Attachment 5. Hazard Identification Summary Tables

1. Upstream Hazard Summary

The following tables contain hazards and mitigation measures that were identified by ExxonMobil in the Upstream Hazard Identification Workshop as having potential offsite impacts.

1.1 Wells

Table 1.1 Fire from vapour cloud ignition during well operation (for Hides, Juha and Angore)

Cause	Release of large hydrocarbon vapour cloud resulting from a hydrate formation in the main line in conjunction with the failure of emergency shutdown valves and pressure sensitive valves, as well as ignition.
Consequence	Fire with potential for escalation to vegetation, resulting in wildfire and environmental damage to terrestrial flora and fauna, in particular to forest ecology, as well as contamination of water sources from ash and eroded soil.
Receptors	– Terrestrial and aquatic flora and fauna. – Watercourses. – Area around Hides is sparsely populated. Unlikely to be receptors nearby. Siabi Village is located approximately 2 km west of Wellpad C at Juha. Angore field located approximately 2 km from Angore village.
Mitigation	– Automatic and manual shutdown of five valves. These valves are located along the pipelines associated with the gathering system, which include the flow line shutdown valve, choke valve, master valve, subsurface safety valve and wing valve. Following 30 seconds of high-pressure venting, the pipeline flow will be restricted by the valves and will limit the amount of gas released. – After approximately 10 years, line pressure will fall below maximum allowable operating pressure and venting will not be required. – Fencing of wellpads will be used to restrict access to the wellpads. In addition, the gates will sound an alarm at the security room when opened. – Wellpads will be constructed to maintain minimum equipment spacing to reduce the risk of equipment damage resulting from a release. – Operational wellpads will be monitored remotely as unmanned stations, with the exception of routine monitoring and maintenance.

Table 1.2 Fire from condensate ignition during well operation (for Hides, Juha and Angore)

Cause	Ignition (for example, from lightning strike or electrical equipment) of condensate release due to pipe blockage, as well as failure of shutdown procedures.
Consequence	Fire with potential for escalation to vegetation, resulting in wildfire and environmental damage to terrestrial flora and fauna, in particular to forest ecology, as well as contamination of water sources from ash and eroded soil. Large-scale condensate releases have the potential to sterilise soil and contaminate water if not contained, with consequent negative impacts on terrestrial and aquatic ecology.
Receptors	As for Table 1.1 and: – Soils
Mitigation	– Spacing of equipment to limit escalation and equipment damages. – Spill response plan. – Pressure sensitive valves will detect drop in pressure from large condensate release and limit the size of the spill. – Fencing of wellpads and gate signal reports on open status to security room. – Site cleared to reduce risk of escalation to vegetation. – Electrical equipment in hazardous areas appropriately protected and certified to reduce ignition risk.

Table 1.3 Fire during well drilling (for Hides, Juha and Agogo)

Cause	Ignition of uncontrolled release of wellbore fluid (gas).
Consequence	Fire with potential for escalation to vegetation, resulting in wildfire and environmental damage to terrestrial flora and fauna, in particular to forest ecology, as well as contamination of water sources from ash and eroded soil.
Receptors	As for Table 1.1.
Mitigation	– PNG-specific and international design standards, industry codes and specifications, as well as company practices, will be implemented as they apply to equipment and procedures. – Automated gas detection system on the rig during drilling will inform operations personnel in the event of a gas release and allow the release to be controlled (for example, through increased mud weight). – Maintenance and inspections procedures for equipment will be followed. – Existing knowledge of reservoir pressures. – A spill response plan will be in place and will detail procedures for different sizes and types of spills. – Site selection and orientation is based on the results of the seismic risk assessment undertaken. This indicated a very low probability of a seismic event that could result in wellbore damage. – Fencing and security to prevent third-party tampering. – Site cleared to reduce risk of escalation to vegetation. – Adherence to electrical standards to limit sources of ignition.

Table 1.4 Liquid diesel release during well drilling (for Hides, Juha and Agogo)

Cause	Diesel leak from major rupture of storage container, line or pump.
Consequence	Contamination of soils and watercourses with negative impacts on both terrestrial and aquatic ecology and downstream users. Potential for ignition, with possible escalation to vegetation, resulting in wildfire and environmental damage to terrestrial flora and fauna, in particular to forest ecology, as well as contamination of water sources from ash and eroded soil.
Receptors	As for Table 1.1 and: – Soils.
Mitigation	– Contractor will be required to implement guidelines; industry practice and construction environmental management plans (EMPs). – A spill response plan will be in place and will detail procedures for different sizes and types of spills. – Fencing and security to prevent third-party tampering. – Limit ignition sources within area. – Areas will be bunded or curbed to contain spills.

1.2 Processing Facilities

Table 1.5 Fire or explosion of gaseous hydrocarbons at Juha Production Facility or Hides Gas Conditioning Plant during operation

Cause	Ignition of uncontrolled release of gaseous hydrocarbons from loss of containment due to: – Equipment or systems failure or third-party interference. – Earthquake. – Landslip.
Consequence	Fire with potential for escalation to vegetation, resulting in wildfire and environmental damage to terrestrial flora and fauna, in particular to forest ecology, as well as contamination of water sources from ash and eroded soil.
Receptors	– Terrestrial and aquatic flora and fauna. – Watercourses. – Siabi village approximately 2 km to west of Juha Production Facility. Scattered habitation receptors to the east from approximately 750 m.
Mitigation	Mitigation through design: – PNG-specific and international design standards and industry codes, as well as company practices, will be implemented as they apply to containment. – Security fences approximately 100 m from facilities (property line fence may be offset from the security fence), pending risk assessment. – Site will be oriented to increase the likelihood of dissipation of vapour from prevailing winds (Hides Gas Conditioning Plant is sited on the crest of a steep slope (to the east), so venting will likely dissipate to higher elevation; and prevailing wind at Hides Gas Conditioning Plant is to the northeast, away from the majority of receptors). – Control room and camp is sufficient distance from hydrocarbon area to reduce the likelihood of impacts from fire. – Spacing of equipment as per design specification to reduce cumulative impacts. – Passive fire protection system through design (e.g. structural supports for equipment). – Lightning protection design for buildings and tower tops. Mitigation through systems: – Pressure relief will occur via a mechanical flare system and electronic management system to reduce pressure to 690 kPa after 15 minutes. – Automated control and shutdown system. – Active firewater/deluge protection prevents escalation by cooling equipment. – Security plan includes intrusion detection and CCTV to mitigate against third-party interference. – Seismic risk assessment undertaken (and in progress) to predict rock movement and soil behaviour. This will be used with earthquake loading code to determine detailed design. Mitigation through geotechnical investigations and analysis undertaken (and in progress) to facilitate the: – Assessment of existing ground conditions and suitability of in situ and locally available material to form founding substrata. – Appropriate selection of foundation system and treatments (eg. soil improvement, piles, spread foundations etc.)

Table 1.6 Fire, involving hydrocarbon liquids (in process) at Juha Production Facility or Hides Gas Conditioning Plant during operation

Cause	Ignition of major leak of hydrocarbon liquids (in process) due to pipe rupture from: – Equipment or systems failure or third-party interference. – Earthquake. – Landslip.
Consequence	Fire with potential for escalation to vegetation, resulting in wildfire and environmental damage to terrestrial flora and fauna, in particular to forest ecology, as well as contamination of water sources from ash and eroded soil. Large-scale liquid hydrocarbon releases have the potential to sterilise soil and contaminate water if not contained, with consequent negative impacts on terrestrial and aquatic ecology.
Receptors	As for Table 1.2.
Mitigation	As for Table 1.2 and: – No storage of hydrocarbon products at this site. – Liquid areas bunded; any small spill would go to open drain sump and be contained. – Shutdown valves between vessels limit the amount involved in any leak. – Designed to ensure liquids do not go up flare stack but are captured in flare knockout drums. – Clearing around plant along fence line.

Table 1.7 Fire at Juha Production Facility or Hides Gas-Conditioning Plant during construction

Cause	Diesel leak from major rupture of tank, vessel or pipeline.
Consequence	Fire with potential for escalation to vegetation, resulting in wildfire and environmental damage to terrestrial flora and fauna, in particular to forest ecology, as well as contamination of water sources from ash and eroded soil.
Receptors	As for Table 1.2.
Mitigation	Site storage for construction will be greater than for operations. The contractor will be required to implement guidelines, industry practice and construction EMPs.

1.3 Pipelines

Table 1.8 Explosion or fire along an onshore gas pipeline

Cause	Pipeline rupture from: – Geotechnical hazard, such as seismic event, karst collapse, landslide. – Third-party damage. – Corrosion. – Flash flood.
Consequence	Fire with potential for escalation to vegetation, resulting in wildfire and environmental damage to terrestrial flora and fauna, in particular to forest ecology, as well as contamination of water sources from ash and eroded soil. Potential danger to habitation.
Receptors	Terrestrial and aquatic ecology. Scattered habitation along route.
Mitigation	Mitigation through design: – Where pipeline is above ground it will located at least 1 km from known current sensitive receptors. – Design is for the serviceability limit event so that pipeline will continue to operate after such an event and a ductility limit event, which allows the pipelines to deform during a seismic event but will still contain the gas. Design parameters include pipe wall design (thickness), aboveground design (e.g., zigzagging) and design of fill around pipe for below ground. – Pipeline has the capacity to span cavities without collapse should karst collapse occur. – Fault identification (LIDAR and aerial photography) used in route selection and pipeline design at specific points. – Emergency shutdown system based on volumetric balance of inflow versus outflow, with isolation of pipeline sections between valves (up to 80 km) according to the requirements of AS 2885.1 – To maintain pipeline integrity and reduce erosion on slopes, diversion berms will be put in place. – Deeper pipe coverage than normal at road crossings (approximately 1,200 mm) to protect against vehicle pressures. – Deeper pipe coverage than normal at watercourse crossings (approximately 1,500 mm) to protect against scour. Operational mitigation: – Post-seismic event inspections according to AS 2885, including intelligent pig (wall thickness, deformity check) and visual aerial inspections. – Visual aerial inspections to check for likely third-party interference. – Right of way will be maintained.

Table 1.9 Liquid hydrocarbons spill along an onshore liquids pipeline

Cause	Pipeline leak or pipeline rupture from: – Geotechnical hazard, such as seismic event, karst collapse, landslide. – Third-party damage. – Corrosion. – Flash flood.
Consequence	Large-scale hydrocarbon releases have the potential to sterilise soil and contaminate water if not contained, with consequent negative impacts on terrestrial and aquatic ecology and downstream water users. Potential for ignition, with escalation to vegetation, resulting in wildfire and environmental damage to terrestrial flora and fauna, in particular to forest ecology, as well as contamination of water sources from ash and eroded soil.
Receptors	Terrestrial and aquatic ecology. Scattered habitation along route.
Mitigation	As for Table 1.8 and: – Cathodic protection of pipeline to prevent corrosion.

Table 1.10 Condensate spill from the onshore condensate pipeline

Cause	Pipeline rupture from: – Geotechnical hazard, such as seismic event, karst collapse, landslide. – Third-party damage. – Corrosion. – Flash flood.
Consequence	Large-scale condensate releases have the potential to sterilise soil and contaminate water if not contained, with consequent negative impacts on terrestrial and aquatic ecology and downstream water users. Potential for ignition, with escalation to vegetation, resulting in wildfire and environmental damage to terrestrial flora and fauna, in particular to forest ecology, as well as contamination of water sources from ash and eroded soil.
Receptors	Terrestrial and aquatic ecology. Scattered habitation along route.
Mitigation	As for Table 1.9.

Table 1.11 Fuel spill during construction of onshore pipelines

Cause	Damage, or collision of a fuel truck.
Consequence	Large-scale fuel spills have the potential to sterilise soil and contaminate water if not contained, with consequent negative impacts on terrestrial and aquatic ecology and downstream water users.
Receptors	Terrestrial and aquatic ecology. Scattered habitation along route.
Mitigation	Construction contractor will be required to have construction EMPs and adhere to ExxonMobil's safe driving requirements and tanker loading and unloading requirements to reduce risk of occurrence. Contractor will also be required to have a spill response plan in place to contain spill.

Table 1.12 Explosion of gaseous hydrocarbons along the offshore pipeline

Cause	Ignition following rupture of underwater pipeline from: – Third-party interference, such as anchor drag, boat impact (under-keel impact), trawl board impact, dynamite fishing etc. – Internal or external corrosion or a construction flaw. – Geohazard event (subsea landside etc.).
Consequence	Fire with potential fatalities for any people on boats in the immediate vicinity. Damage to any bommies of reefs in the vicinity.
Receptors	– Reefs / bommies. – Marine ecology. – Boats and personnel on surface and marine environment.
Mitigation	Mitigation through design: – Pipeline trenched in shallow water; depth at which trenching occurs will be decided following detailed study of shipping traffic in vicinity. – Emergency blowdown (flares) at Kopi and LNG facility (if major rupture both blowdowns would be used). – Pipeline encased in concrete (to weight and protect it). This mitigates against rupture. – Formal offshore risk assessment will be undertaken. – Detailed design (during FEED) will take into account under-keel clearance (for shipping channels); dragged anchor assessment (sizes of anchor that may damage pipeline) with consequent mitigation, such as rock protection where required; trawl board impact assessment. – Pipeline route selected to avoid, where possible, reefs or other sensitive environmental elements, spanning, geohazards, shipping channels, cliff edges, and other infrastructure. – Study to be undertaken on impacts of dynamite fishing on pipeline to inform detailed design. – Surveys will identify any unexploded ordinance requiring clearance. – Remotely operated vehicle (ROV) will be used on installation to identify wrecks etc. – Periodic pipeline surveys both internal (by intelligent pig) and external (by ROV) according to operating codes to ensure pipe integrity. This will reduce likelihood of corrosion causing a pipeline leak or rupture. – Geohazard study/risk assessment will be undertaken. – Up-to-date charts on board, showing the pipeline route and bathymetry. – Delineated channel with required navigation aids and depth. – Vessel bridge team training. – Checklist pretesting of vessel equipment. – Vessels will be at manoeuvring speed. – Use of assist tugs for project vessels while within port area. – Regular maintenance program onboard project vessels. – ExxonMobil's standard vetting procedures for project LNG carriers, condensate tankers and tugs. – Project vessels will be under pilot or mooring master with experience and local knowledge in port area. – Exclusion zone to be established for PNG navigation channel.

Table 1.13 Fuel spill during construction of the offshore pipeline

Cause	Fuel spill from vessels from shipping collision, grounding etc.
Consequence	Negative impacts on marine ecology, (e.g. fish and bird kills, contamination of marine mammals) and contamination of subsistence fisheries.
Receptors	Marine environment.
Mitigation	– Covered by normal construction procedures, guidelines and EMPs. – Spill response plans will be in place. – Exclusion zones around pipelaying vessels will be implemented.

2. LNG and Marine Facilities Hazard Summary

The following tables contain hazards and mitigation measures that were identified by ExxonMobil as part of the LNG and Marine Facilities risk assessments (undertaken to date) as having potential offsite impacts.

Table 2.1 Loss of liquid containment from the inner tank followed by a pool fire in the bund

Cause	– Blast impact or fire from external sources. – Seismic event. – Material failure or manufacturing failure. – Operations overfill. – Foundations failure. – Frost heave due to water under soil freezing. – Cooled too rapidly during commissioning.
Consequence	– Pool fire in the bund leading to potential radiation and escalation to the surrounding area. – Significant cracks in the carbon steel outer tank, resulting in a large LNG leak and associated vapour cloud (with the potential for ignition).
Receptors	Potential settlement up to boundary fence.
Mitigation	– Vacuum relief valves provided. – Appropriate spacing and layout to protect adjacent tanks from radiating heat and fire. – Deluge system to protect against radiating heat and fire. – Bund will contain the spill. – No penetrations of tank wall to minimise potential for leaks. – Tank containment bunds and spill sumps. – High-expansion foam system in spill sump. – Quality control for tank construction and material testing. – Specification for procurement and fabrication including seismic and foundation design. – Tank design according to applicable codes and requirements. – Hydro testing of tank prior to operation. – Instrumentation to detect leaks and level controls. – Operator training for overflow. – Security system. – Operations and maintenance procedures.

Table 2.2 Loss of vapour from the outer tank due to overpressure condition with ignition

Cause	– Rollover. – Tank overfill. – Boil-off gas compressor failure and pressure relief failure. – Ignition source. – Gas blanket control system failure.
Consequence	– Rupture of carbon steel roof, resulting in a large vapour release, with potential for ignition. – Radiation affecting the surrounding area. – Gas cloud would be an asphyxiant to any inhabitants or fauna that came in contact with it.
Receptors	– Potential settlement up to boundary fence. – Surrounding ecology.
Mitigation	– Vacuum-relief valves will be provided. – Pressure relief system. – Pressure and level sensors provided to the tanks. – Appropriate spacing and layout to protect adjacent tanks from radiating heat and fire. – Gas detectors provided in the tanks area.

Table 2.3 Local population encroachment around the LNG Facilities site, including access to the beach and the LNG Jetty

Cause	– Incidents in the LNG Facilities site that affects the public. – Public impacts to site because of unauthorised access to the area.
Consequence	– Injury to members of the local population. – Public causing an ignition source.
Receptors	Potential settlement up to boundary fence.
Mitigation	– Restricted access to site. – Security fences. – Overall site security plan. – Hazard assessment undertaken to define safety distances. – Establishment of safety zone around LNG loading facilities. – Establishment of marine exclusion zone around LNG facilities. – Lighting and intrusion detection systems in place. – Local communities will be educated as to the dangers associated with unauthorised access to the LNG Facilities site.

Table 2.4 Condensate or LNG spill or vapour release during ship loading

Cause	– Excessive loading of vessels. – LNG surge pressures. – Defective cargo tank pressure-release valves on LNG carrier or tanker. – Release from LNG carrier generates vapour cloud that contacts ignition source around moored condensate tanker or moored tug. – Distance between two berths insufficient to prevent LNG vapour traversing berths. – Non-compliance with operating procedures on vessel or terminal (loading rate, door closures into accommodation). – Cargo piping failure.
Consequence	– Negative impacts on marine and terrestrial ecology. – Potential contamination of soil and groundwater. – Gas cloud would be an asphyxiant to any habitation or ecology that comes in contact with it. – Ignition of spilled condensate or LNG with the potential for wildfire and impacts to ecology and habitation.
Receptors	Caution Bay marine and terrestrial environment, isolated local residences.
Mitigation	– Licensed officers on LNG carriers and condensate tankers. – Exclusion zone to be established to control third-party vessels from exposure. – Exclusion zone to be controlled by tugboats during berthing and loading. – Tugboats will be equipped with fire-fighting capability. – Vapour cloud dispersion study to ensure spills are contained in exclusion zone. – LNG carriers and condensate tankers to have redundant gauging systems. – LNG carriers to have spill protection and fire-fighting equipment (water curtain and deluge system). – Condensate spill booms will be available in storehouse on the causeway. – Emergency shutdown valves are provided and properly sequenced to prevent surging. – Segregated berths for LNG carriers and condensate tankers. – Surge protection will be adequately evaluated and engineered in FEED. – Operations to consider optimum role for tugs (patrol boats) regarding security during security risk assessment. – Tugboats to assist with oil spill response and reduce exposure to third-party vessels. – Operations to consider active onboard pollution safety advisor program. – Vetting process to require all condensate tankers and LNG carriers to meet international and terminal regulations. – Operations to consider inclusion of terminal regulations regarding topping-off rates and maximum-fill limits.

Table 2.5 Vessel grounds during inbound or outbound transit between the Gulf of Papua and marine facilities

Cause	– Manoeuvring to avoid collision with another vessel. – Lack of navigation aids. – Mechanical failure. – Inadequate vessel bridge team management e.g., fixing position frequency not complied with as per port passage plan. – Transit speed affecting under-keel clearance. – Insufficient dredging in turning circle. – Rapidly developing winds exceed the vessel's ability to maintain course in channel.
Consequence	– Potential breach of containment causing release of LNG vapour, condensate or ship's bunker, which may lead to impact on population and environmental pollution. – Rupture of subsea gas pipeline.
Receptors	Caution Bay marine environment, isolated local residences.
Mitigation	– LNG carriers and condensate tankers all of double-hull design. – Delineated channel with navigation aids and water depth. – Vessel bridge team training (manning requirements, frequency of fixing position, speed) during port transit. – Checklist for pretesting of ship equipment. – Regular maintenance program on vessels. – Managed speed of vessels. – Pipeline route selection has considered navigation routes. – Planned dredging program in turning circle based on detailed bathymetry data. – ExxonMobil established vetting procedures for project LNG carriers, condensate tankers and tugboats. – Use of assist tugs for project vessels in port area. – Project vessels will be under pilot or mooring master with experience and local knowledge in the port area. – PNG large-scale navigation charts to be developed and to include up-to-date bathymetry data, pipeline location and navigation channel and aids. – Develop PNG tugboat operational guidelines for security, safety, assisting and fire fighting. – Marine traffic study for the area between Port Moresby and Redscar to be undertaken. – Shipping contracts to include ship-to-ship emergency response preparedness for refloating. – Operations to develop a full mission bridge port operation training program for pilots and tugboats operators.

Table 2.6 Collision of LNG carrier, condensate tanker or tugboat with fishing boat

Cause	– Undetected presence of fishing boat in the navigation channel. – Non-compliance with collision regulations. – Inadequate vessel bridge team management on vessel. – Human error (e.g., inadequate lookouts, improper use of radar). – Mechanical failure (loss of steering, loss of propulsion).
Consequence	– Injuries to fishing boat crew. – Structural damage to the fishing boat, potential resulting in sinking.
Receptors	Caution Bay marine environment, local shipping.
Mitigation	– Project vessel personnel trained in compliance with international regulations. – Operator procedures and training for vessel bridge team management and port passage plan. – Planned maintenance for propulsion and steering equipment. – Project vessels in compliance with recognised classification society. – Use of assist tugs for project vessels in port area. – Slow transit speeds to reduce wake affecting stability of fishing boats. – Education of local fishermen will be provided to complement government maritime education efforts. – Marine team to conduct a study to establish the local fishing patterns, seasons and practices. – Project team to work with PNG Government to establish a local port authority with enforcement capabilities.