

Ghana Jubilee Field Phase 1 Development

Non Technical Executive Summary of Environmental Impact Statement

Tullow Ghana Limited

27 November 2009

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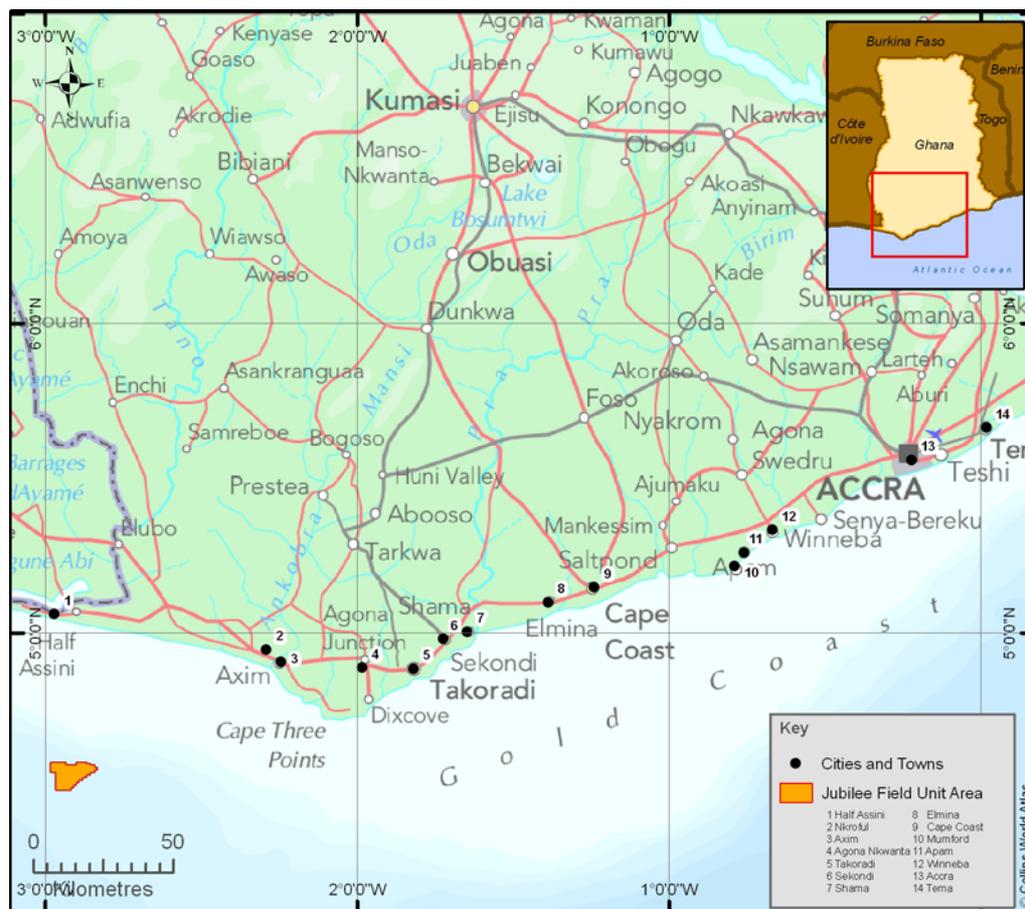
NON TECHNICAL EXECUTIVE SUMMARY

1 JUBILEE FIELD PHASE 1 DEVELOPMENT PROJECT

1.1 INTRODUCTION

The Jubilee Phase 1 Oil and Gas Development project involves the extraction of hydrocarbons from an underground reservoir located in deep water offshore Ghana. The Jubilee field is located approximately 60 km from the nearest coast and is shown in *Figure 1.1*.

Figure 1.1 Location of the Jubilee Field



The participants in the Jubilee Field Joint Venture are Tullow Ghana Limited (Tullow), Kosmos Ghana HC (Kosmos), Anadarko WCTP Company, Sabre Oil and Gas, the EO Group, and the Ghana National Petroleum Corporation (GNPC). Tullow has been designated as the Unit Operator under an Unitisation and Unit Operating Agreement¹ with the Ghana Ministry of Energy (MoE). The project design and execution is being lead by Kosmos as Technical Operator with a project team composed of personnel from all of the joint venture parties.

¹ The *Jubilee Unit Area* is the geographic area defined in the Unitisation and Unit Operator Agreement. The *Jubilee field* is the collective name given to the geological reservoir formations.

This document is the Non Technical Executive Summary of the Environmental Impact Statement (EIS) for the project. It presents an overview of the project and highlights the key impacts identified through the Environmental Impact Assessment (EIA) process and the mitigation and management measures that have been proposed by Tullow to reduce negative impacts and enhance positive impacts. The EIA was undertaken by Environmental Resources Management (based in the UK and South Africa) and ESL Consulting (based in Ghana).

For the purposes of the EIA, the project was defined as all activities necessary for the Jubilee Phase 1 Development and included well completions; installation of subsea infrastructure and the FPSO; testing and commissioning; operation (including production, hydrocarbon processing, crude oil offloading, and support and maintenance activities) and decommissioning. The development drilling activities were previously permitted following submission of separate EISs. For completeness, the previous EISs have been linked to the Phase 1 Development EIS where appropriate.

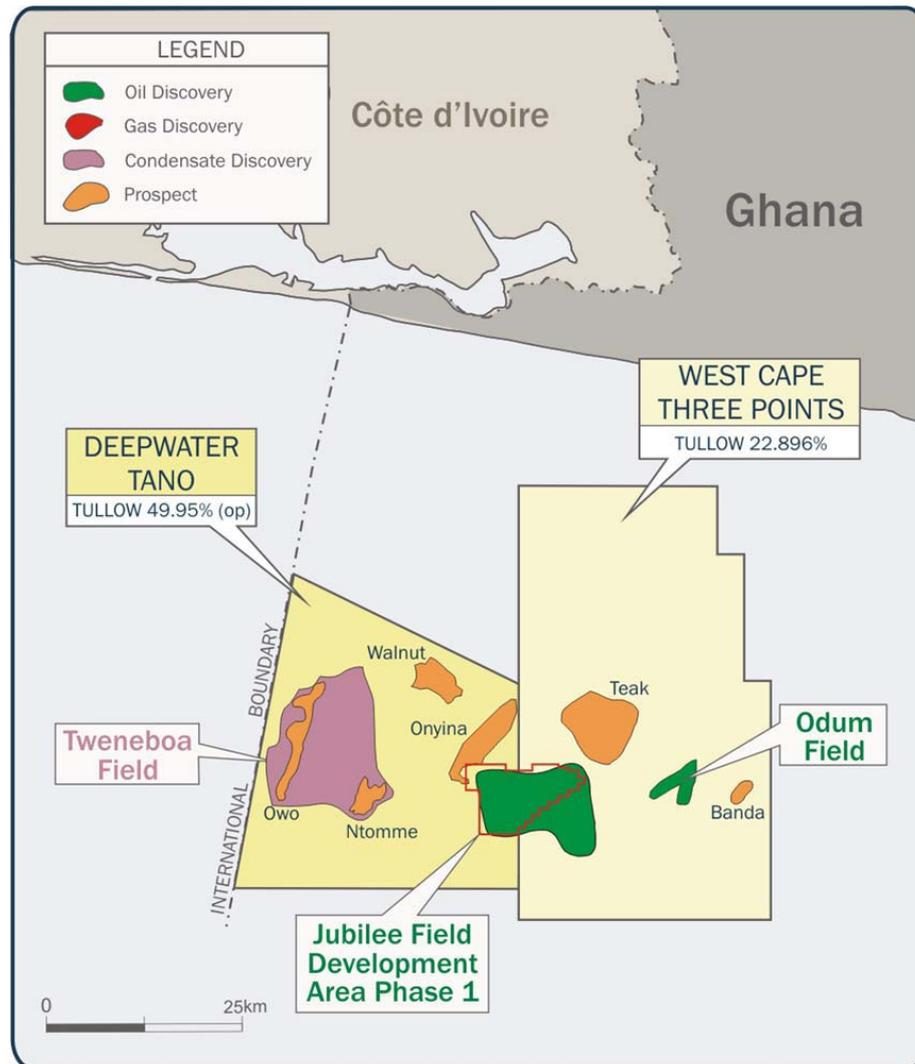
1.2 PROJECT OVERVIEW

The Jubilee Unit Area covers part of the Deepwater Tano and West Cape Three Points licence areas (see *Figure 1.2*). It lies in water depths of between 1,100 and 1,700m and covers an area of approximately 110 km² (*Figure 1.3*). The proposed Phase 1 development will involve the completion of 17 wells comprising a combination of nine production wells used to bring oil and gas from the underground reservoir to the surface, and six water and two gas injection wells used to re-inject water and gas back into the reservoir for pressure maintenance and enhancing oil recovery.

The wells will be connected through a network of valves and pipelines to a Floating Production Storage and Offloading vessel (FPSO) permanently moored at the north of the Jubilee field. On the FPSO the crude oil will be separated from natural gas and water. The processed crude oil will be stored in the FPSO storage tanks and offloaded to oil tanker vessels approximately once a week for delivery to international markets. Separated natural gas will be re-injected into the reservoir to maintain pressure with a small proportion (15%) of the gas being used for power generation to run the FPSO. *Figure 1.4* shows the indicative locations of the 17 planned wells.

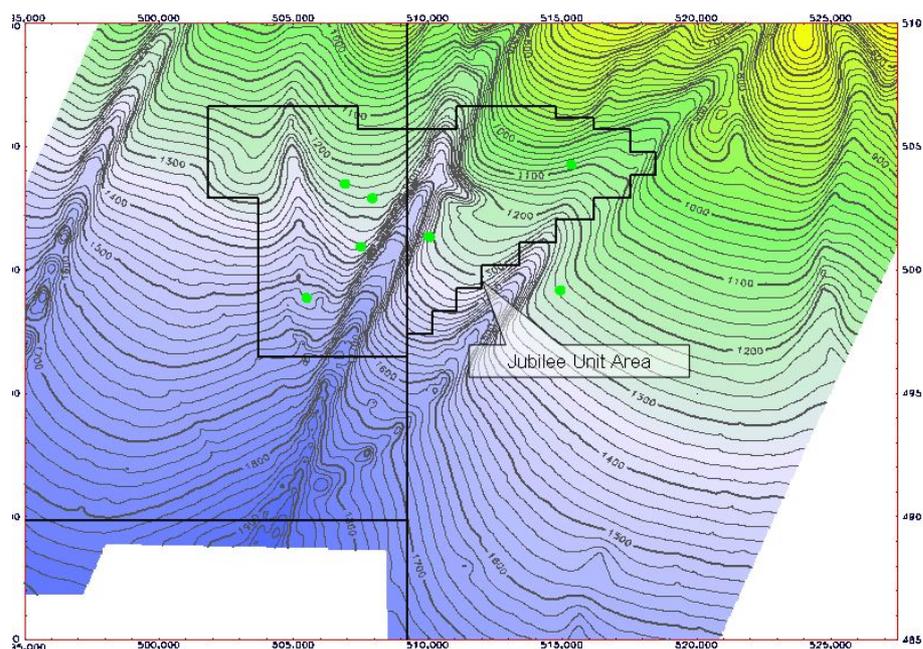
Drilling and completion of the wells commenced in late 2008 and will continue into early 2011. Installation of subsea equipment and the FPSO is planned for late 2009 through to early 2011 with initial oil production targeted for late 2010. Field operations are projected to last for 20 years (ie until 2031). Future phases of development may extend this period significantly and will depend on the success and information obtained during Phase 1. Future developments, including a potential project to export gas by pipeline to a shore based power plant and export terminal, would be subject to separate permitting requirements as prescribed by Ghana environmental law.

Figure 1.2 Location of Jubilee Field and Jubilee Unit Area in Relation to Licence Blocks and other Prospects



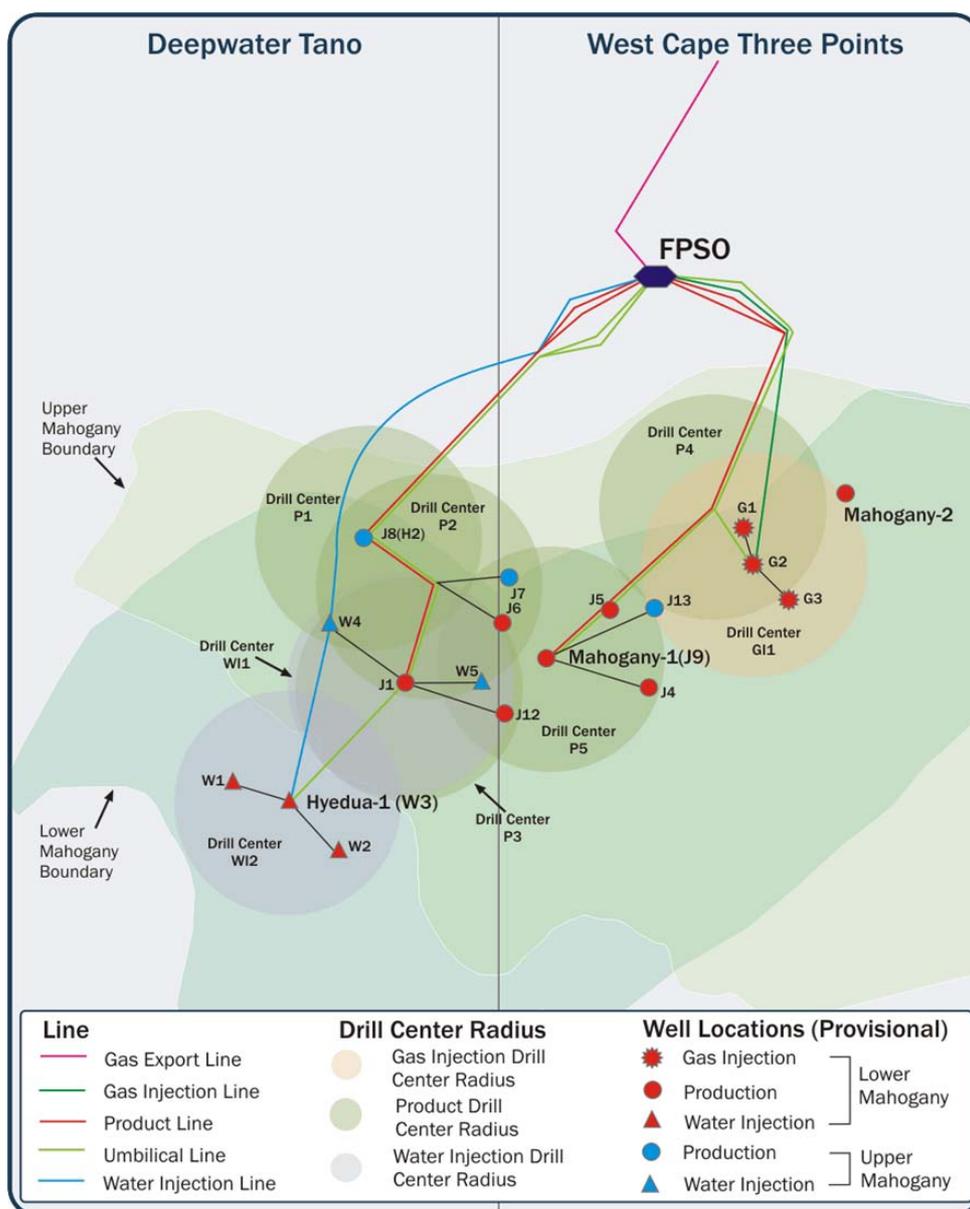
Source: Tullow Ghana Ltd 2009

Figure 1.3 Bathymetric Map of the Jubilee Area (Contour Interval 20 m).



Source: Tullow Ghana Ltd 2009

Figure 1.4 *Drill Centre Locations and Associated Flowlines, Injection Lines and Umbilicals*



Source: Tullow Ghana Ltd 2009

1.3 PROJECT PURPOSE AND BENEFITS

Under the Ghana National Petroleum Act, 1983, MoE is charged with the responsibility to “*promote the exploration and the orderly and planned development of the petroleum resources of the Republic*”. The Jubilee Phase 1 Development is intended to fulfil that obligation. The project will also support the country’s Growth and Poverty Reduction Strategy 2006 to 2009 in the priority areas of infrastructure development and private sector development.

The phased approach being taken for the Jubilee field development is designed to obtain first oil within a relative short time period compared with

other development options. Future phases of development would be dependent on the data obtained from the Phase 1 development.

Income from the project through oil sales, taxes and royalties will contribute to the Ghanaian economy directly, and has the potential to reduce the Ghana balance of payments with respect to energy import costs, and facilitate economic development and growth. There will also be economic benefits through direct employment opportunities and indirectly through training opportunities and the development of oil and gas industry support and related enterprises.

2 ENVIRONMENTAL IMPACT ASSESSMENT

2.1 OBJECTIVES

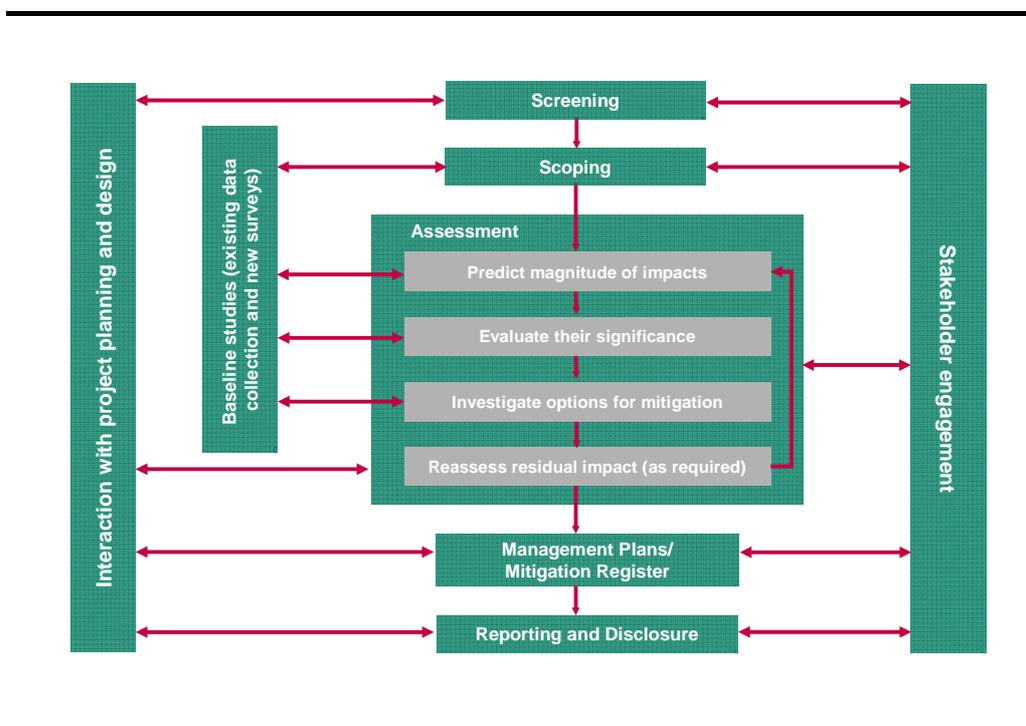
Under the Ghanaian Environmental Assessment Regulations (1999), an EIA is mandatory for all oil and gas field developments. The purpose of an EIA is to provide information to regulators, the public and other stakeholders to aid the decision-making process. The objectives of an EIA are as follows.

- To define the scope of the project and the potential interactions of project activities with the environment (natural and social).
- To identify relevant national and international legislation, standards and guidelines and to ensure that they are considered at all stages of project development.
- To provide a description of the proposed project activities and the existing environmental and social conditions that the project activities may interact with.
- To predict, describe and assess impacts that may result from project activities and identify mitigation measures and management actions to avoid, reduce, remedy or compensate for significant adverse affects and, where practicable, to maximise potential positive impacts and opportunities.
- To provide a plan for implementation of mitigation measures and management of residual impacts as well as methods for monitoring the effectiveness of the plan.

2.2 EIA METHODOLOGY

The EIA for the project followed applicable Ghana regulations. The EIA process is shown schematically in *Figure 2.1*.

Figure 2.1 Overview of the Impact Assessment Process



2.2.1 Screening and Scoping

The proposed project was registered with the Ghana Environmental Protection Agency (EPA) on 4 July 2008 with registration number 3687 and it was determined that an EIA was required. A Scoping Report presenting an overview of the project and outlining the key issues to be studied in the EIA was submitted to the EPA in December 2008. It was approved by the EPA in February 2009 and subsequently disclosed to the public in hardcopy and electronic forms and advertised in the local media.

2.2.2 Baseline Data Collection

For the EIA, baseline data were obtained from the following sources.

- Available data including engineering reports; input from stakeholders including government agencies, fishermen organisations and NGOs; local experts and research and academic organisations; and published sources.
- A marine Environmental Baseline Survey (EBS) conducted in October 2008 to characterise the offshore environment.

- Specific studies undertaken as part of the EIA process including drill cuttings treatment and disposal options; produced water dispersion; and oil spill dispersion modelling.

2.2.3 *Project Planning and Design*

A detailed description of the project was developed for the EIA and project alternatives were considered as required by the Ghana Environmental Assessment Regulations (1999). Project planning, decision making and refinement of the project description continued throughout the EIA and in response to the identified impacts. Mitigation measures were incorporated into project design.

2.2.4 *Stakeholder Engagement*

A Public Consultation and Disclosure Plan (PCDP) for the EIA was developed to ensure that stakeholder engagement was undertaken in a systematic and inclusive manner and provided important input to the EIA process. The objective of engagement is to ensure that sources of existing information and expertise are identified, legislative requirements are met and that stakeholder concerns and expectations are addressed.

A series of 33 consultation meetings involving over 260 people with national and local government stakeholders and other parties such as fishermen's organisations and Non Government Organisations (NGOs) were undertaken for the EIA between November 2008 and June 2009. A Background Information Document presenting information on the project and providing contact details for comments was produced and distributed at meetings and put on the project website.

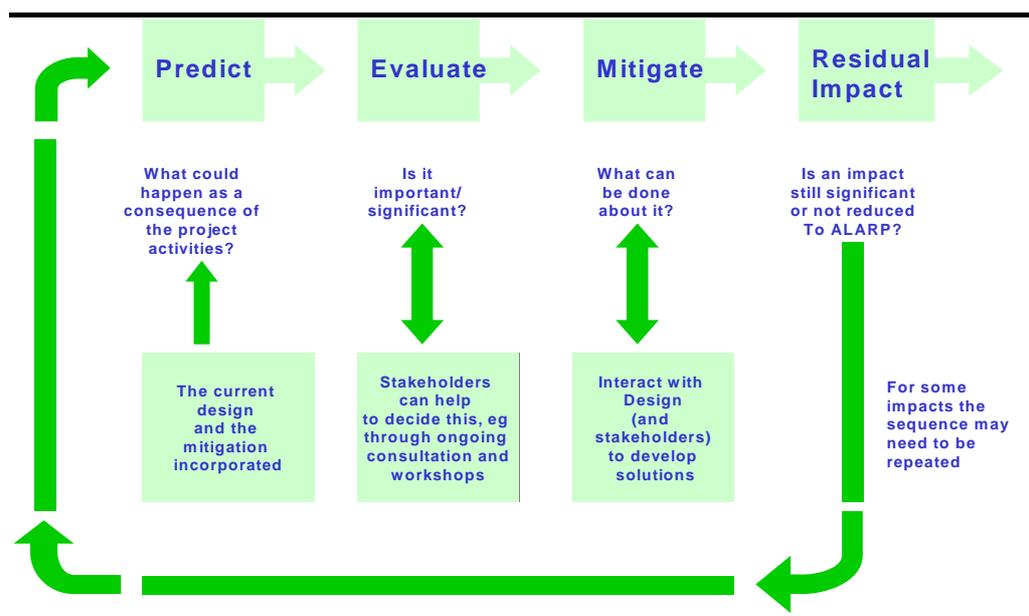
2.2.5 *Impact Assessment*

The impact assessment process followed four steps (*Figure 2.2*).

1. Prediction of what will happen as a consequence of project activities.
2. Evaluation of the importance and significance of the impact.
3. Development of mitigation measures to manage significant impacts where practicable.
4. Evaluation of the significance of the residual impact.

The impact assessment considered both predictable and unpredictable impacts (such as accidents). Impacts were assessed as either significant or not significant. Those that were assessed as significant were further rated as being of minor, moderate or major significance. For significant impacts mitigation measures were developed to reduce the residual impacts to as low as reasonably practicable (ALARP) levels. This approach takes into account the technical and financial feasibility of mitigation measures.

Figure 2.2 Prediction, Evaluation and Mitigation of Impacts



2.2.6 Management Plans

The EIA process identified a range of mitigation measures, management actions and monitoring plans to be implemented during the project to eliminate or reduce adverse environmental and social impacts and enhance positive impacts. Delivery of these will be through the project Environmental Management Plan (EMP). The EIS presents a provisional EMP detailing the specific actions that are required to implement these controls and mitigation measures.

2.2.7 Reporting and Disclosure

The EIA process and outcomes were drawn together into a draft EIS which was submitted to Ghana EPA for review on 5 August 2009. In accordance with Ghana EIA requirements, Ghana EPA disclosed the EIS to the public on 20 August 2009 for a 21 day review and comment period. Copies of the draft EIS were provided to Metropolitan, Municipal and District Assemblies in the coastal areas of the Western Region and government departments. A total of eight public hearings were conducted in the Western Region and Accra in September and November 2009. These hearing were attended by approximately 3,600 interested and affected parties. The EIS was also the subject of a technical review by Ghana EPA and appointed experts. Comments from EPA and comments raised during the public hearings were addressed in the updated final EIS dated 27 November 2009, and subsequently submitted to Ghana EPA for decision-making.

3 *LEGAL AND POLICY FRAMEWORK*

3.1 *NATIONAL ADMINISTRATIVE FRAMEWORK*

The project is subject to regulations implemented and enforced by the following government organisations.

- The Ghana EPA is responsible for ensuring compliance with EIA procedures and is the lead EIA decision-maker. The Ghana EPA is responsible for issuing environmental permits for relevant projects and ensuring that the project controls waste discharges, emissions, deposits or other sources of pollutants.
- The GNPC is empowered to conduct petroleum operations and partner with foreign investors to promote the economic development of Ghana.
- The Ghana Maritime Authority (GMA) is responsible for monitoring, regulation and coordination of all maritime activities to ensure the provision of safe, secure and efficient shipping operations and protection of the marine environment from pollution from ships.
- The Ghana Ports and Harbours Authority (GPHA) is responsible for planning, managing, building and operating Ghana's seaports, including Ghana's two main seaports in Takoradi and Tema.
- The Directorate of Fisheries and the Regional Departments of Fisheries are responsible for policy formulation and implementation, management and control of the fishing industry under the general guidance and direction of the Fisheries Commission.

3.2 *NATIONAL ENVIRONMENTAL REGULATIONS*

The Environmental Assessment Regulations (LI 652, 1999) as amended (2002) require that all activities likely to have an adverse effect on the environment must be subject to environmental assessment and issuance of a permit before commencement of the activity. The Regulations define what is to be addressed within the EIA, how the EIA process should involve the public and outlines the steps to be followed. The Ghana EPA has issued formal guidance on regulatory requirements and the EIA process.

3.3 *INTERNATIONAL CONVENTIONS*

Ghana is signatory to a number of international conventions which are relevant to offshore oil and gas developments. These include:

- the United Nations Convention on the Laws of the Sea (UNCLOS) which covers Ghana rights within its 200 nm Exclusive Economic Zone; and

- a number of International Maritime Organisation (IMO) Conventions including the International Convention for the Prevention of Marine Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78).

3.4

GOOD PRACTICE STANDARDS AND GUIDELINES

Several participants in the Jubilee Joint Venture have sought funding from World Bank Group's International Finance Corporation (IFC) from which there are a number of specific project requirements that the Jubilee Joint Venture partners must adhere to. This includes a series of social and environmental Performance Standards (PS) that have been adopted by the Jubilee Joint Venture for the project along with the following associated Environmental, Health and Safety (EHS) Guidelines.

- EHS General Guidelines (April 2007).
- EHS Guidelines for Offshore Oil and Gas Development (April 2007).
- EHS Guidelines for Shipping (April 2007).
- EHS Guidelines for Crude Oil and Petroleum Product Terminals (April 2007).

The project has also adopted relevant good practice standards provided by:

- International Association of Oil & Gas Producers (OGP) which has established industry guidelines and standards on environmental protection and personnel safety;
- International Petroleum Industry Environmental Conservation Association (IPIECA) on oil spill response and contingency planning for the marine environment.

3.4.1

Project Environmental Standards

The project environmental standards were derived from Ghana regulations and obligations of the various international protocols to which Ghana is a signatory, or which are recommended by IFC Performance Standards or EHS Guidelines.

The Jubilee Phase 1 Development project will be governed by the expectations and operating philosophy of the project's EHS Management System (EHS-MS). Appropriate procedures, plans and programmes will be implemented during the course of the project to ensure that these management expectations are met. These will be based on industry good practice and the Jubilee Joint Venture partners' own internal company EHS policies and standards. Applicable elements expected of subcontractors will be communicated and explicitly included in all contracts, and subcontractor systems, plans and procedures will also adhere to these key elements.

4 PROJECT DESCRIPTION

4.1 ALTERNATIVES CONSIDERED

During the conceptual design phase of the project, the Jubilee Joint Venture evaluated a number of alternatives before defining the approach for final project design. The evaluation of alternatives considered safety, engineering, technical, financial and environmental considerations with the final choice based on the option that provides the best overall performance against these criteria. Underlying the option selection was a formal Safety Case which includes a number of Formal Safety Assessments (FSAs) and the studies of risks such as explosion, fire, ship collision and gas release.

4.1.1 Development Approach

During the project feasibility phase, the following five field development options were considered.

1. Extended well test and later major field development using an FPSO or Tension Leg Platform (TLP).
2. Continued field appraisal with phased development by FPSO.
3. Continued field appraisal with phased development by TLP and Floating Storage Unit (FSU).
4. Full field appraisal followed by full field development with FPSOs.
5. Full field appraisal followed by full field development with TLP and FSU.

The following factors were taken into consideration in the selection of the preferred option.

- Comparisons with development options used in other similar fields worldwide.
- Flexibility to respond to reservoir production information obtained during the project operations.
- Cost, revenue and project schedules.
- Environmental, health and safety considerations.

The project concluded that the second option was the preferred option because it met the requirement for no continuous gas flaring; provided a means for reservoir management (gas and water injection) and efficient utilisation of the oil reserves; and would allow for a relatively short time to first oil production.

4.1.2 FPSO Design

A turret-moored FPSO was selected as the development concept for the receipt, processing and storage of the Jubilee Phase 1 Development reservoir fluids.

The primary factors influencing this choice were:

- water depth, which precluded shallow water options;
- remote location of the field (remote also to any other infrastructure) leading to the need for a relatively high storage capacity that would in turn limit the number of export tanker visits required;
- large area of the field that precluded the use of a centralised drilling platform;
- safety and environmental performance; and
- proven methods in similar fields worldwide.

The use of FPSOs is a well-established development concept deployed across the world and extensively in Atlantic Africa. There are now 138 FPSO vessels operating worldwide. FPSOs are either newly built or converted from existing Very Large Crude Carriers (VLCCs). Tanker conversions into FPSOs are more common than those built new due to the reduced delivery schedule, reduced cost and the large selection of vessels available. The FPSO is sized to accommodate the anticipated production volume with an offloading frequency of approximately seven days. This design was considered to be practical given available offload tanker capacity in West Africa.

The proposed FPSO will be constructed by converting a single-hulled trading tanker into a single-hulled FPSO (*Figure 4.1*). The single-hull FPSO design was determined to meet relevant regulatory requirements and to be suitable for the limited collision and natural hazards risks given the distant location and relatively calm weather and hydrographic (metocean) conditions in the Jubilee field. The completed FPSO will be fully classified under the American Bureau of Shipping (ABS) and under that process the vessel will be verified to ensure it meets required MARPOL standards for fatigue and impact.

Figure 4.1 *VLCC Tohdoh Prior to Conversion to an FPSO Vessel*



Source: Modec 2009

Design measures have been put in place to mitigate the identified risks. These include:

- weather-vaning mooring system to reduce the chance of collision;
- fenders to absorb potential supply boat impact;
- wing tanks will be used for ballast water and slop tanks in the areas where supply boat operations will be conducted;
- collision radar;
- structural design of the hull will be checked to meet side impacts as per class requirements; and
- global structural model showing the FPSO is of adequate strength and has a remaining fatigue life that takes into account hull condition, repairs and predicted corrosion rates for a minimum life of 20 years.

4.1.3 *Mooring System*

Two mooring types were considered for the FPSO: spread mooring and forward-mounted external turret Single Point Mooring (SPM). Spread mooring consists of mooring lines from the extremities of the vessel spreading outwards to anchor points. In a spread mooring configuration the FPSO would be kept in a fixed position. For turret mooring, mooring lines are connected to a turret system that is built into the FPSO. The turret system has a universal joint that allows the vessel to turn freely around the vertical axis and align with the prevailing wind, wave and current conditions (weathervane) (see *Figure 4.2*).

Figure 4.2 ***VLCC Conversion to a Turret Moored FPSO Vessel***



Source: Modec, 2009

A forward-mounted external turret SPM was chosen for the following reasons:

- weathervaning reduces the time the vessel would be “side on” to the weather thus reducing vessel motion caused by ocean conditions;
- weather-vaning reduces the risk of side collision;
- mooring lines are located at the SPM and restriction on movement of support vessels and export tankers is reduced;
- reduced exposure of risers and control lines (umbilicals) during support vessel operations alongside the FPSO; and
- lower mooring and hawser loads during oil transfer operations.

4.1.4 Gas Utilisation

During Phase 1 production, an estimated 120 million standard cubic feet per day (MMscfd) of natural gas will be available when producing 120,000 barrels (approximately 19,000m³) of oil per day. A number of options were considered for utilisation of the natural gas:

- FPSO power requirements;
- gas injection for reservoir pressure maintenance and enhanced recovery; and
- export of the gas to a processing facility or to market.

The project was designed to utilise a portion of the gas for electrical power generation, steam generation and to supply the processing and utility facilities. Approximately 20 MMscfd of gas will be used, leaving up to 100 MMscfd of gas for re-injection or potential future export.

The project intends to use any available gas for reservoir pressure maintenance and improved oil recovery. GNPC is considering a separate gas export project comprising a gas export pipeline from the Jubilee field to a new receiving facility at the shore. The project could accommodate 70 MMscfd of gas when in steady-state operation. If this project was realised the remaining available gas would be used for reservoir pressure maintenance and enhancing oil recovery. The design of the FPSO, however, will allow all the gas to be re-injected so that continuous flaring can be avoided in the event that the receiving terminal is unavailable to receive all the gas due to unplanned events or planned maintenance.

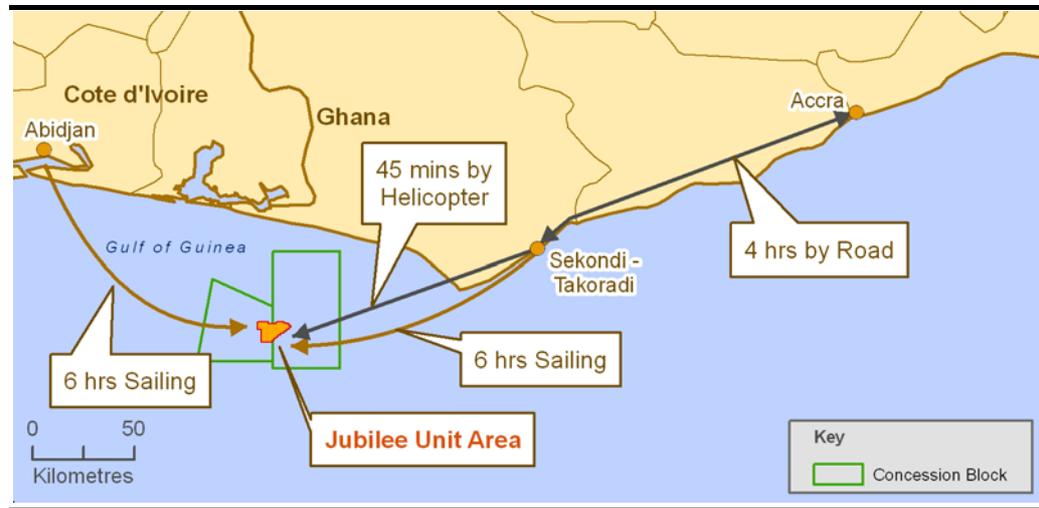
4.1.5 Shore Base

Project construction and operations will require support by personnel and service vessels based at a facility onshore. Takoradi was selected as the location for the support base because it is the nearest Ghanaian port and airfield that can meet projected capacity requirements (*Figure 4.3*). It has the following key features:

- dock space to serve as a loading/offloading point for equipment and machinery supporting offshore operations;

- facilities for dispatching personnel and equipment;
- temporary storage for materials and equipment;
- availability of a 24-hour dispatcher; and
- helicopter support facilities provided by the Ghana Air Force Base.

Figure 4.3 *Alternative Shore Base Locations and Logistics Routes*



4.2 PROJECT FACILITIES

4.2.1 FPSO

The FPSO vessel is being converted from an existing single-hulled, 330 m long and 60 m wide VLCC tanker named *Tohdoh* in Singapore and is due for completion in the first quarter of 2010. Hull repair and life extension will be carried out in compliance with ABS Classification Society Rules and international guidelines.

On completion it will transit under its own power from Singapore to Ghana and is scheduled to arrive in the second quarter of 2010 for mooring and installation. The *Tohdoh* and a similarly sized FPSO are shown in *Figure 4.1* above. The FPSO will be modified to allow for the storage capacity of approximately 1.6 million barrels of oil. The FPSO will have capacity to process up to 120,000 barrels of oil per day and 120 MMscfd of gas, the latter for on-site power generation and reservoir re-injection or for future export.

The FPSO will be designed, built and operated by MODEC Inc. It will be leased from MODEC under a long-term contract. Tullow will set targets for production, safety and environmental performance with MODEC; oversee compliance with contractual obligations; provide supporting logistics; and plan and programme production and oil tanker offloading operations.

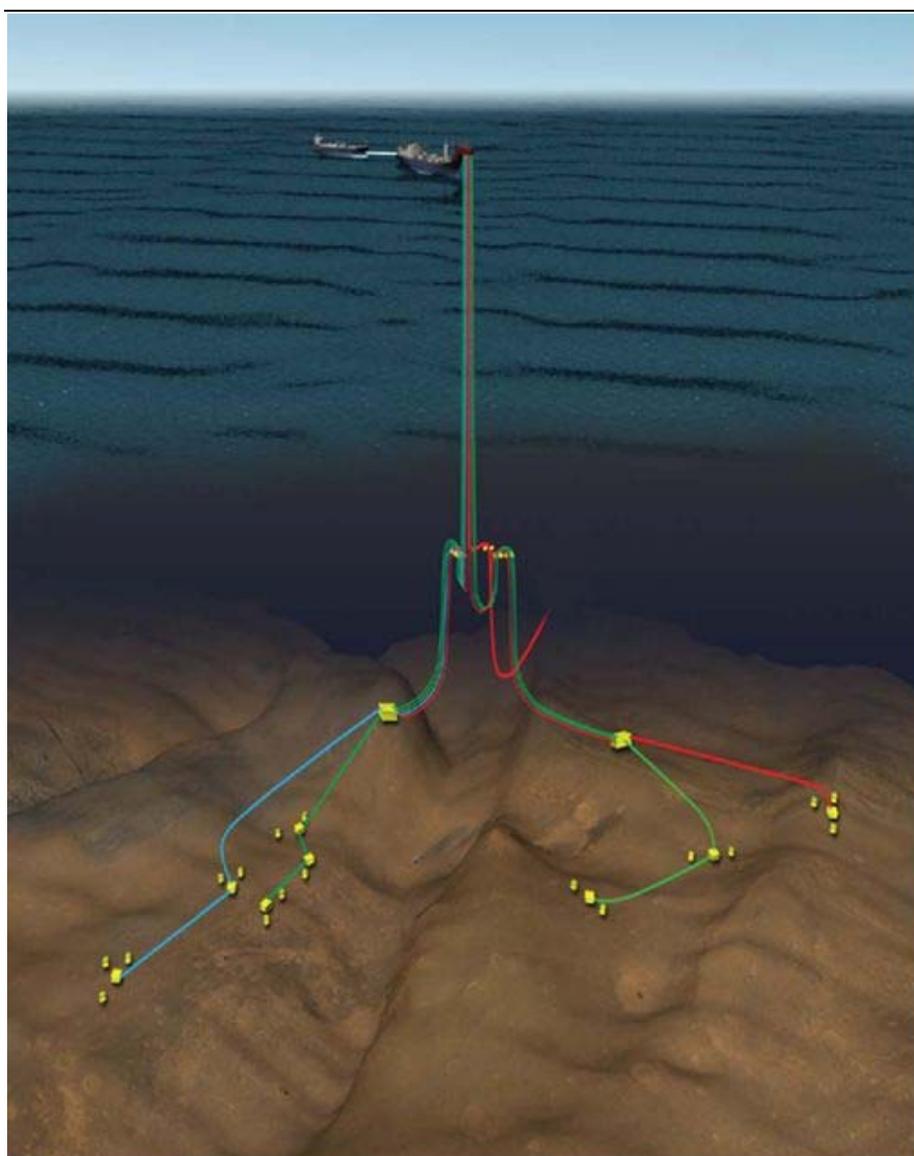
4.2.2

Subsea Systems

Subsea infrastructure will be required to support production, water injection, gas injection and for system control. On the seabed, the production wells will be linked to manifolds and fluids from the production wells will flow through a series of subsea pipelines (flowlines) and through risers up to the FPSO. Dedicated subsea gas and water injection systems (including wells, flowlines and risers) will also be provided (see Figure 4.4).

The subsea manifolds will be installed on suction piles on the seafloor using a dynamically positioned vessel. Flowlines, flexible risers, control cables and umbilicals will be laid on the seafloor between wells, manifolds, riser bases and the FPSO, connecting via the turret Single Point Mooring (SPM) system. The SPM will be fixed in place using a mooring system consisting of nine 1,900 m long chain and polyester rope anchor 'legs'. Each leg will be anchored to the seabed using 4 m diameter suction piles.

Figure 4.4 *Schematic of FPSO and Subsea System*



Key: production (green), water injection (blue), gas injection (red).

Source: Tullow Ghana Ltd, 2008

4.2.3 *Shore Base*

Marine vessels and helicopters will be required to support the Phase 1 installation, production and decommissioning operations. The onshore logistics support base will be at Takoradi. The support base will be used for dock space to serve as a loading/offloading point for equipment and machinery, provide facilities for dispatching equipment and allow for temporary storage of materials and equipment. Once the FPSO has been installed and begins operations, a supply boat will visit the FPSO on a weekly basis. In addition, two helicopter trips to the FPSO will be required daily.

4.3 *PROJECT ACTIVITIES*

4.3.1 *Drilling*

Up to two mobile offshore drilling units (MODUs) will be used for the development drilling programme (*Figure 4.5*). One MODU will be in the Jubilee field between the 4th quarter 2008 and 2nd quarter 2009 (266 days), while another MODU will be on site between the 1st quarter 2009 and at least the 2nd quarter 2011 (1,092 days). It is also possible that a further MODU will be utilised, when required, for short periods. Each well will require approximately 30 days to be drilled.

Figure 4.5 Modular Offshore Drilling Unit (MODU) - Eirik Raude



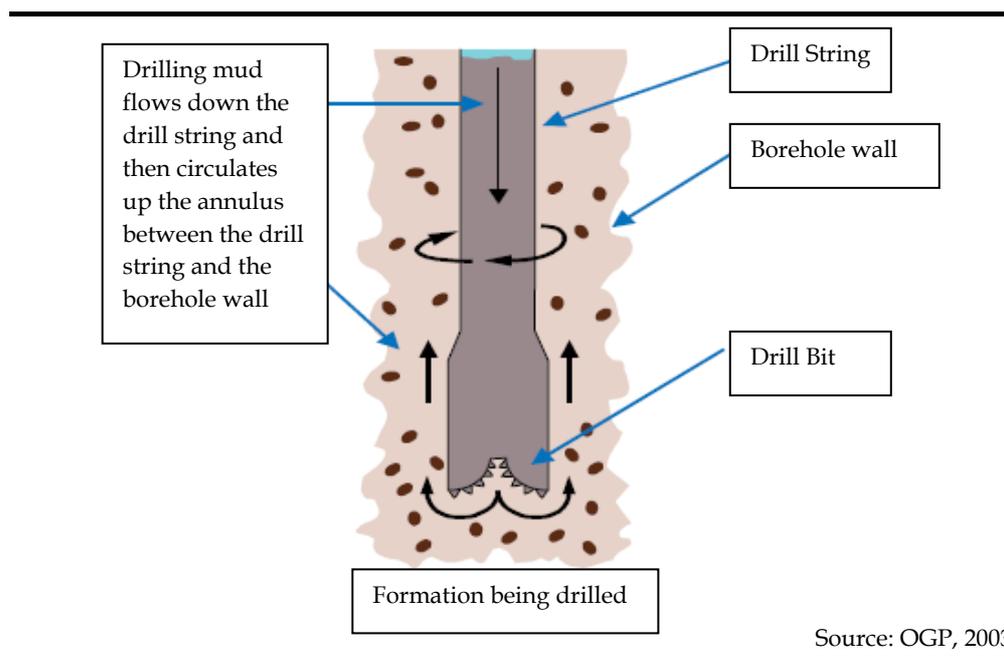
Source: RigZone, 2009

Drilling for oil and gas uses a rotating drill bit attached to the end of a drill pipe (the 'drill string') to bore into the earth to reach oil and gas deposits. The

first part of the well is drilled and then a steel casing (90 cm diameter) is fixed between the MODU and approximately 70 m below the seabed. Drilling continues and a series of progressively smaller sections of casing are cemented in place as the well gets deeper. During drilling the rotating drill bit breaks off small pieces of rock (called drill cuttings) as it penetrates rock strata.

Drilling fluids (also called muds) which are slurries of various solids and additives that are pumped down the drill string during. These fluids serve to maintain a positive pressure in the well, cool and lubricate the drill bit, protect and support the exposed formations in the well and lift the cuttings from the bottom of the hole to the surface (*Figure 4.6*). For the 90 cm casing the drilling fluids (consisting mainly of seawater) and cuttings are discharged onto the seabed. Once the 90 cm casing is in place the drilling fluids can be re-circulated between the MODU and the well thereby allowing control over the drilling fluids and cuttings that are discharged. On the MODU, cuttings are separated from the drilling fluids using solids control equipment involving shale shakers, dryers and centrifuges prior to the cuttings being discharged to sea.

Figure 4.6 *Circulation of Drilling Fluid during Drilling*



4.3.2 Well Completions

After wells have been drilled a process known as well completions is undertaken to install a number of subsurface pipes (tubulars) safety valves to provide pressure isolation and prevent pollution in the event of damage to the wellhead and seabed surface valves. In addition pressure and temperature gauges will be installed into producing wells to provide continuous data during the life of the wells. Data will be transmitted back to the FPSO via umbilicals and will be used in the ongoing reservoir and system management

of the Jubilee field. Completions will be undertaken from the MODUs and for each well is a process that will take approximately 25 days.

Safety valves (Blow-Out Preventers) will be permanently installed on the subsea wells during well completions. These valves close off the well in the event of loss of control of the reservoir fluids.

4.3.3 *FPSO and Subsea Systems Testing and Commissioning*

Extensive testing of the FPSO will be done at the conversion yard in Singapore. Once installed, the subsea systems will be pressure tested with treated water (hydrotested) to verify system integrity. Following testing, the system will be dewatered under controlled conditions with the treated hydro-testing water discharged to sea. Once the FPSO is connected to the subsea infrastructure final commissioning of all systems will take place to ensure compliance with engineering specifications and integrity of fire and process control systems. Commissioning and start-up will take up to six months.

4.3.4 *FPSO Operations and Export Tanker Operations*

Following installation and commissioning, the FPSO will receive and process fluids from the reservoirs, separating the crude oil, gas and produced water. A proportion of the gas will be used for energy generation on the FPSO and the rest re-injected into the reservoir, and the produced water will be treated and discharged to sea. In addition, filtered and treated seawater will be injected into the reservoir to maintain reservoir pressure and enhance oil recovery.

Crude oil stored on the FPSO will be transferred to an export tanker approximately every week, with offloading volumes typically being approximately one million barrels, with offloading time being approximately 20 hours. The export tanker will be manoeuvred into a bow-to-stern position behind the FPSO and secured by a 100 m long mooring hawser. A tug will assist the export tanker in maintaining its position (see *Figure 4.7*). Crude oil transfer will occur via a single 20" (50 cm) hose which splits after 310 m into two 16 inch (40 cm) floating hoses up to the export tanker.

A range of industry standard safety precautions will be instituted to ensure incident free operations:

- operational communications with the export tanker will occur 72 hours prior to offloading to allow sufficient time for planning;
- qualified and competent FPSO crews, export tanker crews and mooring master will be employed;
- clear, concise and approved procedures and checklists will be used;
- adequate number of support vessels will be present for off-loading operations;
- FPSO, infield vessels and shuttle tankers will be regularly inspected, maintained, surveyed and classified; and

- only export tankers of suitable specification for tandem offloading that have passed the vetting procedure will be allowed.

Figure 4.7 *Typical Export Tanker Operations*



Source: Modec, 2009

4.3.5 *Operations Emissions*

Air Emissions

Fuel combustion from Phase 1 activities, including the FPSO facility installation and operation, export tanker operation, flowline and umbilical installation and support vessel and helicopter operations will emit greenhouse gases and varying amounts of other pollutants such as carbon monoxide (CO), oxides of nitrogen (NO_x) and sulphur (SO_x), volatile organic compounds (VOCs) and particulate matter.

Flaring

No continuous flaring of excess hydrocarbon gases during normal operations is planned. The intention is to avoid flaring other than under specified scenarios (nominally to maintain safe conditions such as flare purge gas, facility depressurisation, upset or during limited duration activities such as process start-up, re-start and maintenance activities).

Tank Venting

FPSO cargo tanks will be maintained in a pressurised state and the vapour space created in the storage tanks of the FPSO filled with an inert gas to avoid the potential for fire or explosion. Excess inert gas is vented during cargo tank filling operations.

Routine Water Discharge

The FPSO facility and associated support vessels and export tankers will produce a series of discharges including black water, grey water, produced water, bilge water, and deck drainage. Water discharges will comply with relevant Ghana standards or industry standards. Produced water will be discharged to the sea following treatment to reduce the concentration of dissolved oil to at or below 29 mg/l maximum monthly average and 42 mg/l maximum daily average oil content and no visible sheen. Black water (ie sewage or sanitary effluent) will be treated using a marine sanitation device to a minimum residual chlorine concentration of 1.0 mg/l and no visible floating solids or oil and grease. Grey water (ie domestic waste water) will not require treatment before discharge as allowed by MARPOL.

The FPSO has been designed to contain deck drainage and prevent oily drainage from being discharged directly to the ocean. Deck drainage that may contain oil will be diverted and treated. Only non-oily water of less than 15 parts per million (ppm) oil and grease (maximum instantaneous oil discharge monitor reading) will be discharged overboard.

Support vessels will occasionally discharge treated bilge water. These vessels will comply with the applicable sections of MARPOL. Under these regulations, water must be retained onboard until discharge to an approved reception facility, unless it is treated by approved oily water separators and monitoring equipment before being discharged to the sea.

For the FPSO the primary means of maintaining an even keel, stability and trim will be through management of the distribution of crude oil within the storage tanks, therefore the requirement for ballast water intake and discharge will be minimal. Export tankers in the Jubilee field for cargo transfers may only discharge clean ballast water meeting MARPOL standards (no more than 15 ppm oil and grease). The Jubilee FPSO and visiting export tankers will undertake ballast water management measures in accordance with the *International Convention for the Control and Management of Ships Ballast Water and Sediments*.

Brine generated from reverse osmosis during freshwater generation will be discharged overboard. Sulphates will be removed from seawater by a Sulphate Removal Unit (SRU) on the FPSO prior to re-injection into the reservoir. The SRU will produce a discharge stream of sulphate rich seawater. The discharge will also contain small amounts of chemicals used in the system including a biocide used to control organism growth.

Non-Routine Water Emissions

Discharge of liquids will occur as a result of non-routine or one-time events such as well installation and completions. Well completion and well work-over fluids will mostly remain downhole or will be injected into the formation. Some completion chemicals will be flared off after use or discharged

overboard depending on allowable limits. Before any fluids are discharged overboard they will be tested for oil content and, if above allowable limits, the fluids will be shipped for onshore disposal. Small volumes of fluids containing dye, oxygen scavenger, corrosion inhibitor and biocide will be discharged to the sea during pre-commissioning testing.

The subsea control system will use a water-based glycol as a control fluid and small volumes of fluid will be released from the control system equipment to the sea when given a command to close (typically once per day for each manifold and wellhead).

Noise

Underwater noise emissions will be generated from vessels by propellers whilst transiting at speed or by thrusters used to maintain a vessel's position. Low frequency machinery noise will be generated by large power generation units, compressors and fluid pumps. Noise will be produced from equipment such as flow lines, valves and caissons.

Solid Waste

A number of solid waste streams will be created as a result of project activities. Some domestic waste (eg macerated food waste) can be treated and disposed at sea in accordance with MARPOL requirements. Other solid wastes need to be transferred onshore for treatment, recycling, and disposal at appropriate facilities.

The types of non-hazardous solid waste that would be expected to be generated from the FPSO and the MODU include:

- cabin domestic waste, such as mixed waste from living quarters or galley;
- scrap metal, eg off-cuts and turnings;
- wood, eg pallets, cartons;
- paper and cardboard, flattened and baled;
- metal cans, aluminium and steel and food tins (crushed);
- plastics, eg crushed plastic drinks bottles;
- maintenance cables; and
- glass.

Hazardous wastes will be transported to shore for disposal except waste oils such as lubricating oils from machinery maintenance and servicing which will normally be disposed of by mixing with the production crude stream. If required, there are EPA approved onshore treatment facilities for oily waste. The supply base will produce mostly general and scrap metal wastes and relatively small amounts of hazardous wastes. However, the scale and nature of waste will vary as the duties of such bases change from support of drilling and installation and construction to operation of the FPSO.

4.3.6

Workers

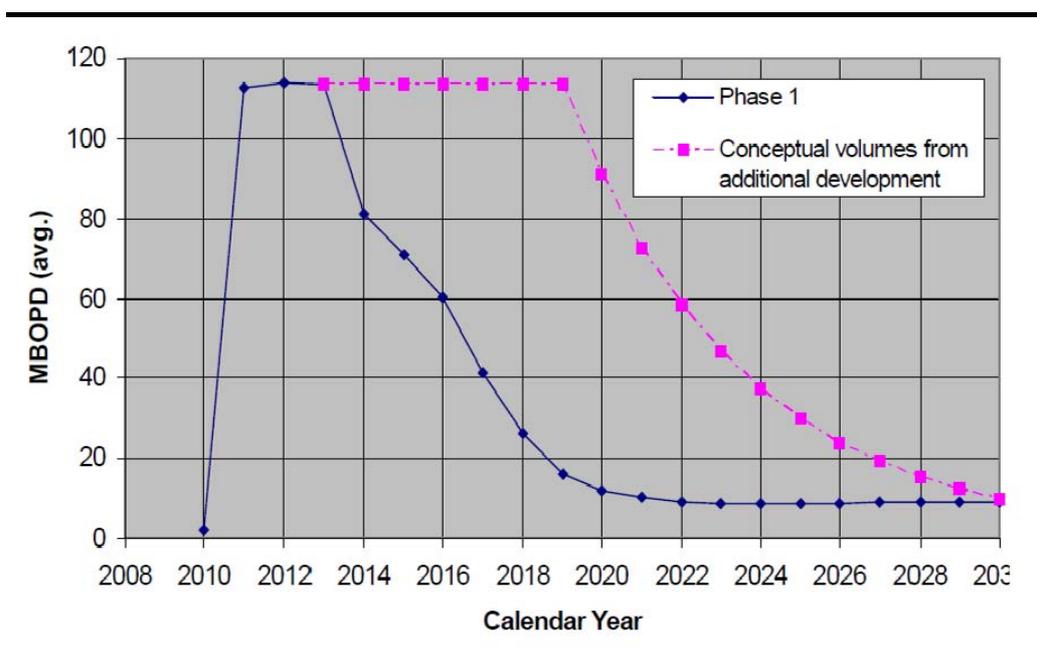
The project expects to employ up to 760 staff at its peak during installation, reducing to approximately 300 during the operational phase. Initially it is expected that there will be approximately 50% national staff and the remainder expatriates in mainly management and technical specialities. Through training, mentoring and job shadowing programmes for national staff the number of national personnel is expected to be up to 90% within 4 to 8 years.

4.4

PRODUCTION PROFILE

First oil production is planned for fourth quarter 2010 and the field is expected to produce oil for 20 years. The estimated production capacity for Phase 1 is up to 120,000 barrels of oil per day (bopd). Oil production will increase from first oil to an average production volume of 115,000 bopd in the first full year (including facilities downtime) and potentially declining after three years as the reservoir(s) are depleted. Ultimately, 278 million barrels of oil (Mmbo) are expected to be recovered over 20 years of Phase 1. Further project phases may extend this period and increase ultimate recovery as shown in *Figure 4.8*.

Figure 4.8 Production Profile Forecast



Source: Tullow Ghana Ltd 2009

4.5

DECOMMISSIONING

The project life is estimated as 20 years, although subsequent phases could extend this period. Decommissioning of project facilities would occur when the reservoir is depleted or the production of hydrocarbons from that reservoir becomes uneconomic. At the end of the economic field life of the Jubilee field, the facilities will be decommissioned. The future use of the FPSO

will depend upon its condition at the end of the production life and upon the options available for refurbishment. If the decision is made to decommission the FPSO, it will be towed from the site to where it will be dismantled and scrapped.

The project will dismantle and remove as much of the subsea infrastructure as practicable given the deepwater location. As is typical in deepwater environments, it is likely that the seabed flowlines, manifolds, wellheads (if they cannot be cut off below the seabed) and the suction piles (protruding 1 m maximum above the seabed) will be flushed clean where relevant and then abandoned in place. The approach and techniques for decommissioning will be in accordance with prevailing legislation and guidelines at the time and shall consider industry good practice, which is continuously being developed.

5 ENVIRONMENTAL AND SOCIO-ECONOMIC BASELINE

5.1 ENVIRONMENT BASELINE

5.1.1 Coastal Habitat Types

The coastal area of Ghana is situated at latitude 5.5° north. The coastline is approximately 550 km long and is generally low-lying, with a maximum elevation of 200 m above sea level. It has a narrow continental shelf extending outwards to between 20 and 35 km, except off Takoradi where it extends up to 90 km.

Approximately 70 percent of the coastline consists of sandy beaches. Over 90 coastal lagoons are located in the back-shore areas, most of which are small and less than 5 km² in surface area. The Ghanaian coastal zone can be divided into the following three zones.

- The Western Coast which covers 95 km of stable shoreline and extends from the Cote d'Ivoire border to the estuary of the Ankobra River, composed of fine sand with gentle beaches backed by coastal lagoons.
- The Central Coast which extends approximately 321 km from the estuary of the Ankobra River near Axim to Prampram, located to the east of Accra, comprised of an embayment coast of rocky headland, rocky shores and littoral sand barriers enclosing coastal lagoons.
- The Eastern Coast which extends along approximately 149 km of shoreline from Prampram, eastwards to Aflao at the border with Togo, characterised by sandy beaches with the deltaic estuary of the Volta River situated halfway in-between.

Major rivers draining the coastal zone are the Tano, Ankobra, Butre, Pra, Kakum, Amisa, Nakwa, Ayensu, Densu and the Volta.

5.1.2

Climate

The regional climate is controlled by two air masses: one over the Sahara desert (tropical continental) and the other over the Atlantic Ocean (maritime). These two air masses meet at the Inter-Tropical Convergence Zone (ITCZ). During boreal winter, the tropical continental air from the northern anticyclone over the Sahara brings in north-easterly trade winds which are dry and have a high dust load. During boreal summer, warm humid maritime air reaches inland over the region. In general, the region is characterised by two distinct climatic periods, namely the dry and wet seasons. The peak of the rainy season occurs from May to July and again between September and November. The maximum northern location of the ITCZ between July and August creates an irregular dry season over the region, whereby rainfall and temperatures decline.

5.1.3

Hydrography and Oceanography

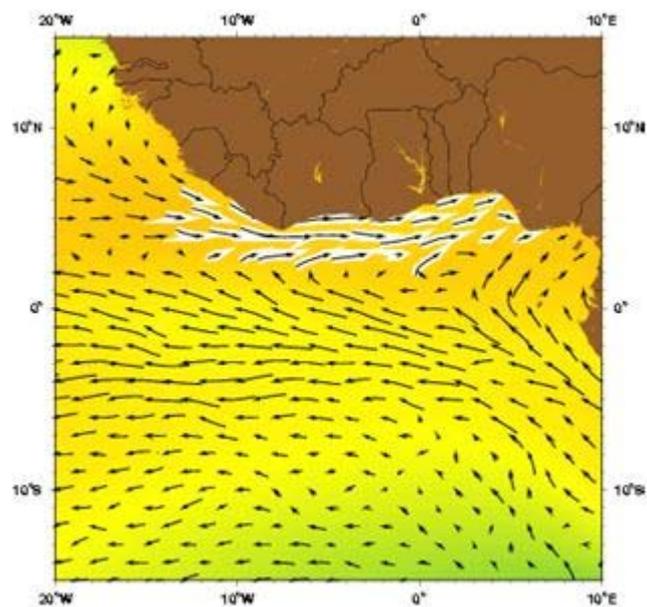
The oceanography of the Gulf of Guinea is largely influenced by the meteorological and oceanographic processes of the South and North Atlantic Oceans, principally their oceanic gyral (circular) currents. Surface water is warm (24 - 29 °C) with the daily sea surface temperature cycle showing annual variability. The thermal cycle occurs only in the upper two elements of the water column which together comprise the tropical surface water mass. The oceanic gyral currents of the North and South Atlantic Oceans spurn a counter current, the Equatorial Counter Current (ECC) which flows in an eastward direction. This ECC becomes known as the Guinea Current as it runs from Senegal to Nigeria (*Figure 5.1*).

During upwelling, cold nutrient-rich water from depths rises to the surface, resulting in increased biological productivity in the surface waters. The major upwelling season along the Ghana coast occurs from July through to September, while a minor upwelling occurs between December and January. The rest of the year is characterised by a strong temperature thermocline ⁽¹⁾, which fluctuates in depth between 10 and 40 m. The major and minor upwellings drive important pelagic (living in the water column) species into the upper layers of the water column, thereby increasing fish catches.

Waves reaching the shores of Ghana consist of swells originating from the oceanic area around the Antarctica Continent and seas generated by locally occurring winds. The significant height of the waves generally lies between 0.9 m and 1.4 m and rarely attains 2.5 m or more. Swells attaining heights of approximately five to six meters occur infrequently.

(1) Layer of water exhibiting a marked change in temperature

Figure 5.1 The Guinea Current



Source: Noble-Denton, 2008

5.1.4 Bathymetry and Seabed Topography

The Jubilee field is located on the continental shelf offshore Ghana in water depths of 1,100 to 1,700 metres. The continental shelf has a generally regular bathymetry with isobaths running parallel to the coast. The continental shelf is at its narrowest (20 km wide) off Cape St Paul in the east and at its widest (90 km) between Takoradi and Cape Coast in the west. The shelf drops off sharply at about the 75 m depth contour.

Ghana's nearshore area comprises various sediment types, varying from soft (mud and sandy-mud) and sandy sediment to hard ground. On the continental shelf, seabed sediments range from coarse sand on the inner shelf to fine sand and dark grey mud on the outer shelf. Sediments on the shelf and upper continental slope are predominantly derived from erosion of rocks from land, with smaller amounts of iron silicate sediments, and biogenic carbonate from mollusc shells.

The seabed in the Jubilee field comprise soft to firm clays and silts that form a generally smooth seabed that slopes to the south-west. The Jubilee Unit Area is crossed by three submarine channels, which appear to be localised drainage points off the continental shelf. All three channels exhibit an active central gully which meanders within each channel.

5.1.5 Ecological Health and Pollution Status

A marine baseline survey of the Jubilee field was conducted as part of the EIA. The survey collected data on seabed sediment and water quality as well as biological community composition (see Figure 5.2). Results of the analysis of

sediment and water samples for chemical determinants indicate that the marine environment has only low levels of contaminants, as would be expected in an offshore deep water area.

Distribution of animals living in the sediment (infauna) showed a relationship to water depth and sediment type. At the Jubilee field samples had varying mixtures of polychaete ⁽¹⁾ worms and bivalves in mainly silt-dominated sediments. In shallower waters nearer the shore the samples were richer in biodiversity and dominated by bivalves and amphipods in medium sand.

Figure 5.2 *Water Sampler and Sub-sampling from Box Corer*



Source: TDI Brooks 2008

5.1.6 *Fish Ecology*

The composition and distribution of fish species in Ghanaian waters is influenced by the seasonal upwelling. The transport of colder, dense and nutrient-rich deep waters to the warmer, usually nutrient-depleted surface water during periods of upwelling stimulates high levels of primary production in phytoplankton. This primary productivity in turn increases production of zooplankton and fish. The fish species found in Ghanaian waters can be divided into four main groups, namely:

- small pelagic species
- large pelagic species (tuna and billfish);
- demersal (bottom dwelling) species; and
- deep sea species.

The most important small pelagic fish species, both commercially and as prey for larger fish found in the coastal and offshore waters of Ghana are:

- round sardinella;
- flat sardinella;
- European anchovy; and
- chub mackerel.

(1) Worms with many legs which can be mobile or sedentary/tube living

Large pelagic fish stocks off the coast of Ghana include tuna and billfish. These species are migratory and occupy the surface waters of the entire tropical and sub-tropical Atlantic Ocean. They are important species in the ecosystem as both predators, and prey for sharks, other tuna and marine mammals as well as providing an important commercial resource for industrial fisheries. The tuna species are skipjack tuna; yellowfin tuna; and bigeye tuna. The billfish species occur in much lower numbers and comprise swordfish; Atlantic blue marlin; and Atlantic sailfish.

Trawl surveys have shown that demersal fish are widespread on the continental shelf along the entire length of the Ghanaian coastline. The demersal species that are most important commercially (in terms of catch volumes) are cassava croaker, bigeye grunt, red pandora, Angola dentex, Congo dentex and West African goatfish.

Over 180 species of fish are thought to occupy the deep sea, including 51 species that are associated with the bottom and a further 106 are listed as bathypelagic (1000 to 4000 m). The remaining species are generally considered to occupy depths to 1000 m but may venture into deeper water during part of their lifecycle. A total of 89 species are likely to be found in Ghanaian waters within the depth range in the Jubilee field (1,100 and 1,700 m).

5.1.7 *Marine Mammals*

There are limited detailed data on the occurrence of marine mammals in Ghana's coastal waters. The ecological significance of the area for dolphins and whales has only recently become the subject of scientific studies and population estimates and natural history remains largely unknown. Small cetaceans of Ghana are documented to suffer pressure from by-catches in drift gillnets and possibly also in industrial purse-seine fishing. Monitoring of landings over a few years has shown the presence of at least 18 different species of dolphins and small whales and all are affected to varying degrees. The Gulf of Guinea humpback whale population seasonally occupies Ghana's shelf zone as a calving and breeding area when they are most vulnerable to disturbance.

5.1.8 *Sea Turtles*

The Gulf of Guinea serves as an important migration route, feeding ground, and nesting site for sea turtles. Five species of sea turtles have been confirmed for Ghana, namely the loggerhead, the olive ridley, the hawksbill, the green turtle, and the leatherback. All five species of sea turtles are listed by the Convention on International Trade in Endangered Species (CITES) and National Wildlife Conservation Regulations. The olive ridley is listed by the International Union for conservation of Nature (IUCN) as vulnerable while the loggerhead and green turtles are listed as endangered. The hawksbill and the leatherback are listed as critically endangered.

Marine turtles spend most of their life at sea, but during the breeding season they go ashore and lay their eggs on sandy beaches. The beaches of Ghana from Keta to Half-Assini are important nesting areas for sea turtle species. Approximately 70 percent of Ghana's coastline is found suitable as nesting habitat for sea turtles, and three species; the green turtle, olive ridley and leatherback turtles (*Figure 5.3*) are actually known to nest. The olive ridley is the most abundant turtle species in Ghana and the majority of nests observed are those of the olive ridley. The nesting period stretches from July to December, with a peak in November.

Figure 5.3 *Olive Ridley, Green and Leatherback Turtles*



Source: seasturtlestatus.org, 2009

5.1.9 *Birds*

The west coast of Africa forms an important section of the East Atlantic Flyway, an internationally-important migration route for a range of bird species, especially shore birds and seabirds. A number of species that breed in higher northern latitudes winter along the West African coast and many fly along the coast on migration. Seabirds known to follow this migration route include a number of tern species, skuas and petrels. Species of waders known to migrate along the flyway include sanderling and knott. The highest concentrations of seabirds are experienced during the spring and autumn migrations, around March and April, and September and October. Waders are present during the winter months between October and March. The marine birds of Ghana include storm petrels and Ascension frigatebirds. The rarity of oceanic birds may be attributable to the absence of suitable breeding sites (eg remote islands and rocky cliffs) off the Ghana coast and in the Gulf of Guinea. One of six Important Bird Areas (IBAs) in Ghana, namely the Amansuri Wetland, is located along the western coastline. The Amansuri IBA includes key bird species including the Sanderling and Royal Tern.

5.2 *SOCIO-ECONOMIC BASELINE*

5.2.1 *Administrative Structures*

The government structure in Ghana is made up of ten administrative regions subdivided into 170 metropolitan, municipal and districts areas, each with an administrative assembly comprised of a combination of appointed and elected officials. Each area has a District Chief Executive (DCE) who heads the local

assembly. The DCE is nominated by the President of the country and is confirmed by the assembly through balloting.

The local government is made up of the Regional Coordinating Council (RCC), four-tier Metropolitan and three-tier Municipal/District Assemblies with Urban/Town/Area/Zonal Councils Unit Committees. The RCC is the apex of the local government system. There are ten RCCs corresponding to ten regions in the country. The RCCs are non-executive bodies responsible for monitoring, coordinating and evaluating the performance of the district assemblies and any Agency of the central government. The RCC is an administrative/ coordinating system rather than a political and policy making body. The Paramount Chiefs are the traditional heads of the people and carry great influence.

The Western Region (the Region closest to the project) currently comprises 14 districts, two municipalities, and one metropolis, the latter being Sekondi-Takoradi Metropolitan Assembly (STMA). The STMA was established during restructuring in 2008. It was formed when the former Shama Ahanta East Metropolitan Assembly (SAEMA) was split into Shama District and STMA.

5.2.2 *Demographics*

The population of Ghana is approximately 23 million (July 2008 estimate) with the Western Region having approximately 2.5 million people. The Western Region has experienced accelerated population growth over the years likely linked to in-migration resulting from increased economic activity, particularly between 1984 and 2000, when the region experienced a boom in both the mining and the cocoa industries. Over one third (36 percent) of the Western Region is urbanised with the remaining 64 percent being rural.

The population of Sekondi-Takoradi Metropolis (STM) was reported as approximately 370,000 in the year 2000. It is the most populated area in the Western Region, comprising about 15% of the region's total population and approximately 80,000 people from neighbouring districts commute to the area for work.

The population of the Western Region is relatively young, with approximately 43 percent of the population 15 years old or younger and five percent of the population are more than 64 years old. STM has the largest proportion of the population (58 percent) in the working age group (15-64 years) in the region likely due to migration of young adults to the commercial and mining towns.

5.2.3 *Economic Activity*

Overview

Ghana's domestic economy currently revolves around agriculture (which includes fishing). This accounts for about 45 to 50 percent of Gross Domestic Product (GDP) and employs about 55 percent of the work force, mainly small

landholders and fishers. Other major sources of employment include mining and quarrying (employing approximately 15 percent of the population), and manufacturing, employing approximately 11 percent of the population.

The major economic activities in STM are related to the port. The STM is the third largest industrialised centre in the country and there are other significant industrial and commercial activities in the manufacturing sector (food processing, spirits production, textiles, metal fabrication) and resources sector (timber, clay). The area has a large food and goods market which is a centre for small and medium size trading enterprises. Fisheries and tourism are the two most important activities in relation to the project and are discussed in further detail below. Other economic activities include agriculture, mining, forestry and coastal salt production.

The poverty incidence in the Western Region of Ghana ranked third highest in the country and contributed about 6.5 percent to the national poverty level. The levels of unemployment in the Western Region are also considered to be high.

Fisheries

Fish and fish products provide the greatest proportion of animal protein in Ghana and contribute approximately 60 percent of the total animal protein intake. About 75 percent of the total domestic production of fish is consumed locally and the per capita consumption is estimated to be about 25 kg annually.

The fishing industry in Ghana is based on resources from both marine and inland (freshwater) waters and from coastal lagoons and aquaculture. The fish landings from coastal lagoons or estuaries, using small scale gear such as gill nets, throw nets and weirs, although comparatively small, provides reasonable quantities of fish products for subsistence purposes.

The traditional artisanal inshore fishery in Ghana is well developed and provides about 70 percent of the total marine fisheries production in the country. There are over 8,000 canoes, of which approximately half are motorised by low powered out-board engines (see *Figure 5.4*). Over one hundred thousand fishermen and fish mongers are engaged in this sector. The main types of fishing gear used by the artisanal fishermen are encircling nets, beach seines, purse seines, set nets, hook and line and drift gill nets. Each gear has very different geographical distributions along the coast and the dominance of any particular gear type in an area is influenced by the target species sought. Drift gill nets and set-nets are the most common gear used in the Western and Central regions.

Within the marine sector target species include pelagic, demersal and shellfish resources. The most important fish species caught by the Ghanaian artisanal fleet are pelagic fish including round sardinella, flat sardinella, anchovy, chub mackerel, sparids and big-eye grunt. Marine fishing activity in Ghana is

strongly linked with the seasonal upwellings. Most fish spawn during upwelling periods and stocks are more readily available to the fishers. For the rest of the year, catches are lower and more sporadic. The artisanal sector on average lands 221,000 tonnes of fish annually, approximately 70 percent of the total annual marine fish catch.

Figure 5.4 *Fishing Canoes in the Western Region*



Source: ERM 2009

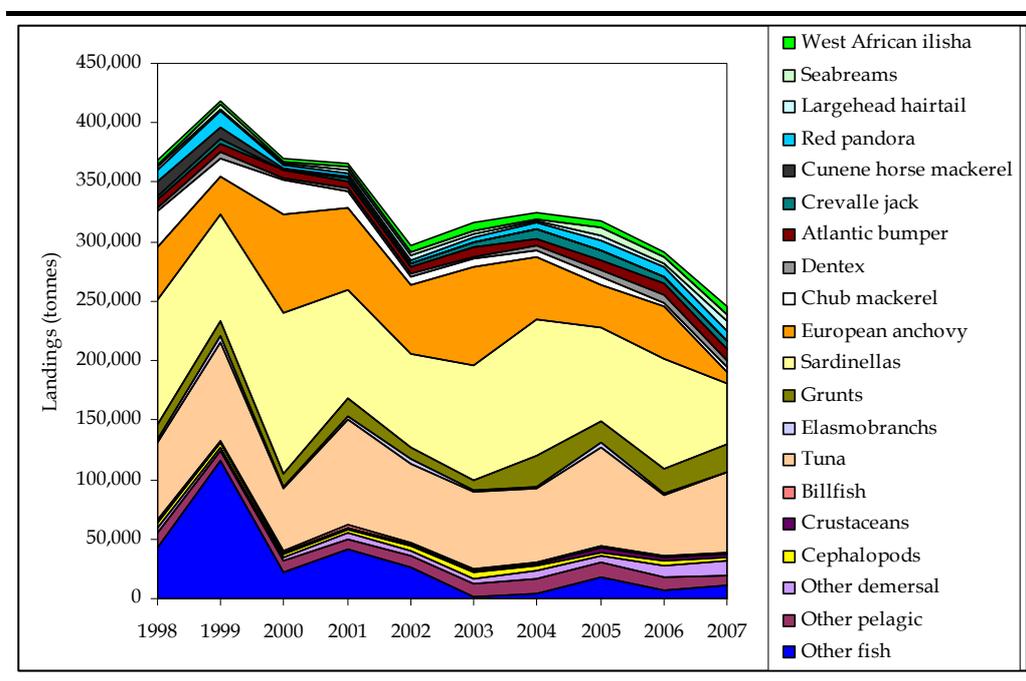
The semi-industrial fleet exploits sardinella, mackerel and a number of different demersal species. The average annual total landing from this fleet over the last ten years was about 8,200 tonnes, representing less than 3 percent of the total annual marine fish catch from Ghanaian waters. The industrial fleet (including trawlers, shrimpers and pair trawls) lands an average of 16,300 tonnes each year, five percent of the total annual marine fish catch. About 60 percent of the fish landed by the industrial vessels are demersal species such as seabream, cuttlefish and cassava croakers.

Overall landings in the last decade have shown a declining trend with a number of the most important species showing marked declines particularly the main pelagic resources such as anchovies and sardinellas (*Figure 5.5*). Declines in less important pelagic resources, such as chub mackerel, Cunene horse mackerel and crevelle jack have also contributed to the overall downward trend. However, demersal species show some increases, with grunts, Atlantic bumper, red pandora, crustaceans and demersal resources in general showing marked increases over the last ten years. Tuna and billfish landings have remained fairly stable.

A number of commercially important species are subjected to heavy exploitation, particularly albacore tuna and swordfish. The International

Commission for the Conservation of Atlantic Tunas (ICCAT) has listed bigeye tuna as the species of greatest concern, after the bluefin tuna, in terms of its population status and the unsustainable levels of exploitation exacted on this species.

Figure 5.5 *Total Landings of Major Target Groups by Ghanaian Fisheries 1998 to 2007*



Source: FAO 2007

Tourism and Cultural Heritage

Ghana has a wide range of natural, cultural and historical attractions which provides the basis for an important tourism industry which is one of the fastest growing sectors of the Ghanaian economy. The number of tourist arrivals and tourists' expenditure has steadily increased, while both public and private investment activity in various tourism sub-sectors have expanded. According to data provided by the Ghana Statistical Service in 2004, the sector attracted more than 500,000 foreign tourists with corresponding tourist receipts of US\$640 million. Tourism potential in the Western Region is related to the number and extent of pristine bathing beaches (*Figure 5.6*) as well as wildlife parks and forest and game reserves featuring tropical rainforests, inland lakes and rivers.

Figure 5.6 Sandy Beach



Source: Environmental Sensitivity Atlas, 2004

6 IMPACT ASSESSMENT

6.1 INTRODUCTION

The project activities with the potential to cause environmental and socio-economic impacts were identified from discussion and workshops with the project team, consultations with stakeholders and from the previous major project experience of the EIA team. A methodical impact assessment was then carried out to predict the magnitude of impacts and quantify these to the extent practicable. The term 'magnitude' covered all dimensions of the predicted impact (ie area impacted and the duration and frequency of impacts). The significance of any particular impact was determined by considering the magnitude of impact in relation to the sensitivity of the affected resource or receptor.

The assessment of impacts took into account the mitigation measures that have been built into the project design. Additional mitigation measures were developed to reduce the severity of identified impacts to as low as reasonably practicable levels. Where impacts could not be fully eliminated by mitigation measures, the residual impact was described.

The assessment addresses the impacts associated with the FPSO installation and operations. Many of the impacts from drilling operations using MODUs will be similar as both the FPSO and MODUs will have similar numbers of people on board and have similar support vessel and supply requirements. The main exception to this is the discharge of drill cuttings and fluid which is discussed under the operational discharges section below.

Impacts associated with the project are grouped under the following headings:

- Project Footprint;
- Operational Discharges;
- Air Emissions;
- Waste Management;
- Oil Spill Risk;
- Socioeconomic and Human Impacts; and
- Cumulative and Transboundary Impacts.

6.2 *PROJECT FOOTPRINT*

This section provides an assessment of the potential impacts from the physical footprint of the Jubilee Phase 1 project and discusses measures to be implemented to mitigate those impacts. The term physical footprint incorporates both the presence of the offshore and onshore structures and equipment and the effects of these on the physical environment and associated resources and receptors. Impacts from the physical footprint include impacts from noise and light sources.

6.2.1 *Subsea Infrastructure*

The Jubilee Phase 1 Development will have a physical footprint on the seabed through placement of infrastructure during the construction and commissioning of subsea infrastructure and from the long-term presence of this infrastructure. This will result in habitat loss or disruption to an area of the seabed of approximately 2 hectares with direct impacts to benthos. The introduction of seabed infrastructure will also provide new substrates for colonisation by benthic organisms and provide areas of shelter for demersal (bottom-dwelling) fish.

To mitigate potential negative impacts the layout of the subsea infrastructure will be designed to avoid seabed features considered geo-hazards. This will also protect areas with potentially more diverse habitats and species. Most subsea flowlines will be laid directly on the seabed and flowline burial using methods such as dredging and jetting will be avoided to reduce suspended sediments.

The area of seabed habitat and associated species is relatively small and not considered to be of high sensitivity from the result of the baseline survey. The impacts would be long term but small scale and the overall significance of direct and indirect impacts is assessed as being of minor significance.

6.2.2 *Project Vessels and Underwater Noise*

Project generated noise includes noise from vessel propellers, power generation units and subsea valves. Localised noise sources, if sufficiently loud, may be detrimental to certain marine species under some circumstances

and may result in physical harm or behavioural changes. Of particular concern are the impacts of underwater sound on marine mammals due to the known reliance on sound for activities such as communication and navigation for some species. The impact assessment determined that the likelihood of impact on such animals is small. Turtles are less reliant on sound and are considered less sensitive to noise. West African manatees are also present in Ghana almost exclusively in continental waters and do not occur in deep offshore waters. Available information on marine fish, shellfish and birds indicates that they are not particularly sensitive to underwater sound. Collisions with marine mammals and turtles from vessel movements are also a source of potential impact, especially near large ports.

To reduce the potential for impact the project will develop and enforce a specific policy and procedures to ensure that traffic and operations of drilling vessels, support vessels and helicopters will minimise disturbance to marine mammals and turtles. Vessels will not be allowed to intentionally approach marine mammals and turtles and, where practicable, will alter course or reduce speed to further limit the potential for disturbance or collision. Marine vessel and helicopter operators will be trained in marine mammal and turtle observation and monitoring to gather information on marine mammal and turtle distribution information to inform future operations.

Noise from project activities is generally continuous or near continuous and of lower energy than from other noisy marine activities such as seismic surveys or percussive piling, that are known to have an effect on the behaviour of some marine mammals. It is considered that marine mammals that frequent the area will become accustomed to these noise sources and will avoid any areas that are detrimental to them. Overall the residual impact on marine mammals is assessed as being of minor significance. It is recognised that there is a lack of information on marine mammal distribution in Ghanaian waters and a programme of marine mammal observations will be undertaken as part of the project.

6.2.3 *Fish Populations*

Deep water fish species and large pelagic fish species (e.g. tuna and billfish) will be present in deep water in the Jubilee Unit Area and could be affected by the presence of subsea infrastructure on the seabed. Pelagic species which inhabit the surface layers of the water column are likely to be attracted to the FPSO. During the night fish species may also be attracted by light emissions from the FPSO. The exclusion zone placed around the FPSO will afford some protection from fishing activity. No mitigation measures are proposed and the residual impact of the physical presence of the FPSO and subsea infrastructure was assessed as being a positive impact of minor significance.

6.3 OPERATIONAL DISCHARGES

Operational discharges will occur throughout the project lifespan from routine activities and non-routine or one-off discharges associated with commissioning and maintenance activities.

6.3.1 Routine Operational Discharges

Routine discharges will include:

- black water (sewage), grey water (washing) and macerated food waste (from FPSO, MODUs, construction and support vessels);
- deck drainage and bilge water possibly contaminated with traces of hydrocarbons (from FPSO, MODUs, supply and support vessels);
- occasional discharge of ballast waters (from export tankers and other vessels);
- hydraulic fluid from daily subsea valve activation; and
- produced water (from FPSO).

In deep water offshore areas such as the Jubilee field the main environmental receptors are the waters in the vicinity of the discharges and the marine organisms that occupy these waters. The waters in the Jubilee field are of good quality, as would be expected in an offshore, deep water area. The water depth, distance offshore and hydrography provides a high level of dilution and dispersion for any discharges.

Mitigation measures include the following.

- Discharge of black water, grey water and food waste will be carried out in accordance with MARPOL requirements and good industry practice.
- Black water will be treated prior to discharge to sea. Approved sanitation units onboard will achieve no floating solids, no discolouration of surrounding water and a residual chlorine content of less than 1 mg/l.
- Organic food wastes generated will be macerated to pass through a 25 mm mesh and discharge more than 12 nm from land including no floating solids or foam.
- The FPSO will be equipped with segregated ballast tanks and all marine vessels will be operated in accordance with the applicable MARPOL requirements (i.e. no discharges with more than 15 ppm oil or grease).
- Visiting export tankers and other vessels discharging ballast water will be required to undertake ballast water management measures in accordance with the requirements of the International Convention for the Control and Management of Ships Ballast Water and Sediments.

- Water based, low toxicity and biodegradable hydraulic fluid will be used for subsea valve activation.
- Produced water will be treated through a three stage treatment process to maintain a monthly average oil concentration of less than 29 mg/l and not to exceed an instantaneous maximum of 42 mg/l.

The dispersion of produced water at a concentration of 42 mg/l of oil was modelled from a surface discharge at the FPSO using hydrographic data from the Jubilee field which showed that the discharge would rapidly disperse and get diluted. The concentration modelled was a worst case based on the maximum instantaneous discharge concentration and the impacts of a 29 mg/l monthly average concentration will be correspondingly lower. The residual impacts for routine discharges were assessed as being of low magnitude, short term and localised and therefore of minor significance.

6.3.2 *Drilling Wastes*

The MODUs will treat drill cuttings prior to disposal. For overboard discharge of cuttings the permit target for oil on cuttings for the exploration wells drilled to date was 6% to 8%, however with improved cleaning using modern solids control equipment a target for the remaining development wells is set at less than 5% oil on cuttings.

Total volume of fluid and cuttings to be discharged from each well is expected to amount to approximately 383 m³ of water based drilling fluids, 283 m³ of cuttings drilled with water based drilling fluids, and 285 m³ of cuttings and residual enhanced mineral oil based drilling fluids. For the 17 wells this will result in approximately 4,845 m³ of enhanced mineral oil based cuttings

Drill cuttings dispersion modelling was undertaken for the EIA to predict the area of seabed around each well that would be impacted from discharged cuttings. The following mitigation measures to minimise the impact of drill cuttings and fluid discharge on the marine environment will be adopted.

- Use of low toxicity and biodegradable drilling fluids.
- Use of solids control systems including dryers and centrifuges to minimise oil on cuttings as far as is achievable with current technology. Programme of continuous improvement by enhanced cuttings treatment to reduce oil on cuttings to less than 5% as a weighted average.

Given the type of drilling fluid being used, the use of improved drilling fluids and cleaning technology and the localised and temporary nature of impacts it is considered that the proposed discharges will have impacts of minor significance on seabed habitats and species.

6.3.3

Non-routine Discharges

Non-routine discharges will include:

- completion fluids and occasional discharge of workover ⁽¹⁾ fluids (from MODUs);
- chemically treated hydrotest waters from the subsea infrastructure during installation and commissioning; and
- potential leaks or accidental releases from tanks, pipes, hoses and pumps, including during loading and unloading from the shore base to the supply vessels.

Mitigation measures to reduce the potential impacts associated with the disposal of non-routine discharges will include the following.

- Selection and use of completion, hydrotest and workover fluids will be managed taking into account its concentration, toxicity, bioavailability and bioaccumulation potential with selection based on the least environmental potential hazard.
- Where possible, used completion and workover fluids will be collected in a closed system and injected into the formation, routed to the flare for combustion, or shipped to shore for recycling or treatment and disposal.
- Those completion and workover fluids that are discharged to sea will be treated to achieve a maximum oil and grease content of 42 mg/l (29 mg/l monthly average) and pH of 5 to 7 prior to disposal.

In the open ocean, discharges will be diluted rapidly and residual impacts are predicted to be of minor significance.

At the shore base, the following mitigation measures will be implemented.

- Chemical and fuel storage areas will have appropriate secondary containment and procedures for managing the containment systems. Impervious concrete surfaces will be in place at all areas of potential chemical and fuel leaks. For chemical and fuel storage, handling and transfer areas, storm water collection channels will be installed with subsequent treatment through oil-water separators.
- Loading and unloading activities will be conducted by properly trained personnel according to formal procedures to prevent accidental releases and fire and explosion hazards. Spill control and response plans will be developed in coordination with the landowners (GPHA Takoradi and Takoradi Air Force base).

Impacts from shore based operations are assessed as being not significant.

(1) A workover is a well intervention to undertake repairs and maintenance involving a MODU or similar drilling vessel

6.4 AIR EMISSIONS

The majority of gaseous emissions from the project will occur offshore within the Jubilee field. Limited gaseous emissions will occur from onshore activities eg from vessels visiting port, and along vessel and helicopter transport routes.

6.4.1 Atmospheric Pollutants

Project activities will emit varying amounts of primary atmospheric pollutants with the potential to impact air quality. These pollutants include carbon monoxide (CO), oxides of nitrogen (NO_x), oxides of sulphur (SO_x), volatile organic compounds (VOCs) and particulate matter (PM).

Emissions from the offshore activities are unlikely to have significant direct impacts given the absence of sensitive receptors and the highly dispersive nature of the environment of the offshore location. Offshore receptors such as fishing vessels and commercial shipping are unlikely to be exposed to poor quality air other than for very short durations, for example if sailing close and downwind of the FPSO during flaring.

Mitigation measures will include the following.

- The MODU, FPSO, construction/installation and support/supply vessels will comply with MARPOL 73/78 Annex VI standards with regards to air emissions.
- Vessels visiting the port will egress at partial power, achieving full power only after leaving the port area and avoiding or limiting the practice of blowing soot from tubes or flues on steam boilers while in port or during unfavourable atmospheric conditions. Where possible onshore power sources will be used for vessels when in port to reduce shipboard power use during loading / unloading activities and vessels will shut down engines when docked.
- Emission guidelines for small combustion sources, including exhaust emissions using liquid fuels, will be implemented. The guidelines will provide limits for PM, SO_x and NO_x. Low-sulphur diesel (<0.1% sulphur) fuel will be used where possible.
- Methods for controlling and reducing leaks and fugitive emissions will be implemented in the design, operation and maintenance of the offshore facilities.
- Routine flaring will be avoided and non routine flaring will be kept to minimum to maintain safe conditions or during short-duration activities such as start-up, re-start and maintenance activities.

- Routine inspection and maintenance of engines, generators, and other equipment will be carried out to maximise equipment fuel efficiency and minimise excess air emissions.
- VOC emissions from hydrocarbon and chemical storage and transfer activities will be controlled by equipment selection.

Overall, impacts due to emission of atmospheric pollutants was determined to be either of minor significance or not significant.

6.4.2 *Greenhouse Gasses*

Project activities will emit varying amounts of Greenhouse Gases (GHGs) (eg carbon dioxide and methane, believed to contribute to global climate change). The principal sources of GHGs from the project will include: the main power generation systems on the FPSO; combustion sources such as back up generators and support vessel engines; non-routine flaring of gas on the FPSO; and purging of oxygen for safety purposes.

The mitigation measures aimed at reducing GHG emissions are built into the design of the FPSO through focus on:

- efficiency of power generation;
- optimisation of overall energy efficiency;
- reduction in flaring; and
- reduction in venting.

The following measures will be implemented.

- The FPSO will be designed with centralised electrical power generation, provided by high efficiency gas turbines, sized and configured to life-of-field power demand.
- The FPSO will be designed to minimise process electricity demand through careful sizing, configuration and selection of energy efficient equipment, in particular, compressors and pumps.
- Throughout engineering design, opportunities to improve energy efficiency will be identified and assessed through engineering studies.
- Flaring during the commissioning stage of gas handling and in particular gas compression systems will be minimised through extensive pre-commissioning testing of the FPSO process systems in the supply factories and the Singapore dockyard prior to the FPSO sailing to Ghana.
- The design of the project will eliminate the need for routine flaring and reduce direct venting.

- The FPSO flare system will be equipped with flow meters to measure flare volumes so that emissions can be tracked and managed.

To monitor the effectiveness of measures to reduce the levels of emissions, the project will quantify annual GHG emission from production and flaring activities in accordance with internationally recognised methodologies and reporting procedures.

Residual impacts from emissions of GHGs are assessed as being of minor significance given the scale of emissions and in the context of relatively low national emissions in Ghana.

6.5 WASTE MANAGEMENT

The project will generate both non-hazardous wastes and hazardous wastes that will require disposal in a manner protective of the natural and human environment. The potential impacts of waste associated with the project throughout the three stages of the waste management process are outlined below.

6.5.1 Storage and Segregation of Waste

The main sources of potential environmental impact resulting from storage, segregation and containment of wastes include:

- accidental discharge or spillage of wastes to the marine environment due to inappropriate storage and containment of wastes on offshore facilities or vessels;
- accidental discharge or spillage of liquid wastes to soil and water resources due to inappropriate storage and containment of wastes at the onshore supply base; and
- degradation to visual appearance, release of odours, and exposure of local communities to health and safety risks due to inappropriate and insecure storage of wastes.

Mitigation of potential impacts will be by operational controls. Procedures for controlling wastes will be contained in the project Waste Management Plan (WMP). The WMP will require that all facilities operated or controlled by the project will adopt specific procedures for the management of wastes in accordance with legal requirements and in a manner that minimises the potential for environmental damage as far as reasonably practicable.

To mitigate the potential impacts on the environment and human health, the project will also construct a secure waste reception, segregation and storage facility at the Takoradi shore base. Through the implementation of these operational controls the residual impacts from project-generated wastes would be of minor significance.

6.5.2

Transport of Wastes

Wastes from project facilities will need to be transported to waste disposal areas. This could result in accidental discharge or spillage of wastes to the marine environment due to inappropriate handling and containment of wastes during transport on supply vessels. Impacts on the onshore environment (eg soils and groundwater) and communities could result from spillage of potentially hazardous wastes during transport, poor security of waste due to inappropriate management and control of vehicles transporting wastes to storage and disposal sites.

Mitigation of potential impacts of waste transport will be by the following operational controls.

- All wastes will be transported in a safe manner, in accordance with the associated Material Safety Data Sheet information for spent chemicals and other industry packaging and transport advice.
- Transportation of wastes will be via well maintained, legally compliant and suitable vehicles or vessels, with appropriate documentation (including Waste Transfer Notes) and operated by fully trained operators.
- Only project and Ghana EPA approved waste contractors, which meet the appropriate standards, will be allowed to transport wastes.

With these good practice controls in place the residual impacts are assessed as being of minor significance.

6.5.3

Onshore Waste Disposal

Project generated waste will need to be disposed in a manner that avoids significant environmental impacts. Potential impacts could result from the following sources.

- Contamination of soils, groundwater and surface waters, and/or release of vapour emissions with the potential to adversely affect air quality or cause a health risk to local communities due to disposal of wastes at dump sites (non-engineered landfills) not designed or operated to the appropriate standards.
- Littering and health and safety risks associated with uncontrolled public access to wastes at landfill sites with inadequate security.
- Impairment of local air quality and increased health risks due to open burning of wastes.
- Contamination of soils, and surface or groundwater, potentially impacting on human health or ecosystems due to illegal dumping ('fly-tipping') of hazardous wastes (solid or liquid).

- Adverse effects on air quality and secondary impacts on the local community health due to improperly treated combustion emissions from incineration.

Mitigation measures for potential impacts associated with waste disposal include:

- selection of a suitable disposal facility(s), likely to require investment by the project to upgrade standards in areas such as landfill, incineration and liquid waste treatment; and
- measures to ensure proper continuous operation and monitoring of the disposal facility.

Most project wastes will be non-hazardous and will either be recycled (eg scarp metal), reused (eg wood) or disposed of at landfill sites in Ghana (ie general domestic waste such as paper). Tullow will continue to work with waste contractors to further maximise recycling of non-hazardous wastes.

The project has conducted a study that assessed the available waste disposal sites in Ghana for suitability and adequacy of the facilities. The results of this study are being used to determine options for medium and long-term treatment of hazardous wastes. The single largest hazardous waste in terms of volume is waste oil/oily water associated with the MODU and support ships. This is currently being disposed of via an approved oil waste facility in the Sekondi-Takoradi area and will continue once the FPSO comes on line. Other hazardous wastes will either be managed using approved waste contractors (eg lead acid batteries) or stored in a secure hazardous waste area pending identification of a suitable contractor/disposal method (eg used filters). The project will work with national and international companies to introduce suitable technology/facilities to manage those hazardous wastes for which there is currently no treatment option.

The residual impacts associated with the onshore disposal of wastes from the project activities are assessed as of moderate significance. This rating is given in the context of the limited (although developing) availability of waste treatment and disposal options and since the project will not have direct control over waste facility operations other than through contractual terms and conditions and by periodic audits. Once suitable facilities have been developed for the identified waste types, the impacts are likely to be of minor significance or not significant.

6.6 *IMPACTS FROM OIL SPILLS*

6.6.1 *Oil Spill Risk*

The risk of an oil spill (including crude oil and fuel oil) into the marine environment is inherent in all offshore oil developments. The likelihood

(probability) of significant oil spills (ie those that can reach the coastline or other sensitive areas) from FPSO operations is very low with oil spills that do occur being very small and having only limited environmental effects. The assessment of risk therefore requires consideration of the likelihood of a particular type and size of spill event occurring and the environmental consequences in the event of a particular spill.

The industry approach to dealing with potential oil spills is to develop technology and operational procedures to reduce the likelihood of oil spills whilst planning appropriate responses to reduce the severity of impacts in the event of a spill. The response procedures form part of the Oil Spill Contingency Plan (OSCP) which is one part of Tullow's overall Emergency Response Plan for the project.

The assessment of the potential impacts of an oil spill to the marine and coastal environment requires consideration of the likelihood of various types of spill occurring and the consequences of these spills. A Quantified Risk Assessment (QRA) was undertaken that examined the frequency of accident events that could result in oil spills of various types and sizes from the project activities. A series of oil spill scenarios were then defined for subsequent quantitative modelling to predict the likely trajectory and fate of an oil spill if it occurred and to give an indication of the likelihood of a particular location area of sea or coast being affected.

Evaluation of frequency, size and nature of historic spills indicated that 99% of spills result from small leaks and spills with the most likely source of a spill being from the transfer hose during oil unloading from the FPSO. Based on historical data a spill of this kind is predicted to occur approximately twice every 10 years. It would be a relatively small spill of less than 1 tonne. Large spill events, such as ship collision, FPSO hull damage, blowouts and cargo tank explosions are highly unlikely to occur. For example an oil spill from a ship collision is predicted to happen only once every 10,000 years.

6.6.2 *Modelling Results*

Oil spill modelling was used to predict the consequences of oil spill scenarios. The model considered the nature of the oil spilled, the location and duration of the spill, the behaviour of the oil in the marine environment, and transport to marine and coastal areas. Eleven spill scenarios covering two oil types (crude oil and marine gasoil) and six oil spill volumes were modelled.

Modelling indicated that the predominant transport of spilled oil would be to the east which would impact the Ghanaian coastline near Cape Three Points. The area of potential impact would vary with spill size, with the distance from the spill location ranging from 40 km for a 10 tonne diesel spill to more than 600 km for a crude oil spill of 1,000 tonnes or more. Shoreline oiling would be possible for all scenarios where spill sizes were greater than 100 tonnes but with a low probability.

The model indicated that spilled oil could reach the Ghana shoreline as quickly as 1 to 1.25 days given worst case scenario wind conditions. The extent of shoreline oiling would be directly related to the duration and volume of the oil release. Approximately 100 to 170 km of shoreline would be at a greater than 10% risk from oiling with the very large spill sizes (20,000 and 28,000 tonnes). Areas with a more than 10% risk of oiling from smaller (up to 5000 tonnes) spills vary between 55 and 115 km. The shoreline with the highest probability of being oiled is the stretch of coastline approximately 100 km west of Cape Three Points. East of Cape Three Points, a longer reach of shoreline could potentially be oiled, but the probability of oiling is generally less than 15%. None of the oil spills modelled indicated that transboundary impacts on neighbouring countries were likely.

6.6.3 *Impact Assessment*

In the event of an oil spill the initial impact will be on the marine environment offshore Ghana. While localised impacts to water quality will occur, the more significant impacts will be on marine biodiversity, and in particular those species that frequent the sea surface, including sea birds, marine mammals and turtles. Fish species in deeper water can be expected to be less exposed to impacts from oil spills as they will tend to avoid the sea surface or vacate the area in the event of a spill.

Assuming a spill has occurred that is greater than 10 tonnes, and the prevailing wind is from the southwest there is a possibility that secondary impacts will be experienced on the coastline if the oil beaches. If oil did reach the coastline, impacts could include contamination of sensitive coastal habitats such as mangroves, wetlands, lagoons and turtle nesting beaches and impacts on species that frequent such habitats such as coastal birds and fish. An additional impact of oil reaching the coastline would be the potential impacts on local communities and populations, for example from the damage to fishing grounds.

6.6.4 *Mitigation Measures*

Mitigation of oil spills will take two forms: spill prevention and spill response. The primary mitigation measure for avoiding the impacts of an oil spill is to prevent any such spill taking place in the first place. This will be done through technology applications as well as operational controls.

Oil spill prevention measures that will be implemented as part of the design of the project will include the following.

- Blow-Out Preventers and sub sea valves will be permanently installed on the wells during well completions, and the double mechanical barrier system will be used during production and injection operations.
- Wells, subsea flowlines, risers and FPSO topsides will be designed to international process codes and with alarm and shutdown systems to

maintain the system within its design criteria at all times. The system will be tested, inspected and maintained to ensure that performance standards are met.

- The FPSO deck and drainage system will be designed to contain spills on the FPSO (as well as leaks and contaminated wash-down water) to minimise the potential for overboard release.
- Notification to other marine users, safety navigation systems (eg radar) and a safety exclusion zone, maintained by the support vessels, will reduce risks of collision incidents that could lead to an oil spill.

Additional oil spill prevention measures and procedures to minimise the risk of oil spills will include:

- fire and explosion prevention systems;
- equipment and instrument inspection programs;
- corrosion control programs; and
- spill prevention training program provided to its personnel.

Specific procedures will be developed for offloading crude from the FPSO onto the shuttle tankers. These will include inspection of tankers involved in offloading, management by trained and experienced personnel in all aspects, the use of a quality marine fleet to undertake the operation of hose handling and tanker movements (including contingencies for any engine failures), and the continuous monitoring and actions to be taken in the event of any non-routine events or equipment failures.

Despite the prevention measures and management procedures built into the design of the project there is always a risk that an oil spill can occur. The project has established an Oil Spill Contingency Plan (OSCP) which contains detailed procedures that will be taken in the event of small, medium and large oil spills (known as Tier 1, 2 and 3). This includes access to international scale response capabilities including trained personnel, clean up equipment and dispersant capabilities.

The likelihood of a large spill is very low, however, the consequences if the spill reaches the coast are very high. Given the likelihood of a large spill is approximately one in every 10,000 years the residual significance is assessed as moderate.

6.7

SOCIOECONOMIC AND HUMAN IMPACTS

Socioeconomic and human impacts include those impacts that may be reasonably expected to affect Ghana at a national level and those that are likely to be experienced at a more regional and local scale (eg in the offshore environment and in the vicinity of the shore base and port). The assessment was made with a number of considerations.

- The project operations are primarily located offshore and there will be few direct interactions with other human activities other than limited numbers of marine users who operate in the area (ie commercial vessels and fishermen).
- The majority of the deepwater offshore infrastructure will be transported to the field by sea from international locations, and the shore base operations in Ghana will be limited to routine project support, supply runs, equipment and materials storage and waste handling.
- This project is the first significant oil development in Ghana and although other discoveries may be made in the future an assessment of potential socioeconomic and human impacts from the potential future development of undiscovered hydrocarbons is not possible.

6.7.1 *Macroeconomic Impacts*

The revenues generated by the project through oil sales, taxes and royalties will be a valuable source of finance for the government with the potential to facilitate investment in the country's socioeconomic development (eg development of infrastructure such as road network, power grid, water network, solid and liquid waste and telecommunications) through central government funding. In addition, the revenue could stimulate investment loans providing further sources of revenue. With the development of Jubilee field there is also the potential for larger scale development of the oil and gas industry in Ghana.

Overall these revenues have the potential for significant positive benefits at a national level over at least the medium term (ie up to 20 years), although revenue would be highest in the first 5 to 10 years of production. Revenue from oil can be unpredictable as it depends on world market prices and the management of these revenues requires good fiscal discipline. Consequently, the benefits of oil revenue will depend on the policies and actions adopted by the Government of Ghana.

Where the project can influence expenditure at the macroeconomic level is through the establishment and financial support for projects through the project's Corporate Social Responsibility (CSR) strategy and in sponsoring training programmes and education in oil industry skills. Tullow is developing a CSR framework plan which will provide details of Tullow commitment to enhancing the positive impacts of its activities.

Overall the socioeconomic impacts at a macroeconomic level are predicted to be positive at a national level. However, as the project cannot control the use of these revenues it is not possible to predict the eventual outcome.

6.7.2

Employment and Training

Direct employment by the project and indirect employment through contractors and suppliers will have a positive impact on those people employed, their families and their local communities from wages and other benefits. There will also be minor benefits to the wider economy through spending of earnings and income taxes. In general, the oil industry is not a large employer in relation to the revenues it can generate, therefore, the spread of money through wages into the wider local economy is less than that experienced for similar sized industries such as manufacturing or service-based industries. Expectations of some of the public in terms of direct access to revenues (ie through employment) from the project are likely to exceed what is possible.

The skills developed through training received and experience gained when employed in the oil and gas sector will be transferred to other sectors of the economy and will provide positive benefits. It will also make Ghanaians more competitive in the international market place, facilitating increased opportunities and skills transfer.

Potential negative effects would include the following.

- Demand for skilled labour could cause a skills drawdown from other sectors as people take jobs in the oil and gas sector ie loss of staff from government and loss of engineers from other sectors.
- Due to lack of skilled labour to meet the specific project staff requirements and the relatively low numbers of staff required, the project is unlikely to meet the high community expectations of employment opportunities.

As mitigation, the project will develop a Human Resource Strategy for the recruitment and development of national staff in its operations (known as 'nationalisation'). The strategy will include methods for effective communication of employment opportunities, selection, evaluation and appropriate induction and dedicated staff training programmes.

Residual negative impacts would be minor in the long-term as a wider base of skilled staff becomes available through training and as the industry develops.

6.7.3

Procurement of Goods and Services

Impacts from procurement of goods and services are likely to be positive through stimulating small and medium sized business development with investments in people (jobs and training) and generation of profits. Business investment in new and existing enterprises that provide goods and services can provide the basis for their longer term sustainable growth as they diversify to provide goods and services to other industries. Secondary wealth generation from the development and use of local providers of goods and

services can be reasonably expected to have a positive impact through the generation of revenue able to flow into the local economy.

Negative impacts could occur due to increased demand by the project for certain goods and services. This may place pressure on supplies and services available for local people and industries and lead to shortages and price increases. To enhance the benefits from procurement of goods and services the project will adopt a procurement strategy with the following elements.

- A policy of procuring services and equipment locally (within available capacity) and of helping to expand local businesses and strengthen their ability to respond to the needs of the oil and gas industry, thereby providing in the longer term a stronger and more experienced service industry.
- Contracting companies to establish longer term commitments to the businesses which will promote sustainable long term growth and help new businesses become established.
- Conduct contractor screening and develop contract conditions to ensure the requirement for local content (nationalisation) is passed to contractors, so goods are purchased locally where possible, and employment rights and conditions are respected.
- Working with suppliers to help them meet the required standards in areas such business awareness, employee rights, training, environment and health and safety.

Tullow will also monitor pressures on local goods and services through community consultations to determine if project related demand is creating a significant effect on the communities. Residual negative impacts are assessed as being not significant.

6.7.4 *Fishing Activities*

Potential impacts on fisheries can arise from:

- loss of access to the area of the FPSO during completions, installation and operations due to presence of vessel, FPSO and the safety exclusion zones;
- attraction of fish to the FPSO, due to the FPSO acting as a fish aggregating device (FAD); and
- disturbance to fishing activities and damage to fishing gear from project support vessels and supply vessels transiting to and from Takoradi.

A legally enforceable safety exclusion zone will be maintained around the project facilities to reduce the risk of collisions at sea and to ensure personnel safety. Fishing vessels will not be able to fish within the safety exclusion zone. Given the area available to fish for the target species in this location, exclusion

from a relatively small area around the project site is not likely to significantly affect catches.

The FPSO is likely to attract fish through its presence on the waters surface acting as a FAD. Some pelagic fish species would be attracted to the FPSO and would not be available to the fishery while beneath the FPSO and within the exclusion zone. Generally, FADs work for only a relatively short period of time as fish shoals and fish will only be present for a number of days or weeks. Given the large areas that pelagic species in this area occupy and the needs for predators (such as tuna) to range widely for their prey, impacts on the fishery are considered to be of minor significance.

Vessel movements to and from onshore base during the installation and operational stages of the project have the potential to interact with fishing activity in the vicinity of the onshore bases and along utilised shipping routes. Near shore artisanal fishing activities could be adversely affected through disturbance of fishing activity and the potential for damage to fishing gear. The infrequent nature of vessel movements during construction and the low frequency of vessel movements during operations mean the probability of an interaction between supply vessels and fishing activity is low and the impact is expected to be of minor significance.

The following mitigation measures will be implemented to minimise any potential impact on the fishing industry.

- The project will employ Community Liaison Officers (CLO) to liaise between fishermen and the project and to provide information to fishing communities, companies regarding Tullow's activities. The CLO will also deal with any claims for gear damage.
- A vessel transit route will be agreed with the Ghana Maritime Authority and communicated to fishermen and other marine users through the CLO.
- The project and contractors will notify mariners of the presence of the FPSO and other marine operations within the Jubilee field.
- Interaction with fishermen and other users will be monitored through the CLO and the project's grievance procedure.

The project will work with the Directorate of Fisheries to identify opportunities to improve understanding of current fishing activity within the Ghanaian EEZ. This information will provide a better indication of fishing activity that occurs in the project area and will serve to ensure that the project is better informed as to the potential interaction between future projects and the Ghanaian fishing industry.

The residual impact on fishing activities was assessed as being of minor significance.

6.7.5 *Commercial Shipping*

The main potential source of impacts to existing navigation and shipping traffic in the area are likely to arise as a result of the additional vessel movements associated with the project, in particular during the installation of the project offshore as more significant numbers of vessels will be involved. The main shipping route through the Gulf of Guinea is approximately 13.5 km south of the Jubilee field. The larger commercial ships that pass through the area and the project related vessels themselves will be well equipped with radar, navigation equipment and ship-to-ship communications. The notification and liaison measures outlined above to manage the potential impacts to fishing will be equally applicable to minimising the risk of collision between shipping vessels and project vessels. Residual impacts on commercial shipping are assessed as being not significant.

6.7.6 *Onshore Operations*

While increased or sustained economic activity and employment at the onshore base will generally be a positive socioeconomic impact there is also the potential for negative impacts associated with the proposed onshore activities as follows.

- The project could strain the capacity of the public utilities and impact use of shared services by local communities.
- Expansion of the workforce in a local community could lead to increased risk of negative social impacts, including traffic accidents, security incidents, alcohol and drug misuse, and prostitution.
- Industrial activities at the base could result in disturbance or damage to the public health of local communities by elevated noise levels, increased traffic on local roads, and activities associated with increased 24 hour port operations.

The environmental and social performance at the shore based locations that the project operates will be covered by the project EHS-MS. This will ensure EHS policies and procedures are in line with project expectations, particularly regarding community impacts such as interactions with neighbours, noise abatement, traffic management and storage of wastes.

A grievance procedure will be implemented and made known to the surrounding communities and the general public. Given the location of the shore base at an existing port and the scale of employment and service industry requirements the residual impacts of the project activities at the shore base and surrounding areas are assessed as being not significant.

Cumulative impacts can result from individually slight but collectively significant activities taking place over a period of time. An assessment of these considered other plans or projects that may act in combination with the proposed project to cause environmental and social impacts.

The main activity that could result in cumulative impacts with the Jubilee Phase 1 Development is the previously consented drilling programme currently underway. The latter stages of the drilling programme will occur in parallel with the well completions, facility installation and the early stages of production. The period of physical overlap would be up to 14 months.

The types and nature of reasonably foreseeable future development that may result in cumulative impacts with the Jubilee Phase 1 Development include:

- expansion of the Jubilee development in future phases;
- new oil and gas exploration and production close to the Jubilee field;
- onshore oil and gas processing; and
- other industrial development induced by oil and gas availability (eg power plants).

The project has the ability to mitigate potential impacts associated with the Jubilee Phase 1 development activities, its drilling programme and any future developments in the Jubilee field, however, it has limited ability to manage or influence activities by others which may result in cumulative impacts. The general approach for mitigating and managing potential cumulative impacts will therefore require coordination of all the relevant industries, enterprises and agencies under the direction of the Government of Ghana.

Strategies that could help manage potential future cumulative impacts include the following.

- A government-led Strategic Environmental Assessment (SEA) would enable a comprehensive consideration of potential impacts that may result from the development of the oil and gas sector in Ghana.
- Build capacity of local administration to plan effectively for future development in the area.
- Companies (especially those engaged in the oil and gas sector) operating in the Western Region and the Government should collaborate to agree on common standards and approaches for managing cumulative impacts.
- A structured programme of data gathering and monitoring studies led by government would allow for the proactive management of negative trends that could arise over time.

- The environmental standards should be collectively applied by the government on all businesses operating in Ghana and especially the Western Region.
- Collaboration of the oil and gas industry, shipping interests and the Government of Ghana to develop and support an integrated approach to oil spill response.

Assessment of potential cumulative impacts indicated that there would be no significant impacts.

No significant transboundary impacts are expected to occur as a result of the project.

A key objective of the EIA was to develop and describe practical, commensurate and cost effective mitigation and management measures that avoid, reduce, control, remedy or compensate for negative impacts and enhance positive benefits. The objectives of mitigation have been established through legal requirements or industry good practice standards and where standards were not available, project-specific standards have been established.

The approach taken to defining mitigation and management measures is based on a hierarchy of decisions and measures (*Figure 7.1*). The majority of mitigation and management measures fall within the upper two tiers of the hierarchy and are effectively built into the design of the project. *Section 9* summarises the key mitigation measure proposed by the Jubilee Joint Venture.

A series of monitoring programmes are proposed to obtain data to verify project performance against agreed standards (eg discharge limits) to record trends to aid continuous improvement (eg flaring volumes, employment levels and responses to complaints), to obtain information to verify prediction (eg seabed monitoring of the effects of drill cuttings) and to gather additional data where there are identified data gaps (eg marine mammal distribution).

Box 7.1

Mitigation Hierarchy

THE MITIGATION HIERARCHY FOR PLANNED PROJECT ACTIVITIES
<p><i>Avoid at Source; Reduce at Source</i></p> <p>Avoiding or reducing at source is designing the project so that a feature causing an impact is designed out (eg a waste stream is eliminated) or altered (eg reduced waste volume).</p>
<p><i>Abate on Site</i></p> <p>This involves adding something to the design to abate the impact eg pollution controls.</p>
<p><i>Abate at Receptor</i></p> <p>If an impact cannot be avoided, reduced or abated on-site then measures can be implemented off-site (eg noise or visual screening at properties).</p>
<p><i>Repair or Remedy</i></p> <p>Some impacts involve unavoidable damage to a resource, eg land disturbance. Repair essentially involves restoration and reinstatement type measures.</p>
<p><i>Compensate in Kind</i></p> <p>Where other mitigation approaches are not possible or fully effective, then compensation, in some measure, for loss or damage might be appropriate.</p>

Implementation of the findings and outcomes of the EIA process are described in the provisional EMP for the Jubilee Phase 1 Development. The elements of this provisional plan will be taken forward and incorporated into a comprehensive Jubilee field EMP that will be used to deliver the project's EHS

regulatory compliance objectives, lender standards (eg IFC Performance Standards) and other related commitments. The Jubilee field EMP will be a component of the Jubilee Joint Venture's overall EHS Management System (EHS-MS) that the project will use to ensure environmental and social performance.

The provisional EMP provides an outline of the procedures and processes that will be incorporated into project activities to check and monitor compliance and effectiveness of the mitigation measures to which the Jubilee field JV has committed. In addition, the EMP is used to ensure compliance with statutory requirements and corporate safety and environmental policies.

Tullow, as the project operator will manage key contractor parties to ensure that the EMP is implemented and monitored. Tullow will conduct this process through contractual mechanisms and day-to-day management. For example, the subsea installation will be undertaken by Technip and the FPSO will be operated by MODEC, but both sub-contractors will report to Tullow. Tullow will have its own supervisory personnel on-board and the Ghanaian Government will have an oversight of the project through its various agencies.

With respect to the significant impacts identified by the EIA, the EMP provides the linkage between each significant impact, the relevant mitigation measures and the monitoring approach. Further, through the EMP, significant impacts are referenced to:

- applicable regulatory requirements, institutional responsibilities and other commitments;
- relevant operational controls (eg management best practices, construction and operation specifications, procedures, and work instructions); and
- mitigation and regulatory monitoring of institutional roles.

The EHS-MS also comprises a number of related detailed management plans and procedures that lay out the specifications for compliance with specific environmental and social elements and describes the plans and processes required for carrying out the necessary activities. Key plans are listed below.

- Environmental Management Plan;
- Waste Management Plan;
- Environmental Monitoring Plan;
- Emergency Response Plan
- Oil Spill Contingency Plan;
- Transport Management Plan;
- Public Consultation and Disclosure Plan;
- Corporate Social Responsibility Management Plan.

Table 9.1 summarises the key issues and residual impacts. The conclusions of the EIA are that with the proposed mitigation and management measures in place during the design, installation, operation and decommissioning stages of the Jubilee Phase 1 Development project all impacts of major significance can be avoided and impacts of moderate and minor significance reduced to as low as reasonably practicable levels.

Table 9.1 *Summary of Residual Impacts*

Issue	Resources and Receptors	Residual Impact
Project Footprint (physical presence, noise and light)	Seabed habitats and species	Minor
	Marine mammals and turtles	Minor
	Fish, marine invertebrates, birds, manatees	Not Significant
Operational Discharges (routine, drill fluid and cuttings and non-routine)	Water quality	Minor
	Seabed habitats	Minor
	Marine organisms	Minor
Air Emissions (of atmospheric pollutants and Greenhouse gases)	Local air quality	Minor
	Green House Gasses (Regional)	Minor
Waste Management (storage, transport and disposal)	Water quality, soil quality and human health from storage	Minor
	Water quality, soil quality and human health from poor disposal facilities	Moderate
Impacts from Oil Spills	Water quality from small diesel spills from bunkering	Minor
	Water quality, coastal resources and economic activities from medium and large crude oil spill	Moderate
Socioeconomic and Human Impacts (Macroeconomics, employment, training, procurement of goods and services, interference with other activities)	Revenues to the Government of Ghana	Moderate Positive
	Employees and local businesses	Minor Positive
	Draw down of resources and interference of onshore economic activities	Not Significant
	Fishing activities	Minor
	Commercial shipping and vessel passage	Not Significant
	Disturbance effects on communities and use of public utilities	Not Significant
Cumulative Impacts	Water quality, air quality, habitats, species and human receptors	Not Significant
Transboundary Impacts	Water quality, air quality, habitats, species and human receptors	Not Significant