanitary effluent as irrigation water for landscaping at MAB Refinery,
- Wash down water, and
- Fire water make-up.

The CFP WWT Systems at the MAA and MAB refineries will be designed for continuous operation. The concept of multiple trains will be used to provide suitable system flexibility. This allows for outages of any individual piece of equipment without a complete shutdown of the WWT System or violation of the applicable discharge standards (at reduced throughput).

Wastewater from the SHU Refinery is currently treated within the refinery prior to being discharged. Post-CFP, wastewater generated from SHU will significantly decrease in conjunction with the retirement of the process units. SHU tank farm wastewater will be routed to the CFP WWT facilities at MAB.

Figure 12A MAA Refinery Wastewater Treatment System Overall Block Flow Diagram (PRELIMINARY)

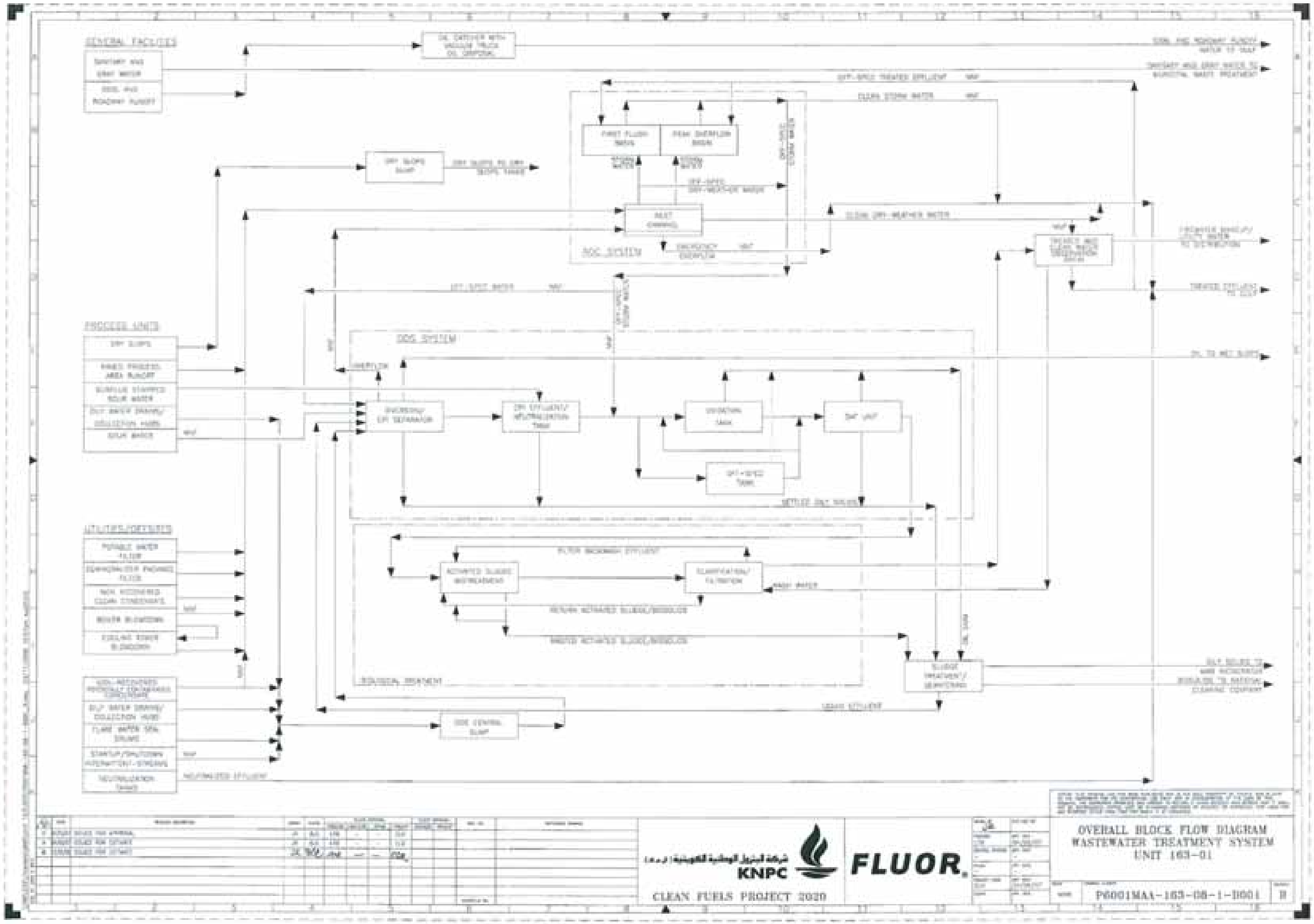
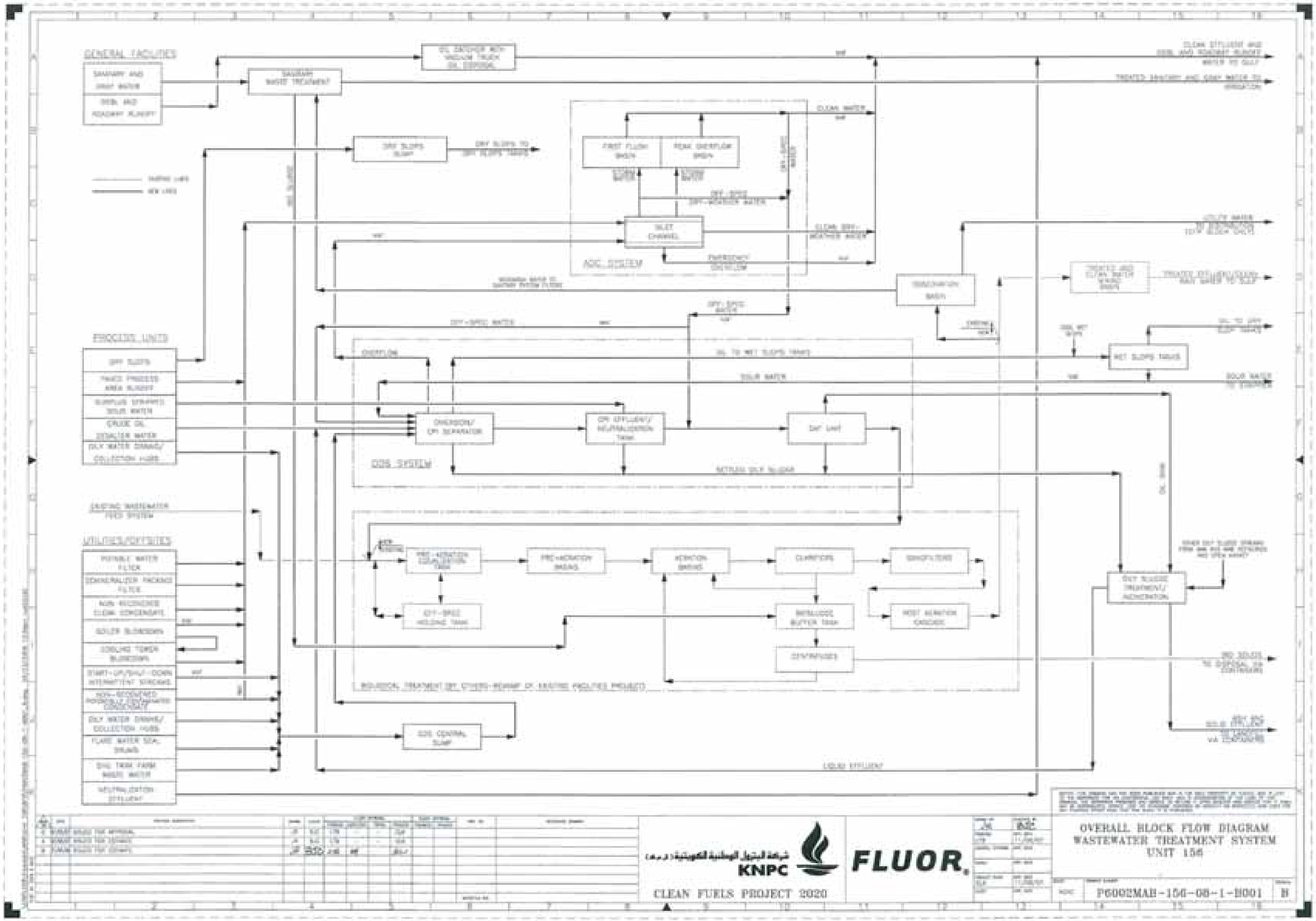


Figure 12B – MAB Refinery Wastewater Treatment System Overall Block Flow Diagram (PRELIMINARY)



12.3.2 Safeguarding against Uncontrolled Discharges

The CFP's wastewater treatment system will incorporate a system of relief devices and instrumentation safeguards to provide against uncontrolled loss of containment. A set of 'Process Safeguarding Flow Schemes' detailing such instrumentation will be included in the wastewater treatment system Operating Manuals.

12.3.3 Specific Wastewater Streams and Treatment

The new and revamped CFP facilities will generate a variety of liquid streams that are generated both continuously and intermittently. Table 12.1 (below) shows the separate industrial effluent drainage systems installed and the sludge collection/treatment system provided.

Table 12.1: Wastewater classifications

Treatment System	Feed Sources
Accidentally Oil Contaminated (AOC) System	• Paved Process Area Storm Water Runoff • Cooling Tower Blowdown • Firewater from all Paved Process Areas • Boiler Blowdown (normally via Cooling Tower Blowdown) • Potable Water Filter • Demineralizer Package Filter • Non-Recovered Clean Condensate
Oil Drips System (ODS)	• Surplus Stripped Sour Water (segregated routing by separate piping) • Crude Oil Desalter Water (MAB Refinery only) • Rotating Equipment Drip Pans • Process Area Collection Hubs • Oily Drains During Equipment Maintenance, Shutdowns and Start-ups • Flare Water Seal Drum Overflows • Non-Recovered Potentially Contaminated Condensate • Off-spec AOC Wastewater
Dry Slops System	• Hydrocarbon Sample Discharge • Collection Hubs and Rotating Equipment Base Plates • Off-Spec Products • Water-Free Oily Drains During Shutdowns / Start-ups
OSBL and Roadway Storm Water Drainage	• Storm water from outside paved process and roadway areas
Sanitary and Grey Wastewater System	• Most permanent buildings (administration, control room, maintenance, shelters, smoking areas, etc.)
Sludge Collection and Treatment System	• Corrugated Plate Interceptor System • CPI Effluent / Neutralization Tank • Dissolved Air Floatation Units • Biological Treatment Clarifier (MAA Refinery only) • Vacuum Trucks

General Note: Sample line open discharges will be diverted into the most suitable and cost effective drainage system without causing adverse impact on the environment and / or WWT System performance.

Focusing on each of these seven wastewater streams, the specific collection and treatment characteristics are as follows:

a) Accidentally Oil Contaminated (AOC) sewer system

The AOC system is an underground gravity flow system that collects normally oil-free and pH-neutral wastewater streams from within and around the individual units, fire fighting water, rainfall runoff from paved process surface areas, and utility systems wastewater streams (i.e. continuous cooling tower and continuous/intermittent boiler blowdown, potable water and demineralizer package filter discharge, non-recovered clean condensate). Continuous/intermittent boiler blowdown is normally routed to the cooling tower basin and it ends up in the AOC system as cooling tower blowdown. Alternate provision also exists for continuous/intermittent boiler blowdown to go directly to the AOC system.

The system is equipped with dry weather flow (DWF; no storm and/or fire event water runoff) pumps with an oil-water analyzer specifically to monitor for any oil accidentally present into the above mentioned streams. Should sampling and analysis of the AOC DWF indicate that it contains unacceptable levels of hydrocarbons, flow will be automatically routed to the appropriate treatment system.

AOC-category wastewater is routed through the AOC drainage network to a controlled discharge facility that consists of Inlet Channel designed for dry weather flows, First Flush basin designed for the "first rain" water runoff, and Peak Overflow basin designed for rainfall after the first flush. Should the AOC influent flow exceed the dry weather pumping capacity of the Inlet Channel (i.e. during a storm or fire event), then water is passively diverted into these impounding basins by sequentially overflowing a set of weirs located between the Inlet Channel and the basins. Impounded water is evaluated for contamination and, if needed, transferred to the appropriate treatment system prior to discharge. Should the AOC dry weather wastewater contain unacceptable levels of hydrocarbons, it is diverted to the Oily Drips System (ODS) facilities for treatment.

b) Oil Drips System (ODS) Drainage and Biological Treatment System

The ODS is an underground gravity flow system that collects and treats wastewater streams contaminated with oil and organics that require removal of oil with Corrugated Plate Interceptor (CPI) and Dissolved Air Flotation (DAF) oil separators and organics via biological treatment (a new biological treatment system will be provided for CFP effluents at MAA; biological treatment for CFP effluents at MAB will be via the revamped KNPC MAB ETF).

The main streams segregated and collected in this system are: non-recovered potentially contaminated condensate, oily wastewater from rotating equipment drip pans, collection hubs, and sampling points, oily drains during equipment/unit shutdowns, and continuous flare seal water blowdown. They are collected in a central sump located within the CFP WWT Units at MAA and MAB. Surplus stripped sour water comes through a separate pipeline directly into the CPI Effluent/Neutralization Tank.

The ODS facilities at the MAA Refinery will consist of free oil removal in CPI separator, followed by neutralization and H_2S oxidation, then emulsified oil removal in parallel DAF separators, biological treatment, clarification, and effluent filtration. Treated effluent is pumped to the Observation Basin and then to the Gulf via an above-ground pipe. Oily solids and waste activated sludge generated in the ODS facilities are sent to the sludge collection/treatment system where they are centrifuged to remove water and oil. Free oil removed in the CPI separators is transferred to the Wet Slops System (Unit 163-Circuit 02) for oil recovery. Oily effluent from the DAF separators has its entrained solids removed in the Sludge Treatment/Dewatering facilities. The liquid effluent will be recycled to the CPI separators. The oily solids will be routed to the new oily sludge treatment / incineration system at MAB. Bio-solids will be sent for offsite treatment and disposal by NCC.

The ODS facilities at the MAB Refinery will consist of free oil removal in parallel CPI separators, followed by neutralization, then emulsified oil removal in parallel DAF separators. The DAF effluent will then be routed to the existing Biological Activated Sludge Treatment (BIOX) system at MAB (which is being provided by a separate ETF revamp project). The BIOX system will provide H_2S removal by oxidation to dissolved sulfate in a pre-aeration section, a biological activated sludge system, clarification and effluent filtration. Treated BIOX effluent will be routed to the Observation Basin, to be used as CFP utilities water as needed. Any remaining portion of the treated effluent will be commingled with other plant effluent in the existing Mixing Basin and then discharged to the Gulf via the existing discharge arrangements.

Oily solids from the CFP and DAF oil separators in the CFP ODS System will be routed to the oily sludge centrifuges for dewatering, and the resulting dewatered cake will be incinerated in a fluidized bed incinerator. This incinerator will be designed with adequate capacity to also incinerate oily sludge streams from the rest of the MAB Refinery, MAA Refinery and open market.

Biological solids will be centrifuged in the existing ETF dewatering system, and then shipped to NCC for disposal. Free oil removed in the CFP separators will be transferred to the wet slops system for oil recovery.

c) Dry Slops System (DS)

The Dry Slops System collects, in a hard-piped gravity flow network, hydrocarbon streams free of water from various equipment drains, rotating equipment drip pans and sampling points located in Hydrocarbon Process, Hydrocarbon Support and Utility units. The network is connected to an underground DS sump along with the ODS sump. The water-free oil collected in the DS sump is pumped to the dry slops tanks.

d) OBSL & Roadway Drainage System

This system collects storm water from outside the paved and diked process areas in drainage systems routed directly to the Gulf via oil catchers as a matter of additional precaution and protection of the environment. Oil separated in the oil catcher is removed and transported via vacuum trucks. Clean CFP OSBL storm water will discharge to the Gulf via new above and below ground pipes at MAA at the edge of Gulf waters. Clean CFP OSBL storm water at MAB will be routed to an existing ditch that discharges to the Gulf.

e) Sanitary and Gray Water Collection System

Sanitary wastewater for CFP will be collected from buildings and routed to sanitary lift stations by gravity flow. Sanitary and gray wastewater is then pumped through sewer systems to:

- Municipal Waste Treatment facility located outside refineries (for MAA).
- A dedicated Activated Sludge Biological Treatment unit (for MAB). Treated effluent from this unit will be used for irrigation. Waste activated sludge will be sent to the Biological Sludge Handling Facility, which is part of a separate KNPC ETF project.

f) Sludge Collection and Treatment System

The sludge collection and treatment system collects and stores sludge from the various pieces of WWT equipment. These various sludge streams are classified into either:

1. Waste activated sludge from biological treatment, or
2. Oily solids from the CPI and DAF oil-separating units.

As previously described, for the MAB Refinery, biological treatment of wastewater from the CFP block will be carried out in the ETF facilities provided by a separate KNPC project. Waste activated sludge resulting from this treatment will be dewatered in the Sludge Dewatering facility which is also a part of the ETF system, and then shipped off-site to the NCC for disposal. Oily solids from the CPI and DAF separators, after removal of oil and water by centrifuging, will be routed to the new CFP oily sludge incineration system at MAB.

At MAA, the collected sludges are transferred appropriately into segregated storage tanks. The oily sludge collection systems will also be equipped with a vacuum truck disposal connection. The contents of each storage tank are treated in separate centrifuges to remove water and oil. The 25% solid content cakes generated by the centrifuges are loaded in roll-off boxes and transported to the appropriate sludge treatment and disposal facilities (i.e. biological sludge shipped to NCC and oily sludge routed to MAB oily sludge incinerator). Liquid recovered from oily sludge centrifuges will be returned to the front end of the ODS system.

After dewatering, the oily sludge cake created at both MAB and MAA WWT facilities will be routed to a new CFP fluidized bed incinerator located at the MAB Refinery. The estimated quantities are as follows:

Table 12.2: Oily Sludge Quantities

Oily sludge	**m3/yr**
Local Marketing	500
MAA Existing Sludge	4,000
MAA CFP Sludge	2,370
MAB Existing Sludge	1,500
MAB CFP Sludge	14,410

The fluidized sludge incinerator will operate two shifts per day. Incinerator ash will be disposed in local landfills.

The biological sludge cakes from both refineries will be transported off-site for disposal by the NCC. Approximately 13,650 m^3/yr of biological sludge will be produced by the process wastewater treatment plant in MAA.

Excess biosludge from the new MAB CFP sanitary wastewater treatment system will be sent to the existing MAB ETF revamp to be combined and disposed of (by NCC) with the existing biosludge that is generated.

12.3.4 Sour Water Stripping Unit (SWSU)

Sour water streams from the CFP process units at the MAA and MAB refineries will be segregated from other industrial wastewater streams. New sour water treating facilities will be provided at both refineries to remove (i.e. "strip off") impurities such as H_2S, NH_3 and hydrocarbons. The overhead stream from these treatment units will be routed back to new sulphur recovery facilities.

At the MAA Refinery, the stripped effluent from the SWSU will be routed to the Delayed Coking Unit (Unit 136) for coke cutting and coke drum cooling with the balance sent for wastewater treatment.

At the MAB Refinery, the stripped effluent from the SWSU will be routed to the Crude Unit Desalter (Units 11/111), ARDS, Hydrotreaters and the balance sent to wastewater treatment.

12.3.5 Cooling Water System

The Cooling Water System at both the MAA and MAB refineries (Unit 175 & Unit 132, respectively) will be a closed-circuit fresh water system. The new facilities at each refinery will include a cooling tower, cooling water pumps, and steam turbine drivers.

Cooling tower blowdown will be piped to the AOC Drain System. Makeup water will be from desalinated water, supplied by MEW, and/or fresh water.

12.3.6 Storm Water Management

Storm water that falls within the CFP process equipment areas will be segregated from storm water that falls outside these areas (such as on road surfaces as well as unpaved or grass covered surfaces, etc.). All storm water within CFP process areas as well as floor wash water and fire water runoff from paved surfaces will be gravity drained via the AOC Drain System.

Clean CFP storm water falling outside process areas from MAA (OSBL) is released into an existing concrete lined ditch along the south side of MAA and winds through the refinery to make its way to a wadi near the southeast corner of MAA (KNPC currently use this wadi to receive clean storm water from existing areas of MAA).

Clean storm water runoff from MAB areas and roadways outside paved process areas is collected in an oil catcher and pumped to the Gulf.

The MAA will discharge approximately 14,600 m^3/hr of clean OSBL storm water during the infrequent rainfall events. An estimated 40,000 m^3/hr storm water will originate from OSBL non-process areas and roads at MAB during the infrequent rainfall events.

12.3.7 Capacity, Rates and Composition at CFP WWT Facilities

The following tables provide the preliminary capacities, rates and composition of the various effluent streams for both MAA and MAB. It should be noted that the numbers below are subject to changes during detailed design.

Table 12.3: MAA – Preliminary Capacities & Flows

System / Influent Source	Normal Flow	Design Flow	Remarks
	m^3/h	m^3/h	
AOC System (Note 1)			
Dry Weather Streams			
Fire Water Jockey Pumps (Note 2)	5	10	Intermittent flow
Cooling Tower Blowdown (Note 3)	19	46	Continuous flow
Potable Water Filter (Note 4)	1	1	Intermittent flow
Demineralizer Package Filter (Note 5)	3	12	Intermittent flow
Utility Water (Note 6)	9	18	Intermittent flow
Non-recov. Clean Condensate (Note 7)	0	5	Intermittent flow
25% Contingency	13	28	
Dry Weather Total	**50**	**120**	
Wet Weather Streams (Note 8)	0	N/A	6,000 m^3/h - Storm Emergency. Overflow Impound Volume - 7,460 m^3
First Flush Basin (Note 8)	N/A	N/A	Impoundment Volume 1,490 m^3
Peak Overflow Basin (Note 8)	N/A	N/A	Impoundment Volume 5,970 m^3
Clean Storm Water (Note 9)	50	100	Intermittent to Gulf
Off-Spec Storm Water (Note 10)	0	50	Intermittent to ODS System
Neutralized Effluent (Note 11)	10	111	Intermittent to Gulf

ODS System Streams			
Stripped Sour Water (SSW) (Note 12)	183	183	Continuous flow
Non-recovered potentially contaminated condensate	3	3	Continuous flow
Oily water drains/Collection Hubs(Note 13)	10	20	Continuous flow
Sludge Dewatering Centrate	23	31	ODS Recycle Flow
Flare Water Seal Drums	1	1	Continuous flow
AOC Off-spec Water w/o contingency	0	50	Intermittent
15% Contingency (Maximum)	30	42	
ODS Total	**245**	**330**	
CPI Feed (No SSW)	**35**	**120**	
DAF Feed (SSW Included)	**245**	**330**	
Effluents			
Utility Water/Fire Water Makeup (Note 14)	25	208	
Wastewater to the Gulf(Note 15)	305	560	
Emergency Overflow to Gulf(Note 8)	0	6,000	
Dry Slops System	97	97	
Sanitary Wastewater (Note 16)	4	8	Impoundment Volume 28 m^3
Sludge Collection/Treatment System			
Excess Biological Solids	27	36	Processed in centrifuges
Oily Solids	1.3	1.7	Processed in centrifuges

Notes for Table 12.3:

(1) AOC System handles dry-weather and wet-weather water streams, with the 10-year storm event as the maximum rainfall case as governing for design of the AOC system. The emergency overflow, First Flush Basin and Peak Overflow Basin volumes were calculated based on a CFP paved process area of 168,000 m2 and the 10-year rain event with the rainfall Intensity of 42 mm, based on the Time of Concentration of 30 minutes.

(2) Based on about 5 hrs/day (1.5 hr per shift) of operation and 120 m3 of water (in 24 hrs) for normal flow rate. The Jockey pump capacity is 40 m3/h. The design flow rate is considered as double of normal flow to account for non-normal events of fire water usage for training and other purposes.

(3) The design value is for valve, piping, and drain sizing. Design value may occur for up to 2-3 days when recovering from chemistry upsets in cooling tower.

(4) The Potable Water filter backwash is one backwash per day at 14 m3 per backwash or 1 m3/hr average. This volume is based on the sum of three flows: 6 m3/h for 15 minutes plus 52 m3/h for 10 minutes plus 24 m3/h for 10 minutes.

(5) The Demineralizer filter backwash is one per day at 67 m3 per backwash (3 m3/h average). This normal flow is based on the sum of three flows: 33 m3/h for 15 minutes plus 265 m3/h for 10 minutes plus 90 m3/h for 10 minutes. The design flow is based on major chemistry upset and the need for additional backwashing.

(6) Design flow rate is based on 4 hoses at 4.5 m3/h used simultaneously for a total flow of 18 m3/h. Normal flow is based on the use of 2 hoses.

(7) This volume is based on 2% loss of steam system load.

(8) Estimated based on the CFP rainfall collection paved surface area (A) of 168,000 m2 and the 10-year rain storm with the rainfall Intensity (I) of 42 mm, based on the Time of Concentration of 30 minutes - A x I x C = 167,943m2 x 0.042m/h x 0.85 = 5,996 m3/h. First Flush Basin and Peak Overflow Basin Volume is based on 20% and 80% of accumulated rainfall, respectively.

(9) Clean Storm Water flow rate is set by two Clean Water Pumpout Basin pumps operating simultaneously at 50 m3/h.

(10) Off-spec pump rate set by the normal flow rate of 50 m3/h. This off-spec pump is used for gradual reprocessing of off-spec AOC water.

(11) Neutralized effluent from Water Treatment is directed directly to the Gulf, as it will contain no oil or other soluble organics. The design flow rate is based on the Demineralization / Polisher / Regenerant tank pumped out in 4 hours.

(12) Stripped Sour Water generated at the maximum operation is treated in the WWT system for removal of sulfides, ammonia, phenol, cyanides, and other soluble compounds creating BOD/COD.

(13) The largest amount of oily water will result from water washing of ARDS Atmospheric Fractionator and VRU Vacuum Column at the same time during turnarounds.

(14) Sum of firewater and utility water usage.

(15) Combined flows from ODS, AOC Dry Weather, and Demin/Polisher/Regenerant pumps to Observation Basin and consequently to the Gulf.

(16) Estimated based on 356 people per shift, 75 gallons (0.284 m3) of water used per day per person, peaking factor of 5, and peaked generation rate for 5 hours.

Table 12.4: MAA Preliminary WWT Feed Composition

	AOC System Influent (mg/l)		ODS System Influent (mg/l)		Sanitary[5] Wastewater (mg/l)
Contaminant	**Normal**	**Maximum**	**Normal**	**Maximum**	**Design Value**
Oil & Grease	<10	500	150	500	20
BOD_5[1]	<25	30	<500[2]	500[2]	250
COD [1]	<100	150	<800[3]	800[3]	400
Phenols	---	---	100	160	-
Sulfides	<1.0	1.0	<15	50	5
pH	6 - 8	6 - 8	7-9	5-10	7.0 – 8.0
TDS	<1000	2000	1000-5000	6000	200
Nitrogen (Total as N)	0	---	<40	100	50
TSS, mg/l	-	-	-	-	300

Notes for Table 12.4:

(1)Values indicated exclude free and emulsified hydrocarbons.

(2) This value is estimated as 60% of the COD value

(3) This value is very dependent on the concentration of H_2S, NH_3, phenol, and other soluble organics in wastewater. Refineries processing similar sour crude oils use BOD and COD values similar to the proposed here.

(4) The Biological Treatment System will not be designed to accommodate higher concentrations. Wastewater with higher COD concentration will be stored in the available equalization capacity and then slowly trickled in not to exceed the design COD value of 800 mg/l.

(5) Sanitary wastewater will be collected in a central lift station and then pumped off-site via an above-ground pipe to an existing municipal treatment facility for treatment.

Table 12.5: MAB Preliminary Capacities & Flows

System / Influent Source	Normal Flow m^3/h	Design Flow m^3/h	Remarks
AOC System (Note 1)			
Dry Weather			
Fire Water Jockey Pumps (Note 2)	5	20	Intermittent flow
Cool. Tower Blowdown (Note 3)	120	145	Continuous flow
Potable Water Filter (Note 4)	2	4	Intermittent flow
Demineralizer Package Filter (Note 5)	8	37	Intermittent flow
Utility Water (Note 6)	9	18	Intermittent flow
Non-recov. Clean Condensate (Note 7)	0	20	Intermittent flow
25% Contingency & misc. leaks	36	61	
Dry Weather Total	**180**	**305**	.
Wet Weather (Note 8)	0	N/A	Emergency Overflow Impounded Volume is 13,350 m^3
First Flush Basin (Note 8)	N/A	2,700	Impound Volume 2,700 m^3
Peak Overflow Basin (Note 8)	N/A	10,650	Impound Volume 10,650 m^3
Clean Storm Water (Note 9)	0	224	Intermittent, 2 pumps at 112 m^3/h
Off-Spec Storm Water (Note 10)	0	50	Intermittent. Sizing to be based on 2 pumps in operation at 100 m^3/h.
Neutralized Effluent (Note 11)	13	152	Intermittent to Gulf
ODS System			
Crude Oil Desalter Water (note 12)	87	174	Continuous flow
Stripped Sour Water (SSW) (Note 13)	188	101	Continuous flow
Non-recovered potentially contaminated condensate	10	10	Continuous flow
Oily water drains/Collection Hubs (Note 14)	10	20	Continuous flow
Flare Water Seal Drums	1	1	Continuous flow
Off-spec Reprocessing	0	50	Intermittent flow
SHU Tank Farm Wastewater	70	70	Intermittent flow
Oily Sludge Centrate	4	9	Continuous flow
Contingency	16	20	
ODS Total	**386**	**455**	Total feed to CPI and DAF units
CPI Feed System	**200**	**300**	SSW fed downstream of CPI
DAF Feed System	**386**	**455**	
Effluents			
Utility Water (Note 15)	72	160	
Wastewater to the Gulf (Note 16)	193	681	
Emergency Overflow to Gulf	0	13,350	
Dry Slops System (Note 17)	184	184	
Sanitary Wastewater (Note 18)	8	14	
Sludge Collection/Treatment System			
Oily Solids to Centrifuging (Note 19)	5	11	
Incinerator			
Oily Cake (containing 25% oily solids)	1	2	

Notes for Table 12.5:

(1) AOC System Design Flow Rate includes 25% peak factor and small contingency for cooling water leaks, steam trap release on pavement, etc. The Quantity of Storm Water Run-off (Q) in m3/hr was calculated based on a CFP process area (catchment area) (A) of 373,700 m2 and a 10-year storm event using the Rational Method outlines in the Shell DEP 34.14.20.31-Gen and Project Variation 34.14.20.31.P60002CFP-00PV. The run-off coefficient (C) used in the calculation was 0.85. The rainfall intensity (I) of 42 mm/hr used in the calculation was determined from the Rainfall Intensity curve for the 10-year rain event and the time of concentration (Tc) of 30 minutes as recommended by the above mentioned Shell DEP. The time of concentration is defined as the time required for storm water to flow from the most distant point of catchment area to the point of flow collection / measurement. The calculation formula was as follows: Q = A x I x C.

(2) Based on about 5 hrs/day (1.5 hr per shift) of operation and 120 m3 of water (in 24 hrs) for normal flow rate. The Jockey pump capacity is 40 m3/h. The design flow rate is considered as double of normal flow to account for non-normal events of fire water usage for training and other purposes.

(3) The design value is for valve, piping, and drain sizing. Design value may occur for up to 2-3 days when recovering from chemistry upsets in cooling tower.

(4) The Potable Water filter backwash is one backwash per day.

(5) The Demineralizer filter normal flow is based on one backwash per day. The design flow is based on major chemistry upset and the need for additional backwashing.

(6) Design flow rate is based on 4 hoses at 4.5 m3/hr used simultaneously. Normal flow is based on the use of 2 hoses for a total flow of 9 m3/hr.

(7) This volume is based on 3% loss of steam system load.

(8) Calculated based on the CFP rainfall collection paved surface area of 373,700 m2 and the 10-year rain storm with the rainfall Intensity (I) of 42 mm, based on the Time of Concentration (Tc) of 30 minutes. The quantity of storm water run-off was divided as follows: first 20% of storm water run-off to be stored in the First Flush Basin and the remaining 80% of storm water fun-off to be stored in the Peak Overflow Basin.

(9) Maximum design Clean Storm Water flow rate is set by two Clean Water Pumpout Basin pumps operating simultaneously. The required pumpout time is 5 days with one pump in operation.

(10) Off-spec pump rate set by the normal flow rate of 50 m3/h. This off-spec pump is used for gradual reprocessing of off-spec AOC water.

(11) The maximum pumpout is the combined neutralized effluent from the polisher regeneration scheduled immediately after the demineralizer regeneration to allow for the waste streams to be neutralized and discharged together to the Gulf, as they contain no oil or other soluble organics. The design flow rate is based on the Demineralizer / Polisher / Regenerant tank pumped out in 1.6 hours.

(12) Desalter Water flow rate at the maximum flow rate, then the Surplus Stripped Sour Water (SSW) flow rate is reduced to 101 m3/hr.

(13) Surplus Stripped Sour Water (SSW) is treated in the WWT system for removal of sulfides, ammonia, phenol, cyanides, and other soluble compounds creating BOD/COD. The SSW flow rate depends upon the Desalter Water flow rate. Both flow rates cannot be at the maximum design flow levels at the same time.

(14) The largest amount of effluent water will result from water washing of Atmospheric Residue Desulphurization (ARDS) Fractionator and Crude Distillation Unit (CDU) Column.

(15) The total Utility Water amount used in the CFP block's Utility Water Distribution System and locally in the WWT System at normal and design flow rate is 30 and 118 m3/hr, respectively. In addition, the intermittent normal and design flow rate of backwash water to the sanitary treatment filter is 42 m3/hr.

(16) Combined flows from AOC Dry Weather clean water, Clean Storm Water, Neutralized Effluent pumps to the Gulf.

(17) Dry Slops System flow rate is estimated based on Non-pumpable hydrocarbon streams.

(18) Estimated based on 712 people per shift, 75 gallons of water used per day per person, and a peaking factor of 5. The total Sanitary Wastewater Treatment System design capacity is 14 m3/hr. One 100% capacity train will be provided.

(19) Estimated based on 0.03% of Sediment content of Crude Oil.

Table 12.6: MAB Preliminary WWT Feed Composition

	AOC System Influent (mg/l)		ODS System Influent (mg/l)		Sanitary Wastewater (mg/l)
Contaminant	**Normal**	**Maximum**	**Normal**	**Maximum**	**Design Value**
Oil & Grease	<10	2000	150	2000	20
BOD_5 (1)	<25	30	<400(1)	400(2)	250
COD (1)	<100	150	<600(2)	600(3,4)	400
Phenols	---	---	50	100	-
Sulfides	<1.0	1.0	<15	50	5
pH	6 - 8	6 - 8	7-9	5-10	7.0 – 8.0
TDS	<1000	2000	1000 - 5000	6000	200
Nitrogen (Total as N)	0	---	<40	100	50
TSS, mg/l	-	-	-	-	300

Notes for Table 12.6:

(1) Values indicated exclude free and emulsified hydrocarbons.

(2) This value is estimated as 60% of the COD value

(3) This value is very dependent on the concentration of H_2S, NH_3, phenol, and other soluble organics in wastewater. Refineries processing similar sour crude oils use BOD and COD values similar to the proposed here.

(4) The existing Biological Treatment System will store the ODS DAF effluent in the available equalization capacity and then slowly trickle it in, not to exceed the design COD value.

12.4 Water Conservation On-site During Operation

Water conservation is a priority for KNPC. Therefore, the CFP project will implement technologies and operating practices to achieve a high degree of effluent reduction. Toward this intent, KNPC will endeavour to reduce wastewater generation and recycle / reuse all treated wastewater to the extent practical. Several different methods will be used to conserve water including:

1. Collection and reuse of steam condensate as BFW.
2. Collection and reuse of boiler blowdown as makeup to the cooling tower.
3. Reuse of process stripped sour water as wash water.
4. Reuse of treated wastewater from equipment areas as utility water.
5. Reuse of treated wastewater from the utility water system for fire fighting water (the first fill of firewater tanks will be from fresh water and thereafter the firewater tanks will be filled from treated wastewater).
6. Reuse of treated sanitary grey wastewater from the MAB facility as irrigation water for landscaping.
7. Use of packed-bed/rinse recycle technology for the water demineralization system which significantly reduces the volume of regeneration wastewater produced.

Figures 12C and 12 D provide Water Balance diagrams for the MAA and MAB refineries, respectively. Some of the water conservation methods previously described are illustrated in blue on these diagrams.

Figure 12C

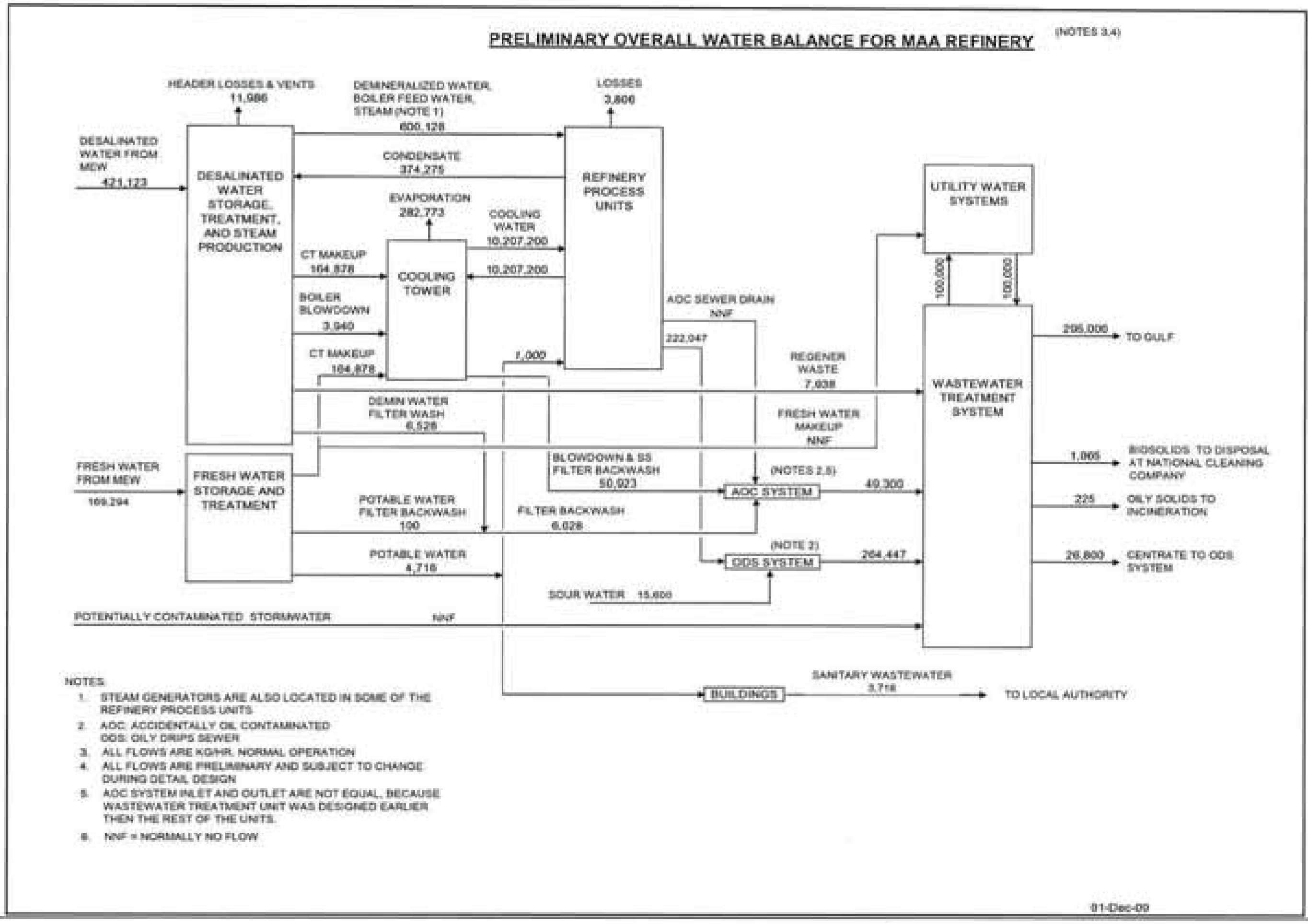
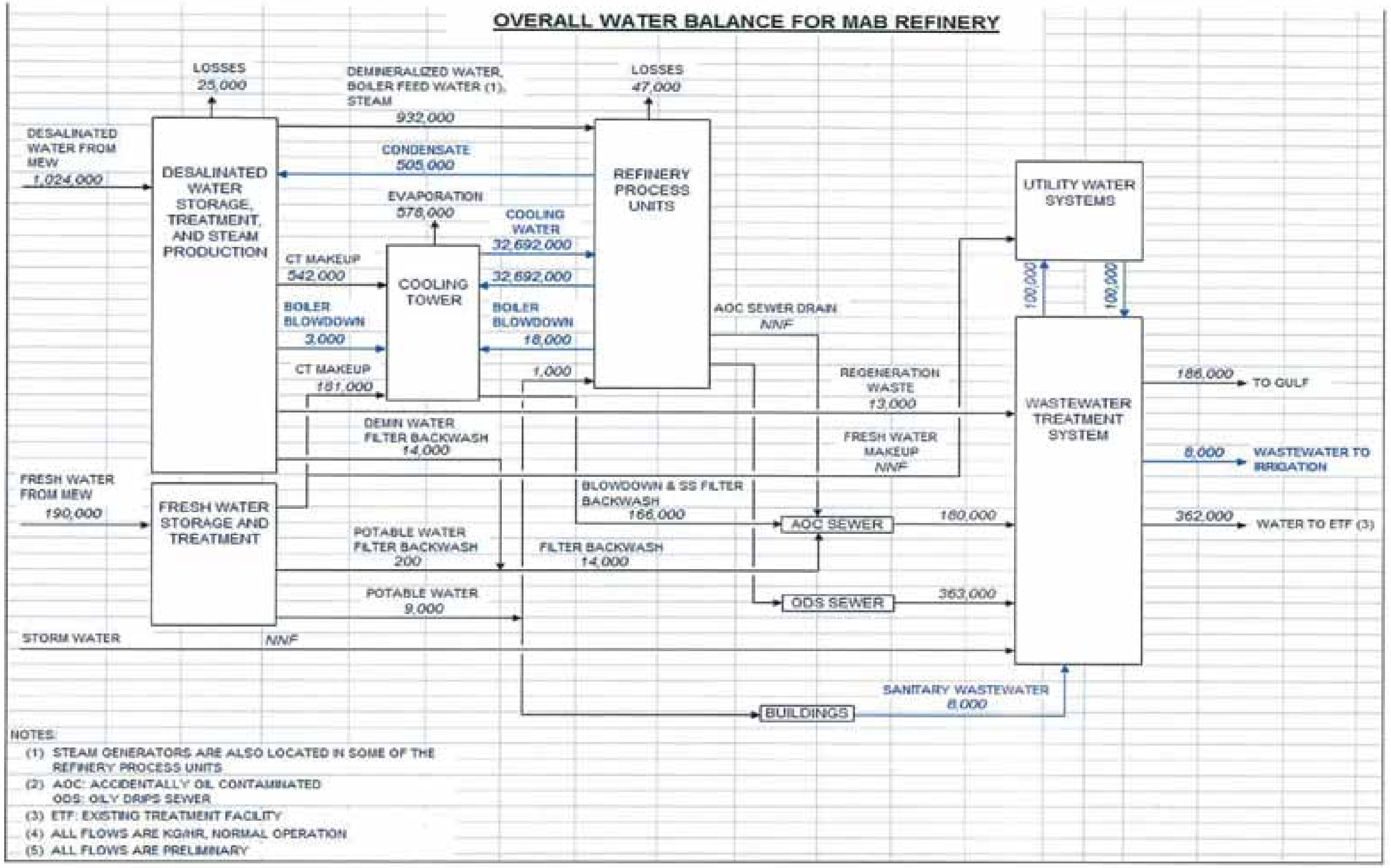

PRELIMINARY OVERALL WATER BALANCE FOR MAA REFINERY
(NOTES 3,4)
HEADER LOSSES & VENTS
11,986
DEMINERALIZED WATER, BOILER FEED WATER, STEAM (NOTE 1)
600,128
LOSSES
3,806
DESALINATED WATER FROM MEW
421,123
DESALINATED WATER STORAGE, TREATMENT, AND STEAM PRODUCTION
CONDENSATE
374,275
REFINERY PROCESS UNITS
EVAPORATION
282,773
COOLING WATER
10,207,200
CT MAKEUP
164,878
COOLING TOWER
10,207,200
BOILER BLOWDOWN
3,940
CT MAKEUP
164,878
1,000
AOC SEWER DRAIN
NNF
222,047
UTILITY WATER SYSTEMS
100,000
100,000
295,006
TO GULF
REGENER WASTE
7,938
WASTEWATER TREATMENT SYSTEM
DEMIN WATER FILTER WASH
6,526
FRESH WATER MAKEUP
NNF
FRESH WATER FROM MEW
169,294
FRESH WATER STORAGE AND TREATMENT
BLOWDOWN & SS FILTER BACKWASH
50,923
(NOTES 2,5)
AOC SYSTEM
49,300
1,065
BIOSOLIDS TO DISPOSAL AT NATIONAL CLEANING COMPANY
225
OILY SOLIDS TO INCINERATION
POTABLE WATER FILTER BACKWASH
100
FILTER BACKWASH
6,028
(NOTE 2)
ODS SYSTEM
264,447
26,800
CENTRATE TO ODS SYSTEM
POTABLE WATER
4,718
SOUR WATER 15,600
POTENTIALLY CONTAMINATED STORMWATER
NNF
NOTES
1. STEAM GENERATORS ARE ALSO LOCATED IN SOME OF THE REFINERY PROCESS UNITS
2. AOC: ACCIDENTALLY OIL CONTAMINATED
ODS: OILY DRIPS SEWER
3. ALL FLOWS ARE KG/HR, NORMAL OPERATION
4. ALL FLOWS ARE PRELIMINARY AND SUBJECT TO CHANGE DURING DETAIL DESIGN
5. AOC SYSTEM INLET AND OUTLET ARE NOT EQUAL, BECAUSE WASTEWATER TREATMENT UNIT WAS DESIGNED EARLIER THEN THE REST OF THE UNITS.
6. NNF = NORMALLY NO FLOW
BUILDINGS
SANITARY WASTEWATER
3,718
TO LOCAL AUTHORITY
01-Dec-09

Figure 12D


OVERALL WATER BALANCE FOR MAB REFINERY
LOSSES
25,000
DEMINERALIZED WATER, BOILER FEED WATER (1), STEAM
932,000
LOSSES
47,000
DESALINATED WATER FROM MEW
1,024,000
DESALINATED WATER STORAGE, TREATMENT, AND STEAM PRODUCTION
CONDENSATE
505,000
REFINERY PROCESS UNITS
EVAPORATION
578,000
COOLING WATER
32,692,000
32,692,000
CT MAKEUP
542,000
COOLING TOWER
BOILER BLOWDOWN
3,000
BOILER BLOWDOWN
18,000
CT MAKEUP
181,000
1,000
AOC SEWER DRAIN
NNF
UTILITY WATER SYSTEMS
100,000
100,000
REGENERATION WASTE
13,000
DEMIN WATER FILTER BACKWASH
14,000
FRESH WATER MAKEUP
NNF
WASTEWATER TREATMENT SYSTEM
186,000
TO GULF
8,000
WASTEWATER TO IRRIGATION
FRESH WATER FROM MEW
190,000
FRESH WATER STORAGE AND TREATMENT
BLOWDOWN & SS FILTER BACKWASH
166,000
AOC SEWER
180,000
362,000
WATER TO ETF (3)
POTABLE WATER FILTER BACKWASH
200
FILTER BACKWASH
14,000
POTABLE WATER
9,000
ODS SEWER
363,000
STORM WATER
NNF
SANITARY WASTEWATER
8,000
BUILDINGS
NOTES:
(1) STEAM GENERATORS ARE ALSO LOCATED IN SOME OF THE REFINERY PROCESS UNITS
(2) AOC: ACCIDENTALLY OIL CONTAMINATED
ODS: OILY DRIPS SEWER
(3) ETF: EXISTING TREATMENT FACILITY
(4) ALL FLOWS ARE KG/HR, NORMAL OPERATION
(5) ALL FLOWS ARE PRELIMINARY

12.5 Discharge Criteria

Treated effluent and clean storm water from the CFP will be discharged to the marine environment (i.e. the Gulf) from both MAA and MAB. The discharges will have met certain water quality standards as a result of the new treatment facilities provided; these facilities have been designed to meet the following K-EPA standards.

The limits for effluent discharge into Gulf are set by the discharge regulations implemented under Law No. 21 of 1995, as amended by Law No. 16 of 1996, regarding environmental requirements and standards in the State of Kuwait – Appendix 13. They are entitled "Maximum Limit for Pollutants of Industrial Discharge Water Permissible to be Discharged into the Sea", and are shown in Table 12.7 below.

Table 12.7: Maximum Pollutant Limits Permissible to be Discharged into the Sea (Source: K-EPA Appendix 13)

Pollutant	Symbol	Unit	Maximum Limit
Colour		---	Clear
pH	pH	---	6-8
Temperature Differential [Note 3]		°C	*10.0
Biological Oxygen Demand	BOD_5	mg/l	30.0
Chemical Oxygen Demand	COD	mg/l	200
Oil/Grease		mg/l	10.0
Total Suspended Solids	TSS	mg/l	10.0
Total Soluble Solids [Note 4]	**	mg/l	1500
Phosphate	PO_4	mg/l	2.0
Ammonia	NH_3-N	mg/l	3.0
Nitrate	NO_3	mg/l	30.0
Total Kjeldal Nitrogen		mg/l	5.0
Total Nitrogen		mg/l	30.0
Total Recoverable Phenol		mg/l	1.0
Fluorides	F	mg/l	25.0
Sulphides	S	mg/l	0.5
Chlorine	Cl_2	mg/l	0.5
Dissolved Oxygen	DO	mg/l	>2.0
Turbidity		NTU	50
Floatables		mg/l	Nil
Aluminium	Al	mg/l	5.0
Arsenic	As	mg/l	0.1
Barium	Ba	mg/l	2.0
Boron	B	mg/l	0.75
Beryllium	Be	mg/l	0.1
Cadmium	Cd	mg/l	0.01
Cyanides	CN	mg/l	0.1
Chromium	Cr	mg/l	0.2
Nickel	Ni	mg/l	0.2
Mercury	Hg	mg/l	0.001
Cobalt	Co	mg/l	0.2
Iron	Fe	mg/l	5.0
Antimony	Sb	mg/l	1.0
Copper	Cu	mg/l	0.2
Manganese	Mn	mg/l	0.2
Zinc	Zn	mg/l	2.0
Lead	Pb	mg/l	0.5
Lithium	Li	mg/l	2.5
Molybdenum	Mo	mg/l	0.01
Vanadium	V	mg/l	0.1
Silver	Ag	mg/l	0.1
All herbicides		mg/l	0.2
Most probable number - Total Coliforms		MPN/100 ml	1000

Notes:

(1) Effluent criteria are applicable to the combined effluent from all systems. Individual systems may vary slightly provided the composite is compliant with the above criteria.

(2) Effluent metal content is not guaranteed as CFP WWT facilities do not treat for metals. Based on historical refinery operations, metals are not expected to be in excess of K-EPA limits and, therefore, no metal removal processes have been included in the WWT design.

(3) Temperature differential refers to the difference between discharged effluent temperature and Gulf water temperature at the point of entry.

(4) Should be considered same as Total Dissolved Solids (TDS).

12.6 Wastewater Monitoring

Monitoring of wastewater generated by new and modified CFP facilities will be incorporated as part of the Environmental Management System (EMS) for the existing KNPC refineries.

Effluent monitoring at the point of discharge from the Observation Basin at the MAA Refinery and from the existing Mixing Basin at the MAB Refinery will be provided. Continuous on-line analyzers will be provided for pH, Total Oil & Grease, and turbidity. In-line sampling for Dissolved Oxygen and temperature will also be provided in the proximity of the effluent pump discharge. Contaminated water will be directed to the ODS System.

Table 12.8 below provides a description of the wastewater parameters and frequency of effluent monitoring that will be applicable to discharges from the CFP facilities based on KNPC's 'Procedure on Monitoring of Wastewater Treatment and Disposal'. All testing will be performed as per K-EPA approved methods. The flow rate and quality of wastewater will be monitored to ensure optimal treatment and compliance with the applicable K-EPA requirements.

In the event that sample test results indicate a deviation or trend of deviation from the specified quality, the operating parameters will be adjusted, maintained and monitored. The effectiveness of the implemented adjustment will be confirmed by test analysis of check samples.

Storm water that falls within the CFP paved (i.e. process) areas will be collected by the AOC system and routed to the WWT Units at MAA or MAB where it will ultimately be monitored at the point of discharge from the Observation Basin (at MAA) or the point of discharge from the existing Mixing Basin (at MAB). Storm water runoff from outside the paved areas (i.e. OSBL) of both MAA and MAB is expected to be clean. However, as an added precaution and environmental best practice measure, this water will be collected and routed to an Oil Catcher. The Oil Catcher is a large concrete sump with a floating oil skimmer and sand traps to remove solids and sand. Skimmed oil will be removed by vacuum truck and taken to the CPI in the WWT Unit. The clean storm water discharge from the Oil Catcher will be pumped to a release point at the shoreline. Continuous monitoring is not provided since the storm water from OSBL areas is normally clean. However, grab samples may be collected and analyzed as required to verify compliance with K-EPA effluent standards prior to storm water discharge.

Table 12.8: Effluent Monitoring - Frequency and Type

Contaminant	Frequency	Contaminant	Frequency
pH	Daily	DO	Daily
	Weekly		Weekly
	Fortnightly		Fortnightly
Total Dissolved Solids	Daily	Sulphides	Daily
	Weekly		Weekly
	Fortnightly		Fortnightly
BOD_5	Daily	Chlorine (Cl_2)	Daily
	Weekly		Weekly
	Fortnightly		Fortnightly
COD	Daily	Total Suspended Solids	Daily
	Weekly		Weekly
	Fortnightly		Fortnightly
Oil and grease	Daily	Phenol	Daily
	Weekly		Weekly
	Fortnightly		Fortnightly
Temperature	Daily	Total Nitrogen	Fortnightly
Lead (Pb)	Fortnightly	Ammonia (NH_3-N)	Daily
Phosphate (PO_4)	Weekly		Weekly
	Fortnightly		Fortnightly
Ammonical Nitrogen	Weekly	TKN	Weekly
	Fortnightly		Fortnightly
Nitrate (NO_3-N)	Weekly	Turbidity	Weekly
	Fortnightly		Fortnightly
Copper (Cu)	Fortnightly	Fluorides (F)	Fortnightly
Coliform bacteria	Fortnightly	Arsenic (As)	Fortnightly
N_2 as NH_3	Fortnightly	Cadmium (Cd)	Fortnightly
Iron (Fe)	Fortnightly	Cyanide (Cn)	Fortnightly
Magnesium (Mg)	Fortnightly	Nickel (Ni)	Fortnightly
Zinc (Zn)	Fortnightly	Cobalt (Co)	Fortnightly
Chromium (Cr)	Fortnightly		

Notes:

1) Continuous monitoring of key parameters performed via on-line analyzers with daily laboratory confirmation.

2) Daily samples to be a composite grab sample taken using on-line composite samplers.

3) Sampling frequency for metals and herbicides will be tested initially at this frequency. Based on developed historical data, these frequencies may be reduced as deemed appropriate.

4) Sampling frequency and type is tentative and subject to change based on K-EPA & EMS requirements.

12.7 Impact Identification and Assessment

Assessing the extent of any impacts from the CFP and its associated wastewater collection, treatment and disposal facilities, and any final discharges, the principal issue is the identification and assessment of any potential adverse impacts both on groundwater and Kuwait's coastal waters. DNV's assessment of such impacts is as follows, and is split between construction and operation.

CFP Construction Phase:

Category: ENVIRONMENT

Consequence evaluation for: Wastewater Management during Construction of the CFP

1. General description (situation and characteristics):

Evaluation of the value / sensitivity:
Note: This section describes the sensitivity of the area in question. Following a review of existing information regarding the site's sensitivity, a sensitivity rating or value is given.

The only discharge of treated wastewater or storm water from the CFP during construction will be after sampling and analysis to verify compliance with the applicable K-EPA discharge criteria. Apart from these discharges, the sensitivity of the area is also relevant if the allocated measures in place to properly manage wastewater and its treatment, reuse and discharge fail, and a contaminating release to ground/groundwater/coastal water occurs.

Although there are no significant groundwater resources in the refinery area, the coastal environment is subject to some stress owing to the industrial nature of the study area. As such, the value/sensitivity is deemed **Medium.**

Low Medium High
|-----------X------------|

2. Description of the extent of effect

Evaluation of extent:
Sanitary wastewater will be generated during the CFP construction phase. However, neither industrial wastewater effluents, nor toxic sludges, will be generated during the CFP's construction phase. The only discharge of treated wastewater or storm water from the CFP during construction will be after sampling and analysis to verify compliance with the applicable K-EPA discharge criteria. The main wastewater risks during the CFP's construction phase arise from:

- Significant volumes of sanitary wastewater (from an overall workforce of up to 33,000 construction staff) will be generated, and currently how it is managed has not been decided. However, KNPC and EPC contractors will handle this sanitary effluent in accordance with all regulatory requirements.
- If there is insufficient temporary sanitary facilities (portacabins & holding tanks) during early stages of construction.
- Storm water discharges containing high levels of suspended solids. This will be discharged after holding period, so that the suspensions will settle down and K-EPA discharge limits will be met.

Provided that:

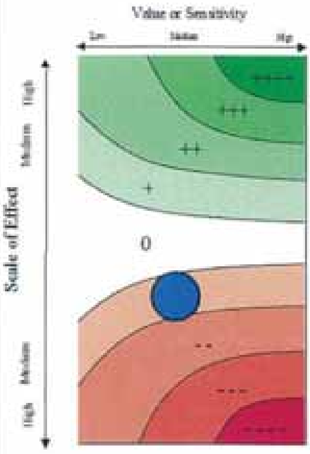
- The management measures described in this chapter are in place to ensure that treated water satisfies K-EPA standards, and
- the measures recommended in the following sections are also implemented to ensure that the wastewater treatment philosophy is implemented adequately,

DNV assesses the extent of any adverse effect to be **Little to Medium Negative**

Very neg. Medium neg. Little/no Medium pos. Very pos.
|---------------|---------X---------|---------------|------------------|

3. Total (environmental) impact

'Small Negative Impact'



CFP Operational Phase:

Category: ENVIRONMENT

Consequence evaluation for: Wastewater Management during Operation of the CFP

1. General description (situation and characteristics):

Evaluation of the value / sensitivity:
Note: This section describes the sensitivity of the area in question. Following a review of existing information regarding the site's sensitivity, a sensitivity rating or value is given.

Wastewater and storm water from the CFP will discharge to Gulf waters (wastewater will discharge via 500m long-Gulf oufalls), after meeting opportunities for water reuse on site (e.g. for irrigation) and after satisfying K-EPA discharge criteria. Apart from the discharges, the sensitivity of the area is also relevant if the allocated measures in place to properly manage wastewater and its treatment, reuse and discharge fail, and a contaminating release to ground / groundwater / coastal water occurs.

Although there are no significant groundwater resources in the refinery area, the coastal environment is subject to some stress owing to the industrial nature of the study area. As such, the value/sensitivity is deemed **Medium.**

Low Medium High
|------------X--------------|

2. Description of the extent of effect

Evaluation of extent:
The following elements have been taken into account in DNV's evaluation of the extent of impact (based on current operational process design data):

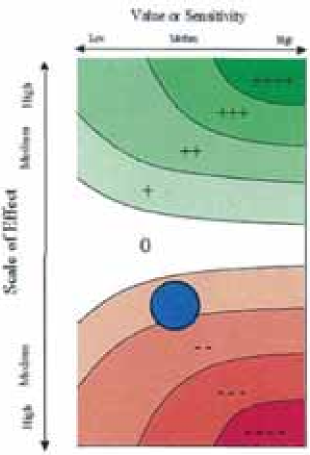
- Large volumes of process wastewater effluents will be generated via all the various process-related activities, plus sanitary wastewater effluents;
- All of this wastewater will be treated in new CFP state of the art wastewater treatment facilities designed to treat it to an acceptable quality to satisfy K-EPA's requirements.
- Monitoring in accordance with KNPC's procedures will be in place.

Provided that all the management and design measures detailed in this chapter are followed in conjunction with the recommendations made in the following sections, DNV assesses that the associated potential environmental impact would be of **Little to Medium Negative** significance.

Very neg. Medium neg. Little/no Medium pos. Very pos.
|------------------|----------X----------|------------------|------------------|

3. Total (environmental) impact

'Small Negative' Impact



12.8 Conclusions

DNV has assessed the environmental impacts from the collection, treatment and reuse of process and sanitary wastewater effluents generated during both the CFP's construction and operational phases as 'Little to Medium Negative Impact'.

Overall, it is concluded that the planned new CFP wastewater collection and treatment facilities are state of the art, and constitute 'best practice' and apply a considerable number of BACT elements. The CFP wastewater facilities will be designed, built and operated in such a way as to meet best practice and K-EPA's environmental criteria.

12.9 Recommendations

In order to augment the robust approach to addressing and mitigating environmental impacts during the CFP's construction and subsequent operations, this study makes the following additional recommendations:

- It will be important to ensure during operation of the CFP's wastewater treatment facilities (for both the construction and operation phases), that the wastewater discharge monitoring results are audited by KNPC HSE on a regular basis as part of EMS, and audited at annual intervals by an independent party.
- It will be important to ensure that the sanitary wastewater and storm water collection/treatment facilities are made available at the earliest stage possible during construction, as it is currently unclear how these will be managed. It is recommended that each EPC contractor make this an early priority for the CFP construction, such that compliance with all regulatory requirements is met.

13.0 Preliminary Traffic Impact Assessment

13.1 Introduction

A preliminary Traffic Impact Assessment (TIA) was conducted during the FEED Phase of the CFP 2020 to ensure that increased traffic resulting from the construction and operation of the CFP would not significantly impact the surrounding area. It focused on the CFP site and surrounding approach roads. The data and information in this Chapter is from the FEED Phase and has not been updated to reflect any FEED Update changes, because a Comprehensive Traffic Impact Assessment will be conducted in the future.

This preliminary TIA took the following items into account:

- Approach to the CFP site
- Baseline traffic flows
- Distribution of traffic
- Traffic generated by construction
- Predicted CFP construction impacts
- Traffic generated by KNPC refinery operations
- Predicted operational impacts

13.2 Methodology

This preliminary TIA incorporates the following elements:

- Desktop review to gain an understanding of road network setting & road classification
- Visit to site to identify main routes and collection of baseline traffic data
- Assessment of traffic impacts
- Recommend mitigation measures

13.3 Site Location and Road Network Setting

13.3.1 Road Classification

Roads are classified into three main categories as shown in Table 13.1. Description of the road conditions and traffic loadings are discussed in Section 13.5.

Table 13.1 Road Categories

Class	Type	Description	Roads
High Width	Motorways/ Highway	There are three or more lanes in each direction and generally have a maximum speed limit of 120 kilometres per hour. They are cross country roads linking important places both within and outside the country such as Kuwait City, Saudi Arabia, etc.	#30 and #40

	Main Roads	These roads usually have high traffic flows and usually have two or three lanes going in each direction. They are the main arteries to Ahmadi Township, Greater Burgan oilfields and Wafra.	#212, #304, #8 and #306
Medium Width	Trunk roads/ Principal Roads	These roads are important roads that link refineries with motorways or major roads.	Link roads between refinery & major roads.
Low Width	Minor Roads	These roads are within the refineries and all maintained and managed by the refinery authorities. They were not covered within the scope of this study.	Small roads inside refineries

13.3.2 Site Location

The CFP sites are located south of Kuwait City, at a distance of approximately 38 km (MAA), 45 km (MAB) and 41 km (SHU). Road #30 borders the three refineries to the west and the Arabian Sea is located to the east.

The sites are linked to two highways or motorways (as shown in Figure 13A below):

- King Fahad Motorway (#40)
- Abdulaziz Bin Abdulrahaman Al-Saud expressway (#30).

Highway #30 is the closest and is situated along the west side of the project area. It is the main road channel for transportation and has 5 lanes (including two emergency lanes) for the traffic flow in each direction and it is approximately 23m wide.

Figure 13A – Location of CFP Sites, Surrounding Roads & Traffic Count Locations

13.3.3 Network setting

Road # 30 has 6 key road crossings or important road junctures in the vicinity of the refineries (as illustrated in Figure 13B), including:

(i) major roads leading to South Sababiya, Ahmadi Township, North Shuaiba, CFP Construction Lay-down area and Wafra to the west towards the desert. The roads numbers are road 8, 304, 305, Ma 1st and road 306 respectively.

(ii) major or trunk roads leading to Fahaheel, MAA, MAB, SHU, petrochemical industries and ports on the opposite (i.e. east) side towards the coastline of the Gulf. The roads are Nos. 213, 304, 305, 8, and 306. Most of the major roads are two-way with 3 lanes each way.

Figure 13B shows the location of these 6 road crossings in relation to the CFP sites as well as the location of the refinery and proposed CFP construction entrances.

The trunk roads connecting the CFP entrances at each of the refineries to Road # 30 are two way roads with two or three lanes in each direction. The roads are approximately 10m wide. The approximate distances between Road #30 and the existing entrance to each refinery are as follows:

- MAA: 1.31 km
- SHU: 1.26 km
- MAB: 1.44 km* *Measurements from Google earth

The average speed of traffic is 30 km/hr on the roads leading to the gate of the refineries. The speed of traffic on the expressways is significantly higher.

13.4 Number of Employees - Existing and Future

The current and future numbers of operational employees, as well as the CFP construction manpower, for the three refineries are detailed below in Table 13.2:

Table 13.2 Current, Future & CFP Construction Employee Numbers (Preliminary data from FEED Phase which is subject to change)

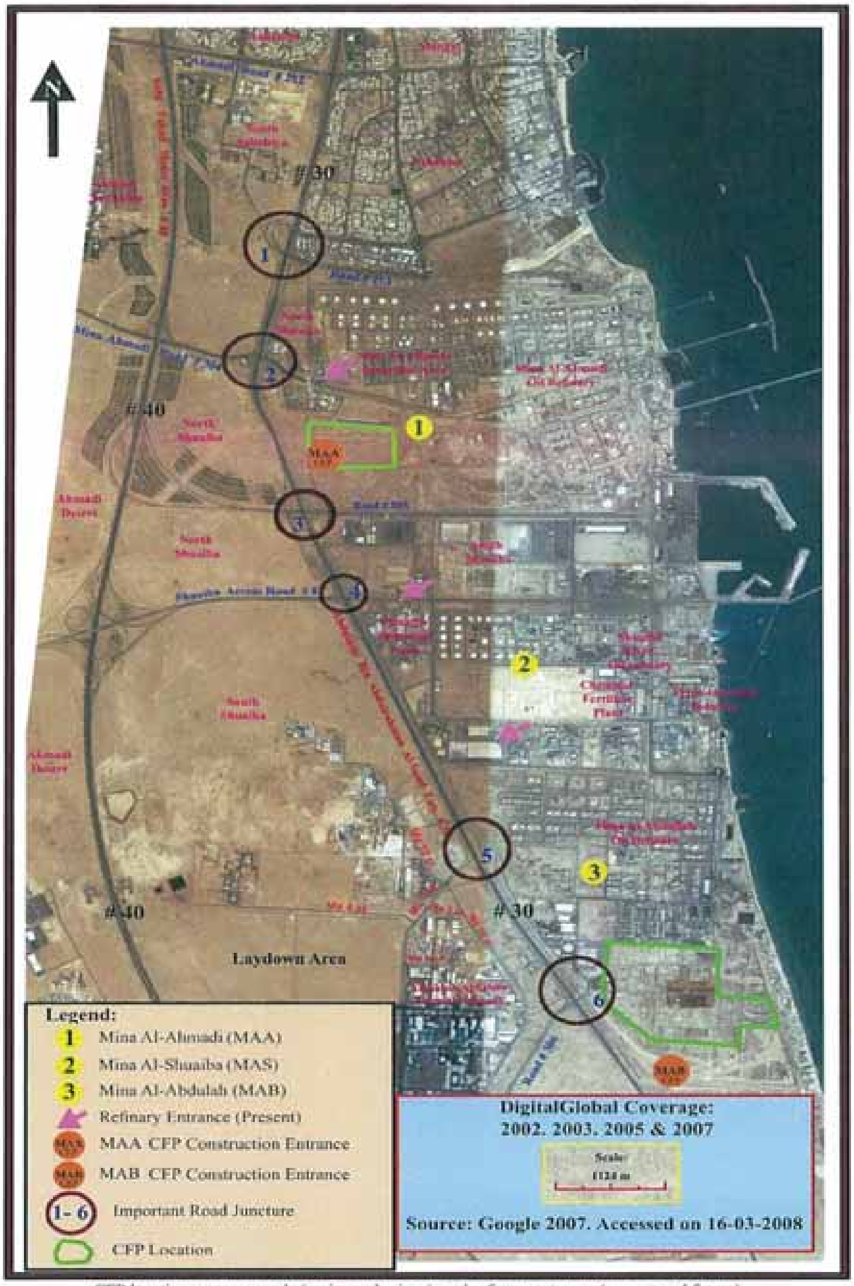
Refinery	Approximate Number of Employees		
	Pre-CFP Operation (Existing)	CFP Construction (workers during peak construction activities)[1]	Post-CFP Operation (Future)
MAA	4,500	12,500	5,750
MAB	3,500	18,750	5,450
SHU	3,000	1,500	400
Total:	11,000	32,750	11,600

Note [1] – Totals include staff related to construction of CFP and exclude refinery operational staff

It can be seen that the combined total number of employees operational for the three KNPC refineries after the CFP facilities become operational is only 5% larger than the number that currently work at the refineries. Increased populations at MAA and MAB are largely offset by reduced numbers that will be experienced at SHU.

It can also be seen that the large numbers of CFP construction workers will significantly increase the numbers of personnel working at the 3 refineries during the CFP construction period.

Figure 13B: CFP location, Access Roads & CFP Construction Entrances (FEED Phase)



CFP locations, access roads (major and minor), and refinary entrance (present and future)

13.5 Site Visit

During the site visit the following conditions were noted:

- There are often traffic jams at peak times on Expressway #30 around the study area. It is busy due to the limited number of lanes (4) and because all 3 refineries are adjacent to each other and fall on the same side of the road. Early morning traffic is high (6:30am-7:15am), as is traffic after KNPC standard office work hours (3:00pm-3:30pm). The roads leading to the existing refinery entrances from road #30 also have high traffic loads during these periods.

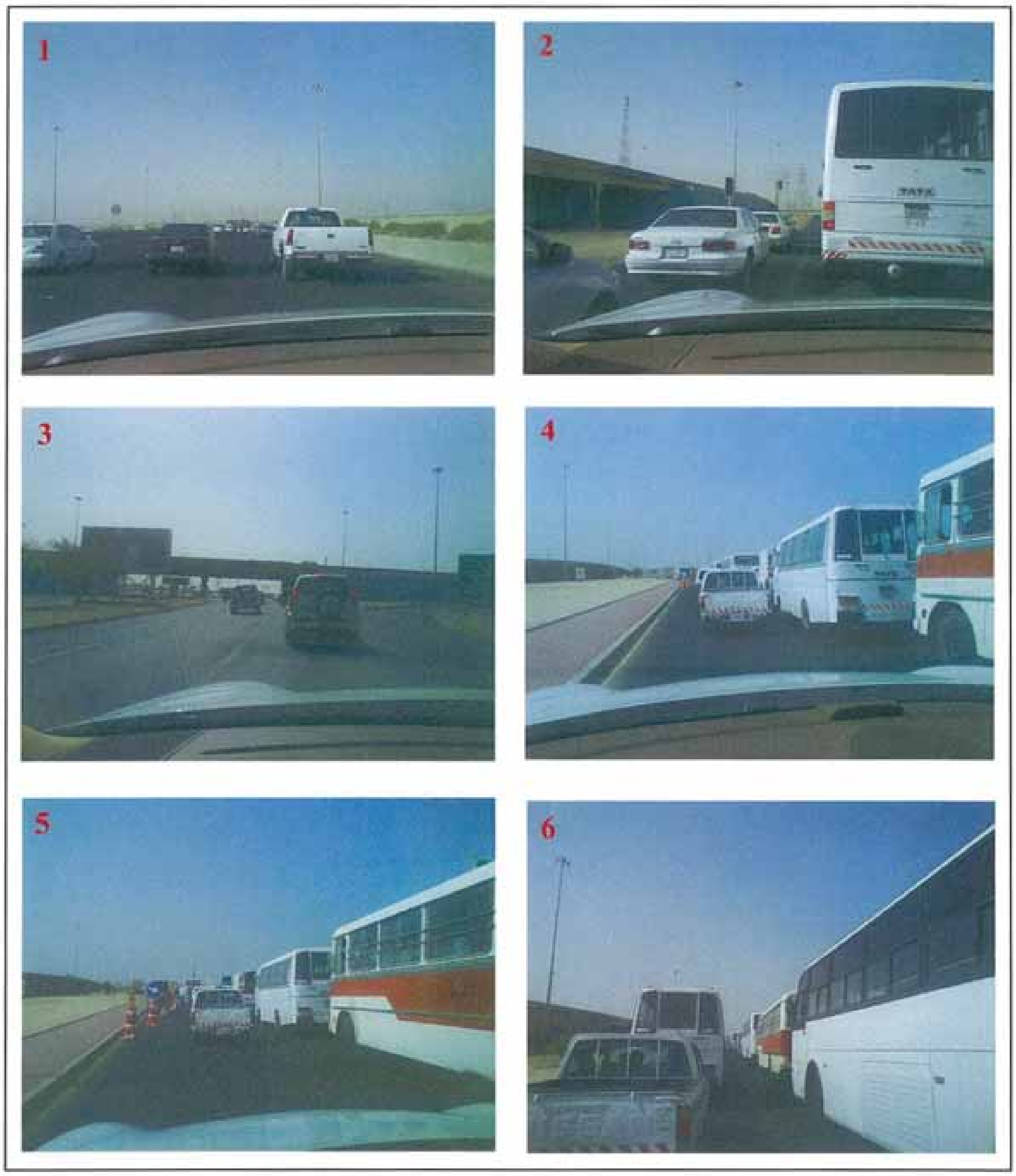
- Parking lots are located close to the main entrance or near to the administrative building of KNPC. From visual observations of parking space, it would appear that parking space is sometimes saturated during peak time.

- Visual inspection suggests that the majority (approximately 80%) of the existing traffic entering the refineries are 'small' (i.e.cars), that less than 10% of traffic is medium (jeeps, 4 wheel drive, mini buses etc), and less than 10% is heavy (buses, trucks, trailers, tankers)

- The two roads going to the MAA and SHU refineries from Road #30 have traffic signals to control the movement of vehicles. The timing and phasing of these traffic signals affects the capacity of the intersections and the connecting roadway sections. As such, these traffic signals may require adjustment as a result of altered future traffic data; this should be examined once detailed traffic data is available.

- Roads appear generally well maintained but require expansion in some areas. Figure 13C (plates 1-6) shows the traffic situation at some locations, which indicates traffic jams at peak periods.
    - Plate 1: 7:15am - illustrates Road #30 towards the refineries.
    - Plate 2: 7:18am - shows traffic at a traffic signal beneath bridge connecting to Road #304.
    - Plate 3: 3:06pm - demonstrates traffic after office hours coming out of refinery MAA.
    - Plate 4: 3:07pm - shows traffic jam at peak after office hours towards Kuwait city on Road #30.
    - Plate 5: 3:08pm - shows road conditions and road construction, which further slow traffic flow when leaving refinery area.
    - Plate 6: 3:09 pm - same as plate 4.

Figure 13C: Photos of traffic conditions around KNPC refineries



13.6 Traffic Data

WES conducted a simple traffic survey to understand the traffic volumes and types of vehicles near the refineries entrances between 6.45am and 3.15pm. The office workers at the three refineries start from 7am, with most of the employees inside the refinery by this time. There is significantly less traffic movement after 7am and before 3pm, when office workers finish for the day.

The traffic survey was divided into three time slots:

1. 6:45am-9:00am,
2. 10:00 am-12:00 noon
3. 1:00pm-3.15pm.

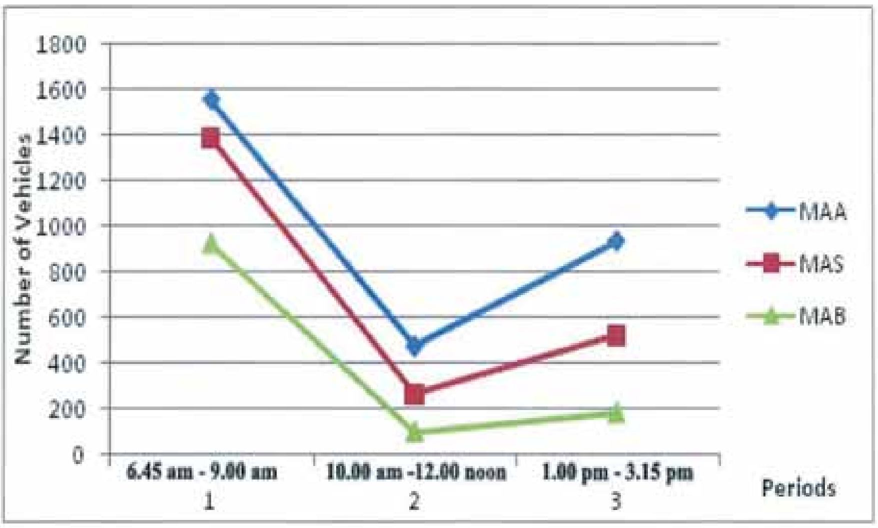
The surveys were carried out on Sunday March 30 2008 (MAA), Monday March 31 2008 (SHU) and Tuesday April 1 2008 (MAB). It should be noted that these figures are indicative only, as they were only collected over one day at each refinery, and are not intended to be comprehensive.

The three locations for the traffic sampling for the three refineries are shown in Figure 13A. All cars that entered the local roads leading to the refinery gates were included within the survey. It should be noted that for Shuaiba this will overestimate traffic, because the road also leads to other Shuaiba industrial organizations.

13.6.1 Current Traffic Volume

The results of the survey capturing the volume of vehicles are shown in Figure 13D below.

Figure 13D: Volume of traffic entering MAA, MAB & SHU (MAS)



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Peak traffic is just before the start of office hours (7:00am) and just after the end of office hours (3:00pm). Traffic is lower during the middle of the working day. Information provided by KNPC suggests that the more than two thirds of traffic takes place during office hours. As might be expected, there is significantly less refinery traffic during weekends.

Note that the traffic survey conducted at Mina Al-Shuaiba was conducted on the road leading not only to Shuiaba refinery, but also to other Shuiaba industrial organizations (e.g. PIC, EQUATE, Gulf Bank). Hence traffic count for Shuaiba is overestimated.

13.6.2 Vehicle types

The categorization of vehicles by size was also estimated; vehicles are broken into three size categories:

- Small (S) – cars
- Medium (M) – jeeps, four wheelers, mini buses etc
- Heavy (H) - big buses, trucks, trailers and tankers

Table 13.3 summarises the types of vehicles entering the refinery during the three time slots.

Table 13.3 Number of Vehicles entering refineries broken down into size categories

Refir	6.45am - 9am				10am - 12pm				1pm to 3.15pm				
	S	M	H	Total	S	M	H	Total	S	M	H	Total	Sum
MAA	1230	170	155	1555	350	70	55	475	550	162	223	935	2965
MAB	830	45	50	925	75	14	13	102	140	17	27	184	1211
SHU	1225	55	110	1390	195	35	40	270	405	35	85	525	2185
Total	3285	270	315	3870	620	119	108	847	1095	214	335	1644	6361

The surveys demonstrate that almost 80% of the vehicles entering the refineries are 'small'.

13.6.3 Estimated CFP Construction Traffic Data

Table 13.4 below shows the estimated numbers of construction employees during the _peak_ construction activities (forecast in 2011) and estimated traffic data. During the 3 year construction period of the CFP, the average number of labourers for the three refinery sites is expected to total approximately 13,000. During the 7 month period that represents the height of construction activities, the average number of construction labourers for the three refinery sites is expected to total 25,000.

Table 13.4: Predicted CFP Peak Construction Data (data from FEED Phase)

Criteria	MAA	MAB	SHU
Number construction employees (peak construction)	12,500	18,750	1,500
Number of shifts	1	1	1
Number of CFP entrances being used for vehicle entry	3	5(1)	1
Anticipated volume (number per day) of vehicles entering the site during peak construction [2[	4000	8000	1000
Effective construction duration (months, excluding early site preparations)	34	35	24

Note (1): to be confirmed
Note (2): Preliminary data based on traffic as a result of construction including material delivery, buses, personal vehicles (cars/jeeps), construction equipment, sewage trucks, catering, construction consumable deliveries (welding gases, fuel trucks), concrete trucks, heavy haul (SPMT), 18 wheelers, etc. The numbers given for the proposed frequency of vehicles entering the site during construction are estimated based on a PMC project of similar scale to the CFP.

Comparison of data in this table against existing traffic data provided in Section 13.6.1 and 13.6.2 illustrates that traffic will increase significantly during CFP construction.

MAA traffic will increase from an average of ~3,000 vehicles/day to ~7,000 vehicles/day . MAB will increase from approximately ~1,200 vehicles/day to ~9,200 vehicles/day. And Shuiaba will increase from ~2,200 vehicles/day to ~3,200 vehicles/day. Regardless of the fact that both the rough traffic survey data and the prediction in CFP construction traffic data are very approximate at this stage, these are all significant increases in traffic.

Table 13.5: Comparison of Current Traffic Volume with Traffic Volume During CFP Construction (FEED Phase data)

Refinery	Current traffic (estimate) per day	CFP construction traffic per day	Total traffic per day including CFP construction	% increase in traffic
MAA	3,000	4,000	7,000	133%
MAB	1,200	8,000	9,200	666%
SHU	2,200	1,000	3,200	45%
TOTAL	6,400	13,000	19,400	203%

To minimize traffic impacts during construction, CFP will use buses to transport most construction workers to and from the work site. At the peak of construction activities, CFP will be using approximately 700 buses with a capacity of 40 people each to transport the 33,000 project construction staff among the three work sites. The actual number of buses required may be reduced assuming that each bus will take multiple trips. Hence, data above includes 700 equivalent bus trips.

13.7 Impact Assessment

13.7.1 Impacts During CFP Construction

It should first be noted that both the traffic data and CFP traffic estimates are approximate and indicative only. The information indicates the potential for traffic impacts during CFP construction, because the number of CFP construction vehicles entering the refineries could be double the existing number of refinery traffic movements (see Table 13.5).

This increase in the volume of traffic could have significant effects on traffic in and around the refineries, particularly considering that current traffic conditions in the study area are congested at peak periods. The exact extent of this impact can only be calculated once more accurate traffic data is available.

However, KNPC will incorporate mitigation measures, such as additional entrances to the refineries to manage the impact of the increased traffic to acceptable levels. These are discussed below.

13.7.2 Impacts During CFP Operation

During operation of the CFP facilities, the total number of employees across the three KNPC refineries will only increase by approximately 5% (there will actually be a reduction in numbers at Shuaiba). Hence, a significant increase in local traffic is not expected once construction is complete. The full extent of this impact can only be known once more accurate traffic numbers are available for the CFP.

In addition, there will likely be an increased number of deliveries of maintenance equipment and supplies to the MAA and MAB refineries due to the presence of the new CFP facilities at those locations.

13.8 Mitigation Measures

The following mitigation measures are recommended to reduce the potential impact of increased traffic during the construction and operation of the CFP facilities:

- Provide additional new entrances at MAA and MAB. These should be located such that congestion is reduced and traffic distributed appropriately.
- Staggered work hours during construction (start and finish times) for construction staff reporting to and leaving the CFP work sites. These hours should not coincide with refinery office start and finish times (7:00am and 3:00pm).

- Optimal selection of construction related traffic routes with the main aim being the minimization of construction-related traffic interference with regular traffic and other activities inside and outside the refineries.
- Co-ordinate and co-operate with the Ahmadi Traffic Department. Decisions concerning the routing and the timing of the operation of construction truck traffic should be made with consultation and agreement of the officials in the Traffic Department.
- Traffic police to help manage the flow of traffic in and out of the CFP worksites
- Implement proposed traffic management practices such as:
    - Optimizing the utilization of high occupancy vehicles to transport workers to the CFP sites both during and after construction.
    - Early works roads to be constructed for optimal traffic flow

Further mitigation measures will be examined in a more comprehensive TIA, and should include the development of a Traffic Management Plan prior to the start of construction.

13.9 Conclusions and Recommendations

This preliminary TIA indicates that CFP could have a significant impact on local traffic conditions during the construction phase, in particular during the seven month period of peak construction activities. The impact on traffic during operation of CFP facilities may be acceptable although the overall volume of traffic is expected to increase.

The long term impact should be positive for traffic around the Shuaiba Refinery due to a substantial reduction in the number of employees at the start of the CFP operational phase.

It is recommended that a more detailed TIA be conducted to further study local traffic patterns with the objective of determining the current status of local roadways relative to their design carrying capacity. This information should be used as the basis for development of a comprehensive CFP Traffic Management Plan to ensure impacts are managed acceptably via detailed traffic control measures.

14.0 Miscellaneous Issues

There are miscellaneous issues relating to the development of the CFP. Some of these issues, which are discussed below, do not have matrix assessment tables, due to the limited availability of information at this early stage of design.

The following miscellaneous issues are considered:

- Landscape and visual impacts
- Socioeconomic issues
- Contaminated land and groundwater

It is recommended that the EPC contractors implement mitigation measures as identified in this chapter.

14.1 Assessment of Landscape and Visual Impact

A basic assessment of the landscape and visual impacts associated with the construction and operation of the CFP is presented below. This assessment is based on the information available at this stage of the design.

14.1.1 Assessment of Landscape Impacts

The CFP area is located south of Kuwait City within the boundaries of the MAA, MAB and SHU refineries. This area is categorised into two broad categories of land cover: Industrial Use Land and Undeveloped Open Space (see EBS). In general, the topography of the CFP area is flat and sandy with undulating high land in a few places to the north of the project area. An example of each of the land cover categories is shown in the figures below.

Figure 14A: Industrial Use Land (taken in MAA showing the fuel filling station)

Figure 14B: Undeveloped Open Space (taken in the south-west corner of MAB along the southern border)

14.1.1.1 Construction Impacts

Short term landscape impacts resulting from construction activities will be minimal. The site elevation has been optimized to balance the cut and fill requirements for the CFP. The following excavation numbers are expected for MAA and MAB:

- MAA Stripped Topsoil - 129,000 m^3
- MAA Cut & Fill - 6,500 m^3 (shortage)
- MAB Stripped Topsoil - 259,000 m^3
- MAB Cut & Fill - 67,000 m^3 (surplus)

No significant valued landscape features or resources will be lost during construction Dust emissions, mainly arising from vehicle movement, are likely to be a significant issue during the construction phase. However, a dust management plan will be implemented, as recommended in Chapter 8.

14.1.1.2 Long term impacts

No significant long term landscape impacts are predicted. The CFP area that is categorised as undeveloped open space currently has limited value and the value of the land should increase once the CFP has been constructed.

14.1.2 Assessment of Impacts to Visual Amenity

The zone of visual influence (ZVI) has been qualified using a desktop assessment of the height of the intervening land and heights of existing buildings compared to the height of the proposed refinery.

There are several sensitive visual receptors in the vicinity of the CFP:

- Beach houses bordering the south-eastern boundary of MAB refinery.
- Road #30 elevated to the west of the refineries
- Fahaheel suburb (approximately 51,210 people) to the north of MAA refinery
- Um Al Haiman residential township (approximately 30,000 people) 1km south of MAB refinery.

The land surface around the project is relatively flat. Within the visual envelope, the main visual impact will be from the south. The key impacted areas will be the beach houses and the Um Al Al-Haiman residential township.

Although already bordering an industrial area, the beach houses adjacent to the south eastern edge of the MAB perimeter will now be much closer visually to the visual industrial footprint site, and as such will be impacted. Similarly, residents at Um Al Haiman will be impacted because the CFP visual footprint comes closer to the township. However, the nature of the existing area (see Figure 14C) is currently so dominated by industry, the impact will be lessened.

Figure 14C: View looking north from south of MAB refinery

There will also be a visual impact of the refinery expansion for the public using the highways (#30) and roads on the western edge of the CFP sites, but the impact will be minimal owing to the transient nature of the receptors.

14.1.2.1 Construction Impacts

Visual impacts during construction will arise from views of the constructed plant as well as general construction activity. These will only cause a temporary change to the visual amenity. They will intrude into or impinge upon views from the south, east and west from nearby residential (village and coastal developments) and transport receptors and on views from other industrial developments.

14.1.2.2 Long term impacts

Long term and visual impacts during operation will arise from views of the proposed refinery plant buildings and lighting. The existing refinery dominates many views and the proposed development fits within this established framework. At night the visual impact of lighting proposed for the extended refinery will be moderated as new lighting will be designed to minimize light spill into the surrounding landscape.

14.1.3 Mitigation of impact

The following mitigation measures will improve the visual impact of the development to be minimized as far as practical:

- Screening of construction and operation works by using hording or earth bunds (using surplus fill), particularly at the refinery fence adjacent to the beach houses at south east of MAB. This may also provide additional benefit to reduce wind-blown dust and alleviate noise impacts.
- Site lighting is recommended to be designed and located to reduce off-site glare to a minimum and minimise the impact on visual amenity at night, having due regard to operational, emergency, security and safety requirements.
- Where possible, tone and colour treatment of plant structures should ensure that the development fits in with surroundings and will blend elements into the horizon and sky line when viewed from a distance e.g. the use of lighter colours on elevated structures and stacks to help reduce the prominence of skyline features and non-reflective paint throughout, where operationally possible.

14.1.4 Conclusions & Recommendations

There are no significant visual impacts from the CFP. From a distance, receptors will consider the refinery in context with the existing industrial developments adjacent to the site.

The proposed project is set in context with adjacent industrial areas where the visual environment is dominated by the existing refineries. Local observers will potentially be visually impacted by the new development, especially the beach houses on the south-eastern edge of the project and mitigation measures have been proposed to minimize visual impacts, in the form of hording or earth bunds using surplus spoil generated during construction.

The impact of the CFP development is minimized due to the CFP development being incorporated within the refinery boundaries.

14.2 Socio-economic Impact

This desk-based socio-economic impact review was completed based on the EBS, and a visit to the proposed CFP sites.

The review is a high-level review and is not based on detailed information. The identified socio-economic issues are shown in Table 14.1 below.

Table 14.1: Outline of Socio-economic Impacts

Issue	Effect	Potential Impact	Assessment	Recommendations
Air Quality	Positive	Air pollution	The CFP will produce cleaner fuels for the State of Kuwait, and consequently SOx levels in Kuwait should improve nationally. At the local level (in the Study Area) there would generally be an improvement in air quality as a result of the CFP.	See Chapter 9
Noise	Potentially negative	Noise nuisance	Addressed in Chapter 7.	See Chapter 7
Economics	Positive	Diversifying, expanding capacity & adding to GDP	An objective of the CFP is to upgrade and modernize existing facilities leading to diversification within the petroleum refining industry. This will result in financial benefit for the Kuwaiti Government, and hence the Kuwaiti public.	N/A
Employment	Positive	Intangible effects (e.g. increased self-esteem, improved quality of life etc)	Construction would generate employment opportunities for a significant number of people (36,000 peak construction workforce) locally and as well from developing countries. Employment will also be generated from extra operational activities and the expansion of the refineries will ensure the continuous employment of KNPC employees.	N/A
Large Foreign Construction Workforce	- Positive - Negative	- Increased business - Cultural differences	There will be a significant number of temporary employees during the construction phase (36,000 max). These employees will predominantly be from developing countries. The main concerns will be the social activities of these employees when not working, and there may be an impact to local residential areas owing to cultural differences, and an increased strain upon local facilities. Medical services for the construction workforce will be provided by an independent and centralized medical services contractor. There will also be potential positive impacts upon the local community in relation to local businesses benefiting from increased business.	Ensure local community is well informed about construction activities. EPC contractor should develop a plan to handle the potential negative social impacts from such a large influx of construction workers.
Water	Negative	Increased use of water, affecting water availability.	The construction and operation of the CFP will put further strain on water scarcity in Kuwait. Seventy-five percent of Kuwait's portable water must either be desalinated or imported. Sustainability and diversification of water source is a concern however KNPC will use best engineering	Use best engineering practices to decrease water demand and protect water supply –

			practices to treat, recover and reuse water to the extent practical.	see Chapter 12.
HSE	Positive	Improved HSE practice	KNPC's HSE practices will likely be enhanced through the upgrading/replacing of aging units. This will generally make the KNPC refineries and their surroundings a safer, healthier and cleaner place to live and work.	N/A
Archaeology & Heritage	Neutral	None	The CFP area contains no known archaeologically significant factors or areas of valued heritage.	N/A
Traffic	Negative	Disruption	The CFP will result in additional traffic during construction and this will need to be managed.	See Chapter 13.

14.3 Contaminated Land & Groundwater

14.3.1 Contaminated Land

In the EBS it was observed that there was no significant contamination identified at MAA and MAB, however, hydrocarbon levels were higher at SHU where contamination was identified at one location. The soil in this location will need to be carefully removed and disposed of correctly. It is recommended that an independent Environmental Advisor is regularly on site during construction whilst soil excavations are taking place to ensure that the soil is excavated and disposed of correctly, and to help identify any other areas of contamination.

The installation of CFP facilities has been planned with a minimum of underground process piping in accordance with current good engineering practices. There are no underground storage tanks in the CFP. Vessels, tanks and piping systems (including underground piping) will be hydro-tested before beginning operations to check for leaks. KNPC regularly inspects equipment for leakages as part of the EMS, in order to minimize the risk of contaminating land and / or groundwater during operations.

Additionally, the KISR study as discussed below in 14.3.2 also includes some investigation into contaminated land onsite.

14.3.2 Groundwater

14.3.2.1 Introduction

KISR conducted a study on behalf of KNPC in order to assess the groundwater pollution and potential for pollution caused by three KNPC refineries, namely MAA, Shuaiba and MAB (*Impact on Oil Refineries on Groundwater Quality and Levels, Kuwait, WM021C, February 2009*).

The assessment, as referenced in the aforementioned KISR report, followed the recognised systematic 3-level approach, commonly referred to as Phase I, II and III assessments, as below.

- Phase I – This phase identifies potential sources of contamination via a desk study using a remote sensing method, the land surface temperature (LST) method.
- Phase II – This phase installed a groundwater monitoring network though the drilling of 47 monitoring and testing wells across the 3 refineries. The monitoring system at MAA consists of 14 wells, at Shuaiba of 13 wells and at MAB of 18 wells. There are also 2 monitoring wells outside the refineries area. The monitoring wells installed are a mixture of multi-level wells specifically designed for contaminants sampling at

selected depth, and dual purpose production/observation wells. The production/observation wells also allowed determination of the depth of the groundwater table at the well locations. Sampling of the well monitoring network was also conducted as part of this phase (with 260 samples taken) for selected chemical and bacteriological parameters.

- Phase III – A preliminary numerical groundwater hydrodynamic model was created, based on information from the previous phases of the study. It was not possible to calibrate the model, as no time-series of groundwater levels were available for any of the sites. Instead, hypothetical contamination scenarios were assessed using literature values (for transport parameters required). Note that the model was also used to assess the applicability of pump-and-treat remediation.

The above are discussed, along with an outline of the methodology used in each phase, in more detail in the following sections. More details are available in the detailed KISR report on groundwater quality (*WM021C, February 2009*).

14.3.2.2 Phase I

14.3.2.2.1 Outline of Methodology

The remote sensing method was used to identify potential hydrocarbon contamination in the study area, and also to aid the selection of monitoring points across the study area.

Definition / delineation of potential hydrocarbon contamination was carried out using LST mapping. This method is based on the fact that various bodies can be differentiated by their thermal properties. For example, when a hydrocarbon spill mixes with soil, the soil composition will change, and so will its thermal properties. This will result in a higher than the background temperature signal. Therefore, mapping the temperature variations across a contaminated site can indicate the extent of the contamination. The preliminary investigations were carried out using IKONOS and RADARSAT data.

It is also noted that the use of remote sensing data can provide an indication of drainage systems, topography and land use / cover in the study area. The results were used to aid the selection of the monitoring well locations for Phase II, as it was assumed that contaminant transport in groundwater would follow existing pathways (i.e. drainage networks).

14.3.2.2.2 Results

A total of 13 sites of potential contamination were identified at MAA, 5 at Shuaiba and 12 at MAB. These are indicated in the figures that follow.

The 13 sources of potential contamination at MAA are shown in Figure 14D. From the 13 sources, 12 involve hydrocarbon contamination, whereas one source involved contamination from spent catalysts. The rising water table is also highlighted as a concern.

The 5 sources of hydrocarbon contamination at Shuaiba are shown in Figures 14E (no sources for spent catalyst contamination were identified at the Shuaiba refinery).

The 12 sources of suspected hydrocarbon and spent catalyst contamination at MAB are shown in Figure 14F.

More details on each source of contamination are provided in the KISR report WM021C.

Some of the sources of potential contamination identified at each site will overlap with CFP areas, hence the need to ensure that these are properly treated and cleaned prior to the start of the construction phase of the project.

These include:

- Contamination sources 2, 3, 4, 5, 6, 7, 9, and 12 at MAA Refinery, indicated in Figure 14D.
- Contamination source 4 at Shuaiba Refinery, indicated in Figure 14E.
- Contamination sources 2, 4, 6, 8, 9, 10 and 11 at MAB Refinery, indicated in Figure 14F.

Figure 14D: Contamination sources at MAA Refinery

Figure 14E: Contamination sources at Shuaiba Refinery

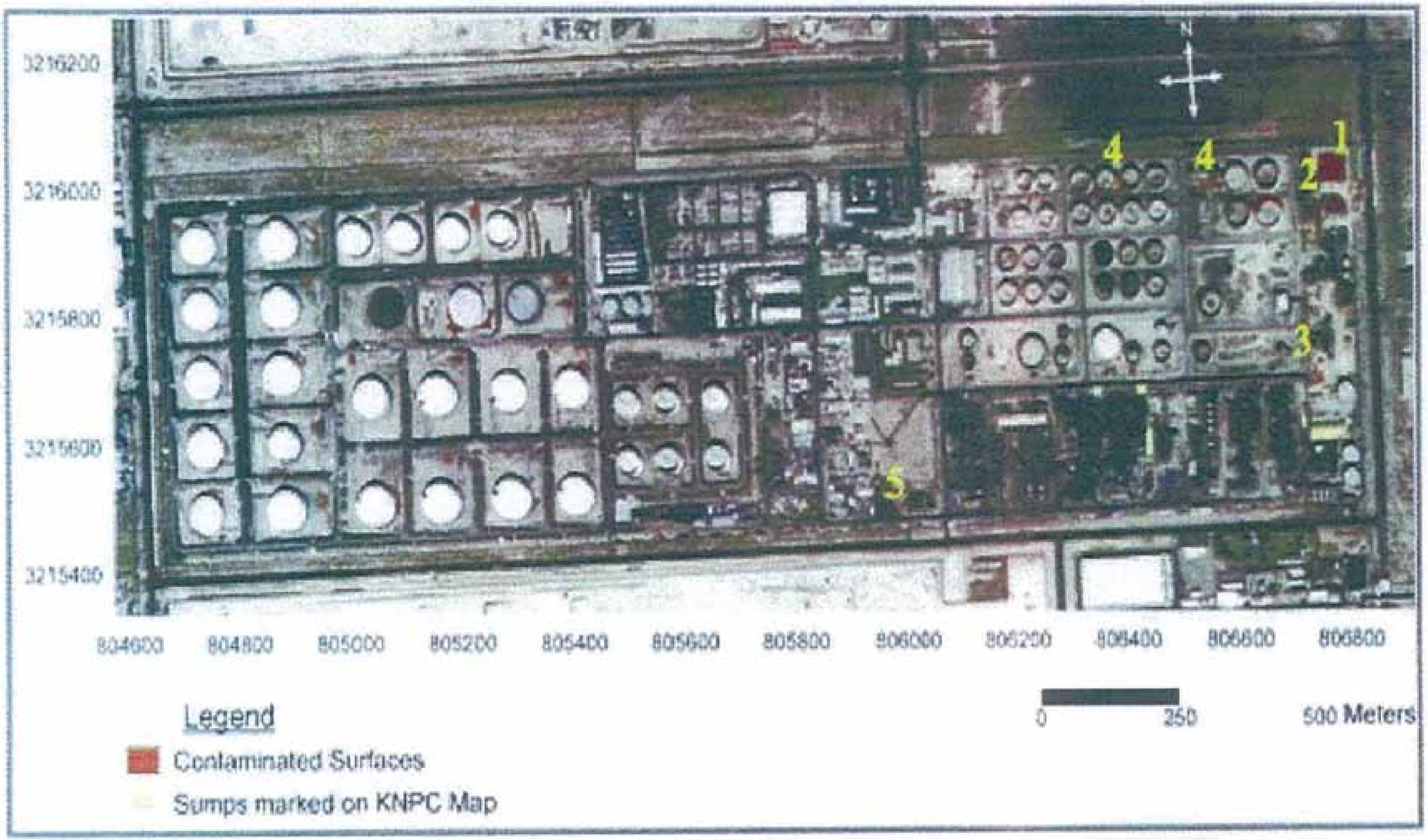


Figure 14F: Contamination sources at MAB Refinery

14.3.2.3 Phase II

14.3.2.3.1 Outline of Methodology

The key objective of Phase II was the design and implementation of a groundwater monitoring network at the three refineries, in order to determine the nature and the extent of contamination, as well as determining the water table levels at the refineries.

A total of 47 monitoring wells were installed across the 3 refineries (and outside the refineries area), as indicated in Figures 14G, 14H and 14I.

Some of the monitoring well locations were selected in consultation with KNPC in order to provide information on the groundwater quality in areas where the new CFP project refinery units will be constructed. These well locations are summarised below:

- At MAA refinery: Monitoring Wells W4, W10, W11, W13 and W14.
- At MAB refinery: Monitoring Wells W1, W2, W5, W18 and W19.

The other monitoring well locations are based on Phase I investigations which identified potential areas of contamination by remote sensing methods (LST).

Figure 14G: Monitoring well locations in MAA Refinery

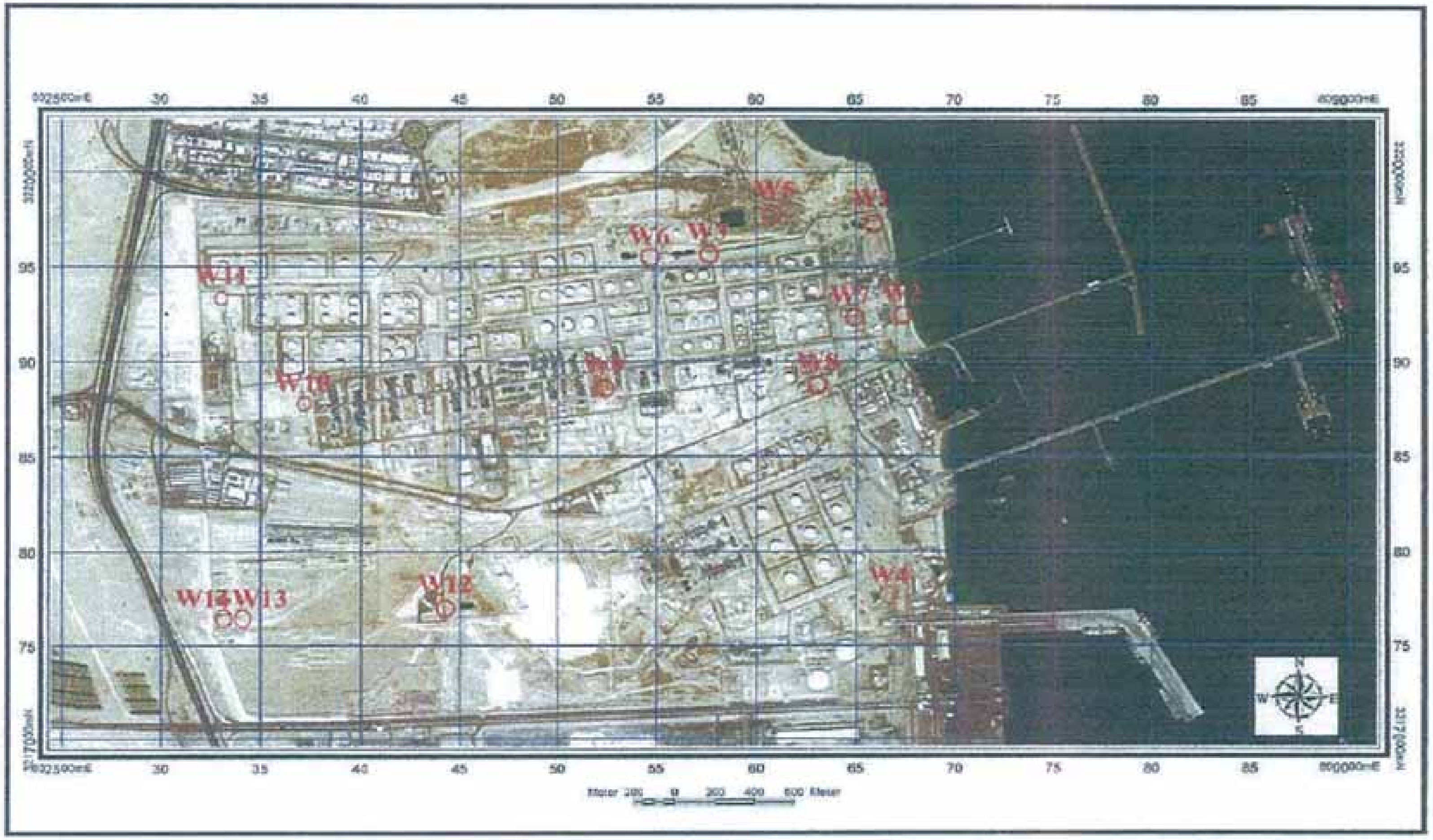


Figure 14H: Monitoring well locations in Shuaiba Refinery

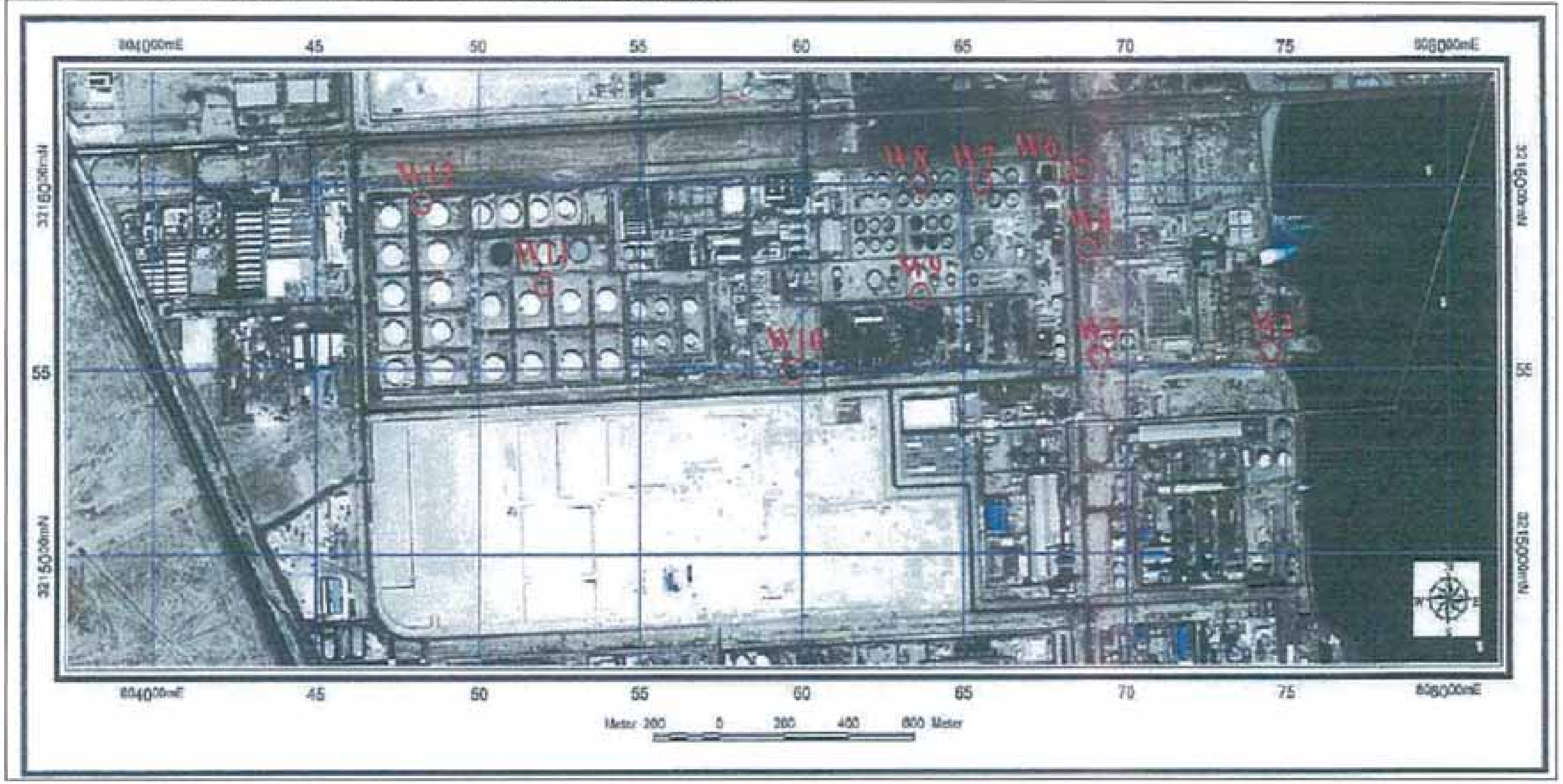
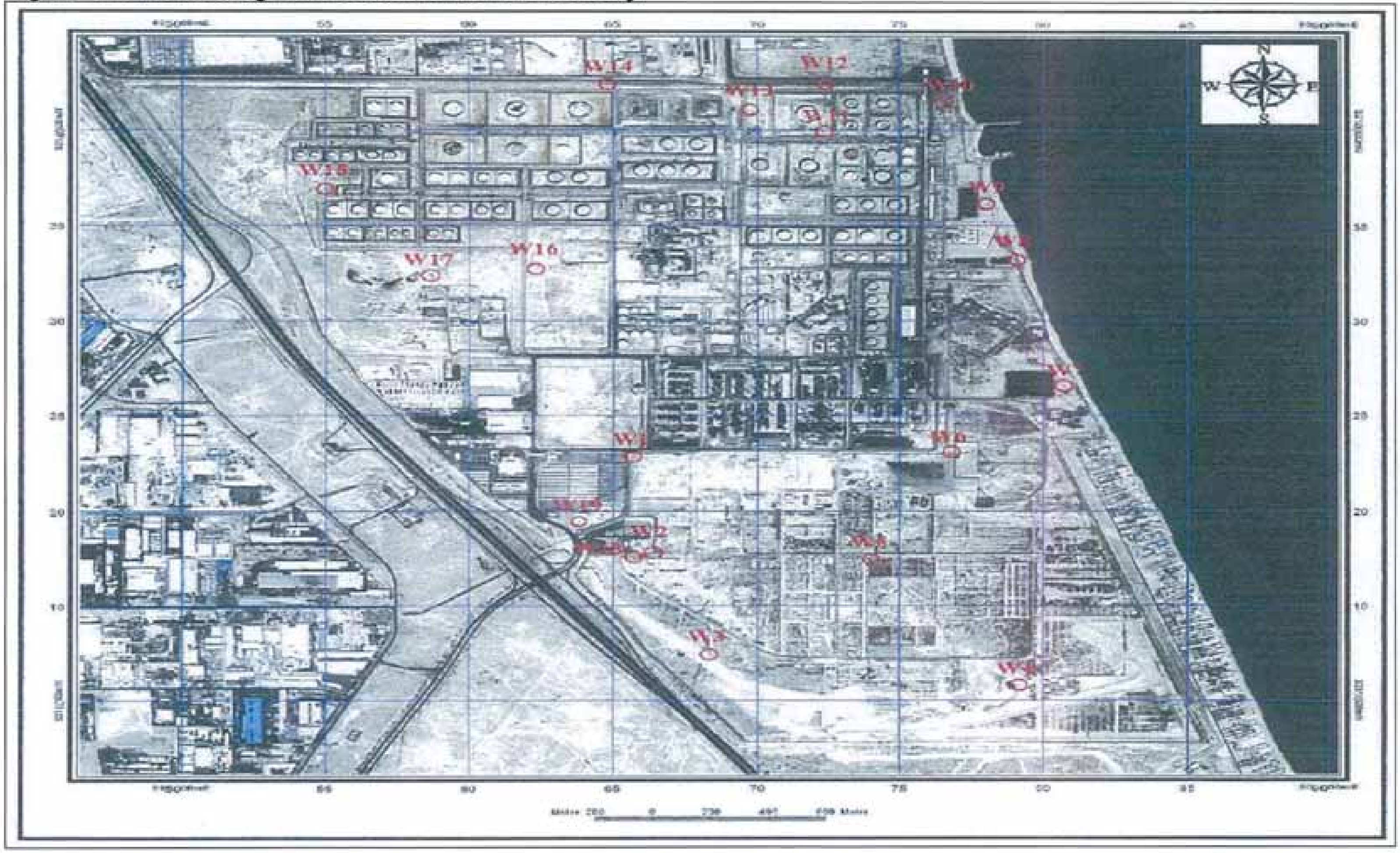


Figure 14l: Monitoring well locations in MAB Refinery



In summary, the monitoring well network at MAA consists of 14 wells, at Shuaiba of 14 wells, and at MAB of 19 wells (the wells at Shuaiba and MAB refineries include 1 well off-site at each refinery).

14.3.2.3.2 Results

Water Table

One of the objectives of this phase was to obtain / measure the water table levels at the three refineries. At each monitoring well, KISR measured the depth of the water table below ground surface. These measurements are briefly outlined below for each refinery.

MAA Refinery:

- The minimum depth of the water table below ground surface was recorded at W1 (0.97 m), which is situated towards the seashore (and is around 2.1 m above the mean sea level).
- The depth of the water table below ground level for all the wells measured ranges from 0.97 m to 14 m.

Shuaiba Refinery:

- The minimum depth of the water table below ground surface was recorded at W6 (2.14 m), which is located approximately 7.6 m above the mean sea level.
- The depth of the water table below ground level for all the wells measured ranges from 2.14 m to 16.64 m.

MAB Refinery:

- The minimum depth of the water table below ground surface was recorded at W8 (1.95 m), which is located towards the seashore.
- The depth of the water table below ground level for all the wells measured ranges from 1.95 m to 22.58 m.

The KISR report indicates that the water table follows the general regional trend of flow in Kuwait.

Groundwater Quality

A total of 260 samples were taken from the monitoring wells described previously, as well as six (from a total of ten existing wells) existing wells at the MAB refinery.

The analysis of the samples taken included the following parameters, which are discussed in more detail in the KISR report:

- Total Organic Carbon (TOC)
- Total Petroleum Hydrocarbons (TPH)
- Benzene, Toluene, Ethyl-benzene and Xylene (BTEX)
- Polycyclic Aromatic Hydrocarbons (PAH)

Water salinity (expressed as TDS), major anions and cations, trace metals and microbiology were also analysed. Field measurements of pH, EC and ORP (Oxidation Reduction Potential) were also taken prior to the sample collection.

Table 14.2 also summarises the parameters analysed for each sample collected (by different laboratories). More details are provided in the KISR reports (and associated appendices).

Table14.2: List of parameters analysed for each groundwater sample

Parameter		Laboratory	Method of Analysis
Inorganic	TDS	Hydrogeology Laboratory (HD) at KISR	Standard Methods for the examination of water and wastewater (Details are presented in Appendix G)
	Major cations (Na, K, Ca, Mg)		
	Major anions (HCO_3, SO_4, Cl, NO_3)		
	Trace elements (AS, Cd, Cr, Mo, Ni, Cu, B, Pb, Se, V, Zn, Hg)	Central Analytical Laboratory (CAL) at KISR	
Organic	TOC	Central Analytical Laboratory (CAL) at KISR & BIOFOCUS Laboratories in Germany	
	TPH		
	Phenol		
	BTEX		
	PAHs		
Microbiology	Total coliforms (TC), Fecal coliforms (FC), Sulfate reduced bacteria (SRB)	Central Analytical Laboratory (CAL) at KISR	

The results obtained from the chemical analysis have been compared against K-EPA criteria for wastewater discharge to the sea. The criteria are summarised in Table 14.3. It is noted here that groundwater quality criteria applied in the EU are more stringent than the K-EPA wastewater discharge criteria applied in this case.

Table 14.3: K-EPA Criteria for maximum allowable limits for industrial wastewater discharge to sea

Parameters	Maximum Limits
Aluminum (Al)-mg/l	5
Ammonia (NH_3-N)-mg/l	3
Antimony (Sb)-mg/l	1
Arsenic (As)-mg/l	0.1
Barium (Ba)-mg/l	2
Beryllium (Br)-mg/l	0.1
BOD (5 day,°20)-mg/l	30
Boron (B)-mg/l	0.75
Cadmium (Cd)-mg/l	0.01
Chlorine (Cl_2)-mg/l	0.5
Chromium (Cr)-mg/l	0.2
Cobalt (Co)-mg/l	0.2
COD (Dichromate)-mg/l	200
Color	Free from contaminates
Copper (Cu)-mg/l	0.2
Cyanide (Cn) -mg/l	0.1
Dissolved Oxygen (DO) -mg/l	<2
Floatables -mg/l	None
Fluorides (F) -mg/l	25
Iron (Fe)-mg/l	5
Lead (Pb) -mg/l	0.5
Lithium (Li) -mg/l	2.5
Manganese (Mn) -mg/l	0.2
Mercury (Hg) -mg/l	0.001
Molybdenum (Mo) -mg/l	0.01
Nickel (Ni) -mg/l	0.2
Nitrate (NO_3) -mg/l	30
Oil/Grease, Hydrocarbons -mg/l	10
Organic Nitrogen -mg/l	5
Pesticides-All Types -mg/l	-
pH	8
Phosphate (PO_4) -mg/l	2
Silver (Ag) -mg/l	0.1
Sulfide (S^{-2}) -mg/l	0.5
Temperature (°C)	10
Total Coliform Bacteria (MPN/100 ml)	1000
Total Nitrogen -mg/l	30
Total Recoverable Phenol -mg/l	1
Total Soluble Solids -mg/l	1500
Total Suspended Solids (TSS) -mg/l	10
Turbidity –NTU	50
Vanadium (V) -mg/l	0.1
Zinc (Zn) -mg/l	2

The results of the analysis of the groundwater samples indicate:

- K-EPA criteria for TPH are exceeded at monitoring wells W12 and W14 at MAB refinery, as well as W8 at Shuaiba refinery.
- K-EPA criteria for phenol are exceeded at monitoring wells W10 at MAB refinery, and W8 at Shuaiba refinery.

- In a number of other wells, K-EPA criteria for faecal coliform bacteria are exceeded. These high bacteria concentrations were detected at MAB wells W3, W4, W12 and W17, Shuaiba wells W2, W3 and W7 and MAA wells W1, W2, W4 and W5. Sulphate reducing bacteria (SRB) were also detected in wells at all refineries. Note that these bacteria under anaerobic conditions may result in hydrogen sulphide release (through reduction of the sulphate ion in the groundwater to sulphide ion).
- High levels of solute concentrations that exceed K-EPA criteria (i.e. the major anions / cations summarised in Table 14.2, such as Na^+, K^+, $SO4^{2-}$, Cl^- etc), have been detected at all three refineries.
- High levels of boron (which is relatively non-toxic in elemental form), exceed K-EPA relevant criteria, were detected at all well samples from MAB refinery, at Shuaiba wells W6 and W12, and at MAA wells W2, W3, W4 and W5.
- Low levels of Chromium, below K-EPA's relevant criteria, were detected at MAB well W4.
- Selenium was detected at Shuaiaba wells W6 and W12 (0.06 to 0.2 mg/l). There are no K-EPA criteria for Selenium, though it is relatively non-toxic (only toxic if taken in excess).
- High levels of Molybdenum (it is noted that acute toxicity has not been observed in humans), exceeding K-EPA's relevant criteria, were detected at MAB wells W4 and W14, Shuaiba wells W6 and W12, and MAA wells W4 and W5.

Existing Groundwater Wells at MAB

As mentioned previously, samples were collected from the existing groundwater wells at MAB refinery. Their locations are shown in the figure below:

Figure 14J: Existing Groundwater Wells at MAB Refinery

Note that only samples from six of the wells (W1-W5 and W10) were analysed, as the other wells were either dry or collapsed.

The results indicated that:

- The salinity exceeds K-EPA criterion (expressed as TDS) for all the samples analysed.

- High levels (exceeding K-EPA criteria) of boron (all samples), molybdenum (W2, W3, W4 and W10), as well as TOC were detected.
- High TPH levels (up to 8.5 mg/l) have been detected at W1, though this is below K-EPA relevant criteria.
- Coliforms were only detected in W1, whereas sulphate reducing bacteria (SRB) were found in all samples analysed.

Surface Water Samples at MAA

Surface water quality at MAA refinery was also assessed, and is summarised below.

The quality of surface water was analysed for five sites at MAA refinery, as shown in the figure below (this includes the MAA Trench located 50 m east of the lagoon):

Figure 14K: Surface Water Sites at MAA Refinery

The results indicated that:

- Slightly alkaline, saline type of water was detected for all samples, with the exception of the lagoon, where the water is brackish.
- High levels of boron were detected in all samples. High levels of molybdenum and vanadium in the lagoon and MAA Trench were also detected.

- High levels of TOC and TPH were detected for the lagoon and MAA Trench samples.
- The MAA Trench sample results indicate high levels of microbial contamination.
- The lagoon sample indicates the presence of PAH.

The salinity (expressed as TDS) and TPH for the lagoon and MAA Trench are exceeding the K-EPA criteria used for the purposes of this study. This also applies for molybdenum and vanadium parameters. It is also noted that leakage from the lagoon might be responsible for the water content contamination in the MAA Trench.

14.3.2.4 Phase III

14.3.2.4.1 Outline of Methodology

The main objective of Phase III was to identify the main aquifer type in the area and set-up a 3-D model for the aquifer underlying the refineries using available field information. Additionally, to characterise the contamination plume and to develop a plan for remediation of the aquifer (and prevent further future pollution).

The approach followed is briefly outlined below:

- Analyse available drilling data and develop a conceptual geologic and hydrogeologic model.
- Perform pump-and-treat scenarios and run hypothetical (i.e. based on literature values for transport parameters) plume simulation to assess the shape and speed of its spread.

14.3.2.4.2 Results

It is noted that the modelling work is based on available information at the time of the study (and would benefit from sustained and continuous monitoring data).

The key findings from this part of the study are briefly summarised below:

- The time of travel from potential sources of contamination to sea was found to be around 40 days for seaside sources and 24 years for inland sources (based on the particle tracking method).
- Complete interception of the release particles is possible at pumping rates of approximately 120 m^3/day.
- Hypothetical simulations of contaminant releases using literature values of transport parameters shows relative containment of the pollutant plume (even after 50 years from release).

14.3.2.5 Conclusions and Recommendations

Determination of possible leakage from specific tank bottoms causing groundwater contamination has not specifically been addressed by the KISR report because this would require close physical examination of each of the tanks (and tank bunds), accompanied by groundwater investigations in the immediate vicinity of each tank (there is a large number of tanks in the refineries, hence large volume of wells / samples would be required).

However, several sources and areas of groundwater contamination have been identified at the refineries. Recommendations for treatment, remediation and preventive measures have been made in the KISR report. These include decommissioning all unlined pits, with the soil beneath them excavated, followed by the removal of free moving solutes from groundwater sources by pump and treat for a limited duration. More details are provided in the *Overall Conclusions and Recommendations* section of the KISR report.

The KISR report identifies (based on comparison against K-EPA wastewater discharge standards) that the groundwater below the refineries is contaminated in some areas by parameters such as TPH, phenol, coliform bacteria, trace elements such as boron and molybdenum, as well as major anions and cations (i.e. the major anions / cations summarised in Table 14.2, such as Na^+, K^+, $SO4^{2-}$, Cl^- etc, which are likely to originate from infiltration of seawater into groundwater). Bacteria (e.g. coliform) contamination suggests the leakage / discharge of sewage to groundwater.

The refineries may be responsible for some of the contamination. Note that groundwater quality criteria applied in the EU are more stringent than the K-EPA wastewater discharge criteria.

It is not the intention of this EIA for the CFP to deal with this historical groundwater contamination, as this EIA deals only with the CFP scope. But the CFP development does need to be considered in the context that existing refinery design and operation has probably resulted in groundwater contamination.

The KISR report has recommended treatment, remediation and preventive measures. It is DNV's consideration that any future risk of groundwater contamination by the CFP will be additionally reduced by improved environmental management of the refinery facilities, via:

- Regular checks for fugitive emissions to ground/groundwater from CFP refinery plant and tanks included as part of the EMS;
- Systematic groundwater monitoring and analysis (against agreed criteria) around the CFP facilities and in the vicinity of the tank farms;
- The CFP has satisfactory wastewater and sewage treatment facilities planned during normal operation - see Chapter 12 – but it is important that EPC contractors implement sufficient and adequate wastewater and sewage

treatment/handling facilities at the earliest stages of construction to ensure that CFP does not exacerbate groundwater contamination.

Additionally, soil and groundwater has been identified in the KISR report as contaminated in locations that overlap with the CFP development. It is recommended that:

- Groundwater encountered during CFP excavation activities is contained and collected onsite and tested to meet K-EPA requirements (TPH, Phenol & coliforms) before discharge via existing storm water discharge outlets at MAA or MAB. If the water quality is not acceptable, the EPC contractor will need to provide means for treating the water prior to discharge.
- Potential soil contamination sources identified in the KISR report that overlap with CFP areas are properly remediated prior to the start of the construction phase of the CFP project. These may include:
    - Contamination sources 2, 3, 4, 5, 6, 7, 9, & 12 at MAA Refinery, indicated in Figure 14D.
    - Contamination source 4 at Shuaiba Refinery, indicated in Figure 14E.
    - Contamination sources 2, 4, 6, 8, 9, 10 and 11 at MAB Refinery, indicated in Figure 14F.

15.0 Emergency Response Plan

15.1 Introduction

The CFP involves the upgrading and modernization of KNPC's existing refinery operations at MAA, MAB and SHU. Since these refineries are currently being operated by KNPC, all of KNPC's policies and procedures will apply to the CFP including the KNPC Major Incident Procedure Plan (MIPP). MIPP is one of KNPC's Emergency Plans that provides a procedural framework for responding to emergency incidents such as fire or a flammable/toxic release.

The sections outlined in this chapter have been abstracted from the MIPP. They are set out and adapted here to demonstrate how an Emergency Response Plan (ERP) would be implemented for the CFP. The information given in this chapter is for general guidance only. The controlled version of the MIPP is available on KNPC intranet. MIPP call-out lists for CFP areas will be developed and role players will be trained before commissioning.

The KNPC refineries and marine terminals, within which the CFP will operate, process, store and distribute large quantities of flammable and toxic materials. An incident, such as fire, explosion or gas release occurring at these sites may have serious consequences, affecting not only the incident site but industries and the public outside the site boundaries as well, which could result in loss of lives and property, and damage to the environment, business and reputation.

KNPC is committed to the safety of its employees, installations and the public. All applicable safety standards, procedures and best practices are followed during process selection, design, construction and operation of various facilities. However, even with the safest working practices, emergency incidents may occur. Therefore, it is imperative that the CFP has an adequate level of 'Emergency Preparedness' to deal with any such incident effectively and efficiently, thereby minimizing the consequences.

Emergency Preparedness includes the following integral components:

- Prevention and mitigation: to eliminate or reduce the chances or lessen the effects of an emergency, for example, by adopting safe design, operating and maintenance practices.
- Emergency plans: written procedures and guidelines on how to respond efficiently and effectively, with the right resources and trained personnel, should an emergency occur.
- Response: activities immediately following the alert or disaster.
- Restoration: returning all used / affected systems and services to normality as soon as practicable after the emergency has been resolved and any adverse impacts mitigated.

The MIPP is one of KNPC's principal emergency plans. It provides a procedural framework for responding to emergency incidents such as fire and flammable / toxic releases. MIPP was initially conceived to ensure a unified and collective KNPC approach for responding to emergencies at its refineries and associated oil terminals, and to replace a number of the individual ERPs previously followed at various sites.

MIPP is supplemented by the KNPC Security Manual and the site specific plans which include call-out lists and the Site Emergency Evacuation Plan (SEEP). KNPC's Crisis Management Plan will be activated in case of an emergency identified as 'crisis' which requires direct involvement of KNPC corporate management.

15.2 MIPP: Purpose and Scope

15.2.1 Purpose

The purpose of KNPC's MIPP is to provide a simple, logical and comprehensive procedural framework to ensure:

- The overall direction of efforts to bring the emergency under control and restore the affected site to normal operation as soon as possible.
- The organisation and coordination of effective action, making the most efficient use of available resources, in order to ensure:
    - Safety of personnel;
    - Minimum damage to KNPC plants and equipment;
    - Protection of both property outside the affected refinery and the environment.
- Those personnel who may be involved in a KNPC site emergency incident fully understand their role, and the roles of others, in effectively dealing with the incident.

15.2.2 Scope

The CFP will be incorporated into the scope of KNPC's MIPP, which currently covers the following:

- Procedure for notifying emergencies, categorization and mobilizing emergency response.
- Emergency handling organization and coordination centres
- Guidelines for developing emergency call-out lists and SEEPs by sites.
- Roles and responsibilities of the key role players, emergency control/coordination centres, called-out personnel and external agencies likely to be involved.
- Any credible incident occurring on one of the above KNPC sites, which could for example, involve:
    - Injuries to personnel;
    - Release of flammable gas or other materials leading to a fire or potential fire;
    - Effects of an explosion;
    - Release of toxic materials such as hydrogen sulphide, chlorine or ammonia to the atmosphere from either a KNPC or adjacent industrial site;
    - A major pollution incident or spillage within the confines of one of the above KNPC sites or their immediate surroundings;

    - Security incidents/threats received through Telephone, fax, email, in person, through media or any other means;
    - Bomb threat, Suspicious packages or devices and Weapons/explosives within KNPC facilities;
    - Hijack or hostile boarding of a ship at marine terminals;
    - Security breaches.

- The interactions between KNPC personnel and outside emergency services (and other bodies) involved in the KNPC MIPP, including:
    - Public Authority for Industries (PAI);
    - Kuwait State Fire Brigade (KSFB);
    - Kuwait State Security Force (KSF);
    - Kuwait State Civil Defence Force (KCDF);
    - Kuwait State Installations Security Force (KISF);
    - Vital & Oil Installations Protection Department (VOIPD)
    - KPC-Incident Management Team (KPC-IMT);
    - Kuwait Environment Public Authority (K-EPA);
    - Kuwait Municipality.
    - Port Facility Security Officer (PFSO)
    - KOC Export & Marine Operations Group (E&MOG)

15.2.3 Reference Emergency Plans and Procedures

A number of Reference Emergency Plans and Procedures are also relevant to the application and implementation of KNPC's MIPP, as follows:

KNPC:

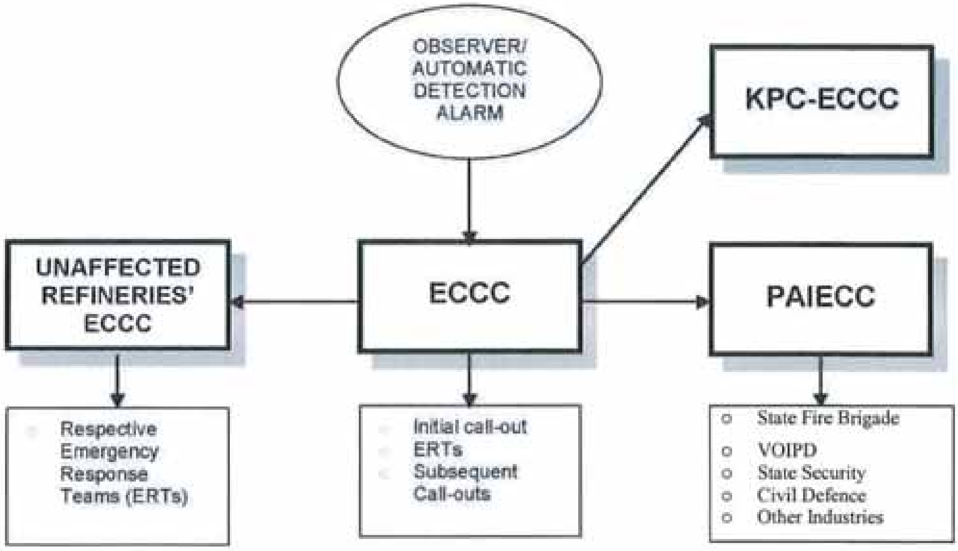
- KNPC Crisis Management Plan (SHE-TSFP-08-2208);
- Security Manual 2007
- KNPC Smart SMS Service for MIPP Call-out (SHE-TSFP-07-2210)
- Site Emergency Evacuation Plans (SEEP);
- Medical Emergency Plan (SHE-MDMA-07-2208)
- Guidelines for MIPP Drills
- Procedure on Environmental Communication (SHE-ESHU-03-1403);

15.3 MIPP: Outline

15.3.1 Overview

All emergencies are reported to KNPC's Emergency Communications Control Centre (ECCC). The ECCC takes action to mobilize the Emergency Response Teams (ERT) and makes personnel call-outs as necessary. The Public Authority for Industry Emergency Control Centre (PAIECC) makes the call-out for assistance from external agencies. KPC-ECCC is also informed (for incidents category-I above). Figure 15A (below) highlights the emergency response in outline.

Figure15A: Emergency Notification and Call-outs



15.3.2 Incident Categorization

Incidents involving fire and potential fire (flammable gas / liquid release etc.) will be categorized according to the scale of KNPC and external forces that need to be mobilized in order to effectively contain the incident. KNPC categorizes incidents via four categories (Section 4.1 MIPP):

- ***Minor Incident***: can be dealt with effectively by the plant personnel and the refinery fire crew responding to the incident, using the equipment and resources that are readily available to them;
- ***Category I Incident***: requires more than one fire crew to bring it under control, but can still be dealt with effectively by the resources of the refinery concerned;
- ***Category II Incident***: requires a response beyond the scope of the resources of the affected refinery and hence requires assistance from the unaffected KNPC refineries as well as outside agencies for effective containment;
- ***Category III Incident***: may have serious effects beyond the site boundary of the affected refinery. Such an incident, possibly an explosion or toxic gas release, may require the evacuation of the site or specific warnings to the nearby general public.

Subsequent reclassification may be necessary – eg. if escalation occurs. Once categorized, any incident may subsequently be reclassified to a higher (or lower) category following joint consultations between the Incident Controller and the Duty Fire Officer to take account of changing circumstances. Incidents involving oil spills shall be additionally classified as per the Oil Spill Response Plan (Section 11 MIPP) for the purpose of containment and recovery of oil spills (see Section 15.3.4, below). Incidents are categorized according to type (fire, gas release, oil spill, etc.) and severity in order to determine the scale of response necessary to control it.

Emergency response levels are as follows:

1. Resources readily available at / near incident location
2. Resources available at the affected refinery
3. Support from unaffected refineries
4. External support (government agencies, mutual aid companies etc.)

15.3.3 Offsite Emergency Plan

This section describes KNPC response to the off-site emergency situations, for example:

- An on-site process incident (fire, explosion or hazardous material release with potential to affect the neighbouring community and industries, causing harm to the property, health and environmental).
- An incident involving KNPC facilities off-site (e. g. IRT lines within Public Authority for Industry-Shuaiba area, KNPC lines passing through PIC, area and the underground and submarine pipelines from refineries to the oil piers).
- A situation where KNPC facilities are not involved, but KNPC management decided to respond to provide requested assistance for another company's incident.

Offsite Emergencies Caused by On-site process incidents

- *Community Safety*: An on-site process incident which may have serious effects beyond the site boundaries is categorized as a category-III incident (section 4). Kuwait Civil Defence, called-in through PAIECC to initiate appropriate action for the safety of the affected community in coordination with the local Civil Administration. Civil Defence will activate the civil defence siren (Alert/Evacuation/All-clear) for the affected area, if necessary. Incident close-out at KNPC site will be done in consultation with Civil Defence in such case.
- *Neighbouring Industries*: Alerting and emergency coordination with the neighbouring industries is done through PAIECC. In addition, the following direct communication procedures exist:

  1. Emergency coordination procedures between KNPC and PIC (6 MIPP Annexure- 6).
  2. Normal and emergency communication between KNPC MAA Refinery

- *Environmental complaints*: (Oil spill, odours etc.) from outside parties are received at ECCC-MAB. Further actions are initiated to address the situation in accordance with the document Procedure on Environmental Communication. Response oil spills is covered in MIPP sections 10 and 11.

Emergencies involving Off-site KNPC Facilities

Emergencies involving KNPC facilities in PAI (Shuiaba) Area and KNPC pipelines passing through PIC area are outlined in MIPP section 4.6 and Annexure 6 respectively

KNPC Response to Other Companies' Incidents

KNPC as a member of the KPC Incident Management Team for oil spill incidents, will respond with its Oil Spill Response Teams and resources to the land oil spill incidents in K-companies when required as per the KPC Oil Spill Contingency Plan.

KNPC response and resource support to other types of incidents shall be decided by KNPC management based on the request received from the affected companies management.

15.3.4 Corporate Crisis Management

In case of emergency situations (triggered by internal or external cause) which might be beyond the capability and authority of the KNPC site management to handle and require involvement of the KNPC top management for strategic directives, coordination with KPC and other national and international agencies, are classified as crisis.
A provisional Crisis Management Plan (SHE-TSFP-08-2208) has been developed for managing the crises.

15.3.5 Emergency Communication and Alarm Systems

There are four principal avenues of communication available during an emergency. Each of these systems is discussed below.

1. Telecommunication facilities
   - *Radios:* Trunking Radio System (TRS) consisting of channels for emergency as well as normal work communication.
   - *Telephones:* Various internal and external permutations
   - *KNPC Smart SMS Service for MIPP Call-out:* Implemented to make emergency callout by sending SMS messages to MIPP role players.
   - *Pagers:* Some employees have been provided with personal pagers to enable them to be called-in when needed.

2. Public Address and Plant Paging
   - *Public Address:* One-way PA system from ECCC Operator to outlets in plant operations control rooms, Medical Centre, MCC, RCC and other buildings.

- *Plant Paging System:* Process Unit areas have been provided with Plant Paging System for communication between control rooms and field.

3. Fire/Gas Detectors and Alarms
   - *Fire Detectors:* Different types of fire detectors and associated alarm systems have been installed in various facilities
   - *Break Glass Fire Alarm Points:* Break glass type fire alarm points are available through out the premises for manual notification of any incident.
   - *Fire Alarm Panels:* Fire alarm panels and graphic display panels have been installed in the ECCC located at the fire stations in each refinery and at control buildings of the marine terminals
   - *Fixed Gas Detectors:* Fixed continuous hydrogen sulphide (H_2S) and Hydrocarbon detectors are installed in certain high risk locations for atmospheric H_2S monitoring.
   - *Portable and Personal Detectors:* Adequate number of personal H_2S detectors and portable gas detector/alarms have been provided to the field operations and maintenance personnel to warn them.

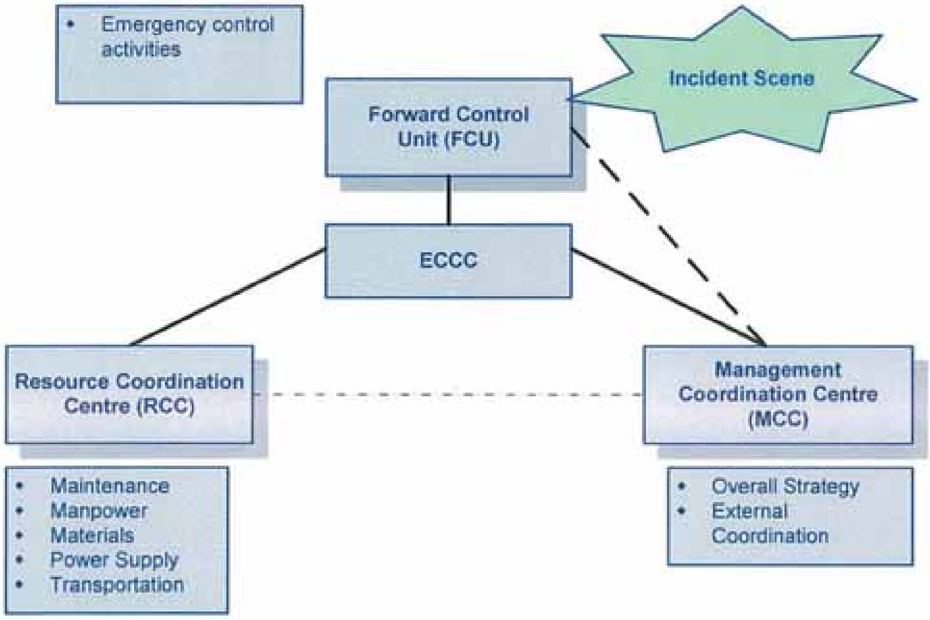
4. Emergency Sirens
   - *Refineries Emergency Sirens:* All three refineries follow a three tone emergency siren system.
   - *Civil Defence Siren System:* The KCDF sirens are located both on-site and off-site. These are actuated by KCDF in case of national emergency.

15.3.6 Emergency Control and Coordination Centres

The following various Emergency Control and Coordination Centres are set-up according to an initial assessment of requirements (as shown in Figure 15B):

- A Forward Control Unit (FCU) is set up close to the Incident Scene to manage emergency control activities. In case of land oil-spill incidents, an Oil Spill Response Vehicle (OSRV) will be mobilized and established at a strategic location near the incident. The FCU may be subsequently withdrawn following a joint decision by the Refinery Shift Leader and the Oil Spill Response Team Leader.
- A Resource Coordination Centre (RCC) to ensure adequate provisions of necessary materials and manpower resources are effectively and speedily mobilised.
- A Management Co-ordination Centre (MCC) to provide overall coordination of the emergency response efforts, to interface with the government, regulatory and other outside agencies, and to deal with enquiries from the press and the public.

Figure 15B: Emergency Control Activities



The personnel likely to be involved / supporting in emergency response and control handling are called-in according to their normal job responsibilities. In addition, certain personnel are assigned the key emergency roles, as follows:

- Incident Controller (at FCU/Incident Scene);
- Duty Fire Officer (at Incident Scene);
- Emergency Coordination Manager (at MCC);
- Emergency Operations Coordinator (at incident Scene).

15.3.7 Major Operational Steps

The essential steps involved in the MIPP are outlined below. Further details relating to individual steps, together with the responsibilities of identified personnel (and their initial actions) are given elsewhere as indicated.

Initial actions:

- The person discovering the incident notifies the emergency to the ECCC (Section 5, MIPP: Reporting of Emergencies).
- The plant operations crew (under the control of the Emergency Operations Coordinator, initially the Shift Supervisor) of the affected plant takes immediate emergency actions (as appropriate) to protect personnel and contain the incident (Section 7.2.4, MIPP).
- The duty ECCC Operator receives the Emergency Call (Section 5, MIPP) and activates the initial call-out (Section 6, MIPP: Emergency Call-out Lists).

- RSL, SFO, one fire crew and Shift Security Officer (SSO) immediately proceed to site. The first person reaching at the incident site will call ECCC to confirm the incident without waiting for categorization.
- ECCC will activate the minor incident call-out (shift call-outs only, no activation of the SMS callout). For incidents that involve injuries, ambulance and medical personnel will also proceed to the Incident Scene
- RSL and DFO/SSO assess the situation, categorize the incident and inform ECCC advising the type and category of the incident. The RSL then takes on the role of Incident Controller (IC) and continues in this capacity until relieved of the IC role by a more appropriate staff member.
- The SFO takes on the role of Duty Fire Officer (DFO) and continues in this capacity until relieved of the role by the refinery Chief Fire Officer (CFO).
- **Note:** For incidents reported in person or through telephone/radio, the initial and minor call-out lists (shift personnel only) shall be activated simultaneously. However, no call-out of non-shift personnel (through SMS or any other means) shall be done without receiving confirmation and categorization by the RSL/IC.

Emergency notification:

- The ECCC Operator, when informed of the emergency categorization, invokes the call-out lists of personnel and services, initiates alarms as appropriate for the incident category (Section 4, MIPP), and informs the PAIECC and ECCCs of the unaffected KNPC refineries (Section 7.1.1, MIPP).
- On notification of the incident and its categorisation, the PAIECC immediately informs the KSFB, the KSF, the KCDF and the KISF. PAIECC will also inform other industries in the PAI area (and the Ports Public Authority).
- The IC, identified by a yellow and white coloured waistcoat, sets up the process FCU at a strategic location close to the Incident Scene. The FCU is identified by a blue flashing light (Sections 7.2.1, MIPP), who in coordination with the DFO, directs resources in order to contain the incident.
- The DFO, identified by a red and white waistcoat, is responsible for directing the efforts of the KNPC Fire Brigade (including attendance from the three unaffected refineries) and for coordinating any response from the KSFB, if called-in (Section 7.2.3, MIPP).
- The Operations Manager is informed of all minor incidents and is called in for all Category I-III incidents (Section 15.3.1, above). When called in, he will familiarise himself with the extent of the incident and the review the action plan with the IC. He will then assume the role of the ECM, in case it is decided to establish a MCC.
- The MCC is established by the Manager Operations for all Category II and III incidents (and for Category I incidents at the discretion of the Manager, Operations) (Section 7.5.1, MIPP).

Emergency response coordination:

- The ECM takes on the overall responsibility for the KNPC role in handling the emergency including coordinating operations in the unaffected areas of the refinery (in consultation with the IC) and interfacing with outside agencies (Section 7.5.2, MIPP).

- Shift maintenance personnel report to the FCU for allocation of duties. Assigned personnel will proceed to the Fire Water Pump House.
- All personnel alerted / called out shall respond as per their role defined in the MIPP and as directed. If called, off-duty firemen should report to the fire station.
- The RCC is set up (by the Engineering and Maintenance Manager) for Category II and III incidents (Section 7.4, MIPP).
- Casualties, if any, are first taken to the site Medical Centre for treatment and logging, and subsequently may be shifted to outside hospitals if required (Section 7.6, MIPP). The external Ambulance Service, if called-out, should report to the Medical Centre of the affected refinery for further instructions.
- The KSFB, if called-out (they will always respond with a predetermined attendance to all Category II-III incidents) should proceed to the designated holding area of the affected refinery, where the Officer in-Charge reports to the MCC (Section 8.8.2, MIPP).
- Any KSF vehicles will be directed to the designated holding area to await instructions, and a senior KSF Officer will report to the MCC (Section 8.8.4, MIPP).
- The KCDF will respond to Category II (discretionary) and Category III (compulsory) incidents by sending two senior KCDF officers to the MCC (Section 8.8.5, MIPP).

Incident close-out:

- Incident close-out is declared by the IC or ECM on advice from the DFO / /OSRT Leader/ Safety Engineer / Environment Engineer /Security. Responsibilities for follow-up action to make the area safe for entry, inspection and repairs are the assigned (Section 14, MIPP).
- Incident investigation and reporting is carried out in accordance with KNPC's Incident Investigation and Reporting Procedure.
- For a Category III Incident, where the Civil Defence alarms have been activated (possible as a precautionary measure), the decision to sound the all-clear will be taken by the ECM after consulting with local emergency services (principally the KSF and KCDF).

Notes:

- Guidelines for actions to be taken by plant personnel during gas release incidents are covered in Section 9 of MIPP.
- For an OPOI the response shall be in accordance with Section 10 of MIPP.
- Response to the emergencies at the KNPC Marine terminals will require involvement of the KOC Marine & Export Department (Section 11, MIPP).
- In the event of more than one incident taking place at any site or for emergencies of longer duration, the appropriate emergency response strategy will be decided by the ECM / IC and additional resources will be arranged as required.

- For incidents involving non-operational areas (office buildings, warehouse etc,) the RSL may decide to hand over the IC role to the CFO / Team Leader Safety & Fire as appropriate. For such areas, an Emergency Operations role is not deemed necessary. However, if decided by the incident controller, the assigned asset custodian shall be called-in.
- Personnel injury incidents are also reported to ECCC. However, in case the personnel injury incidents reported directly to Medical Centre, the Medical Centre shall dispatch the ambulance and inform the ECCC. ECCC, then activate the initial call-out list.
- Response to Security incidents shall be in accordance with Section 12.

15.4 MIPP: Gas Release Incidents

15.4.1 Overview

This section describes the actions required to be taken by site personnel in case of a gas release incident, covering the following scenarios:

- Flammable / toxic gas release within a KNPC refinery;
- Toxic gas release from sources external to KNPC refineries (neighbouring industries);
- Biological and chemical emergencies due to external threats (war emergency).

15.4.2 Initial Actions

Initial actions on discovering a flammable / toxic gas release emergency or hearing a gas alarm are as follows:

Operations personnel in the affected area:

1. The person discovering the (potential) incident shall immediately notify the incident to the central ECCC, first by breaking the glass at the fire-alarm point and then calling the ECCC Operator and providing complete relevant details, including: exact location; details of any casualties; magnitude of release; nature of gas; direction taken by any gas cloud; and advice on approach routes to be avoided (if any).

   If the person discovering the Incident cannot contact the ECCC directly, he must immediately contact his supervisor / Operations Control Room and ask them to contact the ECCC giving all relevant information.
2. All hot work (excluding furnaces) should cease immediately.
3. Operators should either report to, or radio in to the Operations Control Room (for a head-count to be conducted).
4. Barriers at plant access ways/roads where restricted access is required for safety reasons should be erected.
5. Commence taking actions to isolate the leak source (with assistance as help arrives) wearing breathing apparatus (BA) if the gas release is toxic.

6. The Emergency Operations Coordinator should detail someone to obtain the Visitors Logbook, check names and numbers at assembly areas and report any missing persons to the process FCU.
7. Start actions to control the incident – eg. cooling, gas dispersal, further isolation of leak, plant shutdown as required.

KNPC maintenance personnel in the area:

1. Should stop all hot work immediately and ensure that all equipment is left in a safe condition.
2. Should evacuate the area, and assemble at an upwind location (and remain there unless instructed otherwise by the IC). Subsequently, they may be requested by the IC to assist either the operations personnel or the Fire Section.

Contractors / visitors in the area:

1. Should stop all hot work immediately and ensure that all equipment is left in a safe condition.
2. Should leave the plant, and assemble at an upwind location (noting any wind-socks or drifting steam for general wind direction).
3. Should remain at the assembly area until checked off, and then go to normal offices, site offices, or remain at the area, as instructed.
4. Should not re-enter the area or restart work until positively informed by the Senior Safety Engineer that it is safe to do so.

Personnel at adjacent areas:

1. KNPC operating personnel should either report to, or radio in to, their operations Control Room and obtain information on the incident.
2. If downwind of the affected plant, prepare to establish protective water curtains as instructed – eg. at furnaces - and activate as necessary.
3. Sound the plant siren if instructed by either the ECCC Operator or unit supervisor.
4. If upwind of the affected plant, dispatch specialist operators to the FCU to assist the operation crew of the affected plant or area (Section 7. 3 5, MIPP).
5. Contractors / visitors in the area should be ready to respond to their plant alarm in the normal way (Section 9.2, MIPP).

Personnel passing-by or approaching the affected area:

1. Should vacate the area by a safe route unless trained to assist or have a defined role (all such personnel should report to the process FCU).
2. Should never drive a vehicle through a gas cloud (if in a flammable gas cloud, they should pull over to the side of the road immediately, switch off the engine and rapidly abandon the vehicle).
3. Should follow the directions of KNPC Security Officers or other designated KNPC personnel at traffic control points

Response by Doctor / ambulance crew:

1. When responding to an incident, the doctor / ambulance crew must ensure that they are not putting themselves at risk by entering a hazardous area as a result of a release of flammable or toxic gas.
2. They should always follow the directions of the ECCC Operator and Security on directions of approach and route to take.
3. When going to the assistance of casualties in a gas release situation, they must be suitably clothed and wearing positive pressure BA in which they have received adequate training, and must also be supported by firemen or other persons competent in the use of BA.

15.4.3 Toxic Gas Releases

Within a KNPC Refinery

The gases of principal concern are mainly hydrogen sulphide (H_2S) and sulphur dioxide (SO_2): Material Safety Data Sheets (MSDS) detail their hazard data and other relevant information.

Actions in the event within a KNPC refinery of a toxic gas release should be as follows:

1. The MIPP will be invoked immediately.
2. Detailed instructions (set out in MIPP Section 9) should be followed closely.
3. At all times, positive pressure BA must be used when: combating fires or gas leaks that contain toxic gases; or entering a toxic gas contaminated area to rescue or search for personnel or to shut down plant.
4. When briefing emergency services, on initial arrival at the site, the key words "breathing apparatus must be used" must be included.

From Neighboring Industries

H_2S and SO_2 releases from any one of KNPC's refineries might affect other refineries or adjacent facilities. Actions in the event of an external toxic gas release should include:

1. The MIPP shall be activated immediately.
2. Personnel on the Initial Call-Out List will initially respond as if the incident source is located within the affected KNPC area.
3. Once it is established that the source is external to the refinery, the incident should be categorised in the normal way based on the threat posed to KNPC personnel and property by the resultant toxic gas cloud.
4. The PAIECC shall be informed immediately (as per normal MIPP procedures).
5. Detailed instructions set out in Section 9 of the MIPP should be followed, although it obviously will not be possible for KNPC personnel to isolate the emission source. It may however, still be possible to limit the impact of the

toxic cloud on the KNPC site by using water sprays to disperse the toxic cloud.

6. Continuous liaison shall be established with the source-site as well as the PAIECC. Gas-testing shall be carried out by the affected and source sites. It is important that the IC receives regular status reports on the extent and progress of the incident in order for him to make a considered assessment concerning the extent of shut down / evacuation of KNPC property and personnel required.
7. The 'all-clear' signal should not be given until an equivalent 'all clear' and confirmation of termination of the incident at the source-site is received (via the PAIECC), or gas tests show that the KNPC site is cleared of toxic gas and the atmosphere is safe for a return to work.

15.4.4 Biological & Chemical Emergencies due to External Threat (War Emergency)

In the unlikely event of a national emergency such as a threat of war, or sabotage due to terrorist activities, there are possibilities of chemical and / or biological emergencies affecting personnel at KNPC facilities.

Notification of a threat: The appropriate government agencies will carry out the severity assessment at the national level and make the necessary notification on:

- type of attack (biological / chemical);
- severity / extent of contamination;
- do's and don'ts.

Warning of an imminent threat will be provided by the Civil Defence authorities who will activate civil defence sirens, as appropriate.

15.4.5 Activation of Emergency Plans:

Upon notification by the relevant government authorities, KPC shall activate the Extreme Emergency Plan for Oil Sector and a KPC Crisis Management Centre (KPC-CMC) shall be established.

Upon receiving instructions from KPC-CMC, the KNPC Chairman and Managing Director will issue necessary instructions to the KNPC Executive Assistant Managing Directors (SHU) who will in turn inform the HSE Manager on the decision to establish the KPPC-CMC.

ECCC-MAA will make call-outs for KNPC-CMC. MCCs shall be established at all refineries. Respective ECCCs will make the call-out as instructed by the HSE Manager.

15.5 MIPP: Oil Spill Incidents

15.5.1 Overview

An emergency response to an oil-spill incident will initially be the same as for potential fire incidents (as described in Section 4, MIPP). Subsequently, when the fire hazard is eliminated, oil spill containment and recovery actions shall be initiated. KNPC's Oil Spill Response strategy has been developed in line with the KPC Oil Spill Contingency Plan. Oil spill incidents are categorized according to the quantity of the spill, as follows:

- ***Minor spills*** (less than 1 barrel);
- ***Tier I spills*** (less than 10 tonnes);
- ***Tier II spills*** (10-600 tonnes);
- ***Tier III spills*** (more than 600 tonnes).

According to KPC's K-Companies Operational Plan for Oil Spill response, KNPC's responsibilities in the event of an oil-spill incident are as follows:

- All oil-spill incidents (except the 'minor' category) shall be reported to KPC within 24 hours;
- The facility-owner (KNPC) is responsible for the containment, recovery and disposal of any marine and land oil spills originating from the facility;
- The facility-owner (KNPC) will maintain adequate oil spill response resources for the containment, recovery and disposal of any oil spill up to Tier-II level (up to 600 tonnes);
- For Tier III spills (exceeding 600 tonnes) and if necessary for Tier II spills, KNPC shall inform the KPC-Emergency and Pollution Control Coordination Centre (EPCCC) who will activate the KPC Incident Management Team (KPC-IMT) for coordinating the additional support, as required;
- KNPC may be required to respond and provide support for Tier III oil spills in other 'K' Company facilities (and nearby beaches).

15.5.2 Land Oil Spills

Resources

For land oil spills, each KNPC refinery must maintain adequate resources (manpower, equipment and materials) for handling oil spills up to Tier I. For Tier II oil spills, resources from KNPC's three refineries will be pooled. MAA Refinery shall also provide assistance to Local Marketing in handling oils spills at depots, filling stations and road tankers. These resources will include:

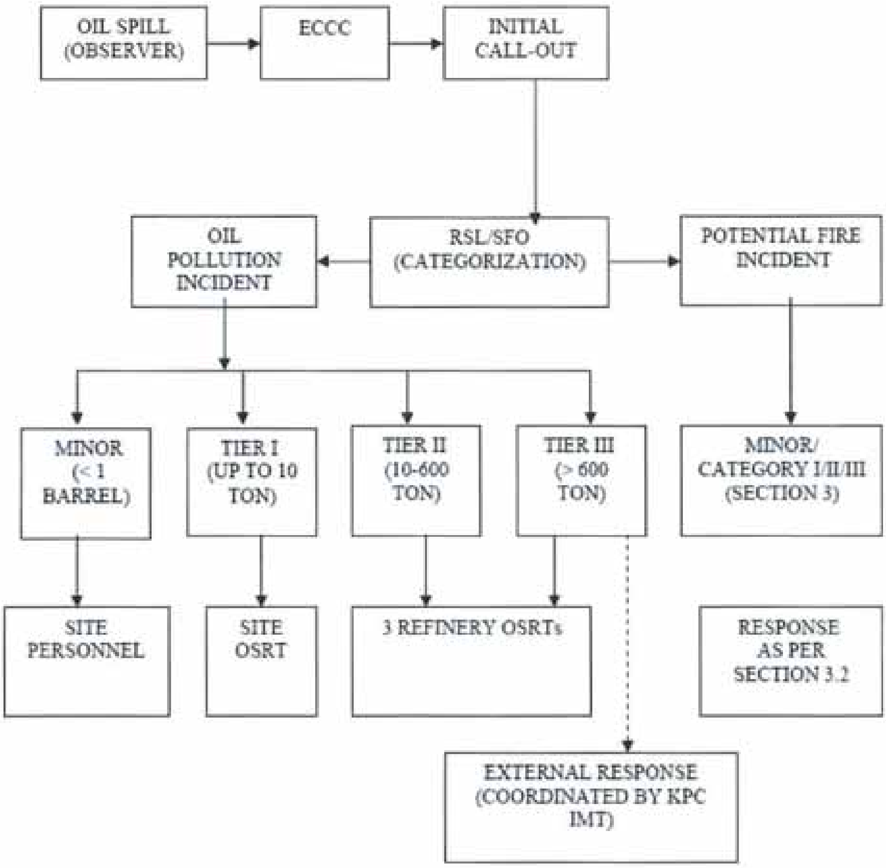
- Oil Spill Response Team:
- Oil Spill Response Vehicle
- Oil Spill Response Equipment

Incident Categorization

All oil spill incidents are potential fire incidents and shall be initially categorized accordingly (as per Section 4, MIPP) and the appropriate call-out lists will be activated. In case there is no fire and it is decided to initiate the oil spill response, the incident will be additionally categorized according to the estimated approximate oil spill quantity (Section 10.1, MIPP).

Response to Minor Oil Spills
A minor oil spill shall be handled by the plant / installation personnel responding to the incident, using the equipment and resources that are readily available to them. The on-call Environment Engineer will advise the site teams on actions to be taken for handling the spill. Figure 15C below shows a flow chart highlighting the procedures in the event of a land oil spill incident.

Figure 15C Land oil spill incident response flow chart



Response to Tier-I Oil Spills:
A Tier I oil spill will require an organized application of specialized resources manpower and equipment. A Tier-I land spill incident can still be dealt with effectively by KNPC resources by the Oil Spill Response Team (OSRT). Upon notification of the 'Tier I Oil Spill' incident by the IC, the refinery ECCC Operator will activate the OSRT Call-out list in addition to the MIPP Category I Incident Call-Out List for land spills. KPC-EPCCC shall be informed. An OSRV will be mobilized and located at a

strategic location close to the incident site. The OSRT will initiate containment action under the guidance of the IC.

Oil Spill Response Team Leader (identified by a green waistcoat) will coordinate the necessary containment and clean-up operations in coordination with the IC and Environment personnel. For a spill incident expected to last more than 8 hours, he may adopt the additional role of IC provided there are no fire, explosion or chemical / gaseous pollution hazards. A RCC and MCC may be activated, if considered necessary by the IC, especially for Tier I spill incidents expected to last more than 8 hours.

Response to Tier-II Oil Spills:
Tier II land spill incidents will need resources and support from the other unaffected KNPC refineries. Upon receiving information regarding an incident and its categorization, the ECCC will inform the ECCCs of the unaffected refineries to activate the OSRT call-out lists and dispatch the OSRVs, activate the MIPP Category II incident call-out list, and inform KPC-EPCCC.

The OSRVs and OSRT members from unaffected refineries will report to the site OSRT Leader at the Incident Scene and provide support as necessary. Support from other K-companies may be requested through KPC-IMT, if required, for large / or longer duration Tier-II oil spills.

Response to Tier-III Oil Spills:
Handling a Tier-III incident will require large resources, more organized effort and expertise. KPC-IMT shall coordinate the response from other K-companies and national, regional and international agencies, if required, to optimally coordinate the necessary response operations.

Termination of Incident:
The termination of an incident is declared by the IC or ECM on advice from the OSRT Leader. Environment personnel will advise on further clean-up and waste disposal.

15.5.3 Marine Oil Spills

Overview

Adequate oil spill response resources shall be maintained at marine terminals to handle spills on the deck areas. Oil spills in sea shall be handled by KOC Marine & Export Division under a special agreement with KNPC.

Emergency Response

Response to incidents involving the KNPC's marine terminals will be in accordance with Section 11 of the MIPP.

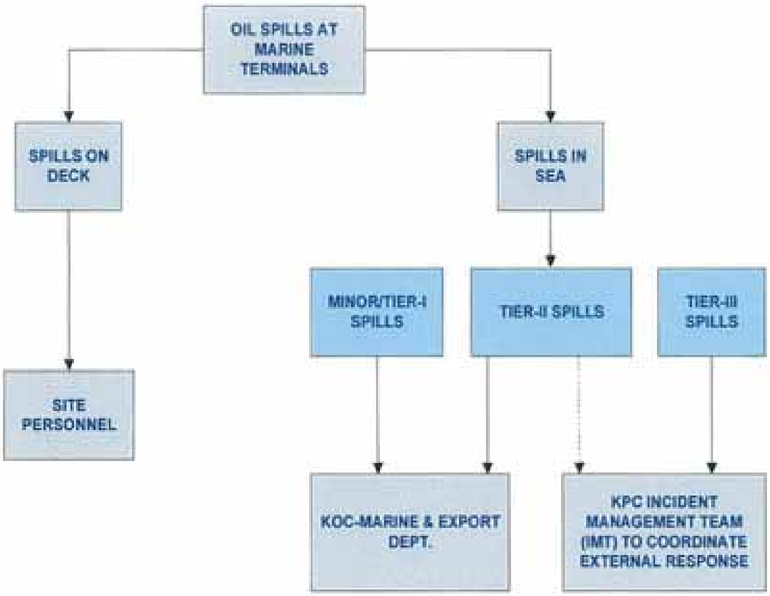
For oil spills limited to deck areas only, the Shift Supervisor will coordinate the appropriate oil spill response, using site personnel and oil spill response material available at the site.

In case of marine spills, the Shift Supervisor will inform the Duty Pilot / Harbour Master who will coordinate mobilization of KOC Marine & Export Department resources to begin carrying out spill combating operations.

For Tier-III oil spills (and if required for Tier II), KPC-IMT will coordinate the response from other K-companies and national, regional and international agencies, as deemed necessary.

If necessary, KPC-IMT will request K-EPA to activate the National Oil Spill Contingency Plan (NOSCP) depending upon the situation.

Figure 15D Marine oil spill incident response flow-chart



Marine Oils Spills (Shallow Water) and Shore Line Clean-up:

Handling of oil spills in shallow waters along shoreline shall be carried out jointly by KOC Export & Marine Operations Group and KNPC Land OSRT.

In the event that shoreline/beach is contaminated by oil due to an activity or spillage from KNPC facilities, KNPC is responsible for taking appropriate action to contain and clean the area (even if the area does not belong to KNPC). These will be handled in accordance to land spill incidents.

15.5.4 Roles and responsibilities:

Oil Spill Response Leader (Team Leader - Workshops & General Works):

Main functions:	**Emergency communications:**
• Ensures that required inventory of the identified oil spill equipment and material is maintained and consumables are replenished (for refinery and oil pier). • Ensures that OSRT members are identified and trained and ECCC has updated call-out list of the OSRT members. • Takes overall responsibilities for oil spill containment and recovery activities at the incident site for land oil spill incidents. Additionally, he may take over as Incident Controller (for oil spill only incidents).	• Telephone, pager • Radio – Red channel
When first called: • Called for all Tier I, II, III land oil spills	**Location / identification:** • Wears green waistcoat 'OSRT Leader' • Operates normally from OSRV

Sr. Engineer / Engineer (Workshops & General Works):

Main Function:	**Emergency communications:**
• Assists OSRT Leader for containment, recovery and storage of the spill materials and disposal of waste.	• Telephone, pager • Radio - Green channel (maintenance)
When first called: • Called out for oil spill incidents Tier I, II, III	**Location / identification:** • Operates normally from OSRV.

Supervisor – Heavy Equipment:

Main function:	**Emergency communications:**
• Maintains OSRV and oil spill response equipment and materials, and mobilizes them when required during oil spill incidents.	• Telephone, pager
When first Called: • As an OSRT member, called out for all Tier I, II, III oil spill incidents	**Location / identification:** • Operates normally from OSRV.

Contractor Supervisor / Foreman:

Main functions:	**Emergency communications:**
• Responsible for mobilizing contractor manpower, equipment and materials identified for oil response.	• Telephone; Pager
When first called: • As an OSRT member, called out for all Tier I, II, III oil spill incidents	**Identification / location:** • Operates normally from OSRV.

15.5.5 KPC-IMT:

KPC IMT comprises of representatives from KPC and its subsidiaries as follows:
- IMT chairman: KPC EAMD (Health, Safety & Environment)
- IMT coordinator
- IMT members representing various K-companies

The Manager, Safety Health & Environment is the IMT Member representing KNPC.

The main function of KPC-IMT is to coordinate with KPC subsidiaries and regional and international agencies, to organise the provision of support in handling major oil spills. KPC-IMT is called by ECCC for oil spill incidents (Tier I, II, and III).

15.6 MIPP: Security Incidents

MIPP will be activated in the case of any credible security incident/threat as listed in section 15.2.2 of this report.

15.6.1 Notification and Initial Action

Actions in the event of a security incident within a KNPC refinery should be as follows:

1. Person finding any suspicious package/device, observing any security breach or receiving security threat information (through telephone, fax, media or any other means) shall immediately notify the incident to ECCC.
2. ECCC shall immediately invoke the initial call-out.
3. Shift Security Officer will proceed to the incident site and assess the situation and decide the action plan.
4. ECCC will be informed of the situation and call-out requirements.

Any security breach observed by the security personnel during the normal security checks/patrols shall be informed to the Shift Security Officer who will decide on the action plan and inform ECCC about the incident and the call-out requirements.

15.6.2 Call Outs and Response

In the case of a confirmed security threat/incident, the ECCC will evoke the Security Incident call-out list shall include:

- Chief Security Officer
- Team Leader Security
- Manager Safety Health & Environment
- DMD (affected refinery & SHU)
- Manager CCD.

Requirement of calling-in of external agencies shall be decided by the Team Leader Security (and Port Facility Security Officer, if involved). This may include but will not be limited to the State Installation Security Force and/or the National Coast Guard. The decision to activate site MCC and or CMC shall be taken by the DMD and MSH&E depending on the requirement.

Security threats or incidents affecting KNPC facilities shall be handled in accordance with the 'Response to Threats' and 'Contingency Plan' sections of the KNPC Security Manual.

15.6.3 Emergency Actions in case of a Security Incident

Process Units: The strategy of operating facilities shall be decided based on the assessment of the potential damage of the security threat/incident. The strategy may include:

- Evacuation, all non-essential personnel from the affected area
- Reduction of unit capacity and preparation for shutdown.
- Total shut down
- Total evacuation.

Marine Terminals: In case of a security incident loading shall be suspended immediately. Depending on the situation the PFSO shall initiate the appropriate action as per the guidelines laid out in the ISPS Code.

Security will block the roads around the affected area. All gates shall be strictly monitored. No entry shall be allowed except for the emergency teams. Identity and time of any person leaving the facility shall be recorded. Refinery fire crews, medical and rescue teams will remain on alert (in a safe area) ready to respond when called.

15.7 Evacuation

15.7.1 Overview

There are emergency situations which may require the evacuation of personnel to safer locations, in order to avoid the risk of injury or loss of life, for example:

- Explosion
- Release of toxic gas
- Release of flammable material having potential to cause fire
- Fire
- Nuclear, Biological or Chemical (NBC) attack
- Bomb threat, sabotage, air raid or other hostile act

A comprehensive and well rehearsed Evacuation Plan is necessary to ensure correct decisions and actions are taken when needed. The MIPP provides guidelines regarding actions to be taken while evacuating personnel in case of an emergency at KNPC site (see MIPP, Section 13). These guidelines will be further supplemented by the SEEPs of the respective sites.

The roles and responsibilities of those involved in the Evacuation Plan are discussed in Section 13.5 of the MIPP. Evacuation procedures are discussed in Section 13.6.

15.7.2 Key Parameters of the Site Evacuation Plan

Leaders and Custodians

- Zone leaders (MAA only): Senior person (Team Leader level) appointed as Evacuation Zone Leader for each of the 6 Zones at MAA.
- Asset Custodians: Assigned for all buildings in three refineries.
- Group leaders: Each zone / building is divided into groups, led by an Evacuation Group Leader who ensures safe and orderly evacuation.

Evacuation Maps and Signs

- Overall Site Evacuation maps showing important points shall be displayed. Evacuation Guidelines shall be written on the maps.
- Floor Plans showing location of emergency exits, paths, evacuation routes, local transfer point and evacuation instructions shall be displayed at strategic locations.
- Illuminated Exit Signs shall be provided at each floor.

Gathering Points

- A designated safe area inside/outside site fence shall be identified, as a gathering point for personnel when a site evacuation is announced.
- Alternate gathering points(s), to be used in case one Gathering point can not be used for safety reasons, shall also be identified.
- Gathering area shall be of sufficient size to accommodate personnel.
- It shall be divided into zones and shall have facilities such as drinking water and first aid. Proper instruction and marking shall be provided for guidance.
- Safety Engineers shall act as Gathering Point Coordinator.

Transfer Points

- Suitable areas adjacent to individual process units, building or group of buildings, shall be identified to be utilized as transfer points, for further transportation to main gathering points.

Evacuation Shelters

- Certain buildings shall be identified at each site to be used as evacuation shelters for the essential personnel.
- Buildings should be air-tight and provided with hazardous gas filters and air-tight dampers in their air intakes.
- Buildings shall be equipped with adequate personal protective equipment, gas masks, drinking water, first-aid facilities. (Also refer Clause 9.5.9 of MIPP)

Transportation

- Shuttle buses and other company provided vehicles, not required to attend the emergency, shall be used for transporting personnel from transfer points to gathering points.
- Contractors shall make their vehicles available.

- Available transport facilities are used to maximum benefit to transport personnel from transfer points to designated gathering points.

15.7.3 Head Count

Accurate head counts require advanced access/exit control systems which cover all employees, contractors and visitors. It should be possible to get a report indicating the number of personnel present on site at any time.

Existing access control systems at the KNPC Refineries need to be upgraded and extended to gathering points. In the interim, the following practice for head count to be used in process areas:

- For the operations on the assigned field duty in that particular unit, the information from the existing attendance procedure can be used for head count when required
- For the maintenance / contractor work groups present in the unit to execute a job with valid work permit, the work permit executer shall keep a record of personnel assigned for the job.
- All other personnel visiting the area shall inform the operations supervisor while entering / leaving the unit.

Head counts at the gathering points shall be carried out manually by the respective group leaders:

- Group Leaders shall maintain updated lists of personnel working within their point of responsibility.
- Visitors shall always follow their KNPC representative.
- Personnel entering the site outside their scheduled hours of work shall make their presence known to the Shift Security Officer.
- On reaching the Gathering Point, all personnel shall report to their respective group leaders. Group leaders will count personnel and compare with their personnel list and hand over the same to the respective Zone Leader.
- Zone Leaders will compile the head count data for their respective zones and hand over the same to the Gathering Point Coordinator.
- The Gathering Point Coordinator will compile the overall head count data and forward the same to the IC/ECM

15.8 Summary

KNPC's MIPP, the principal features of which have been described above, will be implemented for the CFP. This ensures that KNPC will apply a unified and collective approach to responding to emergencies at all its refineries and other associated facilities (e.g. oil terminals).

16.0 Decommissioning and Closure Management Plan

16.1 Introduction

Decommissioning is defined as the shutdown of a facility in order to prepare it for complete closure, clean-up and site reinstatement. At the cessation of CFP operation in approximately 30 years time, the CFP will be decommissioned in accordance with statutory requirements in force at the time. In advance of decommissioning, a 'Decommissioning and Closure Management Plan' (DCMP) will be developed by KNPC. The DCMP will be compiled at a time closer to decommissioning to ensure that all the relevant environmental risks are properly managed.

The decommissioning and closure of the CFP site will be a complex process, especially ensuring that the site is rehabilitated to K-EPA's requirements, thus allowing the sites to either be handed back to government control, or be sold for another private sector use.

It should be noted that the CFP scope of work does not include the retirement or decommissioning of SHU, which is expected to be retired by KNPC when the CFP units are commissioned. The environmental impacts associated with decommissioning of SHU will need to be addressed in a separate decommissioning report by KNPC. SHU units that remain in use during the CFP will be included in the CFP DCMP.

The extent of dismantling, demolition and site clearance will depend upon the future use of the site. There are likely to be three project stages to the CFP decommissioning phase:

- *pre-decommissioning* consents and contracts: covering the site and structures, plant and processes, municipal and site utilities, fire safety, access and transport, and demolition of buildings etc;
- *decommissioning* activity obligations: environmental emissions (e.g. effluent discharges, air pollution, noise and dust generation, waste disposal, ground / groundwater contamination etc), and associated health and safety issues;
- *post-decommissioning* responsibilities: these are to ensure that everything that needs to be known about a decommissioned site (or plant) is passed on to the new site owners, operators or organizations.

This Chapter provides an overview of the basics involved in establishing a DCMP. It also discusses the various environmental aspects which will typically be addressed in a DCMP.

16.2 Decommissioning and Closure Management Plan

16.2.1 Objectives

The specific environmental-related objectives of the DCMP are:

- to meet all pertinent Kuwaiti legal and regulatory requirements, and complete the site clean-up and reinstatement in accordance with applicable K-EPA criteria;
- to protect the public health and safety of local people, and the surrounding environment;
- to ensure that all residual environmental and social impacts are acceptable;
- to ensure that the need for long-term site maintenance is removed as much as possible;
- to ensure that post-reinstatement land-use is in accordance with state (and other key stakeholder) requirements;
- to mitigate and minimise any long-term environmental-related liabilities.

16.2.2 Scope

In accordance with EIA legislative and policy requirements at the time of CFP shutdown (i.e. in approximately 30 years time), KNPC, in consultation with K-EPA, will prepare a conceptual DCMP that addresses the following:

- suitable post-closure land end-uses and decommissioning and closure objectives;
- specific completion criteria for rehabilitated areas, and various closure concept options;
- suitable clean-up and reinstatement prescriptions for all aspects of decommissioning and closure (international best practice requires 3rd-party verification);
- provision of decommissioning and closure monitoring programmes;
- conducting appropriate stakeholder consultation with appropriate parties (e.g. KNPC internally, K-EPA, local communities).

In addition, it should be noted that underground and subsea facilities which go beyond the fence line of the refinery may exist (e.g. pipelines and piers). These will have to be identified accordingly during the decommissioning process. KNPC will need to evaluate whether such facilities can be safely abandoned in place or if they must be removed and disposed of elsewhere.

16.2.3 Roles and responsibilities

Decommissioning and closure management of the CFP, in terms of establishing a conceptual plan, may involve several KNPC internal departments, together with K-EPA plus some local stakeholder engagement.

In terms of the various roles involved in a large decommissioning project such as the CFP, it is likely that the following would be involved:

- KNPC's project management specialists;
- a QA manager;
- Health, Safety, and Environmental (HSE) staff;
- competent decommissioning experts (probably via an external contractor);
- specific technical experts (e.g. waste management etc);
- former CFP operations specialists;
- regulatory authorities.

16.2.4 Environmental Management Liaison group

The DCMP will include some form of decommissioning and environmental management liaison group, to set out the guiding principles to achieve the proposed end-use of the CFP site area. These guiding principles are likely to include the following:

- environmental issues: ensuring that through conducting a full risk assessment and appropriate mapping, characterization and remediation that no pollution, health or safety hazard is posed to areas outside an agreed attenuation zone;
- landform: ensuring that the site is sufficiently and appropriately cleaned up in accordance with its future planned end-use;
- water resources protection: ensuring that there is no diminution of groundwater resources beyond an agreed attenuation zone;
- liability mitigation: ensuring that any long-term residual environmental liabilities pose minimal financial liabilities on the government (e.g. in terms of ongoing site management costs having to be borne by K-EPA or other agencies).

These guiding principles will be applied to the CFP, together with any decommissioning residue areas (e.g. demolition rubble).

16.2.5 Contents

A DCMP is typically structured as follows:

- Introduction (including project description, operating history and current project operations)
- Objectives of decommissioning and closure
- Decommissioning activities and schedule
- Mitigation Measures
- Waste Management
- Environmental Monitoring
- Co-ordination Mechanisms (including roles and responsibilities)

16.3 Environmental Aspects

This section discusses the key environmental aspects that are likely to be associated with decommissioning, clean-up and site reinstatement at the CFP.

16.3.1 Noise and vibration

During decommissioning activities, noise and vibrations may be caused by the operation and transport of heavy moving and excavation equipment. Noise reduction and control strategies such as temporary noise barriers may have to be used.

16.3.2 Air quality

Decommissioning activities will generate emission of fugitive dust caused by a combination of on-site excavation and movement of earth materials, contact of construction machinery with bare soil and exposure of spoil piles to wind. A secondary source of emissions may include exhaust from diesel engines of earth moving equipment as well as from open burning of solid waste on-site. Techniques to consider for the reduction and control of air emissions from decommissioning activities include dust suppression techniques as well as avoiding open burning of solids on site.

16.3.3 Waste

The shutdown and decontamination of processes will result in the collection of residual wastes in columns, decanters, reaction vessels, storage tanks, sewers etc. The safe treatment and disposal of these wastes will be necessary so that the plant and equipment is left in a fully-decontaminated condition. Non-hazardous waste generated from decommissioning activities will include excess fill materials, scrap wood and metals and small concrete spills. Wherever possible the following waste hierarchy should be observed; reduce, reuse, recycle and dispose.

16.3.4 Soil / groundwater contamination

As a result of both operational and post-operational activities, there is potential for release of petroleum based products such a lubricants and hydraulic fuels during storage, use and transfer of the products. Soil samples may have to be taken in areas of concern to determine the extent of contamination and proper remedial measures implemented depending on the level and location of contamination and the intended post-decommissioning land use.

16.3.5 Miscellaneous

Other potential environmental aspects will include increased traffic from decommissioning activities and impacts to landscape and visual amenities. These should be discussed in detail in the DCMP and should include appropriate mitigation measures.

16.4 Conclusions

KNPC will develop a full conceptual DCMP for the CFP when required prior to decommissioning of the CFP in approximately 30 years time. This will ensure that the DCMP is in accordance with contemporary legislation. The DCMP will address all the project stages that CFP decommissioning will go through which are likely to be: pre-decommissioning consents and contracts; decommissioning activity obligations; and post-decommissioning responsibilities. This will send a robust signal that post-closure, the CFP will be optimally decommissioned, prior to handover back to the state or private use.

Specific environmental-related decommissioning and closure objectives associated with the CFP are predicated around meeting all Kuwaiti legal and regulatory requirements (including K-EPA criteria), and mitigating any impacts (environmental, public health, safety, social) within the impact vicinity of the site.

The final goal of the CFP decommissioning will be to ensure that any requirements for post-closure site maintenance are removed as much as possible, and that any long-term environmental-related liabilities are mitigated.

16.5 Recommendations

KNPC will develop a CFP DCMP in accordance with the specifications discussed in this chapter as well as any guidelines or requirements established by the regulatory authorities of Kuwait. The DCMP will be developed at a suitable time near the end of the operational life of the CFP facilities.

The following should be taken into consideration at the time of the DCMP development::

- Dialogue with K-EPA to determine what specific site rehabilitation requirements are likely to be;
- Ensuring that the final DCMP for the CFP is subjected to appropriate stakeholder review; and,
- Replicating or adapting similar DCMP approaches from KNPC's other refineries including a review of lessons learned.

17.0 Environment Management System (EMS)

17.1 Introduction

KNPC has developed and implemented a company wide Environmental Management System (EMS) in line with the requirements of the ISO14001:2004 Standard – Apex Manual for Environmental Management System (SHE-ESHU-04-1401). Since the CFP is within KNPC refinery boundaries, this EMS will also apply to the CFP, ensuring a structured approach to the management of environmental issues existing at the CFP.

The implementation of the EMS will commence during the initial stages of construction and develop as the CFP project becomes fully operational.

17.2 EMS during Construction

The CFP will have ten EPC contractors: three EPC Contractors at MAA, five EPC Contractors at MAB, one EPC Contractor for SHU and an EPC buildings Contractor. There will be three other major contracts: a high voltage contract and two early works contractors (one in MAA and one in MAB). The buildings and high voltage contractors will have activity in both MAA & MAB.

Each of these EPC contractors will be required to have an approved Environmental Management Plan (EMP) in place, covering their own operations. The EPC contractors will also need to implement the following measures identified in this EIS:

- Waste Management Plan;
- Dust Management Plan;
- Solid Waste Management Procedure;
- Wastewater Management Procedure;
- KNPC HSE Guidelines for Contractors (SHE-TSSA-05-1118).

At the start of the Construction Phase, a Centralized Waste Management Contractor will be identified who will be responsible for coordinating the waste disposal activities of all CFP EPC contractors. Each EPC contractor will develop an Environmental Procedures Manual that details all procedures needed to comply with KNPC environmental procedures as well as K-EPA regulatory requirements.

17.3 EMS: during Operational Phase

The following sections provide an overview of KNPC's approach to implementing an EMS. They have been abstracted from the KNPC Apex Manual for Environmental Management System which describes how KNPC's EMS is currently implemented across refineries and associated facilities.

The purpose of the Apex Manual is to describe KNPC's current EMS and to provide a reference source on implementation, maintenance and continual improvement of the system at KNPC. The Apex Manual also assigns environmental responsibilities, as required by the International Environmental Standard ISO-14001:2004 and KNPC's Safety, Health & Environment Management System (SHEMS). The EMS

Management Representative (EMR) is responsible for updating the Apex Manual in accordance with the SHEMS documentation system.

17.3.1 EMS Requirements

The following sub-sections provide some guidance on the principal KNPC EMS requirements which will be implemented at the CFP.

17.3.1.1 General Requirements:

KNPC has established an EMS in line with ISO 14001:2004 and is committed to maintaining and improving it on a continual basis. Specific requirements within the EMS are described in subsequent sections of the Apex Manual.

17.3.1.2 Environmental (SH&E) Policy

KNPC's Environmental (SH&E) Policy has been defined by the Chairman and Managing Director (C&MD) to provide a framework for establishing KNPC's overall environmental objectives and targets. The policy covers all key aspects of KNPC's operations and associated services, is displayed at various strategic locations and is also available on KNPC's intranet, and externally to the public on KNPC's website. The policy also acts as a supplement to tender documents to make KNPC's contractors and suppliers aware of it. Contractors are also advised to ensure that their personnel working for KNPC are aware of KNPC's SH&E Policy.

17.3.1.3 Planning

Environmental aspects

KNPC has established a procedure for identifying the environmental aspects of its activities, products and services that are under its control or can be influenced. Accordingly, aspects are identified and evaluated for significance by respective departments / divisions. A list of significant aspects along with the identified controls is forwarded to the EMR for review and to be recorded. New aspects are also identified prior to execution of new projects or modification / expansion of existing projects as per KNPC's Procedure on Environmental Impact Assessment (SHE-ESHU-03-1407).

Legal and other requirements

Legal and other requirements applicable to the environmental aspects of KNPC's activities, products and related services are identified through considering applicable national and international environmental regulations, and other environmental requirements mentioned in the standards / practices being followed by KNPC. These requirements are listed in KNPC's 'Environmental Legislative Register'.

Regular direct contact is established with K-EPA for updates on any amendments or new regulations on the environment. New information on environmental regulations is also received from KPC. All such amended laws / regulations are studied by KNPC's Environment Division with the relevant regulations being updated in KNPC's Environmental Legislative Register.

The Register is reviewed and updated, if required, once a year or as necessary according to amendments / inclusions to existing applicable regulations. The Register is distributed to all concerned for reference and compliance and can be accessed on the KNPC intranet. Each EPC contractor will have their own Aspect Register.

Objectives, targets and programmes

KNPC has developed environmental objectives based on its significant environmental aspects, SH&E Policy, legal and other requirements, technology options, operational requirements, business requirements, financial resources and views of interested parties. To achieve the above objectives within a specified time frame, environmental targets are set. The targets are applicable either across KNPC as a whole, or to individual departments / divisions. To achieve the objectives and targets, environmental management programmes are established, with responsibilities and action plans at the company, department / division and group levels as appropriate. These programmes are reviewed to keep track of progress towards meeting objectives and targets. Progress on these various programmes is discussed in Management Reviews. Each EPC Contractor will have their own specific environmental objectives, targets and programmes.

17.3.1.4 Implementation and Operation

The roles, responsibilities and authorities of relevant personnel for effective environmental management at KNPC are outlined below:

The C&MD is responsible for:

- appointing the EMS EMR;
- framing the SH&E Policy;
- ensuring the establishment, implementation, maintenance and improvement of the EMS by providing adequate resources.

The EMR is responsible and authorized to:

- establish, implement, maintain and improve the EMS across KNPC;
- appraise top management on EMS performance and action plans for improvement;
- ensure that internal audits are carried out as per the schedule;
- ensure sufficient resources are made available for implementation and maintenance of the EMS.
- communicate with K-EPA and other government bodies on environmental / legal issues.

Project Managers / DMDs / Manager – LM are responsible for the following activities relating to their sites:

- implementing and maintaining the EMS at their sites;
- carrying out all activities in compliance with legal requirements;

- ensuring sufficient resources are made available for implementation and maintenance of the EMS.

Department Managers are responsible for the following relating to their department:

- identifying the training needs for all employees with respect to the EMS, and ensuring appropriate training is implemented;
- identifying aspects and ensuring that significant aspects are appropriately controlled;
- ensuring that all environmental incidents are reported;
- ensuring that resources are available to meet the objectives and targets;
- ensuring that a Document Control System is followed for all EMS documents;
- ensuring that non-conformances are resolved to ensure compliance.

Team Leaders are responsible for the following, relating to their divisions:

- identifying training needs for all employees with respect to the EMS, and ensuring appropriate training is implemented;
- aspects are identified and the Aspects Register is maintained and up to date;
- effective controls are in place for significant aspects;
- programmes to achieve objectives and targets are prepared and implemented;
- objectives and targets are met;
- a Document Control System is followed;
- all key characteristics are identified and monitored;
- all environmental incidents are reported;
- environmental records are maintained;
- all non-conformances are resolved, to ensure compliance.

Senior Engineer / Senior Chemist / Section Head / Lead Engineer / Lead Chemist / Engineer / Chemists are responsible for the following, relating to their sections:

- identifying training needs for all employees with respect to the EMS and facilitating / arranging their training as appropriate;
- identification and updating the Aspects Register;
- identifying effective controls for significant aspects;
- identifying all key characteristics / parameters associated with the significant aspects;
- monitoring all the key characteristics / parameters;
- preparing programmes for objectives and targets;
- meeting objectives and targets;
- following the required Document Control System for EMS documents;
- reporting all environmental incidents, and maintaining environmental records;
- resolving any non-conformances, to ensure compliance (through taking appropriate corrective and preventive actions for any non-conformances).

Supervisors, in their respective sections, are responsible for the following:

- assisting in the identification of training needs for subordinates with respect to the EMS, and facilitating / arranging their training;
- adhering to the work instructions / procedures;
- keeping abreast with significant aspects associated with their activities;
- being aware of controls on the significant aspects;
- being aware of Emergency Handling Procedures;
- reporting environmental incidents immediately;
- monitoring key characteristics / parameters.

Contractor Managers / Engineers, in addition to their assigned responsibilities, are responsible for the following:

- identification of training needs for subordinates with respect to the EMS requirements, and facilitating / arranging their training;
- communication of KNPC's SH&E Policy and respective significant aspects (plus associated controls) to their staff;
- communication of Emergency Handling Procedures to their staff;
- reporting environmental incidents.

For the EMS Site Team, the head of the team will report to respective Site-DMD (for three refineries) or manager (for LM&PD). The Team will assist the site in effective implementation and maintenance of the EMS complying with ISO14001:2004 requirements. In particular, the team shall ensure that:

- The latest HSE Policy is displayed at all strategic locations of the site.
- The Aspects Register is updated in the latest format, by all concerned, as stated in the Apex Manual.
- The latest copy of the Aspects Register is communicated to the EMS-MR office.
- New Objectives and Targets proposed by the site are SMART.
- The Objectives and Targets are tracked and forwarded to the EMS-MR office on a six-monthly basis or whenever requested.
- All employees / contractors are well aware of the KNPC-EMS and that records of training are maintained with the concerned division / department.
- The current KNPC document control procedure is followed by all departments / divisions of the site.
- Hard copies (green folder) of the EMS manuals / procedures are discarded
- All EMS records such as calibration records, monitoring reports, programs to manage objectives and targets, training records, non-conformities and close out reports, waste disposal records and mock drill reports are available to the concerned department/division.
- Key characteristics of activities which can have significant environmental impact are identified and monitored and records are kept by all concerned departments / divisions.

- Root cause analysis is done for all non-conformances and other audit findings and that a compliance plan is submitted to the EMS-MR Office in the prescribed format.
- The status of the previous audit findings is updated and that the status report is submitted to the EMR office on a monthly basis.
- Settlement of decisions is taken in the Management Review by the concerned department / division.

Specific Responsibilities:

Oil Spill Response Team (OSRT) Leaders and Team Leaders (in addition to their responsibilities stated above under 'Team Leaders') are responsible for the following:

- maintaining Oil Spill Response equipment in good working condition;
- establishing OSRC near the incident scene;
- coordinating with other refineries and external agencies, if required, for management of the incident;
- coordinating with OSRT members to equip OSRC with all required emergency handling equipment;
- categorizing any spillage;
- coordinating clean-up activities;
- briefing top management about the incident;
- coordinating with process for storage and reuse of spilled material;
- coordinating with KNPC's Environment Division for disposal of any wastes.

Team Leader Environment (Refineries), in addition to the responsibility stated above under 'Team Leaders', is responsible for ensuring the following:

- that K-EPA and other legal requirements are complied with;
- that new projects / modifications are scrutinized for the requirement of carrying out EIA studies;
- that regular environmental monitoring is carried out;
- that environmental monitoring reports (monthly, quarterly, annual) are generated and issued to all concerned at the relevant levels;
- direct communication with K-EPA on compliance status;
- that KNPC's Legislative Register is updated;
- that environmental aspects of all sites are identified and evaluated for significance;
- that necessary EMS documents are developed and issued for compliance;
- that EMPs are in place for all environmental objectives, and for generating status reports on EMPs.
- that EMS procedures are complied with;
- that effective Oil Spill Response procedures are available;
- that external and internal environmental complaints are properly handled;
- that waste is managed in an environment-friendly manner;

- that regular environmental inspections are carried out, and advice issued;
- that environmental incidents are investigated and recommendations issued;
- that tracking recommendations are issued after incident investigation and environment inspection;
- that regular environment awareness training, and environment campaigns are organized;
- that Planned Environmental Releases are recorded;
- that data desired by shareholders and other external parties are reported / supplied.

Refinery Shift Leader (RSL) and Divisional Heads are responsible for:

- logging and reporting environmental incidents;
- assuming the role of IC for effective management of incidents;
- initial categorization of the incident, and calling-out appropriate personnel for the effective management of the incident;
- logging and coordinating internal as well as external environmental complaints;
- locating the source of the complaint within KNPC (if applicable);
- identifying the incident 'owner';
- activating the investigation team.
- communicating with management about the incident.

Competence, Training and Awareness:

Successful implementation and operation of the EMS depends on all the capabilities of those individuals performing the tasks assigned as required. It is to ensure that all personnel performing tasks which could lead to significant environmental impacts are competent on the basis of appropriate education, training and/or experience. Training needs for such personnel are identified and required training is imparted to them. This training is not only imparted to staff but also to the persons working for or on behalf of KNPC – i.e. contractors and sub-contractors, via their engineers and managers who in turn will train their staff as appropriate. Records of such training should be maintained and kept by the contractor.

Communication:

Environmental communications, internal (within KNPC) as well as external (with external interested parties) are addressed in KNPC's Environmental Communication Procedure. Besides communicating its significant aspects to associated contractors, KNPC is also committed to communicating with local communities.

Documentation:

Various environmental procedures / documents have been developed and must be complied with for effective implementation of the EMS across KNPC's operations. Related documents include:

- ISO-14001:2004 standard;
- KNPC's SH&E Policy, and environmental objectives and targets
- Apex Manual for EMS (ISO 14001) (SHE-ESHU-04-1401).
- KNPC's Environmental Legislative Register (SHE-ESHU-04-1402)
- Environmental Communication Procedure (SHE-ESHU-03-1403)
- Procedure on Air Pollution Monitoring & Control (SHE-EMAB-01-1404)
- Procedure on Monitoring of Wastewater Treatment & Disposal (SHE-ESHU-02-1405)
- Procedure for Solid Waste Management (SHE-ESHU-03-1406)
- Procedure on EIA (SHE-ESHU-03-1407)
- Aspects Registers of respective departments
- KNPC's Major Incident Procedure Plan (MIPP)
- SH&E Training Procedure (SHE –TSTR-05-1501)
- Controlled Documents System Manual (SMS-EI06-04-0001)

In addition to the above, there are various department-specific procedures, such as operations manuals / procedures / standing instructions / maintenance manuals / standard testing methods etc., which are controlled by the respective departments.

Control of Documents:

Necessary controls are exercised to ensure all EMS documents are kept updated and obsolete documents are promptly removed. All documents are reviewed periodically and the changes / modification incorporated are approved and issued by authorized persons as per the 'Controlled Document System Manual'. The author is responsible to keep copies of the manual updated at all relevant locations.

Operational Control:

All operations and activities which are associated with significant environmental aspects are identified by the respective departments / divisions / areas and any necessary operational control procedures are documented.

These Operation Control Procedures include department-specific procedures such as operations manuals / procedures / standing instructions / maintenance manuals / procedures etc. In addition to these, the following environmental procedures are also termed as Operation Control Procedures:

- Procedure on Air Pollution Monitoring & Control (SHE-EMAB-01-1404)
- Procedure on Monitoring of Wastewater Treatment & Disposal (SHE-ESHU-02-1405)
- Solid Waste Management Procedure (SHE-ESHU-03-1406)

Emergency Preparedness and Response:

Major emergencies are identified and addressed by KNPC's Major Incident Procedure Plan (MIPP) – see Chapter 15 of this EIS. MIPP assigns the responsibilities of key personnel in handling the major emergencies such as fire, toxic gas release, oil spill on land or sea etc. The potential for unit-specific environmental emergencies are identified in respective Aspects Registers and addressed via plant-specific Emergency Handling Procedures. To test the efficiency of procedures and the preparation of emergency response, mock drills are periodically conducted involving all the role players.

Checking:

Monitoring and measurement:
Key characteristics / parameters covered by legal and other requirements are monitored by the Laboratory, Environment Division and the Lab Service Contractor. Monitoring results are published in Environment Performance reports issued by the Environment Division. Other key characteristics / parameters that have a significant impact on the environment are monitored by respective departments (or divisions). Lists of instruments used for such monitoring and their calibration reporting (if applicable), along with the monitoring reports, are kept by respective departments. Equipment used for monitoring environmental parameters is calibrated as per appropriate calibration schedules, with records maintained by the respective departments.

Evaluation of compliance:
Legal requirements are listed in KNPC's 'Environmental Legislative Register'. Compliance with various other conditions / stipulations, as prescribed, are also addressed therein, plus other requirements. The Register must be reviewed and updated, if required, once a year or as necessary due to amendment / inclusion in existing applicable regulations.

Non-conformances, corrective and preventive actions:
Non-conformances can arise from several areas including system non-conformance, operational non-conformance, complaints etc. Non-conformances are dealt with according to the 'Procedure for Handling Non-conformances and Corrective Actions & Preventive Actions'. Corrective and preventive actions taken to eliminate the causes of actual and potential non-conformances must be appropriate to the magnitude of the problem, and be commensurate with the environmental impact(s) encountered.

Control of records:
Relevant records that demonstrate effective operation of the EMS must be maintained, legible, identifiable and traceable to the activity, product or service involved, and be kept for a minimum period of three years. However, the retention time of some records may be more than three years based on statutory or other requirements. In such cases, the retention period is decided by the respective department. Adequate back-up of these records is ensured by the respective department to avoid the same being lost due to any unforeseen circumstances. Once the retention period for any record is over, such records can be destroyed by the respective department.

Internal audits:

An internal Environment Management System Audit shall be carried out at least once in a year for each site. Internal audits must be carried out in order to determine whether the EMS conforms to planned arrangements for environmental management including the requirements of ISO 14001:2004, and that it has been properly implemented and maintained. Also, to provide information on the results of audits to management whereby the EMR will plan a series of internal audits on the basis of the 'environmental importance' of the area / services / activity and on the findings of previous audits (as per the 'Procedure for Internal Audit'). EMR may reduce the audit frequency for departments/divisions which are not having a critical role in EMS.

17.3.1.4 Management Review:

Environmental Management Review meetings must be carried out at least twice each year in SH&E Executive Committee meetings to ensure the EMS's suitability, adequacy, and effectiveness. Points to be considered in the Management Review include (as applicable):

- results of internal audits and evaluation of compliance with legal requirements and with other requirements to which KNPC subscribes;
- communications with external interested parties, including complaints;
- the environmental performance of KNPC, and the extent to which objectives and targets have been met;
- the status of all corrective and preventive actions;
- follow-up actions from previous Management Reviews;
- changing circumstances, including developments in legal and other requirements related to KNPC's environmental aspects;
- a review of the SH&E Policy, and its adequacy in relation to changing conditions and information;
- a review of Accidents / Incidents and Emergencies;
- a schedule / plan for the next internal audits;
- any recommendation for improvement;
- any other specific points relating to EMS.

Decisions made in Management Reviews are recorded in the form of Minutes of Meetings (MoM). These decisions include possible changes to KNPC's SH&E policy, objectives, targets and other elements of EMS, consistent with the commitment to continual improvement. All action items of the MoM are followed up by the EMR to ensure compliance.

17.4 Monitoring Compliance

In order to optimise KNPC's response to complying with changing environmental regulations (and its corporate requirements), it is noted that KNPC has already implemented a fully-automated enterprise-level information management system – the 100% browser-based *Essential Suite™ EHS and Crisis Management system* from ESS - at MAA, MAB and SHU. This system will be extended to the CFP facilities.

Essential Suite™ facilitates the use of EHS and crisis management data in support of regulatory reporting and performance monitoring, as well as demonstrating how KNPC is exercising its corporate social responsibility. KNPC is also using Essential Suite™ in the CFP's FEED design phase. Essential Suite™ is also a core component of KNPC's project action plan to address its long-term sustainability. Key Essential Suite™ elements applied at KNPC's refineries include:

- Essential Air™ - an emissions tracking system which shows how changes in everyday operations can impact air permits, by calculating and reporting air emissions and comparing them against permit limits for all emissions sources;
- Essential Water™ - helps to achieve, maintain and prove compliance with Kuwait's National Pollutant Discharge Elimination System (NPDES), by tracking regulatory requirements or internal guidelines, calculating pollutant loadings at each discharge point and comparing results to specified limits, so helping to ensure compliance;
- Essential Waste™ - helps to characterize waste streams, monitor their flow, track waste containers, generate waste manifests and generate reports to ensure compliance;
- Essential Chemical Inventory™ - helps track chemical inventory information for use in satisfying inventory-related regulatory requirements, via a central data repository, which enables amounts / locations of materials to be tracked.
- Industrial Hygiene Module™ – provides the tools needed to characterize workplace conditions, collect, document and analyze exposure monitoring results, communicate monitoring results to employees and management, identify opportunities to further control exposures, and assure compliance.

17.5 Conclusions

KNPC's company-wide EMS, in line with the requirements of ISO14001:2004, will be implemented for the CFP. As a tried and tested system, it will provide the same structured approach for the optimum management of environmental issues at the CFP. The principal mechanism by which this will be done is through KNPC's Apex Manual which sets out how the EMS is currently implemented across KNPC's existing refineries and associated facilities. In addition, ESS's Essential Suite™ EHS and Crisis Management system, shows how compliance monitoring and reporting at the CFP will be optimised.

17.6 Recommendations

KNPC intends to incorporate the CFP into the scope of the EMS. It is recommended that the CFP be included in the first possible EMS internal and external audit to ensure that the EMS is being successfully applied to the CFP.

18.0 Recommendations

18.1 Introduction

The CFP design will incorporate all the appropriate best environmental engineering practices (such as BACT) and environmental mitigation measures necessary to meet (at a minimum) all relevant K-EPA regulatory criteria. The CFP has been designed to mitigate all its potentially significant environmental impacts.

In addition, DNV has made a number of recommendations throughout this EIS report, which are reported in detail in the relevant chapters, in order to further mitigate any potential environmental impacts caused by the CFP. These key additional recommendations are summarised here.

18.2 Noise

The noise impact assessment evaluated the potential community impact due to the noise emissions from the activities associated with CFP. Predictive computational modelling was used to quantitatively estimate the sound pressure level (SPL) at various discrete receptors located near the ground level. From this assessment, the following recommendations are made:

- Construction activities shall not be carried out during the night time except under very exceptional situations. Otherwise, night time community noise levels may significantly breach the relevant K-EPA standards at residential locations close to the site fence lines.
- In order to fully comply with K-EPA community noise standards, additional noise attenuation using acoustic enclosures should be considered for significant noise emitting sources located close to the fence lines, particularly for CFP works near the eastern part of the CFP at MAB refinery.
- The process units where additional attenuation should be considered are U-123, U-125, U-129, U-146, U-149 and U-156. All these units are located in MAB CFP Block and they are close to the residential receptors N11, N13, N14 and N16 on the east side of the site. The additional attenuation required would be about 5 dB(A).
- Noise monitoring will be necessary during both construction and operation to ensure no significant impact upon receptors.

18.3 Air Quality During Construction

Potential issues associated with dust released during the CFP construction phase have been assessed. DNV considers that provided the following recommendations are adopted, impacts upon air quality during construction can be managed satisfactorily.

- A rigorous Dust Management Plan is provided by the EPC contractors and is put into action.
- The Dust Management Plan should include some early commitment to provide temporary construction roads as soon as practicable to minimise dust releases.
- The EPC contractors ensure that appropriate dust mitigation measures are applied, both by themselves and their sub-contractors.
- The EPC contractors conduct ongoing monitoring of dust across the CFP site throughout the construction phase.
- An experienced independent environmental professional visits the site during construction at least twice a week to ensure that these measures (and all other environmental management measures recommended in this EIS report) are being applied by EPC contractors.

18.4 Air Quality During Operations

Overall, particularly during "normal" CFP operation, there will be improvements in air quality at the vast majority of air monitoring locations that currently do not meet K-EPA air criteria. This is mainly due to the fact that pollutant emissions from sources that are to be decommissioned far exceed the emissions associated with new CFP sources.

DNV additionally recommends the following:

- KNPC implement design changes during the EPC phase in order to reduce the relief loads to the flare systems that have the highest potential impact on sensitive receptors outside the refinery boundaries (Units 146, 167 and 62; note that Unit 62 is associated with the Total Power Failure case).
- More detailed air dispersion modelling of the emergency flare scenarios should then be conducted during the detailed design / EPC stages of the project, to verify compliance with applicable criteria.
- Currently, the MIPP provides procedures for responding to gas release incidents. These should be expanded to include details for major emergency flaring events, and appropriate actions defined (e.g. warning residents).
- The CFP clearly improves air quality in the study area on a day-to-day basis, although exceedences for some parameters are still observed. It is recommended that scope for additional air quality improvements at the existing refineries be examined under KNPC's ongoing commitment to continuously improve environmental performance.
- It is important that a strict Leak Detection and Repair (LDAR) programme is implemented and enforced onsite to control VOC emissions. The new CFP facilities will be incorporated in the existing refineries LDAR programme.

- The Environmental Management System for the Clean Fuels Project should include a continuous performance improvement process for evaluating and maintaining the efficacy of emissions control equipment, and energy efficiency. The CFP facilities will be incorporated in the existing refineries' EMS.

18.5 Waste

The CFP will generate a variety of solid wastes that are both hazardous and non-hazardous. The impacts of the wastes generated by the CFP were considered for both the construction and operational phases. The waste management practices that KNPC plans to implement for the CFP are more than adequate and no additional recommendations have been made by DNV.

It is important that all the control measures discussed in this report are fully implemented, including the generation of a Waste Management Plan (WMP), which complies with KNPC's Procedure for Solid Waste Management (SHE-ESHU-03-1406).

18.6 Chemical Hazards Management

The CFP will store and/or handle a variety of potentially hazardous materials, including finished product, raw material and catalysts, many of which are similar to those currently used at the three existing refineries. The hazardous materials will be potentially toxic, corrosive, flammable etc. The hazardous materials management practices that KNPC plans to implement for the CFP are more than adequate and thus no additional recommendations have been made by DNV.

It is important that all the control measures discussed in this report are fully implemented, and that the management systems comply with K-EPA requirements for the handling, storage and disposal of hazardous materials.

18.7 Wastewater

DNV has assessed the environmental impacts from the collection, treatment and reuse of process and sanitary wastewater effluents generated by the CFP. It is concluded that the planned new CFP wastewater collection and treatment facilities are state of the art, constitute best practice and will be designed, built and operated to meet K-EPA environmental criteria.

In order to augment the robust approach to addressing and mitigating environmental impacts during the CFP construction and subsequent operations, DNV made the following additional recommendations with regards to wastewater treatment:

- It will be important to ensure that, during construction, the wastewater, storm water and sanitary wastewater collection and treatment facilities are made available at the earliest stage possible; it is recommended that each EPC contractor makes this an early priority.
- It will be important to review and audit the CFP wastewater discharge monitoring results (during both construction and operation); it is

recommended that monitoring results are audited by an independent party on a regular basis.

18.8 Preliminary Traffic Impact Assessment (TIA)

A preliminary assessment was conducted that highlighted that there could be traffic impacts during CFP construction. It is recommended that a detailed TIA be conducted to further study local traffic patterns with the objective of determining the current status of local roadways relative to their design carrying capacity. This information should be used as the basis for development of a comprehensive CFP Traffic Management Plan to ensure impacts are managed acceptably via detailed traffic control measures.

18.9 Miscellaneous

The following miscellaneous issues were also considered in this EIS:

- Landscape and visual impacts
- Socioeconomic issues
- Contaminated land and groundwater

The following recommendations came from these studies:

- Use good practices to decrease water demand and protect water supply.
- Screening of CFP construction and operation from sensitive receptors by hording or earth bunds, particularly at the refinery fence adjacent to the beach houses southeast of MAB. This may also provide additional benefit to reduce wind-blown dust and noise during construction and operation.
- Site lighting is recommended to be designed and located to keep off-site glare to a minimum and minimise the impact on visual amenity at night, having due regard to operational, emergency, security and safety requirements.
- Where possible, tone and colour treatment of plant structures should ensure that the development fits in with surroundings and will blend elements into the horizon and sky line when viewed from a distance.
- An independent environmental advisor should be present on site while soil excavations are taking place to ensure that the soil is excavated and disposed of in the correct manner, and to help identify any other areas of contamination.
- It is recommended that regular checks for fugitive emissions to ground/groundwater from CFP refinery plant and tanks are included as part of the EMS, and that systematic groundwater monitoring is conducted around the CFP facilities and in the vicinity of the tank farms, and analysed against agreed criteria. Additionally, soil and groundwater identified as contaminated in the KISR report and overlapping with the

CFP location will require remediation prior to the start of CFP construction.

- The EPC contractor should develop a plan to handle the potential negative social impacts from such a large influx of construction workers.

18.10 Emergency Response Plan

The KNPC Major Incident Procedure Plan (MIPP) will be applied to the CFP. MIPP is one of KNPC's Emergency Plans that provides a procedural framework for responding to emergency incidents such as fire or a flammable/toxic release. Currently the MIPP provides procedures for responding to gas release incidents. These should be expanded to include details for major emergency flaring events, and appropriate actions defined (e.g. warning residents).

18.11 Decommissioning and Closure

KNPC will develop a full conceptual Decommissioning and Closure Management Plan (DCMP) for the CFP, which will involve consultation with K-EPA, as closure planning progresses. KNPC will develop the DCMP in accordance with the guidelines and requirements established by the regulatory authorities of Kuwait. The DCMP will be developed at a suitable time near the end of the operational life of the CFP facilities.

18.12 Environmental Management System

KNPC has developed and implemented a company wide Environmental Management System (EMS) in line with the requirements of the ISO14001:2004 Standard – Apex Manual for Environmental Management System (SHE-ESHU-04-1401). Since the CFP is within KNPC refinery boundaries, this EMS will also apply to the CFP, ensuring a structured approach to the management of environmental issues existing at the CFP.

The implementation of the EMS will commence during the initial stages of construction and develop as the CFP project becomes fully operational. It is recommended that the CFP be included in the first possible EMS internal and external audit to ensure that the EMS is being successfully applied to the CFP project.

Abbreviations

ACM	Asbestos Containing Materials
ADMS	Air Dispersion Modelling Software
AGF	Acid Gas Flare
API	American Petroleum Institute
ARU	Amine Regeneration Unit
AOC	Accidentally Oil Contaminated
AR	Atmospheric Residuum
ARDS	Atmospheric Residue Desulfurization
ATF	Aviation Turbine Fuel
BA	Breathing Apparatus
BACT	Best Available Control Technology
bbl	Barrels
BFW	Boiler Feed Water
BPSD	Barrels per Stream Day
C&MD	Chairman & Managing Director
CCR	Central Control Room
CCR	Continuous Catalytic Reformer
CCTV	Closed Circuit Television
CDU	Crude Distillation Unit
CEMS	Continuous Emissions Monitoring System
CFO	Chief Fire Officer
CFP	Clean Fuels Project
CGO	Coker Gas Oil
CLPS	Cold Low Pressure Separator
CMP	Crisis Management Plan
CPI	Corrugated Plate Interceptor
CT	Cooling Tower
DAF	Dissolved Air Flotation
dB(A)	Decibel – A- weighted
DCMP	Decommissioning and Closure Management Plan
DCU	Delayed Coking Unit
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DEP	Design Engineering Practice (Shell)
DFO	Duty Fire Officer
DG	Diesel Generator
DHT	Diesel Hydrotreater
DIB	Deisobutanizer
DIP	Deisopentanizer
DMDS	Dimethyl Disulfide
DNV	Det Norske Veritas
DOT	Department of Transportation
DPK	Dual Purpose Kerosene
E&MOG	KOC Export & Marine Operations Group
EBS	Environmental Baseline Study
ECCC	Emergency Communications Control Centre
ECM	Emergency Coordination Manager
EIA	Environmental Impact Assessment

EICS	Enterprise Integration & Communications System
EIMS	Environmental Information Management System
EIS	Environmental Impact Statement
EMR	EMS Management Representative
EMS	Environmental Management System
EPC	Engineering, Procurement and Construction
ERP	Emergency Response Plan
ERP	Ethane Recovery Project
ERT	Emergency Response Team
ESP	Electrostatic Precipitator
ETF	Effluent Treatment Facility
EU	European Union
FCC NHTU	Fluid Catalytic Cracking - Naphtha Hydrotreater Unit
FCU	Forward Control Unit
FEED	Front End Engineering Design
FGR	Flue Gas Recirculation
FGS	Fuel Gas System
FGRU	Flare Gas Recovery Unit
FGTP	Fourth Gas Train Project
FOSP	Fuel Oil Supply
FRN	Full Range Naphtha
GHGs	Green House Gases
GOD	Gas Oil Desulfurization
HC	Hydrogen Compression
HCGO	Heavy Coker Gas Oil
HCR	Hydrocracker
HDS	Hydrodesulphurization
HFS	Hydrocarbon Flare System
HN	Heavy Naphtha
HOC	Heavy Oil Cooling
HPU	Hydrogen Production Unit
HSAR	High Sulfur Atmospheric Residuum
HSR	Hydrogen Sulfide Removal
HVGO	Heavy Vacuum Gas Oil
Hz	Frequency (cycles per second)
IC	Incident Controller
ICSS	Integrated Control & Safety System
IC5	Isopentane
ID	Identity Number
IRT	Inter-Refinery Transfer
ISO	International Organization for Standardization
KCDF	Kuwait State Civil Defence Force
K-EPA	Kuwait Environment Public Authority
KISF	Kuwait State Installations Security Force
KISR	Kuwait Institute of Scientific Research
KNPC	Kuwait National Petroleum Company
KPC	Kuwait Petroleum Corporation
KPC-IMT	KPC-Incident Management Team
KSF	Kuwait State Security Force

KSFB	Kuwait State Fire Brigade
LDAR	Leak Detection and Repair Programme
Leq	Equivalent sound pressure level (time averaged)
LM	Local Marketing
LN	Light Naphtha
LOBS	Lube Oil Base Stock
LNB	Low NO_X Burners
LPG	Liquid Petroleum Gas
LSAR	Low Sulfur Atmospheric Residue
LST	Land Surface Temperature
m	Meter
MAA	Mina Al Ahmadi
MAB	Mina Al Abdullah
MCC	Management Co-ordination Centre
MDEA	Methyl-Diethanol Amine
MIPP	Major Incident Procedure Plan
MoM	Minutes of Meeting
MOO	Ministry of Oil
MPGF	Multi Point Ground Flare
MSDS	Material Safety Data Sheet
MTY	Million Tons per Year
NBC	Nuclear, Biological or Chemical
NCC	National Cleaning Company
NFPA	National Fire Protection Association
NHTU	Naphtha Hydrotreating Unit
NMHC	Non-methane Hydrocarbons
NOSCP	National Oil Spill Contingency Plan
NOx	Nitrogen Oxides
OAQPS	Office of Air Quality Planning and Standards (US EPA)
ODS	Oil Drip Sewer/System
OMS	Odour Management System
OSRT	Oil Spill Response Team
OSRV	Oil Spill Response Vehicle
PAI	Public Authority for Industries
PAIECC	Public Authority for Industry Emergency Control Centre
PCB	Polychlorinated Biphenyls
PCN	Petrochemical Naphtha
PFSO	Port Facility Security Officer
PM	Particulate Matter
PPE	Personal Protective Equipment
PSA	Pressure Swing Absorption
RCC	Resource Coordination Centre
RSL	Refinery Shift Leader
SAR	Sour Atmospheric Residue
SCADA	Supervisory Control and Data Acquisition System
SCOT	Shell Claus Offgas Treating
SEEP	Site Emergency Evacuations Plan
SFO	Shift Fire Officer
SGP	Saturates Gas Plant

SH	Selective Hydrogenation
SHE	Safety, Health and Environment
SHU	Shuaiba
SMART	Specific, Measurable, Achievable, Relevant and Time-bound
SOx	Sulfur Oxides
SPL	Sound Pressure Level
SPL_1	Sound Pressure Level at 1m from source
SPL_2	Sound Pressure Level at 2m from source
SPM	Suspended Particulate Matter
SR	Straight Run
SRU	Sulfur Recovery Units
SSO	Shift Security Officer
SSW	Stripped Sour Water
STEP	Security Threats Emergency Plan
SWL	Total Sound Power level from frequency bands
SWL or SWL_0	Sound Power Level at Source
TCLP	Toxicity Characteristic Leaching Procedure
TGO	Trim Gas Oil
TGTU	Tail Gas Treating Unit
TPCD	Tons Per Calendar Day
TPH	Total Petroleum Hydrocarbons
TREM	Transport Road Emergency
TRO	Trim Gas Oil
TRS	Trunking Radio System
TSP	Total Suspended Particulate
U&O	Utilities and Offsites
UCO	Unconverted Oil
ULSD	Ultra Low Sulfur Diesel
US EPA	United States Environmental Protection Agency
VGO	Vacuum Gas Oil
VOC	Volatile Organic Compounds
VOIPD	Vital & Oil Installations Protection Department
VSS	Vortex Separation System
WDT	Waste Disposal Ticket
WES	Wataniya Environmental Services
WGD	Waste Generating Department
WHD	Waste Handling Department
WMP	Waste Management Plan
WPS	Waste Profile Sheet
WTM	Waste Transport Manifest
WWT	Wastewater Treating
ZVI	Zone of Visual Influence

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Appendix I – Refinery Tanks under hydrocarbon service

Table I.1: MAA Vertical Fixed Roof (VFR) Storage Tanks

Source Unit Name / Unit Number	Tank Number	Tank Shell Diameter (ft)	Tank Shell Diameter (in meters)	Tank Shell Height (ft)	Tank Shell Height m (Note 1)	Maximum Liquid Height m (Note 2)	Average Liquid Height m (Note 3)	Tank (Working) Volume (BBL)	Total (Working) Volume (BBL)	Total (Working) Volume m^3 (Note 4)	Annual Number of Tank Turnovers (Note 5)	Net Annual Throughput (BPCY)	Net Annual Throughput m^3/yr. (Note 6)	Shell Color (Note 7)	Shell Condition (Note 8)	Roof Color (Note 7)	Roof Condition (Note 8)	Roof Type (Note 9)	Slope of Cone Roof (Note 9)	Radius of Dome Roof (meters) (Note 9)	Height of Cone or Dome Roof (meters) (Note 9)	Name / Description of Liquid Commodity Being Stored	Chemical Abstract Number (CAS Number)	Reid Vapor Pressure (max) (in psia)	Remark(s)
U-141 & U-41/42/81/83	TK-61-664	125.00	38.10	56.00	17.07	16.07	9.03	94,721	189,604	30,145	52	9,864,400	1,568,311	white	good	white	good	cone	0.06	-	1.19	ARDS Lt. Diesel	-	0.5	
U-141 & U-41/42/81/82	TK-61-665	125.00	38.10	56.00	17.07	16.07	9.03	94,883						white	good	white	good	cone	0.06	-	1.19	ARDS Lt. Diesel (Swing Tank)	-	0.5	
U-88 FCC	61-T-0105	125.00	38.10	64.00	19.51	18.52	9.46	129000	129,000	20,509	9	1,164,800	185,188	white	new	white	new	cone	0.06	-	1.19	FCC Distillate	-	0.5	1) FCC Dist. storage is split 2 ways between TK-61-682 & 61-T-0105
U-40/80 CDU	TK-61-623	104.83	31.95	55.00	16.76	15.76	8.88	71,467	71,467	11,366	49	3,530,800	561,351.3	white	good	white	good	good	0.06	-	1.00	CDU HGO	-	0.1	
144 GOD	TK-22-651	120.00	36.58	48.00	14.63	13.63	7.82	77,545	155,012	24,645	80	12,339,800	1,961,836	white	good	white	good	cone	0.06	-	1.14	10 PPM S. GO	-	0.5	
	TK-22-652	120.00	36.58	48.00	14.63	13.63	7.82	77,467						gray/medium	good	gray/medium	good	cone	0.06	-	1.14		-		
10 PPM Gas Oil Blender	TK-61-601	144.00	43.89	48.00	14.63	13.63	7.82	124,621	1,580,324	251,251	14	22,495,200	3,576,444	gray/medium	good	gray/medium	good	cone	0.06	-	1.37	10 PPM S. GO	-	0.5	1) Assume TK-22-608 condition is "good" like other 10 PPM S. GO Tanks
	TK-22-603	168.00	51.21	48.00	14.63	13.63	7.82	153,931						white	good	white	good	cone	0.06	-	1.80		-		
	TK-22-608	50.00	15.24	39.99	12.19	11.19	6.80	11,547						white	good	white	good	cone	0.06	-	0.48		-		
	TK-61-667	162.67	49.58	64.00	19.51	18.51	10.25	193,437						white	good	white	good	cone	0.06	-	1.55		-		
	TK-61-668	190.67	58.12	63.00	19.20	18.20	10.10	270,217						white	good	white	good	cone	0.06	-	1.82		-		
	TK-61-669	190.67	58.12	63.00	19.20	18.20	10.10	270,005						white	good	white	good	cone	0.06	-	1.82		-		
	TK-61-670	190.67	58.12	63.00	19.20	18.20	10.10	269,668						white	good	white	good	cone	0.06	-	1.82		-		
	TK-61-822	190.67	58.12	63.00	19.20	18.20	10.10	281,669						white	good	white	good	cone	0.06	-	1.82		-		
	TK-61-633	29.99	9.14	23.98	7.31	6.31	4.16	2,513						white	good	white	good	cone	0.06	-	0.27		-		
	TK-61-634	29.99	9.14	23.98	7.31	6.31	4.16	2,518						white	good	white	good	cone	0.06	-	0.27		-		
500 PPM Gas Oil Blender	TK-61-600	144.00	43.89	48.00	14.63	13.63	7.82	107,437	415,783	66,104	18	7,425,600	1,180,574	gray/medium	good	gray/medium	good	cone	0.06	-	1.37	500 PPM S. GO	-	0.5	
	TK-61-605	160.01	48.77	53.97	16.45	15.45	8.73	192,938						white	good	white	good	cone	0.06	-	1.52		-		
	TK-61-602	144.00	43.89	48.00	14.63	13.63	7.82	115,406						white	good	white	good	cone	0.06	-	1.37		-		
Isomerization / U-107	61-T-0103	115	35.05	48.00	14.63	13.89	7.18	79,679	159,758	25,399	62	9,937,200	1,579,888	white	new	white	new	dome	-	28.04 min 42.1 max (Note 2)	6.2 @ min Radius 4.7 @ max Radius (Note 2)	Isomerate	(Note 1)	13.32	1) Ingredient CAS# List - 78-78-4, 109-66-0, 106-97-8, 110-54-3, 110-82-7, 71-43-2 2) Dome Radius is by vendor, for estimating purpose, use worst case (min or max). The corresponding height is calculated at each Radius assumption.
	61-T-0104	115	35.05	48.00	14.63	13.89	7.18	79,679						white	new	white	new	dome	-						
U-40/80 CDU	TK-22-761	212.00	64.62	64.00	19.51	18.51	10.25	346,629	1,261,370	200,541	47	59,914,400	9,525,611	white	good	white	good	cone	0.06	-	2.02	AR/HSAR	-	NA	
	TK-22-762	212.00	64.62	64.00	19.51	18.51	10.25	346,818						white	good	white	good	cone	0.06	-	2.02		-		
	TK-61-820	190.83	58.17	63.00	19.20	18.20	10.10	287,236						white	good	white	good	cone	0.06	-	1.82		-		
	TK-61-821	190.83	58.17	63.00	19.20	18.20	10.10	280,687						white	good	white	good	cone	0.06	-	1.82		-		
U-41/42/81/82/141 ARDS	TK-61-831	155.92	47.52	64.00	19.51	18.51	10.25	183,302	883,492	140,464	57	50,377,600	8,009,383	white	good	white	good	cone	0.06	-	1.49	LSAR	-	NA	
	TK-61-832	155.92	47.52	64.00	19.51	18.51	10.25	183,487						white	good	white	good	cone	0.06	-	1.42		-		
	TK-61-755	168.01	51.21	53.97	16.45	15.45	8.73	175,027						white	good	white	good	cone	0.06	-	1.60		-		
	TK-61-756	168.00	51.21	54.00	16.46	15.46	8.73	175,023						gray/light	good	gray/light	good	cone	0.06	-	1.60		-		
	TK-61-757	155.00	47.24	60.00	18.29	17.29	9.64	166,673						gray/medium	good	gray/medium	good	cone	0.06	-	1.48		-		
MAB U-83/183 VR U-136 DCU	TK-61-673	125.00	38.10	64.00	19.51	18.51	10.25	114,745	296,103	47,077	48	14,268,800	2,268,554	white	good	white	good	cone	0.06	-	1.19	UCO/TGO/ CGO	-	NA	
	TK-61-835	125.00	38.10	58.00	17.07	16.07	9.03	86,210						white	good	white	poor	cone	0.06	-	1.19		-		
	TK-61-836	125.00	38.10	58.00	17.07	16.07	9.03	95,148						white	good	white	good	cone	0.06	-	1.19		-		
U-83/183 VR	TK-61-833	125.00	38.10	64.00	19.51	18.51	10.25	106,094	212,325	33,757	107	22,677,200	3,605,380	white	good	white	poor	cone	0.06	-	1.19	VGO	-	NA	
	TK-61-834	125.00	38.10	64.00	19.51	18.51	10.25	106,231						white	good	white	good	cone	0.06	-	1.19		-	NA	
U-12 BITUMEN	TK-22-455	60.00	18.29	40.00	12.19	11.19	6.60	17,422	17,422	2,770	61	1,056,600	167,827	gray/light	good	gray/light	good	cone	0.06	-	0.57	Waxy Dist.	-	NA	
1.0 LSFO Blender	TK-61-702	168.00	51.21	54.00	16.46	15.46	8.73	182,741	528,896	84,088	5	2,875,600	457,163	gray/medium	good	gray/medium	good	cone	0.06	-	1.60	Bunker 180 LSFO	-	NA	
	TK-61-703	168.00	51.21	54.00	16.46	15.46	8.73	176,649						gray/medium	good	gray/medium	good	cone	0.06	-	1.60		-		
	TK-61-752	168.00	51.21	54.00	16.46	15.46	8.73	169,506						gray/medium	good	gray/medium	good	cone	0.06	-	1.60		-		
1.0 LSFO Blender	TK-22-751	168.00	51.21	54.00	16.46	15.46	8.73	169,679	509,072	80,936	23	11,611,600	1,846,093	white	good	white	good	cone	0.06	-	1.60	Bunker380 LSFO	-	NA	
	TK-22-753	168.00	51.21	54.00	16.46	15.46	8.73	169,667						gray/light	good	gray/light	good	cone	0.06	-	1.60		-		
	TK-61-754	168.00	51.21	54.00	16.46	15.46	8.73	169,726						gray/medium	good	gray/medium	good	cone	0.06	-	1.60		-		
Existing Process Slops	TK-22-995	55.00	16.76	48.00	14.63	13.63	7.82	14,588	29,171	4,638	15	437,565	69,567	gray/medium	good	gray/medium	good	cone	0.06	-	0.52	Wet Slops	-	NA	1) Slop Tank turnover is based on 1% of the total crude feed to MAA (332.1 KBPCD) to the total MAA slop storage. Total turnover is 15 / yr. This turnover is assumed to apply to each set of slop tanks.
	TK-22-996	55.00	16.76	48.00	14.63	13.63	7.82	14,583						gray/medium	good	gray/medium	good	cone	0.06	-	0.52		-		

This worksheet applies only to Vertical Fixed Roof (VFR) type hydrocarbon storage tanks.

Note 1: Provide shell height (not including dome or cone roof height) in meters.

Note 2: Provide the maximum liquid height in meters of the liquid within the tank shell. This number must be less than or equal to the tank shell height.

Note 3: Provide the average liquid height in meters of the liquid within the tank shell. This number must be less than or equal to the maximum liquid height.

Note 4: Provide the tank working volume in cubic meters. This number must be consistent with the tank diameter and maximum liquid height. Base the working volume on the maximum liquid height during the last 12 months of normal operation.

Note 5: Turnovers is the estimated number of times per year the tank is emptied and refilled. Turnovers = throughput divided by working volume. This number can be zero if liquid was stored and not pumped in or out for an entire year.
For surge tanks or constant level tanks the number of turnovers should be adjusted by multiplying by the average change in the liquid height in meters and dividing by the maximum liquid height. Enter this value or enter "4" as the default turnover rate. Then, adjust the net throughput by multiplying the adjusted turnovers by the working volume.

Note 6: Provide the annual net throughput in cubic meters per year. This number should be consistent with the tank working volume and number of turnovers per year.

Note 7: Choices for tank shell and roof color are: white, aluminum/specular, aluminum/diffuse, gray/light, gray/medium, or red/primer. Choose the color from this list which most closely matches the actual tank color. If unknown, use "white" as default.

Note 8: External shell and roof paint condition choices are: Good or Poor. Choose one. If unknown, use "Good" as default.

Note 9: Roof type choices are: cone or dome. Choose one. For cone roof tanks, provide the slope in meter/meter. For dome roof tanks, provide radius in meters of the arc of the domed roof. Provide the height of the tank roof in meters NOT including the tank shell.

Table L2: MAA External Floating Roof (EFR) and Domed External Floating Roof (DEFR) Storage Tanks

Source Unit Name / Unit Number	Tank Number	Tank Shell Diameter	Tank Shell Diameter	Tank Shell Height	Tank Shell Height	Tank (Working) Volume	Total (Working Volume)	Total (Working) Volume	Annual Number of Tank Turnovers	Net Annual Throughput	Net Annual Throughput	Shell Color	Shell Condition	Roof Color	Roof Condition	Internal Shell Condition	Primary Seal Type	Secondary Seal Type	Roof Type	Roof Construction	Name / Description of Liquid Commodity Being Stored	Chemical Abstract Number	Reid Vapor Pressure (max)	Remark(s)
		(ft)	(in meters)	(ft)	(m)	(BBL)	(BBL)	m³ (Note 1)	(Note 2)	(BPCY)	m³/yr (Note 3)	(Note 4)	(Note 5)	(Note 6)	(Note 5)	(Note 6)	(Note 7)	(Note 8)	(Note 9)	(Note 9)		(CAS Number)	(in psia)	(Note 10)
MAB HCR/PCNA Blender	TK-22-253	160.00	48.77	48.00	14.63	181,300	181,300	28,824	16	2,912,000	462,970.1	white	good	white	good	good	mechanical shoe	shoe-mounted	welded	pontoon	MAB HCR HN/PCNA	-	10.5	
Reformer Blender	TK-61-255	164.00	49.99	58.00	17.68	177,240	355,142	56,463	64	22,786,400	3,622,741.4	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	CCR Feed	-	10.5	
	TK-61-258					177,902						white	good	white	good	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
PCNA Blender	61-T-0101	130.00	39.62	64.00	19.51	127500	1,029,913	163,743	26	26,644,800	4,236,176.8	white	new	white	new	new	mechanical shoe	shoe-mounted	double deck	pontoon	PCNA	-	10.5	1) Secondary Seal Type is estimated, actual seal type is to be determined by Vendor
	61-T-0102	130.00	39.62	64.00	19.51	127000						white	new	white	new	new	mechanical shoe	shoe-mounted	double deck	pontoon		-		
	TK-61-467	183.58	49.86	64.00	19.51	193,970						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-466	183.58	49.86	64.00	19.51	193,843						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-469	183.58	49.86	64.00	19.51	193,800						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-470	183.58	49.86	64.00	19.51	193,800						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
U-64 HCR	TK-22-506	49.83	15.19	44.00	13.41	12,504	25,018	3,978	407	10,192,000	1,620,395.5	white	good	white	good	good	mechanical shoe	shoe-mounted	welded	pontoon	DPK	-	1.19	
	TK-22-509					12,514						white	good	white	good	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
ATK Blender	TK-22-511	100.07	30.50	33.14	10.10	32116	1,269,048	201,762	17	21,310,545	3,388,099.7	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	ATK	-	1	1) Assume TK-511/512/514/515 construction / condition are similar to that of other KERO Tanks. 2) ATK storage is split 11 ways between these tanks and TK-61-522.
	TK-22-512	79.99	24.38	39.99	12.19	31388						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-22-514	79.99	24.38	39.99	12.19	31114						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-22-515	79.99	24.38	39.99	12.19	32563						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-671	166.00	50.60	60.00	18.29	183,000						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-672	166.00	50.60	60.00	18.29	183,000						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-531	183.58	49.86	64.00	19.51	193,964						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-532	183.58	49.86	64.00	19.51	193,902						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-533	183.58	49.86	64.00	19.51	193,985						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-534	183.58	49.86	64.00	19.51	194,014						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
U-136/U-40/80	TK-61-520	95.42	29.08	52.00	15.85	51,780	224,764	35,735	73	16,489,200	2,621,568.4	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	CDU/Coker Kero	-	1	
U-136	TK-61-622	104.83	31.95	58.00	17.68	69,466						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	Coker Kero	-		
U-40/80 CDU	TK-61-521	95.42	29.08	52.00	15.85	51,780						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	CDU Kero	-		
U-40/80 CDU	TK-22-503	79.76	24.31	40.00	12.19	25,768						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	CDU Kero	-		
	TK-22-504	79.76	24.31	40.00	12.19	25,970						white	good	white	good	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
JP-8 Blender	TK-22-725	50.00	15.24	39.99	12.19	11,547	11,547	1,836	22	254,800	40,509.9	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	JP-8	-	1	1) Assume tank construction / condition are similar to that of other KERO Tanks.
U-40/80 CDU U-39 ECCENE	TK-61-620	182.00	49.36	60.00	18.29	179,131	179,131	28,480	109	19,583,200	3,113,474.2	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	CDU Lt. Diesel	-	0.5	
U-136 DCU	TK-61-621	182.00	49.38	60.00	18.29	179,123	179,123	28,478	10	1,820,000	289,358.3	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	DCU Lt. Diesel	-	0.5	
U-56 FCC	TK-61-662	104.87	31.90	58.00	17.67	64,439	64,439	10,245	18	1,164,800	185,188.1	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	FCC Dist.	-	0.5	1) FCC Dist. storage is split 2 ways between TK-61-662 & 61-T-0105
U-58 GOD	TK-61-661	183.58	49.86	64.00	19.51	193,846	193,846	30,819	90	17,362,800	2,760,459.5	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	10 PPM S. Diesel	-	0.5	
U-186 FCC NHTU	TK-61-275	144.00	43.89	64.00	19.51	150,482	196,731	31,598	24	4,732,000	752,326.5	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	FCC LN	-	10.5	
	TK-61-277	95.17	29.01	50.00	15.24	46,249						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
U-186 FCC NHTU	TK-61-278	125.00	38.10	56.00	17.07	95,528	95,528	15,188	38	3,640,000	578,712.7	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	FCC HN	-	3	
U-25/26 CCR	TK-61-221	114.50	34.90	60.00	18.29	88,393	269,293	42,814	56	14,996,800	2,384,296.2	white	good	white	good	good	mechanical shoe	shoe-mounted	welded	pontoon	Reformate	-	7	
MAB CCR	TK-61-254	164.00	49.99	58.00	17.68	180,900						white	good	white	good	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
MAB HCR	TK-61-272	125.00	38.10	56.00	17.07	94,749	94,749	15,064	17	1,565,200	248,844.5	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	HCR LN	-	10.5	
U-46 ALKY	TK-61-276	144.00	43.89	64.00	19.51	164,999	164,999	26,233	12	1,929,200	306,717.7	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	Alkylate	-	9	
U-45 MTBE IMPORT	TK-61-273	95.17	29.01	50.00	15.24	47,445	94,895	15,087	5	485,333	77,161.7	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	MTBE	-	3	1) MTBE storage is split 3 ways between TK-61-273/274/279
	TK-61-274					47,450						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
MOGAS Blender	TK-61-460	175.00	53.34	64.00	19.51	239,090	1,332,772	211,893	22	29,738,800	4,726,082.6	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	Mogas 95	-	10.5	1) Assume tank construction / condition are similar to that of other MoGas Tanks for TK-61-464.
	TK-61-461	175.00	53.34	64.00	19.51	239,103						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-464	144.03	43.90	63.19	19.26	151,233						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-465	144.00	43.89	64.00	19.51	151,389						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-452	100.00	30.48	48.00	14.63	52,667						white	good	white	good	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-22-456	160.00	48.77	48.00	14.63	128,249						white	good	white	good	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-22-458	144.00	43.89	56.00	17.07	104,935						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-22-462	183.58	49.86	64.00	19.51	182,480						white	good	white	good	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-22-459	144.00	43.89	57.50	17.53	105,626						gray/medium	good	gray/medium	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
MOGAS Blender	TK-61-463	144.00	43.89	64.00	19.51	151,299	375,935	59,769	27	10,301,200	1,637,756.9	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	Mogas 91	-	10.5	
	TK-61-450	82.58	25.17	52.00	15.85	38,234						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-61-453	104.75	31.93	63.92	19.48	79,676						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
	TK-22-457	144.00	43.89	56.00	17.07	106,726						white	good	white	good	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
Existing Process Slops	TK-61-900	78.33	23.27	44.00	13.41	27,281	54,016	8,588	15	810,240	128,818	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	Dry Slops	-	3	1) Slop Tank turnover is based on 1% of the total crude feed to MAA (332.1 KBPCD) to the total MAA slop storage. Total turnover is 15 / yr. This turnover is assumed to apply to each set of slop tanks.
	TK-61-901	76.25	23.24	44.00	13.41	26,735						white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon		-		
MAA Crude Imports	TK-61-225	168.00	51.21	54.00	16.46	154,057	257,717	40,974	437	112,621,600	17,905,370.3	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	pontoon	KEC Crude	-	3	
	TK-22-226	168.00	51.21	54.00	16.46	103,660						white	good	white	good	good	mechanical shoe	shoe-mounted	welded	pontoon		-		

This worksheet applies *only* to External Floating Roof (EFR) or Domed External Floating Roof (DEFR) type hydrocarbon storage tanks.

Note 1: Provide the tank working volume in cubic meters. Base the working volume on the maximum liquid height during the last 12 months of normal operation.

Note 2: Turnovers is the estimated number of times per year the tank is emptied and refilled. Turnovers = throughput divided by working volume. This number can be zero if liquid was stored and not pumped in or out for an entire year.
For surge tanks or constant level tanks the number of turnovers should be adjusted by multiplying by the average change in the liquid height in meters and dividing by the maximum liquid height. Enter this value or enter "4" as the default turnover rate. Then, adjust the net throughput by multiplying the adjusted turnovers by the working volume.

Note 3: Provide the annual net throughput in cubic meters per year. This number should be consistent with the tank working volume and number of turnovers per year.

Note 4: Choices for tank shell and roof color are: white, aluminum/specular, aluminum/diffuse, gray/light, gray/medium, or red/primer. Choose the color from this list which most closely matches the actual tank color. If unknown, use "white" as default.

Note 5: External shell and roof paint condition choices are: Good or Poor. Choose one. If unknown, use "Good" as default.

Note 6: The choices for internal shell condition are: light rust, dense rust, or gunite lining. Choose one. If unknown, use "light rust" as default.

Note 7: The choices for primary seal are: mechanical shoe, liquid-mounted shoe, or vapor mounted shoe. Choose one.

Note 8: The choices for secondary seal vary with the tank construction and primary seal type as follows: for riveted tanks or welded tanks with mechanical shoe primary seals, secondary seal choices are rim-mounted, shoe mounted or none;
for welded tanks with resilient-filled primary seals (both liquid and vapor mounted), secondary seal choices are : none, rim-mounted or weather shield.

Note 9: Choices for roof type are: pontoon or double deck. Choose one. Choices for tank construction are: welded or riveted. Choose one.

Note 10: Under remarks, please note if this is a Domed External Floating Roof (DEFR) type storage tank.

Table I.3: MAA Internal Floating Roof (IFR) Storage Tanks

Source Unit Name / Unit Number	Tank Number	Tank Shell Diameter	Tank Shell Diameter	Tank Shell Height	Tank Shell Height	Tank (Working) Volume	Total (Working Volume)	Total (Working) Volume	Annual Number of Tank Turnovers	Net Annual Throughput	Net Annual Throughput	Self Supporting Columns	Shell Color	Shell Condition	Roof Color	Roof Condition	Internal Shell Condition	Primary Seal Type	Secondary Seal Type	Deck Type	Name / Description of Liquid Commodity Being Stored	Chemical Abstract Number	Reid Vapor Pressure	Remark(s)
		(ft)	(in meters)	(ft)	(m)	(BBL)	(BBL)	m^3 (Note 1)	(Note 2)	(BPCY)	m^3/yr (Note 3)	(Note 4)	(Note 5)	(Note 6)	(Note 5)	(Note 6)	(Note 7)	(Note 8)	(Note 9)	(Note 10)		(CAS Number)	(in psia)	
ATK Blender	TK-61-522	162.00	49.38	60.00	18.29	179,913	179,913	28,604	12	2,131,065	338,810	Y	white	good	white	poor	good	mechanical shoe	shoe-mounted	welded	ATK	-	1	1) ATK storage is split 11 ways between these tanks and other ATK tanks.
U-45 MTBE IMPORT	TK-61-279	95.00	28.96	57.75	17.60	63,803	63,803	10,144	4	242,667	38,580.8	white	good	white	poor	good	good	mechanical shoe	shoe-mounted	welded	MTBE	-	3	1) MTBE storage is split 3 ways between TK-61-273/274/279

This worksheet applies only to Internal Floating Roof (IFR) type hydrocarbon storage tanks.

Note 1: Provide the tank working volume in cubic meters. Base the working volume on the maximum liquid height during the last 12 months of normal operation.

Note 2: Turnovers is the estimated number of times per year the tank is emptied and refilled. Turnovers = throughput divided by working volume. This number can be zero if liquid was stored and not pumped in or out for an entire year. For surge tanks or constant level tanks the number of turnovers should be adjusted by multiplying by the average change in the liquid height in meters and dividing by the maximum liquid height. Enter this value or enter "4" as the default turnover rate. Then, adjust the net throughput by multiplying the adjusted turnovers by the working volume.

Note 3: Provide the annual net throughput in cubic meters per year. This number should be consistent with the tank working volume and number of turnovers per year.

Note 4: Answer "Y" if the tank roof has no supporting columns. Answer "N" if the tank has supporting columns. Most VFR tanks converted to IFR tanks will have columns. The TANKS Program will calculate number of columns based on the tank diameter.

Note 5: Choices for tank shell and roof color are: white, aluminum/specular, aluminum/diffuse, gray/light, gray/medium, or red/primer. Choose the color from this list which most closely matches the actual tank color. If unknown, use "white" as default.

Note 6: External shell and roof paint condition choices are: Good or Poor. Choose one. If unknown, use "Good" as default.

Note 7: The choices for internal shell condition are: light rust, dense rust, or gunite lining. Choose one. If unknown, use "light rust" as default.

Note 8: The choices for primary seal are: mechanical shoe, liquid-mounted shoe, or vapor mounted shoe. Choose one.

Note 9: The choices for secondary seal vary with the tank construction and primary seal type as follows: for riveted tanks or welded tanks with mechanical shoe primary seals, secondary seal choices are rim-mounted, shoe mounted or none; for welded tanks with resilient-filled primary seals (both liquid and vapor mounted), secondary seal choices are : none or rim-mounted.

Note 10: For deck type, the choices are: welded or bolted. If bolted, in the Remarks column also provide (1) the construction type (either continuous sheet or rectangular panel); and (2) deck seam width (sheet choices are: 5 ft (default value), 6 ft or 7 ft; panel choices are: 5 ft by 7.5 ft or 5 ft by 12 ft). The TANKS Program automatically calculates the deck seam length based on deck construction and tank diameter.

Table I.4: MAB Vertical Floating Roof (VFR) Storage Tanks

Name / Description of Liquid Commodity Being Stored	Unit Name / Unit Number	Tank Number	Tank Shell Diameter	Tank Shell Height	Maximum Liquid Height	Average Liquid Height	Tank (Working) Volume	Number of Tank Turnovers	Net Throughput	Shell Color	Shell Condition	Roof Color	Roof Condition	Roof Type	Slope of Cone Roof	Radius of Dome Roof	Height of Cone or Dome Roof	Chemical Abstract Number	Gasoline Reid Vapor Pressure	Remark(s)
			(in feet)	BBL, (Note 1)	ft, (Note 2)	ft, (Note 3)	BBL, (Note 4)	(Note 5)	BBL, (Note 6)	(Note 7)	(Note 8)	(Note 7)	(Note 8)	(Note 9)	(Note 9)	(Note 9)	(Note 9)	(CAS Number)	(in psia)	
Bunker 380	Tank Farm - 52	TK-52-169	120	40	36.5	34.50	47,785	16	783,916	white	good	white	good	Cone	1/16	60	4		0.01	Bunker loading quantity is assumed to be 2% of the total export volume (9,511,764 ton/yr). Convert to bbl/yr. Took ratio b/w TK-52-168 and TK-52-169 = 1.0076. Used ratio to adjust net throughput for each type of tank such that total throughput = 1,561,916 bbl (9,511,764 ton/yr)

This worksheet applies *only* to Vertical Fixed Roof (VFR) type hydrocarbon storage tanks.

Note 1: Provide shell height (not including dome or cone roof height) in feet.
Note 2: Provide the maximum liquid height in feet of the liquid within the tank shell. This number must be less than or equal to the tank shell height.
Note 3: Provide the average liquid height in feet of the liquid within the tank shell. This number must be less than or equal to the maximum liquid height.
Note 4: Provide the tank working volume in barrels. This number must be consistent with the tank diameter and maximum liquid height. Base the working volume on the maximum liquid height during the last 12 months of normal operation.
Note 5: Turnovers is the estimated number of times *per year* the tank is emptied and refilled. Turnovers = throughput divided by working volume. This number can be zero if liquid was stored and not pumped in or out for an entire year.
For surge tanks or constant level tanks the number of turnovers should be adjusted by multiplying by the average change in the liquid height in feet and dividing by the maximum liquid height. Enter this value or enter "4" as the default turnover rate. Then, adjust the net throughput by multiplying the adjusted turnovers by the working volume.
Note 6: Provide the annual net throughput in barrels per year. This number should be consistent with the tank working volume and number of turnovers per year.
Note 7: Choices for tank shell and roof color are: white, aluminum/specular, aluminum/diffuse, gray/light, gray/medium, or red/primer. Choose the color from this list which most closely matches the actual tank color. If unknown, use "white" as default.
Note 8: External shell and roof paint condition choices are: Good or Poor. Choose one. If unknown, use "Good" as default.
Note 9: Roof type choices are: cone or dome. Choose one. For cone roof tanks, provide the slope in feet/feet. For dome roof tanks, provide radius in feet of the arc of the domed roof. Provide the height of the tank roof in feet ***NOT*** including the tank shell.

Table I.5: MAB External Floating Roof (EFR) and Domed External Floating Roof (DEFR) Storage Tanks

Name / Description of Liquid Commodity Being Stored	Unit Name / Unit Number	Tank Number	Tank Shell Diameter	Tank (Working) Volume	Number of Tank Turnovers	Net Throughput	Shell Color	Shell Condition	Roof Color	Roof Condition	Internal Shell Condition	Primary Seal Type	Secondary Seal Type	Roof Type	Roof Construction	Chemical Abstract Number	Gasoline Reid Vapor Pressure	Remark(s)
			(in feet)	BBL, (Note 1)	(Note 2)	BBL, (Note 3)	(Note 4)	(Note 5)	(Note 4)	(Note 5)	(Note 6)	(Note 7,11)	(Note 8,11)	(Note 9)	(Note 9)	(CAS Number)	(in psia)	(Note 10)
ATK	Tank Farm - 50/52	TK-50-113-117	165	832,480	22	49,421,000	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0.1	
		TK-52-153	144	122,227			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
		TK-52-154-156	153	391,362			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
		TK-50-118-121	182	803,000			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
		TK-52-187	150	124,626			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
JP5	Tank Farm - 50	TK-50-139/140	120	135,332	29	3,869,000	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		2	
Naphtha	Tank Farm - 50	TK-50-141-149	140	1,023,124	29	38,471,000	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Double Deck	Welded		11	
		TK-50-0109N/0110N		320,000			White	Good	White	Good	Light Rust							
ULSD	Tank Farm - 50	TK-50-131/132	136	218,000	31	44,908,220	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		2	Total ULSD shipped out minus the throughput for the Continuous Flushing Oil
		TK-50-122-126		902,000			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0.1	
		TK-50-135/136	83	218,470			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0	
DPK	Tank Farm - 50	TK-50-133/134	136	218,470	82	17,958,000	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0.1	
Lt. Naphtha	Tank Farm - 50	TK-50-156/157	96	241,744	20	4,745,000	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Double Deck	Welded		10.5	
Reformate	Tank Farm - 50	TK-50-152/153	96	84,214	60	5,037,000	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Double Deck	Welded		2.9	
ARDR	Tank Farm - 50/52(06)	TK-52-161	185	243,238	3	5,000,000	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0.01	Production is ~ 50,000 BBLS/Train. Shutdown scheduled every 3 months for 25 days for 1 train. Thus total throughput during shutdown is: 50,000 BBLS * 4 Times/Year * 25 Days/Shutdown
		TK-52-162/163	185	489,301			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
		TK-52-157	160	111,420			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
		TK-52-159/160/166	160	362,731			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
		TK-52-158	260	437,121			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
		TK-50-159		41,800			White	Good	White	Good	Light Rust							
Hvy. Naphtha	Tank Farm - 50	TK-50-154/155	96	84,113	35	2,920,000	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Double Deck	Welded		10.5	
Atm Residue	Tank Farm - 52	TK-52-164/165	200	535,297	141	75,555,000	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0.01	
Raw Kero	Tank Farm - 50	TK-50-101-103	136	326,857	1	214,480	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		2	S/D is planned for 14 days once in 30 months (2.5 yrs) for U15.
CGO/TGO/UCO	Tank Farm - 50	TK-50-150/151	130	200,909	16	4,964,000	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Double Deck	Welded		0	
		TK-52-170/174		112,800			White	Good	White	Good	Light Rust							
Bunker 380	Tank Farm - 52	TK-52-168	120	48,148	16	778,003	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0.01	Bunker loading quantity is assumed to be 2% of the total export volume (9,511,764 ton/yr). Convert to bbl/yr. Took ratio b/w TK-52-168 and TK-52-169 = 1.0076. Used ratio to adjust net throughput for each type of tank such that total throughput = 1,561,916 bbl (9,511,764 ton/yr)
Raw Naphtha	Tank Farm - 50	TK-50-106-108	101	139,438	0	24,500	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Double Deck	Welded		10.5	S/D is planned for 20 days, once in 48 months (4 yrs) for U17
Raw Diesel	Tank Farm - 50	TK-50-109-112	165	665,581	0	380,400	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		1.74	Units 116, 216 S/D once in 30 months (2.5 years) for 15 days. Tanks 129/130 serve as Intermittent Flushing Oil supply.
		TK-50-129/130	112	117,947			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
VGO	Tank Farm - 52 (06)	TK-52-171-173	240	939,644	1	540,000	White	Good	White	Good	Light Rust		Rim-Mounted	Pontoon	Welded		0	Accumulation for VGO is 43,200 BPCD --> Total VGO Produced at MAB =101,500 BPCD - Total VGO Consumed during U114 S/D = 58,300 BPCD . S/D is for 25 days once every 2 years.
KEC Crude	Tank Farm - 50	TK-50-168	197	265,000	416	170,157,160	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		13.05	Tanks serve as feed tanks to different units.
		TK-50-127/128	143	143,768			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
Slop	Tank Farm - 50/52(06)	TK-50-169	92	45,000	17	3,257,932	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Double Deck	Welded		1.45	Took Pump P-50-129 A/B Flow @ 13,200 BPSD and assumed 70% efficency.
		TK-52-111	90	16,848			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
		TK-50-160/161	92	66,215			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Double Deck	Welded			
		TK-50-0111N	108	62,000			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Double Deck	Welded			
Spent Diesel	Tank Farm - 50/52(06)	TK-52-112	80	36,009	3	199,959	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		1.74	For the Hydrocrackers: 3 hrs flushing, once in 24 months; took sulfiding rate at 517 m3/hr for one hydrocracker. For ARDS: 3 hrs flushing, once in 15 months; took flushing rate at 300 m3/hr.
		TK-52-113	67	16,142			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
		TK-50-137/138	59	23,917			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
Cont Flushing Oil (ULSD)	Tank Farm - 50	TK-50-162	48	14,100	196	2,760,780	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0.2	Based on rated flow for P-50-118A/B

This worksheet applies *only* to External Floating Roof (EFR) or Domed External Floating Roof (DEFR) type hydrocarbon storage tanks.

Note 1: Provide the tank working volume in barrels. Base the working volume on the maximum liquid height during the last 12 months of normal operation.

Note 2: Turnovers is the estimated number of times *per year* the tank is emptied and refilled. Turnovers = throughput divided by working volume. This number can be zero if liquid was stored and not pumped in or out for an entire year.
For surge tanks or constant level tanks the number of turnovers should be adjusted by multiplying by the average change in the liquid height in feet and dividing by the maximum liquid height. Enter this value or enter "4" as the default turnover rate. Then, adjust the net throughput by multiplying the adjusted turnovers by the working volume.

Note 3: Provide the annual net throughput in barrels per year. This number should be consistent with the tank working volume and number of turnovers per year.

Note 4: Choices for tank shell and roof color are: white, aluminum/specular, aluminum/diffuse, gray/light, gray/medium, or red/primer. Choose the color from this list which most closely matches the actual tank color. If unknown, use "white" as default.

Note 5: External shell and roof paint condition choices are: Good or Poor. Choose one. If unknown, use "Good" as default.

Note 6: The choices for internal shell condition are: light rust, dense rust, or gunite lining. Choose one. If unknown, use "light rust" as default.

Note 7: The choices for primary seal are: mechanical shoe, liquid-mounted shoe, or vapor mounted shoe. Choose one.

Note 8: The choices for secondary seal vary with the tank construction and primary seal type as follows: for riveted tanks or welded tanks with mechanical shoe primary seals, secondary seal choices are rim-mounted, shoe mounted or none;
for welded tanks with resilient-filled primary seals (both liquid and vapor mounted), secondary seal choices are : none, rim-mounted or weather shield.

Note 9: Choices for roof type are: pontoon or double deck. Choose one. Choices for tank construction are: welded or riveted. Choose one.

Note 10: Under remarks, please note if this is a Domed External Floating Roof (DEFR) type storage tank.

Note 11: This information is assumed.

Table I.6: SHUAIBA Vertical Fixed Roof (VFR) Storage Tanks

Name / Description of Liquid Commodity Being Stored	Unit Name / Unit Number	Tank Number	Tank Shell Diameter	Tank Shell Height	Maximum Liquid Height	Average Liquid Height	Tank (Working) Volume	Number of Tank Turnovers	Net Throughput	Shell Color	Shell Condition	Roof Color	Roof Condition	Roof Type	Slope of Cone Roof	Radius of Dome Roof	Height of Cone or Dome Roof	Gasoline Reid Vapor Pressure	Remark(s)
			(in ft)	ft, (Note 1)	ft, (Note 2)	ft, (Note 3)	BBL, (Note 4)	(Note 5)	BBL, (Note 6)	(Note 7)	(Note 8)	(Note 7)	(Note 8)	(Note 9)	(Note 9)	ft, (Note 9)	ft, (Note 9)	(in psia)	
ULSD	Tank Farm / 34	TK-34-408-410/421	200	64	60.50	58.50	1,214,000	18	28,013,833	White	Good	White	Good	Cone	1/16	100	6	2	As per SHU U34 Design Basis, Yearly shipped rate is 42 * 25,000 tonnes + 48 * 40,000 tonnes. Convert to BBLs
	Tank Farm / 34	TK-34-418	194	48	44.50	42.50	207,400			White	Good	White	Good	Cone	1/16	97	6		
	Tank Farm / 34	TK-34-342					128,800			White	Good	White	Good						
VGO	Tank Farm / 34	TK-34-061	150	64	60.50	58.50	180,600	0	305,130	White	Good	White	Good	Cone	1/16	75	5	2	Used the required volume at SHU for one S/D for Unit 84 every 24 months for 25 days. Found the ratio of volume distribution b/w the two types of tanks and adjusted the net throughput to reflect the available volume. Ratio b/w VFR and EFR tanks = 3.39:1
	Tank Farm / 34	TK-34-404/406/419	194	48	44.50	42.50	622,200			White	Good	White	Good	Cone	1/16	97	6		
	Tank Farm / 34	TK-34-420	200	64	60.50	58.50	303,500			White	Good	White	Good	Cone	1/16	100	6		
CGO/TGO/UCO	Tank Farm / 34	TK-34-422-424	200	64	60.50	58.50	910,500	0	253,600	White	Good	White	Good	Cone	1/16	100	6	2	One planned S/D for Unit 86 every 48 months (4 years) for 52 days. Thus the Net Throughput provided is the total throughput during shutdown divided by four (years).
	Tank Farm / 34	TK-34-425	194	48	44.50	42.50	207,400			White	Good	White	Good	Cone	1/16	97	6		

This worksheet applies *only* to Vertical Fixed Roof (VFR) type hydrocarbon storage tanks.

Note 1: Provide shell height (not including dome or cone roof height) in feet.
Note 2: Provide the maximum liquid height in feet of the liquid within the tank shell. This number must be less than or equal to the tank shell height.
Note 3: Provide the average liquid height in feet of the liquid within the tank shell. This number must be less than or equal to the maximum liquid height.
Note 4: Provide the tank working volume in barrels. This number must be consistent with the tank diameter and maximum liquid height. Base the working volume on the maximum liquid height during the last 12 months of normal operation.
Note 5: Turnovers is the estimated number of times *per year* the tank is emptied and refilled. Turnovers = throughput divided by working volume. This number can be zero if liquid was stored and not pumped in or out for an entire year.
For surge tanks or constant level tanks the number of turnovers should be adjusted by multiplying by the average change in the liquid height in meters and dividing by the maximum liquid height. Enter this value or enter "4" as the default turnover rate. Then, adjust the net throughput by multiplying the adjusted turnovers by the working volume.
Note 6: Provide the annual net throughput in barrels per year. This number should be consistent with the tank working volume and number of turnovers per year.
Note 7: Choices for tank shell and roof color are: white, aluminum/specular, aluminum/diffuse, gray/light, gray/medium, or red/primer. Choose the color from this list which most closely matches the actual tank color. If unknown, use "white" as default.
Note 8: External shell and roof paint condition choices are: Good or Poor. Choose one. If unknown, use "Good" as default.
Note 9: Roof type choices are: cone or dome. Choose one. For cone roof tanks, provide the slope in feet/feet. For dome roof tanks, provide radius in feet of the arc of the domed roof. Provide the height of the tank roof in feet *NOT* including the tank shell.
Note 10: Content is DPK designated and tested as ATK.

Table I.7: SHUAIBA External Floating Roof (EFR) and Domed External Floating Roof (DEFR) Storage Tanks

Name / Description of Liquid Commodity Being Stored	Unit Name / Unit Number	Tank Number	Tank Shell Diameter	Tank (Working) Volume	Number of Tank Turnovers	Net Throughput	Shell Color	Shell Condition	Roof Color	Roof Condition	Internal Shell Condition	Primary Seal Type	Secondary Seal Type	Roof Type	Roof Construction	Chemical Abstract Number	Gasoline Reid Vapor Pressure	Remark(s)
			(in feet)	BBL, (Note 1)	(Note 2)	BBL, (Note 3)	(Note 4)	(Note 5)	(Note 4)	(Note 5)	(Note 6)	(Note 7,11)	(Note 8,11)	(Note 9)	(Note 9)	(CAS Number)	(in psia)	(Note 10)
PCN	Tank Farm / 34	TK-34-321-326	130	659,400	15	18,791,800	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		10.5	Based on parcel sizes for the commodity shipped via the pier
		TK-34-402	194	172,700			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
		TK-34-429	180	198,400			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
		TK-34-121/122/145	110	260,700			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
JP5	Tank Farm / 34	TK-34-426-428	180	589,164	8	4,675,502	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		2	Based on parcel sizes for the commodity shipped via the pier
DPK	Tank Farm / 34	TK-34-411/413/417	194	622,400	44	53,254,000	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0.1	Based on parcel sizes for the commodity shipped via the pier
		TK-34-412/414	194	294,800			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
		TK-34-416	200	303,500			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
MGO	Tank Farm / 34	TK-34-342	134	128,700	-	-	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0.1	No impact from CFP
Bunker 380		TK-34-361/362	134	257,600	2	836,014	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0.1	Took 2% of total export and converted to BBLs/yr
Bunker 180		TK-34-343	134	128,700			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0.1	
Mogas 95	Tank Farm / 34	TK-34-124/125/143/144	110	347,200	1	514,000	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		10.5	No impact from CFP
	Tank Farm / 34	TK-34-235-237	90	166,800			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
Mogas 98	Tank Farm / 34	TK-34-123	134	86,900	1	86,900	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		10.5	
VGO	Tank Farm / 34	TK-34-011	160	199,800	0	89,970	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		2	Used the required volume at SHU for one S/D for Unit 84 every 24 months for 25 days. Found the ratio of volume distribution b/w the two types of tanks and adjusted the net throughput to reflect the available volume. Ratio b/w VFR and EFR tanks = 3.39:1
	Tank Farm / 34	TK-34-051/052	90	126,400			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
Raw Kero	Tank Farm / 34	TK-34-131-136	110	528,500	0	105,370	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		2	Used the required volume at SHU for one S/D for Unit 9 every 48 months for 25 days. Thus the Net Throughput provided is the total throughput during shutdown divided by four (years).
	Tank Farm / 34	TK-34-331	134	140,200			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
Raw Diesel	Tank Farm / 34	TK-34-021/022	90	126,400	0	324,435	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		0.1	Used the required volume at SHU for one S/D for Unit 58 every 24 months for 20 days. Thus the Net Throughput provided is the total throughput during shutdown divided by two (years).
	Tank Farm / 34	TK-34-126/137/ 141/142/146/147	110	574,200			White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded			
Kerosene/JP8	Tank Farm / 34	TK-34-238	90	55,600	2	111,200	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		-	Number of Turnovers and Net Throughput based on information from KNPC via KOT.
ATK + DPK	Tank Farm / 34	TK-34-430	160	196,388	39	7,659,132	White	Good	White	Good	Light Rust	Mechanical Shoe	Rim-Mounted	Pontoon	Welded		-	Number of Turnovers and Net Throughput based on information from KNPC via KOT.

This worksheet applies *only* to External Floating Roof (EFR) or Domed External Floating Roof (DEFR) type hydrocarbon storage tanks.
Note 1: Provide the tank working volume in barrels. Base the working volume on the maximum liquid height during the last 12 months of normal operation.
Note 2: Turnovers is the estimated number of times *per year* the tank is emptied and refilled. Turnovers = throughput divided by working volume. This number can be zero if liquid was stored and not pumped in or out for an entire year.
For surge tanks or constant level tanks the number of turnovers should be adjusted by multiplying by the average change in the liquid height in feet and dividing by the maximum liquid height. Enter this value or enter "4" as the default turnover rate. Then, adjust the net throughput by multiplying the adjusted turnovers by the working volume.
Note 3: Provide the annual net throughput in barrels per year. This number should be consistent with the tank working volume and number of turnovers per year.
Note 4: Choices for tank shell and roof color are: white, aluminum/specular, aluminum/diffuse, gray/light, gray/medium, or red/primer. Choose the color from this list which most closely matches the actual tank color. If unknown, use "white" as default.
Note 5: External shell and roof paint condition choices are: Good or Poor. Choose one. If unknown, use "Good" as default.
Note 6: The choices for internal shell condition are: light rust, dense rust, or gunite lining. Choose one. If unknown, use "light rust" as default.
Note 7: The choices for primary seal are: mechanical shoe, liquid-mounted shoe, or vapor mounted shoe. Choose one.
Note 8: The choices for secondary seal vary with the tank construction and primary seal type as follows: for riveted tanks or welded tanks with mechanical shoe primary seals, secondary seal choices are rim-mounted, shoe mounted or none;
for welded tanks with resilient-filled primary seals (both liquid and vapor mounted), secondary seal choices are : none, rim-mounted or weather shield.
Note 9: Choices for roof type are: pontoon or double deck. Choose one. Choices for tank construction are: welded or riveted. Choose one.
Note 10: Under remarks, please note if this is a Domed External Floating Roof (DEFR) type storage tank.
Note 11: This information is assumed.