27. ENVIRONMENTAL HAZARD ASSESSMENT

27.1 Introduction

This chapter outlines the environmental hazard and risk management systems for the PNG LNG Project in the context of Papua New Guinea and international standards and guidelines, as well as internal ExxonMobil standards, philosophies and specifications (Sections 27.2 and 27.3). It also describes the results of hazard assessments undertaken for the project in terms of the identification of hazardous scenarios, potential receptors and mitigation measures (Section 27.4).

The focus of this chapter is on major hazards, which are defined here as scenarios or incidents resulting from the project that may cause adverse, off-site impacts in terms of acute or chronic human health issues, injuries or fatalities, or major impacts on the natural environment.

27.2 Legislative Framework and Guidelines

27.2.1 PNG Legislation

PNG legislation does not contain any specific requirement that an environmental hazard identification or risk assessment be undertaken for this type of project. However, as outlined in Chapter 8, Legal Administrative and Planning Framework, the PNG *Environment Act 2000* and the PNG *Oil and Gas Act 1998* apply to this project. By definition, this requires understanding all potential aspects of a project's activities with the potential to result in impacts and means of risk assessing and mitigating these environmental hazards.

27.2.1.1 *Environment Act 2000*

Section 7(1) of the Environment Act imposes a general environmental duty on persons not to carry out an activity that causes or is likely to cause an environmental harm unless that person takes all reasonable and practicable measures to prevent or minimise that harm.

27.2.1.2 *PNG Oil and Gas Act 1998*

The PNG *Oil and Gas Act*, s. 115, states that the licensee shall be responsible for, and repair any damage resulting from his operations or from the flow of petroleum, petroleum products, water or waste to any improvements, any land capable of being used for any agricultural purpose or the water supply to such improvements or land.

27.2.2 World Bank

27.2.2.1 IFC Environmental, Health and Safety Guidelines and Performance Standards

The International Finance Corporation (IFC) World Bank Group has published a set of environmental, health and safety (EHS) guidelines, which are technical reference documents with general and industry-specific examples of good international industry practice. These guidelines provide an international standard for EHS practices and will be taken into consideration in the preparation of the project environmental management plan (see Chapter 30, Environmental Management, Monitoring and Reporting), in relation to detailed design of the project.

27.2.2.2 World Bank Environmental Assessment Sourcebook

Additionally, the World Bank has published an environmental assessment sourcebook (World Bank, 1997), which requires that environmental hazard identification, including potential receptors and consequence analysis, is undertaken for its projects. The outcomes of this analysis are generally reported in the EIS (in chapters 18 to 26) and for this project, are summarised in Section 27.4, Potential Environmental Hazards and Mitigation Measures. Additionally, the sourcebook states that, in some instances, a risk assessment of these hazards should be undertaken. ExxonMobil undertakes a comprehensive internal risk assessment for all relevant components of its projects. The process and framework by which ExxonMobil undertakes these impact assessments is outlined in Section 27.3, Project Risk Management Approach and Design Criteria.

27.3 Project Risk Management Approach and Design Criteria

27.3.1 ExxonMobil Environment Policy and Risk Management Framework

Management of hazard and risk is integral to ExxonMobil's business and philosophies and is undertaken in consideration of international and local guidelines and legislation, including all those outlined in Section 27.2. The PNG LNG Project has adopted the applicable components of the ExxonMobil Environment Policy (see Figure 1.5). In regard to the management of hazard and risk, the policy requires ExxonMobil to:

- manage its business with the goal of preventing incidents and of controlling emissions and wastes to below harmful levels; design, operate and maintain facilities to this end;
- respond quickly and effectively to incidents resulting from operations, cooperating with industry organizations and authorized government agencies.

To fulfil this policy, ExxonMobil has developed an Operations Integrity Management System (OIMS). The OIMS standards can be applied to projects in all parts of the world as specific project philosophies and specifications, taking into account relevant national and international standards as required. The OIMS (provided as Attachment 6, ExxonMobil Operations Integrity Management System) is compliant with ISO 14001, the International Organization for Standardization's standard for environmental management systems.

Two elements of the OIMS that are specifically applicable to environmental hazards and risks are:

- Element 2 – Risk Assessment and Management. Comprehensive risk assessments are undertaken to reduce safety, health, environmental and security risks and to mitigate the consequences of incidents by providing essential information for decision making. risk is managed by identifying hazards, assessing consequences and probabilities, and evaluating and implementing prevention and mitigation measures and provides that systematic reviews be undertaken of risk assessments.
- Element 3 – Facilities Design and Construction. Inherent safety and security can be enhanced and risks to health and the environment minimised by using sound standards procedures and

management systems for facility design, construction and startup activities. This applies to all construction projects from small improvements to major new expansions are evaluated early in their design for safety, health and environmental impact.

27.3.2 ExxonMobil Environmental Standards

As discussed above, ExxonMobil follows international environmental standards and guidelines that apply to projects the world over and that can be refined into project philosophies and specifications for individual projects. Some of these standards apply to risk management for this project, such as standards relating to flaring and venting, land use, waste management and emission controls.

27.3.3 ExxonMobil Philosophies

ExxonMobil formulates philosophies specific to each project and to individual components of projects. Loss prevention philosophies have been developed for both the upstream and LNG Facilities site components of the project. These philosophies outline the general requirements to prevent personal injury or loss of life and to protect the environment. As part of the loss prevention philosophies, formal hazard assessments are required to be carried out progressively during the execution of the project. The loss prevention philosophies also require that the potential for hazardous scenarios is reduced by the use of design strategies, guidelines and specifications for the project. Items that are included in the design strategy that are relevant to the avoidance/reduction of significant offsite impacts are:

- Plant layout.
- Design accidental loads.
- Minimisation of accidental releases.
- Ignition of accidental releases.
- Fire and gas detection.
- Fire protection.
- Passive fire and blast protection.
- Process control and alarms.
- Emergency shutdown and blowdown.
- Pressure relief, flare and vapour disposal.
- Open and closed drains.

A description of these components and specific mitigation measures is provided in Section 27.4.3, General Mitigation Measures.

27.3.4 Technical Standards and Design Codes

The PNG LNG Project will also be designed, constructed, maintained and operated according to a wide variety of international technical codes and standards. A list of the design codes and standards applicable to this project is given in Attachment 3, Technical Codes and Standards.

27.3.5 ExxonMobil Development Company Risk Management Plan

To fulfil element 2.1 of the OIMS[1] and the loss prevention philosophies for the project, a risk management plan has been formulated by ExxonMobil for the PNG LNG Project, including both the upstream and LNG Facilities site components. The risk management plan is a comprehensive framework that provides the means by which all known elements of the project will be assessed for risk by identifying hazards, assessing consequences and probabilities, and implementing prevention and mitigation measures. The risk management plan contains specific objectives and means by which the objectives will be met.

The specific risk management objectives for the PNG LNG Project are:

- Risks related to project execution and operations are identified by a structured approach to risk identification.
- Risk assessments are planned and conducted in advance of appropriate project milestones or activities to allow resolution of risk without schedule disruption.
- Appropriate personnel are included in risk assessments to ensure risks are correctly identified and assessed.
- Results of risk assessments and the associated risk reduction measures are evaluated by appropriate levels of management and are documented, executed, and monitored to completion to reduce risks to an acceptable level at a reasonable cost.
- Risks and associated resolutions are documented for hand-over to operations personnel, who will take over operations of the completed facility.

The risk management plan contains a sequence of risk management activities designed to ensure that the risk assessment is fully carried out at specific stages of the project lifecycle, documented and closed out. This plan is a dynamic document that will be updated as the project progresses. At the time of writing this EIS, the risk assessment had been undertaken for some components of the process. However, other components have yet to undergo ExxonMobil's formal risk assessment. These include formal hazard assessments that are required to be carried out progressively during the planning of the project as it progresses through FEED and detailed design. The design philosophies also require that the potential of hazardous scenarios be reduced by the use of design strategies, guidelines and specifications for the project. Items that are to be incorporated in the design strategy include:

- Plant layout.
- Design accidental loads.
- Minimisation of accidental releases.
- Ignition of accidental releases.
- Fire and gas detection.
- Fire protection.
- Passive fire and blast protection.
- Process control and alarms.
- Emergency shutdown and blowdown.

[1] Risk is managed by identifying hazards, assessing consequences and probabilities and evaluating and implementing prevention and mitigation measures.

- Pressure relief.
- Flare and vapour disposal.
- Open and closed drains.
- Physical and biological hazards.
- Abnormal operations.

These are to be assessed for environmental hazards and risk as the project progresses.

27.4 Potential Environmental Hazards and Mitigation Measures

A hazard identification and mitigation workshop was held with ExxonMobil in advance of the selected formal risk assessments in order to report on potential hazards and to identify mitigation measures for the upstream components of the project with facilities and pipeline FEED engineers. Results of the workshop have been summarised and are given in Attachment 5, Hazard Identification Summary, and the outcomes of this workshop are reported below in Section 27.4.1, Upstream Hazard Summary, and in Section 27.4.2, LNG and Marine Facilities Hazard Summary. Further description of the mitigation measures are provided below in Section 27.4.3, General Mitigation Measures. Additional environmental risk assessment and modelling for upstream components are scheduled during FEED and detailed design.

27.4.1 Upstream Hazard Summary

27.4.1.1 Wells and Gathering Systems

The wells for the PNG LNG Project will include eight new wells and workovers of two existing wells at the Hides Gas Field, two new wells at Angore Gas Field, four new wells at Juha Gas Field and two new wells at the South East Hedinia oil field (see Chapter 2, Producing the Gas). The typical environmental hazards associated with well sites are impacts to soil (see Section 18.2, Landforms and Soils), groundwater (see Section 18.3, Groundwater), surface water (see Section 18.4, Water Resources and Hydrology) and vegetation (see Section 18.7, Biodiversity). These hazards generally result from operational upsets during drilling and well operation, which will be mitigated through engineering design controls.

The principal hazards connected with well drilling and operation are releases of hydrocarbons and fire.

Gas or condensate releases could be caused, for example, by formation of hydrates in the pipe, by failure of emergency shutdown valves or pressure safety valves or by a pipe blockage, combined with other control failures. Diesel releases could be caused by leakage from a major rupture of a storage container, line or pump. Such releases have the potential to contaminate soil and water if not contained, with consequent negative impacts on terrestrial and aquatic ecology and downstream water users. Additional information on principal issues associated with soils, surface water, groundwater and terrestrial ecology is provided in Chapter 18, Environmental Impacts and Mitigation Measures: Upstream Facilities and Onshore Pipelines.

Fires could be caused by ignition (for example, from lightning strike or electrical equipment) of a gas or condensate release or a diesel leakage (see Attachment 5, Hazard Identification Summary). A wildfire started in such a way would produce environmental damage to terrestrial flora and fauna, as well as property and gardens, with subsequent impacts to watercourses from ash and eroded soil.

Mitigation measures include an automatic gas detection system on the drilling rig, which will inform drilling personnel in the event of a gas release in the well bore and allow the release to be controlled. There are a number of ways to prevent gas release and limit the risks of fire starting or spreading, including:

- Increasing the weight of the drilling mud.
- Installing automatic shutdown of valves in the gathering system on detection of a pressure drop to reduce the amount of gas or condensate released.
- Fencing of wellpads to restrict access and signalling to the security room if a gate in the fencing is opened.
- Remote monitoring of all operational wellpads.
- Spacing of equipment to limit fire escalation and equipment damage.
- Bunding of diesel storage areas.
- Developing a spill response plan (for condensate and diesel).
- Following the prescribed maintenance and inspection procedures for all equipment.
- Clearing of vegetation on the sites to reduce the risk of fire spreading to vegetation.
- Properly protected and certified electrical equipment to reduce ignition risk.
- Adherence to PNG-specific and international design standards, industry codes and specifications and ExxonMobil practices for the equipment and procedures used during well drilling and operation.

Details of proposed mitigation and management measures relating to the wellpads and gathering systems are set out in Section 18.2.2.1, Construction.

27.4.1.2 Processing Facilities

The gas processing facilities for the PNG LNG Project will consist of the Hides Gas Conditioning Plant and the Juha Production Facility.

The Hides Gas Conditioning Plant will separate, dehydrate, condition and compress the gas from the Hides, Angore and Juha fields, and also treat the liquids from those fields to produce a stable condensate product. The gas will be transported by pipeline to the LNG Plant, and the condensate will be transported by pipeline to the existing Kutubu Central Processing Facility. Utilities required to complement the new gas conditioning plant, such as electricity, fuel gas system, mono-ethylene glycol (MEG) regeneration and storage, utility and potable water systems, will also be housed at the Hides Gas Conditioning Plant. A control centre will be situated at the Hides plant to control the Hides Gas Conditioning Plant, the Juha Production Facility, the gathering systems at Hides, Angore and Juha, and all of the project pipelines.

The Juha Production Facility will receive and separate well products from the Juha gas field into gas and liquids for delivery via pipelines to the Hides Gas Conditioning Plant. This smaller production facility will comprise components similar to the Hides Gas Conditioning including inlet facilities to separate hydrocarbon liquids and gas, gas dehydration and compression.

Modifications will also be made to three existing facilities: the Gobe and Agogo production facilities and the Kutubu Central Processing Facility. These plants are already in operation and are governed by their own environmental licenses and approvals. New major hazards at these facilities resulting from the PNG LNG Project are not anticipated.

Further details on the processing systems are given in Chapter 2, Producing the Gas.

The sources of environmental hazards at the Hides Gas Conditioning Plant and the Juha Production Facility will be similar in nature and predominantly relate to the potential for major liquid and gas hydrocarbon spills or leaks through failure or damage to equipment from natural causes (e.g., earthquake, landslide), third-party interference, or equipment or systems failures.

A large hydrocarbon liquid spill or leak at either facility could result in impacts to soil (see Section 18.2, Landforms and Soils), groundwater (see Section 18.3, Groundwater) and surface water (see Section 18.4, Water Resources and Hydrology) in the surrounding areas. The consequence of impacts to water resources in the vicinity of the Hides Gas Conditioning Plant could be severe given the proximity of local settlements and landowner dependence on freshwater resources for food (fish) and water. Contamination of soils from a hydrocarbon spill would have consequent impacts on vegetation.

Ignition of a liquid hydrocarbon spill or leak would have the potential to expand beyond the site as wildfire, threatening local people and nearby flora and fauna (see Attachment 5, Hazard Identification Summary).

Uncontrolled spills or leaks of hydrocarbon gases from buried or submerged infrastructure would permeate through soil and water. The affects tend to be more localised and dissipate as the gas disperses into the atmosphere.

Planning, engineering design and operation controls will all contribute to mitigate potential major hazard events at the processing facilities. Planning controls involve multiple geotechnical investigations to establish subsurface conditions to reduce the risk of plant failure or ruptures in the event of rock movement or soil slip due to earthquakes or landslides. The layout of the Hides Gas Conditioning Plant has been orientated to increase the dissipation of vapours away from sensitive receptors, such as nearby settlements. Security fencing will maintain a 100-m-wide safety buffer between the plant and the security fence, and a further 100-ha buffer zone will surround the site inside a property-line fence (see Section 2.3.1, Hides Gas Conditioning Plant). Local landowners will not be allowed to construct dwellings or gardens in the buffer zone. Vegetation will be cleared around the security fence line to limit an uncontrolled fire moving offsite. Various hydrocarbon safety zones will be established to ensure proper distances are maintained between, for example, the hydrocarbon process areas and the sleeping and general office areas.

Systems controls to mitigate hazards will include pressure relief through a mechanical flare system, an electronic management system to reduce pressure to 690 kPa after 15 minutes, automated control and shutdown systems, and an active firewater deluge protection system that will mitigate escalation of fire by cooling down equipment.

At the Hides Gas Conditioning Plant, diesel tanks will be purpose-built, above ground and within containment bunds. Prior to the operation of the facility, spill response plans will be in place. There will be no storage of produced hydrocarbon products at the Juha Production Facility during operations.

27.4.1.3 Pipelines

The PNG LNG Project will require five gas pipelines and three condensate or liquids pipelines:

- The LNG Project Gas Pipeline from the Hides Gas Conditioning Plant to the LNG Facilities site. This pipeline includes an onshore component from the Hides Gas Conditioning Plant to the Omati River Landfall, as well as a marine section from the Omati River Landfall across the Gulf of Papua to the Caution Bay Landfall near the LNG Facilities site.
- The Juha–Hides Rich Gas Pipeline from the Juha Production Facility to the Hides Gas Conditioning Plant.
- The Kutubu Gas Pipeline, the Agogo Gas Pipeline and the Gobe Gas Pipeline from the respective production and processing facilities to the LNG Project Gas Pipeline.
- The Juha–Hides Liquids Pipeline from the Juha Production Facility to the Hides Gas Conditioning Plant.
- The Hides–Kutubu Condensate Pipeline from the Hides Gas Conditioning Plant to the crude oil storage tanks at the Kutubu Central Processing Facility.
- The Hides–Juha MEG Pipeline from the Hides Gas Conditioning Plant to the Juha Production Facility.

Further details on the transportation system are given in Chapter 3, Transporting the Gas.

Excavation for the pipelines, as well as other project-related linear infrastructure, may pose a risk to public safety. Contractors will be required to develop a project-specific safety plan and to perform risk assessments for various activities, including excavations. Site-specific security measures will be considered and appropriately applied at excavation sites. These measures will include security (watchmen), active dewatering, provision of a physical barrier, community awareness programs and signage as appropriate [M55].

The environmental hazards for the onshore pipelines include fire, explosion, and hydrocarbon leaks or spills; the causes of these hazards are pipeline rupture or leak and damage to or collision of a fuel truck. The types of impacts to soil (see Section 18.2, Landforms and Soils), groundwater (see Section 18.3, Groundwater), surface water (see Section 18.4, Water Resources and Hydrology) and vegetation (see Section 18.7, Biodiversity) are the same as those mentioned under 'Wells and Gathering Systems' above. The extent of the potential environmental hazard increases with the pressure and volume of the pipeline contents and the segment length between safety valves.

Potential causes for rupture can be grouped as natural hazards, such as earthquakes, landslides, karst collapse (sinkhole) or flash floods, or as operational hazards, such as corrosion, unintentional contact with the pipelines, or vehicle or vessel damage. The hazards for the upstream pipelines are primarily mitigated through engineering design and controls. The engineering controls are comparable to the gathering system, however, due to the length of these pipelines, expanded design controls are needed. These include cathodic protection to reduce corrosion, SLE (serviceability limit event), which allows the pipeline to continue to operate after a hazardous event, and DLE (ductility limit event), which allows the pipeline to deform in a seismic event in a manner that will still contain the gas.

Design parameters include pipe wall design (thickness), above ground design (e.g., zigzagging) and design of fill padding around the pipe. Pipelines will also have design considerations for spanning cavities resulting from potential karst collapse. There will be an expansion of emergency shutdown systems and automated block valves (up to 80 km) according to the requirements of AS 2885 (Australian Standards, 2003).

As described in Section 3.3.2, LNG Project Gas Pipeline, the depth of pipeline burial will be increased from the normal 750 mm to 1,200 mm under roads.

In addition to engineering design and controls, pipeline route planning has a major input to hazard avoidance. As described in Section 6.1.1, Routing Constraints and Criteria, the pipeline has been rerouted in several areas to avoid geotechnical hazards such as earthquake zones and fault lines, side slopes and other potentially unstable ground. Where a pipeline is above ground, it will be located at least 1 km away from known sensitive receptors. Routine ROW maintenance during operations will include visual aerial inspections to inspect the integrity of the pipeline. Pipeline marker signs will be installed so that the public will be aware of pipeline location, to help avoid interference and to aid in maintenance and possible emergency response (see Section 3.3.6.6, Pipeline Marker Signs).

The environmental hazards associated with the offshore segment of the LNG Project Gas Pipeline from the Omati River Landfall to the Caution Bay Landfall are explosion of gaseous hydrocarbons during operations and fuel spills during construction (see Attachment 5, Hazard Identification Summary).

Explosion of gaseous hydrocarbons could be caused by ignition following rupture of the pipeline by third-party interference (such as anchor drag, keel impact, trawl-board impact, or dynamite fishing), internal or external corrosion or construction flaws, or a geohazard event (such as a subsea landslide). Such a fire and explosion could cause fatalities for any people on boats in the immediate vicinity, damage to coral bommies or reefs in the vicinity.

Pipeline rupture is the main operational environmental hazards of the offshore pipeline. Processed natural gas hydrocarbon has a soluble component and is an asphyxiant. The impact associated with a subsea release would be localised and affect all marine life within the vicinity of the release. There is also a risk of leak due to corrosion, weld failure and unintentional third party contact with the pipeline.

Corrosion of the pipeline will be mitigated through the use of chemical corrosion inhibitor and properly ensuring the pipeline is fully wrapped and encased during its construction. As described in Section 3.6.3.2, Pipeline Stabilisation and Protection, there are a number of engineered controls that may be used, including burying the pipeline in the shallow water of Caution Bay and at the approaches to landfall at Omati River or using grout bags and rock armour to stabilise and protect against anchors.

Risks of physical damage, for example from fishing gear, anchors or insufficient keel clearance will be mitigated by concrete coating protection, and burial in the nearshore areas of most vessel activity.

In order to understand the risk conditions likely to be encountered in Caution Bay, detailed design and modelling assessments will be undertaken that will take into account the under keel clearance (for shipping channels), dragged anchor assessment (sizes of anchor that may damage pipeline), and trawl board impact assessment. This will determine the need for mitigation such as rock protection and or mattressing. While trawl gear is not likely to be encountered in Caution Bay, other fishing practices such as dynamite fishing are known to occur and the potential risks to the pipeline to assist in the design and/or installation of the pipeline need to be assessed. This is to be conducted during the FEED process. Surveys will also identify any unexploded ordnance requiring clearance prior to construction.

Fuel spills could also occur, for example from the lay barge and support vessels could be caused by vessel collisions or grounding.

Potential collisions will be mitigated by maintaining a 500-m-wide safety exclusion zone between the laybarge spread and other (non-project) marine vessels. The project will comply with the International Convention for the Prevention of Pollution from Ships (MARPOL, 1973/1978) for the management of hazardous materials and a detailed spill response plan will be conducted during FEED and detailed design. A geophysical survey will be completed prior to construction to identify features of natural (e.g., reefs) or anthropomorphic (e.g., shipwrecks, unexploded ordnance) origin on the seafloor that could reduce pipeline integrity. A remotely operated vehicle (ROV) will be used during installation of the pipeline to monitor for undersea structures that could put the pipeline at risk.

27.4.2 LNG and Marine Facilities Hazard Summary

The LNG Facilities site will be constructed on a site that has been substantially modified by previous agriculture and the now frequent seasonal grassfires, but is relatively flat and dominated by grassland.

27.4.2.1 LNG Plant

Environmental hazards associated with the construction of the facility mirror those of pipeline construction, although the site will not interact with as many ecological settings. Predominantly, the environmental hazards for the construction phase are large volume fuel release within a storage area (see Attachment 5, Hazard Identification Summary). This contingency will be mitigated by bunding and an emergency spill response plan outlined in the environmental management plan. The other environmental hazard is uncontrolled runoff into the Vaihua River or other receiving watercourses, which will be managed by a sediment and erosion control program identified in the surface water and stormwater management plan. Details of the sediment and erosion mitigation measures that will limit the mobilisation and dispersion of sediment into freshwater and estuarine environments are addressed in Section 20.4, Hydrology and Sediment Transport, and in Section 20.5, Water Quality.

Environmental hazards associated with the operation of the facility are dominated by large uncontrolled releases of condensate, process chemicals and hydrocarbon liquids. These scenarios may result from seismic events, blast impacts, operations overfill, third party interference and equipment failure. Spills have the potential for mobility of condensate and process chemicals through the soil to interact with the soils and surface/sub-surface water. Engineered controls such as lined storage areas, bunding and surface water runoff controls as well as operating controls, security systems and testing procedures will provide mitigation against spills. Additionally, released LNG may result in a vapour cloud, causing a localised impact. Engineering controls, such as emergency shutdown devices, pressure safety valves, emergency flaring and venting, will assist in mitigating these hazards. Further details of the ignition characteristics of LNG, past incidents and safety requirements are outlined in Section 1.1.1, Liquefied Natural Gas and given in more detail in Attachment 1, LNG Safety.

Accidental ignition of uncontrolled petroleum releases has the potential for explosion and escalation to the surrounding area. The establishment of a safety zone around the LNG Facilities site and a marine exclusion zone around the LNG export and condensate berth will mitigate against public injury offsite. Engineering design controls such as the safe siting of potential ignition sources will also reduce the likelihood of accidental ignition occurring (see Section 4.2.1.3, LNG Facilities Layout). Further studies, which are to be conducted during the FEED and detailed design, include geotechnical studies at the LNG Facilities site.

27.4.2.2 Marine Facilities

The construction of the LNG Jetty/Materials Offloading Facility is described in Section 4.9, Constructing the LNG Jetty. The environmental hazards associated with construction of the marine facilities relate to the potential of a major fuel spill from a vessel collision, grounding or leak, which would impact the important fishing and mangrove resources of Caution Bay. Further studies during FEED and detailed design will include detailed assessment of potential spills and consequences for the design of mitigations and input to emergency response planning.

Operational environmental hazards and mitigation measures associated with the marine facilities arise from condensate or vapour release during loading. These releases could result from LNG surge pressures and operational deficiencies during loading. As described above in Section 27.4.2, LNG and Marine Facilities Hazard Summary, processed natural gas has a soluble component and is an asphyxiant. LNG will behave in the same way once its pressure has equalised. The impact associated with a release would be localised and would affect marine life within the vicinity of the release. Operational controls, engineering controls, such as shut off valves and emergency spill procedures will be the dominant mitigation measures to reduce the likelihood of such a release occurring.

27.4.3 General Mitigation Measures

In addition to the above specific mitigation measures under each identified hazardous scenario, general mitigation measures have been designed to limit the escalation of a series of minor events (such as spills or leaks), none of which is, by itself, a major hazard. Therefore, all of the facilities (both upstream and the LNG Facilities site) shall be designed to detect conditions that could lead to hazardous situations that need rapid (and automatic where necessary) application of corrective measures.

On normally manned facilities, personnel are trained to manage operational activities with the highest regard for safe procedures and to react appropriately in the event of emergencies. The safety of the facilities requires that plant is inspected and maintained, safe procedures are used, and improved based on experience, to minimise the probability of occurrence of hazardous conditions. On unmanned facilities, fire protection systems shall be provided where required.

The following design measures and planning (the majority of which are standard to ExxonMobil operations), will contribute to reducing the potential for hazard events to occur.

27.4.3.1 Plant and Facilities Layout

Plant spacing will be based on the results of gas dispersion, fire radiation and blast overpressure studies being undertaken to reduce risk of escalation of site and equipment damages.

27.4.3.2 Design Accidental Loads

Design accidental loads shall be developed based on assessment of fire and explosion loads to which critical equipment and structures will be designed. Accidental loads will include:

- **Fire loads.** Fire loads are as a result of jet fires and pool fires. A fire hazard assessment will be conducted to identify the impact of potential fire scenarios.
- **Extreme low temperature loads**. Extreme low temperature loads are as a result of leaks and spills of cold (e.g., cryogenic) fluids. The facility design for cold spills will consider the potential for leak, the duration of leak, the structural elements potentially exposed and the potential for escalation of an incident resulting from failure of exposed structural elements.
- **Explosion loads**. Project blast criteria will be established based on an explosion hazard assessment, which will estimate the effects of possible vapour cloud explosions on facility buildings.
- **Dropped object loads**. The design criteria for equipment from dropped object loads is dependent on the weight of lifts, the lift height, their location and the frequency with which operations will be performed. The dropped objects studies (offshore) for the facility will identify specific criteria for protection of equipment as required. At the onshore facilities, lifts over equipment require risk assessment and may result in protecting the equipment during the lift.

27.4.3.3 Minimisation of Accidental Releases

The process design will be such that inventories are minimised, using the smallest vessel and tank sizes consistent with separation and stabilisation requirements, and the design of plant, structures and piping that complies with recognised industry codes and standards for LNG plants.

27.4.3.4 Ignition of Accidental Releases

The probability of the ignition of accidental releases of flammable and combustible materials will be reduced to acceptable levels by plant layout, separating areas of potential release from potential ignition sources and by the application of hazardous area classification rules.

27.4.3.5 Fire and Gas Detection

A system of open and closed drains, connecting to appropriate retention and treatment ponds will be constructed to separate clean from potentially contaminated surface water. Open drains will direct surface water to stormwater retention ponds for settlement. Oily wastewater drains will direct potentially contaminated runoff, washdown, spillage and firewater from sealed (bunded) process areas to retention ponds via appropriate separators and treatment systems.

Detection of an accidental release of toxic or combustible gas (beyond predetermined threshold limits), or fire, by means of a fixed automatic fire and gas monitoring system, will initiate a dedicated alarm (both auditory and visual). The system will be activated by heat, smoke, products of combustion, flame, or any other phenomena indicative of fire or incipient fire in the protected space. The fire detections systems will automatically place active fire protection systems and shutdown systems on standby, or, subject to specific hazard assessment, automatically activate them.

27.4.3.6 Fire Protection (and Passive Fire and Blast Protection)

Both passive and active fire protection techniques will be used, as appropriate for the specific hazards.

Active systems will constitute fixed automatic water spray deluge systems with water supplied by pumps, foam systems for hydrocarbon spill areas and other areas as determined by further hazard analysis. Fixed self-contained automatic water mist systems will be used in turbine and diesel engine enclosures.

Provision will be made for first line fire fighting by the supply of hand-held fire-fighting equipment (e.g., portable fire extinguishers and fire blankets) as appropriate for the local hazards.

Active firewater protection systems will be used for major fixed facilities or elsewhere when determined by further hazard analysis. The primary use of water for fire protection in process areas is for cooling facilities exposed to radiant heat or engulfed in flame to reduce event escalation. Firewater will be directed to the wastewater treatment ponds as indicated in Section 4.2.4.5, Wastewater Treatment Systems.

Passive systems will include design such that blast pressures and fire loads are taken into account in structural design as well as the use of passive fire protection coating, which will be applied to all integrity critical components[2] where pool or jet fire hazards exist.

27.4.3.7 Process Control and Alarms (Process Control System)

A system of alarms will be initiated in the event that process parameters are unable to be kept within their design limits, notifying the control room operators that their intervention is required.

27.4.3.8 Emergency Shutdown and Blowdown

An independent emergency shutdown and blowdown system will be provided.

Sensing instruments, independent of the process control system, will monitor process conditions, so that, if operators are unable to correct parameter excursions notified by the process control system alarm system, the emergency shutdown system will intervene to restore the process to a safe condition. This will be normally accomplished by isolating the affected plant from its feedstock, but may be escalated to remove the affected plant's inventories to a safe disposal facility, such as the flare. If required, the entire process will be brought to a stop, and the plant made safe.

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[2] Integrity critical components are defined as those which, when removed, lead to progressive collapse of the primary structure based on a missing member and joints analysis.

27.4.3.9 Pressure Relief, Flare and Vapour Disposal

A pressure relief, flare and vapour disposal system will be provided. This system provides an additional independent layer of over-pressure protection. It is considered to be a secondary layer, because it is not expected to operate unless there has been a functional failure of the process control system and safety instrument system, or an accident load in excess of the design accident loads used in capacity and functional assessments. The pressure relief system will be in the form of pressure relief valves, discharging either to the flare, or to a local vent to a safe disposal area.

27.4.3.10 Ventilation of Manned Areas

Vents will be located such that harmful levels of vent gases are not experienced in manned locations, and such that gas detectors are not initiated in low wind conditions.

27.4.3.11 Open and Closed Drains

Process chemicals and fuel liquids will be in secure storage containers for the upstream facilities. Impervious secondary containment will be provided to contain 110% of the largest tank volume of MEG or diesel liquid storage areas. Provisions will be made for the drainage of water from these bunds such that there can be no overflow of liquids from the bunds under the worst-case storm inundation event.

27.4.3.12 Establishment of Exclusion Zones

The system of lease boundary and exclusion fencing is described in Section 4.2.1.4, Fencing and Exclusion Zones, and shown in Figure 4.1 and is based on the National Fire Protection Association regulatory requirements for distance from LNG tanks to property line, as well as the results of dispersion modelling and risk criteria associated with ignition sources. Additionally, the marine exclusion zone has been established to prevent an ignition source from entering any area that may contain vapours associated with LNG loading. The exclusion zone is based on International Maritime Organization and United Nations Law Convention on the Law of the Sea distances, combined with the results of a preliminary risk assessment on blast impact distances.

27.4.3.13 Emergency Response Planning

Emergency response procedures for the marine area surrounding the LNG loading facilities will be formulated to contain and limit an emergency situation should one arise. This will include mobilising vessels to evacuate third parties from the area that could be affected by a vapour cloud in order to remove ignition sources. These procedures will be based on risk contour modelling of vapour cloud dispersion and will be updated for different weather conditions.

27.5 Further Assessment

Environmental impacts associated with the PNG LNG Project have been described in Chapter 18, Environmental Impacts and Mitigation Measures: Upstream Facilities and Onshore Pipelines, Chapter 19, Environmental Impacts and Mitigation Measures: Offshore Pipeline, Chapter 20, Environmental Impacts and Mitigation Measures: LNG Facilities and Chapter 21, Environmental Impacts and Mitigation Measures: Marine Facilities with mitigation measures and residual Impact described. As ExxonMobil progresses past the approval stage of the project an into the design stage, environmental hazard and risk will be assessed and mitigated through FEED, emergency response planning and development of Environmental Management Planning as introduced in Chapter 30, Environmental Management Monitoring and Reporting.