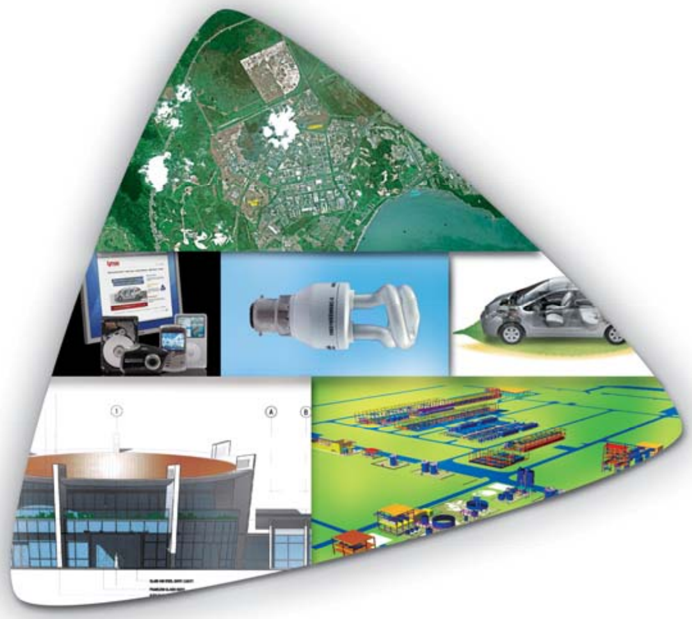
PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT AND QUANTITATIVE RISK ASSESSMENT

**PROPOSED ADVANCED MATERIALS PLANT
GEBENG INDUSTRIAL ESTATE, KUANTAN
PAHANG, MALAYSIA**



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Lynas
MALAYSIA SDN. BHD.

Prepared by:

ENVIRON CONSULTING SERVICES (M) SDN. BHD.
A307, PHILEO DAMANSARA II, 15, JALAN 16/11,
46350 PETALING JAYA, SELANGOR, MALAYSIA
TEL: + 60 3 7665 2986 FAX: + 60 3 7665 2987
www.environcorp.com

Contract No:	*MY110311A*
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Project Manager (signature):	*Viji Samuel*
Project Director (signature):	*Sheila Sharma*
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LIST OF ABBREVIATIONS

2020	Nation's Vision 2020
AELB	Atomic Energy Licensing Board
Ag	Silver
AMP	Advanced Materials Plant
AN	Ammoniacal Nitrogen
APHA	American Public Health Association
As	Arsenic
ASMA	Alam Sekitar Malaysia
Ba	Barium
BOD	Biochemical Oxygen Demand
bgs	below ground surface
Ca	Calcium
$C1_2$	Free Chlorine
Cd	Cadmium
Ce	Cerium
CN	Cyanide
CO	Carbon Monoxide
CO_3	Carbonate
COD	Chemical Oxygen Demand
Cr^{3+}	Chromium Trivalent
Cr^{6+}	Chromium Hexavalent
Cu	Copper
dB	desibel
DIVs	Dutch Intervention Values
DO	Dissolved Oxygen
DOE	Department of Environment
DSM	Department of Standards
Dy	Dysprosium
EAGC	East Asian Growth Corridor
ECID	East Coast Industrial Development
EDTA	Ethylenediaminetetraacetric Acid

EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
Er	Erbium
ERP	Emergency Response Plan
ESC	Erosion and Sedimentation Control Plan
Eu	Europium
FGD	Flue Gas Desulphurisation Residue
FOB	Fine Ore Bin
FGD	Flue Gas Desulphurisation
Gd	Gadolinium
GIE	Gebeng Industrial Estate
H_2SO_4	Sulfuric Acid
HF	Hydrogen Fluoride
Hg	Mercury
HDS	High Density Sludge
HIC	High Intensity Conditioner
Ho	Holmium
Hz	Hertz
INWQS	Interim National Water Quality Standards
IOM	Iron Oxide Material
La	Lanthanum
Ln	Lanthanide
LnO	Lanthanide Oxide
LOR	Level of Reporting
Lu	Lutetium
Lynas Corp	Lynas Corporation Ltd
Lynas	Lynas Malaysia Sdn Bhd
Mg	Magnesium
MM	Modified Mercalli
MMS	Malaysian Meteorological Services
Mn	Manganese
MNA	Malaysian Nuclear Agency
MPK	Majlis Perbadnaran Kuantan / Kuantan Municipal Council

MSL	Mean Sea Level
MVROM	*Ministry Van Volkshuisvesting Ruimtelijke Ordening en Milieubeheer* (Dutch Ministry of Housing, Spatial Planning and the Environment)
Nd	Neodynium
Ni	Nickel
NO_2	Nitrogen Dioxide
NSRs	Nearest Sensitive Receivers
NUF	Neutralisation Underflow Solids from the wastewater treatment process
O_3	Ozone
OSA	On-Stream Analyser
O&G	Oil & Grease
PAHs	Polycyclic Aromatic Hydrocarbons
PASDEC	Pahang State Development Corporation
Pb	Lead (Plumbum)
PETRONAS	Petroleum National Berhad
pH	log $[H^+]$
PID	Photo-ionizing Detector
PM_{10}	Particulate Matter
Pm	Promethium
Pr	Praseodynium
QRA	Quantitative Risk Assessment
ROM	Run-of-Mine
RMAQG	Recommended Malaysian Air Quality Guidelines
S^2	Sulphide
SAS	Sultan Ahmad Shah
SEDC	State Economic Development Corporation
SEG	Samarium, Europium, Gadolinium
SiF_4	Silicon Tetra Fluoride
Sm	Samarium
Sn	Tin
SMIs	Small and Medium size Industries
SO_2	Sulfur Dioxide

SO_3	Sulfur Trioxide
SPT	The Standard Penetration Tests
STPs	Sewage Treatment Plants
Surau	Mosque
SVOCs	Semi- Volatile Organic Compounds
SWL	Static Water Level
Tb	Terbium
TCM	tetrachloromercurate
TLDM	Tentera Laut DiRaja Malaysia / Royal Malaysian Navy
Tm	Thulium
TNB	Tenaga Nasional Berhad
tpa	tonnes per annum
TPH	Total Petroleum Hydrocarbons
TSF	Tailings Storage Facility
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
UMP	Universiti Malaysia Pahang
USCS	Unified Soil Classification System
VOCs	Volatile Organic Compounds
WHO	Worth Health Organization
WLN	Water Leach Neutralization Residue
WLP	Water Leach Purification
VAT	Value Added Tax
Y	Yttrium
Yb	Ytterbium
ZOI	Zone of Impact
Zn	Zinc

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CHAPTER ONE
1.0 INTRODUCTION

1.1 PROJECT OVERVIEW

Lynas Malaysia Sdn. Bhd. (Lynas), a wholly owned subsidiary of Lynas Corporation Limited (Australia) intends to construct and operate an Advanced Materials Plant on privately-owned industrial land located within the Gebeng Industrial Estate (GIE), Kuantan, Pahang. The proposed site is currently vacant and has an area of 100 ha.

The plant will process up to 80,000 tonnes per annum (tpa) wet weight basis of lanthanide concentrate (equivalent to 65,000 tpa dry weight basis) and produce 22,500 tpa (LnO or lanthanide oxide basis) of high purity lanthanide compounds in the form of a suite of six (6) different products. These products will be exported directly to the company's global customers based in the US, Japan, Europe and China.

Lynas Corporation Limited operates an open pit mine on a rich lanthanide deposit at Mt. Weld, Western Australia. At the mine site, the lanthanide ore will be extracted, crushed and concentrated to produce the lanthanide concentrate which is the primary raw material for the proposed plant. The concentrate will be transported from Mt. Weld by road and rail to Port for shipment via sea containers to Port of Kuantan in Pahang. The containers will be transported from the Kuantan Port by road to the project site within the GIE.

The regional location of the proposed plant site and a satellite image showing the site and its immediate surrounding areas are presented in **Exhibits 1.1** and **1.2.**

1.2 PROJECT BACKGROUND

Upon undertaking a project feasibility exercise in 2005-2006, Lynas Corporation Limited identified Malaysia as a viable location for the siting of their proposed Advanced Materials Plant based on economic and infrastructure considerations. Pursuant to this, discussions were held with the Malaysian Industrial Development Authority (MIDA) and other regulatory agencies and a 203 ha plot was identified within the Teluk Kalong Industrial Area (TKIA) in Kemaman, Terengganu as a suitable location for the establishment of the plant. With the intention of investing and operating the plant in Malaysia, the company incorporated its Malaysian subsidiary, Lynas, in November 2006. As required by the Department of Environment, Ministry of Natural Resources and Environment, the Preliminary EIA and QRA reports for the plant operations at this site were prepared and submitted to the department in May 2007. Approval from the department was obtained in July 2007. Lynas also obtained approval from the Atomic Energy Licensing Board (AELB) for the Class A Milling License (Siting and Construction Phases) in August 2007.

In late August 2007, Lynas received advice from MIDA stating that that the Malaysian Government would like to seek the company's consideration in relocating the plant to an alternative location. Given the nature of the operations, the presence of dedicated industrial estates for the chemical and petrochemical industries and the required supporting facilities and infrastructure, Lynas was requested to consider relocating the proposed plant within the State of Pahang. This request was made following high level consultations between the Federal Government and the State of Terengganu.

Realising the many benefits of siting the plant within the State of Pahang, the company decided to relocate the plant to the GIE in Kuantan, Pahang.

This Preliminary Environmental Impact Assessment (EIA) and Quantitative Risk Assessment (QRA) address the environmental impacts and risks arising from the establishment of the plant within the GIE.

1.3 LEGAL REQUIREMENT

In the promotion of environmentally sustainable development, the Government of Malaysia has established the necessary legal and institutional requirements to ensure that environmental factors are deliberated during the early stages of project planning.

Section 34A of the *Environmental Quality Act 1974 (and its Amendments)* requires any person intending to carry out a prescribed activity to submit a report on the impact on the environment to the Director General of the Department of Environmental (DOE) for examination. The *Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987* lists 19 Prescribed Activities that warrant the submission of an EIA to the Director General of the Environment for approval.

The proposed activity falls under *Prescribed Activity 11 (b): Ore processing, including concentrating for aluminium, copper, gold or tantalum* of the Regulations. Therefore, the submission of a preliminary EIA to the Department of Environment (DOE) Pahang for approval prior to project commencement is a legal requirement.

This preliminary EIA report has been prepared in accordance to the following guidelines published by DOE:

- The Handbook of Environmental Impact Assessment Guidelines (1995)
- Environmental Impact Assessment Guidelines for Industrial Projects (1994)

As required under the Guidelines for Industrial Projects published by DOE, a QRA has been undertaken for the proposed plant based on the requirements of the *Environmental Impact Assessment Guidelines for Risk Assessment (2004)* published by the DOE.

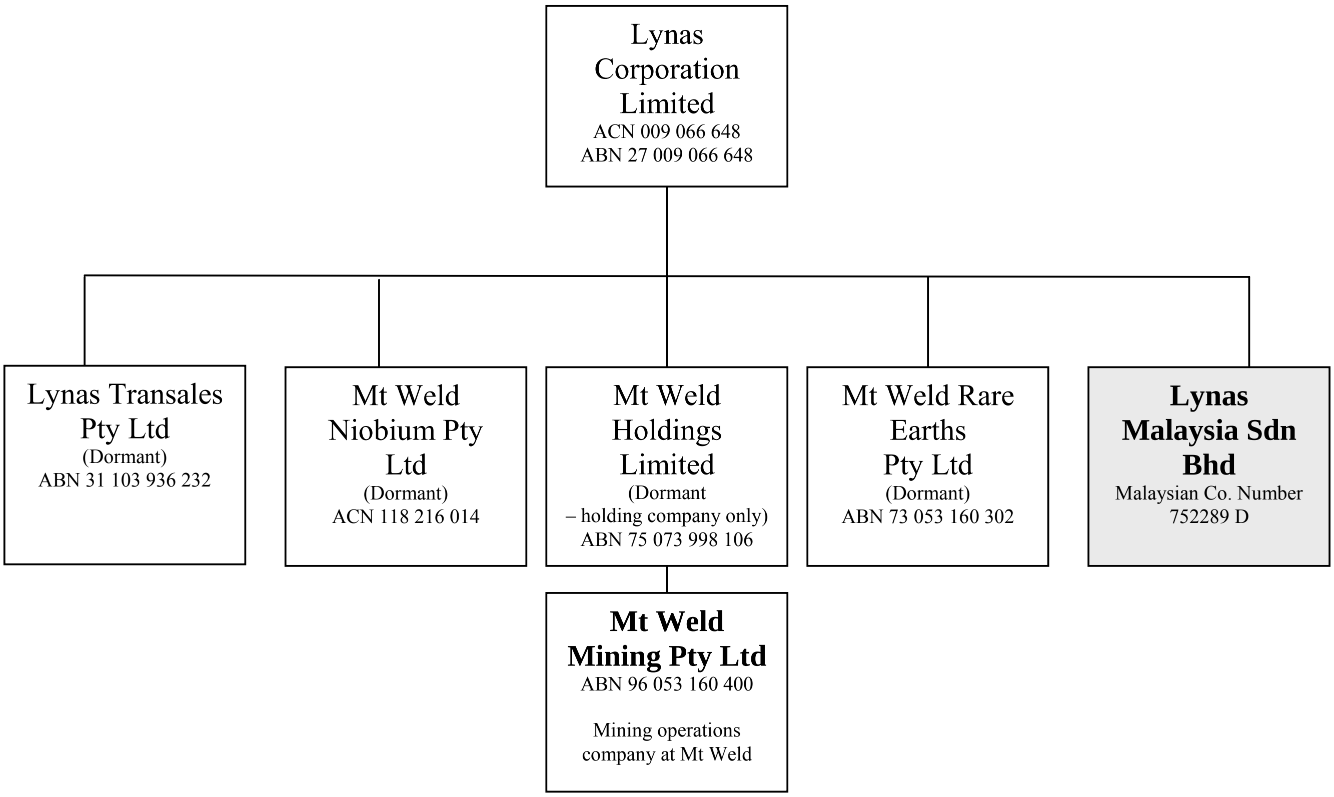
The lanthanide concentrate exhibits a low level of naturally occurring radiation is classified as a radioactive substance under the Atomic Energy Licensing Act, 1984 and therefore the operation of the plant requires a Class A Milling License from the AELB in accordance to the requirements of the Act. Since Lynas is in possession of the Class A Milling Licence (Siting and Construction Phase) for the original site in Teluk Kalong, Terengganu, the AELB has advised Lynas to submit information pertaining to the new site for evaluation and approval. The application was lodged on the 18th of January 2008. The Radiological Consultant for the project is the Malaysian Nuclear Agency (Nuclear Malaysia).

1.4 PROJECT PROPONENT

The Project Proponent is Lynas, a wholly owned subsidiary of Lynas Corporation Limited which is an Australian company headquartered in Sydney, New South Wales. The company is listed on the Australian Stock Exchange and the Singapore Stock Exchange, and has over 20 years of experience in the mining industry and 6 years of experience in the lanthanides industry. The major shareholders of the company are Ospraie Management, Goldman Sachs, JP Morgan and RAB Capital.

The company currently owns one of the few commercially viable lanthanides deposit outside of China, at Mount Weld in Western Australia which is the richest lanthanide oxide deposit globally.

The current corporate structure of the Lynas Group is illustrated below:



All enquires pertaining to the company, the proposed Advanced Materials Plant in Malaysia and the mining and concentration operations at Mt. Weld, Western Australia are to be directed to:

Malaysia

Lynas Malaysia Sdn. Bhd.
PT6869, Pusat Perniagaan Bukit Kuang 2
Bukit Kuang, Kemaman
24000 Terengganu
Malaysia

Telephone: +60 9 8584445
Facsimile: +60 9 8584449

Contact Person:
Mr. Michael Chan Tan Nean
Senior Manager

Australia

Lynas Corporation Ltd
Level 7, 56 Pitt Street
Sydney NSW 2000
Australia

Telephone: +61 2 8259 7100
Facsimile: +61 2 8259 7199

Contact Persons:
Mr. Michael J. Vaisey
Director, Lynas Malaysia Sdn. Bhd.
Vice President (Technical Development), Lynas Corporation Ltd

Mr Michael Wolley
Director, Lynas Malaysia Sdn. Bhd.
Vice President (Operations), Lynas Corporation Ltd

Mr. Nicholas Curtis
Chairman, Lynas Malaysia Sdn. Bhd.,
Executive Chairman, Lynas Corporation Ltd,

1.5 ENVIRONMENTAL CONSULTANT

Lynas has commissioned ENVIRON Consulting Services (M) Sdn. Bhd. to conduct a preliminary Environmental Impact Assessment of the proposed Advanced Materials Plant within the GIE. ENVIRON is registered with the Department of Environment (DOE) Malaysia as an EIA Consulting Firm.

ENVIRON Consulting Services (M) Sdn Bhd is a wholly owned subsidiary of Environ International Incorporation established in the US. As an international technical and scientific consultancy, ENVIRON provides state-of-the-art scientific, engineering, and strategic risk management assistance to clients worldwide including national and multinational industrial and commercial concerns, law firms, developers and property managers, trade associations, lending institutions, insurance professionals, and public sector agencies. The firm has regional offices throughout the US, UK, Europe, and Asia Pacific staffed by professionals with experience and expertise in a wide variety of disciplines, including engineering, geosciences, environmental sciences, life sciences, public health, and regulatory affairs.

Table 1.1 lists the team members and their respective roles and responsibilities in successfully completing this study. The key team members are registered with the DOE as EIA Consultants (Individual Category).

All questions pertaining to this study can be directed to:

ENVIRON Consulting Services (M) Sdn Bhd
A307, Phileo Damansara 2,
15, Jalan 16/11,
Off Jalan Damansara,
46350 Petaling Jaya, Selangor Darul Ehsan.

Telephone: +60 3 7665 2986
Facsimile: +60 3 7665 2987

Contact Persons:
Ms. Viji Samuel/Ms. Sheila Sharma

Table 1.1: EIA Study Team

Name	Designation/Responsibility
Sheila Sharma (DOE Registration No: C0366)	Project Director/ Technical Direction and Overview, Overall Environmental Management, Ecology, Impact Assessment and Mitigation Measures.
Viji Samuel (DOE Registration No: C0105)	Project Manager/ Preparation of EIA Report, Water Quality Solid & Scheduled Waste, Socio-Economy, Traffic & Transportation, Aquatic Biology and Environmental Management.
Nicholas Ng Tuan Hooi (DOE Registration No: AS0131)	Project Engineer/ Geology, Hydrogeology, Soil and Groundwater and Waste Management.
Gaya Indran (DOE Registration No: AC0077)	Project Assistant/ Assisting in preparation of EIA Report, Hydrogeology, Water Quality, Scheduled Waste, Environmental Management.
Taufik Rashidi (DOE Registration No: AC0368)	Site Engineer/Supervision of Baseline Environmental Monitoring Programme & ACAD Support
Brian Bell, Ruth Rogan	Air Quality Modelling Specialist
Ian Mockett HR Wallingford (M) Sdn. Bhd.	Water Quality Modelling Specialist
Daniel Lloyd Lloyd's Acoustics Ptd. Ltd. (Australia)	Noise Modelling Specialist
Henk Hersft Det Norske Veritas	Quantitative Risk Assessment
Environmental Science (M) Sdn Bhd	Environmental Monitoring and Laboratory Analysis
ALS Technichem (M) Sdn. Bhd.	Environmental Monitoring and Laboratory Analysis

1.6 PROJECT CONCEPT

1.6.1 Lanthanides

Lanthanides are a group of chemical elements comprising 15 metallic elements known as the Lanthanide Series. These elements are represented by the single square of Lanthanum in the main part of the periodic table, and listed in a separate sub group to the main groupings as shown in the Periodic Table presented in **Exhibit 1.3.**

The elements within the Lanthanide Series are named in **Table 1.2** below.

Table 1.2: Lanthanides Elements

Lanthanides Element							
Ce Cerium	Dy Dysprosium	Er Erbium	Eu Europium	Gd Gadolinium	Ho Holmium	La Lanthanum	Lu Lutetium
Nd Neodymium	Pr Praseodymium	Pm Promethium	Sm Samarium	Tb Terbium	Tm Thulium	Y Yttrium	Yb Ytterbium

Lanthanides are not found as individual free metals in the earth's crust, rather within a mix of the elements in various mineral forms that need to be separated for their individual or combined commercial use. The Mt Weld deposit in Western Australia is the richest known lanthanide deposit globally.

1.6.2 Industrial Application of Lanthanides

Lanthanides have unique properties which make them indispensable for many technological applications. These elements play a critical role in several sectors including the electronics, automotive, environmental protection and petrochemical industries. In particular, the automotive industry is of great importance, with lanthanides playing a key role in the operation of hybrid vehicles.

As these industries grow and as global research continues to develop new applications for lanthanides, demand for these elements as well as their products is expected to increase. Some of the main applications of lanthanides are listed in **Table 1.3** below.

Table 1.3: Industrial Application of Lanthanides

Application	Examples of Application	Benefits
Environmental Applications	• Catalytic converters • Hybrid vehicles • Water treatment • Lead replacement in paints	Greenhouse Gas Reduction
Digital Technology	• Lanthanide magnets • Flat panel displays • Ceramic capacitors	Enabling miniaturisation
Energy Conservation & Colour and Lights	• Compact fluorescent lights • NiMH batteries • Fuel cells • Phosphors for flat screen displays/monitors using CRT, LCD and PDA technologies • Polishing powders	Energy saving

An illustration of the various lanthanide applications is presented in **Exhibit 1.4.**

1.6.3 Proposed Advanced Materials Plant in Malaysia

Lynas intends to construct and operate the Advanced Materials Plant within the Gebeng Industrial Estate (GIE) in Kuantan, Pahang, Malaysia. The lanthanide concentrate which is the primary raw material for the plant will be obtained from the Mt. Weld mine operations located near Laverton in Western Australia. The lanthanide deposit at Mt Weld was discovered more than 20 years ago and over the years some AUD 25 million has been spent for the improvement of its resource quality. The deposit is based on a concentration of lanthanide elements within a residual weathered horizon which overlies the 3 km-diameter carbonatite intrusive.

The proposed Advanced Materials Plant in Malaysia will process the lanthanide concentrate (raw material) to produce a suite of products comprising individual lanthanide elements or mixtures of elements which can be used directly in selected industries or subjected to further downstream processing.

At Mt. Weld, the lanthanide ore will be extracted via open pit mines, stockpiled and crushed onsite to a particle size of 40mm. These aggregates will then be conveyed to a concentrator plant located within the mine site. The resultant product of the concentration process is the lanthanide concentrate and will be transported to Port, some 1000 km south of Mt. Weld for shipping to Port of Kuantan, Pahang, Malaysia.

From the Port of Kuantan, the concentrate will be transported to the proposed plant site within the GIE which lies about 3 km northwest of the port.

In its natural form, the mined lanthanide ore has low level of radioactivity measuring approximately 30.6 Bq/g. The thorium and uranium contents of the ore are 750 ppm (as ThO_2) and 28 ppm (as U_3O_8) by weight respectively. After the concentration process, the radioactivity of the lanthanide concentrate is estimated at 61.0 Bq/g with thorium and uranium contents of 1600 ppm (as ThO_2) and 29 ppm (as U_3O_8) by weight respectively.

At the Advanced Materials Plant within the GIE, the imported lanthanide concentrate will undergo two main stages of processing, i.e. (1) cracking and separation and (2) product finishing. In the first stage, the concentrate will be roasted with sulphuric acid in rotary kilns at high temperatures and atmospheric pressure and, water leached to produce a lanthanide sulphate solution. This solution will then be subjected to a series of solvent extraction systems for the extraction of the lanthanide elements in solution. The solution will then be further separated and purified into the final products (individual lanthanide elements or mixed lanthanide elements) in the product finishing stage.

The Advanced Materials Plant will be designed for a lanthanide production capacity totalling some 22,500 tpa (LnO or lanthanide oxide basis), distributed over a range of high purity products.

The mix of products can be varied within a range according to market demand, and design capacities for individual lanthanide products are as follows (volumes are LnO equivalent):

SEG/HRE Carbonate	1,160 tpa
LCPN Carbonate	5,400 tpa
Lanthanum Chloride, Carbonate or Oxide	2,800 tpa
Lanthanum-Cerium Carbonate	8,200 tpa
Cerium Chloride, Carbonate or Oxide	5,400 tpa
Dydimium Oxide	5,600 tpa
Neodymium Oxide	2,000 tpa
Praseodymium Oxide	800 tpa

SEG-HRE carbonate is a product containing Samarium, Europium, Gadolinium (SEG) and Heavy Rare Earths (HRE) such as Terbium, Dysprosium and Yttrium, in a carbonate form. The customers for this product are the processors that produce phosphors for colour screens and energy efficient lighting such as compact fluorescent lights.

LCPN Carbonate contains Lanthanum, Cerium, Praseodymium and Neodymium and will be sold to downstream processing plants for separation into individual lanthanide products.

Lanthanum Chloride, Carbonate or Oxide will be produced according to customer requirements, for use in the manufacture of Fluid Cracking Catalysis (used in oil refining) and to the manufacturers of battery alloy for nickel metal hydride (NiMH) rechargeable batteries. There is potential for downstream processing to battery alloy with the addition of a metal production plant. High purity Lanthanum Oxide is used for optical lens glass. Lanthanum chloride is used for chemical catalysts and for water treatment.

Lanthanum-Cerium Carbonate will be sold directly to the manufacturers of glass polishing powder for the plasma TV and LCD TV industries.

Cerium Chloride, Carbonate or Oxide will be produced and sold directly to manufacturers of automotive catalysts powders for the automotive industry.

Didymium Oxide (Praseodymium and Neodymium combined) and Neodymium Oxide will be sold to manufacturers of magnetic alloys, and there is potential to go further downstream with the addition of a metal production plant.

Praseodymium Oxide will be sold to manufacturers of pigments for the colourisation of ceramic tiles and plastics.

The radioactivity levels of these products will be *very low* as the radioactive components present in the ore (uranium and thorium) will be retained in the solid waste streams generated from the processes within the plant.

The finished products from the plant will be packaged and transported to the Port of Kuantan for shipment via containers to the company's global customers.

1.7 PROJECT IMPLEMENTATION SCHEDULE

Preliminary earthworks for the development of infrastructure will commence in mid-January 2008. Approval for these activities has been issued by the Department of Environment, Pahang via written correspondence dated 4th December 2007 (a copy of the letter is attached in Appendix 1 of this section), subject to compliance of a set of approval conditions.

Plant construction activities are scheduled to commence in March 2008 followed by the equipment commissioning activities. Completion of the construction phase is expected to be in June 2009 at which time plant operations will commence. The civil and structural works, equipment installation, dry commissioning and wet commissioning of the various plant components will be undertaken concurrently in stages to achieve this target.

The detailed project implementation schedule is presented in **Exhibit 1.5.**

1.8 STATEMENT OF NEED

1.8.1 Global Lanthanides Market Demand

Global demand for lanthanides was 95,000 metric tons lanthanide oxide equivalents in 2005 and is expected to grow annually by 10% to over 154,000 metric tons by 2010.

The lanthanides applications are expected to grow in line with its increased usage in permanent magnets, consumer electronics and automotive catalytic converters. In particular, demand growth will be seen in the automotive industry as more electric components replace hydraulic systems and more NiMH rechargeable batteries are used in hybrid vehicles.

The expanding lanthanides market will require higher purity mixed and separated lanthanide products to meet the growing demand for the elements in demand. Therefore, strong demand is expected for cerium in automotive catalysts, lanthanum in NiMH batteries and those elements used in Neo magnets (Neodymium, Praseodymium, Dysprosium, and Terbium).

Global supply of lanthanides has experienced significant changes in the past decade. China currently supplies approximately 95% of the global lanthanides market with more than 70% of the supply of light lanthanides originating from one mine in China. With this, global lanthanides processors have relocated their production plants to China resulting in China becoming the dominant supplier of the lanthanide oxides (with over 90% of the total supply capacity) as well as the dominant processor and user of refined lanthanide compounds.

However, with the recent implementation of more stringent regulatory controls imposed by the government, the quantity of lanthanides extracted from China is expected to decrease. Exploitation of alternative sources is now necessary to cater for the high demand for the lanthanide elements and to ensure a steady and adequate supply for the global processors.

Mt Weld in Western Australia has a very high grade deposit containing light lanthanides and Europium, a heavy lanthanide element and is currently the only commercially viable resource of significant size outside of China. The lanthanide deposit at Mt. Weld in Western Australia which has significant commercial value is now deemed an important alternative source for lanthanide elements. The deposit is currently the world's richest lanthanide oxide body, capable of supplying up to 20% of the global market for over 30 years.

The proposal by Lynas to commercially mine the lanthanide deposit and process it into the various elements is therefore timely and justified.

1.8.2 Industrial Development in Pahang, Malaysia

Industrial development is one the core economic sectors of the State of Pahang. Realising the importance of this sector, the State Government has established the necessary mechanisms to promote and support industrial development, specifically heavy industries, iron and steel industries, oil and gas and the chemical & petrochemical sectors. The GIE which comprises predominantly of these industries significantly contributes to the economy of the Pahang State as a whole[1].

[1] Kuantan Structure Plan for 2015, Kuantan Municipal Council

Gebeng falls within the East Coast Industrial Development (ECID) Corridor also known as the East Coast Corridor, a new growth area earmarked for rapid industrial development in the States of Terengganu, Pahang and Kelantan. This corridor also forms part of the East Asian Growth Corridor (EAGC) which includes Sabah, Sarawak, Brunei, the Philippines and Indonesia (Borneo). The EAGC was set up to support bi-lateral economic relationships between Malaysia, Indonesia and Philippines.

Based on its close proximity to Kuantan which is the centre for the ECID, Gebeng has been designated as one of the key growth centres within the ECID.

The State Governments of Terengganu and Pahang envisage that the industrial areas at Kerteh, Chukai-Kemaman and Gebeng will eventually become Malaysia's leading industrial hub, feeding the increasing demand to domestic industries and also taking advantage of the Port of Kuatan and Port of Kemaman as a gateway to lucrative regional and international exports.

Hence, the setting up of the Advanced Materials Plant within the ECID not only complements the vision and aspirations of the State Government but will also encourage the growth of other supporting industries within the locality which will lead to overall positive socio-economic benefits (as discussed below).

1.8.3 Positive Socio-Economic Impacts to Malaysia

Lynas proposal to set up the plant within the GIE is in line with the Pahang State Government's development strategy to encourage and increase the establishment of industrial operations by foreign investors. The State has created a suitable environment for potential multinational investors in all aspects of investment, i.e. the development of dedicated industrial estates, utilities, amenities, infrastructure and other monetary and non-monetary incentives.

The benefits accrued by the GIE, Kuantan and the State of Pahang, as well as the nation resulting from the setting-up of the plant in Malaysia are elaborated below.

a. Inflow of Foreign Direct Investment

The estimated total capital investment for the Advanced Materials Plant in Malaysia is approximately RM 550 million. The operating expenditure in Malaysia for first 15 years is estimated to be RM 2.8 billion, excluding costs of the lanthanide raw material. The proposed investment is wholly in line with the Malaysian Government's efforts to encourage foreign direct investments into the Eastern Corridor of Malaysia. With such a substantial investment budget, Lynas being the pioneer company manufacturing lanthanide products, this project is expected to have a significant positive impact on the Malaysian economy.

The lanthanides industry is inherently capital intensive and technologically advanced. This heavy capital investment into the Eastern Corridor of Malaysia will benefit Malaysia greatly in terms of infrastructure development, creation of business opportunities and jobs for local Malaysian and positive spin-off effects or cluster development of relevant supporting industries in Malaysia.

b. Export Revenue – Foreign Exchange Earnings

The export revenue from the high purity lanthanide products from the Advanced Materials Plant is projected to be RM 9.5 billion over the first 15 years. This constitutes a major contribution to the Malaysian economy and translates into significant cash inflow into the Malaysian economy that will spur the growth of not only the Eastern Corridor but the country as a whole.

c. Transfer of Technology

Processing of lanthanides is a pioneer activity in Malaysia. This significant investment into Malaysia will introduce new manufacturing processes and hence, expose Malaysia to new technologies and expertise, particularly since the technology in this industry is presently predominantly concentrated in China.

Lynas owns propriety technology for the recovery of lanthanide minerals from ores and this will be employed in the proposed plant.

Lynas will also employ state of the art solvent extraction equipment and process technologies for the purification and separation of the lanthanide elements. These technologies enable the production of high purity lanthanide oxides that are the raw

materials for the manufacture of lanthanide metal for magnets and batteries, polishing powders, catalysts, and glass, etc.

This degree of processing proposed by Lynas does not exist in any location outside of China. With the application of modern technology and operation according to high environmental standards, the operation in Malaysia will be a benchmark within the industry in terms of scale of production, product quality, and environmental performance.

From this pioneer investment, the transfer of technology will take place at the point when employees are sent for training in Australia or overseas and also, by way of regular visits by foreign technical specialists who will be sent to Malaysia to provide onsite job training to the local staff based at the plant.

Furthermore, Lynas is currently in talks with the State Government of Pahang to collaborate with the Universiti Malaysia Pahang (UMP) and conduct pioneer research and development activities in Malaysia using both foreign n and local expertise. This will greatly benefit Malaysia as it will help to improve the knowledge and skills of the local workforce thereby creating a new area of skills specialisation which could be applicable for the same or similar/related industries in the near future.

d. The Growth of Supporting Industries and Surrounding Areas

The proposed plant is also expected to contribute to the strengthening of industrial linkages and enhancement of productivity through a full integration of activities aimed at transforming the manufacturing sector in the Eastern Corridor into a resilient, broad based and internationally competitive sector. Notably, competitiveness of the manufacturing industry is generally enhanced by focusing on cluster development through the deepening and broadening of inter-linked and related activities.

Examples of inter-linked and related activities that are expected to develop in the East Coast Corridor through the operation of Lynas' plant in Gebeng are as follows:-

- Chemicals;
- Gas and petroleum;
- Chemical reagents;
- Water;
- Transport/logistics;
- Insurance; and
- Banking.

The proposed project in Malaysia is also expected to contribute towards the Government's efforts in driving the nation to achieve the status of a fully developed nation by the year 2020 (i.e. the nation's Vision 2020) and ensuring a strategic shift towards knowledge-intensive, capital-intensive and high-technology based industries linked by innovative research and development and also, cluster development of supporting industries.

Additionally, the lanthanides plant is expected to complement the Government's efforts in attracting the establishment and relocation of the following industries in Malaysia with the availability of lanthanide products within Malaysia, i.e. through import substitutions:

- Hybrid vehicles
- Catalytic converters
- Lanthanide magnets
- Flat panel displays
- Ceramic capacitors
- Compact fluorescent lights
- NiMH batteries
- Fuel cells
- Phosphors
- Polishing powders

Specifically, the different applications where lanthanides play a vital role include:

- Hybrid vehicles
- Catalytic converters
- Lanthanide magnets
- Flat panel displays
- Ceramic capacitors
- Compact fluorescent lights
- NiMH batteries
- Fuel cells
- Phosphors
- Polishing powders

With the establishment of the plant, it is also expected that development of new, technologically advanced industries including small and medium size industries (SMIs) that use lanthanide products as raw materials/components will be promoted.

e. Employment Opportunities

The proposed plant is expected to employ 398 local Malaysian and 20 expatriate employees in the 1st year of operations.

The role of the expatriate employees will be to train and guide the Malaysian employees, with the objective of further enhancing the Malaysian employees' skills and industry knowledge on lanthanide processing. It is envisioned that the local employees will attain sufficient skills and technical knowledge to subsequently take over the responsibilities from the expatriates.

Consequently, this will lead to further job opportunities for Malaysians not only in the lanthanides industry but also, job opportunities for the manufacturing sector in the Eastern Corridor on the whole as a result of the spin-off effects to related supporting industries and sectors such as chemical, gas and petroleum, chemical reagents, water, transport/logistics, insurance and banking sectors, etc.

f. Economic Benefits

The proposed plant in Malaysia is expected to bring about positive multiplier effects to the Malaysian economy. Positive multiplier effects, resulting from the employment of local and foreign personnel and expenditure by both the company and its employees (both local and foreign) on daily necessities, telephone and utilities, support services such as transport and logistics, banking, insurance etc. and also, tax revenues to the Government is expected.

Based on a multiplier effect factor of 2 (i.e. 2 x multiplier effect of business expenditure and project operating costs), the total direct and indirect contributions to the Malaysian economy over the first 15 years of operations (year 2008 – 2022) by the proposed plant is estimated to be RM6.04 billion. In addition, Lynas' proposed operations in Malaysia are projected to generate approximately RM42 million in tax revenue for the Malaysian Government over its first 15 years of operations (year 2008 – 2022).

The setting up of the plant will also ensure the following:

- Counter-flow of foreign currency by reducing Malaysian imports of lanthanide products, hence, benefiting Malaysia in terms of its balance of payments position;

- Increased export revenue that results in a favourable position in the country's balance of payment position; and

- Creation of demand for local supplies of relevant raw materials and components such as chemical reagents (hydrochloric acid, sulphuric acid, magnesium oxide,
lime, etc.), gas, etc. which is expected to encourage the shift towards the use of local contents by other relevant industries.

1.9 OBJECTIVES OF THE STUDY

The objectives of this EIA study are as follows:

- To select project options which are environmentally sustainable in relation to plant siting, landuse compatibility and plant operations;

- To identify the potential sources of environmental pollution arising from the construction and operation of the proposed plant within the GIE and to assess the

- Direct and indirect significant impacts on the natural, social and economic environments.

- To recommend suitable mitigation measures that can be incorporated into the design and operation of the plant thereby reducing the predicated impacts to sustainable levels which meet the prevailing regulatory requirements.

- To identify residual impacts that may potentially exist even after implementation of mitigation measures, and to outline the requirement for an Environmental Management Plan which includes environmental audits and monitoring programs for the construction and operation phases of the project.

- To provide an outline for an Emergency Response Plan to be developed prior to the commencement of the plant operations.

1.10 STRUCTURE OF THE REPORT

The remaining of this EIA report is structured as follows:

Chapter Two: ***Project Description*** provides a detailed description of the activities carried out during the construction and operational phases of the project.

Chapter Three: ***Project Options*** addresses the various options considered in selecting the site and the proposed plant operations and evaluates the project options by weighing the benefits of the Build-Out Option and No-Build Option.

Chapter Four: Existing Environment describes the environmental conditions within a 3-5 km radius of the Project site prior to the implementation of the project. The environmental quality data presented here represents the baseline data for the site.

Chapter Five: Potential Significant Impacts and Recommended Mitigation Measures assesses the potential environmental impacts arising from the implementation of the project during both the construction and operational phases and recommends mitigation measures.

Chapter Six: Environmental Management Plan (EMP) identifies the residual impacts and outlines a suitable Environmental Monitoring and Audit Programme.

Chapter Seven: Emergency Response Plan (ERP) describes the requirements for the preparation of an ERP for the operational phase of the plant.

Chapter Eight: ***Summary and Conclusions*** which summarises the findings and conclusions of the study.

1.11 LIMITATIONS OF THE REPORT

The conclusions presented in this report represent ENVIRON's professional judgment based on information made available during the course of this assignment and is true and correct to the best of ENVIRON's knowledge as of the date of the assessment. ENVIRON made reasonable efforts to verify the written and oral information provided in this assessment. The findings, opinion and conclusions presented in this report represent ENVIRON's best professional judgment based upon the information available and conditions existing as of the date of the report preparation. In performing its assignment, ENVIRON must rely upon information obtained from Lynas, publicly available information, government agencies and information provided by third parties. Accordingly, the conclusions in this report are valid only to the extent that the information provided to ENVIRON was accurate and complete. ENVIRON found no reason to question the validity of information received unless explicitly noted elsewhere in this report.

CHAPTER TWO
2.0 PROJECT DESCRIPTION

2.1 PROJECT LOCATION

The proposed rare earths processing plant will be located on 100 ha of industrial land within the Gebeng Industrial Estate (GIE) in Kuantan, Pahang.

This chapter describes the various activities envisaged during the pre-construction, construction and operational phase of the project.

2.2 PRE-CONSTRUCTION PHASE

Activities undertaken during this phase are focused primarily on obtaining physical data on the existing conditions at the project area. Key activities include:

- Geotechnical investigation;
- Land topography survey;
- Identification of ecological (terrestrial flora and fauna) resources;
- Environmental baseline monitoring for ambient air quality, river water quality, and boundary noise levels; and
- Soil and groundwater investigation.

During this phase, the conceptual design of the proposed plant and its associated facilities will evolve according to information and analyses obtained on the existing physical conditions and baseline environment at the site.

The geotechnical investigation and topographical survey of the site has been carried out in October/November 2007. The data obtained was used to determine the ground elevation and physical features of the project site for use in earthworks preparation, infrastructure planning, plant design platform level and residue storage facilities planned within the site.

For the activities listed above, some removal of the undergrowth and shrubbery was necessary. Equipment used were specialised drilling rigs as well as hand-augers and mobilisation of equipment and personnel were by small lorries. However, these activities were completed within a short duration with only minimal and temporal disruption to the environment.

A site reconnaissance and an environmental baseline survey were carried out from the in October 2007 by ENVIRON. During this baseline survey of the site, the existing terrestrial ecology at the site was also evaluated. The baseline survey comprised the following:

- Monitoring of ambient air quality and boundary noise levels at the site;
- Monitoring of ambient air quality and boundary noise levels at four locations within the site;
- Establishment of 7 borewells within the site and collection of soil and groundwater samples; and
- Collection of river samples during both the high and low tides from Sungai Balok.

The environmental impacts arising from these activities were minimal.

Overall, the activities carried out during the pre-construction phase are not significant.

2.3 CONSTRUCTION PHASE

The principal activities envisaged during the construction phase are as follows:

- Setting up and management of temporary facilities;
- Clearing of vegetation and undergrowth;
- Excavation and disposal of unsuitable foundation material;
- Site preparation works including filling and formation of platforms;
- Infrastructure and utility development; and
- Landscaping.

2.3.1 Temporary Facilities

Upon commencement of the construction phase, the typical structures that will be erected at the project site include a site office, temporary warehouse cum fabrication yard, construction worker's camp and sanitary facilities. In most instances, the site office will be in the form of transportable cabins and the warehouse typically constructed as an enclosed wooden structure or shed. The warehouse will be used for the storage of equipment and material and; also function as a fabrication yard.

Workers employed by Lynas for construction activities will either be housed within the site or housing facilities will be provided at the nearby residential areas. In the event the workers are housed within the site, a transit construction workers' camp will be set up on-site to house the workers. The workers' camp will generally comprise wooden structures provided with the necessary facilities. Some site clearing and earthworks together with temporary utility provisions will be carried out onsite for this purpose. Basic amenities, i.e. water supply, electricity and sanitation facilities will be provided. Sanitation facilities will be in the form of portable toilets with designs approved by the *Department of Sewerage Services, Ministry of Housing and Local Government.*

In hiring the construction workforce, priority will be given to Malaysians. However, if foreign labour is required to supplement the local workforce, an official hire process will be adhered to prevent the engagement of illegal foreign nationals at the site.

2.3.2 Land Clearing

As the proposed plant site has been largely cleared, only the existing remnant peat swamp vegetation and other secondary invasive species will need to be cleared.

Information on the cut and fill areas, excavated volume for disposal and quantity (and source) of backfill required were not available at the time of reporting. All excavated material will be reused within the site. There will be no removal of excavated material from the site.

The burning of vegetative biomass is strictly prohibited under the *Environmental Quality (Clean Air) Regulations 1978.*

2.3.3 Transportation of Building Materials and Machinery

Major plant and equipment for the construction activities are likely to include:

- Piling rigs
- Bulldozers
- Excavators
- Cranes
- Lorries/transport trucks

Construction machinery and materials will be transported to the site in low loaders and heavy load bearing transport vehicles via the main Gebeng By-pass Road and the main entrance into the GIE. The movement of these vehicles may cause traffic congestion during peak hours. Impedance to the normal traffic flow can be minimised by avoiding the peak traffic hours (i.e. 7.00 am – 9.00 am and 4.00 pm – 7.00 pm).

2.3.4 Infrastructure and Utility Development

Drainage

The drainage network within the site will be designed to convey the increased surface runoff from the site. Although, the drainage system is normally designed to follow its natural course, there will be with some degree of realignment. Drains will be designed as unlined channels. The site drainage will be designed to lead into a stormwater detention pond located close to the southern boundary of the site. The detention pond will provide flood attenuation during peak rainfall incidences. The overflow from this detention pond will find its way into the existing external earth drain which runs along the southern boundary of the site. The drain flows in a westerly direction to discharge into Sungai Balok.

The construction of drains within the site would involve excavation of trenches, laying of the bedding (normally crusher run or sand), followed by the laying and jointing of the pre-cast sections. Options for drains may include closed conduit systems or covered rectangular channels discharging into open main/monsoon drains.

During the construction phase, an adequately designed silt trap will be constructed at the southwestern corner of the site. This area is similar to the area allocated for the stormwater detention pond during the operational phase.

Temporary roads will be constructed for the entry/exit to the site and for the movement of construction machinery and vehicles within the site during the construction phase. The roads will generally be laid with crusher-run. Some of these roads may be converted to permanent roads for the operational phase of the project. All road exits which lead out of the site will be provided with a wheel washing trough to prevent the carry over of mud and sediments onto public roads.

Utility works will involve trenching to lay the respective conduits for potable water supply, sewage, natural gas, telecommunication cables, electricity cables; and construction of utility structures such as water storage tanks, pump houses, sewage treatment plants (STPs) and electrical sub-station. These structures should be suitably located to minimise interruption to traffic flow during the operational phase and adverse visual impacts during maintenance activities. As far as possible, trenching works should be coordinated with road and drainage works.

2.3.5 Construction Activities

Building construction will proceed upon completion of earthworks and will involve the construction of sub-surface and foundation platforms, erection of reinforced concrete frames and construction of buildings/structures.

Specialised rigs, piles (either steel or more commonly, pre-cast concrete) will be mobilised followed by the pile driving process. There are various forms of pile-driving techniques involving hydraulic injection, boring and the conventional drop hammer. The drop hammers are noisier comparatively and due consideration will be given in selecting a more quieter piling method.

Other construction activities will involve the transport of construction materials such as cement, sand, aggregate, formwork and steel reinforcement bars to the site. Ready-mixed concrete will also be imported to the site unless a cement batching plant is set up within the site.

2.3.6 Landscape and Revegetation

Once the building activities are completed, the site will be landscaped and revegetated. Vegetation will be planted along the plant boundary for noise attenuation and filtering of air pollutants.

All denuded areas will be revegetated or paved as soon as possible to minimise erosion risks especially during the monsoon season.

2.4 OPERATIONAL PHASE

2.4.1 Concentration Plant (Mt Weld, Western Australia)

The concentration process will be undertaken at the Concentration Plant located within the mine site at Mt. Weld in Western Australia. The main processes include:

- Crushing
- Milling
- Rougher flotation and three stages of scavenger flotation
- Five stages of cleaner flotation
- Concentrate thickening and filtration
- Tailings, concentrate storage and packaging, and discharge to storage facility

The flotation circuit will consist of one stage of rougher flotation and three stages of scavenger flotation, with the combined rougher-scavenger concentrate fed to a cleaning circuit consisting of five stages of cleaner flotation. The final product will be a concentrate assaying approximately 40% lanthanide oxide basis (LnO), at a design recovery of 63%. Each flotation stage will include conditioning tanks as required for addition of the following:

- Steam for heating.
- Sodium hydroxide solution for pH modification.
- Sodium silicate solution for dispersion.
- Sodium fluorosilicate and sodium sulphide solutions for gangue depression.
- Fatty acid collector, DQ.

The final lanthanide concentrate will be de-aerated and mixed with flocculant and lime before being fed to the concentrate thickener. Thickened concentrate will be pumped to a plate and frame filter for dewatering. The filter will produce a filter cake with $<20\%$ moisture, and a filtrate solution, which will be returned to the concentrate thickener for recovery of ultra-fine solids.

It is envisaged that the lanthanide concentrate filter cake will be directly bagged (2.2 tonne bags or 1 x 20 tonne bag) and placed into sea containers on weigh cells to hold exactly 20 tonnes of material. The sea containers will then be loaded onto road trains for haulage to Leanora where they will be placed on to the rail for haulage down to Fremantle for shipment to the Advanced Materials Plant in Malaysia.

Approximately 66,000 tonnes of lanthanide concentrate at < 20% moisture content will be shipped annually from the Port of Fremantle in Western Australia to the Eastern Wharf of the Port of Kuantan in Pahang. This quantity will be shipped weekly via 60 to 80 sea containers movements per week. The sea containers will then be unloaded at the port after the standard port and customs clearance procedures.

The sea containers will be loaded onto trucks and delivered to the advanced plant site within the Gebeng Industrial Estate which is located about 3 km west of the port. On an average, the transportation frequency is expected to be 6 days per week 13 deliveries per day.

The specific radiation activity (total activity) of the ore is 61.0 Bq/g. The thorium and uranium content of the ore are 1600 ppm (as ThO_2) and 29 ppm (as U_3O_8) by weight respectively. The Malaysian Nuclear Agency, the radiological consultants appointed by Lynas are presently in the midst of determining radiation safety issues pertaining to lanthanide concentrate storage, handling and transport.

2.4.2 Cracking and Separation Plant

The main processes involved in the Cracking & Separation Plant include:

- Lanthanide Concentrate Handling
- Lanthanide Concentrate Cracking
- Leaching
- Upstream Extraction
- Downstream Extraction
- Product Finishing

A block flow diagram representing the processes within the Cracking and Separation Plants is presented in **Exhibit 2.2.**

2.4.2.1 Lanthanide Concentrate Cracking

A diesel powered loader will be used to transfer the lanthanide concentrate from the site stockpile into the concentrate feed hopper (capacity of $10m^3$).

From the hopper, the concentrate will be fed onto a belt conveyor and transported to the cracking plant which will consist of two parallel processing trains. The lanthanide concentrate will be fed via two belt weighfeeders into the concentrate-acid mixers, where sulphuric acid (98%) will be added. The mixed slurry will be pumped into the rotary kilns where it will be heated to approximately 650°C over a period of 2.5 hours. The products from the kilns will comprise cracked concentrate and tail gas.

The kilns are fuelled by hot gas generated by the combustion of Liquified Petroleum Gas (LPG); gas flow will be automatically controlled by the temperature at the hot end of the kiln. To allow for future expansion of the plant's processing capacity, an area has been provided in the layout for two (2) additional rotary kilns. These new kilns will be located in parallel to the original two (2) kilns.
Cracked concentrate discharges from the kiln into the leach tanks. Oversize from the kiln discharge will be collected in a skip, and will be crushed prior to feeding into the water leach circuit.

2.4.2.2 Leaching and Neutralisation

The soluble rare earth sulphates will be recovered from the cracked concentrate in a three stage leaching process. After the primary leach, the slurry will be filtered in two (2) filter presses to enable solid-liquid separation. The primary filter cake will be subjected to a second stage of leaching and filtration. Filtrate from this stage will be recycled to the primary leach circuit and the filter cake will be mixed with water for the third stage of leaching. After filtration, the final solids residue, which is referred to as the Water Leached Purification (WLP) solids, will be stored onsite in the secure WLP storage cell. Filtrate from the tertiary leach is recycled to primary and secondary leaching.

To remove some of the soluble impurities, the primary leach filtrate will be neutralized with magnesium oxide powder to achieve a pH of 3.5-4.0. The neutralized slurry will be filtered in two (2) filter presses. The filtrate from this operation will be filtered through a polishing filter press before being transferred to the first solvent extraction plant.

The filter cake from the neutralization process will be leached with weak sulphuric acid to recover precipitated rare earth oxide. The residue from this process will be filtered through a filter press and the filtrate will be recycled to the primary leach. The filter cake will be water washed and filtered with the tertiary leach product to become part of the WLP solids.

2.4.2.3 Extraction

Solvent extraction will be used to purify, separate and concentrate the lanthanides before their precipitation into products.

In solvent extraction, the lanthanide elements will be selectively extracted from the aqueous phase into an organic phase using a battery of mixer-settlers. A mixer settler refers to a combination of an agitated tank, where the aqueous and organic phases are mixed and the metal extraction occurs, and a rectangular settling vessel where the phases separate into two distinct layers. The organic and aqueous phases will flow through the battery of mixer-settlers counter-current to one another to achieve the optimum levels of organic loading, separation and recovery. As the aim of each stage of extraction is different, the conditions within the mixer-settlers will be controlled to remove part of, or all lanthanide elements to the organic phase from aqueous phase.

To further improve separation efficiencies, the loaded organic phase will in scrubbed with either dilute sulphuric or dilute hydrochloric acid. Scrubbing equipment will be similar to the extraction equipment, involving a group of mixers and settlers.

The scrubbed organic phase, which is loaded with lanthanides, will then be stripped by contact with either 4.5M or 6M hydrochloric acid. Stripping is the transfer of lanthanides from the organic back into the aqueous phase. The lanthanides in the aqueous strip solutions will either be transferred to the next extraction system for separation into individual lanthanide elements or used to produce a mixed lanthanide product directly.

After stripping, the organic phase will be washed with water in additional mixer-settlers. The wash solutions will contain hydrochloric acid, and will be routed to the hydrochloric acid preparation circuit for re-use. The washed organic will be stored in a tank, from where it will be continually recycled to extraction.

A total of five (5) organic liquids will be used for extraction in the cracking and separation plant. These are:

- Extractant: P204, Di(2-ethylhexyl) phosphoric acid ($C_{16}H_{35}O_4P$)
- Extractant: P507, 2-ethylhexyl phosphonic acid mono-2- ethylhexyl ester ($C_{16}H_{35}O_3P$)
- Extractant: N235, Iso Octylamine
- Modifier: Isooctyl alcohol, $C_3(C_2H_5)C_5H_{10}OH$
- Diluent: Kerosene

Hydrochloric acid (0.5M, 4.5 and 6M) will be used in solvent extraction. Concentrated hydrochloric acid (> 30%) will be transported by trucks to the Cracking and Separation Plant area and stored in 3 storage tanks. The acid will be pumped into agitated dilution tanks located within the extraction plant by two concentrated acid feeding pumps. Diluted hydrochloric acid will be fed to the extraction plant from these tanks.

Sodium hydroxide (6M) will also be used in the solvent extraction plant. The sodium hydroxide solution (30wt %) will be transported by trucks and stored in a storage tank. The solution will be pumped via two pumps to the agitated dilution tanks located within extraction plant. Diluted sodium hydroxide will be fed to the extraction plant directly from these tanks.

The extraction process is divided into two systems:

- Upsteam Extraction; which has a sulphate based aqueous phase and uses P204 solvent for extraction, and
- Downstream Extraction; which has a chloride based aqueous phase and uses P507 solvent for extraction.

Upstream extraction consists of three (3) extraction circuits for the purification of the lanthanides as a group:

- SX1 – SEG elements extracted from the LCPN elements
- SX2 – bulk extraction of the LCPN and the remaining SEG elements from SX1 raffinate.
- SX3 – In this battery, N235 is used to remove iron from SX1 and SX2 strip solutions.

Downstream Extraction employs three (3) extraction circuits for the separation of the lanthanides.

- SX5 – LC-PN separation, where PN are extracted away from the LC elements.
- SX6 – L-C separation, where C is extracted from the SX5 raffinate
- SX6 – this battery also includes a N235 extraction to remove Fe from the C strip solution
- SX7 – Didymium Purification, where the SEG elements are extracted from the SX5 strip solution which contains the PN elements.

Area for expansion of the extraction process has been provided for.

2.4.2.4 Product Finishing

In the post-treatment stage, the lanthanide chloride strip solutions will be purified, to remove impurities, and precipitated into carbonate or oxalate forms.

The following lanthanide products will be produced;

a) LCPN Carbonate

LCPN chloride solution from SX2 will be purified by the addition of sodium carbonate solution to achieve pH 4. The neutralized slurry will be filtered in a filter press to remove the solid impurities which will be recycled to the leach circuit. The filtrate will be routed to SX5 or to the LCPN precipitation circuit, for precipitation with sodium carbonate solution. The LCPN carbonate product will be transferred to a centrifuge for solid liquid separation and washing. The wastewater generated from the washing process will be transferred to the High Density Sludge (HDS) plant for treatment.

b) SEG-HRE Carbonate

SEG and HRE chloride solution from the SX1/SX3 extraction lines will be neutralised with magnesia to a pH of 2.5. The neutralised solutions will be filtered in a filter press to remove any precipitated solids which will be releached with acid to recover co-precipitated REO. The final residue from the re-leach will be discharged and the filtrate will be recycled within the SEG/HRE area.

Carbonate salts will be precipitated from the purified SEG/HRE solutions using sodium carbonate. The carbonate products will be transferred to a centrifuge for solid liquid separation and washing. The wastewater generated from the process will be a sodium chloride solution and will be transferred to the HDS system for treatment.

c) LaCe Carbonate

LC chloride solution (raffinate from SX5) will be purified by the addition of sodium sulphide, barium chloride and sodium sulphate solutions. The neutralized slurry will be filtered in a filter press to remove the solid impurities which will be discharged from the circuit. The filtrate will be routed to the precipitation circuit, for precipitation with sodium carbonate solution. The LC carbonate product will be transferred to a centrifuge for solid liquid separation and washing. The wastewater generated from the washing process will be transferred to the High Density Sludge (HDS) plant for treatment.

d) Cerium Carbonate

C chloride solution from SX6 will be purified by the addition of sodium carbonate solution to achieve pH 4. The neutralized slurry will be filtered in a filter press to remove the solid impurities which will be recycled to the leach circuit. The filtrate will be routed to the C precipitation circuit, for precipitation with sodium carbonate solution. The C carbonate product will be transferred to a centrifuge for solid liquid separation and washing . The wastewater generated from the washing process will be transferred to the High Density Sludge (HDS) plant for treatment.

e) Lanthanum Carbonate,

L chloride solution (raffinate from SX6) will be purified by the addition of sodium sulphide, barium chloride and sodium sulphate solutions. The neutralized slurry will be filtered in a filter press to remove the solid impurities which will be discharged from the circuit. The filtrate will be routed to the precipitation circuit, for precipitation with sodium carbonate solution. The L carbonate product will be transferred to a centrifuge for solid liquid separation and washing . The wastewater generated from the washing process will be transferred to the High Density Sludge (HDS) plant for treatment.

f) Lanthanum Oxide

Lanthanum oxide will be produced by calcining Lanthanum carbonate at a temperature of 900°C in the LPG-fired tunnel furnace. The tail gas discharge from lanthanum calcinations process will contain CO_2 and H_2O, and no hazardous elements, and will be emitted to the atmosphere.

g) Dydimium (Dd) Oxide

Dydimium (Dd) is a mixture of Pr and Nd. The chloride solution containing Dd is the SX7 raffinate and will be precipitated with oxalic acid, washed and centrifuged to produce Dd oxalate. The wastewater generated from the Didymium precipitation process is a dilute hydrochloric acid solution, and will be transferred to HDS for neutralisation.

Didymium oxide will be produced from the calcination of didymium oxalate at a temperature of 900°C in the LPG fired tunnel furnace. Tail gas discharge from Didymium calcinations process will contain CO_2 and H_2O with no hazard elements, and will be emitted to the atmosphere.

2.4.3 List of Equipment

The list of main equipment to be installed at the plant is presented in **Table 2.1** below.

Table 2.1: List of Major Equipment within the Advanced Materials Plant

Description	No of Units
Pressure Filters	20
Rotary Kilns	2
Waste Gas Treatment Unit	1
Solvent extraction cells	200
Centrifuges	27
Tunnel furnaces	2
Boilers	2
Water treatment Bio-reactors	3

2.4.4 List of Reagent and Annual Consumption

Reagents consumed at the plant and their anticipated annual usage quantities are presented in **Tables 2.2.**

Table 2.2: Annual Reagent Consumption for the Cracking & Separation Plant

Reagent	Annual Consumption at Start-up (tonnes)
H_2SO_4 (98%)	110,238
HCl (31%)	146,774
MgO	23,348
$BaCl_2.2H_2O$	602
Na_2CO_3	19,632
P204	496
P507	184
NaOH (30%)	81,120
Na_2SO_4	93
Na_2S	164
$H_2C_2O_4$	8,924
Kerosene	1,720
N235 Mixed	24
Hydrated Lime	111,386
Iso-octyl alcohol	24

Separation of the incompatible reagents, sodium fluosilicate and the alkalis has been considered when developing layouts. The dry reagents are separated in the storage shed by a barrier, while the wet chemicals are separately bunded with dedicated sump pumps.

2.4.4.1 Reagent Storage & Handling

a. Caustic Soda

Caustic soda or sodium hydroxide will be supplied to the plant in 24 tonne bulk tankers as a 30% solution w/w. The tanker will discharge into a 330 m^3 storage tank located within the tank farm proposed to the northwest of the plant. The solution will be pumped at full strength via individual pumps to the plant dose points.

b. Sodium Sulphide

Sodium sulphide will be supplied in 1 tonne bulk bags. The main plant storage will therefore be held as dry powder. The powder will be mixed to a 10% solution in a single-stage agitated tank.

A hoist will raise the bags to a bag breaker located above an agitated tank. During reagent mixing, the mix tank will be isolated and the dosing pumps will draw from a small buffer tank. The mixing / storage tank will be filled with water (10 m^3) to allow the target concentration to be met by the addition of 1 tonne of powder. A fume extraction fan will be provided to remove any harmful gaseous by-product. This tank volume is adequate for 50 hours operation. Distribution to the plant will be by a diaphragm dosing pump.

c. Flocculant

The flocculant mixing system will be located separately in the HDS thickener area. A reagent shed for storage of dry chemicals and reagent drums will be located adjacent to the Product Finishing Area.

Flocculant will be supplied in 25 kg bags on 900 kg pallets. The bags will be loaded by hand into a dry powder hopper. The dry powder will be metered into a dry transfer system and will be pneumatically transported to a wetting head. In the wetting head, the powder will be contacted with raw water from a number of spray heads. This concentrate solution will discharge into an agitated tank where water will be added to achieve a 0.25% solution.

This solution will be transferred into a storage tank for distribution to the plant. The facility will be a stand-alone package that will be controlled by a vendor-supplied PLC.

d. Hydrated Lime

Hydrated lime will be used scrubbing of kiln off-gas and for the neutralisation of waste waster. Lime will be supplied in bulk and transferred into a silo before mixing to a 20%-slurry. The milk of lime slurry will be pumped to user locations in waste gas treatment and HDS neutralisation areas.

The mixing-storage tank will consist of two tanks (30 m^3 each) that will be large enough to allow incremental addition of water and lime powder. When the tank levels have declined the tank will be topped up with raw water to a predetermined level and the dry lime powder added. This tank volume is adequate for 4 hours operation so addition of lime with be on an as-required basis.

The reagent mixing area will be bunded separately and will be provided with two sump pumps for clean up.

e. Sulphuric Acid

Sulphuric acid (98% concentration) will be trucked into the site and stored in three (3) storage tanks (250 m^3) within the bunded tank farm. The acid will be pumped into elevated tanks from where the acid will be meter-fed into the concentrate-acid mixers.

Sulphuric acid will be diluted and used to scrub lanthanide impurities from the organic phase in the Extraction Units. The diluted acid will be stored in two (2) tanks within the tank farm area.

f. Hydrochloric Acid

Hydrochloric acid (33% concentration) will be trucked into the site and stored in three (3) storage tanks (330m^3 each) within a bunded tank farm. The acid will be pumped for dilution in the extraction sections where it is prepared to several concentrations for use in the solvent extraction processes.

g. Magnesium Oxide (MgO)

Magnesium Oxide or magnesia will be imported in 1t bags and transported to site in open truck or sea container. This material is a free flowing white powder that easily absorbs carbon dioxide and moisture. The bags will be unloaded and stored in the purification section of the water leaching building - close to the point of use. The bags are hoisted above and emptied into hopers with screw feeders that deliver the material to the process.

h. Sodium Carbonate (Na_2CO_3)

Sodium Carbonate or soda ash will be imported in 1t bags or bulk and transported to site in sea container or pneumatic road tanker. This material is a free flowing white powder that easily absorbs moisture. The bags will be unloaded and stored in the post treatment building - close to the point of use. The bags are hoisted above and emptied into hopers with screw feeders that deliver the material to the process.

i. Oxalic Acid ($H_2C_2O_4$)

Oxalic acid will be imported in 1t or 50kg bags and transported to site in open truck or sea container. This material is a free flowing white powder that easily absorbs moisture. The bags will be unloaded and stored in the post treatment building - close to the point of use. The bags are hoisted above and emptied into an agitated tank.

The magnesia, soda ash and the hydrated lime will be stored separately within the plant due to the volumes consumed, and to ensure these materials are stored separate from acidic chemicals.

j. Industrial Kerosene

A low volatility and high flash point kerosene (65^{0}C) will be used as the base solvent for the extraction liquid. The kerosene will be received in truck tanker or in 200 litre drums, and unloaded into two storage tanks from where the solvent will be pumped to blending tanks for mixing with other organic solvents.

k. D2EHPA (P204)

An acidic phophorus extraction reagent known as D2EHPA or P204 will be used as the extraction agent. The flash point of this material is 206^{0}C. This reagent will be received in 200 litre drums which are emptied by pumping directly into the extraction circuits.

l. P507

An acidic phophorus extraction reagent known as P507 or PC-88A or Ionquest 801 will be used as the extraction agent. This reagent will be received in 200 litre drums which will be emptied by pumping directly into the extraction circuits.

m. N235

A tertiary amine N235 will be used as an extraction agent for the removal of impurities (metals) in the extraction process. This reagent will be received in 200 litre drums which will be emptied by pumping directly into the extraction circuits.

n. Iso-Octyl Alcohol

Iso-Octyly alcohol will be used for dilution of naphthenic acid and N235. This reagent is received in 200 litre drums and emptied by pumping directly into the extraction circuits.

Iso-octyl alcohol, P204, P507 and naphthenic acid will be transported in 200 litre HDPE drums and stored within the chemical store until required in the process. The drums will be transported to the extraction buildings by forklift and mixing of these chemicals will be carried out at the point of use within the plant.

o. Other Chemicals

Other chemicals received in solid powder form include $BaCl_2.2H_2O$, Na_2SO_4, and Na_2S which will be transported to the site in 1t bulker bags or 50kg bags and stored within the chemical store or dedicated storage areas close to the point of use.

Barium chloride is a white solid that absorbs moisture. The 1t bags used to stored the compound will be hoisted above and emptied into a mixing tank to prepare the barium chloride solution. This solution will be added to lanthanide chloride solution to remove sulphates.

Sodium sulphate is a white solid that absorbs moisture, and will be imported in 50kg bags. These bags will be emptied into a mixing tank and then added to the lanthanides chloride solution to remove radium.

2.4.5 Utilities

Process Water Requirement

The process water requirement for the Advanced Materials Plant is expected to range between 330 m^3/hr and 550 m^3/hr under steady state demand. The plant will source the water from the Pahang Water Supply Department.

All waste streams generated from the Advanced Materials Plant will be either recycled within the process or treated in a wastewater treatment system prior to discharge. The final treated effluent will be discharged from the plant at a rate of between 330 m^3/hr and 500 m^3/hr.

Process Air Requirement

Two electric driven compressors will be supplied on a duty / standby arrangement. The two compressors will be connected via a common manifold to supply normal plant and instrumentation air requirements. An air dryer will be fitted to produce air of a quality suitable for instruments. The compressors will be controlled by vendor-supplied PLC's.

A single low-pressure air blower will be provided to supply the air required for the flotation circuit. The blower will be fully manual in operation and will supply low-pressure air to the whole flotation plant via a series of header pipes.

The plant and instrument air compressors have been located on the northern side of flotation area. This location allows the compressors to be located adjacent to the highest usage areas. The blower area is located at the western end of the flotation area, to provide a convenient piping route.

Energy

Liquefied Petroleum Gas (LPG) will be used within the site as fuel for the two rotary kilns, the steam boilers, and the product furnaces. The annual supply requirement is 12,820,000 Nm^3/yr.

The LPG will be sourced form Petronas.

Steam Generation

Steam will be generated from on-site boilers for process heating and is used in the concentration and post treatment processes. The annual steam requirement is expected to be 80,000 tons/yr.

Electricity

Electricity will be supplied by Tenaga Nasional Berhad, the National Electricity Board. A sub-station will be constructed onsite to house transformers required to step down the incoming supply of 33kV.

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CHAPTER THREE

3.0 PROJECT OPTION

3.1 INTRODUCTION

Several options were considered in the planning stages of the project. These include site selection, technological alternatives and; the Build Out or No Build options which are based on assessments of beneficial and adverse environmental and socio-economic impacts brought about by the construction and operation of the Advanced Materials Plant in Kuantan, Pahang.

3.2 SITE SELECTION

During the initial planning stage of the project, Lynas undertook a project feasibility and site selection exercise. After a global search for potential viable sites for the establishment of the Advanced Materials Plant, Lynas selected suitable industrial sites in three (3) different countries, namely China, Abu Dhabi and Malaysia.

The decision to locate the plant outside Australia was solely based on economic considerations. Despite receiving environmental approvals in Australia, the isolated location of the mine site (in Laverton, Western Australia) resulted in significantly higher capital costs for plant and infrastructure construction, which were deemed prohibitive. The operational costs associated with an isolated location, such as the cost of shipping reagents and transporting labour force (by air) was also extremely high. The coastal regions of Western Australia also lack the required chemical industry infrastructure required for the refining of high purity lanthanides that can be found in the three selected suitable industrial sites outside Australia.

In deciding the final site for the plant, numerous visits were undertaken to the actual sites in these countries, discussions held with the local regulatory and industrial development agencies, and several critical factors influencing the economic feasibility of the plant operations were considered. The key factors that ultimately affected the siting location of the plant in Malaysia are briefly outlined below.

China

China was the original proposed location given the readily available expertise and technologies in lanthanide processing. However, the decision was later reversed as a result of the Chinese Government's decision to impose export quotas on ores that are shipped in from outside China for processing. This decision by the government would subject the Lynas Group to lose a significant competitive advantage (i.e. diversification of supply source for international customers). In addition, the removal of VAT (Value Added Tax) rebates for exports would significantly impact the economics of the proposed plant. The inevitable increase in state control of the lanthanides processing industry in China was thereby the main factor in reversing the decision to locate the proposed plant in China.

<u>Abu Dhabi</u>

The main reason for not proceeding with the siting of the plant in Abu Dhabi was the lack of transparency with respect to the project approval process involving the regulators. This is disadvantageous as this factor does not allow the Lynas Group to properly manage and develop key milestones in developing the proposed plant. With regards to supporting infrastructure, the port facilities and associated industrial-related infrastructure within the earmarked area were observed to be developing rapidly but less advanced than Malaysia and, the rate of development observed would not meet the project implementation timeframe. The environmental regulations were also observed to be not comprehensive enough to validate the sustainability of the plant operations. As part of the lanthanides production supply chain, Lynas will need to show its customers that the plant operations are environmentally-friendly and sustainable.

In view of the above, Lynas finally selected Malaysia for the setting up of the plant. The criteria that favoured the Malaysian site are summarized in the section below,

3.3 GEBENG INDUSTRIAL ESTATE, KUANTAN, PAHANG, MALAYSIA

The Gebeng Industrial Estate (GIE) is part of the growth corridor earmarked for rapid industrial development in the States of Kelantan, Terengganu and Pahang.

The GIE was established by the Pahang State Development Corporation (PASDEC) to actively promote the establishment of chemical and petrochemical facilities. The industrial estate, one of the largest industrial areas in the region, covering over 9, 600 ha, was developed as an industrial forerunner in the East Asia region for the development of petrochemical (especially the propylene-based industries) and chemical based industries. The industrial estate is a self-contained estate, equipped with the necessary infrastructure facilities and utilities. Phases I, II and III of the GIE have been fully developed. The development of the final phase, Phase IV is expected to commence in the near future. The establishment of the proposed plant within GIE will ensure compatibility with the surrounding facilities and thereby reducing environmental, health and safety impacts that may arise from conflicting operations. The Phase II area is occupied by the MTBE and Propylene plants, Eastman Chemicals, BP Chemicals, WR Grace, Kaneka and Nikko Fine Products which encompasses some 2100 acres. Phase III of the development, covering an area of 2500 acres accommodate three large plants, developed by BASF in conjunction with PETRONAS as joint venture project. Another chemical plant, Polyplastics Asia Pacific Sdn. Bhd. is also located on the Phase III area. As the GIE is also advantageously sited close to Kertih where raw material (petroleum, its by-products and natural gas) for these industries are readily available, the industrial area expanded rapidly, spurred mainly by foreign investments.

3.3.1 Strategic Location in the Region

The setting-up of the proposed plant within the GIE in Pahang is deemed strategic due to its close proximity to potential regional markets such as Australia, China, India, Indonesia, Japan, Qatar, Saudi Arabia, South Korea and the United Arab Emirates.

3.3.2 Accessibility to Key Infrastructure and Available Utilities

Port Facilities

The proximity of the project site to the Port of Kuantan is also one of the important factors considered. The distance from the site to the port area is relatively short, as the port is located approximately 4 km east of GIE. In addition to its close proximity, the port is the major entry and exit point for sea borne cargo in the East of Peninsular Malaysia. The port is a man-made, deep-water, all weather port handling over 4 million tonnes of shipping annually and has been operational since 1984. The Kuantan Port was developed as a significant part of the East Coast Industrial Development Corridor. The port is fully equipped to handle a wide variety of cargo, and has well-equipped conventional, multi-purpose, container and liquid bulk wharves. The port is linked globally through a network of shipping services, including container liner shipping services of leading lines calling at its dedicated container terminal.

The dedicated facilities for petrochemical vessels and cargo handling include two specialised liquid cargo berths spanning a total length of 2, 205 m with depth alongside of 11.4 m and capable of accommodating vessels up to 53, 000 displacement tonnes. An area of 17.4 hectares near the operational area has been earmarked for development of a commercial centre to enable shipping and other companies to set-up offices warehouses and other facilities. The port handles various types of cargo including containerized cargo, bulk cargo (dry & liquid) and break bulk. It has been privatised since 1998 and is currently managed and operated by Kuantan Port Consortium Sdn Bhd. In the year 2006, the port reportedly handled more than 10,650,000 tonnes of cargo.

The port allows the docking of large vessels and the lanthanides concentrate mined at Mt. Weld, Western Australia can be economically shipped in large quantities to the port in sea containers and enable Lynas to enjoy economies of scale and lower operating costs. Warehousing facilities are also currently available for use at the port.

Kuantan's proximity to the key export markets provides a significant freight advantage and the landed cost per tonne of lanthanides via Kuantan is likely to be significantly lower than the cost of shipping to and from Abu Dhabi. The proximity to the export markets also minimises working capital impact of shipping and handling losses.

Airport

The nearest airport is the Sultan Ahmad Shah Airport, located 30 km south of GIE. The airport is accessible via the main trunk road which is the Federal Route 3 which connects Kuantan to Kuala Terengganu. The Kuala Lumpur International Airport (KLIA) which is a main hub for air transportation in Asia Pacific is located in Sepang, State of Negeri Sembilan approximately 250 km southeast of Kuantan.

Road Network

The Gebeng Industrial Estate (GIE) is linked to the major town of Kuantan and regional port and airport by the main coastal trunk road, Jalan Kuantan-Kemaman (Federal Route 3) and the East Coast Highway. These links also provide access to the southern tip of Johor Bahru whilst the East-West Highway to the north of the industrial area (North of Terengganu) provides direct access to Penang, Ipoh and other major towns in the North-West.

The East Coast Expressway (Phase 1) comprises a 169 km dual carriageway that commences from the Karak Expressway and ends at the Pahang - Terengganu border near Jabur. The construction of the East Coast Expressway began in 2000, and the Phase 1 stretch was opened to vehicles in August 2004.

The Gebeng Bypass is a new highway connecting Jabur, Terengganu to Gebeng which was opened to traffic on December 2006.

All these roads have been designed for the movement of heavy vehicles transporting industrial and oversized loads and are thus advantageous for the transport of raw materials and finished products.

Rail Network

PETRONAS (Petroliam National Berhad) has constructed an industrial railroad which links its oil refinery complex in Kerteh, Terengganu, with the petrochemical complex within the GIE and the Port of Kuantan. The line is exclusively used to transport petroleum products. The rail which runs some 77 km connects the industrial town of Paka to Kuantan. Within the GIE, the rail terminal is located less than 1 km west of the plant site. This railroad is a potential mode of transportation of raw materials and finished products to and from the Port of Kuantan.

Natural Gas Supply

Natural gas and liquefied petroleum gas (LPG) supply is readily available from the national supplier, Petronas Gas or Gas Malaysia via pipelines or tankers.

Power Supply

Tenaga Nasional Berhad (TNB) supplies power to the State of Pahang over a national grid at 275 kV and 132 kV. The GIE obtains its power supply from the Tanjung Gelang substation which generates power at a capacity of 2 x 15 MVA. Power supply is available via the exiting TNB substation (intake station) located within the GIE less than 3 km south to the south of the project site.

Water Supply

The water supply network for Gebeng managed by the Pahang Water Supply Department comprises a 32 MGD supply from the Semambu Water Treatment Plant, with 3 balancing reservoir at 4.5 MGD. There are also two other sources, namely the 2 MGD and 1.5 MGD reservoirs at Bukit Penggorak, Gebeng, and 0.5 MGD and 1.0 MGD reservoirs at Bukit Merah Gebeng. Currently the existing industries utilize about 12 MGD of water. There is a balance of 8 MGD water supply for the GIE.

The existing water supply resource is adequate for the process and potable water requirements of the plant.

3.3.3 Availability of Local Suppliers

There are readily available chemical reagents manufacturers within the Teluk Kalong Industrial Area in the neighbouring state of Terengganu, namely the Malay-Sino Chemical Industries, Sen Sen Chemical, Petronas and Unichamp. Discussions are presently ongoing with these Malaysian suppliers to ensure a steady and readily available source of chemical reagents to meet the proposed plant’s requirements.

3.3.4 Availability of Skilled Workforce

The Gebeng Industrial Estate (GIE) is one of development components of the Sungai Karang Development Planning Block under the Kuantan town plan. This block of 25,365 ha comprises Cendur, Cerating, Sungai Ular, Sungai Baging and Gebeng. The total population in this area is 12,660. The town of Kuantan which is the capital of the State of Pahang lies approximately 20 km to the southwest of the GIE. The town which covers an area of 2,960 km^2 is made up of a total population of 394,500. It is bounded by Jerantut to the north-east, Maran to the south-west and Pekan to the south-east. Kuantan is bounded by Kemaman, Terengganu in the north-east direction. Based on the Kuantan 2015 Structure Plan published in December 2006, the population within the district is about 12,660.

Due to proximity to the population centres, the proposed location in Gebeng provides good access to essential and developed infrastructure facilities and also, pools of experienced and qualified labour. In addition, Kuantan area remains an attractive location for skilled labour force looking to relocate from the capital.

In addition, there are well established labour hire organisations which can provide the labour required for the Gebeng project if necessary.

3.4 BUILD-OUT VERSUS NO-BUILD OPTIONS

3.4.1 Build-Out Options

The Build-Out option would entail the implementation of the proposed Advanced Materials Plant within the GIE as proposed by Lynas. It is clearly evident that the implementation of the project would accrue positive economic benefits to the State Government and Lynas. Positive social and economic impacts to the local populace are also predicted in the form of increased job opportunities, skills and hence a better quality of living.

The potential concerns arising from the implementation of the project involve environmental issues. In the event adequate mitigation measures are not incorporated in the design and operation of the plant, the following potential environmental impacts are envisaged:

- ***Degradation of the Sg. Balok river water quality***: As the proposed plant site is not within a potable water catchment area, all discharges arising from the plant will be required to comply with the less stringent Standard B discharge limits as required under the *Environmental Quality (Sewage and Industrial Effluent) Regulations, 1978.* Based on the plant design, treated effluent from the wastewater treatment plant will be discharged into the stormwater retention pond on the plant site. From the pond, the combined discharge will flow out into the external earth drain which runs along the southern boundary of the site in a westerly direction into Sg. Balok. This discharge will increase the pollutant loading in the river system. If the Standard B limits are significantly breached the carrying capacity of the river will be affected. Increased organic, suspended solids and chemical loading of the river will result in adverse impacts to the general health of the river body. These impacts can be minimised by ensuring effective wastewater treatment technological options are given due consideration during the design phase.

- ***Deterioration of Ambient Air Quality:*** The plant, its ancillary facilities and operations are potential sources of air pollution. Sources of major, minor and fugitive emissions arising from the plant operations will be evident during the operational phase. The main sources of air emission from the operation of the plant will be the waste gas treatment system and to a lesser extent the gas fired boilers and product calciners. Suitable air control measures are necessary to ensure the concentration of pollutants arising from these sources are within the regulatory limits and have minimal adverse impacts on the people working and residing within the Zone of Impact (5 km radius of the project site).

- ***Increased Ambient Noise Levels:*** The operation of the plant is expected to increase the ambient noise levels at the site and its immediate surrounding area. However, the nearest sensitive receivers identified are Taman Balok Perdana and Taman Balok Makmur about 3 km south of the site. They are located along the Kuantan-Pelabuhan By-pass road, across the GIE. Thus, noise impacts to these residential areas are not expected to be significant. However, in the absence of appropriate noise abatement measures, the employees working within the plant boundary may be subjected to increased occupational noise which may have potential adverse impacts as a result of prolonged exposure. In designing the plant building structure, due importance must be given for noise attenuation at the source to ensure the noise levels at the site boundary are within the regulatory limits.

- ***Potential Soil and Groundwater Contamination:*** The operation of the plant will result in the generation of three major residue steams, namely the Water Leach Purification Residue (WLP) from the cracking and separation process, the Flue Gas Desulphurisation Residue (FGD) from the waste gas treatment system (scrubber) and the Neutralisation Underflow Solids from the wastewater treatment process (NUF). These waste streams have been classified as radiological wastes by the Atomic Energy Licensing Board (AELB) and thus will be handled and stored in accordance to the requirements of the Board. Lynas proposes to segregate and temporarily store these wastes within engineered residue cells constructed within the plant site. The design of these cells will be developed by Lynas and the EPCM Contractor Ranhill Worley-Parsons in conjunction with the recommendations of the Malaysian Nuclear Agency (MNA) which are based on the agency's Radiological Impact Assessment carried out for the project. Storage of these residues within the site may be a potential source of soil and groundwater contamination in the event of loss of integrity of the residue storage cells and, inadequate provision of soil and groundwater protection measures.

- ***Storage of Hazardous Materials***: Potential for contamination of land and water resources exists due to the bulk storage of hazardous reagents including concentrated acids. In mitigating such events, containment measures for such substances must be in place. These measures should be designed to contain spills and leaks, preventing them from escaping into the environment under normal operating conditions.

Chapter Five of this report provides detailed description of these impacts and the recommended mitigation measures to ensure environmental protection and regulatory compliance. It is the responsibility of the Project Proponent to give due consideration for the environmental impacts highlighted in this study; and incorporate the recommended mitigation measures into project planning and design.

3.4.2 No-Build Option

The construction and operation of the Advanced Materials Plant is expected to bring about significant positive benefits to Lynas as the Project Proponent, the State Government of Pahang, and the locals residing in the area as described in Section 1.7 in Chapter 1 of this report. In the event the project does not go ahead and the plant is not built on the proposed site, the benefits described in Section 1.7 will fail to materialise.

However, from an environmental perspective, the potential environmental concerns described in the section above will cease to exist and there will be no change to the prevailing environment condition.

3.5 RECOMMENDATION

The findings of this report will demonstrate that the predicted environmental impacts arising from the operation of the Advanced Materials Plant can be effectively mitigated and reduced to sustainable levels with the implementation of appropriate mitigation measures. The findings will also show that there will be no detrimental or harmful impacts which cannot be mitigated or, unavoidable. These measures will include technologically sound practices and environmental best management practices and thus any change in ambient air quality or river water quality will remain within regulatory limits. Additionally, an Environmental Management Plan which includes periodical environmental monitoring and audits for the construction and operational phases of the project will be developed and implemented. This is to ensure that all recommendations of this EIA and the requirements of the relevant government agencies are executed by Lynas.

In considering the above, and the significant positive economic and social benefits of the project to the local area of Gebeng, the state of Pahang and the country, the Consultants recommend that the *Build-Out* Option be adopted.

CHAPTER FOUR

4.0 EXISTING ENVIRONMENT

4.1 INTRODUCTION

This section provides a description of the physio-chemical, biological and social aspects of the environment within the Zone of Impact (ZOI), highlights the components of environmental concern and establishes the baseline conditions prior to the implementation of the Advanced Materials Plant within the Gebeng Industrial Area, Kuantan, Pahang.

The ZOI is the term used to describe the area most likely to be impacted by the implementation of the project. For the purpose of this study, the ZOI represents the sector within a 5 km radius of the plant site. The information provided within this chapter forms the basis of the impact assessment in *Chapter Five.*

The description is based on both primary and secondary data. Primary data was obtained from field surveys and ad-hoc environmental monitoring programmes. Secondary data was obtained from publications by the Department of Environment (DOE), the Local Authority (Kuantan Municipal Council or Majlis Perbandaran Kuantan), Department of Fisheries (Kuantan District), Department of Statistics (Headquarters, Putrajaya), Alam Sekitar Malaysia (ASMA) and other relevant government agencies. Information was also extracted from the Consultant's in-house database on the project area.

The ad-hoc environmental quality monitoring programme for ambient air, boundary noise and surface water quality was undertaken by Environmental Science (M) Sdn. Bhd, (SAMM No: 076). Soil and groundwater samples collected by ENVIRON from seven bore wells within the site were analysed by ALS Technichem Sdn. Bhd. (SAMM No: 147). Both laboratories are accredited by the Department of Standards (DSM), Malaysia.

The area encompassed by the ZOI is presented in **Exhibit 4.1a** whilst the current and planned landuses within the ZOI is presented in **Exhibit 4.1b** which was extracted from the document entitled Kuantan 2015. The publication is the Kuantan District Local Structure Plan (2004-2015) issued by the Kuantan Municipal Council. A detailed description of the project site and its surroundings are presented in the proceeding sections.

4.2 Site Setting

4.2.1 Project Site

The site earmarked for the establishment of the proposed Advanced Materials Plant is a parcel of industrial land located centrally within the Phase III area of the Gebeng Industrial Estate (GIE) in the Mukim of Sungai Karang, District of Kuantan, State of Pahang. The site lies at approximately latitude 04°00'N, and longitude 103°22'E. The total area of the site is 100 hectares.

The location of the site within the GIE is indicated in **Exhibit 4.2.** The main industrial facilities operating within the GIE are Petronas MTBE-Polypropylene, BP Chemicals, WR Grace, EASTMAN, Kaneka, Cryovac, Polyplastics Asia Pacific, BASF-Petronas and PDH Plant among others.

Based on a site reconnaissance survey carried out at the site in early October 2007, the proposed site was observed to be largely cleared and filled to the existing platform level but speckled with sparse secondary vegetation and shrubbery. The land plots adjoining the site to the northern and western boundaries of the site are overgrown with a mix of secondary vegetation and remnant peat swamp vegetation. To the east is cleared vacant industrial land and to the south of the site across the site is the Polyplastics facility.

The site can be accessed via two turn-offs from the Gebeng Bypass heading towards Jabur. The first turn-off is a dirt track that accesses the site directly from its north-eastern boundary whilst the second is a main trunk road that leads into the GIE. This road connects to another internal road that leads to the site.

The site layout is presented in **Exhibit 4.3** and a photolog which describes the physical characteristics of the site is presented in **Exhibit 4.4.** Notations (arrows) on the location of the various settings of the site captured by the photos are also included in Exhibit 4.3. The direction of the arrows corresponds with the direction in which the photos were taken.

4.2.2 Topography

Regionally, the GIE is located on the Kemajuan Tanah Tanah Merah area where Bukit Tanah Merah was flattened to construct the GIE. The GIE is located within the Sungai Balok catchment. The catchment is low-lying and is predominantly swampy. The estimated average land elevation is 7 m above mean sea level.

The hilly areas located within the ZOI include Bukit Balok which is located about 6 km southwest of the GIE at a height of 230 m above mean sea level (MSL). Bukit Pangram which rises 197 m above MSL is located 7.5 km southeast of the industrial estate. Sungai Balok flows 3 km west of area flowing in the southerly direction. The nearest coastline is 3 km to the east.

A topographical survey of the site was carried out by Jurukur Teguh (Terengganu) in October 2007. The survey details are provided in **Exhibit 4.5.** The regional topographical setting is presented in **Exhibit 4.1.**

The topographical survey indicates that the site is relatively flat with an overall natural gradient of 0°. The ground levels at the site generally ranged between 7.4 m and 7.8 m above MSL. There is a shallow earth trench that cuts across the site in a south easterly direction. A second shallow earth trench bisects the site in a north-south direction.

4.2.3 General Geology, Soil and Hydrogeology

Literature Review

Information regarding the general geology, soil and hydrogeology of the site and the surrounding area was extracted from the following sources:

- District Memoir 6: The Geology and Mineral Resources of the Neighbourhood of Kuantan, Pahang (1952);
- Geological Map of the Kuantan Sheet, Pahang in 1 : 63,360 scale (1951);
- Geological Map of Peninsular Malaysia in 1 : 2,000,000 scale (8th Edition) (1985);
- Quaternary Geological Map of Peninsular Malaysia in 1 : 1,000,000 scale (1st Edition) (1989);
- Reconnaissance Soil Map of Peninsular Malaysia in 1 : 500,000 scale (1968); and
- Hydrogeological Map of Peninsular Malaysia in 1: 500,000 scale (1975).

The Reconnaissance Soil Map of Peninsular Malaysia indicates that surface soils at the site and the surrounding areas are alluvial in nature and comprise mainly of peat. A review of published geological memoirs and geological maps of the Kuantan area revealed that geologically, the site and much of Mukim Sungai Karang are underlain by alluvium up to a depth of approximately 115 feet (ft) or 38 meters (m). The general area was swampy and had been deposited with soil debris brought down by rivers. The Quaternary Geological Map further describes that this alluvial layer to consist of peat, humic clay and silts of the Beruas and Simpang Formations.

Granite, reportedly formed in Cretaceous times, underlies the Quaternary Alluvium layer. This granite intruded into both the older Lower Carboniferous strata and older beds of the Arenaceous Series, and forms much of the bedrock underlying the GIE with the most prominent outcrop at Bukit Pangram, about 3.0 km southeast of the site. The granite is reportedly variable in composition and texture but is commonly porphyritic, medium grained biotite.

Arenaceous sedimentary rocks are reported in the Bukit Balok area and at Tanjung Gelang area approximately 6.0 km southwest and 7.5 km southeast from the site respectively. The Arenaceous series predominantly consists of quartzite, grit and conglomerate.

In addition, basaltic rocks were also observed at shallow depths in a few small areas to the west and southwest near Sungai Balok. Reportedly, the basaltic magma rose, mostly through fissures in the granite.

The geological map of the site and surrounding areas are presented in **Exhibit 4.6**.

The *Hydrogeological Map of Peninsular Malaysia* indicates that the unconsolidated alluvial deposits in the general area have an estimated potential yield of between 4,000 and 6,000 gallons/hour/well.

Site Investigations

Geotechnical site investigations carried out at the proposed project site revealed that subsurface conditions to be generally consistent with the information obtained from published geological reports and maps. The subsurface of site can generally be classified into the following:

- Fill material;
- Alluvium; and
- Weathered bedrock.

The upper fill material across the site consists of Clayey Sandy Gravel and Clayey Gravelly Sand, generally between 0.8 m and 1.8 m thick. Reportedly, the fill material was sourced from a local borrow and placed approximately four years ago.

Alluvial deposits, with a thickness of up to about 35 m, underlie the fill layer across the site. The alluvial deposits can be further subdivided into several sublayers. The upper alluvial layer comprises very soft medium plasticity Organic Clay and Peat. This layer has a thickness of about 0.6 m to 1.7 m, and contains partially decomposed plant material. The Organic Clay generally grades into a green-brown soft Clay and light grey loose Silty/Clayey Sand. Beneath this, alternating layers of Silty/Clayey Sand, Sandy/Clayey Silt and Sandy Clay of variable thickness were observed across the site.

Weathered bedrock and associated residual soils comprising hard Sandy Silt and Sandy Clay were encountered at depths of around 35 m below ground surface (bgs).

At the time of site investigations, stabilized groundwater level observed at boreholes, test pits and monitoring wells within the site were in the range of 0.95 to 3.5 m bgs. The water table appears to coincide with the Organic Clay of the upper alluvial deposits. Groundwater recharge at the site is anticipated to come almost entirely from rainfall. Increased recharge can be expected during the wet monsoon period in November and December. Field tests performed indicated that the hydraulic conductivity of Organic Clay and the underlying Silty Sand to be in the range of 10^{-7} – 10^{-8} m/s and 10^{-6} m/s respectively. More details are provided under **Section 4.6.9** of this chapter.

4.2.4 Water Resources

The GIE where the proposed plant site is to be located was formerly part of the the Paya Tanah Merah peat swamp forest. Subsequently, when the GIE was developed, the area was reclaimed using fill quarried from the nearby hilly areas. The two main rivers that drain the GIE are Sungai Balok and Sungai Tunggak. Sg. Balok originates as Sungai Batang Panjang from the hills to the northwest of GIE and generally serves the western catchment of the GIE. Sungai Tunggak originates from the Tanah Merah peat swamp forest and flows south along the eastern boundary of the GIE. which generally drains the areas within the eastern sector of the site (**Exhibit 4.7**). The site is within the Sungai Balok catchment.

All drainage from the proposed plant site will be discharged into Sungai Balok.

The tide for the Kuantan area is predominantly diurnal, with a tidal range of 2 m – 3.5 m. Sungai Balok is likely to be tidal up to almost 10 km upstream of the river mouth.

Sungai Balok flows along the western boundary of GIE in a southerly direction before its confluence into the coastal waters of the South China Sea. The primary source of pollution into this river is the drainage discharge from the GIE at two locations along the river channel.

Sunggai Tunggak which is a tributary of Sungai Balok flows serves the eastern catchment of the GIE flows in a southerly direction before its confluence at Sungai Balok.

No historical river flow data are available for Sungai Balok and Sungai Tunggak from published records reviewed during the course of this study.

There are no impoundments for potable water supply within the catchments of Sungai Balok and Sungai Tunggak.

A photolog of the Sungai Balok, its riparian areas and the two GIE drainage discharge outlets are presented in **Exhibit 4.8.**

4.3 CLIMATE AND METEOROLOGY

The climate of Malaysia is equatorial characterized by fairly high but uniform temperatures, high humidity and copious rainfall throughout the year with little seasonal variation.

Rainfall distribution patterns over the country are affected by local topography and wind directions. Based on predominant wind flow regimes, four periods can be distinguished. The southwest monsoon is usually established in the later half of May or early June and ends in September. The prevailing wind flow is generally south-westerly and light. The northeast monsoon usually commences in early November and ends in March. During this period, steady easterly or north-easterly winds blowing from the South China Sea result in high precipitation, particularly to the east coast region of Peninsula Malaysia. The months of April and October are transitional or inter-monsoon periods and are characterized by variable wind conditions.

The nearest Malaysian Meteorological Service (MMS) station to the project site is located at the Sultan Ahmad Shah (SAS) Airport in Kuantan, Pahang approximately 30 km southwest of the GIE. The station is located at latitude 3° 47' N and longitude 103° 13'E at 15.3 m above MSL. As the airport is located 30 km southwest of GIE and further inland (12 km compared to 2 km), small differences in the microclimate are likely between the sites although the macroclimate is essentially the same. For purposes of this study, climate and rainfall data was obtained from the station for the period 1951 – October 2007, while other meteorological data was obtained for the period 1975 – 2006.

4.3.1 Wind Speed and Direction

The annual wind rose and a wind speed/direction distribution matrix for the Sultan Ahmad Shah (SAS) Airport are presented in **Exhibit 4.9.**

On an annual basis prevailing winds are from the north (~ 26.5% of the time) and southwest (~11.6% of the time). However, wind speeds are generally low occurring below 3.3 m/s for 80.3% of the time and rarely exceeding 5.4 m/s (1.7%). Higher wind speeds are typically associated with winds from the north, northeast, east and southwest.

Exhibit 4.10 which presents the seasonal wind roses for the period 1975–2005 clearly demonstrate the monsoonal wind regimes experienced between May and September (SW Monsoon) and November to March (NE Monsoon). Variable wind conditions are observed in the inter-monsoon periods in April and October.

Due to the close proximity of the proposed project site to the sea, the project site also experiences the effects of diurnal wind patterns (land and sea breezes) typically experienced at coastal locations.

4.3.2 Temperature

Temperature records for the period 1968–2007 showed fairly uniform temperatures throughout the year, with mean monthly temperatures ranging from 25°C in the months of January and December to 27.3°C in March. The slightly lower 24-hour mean temperatures observed in the period of November–February each year can be attributed to the high precipitation and high cloud cover during the wet northeast monsoon period. The mean annual temperature is averaged at 26.3 °C.

The mean monthly temperature variation for the period 1968 to 2007 is graphically illustrated in **Exhibit 4.11.**

4.3.3 Relative Humidity

The mean 24-hour relative humidity is also fairly high and constant throughout the year typically ranging from 83.7% in the period between July and August to 89% in the period between November and December. The average annual 24-hour relative humidity is 85.2%.

Mean monthly relative humidity variation for the period 1968 to 2007 is graphically illustrated in **Exhibit 4.11.**

4.3.4 Rainfall

The average annual rainfall recorded at the station over the period 1951–2007 is 2,958 mm with an average of 189 rainy days annually. The highest annual rainfall was recorded in 1967 at 4,268 mm.

Although rainfall is heavy throughout the year, variations are evident. The wettest months are October, November, December and January (NE Monsoon) with a monthly average of 277 mm, 363 mm, 621 mm and 310 mm respectively. The highest monthly rainfall was recorded in the month of December 2001 at 1,471 mm and the lowest monthly rainfall was recorded in February 1998 at 1.2 mm. The average monthly rainfall for the remaining months was in the range of 147 mm and 215 mm.

Summaries of average annual rainfall and the number of rainy days recorded at the station are presented in **Exhibit 4.12.**

4.3.5 Seismology

Peninsular Malaysia is classified as a seismically stable area. It is not located within a recognised earthquake zone although minor tremors may be felt on the west coast of the peninsular from earthquakes that occur in neighbouring Sumatra, Indonesia. According to records provided by the Seismology Division of the Meteorological Department of Malaysia, the proposed project site is located in Zone III of Maximum Observed Intensity based on the Modified Mercalli (MM) Scale of 1931. MM Intensity Scale III is defined as:

> *"Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing truck."*

4.4 LANDUSE WITHIN THE ZOI

4.4.1 Regional Landuse Pattern

A breakdown of the various landuse within a 5 km radius of the proposed advanced materials plant site (ZOI) is presented in **Table 4.1.**

Table 4.1 Summary of Current Land Uses within the Zone of Impact (ZOI)

Radial Distance from the Centre of the Site	Land Use			
	North	**South**	**East**	**West**
< 1 km	This area is within the site boundary.	This area is within the site boundary.	This area is within the site boundary.	This area is within the site boundary.
1 km – 3 km	Unoccupied industrial plots overgrown with secondary vegetation (part of the GIE). The Gebeng Bypass (Jabur-Cherating Link) is located to the north of the site. The Kuantan Port – Kerteh railway line runs along to the north east of the site.	Polyplastics Asia Pacific Sdn Bhd is located about 50 m across the railway line and road from the southern boundary of the site. Unoccupied industrial plot (part of the GIE) to the north-eastern boundary of Polyplastics. Unoccupied industrial plots (part of the GIE) located to the south of Polyplastics. Industries operating south of Polyplastics are a Biodiesel Plant, Erupee Sugar, Kaneka, Flexsys, Eastman, WR, Cryovac, BP Chemicals and MTBE.	The Kuantan Port-Kerteh railway line runs along the eastern boundary of the site. This rail link is presently not in use. The Petronas gas pipe runs on line to the east of the site. Unoccupied industrial plots overgrown to the east of the site, across the railway line. Undeveloped plots of land with the GIE on the southeast side of the site.	The Kuantan Port – Kerteh railway line runs along the railway terminal located to the west of the site. The utilities reserve runs along the railway line. Gebeng Railway Terminal which is part of the Kuantan Port-Kerteh railway network is located to the west of the site. This is presently not in use. Unoccupied industrial plots overgrown with secondary vegetation (part of the GIE).

Radial Distance from the Centre of the Site	**Land Use**			
	North	**South**	**East**	**West**
1 km – 3 km		Across the road from the Kuantan-Pelabuhan Bypass are two residential settlements, namely Taman Balok Perdana and Taman Balok Makmur.		To the south-west of the site is a Petronas Emergency Response Centre. To the west of the centre is the BASF complex. Sungai Balok flows 3 km to the west in a southerly direction.
3 km – 5 km	Secondary forests cover the areas to the north and northwest of the site. Sporadic clusters of residential and commercial properties are located to the northeast along the coastal road leading to Kuala Terengganu.	The Kuantan-Pelabuhan Bypass runs 4 km south of the site. Sungai Tunggak flows approximately 5 km south of the site. Sporadic clusters of residential and commercial properties are located along the coastal road leading from Kuantan to the Port.	The East-Coast Highway runs about 4 km from the eastern boundary of the site. The Kuantan Port facilities lie about 4.5 km to the south-east of the site. The Cherating Beach lies about 5 km east of the site.	Unoccupied industrial land overgrown with peat swamp vegetation is located to the west of the site.

4.4.2 Gebeng Industrial Estate (GIE)

The GIE is one of the main industrial areas in Pahang is located approximately 35 km north of the Kuantan town centre. The nearest airport is the Sultan Ahmad Shah Airport, located 30 km south of GIE. Kuantan Port is located 4 km east of GIE. Both the airport and the port are accessible via the main trunk road which is the Federal Route 3 (connects Kuantan to Kuala Terengganu). The Phase 1 stretch of the East Coast Expressway leads to the GIE.

The Pahang State Development Corporation (PASDEC) is responsible for the management of the GIE. Discussion with PASDEC and review of historical information indicates that construction of the estate commenced in 1982 with the initial development of the Phase I area. Prior to development, the area consisted of a mixture of low lying peat swamp forest, disturbed secondary forest and stretches of rubber plantation belonging to the State Government and the PASDEC.

A forested hill was reportedly located towards the west of the Phase III area. The Phase II area comprised mainly of the peat swamp, rubber plantation and stretches of secondary re-growth. Some parts of the Phase II area were reportedly used as a borrow area to provide fill for the Phase I development.

The total land area allocated for GIE is 9,600 acres. PASDEC developed the industrial area in four phases (Phase I to IV). Details of various development stages are summarised below in **Table 4.2**.

Table 4.2 Development Stages of the Gebeng Industrial Estate (GIE)

Phase I	Established in 1982 and located to the south of the Phase II development. The development comprises an area of 700 acres and is fully occupied. The existing industries include MTBE, Polypropylene, AMC, Demi Bintang, Choice Woods, Hassan Milling, ATD, MEICO, Suasa Unik and Cargill Oil Palm.
Phase II	Established in 1993 and covers an area of 1,400 acres. At present only 80% of total area is occupied. The industries located here include BP Chemicals, Eastman, WR Grace, Cryovac, Kaneka, Flexsys and Kontena Nasional.
Phase III	Development commenced in 1997 and still expanding. Located northwest of the Phase II development, it covers a development area of 2,500 acres. The present occupants are BASF Petronas Chemicals, Petronas CUF, Petronas PDH and Polyplastic.
Phase IV	Presently undeveloped. It has total potential development area of 5,000 acres and PASDEC has allocated 60% from this area for petrochemical industries.

These industries are mainly situated on the western, southern and eastern sections of the GIE (see **Exhibit 4.2**). A photolog describing the surrounding industrial facilities areas are presented in **Exhibit 4.13.**

Polyplastics Asia Pacific Sdn Bhd which is located 50 m south of the site is the nearest industrial facility to the site.

4.5 HUMAN ENVIRONMENT

Residential settlements in the vicinity of the GIE are primarily located along the existing road network.

The nearest human settlements to the project site are Taman Balok Perdana and Taman Balok Makmur which is located about 3 km south of the site along the Kuantan-Pelabuhan Bypass road.

Based on statistical data obtained during the most recent population census in 2000 by the Department of Statistics Malaysia, the total population count for Taman Balok Perdana, Taman Balok Makmur and Kem TLDM Kampung Seberang Balok is 5,973. Of this population number, about 57% are 25 years and below. Eighty-seven percent of the population comprise Malays, 0.2% of the population are Chinese, while 2.2% of the population are Indians.

Other settlements neighbouring the site are Kampung Sungai Ular (2.5 km north of Kampung Gebeng), Kampung Hulu Balok (3km south-east of the site), Kampung Berahi (4.5 km south of the site), Kampung Seberang Balok (6 km south of the site).

South of Kampung Seberang Balok is Kampung Balok and Kampung Balok Baru. These settlements comprise residential and commercial structures. The majority of the areas are sparsely populated.

Other settlements include Kampung Gebeng (3 km north-east of the site) and Kampung Selamat (4 km south-east of the site).

4.6 ENVIRONMENTAL BASELINE INVESTIGATION

Environmental baseline data was collected from the project site, its boundaries and at the sensitive receivers during the period 29th October – 01st November 2007.

The data collected represents the prevailing noise levels, ambient air quality, soil and groundwater quality and the water quality of Sungai Balok. Riverbed sediments were also collected and analysed for heavy metals, and plankton and macrobenthos biodiversity.

The environmental samples were collected by Environmental Science Malaysia, an analytical laboratory accredited by the Department of Standards, Malaysia.

The location of the environmental monitoring stations is presented in **Exhibit 4.14.**

4.6.1 Noise Measurements

4.6.1.1 *Noise Monitoring Locations*

Boundary noise levels were recorded at four (4) monitoring stations representing the prevailing noise levels almost along the site boundaries. The description of the monitoring locations is detailed in **Table 4.3** below.

Table 4.3: Noise Monitoring Stations

Station No	Location	Description	Parameters Monitored
N1	N04°00.296’ E103°23.039’	At an open space located at the south east corner of the site.	LAeq, LA10, LA90, Lamax, LAmin
N2	N04°00.761’ E103°22.459’	At an open space located at the north east corner of the site.	
N3	N03°59.907’ E103°22.459’	At an open space located at the south west corner of the site.	
N4	N04°00.362’ E103°22.239’	At an open space located at the west quadrant of the site.	

4.6.1.2 *Methodology*

Noise monitoring was carried out using the ISO 1996 methodology. Noise measurement was recorded using a pre-calibrated precision integrating noise meter stationed at the selected monitoring stations. In recording the noise levels, the noise meter was mounted on a tripod at a height of about 1.2 meter above ground level. The microphone was provided with a wind shield throughout the measurement period to prevent interference caused by wind. Standard acoustic principles and practices were followed in the measurement of the noise data.

The noise meter was calibrated acoustically before using a Rion pistonphone (Model NL – 06) set at 250 Hz and 114 dB followed by electric calibration using the built-in function mode. Noise measurement was made using the time weighting characteristic of “fast” and “A” weighted decibel scale.

Noise data was recorded over a period of 24 hours at 15 minutes interval at each monitoring station. The integrating noise meter which was set at the A-weighted mode recorded noise level automatically every 2 seconds during the pre-set measurement interval. The recorded noise level for each interval was systematically and automatically integrated by the in-built electronic system. The integrated noise levels in terms of LA_{eq}, LA_{max}, L_{A5}, L_{A10}, L_{A50}, &L_{A90}& L_{A95} were then printed out.

4.6.1.3 *Assessment of Results*

The results obtained from the noise measurements at the four (4) monitoring locations are graphically represented in the form of noise profiles (refer **Exhibit 4.15(a) – (d)**). The actual noise data recorded at these stations are presented in **Appendix 2.**

The noise levels are summarised and tabulated in **Table 4.4.**

The results of the noise monitoring programme are compared against the recommended limits prescribed within *Planning Guidelines for Environmental Noise Limits and Control (2004)* published by the Department of Environment (DOE) (see **Table 4.5**).

Table 4.4: Summary of Noise Levels (LAeq (dBA))

Location monitored	Date monitored	Range of LAeq reading in dBA		Percentage exceeded Maximum Permissible Sound Level for		*Maximum Permissible Sound Level in dBA(1)
		Day time	Night time	Day time	Night time	
N1	30/10/07 – 31/10/07	35.7 – 58.3	47.3 – 53.5	0	0	Daytime = 70 Night time = 60
N2	30/10/07 – 31/10/07	35.3 – 61.4	41.0 – 50.6	0	0	
N3	29/10/07 – 30/10/07	40.2 – 63.8	39.4 – 51.5	0	0	
N4	29/10/07 – 30/10/07	47.7 – 67.7	48.1 – 67.0	0	17	

(1): Maximum Permissible Sound Level (LAeq) for Designated Industrial Zones.

Table 4.5: Maximum Permissible Sound Level (L_{Aeq}) by Receiving Landuse for Planning and New Development

Receiving Land Use Category	Day Time (7.00 am – 10.00 pm)	Night Time (10.00 pm to 7.00 am)
Noise Sensitive Areas, Low Density Residential, Institutional (School, Hospital), Worship Areas	50 dBA	40 dBA
Suburban Residential (Medium Density) Area, Public Spaces, Parks, Recreational Areas	55 dBA	45 dBA
Urban Residential (High Density) Areas, Designated Mixed Development Areas (Residential-Commercial)	60 dBA	50 dBA
Commercial Business Zones	65 dBA	55 dBA
Designated Industrial Zones	70 dBA	60 dBA

The LAeq readings at the three locations of the project site (N1, N2 and N3) were lower than the maximum permissible sound level of 70 dBA for daytime and 60 dBA for night time. The noise levels at N4 were compliant during the daytime but the night time noise readings exceeded the limit of 60dBA 17% of the time.

It was noted that, nocturnal insect sounds and vehicular movement along the nearby main road were among the noise sources observed at the monitoring locations. **Table 4.6** describes some of the main noise sources at the four noise monitoring locations.

Table 4.6: Noise Sources at the Noise Monitoring Stations

Location	Noise Sources	
	Daytime	Night time
N1	▪ Noise from insects ▪ Noise from nearby industrial facilities ▪ Vehicular movement	▪ Noise from insects ▪ Noise from nearby industrial facilities ▪ Vehicular movement
N2 N3 N4	▪ Noise made by nocturnal insects ▪ Vehicular movement	▪ Noise made by nocturnal insects ▪ Vehicular movement

4.6.2 Ambient Air Quality

4.6.2.1 *Ambient Air Monitoring Locations*

The location of the monitoring stations selected for the baseline ambient air quality monitoring at the site is similar to the noise measurement locations. Description of the monitoring locations is detailed in **Table 4.7** below.

Table 4.7: Air Monitoring Stations

Station No	Location	Description	Parameters Monitored
A1	N04°00.552’ E103°22.976’	At an open space located at the south east corner of the site.	TSP, PM10, NO_2, SO_2, H_2SO_4, HF, Acid mist
A2	N04°00.740’ E103°22.416’	At an open space located at the north east corner of the site.	
A3	N04°00.740’ E103°22.416’	At an open space located at the south west corner of the site.	
A4	N04°00.267’ E103°22.279’	At an open space located at the west quadrant of the site.	

Ambient air quality at the identified monitoring locations were analysed for Total Suspended Particulates (TSP), Particulate Matter (PM_{10}), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). These are the primary ambient air quality pollution indicators.

4.6.2.2 *Methodology*

An automatic wind sensor (propeller type) and wind translator were used to record wind direction and velocity. The propeller was set up at a pole. This was to ensure that the measurement taken had good exposure of the instrument to the ambient wind. To obtain the best accuracy orientation of the sensor to true north was carried out using a prismatic compass. Recording was made for a period of twenty-four (24) hours continuously.

Total Suspended Particulate in Ambient Air (ASTM D4096, 1993)

A high volume sampler was used to collect total suspended particulate samples for a continuous period of 24 hours at the monitoring locations. The filtration medium was pre-dried in an oven and transferred to a desiccator to maintain its constant weight. After weighing, the filtration medium was sealed and to be used during fieldwork.

During sampling, the filter was loaded into the filter holder of the high volume sampler. Air was sampled and drawn through the filtration medium by using a pump. Total suspended particulate in the air was detained by the filtration medium. The volume of air sampled was recorded automatically.

Particular Matter 10 Micron in Ambient Air (ASTM D4096, 1993)

A pre-calibrated PM_{10} high volume sampler was used to collect particulate matter measuring 1- micron and less for continuous period of 24 hours. The atmospheric particulate matter as PM_{10} is based on selection of PM_{10} particles by internal separation, followed by filtration and gravimetric determination of the PM_{10} mass on the filter substrate. The volume of air sampled was recorded automatically by the high volume sampling system. Filtration medium preparation for PM_{10} is the same as for total particulate matter.

Nitrogen Dioxide Content in the Ambient Air (ASTM D 1607, 1991)

Nitrogen dioxide (NO_2) in the ambient air was absorbed by aspirating a measured volume of air through an azo-dye forming reagent in a gas washing bottle along the sampling train. The sampling flow rate used was 200 ml/min for a period of one (1) hours. The NO_2 present reacts with the azo-dye forming reagent to produce a colour complex. The colour intensity was measured at 550 nm using UV-Visible spectrophotometer.

Sulphur Dioxide Content in the Ambient Air (ASTM D 2914, 1993)

Sulphur dioxide (SO_2) in the ambient air was absorbed by aspirating a measured volume of air through a tetrachloromercurate (TCM) solution. The sampling flow rate used was 200 ml/min for a period of twenty four (24) hours. SO_2 in the sample reacted with the TCM solution to form a dichlorosulfonatomercurate complex. EDTA was added to this solution to complex heavy metals that might interfere with the measurement.

The collected sample was treated with a solution of sulfamic acid to destroy the nitrite anion formed. It was then treated with a solution of formaldehyde and specially purified acid-bleached pararosaniline containing phosphoric acid to control pH. The reaction gave an intensely coloured solution, which was measured at 548 nm using UV-Visible spectrophotometer.

Sulphuric Acid (H_2SO_4) and Hydrogen Fluoride (HF) in the Ambient Air (Adopted from NIOSH 7903, 1994)

Sampling of H_2SO_4 and HF are carried out by using washed silica gel sorbent tube coupled with tri-gas sampler. The ends of the sorbent tube are broken just before sampling and the sorbent tube containing acid treated silica gel (silica gel 400 mg / 200 mg) is connected to the inlet of a tri-gas sampler. The suction pump of the tri-gas sampler draws the ambient air sample at a flow rate of not more than 0.5 liter per minute. As the air sample passes through the sorbent material an inorganic acid gas present in the air sample is detained.

At the end of the sampling period, the loaded sorbent tube is collected, capped at both ends and sent to the laboratory. After breaking the sorbent tube, the sorbent is transferred to a 15 ml graduated centrifuge tube. 6 ml of eluent (bicarbonate/carbonate buffer solution) is then added to the centrifuge tube. For 10 minutes, they are heated in a boiling bath and then cooled before topping it up to 10 ml with eluent. H_2SO_4 and HF present are to be analysed using ion chromatograph. The concentration of the acid gases in the ambient air is calculated based on the amount of acid detected versus the volume of air sampled

Acid Mist in the Ambient Air (Adopted from NIOSH 7903, 1994)

Acid mist in the air was absorbed by aspirating a measured volume of air through an absorbing solution in a gas washing bottle along the sampling train. For a period of eight (8) hours the sampling flow rate used was 200 ml/min. Acid-base titration method was used with pH as an indicator to analyse the concentration of acid mist in the absorbing solution. The concentration of acids mist in the absorbing solution was calculated and expressed in terms of H_2SO_4 in air. This was calculated based on the amount of H_2SO_4 detected versus the volume of air sampled (JIS K 10106, modified).

4.6.2.3 *Assessment of Results*

Concentrations of total suspended particulates, particulate matter (10µm) and gaseous pollutants in the ambient air at the four (4) monitoring stations are summarised in **Table 4.8** below. The actual wind data recorded at these stations are presented in **Appendix 2.**

Table 4.8: Ambient Air Quality Monitoring Results

Parameter Tested	Results (µg/m^3)				
	A1	A2	A3	A4	RMAQG
Total Suspended Particulate (TSP)	20	23	33	30	260 µg/m^3 (24 hours averaging time)
Particulate Matter 10µm (PM10)	11	14	15	16	150 µg/m^3 (24 hours averaging time)
Sulphur Dioxide as SO_2	<5	<5	<5	<5	105 µg/m^3 (24 hours averaging time)
Nitrogen Dioxide as NO_2	<5	94	69	<5	320 µg/m^3 (1 hour averaging time)
Sulphuric Acid as H_2SO_4	<10	33	<10	<10	-
Hydrogen Fluoride as HF	<10	<10	<10	<10	-
Acid Mist					-

RMAQG: Recommended Malaysian Air Quality Guidelines

The results obtained above are compared against the Recommended Malaysian Air Quality Guidelines (RMAQG). The complete list of air quality parameters prescribed within the RMAQG is presented in **Table 4.9.** The limits stipulated by the World Health Organisation (WH0) (2005) are also presented for comparison.

Table 4.9: Ambient Air Quality Criteria

Pollutant	Averaging Time	Malaysian Air Quality Guidelines		WHO (2005)
		ppm	μg/m^3	μg/m^3
Sulphur dioxide (SO_2)	1 hr	0.13	350	
	24 hrs	0.04	105	20
PM_{10}	24 hrs		150	50
	1 year		50	20
TSP	24 hrs		260	-
Nitrogen dioxide (NO_2)	1hr	0.17	320	200
	24 hrs			-
	1 year	0.04	90	40
Carbon Monoxide (CO)	1 hr	30.00	35 mg/ m^3	
	8 hrs	9.00	10 mg/ m^3	
Ozone (O_3)	1 hr	0.10	200	-
	8 hrs	0.06	120	100
Lead (Pb)	3 months		1.5	1.5

The air quality data obtained showed that the 24-hours averaging concentrations of total suspended solids (TSS) at all four (4) monitoring locations ranged from 20 $\mu g/m^3$ to 33 $\mu g/m^3$ while the 24-hours averaging concentrations of PM_{10} varied from 11 $\mu g/m^3$ to 16 $\mu g/m^3$. These concentrations were very well below the limit prescribed in the RMAQG at 260 $\mu g/m^3$ and 150 $\mu g/m^3$ respectively for TSS and PM_{10}.

Monitoring of gaseous sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) showed that concentrations of these gases were below their respective detection limits of 5 $\mu g/m^3$at all stations except for NO_2 at A2 (94 $\mu g/m^3$) and A3 (94 $\mu g/m^3$). SO_2 has a 24-hours averaging concentration limit of 105 $\mu g/m^3$ while NO_2 has a 1-hour averaging concentration limit of 320 $\mu g/m^3$

The acid gaseous monitored, sulphuric acid (as H_2SO_4) and hydrogen fluoride (HF) were below their detection limit of 10 ug/m^3 at all stations except station A2 which recorded H_2SO_4 concentration of 33 ug/m^3.

Concentration of TSP, PM_{10}, SO_2 and NO_2 obtained at all the sampling locations during this sampling exercise complied with their respective limits prescribed in the RMAQG.

Based on metrological data on annual wind speeds, prevailing winds are from the north 25% of the time. This indicates that the sensitive receivers are upwind of the project site.

4.6.3 Wind Monitoring

4.6.3.1 *Wind Monitoring Location*

Wind monitoring was recorded at one (1) monitoring station within the project site. The details of this monitoring location and the parameters monitored are presented in **Table 4.10** below.

Table 4.10: Wind Monitoring Stations

Monitoring Station	Description	Parameters Monitored
WD1	At an open space, at the northern sector of the site. [N04° 00.632’ E103° 22.872’]	Speed and Direction

4.6.3.2 *Methodology*

An automatic wind sensor (propeller type) and wind translator were used to record wind direction and velocity. The propeller was set up at a pole. This was to ensure that the measurement taken had good exposure of the instrument to the ambient wind. To obtain the best accuracy orientation of the sensor to true north was carried out using a prismatic compass. Recording was made for a period of twenty-four (24) hours continuously.

4.6.3.3 *Assessment of Results*

Percentage frequency of various wind direction and speed is tabulated in **Table 4.11**, while the summary of wind direction and speed is summarised in **Table 4.12**. The actual wind data recorded at these stations are presented in **Appendix 2.**

Table 4.11: Summary of Percentage Frequency of Various Direction and Speed

	Point WD 1 (30/10/2007 - 31/10/2007)							
	<0.3	**0.3 - 1.5**	**1.5 - 3.3**	**3.3 - 5.4**	**5.4 - 7.9**	**7.9 - 10.7**	**>10.7**	**Total**
Calm	8.3	-	-	-	-	-	-	8.3
N	-	3.1	2.1	4.2	1.0	0.0	0.0	10.4
NNE	-	1.0	1.0	2.1	1.0	0.0	0.0	5.2
NE	-	1.0	1.0	0.0	0.0	0.0	0.0	2.1
ENE	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E	-	1.0	0.0	0.0	0.0	0.0	0.0	1.0
ESE	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SE	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SSE	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SSW	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SW	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WSW	-	1.0	1.0	0.0	0.0	0.0	0.0	2.1
W	-	3.1	3.1	4.2	0.0	0.0	0.0	10.4
WNW	-	17.7	5.2	1.0	0.0	0.0	0.0	24.0
NW	-	7.3	11.5	2.1	1.0	0.0	0.0	21.9
NNW	-	7.3	2.1	3.1	2.1	0.0	0.0	14.6
Total	8.3	42.7	27.1	16.7	5.2	0.0	0.0	100.0

Table 4.12: Summary of Wind Direction & Speed

Period (LT) (30/10/2007 – 31/10/2007)	**1525 to 1910 hrs**	**1925 to 0010 hrs**	**0025 to 0710 hrs**	**0725 to 1510 hrs**
Speed (m/s)	3.28 – 6.29	1.07 – 3.76	0.00 – 2.54	0.00 – 4.11
Predominant Direction	N, NNW, NW	NNW, N NW	WNW, NW	WNW, NNW

It is seen that over the two days, 42.7% of the time, the wind speed was between 0.3m/s – 1.5m/s. It is also noted that 24.0% during the monitoring time, the wind was in the west-northwest direction.

However, this ad-hoc 24-hours monitoring at one station within the proposed site location is only representative of the wind conditions at the time of air quality monitoring and does not represent the average wind condition at the site. Annual metrological data from the Department of Metrology would be more accurate and representative.

4.6.4 Water Quality

4.6.4.1 *Water Sampling Stations*

A total of seven (7) water samples were collected from Sungai Balok using the grab sampling technique. The details of these locations are presented in **Table 4.13.**

As Sungai Balok is subject to tidal influence, water quality samples were collected during both the high and low tide cycles. At each sampling location, three (3) samples were collected and mixed in a single container. From this storage container, one sample was drawn out, representing a composite sample for analysis. At each sampling location, the three samples were collected from the surface, mid-depth and slightly above the seabed.

Sample W1 was collected from the river mouth of Sungai Balok as it represents the water quality of the river close to its estuary. Sample W2 was collected 100 m downstream of confluence of Sungai Tunggak.

Sample W3 sample was collected 100 m downstream of the first drainage outlet from the GIE. Station whilst sample W4 was collected 100 m downstream of the second drainage outlet of the GIE. The fifth sample (W5) was collected 100 m upstream of the second drainage outlet.

The W6 sample represents the water quality of the river 100 m downstream of the proposed Lynas discharge outlet.

Station W7 was collected approximately 100 m upstream of the road bridge on the Gebeng Bypass road.

Table 4.13: Water Quality Monitoring Stations

<table>
<tr><th>Station</th><th>Description</th><th>Parameters Monitored</th></tr>
<tr><td>W1</td><td>Water sample collected from the river mouth of Sungai Balok.
[N 03^{0} 56.468; E 103^{0} 22.383]</td><td rowspan="7">pH
Temperature
DO
Total Coliform
Conductivity
BOD
COD
TSS
Hg
Cd
Cr^{6+}
As
CN
Pb
Cr^{3+}
Cu
Mn
Ni
Sn
Zn
Free Cl_2
S^{2-}
O&G
NH_3
TDS
Ca
Mg
Ag
Ba
Carbonate</td></tr>
<tr><td>W2</td><td>Water sample collected 100 m downstream of the confluence of Sungai Tunggak.
[N 03^{0} 56.700; E 103^{0} 22.331]</td></tr>
<tr><td>W3</td><td>Water sample was collected 100 m downstream of the first drainage outlet (from the GIE).
[N 03^{0} 57.552; E 103^{0} 21.801]</td></tr>
<tr><td>W4</td><td>Water sample collected 100 m downstream of the second drainage outlet (from the GIE).
[N 03^{0} 57.872; E 103^{0} 21.890]</td></tr>
<tr><td>W5</td><td>Water sample collected 100 m upstream of the second drainage outlet (from the GIE).
[N 03^{0} 58.192; E 103^{0} 21.687]</td></tr>
<tr><td>W6</td><td>Water sample collected 100 m downstream of the proposed Lynas discharge outlet.
[N 03^{0} 59.534; E 103^{0} 21.472]</td></tr>
<tr><td>W7</td><td>Water sample collected 100 m upstream of the road bridge (across the Gebeng Bypass road).
[N 04^{0} 00.381; E 103^{0} 21.107]</td></tr>
</table>

4.6.4.2 *Methodology*

The samples collected were preserved and sent back to the laboratory for chemical analysis. A summary of the parameters analyzed and the analytical methods used for these water samples is provided in **Table 4.14.**

Table 4.14: Method of Chemical Analysis

Parameters	Method
pH value	APHA 4500-H^+B, 1995
Biochemical Oxygen Demand @ 5 days at 20 ºC (BOD)	APHA 5210 B, 1995/APHA 4500 O G, 1995
Chemical Oxygen Demand (COD)	APHA 5220 B, 1995
Total Suspended Solids (TSS)	APHA 2540 D, 1995
Mercury as Hg	USEPA 245.1, 1991
Cadmium as Cd	APHA 3111 B, 1995
Chromium Hexavalent as Cr^{6+}	APHA 3500-Cr D, 1995
Arsenic as As	IH-PE: B3505: As, 1994
Cyanide as CN	APHA 4500-CN C&F, 1995
Lead as Pb	APHA 3111 B, 1995
Chromium Trivalent as Cr^{3+}	APHA 3111 B, 1995/APHA 3500-Cr D, 1995
Copper as Cu	APHA 3111 B, 1995
Manganese as Mn	APHA 3111 B, 1995
Nickel as Ni	APHA 3111 B, 1995
Tin as Sn	IH-PE: B3505: Sn, 1994
Zinc as Zn	APHA 3111B, 1995
Free Chlorine as $C1_2$	IH-BS 1427, 1962
Sulphide as S^{2-}	APHA 4500 S^{2-}F, 1995
Oil and Grease	APHA 5520 B, 1995
Ammoniacal Nitrogen	APHA 4500-NH_3 B&C, 1992
Temperature	APHA 2550 B, 1995
Dissolved Oxygen	APHA 4500-O G, 1995
Conductivity	APHA 2510 B, 1995
Total Dissolves Solids	APHA 2540 C, 1995
Total Coliform	ISO 9308-1
Calcium as Ca	APHA 3111 B, 1995
Magnesium as Mg	APHA 3111 B, 1995
Silver as Ag	APHA 3111 B, 1995
Barium as Ba	APHA 3111 D, 1995
Carbonate as CO_3	APHA 2320B, 1995

US-EPA: Environmental Monitoring Systems, Laboratory Office of Research and Development, United States Environment Protection Agency.
APHA: Standard Methods for Examination of Water and Wastewater (1995), American Water Works Association and American Public Health Association.
IH: In-House Method (approved by the Department of Standards, Malaysia)
ISO: International Standard, International Standard Orgnanization for Standardization, 1990.

In-situ measurements were recorded at the site during sampling using a portable meter at mid-depth. Physical measurements recorded include temperature, pH, dissolved oxygen and conductivity.

4.6.4.3 *Assessment of Results*

The results of the water quality analysis are compared against the *Interim National Water Quality Standards (INWQS)* which is used to classify rivers in Malaysia. The data was compared against and Class III of the standards which apply to river bodies not used for the abstraction of potable supply (unless extensive treatment is carried out) but suitable for fisheries. A general comparison was also made against Class II of the standards which requires conventional treatment for water supply, suitable water quality for sensitive aquatic species and also suitable for recreational use with body contact.

A description of some of the critical water quality parameters is provided below.

The conductivity of a solution is related to the concentration of ionised substances present in the solution, temperature and sum of conductance of individual ions, both positive and negative. Salinity refers to the concentration of dissolved salts, and is normally stable in marine and coastal waters, but differs both vertically and horizontally in estuarine waters.

Total Suspended Solids (TSS) comprises organic and mineral particles that are transported in the water column. The presence of TSS in high concentrations within a river body denotes land-based erosion occurring within the catchment area as a result of anthropogenic activities. It is also linked to the transport of nutrients (especially phosphorus), metals and a wide range of industrial and agricultural chemicals.

Dissolved oxygen (DO) is a vital component of a river system. Degradation of DO levels will result in serious impediment to the biological activities of the riverbody. High DO levels indicate low organic loading and conversely low DO indicates high organic loading. If the organic load of a river system exceeds its carrying capacity, the river becomes anoxic and anaerobic processes will dominate, emitting foul odours and discolouring the river body. Subsequently the 'life' of the river body deteriorates.

Biochemical Oxygen Demand (BOD) is typically used as a measurement of organic loading of a natural watercourse. High BOD levels denote the presence of decomposing organic matter (organic pollution) and these high levels normally correspond with low DO levels; as DO is utilised by aerobic bacteria.

The presence of non-biodegradable matter in a watercourse is measured by concentration of the Chemical Oxygen Demand (COD). High COD levels indicate heavy loading of non-organic origin (non-biodegradable) and thus can be used as an indicator of chemical pollution.

The presence of excessive nutrients (ammoniacal nitrogen (AN) and phosphorus) will lead to increased biological activities, such as eutrophication which results in decreased DO values. Eutrophication impedes the regeneration of the benthic organisms and the quality of the river ecosystem by reducing the mortality of other aquatic organism such as fishes, crustacean, etc. Typical sources of these nutrients include agricultural run-off containing organic fertilisers, animal husbandry activities and chemical pesticides/fertilisers.

pH is the expression of the molar concentration of the hydrogen ion as its negative logarithm. It is one of the primary indicators to evaluate surface water quality and suitability for beneficial water uses. Most natural waters have a pH value between 5.0 and 8.5 and seawater has pH values typically in the range of pH 8.0 and 8.5.

River Samples Collected During High Tide

The four river water samples (W1, W5, W6 and W7) collected during high-tide had pH values ranging from 6.66 to 6.98 and dissolved oxygen (DO) levels ranging between 3.52 mg/l and 4.23 mg/l. All the pH values and DO levels recorded were well within the Class III range limit of 5 to 9 (pH) and 3.0 mg/l to 5.0 mg/l (DO). pH values complied with Class II range limit of 6 to 9 but did not comply with DO limits of 5.0 mg/l to 7.0 mg/l.

Concentrations of Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), total coliform and ammoniacal nitrogen (AN) recorded for samples were lower than their respective Class III limits except for AN in sample W5 which recorded at 2.2 mg/l and was higher than the Class III limit of 0.9 mg/l for AN. BOD, TSS and Total Coliform also complied with Class II at all locations. However, only W1 complied with Class II AN limit of 0.3 mg/l while the other three stations were between 0.7 – 2.2 mg/l.

Chemical Oxygen Demand (COD) concentrations for these water samples were slightly higher than the Class III limit (50 mg/l) except for sample W5 which recorded 50 mg/l. All four locations exceeded the Class II limit of 25 mg/l with levels of 50 – 59 mg/l.

No traces of cyanide, free chlorine, or oil and grease were detected in the samples analysed. Sulphide was detected in all samples with readings ranging from 0.1 mg/l to 0.4 mg/l except for sample W1 which was not detected.

The heavy metals analysed, i.e.Hg, Cd, Cr^{6+}, As, Pb, Cr^{3+}, Cu, Mn, Ni, Sn, Zn, Ag and Ba, were either not detected or found in trace levels in all the samples. Among the heavy metals detected were lead (Pb), manganese (Mn), zinc (Zn), nickel (Ni) and Barium (Ba). Barium was detected in all samples with concentrations ranging between 0.01 mg/l to 0.03 mg/l. Manganese, nickel and zinc were detected in samples W5, W6 and W7 with readings ranging from 0.021 mg/l to 0.033 mg/l (Mn), 0.008 mg/l to 0.011 mg/l (Ni) and 0.012 mg/l to 0.052 mg/l (Zn). Readings of manganese, nickel and zinc were well below the Class III limits.

Readings of conductivity and total dissolved solids of the water samples were in the range of 29 us/cm to 19740 us/cm (conductivity) and 28 mg/l to 12990 mg/l (TDS) respectively, while calcium (Ca) and magnesium (Mg) concentrations were recorded in the range of 2.78 mg/l to 117 (Ca) and 0.71 mg/l to 384 mg/l (Mg), respectively. Carbonate (CO_3) was not detected in all these samples.

The W2 sample recorded a pH value of 7.14 and DO reading of 3.81 mg/l, both well within the Class III range limit. pH level also complied with the Class II limit but DO exceeded Class II limit of 5.0 mg/l to 7.0 mg/l. Concentrations of BOD, TSS, ammoniacal nitrogen and counts of Total Coliform recorded for this water samples were lower than their respectively Class III limits as well as Class II limits. The COD concentration was 51 mg/l, marginally higher than the Class III limits of 50 mg/l and much higher than the Class II limit of 25 mg/l. Readings of conductivity, concentration of TDS, Ca and Mg recorded were 15720 us/cm (conductivity), 9670 mg/l (TDS), 89 mg/l (Ca) and 305 mg/l (Mg). Carbonate (CO_3) was not detected in this sample. Results for the rest of the parameters tested were either not detected or detected below their respective Class III limits

The two water samples (W3 and W4) collected downstream of the first and second drainage outlets respectively had pH values of 6.71 (W3) and 6.53 (W4), and DO readings of 3.08 mg/l (W3) and 2.17 mg/l (W4). Both the pH and DO readings were well within the Class III range limit. The pH value was also within the Class II limit but exceeded the DO limit of 5.0 mg/l to 7.0 mg/l. Concentrations of BOD, COD, TSS, and counts of Total Coliform recorded for these two water samples were lower than their respective Class III limits for both the water samples collected. BOD, TSS and Total Coliform were also within their respective Class II limits. COD levels were 46 mg/l (W3) and 34 mg/l (W4), exceeding the Class II limit of 25 mg/l.

Ammoniacal nitrogen readings recorded at 2.2 mg/l (W3) and 17.8 mg/l (W4) were higher than the Class III limit of 0.9 mg/l. Readings of conductivity, TDS, Ca and Mg for W3 and W4 were recorded at 1102 us/cm and 5300 us/cm (conductivity), 671 mg/l and 3570 mg/l (TDS), 12.4 mg/l and 15.2 (Ca), and 25.8 mg/l and 39.4 mg/l (Mg) respectively. Carbonate (CO_3) was not traced in these two samples. Results for the rest of the parameters tested were either not detected or detected below their respective Class III limits

The analytical results obtained for the samples collected at W1, W2, W3, W4, W5, S6 and W7 during high tide are presented in **Table 4.15** below while the complete laboratory results are attached in **Appendix 2**.

Table 4.15: Water Quality Results (W1, W2, W3, W4, W5, W6 & W7) (High Tide)

Parameters	Unit	Results						Class III	Class II
		W1	W2	W4	W5	W6	W7		
pH value	-	6.98	7.14	6.53	6.89	6.76	6.66	5 – 9	6 – 9
Biochemical Oxygen Demand	mg/l	<2	<2	<2	<2	<2	<2	6	3
@ 5 days at 20 ºC									
Chemical Oxygen Demand	mg/l	52	51	34	50	59	54	50	25
Total Suspended Solids	mg/l	5	4	<2	3	3	2	150	50
Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.001
Cadmium as Cd	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	0.01
Chromium Hexavalent as Cr^{6+}	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.4	0.01
Arsenic as As	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.40	0.05
Cyanide as CN	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.06	0.02
Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01	0.01	0.01	0.02	0.05
Chromium Trivalent as Cr^{3+}	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	2.50	-
Copper as Cu	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	0.02
Manganese as Mn	mg/l	<0.001	<0.001	<0.001	0.033	0.027	0.021	0.10	0.1
Nickel as Ni	mg/l	<0.005	<0.005	<0.005	0.011	0.008	0.011	0.90	0.05
Tin as Sn	mg/l	*<0.004*	*<0.004*	<0.004	<0.004	<0.004	<0.004	0.004	-
Zinc as Zn	mg/l	<0.005	<0.005	<0.005	0.015	0.052	0.012	0.4	5

Parameters	Unit	Results						Class III	Class II
		W1	W2	W4	W5	W6	W7		
Free Chlorine as Cl_2	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	N/A
Sulphide as S^{2-}	mg/l	<0.05	<0.05	0.20	0.20	0.40	0.10	-	0.05
Oil and Grease	mg/l		ND(<1)	ND(<1)	ND(<1)	ND(<1)	ND(<1)	*Free from visible layer, discoloration, deposits*	*Free from visible layer, discoloration, deposits*
Ammoniacal Nitrogen as AN	mg/l	0.2	0.1	17.8	2.2	0.7	0.8	0.9	0.3
Temperature	ºC	29.2	29.5	30.8	30.1	28.3	29.5	Normal ±2	Normal ±2
Dissolved Oxygen	mg/l	4.23	3.81	2.17	3.52	3.52	3.71	3 – 5	5 – 7
Conductivity	us/cm	19740	15720	5300	270	655	29	-	1000
Total Dissolved Solids	mg/l	12990	9670	3570	190	377	28	-	1000
Total Coliform	Count/100ml	300	700	2100	600	800	300	50000	5000
Calcium as Ca	mg/l	117	89	15.2	3.52	6.83	2.78	-	-
Magnesium as Mg	mg/l	384	305	39.4	2.63	9.95	0.71	-	-
Silver as Ag	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0002	0.05
Barium as Ba	mg/l	0.01	<0.01	<0.01	0.03	0.02	0.02	-	1
Carbonate as CO_3	mg/l	<1	<1	<1	<1	<1	<1	-	

Note:

1. ***Parameter limits of Class III under the DOE Proposed Interim National Water Quality Standards for Malaysia.***
2. ***ND means not detected.***

River Samples Collected During Low Tide

All the pH values and DO levels of samples W1, W5, W6 and W7 collected well within the Class III range of 5 to 9 (pH) and 3.0 mg/l to 5.0 mg/l (DO). All stations also complied with Class II pH limit of 6 to 9 but did not comply with the DO limit of 5.0 mg/l to 7.0 mg/l. The readings ranged between 3.60 mg/l to 4.12 mg/l.

Concentrations of Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), total coliform and ammoniacal nitrogen (AN) recorded for all the water samples were lower than their respective Class III limits. BOD, TSS and total coliform concentrations complied with their respective Class II limits. AN levels were between 0.5 mg/l to 0.7 mg/l exceeding the Class II limit of 0.3 mg/l by a small difference.

Chemical Oxygen Demand (COD) concentrations for these water samples which were recorded ranging between of 54 mg/l to 55 mg/l were slightly higher than Class III limit (50 mg/l) except for sample W7 which recorded at 48 mg/l which was below the said limit. All samples exceeded the Class II limit of 25 mg/l.

No traces of cyanide, free chlorine, or oil and grease were detected in these samples analysed while sulphide was present in most samples with readings ranging from 0.2 mg/l to 0.4 mg/l except for sample W1 which was not detected.

As for the heavy metals analysed, they are either not detected or found only in trace levels. Among the heavy metal detected were copper (Cu), manganese (Mn), zinc (Zn), nickel (Ni) and Barium (Ba). Barium, manganese and nickel were detected in samples W5, W6 and W7 with concentrations ranging between 0.02 mg/l to 0.05 mg/l (Ba), 0.019 mg/l to 0.030 mg/l (Mn) and 0.006 mg/l to 0.011 mg/l (Ni). Copper was traced in samples W5 and W6 with readings of 0.014 mg/l and 0.005 mg/l respectively. Readings of manganese, nickel and zinc were well below the Class III limits.

Conductivity was recorded at ranging from 27 us/cm to 10450 us/cm, and total dissolved solids of the water samples were in the range of 36 mg/l to 6182 mg/l. Calcium (Ca) and magnesium (Mg) concentrations were recorded in the range of 2.11 mg/l to 53.2 (Ca) and 0.44 mg/l to 160 mg/l (Mg), respectively. Carbonate (CO_3) was not traced in all these samples.

The W2 sample had pH of 6.97 and DO of 3.89 mg/l. Both the pH and DO readings were well within their respective Class III range limit. The pH reading also complied with Class II but the DO concentration exceeded the Class II limit of 5.0 mg/l to 7.0 mg/l. Concentrations of BOD, TSS, ammoniacal nitrogen and counts of Total Coliform recorded for this water samples were lower than their respective Class III limits. BOD, TSS and total coliform were within their respective Class II limits. AN however was 0.7 mg/l exceeding the Class II limit of 0.3 mg/l.

The COD concentration recorded was at 52 mg/l marginally higher than the Class III limits of 50 mg/l, but much higher than the Class II limit of 25 mg/l.. Readings of conductivity, TDS, Ca and Mg recorded at 8310 us/cm (conductivity), 4866 mg/l (TDS), 34.9 mg/l (Ca) and 136mg/l (Mg). Carbonate (CO_3) was well within the Class III limit. The results obtained for the rest of the parameters tested were either not detected or detected below their respective Class III limits

The two water samples (W3 and W4) collected from downstream of the first and second drainage outlets had pH values of 6.87 (W3) and 6.45 (W4) which were well within the Class III range limit of 5 to 9 and Class II limit of 6 to 9. DO was recorded at of 3.57 mg/l (W3) which was also well within the Class III range limit of 3 mg/l to 5 mg/l, while DO reading in W4 which recorded 2.70 mg/l was lower than the said limit. However, both W3 and W4 DO concentrations did not comply with the Class II limit of 5.0 mg/l to 7.0 mg/l.

Concentrations of BOD, COD, TSS, and counts of Total Coliform recorded for these two water samples were lower than their respective Class III limits for both the water samples except for COD reading in sample W3 which recorded 65 mg/l being higher than the COD Class III limit. BOD and TSS were also lower than their respective Class II limits. COD at W3 of 65 mg/l exceeded the Class II limit of 25 mg/l while W4 was just within the limit with 25 mg/l concentration. W3 had total coliform count of 5,000 staying within the Class II limit of 5,000 mg/l, while W4 exceeded the limit with 5,700 mg/l. Ammoniacal nitrogen readings were recorded at 1.4 mg/l (W3) and 14.9 mg/l (W4) respectively, which were higher than the Class III limit of 0.9 mg/l. AN at both W3 and W4 exceeded Class II limit of 0.3 mg/l with 1.4 mg/l and 14.9 mg/l respectively.

Readings of conductivity, TDS, Ca and Mg for W3 and W4 were recorded at 1779 us/cm and 3230 us/cm (conductivity), 986 mg/l and 2039 mg/l (TDS), 8.46 mg/l and 16.0 (Ca), and 13.0 mg/l and 5.06 mg/l (Mg) respectively. Carbonate (CO_3) was not detected in both these two samples. Results for the rest of the parameters tested were either not detected or detected below their respective Class III limits

The analytical results obtained for the samples collected at W1, W2, W3, W4, W5, W6 and W7 during low tide are presented in **Table 4.16** below while the laboratory results are attached in **Appendix 2**.

Table 4.16: Water Quality Results (W1, W2, W3, W4, W5, W6 & W7) (Low Tide)

Parameters	Unit	Results							Class III	Class II
		W1	W2	W3	W4	W5	W6	W7		
pH value	-	7.08	6.97	6.87	6.45	6.89	6.70	6.82	5 – 9	6 – 9
Biochemical Oxygen Demand	mg/l	<2	<2	<2	<2	<2	<2	<2	6	3
@ 5 days at 20 ºC										
Chemical Oxygen Demand	mg/l	54	52	65	25	55	55	48	50	25
Total Suspended Solids	mg/l	12	9	14	<2	7	3	2	150	50
Mercury as Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.001
Cadmium as Cd	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.001	0.01
Chromium Hexavalent as Cr^{6+}	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1.4	0.01
Arsenic as As	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.40	0.05
Cyanide as CN	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.06	0.02
Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.05
Chromium Trivalent as Cr^{3+}	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	2.50	-
Copper as Cu	mg/l	<0.005	<0.005	<0.005	0.015	0.014	0.005	<0.005	-	0.02
Manganese as Mn	mg/l	<0.01	<0.01	0.044	0.073	0.030	0.026	0.019	0.1	0.1
Nickel as Ni	mg/l	<0.05	<0.005	0.012	0.048	0.006	0.011	0.009	0.90	0.05
Tin as Sn	mg/l	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.004	-

Parameters	Unit	Results							Class III	Class II
		W1	W2	W3	W4	W5	W6	W7		
Zinc as Zn	mg/l	<0.005	<0.005	0.032	0.054	0.032	0.018	<0.005	0.4	5
Free Chlorine as $C1_2$	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	N/A
Sulphide as S^{2-}	mg/l	<0.05	0.20	0.40	0.40	0.40	0.30	0.20	-	0.05
Oil and Grease	mg/l	ND(<1)	ND(<1)	ND(<1)	ND(<1)	ND(<1)	ND(<1)	ND(<1)	Free from visible layer, discoloration, deposits	*Free from visible layer, discoloration, deposits*
Ammoniacal Nitrogen as N	mg/l	0.7	0.7	1.4	14.9	0.6	0.6	0.5	0.9	0.3
Temperature	ºC	29.8	30.2	30.1	31.0	29.6	29.7	29.2	Normal ±2	Normal ±2
Dissolved Oxygen	mg/l	4.11	3.89	3.57	2.70	3.60	4.07	4.12	3 – 5	5 – 7
Conductivity	us/cm	10450	8310	1779	3230	355	374	27	-	1000
Total Dissolved Solids	mg/l	6182	4866	986	2039	239	222	36	-	1000
Total Coliform	Count/100ml	1400	5000	5700	900	900	2400	600	50000	5000
Calcium as Ca	mg/l	53.2	34.9	8.46	16.0	4.85	5.13	2.11	-	-
Magnesium as Mg	mg/l	160	136	13.0	5.06	4.56	5.03	0.44	-	-
Silver as Ag	mg/l	<0.005	<0.005	<0.005	<0.005	0.094	<0.005	<0.005	0.0002	0.05
Barium as Ba	mg/l	<0.01	<0.01	0.01	0.03	0.03	0.02	0.05	-	1
Carbonate as CO_3	mg/l	<1	<1	<1	<1	<1	<1	<1	-	

1. Parameter limits of Class III under the DOE Proposed Interim National Water Quality Standards for Malaysia.
2. ND means not detected.

4.6.5 Alam Sekitar Malaysia (ASMA)

Secondary river water quality data for Sungai Balok and Sungai Tunggak from published records for January and July 2007 were reviewed during the course of this study. Data was obtained from Alam Sekitar Malaysia Sdn Bhd (ASMA), the company that undertakes routine monitoring of river systems in Malaysia for the Department of Environment (DOE). **Table 4.17** lists the data for both rivers. The location of the monitoring stations is indicated in **Exhibit 4.16**.

4.6.5.1 *Assessment of Results*

Upstream Sungai Balok, 4BL02

All parameters monitored at this location were within their respective Class III limits for both monitoring dates. Iron however exceeded the limit of 1mg/l with 1.03mg/l in July2007. Total coliform was 116,000 exceeded the Class III limit of 50,000.

Dissolved oxygen (DO), ammonical nitrogen (AN), conductivity, salinity and iron exceeded their respective Class II limits during both monitoring times. Dissolved solids, chlorine and total coliform only exceeded Class II limits for the July 2007 monitoring.

The water quality index (WQI) in July 2007 exceeded the Class II limit of 76.5 – 92.7 with 72, falling into a Class III category.

January 2007 monitoring has better water quality results probably due to the flushing during the monsoon season.

Downstream Sungai Balok, 4BL01

Dissolved oxygen exceeded the Class III limit of 3-5 mg/l in January 2007 with 5.02 mg/l at the 4BL01 station at Sungai Balok indicating that the DO level is within the higher Class II category. The BOD concentrations were observed to be low, falling within the higher Class I category. Total coliform exceeded the limit of 50,000 during both monitoring times with 52,000 and 101,000 for January and July 2007 respectively. All other parameters complied with the Class III limits at that location.

DO, chlorine and coliform exceeded the Class II limits of concentration during the January and July 2007 monitoring. Arsenic exceeded the Class II limit of 0.05 mg/l with 0.117 mg/l during the July 2007 monitoring.

The water quality index at this station was well within the Class II limit of 76.5 – 92.7 with 83 (January 2007) and 80 (July 2007).

Downstream Sungai Tunggak, 4T003

Dissolved oxygen at the Sungai Tunggak location of 4T003 exceeded the limit during both monitoring in 2007 with 6.06 mg/l and 5.78 mg/l respectively in January and July 2007. This indicates that the DO concentration is within the higher Class II category. The BOD concentrations were observed to be low, falling within the higher Class I category. Total coliform exceeded the Class III limit of 50,000 with 67,000 in January 2007. Other than that, all other parameters complied with the Class III limits at this location.

Dissolved solids, chlorine, arsenic and coliform exceeded their respective Class II limits for both monitoring times (January and July 2007). TSS of 64 mg/l in July 2007 exceeded the Class II limit of 50 mg/l in July 2007.

The water quality index at this station was well within the Class II limit of 76.5 – 92.7 with 89 (January 2007) and 87 (July 2007).

Based on the monitoring data taken in January and July 2007 (representing the monsoon and dry season respectively), both Sungai Balok and Sungai Tunggak generally are seen to be of Class II river water quality standard.

Table 4.17: Secondary Water Quality Data from Sungai Balok & Sungai Tunggak

Parameters	Unit	Results						Class III	Class II
		4BL01		4BL02		4T003			
		24.01.2007	20.07.2007	24.01.2007	23.07.2007	24.01.2007	20.07.2007		
Dissolved Oxygen (saturated)	-	70.8	73.3	67.3	51.58	82.3	88.9	N/A	N/A
Dissolved Oxygen	mg/l	5.02	5.00	4.97	3.94	6.06	5.78	3-5	5 – 7
Biochemical Oxygen Demand @ 5 days at 20 ºC	mg/l	1	1	1	2	1	1	6	3
Chemical Oxygen Demand	mg/l	16	19	18	23	18	15	50	25
Total Suspended Solids	mg/l	35	35	20	32	16	64	150	50
pH value	-	7.62	7.42	7.79	6.20	7.89	7.21	5 – 9	6 – 9
NH_3_N	mg/l	0.26	1.00	0.48	0.84	0.11	0.15	0.9	0.3
NH_4F	mg/l	N/A	N/A	0.87	N/A	N/A	0.20	N/A	N/A
Cyanide as CN	mg/l	N/A	N/A	N/A	N/A	N/A	N/A	0.06	0.02
Temperature	ºC	29.97	29.09	29.90	28.60	29.86	28.61	Normal +2	Normal +2
Conductivity	us/cm	18971	34643	5914	6173	21650	46662	-	1000
Salinity	ppt	10.13	19.95	2.89	3.34	12.84	28.04	-	1
Turbidity	NTU	17.8	13.5	31.3	22.7	30.2	8.3	-	50
Dissolved Solids, DS	mg/l	2920	16100	29	3390	6460	20900	-	1000
Total Solids, TS	mg/l	2955	16135	49	3422	6476	20964	N/A	N/A
NO_3	mg/l	0.09	0.07	0.06	0.23	0.15	0.06	-	7
Chlorine, Cl	mg/l	1500	8900	9	1810	3650	10400	-	200
PO_4	mg/l	<0.01	0.02	0.01	0.02	<0.01	0.01	N/A	N/A
Arsenic as As	mg/l	0.009	0.117	<0.001	0.010	0.019	0.148	0.40	0.05

Parameters	Unit	Results						Class III	Class II
		4BL01		4BL02		4T003			
		24.01.2007	20.07.2007	24.01.2007	23.07.2007	24.01.2007	20.07.2007		
Mercury as Hg	mg/l	<0.0002	<0.0002	<0.0002	0.0002	<0.0002	<0.0002	0.004	0.001
Cadmium as Cd	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.01
Total Chromium	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	N/A	N/A
Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.05
Zinc as Zn	mg/l	0.09	0.02	0.13	0.03	0.04	0.02	0.4	5
Calcium, Ca	mg/l	39.20	234.00	2.19	34.20	96.50	343.00	-	-
Ferrum, Fe	mg/l	0.86	0.04	0.88	1.03	0.41	0.02	1	0.3
Potassium, K	mg/l	35.90	217.00	1.12	29.30	61.90	315.00	-	-
Magnesium, Mg	mg/l	110.00	790.00	2.13	99.30	267.00	1130.00	-	-
Sodium, Na	mg/l	912.0	5560.0	6.2	845.0	2170.0	5300.0	-	-
Oil & Grease	mg/l	<1	<1	<1	<1	<1	<1	*Free from visible layer, discoloration , deposits*	*Free from visible layer, discoloration , deposits*
MBAS	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	5,000	500
E.Coli	-	1100	10000	16	12000	3900	5000	N/A	N/A
Coliform	-	52000	101000	1000	116000	67000	19000	50,000	5,000
WQ Index	-	83	80	81	72	89	87	51.9 – 76.5	76.5 – 92.7

**Source: Alam Sekitar Malaysia Sdn Bhd (ASMA)*

4.6.6 Riverbed Sediment Quality Monitoring

4.6.6.1 *Riverbed Sediment Monitoring Locations*

A total of four (4) riverbed sediment samples were collected from Sungai Balok using the grab sampling technique. The details of these locations are presented in **Table 4.18.**

Table 4.18: Riverbed Sediment Monitoring Stations

Monitoring Station	Description	Parameters Monitored
S1	Sample collected 100 m downstream of the confluence of Sungai Tunggak. [N03° 56.700’ E103° 22.331’]	Hg, Cd, As, Pb, Cu, Mg, Ni, Sn, Zn, Ca, Ag TOC
S2	Sample collected 100 m downstream of the second drainage outlet (from the GIE). [N03° 57.872’ E103° 21.890’]	
S3	Sample collected 100 m downstream of the proposed Lynas discharge outlet. [N03° 59.534’ E103° 21.472’]	
S4	Sample collected 100 m upstream of the road bridge (across the Gebeng Bypass road). [N04° 00.381’ E103° 21.107’]	

4.6.6.2 *Methodology*

The riverbed sediment samples were collected by grab sampling technique, then were preserved and sent back to the laboratory for chemical analysis. A summary of the parameters analyzed and the analytical methods used for these riverbed sediment samples is provided in **Table 4.19**.

Table 4.19: Method of Chemical Analysis

Parameters	Methods
Mercury as Hg	APHA 3120 B, 1995
Cadmium as Cd	APHA 3120 B, 1995
Arsenic as As	APHA 3120 B, 1995
Lead as Pb	APHA 3120 B, 1995
Copper as Cu	APHA 3120 B, 1995
Nickel as Ni	APHA 3120 B, 1995
Zinc as Zn	APHA 3120 B, 1995
Total Organic Carbon	MS 679, Part III, 1980
Calcium as Ca	APHA 3120 B, 1995
Magnesium as Mg	APHA 3120 B, 1995
Silver as Ag	APHA 3120 B, 1995
Tin as Sn	APHA 3120 B, 1995

4.6.6.3 *Assessment of Results*

A summary of the chemical analysis for the riverbed sediment samples is provided in **Table 4.20** below.

All four riverbed samples had no presence of Hg, As, Sn and Ag when analysed for heavy metals (Hg, Cd, As, Pb, Cu, Ni, Zn, Sn, and Ag). All other parameters were in the range of 1-44 mg/kg, where zinc had the highest concentrations followed by lead. Concentrations of alkaline metals analysed were for Ca and Mg which ranged from 89 mg/kg to 1038 mg/kg (Ca) and 208 mg/kg to 2085 mg/kg (Mg) respectively. The total organic carbon (TOC) content of these sediment samples were found to be in the range of 0.5 % w/w to 2.5 % w/w. It was observed that generally sample S1 had the highest contents of heavy metals, alkaline metals and TOC, followed by sample S2, S3 and the lowest being sample S4.

Table 4.20: Results of Chemical Analysis

Parameters	Unit	Results			
		S1	**S2**	**S3**	**S4**
Mercury as Hg	mg/kg	<0.02	<0.02	<0.02	<0.02
Cadmium as Cd	mg/kg	8.1	3.6	4.6	3.0
Arsenic as As	mg/kg	<0.1	<0.1	<0.1	<0.1
Lead as Pb	mg/kg	18	13	2	1
Copper as Cu	mg/kg	11	10	8	1
Nickel as Ni	mg/kg	18	7	5	2
Tin as Sn	mg/kg	<0.4	<0.4	<0.4	<0.4
Zinc as Zn	mg/kg	44	20	14	6
Calcium as Ca	mg/kg	1038	381	147	89
Magnesium as Mg	mg/kg	2085	747	208	445
Silver as Ag	mg/kg	<0.5	<0.5	<0.5	<0.5
Total Organic Carbon	% w/w	2.5	1.9	0.7	0.5

4.6.7 Plankton

4.6.7.1 *Monitoring Locations*

A total of four (4) samples were collected to monitor plankton from Sungai Balok, using the grab sampling technique. The details of these locations are presented in **Table 4.21.**

Table 4.21: Plankton & Macrobenthos Monitoring Stations

Monitoring Station	Description	Parameters Monitored
P1/MB1	Sample collected 100 m downstream of the confluence of Sungai Tunggak. [N03° 56.700’ E103° 22.331’]	Plankton and Macrobenthos
P2/MB2	Sample collected 100 m downstream of the second drainage outlet (from the GIE). [N03° 57.872’ E103° 21.890’]	
P3/MB3	Sample collected downstream of the proposed Lynas discharge outlet. [N03° 59.534’ E103° 21.472’]	
P4/MB4	Sample collected upstream of the road bridge (across the Gebeng Bypass road). [N04° 00.381’ E103° 21.107’]	

4.6.7.2 *Methodology*

The plankton samples were sampled and analysed using the APHA 10200, 1995 methodology.

Sample Collection

Samples were collected as close to the water surface as possible. This is to ensure a good representation of the composition of plankton at the various sites. The samples were then preserved in formalin solution (40ml. buffered formalin to 1 litre of sample) immediately upon collection. The sample bottles were stored in ice-cooled containers for transportation to the laboratory where they were refrigerated before analysis was carried out.

Concentration of Samples

The plankton (Phytoplankton and Zooplankton) collected in the water was concentrated before analysis. The sedimentation technique was used for concentrating the plankton (recommended by APHA). The method was preferred as it was non-selective (unlike filtration) and non-destructive (unlike centrifugation). Qualitative and quantitative analysis was carried out on the concentrated samples.

Sample Analysis

A standard compound microscope with 10x ocular and 10x, 20x, 40x, and 100x objectives was used for the enumeration of plankton composition in the collected samples. A stereomicroscope with zoom facility, 10x ocular and 1x to 8x objectives was used for large plankters. The analysis of the density and diversity of the plankton was carried out using the "Lackey Drop Microtransect Counting method" as recommended by APHA.

4.6.7.3 *Assessment of Results*

A summary of plankton species recorded at the selected monitoring points are tabulated as seen in **Table 4.22** below.

Results of the analysis showed that plankton density and diversity was generally low at all the monitoring locations. Plankton density varied from 5.72 x 10^3 plankton per liter at P4, to 17.68 x 10^3 plankton per liter at P2. No one species of plankton was observed to be the dominant plankton at any of the sampling sites. *Mollusca larva* (zooplankton) was the most dominant plankton at P1, whereas *Fragilaria* (Freshwater plankton) was observed to be dominant at P2 and P3, while *Navicula* (Freshwater plankton) was the dominant plankton at P4. Mollusca larva was the dominant plankton as correlated by the presence of a high density of Mollusca (5896 individuals per m^2) in the macrobenthos sample at site P1.

All the monitored locations showed a mixture of marine and freshwater plankton. A total of only seventeen (17) species of plankton were recorded. The higher distribution of marine plankton in the samples were *Chaetoceros, Coscinodiscus, Ditylum, Peridium, Pleurosigma, Rhizosolenia, Copepod, Mollusca larvae*, and *Tintinnopsis,* while *Arcella, Fragilaria, Navicula, Nostoc, Spirogyra, Staurastrum, Surirella* and *Tribonema* were noted to be the higher distributed freshwater plankton generally at all four locations. P1 sample was made up of 74% marine plankton and 26% freshwater plankton. Samples P2, P3 and P4 were made up of 84%, 78%, and 100% freshwater plankton respectively.

Diversity Index (H) at the monitoring locations showed values as low as 1.46 (sites P1 and P4) to a high of 1.74 (site P3).

The water samples collected from the various locations were found to have a high content of suspended solids and was turbid (based on visual observation), except for site P 1 where the sample was clear. The suspended solids were noted to be mainly of decomposing vegetation. The high suspended solids and turbidity might have contributed to a low plankton density and diversity.

The physical and chemical characteristics of the sampling sites affect the density, diversity, distribution and stability of the plankton. Therefore the density and distribution of plankton studied can be used as comparison in future monitoring programme. The plankton monitoring report should be read in conjunction with the monitoring report for the physio-chemical parameters, as changes in the physical environment would eventually affect the ecology of the surrounding environment including plankton.

Table 4.22: Results of Plankton Recorded at Monitoring Stations

Plankton	Results			
	P 1	P 2	P 3	P 4
Arcella *	-	0.52	1.04	-
Chaetoceros	-	0.26	-	-
Coscinodiscus	-	0.26	-	-
Ditylum	0.26	-	-	-
Fragilaria *	2.08	6.50	4.16	0.26
Navicula *	-	5.20	2.60	3.12
Nostoc *	0.52	1.56	1.04	-
Peridinium	-	-	-	0.52
Pleurosigma	0.26	-	-	-
Rhizosolenia	0.78	-	-	-
Spirogyra *	-	1.30	1.56	0.52
Staurastrum *	-	-	-	0.26
Surirella *	-	0.26	-	-
Tribonema *	-	-	-	0.26
Copepod	0.52	-	0.52	0.78
Mollusca Larvae	5.20	1.56	1.04	-
Tintinnopsis	0.26	0.26	-	-
No. Per Litre (X10^3)	**9.88**	**17.68**	**11.96**	**5.72**
Shannon-Weiner Index (H)	**1.46**	**1.70**	**1.74**	**1.46**

Notes:
1. ND. Density less than 0.2 x 10^3 /litre.
2. * means freshwater Plankton.

4.6.8 Macrobenthos Monitoring

4.6.8.1 *Macrobenthos Monitoring Locations*

A total of four (4) samples were collected to monitor macrobenthos from Sungai Balok using the grab sampling technique. These samples were taken from the same locations as per the plankton monitoring. The details of these locations are presented in **Table 4.21** under the plankton monitoring section.

4.6.8.2 *Methodology*

The macrobenthos samples were sampled and analysed using the APHA 10500, 1995 methodology.

Sample Collection

An Ekman Grab sampler (0.15m x 0.15m) was used to sample the macrobenthos. Samples were collected at the same locations where water samples were taken for water quality and plankton analysis. The bottom grab samples collected were stored in double layered plastic bags and kept in ice packed boxes before being transported to the laboratory for analysis.

Sample Analysis

Analysis was carried out using the recommended method in the "Standard Methods for The Examination of Water and Wastewater" published by the American Public Health Association (APHA). Bottom grab samples were first diluted with water and the slurry was then sieved through a series of sieves of mesh size 1.00mm aperture (US standard No. 28 sieve) and mesh size 0.50mm aperture (US standard No. 35 sieve).

The screened material from the US Standard No.35 sieve was washed, collected in a container and labelled. The content was then preserved in 70% alcohol. Using a stereoscopic microscope, the samples were later identified and quantified. The number of organisms observed was expressed as number of individuals per meter square (individuals / m^2).

4.6.8.3 *Assessment of Results*

A summary of Macrobenthos recorded at the selected monitoring points are tabulated as seen in **Table 4.23** below.

The analysis showed that the macrobenthos at locations MB1, MB2, MB3 and MB4 consisted of three (3) phyla of organisms. They were *Annelida (Polychaeta), Arthropoda (Crustacea)* and *Mollusca*. A total of nine (9) species of organisms were observed at the four locations. Three (3) species were recorded from *Annelida*; two (2) species were recorded from *Arthropoda (Crustacea),* and four (4) species from the *Mollusca* phyla. This indicated that there is a low diversity of macrobenthos at the sampling locations.

The *Mollusca* was the dominant phylum with 95% of the total organisms in the macrobenthic community. This was followed by *Arthropoda (Crustacea)* (3%) and *Annelida* (2%).

There was a high content of decomposing vegetation observed in the samples collected from all locations. Sediments collected from MB2 were found to be oily (visual observation). It was also noted that all the samples emitted an odour of Hydrogen Sulphide gas while the samples were being processed, an indication that the monitoring locations could be polluted. Density of macrobenthos was low at all the locations. The density of macrobenthos varied from sample to sample. The densest sample was MB1 with 6116 individuals per m^2. The least dense sample was MB2 with 44 individuals per m^2. No macrobenthos was recorded at MB4 (ie: less than 44 individuals/m^2).

Annelida was observed at MB1, MB2 and MB3 with densities between 44 and 88 individuals/m^2. *Arthropoda (Crustacea)* was recorded at two (2) sites, namely MB1 and MB3. with densities of 176 individuals/m^2 (single species of *Balanus (Cirripedia)*, commonly known as barnacle) and 44 individuals/m^2 (single freshwater species of *Gammarus (Amphipoda)*) respectively. *Mollusca* were also observed at MB1 and MB3 with densities of 5896 individuals/m^2 (MB1) and 1144 individuals/m^2 (MB3).

Shannon-Wiener Diversity Index (H) is employed to measure the diversity of macrobenthos at the monitoring sites. Diversity was low. Diversity Index (H) ranging from 0 at locations MB 2 and MB 4, to 0.64 at location MB 3.

Physical and chemical factors such as sediment types, temperature, productivity, salinity, oxygen and depth of the sampling sites are known to be among the various factors that affect the density and composition of the macrobenthos. The density and distribution of macrobenthos studied will provide useful data and information for comparison in future monitoring programme. The macrobenthos monitoring report should be read in conjunction with the monitoring report for the physio-chemical parameters as well as the plankton data, as changes in the physical environment would eventually affect the ecology of the surrounding environment.

Table 4.23: Results of Macrobenthos Recorded at Monitoring Stations

Microbenthos	Results			
	MB 1	MB 2	MB 3	MB 4
Annelida (Polychaeta)				
- Lumbrinerideа	-	-	88	-
- Nereidae	-	44	-	-
- Polychaete Tube	44	-	-	-
Total (Annelida)	**44**	**44**	**88**	**0**
Arthropoda (Crustacea)				
- Balanus (Cirripedia)	176	-	-	-
- Gammarus (Amphipoda) *	-	-	44	-
Total Arthropoda	**176**	**0**	**44**	**0**
Mollusca				
- Cerithidea (Cerithiidae)	5676	-	88	-
- Donax (Donacidae)	88	-	-	-
- Littorina (Littorinidae)	132	-	-	-
- Turritella (Turritellidae)	-	-	1056	-
Total (Mollusca)	**5896**	**0**	**1144**	**0**
Total Density (Individuals/m^2)	**6116**	**44**	**1276**	**0**
Sh- Weiner Index(H')	**0.35**	**0.00**	**0.64**	**0.00**

Notes:
1. 0 values mean Not Detected. Less than 44 Individuals/m2.
2. Above values are expressed as: Individuals/m2 except for SH-Weiner Index
3. * means Freshwater Macrobenthos.

4.6.9 Soil and Groundwater

A soil and groundwater investigation was performed at the proposed project site to obtain baseline information regarding the environmental quality of the on-site soil and groundwater. Soil and groundwater samples were collected at seven (7) locations within the proposed project site boundary for chemical analyses (**Exhibit 4.17**). The following sections describe the field activities and investigation methodology, and results of the assessment.

4.6.9.1 *Methodology*

a. Drilling Protocol

Between 3 and 5 October 2007, seven (7) boreholes, designated MW1 through MW7, were drilled at the proposed project site to a depth of 4 m below ground surface (bgs). The boreholes were advanced using a cable tool percussion drill rig. No drilling fluids were used. Soil samples were collected from the drill barrel and were visually logged in accordance with the Unified Soil Classification System (USCS). Samples were also checked for any unusual odour or staining. The soil boring logs are presented in **Exhibit 4.17.**

b. Soil Sampling

A representative soil sample was selected at each borehole for chemical analysis, biased toward any field evidence of contamination. The soil sample was screened for total volatile organic vapour using the head space screening method using a photo-ionizing detector (PID). In the absence of field evidence of contamination, a sample above the water table was collected. Samples intended for chemical analyses were placed in laboratory-supplied jars, properly labelled, and kept chilled until delivery to the laboratory.

c. Installation of Groundwater Monitoring Wells

All boreholes were converted into 50 mm diameter permanent groundwater monitoring wells. The well construction details at each borehole are presented in **Exhibit 4.17.** Upon completion of installation, the monitoring wells were developed to remove fine materials and establish hydraulic continuity between the target groundwater zone and well intake area. Well development was performed using dedicated bailers to minimize the potential of cross-contamination.

d. Well Elevation Survey and Static Water Level Measurement

All monitoring wells were surveyed for their top-of-casing levels. Stabilized standing water level (SWL) measurements were obtained from each monitoring well on 6 October 2007. The SWL measurements and estimated groundwater elevations are summarised in **Table 4.24**.

On the basis of the measured static water levels in the wells, groundwater was generally encountered at shallow depths of between 0.97 and 2.17 m bgs. Based on the derived groundwater reduced levels, the groundwater beneath the subject site is inferred to flow towards the south. The inferred groundwater flow direction is shown in **Exhibit 4.17**. The groundwater gradient at the site is calculated to be approximately 0.001.

Table 4.24: Groundwater Elevation Data

Monitoring Well Number	Top-of-Well Casing Elevation (m RL)	Depth to Groundwater (m below TOC) [1]	Groundwater Elevation (m RL)	Depth to Groundwater (m BGS)
MW1	7.97	1.39	6.58	0.97
MW2	7.99	1.60	6.39	1.13
MW3	8.35	2.60	5.75	2.17
MW4	8.41	1.74	6.67	1.26
MW5	8.19	1.86	6.33	1.43
MW6	8.47	1.88	6.59	1.48
MW7	8.32	1.43	6.89	1.04

Notes:
m below TOC - metre below top of well casing; m RL - metre reduced level; [1] Measurements taken on 6 October 2007.

e. Groundwater Sampling

The groundwater monitoring wells were sampled on 6 October 2007. Sampling was performed using dedicated bailers. A minimum of three well volumes of standing groundwater in each well was purged prior to obtaining a sample. Groundwater recovery rates during purging were observed to be low to moderate. Samples were placed in laboratory-supplied containers, properly labelled and kept chilled until delivery to the laboratory.

4.6.9.2 Laboratory Analyses

A total of eight (8) soil and eight (8) groundwater samples, including 1 soil and 1 groundwater duplicates were submitted to the laboratory for chemical analysis. ALS Technichem (M) Sdn. Bhd. was engaged to perform chemical analyses of the soil and groundwater samples. The samples were analysed for:

- Total Petroleum Hydrocarbons (TPH);
- Volatile Organic Compounds (VOC) comprising 63 individual compounds of monocyclic aromatics, fumigants, halogenated aliphatics, halogenated aromatics, trihalomethanes and oxygenated compounds;
- Semi-Volatile Organic Compounds (SVOC) comprising 87 individual compounds of polycyclic aromatic hydrocarbons (PAHs), phenols, phthalate esters, nitrosamines, nitroaromatics, ketones, haloethers, chlorinated hydrocarbons, anilines and benzidines;
- Pesticides comprising 17 individual organochlorine and 14 organiphosphorus pesticide compounds;
- Polychlorinated biphenyls (PCB);
- Metals comprising arsenic, barium, cadmium, chromium, cobalt, copper, mercury, lead, molybdenum, nickel, zinc and antimony;
- Cyanide;
- Anions (chloride, sulphate and phosphate) in groundwater; and
- Cations (sodium, potassium, calcium and magnesium) in groundwater.

4.6.9.3 Results and Discussion

As there are currently no compound-specific reference standards for assessing the presence of soil and groundwater impact in Malaysia, the baseline analytical results were compared with the "*Dutch Ministry of Housing, Spatial Planning and the Environment (MVROM)–Soil and Groundwater Standards*" to assess soil and groundwater quality. Though not enforceable in Malaysia, these standards are widely used in the evaluation of soil and groundwater quality in Malaysia and other countries outside of the Netherlands. The MVROM standards can be used as a guideline reference /investigation/screening criteria for this site.

The MVROM standards are subdivided into two general categories:

- Target values are characteristic of clean, uncontaminated soil and groundwater, representative of background values in the Netherlands; and

- Intervention values indicate the presence of constituents or compounds at levels above which there is a serious case of soil and groundwater contamination.

Given the proposed industrial use of the site and its surroundings, the above generic screening criteria are likely to be over-protective, particularly the target values (DTV). The Dutch Intervention Values (DIV) has been selected as the appropriate baseline screening criteria for this site.

a. Soil Sampling Observations and Analytical Results

Soils encountered during soil boring and sampling activities throughout the field survey did not exhibit any apparent evidence of contamination, i.e. on the basis of the soil headspace screening and visual and olfactory inspection. Measured soil total organic vapour values indicated negligible concentrations of ionizable VOCs.

Table 4.25 summarises the laboratory analytical results for soil samples while the complete laboratory results are attached in **Appendix 2**. The results indicate that all organic parameters (TPH, VOC, SVOCs, pesticides and PCBs) and cyanide were below their respective laboratory level of reporting (LOR) in all soil samples analyzed. A few metals were detected above their respective LOR, however, the detected levels were below the respective DTVs and DIVs.

b. Groundwater Sampling Results

During the gauging and sampling episodes, no oily sheen or hydrocarbon odour was observed in any groundwater samples. Field water quality parameters measured indicated the following:

- Groundwater pH ranged between 3.6 and 4.0 indicating acidic conditions, generally associated with peaty swampy conditions;

- Electrical conductivity ranged between 1 μS/cm and 82 μS/cm, indicative of very low total dissolved solids content (ie. freshwater conditions);

- Dissolved oxygen ranged between 2.6 and 4.4 mg/l, indicative of low to moderate dissolved oxygen content; and

- Oxidation and reduction potential (ORP) ranged between 154 and 275 mV, indicative of slightly oxidizing conditions.

The groundwater analytical results are summarised in **Table 4.26**. The full laboratory results are presented in **Appendix 2**. The results indicate that:

- Selected metals were detected at or above their respective LORs in a few of the groundwater samples. However, the detected levels were below the respective DTVs and DIVs, with the exception of barium in MW4 detected at a concentration of 57 μg/l which slightly exceeded the DTV of 50 μg/l. The DIV for barium is 625 μg/l. The concentrations of all other metals analyzed were below the respective LORs and DIVs; and

- All organic parameters (TPH, VOC, SVOCs, pesticides and PCBs) and cyanide were below their respective laboratory level of reporting (LOR) in all groundwater samples analyzed.

- Concentrations of chloride, sulphate and phosphate ranged from 7.5–10.5 mg/l, 1.4–28 mg/l, and 0.1–0.82 mg/l respectively. Calcium, magnesium, sodium and potassium were detected at concentrations of 0.4–3.3 mg/l, 0.1–0.6 mg/l, 2.3–23.4 mg/l, and 0.3–1.7 mg/l respectively. Guideline values have not been set by MVROM for these anions and cations. The concentrations were considered low and indicative of natural background levels.

b. QA/QC Results

One duplicate soil sample (labelled as MW8(1.0m)) of MW2(1.0m) and one duplicate groundwater sample (labelled as MW8) of MW6 were collected. Relative percentage difference (%RPD) for all analytes were within the acceptable RPD criteria except for phosphate and sodium in groundwater. These variances are noted to not have any material implications in the overall conclusions of the baseline soil and groundwater assessment.

TABLE 4.25: Summary of Detected Constituents in Soil

	PID	*Dutch List - Organic Analytes*						*Other Organic Analytes* [(3)]							
		Aromatic Compounds	Polycyclic Aromatic Hydrocarbons	Chlorinated Hydrocarbons	Pesticides	Other Pollutants		Total Petroleum Hydrocarbons				Volatile Organic Compounds	Semivolatile Organic Compounds	Organochlorine & Organophosphorus Pesticides	Polychorinated Biphenyls
	Maximum Reading	10 Cornpounds	10 Compounds	29 Compounds	17 Compounds	6 compounds	Mineral Oil	C6-C9	C10-C14	C15-C28	C29-C36	63 Compounds	87 Compounds	31 Compounds	10 Compounds
	ppm	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Limit of Reporting (LOR)		*Various*	*Various*	*Various*	*Various*	*Various*	*5*	*5*	*50*	*100*	*100*	*Various*	*Various*	*Various*	*Various*
Screening Criteria															
Dutch Target Values [(1)]		*Various*	*Various*	*Various*	*Various*	*Various*	*50*	*NS*	*NS*	*NS*	*NS*	*Various* [(2)]	*Various* [(2)]	*Various* [(2)]	*NS*
Dutch Intervention Values [(1)]		*Various*	*Various*	*Various*	*Various*	*Various*	*5000*	*NS*	*NS*	*NS*	*NS*	*Various* [(2)]	*Various* [(2)]	*Various* [(2)]	*NS*
Sample ID															
MW1 (1.0m)	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW2 (1.0m)	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW3 (1.0m)	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW4 (1.0m)	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW5 (1.0m)	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW6 (1.5m)	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW7 (1.0m)	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
QA/QC Sample - Duplicate of MW2															
MW8 (1.0m)	0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RPD (%)	0	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

Notes:

mg/kg - milligrams per kilogram

NS - DIV or DTV not specified

ND - not detected above the Limit of Reporting (LOR)

indicates value exceeding the Dutch Intervention Value (DIV)

indicates exceedance of the acceptable QA/QC criteria (RPD of less than -30% or exceeding 30%)

Where both analytical values of the primary and duplicate samples are below 10 times the LOR, RPDs of ± 50% are considered acceptable.

[(1)] Dutch Ministry of Housing, Spatial Planning and Environment (MVROM). Circular on Target and Intervention Values for Soil Remediation. February 2000.

[(2)] Values are available for selected compounds only. Refer to the relevant documents for further information.

[(3)] Some compounds are the same as the Dutch List compounds.

Table 4.25 (Con't): Summary of Detected Constituents in Soil

	Inorganic Analytes												
	Cyanide	Metals											
	Total Cyanide	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Mercury	Lead	Molybdenum	Nickel	Zinc	Antimony
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Limit of Reporting (LOR)	*0.5*	*1*	*5*	*0.05*	*0.05*	*0.5*	*0.5*	*0.05*	*1*	*0.5*	*0.5*	*0.5*	*5*
Screening Criteria													
Dutch Target Values [(1)]	*NS*	*29*	*160*	*0.8*	*100*	*9*	*36*	*0.3*	*85*	*3*	*35*	*140*	*3*
Dutch Intervention Values [(1)]	*NS*	*55*	*625*	*12*	*380*	*240*	*190*	*10*	*530*	*200*	*210*	*720*	*15*
Sample ID													
MW1 (1.0m)	ND	ND	ND	ND	65	1	4	0.1	4	ND	1	7	ND
MW2 (1.0m)	ND	ND	ND	ND	1	ND	2	0.1	1	ND	ND	ND	ND
MW3 (1.0m)	ND	ND	ND	ND	2	ND	2	0.1	ND	ND	ND	1	ND
MW4 (1.0m)	ND	ND	7	0.1	75	6	7	0.1	4	ND	2	6	ND
MW5 (1.0m)	ND	ND	ND	0.1	79	1	6	0.1	2	ND	1	6	ND
MW6 (1.5m)	ND	ND	ND	ND	63	2	7	0.2	3	ND	8	6	ND
MW7 (1.0m)	ND	ND	ND	ND	79	4	8	0.1	3	ND	2	7	ND
QA/QC Sample - Duplicate of MW2													
MW8 (1.0m)	ND	ND	ND	ND	1	ND	2	0.1	1	ND	ND	1	ND
RPD (%)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*18*	*0*

Notes:

mg/kg - milligrams per kilogram
NS - DIV or DTV not specified
ND - not detected above the LOR

indicates value exceeding the Dutch Intervention Value (DIV)
indicates exceedance of the acceptable QA/QC criteria (RPD of less than -30% or exceeding 30%)
Where both analytical values of the primary and duplicate samples are below 10 times the LOR, RPDs of ± 50% are considered acceptable.

[(1)] Dutch Ministry of Housing, Spatial Planning and Environment (MVROM). Circular on Target and Intervention Values for Soil Remediation. February 2000.

Table 4.26: Summary of Detected Constituents in Ground Water

	Dutch List - Organic Analytes						*Other Organic Analytes* [(3)]							
	Aromatic Compounds	Polycyclic Aromatic Hydrocarbons	Chlorinated Hydrocarbons	Pesticides	Other Pollutants		Total Petroleum Hydrocarbons				Volatile Organic Compounds	Semivolatile Organic Compounds	Organochlorine & Organophosphorus Pesticides	Polychorinated Biphenyls
	10 Coumpounds	10 Compounds	29 Compounds	17 Compounds	6 compounds	Mineral Oil	C6-C9	C10-C14	C15-C28	C29-C36	63 Compounds	87 Compounds	31 Compounds	10 Compounds
	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
Limit of Reporting (LOR)	*Various*	*Various*	*Various*	*Various*	*Various*	*5*	*5*	*50*	*100*	*100*	*Various*	*Various*	*Various*	*Various*
Screening Criteria														
Dutch Target Values [(1)]	*Various*	*Various*	*Various*	*Various*	*Various*	*50*	*NS*	*NS*	*NS*	*NS*	*Various* [(2)]	*Various* [(2)]	*Various* [(2)]	*NS*
Dutch Intervention Values [(1)]	*Various*	*Various*	*Various*	*Various*	*Various*	*600*	*NS*	*NS*	*NS*	*NS*	*Various* [(2)]	*Various* [(2)]	*Various* [(2)]	*NS*
Sample ID														
MW1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
QA/QC Sample - Duplicate of MW6														
MW8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RPD (%)	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Trip Blank	-	-	-	-	-	-	-	-	-	-	ND	-	-	-

Notes:

µg/l - micrograms per litre

NS - DIV or DTV not specified

ND - not detected / below LOR

indicates exceedance of DIV

indicates exceedance of the acceptable QA/QC criteria (RPD of less than -30% or exceeding 30%)

Where both analytical values of the primary and duplicate samples are below 10 times the LOR, RPDs of ± 50% are considered acceptable.

[(1)] Dutch Ministry of Housing, Spatial Planning and Environment (MVROM). Circular on Target and Intervention Values for Soil Remediation. February 2000.

[(2)] Values are available for selected compounds only. Refer to the relevant documents for further information.

[(3)] Some compounds are the same as the Dutch List compounds.

Table 4.26 (Con't): Summary of Detected Constituents in Ground Water

	Inorganic Analytes																				
	Cyanide	Anions				Common Metals				Trace Metals											
	Total Cyanide	Chloride	Sulphate	Phosphate	Alkalinity	Calcium	Magnesium	Sodium	Potassium	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Mercury	Lead	Molybdenum	Nickel	Zinc	Antimony
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
Limit of Reporting (LOR)	*0.05*	*0.1*	*0.1*	*0.01*	*1*	*0.1*	*0.1*	*0.1*	*0.1*	*1*	*5*	*1*	*1*	*1*	*1*	*0.3*	*1*	*1*	*1*	*5*	*1*
Screening Criteria																					
Dutch Target Values [1]	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*10*	*50*	*0.4*	*1*	*20*	*15*	*0.05*	*15*	*5*	*15*	*65*	*-*
Dutch Intervention Values [1]	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*60*	*625*	*6*	*30*	*100*	*75*	*0.3*	*75*	*300*	*75*	*800*	*20*
Sample ID																					
MW1	ND	10.5	27.8	0.76	21	0.4	ND	23.4	0.6	ND	4	ND	1	ND	ND	ND	ND	ND	ND	6	ND
MW2	ND	7.7	2.4	0.82	2	1.1	0.5	5.3	0.9	ND	12	ND	ND	ND	ND	ND	ND	ND	2	11	ND
MW3	ND	10.0	1.4	ND	ND	1.0	0.4	3.2	0.7	ND	8	ND	ND	1	ND	ND	ND	ND	2	13	ND
MW4	ND	11.4	11.2	ND	ND	3.1	0.6	4.4	1.7	ND	57	ND	ND	1	ND	ND	14	ND	2	14	ND
MW5	ND	9.0	4.9	ND	ND	1.3	0.3	3.0	0.3	ND	16	ND	ND	2	ND	ND	ND	ND	1	14	ND
MW6	ND	8.2	8.7	ND	ND	1.9	0.4	2.3	0.5	2	19	ND	ND	8	ND	ND	2	ND	7	22	ND
MW7	ND	7.5	3.9	0.03	1	3.3	0.3	2.5	0.5	2	18	ND	ND	ND	ND	ND	7	ND	1	21	ND
QA/QC Sample - Duplicate of MW6																					
MW8	ND	8.2	8.5	0.09	ND	1.8	0.4	4.6	0.6	2	17	ND	ND	7	ND	ND	2	ND	5	20	ND
RPD (%)	*0*	*0*	*-2*	*160*	*0*	*-5*	*0*	*67*	*18*	*0*	*-11*	*0*	*0*	*-13*	*0*	*0*	*0*	*0*	*-33*	*-10*	*0*
Trip Blank	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes:

µg/l - micrograms per litre
NS - DIV or DTV not specified
ND - not detected / below LOR

(solid box) indicates exceedance of DIV
(dotted box) indicates exceedance of the acceptable QA/QC criteria (RPD of less than -30% or exceeding 30%)
Where both analytical values of the primary and duplicate samples are below 10 times the LOR, RPDs of ± 50% are considered acceptable.

[1] Dutch Ministry of Housing, Spatial Planning and Environment (MVROM). Circular on Target and Intervention Values for Soil Remediation. February 2000.

4.7 ECOLOGY

The proposed plant site has been largely cleared and filled to the existing platform level. Secondary vegetation were found sparsely distributed within the site. The vegetation type is typical of a disturbed area, and all species observed are very common pioneer and invasive species, typical of an open and disturbed vegetation type. No vegetation of ecological significance was observed at the site.

4.8 SOCIO-ECONOMIC ENVIRONMENT

Kuantan with an area of 2,960 km^2, is divided into seven districts comprising a total population of 394,500 (Statistics Department Malaysia 2004).

Based on the Population and Housing Census of Malaysia (2000), the Kuantan township has a total population of 344,319. The mukim (sub-district) where the site is located, Sungai Karang, has a population of 31,625. Based on the population records, the population distribution in Kuantan is not uniform. The population of the mukims closest to the site in Sungai Karang, i.e. Beserah in the south is 11,744, and Kuala Kuantan (south of Beserah) is 269,721 estimated people. Sungai Karang is the second most populous sub-district in Kuatan with 31,625 people accounting for approximately 9.2% of the Kuantan District population.

These three sub-districts are highly populated with respect to the other sub-districts in Kuantan. Kuala Kuantan is the most populous as it the capital city of the state of Pahang with all state administrative offices located there. Sungai Karang and Beserah are the next two most populous sub-districts and this is attributed primarily to the development of the GIE and the Kuantan Port, generating significant employment opportunities. Of the total population in these 3 mukims, Malaysian citizens comprised 97.7 % whilst the remaining was made up of non-citizens (2.3%).

Based on the Structure Plan of Kuantan (2015), the Kuantan district population is projected to increase to more than 590,000 people in 2015, whilst the population of Sungai Karang and Beserah combined is expected to reach almost 88,417 persons compared to 43,369 current population. The average population growth is forecasted to be 4.2% a year for the period 2005–2015.

The main labour workforce within the age bracket of 20–64 years comprises 51.6% of the total population of the Kuantan district. The structure plan also notes that in 2000, the majority (26.5%) of the existing work force in the district was employed in community service, social service and self-employment. About 24.53% of the workforce was employed in the manufacturing and construction sectors. By year 2015, this industrial sector workforce is forecasted to almost triple the number.

The Lynas project site will be discharging its effluent into a drain that leads into Sungai Balok. According to the Department of Fisheries (Kuantan branch), there are fishing villagers at Sungai Balok, particularly at the river mouth leading into the South China Sea. Apparently, these fishermen are 100% dependent on the sea, and not dependent on Sungai Balok. Sungai Balok in itself is occasionally used by anglers who fish during their pass time or as a hobby.

4.9 PORT OF KUANTAN

Kuantan Port is an all weather deep sea port situated strategically at Tanjung Gelang (Latitude 3°58'N, Longitude 103° 26'E) some 25 kilometres North of the fast growing municipality of Kuantan in the State of Pahang at the crossroad of international shipping lanes of the South China Sea. The port is the gateway for trading between Malaysia and the Far East and linking the East Coast State of Peninsular Malaysia to the rest of the world. Kuantan Port is an ISPS-compliant, multipurpose all-weather port with road and rail networks that make it the leading maritime trade and logistics centre in the East Coast Region of Peninsular Malaysia.

Kuantan Port handles various type of cargoes including containerized cargo, bulk cargo (dry & liquid) and break bulk. It has been privatised since 1998 and is currently managed and operated by Kuantan Port Consortium Sdn Bhd. In year 2006, it handled more than 10,650,000 tonnes of cargo.

Kuantan Port Authority is a Federal Statutory Body established on 1st September 1974 under the Port Authorities Act 1963 and placed under the purview of Ministry of Transport.

Kuantan Port is also well-connected by road and rail to other parts of Peninsular Malaysia and by air to major world destinations via Kuala Lumpur. Located approximately 220 kilometres away from Kuala Lumpur, Kuantan Port is about 3 hours by road or 40 minutes by air from Kuala Lumpur. Kuantan Airport is 12 kilometres to Kuantan town and approximately 38 kilometres to the Port.

The port also has warehousing facilities. The existing warehouse at the port can be used if required for the transit storage of the Lanthanide concentrate.

The layout of the port is presented in **Exhibit 4.18**. The Kuantan Port Industrial Area is made up of mainly tankage storage areas and chemical plants such as Kaneka, Petronas, BASF, Mobil and Shell. There also is some area set aside as warehouse facilities. These include facilities like Felda and Kuantan Oleo Chemical.

For the export of the finished products, Lynas is will truck the containers to the Kuantan Port for shipment overseas. The Kuantan Port is located about 5km south-east of the GIE.

4.10 ROAD NETWORK

The Gebeng Industrial Estate (GIE) is linked to the major town of Kuantan and regional port and airport by the main coastal trunk road, Jalan Kuantan-Kemaman (Federal Route 3) and the East Coast Highway. These links also provide access to the southern tip of Johor Bahru whilst the East-West Highway to the north of the industrial area (North of Terengganu) provides direct access to Penang, Ipoh and other major towns in the North-West. The existing road network is presented in **Exhibit 4.19**.

Jalan Kuantan-Kemaman which is part of Federal Route 3 is a single lane dual carriageway road. At present, there are three roads that connect the Gebeng Industrial Area to the Jalan Kuantan-Kemaman.

Gebeng Bypass bypasses the area of Kuantan Port and is a 2-lane dual carriageway. Currently, there is only one road that connects the Gebeng Bypass to the GIE.

The proposed plant site is connected to the Kuantan Port through Jalan Kuantan-Kemaman and Jalan Gebeng Bypass. Jalan Kuantan-Kemaman is located at the south of the development site, whilst Jalan Gebeng Bypass is located at the north of the plant site. The plant site is connected to Jalan Kuantan – Kemaman through three roads i.e. Jalan Gebeng 1/1, Jalan Gebeng 1/11 and Jalan Gebeng 2/5, whilst the plant site is connected to the Gebeng Bypass through an existing road located at the west of the plant site.

The roads within the Gebeng Industrial Estate including the road in front of the proposed plant site are mainly 2-lane roads with varying carriageway widths.

CHAPTER FIVE

5.0 POTENTIAL ENVIRONMENTAL IMPACTS AND RECOMMENDED MITIGATION MEASURES

5.1 INTRODUCTION

This chapter of the study assesses the potential environmental impacts arising from the construction and operation of the proposed Advanced Materials Plant within the Gebeng Industrial Estate in Kuantan, Pahang and recommends suitable mitigation measures to minimise these impacts to a sustainable level, ensuring compliance to governing legislation on environmental protection.

The assessment is presented under the following sub-headings:

- Surface Water
- Soil and Groundwater
- Ambient Noise
- Solid Waste
- Ambient Air
- Socio-Economic Issues
- Biological Resources
- Traffic and Transportation

The relevant legislation and standards governing these issues which are applicable to the project are also discussed under each of the above sub-headings. The potential adverse/beneficial impacts and the recommended mitigation measures are discussed under two sections; each section representing a stage in the life-cycle of the project, i.e. construction and operational phases. As the proposed plant will be constructed on an industrial plot already cleared and filled, the activities carried out for the pre-operational phase such as the geotechnical investigation, topographical surveys, and baseline environmental sampling will not impact the environment at the site. Therefore, these impacts will not be assessed further in this chapter.

In the assessment process, the impacts are categorized based on their duration of occurrence:

- *Short-term impacts*: Impacts which are temporary or transient in nature and will occur during the construction phase of the project. This category of impact will diminish/become non-existent as soon as the construction phase of the project is completed.

- *Long-term impacts*: Impacts which are chronic in nature and may prevail throughout the operational lifetime of the Advanced Materials Plant.

- *Permanent impacts*: Impacts which result in a permanent/irreversible change to existing environmental resources in the vicinity of the project.

It is noteworthy to state that the potential impacts cannot be predicted with absolute certainty. Predictions are limited by the quality and certainty of information provided or available and the accuracy of predictive techniques employed is a function of the level of scientific knowledge or understanding. Therefore the predictions and assessment presented in this chapter should be viewed as general indications of the likely magnitude and significant of possible impacts. Where information is unavailable or uncertain, or where extrapolations have been made, these have been made explicit in each case.

5.2 SURFACE WATER

5.2.1 Regulatory Requirements

The proposed Advanced Materials Plant site is located within the catchment of Sungai Balok. As there are no potable water abstraction stations located within this catchment, all sewage and industrial wastewaters generated from the operation of the plant shall comply with the less stringent Standard B discharge limits stipulated in *the Environmental Quality (Sewage and Industrial) Effluent Regulations, 1978.* These limits are presented in **Table 5.2.1.**

Discharges from sediment retention structures including silt traps constructed during the construction phase of developmental projects are regulated by the concentration of Total Suspended Solids (TSP) and Oil and Grease (O&G). Typically, for construction projects, the Department of Environment (DOE) will impose a control limit of 50 mg/l or 100 mg/l for TSS (depending on the sensitivity of the receiving water course) and the absence of any O&G traces in the overflow from these structures. The limit will be specified by DOE in the EIA approval conditions.

Inland waters including river systems are classified into five classes based on the *National Interim Water Quality Standards for Malaysia* (*NIWQSM*). The classes of the *NIWQSM* are as follows:

- *Class I* : Conservation of natural water supply- practically no treatment necessary
- *Class IIA*: Conventional treatment required
- *Class IIB*: Recreational use with body contact.
- *Class III*: Extensive treatment required
- *Class IV:* Irrigation
- *Class V*: None of the above

The *NWQSM* criteria limits for all five classes are presented in **Table 5.2.2**.

Table 5.2.1: Standard A and B Effluent Discharge Limits[2]

Parameter	Unit	Standard	
		A	B
Temperature	^{o}C	40	40
pH Value		6.0-9.0	5.5-9.0
BOD_5 at 20 ^{o}C	mg/l	20	50
COD	mg/l	50	100
Suspended Solids	mg/l	50	100
Mercury	mg/l	0.005	0.05
Cadmium	mg/l	0.01	0.02
Chromium,VI	mg/l	0.05	0.05
Arsenic	mg/l	0.05	0.10
Cyanide	mg/l	0.05	0.10
Lead	mg/l	0.10	0.5
Chromium III	mg/l	0.20	1.0
Copper	mg/l	0.20	1.0
Manganese	mg/l	0.20	1.0
Nickel	mg/l	0.20	1.0
Tin	mg/l	0.20	1.0
Zinc	mg/l	1.0	1.0
Boron	mg/l	1.0	4.0
Iron	mg/l	1.0	5.0
Phenol	mg/l	0.0001	1.0
Free Chlorine	mg/l	1.0	2.0
Sulphide	mg/l	0.50	0.50
Oil and Grease	mg/l	ND	10.0

ND: Not Detected

Standard A: Applicable to discharges arising within water supply catchment areas

Standard B: Applicable to other inland waters (outside catchment areas) or any part of the sea abutting the foreshoe and other body of natural or artificial surface or subsurface water.

[2] Schedule III, Environmental Quality (Sewage and Industrial Effluent) Regulations, 1979

Table 5.2.2: National Interim Water Quality Standards for Inland Waters

Parameters	***(Units)***	***Classes***					
		I	***IIA***	***IIB***	***III***	***IV***	***V***
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	>2.7
BOD	mg/l	1	3	3	6	12	>12
COD	mg/l	10	25	25	50	100	>100
DO	mg/l	7	5-7	5-7	3-5	<3	<1
pH		6.5-8.5	6-9	6-9	5-9	5-9	-
Colour	TCU	15	150	150	-	-	-
Elect. Cond.*	µmhos/cm	1000	1000	-	-	6000	-
Floatables		N	N	N	-	-	-
Odour		N	N	N	-	-	-
Salinity*	$^{o}/_{00}$	0.5	1	-	-	2	-
Taste		N	N	N	-	-	-
Total Diss. Solid*	mg/l	500	1000	-	-	4000	-
Total Susp. Solids	mg/l	25	50	50	150	300	>300
Temperature	ºC	-	Normal±2	-	Normal±2	-	-
Turbidity	NTU	5	50	50	-	-	-
Feacal coliform.**	Counts/ 100ml	10	100	400	5000 (20000)$_{\in}$	5000 (20000)$_{\in}$	
Total Coliform.	Counts/ 100ml	100	5000	5000	50000	50000	>50000
AI	mg/I	↑	-	-	(0.06)	0.5	↑
As	mg/I	|	0.05	0.4	(0.05)	0.1	|
Ba	mg/I	|	1	-		-	|
Cd	mg/I	|	0.01	0.01*	(0.001)	0.01	|
Cr (VI)	mg/I	|	0.05	1.4	(0.05)	0.1	|
Cr (III)	mg/I	|	-	2.5		-	|
Cu	mg/I	|	1	-		0.2	|
Hardness	mg/I	|	250	-		-	|
Ca	mg/I	|	-	-		-	|
Mg	mg/I	|	-	-		-	|
Na	mg/I	|	-	-		3 SAR	|
K	mg/I	|	-	-		-	|
Fe	mg/I	|	0.3	1		1 (leaf)	|
		N				5	L
Pb	mg/I	A	0.05	0.02*	(0.01)	5	E
Mn	mg/I	T	0.1	0.1		0.2	V
Hg	mg/I	U	0.001	0.004	(0.0001)	0.002	E
Ni	mg/I	R	0.05	0.9*		0.2	L
Se	mg/I	A	0.01	0.25	(0.04)	0.02	S
Ag	mg/I	L	0.05	0.0002		-	
Sn	mg/I		-	0.004		-	A
U	mg/I	L	-	-		-	B
Zn	mg/I	E	5	0.4*		2	

Table 5.2.2: National Interim Water Quality Standards for Inland Waters (cont'd)

		V					V
B	mg/I	E	1	-	(3.4)	0.8	E
CI	mg/I	L	200	-		80	
CI_2	mg/I	|	-	-	(0.02)	-	IV
CN	mg/I	|	0.02	0.06	(0.02)	-	|
F	mg/I	|	1.5	10		1	|
NO_2	mg/I	|	0.4	0.4	(0.03)	-	|
NO_3	mg/I	|	7	-		5	|
P	mg/I	|	0.2	0.1		-	|
Si	mg/I	|	-50	-		-	|
SO_4	mg/I	|	250	-		-	|
S	mg/I	|	0.05	-	(0.001)	-	|
CO_2	mg/I	|	-	-		-	|
Gross - α	Be/I	|	0.1	-		-	|
Gross - β	Be/I	|	1	-		-	|
Ra – 226	Bq/I	|	<0.1	-		-	|
Sr - 90	Bq/I	↓	<1	-		-	↓

*: *At hardness 50 mg/I $CaCO_3$. @: Maximum (outside parentheses) and 24 hr average (inside parentheses) concentrations*
N: *No visible floatable material/ debris, no objectionable odour, no objectionable taste.*
*: *Related parameters, only one recommended for use*
**: *Geometric mean*
∈: *Maximum not to be exceeded*

Table 5.2.2: National Interim Water Quality Standards (INWQS) (cont'd)

Parameters	*(Units)*	*Classes*					
		I	*IIA/IIB*	*III@*	*III*	*IV*	*V*
CCE	µg/I	↑	500	-		-	-
MBAS/BAS	µg/I	N	500	5000	(200)	-	-
O & G (mineral)	µg/I	A	40;N	N		-	-
O & G (emulsified edible)	µg/I	T	7000;N	N		-	-
PCB	µg/I	L	0.1	6	(0.05)	-	-
Phenol	µg/I	E	10	-		-	-
		V					
Aldrin / Dieldrin	µg/I	E L	0.02	0.2	(0.01)	-	-
BHC	µg/I	S	2	9	(0.1)	-	-
Chlordane	µg/I		0.08	2	(0.02)	-	-
t-DDT	µg/I	O	0.1	1	(0.01)	-	-
Endosulfan	µg/I	R	10	-		-	-
Heptachlor / Epoxide	µg/I	 A	0.05	0.9	(0.06)	-	-
Lindane	µg/I	B	2	3	(0.4)	-	-
		S					
2, 4-D	µg/I	E	70	450		-	-
2, 4, 5 - T	µg/I	N	10	160		-	-
2, 4, 5 – TP	µg/I	T	4	850		-	-
Paraquat	µg/I	↓	10	1800		-	-

N: Free from visible film, sheen, discoloration and deposits
@: Maximum (outside parentheses)) and 24 hr average (inside parentheses) concentration

5.2.2 Construction Phase

The total area of the proposed plant site is 100 ha. The site was developed in the mid 90s as part of the Phase III expansion of the Gebeng Industrial Estate (GIE) and thus has been cleared and filled to the existing platform level. However, sparse pockets of secondary vegetation and shrubs can be found within the site.

5.2.2.1 Potential Sources of Impacts

Sources of water quality impacts predicted during the construction phase include:

- Site preparation works;
- Construction runoff and drainage; and
- Sewage from on-site worker camps (if the construction labour force is housed on-site).

a. Site Preparation Works

Vegetation plays an important role in cohesively binding soil particles and preventing displacement. The removal of secondary vegetation and associated undergrowth will result in exposed, denuded soil which will result in erosion of, especially during heavy rainfall events.

The subject site was cleared and filled for industrial use in the mid 90s. Impacts associated to soil erosion occurred at the time of land preparation and over the years, the erosion potential of the site has declined. Clearing of the sparse vegetation within the site is not expected to result in significant erosion.

However, subsequent earthworks which involve excavation, backfilling, grading, laying of infrastructural facilities and other related activities will have a potential to expose the soil to erosion. Generally, the susceptibility of any land surface to erosion, i.e. the erosion potential is related to a combination of factors including rainfall, runoff, soil erodibility, surface hydrology, surface slope and length, surface cover and condition, and land use.

b. Construction Runoff and Drainage

Surface runoff and drainage from material stockpiles areas, excavated areas and temporary drainage channels contain increased sediments and other water quality contaminants. Potential contaminations include:

- Grouting and other ‘wet’ building materials;
- Various types of lube oil, spent/waste oil and residues from construction equipment, vehicles and diesel generators;
- Residues and waste of industrial paints, pigments, lacquers, curing compounds, etc;

- Debris and rubbish such as packaging material, plastics, reject construction materials and discarded containers ; and
- Spillages of fuel oil (diesel), liquid chemicals, paints and other liquid waste residues.

c. Sewage Effluent and Domestic Wastewaters

During the construction phase, temporary accommodation facilities may need to be set up on-site to house the construction workers. Wastewaters generated will be in the form of sewage effluent and domestic wastewater. During the construction phase, preceding the building of the operating sewage system, the waste sewage generated will be collected and removed from site from the interim septic tank systems.

5.2.2.2 Assessment of Impacts

The impacts to water quality during the construction phase can be categorised as physical, chemical or biological impacts.

- **Physical Impacts:** The most significant physical impact to water quality is an increase in the level of suspended solids. The degree of the impact is determined by the amount of material put into suspension and the size of the sediments. Extremely fine particles such as clay and silt will go into suspension during excavation works, and remain this way for a longer period compared to coarse-grained particles that settle fairly quickly. Increased suspended solid levels will lead to a reduction in light penetration and increase heat retention within the water column.

- **Chemical Impacts:** Chemical impacts result from the release of toxic metals and complex organic compounds or materials in the construction runoff and contaminated sediment in the eroded soils that have an oxygen demand. These effects are a function of the degree of sediment contamination. Contaminants found in the soil will subsequently be ingested by organisms living within the water column and thus introduced into the food chain. The presence of suspended solids in the water column will reduce sunlight penetration which results in a lower rate of photosynthesis within the water body. This will result in lower oxygen concentration in the water (lower dissolved levels). Increase concentrations of SS will also trap energy from sunlight, giving rise to the water temperature. This also acts against oxygen levels as oxygen is more soluble in colder waters.

- **Biological Impacts**: In general, biological impacts occur as a consequent of chemical changes in the water. As discussed, the increase in suspended solid levels will result in decreased photosynthesis rates within the water column thereby reducing the concentration of dissolved oxygen. This effect may be further exacerbated during low flow conditions. These conditions will effect the horizontal and vertical distribution of bacteria and fungi in the water body. As for the larger marine life, low oxygen levels may result in fish kills.

The increased sediment content in the water column may cause abrasion of gill filaments and clog opercular cavities of aquatic organisms. The fresh water cage cultures located along the western and eastern river banks of Sg. Chukai downstream of the site may potentially be affected by the increased sediment loading into the river.

a. Site Preparation Works and Construction Runoff/Drainage

The removal of the sparse vegetation within the site is not anticipated to cause significant soil erosion. However, uncontrolled earthworks including excavation, backfilling, grading, laying of infrastructural facilities and other related activities will continue to expose the soil to erosion. These activities will require proper management to minimise the washout of silt and sediment into the earth drain which runs along the southern boundary of the site and flows in a westerly direction into Sungai Balok.

Earthwork details including cut and fill quantities and the Road and Drainage Layouts for the construction phase will be submitted to DOE Pahang prior to the commencement of work at the site, i.e. as part of the Environmental Management Plan (Construction Phase).

The site drainage layout plan for the construction phase presented in **Exhibit 5.2.1** indicates the existing drainage channels at the site, the temporary earth drains proposed during the construction phase and the location of the wash trough and the silt trap. To minimise cut and fill impacts, the silt trap will be excavated at the area proposed for the stormwater detention pond (operational phase). Based on the site drainage plan, all surface runoff will be conveyed to a silt trap located on the southwestern corner of the site for the removal of soil and sediment. The silt trap will be sized adequately to cater for run-off from the works area. The plan and cross sectional view of the silt trap and the earth drain are presented in Exhibit 5.2.2. The clear overflow from the silt trap will flow from its outlet into the existing earth drain which runs outside the site's southern boundary. This drain which is part of the drainage network of the GIE flows into Sungai Balok, west of the site. A wash trough has been proposed at the entrance of the main access road (refer Exhibits 5.2.1 and 5.2.3). The design of the site drainage is based on a 100 year flood event.

With these measures in place, the site preparatory works are not expected to result in adverse erosion potentials. The impacts arising are transient in nature, occurring only during the site preparation stage of the construction phase. The impacts to the water quality of Sungai Balok are therefore not significant. With the effective implementation of these measures, this risk will be further reduced.

b. Construction Runoff and Drainage

Water quality impacts from site drainage will become significant in the event the runoff is uncontrolled and permitted to discharge directly into Sungai Balok without any form of pre-treatment. Temporary and/or permanent drainage conveyance systems will be installed immediately following the site preparation works. Provided the construction runoff and drainage are effectively managed and controlled with the implementation of the recommended mitigation measures described under Section 5.2.3, the impacts to the river is not predicted to be significant.

c. Sewage Effluent and Domestic Wastewaters

Untreated or inadequately treated sewage effluent and domestic wastewaters which are high in organic content will increase the Biological Oxygen Demand (BOD) and Ammoniacal Nitrogen (AN) concentration in the receiving waterways. These effluents will also have high counts of faecal coliform, *Escherichia coli* and other disease carrying bacteria.

To eliminate this source of pollution, portable toilets will be provided for use at the proposed site to prevent any release of untreated sewage into the earth drain.

5.2.2.3 Mitigation Measures

Major water quality impacts anticipated from the construction phase are related to soil erosion, sediment runoff and contaminated construction runoff. In mitigation, measures must be taken during the site clearing and excavation works to ensure that all losses of material to the receiving drainage channels are minimised.

Upon the onset of physical works, it is important that the nominated EPCM Contractor be guided in the approach and planning of site clearance and earthworks. Earthwork plans and phasing details complete with the relevant mitigating measures will be submitted to the Local Authority for approval before the commencement of works. It is recommended that an Erosion and Sedimentation Control Plan (ESC) be integrated into the earthworks plan; and that the Contractor at all times comply with the details of the plan.

An ESC plan is a document that explains and illustrates the measures to be taken to control erosion and sedimentation during construction. Typically, an ESC includes the following:

- Description of predominant soil types within the affected area;
- Details of site topography including existing and proposed levels;
- Design details and locations for structural controls;
- Details of temporary and permanent stabilisation measures; and
- Description of the sequence of construction.

The ESC plans ensure that provisions for control measures are incorporated into the site planning stage of development and provide for the reduction of erosion and sediment problems.

Given below are general guidelines for non-structural and structural erosion control measures that should be incorporated in the ESC plan and enforced during the construction phase. The effectiveness of the ESC plan can be evaluated during the implementation of the Environmental Management Plan (EMP) which includes regular monitoring and audits.

. *a. Earthworks*

- All temporary discharge points required in the earthworks will be located, designed and constructed in a manner that will minimise the potential threat of downstream flooding.

- Any disturbed earth caused by construction activities or fill operations must be firmly consolidated and compacted by earth moving vehicles and compactors to reduce the rate of possible erosion and release of loose soil particles

- Denuded stretches must be re-vegetated or sealed immediately after the construction works. Suitable re-vegetation programmes employing leguminous creepers, which are native grass that require minimal or no maintenance, should be planted as quickly as possible on exposed areas as a temporary measure to reduce surface runoff and sediment loss. Species such as *Pueraria javanica, Pueraria phaseoloides, Centrosema pubescens and Calopogonium muconoides* may be used for this purpose.

- Uncovered stockpiles of excavated material or topsoil and fill material are prone to erosion and therefore must be protected. Small stockpiles can be covered with plastic sheets and large stockpiles should be stabilised by erosion blankets and regularly damped.

- Stockpiles of construction aggregate, spoil and excavated soil should be located at areas within the project site that do not permit direct run off into water courses and are generally flat. On site storage of excessive quantities of such materials should be avoided.

c. Sediment Retention Structures

- Sediment retention structures such as silt traps and settling basins of adequate sizes should be provided at suitable locations prior to discharge into the receiving drainage channels. One silt trap has been proposed at the southwestern corner of the site as indicated in the site drainage layout plan presented in Exhibit 5.2.1. Details of the silt trap design are presented in Exhibit 5.2.2. The location of the silt trap is tentative pending approval from the Local Authority. Once the layout is confirmed, the silt trap will be sized accordingly.

- The proposed silt trap will be regularly maintained and desilted to provide maximum silt removal efficiencies. Oil and grease removal facilities will also be provided to ensure the overflow from the silt trap does not have traces of oil and grease. Weekly inspection of silt trap will be carried out by the Contractor.

d. Others

- The contractor will ensure that site management is optimised and that any solid materials, debris, litter or wastes are not indiscriminately dumped on site or disposed of in the existing unlined drains in the vicinity of the site or on other unoccupied plots within the GIE. Appropriate waste receptacles will be provided and periodic removal of any accumulated waste from the site should be arranged.

- Sewage effluent generated from the workers' camps will be treated prior to discharge. Portable treatment units certified by the Department of Sewerage Services are available which treat the effluent to meet the Standard B limits.

5.2.3 Operational Phase

5.2.3.1 Potential Sources of Impacts

In the operational phase of the project, the primary source of wastewater is the Cracking & Separation Plant. The wastewater generated will arise from the upstream extraction, downstream extraction, and product finishing processes of the plant.

Other forms of wastewater and contaminated streams generated from the plant operations include:

- Supernatant liquors and surface runoff associated with the Residue Storage Facility (RSF);
- Waste gas treatment system blowdown;
- Discharge of water (drain-off) from the cooling towers;
- Boiler blowdown;
- Contaminated stormwater collected from bunded areas within the plant, namely the reagent storage tank bunded areas;
- Floor cleaning waters; and
- Sewage and domestic wastewaters.

All wastestreams and liquor (if not recycled in the process) from the plant operations identified above will be treated within the Wastewater Treatment Plant (WWTP) (bio-treatment plant) and the treated effluent will be conveyed to clears for further polishing. (The wastewaters from the Cracking and Separation Plant will be pre-treated via a neutralization process within the High Density Sludge (HDS) system prior to entering the WWTP).

From the clear wells, the treated wastewater will be pumped into the stormwater detention pond which discharges into an external earth drain running along the southern boundary of the site. The drain flows into Sungai Balok which flows in a southerly direction some 3 km west of the site.

a. Liquor and Potentially Contaminated Surface Runoff from the TSF

Surface water runoff (including rainfall runoff) and supernatant liquor from the RSF will be segregated from the main plant site drainage system and managed separately. This is to ensure that these sources of water pollution do not mix with uncontaminated surface water from other parts of the plant site. Any supernatant liquors and surface runoff associated with RSF cells will be conveyed to dedicated RSF retention ponds prior to return to the waste water treatment facility (WWTF), or to the cracking and separation process in the case of the WLP storage cells.

During the operational phase, the surface of active FGD, NUF and WLP residue containment cells will be continuously contoured by earthmoving equipment to a slope of approximately 100H:1V as the residue are placed within the respective cells. The residue will then be compacted to direct surface water towards a single supernatant/surface runoff retention pond within the RSF cells. The FGD and NUF cells will share a common pond whilst the WLP containment cell will have a separate dedicated retention pond due to its physio-chemical properties.

The retention ponds will be lined with high density polyethylene (HDPE) and the capacity designed to cater for the 1 in 100 year storm event based on climatic data for the region. Water from this pond will be discharged to the nearest pipeline access point for return to the Wastewater Treatment Plant (WWTP) located within the plant process area.

The composition of surface water runoff and supernatant liquors from the WLP residue is not expected to be suitable for release back into the environment. Instead this water stream will be recycled into the cracking and separation process stream and as such, surface water runoff will be directed or pumped to a separate HDPE-lined surface water retention pond with capacity for the 1 in 100 year storm event based on climatic data for the region. From the retention pond, the effluent will be pumped via pipeline to the nearest pipeline access point for return to the cracking and separation facility.

At closure, residue cells will be capped with suitable low-permeability materials to prevent infiltration into the permanently stored residue mass and a landform will have been created with positive surface drainage. Surface water runoff from capped cells will not interact with stored residue and the final site topography will encourage surface water to drain off-site to prevent ponding and standing water.

b. Cooling Tower Drain-Off and Boiler Blowdown

The drain-off from the cooling towers and the boiler blowdown will be pumped to the WWTP. Potentially contaminated runoff collected within the reagent storage bunded areas (acid and alkali storage farm) will be either pumped out or conveyed directly via pipelines to the site's WWTP. Similarly, floor cleaning waters arising from the Cracking & Separation Plant, if contaminated with process liquor will be conveyed to the wastewater treatment system. Cleaning waters from other non-polluting areas of the site will be conveyed into the site's stormwater drainage system.

c. Sewage and Domestic Wastewaters

The maximum number of operations personnel on-site during normal working hours (0800 – 1700) is expected to be 200, with 50% of the personnel based in the field control rooms. The central administration area (with adjacent buildings for laboratory, canteen, maintenance and stores) will have toilets piped to the on-site sewage treatment system (aerobic sludge system) which will be designed for a minimum Population Equivalent (P.E) of 200. The remote control rooms will have local septic tanks. The treated water from the sewage treatment plant will be conveyed to the site's main treatment plant.

5.2.3.2 Assessment of Impacts

All waste streams and liquor (if not recycled in the process) from the Advanced Materials Plant operations identified above will be treated prior to discharge into Sungai Balok.

Two treatment systems, i.e. the High Sludge System (HDS) and the WWTP (bio treatment plant) have been proposed for the plant operations. The HDS system is essentially a neutralisation pre-treatment process for the wastewaters from the Cracking & Separation Plant. Details of the treatment process are discussed in Section 5.2.3.3.

All other process waste streams and contaminated streams will enter the WWTP directly without any pre-treatment. Sewage and sanitary wastewaters will be routed to a Sewage Treatment Plant and the treated discharge will pumped into the WWTP. The wastewater block flow diagram presented in **Exhibit 5.2.4** identifies the major sources of waste streams and their inflow into the HDS and the WWTP.

The final treated effluent from the WWTP will be held in clear wells and then pumped into the stormwater detention pond (at an average rate of 500 m^3/hr) and the combined discharge will be released into the earth drain (external to the site's southern boundary) which flows into Sungai Balok.

The untreated waste streams entering the HDS process and WWTP identified in the section above will contain the following chemical species:

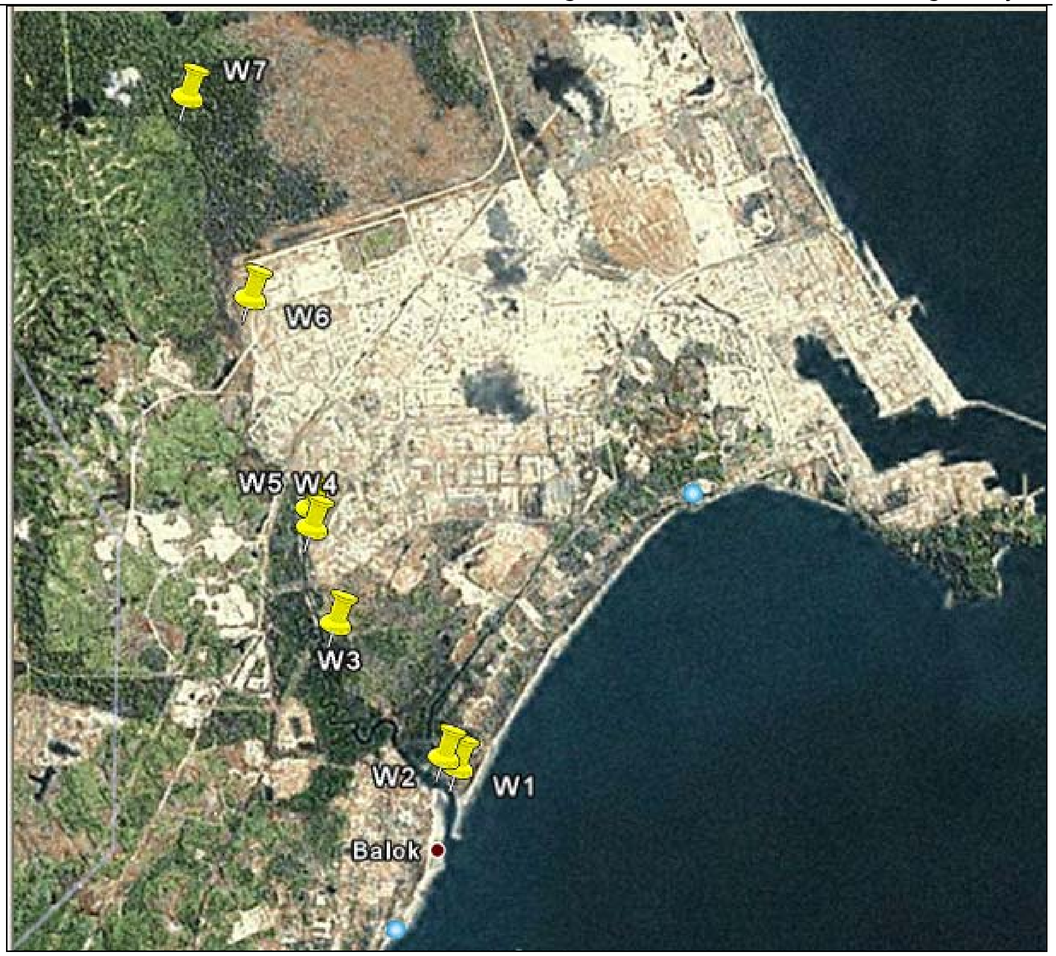
- Suspended solids (SS)
- NH3-N
- Phosphate
- Cations: Low concentrations of Cu, Zn, Mn, Cl, Hg, As, Pb, Cr, Th, Mg, Sr, U, Ca, Al, Si, K, Ba, Fe, Na, K+Na
- Calcium sulphate ($CaSO_4$)
- Magnesium sulphate ($MgSO_4$)

If *untreated*, these waste streams will impact the Sungai Balok river quality in terms of physical, biological and chemical impacts similar to those discussed under Section 5.2.2.2. To mitigate these affects, these waste streams will be subjected to treatment within the HDS and the WWTP prior to discharge.

The impacts of discharging the *treated* effluent from the plant during the operational phase have been assessed quantitatively to simulate the pollution loading to Sungai Balok and predict the changes in water quality of the river with the added discharge of the effluent from the Advanced Materials Plant.

a. Methodology

Access to hydrodynamic data related to the Sungai Balok is limited but simple observations were made of the channel width and depth during the water quality survey, along with estimates of flow. The survey locations are presented in the image below.



The observations were made at high and low water. These flow measurements do not indicate the peak flow values. However, for the purposes of water quality assessments typical low flows in the river are more important rather than peak or flood flows. Thus, information on flood flows was not critical for purposes of this study.

The tables below summarise the available hydrodynamic information. River channel width and water depth information are presented in Table 5.2.3. Only one flow velocity measurement was taken at each location during the survey and each measurement was taken at about 0.5 m below the water surface in the middle of the river. Therefore the velocities of the river flow that are presented in **Table 5.2.4** are very close to the maximum flow velocities and the average flow velocities are expected to be in the order of 30%-50% of the measured velocities. Therefore, the likely average river currents at high and low water are in the range 0.1 to 0.6 m/s. There is no information on the variation of current speeds during ebb and flood.

Table 5.2.3: Water Depth and Channel Width at Survey Sites

	High Tide		Low Tide	Comments
Point	**Depth (m)**	**Estimated Top Width (m)**	**Depth (m)**	
W1	5	30	3.4	
W2	2	27	0.4	
W3	2	10	0.5	
W4	1.5	8	0.3	
W5	8	15	6.9	
W6	6	13	6	less tidal influence
W7	3	8	3	less tidal influence

**Note: The location of stations W1-W7 corresponds with the water quality monitoring stations established for the baseline river water quality sampling. Refer Exhibit 4.14.*

Table 5.2.4: Flows of Sungai Balok

	Flow velocity (m/s)	
Point	**High Tide**	**Low Tide**
W1	0.91	0.61
W2	0.61	0.85
W3	0.61	0.55
W4	0.46	0.30
W5	0.30	0.21
W6	0.55	0.30
W7	1.22	0.91

The low and high tide records obtained from the Kuantan Port Authority indicate that the difference between high water and low water was 1.5 m. The typical tidal levels at the mouth of Sungai Balok are expected to range from 0.5 m to 2.5 m (see **Table 5.2.5**).

Table 5.2.5: Tidal levels at the Sungai Balok Estuary (Tidal station at Tanjung Gelang)

MHHW	MLHW	MHLW	MLLW
3.34 m CD	2.28 m CD	1.57 m CD	0.5 m CD

b. Existing Water Quality of Sungai Balok

Based on the river water quality monitoring event carried out in October 2007 (refer Section 4.6.4 of Chapter Four), the results show that the river is tidal as far as point W7, with total dissolved solids (TDS) of 36 – 6,182 mg/l (low tide) and 28 – 12,990 mg/l (high tide). This indicates that the water is brackish.

At all locations, metal concentrations were below the detection limit and very much lower than the Class III water quality standard. Most of the parameters analysed complied with the Class II limits. The following metals were tested for in the river samples arsenic, cadmium, copper, manganese, lead, nickel, tin and zinc.

The level of organic pollution can be inferred from the five day Biochemical Oxygen Demand (BOD_5) and the Chemical Oxygen Demand (COD). At stations W1 to W7, the BOD_5 concentrations were < 2 mg/l while the COD value is in the range 25-65 mg/l (for both the tide cycles). The relationship between BOD_5 and COD is dependent on the characteristics of the water body and its inputs; however such a large COD to BOD_5 suggests that the river has low amounts biodegradable material, and hence receives low amounts of organic pollution.

c. Quality of Treated Effluent Discharge

The characteristics of the treated effluent discharged from HDS Neutralisation system is presented in **Table 5.2.6.** The effluent meets the *Standard B* discharge criteria stipulated in the *Environmental Quality (Sewage and Industrial Effluent) Regulations, 1978* except for COD which exceeds the limit of 100 mg.l.

Table 5.2.6: WWTP Treated Effluent Quality

Species	HDS Neutralisation Wastewaters mg/l	Malaysian Standards B mg/l
pH		5.5-9
SS	100 mg/l	100
COD	2000	100
BOD_5	-	50
oils		50
Cu	< 1	1.0
Zn	0.462	2
Mn	< 1	1.0
Cd	-	0.02
Hg	-	0.05
As	-	0.1
Pb	0.07	0.5
Sn	< 1	1.0
B	-	4.0
Cr	-	0.05, 1
Fe	< 1	5.0
Phenol	-	1.0
S	496	0.5

The treated water from the HDS system is stored in the then conveyed to the WWTP (Sequential Batch Reactors) for COD reduction. The WWTP has been designed to treat up to a maximum of 2000 mg/l. It should be noted that this point that the quality of the wastewater from the HDS neutralisation (pre-treatment) process complies with Standard B for all the heavy metals and total suspended solids. Only the COD concentration exceeds the limit.

From the WWTP, the treated water will be discharged at an average flow rate 500 m^3/hr into the stormwater detention pond. Prior to discharge into the detention pond, the treated water is allowed to settle in clear wells/surge ponds where samples will be collected for analysis. The water will be pumped into the detention pond only when all parameters stipulated in Standard B are complied with.

d. Approach and Methodology

Ideally, the impact of the discharge on water quality in the river would be assessed by constructing a one-dimensional model of the river. However, even a very approximate model of the system would require a reasonable amount of data relating to river cross-sections, downstream water levels and upstream river flows.

Given the limitations in the data, a different approach was adopted using a mass balance model based on the likely combined flows from the stormwater detention pond into the drain and hence into the river. The basic assumptions are:

- The discharge from the detention pond is constant for a given rainfall event;
- The quality of the stormwater can be estimated using event mean concentrations from literature;
- The treated effluent from the WWTP is fully mixed with any storm water in the retention pond;
- Little or no other flow enters the external earth drain;
- The discharge from the storm drain is fully mixed through the water column and across the width of the river channel; and
- That the river flow in Sungai Balok is of the order of 20 m^3/s and that the tidal currents in the section of the river are weak, so that the bulk of the dilution of any effluent is due to freshwater river flow.

e. Stormwater Discharges

Stormwater runoff from the site is to be collected in a detention pond before being discharged to the storm drain, and then to Sg Balok. Stormwater discharges to the pond provided by the engineering designers as follows:

- For 5 year ARI - Average stormwater inflow into detention pond (5.56 m^3/s), peak outflow from detention pond (6.64 m^3/s)
- For 50 year ARI - Average inflow into detention pond (8.80 m^3/s), peak outflow from detention pond (10.45 m^3/s)

- For 100 year ARI - Average inflow into detention pond (9.94 m^3/s), peak outflow from detention pond (11.56 m^3/s)

- In addition, the average inflow for a typical period of low rainfall was calculated. Assuming an average rainfall of 17.6mm, the average inflow into the detention pond would be 2.03m^3/s.

*(*Note: ARI: Average Recurrence Interval)*

f. Stormwater Quality

The water quality of storm water discharging into a drain or river largely depends on the use of the land from which storm water runs off. The load of pollutant washed off the land by stormwater is usually determined using the Event Mean Concentration (EMC) methodology. This assumes that the load of a particular pollutant can be determined from a representative mean concentration likely to be achieved during a rainfall event. The load is simply the product of the runoff, the catchment area and the EMC. The value of this EMC depends on the use of the land. Various bodies including the Department of Irrigation and Drainage (DID) of Malaysia quote guideline values to be used to estimate stormwater loads. **Table 5.2.7** provides a summary of EMC values derived from US and European sources.

Table 5.2.7: Summary of Event Mean Concentrations (EMC)

Pollutant	EMC-Industrial land use (mg/l)	EMC-Agriculture with significant vegetation land use (mg/l)	EMC-Urban Land use (mg/l)	EMC- Bare land use (mg/l)
BOD	29	0	8.3	6
COD	120	0	70	23
SS	159.	12.7	55	42.5
TN	2.0	2.8	3.2	1.5
NOx-N	0.5	0	0.4	1.3
NH3-N	0.1	0	0.2	0.2
TKN	1.8	0	0.9	0.9
TP	0.3	1.5	0.34	0.16
Cd	0	0	0.0024	0
Cu	0.05	0	0.0036	0.09
Fe	4.6	0	4.6	0
Pb	0.12	0	0.16	0.03
Zn	0.25	0	0.19	0.07

Note: Compiled from 1.Urban and Road Specific Event Mean Concentrations (Mitchell 2001), 2. US EPA. 1993c, Handbook Urban Runoff Pollution Prevention and Control Planning. EPA 625-R-93-004. Washington, DC., 3. Recognized Event Mean Concentration, (www.sfrpc.com/ftp/pub/watershed/swakon%20tables%20formatted.pdf).

The draft of the Urban Stormwater Management Manual for Malaysia (Manual Saliran Mesra Alam Malaysia (MSMA)) (DID, 2001)[3] gives guideline values for EMC for a selection of variables (Table 8). However, the MSMA table does not give values for COD and gives a wide range of values for other parameters for runoff from industrial land. For the purpose of the analysis the values for industrial land in **Table 5.2.8** were used.

[3] *Table 15.2, Manual Saliran Mesra Alam Malaysia, Department of Drainage and Irrigation, Malaysia (2001)*

Table 5.2.8 Typical Event Mean concentration values (EMC) from MSMA

Pollutant	Land use/vegetation categories				
	Native vegetation/ forest	Rural grazing	Industry	Urban	Construction
Sediment [1]	85 [3]	500	50 to 200	50 to 200	4,000
Suspended solids [2]	6	30	60	85	
Total Nitrogen [2]	0.2	0.8	1.0	1.2	
Total Phosphorus [2]	0.03	0.09	0.12	0.13	
Ammonia [5]	0.01 to 0.03	0.01 to 0.26		0.01 to 9.8	
Faecal coliforms [5]	260 to 4,000	700 – 3,000		4,000 – 200,000	
Copper				0.03 to 0.09	
Lead				0.2 to 0.5	
Zinc				0.27 to 1.1	

Sources:
1. Auckland Regional Council (1992)
2. Willing & Partners (1999)
3. from Sungai Kinta Dam Project, *Flood Hydrology Report*, Angkasa GHD Engineers (1998).
4. NURP (USA) National Average, from Schueler (1987)
5. EPA, NSW (1997a)

g. Results and Discussion

Using the assumptions laid out in Section 3.1, the likely impact of the plant effluent on the river was estimated for two plant treatment options and three rainfall conditions.

The two plant treatment operations are:

- Normal Operation : Full treatment, average effluent flow of 500 m^3/hr
- Treatment plant failure - No treatment , maximum effluent flow of 700 m^3/hr

The three rainfall conditions considered are:

- No rainfall
- Low rainfall (based on average daily rainfall of 17.6 mm)
- 5 year ARI

The river quality was based on that observed at site W6 on 31st October 2007.

The plant effluent is expected to be brackish with sodium and chloride concentrations of 1360 mg/l and 5197 mg/l respectively. This effluent will be denser than either the storm water or the river water. At W6, the observed TDS was < 500 mg/l (based on the baseline environmental sampling). The assumption is made that there will be sufficient mixing in the river or retention such that any density difference does not significantly affect the fate of the effluent.

The analysis was carried out for five parameters:

- TSS
- COD
- BOD
- Zn
- Pb

The choice of parameters was limited by the plant effluent data, the availability of appropriate EMC values for the stormwater, parameters analysed in the river samples and parameters for which are included in the river quality standards. For the untreated case the NH_3-N was added.

The base case of normal operation during the period of no rainfall is shown in **Table 5.2.9.** This shows that for the parameters tested, the effluent has little impact on the river water quality as the effluent will be diluted by a factor of at least 150 when fully mixed with the river water. It should be noted that the COD observed on 31st October 2007 at site W6 (51-55mg/l) was already in excess of the River Water Quality Standard (Class III) value (50mg/l). However, the secondary data obtained from Alam Sekitar Malaysia (ASMA) samples in 2007 show lower COD values in Sg Balok (16-23 mg/l) than were measured in any of the samples collected for the EIA study. Therefore, it is likely that under these conditions the effluent will not cause the river water quality to exceed the standard values.

Table 5.2.9: Normal operation with No Rainfall

Species	Treated effluent	Storm water	Effluent from detention pond	River upstream	River down stream	River WQ Standard III
Q m^3/s	0.14	0	0.14	20	20.2	-
TSS mg/l	50	-	50	2.5	2.8	150
COD mg/l	100	-	100	51	51.3	50
BOD mg/l	50	-	50	2	2.3	6
Zn mg/l	0.462	-	0.462	0.012	0.02	0.4
Pb mg/l	0.07	-	0.07	0.01	0.01	0.02

In the presence of low rainfall, the concentrations of all parameters are increased (**Table 5.2.10**). This is mainly because the EMC values used for the storm water are in excess of the treated effluent concentrations. Therefore, the storm water is the major contributor to any increase in river concentrations.

Table 5.2.10: Normal Operation in Low Rainfall Period

Species	Treated effluent	Storm water	Effluent from detention pond	River upstream	River down stream	River WQ Standard III
Q m^3/s	0.14	2	2.2	20	22	-
TSS mg/l	50	160	152.9	2.5	17.03	150
COD mg/l	100	120	118.7	51	57.54	50
BOD mg/l	50	29	30.4	2	4.75	6
Zn mg/l	0.462	0.23	0.25	0.012	0.04	0.4
Pb mg/l	0.07	0.12	0.12	0.01	0.02	0.02

As the stormwater flow rate increases by increasing rainfall, the combined impact of the treated effluent and site stormwater increases (**Table 5.2.11**) in the 5 year ARI rainfall scenario. There is a risk that the combined effluent will cause the river quality to marginally exceed the water quality standard for COD, Zn and Pb.

Table 5.2.11: Normal Operation with 5 year ARI Rainfall

Species	Treated effluent	Storm water	Effluent from detention pond	River upstream	River down stream	River WQ Standard III
Q m^3/s	0.14	5.56	5.7	20	26	-
TSS mg/l	50	160	157.3	2.5	36.8	150
COD mg/l	100	120	119.5	51	66.2	50
BOD mg/l	50	29	29.5	2	8.1	6
Zn mg/l	0.462	0.23	0.24	0.012	0.07	0.4
Pb mg/l	0.07	0.12	0.12	0.01	0.03	0.02

In the case of the release of untreated effluent in the dry period the effluent concentrations will be significantly higher than with the treated effluent. For the analysis, the maximum COD of 2000mg/l was assumed. Despite the high concentrations, the effluent flow is small compared to the river flow, and the effluent will undergo significant dilution in the river. The resulting river concentrations will be higher than those experienced in similar conditions with treated effluent. With no rainfall, the contribution of the plant effluent is small with the exception of COD, which could be increased by up to 25-30% (**Table 5.2.12**). However, as there is some uncertainty as to the typical COD concentration in the river, this may not be lead to a concentration in excess of the river quality standard.

Table 5.2.12: Releasing of Untreated Effluent with No Rainfall (Worst Case Scenario)

Species	Untreated effluent	Storm water	Effluent from detention pond	River upstream	River down stream	River WQ Standard III
Q m^3/s	0.19	0	0.19	20	20.2	-
TSS mg/l	100	-	100	2.5	3.1	150
COD mg/l	2000	-	2000	51	64.4	50
BOD mg/l	82	-	82	2	2.6	6
NH_3-N mg/l	1.3	-	1.3	0.1	0.11	0.5
Zn mg/l	0.462	-	0.462	0.012	0.02	0.4
Pb mg/l	0.07	-	0.07	0.01	0.01	0.02

As contribution from stormwater is increased, then the impact of the combined effluent on the river increases (**Tables 5.2.13** and **5.2.14**). The contribution of the stormwater can be as significant as the untreated storm water particularly for BOD.

Table 5.2.13: Release of Untreated Effluent in Low Rainfall Period

Species	Untreated effluent	Storm water	Effluent from detention pond	River upstream	River down stream	River WQ Standard III
Q m^3/s	0.19	2	2.2	20	22	-
TSS mg/l	100	160	154.7	2.5	17.6	150
COD mg/l	2000	120	286.6	51	74.3	50
NH_3-N mg/l	1.3	0.1	0.21	0.1	0.11	0.5
BOD mg/l	82	29	33.7	2	5.1	6
Zn mg/l	0.462	0.23	0.25	0.012	0.04	0.4
Pb mg/l	0.07	0.12	0.12	0.01	0.02	0.02

Table 5.2.14: Release of Untreated Effluent with 5 year ARI Rainfall

Species	Untreated effluent	Storm water	Effluent from detention pond	River upstream	River down stream	River WQ Standard III
Q m^3/s	0.19	5.56	5.75	20	22	-
TSS mg/l	100	160	158.0	2.5	37.2	150
COD mg/l	2000	120	183.53	51	80.6	50
BOD mg/l	82	29	30.8	2	8.4	6
NH_3-N mg/l	1.3	0.1	0.14	0.1	0.11	0.5
Zn mg/l	0.462	0.23	0.24	0.012	0.07	0.4
Pb mg/l	0.07	0.12	0.12	0.01	0.03	0.02

h. Conclusions

A quantitative analysis of the mixing of the plant effluent with storm water from the site before discharging in to the river has lead to the following conclusions:

- Discharge rate of the WWTP treated effluent is very low compared to likely storm water and river flow rates;

- The impact of treated effluent alone on river quality is very low, and is likely to be diluted by a factor of 150 by the river water.

- The contribution of storm water runoff from the site to river impact could be more significant than from the plant effluent.

- Discharging untreated effluent to the river will worsen river water quality. The COD concentration could be increased by up to 30% but this impact is expected to be only short term. It should also be noted that existing COD in the river system is greater than 50mg/l as per Class III water quality standard. If there is a desire to improve the water quality of Sungai Balok further then there needs to be consideration of all discharges into the river system rather than considering only one point source such as the Advanced Materials Plant.

The conclusions drawn from the analysis are subject to the following limitations

- Sg Balok river flows are unknown;
- Other pollution loading into external earth stormwater drain is not quantified; and
- Uncertainty in EMC values.

5.2.3.3 Recommended Mitigation Measures

The water quality assessment described in the section above assumes that the effluent is treated by the WWTP and meets the Standard B discharge quality with an average discharge flow rate of 500 m^3/hr. Therefore, it is critical that all the major waste streams are treated within the proposed treatment systems proposed, i.e. the HDS and the WWTP and these systems are well maintained and in good working order at all times.

A description of the proposed treatment systems is provided below.

a. High Density Sludge (HDS) System

The waste water from the cracking plant will undergo pre-treatment prior to entering the main WWTP. HDS is a process used to treat acidic process wastewater from Cracking and Separation, which contains Cl^-, SO_4^{2-} and metal ions such as iron, aluminium, manganese, sodium, magnesium, calcium, etc. Neutralization and precipitation takes place at pH 10.5 to reduce the concentration of metal ions to the required levels.

- Milk of lime is produced from powdered hydrated lime in two agitated 3600φ × 3000 mm agitated slurry tanks. The acidic wastewater generated from the scrubber is stored in 2 x 4500φ × 4500 mm tanks prior to treatment.

- The milk of lime is mixed with the wastewater and then sent to a reaction zone, where neutralization followed by chemical precipitation takes place. At a reaction end point pH of 10.5, most of the metal ions have been precipitated. The wastewater neutralization tank is divided into three zones, the first provided with high speed agitators to ensure rapid mixing and the last with low speed agitators to allow slow (complete) reaction. The size of each zone is 4500×4500×3000mm.

- The neutralised wastewater slurry flows to a thickener which separates the supernatant from the solids which contain the metals and calcium sulphate. The supernatant overflows from the top of the thickener, and is pumped to the WWTP.

- The thickener underflow is processed in 4 plate and frame filter presses to produce a filter cake Neutralised Underflow Residue (NUF) of approximately 30-40% moisture which will be stored in the NUF tailings storage facility (RSF). The filtrate may either be returned to the HDS inlet or sent to the WWTP. The plate and frame filter presses will also dewater the FGD slurry independently of the NUF solids, producing a filter cake of approx 30-40% moisture for placement into the FGD RSF.

b. Wastewater Treatment Plant (WWTP)

The Wastewater Treatment Plant employs a is a biotreatment process and has been designed primarily to reduce COD and BOD in all the wastewater streams from the plant and to produce water complying with Malaysian water quality Standard B. The WWTP will consist of the following steps as necessary to achieve the standard.

- Inlet neutralisation and storage
- BOD/COD reduction
- Settling and clarification
- Sludge processing

- Wastewater exit.

Inlet Neutralisation & Storage

The treatment/equipment proposed may consist of the following:

1. Receiving and blending incoming streams to minimise quality variations.
2. pH adjustment/chemical dosing

Aeration and oxidant dosing

The process proposed combines biological oxidation with final reduction using a strong oxidant as necessary. The treatment/equipment proposed may consist of the following:

1. Aeration for first stage (biological) treatment
2. The use of surface aerators or diffusers is being considered.
3. Treatment with strong oxidant dosing (hydrogen peroxide)

Flocculation and Settling

Flocculation followed by settling and sludge removal is proposed. The use of a Lamella clarifier is being considered. The treatment/equipment proposed may consist of the following

1. Dosing of flocculent and coagulant
2. Mixing
3. Sludge/supernatant separation (thickening)
4. Sludge removal

Sludge Processing

A fabric bag collection and disposal system is proposed. Large Geotextile fabric bags are often used in the mineral processing industry and are considered to be an economic solution. Three x 3 m diameter x 25 m long bags annually may be used. A typical treatment/equipment consists of the following stages:

1. Preparation of sludge (addition of flocculent)
2. Filling of Geotextile bag #1 with sludge.
3. Filling of Geotextile bag No 2 with sludge while liquor drains from bag No. 1 (bag draining)

4. Disposal of liquor (recycle to WWTP).
5. Repeat of steps 2 and 3 until bags are filled with high solids and no further space remains after drainage.
6. Open bag and dry/dispose solids.

The usual practice is for three bags to be in operation located and contained in an (impervious) kerbed area. One bag is being filled, one draining/drying and one in disposal. Disposal is by cutting open the bag and removing the sludge. About 100 – 200 tons/year of sludge is expected which is disposed to the WLP RSF. Flocculent may be added to assist in the draining of the liquor from the sludge. No further treatment of the sludge prior to fabric bag collection is required. Options of filters and a centrifuge were considered but discarded.

Wastewater Storage and Exit

The clarified wastewater will be sent to clear wells/surge ponds prior to discharge to the stormwater detention pond.

Water Recycling

Maximum use has been made of recycled water within the Cracking and Separation Plant. The liquor entrapped within the RSF for the Water Leach Purification (WLP) residue will be collected and recycled to the Water Leach circuit (Cracking & Separation Plant). It is possible that liquor entrapped within the RSF Facility for the NUF & FGD will also be recycled into the Water Leach circuit.

Waste Water Testing

In order to estimate the composition of the various wastewater streams produced from the Cracking & Separation Plant, the following testwork has been undertaken:

The Cracking and Separation Plant wastewater data used in the modelling has been "built-up" from in-house Lynas operational experience and a pilot study carried out by the wastewater treatment plant consultant which has been verified by testwork conducted by Australian Nuclear Science Technology Organisation (ANSTO).

5.3 SOIL AND GROUNDWATER

5.3.1 Regulatory Requirements

The *Environmental Quality Act, 1974* (EQA) and amendments provide for the protection of soil, and indirectly groundwater, under Section 24. This section broadly states that "no person shall, unless licensed, pollute or cause or permit to be polluted any soil or surface of any land in contravention of the acceptable conditions specified under Section 21". The "acceptable conditions", however, have not been defined in the regulations.

At present, there are no formal or enforceable standards in Malaysia for evaluating soil and groundwater quality. As such, suitable soil and groundwater investigation criteria for comparing with measured site concentrations were selected from sources established in other countries. The Dutch Ministry of Housing, Spatial Planning and Environment's (MVROM) soil and groundwater quality guideline values have been prescribed in several environmental impact assessments (EIA) guidance documents published by the DOE for use in assessing soil and groundwater quality.

5.3.2 Construction Phase

5.3.2.1 Potential Sources of Impacts

Impacts on soil and groundwater quality during the construction phase are commonly attributed to improper management and handling of hazardous materials stored at the site. Potential sources of soil and groundwater quality impacts include:

- Accidental spillage and leakage arising from the handling and storage of hazardous materials/chemicals in diesel skid tanks, chemical/fuel dispensers and storage drums, jerry cans or carboys that contain lube oil, hydraulic oil, paints and organic solvents and other chemicals used during the construction phase;
- Leakage arising from vehicle engine oil change, equipment and machinery, as well as refueling activities;
- Inappropriate hazardous waste storage and disposal practices;
- Improper discharge of untreated sewage; and
- Groundwater dewatering activity.

5.3.2.2 Assessment of Impacts

Soil and groundwater impacts arising from accidental spillage and leakage of hazardous chemicals and wastes during the construction phase are assessed to be low due to the limited quantities of chemicals used at any one time on-site during construction. In addition, the extent of soil and groundwater contamination is likely to be localized and surficial. These impacts can be readily addressed by implementing appropriate mitigation measures discussed in the proceeding section.

Groundwater pumping may be required where foundation excavations extend below static water levels. Such dewatering may be required for some refinery foundations. However, the need for significant groundwater discharge is unlikely. In the unlikely event that some dewatering is required, the extracted water will be conveyed via the silt trap proposed for the construction works area prior to discharge into the site's drainage system.

5.3.2.3 Recommended Mitigation Measures

The risks of soil and groundwater contamination during the construction phase will be appropriately managed and controlled by the following:

- A secured area (enclosed with hardstanding imprevious base) will be provided for the storage of any hazardous materials (including hazardous wastes);

- All temporary fuel tanks and drum storage areas will be provided with drip collection devices and be sited on sealed areas (for example, concrete paved areas) with appropriate bunding for accidental spill containment. A valve should be installed at the discharge outlet of the bunded area;

- All activities that may result in the potential release of hazardous materials to the ground such as changing of engine oils and lubrication oils from construction vehicles, equipment and generators on site will be performed only on designated sealed areas or on drip trays to reduce the risk of direct spill into the underlying soil and groundwater. Spent oil must be handled and disposed of as scheduled waste;

- Any accidental spills of fuel, oil or other hazardous chemicals will be cleaned up immediately. The recovered media (contaminated soil, absorbent pads, rags etc) should be disposed of as scheduled waste; and

- Appropriate sanitary facilities will be provided and properly maintained for construction workers throughout the construction stage. Direct discharge of untreated sewage into underlying soil, groundwater or surface water is prohibited. If portable toilets are procured to the site, they must be of sufficient numbers and meet the requirements of Department of Sewerage Services, Ministry of Housing and Local Government.

5.3.3 Operational Phase

5.3.3.1 Potential Sources of Impacts

The areas of concern for the potential soil and groundwater contamination during the operational phase include:

- Lanthanide Concentrate Storage Shed;
- Residue Storage Facility (RSF);
- WLP Retention Pond;
- NUF and FGD Retention Pond;
- Acid storage area (tank farm);
- Chemical Store;
- The 10,000-litre aboveground diesel storage tank;
- The emergency firewater pumphouse (with 1,000-litre diesel storage tank);
- Diesel generators (with 5,000 litre diesel storage tank each); and
- Scheduled wastes (waste oil, expired chemicals, etc) storage area.

In addition, other potential sources of impact include the periodic handling and dispensing of chemicals with the process areas, spills of fuels and lubricating oils, albeit in small quantities, may lead to minor spills and leakages. Such accidental releases are usually a result of poor chemical handling practices and may likely occur at the maintenance workshop and hazardous substances handling and storage areas.

5.3.3.2 Assessment of Impacts

Accidental release of chemicals such as petroleum hydrocarbons, acids, reagents and other chemicals (as described in **Tables 2.2a** and **2.2b** in Chapter Two of this report) have the potential to result in adverse impacts on soil and groundwater resources during the operation of the plant.

Both organic and inorganic contaminants in soil and groundwater have the potential to pose short term and long term threats to human health, safety and sensitive environmental receptors. For example, the accumulation of volatile organic compounds (VOCs) as a result of petroleum hydrocarbon spills into the underlying soil and groundwater may reach explosive levels in subsurface utility systems, or the concentrations of these vapours may cause acute health effects to facility and maintenance workers.

Changes in pH from acid and chemical spills have the potential to affect microorganisms in soil and groundwater and affect the natural soil processes such as biodegradation.

Contaminants present in groundwater on-site have the propensity to migrate to downgradient neighbouring properties and affect underlying aquifers or threaten sensitive habitats in rivers. Excavation or construction workers may potentially be exposed to these contaminants via dermal contact, inhalation of vapours or accidental ingestion when carrying out sub-surface activities.

Groundwater contamination problems are also long-term in nature. Certain contaminants are resistant to biodegradation and will persist in the environment for many years after the source of contamination has been removed. The presence of these residual contaminants in the soil and groundwater may pose an unacceptable risk particularly if the land is to be redeveloped into a more sensitive land use such as for residential or recreational purposes.

During the operational phase of the project, groundwater will not be abstracted for use within the site. Potable water supply will be obtained from the Department of Water Supply for use within the site. Thus, there will be no direct impacts on the local groundwater system. However, there is potential to indirectly affect groundwater by the seepage of contaminated water from the plant operations and the RSF.

The raw material for the plant which is the lanthanide concentrate will be stockpiled within the lanthanide concentrate storage shed. The concentrate will arrive at the plant site (from the Port of Kuantan) in sea containers. The concentrate will either be bagged in bulker bags (1 tonne) or the entire container will be lined (20 tonnes). At the site, the concentrate will be off-loaded from the containers and stockpiled within the storage shed before it is loaded onto the hopper. The stockpile is not expected to generate significant leachate. Further, the concentrate will be stored within a covered shed for prevention of rainwater ingress and the ground paved to minimise impacts to the groundwater.

Trace metals from the residue stored at the RSF has the potential to leach or to be released into the underlying shallow groundwater if no appropriate containment is provided. The assessment of soil and groundwater impacts arising from the RSF is deliberated in the next section (**Section 5.6.3**).

Storage ponds within the site include the liquor containment ponds: WLP Retention Pond, the NUF & FGD Retention Pond, and the Emergency Storage Lagoon. The contents of the liquor ponds could potentially contain contaminants that could impact the groundwater quality. To prevent the seepage of these contaminants into the soil and groundwater, these ponds will be provided with a high density polyethylene (HDPE) liner.

The entrapped liquor within the NUF and FGD pond will be removed and returned to the nearest pipeline access point for return to the waste water treatment plant (WWTP) within the process area. However, the liquor collected within the WLP pond is not expected to be suitable for release into the environment and thus will be recycled in the Cracking & Separation Plant. With the above safeguard measures, the potential impacts to soil and groundwater resources can be effectively mitigated.

Based on groundwater level gauging data, groundwater gradient at the site is calculated to be approximately 0.001. Single well falling head test data conducted in selected monitoring wells indicated that hydraulic conductivity for the organic clay layer and the underlying silty sand material were in the order of 10^{-8} m/s and 10^{-6} m/s respectively. Based on an assumed preliminary conservative estimate of effective porosity of 0.35, the seepage velocity or flow rate of the shallow groundwater beneath the site is estimated at approximately 0.1–10 cm/year.

Data from the baseline groundwater gauging indicate that the shallow groundwater beneath the site generally flows along a southerly direction. Given the relative low seepage velocity in a silty/clayey soil media and the absence of potentially sensitive groundwater receptors on site and immediately downgradient, the risks associated with soil and groundwater contamination is anticipated to be low.

Impacts to soil and groundwater resources associated with plant operations could be easily addressed, prevented and overcome by implementing appropriate mitigation measures discussed in the following subsection.

5.3.3.3 Recommended Mitigation Measures

The facilities should be designed and operated to ensure that as far as practicable, leakage and accidental release of chemicals into the underlying soil and groundwater do not occur. Prevention and control measures include the following:

- The diesel fuel storage tank and reagent storage tanks will be located within concrete-bunded enclosures capable of containing 110% of the contents of the tank within each enclosure. The floor of the bunded enclosures will be concrete-lined with an impermeable liner to prevent contaminant from permeating into the ground;

- Appropriate instrumentation and control/trigger alarm to warn of possible overfilling and to provide an alert mechanism in the event of significant fuel/chemical loss should be provided for the storage tanks;

- Operational control which includes regular/routine surveys, inspection and maintenance of the diesel fuel tank, chemical tanks and their ancillary facilities (pumps, valves and pipes) will be integrated into the plant's environmental management practices so as to identify and rectify any significant product losses or ongoing spills/leakages which may be occurring;

- Areas where regular or periodic handling and dispensing of liquid chemicals are undertaken, such as maintenance workshop and hazardous waste storage areas, should be concrete-paved with appropriate secondary containment (drip trays and bunded areas) provided.

- Any accidental spills will be assessed on a case by case basis and remedied, including excavation and disposal of any contaminated soil (classified as scheduled wastes) at a secure disposal facility.
- Procedures and work instructions on proper chemical handling should be effectively communicated to all operations and maintenance personnel;

- Hazardous materials and waste storage, handling and disposal procedures will be developed; and

- Corrosion protection for steel tanks and their ancillary facilities (pumps, valves and pipes) will be provided to prevent leaks.

Mitigating measures associated with the management of scheduled wastes and the residue streams within the RSFs have been discussed in **Section 5.5** below.

In addition, groundwater should be monitored on a regular basis during the lifetime of the plant operation. The groundwater monitoring wells should be located and installed at upgradient and downgradient locations of the site, as well as at strategic locations around the site (such as in the vicinity of potential areas of concern) that will allow the detection of suspected release of contaminants.

If contaminants are present at concentrations above the groundwater quality screening levels such as the Dutch Intervention Values (DIVs), further assessments will be necessary to determine the nature and extent of the contamination, as well as to remove the potential source(s) of contamination. A Human Health Risk Assessment (and/or an Ecological Risk Assessment, where appropriate) may be required to determine if the concentrations detected in the impacted media pose an unacceptable risk to human health and the environment.

5.4 ENVIRONMENTAL NOISE

5.4.1 Regulatory Requirements

There are presently no regulations on limits for noise levels for construction activities and industrial noise under the Environmental Quality Act, 1974. However, DOE has published the following guidelines for the management and control of noise:

- *Guidelines of the Siting and Zoning of Industries (1976):* These guidelines were developed with the objective to assist Federal, State and Local Governments, planners and industrial/residential developers etc. in determining suitable sites and adequate buffer zones when locating new industries/industrial areas or residential areas. These guidelines are also aimed to ensure systematic planning to reduce to the maximum possible, impact of residual pollutants to nearby residents.

- *Planning Guidelines for Environmental Noise Limits and Control (2004):* The purposes of these guidelines are (a) for planning purposes, typically by project proponents, local authorities and consultants (b) to be used in noise impact assessments, and pre and post EIA compliance verification (c) in quantifying a noise disturbance on a quantitative manner; and (d) to offer an introductory explanation in environmental noise control. The document specifies noise limits for the protection of the public from excessive noise, procedures on environmental noise measurements and impact assessment, noise parameters for the assessment of different noise sources; and noise abatement through planning and control.

- *The Guidelines for Noise Labelling and Emission Limits of Outdoor Sources (2004):* The guidelines were developed to present a uniform method in the measurement and labeling of outdoor noise sources and to prescribe recommended maximum permissible sound emission levels for a variety of outdoor noise sources for the protection of the public from excessive noise.

- The document also presents guidance for specifying noise emission levels and noise labeling requirements, procedures for measurement and labeling of noise emission of outdoor noise sources; and noise parameters for the description of noise emission of outdoor noise sources.

- *The Planning Guidelines for Vibration Limits and Control in the Environment (2004):* These guidelines are to be used for planning purposes, in vibration impact assessment, pre and post EIA compliance verification, in quantifying a vibration disturbance on a quantitative manner; and to provide an introductory explanation in environmental vibration control.

For the management of construction and operational noise, the relevant criteria are stipulated in Schedule 6 and Schedule 1 respectively of *The Planning Guidelines for Environmental Noise Limits and Control* document.

The Schedule 6 criteria which will be used for the management and control of construction noise are presented in **Table 5.3.1.**

Table 5.4.1: Schedule 6: Maximum Permissible Sound Levels (Percentile L_n and L_{max}) of Construction, Maintenance and Demolition Work by Receiving Land Use

Receiving Land Use Category	Noise Parameter	Day Time 7.00a.m. – 7.00 p.m.	Evening 7.00p.m. – 10.00p.m.	Night Time 10.00p.m. – 7.00 a.m.
Residential (Note 2**)	L_{90}	60 dBA	55dBA	* (Note 1)
	L_{10}	75 dBA	70 dBA	*
	L_{max}	90 dBA	85 dBA	*
Commercial (Note 2**)	L_{90}	65 dBA	60 dBA	NA
	L_{10}	75 dBA	70 dBA	NA
Industrial	L_{90}	70 dBA	NA	NA
	L_{10}	80 dBA	NA	NA

Notes

***1.** At these times the maximum permissible levels as stipulated in the Schedule 1 for the respective residential density type shall apply. This may mean that no noise construction work can take place during these hours.

**2. A reduction of these levels in the vicinity of certain institutions such as schools, hospitals mosque and noise sensitive premises (apartments, residential dwellings, hotel) may be exercised by the local authority or Department of Environment.

Where the affected premises are noise sensitive, the limits of the Schedule 1 shall apply.

3. In the event that the existing ambient sound level (L_{90}) without construction, maintenance and demolition works is higher than the L_{90} limit of the above Schedule, the higher measured ambient L_{90} sound level shall prevail. In this case, the maximum permissible L_{10} sound level shall not exceed the Ambient L_{90} level + 10 dBA, or the above Schedule L_{10} whichever is the higher.

4. NA = Not Applicable

In the operational phase of the project, Schedule 1 which recommends the maximum permissible sound levels of construction, maintenance and demolition activities as measured at the property boundary of various receiving landuses (**Table 5.3.2)** will be applicable.

Table 5.4.2: Schedule 1: Maximum Permissible Sound Level by Receiving Land Use for Planning and New Development

Receiving Land Use Category	Day Time 7.00 am - 10.00 pm L_{Aeq}	Night Time 10.00 pm - 7.00 am L_{Aeq}
Noise Sensitive Areas, Low Density Residential, Institutional (School, Hospital), Worship Areas.	50 dB	40 dB
Suburban Residential (Medium Density) Areas, Public Spaces, Parks, Recreational Areas.	55 dB	45 dB
Urban Residential (High Density) Areas, Designated Mixed Development Areas (Residential - Commercial).	60 dB	50 dB
Commercial Business Zones.	65 dB	55 dB
Designated Industrial Zones	70 dB	60 dB

Under normal circumstances, the above sound levels apply to outdoor locations at the real property boundary of the receiver (typically residential areas, or other noise sensitive area). However, for industrial noise sources in an industrial zone, the sound level shall be at the property boundary of the industrial site or plant under assessment.

For new industrial developments in areas of existing high environmental noise climate, the maximum permissible sound level at the receiver locations should not be higher than noise limits prescribed in *Schedule 2* of the Guideline. This schedule presents an absolute limit for the noise level L_{Aeq} based on the existing ambient percentile index L_{A90} plus an allowable noise increment. For industrial land uses the allowable noise increment is 10 dB.

A perimeter noise survey was undertaken between the 29 and 31 October 2007. The results showed that the existing night-time L_{A90} noise levels were all below 50 dB. Therefore the criterion for noise levels at the property boundary is L_{Aeq} 60 dB during the night-time period.

5.4.2 Construction Phase

5.4.2.1 Potential Sources of Impacts

Major noise sources during the construction phase of the project include:

- Site preparation works;
- Building construction activities including piling; and
- Transportation of construction equipment and materials: Vehicular noise will be generated from the ingress/egress of trucks carrying materials to/from the site.

5.4.2.2 Assessment of Impacts

The nearest noise sensitive receivers are the residential properties located at Kampung Sg. Ular (3 km northeast of the site), Kg. Gebeng (2.5 km east of the site) and Tanah Kemajuan Gebeng (2.5 km southwest). The noise impacts arising from the plant will not impact the noise environment at these receivers.

During the construction phase, activities will be carried out at the site up to *24 hours per day for 7 days* in a week. This will increase the prevailing noise levels at the boundary of the project site.

The quantification of construction noise requires detailed information on the types, models, numbers and sound power levels of all construction vehicles, machinery and equipment and the detailed construction works programme. This information was not available at the time of reporting and thus the impacts arising from construction noise are assessed qualitatively. Predictions of noise levels are made for three high-noise level construction activities.

a. Site Preparatory Works & Piling

Construction vehicles such as bulldozers, tractors, trucks and graders will be used for site clearing and earthworks. **Table 5.4.3** shows the typical noise levels arising from these vehicles. The cumulative impact of the operation of these vehicles is predicted to increase the existing noise levels to between 58.2 dBA – 75.2 dBA at areas within a 100 m radius of the work site. The maximum noise level of 75.2 dBA represents the worst case scenario in which all the specified equipment are working together within the same area with no shielding between the source and the receptor.

Piling activities typically create a sequence of high intensity noise pulses. Typical noise levels from some of the common types of piling equipment (without shielding) are presented in **Table 5.4.4.** The predicted noise level a 100 m distance from the piling rig is expected to be in the range of 73.3 – 100.3 dBA depending on the type of equipment employed. The use of quieter piling methods such as the bored piles will further reduce the noise experienced.

Table 5.4.3: Noise Levels for Typical Equipment Used for Construction

Equipment Involved	Sound Power Level (dBA)	Façade Sound Pressure Level			
		50m	100m	1000m	2500m
		Sound Pressure Level (dBA)			
Bulldozer	112	70.2	64.2	44.2	36.3
Truck	120	78.2	72.2	52.2	44.3
Lorry	106	64.2	58.2	38.2	30.3
Compactor	120	78.2	72.2	52.2	44.3
Cumulative noise levels from the above vehicles (a single unit each).		64.2-81.2	58.2-75.2	38.2-55.2	30.3-47.3

Table 5.4.4: Noise Levels for Typical Equipment used during Piling Activities

Equipment Involved	Sound Power Level (dBA)	Facade Sound Pressure Level			
		10m	20m	50m	100m
		Sound Pressure Level (dBA)			
Diesel Hammer (Sheet Piles)	147	119.1	112.8	106.2	100.3
Drop Hammer (Precast Concrete Piles)	128	100.1	93.8	87.2	81.3
Vibratory System (Sheet Piles)	120	92.1	82.8	79.2	73.3

As the predicted noise levels are not significantly higher than the levels presently experienced at the boundary of the residential property, the noise impacts are short term, occurring during the construction phase and not adversely significant. With the implementation of sound construction management practices and implementation of the recommended mitigation measures, noise impacts are not expected to be a nuisance during the construction phase.

b. Transportation of Construction Materials and Equipment

The transportation of construction materials and equipment to the plant site will increase noise in the vicinity of the site. Presently, the site can be accessed from the main Gebeng Bypass, the Kuantan-Kemaman Road (Federal Route 3) and East Coast Highway. These ingress/egress points will be utilised during the construction phase for the transport of construction materials, equipment and earthmoving machinery. The duration and magnitude of traffic movements are likely to vary with the stage of construction resulting in noise fluctuations over time. As the ingress points from these roads into the GIE are away from residential areas, the noise impacts from the movement of construction machinery are predicted to be short term, localised and not significant.

Overall, the noise impacts during the construction phase are predicted to be short-term, transient and localised to the site and its immediate surrounding (within the buffer zone of the industrial area).

5.4.2.3 Recommended Mitigation Measures

The following standard noise control practices and measures will be implemented during the construction phase:

- Machinery and construction vehicles that may be in intermittent use will be shut down between work periods or will be throttled down to a minimum;

- The impact of piling noise can be minimised by the selection of quieter pile drivers such as hydraulic pile, or bored piles.

- Material stockpiles and other structures will be effectively utilised, where practicable, to act as a screen for noisy equipment operating within the construction works area.

- Noisy equipment, such as generators, will be checked for proper installation of engine silencers to reduce emitted noise. Other machinery with high noise level should be operated within enclosures.

- All transport vehicles must comply with the noise requirements made under the *Environmental Quality (Motor Vehicle Noise) Regulations 1987*. The maximum sound level permitted for trucks used in the transport of goods or materials should not exceed 88 dBA. Moreover, transportation vehicles should not be overloaded to avoid driving with full engine capacity which results in higher noise being emitted.

- In terms of workers safety and health, workers spending long hours on site, operating machinery and equipment that generate loud noise, will be provided with protective ear mufflers to prevent hearing impairment/loss.

5.4.3 Operational Phase

5.4.3.1 Potential Sources of Impact

Noise is recognised as a form of pollution because it is a public health hazard capable of causing hearing impairments and psychological stress. Prolonged exposure to high noise level can cause permanent hearing impairment. This type of impairment may be incurable although the degradation process is usually gradual. Besides, noise can cause other negative effects such as loss of concentration and speech interference effects.

In this section, noise generated from the Advanced Materials Plant during the operational phase is assessed from an environmental pollution perspective. Matters pertaining to occupational noise exposure falls within the jurisdiction of the Department of Occupational, Safety and Health and thus not within the scope of this EIA report.

There are a number of significant noise sources throughout the plant site including pumps, motors, process equipment, fans and compressors. For purposes of this study, only the significant noise sources were identified from the equipment list provided provide by the Project Proponent.

5.4.3.2 Assessment of Impacts

The future noise levels at the plant site boundaries were quantitatively predicted with the use of a well established computer modelling programme *SoundPlan 6.2* (developed by Braunstein + Berndt, GmbH and accepted for use by the regulatory authorities in Australia). The data required for input into the model include:

- Meteorological information;
- Topographical data;
- Ground absorption;
- Building transmission loss; and
- Noise source sound power levels.

The objective of the noise assessment is to quantitatively predict:

- The highest noise level at the boundary of the plant site; and
- Noise levels when propagated over a 5 km radius of the site.

a. Methodology

For operational and truck noise impacts, the computer model utilised the *CONCAWE* algorithms. The *CONCAWE* methodology was developed from a research paper, published in 1981, under the title, “The propagation of noise from petroleum and petrochemical complexes to neighbouring communities”. It has been used as it explicitly deals with the influence of wind and the stability of the atmosphere.

b. Modelling Scenarios and Assumptions

A single scenario was modelled which represents the combined noise levels from the operation of the plant and the movement of trucks transporting raw material (lanthanide concentrate), reagents and finished products.

The predictions are based on two assumptions:

- Worst-case environmental conditions when the prevailing wind blows 100% of the time in the direction of the receiver, i.e. in a north-easterly-easterly direction.
- All equipment and machinery within the plant are operating simultaneously.
- Truck movements consisting of 68 trucks per day for the reagents and 18 trucks per day for the concentrate;
- Trucks operating 24 hours per day; and
- Speed on site is 30 km/h.

As the plant is to operate continuously, the night-time (10.00 pm - 7.00 am) noise level criteria is the most critical and as such, the results are calculated as $L_{Aeq\,(9\,hour)}$ dB levels.

c. Meteorological Data

The meteorological data used in the assessment is based on a 20-year period data obtained from the Sultan Abdul Aziz Shah Airport in Kuantan, Pahang. (described in detail in Chapter Four of this document).

d. Topography

As the subject site and surrounding land is relatively flat, it has been assumed that the there are no significant hills in the area that can attenuate the sound propagation. This is considered to be a conservative approach to the noise prediction.

e. Ground absorption

Ground absorption varies from a value of 0 to 1, with 0 being for an acoustically reflective ground (e.g. water or bitumen) and 1 for acoustically absorbent ground (e.g. grass). In this instance, as this project is predominately located around industrial area, the ground absorption has been set to a value of 0.5 (50% hard ground).

f. Building Transmission Loss

When noise sources are located within a building, the transmission loss of the building material is required in order to calculate the noise reduction from inside to outside. **Table 5.4.5** shows the transmission loss values in octave bands assumed in the noise modelling.

Table 5.4.5: Transmission Loss Values Used in Modelling, dBA

Wall Construction	Octave Band Centre Frequency (Hz)						
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**
Sheet Metal	14	18	22	27	32	37	42
Inner Leaf Brickwork, Outer Leaf Sheet Metal	32	34	34	43	58	73	83

g. Sound Power Data

Source sound power level data for the proposed plant have been obtained from file data of similar plant measured by Lloyd George Acoustics. The sound power levels are provided in *Table 5.4.6.*

Table 5.4.6: Source Sound Power Levels, dB

Source/Quantity	One-Third-Octave Band Centre Frequency (Hz)								Overall, dB(A) per Unit
	25 31.5 40	50 63 80	100 125 160	200 250 315	400 500 630	800 1k 1.25k	1.6k 2k 2.5k	3.15k 4k 5k	
Conveyors (Covered)	88	82	80	75	72	68	65	59	77/m
	86	80	78	72	70	66	64	56	
	85	78	76	72	69	65	61	54	
Compressor House	111	105	104	104	101	97	95	94	108
	110	102	105	105	101	99	94	92	
	108	105	108	103	98	95	94	92	
Cooling Tower	95	110	110	108	105	101	98	95	107
Rotary Kiln	110	101	101	100	102	101	94	84	105
Rotary Kiln Blower	93	99	104	100	104	97	95	92	104
Conveyor Drives	93	95	97	99	99	99	101	94	105
Blowers/Exhaust Fans	90	99	104	100	104	97	95	92	104
Pumps	100	90	94	92	91	97	95	89	106
	90	97	98	93	95	98	95	85	
	91	100	90	89	97	99	90	83	
Front-end Loader CAT 966 or Volvo L330C	105	114	110	105	106	102	99	95	108
Truck Moving at 30km/h	94	97	99	107	99	96	95	91	103

Note 1: The sound power level for the conveyor is for standard idlers at reasonably high speed.

As manufacturer's data for the plant proposed for the project was not available at the time of preparing this assessment, the following noise levels, when measured at one metre from the plant, should be specified:

- Rotary Kiln 97 dB(A)
- Cooling Tower 99 dB(A)
- Kiln Blower 97 dB(A)
- Covered Conveyor 70 dB(A)
- Conveyor Drive 97 dB(A)
- Exhaust Fans 96 dB(A)

- Compressor House 85 dB(A)
- Pumps 98 dB(A)
- Front-end Loaders 100 dB(A) – (or 86 dB(A) at 5 metres)

h. Results and Discussion

The results of the noise assessment are presented in **Exhibits 5.4.1** and **5.4.2**, as noise level contours overlaid on a map of the surrounding area. As the plant is to operate continuously, the night-time (10.00 pm - 7.00 am) noise level criteria are the most critical and as such, the results are calculated as $L_{Aeq\ (9\ hour)}$ dB levels.

From the results presented in Exhibits 5.4.1 and 5.4.2, the highest predicted noise level from the operation is received on the northern boundary of the proposed site. This level, which includes truck noise, is $L_{Aeq\ (9\ hour)}$ 62 dB. The predicted noise level is dominated by the front-end loaders moving between the Tertiary Leaching Plant and the Residue Storage Facilities.

The nearest noise sensitive receivers are the residential properties located at Kampung Sg. Ular (3 km northeast of the site), Kg. Gebeng (2.5 km east of the site) and Tanah Kemajuan Gebeng (2.5 km southwest). The predicted noise levels are these locations are calculated to be below L_{Aeq} 35 dB and therefore not considered to be of significance.

When compared to the Department of Environment Malaysia's *The Planning Guidelines for Environmental Noise Limits and Control,* it can bee seen that the night-time level at the northern boundary marginally (2 dB) exceeds the night-time criterion of $L_{Aeq\ (9\ hour)}$ 60 dB. However, these predictions assume that all four front-end loaders will be operating continually and simultaneously for the entire night-time period, which may not be the case in reality. Should the operation be intermittent, the $L_{Aeq\ (9\ hour)}$ level would be lower and may then comply.

It is therefore recommended that once the plant is operational, a noise survey be undertaken on the boundary of the site. Should it be found that the front-end loaders or other plant is causing the noise levels to exceed the criterion, noise control can be undertaken to ensure compliance. For the front-end loaders, suitable noise control can include upgrading the engine covers and exhaust system.

The impact from trucks on public roads is considered to be minimal considering the low truck volumes (86 trucks per day) and the existing traffic volumes. Also, as the trucks are likely to be taking different routes to the site, unlike the scenario of trucking campaigns from a port to a particular site, there is not a concentration of noise at specific locations.

Assuming the plant specifications and expected truck movements used in the model, the results clearly indicate that during both normal operation and with the additional noise associated with transportation of the lanthanide concentrate from the port, the operation of the plant complies with the Department of Environment Malaysia's *The Planning Guidelines for Environmental Noise Limits and Control* at all times.

5.4.3.3 Recommended Mitigation Measures

Assuming the plant specifications and expected truck movements as detailed in Section 5.4.3.2, the predicted noise levels from the proposed Advanced Materials Plant are expected to marginally exceed the perimeter noise criteria prescribed in the Department of Environment Malaysia's *The Planning Guidelines for Environmental Noise Limits and Control* along the plant's northern boundary. However these predictions are conservative in their approach and it is recommended that once the plant is operational, a survey is undertaken on the boundary of the site and noise control is undertaken if the criteria is exceeded.

However, to further reduce the plant operating noise and as best industrial practice, the following measures will be implemented:

- When selecting the equipment models for the plant from the various vendors, the noise attenuation features of the equipment will be given due consideration. In general, the newer equipment models tend to have more effective noise attenuation features. Where practical and cost effective, these equipment should be given priority. It is recommended that performance guarantee or contract specifications stipulate a requirement limiting the noise level of the equipment to a maximum of 85 dB(A) at 1m where practical.

- For additional noise attenuation, engineering measures such as installing mufflers, enclosures, barriers, lagging, noise-absorptive materials and silencers may be employed where practical.

- Where practical and feasible, noisy equipment should be housed within a building or an enclosure. The enclosures may range from a complete fully accessible room with proper air ventilation system to a structure which has side claddings that act as noise barrier.

- Insulation of equipment piping accord further noise reduction.

- The orientation of the equipment within the plant area will be such, so as to capitalise on the existing buildings and structures as noise barriers. Barrier shielding in many instances has been observed to significantly attenuate noise levels. For example, an intervening building between source and receiver may reduce the noise level by about 5 dBA.

- The layout of noisy equipment within the plant will be aligned in a manner such that the distance of the equipment from the boundary is maximized, at least 25 metres from the nearest neighbouring site boundary.

- Noise emitted by the compressors, fans and pumps can be further controlled by reducing the vibration level of the machinery and their ancillaries.

For the control of occupational noise, workers operating within noisy areas of the plant will be provided with ear plugs or ear muffs. In high noise level environments within the plant, it is advisable to wear both types in combination. The noise attenuation or protection afforded by ear protectors varies with the frequency of the noise, providing more protection at higher frequencies. At average frequencies of 500 Hz to 1000 Hz, ear plugs alone provide protection of about 22 dB (A). Ear muffs are better, providing attenuation of 30 dB(A) and in combination, the protection accorded is in the range of 34 dB(A).

5.5 SOLID WASTE

5.5.1 Regulatory Requirements

General industrial, commercial and domestic wastes are controlled under the *Local Government Act 1976* and *Refuse Collection, Removal and Disposal By-Laws* stipulated under the Act. This Act enables State Authorities to prohibit the deposition of wastes in streams, watercourses and public drains. The by-laws specify that commercial and industrial wastes may be collected and disposed of on a fee basis as prescribed by Local Authorities. Contravention of the by-laws is an offence. In addition, the *Solid Waste and Public Cleansing Management Act, 2007* was recently gazetted and will come into operation in the near future.

The *Environmental Quality (Scheduled Wastes) Regulations, 2005*, under the *Environmental Quality Act, 1974*, regulates the responsibilities and procedures related to storage, handling, transport and disposal of scheduled or hazardous wastes. Under the First Schedule of the regulations, hazardous wastes have been grouped under 5 broad groups: Metal and Metal Bearing Wastes (SW1); Wastes containing principally inorganic constituents which may contain metals and organic materials (SW2); Wastes containing principally organic constituents which may contain metals and inorganic materials (SW3); Wastes which may contain either inorganic or organic constituents (SW4); and Other wastes (SW5). Under the five groups 77 types of wastes have been classified as scheduled waste with designated codes.

Under these Regulations, waste generators are required to keep an up-to-date inventory of scheduled waste generated, treated and disposed off. The regulation also requires proper labelling of containers and storage areas as well as prohibition of storage of incompatible waste. In the case of transporting the waste from the waste generator to the treatment and disposal facilities, the transport of waste shall conform to the specified consignment note system and only carried out by DOE-licenced transporters. Scheduled wastes may only be transported to scheduled waste treatment and disposal facilities which have a valid licence to occupy or use the premises from the DOE.

5.5.2 Construction Phase

5.5.2.1 Potential Sources of Impacts

The types of solid wastes generated during the construction phase can be broadly categorised based on their nature and ultimate disposal method into the following:

- Municipal waste;
- Scheduled waste (regulated hazardous wastes); and
- Unregulated wastes.

Improper disposal of these wastes at unauthorised areas will contribute to unhealthy and unattractive surroundings. Poor management of construction waste will result in the creation of illegal dumping grounds in secluded areas at the nearby villages and surrounding forested areas. These illegal dumps provide an ideal habitat for disease-vectors such as mosquitoes, flies and rats which potentially cause health impacts to nearby settlements. In addition improper disposal of hazardous waste will result in contamination of the soil and potentially groundwater. They also pose fire hazards during the dry seasons, clog the local drainage system and caused localised ponding and even flooding of nearby streams and river systems during the monsoon season. The dumps are also sources of adverse negative odour impacts.

5.5.2.2 Assessment of Impacts

a. Municipal Wastes & Scheduled Wastes

Waste material under this category would include the following:

- Construction spoil originating from the construction works. These include inert and non-toxic materials such as crushed stones and gravel, rejected wood based material, bricks, concrete slabs, steel frames, PVC pipes, cement/grouting mixes, etc.

- General waste which includes non-inert and non-toxic waste such as plastics, packaging, paper, glass, metals, planks, putrescible food and other wastes generated from daily activities of the site.

- Vehicle/equipment parts such as tyres, metal components, etc.

- In the event foreign workers are employed for the construction phase, there would be a need to provide temporary accommodation facilities. These facilities will give rise to the generation of solid waste and sewage. As the industrial area is not remotely located with easy access to the towns of Balok and Gebeng, accommodation may be provided at existing residential areas. However, in the event construction activities extend beyond the normal working hours and for convenience these temporary housing facilities may be erected onsite).

- Domestic waste generated from the site offices and workers' camp include plastic wrappings or other packaging material, paper, glass and putrescible waste material from the kitchen.

Schedule wastes generated on site include the following:

- Spent filter cartridges, scrap batteries, mineral oils/engine cleaning fluids;

- Residues and waste of industrial paints, pigments, lacquers, curing compounds, etc;

- Various types spent/waste oil and soil/rags contaminated with oily residues from construction equipment, vehicles and diesel generators; and

- Spent solvents.

The potential impacts arising from improper management of both these waste categories include the following:

- Odour nuisance from decaying organic and food wastes from municipal wastes;

- Improper disposal of putrescible municipal wastes on-site would attract disease carrying rodents and insects. This may subsequently result in public health impacts (such as dengue) within the nearby villages.

- Improperly managed wastes will be washed into the temporary drainage channels during rainfall events potentially obstructing the drainage flow. If unattended, this will result in stagnant water in the drains.

- Contamination of soil and groundwater resources as the shallow groundwater table within the project site is at 1.0–3.5 m bgls;

- Aesthetic issues due to poor management of the wastes;

- The wastes are also potential fire hazards within the site. Any fires occurring within the site, if uncontrolled can spread to the surrounding areas.

c. Unregulated Wastes

The unregulated wastes generated by the project would include the following:

- Excavated topsoil;
- Excavated unsuitable soil; and
- Vegetative biomass.

During the construction phase, topsoil and unsuitable foundation material will be removed at the construction works area.

As the site has been largely cleared (approximately 98% cleared with very little sparse vegetation and shrubs) the quantity of waste vegetative biomass generated is therefore very small. Options such as mulching and composting within the site, where practical should be considered, if necessary.

5.5.2.3 Recommended Mitigation Measures

Burning of vegetative biomass residues and construction wastes within the site is *strictly prohibited* as apart from polluting the atmosphere and contributing to the occurrences of haze events, the activity poses a risk of fire spreading to the adjoining green areas. In addition open burning of activities other than the ‘declared activities’ identified in the *Environmental Quality (Declared Activities) (Open Burning) Order, 2003* is illegal. The declared activities are mainly activities related agriculture and animal husbandry.

a. Municipal Waste

The potential environmental impacts arising from the improper management of municipal wastes can be minimised with the implementation of the following practices:

- Good housekeeping practices are essential within the site and especially critical at the workers’ camp (if set-up within the site premises).

- General construction spoil should be recycled on site as much as possible. For example, construction aggregate materials, cement and rock are readily used on site where possible as backfill material for low lying areas.

- Domestic waste generated from the workers' camps should be stored in garbage bins/secure containers and be collected regularly by a licensed contractor for disposal at an approved landfill.

- Unsalvageable construction spoil should be stockpiled at a designated site and sold to salvage yard operators or other contractors interested in recycling the material. Alternatively, disposal arrangements can be made with registered private contractors or Majlis Perbandaran Kuantanto carry out regular collection and off site disposal at the approved disposal site.

b. Scheduled Wastes

Types of scheduled wastes potentially generated during the construction phase will require proper handling, storage and disposal in compliance to the scheduled waste regulations. The copies of the waste consignment notes will be filed by the Contractor for record.

The construction works Contractor shall ensure that only licensed scheduled waste contractors are employed for the transportation of these scheduled wastes to the scheduled waste disposal facility, the Integrated Scheduled Waste Management Centre (ISWMC) at Bukit Nanas, Negeri Sembilan.

To prevent potential soil and groundwater, the mitigation measures recommended in **Section 5.5.2.3** shall be applicable.

c. Unregulated Waste

Topsoil refers to soil layers that can be used as a revegetation medium during rehabilitation or landscaping of the site. Topsoils have chemical, physical and biological attributes that assist in the rapid re-establishment of plants as these soils contain a natural stock of seeds and beneficial micro-organisms. Due to their higher organic matter, the excavated soil may be stockpiled within the site and then reused within the 'green' areas proposed at the site.

5.5.3 Operational Phase

5.5.3.1 Potential Sources of Impacts

Solids wastes generated during the operational phase of the Advanced Materials Plant include:

- Residues from the physio-chemical processes within the Cracking & Separation Plant;

- Scale from neutralisation tanks and clarifiers in the Neutralisation Plant;
- Scale from process piping and vessels that handle lanthanide sulphate solution;
- Waste refractory from kiln maintenance;
- Filter cloths from the FGD, NUF and WLP filtration processes;
- Sludge from the Waste Water Treatment Plant (WWTP);
- Scheduled wastes; and
- General wastes.

With the exception of scheduled wastes and general wastes, all other wastes listed above are classified as radioactive wastes by the Atomic Energy Licensing Board (AELB) and thus the storage and management of these wastes must comply with the applicable regulations under the *Atomic Energy Licensing Act, 1984* and, endorsed by the AELB. Matters pertaining to the on-site storage and management of these wastes come under the purview of the Board. Lynas has engaged Malaysian Nuclear Agency (Nuclear Malaysia) as the Radiological Consultants for this project and for the preparation of a Radiological Impact Assessment (RIA) which evaluates the radiological impacts of the plant operations to humans and the environment. A copy of the RIA has been submitted to the AELB for approval as part of the *Class A Milling Licence* application requirements. The Class A Milling Licence is required under the *Atomic Energy Licensing Act, 1984* for plants involved in the processing of radioactive materials.

For purposes of this EIA, only the non-radiological impacts pertaining to the waste management are identified and assessed as the management of radioactive wastes comes under the purview of the AELB (refer **Appendix 1**).

a. Radioactive Wastes

Residues, Refrcatory, Filter Cloths & WWTP Sludge

The three residue streams produced will include:

- Water Leach Purification (WLP) residue resulting from the leaching and purification of the water soluble lanthanide components from the calcined, cracked concentrate in the Cracking & Separation Plant;
- Flue Gas Desulphurisation (FGD) residue from waste gas scrubber system; and

- Neutralization Underflow (NUF) residue from the High Density Sludge system which is the pre-treatment system of the liquid waste streams arising from the Cracking & Separation Plant.

All residue streams and the filter cakes will be stored onsite within the engineered Residue Storage Facility (RSF) until a suitable permanent disposal option is selected by Lynas in conjunction with the AELB. The location of these RSF units is presented in **Exhibit 2.1** (Chapter Two).

Based on the basic engineering design, an estimated 145,200 tons of residues will be generated annually. A summary of the three residue streams in terms of annual dry mass and volume generated, and the state of residue during disposal is presented in **Table 5.5.1**.

Table 5.5.1: **Residue Streams Summary**

Residue Stream	Annual Dry Mass (Tons/annum)	Assumed Dry Density (t/m^3)	Volume (m^3) for 10 Year Project Lifespan	State[2] of Residue
Water Leach-Purification (WLP) solids	32,000	0.70	478,800	Paste
Flue Gas Desulphurisation (FGD) Solids	27,900	1.05	162,600	Paste
Neutralisation Underflow (NUF) Solids	85,300	1.05	91,600	Paste
Total	**145,200**		**2,766,600**	

Notes:

[1] Dewatered residues with water content between 30–40% are referred to as paste.

Typical compositions and radioactivity of the three residue streams and sludge from the WWTP are shown in **Table 5.5.2.**

Table 5.5.2: Major Waste Composition of the Residue Streams and Sludge from the WWTP

	WLP	FGD	NUF	Sludge *
Composition	**Weight %**	**Weight %**	**Weight %**	**Weight %**
Iron Oxide	19.74	0.16	0.17	2.4
Phosphorus Oxide	19.77	0.00	0.00	0.3
Aluminium Oxide	2.86	0.12	0.23	0.4
Calcium Oxide	1.36	28.39	22.31	-
Magnesium Oxide	0.03	0.00	7.06	4.2
Manganese Oxide	0.37	0.00	0.37	-
Barium Oxide	0.3	-	-	0.01
Sulphite	0.00	0.00	0.03	-
Zinc	0.1	-	-	-
Strontium Oxide	0.4	-	-	-
	ppm	**ppm**	**ppm**	**ppm**
Fluoride	-	1800	-	71
Thorium Oxide	1655	0.00	0.00	26
Uranium Oxide	22.5	-	-	1.1
Sodium Oxide	-	0.00	0.13	36
Potassium Oxide	-	0.00	0.00	28
	Bq/g	**Bq/g**	**Bq/g**	**Bq/g**
Radiation (Specific Activity)	62.0	0.47	0.25	1.1

****Note**: Sludge is from Wastewater Treatment Plant*

Scales

Calcium sulfate scale from the neutralisation tanks and clarifiers in the HDS Neutralisation Plant have similar physico-chemical characteristics as the NUF solids and will be disposed of in the NUF cell of the RSF.

Calcium sulfate scale from process piping and vessels that handle the lanthanide sulphate solution primarily consists of calcium sulphate and low levels of radium, and will be disposed of at the WLP solids cell of the RSF.

Waste Kiln Refractory and Filter Cloths

Waste refractory from kiln maintenance (which will be generated at an estimated 5 – 50 tonnes every two years) and filter cloths from filtration processes (estimated at 5 – 50 tons per annum) may exhibit low levels of radioactivity and will be disposed of at the RSF.

b. Scheduled Wastes

Scheduled wastes generated from site operations are anticipated to include:

- Used engine, hydraulic and lubricating oil from maintenance workshop and general lubricating and maintenance activities;
- Used batteries from vehicles and equipment;
- Discarded or off-specification chemicals (including acids, alkalis and reagents used);
- Containers, bags or equipment contaminated with chemicals or mineral oil; and
- Rags, plastics, papers or filters contaminated with chemicals or oils.

c. General Waste

General/municipal wastes arising from the operation of the plant include canteen waste, office wastes from the administration offices and miscellaneous wastes from other working areas which may include, waste paper, plastic, cardboards etc.

5.5.3.2 Assessment of Impacts

a. Radioactive Wastes

Potential environmental impacts associated with on-site residue storage (RSF) include:

- Soil and groundwater contamination; and
- Residue embankment slope stability and erosion problems.

As shown in **Table 5.6.2** the residues are primarily composed of oxides of iron, aluminium, silicon, magnesium, calcium and phosphorus. These are compounds that are readily found as major constituents that make up soil minerals.

The complete environmental impact assessment of these radioactive wastes will be undertaken as part of the Radiological Impact Assessment by the Malaysian Nuclear Agency for submission to the Atomic Energy Licensing Board.

The potential leaching of trace metals, including radioactive lanthanide metals, from the residues may result in contamination of the underlying soil and groundwater resources.

It is noted that there are no groundwater abstraction points or direct groundwater users have been identified on-site or at immediate down-gradient locations. Additionally, there are no other potentially sensitive groundwater receptors within the zone of impact.

Residue embankment slope stability and erosion may also result in release of residues outside of lined cells and pose a potential health and safety problem in addition soil and groundwater contamination. A preliminary embankment slope stability assessment has been conducted based on the subsurface profile encountered during the site investigation and estimated design parameters in order to ensure the factor of safety (FOS) of slopes against global failure. In accordance with ANCOLD (Australian National Committee on Large Dams) guidelines the required FOS for short-term and long-term stability are 1.3 and 1.5, respectively. The preliminary slope stability assessment indicates that the FOS against global failures for embankment height up to 8m is acceptable in the long term case but not the short term case. Slope stability impacts should be appropriately addressed (see Section 5.5.3.3).

b. Scheduled Wastes

The primary concern with regards to scheduled waste management is spillages which will potentially contaminate surface-runoff, soil and groundwater.

Based on the types of scheduled waste potentially generated from the site, the quantities will not be significant. These wastes can be sold to scheduled waste recycling contractors who are licensed by DOE. The impacts arising from the storage and handling of the scheduled wastes categories identified are not significant.

5.5.3.3 Recommended Mitigation Measures

a. Radioactive Wastes

In ensuring that the potential environmental impacts arising from the on-site storage of the radioactive residue streams are minimised to a sustainable level, Lynas has developed a technically sound waste management strategy which is described Section 3.2 *'Preliminary Comparison of Residue Disposal Options'* (Refer **Appendix 3)**. It is recommended that this strategy be incorporated into the Environmental Management Plan (EMP) prepared for operational phase and endorsed by the AELB and the DOE for implemention. The waste management strategy developed by Lynas is directed towards the design of an environmentally sustainable residue storage facility (RSF) while maximizing the potential for recycling or reuse of each residue stream back into the process.

The Project Proponent has commissioned a conceptual engineering design of the RSF, taking into account key engineering design and environmental considerations. Each residue stream has different characteristics in terms of water content, its composition and radioactivity. Design considerations of the RSF as well as residue management are dependent on these characteristics. One conceptual design scenario has been presented to the AELB and are currently under evaluation.

The key features of the RSF design which provides for the protection of environmental resources, namely soil and groundwater are summarised below:

- Fill material will be placed at low-lying areas to ensure that the base of the RSF is at least 1 m above groundwater level. It is recommended that the fill material comprises soils with low permeability;

- All residue storage cells will be lined with 300 mm low permeability compacted clay liner overlain by a 1 mm thick HDPE liner to prevent seepage into the underlying soil and groundwater;

- All supernatant liquors and rainfall runoff from FGD and NUF residue cells will be collected and pumped via pipeline to a HDPE-lined FGD/NUF surface water retention pond with capacity for the 1 in 100 year storm event based on climatic data for the region. Water from this pond will be directed to the Waste Water Treatment Plant (WWTP). The treated waste water will then be discharged off-site into an external earth drain which discharges into Sungai Balok. All off-site discharges will be monitored to comply with the limits stipulated in *Standard B* of the *Environmental Quality (Sewage and Industrial Effluent) Regulations, 1979*;

- Supernatant liquors and rainfall runoff from the WLP residue cell will be pumped to a separate HDPE lined surface water retention pond (with capacity for the 1 in 100 year storm event based on climatic data for the region) and subsequently recycled into the cracking and separation process stream. No off-site discharge is anticipated;

- During heavy rainfall and in particular the monsoonal wet season the surface of the residue is expected to become wet, soft and slippery making placement of residue during this period problematic due to the poor trafficability of the residue surface. Therefore, a temporary cover may be required to keep the area of active residue placement dry during the wet season. A potential solution to this problem is to size the drying shed with sufficient capacity so residue can be stockpiled during the wet season awaiting placement in the RSF during drier weather;

- To ensure a long term slope stability, perimeter RSF embankment walls will be designed and built with a gentle gradient of 3H:1V. In addition, the maximum height of embankment will be limited to 8 m above existing ground level. The preliminary slope stability assessment indicates that the proposed embankment fill height of 8m results in a FOS of less than the acceptable minimum of 1.3 under short-term undrained conditions. This can be overcome by the placement of an additional 1.0m of well compacted select fill across the RSF area. Further assessment of the consolidation behaviour of the subsurface soils is required to confirm the short-term stability of the embankments; and

- Erosion protection in the form of rip-rap or geotextiles will be incorporated.

A conceptual cross-sectional design of the RSF showing liner and embankment details are provided in **Exhibits 5.5.1 – 5.5.4.**

In addition to constructing the RSF which incorporates environmental protection features, the Project Proponent is also exploring the potential beneficial uses of each of the three residue streams. The reuse of residues will significantly reduce the quantity of residue for on-site storage and the allocated footprint for the RSF within the site. Details of these reuse options are presented in the *'Preliminary Comparison of Residue Disposal Options'* presented in **Appendix 3**.

A summary of these end uses are presented in **Table 5.5.3** below.

Table 5.5.3: Summary of Potential Residue End Uses

Residue Stream	Potential Residue End Uses
Water Leach-Purification (WLP) residue	• Fertilizer (high levels of phosphorus and magnesium) • Raw material for Cement manufacture
Flue Gas Desulphurisation (FGD) residue	• Plasterboard market (calcium sulphate) • Raw material for cement manufacture
Neutralisation Underflow (NUF) residue	• Fertilizer (high levels of magnesium, aluminium and calcium sulphate) • Raw material for cement manufacture

In addition, the design, construction and operation of the RSF must be monitored and carried out so that it does not result in adverse impacts identified in the previous section. Prevention and control measures include the following:

- RSF surface water retention ponds should be sized to accommodate monsoon and storm events over the life of the project;

- A detailed settlement and slope stability including seismic sensitivity analyses to ensure the stability of the landform created should be considered;

- During the construction of the RSF, QA/QC procedures should be implemented to ensure that the liner system of the RSF is installed without any compromise to its integrity. This includes on-site full time supervision of a qualified engineer during liner installation and strict quality inspection checks;

- Frequent inspection and maintenance of the surface runoff and leachate collection and treatment systems must be carried out to ensure continuous operation, particularly during the wet season;

- Monitoring of groundwater quality in the vicinity of the RSF should be conducted on a regular basis. More groundwater monitoring wells should be installed at strategic locations to detect potential groundwater contamination;

- Access to the RSF should be restricted to authorized personnel only and appropriate personal protective equipment (PPE) must be worn to reduce the risk of potential exposure to low level radiation and other contaminants from the residues; and

- A *RSF Management Plan* which covers aspects of residue deposition, rainfall runoff management, dust generation and entrainment, environmental monitoring, health and safety as well as site closure and rehabilitation should be developed and implemented as part of the EMP prepared for the operational phase of the plant.

As part of the fill/construct methodology for the RSF, cells will be capped once design capacity is achieved creating a landform with positive drainage. Capping is envisaged to comprise a 500mm thick rock-fill layer to serve as a capillary break, overlain by low permeability clayey soil and topsoil to lower the risk of infiltration. Interaction between rainfall and surface water runoff from capped cells and permanently stored residues will be minimised and the final site topography will encourage surface water to drain off-site to prevent ponding and standing water.

b. Scheduled and General Waste

Scheduled wastes generated from plant operations will require proper handling, storage and disposal. These practices shall meet the requirements stipulated in the *Environmental Quality (Scheduled Waste) Regulations, 2005.*

Scheduled wastes generated at the site can either be recycled or disposed at approved facilities. There is currently a market of spent oils, solvents, lead batteries, oil filters and paints. These can be readily sold to DOE-licensed recyclers. There are a few facilities licenced to recover spent catalyst, waste oil, spent hydraulic oil and chemicals that are discarded or off-specification located nearby in the Gebeng Industrial Area and Teluk Kalong Industrial Area.

Scheduled wastes which cannot be recycled but require disposal will need to be disposed at the Integrated Scheduled Waste Management Center (ISWMC) operated by Kualiti Alam which is presently the only licensed facility in Malaysia. Upon signing a contract with Kualiti Alam, the company will arrange for their marketing division to coordinate the entire packaging and transportation of the wastes to the integrated facility.

Specifications for scheduled waste storage (pending off-site removal) have been stipulated in the Regulations. The wastes shall be stored within a designated storage area and the design of the storage area shall comply with the requirements of the Regulations.

Salient features of the design include:

- Provision of hardstanding, with impervious flooring (such as concrete);
- A bund wall capable of containing 110% of the contents of the largest storage tank volume in the event of spill;
- The discharge outlet of the bunded area must be appropriately designed (e.g. with valve) so that there is no direct discharge or release of material away from the storage area;
- Preferably constructed with walls and roof to protect against the weather (sun and rainwater ingress);
- Well-ventilated and well-lit;
- Incompatible scheduled wastes must be stored in separate containers and placed in separate secondary containment areas; and
- Locked when access is not required and should be accessible only to authorized persons.

Other key requirements of the regulations are as follows:

- DOE shall be notified on the generation of the scheduled waste within the facility;

- Up to date inventories of the scheduled waste generated, treated and disposed of are to be maintained for inspection by DOE;

- All storage bins/areas should be properly labelled and identified. Storage of incompatible wastes is prohibited;

- The off-site transport of scheduled wastes from the point of generation to the final disposal facility must utilise the Consignment Note System; and

- The waste generator is responsible for informing the (DOE-licensed) waste transport contractor on the nature of the waste and of the precise actions necessary to preserve human life and the environment in the event of an accident during the transport.

5.6 AMBIENT AIR

5.6.1 Regulatory Requirements

Industrial gaseous emissions are regulated by the *Environmental Quality (Clean Air) Regulations 1978*. Under these Regulations, industrial facilities are required to comply with three types of standards: A, B and C under the *Stack Gas Emission Standards* specified under sub-regulation 27.

All new operations are required to comply with Standard C, while Standards A and B are applicable for operations which commenced prior to the promulgation of this regulation in 1978. These standards are regarded as acceptable conditions for air emissions in Malaysia. The standards are given based on the sources of emission for certain activity or from "any other sources", which is normally applicable for most manufacturing industries. No standards have been listed specifically for general manufacturing operations although standards exist for sulphuric acid mist/sulphur trioxide, solid particles, metal and metallic compounds, chlorine gas, hydrogen chloride, fluorine, hydrofluoric acid, inorganic fluorine compound, hydrogen sulphide and oxides of nitrogen from "any source". The limits prescribed are presented in **Table 5.6.1.**

Any erection, installation, re-siting or alteration of fuel burning equipment or of a chimney, from or through which air impurities may be emitted or discharged, will require a Written Approval from the DOE Pahang State office. This includes the installation of boilers and emergency/back-up generators that are rated to consume any liquid or gaseous matter at or more than 15 kg or more per hour. The application for the Written Approval can be made to the DOE State office using Form AP/E/1/98. Information to be provided in the application form include design and operational details of the fuel burning equipment/chimney/pollution control equipment. The processing duration for the Written Approval is approximately 1 month.

Currently, there are no established standards for ambient air quality in Malaysia but DOE has adopted some recommended guideline levels (*Recommended Malaysian Air Quality Guidelines (RMAQG)*) for a number of pollutants including ozone (O_3), carbon monoxide (CO), nitrogen oxide (NO_2), sulphur dioxide (SO_2), particulates (Total Suspended Particulates (TSP)) and respirable dust (PM_{10}), lead and dustfall. The *RMAQG* was prepared by the DOE in 1989 based on the Australian and New Zealand national standards for the protection of public health. The levels will apply for ambient air quality monitoring. The criteria stipulated in the *RMAQG* are presented in **Table 5.6.2.** The corresponding limits recommended by the World Health Organization (WHO, 2005) are also presented in the table.

The *Environmental Quality Act, 1974* prohibits the burning of any combustible material or refuse unless a license is granted by the Director General of the Environment. This would include a variety of waste materials (e.g. palm oil, rubber trees & other vegetation and waste generated by construction) during both the construction and operational phase of the project.

Under the *Environmental Quality (Declared Activities) (Open Burning) Order 2003,* open burning is strictly prohibited within industrial premises unless it is a declared activity. The Order specifies 15 declared activities which is generally related to research, religious rites/worshipping, small scale social activities, permitted industrial gas flaring, disease control and agricultural activities.

The *Environmental Quality (Dioxin and Furan) Regulations 2004,* specifies a not to exceed concentration limit of 0.1 nanogram/Nm^3 TEQ for air emission of dioxin and furan for incinerators of schedule waste, municipal waste, pulp & paper industry sludge and sewage sludge.

Table 5.6.1: Recommended Malaysia Air Quality Guidelines

Pollutant	Averaging Time	Malaysian Air Quality Guidelines		WHO (2005)[4]
		ppm	µg/m^3	µg/m^3
Sulphur dioxide (SO_2)	1 hr	0.13	350	
	24 hrs	0.04	105	20
PM_{10}	24 hrs		150	50
	1 year		50	20
TSP	24 hrs		260	-
Nitrogen dioxide (NO_2)	1hr	0.17	320	200
	24 hrs			-
	1 year	0.04	90	40
Carbon Monoxide (CO)	1 hr	30.00	35 mg/ m^3	
	8 hrs	9.00	10 mg/ m^3	
Ozone (O_3)	1 hr	0.10	200	-
	8 hrs	0.06	120	100
Lead (Pb)	3 months		1.5	1.5

Emission of black smoke from diesel powered vehicles and construction equipment must comply with the emission limits specified under Schedule I of the *Environmental Quality (Control of Emission from Diesel Engines) Regulation 1996.*

[4] World Health Organisation (WHO) (2000): Guidelines for Air Quality, World Health Organisation.

Table 5.6.2: Permissible Gaseous Emissions Limits from any Trade, Industry or Process (Environmental Quality (Clean Air) Regulations, 1978)

Substance Emitted	Sources of Emission	Standards
(a) Acid Gases	Manufacture of sulphuric acid	1. Equivalent of: Standard A: 7.5 Standard B: 6.0 Standard C: 3.5 gramme of sulphur trioxide / Nm^3 of effluent gas, 2. Effluent gas free from persistent mist
(b) Sulphuric acid mist or sulphur trioxide or both	Any source other than combustion process and plant for manufacture of sulphuric acid as in (a) above.	1. Equivalent of: Standard A: 0.3 Standard B: 0.25 Standard C: 0.2 gramme of suplhur trioxide / Nm^3 of effluent gas, 2. Effluent gas free from persistent mist
(c) Chlorine gas	Any source	Standard A: 0.3 Standard B: 0.25 Standard C: 0.2 gramme of hydrogen chloride / Nm^3
(d) Hydrogen chloride	Any source	Standard A: 0.6 Standard B: 0.5 Standard C: 0.4 gramme of hydrogen chloride / Nm^3
(e) Fluorine, hydrofluoric acid, or inorganic fluorine compound	Manufacture of aluminium from alumina	Equivalent of: Standard C: 0.2 gramme of hydrofluoric acid/Nm^3 of effluent gas
(f) Fluorine, hydrofluoric acid, or inorganic fluorine compound	Any source other than manufacture of aluminium from alumina as in (e) above	Equivalent of: Standard A: 0.15 Standard B: 0.125 Standard C: 0.100 gramme of hydrofluoric acid/Nm^3 of effluent gas
(g) Hydrogen sulphide	Any source	Standard A: 6.25 Standard B: 5.00 Standard C: 5.00 Parts per million volume for volume

Table 5.6.2: Permissible Gaseous Emissions Limits from any Trade, Industry or Process (Environmental Quality (Clean Air) Regulations, 1978 (cont'd)

Substance Emitted	Sources of Emission	Standards	
(h) Oxide of nitrogen	Manufacture of nitric acid	Equivalent of: Standard A: 4.60 Standard B: 4.60 Standard C: 1.7 and effluent gas substantially colourless gramme of sulphur trioxide / Nm^3.	
(i) Oxides of nitrogen	Any source other than combustion processes and manufacture of nitric acid as in (h) above	Equivalent of: Standard A: 3.0 Standard B: 2.5 Standard C: 2.0 gramme of sulphur trioxide/Nm^3	
(j) Solid Particles	Fuel Burning Equipment / industrial plant used for heating of metals (other then cold blast foundry cupolas.	Standard A: 0.30 gm/Nm^3 Standard B: 0.25 gm/Nm^3 Standard C: 0.20 gm/Nm^3	
Solid Particles	Fuel Burning Equipment / industrial plant used for other than heating of metals	Standard A: 0.6 gm/Nm^3 Standard B: 0.5 gm/Nm^3 Standard C: 0.4 gm/Nm^3	
(k) Metals & Metallic Compounds	Standard A	Standard B	Standard C
Mercury	0.02	0.01	0.01
Cadmium	0.025	0.015	0.015
Lead	0.04	0.025	0.025
Antimony	0.04	0.025	0.025
Arsenic	0.04	0.025	0.025
Zinc	0.15	0.1	0.1
Copper	0.15	0.1	0.1
(l) Asbestos and Free Silica	For any trade, industry or process which emits or discharges dust or any solid particles containing asbestos or free silica the concentration of air impurities shall not exceed the following:	Standard A: 0.4 gm/Nm^3 Standard B: 0.2 gm/Nm^3 Standard C: 0.12 gm/Nm^3	

For purposes of this study, RMAQG is used as the criteria for ground level concentration of the pollutants under assessment and where compounds are not covered by the RMAQGs (i.e. HF and H_2SO_4), the World Health Organisation (WHO) Air Quality Guidelines and the Office of Environmental Health Hazard Assessment (OEHHA, 2005)[5] Chronic Reference Exposure Levels.

The primary aim of the WHO guidelines is to provide a basis for protecting public health from adverse effects of air pollution and for eliminating, or reducing to a minimum, those contaminants of air that are known or likely to be hazardous to human health and well-being. These guidelines are intended to provide background information in making assessments of risk. They are intended as guidelines, rather than strict standards, but also aim to provide a basis for setting standards or limit values for air pollutants by setting levels below which exposure for a given period of time does not constitute a significant health risk.

The OEHHA guidelines have been applied for the compounds not covered by the RMG or WHO guidelines. The OEHHA guidelines are typically based upon values published by other reputable authorities rather than being developed from first principles based on results of actual toxicological studies. The OEHHA guidelines are, however, considered useful for this assessment in that they are one of the few sources that publish acute health protective guidelines for a wide list of compounds. The criteria used for the Advanced Materials Plant emissions operational phase are presented in Table 5.6.3.

Table 5.6.3: Ambient Air Quality Criteria for the Advanced Materials Plant

Compound	Air Quality Guideline ($\mu g/m^3$) for Different Averaging Times[1]			Reference
	1 hour	24 hour	Annual	
SO_2	350	105	-	RMG
	-	-	50	WHO
HF	240	-	0.5	OEHHA
H_2SO_4	120	-	1	OEHHA
PM_{10}	-	150	50	RMG

Notes: 1. Referenced to a temperature of 0ºC and absolute pressure of 101.3 kPa.

[5] Office of Environmental Health (OEH) (1999): 1999 Update – Arizona Ambient Air Quality Guidelines. Report prepared for the Arizona Department of Environmental Quality.

The American Conference of Governmental Industrial Hygienists (ACGIH) recommends Short-Term Exposure Limits (STELs) for a number of chemical substances which workers may be exposed to within an occupational setting. STELs are defined as a 15 minute Time Weighted Average (TWA) which should not be exceeded at any time during a workday (ACGIH, 2002). The STELs relevant to this study are presented in **Table 5.6.4** below.

Table 5.6.4: Short-Term Exposure Levels

Compound	STEL ($\mu g/m^3$)	Reference
SO_2	14,300	ACGIH
H_2SO_4	3,000	

5.6.2 Construction Phase

5.6.2.1 Potential Sources of Impacts

During the construction phase of the project, the ambient air quality will be potentially impacted by fugitive dust emissions and exhaust emissions. These emissions will reduce visibility and reduce the prevailing ambient air quality.

Construction activities most likely to result in the emission of fugitive dusts include:

- Site preparation works such as excavation, levelling, compaction and trenching;
- Movement of heavy construction vehicles and machinery within the site and during transportation operations;
- Material handling (delivery, unloading and use of construction aggregates and structural fill); and
- Material/soil tracked out of the site and deposited on local roads.

The exhaust emissions emitted from vehicle and machinery engine exhaust emissions will contain NO_x , SO_x , CO, volatile organic compounds (VOC), particulates and smoke.

5.6.2.2 Assessment of Impacts

Construction works may potentially impact the ambient air quality and public health as well as generate significant nuisance effects if left uncontrolled. The main concern in terms of air quality impacts is the emission of fugitive dust from the construction works area, and to a lesser extent emission from vehicles and construction machinery stationed on-site. Fugitive dust emissions will be a concern especially during dry weather. Although these impacts are localised and short-termed, the local air quality will be significantly affected during the dry weather if no control measures are put in place, and may worsen the frequent haze conditions experienced in the state and country.

a. Fugitive Dust

The amount of fugitive dust stirred into the atmosphere is dependent on the following factors:

- Frequency of operations;
- Ambient weather conditions;
- Soil conditions (including the particle size distribution, silt and moisture content);
- Total area of land to be cleared;
- Quantities of materials handled;
- Number of vehicles working, routing and transit speeds; and
- Transport of fill material.

The dispersion of particulates is expected to vary daily depending of the factors identified above. For example, under moderate wind speeds (5.5 m/s – 7.9 m/s), particulates larger than ~ 100 µm would be expected to settle out within ~ 10 m whereas those in the size range of 30 - 100 µm in diameter will undergo impeded settling due to atmospheric turbulence and settle out within 100 m of the source. Smaller particles, especially PM_{10} (size lesser than 10 µm) have a much lower gravitational settling rate and are more likely to have their settling rate retarded by atmospheric turbulence[6]. Dust impacts in this instance are significant to the workforce involved.

In the case of mobile dust sources, significant quantities of dust may be stirred into the ambient air by heavy vehicles moving in and out of the site for the delivery of ready-mix concrete, construction machinery and off site disposal of construction wastes. The action of wheels on the road surface causes pulverisation of soil particles and the air turbulence created behind the vehicle that exceeds 5 m/s will potentially disperse the fine soil particles to a significant distance.

[6] AP-42: Compilation of Air Pollution Emission Factors – Volume 1, Stationary Sources, US

The principal meteorological characteristics which influence the generation of fugitive dust and its subsequent impact on the surrounding environment are rainfall and wind speed/direction, and to a lesser extent atmospheric stability and relative humidity. The plant site experiences prevailing winds from the north ~ 25% of the time and southwest ~11% of the time annually. However, wind speeds are generally low occurring below 3.3 m/s for 79% of the time and rarely exceeding 5.4 m/s (20 km/h). Higher wind speeds are typically associated with winds from the north, northeast, east and southwest.

The frequent occurrence of rainfall (The average annual rainfall recorded at the station over the period 1951–2005 is 2,957 mm with an average of 189 rainy days annually) and the low wind speeds (mean of 3 m/s) at the plant site will tend to reduce fugitive dust entrainment from sources (e.g. stockpiled materials etc.), but will have limited effects on entrainment from mobile dust sources (e.g. mobile plant, spoil transfer operations).

Based on the above, the impacts are predicted to be generally localised within an estimated 100 m radial distance of the works area, with the implementation of standard dust control measures within the construction works site. The impacts arising from construction activities at the proposed site is therefore anticipated to be short-term, lasting during the construction phase.

Regionally, particulates especially the finer material PM_{10} will potentially contribute to haze formation during the drier and calmer months of the year. Incidences of haze in Pahang (and Malaysia) have been prevalent in recent years, giving rise to respiratory and eye related health problems.

b. Exhaust Emissions

Apart from dust particulates, the ambient air quality may also be reduced due to the increase of other pollutants such as sulphur dioxide and nitrogen oxides released from exhaust emissions of trucks and other diesel powered construction machinery/equipment within the site. Typical air emissions from construction equipment are presented in **Table 5.6.5.**

Table 5.6.5: Emission Factors for Construction Equipment

Equipment	*CO (g/hr)*	*VOC (g/hr)*	*NO_x (g/hr)*	*SO_x (g/hr)*	*Particulates (g/hr)*
Tracked-type tractor	157	55	571	62	51
Wheeled-type tractor	1623	85	576	41	62
Scraper	568	128	1741	210	184
Motor Grader	69	18	324	39	28
Wheeled loader	260	91	859	83	78
Truck	817	87	1889	206	116

Impacts arising from exhaust emission from construction plant and vehicles will depend on the number of vehicles and plant stationed on site. Details on the number and type of construction machinery had not been firmed up at the time of reporting. However, the impacts arising can be effectively mitigated with proper and regular maintenance of the emission sources which would prevent the generation of excessive noxious emissions and black smoke.

5.6.2.3 Recommended Mitigation Measures

The potential air quality impacts arising from the plant site during construction works will be mitigated by observing standard dust suppression measures as described below.

- Carrying out regular surface damping or wetting on general site areas, stockpiled fill and aggregates especially during dry ambient conditions. Effective wetting of at least the initial 6 cm of the top soil is necessary. This would bind the loose soil particles, increase its effective size and weight, and reduce the amount of fugitive dust generated;

- Providing side enclosure and covering of any aggregates or stockpiles;

- Ensuring that all hardstanding areas and access roads within the site remain wet during use;

- Ensuring construction vehicles moving in/out of the site do not track soil off-site and deposit soil on public roads (the Gebeng Bypass and the Kuantan-Kemaman Road (FR 3)) by providing wheel-washing facilities/trough at the ingress/egress points. These facilities will be equipped with (1) a temporary concrete hardstanding of sufficient size to accommodate a standard sized vehicle and equipped with a sump; and (2) high pressure water jets. The location of the wheel wash trough is presented in **Exhibit 5.2.1** (under the Surface Water section).

- All vehicles operating within the plant site and especially within the construction works area and the ingress/egress points will adhere to speed limits not exceeding 30 km/hr.

- A 50 m road stretch on the public road before and after each ingress/egress point into the site will be wetted regularly to minimise dust emissions from the surface of the road.

- All construction vehicles transporting dusty materials should be secured with tarpaulin sheets to prevent the escape of fugitive dust.

- Open burning on the site premises is strictly prohibited on-site. All construction spoil must be transported to approved disposal sites by licensed contractors.

The control of vehicular emissions can be achieved by observing good construction practice procedures such as:

- Turning of equipment when not in use;
- Lorries/trucks waiting for more than 10 minutes should turn off their engines; and
- Regular maintenance of construction vehicles/equipment.

5.6.3 Operational Phase

5.6.3.1 Potential Sources of Impacts

In the operational phase of the Advanced Materials Plant, air emission sources identified within the Cracking & Separation Plant include the following:

- Tunnel furnace used for product calcination;
- Boiler used for steam generation; and
- Waste gas treatment system (wet scrubber).

Tunnel Furnace and Boiler

In the product calcination stage within the Cracking & Separation Plant, Lanthanum oxide and Didymium oxide will be produced by calcination of the oxalate compounds of these metals at a temperature of 900^0C in a tunnel furnace which will be powered by natural gas.

Similarly, the boiler used for steam generated within the plant will be powered by natural gas.

Natural gas is the cleanest of all the fossil fuels. Composed primarily of methane, the main products of the combustion of natural gas are carbon dioxide and water vapour with very small amounts of sulphur dioxide and nitrogen oxides, virtually no ash or particulate matter, and lower levels of carbon dioxide, carbon monoxide, and other reactive hydrocarbons. The emissions from the calcinations process and the boiler will be emitted directly to the atmosphere without any form of pre-treatment. No air quality impacts envisaged from these emissions sources.

Waste Gas Treatment System

The primary source of air emissions arising from the plant during the operational phase will be the waste gas scrubber system at the Cracking & Separation Plant. The layout and cross sectional view of the treatment system are provided in **Exhibits 5.6.1** and **5.6.2.**

In the Cracking & Separation Plant, the lanthanide concentrate will be mixed with sulphuric acid (98%), blended for a set time and the mixture/slurry will then flow into two (2) rotary kilns for intensive roasting at 400±50 (^{0}C) for a period of 2.5 hours. The roasted products will comprise roasted concentrate and waste (tail) gas. As the sulphuric acid will be complete evaporated, during the cracking process, the exhaust gas will not carry any liquid aerosols.

The kilns are fuelled by natural gas and the gas flow will be automatically controlled by the temperature at the hot end of the kiln. Two (2) fuel gas burners are proposed for each rotary kiln.

The waste gas will be conveyed to a waste gas scrubber system for treatment prior to release to the atmosphere. The treated gas is expected to contain small quantities of sulphur dioxide (SO_2), hydrogen fluoride (HF), sulphuric acid mist and particulate matter (PM).

High concentrations of SO_x in the atmosphere, with levels exceeding 40 ppb or 105 $\mu g/m^3$, will significantly impact humans, animals and agricultural activities within the impact zone in the following manner:

- Increased incidences of respiratory diseases amongst residents;
- Lowering of agricultural produce; and
- Increased acidity in the rain water which will subsequently affect terrestrial and aquatic flora/fauna.

Hydrogen fluoride (HF) readily dissolves when mixed with water. It has the potential to be transported and subsequently deposited as acid rain. Concentrated hydrogen fluoride is very corrosive and would badly burn any plants, birds or land animals exposed to it. The concentrations of hydrogen fluoride found in close proximity to sources may adversely affect some species of plants. Small quantities of hydrogen fluoride will be neutralised by the natural alkalinity in aquatic systems and larger quantities may lower the pH for extended periods of time. However, fluorides are not expected to bioaccumulate. Acute (short-term) inhalation exposure to gaseous hydrogen fluoride can cause severe respiratory damage in humans, including severe irritation and pulmonary edema.

5.6.3.2 Assessment of Impacts

As the emission from the waste gas treatment system (wet scrubber) is the primary air pollution source, an air dispersion modelling was carried out for this point source.

In developing the air dispersion model, two operational modes have been identified for the proposed plant, namely (1) normal and (2) emergency operations. Under normal operations, small quantities of sulphur dioxide (SO_2), hydrogen fluoride (HF), sulphuric acid mist (H_2SO_4) and particulate matter (PM) will be emitted from the waste gas treatment system following treatment of the kiln off-gas. Under emergency operations, SO_2 and H_2SO_4 mist will be emitted from standby caustic scrubbers following treatment of emissions from the kilns operating in shutdown mode. A summary of the operational modes defined for the proposed plant is provided in **Table 5.6.6.**

Table 5.6.6: Proposed Advanced Materials Plant – Summary of Operational Modes

Operating Mode	Sources	Pollutants Emitted	Description
Normal	1 Kiln	SO_2 HF H_2SO_4 mist PM	One rotary kiln in operation. Emissions are treated within the waste gas scrubber system (A) prior to discharge to atmosphere.
	2 Kilns		Two rotary kilns in operation. Emissions from each kiln are treated within the waste gas scrubber system (A) prior to discharge to atmosphere via a single stack.
	4 Kilns		Four rotary kilns in operation. Emissions from each pair of kilns are treated within separate waste gas scrubber systems (A and B) prior to discharge to atmosphere via two individual stacks.
Emergency	1 Emergency Scrubber	SO_2 H_2SO_4 mist	One emergency scrubber in operation. Emissions from a single kiln in shutdown mode are treated within a standby caustic scrubber and discharged to atmosphere via a single stack.
	2 Emergency Scrubbers		Two emergency scrubbers in operation. Emissions from each of the two kilns in shutdown mode are treated within individual standby caustic scrubbers and discharged to atmosphere via two separate stacks.
	4 Emergency Scrubbers		Four emergency scrubbers in operation. Emissions from each of the four kilns in shutdown mode are treated within individual standby caustic scrubbers and discharged to atmosphere via four separate stacks.

Three events have been identified by the Project Proponent which would trigger emergency operations:

1. Utility power failure (external);
2. Plant system power failure (internal); and
3. Loss of liquid-flow to the waste gas scrubber system.

In each of the three emergency events, kiln feed will cease whilst primary and secondary combustion air fans continue to operate to maintain a high gas flow rate that aids cooling of the kiln and dispersion of emitted gas. The evolution of SO_2, SO_3 and H_2SO_4 from the kiln contents may continue for up to 20 hours following a shutdown although the rate of evolution drops sharply during the first hour.

Emergency operations due to an external power failure are expected to occur once per annum for a duration of 4-hours, while emergency operations due to an internal power failure are expected to occur once every 25 years for a duration of 21-hours. All operational kilns will be impacted in both cases.

Emergency operations due to a loss of liquid-flow to the waste gas scrubber system are also expected to occur once per annum for a duration of 4-hours. However, while only a single operational kiln is expected to be impacted at any one time, all kilns are predicted to be impacted once per annum.

For the purposes of the air dispersion modelling, it has been assumed that the emissions of particulate matter are all within the PM_{10} size fraction. This assumption is conservative and is likely to result in an over prediction of the ground level concentrations (GLCs) of PM_{10} compared to what would be expected to occur in reality.

Further details of the emission information and release parameters for the proposed plant as used in the air dispersion modelling for the Normal and Emergency operating scenarios is provided in the proceeding sections.

For the purposes of the air dispersion modelling, it has been assumed that the emissions of particulate matter will all be within the PM_{10} size fraction. This assumption is conservative and is likely to result in an over prediction of the ground level concentrations of PM_{10} compared to what would be expected to occur in reality.

To determine the dispersion pattern of the pollutants released from the emissions of the waste gas treatment system and to quantify their respective concentrations in the atmosphere, the BREEZE Industrial Source Complex – Short Term Version 3 with Plume Rise Enhancements (BREEZE ISC3 Prime) air dispersion model was used to predict the potential ground level impacts arising from emissions of the waste gas scrubber stack.

The BREEZE ISC3 Prime model was used to predict the maximum GLCs over 10-minute, 1-hour, 24-hour and annual averaging periods to correspond with the relevant ambient air quality criteria for each of the modelled compounds. Short-term average (15 minute) GLCs were calculated from 1-hour concentrations for the Emergency operations scenario for compounds where STELs apply using the Hanna, Briggs and Hosker Power Law[7].

a. Assessment Methodology

Synoptic Meteorological Data

A site specific meteorological file for the project area was generated using The Air Pollution Model (TAPM). Local wind fields were predicted by this model based on synoptic meteorology, local topography and land surface characteristics (i.e. soil type, vegetation cover). TAPM was developed by the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) and consists of coupled prognostic meteorological (i.e. using the larger-scale meteorology provided by synoptic analyses) and air pollution concentration components. The synoptic meteorological data is derived from GASP (Global Analysis and Prediction) analysis data used by the Australian Bureau of Meteorology (BoM).

Synoptic meteorological data for the year 2005 for Malaysia were used as input into the TAPM model. A windrose derived from the TAPM generated data for the 2005 period is presented in **Exhibit 5.6.4** illustrating light winds between 1.5 m/s and 3 m/s occur most frequently, for approximately 60% of the year. Stronger winds between 3 m/s and 4.5 m/s tend northeasterly and south-southwesterly and are experienced for close to 26% of the year, while winds greater than 4.5 m/s are less frequent and are predominantly north-northeasterly. The strong influence of the southwest and northeast monsoon periods on meteorological conditions is also evident in the annual windrose.

Model Parametisation

Table 5.6.7 presents a summary of the emission information and release parameters for the waste gas scrubber and emergency scrubber stacks at the proposed plant, as used in the air dispersion modelling for the normal and emergency operating scenarios. Information on the emissions for the plant during the operational phase was provided by the Project Proponent. The stack height and exit velocity used in the study were developed based on information provided by the engineering consultant and preliminary modelling results.

[7] Hanna, Briggs and Hosker Power Law: $GLC_{[n\ hrs]} = GLC_{[m\ hrs]} \times [m/n]^{0.2}$

The emission of H_2SO_4 from the caustic scrubber(s) operating under emergency conditions is expected to decrease sharply during the first 2-minutes of release, before continuing to slowly decrease during the following 9-hours of release (if the emergency release is of that duration, although most emergency releases are expected to last less than 4 hours). In order to capture the acid decay rate within the air dispersion modelling, the average emission rate for the first 15-minutes of release (9.9 g/s per emergency scrubber) was adopted to predict the short-term (15-minute) H_2SO_4 GLCs and the average emission rate for the first 1-hour of release (7.8 g/s per emergency scrubber) was adopted to predict the 1-hour H_2SO_4 GLCs. For emergency releases lasting longer than 1-hour these emissions rates are very conservative.

The information in Table 5.6.7 also indicates the emission concentrations under normal operations (at standard temperature and pressure (STP)) comply with the DoE's Emission Standards for Stationary Sources outlined in Table 4. Note emissions released under emergency operations are not subject to the DoE's Emission Standards and the frequency of such an event occurring is considered low.

Table 5.6.7: Emissions Information and Stack Release Parameters – Normal and Emergency Operations

Parameters	Units	Normal Operations			Emergency Operations			
		WGTS [1] A – 1 Kiln	WGTS [1] A – 2 Kilns	WGTS [1] B – 2 Kilns	Scrubber 1	Scrubber 2	Scrubber 3	Scrubber 4
Easting	m	319530	319530	319542	319492	319497	319502	319507
Northing	m	442819	442819	442780	442810	442797	442780	442766
Stack height	m	55	55	55	40	40	40	40
Stack diameter	m	1.2	1.2	1.2	0.6	0.6	0.6	0.6
Exit temp.	ºC	70	70	70	50	50	50	50
Exit velocity	m/s	7.5	15	15	15	15	15	15
Pollutant Emission Rates								
SO_2	g/s	3.5	6.9	6.9	1.6	1.6	1.6	1.6
HF	g/s	0.3	0.7	0.7	na	na	na	na
H_2SO_4 mist	g/s	0.3	0.7	0.7	9.9/7.8 [2]	9.9/7.8 [2]	9.9/7.8 [2]	9.9/7.8 [2]
PM_{10}	g/s	0.7	1.4	1.4	na	na	na	na
Emission Concentrations at STP								
HF	g/Nm^3	0.05	0.05	0.05	na	na	na	na
H_2SO_4 mist	g/Nm^3	0.05	0.05	0.05	na	na	na	na
PM_{10}	g/Nm^3	0.1	0.1	0.1	na	na	na	na

Notes

1. Waste Gas Treatment System (WGTS)
2. 9.9 g/s adopted to calculate 15-minute GLCs and 7.8 g/s adopted to calculate 1-hour GLCs

b. Model Results – Normal Operations

Table 5.6.8 presents the maximum predicted GLCs resulting from the proposed plant under normal conditions with 1, 2 or 4 kilns in operation. Also presented is the percentage of the STELs and AAQ guidelines that the predicted concentrations represent. Where maximum predicted GLCs are greater than 50% of the applicable guidelines, contours of the predicted GLCs for the relevant scenario have been produced and are presented as **Exhibits 5.6.4** and **5.6.5.**

Table 5.6.8: Maximum Predicted Ground Level Concentrations for Normal Operations

Pollutant	Averaging Period	AAQ Guideline (µg/m^3)	Maximum Predicted GLCs (µg/m^3)		
			1 Kiln	2 Kilns	4 Kilns
SO_2	10-minute	500	101	139	283
		% Guideline	*20%*	*28%*	*57%*
	15-minute [1]	14,300	93	128	261
		% Guideline	*1%*	*1%*	*5%*
	1-hour	350	71	97	198
		% Guideline	*20%*	*28%*	*57%*
	24-hour	105	10	17	33
		% Guideline	*10%*	*16%*	*31%*
	Annual	50	1.3	1.8	3.6
		% Guideline	*2.6%*	*3.7%*	*7.2%*
HF	1-hour	240	7.0	9.7	20
		% Guideline	*2.9%*	*4.1%*	*8.2%*
	Annual	0.5	0.1	0.2	0.4
		% Guideline	*25%*	*37%*	*72%*
H_2SO_4	15-minute [1]	3,000	9.2	13	26
		% Guideline	*0.3%*	*0.4%*	*0.9%*
	1-hour	120	7.0	9.7	20
		% Guideline	*5.8%*	*8.1%*	*16%*
	Annual	1	0.1	0.2	0.4
		% Guideline	*13%*	*18%*	*36%*
PM_{10}	24-hour	150	2.1	3.3	6.5
		% Guideline	*1.4%*	*2.2%*	*4.3%*
	Annual	50	0.3	0.4	0.7
		% Guideline	*0.5%*	*0.7%*	*1.4%*

Notes

1. Maximum predicted 15-minute GLCs have been compared to the STEL, applicable onsite.

The results presented in Table 5.6.8 show that the predicted GLCs of SO_2, HF, H_2SO_4 and PM_{10} are below each of the applicable STELs and AAQ guidelines. Further details for each of the modelled compounds are provided below.

Sulphur Dioxide

Maximum predicted 15-minute SO_2 GLCs remain well below the STEL applicable onsite, representing no more than 5% of the guideline value for each of the normal operating scenarios modelled.

The maximum predicted 10-minute and 1-hour SO_2 GLCs are no greater than 57% of the corresponding AAQ guidelines for 1, 2 or 4 kilns operating under normal conditions, while the maximum predicted 24-hour SO_2 GLCs are no greater than 31% of the 24-hour guideline for any of the modelled normal operating scenarios. Annual GLCs also remain well below the annual AAQ guideline, representing no more than 7.2% of the guideline value for 1, 2 or 4 kilns operating under normal conditions.

The contours of the maximum predicted 1-hour SO_2 GLCs[8] for 4 kilns under normal operation (5.6.4) show that the maximum concentrations are predicted to occur within close proximity to the southern boundary of the proposed plant.

Hydrogen Fluoride

The maximum predicted 1-hour HF GLCs represent no more than 9% of the 1-hour AAQ guideline for 1, 2 or 4 kilns operating under normal conditions. Annual GLCs also remain below the applicable guideline, representing no more than 37% of the annual guideline for 1 or 2 kilns operating under normal conditions, while the annual average GLC predicted for 4 kilns operating under normal conditions represents 72% of the annual guideline.

The contours of the annual average HF GLCs predicted for 4 kilns under normal operation (Figure 5.6.5) indicate the maximum concentrations are predicted to occur within a localized area close to the north-east boundary of the proposed plant.

Sulphuric Acid Mist

Maximum predicted 15-minute H_2SO_4 GLCs remain well below the STEL applicable onsite, representing no more than 5% of the guideline value for any of the modelled normal operating scenarios.

The maximum predicted 1-hour H_2SO_4 GLCs represent no more than 16% of the relevant AAQ guideline for 1, 2 or 4 kilns operating under normal conditions. Annual H_2SO_4 GLCs also remain below the applicable guideline, representing no more than 36% of the annual guideline for 1, 2 or 4 kilns operating under normal conditions.

[8] As the maximum predicted 10-minute SO_2 GLCs were calculated from the maximum predicted 1-hour SO_2 GLCs, the GLCs for each averaging period are expected to maintain similar dispersion patterns. Contours of the 10-minute SO_2 GLCs can therefore be scaled against contours of the 1-hour SO_2 GLCs.

Particulate Matter

The maximum predicted 24-hour PM_{10} GLCs remain well below the AAQ guideline, representing no more than 4.3% of the guideline value for 1, 2 or 4 kilns operating under normal conditions, while annual PM_{10} GLCs represent no more than 1.4% of the annual guideline for any of the modelled normal operating scenarios.

c. Model Results – Emergency Operations

Table 5.6.9 presents the maximum predicted GLCs resulting from the proposed plant under emergency conditions with 1, 2 or 4 emergency scrubbers in operation. Also presented are the percentages of the AAQ guidelines and STELs that the predicted concentrations represent. Where the maximum predicted GLCs are greater than 50% of the applicable guidelines, contours of the predicted GLCs for the relevant scenario have been produced and are presented as Exhibits 5.6. through 5.6.12.

As emergency operating conditions are expected to be of short duration (release events from the emergency scrubbers being no longer than 21 hours (once very 25 years) but typically less than four hours) the maximum predicted GLCs have been presented for short-term averaging periods only.

Table 5.6.9: Maximum Predict Ground Level Concentrations for Emergency Operations

Pollutant	Averaging Period	AAQ Guideline (µg/m³)	Maximum Predicted GLCs (µg/m³)		
			1 Scrubber	2 Scrubbers	4 Scrubbers
SO_2	10-minute	500	129	254	447
		% Guideline	*26%*	*51%*	*89%*
	15-minute [1]	14,300	119	234	412
		% Guideline	*0.8%*	*1.6%*	*2.9%*
	1-hour	350	90	177	312
		% Guideline	*26%*	*51%*	*89%*
	24-hour	105	19	38	79
		% Guideline	*18%*	*36%*	*76%*
H_2SO_4	15-minute [1]	3,000	730	1433	2524
		% Guideline	*24%*	*48%*	*84%*
	1-hour	120	**431**	**846**	**1490**
		% Guideline	***359%***	***705%***	***1242%***

Notes

1. Maximum predicted 15-minute GLCs have been compared to the STEL, applicable onsite.

2. Bold indicates an exceedence of the corresponding guideline.

The results presented in **Table 5.6.9** show that the predicted GLCs of SO_2 are below the applicable STEL and AAQ guidelines and for 1, 2 and 4 scrubbers operating under emergency conditions. Predicted GLCs of H_2SO_4 are also below the 15-minute STEL, however exceedences of the 1-hour H_2SO_4 AAQ guideline are predicted for each of the modelled scenarios. Further details for each of the modelled compounds are provided below.

Sulphur Dioxide

The maximum predicted 10-minute, 1-hour and 24-hour SO_2 GLCs are no greater than 51% of the corresponding AAQ guidelines for 1 or 2 emergency scrubbers operating under emergency conditions. The maximum SO_2 GLCs predicted for 4 emergency scrubbers operating under emergency conditions are no greater than 89% of the 10-minute or 1-hour AAQ guidelines and remain less than 76% of the 24-hour guideline. It should be noted that these maximum predicted concentrations are extremely conservative as they have been predicted assuming that the emergency scrubbers operate continuously. In reality they operate for approximately 0.2% of the time and the probability of an emission occurring under the conditions required to produce the maximum concentrations is very low.

The contours of the maximum predicted 1-hour SO_2 GLCs[9] for 2 emergency scrubbers operating under emergency operations (**Exhibit 5.6.6)** and for 4 emergency scrubbers operating under emergency operations (**Exhibit 5.6.7**) show that the maximum concentrations are predicted to occur within close proximity to the northeast boundary of the proposed plant. Contours of the maximum predicted 24-hour SO_2 GLCs for 4 emergency scrubbers in operation (**Exhibit 5.6.8**) also show that the maximum concentrations are predicted to occur within a similar location.

Maximum predicted 15-minute SO_2 GLCs remain well below the STEL applicable onsite, representing no more than 3% of the guideline value for each of the emergency operating scenarios modelled.

The SO_2 GLCs predicted for the proposed plant operating under emergency conditions are considered conservative as the modelling assumes continuous operation of the emergency scrubbers, while the total number of operational hours is not expected to exceed 20-hours over the course of a year (for no more than 4-hours at a time) or a one in 25 year release event lasting 21-hours. Furthermore, SO_2 emissions from each of the emergency scrubbers have been modelled at a steady rate, although SO_2 emission rates are expected to decay alongside H_2SO_4 emission rates, compounding the level of conservatism within the predicted GLCs.

[9] As the maximum predicted 10-minute SO_2 GLCs were calculated from the maximum predicted 1-hour SO_2 GLCs, the GLCs for each averaging period are expected to maintain similar dispersion patterns. Contours of the 10-minute SO_2 GLCs can therefore be scaled against contours of the 1-hour SO_2 GLCs.

Sulphuric Acid Mist

Maximum predicted 15-minute H_2SO_4 GLCs remain below the STEL applicable onsite, representing no more than 48% of the guideline value for 1 or 2 emergency scrubbers operating under emergency conditions and no more than 84% of the guideline value for 4 emergency scrubbers operating under emergency conditions. Contours of the maximum predicted 15-minute H_2SO_4 GLCs for 4 emergency scrubbers in operation (**Exhibit 5.6.9**) show that the maximum concentrations are predicted to occur within close proximity to the northeast boundary of the proposed plant.

Maximum predicted 1-hour H_2SO_4 GLCs are predicted to exceed the corresponding AAQ guideline for 1, 2 and 4 emergency scrubbers operating under emergency conditions, by up to 12 times. Contours of the maximum predicted 1-hour H_2SO_4 GLCs for 1, 2 and 4 emergency scrubbers in operation (**Exhibits 5.6.10, 5.6.11 and 5.6.12** respectively) show that exceedences of the 1-hour H_2SO_4 AAQ guideline value of 120 $\mu g/m^3$ occur roughly within a 4km radius from the proposed plant with a single emergency scrubber in operation and extend throughout the majority of the modelled domain with 4 emergency scrubbers in operation. As for SO_2, it should be noted that these maximum predicted concentrations are extremely conservative as they have been predicted assuming that the emergency scrubbers operating continuously. In reality they operate for approximately 0.2% of the time and the probably of an emission occurring under the conditions required to produce the maximum concentrations is very low.

Further analysis of the modelling results indicates that the maximum frequency of exceedence of the 1-hour H_2SO_4 AAQ guideline occur for no more than 2.6% of the year (231-hours) for 1 emergency scrubber in operation, 6.9% of the year (605-hours) for 2 emergency scrubbers in operation and 9.6% of the year (841-hours) for 4 emergency scrubbers in operation. The contours of the frequency of exceedence of the 1-hour H_2SO_4 AAQ guideline for 1, 2 and 4 emergency scrubbers in operation (**Exhibits 5.6.13, 5.6.14 and 5.6.15 respectively)** show that the highest number of exceedence events are predicted to occur within close proximity to the northeast boundary of the proposed plant.

The H_2SO_4 GLCs predicted for the proposed plant operating under emergency conditions are considered conservative as the modelling assumes continuous operation of the emergency scrubbers, while the total number of operational hours for any one kiln is not expected to exceed 8-hours over the course of a year (for no more than 4-hours at a time) or a one in 25 year release event lasting 21-hours.

A summary of the overall probability of an exceedence of the 1-hour H_2SO_4 guideline is presented in **Table 5.6.10**, for each of the modelled scenarios. The overall probability, as calculated from the combination of an emission occurring and the probability of an exceedence occurring, under a worst case scenario (i.e. 4 emergency scrubbers in operation) is 10.1 x 10^{-5} (0.01%), or 101 in a million. For two kilns in operation, the overall probability of an exceedence of the 1-hour H_2SO_4 guideline under emergency

operation is 62.2 x 10^{-6} (0.006%) or 62 in a million. Therefore, it is considered that the risks of unacceptable impacts arising from the proposed plant operating under emergency conditions are relatively small and manageable within an industrial estate.

Table 5.6.10: Summary of Probability of an Exceedence Event Occurring

Operating Scenario	**Frequency of exceedence of AAQG** [1]	**2 Kilns**		**4 Kilns**	
		Frequency of operations	Probability of exceedence	Frequency of operations	Probability of exceedence
1 Emergency Scrubber	2.6% of the year	0.09% (8hrs) of the year [2]	0.002%	0.18%(16-hrs) of the year [2]	0.47%
2 Emergency Scrubbers	6.9% of the year	0.06% (4.84hrs of the year) [3]	0.003%	NA	NA
4 Emergency Scrubbers	9.6% of the year	NA	NA	0.06% (4.84hrs of the year) [3]	0.005%
		Total	**0.006%**		**0.01%**

Notes

1. Assuming continuous operations
2. 4-hours per emergency scrubber per year
3. Includes both external and internal power failure events

c. Conclusions

The results of the air dispersion modelling indicate that under normal conditions with 1, 2 or 4 kilns in operation, emissions from the proposed plant are predicted to result in maximum GLCs that are below all of the identified AAQ criteria for SO_2, H_2SO_4, HF and PM_{10}. The maximum predicted 15-minute average GLCs of SO_2 and H_2SO_4 also remain below the on-site STELs for each of the normal operating scenarios.

The results also indicate that under emergency conditions with 1, 2 or 4 caustic scrubbers in operation, emissions from the proposed plant are predicted to result in maximum GLCs that are below the AAQ criteria and STEL for SO_2, and the STEL for H_2SO_4. The maximum 1-hour H_2SO_4 GLCs are however, predicted to exceed the AAQ guideline of 120 µg/m^3 by approximately 3.5 times with 1 scrubber in operation, by 7 times with 2 scrubbers in operation and by close to 12 times with 4 scrubbers in operation. These exceedences are predicted to occur within an approximate 4km radius from the proposed plant with a single scrubber in operation and extend throughout the majority of the modelled domain with 4 scrubbers operating.

It should be noted that these predicted maximum H_2SO_4 concentrations are extremely conservative as they have been determined assuming that the emergency emissions occur continuously throughout the year, whereas the total cumulative frequency of all of the emergency cases identified is approximately 0.2% of the time.

Further analysis of the modelling results for the emergency emissions indicates that the maximum frequency of exceedence of the 1-hour H_2SO_4 AAQ guideline, assuming continuous operations, occurs for no more than 9.6% of the year (841-hours) with 4 emergency scrubbers in operation. However, this emergency emission scenario is only expected to occur for 0.06% of the time (i.e. external power failure of 4-hours/year and internal power failure for 21 hours once every 25 years). The combination of the probability of the total power loss emergency scenario occurring and the probability of this resulting in an exceedence of the AAQ guideline results in an overall probability of this scenario resulting in an exceedence of the H_2SO_4 AAQ guideline of 5.3×10^{-5}, or 53 in a million.

Similar analysis undertaken for the other identified emergency release scenarios indicates that the overall probability of an exceedence of the 1-hour H_2SO_4 guideline (assuming all three events which trigger an emergency emission scenario occur), with 4 emergency scrubbers in operation, is 10.1×10^{-5}, or 101 in a million. For two kilns in operation, the overall probability of an exceedence of the 1-hour H_2SO_4 guideline under emergency operation is 62.2×10^{-6}, or 62 in a million. Therefore, it is considered that the risks of unacceptable impacts arising from the proposed plant operating under emergency conditions are relatively small and manageable within an industrial estate.

In summary, the air dispersion modelling indicates that the atmospheric emissions from the proposed plant are predicted to result in:

- maximum GLCs of SO_2, H_2SO_4, HF and PM_{10} below all of the applicable AAQ guidelines and STELs, across the model domain, for 1, 2 or 4 kilns operating under normal conditions and where the highest concentrations are predicted to occur in relative close vicinity to the plant;

- maximum GLCs of SO_2 below all the applicable AAQ guidelines and STELs, across the model domain, for 1, 2 or 4 caustic scrubbers operating under emergency conditions;

- maximum GLCs of H_2SO_4 below the corresponding STEL for 1, 2 or 4 caustic scrubbers operating under emergency conditions; and

- an exceedence of 1-hour H_2SO_4 AAQ guidelines under emergency operating conditions, although the worst-case probability of this operating mode occurring and resulting in an exceedence is 101 in a million.

The results of the air dispersion modelling indicate that the proposed Advanced Materials Plant is not expected to result in unacceptable air quality impacts under normal operations for SO_2, H_2SO_4, HF and PM_{10} and while exceedences of 1-hour H_2SO_4 AAQ guideline are predicted under emergency operating conditions, the frequency of this occurring is considered low.

5.6.3.3 Recommended Mitigation Measures

The air dispersion modelling has been carried out based on the design stack height of the proposed waste gas treatment system, the emission rates and pollutant concentrations of the treated/exit gas, heights of the building structures proposed within the plant site and local conditions such as the meteorological conditions and the site (and immediate surrounding) topography. Therefore, in achieving the desired efficiency and meeting the predicted ground level concentrations of the pollutants under assessment, i.e. $SO_{2,}$ HF, H_2SO_4 mist and $PM_{10,}$ the waste gas scrubber design parameters will need to be maintained. In the event, there are changes in the design prior to project implementation, it is recommended that the air dispersion model be re-run and the assessment reviewed. This is to ensure the ground level concentration for the pollutants concerned meet the regulatory requirements.

A description of the proposed waste gas scrubber system is provided below.

The main equipment/systems which comprise the proposed waste gas scrubber comprise the following equipments/systems:

- Quench and Venturi Scrubber System
- Fans
- Absorption Tower Scrubber System
- Mist Eliminator
- Wet Electrostatic Precipitator
- Recirculation systems
- Emergency Scrubber System including pumps, scrubber, fans, recycle solution tanks etc.
- H_2SO_4 Acid Cooler Heat Exchanger

In the proposed waste gas scrubbing system, the inlet gas from the rotary kilns will undergo the following stages of treatment:

- Gas cooling, sulphuric acid condensation, dust removal, and sulphur trioxide absorption in the primary Venturi scrubber;
- Sulphuric acid mist in the second stage Venturi scrubber;
- Sulphur dioxide scrubbing and aerosol polishing in the hydrated lime spray towers and demister; and
- Removal fine sulphuric acid particulates in wet ESP.

The driving force of the exhaust comes from the fan system located downstream of the Venture scrubbers. The arrangement of the system is (1) individual Venturi scrubbing systems for each kiln, and (2) common to two kilns are the fans, lime absorption columns, and wet ESP.

In the primary Venturi scrubber, the gas will be quenched to about 110 ˚C, and then contacted with concentrated sulphuric acid for the absorption of sulphuric acid, sulphur trioxide, and removal of the dust particulates present in the inlet gas. The function of second stage Venturi scrubber is for the removal of sulphuric acid aerosols and residual dust. The gas is cooled further to about 86 ˚C.

The exhaust streams from the two kilns which have undergone scrubbing in the parallel Venturi systems will be combined into one common header, upstream of the forced induction fans, and conveyed into the sulphur dioxide removal spray tower. Two spray towers have been proposed to operate in series for the removal of sulphur dioxide with hydrated lime suspension. The scrubbed gas passes through demister elements at the top of the lime spray towers for removal of droplets..

The scrubbed gas stream finally passes through a Wet Electrostatic Precipitator (wet ESP), which remove the low concentration of sub micron sulphuric acid mist that may pass through the venturi scrubbers.

To prevent the release of noxious untreated gas into the atmosphere during upset or abnormal operations, the necessary safety equipment and instrumentation have been incorporated into the design of the waste gas treatment system.

An emergency scrubbing system is included for each kiln which will be employed in the event of power failure or unplanned shutdown of the main waste gas treatment system. The emergency scrubbing system consists of a packed absorption column employing sodium hydroxide solution for the scrubbing of sulphur dioxide and sulphuric acid.

The system will be subjected to periodical maintenance to ensure equipment reliability and scrubbing efficiency. Monitoring of stack and ambient air quality at the site boundary and the nearest sensitive receivers will be carried out.

Overall, the air quality impacts arising from the operation of the plant can be mitigated by best technological means and reduced to meet regulatory requirements.

5.7 BIOLOGICAL RESOURCES

5.7.1 Construction and Operational Phases

The biological resources affected in the construction phase of the project are:

- Terrestrial flora and fauna species at the proposed Advanced Materials Plant site; and
- Aquatic biological resources within Sungai Balok.

5.7.1.1 Assessment of Impacts

a. Terrestrial Flora and Fauna

Construction Phase

As discussed in Chapter Four of this document, prior to the development of the Gebeng Industrial Estate (GIE) in the 1990s, the area was waterlogged peat swamp forest. Ecological impacts arising from the land conversion activities have since occurred at the site. The various species of fauna that inhabited the area are expected to have perished or migrated to other forested areas nearby while the original vegetation would have been completely cleared away.

As the site had remained vacant (undeveloped) since the land conversion, it has been progressively colonised by secondary vegetation comprising the more common, hard and invasive species. Only sparse vegetation was observed across the site comprising secondary dryland scrub vegetation with low species diversity. No faunal species of conservation value is expected to occur. Any remaining vegetation removed is not significant or of conservation value.

Overall, the impact from the site activities on the terrestrial flora and fauna is not considered significant.

b. Aquatic System

The aquatic ecosystem within Sungai Balok is an estuarine ecosystem bordered by the brackish water river ecosystem up to 10 km upstream and by coastal ecosystems at the river mouth/coastal area. The habitats within this ecosystem include the aquatic and estuarine habitat, marine (coastal) habitat and benthic habitat. Biological components in these habitats include:

- Phytoplankton
- Zooplankton
- Benthos
- Fisheries resources

Impacts on the mortality of the aquatic biological resources are primarily associated with increased suspended solids in the water column of the river.

An increase in suspended solids leads to a reduction in sunlight penetration which over time decreases photosynthesis, thereby reducing the rate of oxygen production within the water column. This effect may be further exacerbated during low flow conditions leading to anoxic conditions. Additionally, a reduction in primary production (photosynthesis) also diminishes the uptake of nutrients from the water column. Increase light penetration causes more energy from sunlight to be retained in the water column creating increases the ambient water temperature. This negatively impacts oxygen concentrations as oxygen is more soluble in colder waters.

The conditions described above will effect the horizontal and vertical distribution of organisms in the water body.

As Suspended sediment (SS) fluxes occur naturally in the aquatic environment, fish have evolved behavioural adaptations to tolerate the increased SS load (e.g, clearing their gills by flushing water through them). Where SS levels become excessive, fish will migrate to clearer waters. This level is defined as the tolerance threshold, which varies from species to species and at different stages of the life cycle. If SS levels exceed tolerance thresholds, fish are likely to become stressed, injured and may ultimately die as the increased sediment content in the water column may cause abrasion of gill filaments and clog opercular cavities.

However, based on personal correspondence with the Department of Fisheries in Kuantan, the fisheries resources within Sungai Balok are not harvested for commercial fishing and livelihood. The local fishermen from the main fishing village of Kampung Balok carry out deep-sea fishing. Only recreational fishing is carried out along Sungai Balok by anglers. Common names of fish species typically found in the river include Siakap Puteh, Siakap Merah, Sembilang, Duri and Baung,

5.7.1.2 Recommended Mitigation Measures

Construction Phase

To minimise the transport of suspended solids into the river, the efficiency of the silt trap will be maintained by regular desilting using an excavator. The overflow from the silt trap will be monitored frequently for Total Suspended Solids and Oil & Grease in accordance to the frequency stipulated by DOE for the construction phase of the development. The concentration of TSS shall not exceed 50 mg/l and there shall be no traces of Oil & Grease.

To prevent the washout of other water quality contaminants, a proper materials management system for the storage of fuel oil, spent oil, grouting materials, paints, curing compounds, etc. on-site will be necessary (as identified in Section 5.4).

Operational Phase

The impacts to the aquatic biological resources in Sungai Balok are dependent on the efficient management of process wastewaters and contaminated surface runoff. The proposed wastewater treatment plant shall be subjected to periodic performance maintained to ensure its efficiency. The treated effluent from the plant shall comply with the Standard B discharge limits at all times.

5.8 SOCIO-ECONOMIC ISSUES

5.8.1 Construction Phase

5.8.1.1 Assessment of Impacts

Employment of workers to make-up the construction labour force project will be necessary during the construction phase. Although priority will be given to local residents working in this sector, employment of foreign labour may be expected in the event of local labour shortage. If the labour force is housed on-site, proper accommodation facilities will have to be provided with basic amenities such as potable water supply, electricity, solid waste disposal and sanitary treatment facilities.

The employment of foreign labour may result in the import of communicable diseases not indigenous to the area, for example malaria, dysentery and cholera which could spread to the local residents, in the event of poor hygiene practices, as these diseases are vector borne or waterborne.

5.8.1.2 Recommended Mitigation Measures

To prevent undue aberrations with the local community, the nominated EPCM Contractor when hiring foreign labour must ensure that the workers are legally registered with the Department of Immigration. This will ensure that these workers have medical and health certificates testifying to their personal health. Under the procedures of the department, regular check-ups are necessary for the annual renewal of their work permits.

To further ensure that socio-cultural impacts are kept to the minimum, contractors are highly recommended to ensure that the workers are well managed and confined to their worksite with minimum confrontation with the local community.

5.8.2 Operational Phase

5.8.2.1 Assessment of Impacts

a. Overall Regional and National Impacts

Significant long-term positive socio-economic impacts are predicted during the operational phase of the project. The benefits accrued by the District of Kuantan, the State of Pahang and the nation are deliberated in Chapter 1 of this document. The key benefits are:

- **Inflow of Foreign Direct Investment**: The estimated total capital investment and operating expenditure for this project are significant and the proposed investment is wholly in line with the Malaysian Government’s efforts to encourage foreign direct investments into the Eastern Corridor of Malaysia.

- **Export Revenue – Foreign Exchange Earnings:** The export revenue of the proposed project constitutes a major contribution to the Malaysian economy and translates into significant cash inflow into the Malaysian economy that will spur the growth of not only the Eastern Corridor but the country as a whole.

- **Transfer of Technology:** Processing of lanthanides is a pioneer activity in Malaysia and thus the setting up of the Advanced Materials Plant will introduce new technologies and expertise in lanthanide processing. The Project Proponent owns propriety technology for the recovery of lanthanides from the imported lanthanide concentrate, and this will be employed in the plant. Lynas will also employ state of the art solvent extraction equipment and process technologies for the purification and separation of the elements. These technologies enable the production of high purity lanthanide products for the manufacture of magnets and batteries, polishing powders, catalysts, and glass, etc. The transfer of technology will take place at the point when employees are sent for training in Australia or overseas and also, by way of regular visits by foreign technical specialists who will be sent to Malaysia to provide onsite job training to the local staff based at the plant in Kuantan. The Project Proponent is currently in talks with the State Government of Pahang to collaborate with the University Pahang Malaysia on Research & Development. This will also create trained, professional workforce. In addition, the transfer of technology will also take place domestically with staff learning the skills while on the job.

- **Growth of Other Supporting Industries and Surrounding Areas**: The proposed plant in Malaysia is expected to create new business opportunities for the following industrial sectors:

  - Gas and petroleum;
  - Chemical reagents;
  - Water;
  - Transport/logistics;
  - Insurance; and
  - Banking.

Additionally, the plant is expected to complement the Government's efforts in attracting the establishment and relocation of the following industries in Malaysia with the availability of lanthanide products within Malaysia, i.e. through import substitutions:

  - Hybrid vehicles
  - Catalytic converters
  - Neo magnets
  - Flat panel displays
  - Ceramic capacitors
  - Compact fluorescent lights
  - NiMH batteries
  - Fuel cells
  - Phosphors
  - Polishing powders

The setting up of the proposed plant within the GIE in Kuantan is also expected to promote the development of new, technologically advanced industries including small and medium size industries (SMIs) that use lanthanide products as raw materials/components, that are geared towards meeting the demands of relevant globally competitive industries.

- **Increased Employment Opportunities:** The plant is expected to employ 398 local Malaysian and 20 expatriate employees in the 1st year of operations. The expatriate employees will train locals until such time the locals attain sufficient skills and technical knowledge to subsequently take over the responsibilities from the expatriates. Additionally, further job opportunities will become available for Malaysians not only in the this industry but also, job opportunities for the manufacturing sector in the Eastern Corridor on the whole as a result of the spin-off effects to related supporting industries and sectors such as chemical, gas and petroleum, chemical reagents, water, transport/logistics, insurance, banking sectors, etc.

- **Economic Benefits:** The proposed Advanced Materials Plant in Malaysia is expected to bring about positive multiplier effects to the Malaysian economy. Based on a multiplier effect factor of 2 (i.e. 2 x multiplier effect of business expenditure and project operating costs), the total direct and indirect contributions to the Malaysian economy over the first 15 years of operations (year 2008 – 2022) by the proposed plant is expected to be significant. In addition, Lynas' proposed operations in Malaysia are projected to generate significant tax revenue for the Malaysian Government over its first 15 years of operations (year 2008 – 2022).

- **Business for Local Suppliers**: Creation of demand for local supplies of relevant raw materials and components such as chemical reagents (hydrochloric acid, sulphuric acid, magnesium oxide, lime, etc.), gas, etc. which is expected to encourage the shift towards the use of local contents by other relevant industries.

5.9 TRAFFIC AND TRANSPORTATION

At present, the proposed plant site is accessible from Kuantan-Kemaman (Federal Route 3) Road and Gebeng Bypass Road. Jalan Kuantan-Kemaman is part of Federal Routh 3 and is a two-lane road. From this road, there are three roads that connect to the GIE. The Gebeng Bypass is a new road that bypasses the Kuantan Port.

In assessing traffic impacts, a Traffic Impact Assessment (TIA) was undertaken for the Advanced Materials Plant in November 2007. The complete report is appended in **Appendix 4.** However, the traffic volume assessed for the operational phase of the TIA is based on higher vehicle numbers which were estimated in November 2007. Since then, the traffic volume for the plant in its operational phase has been revisited by the Project Proponent and new numbers have been generated. These vehicle numbers are observed to be lower than the initial case. At the time of reporting, the TIA was being updated and revised to reflect the impact arising from the new data set and thus was not ready for inclusion in this report. However, since the conclusions and recommendations of the assessment of the original report remain the same, these are summarised below.

5.9.1 Construction Phase

In the earthworks phase, heavy earthmoving plant such as bulldozers, excavators and compactors would be transported to the site via low loaders. Low loaders by virtue of their size occupy most of the carriageway and are generally slower in speed. These factors combined will cause inconvenience to other commuters and also pose a safety risk.

Construction activities will comprise civil works, mechanical and electrical services, and support services. The initial construction activities will therefore require the delivery to site by road of construction materials such as concrete and structural steel. As construction continues, the proposed plant components and associated infrastructure items will be brought to site. In addition, smaller machinery and materials such as some mechanical equipment, pipework, valves, electrical cabling and wiring, and instrumentation will be delivered by light vehicles. The majority of construction material deliveries during initial construction will be by standard low loaders, trailers and trucks.

Off-site transport of construction spoil/debris will also be carried out. Similarly, this will result in increased traffic movement. Prolonged and repeated overloading by heavy vehicles would also potentially affect road surfaces causing breakages and potholes which will further inconvenience road users.

The estimated number of truck movements generated during the peak construction phase was not available at the time of reporting. However, the majority of these trips will be from the construction materials suppliers in Kuantan and Kemaman. In addition, in the event the construction workers are provided accommodation off-site, they will generate a combination of car, van and motorcycle traffic on the road. This traffic will peak at each change of shift for the workforce.

Based on the TIA, the predicted volume of construction traffic is expected to be less than 100 vehicles per hour. Considering the low volume of construction traffic, it is not likely to cause significant impact on the performance of the surrounding road network. However, it is recommended that the vehicles use the Gebeng Bypass and enter the proposed plant site through the 2-lane road located to the west of the site. This is in view of the low volume traffic on the roads.

Impacts arising from increased traffic to and from the plant site during the construction phase will be minimised by observing the following:

- Transportation of construction machinery and materials will be carried out only during off-peak hours of the day. Off-site transportation of waste material will be regulated to avoid peak traffic periods (6.30 - 8.30 am and 4.30 - 6.30 pm);

- Speed of vehicles will be restricted to 90 km/hr to reduce the impacts of dust dispersion and material spillage;

- Safety measures with regard to loading and transporting of heavy machinery construction materials, raw material cargo and finished products will be observed at all times. All loads will be secured with chains or strong rope. Dusty material will be secured with tarpaulin covers.

- The transportation vehicles used will be well maintained and, the drivers licensed and competent. This is to prevent any undue incidents as there are residential areas located along the transportation route.

b. Operational Phase

Increased traffic will also be generated from the movement of in-coming raw material supply vehicles and out-going transportation vehicles carrying the product from the plant. The results of the traffic analysis indicate that the increase will not be significant.

As the lanthanide concentrate is classified as a radioactive raw material in accordance with the Atomic Energy Licensing Act, 1984, a transportation licence is required from the AELB to transport the concentrate from the Port of Kuantan to the plant site. The Project Proponent will apply for this licence once the Class A Milling Licence has been issued for the operational phase. The transport licence will state the transportation requirements and conditions, and the Project Proponent is committed to ensuring compliance to these requirements.

For trucks/tankers that would be involved in the transportation of chemicals (including concentrated acids, corrosive substances), finished products and raw material (lanthanide concentrate) during the operational phase, the following measures are necessary:

- The use specially designed trucks dedicated for the transport of chemicals;

- The use of adequate warning and information signs and safety equipment on all trucks/tankers;

- The use of major highway routes and avoiding smaller roads which pass through community areas;

- The strict adherence to the relevant regulations pertaining to road transport;

- Provision of proper training to plant technicians involved on loading and unloading operations at the plant area;

- Equipping the trucks/tankers with the appropriate safety equipment, both personal (protective clothing) and emergency equipment (radios, spill containment kits, etc.);

- Designing the facilities on the tankers to minimise the likelihood of spillages occurring due to overspilling and incorrect positioning of the vehicles;

- Where possible, to select transport routes that avoid built-up or congested areas as much as possible;

- Proper scheduling of the lanthanide concentrate transportation trucks should be carried out to ensure the truck turn-around time is not delayed and to prevent truck-waiting within the site which will lead to a line-up of trucks along the Kuantan-Kemaman Road and the Gebeng Bypass. This would pose a safety hazard in addition to obstructing the smooth flow of traffic along the public road.

CHAPTER SIX

6.0 ENVIRONMENTAL MANAGEMENT PLAN

6.1 PROJECT OVERVIEW

This section presents the environmental management requirements for the construction and operational phases of the proposed Advanced Materials Plant. Effective management and monitoring of activities on the site will be essential to ensure environmental objectives are met and operations are carried out in an environmentally sustainable manner.

In Chapter Five of this report, the potential environmental impacts have been assessed and suitable mitigation measures recommended tominimise these impacts to meet regulatory limits and comply with best industrial environmental management practices. The mechanisms for ensuring that these mitigation measures are implemented, and are effective, are recommended in this chapter. The base document for the environmental management of the project is called the Environmental Management Plan (EMP).

Separate EMPs will be developed for the construction and operational phases of the plant to describe how the recommendations of this preliminary EIA, and any further conditions imposed by DOE Pahang would be implemented by the nominated EPCM Contractor and Lynas during the construction and operational phase respectively.

As per the requirements of DOE, the construction phase EMP will be developed and approved by the department prior to the commencement of construction works and likewise the operational phase EMP prepared and approved before the start of the plant operations.

6.2 EMP FORMAT

The EMP will be developed in accordance to the latest guidelines prepared by DOE. A typical format of the document and the key information to be included in each of the chapters are presented below:

Chapter 1: Introduction: States the objectives of the EMP, the scope of the EMP, a statement of key environmental issues identified in the establishment of the plant within the Gebeng Industrial Estate (GIE) and details of the environmental management requirements stipulated by DOE as part of the conditions of approval for the project.

Chapter 2: Policy: Provides an outline of the company's objectives in protecting the environment, its environmental policy; and long term commitment in practising sustainable development.

Chapter Three: Organisation Chart/Budget: Provides details of top management personnel responsible in managing environmental issues; details of the nominated environmental consultants and laboratory employed for the environmental monitoring, frequency and nature of training provided to the employees on safety and environmental issues; and estimated budget for implementing the EMP. In addition, a statement on the reporting procedures, complaint response procedures, and actions to be undertaken if adverse monitoring results are reported will also be presented.

Chapter Four: Environmental Requirements: Describes the EIA approval conditions, related standards and regulations stipulated under the *Environmental Quality Act, 1974.*

Chapter Five: Monitoring Programme: Details the requirements for baseline environmental monitoring which will be carried out prior to project implementation; and the proposed monitoring programme for both the construction and operational phases of the project.

Chapter Six: Significant Impacts and Pollution Control Measures: Summarises the significant impacts identified and the proposed pollution control or mitigation measures to be implemented.

Chapter Seven: Environmental Contingency Plan: Outlines the requirements for emergency procedures for unplanned incidences that may potentially result in adverse environmental impacts such as hazardous spills, failure of pollution control equipment, etc. A list of personnel involved and the relevant government agencies will also be presented.

Chapter Eight: Summary: States the salient features of the various chapters within the EMP document.

6.3 GUIDELINES FOR THE CONSTRUCTION PHASE EMP

The primary objective of the construction phase EMP will be to ensure that sound environmental practices are adhered to during the construction phase. This will include the recommendations presented in this report, DOE's EIA Approval Conditions, and further requirements which become evident during the construction process itself.

The EMP will be prepared in accordance to the format outlined in Section 6.2 above. In addition, the following management procedures are recommended:

- The contract between the Project Proponent and the nominated EPCM Contractor shall specify that the EPCM Contractor and their Subcontractors are required to adhere to the environmental protection measures recommended in this PEIA, legal provisions of the *Environmental Quality Act, 1974* and all other requirements by DOE which will be stated in the EIA Approval Conditions.

- A designated site personnel, i.e. Site Manager/Engineer or Supervisor who has a background in environmental management practices will be appointed to assume responsibility for the execution of the requirements of the EMP throughout the duration of the construction phase.

- The findings of the environmental compliance audits (discussed under Section 6.7) will form the basis of corrective actions to be resolved by the EPCM Contractor/Sub-Contractor.

As the duration of the construction phase of the project is approximately 15 months, it will not be necessary to review the EMP after the first year of construction. However, in the event unanticipated incidences which result in adverse impacts occur on site, the EMP will be updated immediately to incorporate the particular scenario.

6.4 GUIDELINES FOR THE OPERATIONAL PHASE EMP

The format of the EMP developed for the operational phase of the project will be similar to the format outlined under **Section 6.2**. Some of the additional information to be incorporated in the EMP includes the following:

- Development of a set of brief, written environmental management procedures for the various activities in the operational phase. Management personnel and the employees (operators) would be required to adhere to these practices as part of their job function;

- Selection of an Environmental Officer to ensure that the measures recommended in the EMP and other specific written environmental procedures are adhered to. The person shall possess the relevant experience in environmental management and capable of handling emergency situations. The person should also be empowered with sufficient authority to effect rapid action in the event of an emergency situation where potential adverse impacts to the environmental are likely.

- Easy access by employees to technical support and advice; and pollution control equipment in the event problems arise;

- Provision should be made for the management of unforeseen incidents or events via an Emergency Response Plan. This would include ensuring that site personnel know whom to contact for technical advice or equipment if there is an emergency; and

- Training of plant operators in basic environmental management practices.

Assuming there are no changes in the plant operations, the EMP will be reviewed after the first year of operation and every two years thereafter. However, if there are process related or operational changes which require a change in environmental management practices, the EMP document shall be revised accordingly before the change is effected. Also, if any shortcomings in the document are identified based on the findings of the periodical environmental audits, these sections will be revised/updated as necessary in line with the company's corporate environmental management policies.

6.5 ENVIRONMENTAL MONITORING AND AUDITING

Environmental monitoring will be required for the following during both the construction and operational phases of the project:

- Sungai Balok river water quality and river bed sediment quality,
- Boundary noise levels;
- Ambient air quality;
- Emissions arising from the waste gas treatment system; and
- Soil and groundwater

These recommendations are based on the findings of this PEIA study and will be incorporated within the EMP document. For the construction phase, the Consultants recommend that these requirements be specified in the tender document for EPCM Contractors (and their respective Sub-contractors). The data collected from these monitoring events shall be submitted to DOE Pahang. Monitoring events undertaken for submission to DOE shall be carried out by analytical laboratories which are certified by the Department of Standards of Malaysia.

Scheduled environmental audits shall also be undertaken as specified by DOE Pahang in the EIA Approval Conditions.

The objectives of the environmental monitoring programme are:

- To develop a database to facilitate the identification of any short or long term environmental impacts arising from the construction and operation of the plant;

- To provide an early indication if any of the environmental control measures or practices are failing to achieve the acceptable standards; and

- To provide environmental quality data to support the findings of the compliance audit during both the construction and operational phases of the project.

6.5.1 Baseline Data

The baseline environmental quality data presented in Chapter Four of this report provides a general indication of the baseline environmental conditions at the time of reporting. Environmental data at the site boundary were collected during a monitoring event undertaken in October 2007. This information was used as a basis for both qualitative and quantitative impact assessment in this EIA.

Since the Project Proponent intends to commence construction activities in March 2008, a second monitoring event for the collection of baseline environmental quality data is not required as the proposed site is a cleared site with no on-going activities. The data obtained thus far is deemed sufficient to represent the plant site's baseline conditions unless there is a specific requirement from the DOE in the EIA Approval Conditions to re-assess the baseline environmental quality shortly before the onset of construction activities.

The results obtained from the monitoring programme carried out during the construction and operational phases will be compared against these baseline conditions, and the findings used to indicate if the project implementation activities have attributed to the change in the environment; and to assess the effectiveness of the mitigation measures.

6.5.2 Water Quality Monitoring

6.5.2.1 Construction Phase

In the construction phase, the main concern will be increased sediment loading into Sungai Balok as a result of soil displacement from the site due to construction activities. The loading is not expected to be significant as the activities will be largely confined to the areas where structures are proposed. Additionally, the topography of the site is generally flat and cut and fill activities will be limited to areas the built-up areas.

One silt trap has been proposed in the south western corner of the site which will cater for all construction runoff within the construction area. The silt trap details are discussed in Section 5.2.2 in Chapter Five of this report.

To ensure the efficiency of the silt trap in the removal of soil particles and oil and grease, the monitoring of the overflow from the silt trap at its outlet is required for both these pollutants. The overflow from the silt trap shall comply with the 50 mg/l limit and will not contain any traces of Oil & grease. The silt trap will be maintained by regular desilting by the Contractor.

Additionally, river water samples will be collected from Sungai Balok at seven stations (W1-W7) along its 15 km stretch (commencing from the river mouth to a location slightly upstream of the site) using the grab sampling technique. The details of these locations are presented in Section 4.6.4 within Chapter Four of the report. The station locations are marked in **Exhibit 4.14.**

As the Sungai Balok river has tidal influence, samples will be collected during high and low tides. At each location, three (3) samples will be collected (at the surface, mid-depth and above the seabed) and mixed in a single container, and one sample drawn out to represent a composite sample for laboratory analysis.

For the construction phase, it will suffice to monitor only the following parameters: TSS, Oil and Grease, DO, BOD, COD, pH and temperature. It is recommended that samples be taken once a month for the first six months of the construction phase when the activities onsite will be the most intensive. Subsequently, the monitoring can be staggered to once every quarter until the completion of the construction phase. This recommendation will require confirmation from DOE Pahang.

6.5.2.2 Operational Phase

In the operational phase, the treated effluent from the Wastewater Treatment Plant (WWTP) will be discharged directly into Sungai Balok via the site stormwater detention pond and an earth drain which will run west from the site to the river for a distance of about 3 km.

To ensure the treated effluent leaving the site complies with the parameter limits of Standard B of the *Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979* the discharge from the treated water storage pond will be monitored on a continual basis for flowrate, pH, temperature and suspended solids. Samples will be collected periodically for laboratory analysis of the 23 parameters of the Standard B. For quick turnaround, the use of COD & BOD kits may be considered. Discharge of treated effluent into Sungai Balok will immediately be discontinued if the samples do not comply with the stipulated limits.

The stormwater detention pond will be provided with automatic level control to maximise the volume available within the pond for containment of rainwater or spills. The pond will be inspected on a daily basis to ensure that the equipment is operating effectively and to determine if any incidental spills have reached the pond.

To assess the impact of the treated effluent discharge on the receiving waterbody, Sungai Balok, water samples will be collected from seven locations within the river body. These sampling locations are similar to the locations recommended for the construction phase which are marked in **Exhibit 4.14**. The parameters to be monitored shall be similar to the parameters monitored for the baseline river water quality monitoring events carried out as part of the EIA study (Table 4.14 in Chapter Four of this report). The details of the monitoring programme will require confirmation from DOE Pahang.

6.5.3 Boundary Noise Monitoring

6.5.3.1 Construction Phase

Boundary noise levels will be recorded at four (4) monitoring stations (N1, N2, N3 & N4) which represent the prevailing noise levels along the site boundaries (four corners of the site).

The details of these monitoring locations and the parameters monitored are described in Section 4.6.1 in Chapter Four of this report.

As the site is located within the Gebeng Industrial Estate (GIE), the surrounding receptors are generally industrial facilities. The nearest human settlements to the project site are Kampung Sg. Ular, Kampung Gebeng and the Tanah Kemajuan Gebeng which are located 3 km to the east-northeast of the site. Thus, noise monitoring at these receivers is not required.

The location of these monitoring stations is presented in **Exhibit 4.14.**

Noise data will be recorded over a period of 24 hours at 15 minutes interval at each monitoring station and the integrated noise levels in terms of LA_{eq}, LA_{max}, L_{A5}, L_{A10}, L_{A50}, &L_{A90}& L_{A95} will be calculated.

It is recommended that boundary noise monitoring be carried out monthly during the first six months of the construction phase and thereafter once every quarter. This monitoring frequency will require confirmation from DOE Pahang.

6.5.3.2 Operational Phase

The noise monitoring programme recommended for the operational phase of the plant is similar to the construction phase programme with regards to the numbers and location of the monitoring stations. It is recommended that noise monitoring be undertaken once every quarter subject to confirmation from DOE Pahang.

6.6 AIR QUALITY MONITORING

6.6.1 Construction Phase

Ambient air quality will be monitored at four (4) monitoring stations (A1, A2, A3 & A4) which represent the ambient air quality along the site boundaries (four corners of the site).

The details of these monitoring locations and the parameters monitored are described in Section 4.6.2 in Chapter Four of this report.

As the site is located within the GIE, the surrounding receptors are generally industrial facilities. The nearest human settlements to the project site are Kampung Sg. Ular, Kampung Gebeng and the Tanah Kemajuan Gebeng which are located 3 km to the east-northeast of the site. Thus, air monitoring at these receivers is not required.

The air samples collected will be analysed for Total Suspended Particulates (TSP), Particulate Matter (PM_{10}), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) which are the primary ambient air quality pollution indicators.

The results of the monitoring exercise will be used to ascertain if the dust suppression measures implemented for potentially dusty construction activities; and vehicle movement are effective. The monitoring exercise will also ensure regular maintenance of construction vehicles and equipment and prevent excessive noxious exhaust emissions.

6.6.2 Operational Phase

During the operational phase of the plant, the emissions arising from the waste gas scrubber system will require periodical monitoring to ensure compliance to the *Environmental Quality (Clean Air) Regulations, 1978*.

It is recommended that the stack emissions from the waste gas treatment system be monitored every month for the first two years of the operational life of the plant and once every quarter thereafter and the results submitted to DOE Pahang. Unless the monitoring data show inconsistencies in the performance of the waste gas scrubber system, the quarterly monitoring programme recommended should suffice. However, in the event, the results show signification fluctuations, the monthly frequency will be maintained until such time the readings are generally constant. The parameters to be monitored include sulphuric acid mist or sulphur trioxide or both, hydrofluoric acid and Total Suspended Particulates (TSP) and the limits shall comply with Standard C of the Regulations. The final parameters will be set by DOE Pahang.

Ambient air quality at the site boundaries will need to be identified. The location of the stations and the parameters to be monitored are similar to those recommended for the construction phase. It is recommended that ambient air monitoring be undertaken once every quarter subject to confirmation from DOE Pahang.

6.6.3 Soil and Groundwater Monitoring

6.6.3.1 Construction Phase

No soil or groundwater quality monitoring is necessary during the construction phase.

6.6.3.2 Operational Phase

Soil and groundwater quality monitoring is recommended to be carried out bi-annually for the lifetime of the project. For the collection of baseline groundwater quality, seven (7) bore wells were established at the undeveloped site to represent groundwater quality up-gradient and down-gradient of the site. With the establishment of the plant and associated facilities, some of these wells will need to be abandoned to make way for the structures. Thus, the location of the monitoring wells will need to be revised upon completion of the detailed engineering design of the plant and based on the findings of the Radiological Impact Assessment by the Malaysian Nuclear Agency. It is recommended that more wells be established around the Residue Storage Facility (RSF).

The groundwater samples shall be analysed for:

- pH;
- Total Petroleum Hydrocarbons, TPH (USEPA Method 8015/8260);
- Volatile Organic Compounds, VOCs (USEPA 8260);
- Semi-Volatile Organic Compounds, SVOCs (USEPA 8270);
- Anions (Chloride and Sulphate); and
- 13 Pollutant Metals i.e. antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium and zinc (USEPA 6010/6020 for all & 7471 for mercury).

6.7 ENVIRONMENTAL COMPLIANCE AUDITING

Environmental compliance auditing will be carried out to spot check for compliance with the EMP, i.e. to ensure that the environmental management procedures, recommended mitigation measures and monitoring programmes are implemented at the site. The EMP developed will include a checklist (for the construction and operational phases) which will be used by the Auditor during the compliance audit. The audit will also include a review of the relevant permits and licences required by the DOE, environmental monitoring data, review of complaints received from the public (if any) and other related issues as well as a thorough inspection of site activities.

The results of the audit will be used to identify any weaknesses in the EMP and to provide information for updates where necessary.

It is recommended that quarterly audits are carried out during both the construction and operational phases of the project.

The audit protocol shall include the following activities:

- Review and verification of historical environmental quality data;
- Identification of specific issues of non-compliance;
- Recommendation of suitable mitigation measures to mitigate the non-compliance observed; and
- Assessment of the overall adequacy of the mitigation measures implemented and if there are any short-comings, the auditor will recommend suitable modifications which will be incorporated in the EMP.

CHAPTER SEVEN

7.0 EMERGENCY RESPONSE PLAN

7.1 INTRODUCTION

An Emergency Response Plan (ERP) is an essential component of a facility's safety and loss strategy and provides an organised structure for a chain of actions to be put into motion in the event of an emergency on the site. An emergency, in the context of the ERP, is defined as an incident which has the potential to cause injury or loss of life, and/or damage to plant, property and the surrounding environment.

This section outlines the requirements for the preparation of an ERP. This general outline of the plan is not intended to provide specific details on how to handle potential emergency situations but for use as a template or guide in the development of a more detailed site specific plan.

An ERP is required for the operational phase of the Advanced Materials Plant.

7.2 OBJECTIVES

The main objectives of developing the ERP for the Advanced Materials Plant operations are to:

- Establish a formalised emergency organisation structure and counter-procedures to control and contain any emergency on site through prompt and effective response measures so that its effect is localised;

- Ensure that trapped or injured persons are rescued and given prompt and appropriate medical assistance;

- Control the spread of the damage arising from the emergency situation to the environment including the nearest sensitive receptors;

- Communicate information on the emergency to the relevant plant personnel and the relevant offsite parties including the Royal Malaysian Police, Fire Fighting Department (BOMBA), Department of Occupational Safety and Health (DOSH), Department of Environment (DOE) and the Local Authority (Majlis Perbandaran Kuantan);

- Maintain information and records of investigation into the incidents/accidents;

- Restore normality at the site prior to facility personnel re-entering the site after an emergency and resuming work; and

- Provide training for the site personnel in emergency response management to maintain a high level of preparedness at all times.

7.3 BASIS OF EMERGENCY RESPONSE PLAN (ERP)

The ERP is a formal document that identifies the potential emergency conditions at the plant and specifies pre-planned actions to be followed to minimise property damage and loss of life. The document specifies the actions the plant's management should undertake to moderate or alleviate the impact from accidents and contains step-by-step procedures and information to assist in issuing early warning and notification messages to responsible emergency management authorities.

The effectiveness of the ERP can be enhanced by promoting a uniform format whereby all aspects of emergency planning are covered in each plan. Uniform emergency action plans and advanced coordination with local and federal emergency management officials and organisations should facilitate a timely response to an emergency situation. An emergency response plan generally contains the six main elements described below:

- **Identification of Possible Emergency Situations**

  The list of hazards resulting in activation of the ERP cascades down from the full Hazard Identification exercise. From the exercise, the high and medium risk hazards will be identified and the threats documented. The emergency response actions relevant to each of these hazards will form the focus of the emergency planning exercise.

- **Notification Flowchart**

  A notification flowchart indicates the nominated persons who are to be notified during the emergency and in the order of priority. The information presented on the flowchart is needed to ensure the timely notification of persons responsible for handling the emergency situations.

- **Emergency Detection, Evaluation and Classification**

  Early detection and evaluation of the situation(s) triggering event(s) that initiates or require an emergency action is crucial. The establishment of procedures for reliable and timely classification of an emergency situation is necessary to ensure the appropriate course of action is taken based on the urgency of the situation.

- **Responsibilities of Personnel in an Emergency**

  A clear definition of the responsibilities of personnel for ERP related tasks must be determined during the formulation of the plan. Facility operators are responsible for developing, maintaining, managing and implementing the ERP. Federal and local emergency management officials have statutory obligations for warning and evacuating affected areas. The ERP must clearly specify the responsibilities of operators and when (and how) those responsibilities are transferred to government officials, to ensure timely and effective action.

- **Emergency Preparedness**

  Actions of the ERP are taken to moderate or alleviate the effects of a potential situation and, the facility's responses to such situations.

- **Impact Zone Maps**

  Impact zone maps delineate the areas that could be affected as a result of accidental events at the facility. Impact zone maps are used both by the facility operators and emergency management officials to facilitate timely notification and evacuation of areas affected by accidental events.

7.4 EMERGENCY RESPONSE PLAN (ERP)

7.4.1 Organisation

In the operational phase of the project, the plant management have to set-up a Health, Safety and Environmental (HSE) committee to ensure all issues related to safety, health and environment pertaining to the plant, employees and surrounding environment, are adequately incorporated into the actual implementation of the ERP.

Upon agreement or acceptance of the proposed ERP by DOE, the HSE committee shall ensure that all personnel are familiar with the plan. To ensure workability of the plan, training session and regular rehearsals by means of drills have to be conducted.

7.5 LOCAL RESPONSE TEAMS

The Gebeng Industrial Area has a Local Response Team, i.e. Gebeng Emergency Mutual Aid (GEMA) comprising the HSE committee members of the other industrial facilities operating within the industrial area. The local team would also be made-up of representatives from the relevant government agencies and local authorities such as the local BOMBA, DOSH and DOE. It is recommended that representatives from the RE Plant become members of this team.

7.6 TYPES OF EMERGENCY

An emergency is an unforeseen combination of circumstances that disrupts normal operating conditions and poses a potential threat to human life, health and property or the environment if not controlled, contained or eliminated immediately. A number of potential emergency events likely to occur during the plant operation are provided below:

- Natural Hazards:
  - Floods during monsoon events
  - Landslide/ Subsidence
- Internal Plant Hazards/ Threats:
  - Fire
    - ⇨ equipment malfunction
    - ⇨ spillages of unattended fuel (diesel)
    - ⇨ spillages of corrosive concentrated acids
    - ⇨ ignition of leaked flammables
    - ⇨ fire in office building
  - Explosion
    - ⇨ equipment malfunction,
    - ⇨ ignition of leaked diesel fuel used for on-site vehicles,
  - Internal road vehicle accident
    - ⇨ transport trucks carrying concentrate and/or chemicals overturn spilling material onto the ground;
    - ⇨ collision of vehicles moving within the site, etc.
  - Spillages/releases of flammable liquid or gases
    - ⇨ fuel used for on-site vehicles and machinery hydraulic fuel
    - ⇨ natural gas release due to leaks
  - Rescue of personnel
    - ⇨ Pinned under vehicles involved in accidents
    - ⇨ Involved in accidents within the operating areas of the plant, etc
- External Hazards/ Threats:
  - Violent protest action
    - ⇨ fuelled by political, business or environmental events or circumstances
  - Bomb threats

7.6.1 Emergency Classification Levels

Emergencies are classified according to their severity and urgency. An emergency classification system is one means of classifying emergency events according to the different times at which they occur and to the varying levels of severity. The emergency classification level for the types of emergencies described in the previous section can be further divided into three (3) levels of response. This three-level system is proposed as a general principle to activate the type of emergency response as follows:

- **Level 1 (Local Level)**

  This is an emergency situation where only the plant's operation personnel would be required to manage and control the emergency. Level 1 emergency would normally call for the plant's own resources and equipment for the response.

- **Level 2 (Area Level)**

  This is an emergency situation which requires action and management by the combined efforts of the in-house response team and external assistance by the neighbouring facilities response teams.

- **Level 3 (Divisional Level)**

  This is an emergency situation where a Level 2 emergency has escalated into an uncontrolled situation and has resulted, or would further result in the loss of many human lives, extensive property or environmental damage that has reached a scale that is beyond the control and capabilities of all response teams combine. The Evacuation Action Plan is then needed to be activated.

7.6.2 General Responsibilities of On Scene Commander (OSC) and Emergency Response Teams

The purpose of having a dedicated emergency response team within the plant site is to take immediate action to combat the emergency at local level (Level 1). In the event the emergency escalates to Level 2 or 3, the emergency response team has to ensure proper actions are taken to control the emergency while waiting for the arrival of external assistance from BOMBA and other external aids.

The emergency response team is lead by an On Scene Commander (OSC). The OSC is usually a general officer who has operational control of emergency response forces and supervises all on-site operations at the scene of the accident. He is the responsible person for all decisions relating to the management of the incident. As an OSC, he should be well versed with the plant's operation and must have in-depth knowledge on occupational safety and health.

The general responsibilities of an OSC during an emergency are as follows:

- To ensure all emergency response team members assemble at a pre-determined location according to their respective responsibilities.
- To assess information and situation and decide on the actions to be taken as outlined in the response flowchart.
- To approve changes to the response plan during the event if necessary.
- To direct the orderly evacuation of personnel not involved in the emergency response to a safe place.
- To ensure that all personnel are accounted for and coordinate search and rescue if necessary.
- To make the decision on ~~raising the~~ raising the alarm for external assistance in the event the emergency escalates from Level 1 to Level 2 or 3.
- To coordinate between the team members and the sub-team members.
- To coordinate efficient hand over of fire fighting, area containment or other responsibilities upon the arrival of external assistances such as BOMBA.
- To assist the external assistance team(s) to combat the emergency event ~~as~~ whenever required.
- To ensure that the incident is recorded and reported to the HSE committee and to the necessary government agencies such as BOMBA DOSH, DOE, etc.

Emergency Response Team

A typical emergency team comprises of sub-teams that are represented by individuals who are familiar with the respective area of responsibility. For example, the First Aid Team member would comprise of individuals who have basic knowledge and training in First Aid and CPR (An example is provided in **Exhibit 7.1**). Each of the team members shall acknowledge his/her responsibilities as an emergency response member having pertinent duties and responsibilities in the event of emergency situations. For each designated position in the team, there should be at least one (1) name assigned and two (2) others as standby.

The following sub-teams shall be established as part of the emergency response team.

- **Fire Fighting Team**

  The Fire Fighting Team members should comprise of employees that are familiar and trained for fire fighting. Preferably, the team members should be experienced in handling the fire fighting equipment.

- **Area Containment Team**

  The Area Containment Team shall comprise of designated employees that have adequate knowledge in toxic and hazardous materials on-site. The main responsibility of the team is to provide containment area for diesel spillage, concentrated acids, release of other chemicals and in the event of overspill of concentrate onto road or public areas.

- **Security Control Team**

  During an emergency event the Security Control Team will be responsible to maintain order at the premise and ensuring security at all times. This is crucial as there may be presence of outsiders in the site during the emergency event. Some of the primary responsibilities of the Security Control Team include prevention of unauthorised entry during the emergency, control of vehicle movement and provision of access to external assistance team(s), take head counts and conduct search and rescue if needed.

- **First Aid Team**

  The First Aid Team members shall comprise personnel with basic knowledge of First Aid and CPR. In an emergency event, the First Aid Team will be required to provide immediate first aid to injured persons while waiting for the arrival of ambulance/paramedical staff.

- **Communication Team**

  The Communication Team assumes the role of team coordination and provides instructions through the command of OSC. The main responsibility of the team is to ensure the instructions are correctly and timely conveyed to the right parties during an emergency. The team will record instruction conveyed out by OSC and received from all parties.

- **Restoration/Remediation Team**

  The Restoration/Remediation Team is responsible for the recovery of any losses and damages caused by the incident. After overcoming the emergency and the situation has been secured, the team will investigate the cause of the incident and estimate the damages and losses. It is also the team's duty to propose remedial steps to restore the affected area (with the collaboration of government agencies if required) and propose the mitigation measure to prevent future occurrence.

7.6.3 Emergency Equipment and Materials

An emergency response plan must be based on realistic assessment of the availability of the emergency response facilities and equipment. To ensure that the Emergency Response Team is able to control an emergency situation, the team has to be fully equipped by proper facilities and dedicated equipment. It is the responsibility of the Plant Manager with the assistance of HSE committee to ensure the availability and proper working condition of the equipment. Some of the typical equipment and materials are as listed below:

- Fire Fighting Equipment and Materials
  - Fire hydrants with dedicated Fire Water Pumps and Fire Water supply
  - Fire extinguishers
  - Hoses and nozzles
  - Fire blankets
  - Rope
  - Respiratory protection equipment
  - Aluminium ladders or mobile lift platforms
  - Hydraulic metal cutting equipment

- Communication Equipment and Materials
  - Alarms such as bells, sirens, flashing, rotating lights, etc
  - Smoke alarms
  - Intercoms
  - Walkie-talkies
  - Hailers
  - Dedicated emergency phone line
  - Signboards indicating emergency gathering location

- Other equipment and materials
  - Absorbent materials and booms
  - Protective apparel such as coveralls, gloves and boots
  - Safety masks and goggles
  - Gas detectors – for detection of leak gases if required
  - Torch lights
  - Fully equipped First Aid supplies
  - Stretchers

Some of the other general contact details and communication materials that should be provided include the following:

- Dedicated "hotline" that enables calls to off-site response authority
- Mobile tele-communication equipment
- Copy of latest Emergency Response Plan
- Plant emergency plans/ flowcharts
- Diagrams of the plant site which indicate the location of fire hydrants and fire fighting facilities
- Material Safety Data Sheets (MSDS) and Waste Cards for all hazardous materials and wastes stored within the site
- List of operating instructions for the usage of emergency equipment
- Updated staff duty roster
- Relevant standing instructions list
- Emergency Response Team Organisation with the corresponding Duty Chart
- Contact list consisting of names and telephone numbers of persons to call during emergency
- A full set of as-built facilities drawings (architectural, civil, structural, mechanical and electrical drawings)
- Safety Manuals

7.7 EMERGENCY RESPONSE FLOW CHART AND RESPONSE PROCEDURES FOR ON-SITE EMERGENCIES

The purpose of the on-site emergency response flow chart is to provide instructions on the various actions to be taken on a step-by-step basis during the emergency. An example is provided in **Exhibit 7.2**. For the actual ERP, details such as actual actions to be taken and the responsibilities of each team members has to be clearly defined in the flowchart and included in the ERP.

CHAPTER EIGHT

8.0 SUMMARY AND CONCLUSION

8.1 INTRODUCTION

This EIA study has assessed the potential impacts to the environment arising from the development of the proposed Advanced Materials Plant on Lots PT 8249 and PT 13637 within the Gebeng Industrial Estate (GIE), Kuantan, Pahang. Mitigation measures to manage and control the predicted impacts to a sustainable level and to comply with the requirements of the *Environmental Quality Act, 1974* and its subsidiary legislation have also been recommended.

The following sections summarise the findings of the assessment.

8.2 WATER QUALITY

8.2.1 Construction Phase

Sources of water quality impacts predicted during the construction phase include:

- Site preparation works;
- Construction runoff and drainage; and
- Sewage from on-site worker camps (if the construction labour force is housed on-site).

Based on the above, the site preparatory works are not expected to result in adverse erosion potentials as the proposed site has been cleared and filled to platform level. The impacts arising are transient in nature, occurring only during the site preparation stage of the construction phase. With the implementation of effective mitigation measures, this risk will be further reduced.

Control of the construction phase impacts can be effectively mitigated with the development of an Erosion Control and Sedimentation (ECS) Plan. An ESC plan is a document that explains and illustrates the measures to be taken to control erosion and sedimentation during construction. Typically, an ESC includes the following:

- Description of predominant soil types within the affected area;
- Details of site topography including existing and proposed levels;
- Design details and locations for structural controls;
- Details of temporary and permanent stabilisation measures; and
- Description of the sequence of construction.

The ESC plans ensure that provisions for control measures are incorporated into the site planning stage of development and provide for the reduction of erosion and sediment problems.

The effectiveness of the ESC plan can be evaluated during the implementation of the Environmental Management Plan (EMP) which includes regular monitoring and audits. Mitigation measures include:

- The clearing of vegetation and undergrowths should only commence after the site layout/design has been completed and the site is ready to be worked upon.

- All temporary discharge points required in the earthworks will be located, designed and constructed in a manner that will minimise the potential threat of downstream flooding.

- Any disturbed earth caused by construction activities or fill operations must be firmly consolidated and compacted by earth moving vehicles and compactors to reduce the rate of possible erosion and release of loose soil particles

- Denuded stretches must be re-vegetated or sealed immediately after the construction works.

- Uncovered stockpiles of excavated material or topsoil and fill material are prone to erosion and therefore must be protected. Small stockpiles can be covered with plastic sheets and large stockpiles should be stabilised by erosion blankets and regularly damped.

- Stockpiles of construction aggregate, spoil and excavated soil should be located at areas within the project site that do not permit direct run off into water courses and are generally flat. On site storage of excessive quantities of such materials should be avoided.

- Sediment retention structures such as silt traps and settling basins of adequate sizes should be provided at suitable locations prior to discharge into the receiving drainage channels. One silt trap has been proposed at the south western corner of the site as indicated in the site drainage plan presented in **Exhibit 5.2.1.** Details of the silt trap design are presented in **Exhibit 5.2.2.** The location of the silt trap is tentative pending approval from the Local Authority.

- The proposed silt trap will be regularly maintained and desilted to provide maximum silt removal efficiencies. Oil and grease removal facilities will also be provided to ensure the overflow from the silt trap does not have traces of oil and grease. Weekly inspection of silt trap will be carried out by the Contractor.

- The contractor will ensure that site management is optimised and that any solid materials, debris, litter or wastes are not indiscriminately dumped on site or disposed of in the existing unlined drains in the vicinity of the site or on other undeveloped sites within the GIE. Appropriate waste receptacles will be provided and periodic removal of any accumulated waste from the site should be arranged.

- Sewage effluent generated from the workers' camps will be treated prior to discharge. Portable integrated treatment units certified by the Department of Sewerage Services are available which treat the effluent to meet the Standard B limits.

8.2.2 Operational Phase

In the operational phase of the project, the primary source of industrial wastewater is the Cracking & Separation Plant. The wastewater generated from the plant will arise from the upstream extraction, downstream extraction, and product finishing processes.

Other forms of wastewater and contaminated streams generated from the plant operations include:

- Supernatant liquors and surface runoff associated with the Residue Storage Facility (RSF);
- Waste gas treatment system blowdown;
- Discharge of water (drain-off) from the cooling towers;
- Boiler blowdown;
- Contaminated stormwater collected from bunded areas within the plant, namely the reagent storage tank bunded areas;
- Floor cleaning waters; and
- Sewage and domestic wastewaters.

Two treatment systems, i.e. the High Sludge System (HDS) and the WWTP (bio treatment plant) have been proposed for the plant operations. The HDS system is essentially a neutralisation pre-treatment process for the wastewaters from the Cracking & Separation Plant. Details of the treatment process are discussed in Section 5.2.3.3.

All other process waste streams and contaminated streams will enter the WWTP directly without any pre-treatment. Sewage and sanitary wastewaters will be routed to a Sewage Treatment Plant and the treated discharge will pumped into the WWTP. The wastewater block flow diagram presented in **Exhibit 5.2.4** (Chapter Five) identifies the major sources of waste streams and their inflow into the HDS and the WWTP.

The final treated effluent will be held in clear wells and then pumped into the stormwater detention pond (at an average rate of 500 m^3/hr) and the combined discharge will be released into the earth drain (external to the site's southern boundary) which flows into Sungai Balok.

The untreated waste streams entering the HDS process and WWTP identified in the section above will contain the following chemical species:

- Suspended solids (SS)
- NH3-N
- Phosphate
- Cations: Low concentrations of Cu, Zn, Mn, Cl, Hg, As, Pb, Cr, Th, Mg, Sr, U, Ca, Al, Si, K, Ba, Fe, Na, K+Na
- Calcium sulphate ($CaSO_4$)
- Magnesium sulphate ($MgSO_4$)

If *untreated*, these waste streams will impact the Sungai Balok river quality in terms of physical, biological and chemical impacts similar to those discussed under Section 5.2.2.2. To mitigate these affects, these waste streams will be subjected to treatment within the HDS and the WWTP prior to discharge.

The impacts of discharging the *treated* effluent from the plant during the operational phase have been assessed quantitatively to simulate the pollution loading to Sungai Balok and predict the changes in water quality of the river with the added discharge of the effluent from the Advanced Materials Plant.

The main conclusions of the quantitative assessment are summarised below:

- Discharge rate of the WWTP treated effluent is very low compared to likely storm water and river flow rates;

- The impact of treated effluent alone on river quality is very low, and is likely to be diluted by a factor of 150 by the river water.

- The contribution of storm water runoff from the site to river impact could be more significant than from the plant effluent.

- Discharging untreated effluent to the river will reduce the river water quality. The COD concentration could be increased by up to 30% but this impact is expected to be only short term. It should also be noted that existing COD in the river system is greater than 50mg/l as per Class III water quality standard. If there is a desire to improve the water quality of Sungai Balok further then there needs to be consideration of all discharges into the river system rather than considering only one point source such as the Advanced Materials Plant.

The conclusions drawn from the analysis are subject to the following limitations

- Sg Balok river flows are unknown;
- Other pollution loading into external earth stormwater drain is not quantified; and
- Uncertainty in EMC values.

8.3 SOIL AND GROUNDWATER

8.3.1 Construction Phase

Impacts on soil and groundwater quality during the construction phase are commonly attributed to improper management and handling of hazardous materials stored at the site. Potential sources of soil and groundwater quality impacts include:

- Accidental spillage and leakage arising from the handling and storage of hazardous materials/chemicals in diesel skid tanks, chemical/fuel dispensers and storage drums, jerry cans or carboys that contain lube oil, hydraulic oil, paints and organic solvents and other chemicals used during the construction phase;

- Leakage arising from vehicle engine oil change, equipment and machinery, as well as refueling activities;

- Inappropriate hazardous waste storage and disposal practices;

- Improper discharge of untreated sewage; and

- Groundwater dewatering activity.

Soil and groundwater impacts arising from accidental spillage and leakage of hazardous chemicals and wastes during the construction phase are assessed to be low due to the limited quantities of chemicals used at any one time on-site during construction. In addition, the extent of soil and groundwater contamination is likely to be localized and surficial. These impacts can be readily addressed by implementing appropriate mitigation measures discussed in the proceeding section.

Groundwater pumping may be required where foundation excavations extend below static water levels. Such dewatering may be required for some refinery foundations. However, the need for significant groundwater discharge is unlikely. In the unlikely event that some dewatering is required, the extracted water will be conveyed via the silt trap proposed for the construction works area prior to discharge into the site's drainage system.

The risks of soil and groundwater contamination during the construction phase will be appropriately managed and controlled by the following:

- A secured area (enclosed with hardstanding imprevious base) will be provided for the storage of any hazardous materials (including hazardous wastes);

- All temporary fuel tanks and drum storage areas will be provided with drip collection devices and be sited on sealed areas (for example, concrete paved areas) with appropriate bunding for accidental spill containment. A valve should be installed at the discharge outlet of the bunded area;

- All activities that may result in the potential release of hazardous materials to the ground such as changing of engine oils and lubrication oils from construction vehicles, equipment and generators on site will be performed only on designated sealed areas or on drip trays to reduce the risk of direct spill into the underlying soil and groundwater. Spent oil must be handled and disposed of as scheduled waste;

- Any accidental spills of fuel, oil or other hazardous chemicals will be cleaned up immediately. The recovered media (contaminated soil, absorbent pads, rags etc) should be disposed of as scheduled waste; and

- Appropriate sanitary facilities will be provided and properly maintained for construction workers throughout the construction stage. Direct discharge of untreated sewage into underlying soil, groundwater or surface water is prohibited. If portable toilets are procured to the site, they must be of sufficient numbers and meet the requirements of Department of Sewerage Services, Ministry of Housing and Local Government.

8.3.2 Operational Phase

The areas of concern for the potential soil and groundwater contamination during the operational phase include:

- Lanthanide Concentrate Storage Shed;
- Residue Storage Facility (RSF);
- WLP Retention Pond;
- NUF and FGD Retention Pond;
- Acid storage area (tank farm);
- Chemical Store;
- The 10,000-litre aboveground diesel storage tank;
- The emergency firewater pumphouse (with 1,000-litre diesel storage tank);
- Diesel generators (with 5,000 litre diesel storage tank each); and
- Scheduled wastes (waste oil, expired chemicals, etc) storage area.

In addition, other potential sources of impact include the periodic handling and dispensing of chemicals with the process areas, spills of fuels and lubricating oils, albeit in small quantities, may lead to minor spills and leakages. Such accidental releases are usually a result of poor chemical handling practices and may likely occur at the maintenance workshop and hazardous substances handling and storage areas.

Impacts to soil and groundwater resources associated with plant operations could be easily addressed, prevented and overcome by implementing appropriate mitigation measures discussed in the following subsection.
Prevention and control measures include the following:

- The diesel fuel storage tank and reagent storage tanks will be located within concrete-bunded enclosures capable of containing 110% of the contents of the tank within each enclosure. The floor of the bunded enclosures will be concrete-lined with an impermeable liner to prevent contaminant from permeating into the ground;

- Appropriate instrumentation and control/trigger alarm to warn of possible overfilling and to provide an alert mechanism in the event of significant fuel/chemical loss should be provided for the storage tanks;

- Operational control which includes regular/routine surveys, inspection and maintenance of the diesel fuel tank, chemical tanks and their ancillary facilities (pumps, valves and pipes) will be integrated into the plant's environmental management practices so as to identify and rectify any significant product losses or ongoing spills/leakages which may be occurring;

- Areas where regular or periodic handling and dispensing of liquid chemicals are undertaken, such as maintenance workshop and hazardous waste storage areas, should be concrete-paved with appropriate secondary containment (drip trays and bunded areas) provided.

- Any accidental spills will be assessed on a case by case basis and remedied, including excavation and disposal of any contaminated soil (classified as scheduled wastes) at a secure disposal facility.
- Procedures and work instructions on proper chemical handling should be effectively communicated to all operations and maintenance personnel;

- Hazardous materials and waste storage, handling and disposal procedures will be developed; and

- Corrosion protection for steel tanks and their ancillary facilities (pumps, valves and pipes) will be provided to prevent leaks.

In addition, groundwater should be monitored on a regular basis during the lifetime of the plant operation. If contaminants are present at concentrations above the groundwater quality screening levels such as the Dutch Intervention Values (DIVs), further assessments will be necessary to determine the nature and extent of the contamination, as well as to remove the potential source(s) of contamination.

8.4 NOISE

8.4.1 Construction Phase

Major noise sources during the construction phase of the project include:

- Site preparation works;
- Building construction activities including piling; and
- Transportation of construction equipment and materials: Vehicular noise will be generated from the ingress/egress of trucks carrying materials to/from the site.

The nearest noise sensitive receivers are the residential properties located at Kampung Sg. Ular (3 km northeast of the site), Kg. Gebeng (2.5 km east of the site) and Tanah Kemajuan Gebeng (2.5 km southwest). The noise impacts arising from the plant will not impact the noise environment at these receivers.

Based on the assessment of construction noise, the impacts during predicted are short-term, transient and localised to the site and its immediate surrounding (within the buffer zone of the industrial area).

The following standard noise control practices and measures will be implemented during the construction phase:

- Machinery and construction vehicles that may be in intermittent use will be shut down between work periods or will be throttled down to a minimum;
- The impact of piling noise can be minimised by the selection of quieter pile drivers such as hydraulic pile, or bored piles.
- Material stockpiles and other structures will be effectively utilised, where practicable, to act as a screen for noisy equipment operating within the construction works area.
- Noisy equipment, such as generators, will be checked for proper installation of engine silencers to reduce emitted noise. Other machinery with high noise level should be operated within enclosures.
- All transport vehicles must comply with the noise requirements made under the *Environmental Quality (Motor Vehicle Noise) Regulations 1987*. The maximum sound level permitted for trucks used in the transport of goods or materials should not exceed 88 dBA. Moreover, transportation vehicles should not be overloaded to avoid driving with full engine capacity which results in higher noise being emitted.

- In terms of workers safety and health, workers spending long hours on site, operating machinery and equipment that generate loud noise, will be provided with protective ear mufflers to prevent hearing impairment/loss.

8.4.2 Operational Phase

The primary dominant noise sources during the operational phase of the plant include the following: (the respective noise levels, when measured at one metre from the plant, is also specified):

- Rotary Kiln 97 dB(A)
- Cooling Tower 99 dB(A)
- Kiln Blower 97 dB(A)
- Covered Conveyor 70 dB(A)
- Conveyor Drive 97 dB(A)
- Exhaust Fans 96 dB(A)
- Compressor House 85 dB(A)
- Pumps 98 dB(A)
- Front-end Loaders 100 dB(A) – (or 86 dB(A) at 5 metres)

The future noise levels at the plant site boundary were quantitatively predicted with the use of a well established computer modelling programme *SoundPlan 6.2* (developed by Braunstein + Berndt, GmbH and accepted for use by the regulatory authorities in Australia).

A single scenario was modelled which represents the combined noise levels from the operation of the plant and the movement of trucks transporting raw material (lanthanide concentrate), reagents and finished products.

The predictions are based on two assumptions:

- Worst-case environmental conditions when the prevailing wind blows 100% of the time in the direction of the receiver, i.e. in a north-easterly-easterly direction.
- All equipment and machinery within the plant are operating simultaneously.
- Truck movements consisting of 68 trucks per day for the reagents and 18 trucks per day for the concentrate;
- Trucks operating 24 hours per day; and

- Speed on site is 30 km/h.

As the plant is to operate continuously, the night-time (10.00 pm - 7.00 am) noise level criteria is the most critical and as such, the results are calculated as $L_{Aeq\ (9\ hour)}$ dB levels.

From the results obtained, the highest predicted noise level from the operation is received on the northern boundary of the proposed site. This level, which includes truck noise, is $L_{Aeq\ (9\ hour)}$ 62 dB. The predicted noise level is dominated by the front-end loaders moving between the Tertiary Leaching Plant and the Residue Storage Facilities.

The nearest noise sensitive receivers are the residential properties located at Kampung Sg. Ular (3 km northeast of the site), Kg. Gebeng (2.5 km east of the site) and Tanah Kemajuan Gebeng (2.5 km southwest). The predicted noise levels are these locations are calculated to be below L_{Aeq} 35 dB and therefore not considered to be of significance.

When compared to the Department of Environment Malaysia's *The Planning Guidelines for Environmental Noise Limits and Control,* it can bee seen that the night-time level at the northern boundary marginally (2 dB) exceeds the night-time criterion of $L_{Aeq\ (9\ hour)}$ 60 dB. However, these predictions assume that all four front-end loaders will be operating continually and simultaneously for the entire night-time period, which may not be the case in reality. Should the operation be intermittent, the $L_{Aeq\ (9\ hour)}$ level would be lower and may then comply.

It is therefore recommended that once the plant is operational, a noise survey be undertaken on the boundary of the site. Should it be found that the front-end loaders or other plant is causing the noise levels to exceed the criterion, noise control can be undertaken to ensure compliance. For the front-end loaders, suitable noise control can include upgrading the engine covers and exhaust system.

The impact from trucks on public roads is considered to be minimal considering the low truck volumes (86 trucks per day) and the existing traffic volumes. Also, as the trucks are likely to be taking different routes to the site, unlike the scenario of trucking campaigns from a port to a particular site, there is not a concentration of noise at specific locations.

Assuming the plant specifications and expected truck movements used in the model, the results clearly indicate that during both normal operation and with the additional

noise associated with transportation of the lanthanide concentrate from the port, the operation of the plant complies with the Department of Environment Malaysia's *The Planning Guidelines for Environmental Noise Limits and Control* at all times.

However, to further reduce the plant operating noise and as best industrial practice, the following measures will be implemented:

- When selecting the equipment models for the plant from the various vendors, the noise attenuation features of the equipment will be given due consideration. In general, the newer equipment models tend to have more effective noise attenuation features. Where practical and cost effective, these equipment should be given priority. It is recommended that performance guarantee or contract specifications stipulate a requirement limiting the noise level of the equipment to a maximum of 85 dB(A) at 1m where practical.

- For additional noise attenuation, engineering measures such as installing mufflers, enclosures, barriers, lagging, noise-absorptive materials and silencers may be employed where practical.

- Where practical and feasible, noisy equipment should be housed within a building or an enclosure. The enclosures may range from a complete fully accessible room with proper air ventilation system to a structure which has side claddings that act as noise barrier.

- Insulation of equipment piping accord further noise reduction.

- The orientation of the equipment within the plant area will be such, so as to capitalise on the existing buildings and structures as noise barriers. Barrier shielding in many instances has been observed to significantly attenuate noise levels. For example, an intervening building between source and receiver may reduce the noise level by about 5 dBA.

- The layout of noisy equipment within the plant will be aligned in a manner such that the distance of the equipment from the boundary is maximized, at least 25 metres from the nearest neighbouring site boundary.

- Noise emitted by the compressors, fans and pumps can be further controlled by reducing the vibration level of the machinery and their ancillaries.

For the control of occupational noise, workers operating within noisy areas of the plant will be provided with ear plugs or ear muffs. In high noise level environments within the plant, it is advisable to wear both types in combination. The noise attenuation or protection afforded by ear protectors varies with the frequency of the noise, providing more protection at higher frequencies. At average frequencies of 500 Hz to 1000 Hz, ear plugs alone provide protection of about 22 dB (A). Ear muffs are better, providing attenuation of 30 dB(A) and in combination, the protection accorded is in the range of 34 dB(A).

8.5 WASTE

8.5.1 Construction Phase

The types of solid wastes generated during the construction phase can be broadly categorised based on their nature and ultimate disposal method into the following:

- Municipal waste;
- Scheduled waste (regulated hazardous wastes); and
- Unregulated wastes.

Improper disposal of these wastes at unauthorised areas will contribute to unhealthy and unattractive surroundings. Poor management of construction waste will result in the creation of illegal dumping grounds in secluded areas at the nearby villages and surrounding forested areas. These illegal dumps provide an ideal habitat for disease-vectors such as mosquitoes, flies and rats which potentially cause health impacts to nearby settlements. In addition improper disposal of hazardous waste will result in contamination of the soil and potentially groundwater. They also pose fire hazards during the dry seasons, clog the local drainage system and caused localised ponding and even flooding of nearby streams and river systems during the monsoon season. The dumps are also sources of adverse negative odour impacts.

The implementation of proper waste management practices within the site will minimise the impacts arising from the above waste sources. Mitigation measures recommended include:

The potential environmental impacts arising from the improper management of municipal wastes can be minimised with the implementation of the following practices:

- Good housekeeping practices are essential within the site and especially critical at the workers' camp (if set-up within the site premises).

- General construction spoil should be recycled on site as much as possible. For example, construction aggregate materials, cement and rock are readily used on site where possible as backfill material for low lying areas.

- Domestic waste generated from the workers' camps should be stored in garbage bins/secure containers and be collected regularly by a licensed contractor for disposal at an approved landfill.

- Unsalvageable construction spoil should be stockpiled at a designated site and sold to salvage yard operators or other contractors interested in recycling the material. Alternatively, disposal arrangements can be made with registered private contractors or Majlis Perbandaran Kuantanto carry out regular collection and off site disposal at the approved disposal site.

Types of scheduled wastes potentially generated during the construction phase will require proper handling, storage and disposal in compliance to the scheduled waste regulations. The copies of the waste consignment notes will be filed by the Contractor for record.

The construction works Contractor shall ensure that only licensed scheduled waste contractors are employed for the transportation of these scheduled wastes to the scheduled waste disposal facility, the Integrated Scheduled Waste Management Centre (ISWMC) at Bukit Nanas, Negeri Sembilan.

8.5.2 Operational Phase

Solids wastes generated during the operational phase of the Advanced Materials Plant include:

- Residues from the physio-chemical processes within the Cracking & Separation Plant;
- Scale from neutralisation tanks and clarifiers in the Neutralisation Plant;
- Scale from process piping and vessels that handle lanthanide sulphate solution;
- Waste refractory from kiln maintenance;
- Filter cloths from the FGD, NUF and WLP filtration processes;
- Sludge from the Waste Water Treatment Plant (WWTP);
- Scheduled wastes; and
- General wastes.

With the exception of scheduled wastes and general wastes, all other wastes listed above are classified as radioactive wastes by the Atomic Energy Licensing Board (AELB) and thus the storage and management of these wastes must comply with the applicable regulations under the *Atomic Energy Licensing Act, 1984* and, endorsed by the AELB. Matters pertaining to the on-site storage and management of these wastes come under the purview of the Board. Lynas has engaged Malaysian Nuclear Agency (Nuclear Malaysia) as the Radiological Consultants for this project and for the preparation of a Radiological Impact Assessment (RIA) which evaluates the radiological impacts of the plant operations to humans and the environment. A copy of the RIA has been submitted to the AELB for approval as part of the *Class A Milling Licence* application requirements. The Class A Milling Licence is required under the *Atomic Energy Licensing Act, 1984* for plants involved in the processing of radioactive materials.

For purposes of this EIA, only the non-radiological impacts pertaining to the waste management are identified and assessed as the management of radioactive wastes comes under the purview of the AELB.

In ensuring that the potential environmental impacts arising from the on-site storage of the radioactive residue streams are minimised to a sustainable level, the Project Proponent has developed a technically sound waste management strategy which is described Section 3.2 *'Preliminary Comparison of Residue Disposal Options'* (Refer **Appendix 3)**. It is recommended that this strategy be incorporated into the Environmental Management Plan (EMP) prepared for operational phase and endorsed by the AELB and the DOE for implementation.

The Project Proponent has commissioned a conceptual engineering design of the RSF, taking into account key engineering design and environmental considerations. Each residue stream has different characteristics in terms of water content, its composition and radioactivity. Design considerations of the RSF as well as residue management are dependent on these characteristics. One conceptual design scenario has been presented to the AELB and are currently under evaluation.

The key features of the RSF design which provides for the protection of environmental resources, namely soil and groundwater are summarised below:

- Fill material will be placed at low-lying areas to ensure that the base of the RSF is at least 1 m above groundwater level. It is recommended that the fill material comprises soils with low permeability;

- All residue storage cells will be lined with 300 mm low permeability compacted clay liner overlain by a 1 mm thick HDPE liner to prevent seepage into the underlying soil and groundwater;

- All supernatant liquors and rainfall runoff from FGD and NUF residue cells will be collected and pumped via pipeline to a HDPE-lined FGD/NUF surface water retention pond with capacity for the 1 in 100 year storm event based on climatic data for the region. Water from this pond will be directed to the Waste Water Treatment Plant (WWTP). The treated waste water will then be discharged off-site into an external earth drain which discharges into Sungai Balok. All off-site discharges will be monitored to comply with the limits stipulated in *Standard B* of the *Environmental Quality (Sewage and Industrial Effluent) Regulations, 1979*;

- Supernatant liquors and rainfall runoff from the WLP residue cell will be pumped to a separate HDPE lined surface water retention pond (with capacity for the 1 in 100 year storm event based on climatic data for the region) and subsequently recycled into the cracking and separation process stream. No off-site discharge is anticipated;

- During heavy rainfall and in particular the monsoonal wet season the surface of the residue is expected to become wet, soft and slippery making placement of residue during this period problematic due to the poor trafficability of the residue surface. Therefore, a temporary cover may be required to keep the area of active residue placement dry during the wet season. A potential solution to this problem is to size the drying shed with sufficient capacity so residue can be stockpiled during the wet season awaiting placement in the RSF during drier weather;

- To ensure a long term slope stability, perimeter RSF embankment walls will be designed and built with a gentle gradient of 3H:1V. In addition, the maximum height of embankment will be limited to 8 m above existing ground level. The preliminary slope stability assessment indicates that the proposed embankment fill height of 8m results in a FOS of less than the acceptable minimum of 1.3 under short-term undrained conditions. This can be overcome by the placement of an additional 1.0m of well compacted select fill across the RSF area. Further assessment of the consolidation behaviour of the subsurface soils is required to confirm the short-term stability of the embankments; and

- Erosion protection in the form of rip-rap or geotextiles will be incorporated.

In addition to constructing the RSF which incorporates environmental protection features, the Project Proponent is also exploring the potential beneficial uses of each of the three residue streams. The reuse of residues will significantly reduce the quantity of residue for on-site storage and the allocated footprint for the RSF within the site. Details of these reuse options are presented in the *'Preliminary Comparison of Residue Disposal Options'* presented in **Appendix 3**.

Scheduled Wastes

Scheduled wastes generated at the site can either be recycled or disposed at approved facilities. There is currently a market of spent oils, solvents, lead batteries, oil filters and paints. These can be readily sold to DOE-licensed recyclers. There are a few facilities licenced to recover spent catalyst, waste oil, spent hydraulic oil and chemicals that are discarded or off-specification located nearby in the Gebeng Industrial Area and Teluk Kalong Industrial Area.

Scheduled wastes which cannot be recycled but require disposal will need to be disposed at the Integrated Scheduled Waste Management Center (ISWMC) operated by Kualiti Alam which is presently the only licensed facility in Malaysia. Upon signing a contract with Kualiti Alam, the company will arrange for their marketing division to coordinate the entire packaging and transportation of the wastes to the integrated facility.

8.6 AMBIENT AIR

8.6.1 Construction Phase

Construction activities most likely to result in the emission of fugitive dusts include:

- Site preparation works such as excavation, levelling, compaction and trenching;
- Movement of heavy construction vehicles and machinery within the site and during transportation operations;
- Material handling (delivery, unloading and use of construction aggregates and structural fill); and
- Material/soil tracked out of the site and deposited on local roads.

The exhaust emissions emitted from vehicle and machinery engine exhaust emissions will contain NO_x, SO_x, CO, volatile organic compounds (VOC), particulates and smoke.

The frequent occurrence of rainfall (The average annual rainfall recorded at the station over the period 1951–2005 is 2,957 mm with an average of 189 rainy days annually) and the low wind speeds (mean of 3 m/s) at the plant site will tend to reduce fugitive dust entrainment from sources (e.g. stockpiled materials etc.), but will have limited effects on entrainment from mobile dust sources (e.g. mobile plant, spoil transfer operations).

Based on the above, the impacts are predicted to be generally localised within an estimated 100 m radial distance of the works area, with the implementation of standard dust control measures within the construction works site. The impacts are anticipated to be short-term, lasting during the construction phase.

Impacts arising from exhaust emission from construction plant and vehicles will depend on the number of vehicles and plant stationed on site. Details on the number and type of construction machinery had not been firmed up at the time of reporting. However, the impacts arising can be effectively mitigated with proper and regular maintenance of the emission sources which would prevent the generation of excessive noxious emissions and black smoke.

The potential air quality impacts arising from the plant site during construction works will be mitigated by observing standard dust suppression measures as described below.

- Carrying out regular surface damping or wetting on general site areas, stockpiled fill and aggregates especially during dry ambient conditions. Effective wetting of at least the initial 6 cm of the top soil is necessary. This would bind the loose soil particles, increase its effective size and weight, and reduce the amount of fugitive dust generated;

- Providing side enclosure and covering of any aggregates or stockpiles;

- Ensuring that all hardstanding areas and access roads within the site remain wet during use;

- Ensuring construction vehicles moving in/out of the site do not track soil off-site and deposit soil on public roads by providing wheel-washing facilities at the ingress/egress points. These facilities will be equipped with (1) a temporary concrete hardstanding of sufficient size to accommodate a standard sized vehicle and equipped with a sump; and (2) high pressure water jets.

- All vehicles operating within the plant site and especially within the construction works area and the ingress/egress points will adhere to speed limits not exceeding 30 km/hr.

- A 50 m road stretch on the public road before and after each ingress/egress point into the site will be wetted regularly to minimise dust emissions from the surface of the road.

- All construction vehicles transporting dusty materials should be secured with tarpaulin sheets to prevent the escape of fugitive dust.

- Open burning on the site premises is strictly prohibited on-site. All construction spoil must be transported to approved disposal sites by licensed contractors.

The control of vehicular emissions can be achieved by observing good construction practice procedures such as:

- Turning of equipment when not in use;
- Lorries/trucks waiting for more than 10 minutes should turn off their engines; and
- Regular maintenance of construction vehicles/equipment.

8.6.2 Operational Phase

8.6.2.1 Potential Sources of Impacts

Cracking & Separation Plant

Air emission sources identified within the Cracking & Separation Plant include the following:

- Tunnel furnace used for product calcination;
- Boiler used for steam generation; and
- Waste gas scrubber system.

As both the tunnel furnace and the boiler will be fuelled by natural gas, no impacts are predicted from these sources. The primary source of air emissions arising from the plant during the operational phase will be the waste gas scrubber system at the Cracking & Separation Plant. To determine the dispersion pattern of the pollutants released from the waste gas scrubber stack and to quantify their respective concentrations in the atmosphere, the BREEZE Industrial Source Complex – Short Term Version 3 with Plume Rise Enhancements (BREEZE ISC3 Prime) air dispersion model was used to predict the potential ground level impacts arising from emissions of the waste gas scrubber stack.

The BREEZE ISC3 Prime model was used to predict the maximum ground level concentrations over 1-hour, 24-hour and annual averaging periods to correspond with the relevant ambient air quality criteria for each of the modelled compounds.

As the emission from the waste gas treatment system (wet scrubber) is the primary air pollution source, an air dispersion modelling was carried out for this point source.

In developing the air dispersion model, two operational modes have been identified for the proposed plant, namely (1) normal and (2) emergency operations. Under normal operations, small quantities of sulphur dioxide (SO_2), hydrogen fluoride (HF), sulphuric acid mist (H_2SO_4) and particulate matter (PM) will be emitted from the waste gas treatment system following treatment of the kiln off-gas. Under emergency operations, SO_2 and H_2SO_4 mist will be emitted from standby caustic scrubbers following treatment of emissions from the kilns operating in shutdown mode.

A summary of the air dispersion modelling findings are presented below:

- maximum GLCs of SO_2, H_2SO_4, HF and PM_{10} below all of the applicable AAQ guidelines and STELs, across the model domain, for 1, 2 or 4 kilns operating under normal conditions and where the highest concentrations are predicted to occur in relative close vicinity to the plant;

- maximum GLCs of SO_2 below all the applicable AAQ guidelines and STELs, across the model domain, for 1, 2 or 4 caustic scrubbers operating under emergency conditions;

- maximum GLCs of H_2SO_4 below the corresponding STEL for 1, 2 or 4 caustic scrubbers operating under emergency conditions; and

- an exceedence of 1-hour H_2SO_4 AAQ guidelines under emergency operating conditions, although the worst-case probability of this operating mode occurring and resulting in an exceedence is 101 in a million.

The results of the air dispersion modelling indicate that the proposed Advanced Materials Plant is not expected to result in unacceptable air quality impacts under normal operations for SO_2, H_2SO_4, HF and PM_{10} and while exceedences of 1-hour H_2SO_4 AAQ guideline are predicted under emergency operating conditions, the frequency of this occurring is considered low.

The air dispersion modelling has been carried out based on the design stack height of the proposed waste gas treatment system, the emission rates and pollutant concentrations of the treated/exit gas, heights of the building structures proposed within the plant site and local conditions such as the meteorological conditions and the site (and immediate surrounding) topography. Therefore, in achieving the desired efficiency and meeting the predicted ground level concentrations of the pollutants under assessment, i.e. SO_2, HF, H_2SO_4 mist and PM_{10}, the waste gas scrubber design parameters will need to be maintained. In the event, there are changes in the design prior to project implementation, it is recommended that the air dispersion model be re-run and the assessment reviewed. This is to ensure the ground level concentration for the pollutants concerned meet the regulatory requirements.

8.7 BIOLOGICAL RESOURCES

8.7.1 Construction & Operational Phases

The biological resources affected in the construction phase of the project are:

- Terrestrial flora and fauna species at the propossed Advanced Materials Plant site; and
- Aquatic biological resources within Sungai Balok.

As discussed in Chapter Four of this document, prior to the development of the Gebeng Industrial Estate (GIE) in the 1990s, the area was waterlogged peat swamp forest. Ecological impacts arising from the land conversion activities have since occurred at the site. The various species of fauna that inhabited the area are expected to have perished or migrated to other forested areas nearby while the original vegetation would have been completely cleared away.

As the site had remained vacant (undeveloped) since the land conversion, it has been progressively colonised by secondary vegetation comprising the more common, hard and invasive species. Only sparse vegetation was observed across the site comprising secondary dryland scrub vegetation with low species diversity. No faunal species of conservation value is expected to occur. Any remaining vegetation removed is not significant or of conservation value.

Overall, the impact from the site activities on the terrestrial flora and fauna at the site is not considered significant.

Based on personal correspondence with the Department of Fisheries in Kuantan, the fisheries resources within Sungai Balok are not harvested for commercial fishing and livelihood. The local fishermen from the main fishing village of Kampung Balok carry out deep-sea fishing. Only recreational fishing is carried out along Sungai Balok by anglers. Common names of fish species typically found in the river include Siakap Puteh, Siakap Merah, Sembilang, Duri and Baung,

8.8 SOCIO-ECONOMIC IMPACTS

8.8.1 Construction Phase

Employment of workers to make-up the construction labour force project will be necessary during the construction phase. Although priority will be given to local residents working in this sector, employment of foreign labour may be expected in the event of local labour shortage. If the labour force is housed on-site, proper accommodation facilities will have to be provided with basic amenities such as potable water supply, electricity, solid waste disposal and sanitary treatment facilities.

The employment of foreign labour may result in the import of communicable diseases not indigenous to the area, for example malaria, dysentery and cholera which could spread to the local residents, in the event of poor hygiene practices, as these diseases are vector borne or waterborne.

To prevent undue aberrations with the local community, the nominated EPCM Contractor when hiring foreign labour must ensure that the workers are legally registered with the Department of Immigration.

8.8.2 Operational Phase

Significant long-term positive socio-economic impacts are predicted during the operational phase of the project at a regional and national level.

8.9 CONCLUSION

The findings of this report indicate that the predicted environmental impacts arising from the construction and operational phases of the Advanced Materials Plant can be effectively mitigated and reduced to meet regulatory limits with the implementation of appropriate mitigation measures. The findings also show that there are no detrimental or harmful impacts which cannot be mitigated or, are unavoidable.

The recommended mitigation measures include technologically sound practices and environmental best management practices that will minimise the potential impacts to sustainable levels. To ensure the effectiveness of the mitigation measures, an Environmental Management Plan which includes requirements for periodical environmental monitoring and audits for the construction and operational phases of the project will be developed and implemented. This is to ensure that all recommendations of this EIA and the requirements of the relevant government agencies are executed by Lynas.

The Project Proponent is committed to operating the plant in an environmentally sustainable manner, in compliance with all prevailing environmental regulations.