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Block 15/06 West Hub Development Project, Soyo, Angola

Environmental, Social and Health Impact Assessment

Report Prepared for

ENI S.P.A

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Environmental, Social and Health Impact Assessment

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List of Acronyms and Abbreviations

Al	Aluminum
ALARP	As Low As Reasonable Practicable
ALNG	Angola Liquefied Natural Gas Plant
ARC	Angola Resources Consultants, lda
BOD	Biochemical Oxygen Demand
BOP	Blow-Out Preventer
BOPD	Barrels of Oil Per Day
BWPD	Barrels Water Per Day
CBO	Community Based Organizations
CH4	Methan
CO2	Carbon Dioxide
CSIR	Council for Scientific and Industrial Research
CSR	Corporate Social Responsibility

Cu	Copper
DALYs	Disability Adjusted Life Years
dB	decibel
DC	Drill Centres
DOC	Dissolved Organic Carbon
DRC	Democratic Republic of Congo
DT	Detection Threshold
EAR	Environmental Audit Report
EIA	Environmental Impact Assessment
EITI	Extractive Industries Transperancy Initiative
EMP	Environment Management Plan
ESD	Emergency Shut Down
ESHIA	Environmental, Social and Health Impact Assessment
ESH	Environmental, Social and Health
FAD	Fish Aggregating Device
FGS	Fire and Gas System
FPSO	Floating Production Storage and Offloading Unit
FPSO	Floating Production, Storage and Offloading
GHG	Green House Gas
GWP	Global Warming Potentials
HAZOP	Hazard and Operability Studies
HDI	Human Development Index
HIA	Health Impact Assessment
HLV	Heavy Lift Vessel
HV/LV	Hugh Voltage / Low Voltage
HVAC	Heating, Ventilation and Air-Conditioning
ICSS	Integrated Control and Safety System
IMO	International Maritime Organization
In	Indium
INAMET	Instituto Nacional de Meteorologia e Geofísica (National Institute of Metheorolgy and Geophysics)
INE	Instituto Nacional de Estatística (National Institute of Statistics)
INIP	Instituto Nacional de Investigação Pesqueira (National Institute of Fisheries Research)
IPA	Instituto de Desenvolvimento da Pesca Artesanal (Institute for Artisanal Fisheries)
LFL	Lower Flammable Limit
MAPESS	Ministério da Administração Pública Emprego e Segurança Social (Ministry of Public Administration, Employment and Social Security
MASL	Meters Above Sea Level
Mg	Magnesium
MGO	Marine Gas Oil
MINSA	Ministério da Saúde (Ministry of Health)
MMscfd	Million Standard Cubic Feet per Day

Mn	Manganese
MSDS	Material Safety Data Sheet
MWMP	Marine Waste Management Plan
NL	Noise Level
OBM	Oil Based Mud
Pa	Pascal
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCS	Process Control System
PLET	Pipeline End Termination
POC	Particulate Organic Carbon
PPE	Personal Protective Equipment
ppm	Parts per million
RL	Received Level
RMS	Root-Mean-Square
ROV	Remote Operating Vehicle
SBM	Synthetic Oil Based Mud
SCSSV	Surface Controlled Subsurface Safety Valve
SEL	Sound Exposure Level
SHBA	Social and Health Baseline Assessment
SHE	Safety, Health and Environment
Si	Silicon
SIA	Social Impact Assessment
SIL	Sound Intensity Level
SL	Source Level
SME	Small and Medium Enterprises
SMP	Stakeholder Management Plan
SNR	Signal to Noise Ratio
SO_2	Sulphur Dioxide
SOPEP	Shipboard Oil Pollution and Emergency Plan
SPL	Sound Pressure Level
SRK	SRK Consulting (South Africa) (Pty) Ltd
SRP	Sulphate Removal Package
SURF	Subsea Umbilicals, Risers and Flowlines
TEG	Tri-Ethylene Glycol
TL	Transmission Loss
TOC	Total Organic Carbon
VHL	Volatile Hydrocarbon Liquids
WAG	Water Alternating Gas
WBM	Water Based Mud

WHO	World Health Organization
Zn	Zinc

1 Introduction

1.1 Background

Eni Angola Exploration and Production (Eni) propose to develop an oil field in the west hub of Angola Offshore Block 15/06 (see Figure 1-1). Block 15 extends over an area of just over 4 100km² (Block 15/06 comprises nearly 3 000km²), approximately 130km west (offshore of) Soyo at the Congo River mouth on the northern border of Angola with the Democratic Republic of the Congo (DRC), and 370 km northwest of Luanda. Water depth across the Block 15/06 Field is ranging from approximately 200 to 1700m. The proposed West Hub development area (project area) is located in the north-western corner of the Block (refer to Figure 1-1).

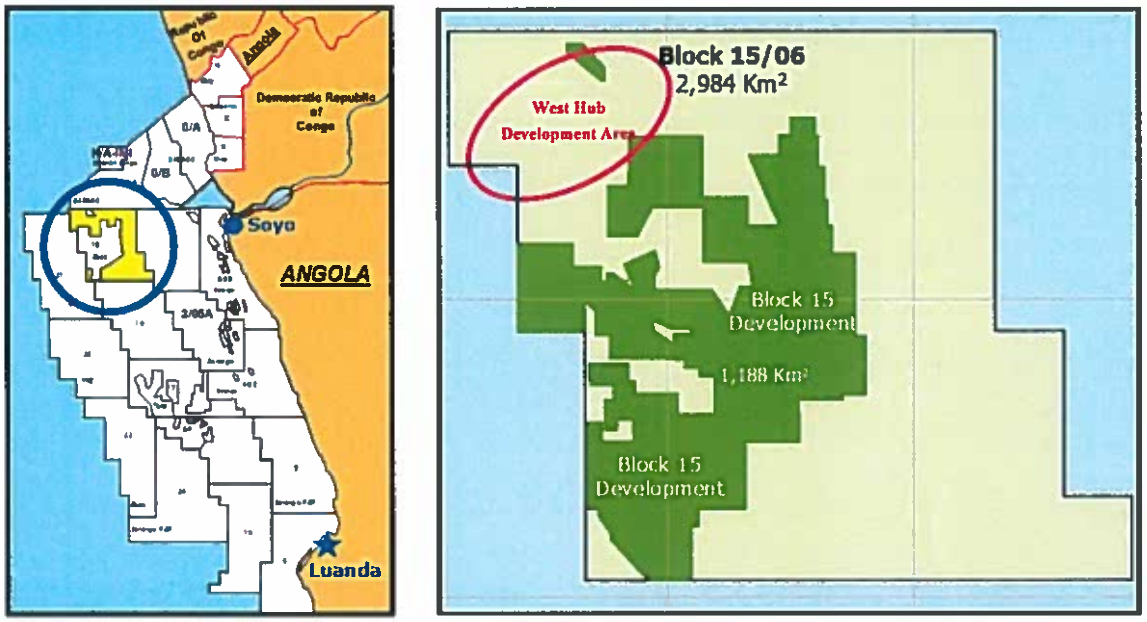

Figure 1-1: Maps showing the extent of the Block 15/06 concession area, existing Block 15 development areas and the approximate location of the proposed West Hub development area.

The proposed West Hub development entails ten (10) producer wells and six (6) water and/or gas injections wells in the Ngoma, Sangos and Cinguvu fields in the north-western part of Block 15/06. These 16 wells will be tied back to a single Floating, Production, Storage and Offloading vessel (FPSO) through various production, gas lift, water injection, gas injection, umbilical and other pipelines on the seafloor (refer to Figure 1-2).

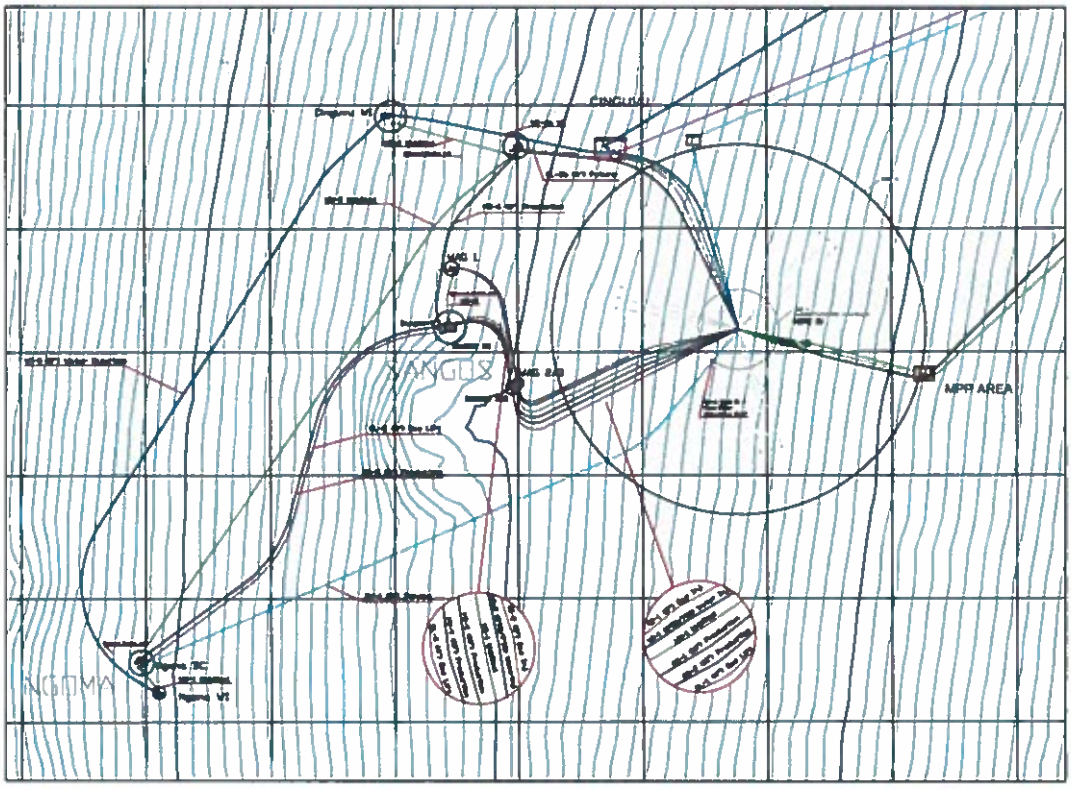

Figure 1-2: Proposed layout of the West Hub development, showing well locations, FPSO mooring location and subsea pipelines, as well as local bathymetry.

In terms of Angola's General Environmental Law No. 5/98, the Decree on Environmental Impact Assessment No. 51/04 and the more recently promulgated Decree on Environmental Licensing No. 59/07, an Environmental Impact Assessment (EIA) is required to evaluate the potential environmental, health and social effects of the proposed project, and to recommend measures to mitigate potentially-harmful impacts of the operation and enhance potential benefits.

Eni commissioned Angola Resources Consultants Lda (ARC) to support Eni in compiling the required Environmental, Social and Health Impact Assessment (ESHIA) for the proposed development. ARC appointed Lwandle Technologies Ltd (Lwandle) to undertake the Environmental (Marine) Baseline Field Survey required by Eni in support of their ESHIA. The results of that survey are included in this report.

1.2 Purpose of the ESHIA

The main purposes of this ESHIA are to:

- Gather sufficient information from Eni and other sources to enable the undertaking of an ESHIA to investigate the key issues of concern with regard to the proposed activities;
- Provide a brief description of the proposed project and associated activities;
- Describe the potentially affected (baseline) biophysical, socio-economic and health environment in the project affected area;
- Provide a summary of the stakeholder consultation process conducted;
- Identify and assess the significance of the potential environmental and socio-economic impacts of the proposed activities;

- Recommend mitigation measures to avoid or minimise potential negative impacts (and enhance and benefits);
- Provide an Environmental Management Plan (EMP) to be implemented during all stages of the project activities; and
- Inform the decision by the Angolan authorities on whether to issue an Environmental License for the proposed activities.

1.3 Assumptions and Limitations

Biophysical Environment

The following assumptions and limitations should be borne in mind when considering the information presented in this report:

- The project (location) information provided by Eni to ARC and used in this study was correct at the time of compiling of this report. In the event that project location information changes significantly, further studies may be warranted;
- It is assumed that Lwandle's Marine Environmental Survey Report dated 26/07/2011 is the final version of that report and that the information provided is correct; and
- The documented scientific knowledge base available in Angola is limited. However, any data gaps are unlikely to have a significant bearing on the results of the assessment and the mitigation measures recommended in this report take account of any potential risks associated with any data gaps.

Anthropic Environment

The limitations encountered during the preparation, research and writing of the Social, Health Baseline Analysis (SHBA) relate to pressures in time and the lack of available data. Secondary data in this study is limited by availability, as statistics in Angola are often dated and only presented on a nationwide level. As mentioned in the preliminary report, when national health and social statistics are presented on the countrywide level, they were selected because they are considered relevant to the Soyo region. It must be noted that limitations exist for countrywide data; some statistics from international agencies such as the World Health Organization (WHO) and the World Bank, for example, were found to be outdated and often based on estimations. Some references made in this report to a previous ARC/SRK report from 2007 include data on Soyo town and the closest villages, amounting to a slightly smaller area than the *comuna*.

Just as basic secondary data is limited and difficult to find in Angola, primary data was at times obscure and difficult to come by. While gathering both primary and secondary data on site in Soyo, research teams found certain basic information nonexistent. These data gaps were commonly encountered in the field research process. Without the amount of time or resources to do a full-scale, primary demographic and health survey of Soyo *Comuna*, the consultant team used the data that was available to create a foundation to base the analysis.

Despite these limitations, ARC is confident that the information gathered and analysed for this report provides a sound base for understanding the social and health conditions of the local communities and for identifying the key intervention areas for promoting social development.

It is assumed that Eni has in place, or will compile, approved management plans as required by Angolan legislation, e.g. an Oil Spill Emergency Response Plan, a Waste Management Disposal and Deposit Plan (WMDDP) and an Operational Discharges Management Plan (ODMP).

1.4 Structure and Authors of this Report

This report consists of eleven chapters, as set out in Table 1-1 below.

Table 1-1: Chapters in this ESHIA.

Chapter		Overview of content
1.	Introduction	Provides an introduction and background to the proposed project and outlines the purpose of this document, the ESHIA process and the assumptions and limitation applicable to the study.
2.	Legal Framework	Provides a brief summary and interpretation of national legislation, international regulations and corporate requirements relevant to the EIA and the proposed well drilling programme.
3.	Project Justification	Provides the justification to go ahead with the project presenting also alternatives.
4.	Project Description	Provides a brief description of the planned activities.
5.	Environmental Baseline	Provides a description of the offshore and coastal onshore biophysical environment of the affected area.
6.	Social Baseline	Provides a description of the socio-economic environment in the coastal area related with Block 15/06, Soyo Comuna.
7.	Health Baseline	Provides a description of the health environment in the coastal area related with Block 15/06, Soyo Comuna.
8.	ESH Impact Assessment	Identifies and assesses the potential impacts of the proposed activities on the biophysical, socio-economic and health components of the affected environment and recommends key mitigation measures.
9.	Environmental Management Plan	Presents an Environmental Management Plan (EMP) for implementation during the proposed operations in order to ensure that impacts are managed at acceptable levels.
10.	Stakeholder Engagement	Provides an overview of the stakeholder engagement conducted as part of the EIA to date.
11.	Conclusions	Summarises the key findings of the report.

The following authors contributed to this report:

- Ms. Ana Ramos – ARC, Legal Aspects and compilation;
- Ms. Katie King – ARC, socioeconomic baseline and compilation;
- Ms. Vanessa Mateus – ARC, stakeholder consultation;
- Ms. Elayne Jordão – ARC, stakeholder consultation;
- Ms. Annette Gerritsen – EPI Result, health baseline;
- Ms. Sue Lane – Lwandle Technologies, marine specialist assessment;
- Dr. Robin Carter – Lwandle Technologies, marine specialist assessment and environmental baseline survey;
- Ms. Danelle Fourie – SRK, environmental, social and health impact assessment; and

- Mr. Chris Dalgliesh – SRK, review.

2 Legal Framework

2.1 Introduction

The Republic of Angola is a unitary state based on the Constitution of 1975 (as amended, most recently in 2010), which provides the framework for the national administrative and organisational structure. Article 16 of the Constitution states that all natural resources existing in the soil and subsoil, in the territorial waters, in the economic exclusive zone and on the continental shelf, shall be the property of the state, which shall determine the conditions for its concession, prospect and exploration, under the terms of the Constitution, law and International Laws. Article 39 of the Constitution provides for the fundamental right of individuals to live in a healthy and non-polluted environment and establishes an obligation on the State to take the necessary actions to protect the environment and maintain the ecological balance.

Angolan law is enacted at the national level through different legislative instruments. The most important of these are laws and decrees as described below:

- **Laws**: the primary legislation passed by the National Assembly. They tend to cover broad issues and provide the enabling framework for the competent authorities to issue more detailed implementing legislation, e.g. decrees. Laws issued at national level apply throughout Angola, with implementation, monitoring, and enforcement carried out at both the national and provincial levels.
- **Decree-laws and Decrees**: legislation passed by the Council of Ministries, while Regulations (Executive Decrees) and Dispatches and are normally issued by a ministry. They provide a subordinate form of primary legislation and tend to cover more specific issues (and are analogous to regulations adopted in many other countries).

This ESHIA has been undertaken within the context of Angolan laws and regulations. Several pieces of national law refer to pollution of the environment, environmental impact assessment and the protection of the environment in general. In addition, guidelines exist that aim to address potential environmental damage associated with the petroleum industry in particular. Many of these laws and guidelines apply to the current project. With respect to regulations it should be noted that Angolan regulations tend to be fairly broadly framed and – as a rule – do not provide detailed standards (e.g. air quality, noise levels etc.) against which compliance can be measured. In the absence of such standards the default is to international standards (e.g. World Bank) and, sometimes, to regional standards (e.g. South African, European Directives). A synopsis of the relevant legislative and administrative framework is provided further below.

In addition to Angola's national regulatory requirements, other international standards and requirements may be relevant. These include international treaties and conventions to which Angola is a signatory. Furthermore, ENI Angola is also obliged to comply with their HSE policy.

Note that other legislative, regulatory and administrative requirements may pertain to the proposed operations, but identification and interpretation of these is beyond the brief of this study. As such, the summary provided below is not intended to be definitive or exhaustive, and serves to highlight key environmental legislation and obligations only.

2.2 Regulatory Framework

2.2.1 Ministry of Petroleum

Oil and gas industry activities in Angola are regulated by the Ministry of Petroleum (MinPet). MinPet's responsibilities include the administration of *Decree 39/00 on Environmental Protection for the Petroleum Industry* (see section 2.3.1.2 below) in the development of petroleum activities.

2.2.2 Ministry of Environment

The Ministry of Environment (MinAmb) is responsible for the development and coordination of the country's environmental policy and the National Programme of Environmental Management. The National Directorate for Prevention and Environmental Impact Assessment (DNPAIA) from MinAmb, is required to review EIAs and advise MinPet on the acceptability of proposed development activities. MinAmb has responsibility to approve EIAs under *Decree No. 51/04 on Environmental Impact Assessment* and issue environmental licenses in terms of *Decree No. 59/07 on Environmental Licensing*. For oil and gas projects, licenses are issued in consultation with MinPet.

2.3 Legislative Framework

The main component of Angolan legislation is the requirement to carry out a comprehensive EIA (i.e. an EIS, incorporating environmental management plans, followed by a comprehensive review by the authorities) for the project. Five items of legislation, which regulate the way in which EIAs are undertaken and environmental licensing, are currently in force and are discussed below. They are:

- The General Environmental Law No 5/98 (19/06/1998);
- Decree No. 39/00 on Environmental Protection for the Petroleum Industry (10/10/2000);
- Decree No. 51/04 on Environmental Impact Assessment (23/07/2004);
- Decree No. 59/07 on Environmental Licensing (13/07/2007);
- Executive Decree No. 130/09 on Environmental Licensing Fees (substitutes the table of Decree No. 96/09) (26/11/2009);
- Executive Decree No. 87/12 on Public Consultation for Projects Subject to Environmental Impact Assessment (24/2/2012); and
- Executive Decree No. 92/12 on the Terms of Reference for Environmental Impact Studies (1/3/2012).

Additional legislation with relevance to the proposed development operations includes:

- Executive Decree No. 8/05 on the Management, Disposal and Deposition of Waste (05/01/2005);
- Petroleum Activities Law No. 10/04 (12/11/2004);
- Decree No. 1/09 on Petroleum Operations (27/01/2009);
- Decree No. 38/09 on Safety, Hygiene and Health at Petroleum Operations (14/08/2009);
- Executive Decree No. 11/05 on Notification of Occurrence of Spills (12/01/2005);
- Presidential Decree No. 194/11 on Liability on Environmental Damage (07/07/2011);
- Executive Decree No. 224/12 on Operational Discharges Management (16/07/2012);
- Law No. 6-A/04, on Biological Aquatic Resources (08/10/2004);

- Law No. 14/2010, on Territorial Sea, Contiguous Zone and Exclusive Economic Zone Act (14/07/2010);
- Presidential Decree No. 141/12 on Prevention and Pollution Control in National Waters (21/06/2012).
- Resolution No. 42/06 on the National Biodiversity Strategy and Action Plan (NBSAP) (26/07/2006); and
- Presidential decree No. 190/12, on Waste Management (24/08/2012).

These are all briefly discussed below.

2.3.1 EIA Legislation

2.2.1.1 General Environmental Law No. 5 of 1998

The General Environmental Law No. 5 of 1998 (GEL, *Lei de Bases do Ambiente*) was promulgated in accordance with the Constitutional Law of the Republic of Angola (paragraphs 1, 2 and 3 of Article 24 and paragraph 2 of Article 12). The purpose of the law is to "*define the basic concepts and principles for the protection, preservation and conservation of the Environment, promotion of the Quality of Life and the rational use of Natural Resources*" (Article 1). The GEL incorporates international declarations which Angola has ratified (e.g. Agenda 21) and defines citizens' rights and responsibilities. Further, the GEL introduces the concept of legal penalties for illegal activities that have caused damage to the environment.

Article 4 includes a number of principles guiding GEL, including a principle in respect of liability: "all persons or organisations which through their actions cause harm to the environment, or the degradation, destruction or depletion of national resources, shall be held liable for the same, and shall be required to repair such damage and/or pay compensation for the damage caused".

Article 16 of GEL requires that an EIA, including public consultation (Article 10 and 32), be mandatory for all undertakings which have an impact on the balance and wellbeing of the environment and society. Clause 2 of this Article states that more specific legislation on EIAs will be developed by the government. An excellent example is Decree No. 51/04 on Environmental Impact Assessment.

An Environmental License is issued on the basis of the EIA and this license is required before any other license required by law will be granted (Article 17(2)). According to the GEL, MinAmb is responsible for issuing Environmental Licenses, except for activities related to the petroleum industry, which are licensed by MinPet. Subsequent legislation overrides this and delegates responsibility back to MinAmb, who issue environmental licences in consultation with MinPet for activities related to the Oil and Gas sector.

Legal requirements for this project

In terms of the GEL, Eni is required to apply for an Environmental Licence for the proposed activities, and has a responsibility to minimise (and repair) any damage to the environment caused through operational activities.

2.2.1.2 Decree No. 39 of 2000 on Environmental Protection for the Petroleum Industry

Whereas the General Environmental Law No. 5/98 deals with any activity which has an impact on the balance and wellbeing of the environment and society, the Decree on Environmental Protection for the Petroleum Industry No. 39/00 (PIEPD) deals more specifically with activities related to the Petroleum Industry and their operations. The purpose of the Decree (article 2) is to provide for the protection of the environment (including health, water, land and sub-land, air, flora, fauna, ecosystems, landscape, atmosphere and the cultural, archaeological and aesthetic values) in the course of

petroleum-related activities. Article 3, states that this Decree regulates the system of protection of the Environment, either onshore or offshore, to which the Petroleum Activities shall be subject. The preamble to PIEPD requires that the petroleum companies must give highest priority to reduction, recycling, disposal and adequate deposit of wastes.

This decree also refers that the Concessionaire and the Associates, through the Operator, should take the necessary precautions to prevent the negative impact of pollution and to limit to the extent possible the consequences if such impact has already occurred. The Concessionaire and the Associates, through the Operator should also ensure that the personnel who carry out the petroleum operations comply with this Decree.

The Decree requires that companies and others involved in the petroleum industry (both offshore and onshore) prepare and apply "Environmental Management Instruments" (actions and practical measures) in order to avoid undue harm to the environment. These instruments cover a range of plans and studies including an EIA.

Decree No. 51/04 on EIA, promulgated subsequent to PIEPD, lists petroleum-related activities requiring EIA. The purpose of the EIA is to identify likely environmental impacts and determine appropriate mitigation measures to reduce negative impacts. For petroleum-related activities in Angola the environmental licensing authority is MinAmb in consultation with the MinPet (Article 6). The Decree states that *"if the opinion is favourable, the Ministry of Urbanism and Environment* (now MinAmb) *will issue an Environmental License".*

Article 15 states that all spills that may cause damage to the environment must be reported to MinPet, in accordance with Executive Decree No. 11/05 on Notification of Occurrence of Spills.

According to Article 16, the operator of the facility which caused the spill must take immediate, appropriate and effective steps to control, clean and respond to the spill. This may include requesting the assistance of other petroleum companies operating in Angolan offshore waters.

According to the PIEPD the following plans must be submitted to the MinPet for proposed petroleum-related projects: Spill Prevention Plan, Spill Response Plan, Waste Management, Disposal and Deposit Plan (WMDDP) and Operational Discharges Management Plan (ODMP).

Legal requirements for this project

Decree No. 39/00 applies to Eni application for environmental licensing of the proposed project. In terms of the PIEPD, Eni Angola must conduct an EIA and must implement measures to reduce the environmental impacts that are likely to be associated with the proposed project. Eni is also required to compile and submit to MinPet a Spill Prevention Plan, Spill Response Plan, WMDDP and an Operational Discharges Management Plan.

2.2.1.3 Decree No. 51 of 2004 on Environmental Impact Assessment

Decree No. 51/04 on Environmental Impact Assessment was established under the GEL to ensure better environmental protection from human activities likely to have an impact on the environment. It establishes a set of procedures to be followed when carrying out an EIA and compiling an EIS.

According to this decree, an EIS should achieve the following objectives:

- Provide a description of the project;
- Report on the environmental impact study; and
- Take into account all technological alternatives and the location of the project, bearing in mind the probability of non-execution of the project.

Article 4 refers to a list of activities, annexed to the Decree, that require an EIA. Activities listed in this annex must acquire an Environmental License before commencement. Other (unlisted) projects that may cause significant damage to the environment (as identified by MinAmb) may also be required to undergo an EIA and licensing process.

Article 7 prescribes technical measures required for the actual EIA, including a description of the ecological, biological and social environment, the identification of impacts, the 'definition of mitigation measures' and the requirement to draw up an observation and monitoring programme.

Article 10 of the decree also provides for public consultation to be organised by the licensing authority, but, other than specifying the release of a non-technical summary, does not specify the form of consultation.

According to the Decree, the EIA licensing process is the responsibility of the "*Minister responsible for the environment*" (assumed to be the MinAmb), exercised jointly with the Minister responsible for the relevant sector of the project (Article 11), (assumed to be MinPet in this instance). Subsequent legislation delegates the licensing responsibility to MinAmb who issues environmental licenses in consultation with MinPet for projects in the oil and gas sector.

Ultimately the project must be licensed or approved by the entity authorised to license or approve the project, assumed to be MinAmb in this instance. The decision taken by MinAmb can be appealed in accordance with the general terms of administrative procedures and litigation.

Legal requirements for this project

In terms of the Decree No. 51/04, Eni must undertake an EIA for their proposed activities to inform the decision on environmental licensing to be taken by MinAmb.

2.2.1.4 Decree No. 59 of 2007 on Environmental Licensing

Decree No. 59 of 2007 on Environmental Licensing adopts provisions concerning requirements, criteria and administrative procedures related to environmental licenses.

In terms of Section II Article 10, any activity requiring an EIA must acquire an Environmental License. Environmental licenses are "*issued by the entity responsible for environmental policy*" (assumed to be MinAmb).

Two types of environmental licences are required for listed activities: an environmental licence is acquired first and is needed for the establishment or undertaking of a listed activity, while an operation environmental licence is issued once compliance with all the requirements of the EIA has been demonstrated.

In order to obtain an environmental license, an application must be submitted to the administrative offices of the entity responsible for the environmental policy. According to Article 6 of the decree, an Environmental Impact Assessment Report must be summarised in the application and the entire report attached to the application. The decision on the application is announced within 90 days of receipt of the application (Article 8).

Legal requirements for this project

In terms of the Decree No. 59/07, Eni must undertake an EIA for their proposed activities and submit it to MinAmb in order to inform their decision on environmental licensing, which is to be taken in consultation with MinPet.

2.2.1.5 Executive Decree No. 130 of 2009 and Decree No. 96 of 2009 on Environmental Licensing Fees

Decree No. 96 of 2009 sets out the fees payable by the proponent when an environmental licence is granted and determines that 40% of the revenue from such fees are to be allocated to MinAmb.

Executive Decree No. 130/09 (which substitutes the table annexed to Decree No. 96/09) sets out the fees payable by the proponent for an environmental license, and other administrative costs. Fees for construction and operational environmental licences are based on a percentage of the project cost: the percentage is based on the value of the investment.

Legal requirements for this project

In terms of Decree No. 96/09 and Executive Decree No. 130/09, Eni will have to pay a fee to acquire an Environmental License for the proposed activities, based on the investment value of the project.

2.2.1.6 Executive Decree No. 87/12 on Public Consultation for Projects Subject to Environmental Impact Assessment

Executive Decree No. 87/12 defines and sets out the purpose of public consultation for projects that require EIA. While the need for public consultation following submission of the EIS to the relevant Ministry, before approval and issuing of an Environmental License, is prescribed in legislation prior to the promulgation of Executive Decree No. 87/12, this Decree provides a more detailed and extensive explanation of the objectives of and requirements for public consultation.

The new regulations include a list of definitions related to public consultation (Article 1), the objectives and purpose of public consultation (Article 2 and 3), as well as the composition of the committee to preside over public consultation and their roles (Article 4 to 7). In Article 8, the requirements for information disclosure at public consultations are explained, including the role of the Non-Technical Summary. Administrative details such as the timeframe within which consultation must take place (5 – 10 days), compilation of a public consultation report and the fact that all costs associated with public consultation must be born by the developer, are also set out in the regulations.

Legal requirements for this project

In terms of Executive Decree No. 87/12, Eni will be required to carry the cost of any public consultations required by the authorities and to ensure that the information presented at such public consultations comply with the requirements of Executive Decree No. 87/12.

2.2.1.7 Executive Decree No. 92/12 on the Terms of Reference for Environmental Impact Studies

Decree No. 92/12 sets out the terms of reference for the EIS and specifies its general content. This Decree establishes that the EIS must be compiled in terms of the legislation on EIA and should follow the guidelines contained in any relevant sector-specific standard terms of reference for EIS (currently being developed by MinAmb) once promulgated.

The Decree includes three annexes providing guidance for the information to be presented to the Ministry. Annex I is an application form for the project proponent to indicate which Environmental License is being applied for and Annex II provides a form for the provision of simplified preliminary project information. Annex III outlines the required content and structure for the EIS, but does not provide details on the required content of each section. It is understood that such details are currently being developed by the Ministry of Environment, but this has not been made available at the time of writing this report.

Legal requirements for this project

In terms of Executive Decree No. 92/12, Eni should complete and submit the required forms in Annexes I and II and must ensure that the EIS complies with the content requirements set out in Annex III and follows the guidelines set out in the terms of reference for EISs for drilling activities being developed by MinAmb.

2.3.2 Additional legislation

2.2.2.1 Executive Decree No. 8 of 2005 on the Management, Disposal and Deposition of Waste

Article 1 of this Decree prescribes the preparation of rules and procedures for the management, disposal and deposition of waste to be implemented by the operator and other companies, with a view to ensuring the prevention or minimization of damage to the health of persons and to the environment. This applies to all waste generated in the course of oil-related activities, provided for in Article 1, paragraph (a) of Decree No. 39/00, namely all the activities related to the prospecting, exploration, appraisal, development, production, transportation, refining, processing, storage, distribution and sale of oil and its by-products, as well as the use and storage of chemical products for the performance of petroleum activities.

Thus, within the scope of the present decree (Article 3, Section 1), operators and other oil companies must develop and keep an updated Plan for the Management, Disposal and Deposition of Waste which (in addition to what is referred to in Decree No. 39/00) also includes:

- Classification of waste, in terms of the danger level of the determined waste, for health and the environment;
- Identification of the main activities that generate significant amounts of waste, with reference to the procedures to be implemented with regard to handling, storage, transport, treatment (justification of the treatment option adopted) and disposal;
- Control of waste with regard to systematic record-keeping;
- Maintenance programs for equipment used in any operation;
- Environmental monitoring program for any of the continuous operations of the waste management activity.

In the management of waste, preference must be given to the following guidelines:

- Reduction at source (implementation of methods which minimise the generated quantity of waste or which reduce the presence of noxious substances in the waste, through more efficient practices);
- Reuse and recycling of materials and/or products;
- Use of waste as a raw material for other sectors of activity; and
- Return of waste/recycled waste to suppliers.

Legal requirements for this project

In terms of Executive Decree No. 8/05, Eni must draft and maintain a WMDDP for the proposed appraisal well drilling activities.

2.2.2.2 Petroleum Activities Law No. 10 of 2004

The Petroleum Activities Law No. 10/04 sets out the fundamental principles that regulate the exploitation of Angola's petroleum potential.

This law addresses in particular the aspects concerning ownership of natural resources and operating licences (Chapter IV). The law prohibits offshore flaring of gas flaring except for very short periods or during tests (Chapter VI, Section II, Article 73). Impacts should be assessed in a plan explaining measures to be taken by the operator to prevent damages to the environment. HSE responsibilities are detailed in Article 25 (Section II). Requirements for environmental protection and the evaluation of environmental impacts in oil and gas operations are presented in Article 24 (Section II).

Legal requirements for this project

Law No. 10/04 requires that Eni must undertake an EIA of the proposed operations and must submit to MinPet plans specifying the management measures to be implemented in order to prevent harm to the environment.

2.2.2.3 Decree No. 1/09 on Petroleum Operations

This Decree approves the regulations applicable to oil-related operations, defining and establishing the conditions and methods to observe in operations carried out on and offshore, under the terms of Law No. 10/04.

According to article 17(1), item g) (on Section I: Prospection, Research and Evaluation), the annual work plan to be elaborated by National Concessionaire and associates should include seismic surveys and well drilling and include the environmental impact study, in accordance with the current legislation. In Section II, concerning Development and Production Activities (articles 22 and 27), an environmental and socioeconomic impact study is also required, with particular emphasis on technical solutions to prevent, minimize and fight pollution.

Legal requirements for this project

In terms of Decree No. 1/09, Eni must undertake an environmental impact study of the proposed drilling project.

2.2.2.4 Decree No. 38/09 on Safety, Hygiene and Health at Petroleum Operations

This regulation aims to define rules and procedures to ensure oil-related activities are carried out in accordance with health, hygiene and safety standards set out in current legislation and with internationally accepted standards in the oil industry. This Decree is applicable to the facilities and the entire life cycle of oil-related operations both on and offshore. According to article 4, the operator must ensure that all the staff involved in oil-related activities is adequately trained to execute their tasks in full compliance with all relevant legislation on health, hygiene and safety issues. Article 14 states that the operator must adopt protection measures to ensure workers are not routinely exposed to noise levels liable to cause damage to human beings, as defined in applicable national or international standards.

Legal requirements for this project

Eni must ensure full compliance of this Decree for the proposed Project and monitor its implementation. The operator must ensure that workers are not exposed to high noise levels capable of causing hearing damage.

2.2.2.5 Executive Decree No. 11 of 2005 on Notification of Occurrence of Spills

This Decree defines and standardises the procedures for notifying the MinPet of the occurrence of spills. According to Article 2, all spills in quantities exceeding one barrel (bbl)[1] or spills for which environmental impacts are considered significant, must be reported within a period of eight hours, measured from the moment members of the emergency response group of the operator and other oil companies observe the spill.

In the case of a major spill, all companies in Angola with the equipment, personnel, supplies and other means to control, respond and clean up the spill, are obligated to co-operate. A National Oil Spill Contingency Plan has been developed by the MinPet and the oil industry in Angola.

[1] A barrel (bbl) is the standard unit of volume measurement in the petroleum industry and is equivalent to 42 US gallons or approximately 0.159 m^3 (159 litres).

Legal requirements for this project

In terms of Executive Decree No. 11/05, Eni is required to notify MinPet of any spills of potential contaminants exceeding one bbl during the proposed operations.

2.2.2.6 Presidential Decree No. 194 of 2011 on Liability on Environmental Damage

These Regulations aim to establish strict liability for the degradation of the environment, based on the "polluter-pays" principle, with a view to preventing and repairing environmental damages.

According to item 1 of Article 3, these regulations are applicable to all activities capable of causing environmental damages. These Regulations are applicable to all activities capable of causing environmental damages.

In Article 5, item 1 states that anyone who, acting with wilful misconduct or negligence, has caused environmental damages shall be required to repair the damages and/or compensate the State and private entities or individuals for losses and damages arising therefrom, by way of compensation for damages and environmental recovery measures.

Whenever environmental damages occur, according to Article 11, the operator shall promptly advise the competent authority of all relevant aspects of the situation and take the following measures:

(a) The proper steps to immediately control, contain, eliminate or otherwise manage the relevant pollutant elements and any other hazardous factors in order to limit or prevent additional environmental damages and adverse effects on human health or further deterioration of services;

(b) The necessary repair measures.

Legal requirements for this project

In case environmental damage could occur, where an imminent threat thereof exists, Eni shall promptly adopt the necessary preventive measures. Eni shall bear all costs related to the prevention and repair of damages it causes.

2.2.2.7 Executive Decree No. 224/12 on Operational Discharges Management

Executive Decree No. 224/12 (which revokes Executive Decree No. 12/05) sets out the rules and procedures regarding management of operational discharges by oil companies operating onshore and offshore in Angola.

According with item 3 of Article 4, discharges of the following effluents resulting from operations in the maritime zone are prohibited and these must be treated as hazardous waste:

- Drill cuttings contaminated with non-water based drilling muds;
- non-water based drilling fluids; and
- Produced sands.

According to Article 5, the operator must compile an Operational Discharges Management Plan (ODMP) that specifies the main wastes produced, the discharge points for all operational discharges, chemical products used and the Material Safety Data Sheet (MSDS), environmental monitoring plan according with Articles 16, 17 and 19, and procedures and equipment to adopt for the monitoring and mitigation of air emissions. Article 17 states that environmental monitoring activities should be in place before the beginning of the operations to establish a baseline for the EIS; regularly during the life time of the project and whenever an incident occurs.

Legal requirements for this project

In terms of Executive Decree No. 224/12, Eni is required to compile and maintain an ODMP during the proposed drilling program. According with Article 4, item 2, Eni must implement measures to

protect soils, surface water and groundwater from and monitor contamination by operational discharges. The compilation of the ODMP is outside the scope of this EIA.

2.2.2.8 Law No. 6-A of 2004 on Biological Aquatic Resources

This law establishes standards to ensure the conservation and sustainable use of biological resources existing in the waters under the sovereignty of the Angolan State, as well as the general basis of the activities related thereto, especially fishing and aquaculture.

According to Article 92, in the exclusive economic zone, territorial sea, continental waters, coastal waters and riverside waters, the following activities are forbidden:

a) The introduction of prohibited substances into the marine environment and / or beyond the limits of the respective international conventions to which Angola is a party, including MARPOL 73/78 and its annexes, subject to the effluent discharges and other substances permitted under the law on prevention and control of pollution from petroleum activities;
b) The introduction into the aquatic environment, including coastal and freshwater, any other substances from any source which causes damage to the environment or biological resources, on terms to be set by decree and without subject to the law on environmental and natural resources applicable;
c) Engaging in activities that involve or may involve danger of pollution or degradation of the aquatic environment, except in case of joint authorization, under the conditions prescribed by regulation, the competent Minister who oversees environmental policy and, in the case of the continental waters, the Minister of Energy and Water and subject to the legislation on other natural resources, environmental protection and transport equipment.

Article 93 (on the polluter pays principle) states that all natural or legal persons (e.g. companies, individuals, etc.) whose activities cause pollution of the aquatic environment are required to apply at their own expense measures to prevent and minimize pollution that may be defined by regulation.

Legal requirements for this project

Following this, Eni should put in place all instruments internationally and nationally required to prevent damage of the environment. In case of an accident, measures to remediate the incident should clearly be established.

2.2.2.9 Law No. 14 of 2010 on Territorial Sea, Contiguous Zone and Exclusive Economic Zone

This law defines the limits of maritime zones under national jurisdiction, applying to all areas of maritime extension of the national territory and beyond the sea, under the UN Convention on the Law of the Sea. The provisions of this Law shall not affect the powers exercised by the Angolan state in the maritime states of others or in specific maritime spaces, as defined in international law.

Maritime zones under national jurisdiction are: inland waters, territorial sea, contiguous zone, Exclusive Economic Zone (EEZ) and continental shelf.

According to Article 9, the outer limit of the EEZ is the line whose points are located 200 nautical miles from the nearest point of the baselines.

Legal requirements for this project

The Angolan State is responsible for adopting preventive measures to reduce the emission of toxic substances, and measures to prevent, reduce and control pollution related with discharges/deposition (e.g. wastes, equipments, materials, etc) to the sea. Therefore, Eni is responsible to put into practice all instruments required by Angolan law to protect the marine environment.

2.2.2.10 Presidential Decree No. 141/12 on Prevention and Pollution Control in National Waters

This regulation has the objective of establishing a framework for the prevention, inspection and control of pollution of national waters by vessels, rigs and industrial facilities. According to Article 8 of this decree, vessels and oil rigs are obliged to have up to date certificates on contamination prevention. Article 9 sets the requirement for a MARPOL-compliant Emergency Plan for each vessel or oil rig detailing how they would combat water pollution. Article 11 states the need to inform the environmental authority and maritime authorities on any discharges or spills that are not permitted under MARPOL. Any hydrocarbon discharge is forbidden in national waters, with the exception of specific discharges covered by this law, as well as discharges permitted under the operational discharges management regulations and all conventions where Angola is a signatory.

Legal requirements for this project

In terms of Presidential Decree No. 141/12, any spills of potential contaminants during the proposed activities must be reported to the regulators. Eni has to comply with all requirements under this law.

2.2.2.11 Resolution No. 42/06 on the National Biodiversity Strategy and Action Plan

To implement the recommendations from the United Nations Convention on Biological Diversity (UNCBD, ratified by the Resolution No. 23/97) the Government approved through Resolution No. 42/06 of July 26th the National Biodiversity Strategy and Action Plan (NBSAP). This strategy aims to incorporate measures for the conservation and sustainable use of biological diversity, and the fair and equitable distribution of biological resources in favour of all Angolans, into policies and development programmes.

The NBSAP has eight Strategic Areas that were defined through a process of public consultation that involved representatives of government institutions, local and traditional authorities, environmental protection institutions, the education sector, the private sector and the press. These areas include:

- Strategic Area A: Research and Information Dissemination;
- Strategic Area B: Education for Sustainable Development;
- Strategic Area C: Biodiversity Management in Environmental Protected Areas;
- Strategic Area D: Sustainable Use of Biodiversity Components;
- Strategic Area E: The Role of Communities in Biodiversity Management;
- Strategic Area F: Institutional Strengthening;
- Strategic Area G: Legislation and its Implementation; and
- Strategic Area H: Management, Coordination and Monitoring.

This strategy recommends a number of activities which include the identification and adoption of practices that will contribute to the conservation and sustainable of use of biodiversity.

2.2.2.12 Presidential Decree No. 190/12 on Waste Management

Presidential Decree n. 190/12 fills an existing gap in national legislation and will come into force 90 days after it was published (i.e. on 24 November 2012). This Decree establishes the rules concerning waste generation and disposal; discharges to water and the atmosphere; collection, storage and transport of any wastes, with the exception of radioactive wastes or any other subject to specific regulations. These rules aim to prevent or minimize the negative impacts on people's health and the environment, without prejudice to the establishment or rules aiming to reduce, reuse, recycle, recover and dispose of waste. According to Article 2, this regulation applies to all activities that might generate

wastes or are involved in waste management. Article 5 identified different categories of non-hazardous wastes and refers to Annex IV where the different categories of hazardous wastes are identified.

Paragraph 1 of Article 7 establishes that all private or public entities producing wastes should develop a Waste Management Plan. This plan is valid for four (4) years and should be submitted to MinAmb 90 days before the expiry date and every time there are substantial changes to the submitted plan.

Paragraph 3 of Article 18 states that hazardous wastes should be packaged or treated according to technical rules to be established through specific instructions on hazardous waste treatment, and labelled according to the sign codes contained in Annex V.

The producer of hazardous wastes must fill in a manifest (in quadruplicate), mentioning quantities, quality and destination of the collected wastes. One of the copies must be submitted to MinAmb. Within the producer's facilities, hazardous wastes should be transported through the use of adequate equipment.

Legal requirements for this project

In accordance to this decree, Eni must compile a Waste Management Plan for the proposed drilling operations and must guarantee that contractors that will deal with the waste management should follow this Decree.

2.4 International conventions

Angola has ratified important international conventions with relevance to the management of impacts on the marine environment, in particular pollution. The key conventions are briefly discussed below and include:

- International Convention for the Prevention of Pollution from Ships 73/78 (MARPOL);
- Convention for the Safety of Life at Sea, 1974 (SOLAS);
- Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGS);
- United Nations Convention on Law of the Sea 1982 (UNCLOS);
- Convention on Biological Diversity 1992; and
- United Nations Framework Convention on Climate Change and the Kyoto Protocol.

2.4.1 International Convention for the Prevention of Pollution from Ships 73/78 (MARPOL)

The MARPOL Convention is the main international convention and aims to prevent pollution of the marine environment by ships from operational causes and to minimise accidental discharge of such substances. It is currently ratified by 136 nations, including Angola, and contains six annexes that address the prevention of different forms of pollution from ships, namely (from www.imo.org):

- *Annex I: Oil*, which lists the conditions under which vessels are allowed to discharge oil into the sea, including the following conditions:
  - The total quantity of oil which a tanker may discharge in any ballast voyage whilst under way must not exceed 1/15 000 of the total cargo carrying capacity of the vessel;
  - The rate at which oil may be discharged must not exceed 60 litres per mile travelled by the ship; and
  - No discharge of any oil whatsoever must be made from the cargo spaces of a tanker within 50 miles of the nearest land.

- *Annex II: Noxious Liquid Substances*, which details the discharge criteria and measures for the control of pollution of 250 identified noxious liquid substances carried in bulk (no discharge of residues containing noxious substances is permitted within 12 miles of the nearest land);
- *Annex III: Harmful Substances Carried in Packaged Form*, which contains general requirements for the issuing of detailed standards on packing, marking, labelling, documentation, stowage, quantity limitations, exceptions and notifications for preventing pollution by harmful substances;
- *Annex IV: Sewage*, which requires vessels to be equipped with either a sewage treatment plant, a sewage comminuting (reduce to small pieces or particles by pounding or abrading) and disinfecting system or a sewage holding tank;
- *Annex V: Garbage*, which specifies distances from land and the manner in which different types of garbage may be disposed of and imposes a complete ban on the dumping of all forms of plastic into the sea; and
- *Annex VI: Air Pollution*, which sets limits on sulphur oxide and nitrogen oxide emissions from vessel exhausts and prohibits deliberate emissions of ozone depleting substances.

Angola has ratified all of these annexes except the last (Annex VI). Further detail about specific MARPOL requirements are discussed where relevant in the Project Description section and on the Impact Assessment section of this EIS.

2.4.2 Convention for the Safety of Life at Sea, 1974 (SOLAS)

The SOLAS Convention is generally regarded as the most important international maritime safety treaty. Originally passed in 1914 in response to the sinking of the Titanic, it has been amended and updated several times over the years. Angola acceded to the 1974 version in 1992.

The SOLAS Convention specifies minimum standards for the construction, equipment and operation of ships to ensure their safety. An Annex containing 12 chapters sets requirements for specific operational aspects such as fire protection, life-saving equipment and procedures, radio communications and safety of navigation.

Flag States are responsible for ensuring that ships under their flag comply with its requirements in terms of the SOLAS Convention.

2.4.3 Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGS)

The COLREGS sets out the rules of conduct to be followed by ships and other vessels when at sea and covers steering and sailing, conduct of vessels when in sight of one another, conduct of vessels in restricted visibility, navigational lights to be used at night, as well as manoeuvring and warning sound and light signals. Annexes contain technical requirements for lights, shapes and additional signals for fishing vessels in close proximity. The COLREGS also covers the rules of conduct with regard to a 'vessel restricted in her ability to manoeuvre', the definition of which includes 'a vessel engaged in a towing operation such as severely restricts the towing vessel and her tow in their ability to deviate from their course'.

2.4.4 United Nations Convention on Law of the Sea 1982 (UNCLOS)

The UNCLOS or Law of the Sea Convention has been signed by 155 parties and defines the rights and responsibilities of nations in their use of the oceans. The Convention replaced four previous treaties, namely:

- The Convention on the Territorial Sea and Contiguous Zone;
- The Convention on the Continental Shelf;

- The Convention on the High Seas; and
- The Convention on Fishing and Conservation of Living Resources of the High Seas.

The Law of the Sea Convention defines the rights and responsibilities of nations in their use of the oceans and establishes guidelines for businesses, the environment and the management of marine natural resources.

2.4.5 Convention on Biological Diversity 1992

In addition to the marine conventions mentioned above, Angola is also party to the Convention on Biological Diversity of 1992. The objectives of this convention are:

- The conservation of biological diversity;
- The sustainable use of its components; and
- The fair and equitable sharing of benefits arising from genetic resources.

Member states are required to develop national strategies for the conservation and sustainable use of biological diversity and Angola has compiled a National Biodiversity Strategy and Action Plan in its fulfilment of its obligations under the Convention.

2.4.6 United Nations Framework Convention on Climate Change and the Kyoto Protocol

Angola ratified the Convention in 2000 and the Kyoto Protocol in 2007, and therefore have to comply with the provisions in these two international legal instruments. The objective of the convention is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The convention itself sets no mandatory limits on greenhouse gas emissions for individual countries and contains no enforcement mechanisms. The treaty provides for updates (called "protocols") that would set mandatory emission limits. The main update is the Kyoto Protocol.

Member states are required to develop national strategies and respective plans for climate change, and Angola has compiled a National Strategy in fulfillment of its obligations under the Convention and Kyoto Protocol.

2.5 Eni's HSE Policy

Eni Angola Exploration BV and Eni Angola Production BV are committed to protecting:

- The Health and Safety of all employees and associated personnel; and
- The Environment in our business activities, through eliminating the adverse impacts of our operations.

To meet our commitment, we:

- Implement an HSE Integrated Management System (IMS) in all our activities, which meets the requirements of health, safety and environmental standards;
- Ensure that all our activities fully comply with Angolan and International legislative requirements;
- Implement controls to protect all personnel involved in ENI Angola activities;
- Actively promote awareness of HSE issues;
- Foster a culture where accidents, incidents and near misses are reported and investigated and lessons learned are shared throughout the organisation;

- Seek to implement best industry practice and endeavour to set new standard of care in our operations;
- Encourage everyone involved in our operations to bring forward proposal for improving HSE performance;
- Provide HSE training to all our employees and work with contractors to ensure they meet the same standards of care;
- Ensure that a high priority is placed on planning for emergencies and other unforeseen events;
- Continually monitor our performance and conduct regular audits of our operations to ensure the effectiveness of established controls and that our goals are being achieved;
- Consult with and respond to the concerns of other stakeholders on HSE issues; and
- Drive continuous improvement of HSE performance targets.

We believe that excellence in HSE performance is essential for good business and it contributes to improved business performance.

Responsibility for compliance with the HSE policies of ENI Angola Production B.V. lies with all managers and their staff.

2.6 Eni's Approach to Sustainability

Eni´s company sustainability goals include protection of the environment and contribution to the quality of life and socioeconomic development of the local communities where its projects take place. Conducting research and producing analyses of the local context in their projects´ areas ensures the management of relevant local and societal issues, to the mutual benefit of stakeholders and society in general. By engaging in this process, Eni reinforces its position as an active corporate citizen.

In the following corporate documents, Eni´s core values and principles are summarized:

- Code of Ethics;
- Annual Report (section on "Commitment to Sustainable Development");
- Eni Guidelines on the Protection and Promotion of Human Rights; and
- The Sustainability Report.

ENI´s sustainability efforts include its commitment to operate within the framework of the United Nations Universal Declaration of Human Rights, the Fundamental Conventions of the International Labour Organization (ILO), and the OECD Guidelines on Multinational Enterprises. Additionally, Eni has subscribed to several international agreements including:

- The UN Global Compact Initiative;
- The Agreement on Transnational Industrial Relations signed with ICEM;
- The Extractive Industry Transparency Initiative (EITI).

For the sustainable development of local communities, Eni´s approach includes identifying priority areas of intervention in line with international best practices. The main tools used in this process include: analysis of the context, organized dialogue with local stakeholders, Social Impact Assessment (SIA), Health Impact Assessment (HIA), and the development of initiatives and partnerships with local communities.

3 Project Justification

3.1 General

This chapter presents the needs, benefits and value for the Eni's proposed Block 15/06 Wells drilling programme; Laying and operation of Transport Systems (flowlines); Installation and operation of FPSO/ mooring system and Installation, operation/ removal of well heads as well as the envisaged environmental, social and economic and technical sustainability. Also presented are the project options considered.

3.2 The Need for the Project

The proposed project which involves the drilling, Laying and operation of Transport Systems (flowlines); Installation and operation of FPSO/ mooring system etc, of a number of wells in the Block 15/06 area of the concession is specifically needed to:

- Increase oil production;
- Maintain proper reservoir pressure for gas lifting for enhanced hydrocarbon recovery;
- Ensure that ENI Angola complies with national policy on environmental protection;
- Support ENI Angola's long term oil growth targets;
- Stimulate interest of stakeholder's;
- Increase economic reserves; and
- Maintaining ENI Angola's business profile.

3.3 Benefits/Value of the Project

Key drivers of the project are:

- Economics and time to production;
- Maximize local industry involvement;
- Compliance with local laws and Company policy;
- Concept of "zero flaring";
- Flexibility for future expansions; and
- No sensitive impact on ecosystem.

Peak oil production is expected to be in the range of 85-90K BOPD. According to these features, the project will allow to improve Angolan oil production, without compromising environment and sharing revenues with local industry and population. Potential indirect benefits are an increased standard of living and better education, social services and amenities.

3.4 Project Options

The project alternatives considered were based mainly on Health, Safety and Environment (HSE) requirements as well as economic and technical feasibilities.

3.4.1 Do Nothing Option

This implies that no hydrocarbon well drilling, Laying/operation of flowlines; Installation and operation of FPSO/mooring system, etc. This means the non-implementation of the planned activities in the project area.

The implications of this are that the benefits outlined in Section 2.3 would not be achieved. For example:

- Impacts associated with oil and gas exploration and production will remain as it is in the area;
- The huge reserve of crude oil would remain unexploited; and
- Pressures in the target reservoirs would continue to decline.

This option was therefore rejected.

3.4.2 Drilling, Laying/Operations of Flowlines, Installation and Operation of FPSO, Mooring System and Well-heads in Block 15/06

This project entails the drilling; Laying and operation of Transport Systems (flowlines); Installation and operation of FPSO/ mooring system and Installation, operation/ removal of well heads in the project area. This shall be carried out using the most up-to-date and proven technology. Also, International ENI HSE Guidelines and Standards and acceptable best practices shall be adopted at all phases of the project execution. This option, which assures the realization of the aspirations of the Angola Government and the stakeholders with its various benefits as well as the sustainability, has been selected for implementation. The potential direct benefits to the region and the country from the exploitation of natural resources are financial income and local business opportunities. Secondary indirect benefits are a potentially increased standard of living and better education, social services and amenities, all of which can potentially help raise awareness of the importance of environmental protection in the area.

4 Project Description

A brief description of the proposed West Hub development and associated project infrastructure and activities is provided in this section. The description is not intended to be technically comprehensive, but aims rather to provide a general understanding of what is proposed and to describe those project aspects that could potentially cause environmental impacts.

4.1 Background and Introduction

As noted in Chapter 1, Block 15/06 extends over an area of 2 984 km^2 in the Angolan Deep Offshore and is located approximately 370 km NNW of Luanda and 130 km W of Soyo. Water depths in the block range from approximately 200 m to 1 700 m.

Historical exploration activities by Eni in Block 15/06 included the following drilling campaigns during which six exploration wells were drilled:

- The first drilling campaign commenced in January 2008 with the objective to drill three wells, namely Sangos-1 (targeting LM26 sand), Ngoma-1 (targeting LM20/22 sand) and Omocola-1. Oil was discovered in Sangos-1 and Ngoma-1. Both wells were successfully tested by applying sand control techniques and were temporarily suspended in order to be able to convert the wells to production wells in future field development. Omocola-1 was suspended after running and cementing the 20-inch casing. The first drilling campaign concluded in October 2008.
- The second drilling campaign started in February 2009. Omocola-1 (originally drilled during the first drilling campaign) was re-entered and drilled further. After testing the well was plugged and abandoned. Three more exploration wells were drilled, namely Cabaça North-1 (targeting UM8 sands), Nzanza-1 (targeting LM22 sands) and Cinguvu-1 (targeting LM18 sands). Oil was discovered in all three wells, which were successfully tested by applying sand control techniques. All three wells were temporarily suspended with lower completion in place to allow for conversion to production wells in future field development.

Following the successful discoveries in the exploration wells, the development of the Sangos (two reservoir levels, namely LM20 and LM26), Ngoma and Cinguvu fields is proposed as part of the West Hub development, while the development of Nzanza and Cabaça are temporarily suspended.

4.2 Project Overview

Development studies carried out from 2008 to 2011 have established the technical feasibility and economic viability of developing the discoveries in the West Hub. The planned development will entail the drilling of 16 wells from four drilling centres, one in each of the oil fields (Sangos LM26, Ngoma, Cinguvu and Sangos LM20). These wells will be a combination of production wells and water and/or gas injection wells. The wells will be connected on the seabed through a series of sub-sea wellheads, manifolds and pipelines to a Floating Production, Storage and Offloading (FPSO) vessel located at the surface.

Following the completion of well drilling (see Section 4.3 below) and completion of the wells with the installation of the subsea production valves (Christmas trees), the subsea umbilicals, risers and flowlines (SURF) system (see Section 4.4 below) will be installed, which will include various production, gas injection, gas lift, water injection and other pipelines, as well as a number of subsea manifolds and Pipeline End Termination (PLET) structures. Installation of the subsea infrastructure (manifolds, flowlines, umbilicals, etc.) will be undertaken by contractor(s) appointed by Eni using specially equipped vessels such as dynamically positioned construction and pipe lay vessels. Supply vessels and/or cargo barges towed by tugs will re-supply the construction and/or pipe lay vessels with

equipment, materials and fuel. The installation plan will be based on the availability of an onshore port or yard in Angola where permanent materials and installation equipment can be delivered and/or parked.

Once the SURF system has been installed on the seafloor, the FPSO will be brought to location for mooring and installation. The FPSO towed to site and will be moored using the vessel's built-in turret mooring system consisting of several anchors connected to mooring lines. The production risers and umbilicals, which provide the hydraulic and electrical power to control the valves and other subsea control systems and deliver chemicals for injection and gas for reinjection, will be connected to the FPSO. The FPSO to be used in the West Hub development is the Xikomba FPSO, which until September 2011 operated in the Exxon-operated Xikomba field in Angola Block 15 and is being refurbished for use in the West Hub development (see Section 4.5 below).

Once all offshore infrastructure and equipment are in place, production can commence. Reservoir fluids will flow continuously from the subsea Christmas trees through the subsea pipelines and via the risers to the process facilities on the FPSO. Initial processing of the reservoir fluids will take place on the FPSO, resulting in the production of crude oil, produced water and associated gas.

Processed crude oil will be stored in the cargo tanks on board the FPSO and exported to market using shuttle tankers. Shuttle tankers will periodically be moored to the FPSO and the stored crude oil will be pumped to the shuttle tanker via an offloading hose. Normal production activities will not be affected by the crude export operations.

The West Hub FPSO processing facilities will be designed to have a processing rate of 100 thousand barrels of oil per day (kBOPD). It is estimated that the West Hub reservoirs has a total hydrocarbon content of approximately 383.4 Million Barrels of Oil (MBO) and, with an estimated Recovery Factor (RF) of 35%, an Estimated Ultimate Recovery (EUR) of 134.3 MBO (see Table 4-1).

Table 4-1: West Hub reservoirs well counts and estimated reserves.

Reservoir	Number of wells				STOOIP*	RF	EUR
	Production	Water Injection	WAG	Total	(MBO)	(%)	(MBO)
Sangos LM26	4	-	2	6	116.7	46.7	54.5
Sangos LM20	2	-	2	4	102.4	34.1	35.0
Cinguvu LM18	2	1	-	3	75.1	27.0	20.3
Ngoma LM18-26	2	1	-	3	89.2	27.4	24.5
TOTAL	10	2	4	16	383.4	35.0	134.3

* Stock Tank Original Oil In Place = total oil content

The associated gas produced during initial processing of the reservoir fluids will be utilised to power the FPSO and associated facilities. Excess gas will be used to maintain pressure in the Sangos reservoirs and facilitate reservoir fluid flow by reinjection of the gas via the WAG wells. Treated seawater will also be injected into the reservoirs via the WAG and/or special water injection wells to maintain reservoir pressure.

Oil production in the West Hub development will start at approximately 50 000 barrels per day (producing from the Sangos reservoirs only) and will peak at approximately 80 000 barrels per day (all reservoirs) about 2 years after first production (scheduled for 2014), after which oil production from the West Hub reservoirs will reduce. The lifespan of the West Hub development is estimated at about 15 to 20 years, with production commencing in 2014.

The subsequent sections of this chapter describe the following aspects of the proposed Block 15/06 West Hub development in more detail:

- Well drilling activities and equipment;
- Offshore infrastructure (SURF and FPSO);
- Resource use, emissions, discharges and wastes; and
- Decommissioning.

4.3 Well Drilling Operations and Equipment

4.3.1 Description of the Planned Wells

In order to develop the Block 15/06 West Hub, a total of 10 new production wells and six new injections wells will be drilled in the Sangos (LM26 and LM20), Ngoma and Cinguvu fields. The wells will be drilled from four Drilling Centres (DCs), one in each field, as set out below.

Sangos LM26

Four production wells and two Water Alternating Gas (WAG) injection wells[2] are planned for the Sangos LM26 reservoir. In addition, the exploration well Sangos-1 will be re-entered and completed as a production well. The location coordinates of the Sangos LM26 field DC and planned wells are provided in Table 4-2 below.

Table 4-2: Sangos LM26 drilling centre and wells.

	X (m Easting)	Y (m Northing)	Estimated Water Depth	Target Depth (TVDss)*
Sangos LM26 Drilling Centre	443 900.00	9 321 400.00	1 320 m	n/a
Production well SP-1	443 914.69	9 321 279.78	1 320 m	2 900 m
Production well SP-3	443 923.77	9 321 407.72	1 320 m	2 900 m
Production well SP-4	443 876.23	9 321 407.72	1 320 m	2 900 m
Production well SP-5	443 885.31	9 321 379.78	1 320 m	2 900 m
Injection well WAG-1	443 838.00	9 322 358.00	1 320 m	4 406 m
Injection well WAG-2	443 910.00	9 322 349.00	1 320 m	4 406 m

* True Vertical Depth Subsea (TVDss) refers to the vertical depth below mean sea level.

The planned production wells in the Sangos LM26 field will be located around the DC at distances of about 20 to 25 m. The locations of the DC and production wells were chosen in order to avoid the salt dome present in the southern part of the reservoir. Due to the relatively shallow depths of the reservoirs and the distance from the DC, most of the wells will be drilled at moderate to high angles (40-70 degrees of inclination). The locations of all the Sangos LM26 wells are within the area covered by a shallow hazard study that was conducted prior to drilling of the Sangos-1 exploration well. According to preliminary information there is no risk of shallow gas or water at the proposed locations, however further studies may be required.

Ngoma

Two production wells and one water injection well will be drilled in the Ngoma field from a single DC. The location coordinates of the Ngoma field DC and planned wells are provided in Table 4-3 below.

[2] WAG injection systems involve alternating between injecting gas and water into a reservoir to facilitate oil recovery from the reservoir.

Table 4-3: Ngoma drilling centre and wells.

	X (m Easting)	Y (m Northing)	Estimated Water Depth (m)	Target Depth (TVDss)
Ngoma Drilling Centre	438 923.00	9 315 965.00	1 421	n/a
Production well NP-1	438 898.57	9 315 970.95	1 421	3 325 m
Production well NP-2	438 916.24	9 315 988.62	1 421	3 325 m
Water injection well NWI-1	439 309.32	9 315 378.62	1 320	3 375 m

Due to the very shallow depths of the reservoir in the Ngoma field, the first well will be drilled horizontally (90 degrees of inclination) and the second sub-horizontally (84 degrees of inclination). Due to the necessity to intersect a large portion of penetrated sands in order to optimise the injector capability, the water injection well will be drilled subhorizontally (86 degrees of inclination).

The locations of all of the proposed Ngoma wells are within the area covered by the shallow hazard study prepared before drilling the exploratory well Ngoma-1. According to a preliminary overview, there is no risk of shallow gas or water at the proposed locations, however further studies may be required.

Cinguvu

Two new production wells and one water injection well will be drilled in the Cinguvu field. Preliminary location coordinates are provided in Table 4-4.

Table 4-4: Cinguvu drilling centre and wells.

	X (m Easting)	Y (m Northing)	Estimated Water Depth (m)	Target Depth (TVDss)
Cinguvu Drilling Centre	445 200.00	9 323 700.00	1 236	n/a
Production well CP-1	n/a	n/a	n/a	2 791 m
Production well CP-2	n/a	n/a	n/a	2 720 m
Water injection well CWI-1	n/a	n/a	n/a	2 845 m

Sangos LM20

Two production wells and two WAG injection wells will be drilled in the Sangos field LM20 reservoir. The wells will be drilled from one DC and at high angles. Location coordinates are provided in Table 4-5 below.

Table 4-5 Sangos LM20 drilling centre and wells.

	X (m Easting)	Y (m Northing)	Estimated Water Depth (m)	Target Depth (TVDss)
Sangos LM20 Drilling Centre	444 907.00	9 320 408.00	1 295	n/a
Production well SP-1	n/a	n/a	n/a	2 891 m
Production well SP-2	n/a	n/a	n/a	2 907 m
Sangos LM20 WAG Drilling Centre	444 907.00	9 320,408.00	1 295.00	n/a
Sangos LM20 WAG-1	n/a	n/a	n/a	3 259 m

It is anticipated that water-based mud (WBM) will be used as drilling fluid during the first stages of the drilling of each well, while oil-based mud (OBM) will be used in the deeper stages (see Section 4.3.5

below). Sand control techniques will be required to complete all wells to minimise and manage the production of sand and fines during oil production, due to the shallow and unconsolidated nature of the reservoirs. Production wells will be completed using the Open Hole Gravel Pack method, while injections wells will be completed using the Stand-Alone Screen method. The wells will be completed in the upper part by a "single completion", i.e. to produce from a single reservoir level using a single tubing string.

4.3.2 Description of the Drilling Unit

The well drilling operations will be performed using the semi-submersible Scarabeo-7 (or a similar drilling unit), which is capable of operating in water depths of up to 1 500 m. Technical specifications for the Scarabeo-7 were provided in the West Hub Drilling Project ESHIA. The unit's seaworthiness certification as well as Eni's Safety, Health and Environment (SHE) standards require that safety precautions must be taken to minimise the possibility of an accident during drilling operations. Collision prevention equipment includes radar, multi-frequency radio, fog horns, etc. Additional precautions include a supply vessel normally stationed at the well location, 24-hour watches, establishment of a 500 m-radius exclusion zone around the drilling unit and access to current weather data to monitor potentially dangerous conditions.

The drilling unit's onboard equipment allows for drilling deep wells (>7 500 m). The Scarabeo 7 has a catamaran configuration: it is more than 110 m long, 61 m wide and its total height is approximately 110 m. Thanks to its special design, the Scarabeo 7 can operate in conditions with up to 15 m high waves while maintaining sufficient stability. The drilling unit is kept in position by means of eight anchors and a computer-aided dynamic positioning system that can correct, in real time, any deviation caused by waves and currents, using the rig's own propellers and thrusters. Up to 120 people can be housed on board the rig.

Figure 4-1: The Scarabeo 7 drilling unit.

The drilling system includes rotating parts, the mud circulation system and safety equipment. The rotary system transfers the rotary movement from the surface to the drill bit and comprises an injection head, top drive and drill string.

The top drive produces the rotary motion. The top drive is essentially made up of a high-power engine with a rotor that is connected to the drill string. The top drive also includes the injection head (which can pump mud into the drill string while it is turning), a make-up/breakout system for connecting/releasing the drill string and a valve to control the mud pumped into the well.

The pipes that make up the drill string are divided into drill pipes and extra-heavy pipes (of greater diameter and thickness). An appropriate number of the latter are installed upstream of the bit to ensure that adequate weight is brought to bear on the bit itself. All pipes in the string are screwed together so as to ensure that the torsion is transmitted to the bit and hydraulic seal.

4.3.3 Mud Circulation System

In a drilling system, the mud circulation system is particularly complex as it must be able to separate drill cuttings and treat the mud itself.

The mud is fed into the drill pipes using high pressure pumps; it exits special holes in the bit at the bottom of the well, incorporates the drill cuttings and then rises back up to the surface. When exiting the well it passes through a system that separates out the drill cuttings before the mud is reconditioned in special tanks and then pumped back into the well.

Various storage tanks are also part of the system to keep an adequate reserve of mud on hand to handle any sudden needs that may arise due to leaks in circulation or absorption into the well.

4.3.4 Drilling Methodology

Drilling is achieved using a drill bit (see Figure 4-2) set at the end of a drill sting of hollow circular pipes, each approximately 10 meters long. These pipes are screwed together so that they can be lowered into, and removed from, the well. They facilitate the rotary motion (generated at the surface by the top drive system) and the circulation of the drilling mud, and exert weight on the drilling tool.

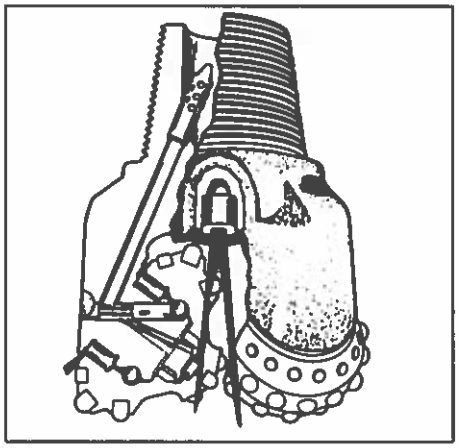

Figure 4-2: Schematic of a drill bit.

Circulation of the mud ensures that the cuttings created by the bit are removed from the well. The composition of the drilling mud is controlled to ensure that it meets specific density and viscosity characteristics. It also serves to counterbalance the pressure exerted by fluids in the rock being drilled through as well as provide support for the wall of the well during the drilling phase. The hydrostatic pressure exerted by the column of mud is, in fact, greater than the normal hydrostatic gradient and even abnormal pressures can be contained by adding substances that increase the density of the mud.

Rotary drilling makes drilling of boreholes relatively simple and fast, even when thousands of meters deep.

Once the borehole has been drilled, in order to insulate the rock formations that are drilled through and to support the borehole walls, the well is lined with steel pipes (i.e. casing) which are jointed together and cemented into the borehole itself. A drill bit with a smaller diameter is lowered into the casing to drill the next section, which is then protected by another casing. The goal is achieved by drilling boreholes of decreasing diameter, each protected by a casing (see Figure 4-3).

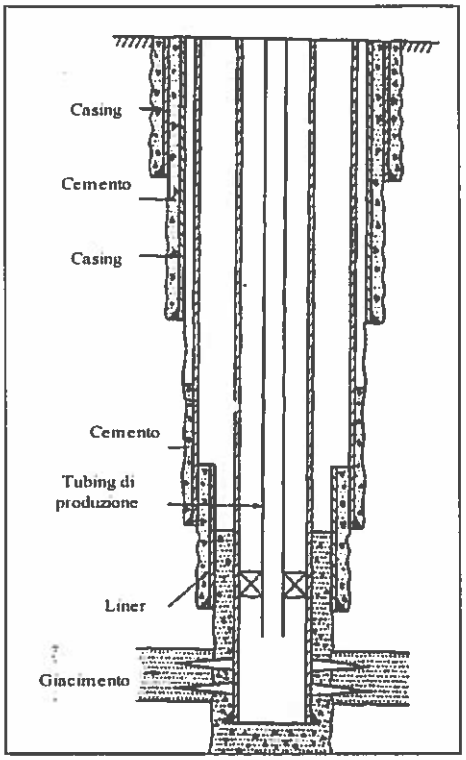

Figure 4-3: Casings and cementing

Drilling is a continuous, 24 hours a day operation.

The initial borehole diameter is typically 16-30 inches, but this decreases according to the number of casing columns used. At the bottom of the well the diameter is reduced to 4-8 inches.

The borehole is rarely perfectly vertical but in most cases any vertical deviation is kept within a few degrees, and thus the shift in coordinates between the bottom of the well and the surface is limited to less than 100 m.

In some cases, in order to reach underground targets as much as a few hundred meters away, the borehole is intentionally deviated, reaching a slope of as much as 50 – 60°. Thus, from a single surface structure, it is possible to drill several wells that reach the reservoir at different, distant points.

In recent years, with the aid of special equipment and techniques, it has also become possible to drill horizontal bore sections (see Figure 4-4). This technique makes it possible to cover considerable lengths, mining them through the system of fractures that allows hydrocarbons to drain through the reservoir rocks, thus improving recovery of the fluids throughout the production life of the well.

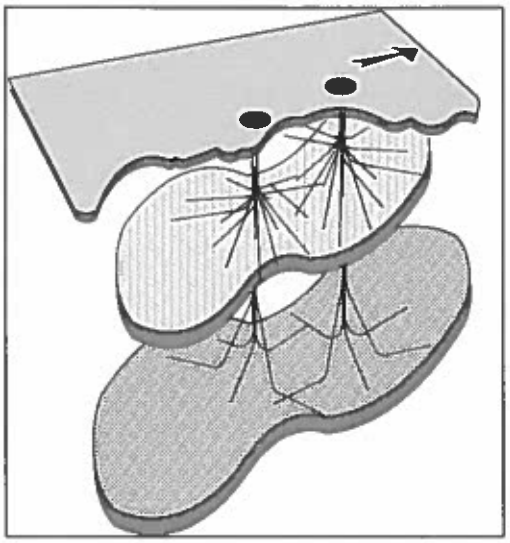

Figure 4-4: Directional and horizontal wells

The type and pressure of the fluids contained in the rock being drilled through vary as the depth increases, and such variation can be quite unpredictable.

One must be fully aware of the lithology of the succession of rock being passed through, as well as the nature and pressure of the fluids contained therein. Such research must be performed both prior to drilling of the borehole, through a seismic survey, and during the course of drilling, through rock sequence analysis performed on drill cuttings samples. Additional testing is done through the use of special instruments (logs) that can take electronic measurements and process them to determine the characteristics of the rock and fluids contained therein.

Once the drilling operation is completed, purposely designed "production tests" will give accurate information on the nature and pressure of the formation fluids.

The well must be drilled in such a manner as to prevent uncontrolled release of the formation fluids from the well (i.e. a "well blow-out"). This is achieved by using mud with densities that can offset the densities of the formation fluids and by using a system of valves installed on top of the well opening at the surface, i.e. the well head and Blow-out Preventer (BOP), to close the well.

When the borehole is being drilled (i.e. before lowering the casing column that insulates the borehole from the rock formations), the drill string and mud are in direct contact with the rock formations that are being drilled through. During this transitory phase, instability of the newly drilled borehole is always possible and can lead to anomalies, as opposed to the smooth progression of operations. Such anomalies can include absorption of the mud into the fractures and pores in the rock, collapse of the walls of the borehole, catching of the bit or of the drill string on the rock and/or breakdown of the drill string due to difficult working conditions.

For production wells, the drilling phase is completed once the entire borehole is lined with steel casing pipes (production string) or, for wells where no hydrocarbons are found, with complete abandonment using cement plugs.

4.3.5 Drilling and Completion Fluids

Drilling fluids (muds) are normally made up of a liquid (water or oil) set in a colloidal state and weighted down with specific products. The colloidal properties are achieved with special clays (bentonite) and enhanced by particular compounds that give the mud particular rheological properties, turning it into a gel able to keep the weighting additives and debris in suspension, even when circulation is cut off.

Drilling fluids are used to:

- Remove cuttings from the bottom of the well and carry it up to the surface;
- Cool and lubricate the drilling bit;
- Contain the fluids present in the rock formations through hydrostatic pressure;
- Consolidate the walls of the borehole and reduce infiltration into the formation by coating the borehole; and
- Prevent the borehole from collapsing and damage to the production formations.

To satisfactorily perform all its functions at once, the drilling fluids must be continually enhanced with chemicals and their rheological properties checked.

The type of mud used (and its chemical components) is determined largely by subsurface rock temperatures as excessive temperatures can alter the rheological properties of mud (subsurface temperatures can exceed 200°C). Selection and definition of the drilling fluids are based on experience gained in the field. The various types of materials for circulation will be stocked on the drilling unit in sufficient quantity to make up for any losses, along with suitable pills[3] (e.g. to free stuck pipes).

For example, the tables below showing the proposed well design for two wells that are typical of the wells proposed, namely a Sangos production well and Ngoma production well.

The surface sections of each well will be drilled using water-based mud (WMB) in the form of a sea water-bentonite mud system, and high viscosity pills. During the deeper phases of each well, a synthetic oil-based mud (SBM) system will be used. The mud densities shown in the tables are estimates and the real densities of the mud to be used will be decided according to operational requirements.

Table 4-6: Mud systems and mud density ranges for each phase of typical West Hub production wells, namely a Sangos production well (top) and a Ngoma production well (bottom).

Typical Sangos Production Well:						
Casing size	**Hole size**	**Estimated setting depth**	**Estimate pore pressure grad.**	**Estimated mud weight**		**Estimated fracture pressure grad.**
(inches)	**(inches)**	**(m TVD)**	**(kg/cm²/10m)**	**Specific gravity**	**Type**	**(kg/cm²/10m)**
36	jetted	1 417	1.04	1.04	Seawater + high-viscosity pill	-
20 x 13⅜	17½	2 000 – 2 070	1.04	1.04	Seawater + high-viscosity pill	1.21 – 1.22
9⅝ x 10¾	12¼	2 650 – 2 750	1.04	1.11 – 1.14	Oil-based mud	1.37 – 1.39
-	8½	2 850 – 2 900	1.05 – 1.07	1.14 – 1.16	Oil-based mud – low solid	-
Typical Ngoma Production Well:						
Casing size	**Hole size**	**Estimated setting depth**	**Estimate pore pressure grad.**	**Estimated mud weight**		**Estimated fracture pressure grad.**
(inches)	**(inches)**	**(m TVD)**	**(kg/cm²/10m)**	**Specific gravity**	**Type**	**(kg/cm²/10m)**
36	jetted	1 518	1.04	1.04	Seawater + high-viscosity pill	-
20	26	1 850	1.04	1.04	Seawater + high-viscosity pill	1.14
13⅜	16	2 100	1.04	1.11 – 1.12	Seawater + high-viscosity pill	1.22
9⅝ x 10¾	12¼	2 300	1.04	1.12 – 1.14	Oil-based mud	1.25
-	8½	2 300 – 2 390	1.04 – 1.05	1.14 – 1.16	Oil-based mud – low solid	-

[3] A pill is any relatively small quantity of a special blend of drilling fluid to accomplish a specific task that the regular drilling fluid cannot perform.

In addition, suitable pills must be used to clean the wellbore and the surface mud tanks before the type of drilling fluid is changed (i.e. from WBM to SBM).

4.3.6 Blow-Out Prevention

Under particular geological conditions, the pressure of the formation fluids may be higher than the hydrostatic pressure exerted by the mud. In such cases, there may be a sudden inflow of formation fluids into the borehole and, since such fluids are less dense than the mud, they will rise to the surface.

This so-called "kick" induces an increase in the volume of the mud in the tank and can cause a well blow-out (an uncontrolled release of formation fluids at the surface). To prevent blow-outs, safety equipment known as Blow-Out Preventers (BOPs) are installed on top of the well head.

A BOP comprises a set of valves that can be closed to contain any natural pressure from the well bore. There are two basic types of BOP, namely annular and ram.

Annular BOPs are installed at the top fo the BOP stack. They have a suitably shaped rubber element and, when a hydraulic piston exerts an axial pressure against this element, it adheres to the internal shape, thus closing it tightly. Such closing is ensured for every diameter and for every drill string or casing, no matter what the shape. Even when the borehole is free of the drill string, the annular BOP always ensures tightness.

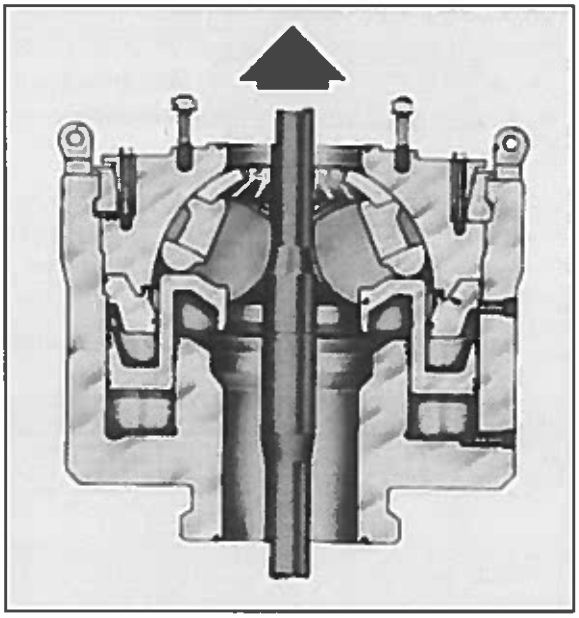

Figure 4-5: Safety equipment: Annular BOP.

Ram-type BOPs have two prismatic gates appropriately shaped to fit the diameter of the equipment in the borehole and may be secured together with a hydraulic mechanism. The number and size of the rams depend on the diameter of the elements in the drill string.

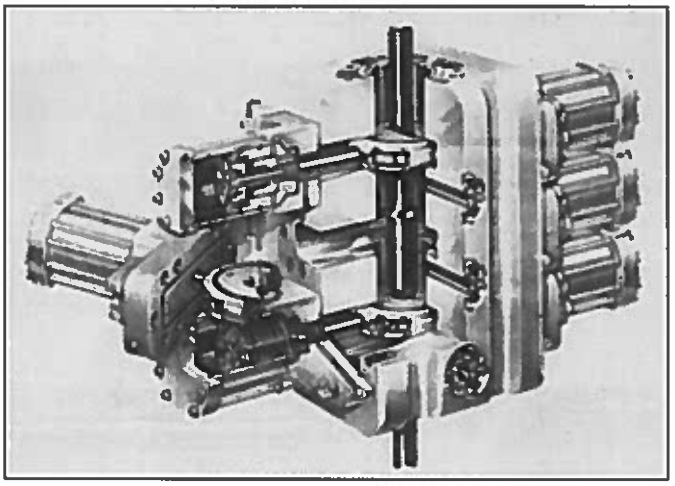

Figure 4-6: Safety equipment: Ram-type BOP

There is also a set of shear rams that ensure total closing of the borehole when it is free of any equipment. In an emergency, these rams can even sear the drilling pipes if they are present when it is tripped.

These elements are normally assembled to form the "BOP stack" generally composed of one or two annular BOPs and three or four rams. The BOPs are operated hydraulically from two remote panels.

The formation fluids are circulated and expelled using high pressure lines — called choke and kill lines — and special variable section valves — called choke valves — able to control the pressure and flow rate.

Floating deep-sea off-shore rigs use a BOP stack installed on the well head at the sea floor. Like the valves and kill and choke lines, the BOPs are operated from the surface using electrodynamic controls. All functions and controls are redundant and "fail-safe".

The number and type of BOPs actually employed for the activities planned in Block 15/06 depend on the drilling equipment employed and on the features of the drilled formations and waters encountered.

4.3.7 Drilling parameters monitoring

Drilling parameters are monitored by two independent systems of sensors that operate in continuous mode and throughout all drilling operations. Such monitoring is essential as it permits prompt recognition of any operating anomalies. The first monitoring system is inserted on the drilling rig, the second is composed of a computerized unit manned by skilled personnel and installed on the drilling rig. The latter provides geological assistance and controls drilling activities.

4.3.8 Production Tests

The performance of specific "production tests" on conclusion of the drilling operations will provide accurate information concerning the presence of hydrocarbons in the strata investigated, their nature and their pressure characteristics. Quantity estimates will also be obtained.

At present, the intention is to perform production tests in each field. These tests will vent the levels and provide estimates of their potential; waste gas and oil resulting from the production tests will be sent to the flare.

4.3.9 Completion Activities

The term completion is used to indicate the operations performed on a well at the end of the drilling phase, before it is set into production. Completion serves to make permanent arrangements for production and to secure the drilled well.

The major principles applied in well completion are as follows.

- Hydrocarbons in the wellbore are brought up to the surface through a series of production pipes called the "completion string". This string is composed of a series of tubings and other equipment that ensure well production function and safety;
- If there are several production levels in the wellbore, only one completion string is used and is composed of several tubings that are able to independently produce from different levels; and
- An SCSSV ("Surface Controlled Subsurface Safety Valve") is installed along the completion string. This valve automatically closes the production string if operating emergencies arise (e.g. well head failure).

Key completion equipment include the following:

Completion string

The completion string comprises:

- *Tubings:* these pipes generally have small dimensions (4 1/2" to 2 1/16") but high pressure resistance. They are screwed together in series according to the depth of the well;
- *Packers:* a metal unit with rubber gaskets to ensure a tight seal. They hydraulically insulate the section in communication with the production zones from the rest of the string. For safety purposes, it is kept full of completion fluid. The number of packers in a string depends on how many production levels the well has; and
- *Safety valves*: these are installed in the pipe string. They are used in gusher wells and serve to automatically close the entire tubing if the well head fails, thus blocking hydrocarbon flow to the surface.

Completion well head

Above the first elements in the well head, additional well head completion elements are hooked and flanged onto the casings installed during the drilling phase. These elements provide the well head with enough valves to control production. The main parts of the completion well head are:

- *Tubing spool*: the lower part of this spool holds the production column tightness elements while the upper part holds the housing for the steel block with gasket, called the "tubing hanger" which supports the completion string; and
- *Christmas tree*: a well completion unit connected to the well head by special mechanical or hydraulic connectors. It consists of a series of gated cut-off valves having a hydraulic or pneumatic actuator, or manual valves located on a T or V cross.

4.3.10 Drilling and Completion Timeframes

Table 4-7 below indicates the envisaged timeframes for the operations involved in each of the planned activities.

Table 4-7: Timeframes for drilling and completion activities at each field.

Operation	Expected time (days)
Sangos LM26	488
Ngoma	269

Cinguvu	150
Sangos LM20	214
TOTAL FOR DRILLING & COMPLETION	**1 121**

4.4 Subsea Umbilicals, Risers and Flowlines (SURF)

As noted previously, the proposed field development is based on a number of subsea wells tied back to a single FPSO vessel by means of a subsea umbilicals, risers and flowlines (SURF) system, including various production, gas injection, gas lift, water injection and other pipelines, as well as a number of subsea manifolds and Pipeline End Termination (PLET) structures. The riser and flowline systems will comply with the latest versions of the applicable Eni and international codes and standards.

4.4.1 Overview and layout

The proposed subsea layout of the various drilling centres (DCs) and SURF system is illustrated in Figure 4-7 and a SURF schematic is provided in Figure 4-8 below. The planned production wells will be arranged in a cluster manifold configuration, meaning that at each DC the relevant wells will be clustered around and connected to a common manifold with flowline jumpers. The injection wells (water or gas injection) will be arranged as satellites.

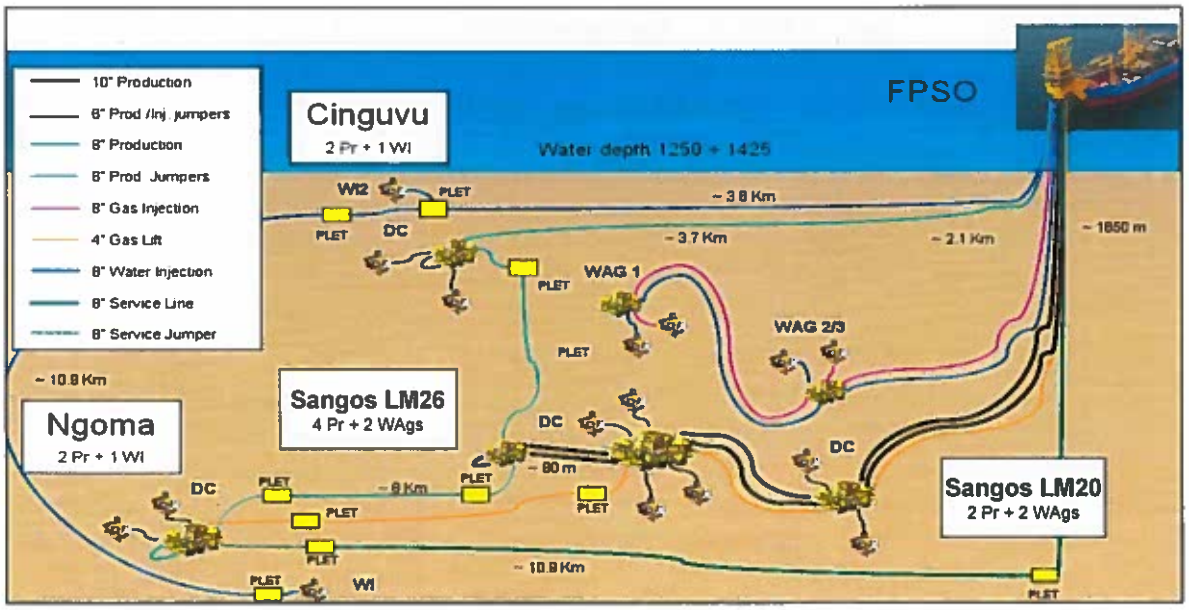

Figure 4-7: Proposed West Hub development subsea layout.

The production wells in the West Hub development will be completed with horizontal Christmas trees equipped with multiphase flowmeters to calculate flowrates, and the SURF pipelines will comprise a combination of flexible risers, flowlines and jumpers as well as rigid flowlines (see Figure 4-8).

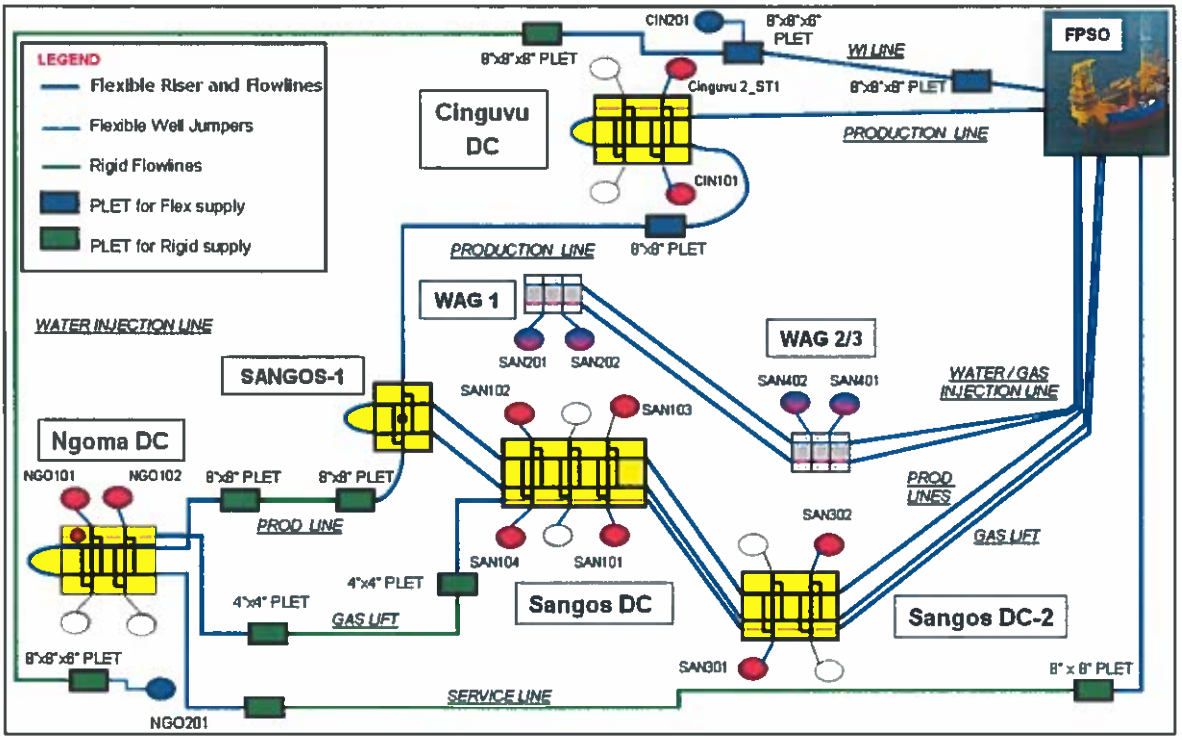

Figure 4-8: Proposed West Hub development SURF schematic.

The Sangos subsea production system will be based on 10-inch flexible risers and flowlines, connecting to Sangos production manifolds to the FPSO and terminating at the Sangos-1 manifold approximately 200 m west of the main Sangos DC manifold (LM 26). Four WAG wells will be used to maintain reservoir pressure in the Sangos field, two in each of the Sangos reservoir levels (LM20 and LM26). The WAG manifolds will allow for switching between water and gas injection in the wells. The WAG manifolds will be connected directly to the FPSO by separate 8-inch flexible injection lines. Gas lift injection will be provided for with a dedicated 4-inch thermally insulated gas lift line connecting the FPSO with the Sangos manifolds. A single umbilical will provide control and chemicals injections to all of the subsea manifolds and trees in the Sangos fields.

The Cinguvu and Ngoma fields will be developed as satellites of the main Sangos field, with production fluids from the Cinguvu and Ngoma fields routed with 8-inch production lines through the Sangos manifolds and then on to the FPSO. A service line (for diesel circulation) from the FPSO to the Cinguvu field will however be insulated in order to provide for the possible use of this line as a production line if required in the future. A single water injection line will connect the FPSO with the Cinguvu water injection well about 2 km from the Cinguvu DC and further on with the Ngoma water injection well. A single umbilical will provide control and chemicals injections to the Cinguvu manifold and Christmas trees from the FPSO, and the same umbilical will be daisy-chained to control the Ngoma field as well. Downhole gas lift at the Cinguvu field is not anticipated, but provision will be made for the possible future installation of a dedicated gas lift line in the design of the Christmas trees and manifolds. The Ngoma wells, however, will require downhole gas lift which will be provided by the extension of the Sangos gas lift line with a 4-inch flowline from the Sangos DC manifold to the Ngoma DC manifold. A dedicated 8-inch service line will link the FPSO with the Ngoma DC manifold.

The West Hub subsea system will be controlled by a multiplexed electro-hydraulic control system routed from the FPSO via a control umbilical to each subsea system. The umbilicals shall consist of hydraulic lines and electrical power/communication lines to each subsea manifold and then to the trees (wellheads).

4.4.2 Installation

Construction and installation of the SURF system will be undertaken by a contractor or a number of contractors using a range of specialised vessels, including a number of Heavy Lift Vessels (HLVs), a cargo liner, main and light construction vessels, as well as a pipelay vessel. These vessels will be equipped to undertake all subsea construction and installation activities and will be supported by supply vessels, helicopters, etc. Crew accommodation will be provided for on each of the vessels.

The subsea manifolds and PLET structures will be lowered to and installed on the seafloor at the various locations in the West Hub area using a dynamically positioned construction vessel equipped with various positioning systems to ensure that each structure is located precisely. The subsea flowlines will be installed by the dynamically positioned pipelay construction vessel, which will lower the pipelines to the seafloor and install them between the FPSO location and the various manifolds, PLETs, etc. The pipelay vessel will be supplied with pipes, fuel, etc. either by supply vessel or by the cargo liner. The control umbilicals will be installed in a similar manner.

4.4.3 Operation, maintenance and control

The proposed flowlines and risers operating procedures shall be in accordance with Eni Angola corporate safety rules which is focused on safety, accident prevention and the reduction of risks to as low as practicable. In addition, hazard and operability (HAZOP) studies shall be carried out on the final designs and drawings for the subsea systems in order to verify safety systems and the integrity of pipelines. Safety barriers, referring to any element or group of elements designed to prevent or limit the impact of an accidental event, will be included in the design. The general safety philosophy shall be based on "double barrier" concept, which entails the application of two independent barriers in series, so that only the failure of both barriers could cause a potential accident. One barrier will be controlled with manual activation and the other with automatic activation.

The subsea design shall make provision for various maintenance and control functions, including for the following:

- *Corrosion protection:* The potential for corrosion shall be minimised through good design, monitoring and protection. Crude oil entering the system will be treated to reduce the possibility of corrosion. Additional safeguards such as chemical inhibition will also be provided for. Sand detectors shall be provided on all production Christmas trees with continuous monitoring. Internal corrosion of the subsea systems shall be managed by a combination of material selection and injection of corrosion inhibitor. Corrosion in the water injection system shall be controlled by treating the water to reduce oxygen concentration to acceptable levels. Corrosion inhibitor injection is not foreseen;
- *Scale management:* Scale formation shall be managed using scale inhibitor and by sulphate reduction of the injected water. A sulphate removal unit is required along with continuous injection of scale inhibitor. A separate injection line to each production well shall be provided for scale inhibitor to prevent mixing with other chemicals prior to injection in the case that scale inhibitor results to be incompatible with other chemicals;
- *Asphaltene management*: Asphaltene deposition occurrence shall be evaluate/ estimated in the subsea production system or the oil offloading system. The subsea system shall provide the capability to circulate an asphaltene solvent down the risers through the flowlines, and manifold headers.
- *Paraffin management*: In general, paraffin (wax) deposition in the production flowlines and risers shall be managed by maintaining temperatures. In addition, the production flowlines shall be "round trip" piggable for the removal of any residual wax. Provision will be made for the use of paraffin inhibitors in the production flowlines and riser;

- *Hydrate management*: Hydrates shall be managed using a combination of inhibitor, thermal insulation and operating practices. Hydrate inhibitor shall be used during system start-up and shutdown. Inhibitor shall not be used continuously during normal operations. Hydrates are to be managed during normal production by maintaining temperature outside the hydrate region; and
- *Cathodic protection:* The cathodic protection system shall be by impressed current with sacrificial anode and ground bed. This shall involve minimal excavation of small holes at predetermined locations for installation of ground beds and electrical connection of the system to the pipeline.

4.5 Floating, Production, Storage and Offloading (FPSO) Vessel

4.5.1 Overview and FPSO upgrades

The Xikomba FPSO, which was operating in the Exxon-operated Xikomba field in Angola Block 15 up to September 2011, will be utilised in the West Hub development. The FPSO is undergoing a refurbishment and life extension program designed to achieve a design life of 15 years without dry-docking. The existing turret mooring system on the FPSO will undergo reconfiguration to increase the riser tie-in capacity from seven (as used in the Xikomba development) to 16 risers.

Figure 4-9: The Xikomba FPSO.
Source: http://www.photoship.co.uk/

The FPSO's topsides facilities consist of a single three-stage oil separation train to process up to 125 000 barrels per day (bpd) of gross reservoir fluids. The FPSO will have storage for 1.5 million barrels of crude which will be exported via tandem offloading to shuttle tankers. The associated gas will be utilised as fuel gas (to power the facilities on the FPSO), and as lift gas to aid production. As noted above, excess associated gas will be re-injected via the WAG wells into the Sangos reservoir. No gas flaring is foreseen during normal operation of the Block 15-06 West Hub FPSO.

A major upgrade to the existing Xikomba FPSO facilities is the addition of spare injection and flash gas compressor trains to ensure high availability in line with the no-flaring policy. Produced water will be treated and discharged overboard. Treated seawater injection will be provided for to maintain reservoir pressure and facilitate production. Seawater treatment will include sulphate removal to

control barium and strontium sulphate scaling and to minimize reservoir souring potential due to sulphate removing bacteria.

The following sections summarise the main functional requirements of the FPSO for service in Block 15/06 West Hub.

Hull and Marine Systems

The service life of the FPSO vessel will be 15 years of continuous service on site, without the need for dry-docking or offsite maintenance. The main refurbishment and life extension works to be performed on hull and marine systems of the Xikomba FPSO include:

- Complete removal of all encapsulated asbestos from the accommodation and engine room;
- Replacement of about 4 000 tons of hull steel. Steel renewal criteria will assure that no hull structure failures necessitating repair will occur during the design life and to avoid substantial corrosion of any part of the hull;
- Installation of new bulkheads in the cargo tanks to ensure compliance with the latest MARPOL rules regulating the maximum possible outflow from cargo tanks;
- Installation of a new 1 800 m3 methanol tank;
- Construction of an anti-collision structure where required to protect the cargo tanks;
- Complete external coating of the hull;
- Cargo piping renewal;
- Refurbishment of the pump room, engine room and accommodation, including renewal of the Heating, Ventilation and Air-Conditioning (HVAC) system; and
- Overhauling of the main steam boiler (120 t steam) and installation of a new 14 MW Steam turbo alternator & condenser and a new 5 MW Gas Turbine to power hull and topsides consumers.

The hull shall have a storage capacity of 1 500 000 bbls. The offloading system will be provided to allow a 350 000 DWT tanker to be moored at the stern of FPSO in tandem configuration.

The accommodation block of the FPSO shall be refurbished and modified according to all HSE requirements to ensure that there is sufficient capacity to commission, operate and maintain the FPSO from start-up through to end of field life.

Turret

The turret shall be fitted with fluid transfer and swivel systems allowing the produced reservoir fluids, water (for injection), gas (for lift and injection), hydraulic and service fluids, electrical signals and power to be continuously transferred to/from the FPSO while the vessel is weathervane.

The development of the West Hub will require a riser configuration comprising of 10 risers, as well as provision for future riser tie-ins from other nearby fields (e.g. the Mpungi field), and one power spare for future subsea modification.

The FPSO's turret was designed to handle up to 16 risers, however it was configured for seven risers in the Xikomba field. It will therefore be re-configured in terms of space and functionality to connect and operate the West Hub risers as well as potential future risers, umbilical and power cables to reach a total of 16 risers. The re-configuration will include the extension and strengthening of the gantry structure, the addition of a new manifold deck and complete pipe-work replacement;

Topsides processing facilities

The design flowrates for the FPSO topsides facilities are summarised in Table 4-8 below.

Table 4-8: Design flowrates for the FPSO topside facilities.

Facility	Design flowrate
Oil Production	100 000 BOPD*
Total Liquid Max Production	125 000 BLPD
Gas Lift	70 MMscfd**
Gas Production	80 MMscfd
Gas Injection	100 MMscfd
Water Injection	120 000 BWPD***
Produced Water	100 000 BWPD

* BOPD: Barrels of Oil Per Day
** MMscfd: Million Standard Cubic Feet per Day
*** BWPD: Barrels Water Per Day

The main upgrades to the existing topsides facilities on the Xikomba FPSO include:

- Debottlenecking of process facilities to meet new throughput requirements as follows:
  - Crude oil processing increase from 90 000 bpd to 100 000 bpd;
  - Gas processing capacity increase from 95 MMscfd to 115 MMscfd;
  - Produced water treatment increase from 55 BWPD to 112.5 bwpd; and
  - Water injection increase from 90 bwpd to 120 BWPD;
- Replacement of the high-pressure separator;
- Addition of gas injection and flash gas compressor trains to ensure 97% facility availability with no flaring policy;
- Addition of new produced water treatment package including hydrocyclones;
- Replacement of seawater lift pumps and addition of sulphate removal package (SRP) to the seawater injection treatment system to control sulphate scaling and to minimise reservoir souring potential due to sulphate removing bacteria;
- Replacement of deaeration tower and refurbishment of water injection pumps;
- Addition of pumps for circulation of hot oil for preservation and start up of the flowlines;
- Addition of methanol charge pumps due to an increase in the methanol tank size; and
- Upgrade of electrical power generation / distribution system to accommodate the increased power demand from new modules and to provide flexibility for future equipment such as multi phase pumps that may be required for future tie-ins.

The layout of the FPSO Xikomba showing the existing facilities to be refurbished / upgraded and new modules to be added is shown in Figure 4-10.

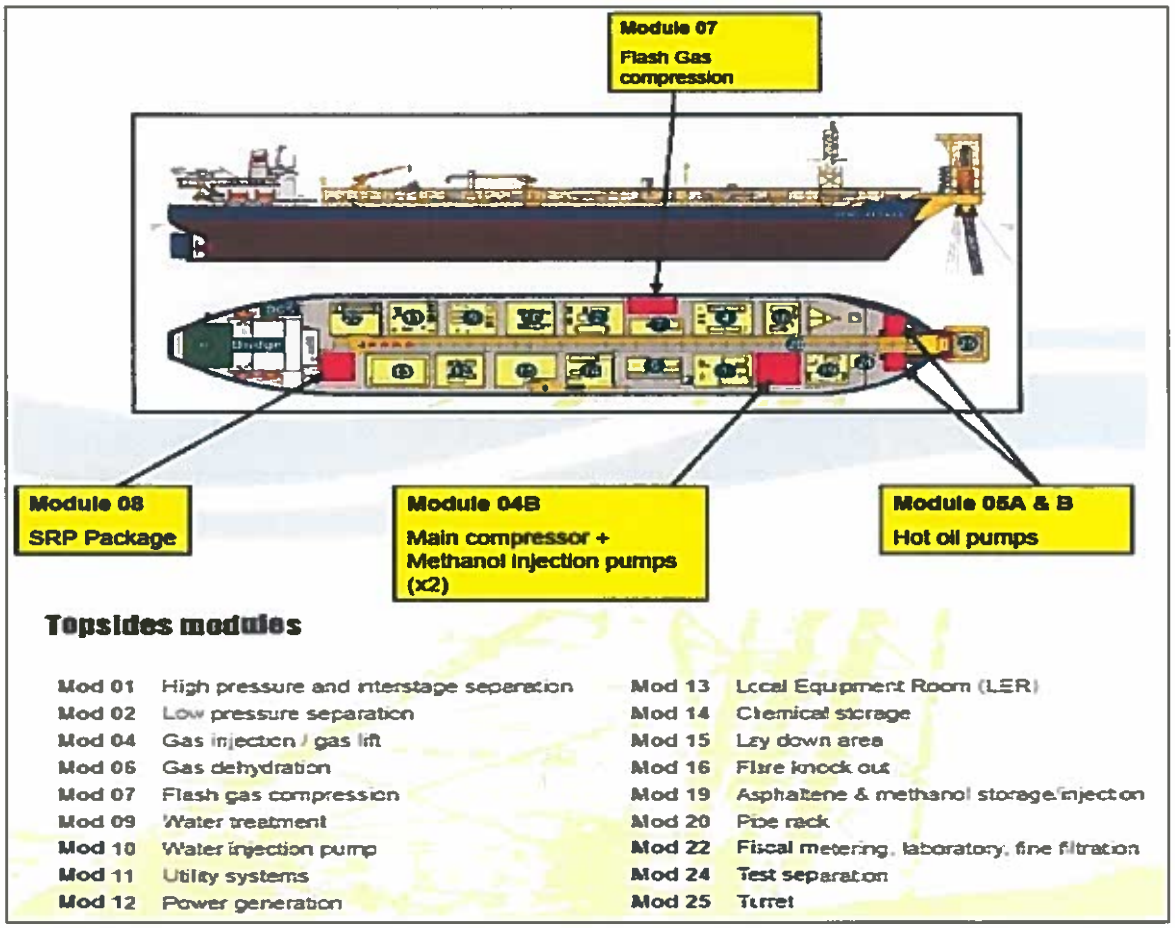

Figure 4-10: Layout of topsides facilities on the Xikomba FPSO showing new modules in red.

4.5.2 FPSO installation

Typically installation of the FPSO commences with the installation of the mooring system using a dynamically positioned construction or anchor handling vessel. The anchors will be placed on the seafloor and the mooring lines connected. Once the mooring system is in place, the Xikomba FPSO will travel to the West Hub area and the mooring lines will be connected to the FPSO using one or more construction and/or anchor handling vessels. A vessel will pick up the top end of the preinstall mooring line and connect the mooring wire to the FPSO turret. Once the FPSO has been successfully moored, the installation of the risers (umbilical, production, gas injection and water injection risers) will be undertaken. The risers will be suspended underneath the turret of the PFSO, and construction vessel will connected risers, first to the flowlines or riser base on the seafloor, and then to the FPSO.

4.5.3 Operation and control

The main operational, processing, utility and control systems (facilities and relevant processes) on the FPSO are briefly discussed below:

Accommodation block and helideck

The accommodation block on the FPSO will accommodate up to 80 personnel and will comprise the living quarters, working spaces, technical and machinery rooms, the central control room and the telecommunications room. A helicopter deck will be located above the accommodation block at the stern of the vessel.

Telecommunication systems

The telecommunication systems on the FPSO will comprise an internal Public Address/General Alarm (PA/GA) system to facilitate public announcements and to provide audible and visual alarm signals in case of emergency. In addition, provision will be made for an automatic telephone system with an electronic public exchange switchboard and telephone sets throughout the FPSO.

Provision for external communications will be made through various general and emergency systems located in the central control room and/or the telecommunications room. This will include satellite communication, aeronautical communication, a Global Maritime Distress & Safety System (GMDSS), etc.

Deck cranes

The FPSO will be equipped with deck cranes to facilitate the transfer of goods and personnel to and from supply boats moored alongside the FPSO, and to transfer equipment and goods within the lay down area on the main deck.

Oil separation and stabilisation

Production fluids brought to the FPSO will be tested and pressure controlled and then processed in a multistage flash separation system to separate the crude oil from the emulsified water and brine and associated gas in the reservoir fluids, resulting in stabilised crude oil (to the required specifications), produced gas and produced water streams. The process will involve one or more oil separation trains to ensure effective and reliable fluids separation and oil stabilisation prior to storage in the cargo tanks, as well as a high flash gas recovery. The highly saline produced water will be diluted with fresh water.

Gas processing and compression

Produced gas must be processed to provide the gas quality and conditions so that the gas can be used for gas list, as fuel gas or for gas injection into the reservoirs via the WAG wells. Treatment for use as injection gas will include the use of a conventional tri-ethylene glycol (TEG) absorption dehydration system to prevent hydrate formation in the gas lift and gas injection system where the high pressure gas will cool down to seabed temperatures. This is to minimise the potential for corrosion of the subsea pipelines and other potential hydrate issues. The TEG used in dehydration will be recycled through a TEG regeneration system where water and other impurities will be removed and the purified TEG circulated back to the gas dehydration unit. Compression is required to ensure and maintain suitable pressures.

Water injection

Seawater will be treated to make it suitable for injection into the reservoirs to assist with maintaining reservoir pressures. Seawater is supplied to the water injection system by seawater lift pumps that will meet the water demand for injection, as well as for cooling and sulphate reduction. Seawater taken up will first be used as coolant in various topsides facilities, after which some (as the quantity of injection water required is smaller than the amount required for cooling) will be treated further. Excess water is dumped overboard.

The treatment of seawater in the water injection system will involve coarse and fine filtration to remove suspended solids (particles larger than 5 microns), sulphate removal and de-aeration to remove oxygen. Water injection booster pumps will increase the pressure required for the water injection pumps, which will provide the final suitable pressure to inject the treated seawater into the water injection wells. Injection points for the injection of biocides, foam inhibitor, oxygen scavenger and filter aids will be provided for in the water injection system.

Chemical injection

The chemical injection system will comprise packages for the storage and supply of methanol (for gas lift and gas injection headers, flowlines and wellheads during TEG outages, start-up and shut-down), chemicals for the topsides production facilities and subsea systems, chemicals for the water injection system, as well as a subsea chemical metering and distribution unit. Provision will be made for the storage and supply of biocides, corrosion inhibitor, oxygen scavanger, demulsifier, foam inhibitor, scale inhibitor and methanol (hydrate inhibitor) for the topsides facilities; as well as corrosion inhibitor, scale inhibitor, methanol (hydrate inhibitor), low dosage hydrate inhibitor, wax inhibitor or pour point depressant for the subsea systems.

The chemicals will all be compatible with each other in case of common injection points, and injection will be done at suitable pressure to ensure that the chemicals are supplied where it is required.

Fuel gas system

The fuel gas system will supply fuel gas to all topsides facilities. Produced gas will be conditioned to remove rich heavy hydrocarbons before it can be used as fuel gas in the gas turbine generators which will generate electricity to power the FPSO facilities. Under normal conditions, fuel gas will be taken from the gas compression system, but during start-up conditions, gas can be drawn directly from the oil separation system to enable gas firing of the boilers. The fuel gas system is subdivided into high-pressure (HP) and low-pressure (LP) fuel gas systems to provide gas to the various facilities as suitable pressures and temperatures.

Power generation

The main power generation on the FPSO will consist of steam turbines powered by fuel gas (treated produced gas) during normal operations. A stand-by generator will be also available to generate power during start-up, and will automatically start and supply power in case one of main power generators fails. During normal operations the stand-by generator will use fuel gas, but during start-up (when produced gas is not yet available) diesel (marine gas oil or MGO) will be used. An MGO pressurised main will feed MGO from the vessel's engine room to the stand-by generator as well as to various other utility stations on the vessel, as required. A separate, non-pressurised MGO header will provide top-up for the day tanks of various equipment on the vessel, e.g. the deck cranes, fire pump, pigging pumpt etc. Accumulator vessels will be installed on MGO supply lines near the gas turbines to ensure pressure is maintained during switchover from fuel gas to MGO.

Flare, vent and blowdown system

The flare stack is located as far forward towards the bow of the vessel as possible in order to maximise the distance between the flare and the accommodation block (located at the stern). A general "no flaring" policy will be adopted, which means that there will be no continuous flaring during normal operations. Intermittent flaring may however be required during emergency conditions, maintenance operations as well as during start-up. In addition to flaring, purging of the fuel gas flare and venting of the TEG regeneration package and plant compressor sealing system will be required.

The oil production and compression systems will be equipped with isolation valves to allow for remotely isolating sections of the facilities in case of emergency. Each section will also be equipped with depressurisation valves to allow for remote depressurisation. The blowdown gathering system will ensure that cold HP gas streams from the compression trains will not be mixed with the wet gas or liquid streams coming from the oil production train, which will prevent possible ice formation in case of simultaneous discharge.

Tanks

Cargo tanks will make provision for receiving, distributing and storing on-spec crude from the FPSO processing facilities, as well as off-spec crude in a dedicated off-spec cargo tank (before recirculation back to the processing facilities by means of the cargo pumps). The cargo system storage capacity of approximately 2 million barrels (bbl) will provide storage of approximately 20 days at the processing design rate of 100 kBOPD.

The cargo system is also used as a ballast system and will make provision for emergency ballasting with seawater if required.

Slop tanks are used to receive and store oily water from the washing of tanks, from cargo tank stripping as well as off-spec produced water and drains from the processing facilities. The cargo tanks will be regularly washed (with crude oil) to remove deposits and bottom sediment from the tanks, which will be discharged with the cargo into the export tankers. This is normally done during export operations, but could be done at any time providing sufficient crude oil is available on board. Water washing of cargo tanks will be conducted in case of tank inspection or maintenance and will normally be done immediately after offloading with the FPSO nearly empty of crude oil. Hot water washing of tanks will use water from the slop tanks, heated by the slop tanks heating coils.

Crude export system

Stabilised crude oil will be continuously loaded into the cargo tanks from the processing facilities, with simultaneous offloading into shuttle tankers at regular intervals. Crude will be exported from the cargo systems to the shuttle tankers via an offloading hose string consisting of one main line. The line will be long enough to accommodate the largest anticipated tanker.

The export system will be equipped with a quick release mechanism in case of an emergency. A metering system installed on the FPSO main deck (upstream of the offloading station) will ensure that the quantity of crude oil transferred during offloading is measured.

Inert gas and tank venting system

The inert gas and tank venting system facilitates the intermittent relieving of pressure that builds up in the FPSO's cargo and slop tanks through manual and/or automatic venting. Inert gas is also used to maintain pressure in the cargo tanks by filling the space created when cargo tanks are emptied with an inert gas, which also requires venting when the cargo tanks are filled up again. Provision will also be made for the temporary inserting of the ballast tanks in the cargo area in case hydrocarbons leak into the ballast tanks.

Produced water treatment

Produced water from the oil separators will be routed to the produced water treatment system, where it will be treated to ensure that the oil-in-water content is below the required level prior to disposal overboard. The treatment process will involve degassing, cooling, two-stage oil/water separation and further de-oiling in the slop tanks. Gas from this system will be routed to the flare. Pressure will be maintained via a LP fuel gas blanket and pressure control to flare.

Flowline pigging system

A pigging system will provide for round-trip pigging through the production flowlines. Dead oil will be used as the pigging fluid, but MGO is likely to be used for pigging operations prior to start-up. The pigging system consists of pig launchers and receivers as well as a crude pigging pump on the FPSO. The pigging pump will be capable of pumping the pigging fluid to pressures suitable to perform the flowline cleaning/flushing operation.

The system will allow for round-trip pigging toeach of the production drill centres. This system will also be used to displace produced fluids from the flowlines as part of the hydrate mitigation strategy.

Heating and cooling medium systems

Heating of process streams is required to meet the crude oil product specifications, to pre-heat wash water, to melt possible wax dispositions in the flare drum boots and to superheat fuel gas. A closed circuit heating medium system, involving hot (fresh) water continuously circulated (pumped) in a close system, will be used on the West Hub FPSO. Heat will be provided via LP steam condensers fed with LP steam from the FPSO vessel boiler.

Cooling of process streams is required to remove the heat generated in the compression systems, the gas turbine lube oil coolers for gas compressors and TEG regeneration package crude oil cooler and produced water coolers. The cooling medium system will also be a closed circuit system with cold (fresh) water continuously circulated between these systems and the sea water coolers, which will be supplied with sea water via the sea water lift pumps. The cooling medium temperature range shall be between 25°C and 34°C.

Control and safeguarding system

The control and safeguarding system to be implemented on the FPSO will comprise of a Process Control System (PCS) that provides for the monitoring of all process conditions and the application of corrective actions when necessary, an Emergency Shutdown (ESD) system to safeguard equipment against abnormal conditions, a Fire and Gas System (FGS) to prevent hazardous fire and gas situations, as well as the PA/GA system to alert personnel of potentially hazardous situations.

Evacuation, escape and rescue operations will be facilitated by ensuring that sufficient escape routes are provided on the FPSO and that these are adequately marked and sized to accommodate personnel wearing full fire fighting gear and/or transporting injured persons on stretchers. Facilities will be provided to rescue persons from the water and life rafts, buoys, lifejackets and other safety equipment such as portable fire extinguishers will be readily available.

4.6 Routine Emissions, Discharges and Waste Generation

This section identifies and discusses the main sources of air emissions, discharges to the sea and wastes generated and disposed of that will result from the proposed West Hub development project during production well drilling, installation (construction) of the SURF system and FPSO, and during production (operation of the SURF system and FPSO).

4.6.1 Air emissions

Air emissions will be generated by a number of sources during all phases of the project, and the main emissions to air will comprise:

- Exhaust emissions;
- Flaring; and
- Fugitive emissions / venting.

Each of these are discussed in more detail below:

Exhaust emissions

The most significant contribution to air emissions from the West Hub development project will be in the form of exhaust emissions from the main engines, electricity generators, boilers, turbines, etc. on the various vessels involved in the project, namely the Scarabeo-7 drilling unit and supply vessels, the various construction and supply vessels, as well as the Xikomba FPSO. Exhaust emissions comprises

mostly carbon dioxide (CO_2), nitrogen oxides (NO_X), sulphur dioxide (SO_2) and methane (CH_4), as well as much smaller volumes of carbon monoxide (CO), ozone (O_3), particulate matter (mostly soot) and unburned hydrocarbons from incomplete combustion.

Data on fuel consumption by the Scarabeo-7 for the years 2007 to 2009 (from Eni's environmental database) indicate that the drilling unit's mean daily fuel consumption is approximately 17 tons of diesel. Using emission factors from Eni's environmental database, the daily exhaust gas emissions from the engines and generators of the Scarabeo-7 are summarised in Table 4-9 below, along with the total emissions during the drilling programme, assuming a drilling duration of 1 121 days.

Table 4-9: Estimated exhaust gas emissions by the Scarabeo-7 during West Hub drilling.

Pollutant	Per day	Total drilling programme
CO_2	53.7 tons	60 198 tons
CH_4	2.9 kg	3.26 tons
NO_X	947.5 kg	1 062.2 tons
SO_2	274 kg	307.1 tons

Note this excludes exhaust gas emissions from the service/supply vessels, which is estimated to add another 26 182 tons of CO_2 to the emissions of the Scarabeo-7.

During installation of the SURF system and FPSO, most of the construction vessels will run on MGO, although some may use diesel. All construction vessels, with the exception of the supply vessel, will travel from European ports, and most of the vessels' exhaust emissions will therefore be as a result of transit consumption. The estimated fuel consumption for each vessel during transit to the West Hub development area, while dynamic positioning (i.e. while operating in the West Hub development area) and when on stand-by at port were calculated based on each vessel's known fuel consumption rates, the speed at which the vessels will be travelling and the anticipated number of days that each vessel will be active. The total fuel consumption of the construction vessels during transit to and operations at the West Hub development area is estimated at just under 19 000 tons (see Table 4-10**Table 4-10**).

Table 4-10: Construction vessels anticipated fuel consumption during installation of the SURF system and FPSO.

Vessels	Fuel consumptoin (t)			Total fuel consumption (t)
	Transit	Dynamic Positioning	Stand-by	
HLV-1	2 039	60	211	**2 310**
HLV-2	2 000	n/a	99	**2 099**
HLV-3	2 000	n/a	28	**2 028**
Cargo liner	948	n/a	40	**988**
Main Construction	2 813	1 575	342	**4 730**
Light Construction	508	1 249	84	**1 841**
Rigid Construction	2 908	346	170	**3 424**
Supply	604	630	107	**1 341**
Total	**13 820**	**3 860**	**1 081**	**18 761**

Using emission factors from Eni's environmental database, the estimated volumes of the key pollutants that will be emitted as exhaust gas during the installation of the SURF system and FPSO in the West Hub development area is summarised in Table 4-11 below (based on a total estimated fuel consumption of 19 000 tons).

Table 4-11: Estimated exhaust gas emissions by the construction vessels during installation of the SURF system and FPSO.

Pollutant	Estimated emissions
CO_2	59 994 tons
CH_4	3.25 tons
NO_X	1 059 tons
SO_2	317 tons

Exhaust emissions by the Xikomba FPSO will arise mainly from the onboard turbines and boilers located in the power generation unit as well as the main gas compressor, water and chemical injection pumps, etc. Both diesel, MGO and fuel gas (produced gas) will be used on the FPSO to power these various facilities. While the anticipated fuel consumption of the modified Xikomba FPSO during the proposed West Hub development is not known, historical emissions data from the FPSO's operations in the Xikomba oil field during the first half of 2011 are used in Table 4-12 below to calculate average monthly emissions and predict estimated total emissions during the planned 15-year lifespan (180 months) of the West Hub development.

Table 4-12: Estimated exhaust gas emissions by the FPSO during operation (production) in the West Hub oil fields.

Pollutant	Per month*	Total emissions (180 months)
CO_2	4 180 tons	752 400 tons
CO	3 083 tons	554 940 tons
CH_4	0.68 tons	112.4 tons
NO_X	9.94 tons	1 789 tons
SO_2	2 667 tons	480 060 tons

* Average monthly emissions from the Xikomba FPSO while operating in the Xikomba oil field during the first half of 2011.

It should be noted that the sources of the emissions discussed above will be spread out over time as well as spatially, meaning that the emissions at any one location will be significantly less than described above.

Flaring

Continuous flaring off the coast of Angola is not permitted, but small pilot flares will be in effect on the drilling rig during well drilling and on the FPSO, and intermittent flaring will take place as follows:

During well testing it may necessary to flare off any produced hydrocarbons (gas or oil). The flaring of oil and gas during production tests will release an estimated 10 570 tons of CO_2 into the atmosphere during the West Hub drilling programme;

During production (operation of the FPSO), intermittent routine flaring will take place during maintenance operations and excess gas (produced gas not used as fuel gas onboard or injected into the reservoirs via the WAG injection wells) from the oil separation and stabilisation unit, the produced water treatment unit, etc. will be flared. While the likely volumes of gas to be flared during the planned West Hub development was not known at the time of writing this report, emissions can be estimated based on historical emissions data for the Xikomba FPSO operating in the Xikomba oil field during the first half of 2006. As indicated in Table 4-13, the total carbon emissions from flaring on the FPSO during production in the West Hub oil fields is broadly estimated at 577 260 tons (consisting mostly of CO_2);

Flaring of hydrocarbons on the FPSO will also be required during production start-up, as well as during any unforeseen emergency conditions. Likely emission volumes are not known.

Table 4-13: Estimated emissions from flaring by the FPSO during operation (production) in the West Hub oil fields.

Pollutant	Per month*	Total emissions (180 months)
CO_2	3 186 tons	573 480 tons
CO	21 tons	3 780 tons
CH_4	57 tons	10 260 tons
NO_X	4 tons	720 tons
SO_2	0.04 tons	7.2 tons

* Average monthly emissions from the Xikomba FPSO while operating in the Xikomba oil field during the first half of 2011.

Fugitive emissions / venting

Additional atmospheric emissions generated by the proposed development of the West Hub oil fields will include fugitive emissions as a result of leaking pipes, valves, flanges, pumps, tanks, etc. on the drilling unit, supply and construction vessels and the FPSO.

During drilling, ventilation of the mud circulation system (pits and shakers), refuelling operations and well testing will also result in the release of fugitive emissions. In addition, any gas influx that may occur in the well bore during drilling will be cold vented into the atmosphere from a stack at the same elevation as the top of the drilling rig.

During production (operation of the FPSO), purging of the fuel gas flare, venting of the TEG regeneration package and plant compressor sealing system and operation of the inert gas and cargo tank venting system will result in the release of fugitive emissions into the atmosphere.

It is not possible to predict the volumes of pollutants (mostly hydrocarbons) that may be released as a result of fugitive emissions and venting.

Incinerator emissions

Small volumes of burnable waste, including used lubricating oil, etc., may also be incinerated on board the vessels during the West Hub development project. This will be done in accordance with MARPOL Annex VI and volumes involved will be small.

Total carbon emissions

The total anticipated carbon emissions (mostly CO_2) as a result of production well drilling, installation of the SURF system and FPSO and operation of the FPSO during the proposed development of the West Hub oil fields is broadly estimated at approximately 2 Mt (see Table 4-14). This estimate is based on a combination of anticipated fuel consumption values, historical emissions data from the (unmodified) Xikomba FPSO for the first half of 2011 and emission factors from various sources and, as such, can be considered a very indicative and probably conservative value only.

By comparison, Angola's total carbon emissions from fuel combustion for 2009 are estimated at 12.92 Mt (IEA, 2012), which is nearly 6.5 times the volume of carbon emissions expected from the entire West Hub development project.

Table 4-14: Estimated total carbon emissions.

Activity	Total carbon emissions
Well drilling (drilling unit exhaust emissions)	60 198 tons
Well drilling (supply vessels exhaust emissions)	28 182 tons
Installation (construction vessels exhaust emissions)	59 994 tons
Production (FPSO exhaust emissions)	1 307 340 tons
Production (FPSO gas flaring)	577 260 tons
TOTAL	2 032 974 tons

4.6.2 Noise emissions

During drilling operations, low frequency noise will be generated on the drilling rig by the operation of equipment such as the diesel engines, rotary table, winch, pumps and cementing unit. Noise levels on the drilling rig itself will be highest near the engines and cementing unit (typically around 105 dBA equivalent continuous sound level or L_{eq}), with lower levels on the derrick floor (typically around 94 dBA L_{eq}) and in the pump zone (typically around 86 dBA L_{eq}).

In addition, noise emissions during all phases of the proposed West Hub development will be generated by propellers and thrusters (shipping noise) and machinery noise from power generators, compressors, pumps, etc. Helicopter flights will also generate noise.

Eni will set a maximum (onboard) sound pressure level of 85 dBA for external work areas in contracts with contractors, with lower values set for offices, control rooms, living quarters, etc.

Underwater noise will be generated by the above activities, as well as by the underwater installation and operation of the SURF system equipment, such as flow lines and valves. Underwater noise generated by project activities will generally be of a low frequency with strongest tones at around 100 kHz (ERM, 2006).

4.6.3 Routine discharges to sea

Routine discharges to sea during normal operations in the West Hub development will include the release of drill cuttings and small volumes of cement and hydraulic fluid (during well drilling), sewage and grey water (from showers, etc.), produced water (during production) and miscellaneous discharges such as deck drainage, bilge water, ballast water, cooling water (sea water return), etc.

Drill cuttings

The disposal of drill cuttings into the sea is one of the key discharges during offshore well drilling operations. LTOBM drill cuttings will be dried in a cuttings drier prior to discharge, in compliance with Angolan legislation, which specifies a maximum of 5% associated organic material in cuttings discharged overboard. Cuttings consist of crushed rock and can range from clay to coarse gravel, depending on the types of sedimentary rock that are penetrated and crushing specifications of the drill bit. Cuttings are usually relatively inert, but may contain small amounts of trace metals, hydrocarbons and drilling mud components, which will be released into the sea (Neff, Rabalais and Boesch, 1987 referenced in CCA Environment, 2007).

The estimated volumes of the drill cuttings to be treated and discharged to sea in each of the four fields are summarised in Table 4-15 below. The total volume of cuttings to be discharged to the sea during well drilling operations in the West Hub development is estimated at 2 620 m^3 (4 735 tons).

Table 4-15: Estimated volumes of cuttings to be treated and discharged during West Hub drilling operations.

Wells	Cuttings volume (m^3)	Cuttings weight (ton)
Sangos LM26 (6 wells)	890	1610
Ngoma (3 wells)	525	945
Cinguvu (3 wells)	545	980
Sangos LM20 (4 wells)	660	1200
Total West Hub well drilling:	**2 620**	**4 735**

Sewage and grey water

Sewage and grey water (from toilets, washbasins, etc.) generated on all of the vessels involved in the West Hub development project will be treated in onboard purification systems prior to discharge, as per the requirements of MARPOL Annex IV. The treated effluent will be discharged into the sea when the vessel is seaward of the 12 nautical mile (nm) limit of the territorial waters. Inside territorial waters the sewage will be stored in onboard conservancy tanks and taken to shore for disposal.

It is estimated that approximately 14 400 litres per day of sewage and grey water will be treated and discharged from the drilling unit during the West Hub drilling operations (i.e. a total volume of approximately 17 438 kilolitres). Estimated volumes of treated sewage and grey water to be released by the supply and construction vessels, as well as the FPSO were not available at the time of writing this report. However, if it is assumed that one person generates approximately 320 litres of sewage and grey water every day, based on the FPSO's accommodation capacity of 80 personnel it can be estimated that FPSO operations will result in the release of 26 400 litres of treated sewage and grey water every day (i.e. a total volume of approximately 144 540 kilolitres over the 15-year lifespan of the project). Personnel numbers for the supply and construction vessels were not available at the time of writing this report, and similar estimates for sewage and grey water discharge volumes from these vessels were not possible.

Produced water

During production (operation of the FPSO), produced water will be generated in the oil separation and stabilisation unit where reservoir fluids will be separated into formation water, crude oil and produced gas. Produced water is typically very saline and contains particulates as well as oil. As described in Section 4.5.3 above, produced water will be treated in the produced water treatment system onboard the FPSO to ensure compliance with the relevant regulations (e.g. MARPOL) prior to discharge into the sea. Off-spec produced water will be sent to the slop tanks in the cargo tank area. The discharge of treated produced water will be a continuous discharge from the FPSO as long as oil production is ongoing. While the anticipated volume of treated produced water to be discharged from the FPSO is not known, the (unmodified) Xikomba FPSO has the capacity to discharge approximately 100 000 bbl of treated produced water a day (666 m^3/hr). The *maximum* volume of produced water to be discharged over the 15-year lifespan of the West Hub project is therefore anticipated to be about 550 million bbl, but the actual volume will be much less as produced water discharge volumes can be extremely variable over the lifetime of the project. Produced water volumes generally start small and reach a maximum when maximum oil production rate is reached, followed by a steady decline until the end of the oil field's life.

Cooling water and seawater return

During operation of the FPSO (production), continuous discharge into the sea of various cooling water and seawater return streams will take place. Seawater will be lifted into the FPSO and will be

continuously discharged back into the sea after use as cooling water in various units and systems on the FPSO. The discharged cooling water (seawater) will have temperatures ranging from 35 to 50°C.

The key continuous discharges listed above, as well as a number of less significant and/or intermittent discharges to sea anticipated during all phases of the West Hub development project are summarised in Table 4-16 below.

Table 4-16: Summary of discharges to sea.

Discharge stream	Sources	Continuous/intermittent/ once-off
Sewage and grey water	All vessels	Continuous
Drill cuttings	Drilling unit	Continuous
Cement	Drilling unit (seafloor)	Intermittent
Hydraulic fluid	Drilling unit (seafloor)	Intermittent
Completion and well workover fluids	Drilling unit	Once-off
Deck drainage and bilge water	Support and supply vessels, construction vessels	Continuous
Pre-commissioning and line flushing fluids	Construction vessels / FPSO	Once-off
Ballast water	Support and supply vessels, construction vessels	Intermittent
Produced water	FPSO	Continuous
Cooling water and seawater return	FPSO	Continuous

4.6.4 Solid and liquid waste disposal on land

Several types of solid and liquid wastes will be generated on board the drilling unit that will not be discharged to sea, but will be transported to shore for treatment and/or disposal at suitable facilities on land, using an appropriate Waste Contractor, and as per the MinPet-approved WMDDP, which Eni is required to have in place in terms of Angolan legislation.

A summary of the different types of wastes, sources and typical management/disposal methods is provided in

Table 4-17 below. Likely volumes of each waste type that will be generated during the operation.

Table 4-17: Types of wastes and management methods for land-based disposal.

Waste type	Management / disposal methods	Sources
Deck drainage: rainwater potentially contaminated with lubricants, grease, oil and detergents.	Most modern vessels are equipped with 'curbing' to isolate clean runoff from areas where runoff may contact these contaminants. Contaminated deck drainage is collected for storage on the drilling rig, and is periodically pumped into tanks on the supply vessels and taken to shore for treatment and disposal (i.e. there will be no discharge of deck drainage into the sea).	Drilling unit, FPSO
Vessel machinery space drainage: generally contains oils, grease and other potential contaminants.	Machinery spaces (machine room, pump zone and engine area located below the main deck) are also fitted with curbing and the drainage is collected and sent to the on board oil-water separation system. The water that is separated out is sent to the deck drainage collection tank described above, while the oil is stored in special drums on board the vessel until such time is can be taken to land for treatment and disposal.	Drilling unit, FPSO
Used drilling fluid (LTOBM)	Stored in a dedicated tank on the drilling rig and transported to shore for treatment (with a thermal desorption method) by the waste service company.	Drilling unit

Waste type	Management / disposal methods	Sources
General domestic waste: garbage such as waste paper, plastics, wood, glass, etc.	Collected on board, transported to shore and disposed of at a suitably licensed landfill facility, as per the London Convention.	All vessels
Scrap metal	Reused where possible, otherwise transported to shore and disposed of at a suitably licensed landfill facility.	All vessels
Empty drums and containers, which may contain contaminating residues.	Transported to shore and recycled where possible (steel containers), otherwise disposed of at a suitably licensed landfill facility, after rinsing and crushing/shredding. If rinsed onboard, rinse water must be disposed of according to MARPOL or transported to shore and disposed of as per the WMDDP.	All vessels
Used oil such as lubricating oil, gear oil, solvents, petroleum-based detergents, machine oil, etc.	Transported to shore in secured containers and recycled where possible (as fuel oil), otherwise incinerated, or solidified, stabilised and disposed of at a suitably licensed disposal facility.	All vessels
Hazardous and chemical wastes such as radioactive materials, toner cartridges, etc.	Disposal on a case-by-case basis and according to relevant legislation and/or appropriate regulatory authorities.	All vessels
Medical waste such as used bandages and needles and infectious wastes such as food wastes from persons with infectious diseases.	Transported to shore and disposed of at suitably licensed disposal facility.	All vessels
Filters and filter media: oily residue and media in oil filters may contain metal fragments	Transported to shore and disposed of at suitably licensed disposal facility.	All vessels

4.7 Decommissioning

At the end of the life span of the West Hub development (anticipated to be approximately 15 years) the wellheads and Christmas trees, SURF system, FPSO and associated facilities will be decommissioned and all subsea infrastructure (i.e. wellheads and pipelines) abandoned in accordance with international guidelines for abandonment of oil and gas facilities.

While a detailed decommissioning and abandonment programme cannot be compiled at this early stage, minimum requirements are already defined as follows:

- All the reservoirs will be sealed off with cement plugs and all permeable zones will be plugged individually to avoid any cross flow. Cement plugs shall be set with top and bottom at least 50 m above and below each zone. A cement plug at least 150 m long will be placed 50 m below the seabed;
- Process equipment on the FPSO will be cleaned out, purged and certified gas free;
- The FPSO mooring lines will be removed, but the anchors will be abandoned on the seafloor;
- The FPSO itself will be towed from site and will be refurbished for re-use, or decommissioned / dismantled;
- Subsea flowlines, risers and umbilicals will be flushed and abandoned on the seafloor, although some may be removed; and

- Subsea Christmas trees and associated equipment will be retrieved (but wellheads will be left on the seafloor).

5 Environmental Baseline

5.1 Introduction

This chapter provides a description of the marine (biophysical) environment that may be affected by Eni's proposed West Hub oilfield development operation.

This Environmental Baseline section provides an overview of the biophysical environment in the offshore (marine) region of northern Angola, with a focus on Block 15/06 and the proposed West Hub development area.

The study area for the purposes of this biophysical baseline description is defined by the Angolan Territorial Waters and the Exclusive Economic Zone up to 200 nautical miles (nm) offshore (as well as the High Seas where relevant) and the coastline in the region of the Congo River mouth, roughly between the latitudes of 5°S and 7°S.

5.2 Climate and weather

The climate of the study area is tropical, moderately warm and moist, with air temperatures varying between approximately 24°C in winter (July to August) and 32°C in summer (February to April). Annual rainfall is 350mm to 600mm and strongly seasonal: most rain falls between February and April, which correlates with the hottest months. Notably less rain falls in the cooler months of June to September. The wind regime in the study area is dominated by southerly winds that are generally low to moderate in strength (averaging 6–7 m/s) (see Figure 5-1). Winds are generally weak in the morning, strengthening and becoming more onshore in the late afternoon. Extreme wind conditions appear to be rare.

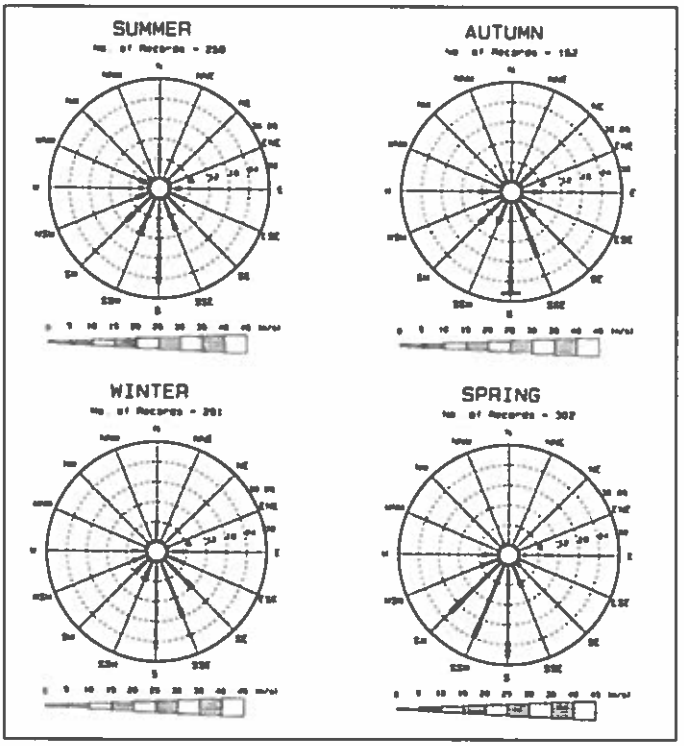

Figure 5-1: Seasonal wind roses for the study area.
Source: South African Data Centre for Oceanography VOS data

5.3 Physical Oceanography

5.3.1 Topography

The continental shelf in the region slopes at about 35m/km in the 200m to 500m depth range and flattens out to a slope of about 13m/km in deeper water. Water depths in the proposed West Hub development area range from approximately 1 000m to 1 450m.

The major bathymetric feature of the larger study area is the Congo canyon, which is a narrow, deep trench across the continental shelf aligned with the Congo River. The canyon is eroded to 100m deep as far upstream as Malela in the lower reaches of the Congo River. At the mouth of the river the canyon is 425m deep and reaches a depth of 1 500m at the shelf edge (Eisma and van Bennekom, 1978). The canyon allows significant across shelf penetration of oceanic water at subsurface depths and is thus a major role player in the near shore oceanography of the region.

Apart from the major feature of the Congo canyon, the seafloor in the region slopes gently out to the 100m depth isobath about 53 km offshore and the 200m isobath (commonly accepted as the outer edge of the continental shelf) about 90 km offshore. On the shelf the isobaths are generally parallel to the coast (i.e. northwest to southeast).

The bathymetry of the proposed West Hub development area (~130km offshore) shows several ridge type features with relatively steep topography to the west of each feature. One of these features is located in the Sangos field and had to be avoided by the proposed layout of the relevant production and gas lift lines (refer to Figure 1-2).

Cold water coral reefs are known to occur in the greater study area and are apparently associated with hydrocarbon seeps and faults. These reefs can reach heights of 30m above the seafloor and are formed by the scleractinian (stony corals) reef building corals *Lophelia pertusa* and *Madrepora oculata*. Video records taken by remotely operated underwater vehicles in the Canuku oil field in Block 3 (to the southwest of Block 15/06) showed low relief sand stone reef systems (Figure 5-2). It is possible that similar features occur in the vicinity of the West Hub development area, although no evidence of this was found during the sediment and benthos sampling field survey (Lwandle, 2011).

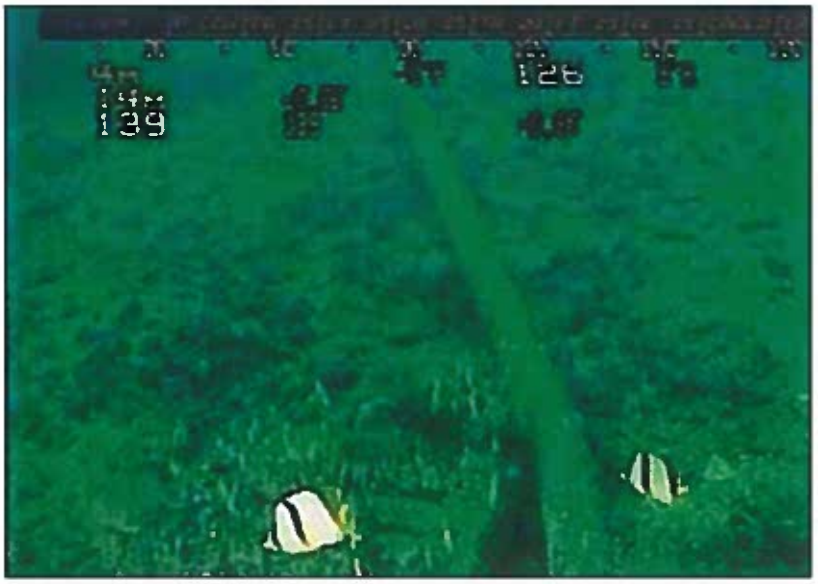

Figure 5-2: Low relief rock reef with flowline in the Canuku oil field in offshore Block 3, Angola. *Photographed by Oceaneering in 2009.*

5.3.2 Sediments

The texture and particle size distribution, as well as trace metal and organic content of seafloor sediments in the proposed West Hub development area were sampled during the field survey conducted Lwandle. The information presented below was taken from the field survey report (Lwandle, 2011).

Sediments in the survey area were found to range from sand to sandy mud texture. The coarser sediments were mainly concentrated in the centre of the survey (sampling) area and extended to the west and northwest. Sediments at the proposed FPSO mooring location were mainly clay (see Figure 5-3).

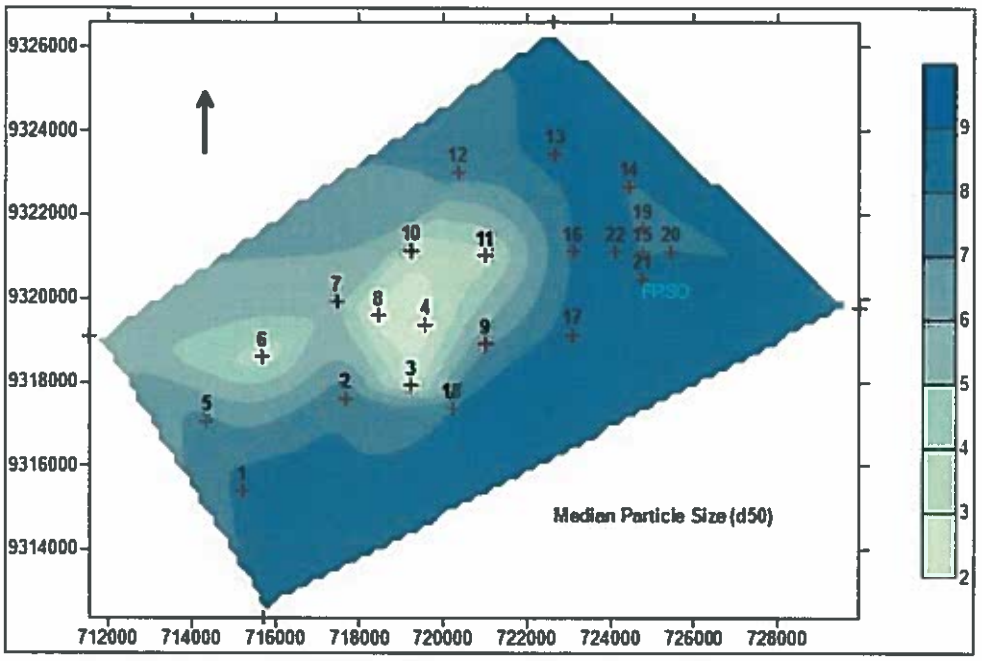

Figure 5-3: Distribution of sediment median particle size (phi, d50) in the survey area, showing sampling sites and the proposed FPSO mooring location.
source: Lwandle, 2011

The presence of fine sand in the survey area is considered anomalous as previous studies in the region found that sediments comprise mostly clay (e.g. ERM, 2005). The sources of this coarser sediments in the survey area is unclear, as sea floor wave effects and currents at water depths in Block 15/06 are too low to present a natural mechanism for delivering fine sands to the site. Sediments with highest median particle size were found to be located at the western edge of the ridge feature described in Section **Error! Reference source not found.** above, which partially account for the variability in sediment texture.

Apart from this anomaly, all other sediment properties, including carbon and carbon/nitrogen ratios were found to be within the expected ranges for the region. The silts and clays in the survey area appear to have a terrigenous source (due to its high aluminium content) and most likely originates from the Congo River outflow (Mariotti *et al.*, 1991). However the source of the organic carbon in the sediments appears to be largely from marine phytoplankton (Rabouille *et al.*, 2009) and not from terrestrial organic detritus derived from land plants that would also be supplied to the area by the Congo River outflow.

Trace metal distribution showed minimum concentrations of aluminium, barium, copper, nickel and lead in the centre of the survey area, while iron, chromium and zinc were found to have maximum concentrations in the same location. The distributions of arsenic, cobalt and vanadium were found to be more diffuse with less clear patterns of minimum and maximum concentrations. Trace metals had markedly higher concentrations during strong acid extraction in the laboratory than during weak extraction, which indicates that the trace metals tested for are not readily bioavailable and are unlikely to be released in large concentrations through agitation or physical disturbance of the sediments. In addition, comparisons between the measured trace metal concentrations and sediment quality guidelines for the region (BCLME, 2006) implied that the more readily bioavailable trace metals in the survey area do not present any toxicity risk to benthic or other organisms in the area.

Concentrations of organic compounds such as all hydrocarbons, including Polycyclic Aromatic Hydrocarbons (PAHs), and Polychlorinated Biphenyls (PCBs) in the sediments tested were below the detection limits of the analytical procedures followed. This is consistent with the mostly low total hydrocarbon concentrations that have been recorded elsewhere in the region (ERM, 2005), which also indicated that background concentrations are less than 16 mg/kg. Pollution effects and pollution risks from these compounds in sediments in the survey area therefore appear highly unlikely.

5.3.3 Circulation and Currents

The dominant circulation feature of the continental shelf in the vicinity of the study area is the South Equatorial Counter Current, which feeds into the warm, south-flowing Angola Current (Figure 5-4). The Angola Current is fast-flowing (with typical velocities of 25 to 50cm/s), stable and penetrates to 250–300m depth covering the continental shelf and slope. It is therefore best developed inshore but also to the south of the proposed West Hub development area.

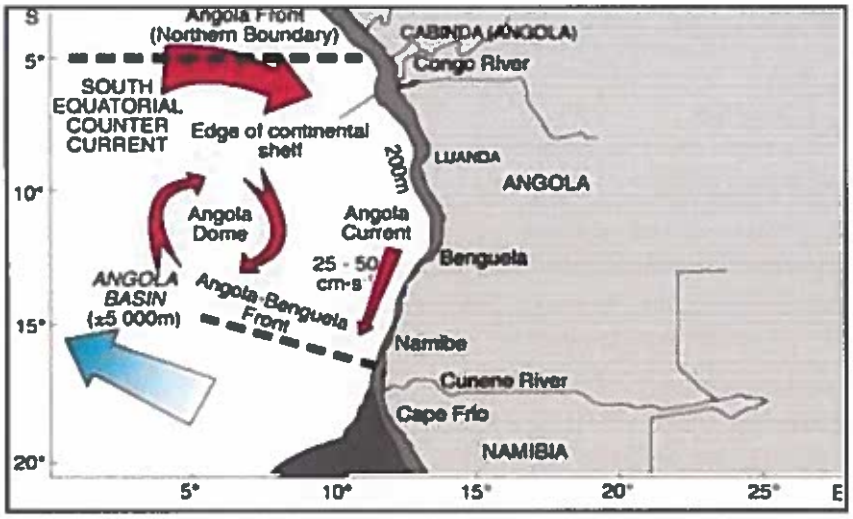

Figure 5-4: The main hydrographic features of the Benguela Current system

Source: N Sweijd, BCLME

Surface drifting buoy trajectories for the south-eastern Atlantic Ocean show south, north and westward flow on the Angolan continental shelf, although data for the area is sparse. Direct current measurements show that maximum current velocities are generally highest at the surface and decline with depth to speeds of 20 cm/s (Figure 5-5) and lower (Shannon and O'Toole, 1998 and Van Griesheim *et al.*, 2005).

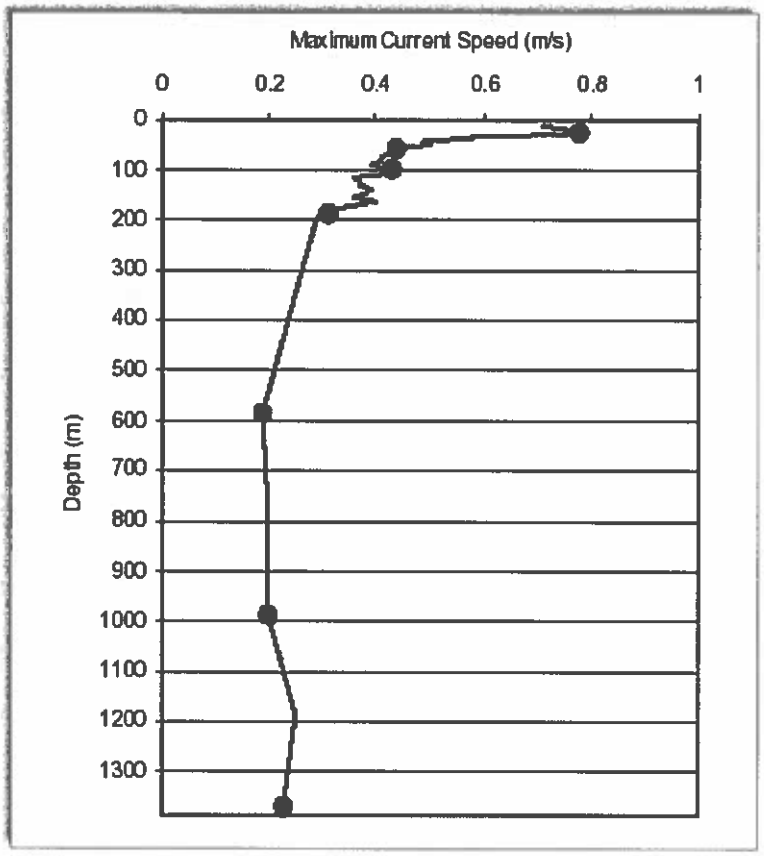

Figure 5-5: Vertical profile of maximum current velocity from ADCP measurements in offshore Block 18.
source: ERM, 2005

5.3.4 Water Column Properties

Water column properties – vertical profiles of temperature, salinity (conductivity), dissolved oxygen, turbidity, pH and chlorophyll fluorescence up to 200m depth, as well as levels of nutrients, trace metals, hydrocarbons and PCBs – were measured during the field survey referred to above and the information presented below was taken from the field survey report (Lwandle, 2011).

The salinity and turbidity vertical profiles indicate the presence of fresher, more turbid water at the surface, which is also confirmed in the temperature/salinity plot compiled for the survey area (Figure 5-6). Temperature, dissolved oxygen and chlorophyll fluorescence profiles showed variability in the upper water column (~100m water depth), indicative of thermocline depth and short-term variations therein, as well as in the upper mixed layer. The warm, low salinity, turbid water at the surface is probably derived from the Congo River outflow.

The results of the water column measurements in the surveyed area are consistent with other measurements in the region (e.g. ERM 2005, Hill et al. 1998, Shannon and O'Toole 1998), with the main features being the variability above 100m depth, presence of fresher, warm water (probably from the Congo River outflow), low turbidities throughout (despite the probable presence of Congo River outflow water) and a well-developed subsurface chlorophyll maximum.

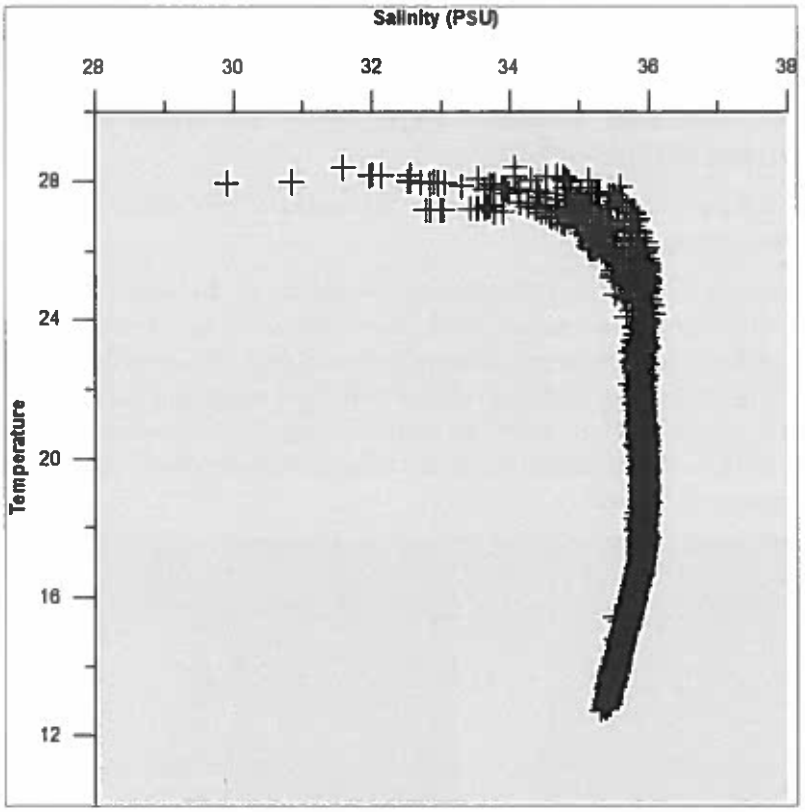

Figure 5-6: Temperature/salinity plot for the surveyed area.
source: Lwandle, 2011

Inorganic nutrient levels, total nitrogen and dissolved organic carbon concentrations in the water column in the surveyed area were found to be low. Only nitrate and nitrite nitrogen were measured at moderate concentrations and displayed vertical concentration gradients. High nitrate nitrogen concentrations are typical of the Benguela Current Large Marine Ecosystem (BCLME) region (Chapman and Shannon 1985).

Trace metal concentrations were low as is expected for this open ocean environment, with median trace metal concentrations generally within the recommended water quality guidelines for the region. However, copper and arsenic were measured at concentrations above the detection limits in some of the samples, with arsenic increases correlating positively with iron. Iron is imported into the area through the outflow of the Congo (e.g. van Bennekom et al. 1978) and other rivers, and it is possible that arsenic also enters the marine environment in this way.

Hydrocarbons and PCB measurements in the upper water column were at or below the detection limits of the analytical procedures used, but water quality guidelines for PAH compounds for the region (BCLME 2006) may be lower than the detection limits so the data are insufficient to identify whether there is a toxicity risk from these compounds or not. Given the distance of the survey site from industrial developments or discharges it is considered to be probable that, even if present, concentrations of these compounds would be very low.

5.4 Biological Oceanography

5.4.1 Plankton

Plankton range from single-celled bacteria to large jellyfish, and include bacterio-plankton, phytoplankton, zooplankton and ichthyoplankton.

Phytoplankton distributions off the Angolan coast are variable, and mainly associated with discontinuous upwelling processes.

Examples of phytoplankton biomass (as chlorophyll a) distributions for the region are shown in the four satellite images in Figure 5-7. The images (composite images over 3 days) provide no information to suggest seasonal patterns, but provide an indication of the variability. This extends from the almost complete absence of any phytoplankton biomass in the region in the March and December images, to fairly well developed distributions in June, to extensive high concentrations in September. Phytoplankton is low in the oceanic areas but increases closer to the Congo River plume and adjacent to the coast in most months of the year.

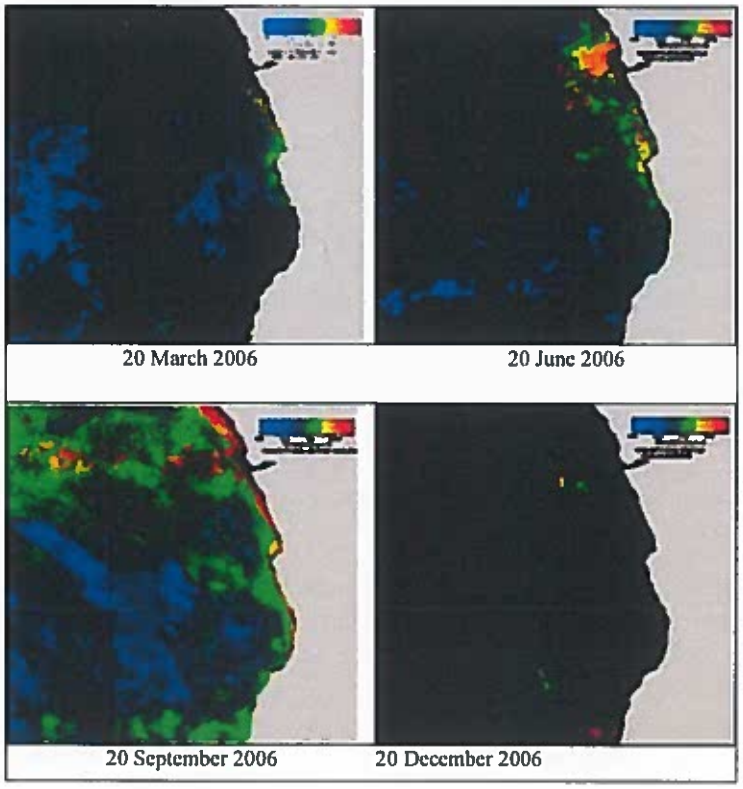

Figure 5-7: MODIS satellite images showing the presence of chlorophyll a, an indicator of phytoplankton biomass off Angola on different days in 2006.
Note: colours indicate a range from blue being the lowest to red the highest.

Source: http://www.rsmarinesa.org.za

There are few taxonomic studies on phytoplankton but Silva (1955, cited in Shannon and Pillar, 1986) recorded mostly diatom species in the region with few dinoflaggelates. In this the flora was similar to neritic waters south of the Angola-Benguela Front.

The zooplankton of the region is not well known but data obtained for the Angola-Benguela Front area to the south shows that species in and immediately north of the front, i.e. in the southern part of the Angola Current, appear to be similar to those of the northern Benguela Current, with calanoid copepoda (*Calanoides* and *Calanus* sp.) dominant.

Ichthyoplankton distributions (eggs and larvae of fish) are also poorly known in Angolan waters but sardine *Sardinops sagax*, sardinella *Sardinella aurita*, anchovy *Engraulis encrasicolus*, horse mackerel *Trachurus trachurus capensis* and hake *Merluccius* sp. eggs and larvae occur in the area of the Angola-Benguela Front in addition to mesopelagic species. Sardinella (*S. aurita* and *S. eba* (= *maderensis*)) juveniles and immatures may be widely distributed on the Angolan continental shelf (Wysokinski, 1986) and it is probable that these species will be important components of the ichthyoplankton in the region along with Cunene horse mackerel *Trachurus trecae*.

5.4.2 Benthic Fauna

Benthos samples were also collected during the field survey referred to above. The information presented below was taken from the field survey report (Lwandle, 2011).

Only 68 specimens from 27 taxa were collected in the 16 samples taken from the survey area, with a mean abundance per sampling station of a low 4.25 individuals. Polychaetes were by far the most abundant, followed by echinoderms, amphipods and molluscs (Figure 5-8).

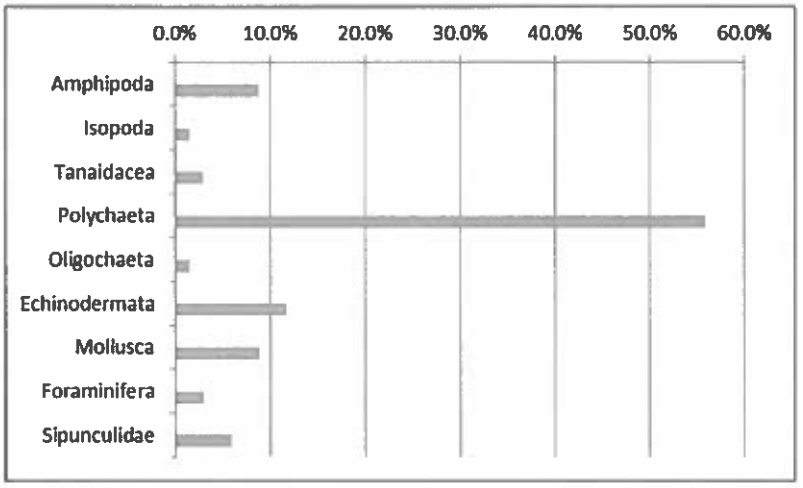

Figure 5-8: Proportional abundances of major taxonomic benthos groups in the survey area.
source: Lwandle, 2011

The benthos community in the surveyed area appears to be impoverished in terms of abundances of organisms and overall species diversity. In contrast, the benthos recorded elsewhere in the region (e.g. Block 18) was much more abundant (38 to 164 individuals/sample) and more diverse (19-67 species/sample), with polychaetes also the dominant group. The reasons for this apparent impoverished benthos in the surveyed area are not known.

Several deep-sea benthic macrofauna collection surveys have been undertaken offshore of Angola (as well as Gabon and Equatorial Guinea), commissioned primarily by oil companies. One hundred and forty-one benthos taxa have been listed, however, only 25% of these have been identified to species level and 46% to genus level. The remaining 29% have not been identified further than family and, in some cases, order or even phylum level. This is attributed to the fact that West African benthic fauna are poorly known.

Distribution data for the fauna that have been identified to species level indicate that these have wide distributions; typically also occurring in the North Atlantic or on the continental shelf of South America. Some species have wider distributions extending to Mozambique and China in the Indo-Pacific region. Thus the small component of the fauna identified to species level does not indicate a unique Angola/tropical West Africa faunal assemblage. However, this does not prove that there is no such assemblage as about 75% of the taxa are not classified to the required level.

5.4.3 Fish

The important groups of fish that occur in the area are those that support the industrial, semi-industrial, and artisanal (subsistence) fisheries. These are divided into pelagic and demersal fish, and crustaceans (shrimps (prawns) and crabs) as indicated in Table 5-1.

Table 5-1: Species and species groups of fish important for Angolan continental shelf fisheries.

Pelagic species/species groups	
Clupeids	*Sardinella aurita, S. maderensis*
Carangids	*Trachurus trecae, T. Trachurus capensis* (rarely)
Big eye grunt	*Brachydeuterus auritus*
Hairtails	*Trichiurus sp*
Barracudas	*Sphyraena sp*
Scombrids	Skipjack tuna, Albacore, Yellow fin tuna, Big eye tuna, Sword fish
Demersal species/species groups	
Sparidae	*Dentex Spp, Pagellus spp*
Croakers	*Sciaenidae:Pseudolithus spp*
Grunts	*Haemulidae: Pomadasys spp*
Groupers	*Epinephelus Spp*
Hakes	*Merluccius polli*
Invertebrates	
Deep sea rose shrimp	*Parapenaeus longirostris*
Striped red shrimp	*Aristeus varidens*
Red crab	*Chaceon maritae*

Source: INIP, 2007 and FAO, 1999

Distributions of these species groups on the northern Angolan continental shelf are illustrated in Figure 5-9 to Figure 5-12 in relation to offshore Block 15 and the proposed West Hub development area (fish plots provided by Capricorn Fishing).

These show that Block 15/06 in general and the proposed development area specifically are well offshore of the (mainly inshore) ranges of sardinella and horse mackerel, as well as the the mid to outer continental shelf ranges of the major demersal fishery species (seabreams and hake) and deep sea shrimp.

Block 15/06 lies within the offshore range of the large pelagic fish species (Figure 5-12) but most of the fishing effort in the block itself is located in its eastern part and mostly inshore of the proposed development area. The large pelagic species important in the area are yellowfin tuna (*Thunnus albacares*), skipjack (*Katsuwonus pelamis*) and albacore (*T. alalunga*) (INIP, 2006). These species migrate through the region between spawning and feeding grounds being most common in early summer. All of the tunas have wide distributions (Shannon *et al.* in Payne and Crawford, 1989).

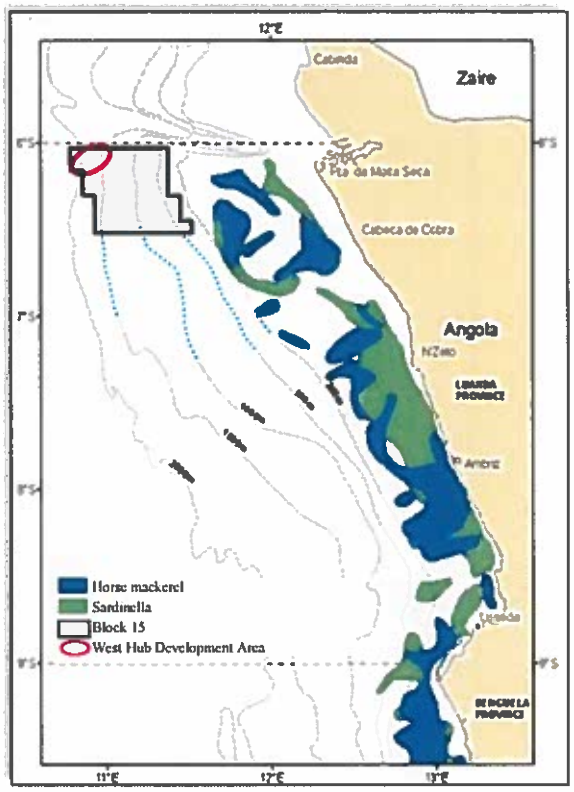

Figure 5-9: Distribution of (small pelagic) sardinellas and horse mackerel in relation to Block 15 and the proposed development area.

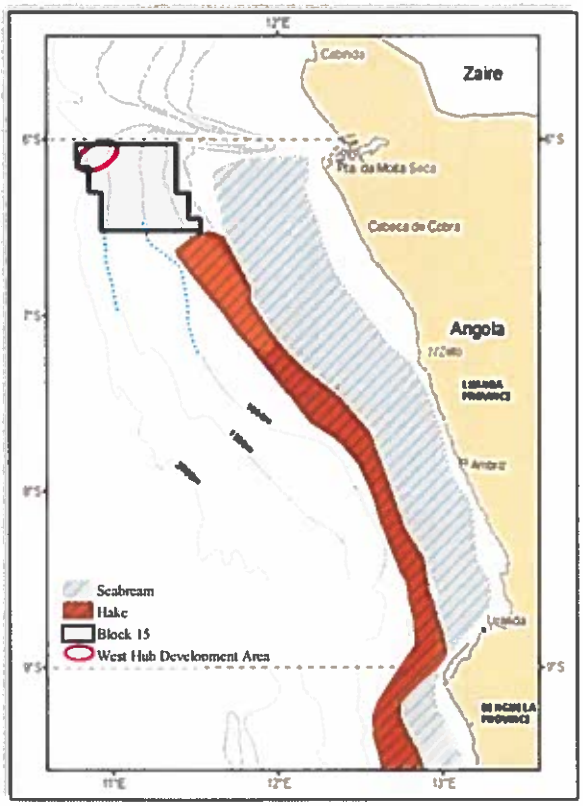

Figure 5-10: Distribution of demersal seabreams (mainly Dentex) and Benguela hake in relation to Block 15 and the proposed development area.

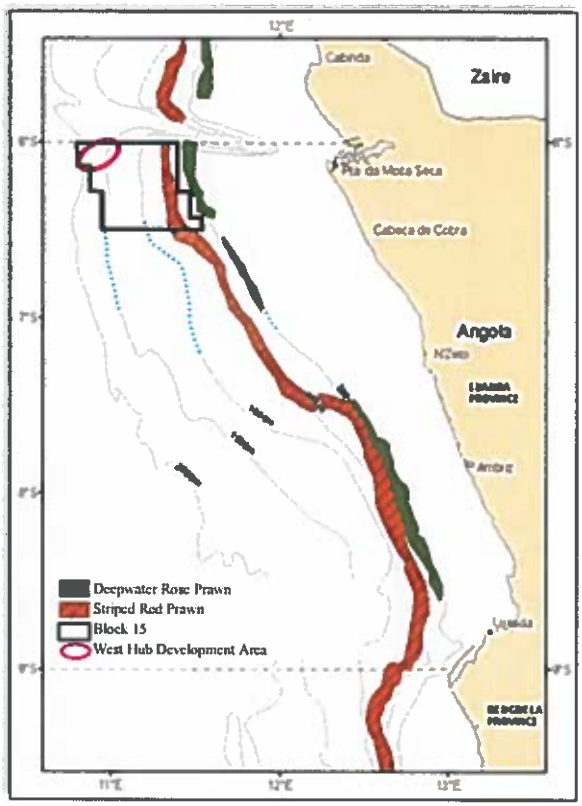

Figure 5-11: Distribution of deep sea shrimp in relation to Block 15 and the proposed development area.

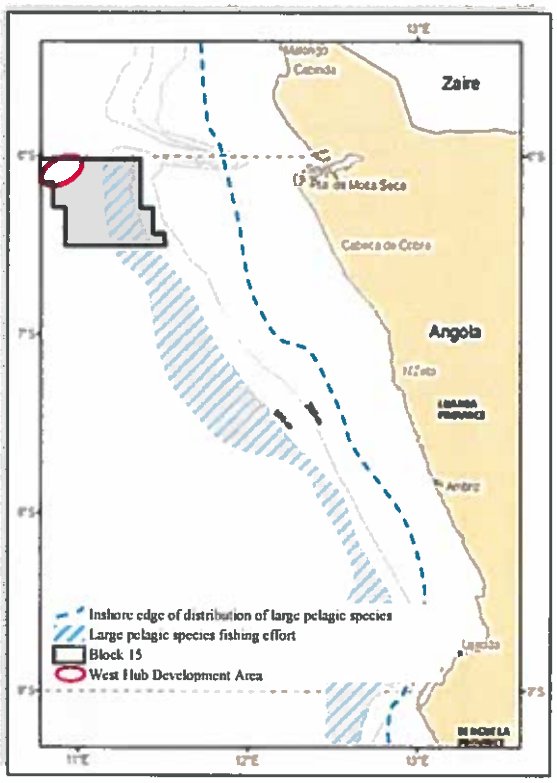

Figure 5-12: Distribution of large pelagic species and directed fishing effort in relation to Block 15 and the proposed development area.

Other species that occur in the deeper areas of the continental slope include squid, shrimp, crab and cardinals (*Synagrops microlepis*). Further to these Le Guilloux *et al.* (2009) observed the following fish taxa, both in association with cold water coral reefs and on the immediately adjacent seafloor off Angola:

- Zoarcidae;
- Macrouridae (*Malacocephalus* sp.);
- Anguilliforme;
- Synaphobranchidae;
- Scorpaenidae (*Helicolenus dactylopterus*);
- Chaunacidae (*Chaunax pictus*);
- Ogcocephalidae (*Halieutaea* sp.);
- Lophiidae (*Lophiodes* sp.);
- Trachichthyidae (*Gephyroberyx darwinis*);
- Moridae (*Laemonema laureysi*);
- Zeidae (*Zenopsis conchifera*);Soleidae;
- Rajidae (*Raja* sp.); and
- Torpedinidae (*Torpedo* sp.).

Eelpout and Ophiuroid on seafloor at depth.

5.4.4 Birds

The CSIR (2003) compiled an 'expected occurrence' bird list for the Angolan coast and continental shelf areas, identifying 22 species that may be found in the area. Actual counts that have been made in the area over the recent past have revealed the presence of 27 species (Table 5-2). Some of the species were abundant in the area, e.g. Cape gannet and Cape and Great winged petrel, with Brown skua and Storm petrel being common. All of the species listed in Table 5-2 have wide distributions in the Benguela Current system.

Table 5-2: Seabirds observed in the study area during fishery research cruises.

Family	Species	English name	Number
Diomedeidae	*Thalassarche melanophris*	Black-browed Albatross	2
Diomedeidae	*Thalassarche chlororhynchos*	Atlantic yellow-nosed Albatross	127
Diomedeidae	*Thalassarche chrysostoma*	Grey-headed Albatross	1
Diomedeidae	Procellariidae	Shearwaters and Petrels	5
Diomedeidae	*Daption capense*	Cape Petrel	1 396
Diomedeidae	*Puffinus puffinus*	Manx Shearwater	1
Diomedeidae	*Puffinus gravis*	Great Shearwater	10
Diomedeidae	*Puffinus griseus*	Sooty Shearwater	3
Diomedeidae	*Procellaria aequinoctialis*	White-chinned Petrel	1
Diomedeidae	*Pterodroma mollis*	Great-winged Petrel	1 567
Diomedeidae	Hydrobatidae	Storm-Petrels	648
Diomedeidae	*Oceanites oceanicus*	Wilson´s Storm-Petrel	26
Sulidae	*Morus capensis*	Cape Gannet	5 106
Phalacrocoracidae	*Phalacrocorax capensis*	Cape Cormorant	2
Phalacrocoracidae	*Phalacrocorax carbo*	White-breasted Cormorant	1
Stercoraridae	*Stercorarius sp*	Skuas	1
Stercoraridae	*Stercorarius pomarinus*	Pomarine Jaeger	36
Stercoraridae	*Stercorarius parasiticus*	Parasitic Jaeger	1

Family	Species	English name	Number
Stercoraridae	*Catharacta antarctica*	Brown Skua	400
Laridae	*Larus cirrocephalus*	Grey-headed Gull	110
Laridae	*Larus sabini*	Sabine's Gull	1
Laridae	Sternidae	Terns	3
Laridae	*Sterna hirundo*	Common Tern	194
Laridae	*Sterna maxima*	Royal Tern	2
Laridae	*Sterna sandvicensis*	Sandwich Tern	8
Laridae**	*Chlidonias niger*	Black Tern	5
Laridae**	*Larus dominicanus vetula*	Kelp Gull	62

(data from INIP 2006).

5.4.5 Whales and Dolphins

Whales and dolphins are abundant off the Angolan coast with 11 dolphin and 14 whale species confirmed to be present in the region. Of these, four whales are classified as threatened under the IUCN criteria (IUCN, 2011): Sei, Blue and Fin whales are considered to be Endangered, whilst Sperm whales are classed as Vulnerable. Of the dolphins, only Atlantic humpback is classified as Vulnerable.

The majority of whales and dolphins occur in the deeper water off the coast with some also frequenting the near-shore. Whales seen in the deeper water include Sperm, Dwarf sperm, Fin, Cuvier's beaked, Killer, False killer, and Melon-headed (www.ketosecology.co.uk). Whales that are likely to be seen in shallow water areas as well as deeper water include: Bryde's, Killer and Short-finned pilot whales (Best, 2007).

Humpback whales are seasonal: they migrate into the region for calving in July–October and are often accompanied by calves during September–October, but they are generally more common on the shelf break (~200m depth, Best, 2007), well inshore of the proposed development area. Sperm whales occupy the area throughout the year but are more common during calving in deep water (>850m depth) in January–May (www.ketosecology.co.uk). Best (2007) indicates that males may be found over the continental slope (200–500m deep) but that females are rarely found in water <1 000m deep. Southern right whales (*Eubalaena australis*) may also occur as this species (as well as Bryde's and Humpback) were landed by pirate whalers in the 1970s (Best, 2007). Similar to Humpback, Southern right whales are more likely to occur in shallower water, inshore of the proposed development area.

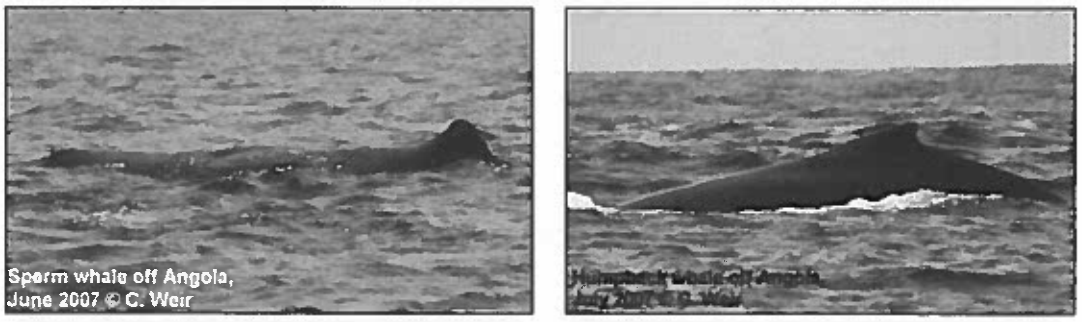

Figure 5-13: Sperm whale (left) and Humpback whale (right) photographed off Angola in 2007.

Source: www.ketosecology.co.uk

5.4.6 Turtles

Five turtle species have been recorded in Angolan coastal waters, namely Leatherback (*Dermochelys coriacea*), the Olive ridley (*Lepidochelys olivacea*), Green (*Chelonia mydas*), Loggerhead (*Caretta caretta*) and Hawksbill (*Eretmochelys imbricate*) (Carr & Carr, 1991 and Weir *et al.*, 2007). Of these,

only the Green, Olive ridley and Leatherback turtles are confirmed to breed in Angola (Carr & Carr, 1991 and Fretey, 2001).

Olive ridley is the most wide-spread and regularly encountered of all the turtle species in Angola (Weir *et al.*, 2007). It is confirmed to nest along the entire coast from Cabinda in the north to the Kunene River in the south (Hughes, 1982), and high nesting densities (reaching 30 crawls on a 500m stretch of beach) have been recorded in the past (Hughes *et al.*, 1973). Leatherback turtles nest primarily in the northern and central regions of Angola (Fretey, 2001), but have also been reported to nest from Cabinda southwards to Baia Farta (Hughes *et al.*, 1973, Carr & Carr, 1991). Weir *et al.* (2007) recorded an average of 122.7 Olive ridley nests and 13.3 Leatherback nests per breeding season at Palmeirinhas (a protected site south of Luanda). However, both Carr & Carr (1991) and Weir *et al.* (2007) note that the latter species may be part of a larger population that nests mainly in southern Gabon.

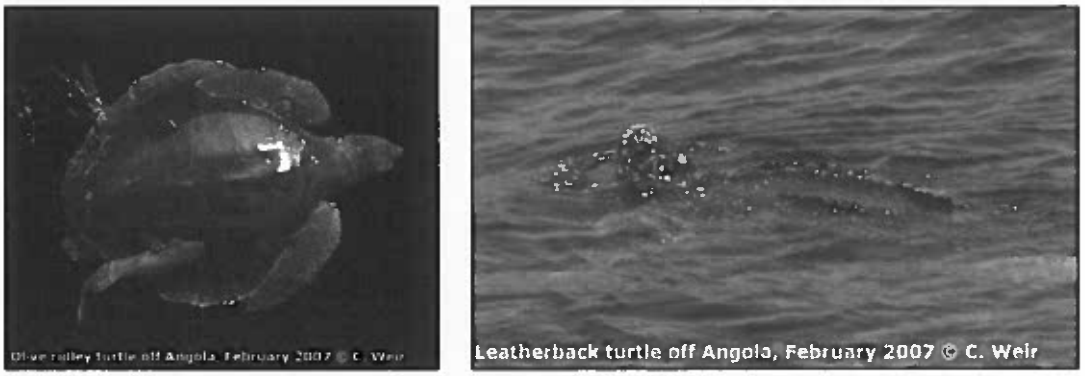

Figure 5-14: Olive ridley (left) and Leatherback (right) turtles photographed off Angola in 2007.

Source: www.ketosecology.co.uk

Of 82 offshore sighting records where the species could be identified 79% were Olive ridley and 15% Leatherback with the balance being Loggerhead (5%) and Green (1%) turtles. The latter species is locally common off the Kunene River mouth (Dr R Carter, personal communication) and nest on Namibe Province beaches (Weir et al., 2007), with juveniles apparently foraging in Mussulo Bay, adjacent to Luanda (Carr & Carr, 1991; ERM, 2005 and Weir et al., 2007). Loggerheads appear to be rare in the region and Weir et al. (2007) did not record any nesting activity by this species, but it appears that unpublished data exist about limited nesting activity on the northern Angolan coast. Hawksbills are similarly rare and recently have only been observed at sea (Weir et al., 2007).

All of the turtle species are widely distributed in the south eastern Atlantic and nest at least from Gabon in the north to Angola in the south. Figure 5-15 shows the known turtle nesting sites along the coastline of northern Angola.

Figure 5-15: Google Earth image showing the locations of known turtle nesting areas on the northern Angola coast.
Compiled from Fretey (2001) and Weir et al. (2007)

Turtle nesting appears to be linked to the commencement of the rainy season. The bulk of activity occurs in the period October to February, although this may extend to March (Carr & Carr, 1991 and Weir *et al.*, 2007). Hatching would thus commence at the middle of this period and extend into May. Weir *et al.* (2007) report that adult turtles appear to aggregate approximately 100km offshore in the weeks immediately prior to the egg laying period and have observed Olive ridleys mating at sea during September.

All of the turtle species that occur in the region are classified as Endangered or Critically Endangered (IUCN, 2011). All of the populations face various threats including direct and indirect effects of fishing, hunting, egg collection, predation (by jackals, genets, birds, dogs and pigs) and nest flooding and collapse. In areas where there are high levels of human habitation, e.g. beaches adjacent to Luanda and Benguela, it is thought that there may be 100% nest mortality as well as a high level of hunting of mature females (Weir *et al.*, 2007). Recent research has recorded alarming levels of mortality in various fishing operations, as large numbers are taken as bycatch in pelagic longline fisheries. In Angola, sea turtles are not only caught by industrial longliners but also by coastal artisanal fisheries (e.g. in gill nets, beach seines and longlines). Most of the captured sea turtles are used for consumption and a small percentage are used commercially (carapaces and oil). No bycatch data exit for the Angolan fisheries and the level of bycatch can thus not be quantified, but it is clear that turtle bycatch is widespread in coastal fishing communities. All of the populations therefore merit especial attention in terms of conservation and reduction of anthropogenic disturbances.

5.5 Offshore Ecosystem Services

Other than the exploitation of oil and gas reserves in the offshore region off Angola, the ecosystem services presented by and utilised in the marine area in the vicinity of Block 15/06 are those related to the fishing industry and marine transport (shipping and navigation) activities.

5.5.1 Fishing Industry

The national fishing industry supports up to half the nation's population in terms of food, income and employment and, together with agriculture, accounts for about 20% of annual Gross Domestic Product (GDP).

Fisheries in the region can be divided into artisanal fisheries, which are conducted generally within six nautical miles (nm) of the coast using small vessels launched from the shore, and industrial-level fisheries using larger vessels.

Each of the relevant fisheries is briefly discussed below, although, as indicated by the fish distribution plots presented in Figure 5-9 to Figure 5-12 there is unlikely to be any interaction between the proposed West Hub development activities and fishing activities, which are mostly located well inshore and south of the proposed development area.

5.5.2 Artisanal Fishing

Artisanal fishing is recognized by the Government of Angola as an important livelihood and source of protein for coastal communities. The fishery is monitored and supported by the *Instituto de Desenvolvimento da Pesca Artesanal* (IPA), part of the Ministry of Fisheries, in Luanda. The IPA collects statistics on the (national) fishery and addresses identified problems such as the provision of fish landing and processing facilities, training etc. The vessels used in the fishery are registered and landings monitored and reported to IPA.

Artisanal fishing in Angola is typically done with boats varying from small rowing and sailing craft (*canoas* and *chatas*) to inboard diesel-powered vessels 7–10m in length (*catrongas*) (see Figure 5-16).

Figure 5-16: Boats used by artisanal fishermen in Soyo.

Artisanal fishermen use a range of fishing gear including beach seine nets (*banda banda*), seine nets modified to catch demersal fish (*rapa*), gill nets, and hook and line. Species targeted are those accessible to the fishery, mainly occurring in nearshore waters (within 6 nautical miles of the coast) due to the size of the craft used and a general lack of motorized vessels. Fishermen typically stay at sea for 8-15 days at a time. Launching and landing sites are sparsely located along the coast as beach access in most parts is restricted by cliffs and other physical barriers. In 2006, the total catch of artisanal fishermen in Zaire province represented 8% of the country's total catch from non-commercial sources and the main species caught were catfish (*bagre*), African threadfin (*barbudo*), burro, Black

Croaker (*corvina preta*), croaker, menhaden (*savelha*), and shark (*tubarao*), all using gill nets (IPA, 2007).

Zaire and Bengo Provinces have relatively low effort in terms of licences, boats, fishermen and revenue/fisher compared with the adjacent provinces of Cabinda and Luanda (IPA, 2007). Part of the reason for this may be distance to the major fish market of Luanda and therefore having to sell salted, dried or otherwise preserved as opposed to fresh fish.

A survey of the artisanal fishing communities revealed that between 50-100% of households in the fishing settlements along the coast were involved in the artisanal fishing industry, with half comprising women and children who dry and sell the fish in the area (Duarte *et al.*, 2006). Due to lack of infrastructure for processing and preserving the fish (canning, refrigeration), vendors are under great pressure to make rapid sales – often compromising their economic power. Relatively low catches and poor infrastructural support conspire to keep artisanal fishermen working every day simply in order to sustain themselves and their families. As most of the effort is focused in shallow, nearshore waters, much of the catch consists of immature fish which use these areas as nursery grounds. This affects recruitment to breeding populations and is probably unsustainable over any appreciable length of time (decades).

5.5.3 Industrial Fishing

Aside from artisanal fishing in the nearshore region, the waters near Block 15/06 are also utilised by industrial fisheries. Industrial fisheries include demersal trawl, small pelagic (purse seine), pelagic/midwater trawl, large pelagic pole and line and prawn trawling.

Reliable fisheries data for Angola are lacking although recent reviews have provided some information on rightsholders and domestically registered fishing operations (BCLME, 2006). In the various fishing sectors approximately 38 vessels target deep water shrimp, 110 target small pelagic species (purse seine), 17 focus on mid-water trawls for horse mackerel, 49 on demersal trawl and 56 on long line and pole fishing for large pelagic species. Fishing effort is distributed throughout the Angolan continental shelf but focal points are immediately north of Luanda and in Namibe Province for small pelagic species and the central Angolan continental shelf for demersal *Dentex* species. These indicate that the main fishing port in Angola is Luanda with smaller ports such as Lobito Bay being of limited importance for industrial fishing operations. In Zaire Province, the main port is in Soyo and located on the south bank of the Congo River close to its mouth. It is managed by *Fina Petroleos de Angola*.

Fisheries for small pelagic species

Small pelagic species are distributed throughout the Angolan coast (refer to Figure 5-9). Presently, the small pelagic industry is the largest of the Angolan fisheries, representing 80% of the total fish catch. The main species targeted are:

- Round sardinella (*Sardinella aurita*);
- Flat sardinella (*Sardinella maderensis*);
- Cunene horse mackerel (*Trachurus trecae*); and
- Cape horse mackerel (*Trachurus capensis*).

Sardinellas are usually found in upper water layers and near the surface from shallow (10m deep) inshore bays to 200m depths on the middle and outer continental shelf. Of the sardinellas, *S. maderensis* is the dominant small pelagic species in Angolan waters, and is widely distributed on the whole shelf and migrates seasonally with another small pelagic species, *S. aurita*. During the cold season, when upwelling occurs throughout the Angolan coast, juvenile sardinellas move northwards

into "nursery areas" (Luanda – Cabinda fishing zone). During the warm season they move south and aggregate in high concentrations mainly off central and southern Angola (FAO, 1999).

The pelagic purse seine fishery targeting sardinellas is concentrated in Luanda with ~93% of the 135 000 tonnes of the total allowable catch (TAC) being landed there in 2004. Catches are made throughout the year but peak in the period April – August.

Fisheries for midwater species

Horse mackerels are pelagic shoaling species occurring over the continental shelf, mostly over sandy bottom. Two species of horse mackerel are fished in Angola: in the north the Cunene horse mackerel dominates the warmer Angola current, while Cape horse mackerel is associated with the cold Benguela current in the south of Angola. Cunene horse mackerel is dominant in the inner part of the shelf, while most of the Cape horse mackerel is found more offshore. As with the sardinella, the former species migrates northwards towards the Congo/Gabon border area where juveniles mostly occur (nursery area).

Chub mackerel *Scomber japonicus* are also harvested by the mid-water trawl fishery. They occur in surface and sub-surface water to depths of 300 m.

Other pelagic fish that may be landed by mid-water trawlers include:

- Hairtails (ribbon fishes);
- Barracudas;
- Bumper, *Chloroscombrus chrysurus*;
- Lookdown, *Selene dorsalis*; and
- Scombridae (bonito, Spanish mackerel, chub mackerel, little tunny).

Highest landings in midwater trawl fishery catches occur in the summer/early winter period (January – July). No fishing takes place in the period August to November. Aggregated catch data indicate that the provinces of Luanda and Namibe contribute most of the catch and are responsible for 26% and 41% of total landings, respectively.

Demersal trawl fisheries

Trawl fisheries fall into two major groups in Angola:

- Fisheries targeting demersal (bottom dwelling) finfish; and
- Fisheries targeting prawn / shrimp (also bottom dwelling).

The demersal trawl fishery consists of sub-fisheries, based on the targeted species. The relatively small hake fishery is based mainly in the south, targeting the Benguela hake *Merluccius polli*; in the extreme south, the Cape hake *M. capensis* is also taken. The larger dentex-based fishery takes place in Angola's central and northern fishing grounds (refer to Figure 5-10). Also caught by demersal trawlers are the big-eye grunt, hairtails and other Carangidae and barracudas, while off northern Angola Cunene horse mackerel may also be caught in this fishery. The big-eye grunt is most commonly caught at depths down to 100m; also expected in this area but at shallower depths (10-50m) are the Big-eye grunt, the Bastard grunt (*Pomadasys incises*), the Sompat grunt (*P. jubelini*) and the Rubberlip grunt (*Plectorhynchus mediterraneus*).

Cephalopods are also an important component of demersal trawl catches off northern Angola with the most abundant being the cuttlefishes (Sepiidae) and shelf squids (Loliginidae). Octopus (Octopodidae)

is also caught but at relatively low abundances. Cephalopod catches are highest in the 50–110m depth range.

Part of the demersal trawl catch consists of a by-catch of deep-water prawns and to a lesser extent, the deep-water red crab. Conversely, hakes are taken as a by-catch in the deep-sea prawn trawl fisheries.

About 88% of the demersal fishery landings in Angola are made in Luanda and therefore the bulk of the trawlers involved in this fishery are based there. Apart from TAC, other forms of effort control include a limitation of the number of vessels in the fishery, the prohibition of trawling close to the coast, and minimum size limits.

Deep water shrimp fishery

Trawling for offshore prawn usually takes place in central and northern Angola (refer to Figure 5-11). The offshore prawn trawl catch comprises:

- The deepwater rose prawn *Parapenaeus longirostris* (found in the upper slope at 150–350m deep), which is the main target of the commercial fishery;
- The striped red prawn *Aristeus varidens*, which mostly occurs in the depth range 400–800m on the continental slopes, and
- The Scarlet shrimp *Plesiopenaeus edwardsianus* caught in deep-water (400–900m depth range), and Golden shrimp, Plesionika martia, caught in in 300–700m.

The fishery for the rose shrimp is restricted to daytime, whereas the species in deeper waters may be fished both by day and at night. The commercial shrimp fleet fishes the 200–300m deep fishing grounds during the day and the deeper grounds (400–500m and deeper) during nighttimes.

In addition to the industrial level offshore prawn fishery there is also a semi-industrial inshore prawn fishery that targets coastal species such as the pink prawn *Penaeus duorarum* and the Caramote prawn *Penaeus kerathurus*. These species are more usually targeted by artisanal fishermen in Angola as they predominantly occur in the designated artisanal fishing zone.

Large pelagic species fishery

Tunas comprise the bulk of this fishery. These fish are highly migratory and occur seasonally in deeper waters, particularly aggregating around temperature fronts mainly in off southern Angola. Commercial long-line tuna fishing takes place along the edge of the continental shelf, deeper than 500m. Species targeted include bluefin *Thunnus thynnus*, yellowfin *T. albacares*, bigeye *T. obsesus*, and longfin or albacore *T. alalunga*. Bluefin and yellowfin comprise the bulk of the Angolan large pelagic fishery. Smaller tunas tend to be found on the narrow coastal shelf between Lobito and Tombwa, where they congregate at certain times during the year. Tuna catches, averaging 10 000 t/year from 1950-70, have dropped significantly in recent years to 1 833 t in 2004 (CapFish, 2007). Tuna fishing is dominated by foreign-owned vessels employing longlines (18 vessels) and purse-seine nets (15 vessels) (CapFish, 2007). Long lines with evenly spaced baited hooks can extend 10km or more in length. The main fishing season is in November.

5.5.4 Shipping and Navigation

The major shipping routes along the coast of Angola are shown in the southern African context in Figure 5-17 and are between:

- Luanda and European ports;

- West Africa (Nigeria) and Cape Town, South Africa; and
- Cabinda and Cape Town.

Most of the shipping coming in and out of the country is through Luanda, mostly related to freight. Major shipping routes along the coast of Angola connect South Africa to Luanda, Cabinda, Nigeria, and Europe. As Zaire Province develops and the Angola LNG plant takes effect, shipping activity will likely increase out of the Port of Soyo. Much of the activity in the study area is probably linked to the movements of oil and freight tankers.

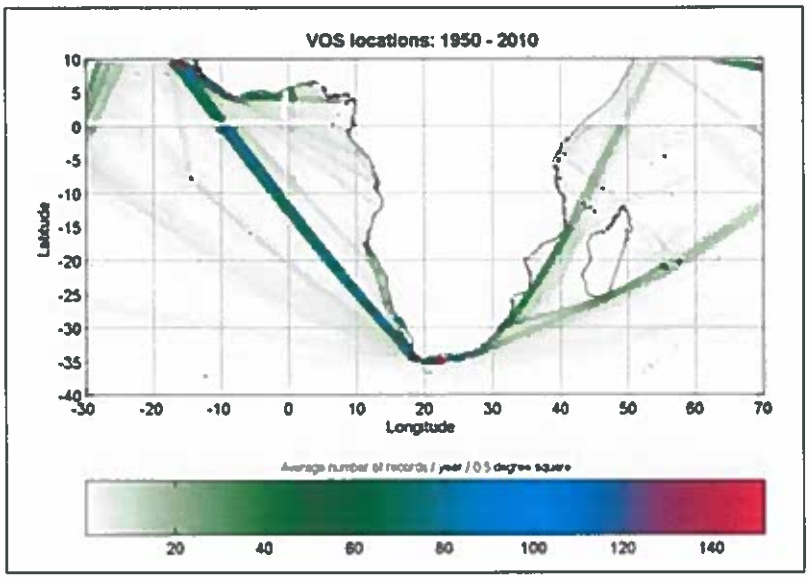

Figure 5-17: Shipping routes off the west coast of Africa south of the equator based on Voluntary Observing Ships (VOS) data.
(figure supplied by SADCO).

5.6 Coastal Environment

5.6.1 Coastal Landforms

The northern Angolan coastline is largely characterized by a relatively narrow (approximately 50m wide) sandy intertidal zone, backed by low red sandstone cliffs making coastal access difficult for large parts of the coastline. The cliffs are often severely undercut and the littoral zone may consist of boulders that have fallen from the cliffs and lie embedded in the sandy beaches.

Of the approximately 390 km long northern Angolan coastline extending from Peninsula Mussulo in the south to Soyo at the Congo River mouth, about 75% comprises sandy beaches and 25% rocky shores (boulder shores). An extensive cliff line lies between the Lucunga River and the Congo River mouth, extending for over 90km, and smaller 20 to 35km long cliffs extend from Ponta do Musserra to N'Zeto and from Ponta Spilimberta to Ponta do Dande (Sogreah-Magelis, 2005). Key features of the coastline are discussed below.

5.6.2 Rivers, Lagoons, Estuaries and Mangroves

There are several perennial rivers along the study area coastline that are either permanently open to the sea or are closed by a beach berm when the river flow is low. Some have coastal lagoons in the lower reaches, e.g. the Nzombo River about 30km south of Soyo, which forms a lagoon-like estuary with small mangrove forest (see Figure 5-18). At some river mouths, lagoons are formed by north-south aligned sand spits (or 'restingas'), which are usually found at river mouths where high sediment

levels coincide with northward long-shore drift. Restingas are dynamic in nature due to the influence of wave action, and are regarded as fragile coastal features.

Figure 5-18: Google Earth image of the sandy beach coastline south of the Congo River, showing the Nzombo River mouth and associated mangrove forests.

Mangrove forests in Angola are most extensive in Cabinda and along the Congo River but sparser and with lower diversity further south (towards Luanda) as the coast becomes more arid and sea temperatures decline nearer the Angola Benguela Front.

5.6.3 Intertidal Habitats and Coastal Fauna

The area extending from central Angola to central Gabon lies in the tropical zone, in which faunal and floral communities have more tropical affinities. It is therefore likely that the rocky shores of northern Angola also belong to the Gulf of Guinea regime, although the frequent occurrence of low salinities from the Congo River outflow may affect and influence the distribution patterns of communities close to this river mouth. Little research has been done on the intertidal fauna of northern Angola and much of the information contained below is sourced from a 2006 survey of rocky shore habitat of southern and central Angola (Hutchings *et al*, 2007).

Rocky shores

In general, species composition and patterns of shore zonation resemble those found in tropical countries to the north of Angola abutting the Gulf of Guinea, although some differences are reported.

The rocky shore is divided into:

- The littoral fringe on the upper beach, dominated by gastropods *Echinolittorina pulchella* (=*Littorina punctata*) and *Littorina angulifera*, which occur on rocks and mangrove trees on the shores of estuaries;
- The upper mid-littoral zone, characterised by barnacles *Balanus Amphitrite* and *Chthamalus dentatus*, together with the oyster *Saccostrea cucullata*, the limpets *Cymbula* (= *Patella*)

safiana and *Siphonaria pectinata*, and the gastropod *Nerita senegalensis* at more exposed shores; and

- The lower mid-littoral zone, characterised by a wide variety of algae, including *Basispora africana*, a regional tropical west coast endemic. Animals found here include the brown mussel *Perna perna*, limpets *C. safiana* and *Fissurella nubecula*, carnivorous whelks *Stramonita* (= *Thais*) *haemostoma*, *S. forbesi*, and *S. nodosa*, and the large barnacle *Austromegabalanus tintinnabulum*. Ranging over the entire littoral is the crab *Grapsus grapsus*, common throughout the region.

Intertidal sandy beaches

The fauna of sandy beaches comprises primarily invertebrates that burrow beneath the surface with crustaceans, polychaetes and molluscs being the most conspicuous. Most burrowing invertebrates are filter-feeders (siphoning food out of water) or deposit feeders (consuming food at the surface). They provide an important food source for fish and birds. The coastline immediately south of the Congo River is predominantly of the narrow sandy beach type (refer Figure 5-18).

Steep and narrow sandy beaches are probably the norm along the exposed coastline of West Africa, whereas flatter and wider beaches tend to occur in bays, lagoons or estuaries where they are protected from direct wave energy.

Steep beaches with coarse sand are generally nearly devoid of biota, with the ghost crab (*Ocypoda hippeus*) at the uppermost part and a sparse population of *Donax rugosus* at the low water mark. Less steep and wider (>50m wide) beaches tend to have a richer fauna. The top of the beach is characterized by *O. hippeus*, the isopod *Excirolana latipes*, and the polychaete *Nerine cirratulus*. Lower down the beach the bivalve mollusc *Donax pulchella* is abundant, accompanied by amphipods (*Urothoe grimaldi* and *Pontharpinia intermedia*) and below the *Donax* population is the mysid *Gastrosaccus spinifer* and the mole crab *Hippa cubensis*. This structure is similar to beaches in Senegal and Sierra Leone.

Lagoons, estuaries and tidal inlets

The characteristic animal of the upper sandy beaches in brackish-water habitats is the fiddler crab *Uca tangeri*, which is often present in large numbers to the southernmost limit of its range in southern Angola. In muddy sand of the lower beach, common animals are the polychaetes *Cirratulus filiformis*, *Diopatra neapolitana* and *Macroclymene monilis*. The blood cockle *Arca senilis* occurs in lagoons and is associated with other bivalves such as *Aloidis* sp. and *Tellina nyphalis*, and the whelk *Stramonita haemostoma*.

Mangroves

Mangroves are biologically productive and ecologically important habitats that occur mostly at the river mouths at intervals along the central-northern Angolan coastline. They serve as fish nursery areas and stabilise the coast against erosion processes, but are under threat from local people for firewood resulting in reduced fish landings and degradation of the coastal environment. Angola is estimated to have 700 km^2 of mangroves, most occurring in the more tropical northern area (north of Lobito at 12°S).

The mangroves in the study area belong to the east Atlantic floristic zone. Three *Rhizophora* species are present: *Rhizophora racemosa* and *R. harrisonii* are fairly common, whilst *R. mangle* occurs less frequently. Other species are *Avicennia nitida* and *Laguncularia racemosa*. The *Rhizophora* species mainly occur within the normal tidal range (mostly below mean high water), while *Avicennia* species occur relatively high in the tidal range on the inland side of the mangroves.

Coastal Birds

Inshore coastal birds include the phalaropes (Phalaropidae), gulls (Laridae) and terns (Sternidae), with terns being the most abundant group occurring along the Angolan coast. Several breeding species are found, including the Red Data-listed Damara tern (*Sterna balaenarum*).

A large number of waterbirds associated with freshwater systems occur in the vicinity of river mouths and lagoons, e.g. herons, egrets, storks, ibises, flamingos and pelicans. Groups of birds comprising Marabou stork (*Leptoptilus crumeniferus*), Lesser flamingo (*Phoenicopterus minor*), Little egret (*Egretta garzetta*), Grey heron (*Ardea cinerea*), Sacred ibis (*Threskiornis aethiopicus*) and Vulturine fish eagle or Palmnut vultyure (*Gypohierax angolensis*) have been observed on the beach at the mouth of the Bengo River, north of Luanda.

5.6.4 Coastal Conservation Areas

There are five formally protected areas (four National Parks and one Nature Reserve) along the West African coast from Angola to Gabon as well as five Ramsar sites[4], with only one of these – the DRC's *Parc National des Mangroves* – located within the study area of this report.

The *Parc National des Mangroves* is located on the northern bank of the Congo River mouth and comprises approximately 100 000 ha of which 66 000 ha is a designated Ramsar site. However, because of a number of threats to its status as a Ramsar site, the park has been entered on the Montreux Record[5].

The closest of Angola's coastal conservation areas are located well to the south near Luanda. There are currently no marine protected areas in Angola, although there is intent to establish these.

[4] Wetlands of international importance.

[5] "a record of Ramsar sites where changes in ecological character have occurred, are occurring or are likely to occur" (www.ramsar.org)

6 Social Baseline

6.1 Introduction

The following section comprises the full Social and Health Baseline Analysis, a study utilizing the primary and secondary data for *Soyo Comuna* to understand the local social reality onshore adjacent to where the proposed project will take place offshore. Conducting a Social and Health Baseline Analysis is part of the ESHIA process, a requirement both by ENI's corporate policy and Angolan law. By understanding the baseline characteristics of the onshore affected community, an impact assessment regarding both health and social components can be conducted. Together with the environmental impact assessment, these analyses together fulfil the company's requirements to foresee future impacts of the project on the local area.

The following section on social characteristics of the communities in the Soyo *Comuna* serves to provide a baseline of the living conditions and culture in the project study area. In order to understand the social, along with health-related, conditions in Soyo, ARC utilized initial secondary data from desktop research and then primary data gathered during field visits to the study area. This report includes both aspects of research for a comprehensive baseline study of the local communities in focus.

For one to understand the social conditions in Soyo, it is important to first see the larger socioeconomic conditions in Angola. As a developing African country with strong economic growth, Angola is one of the fastest expanding economies in the world. After three decades of civil war, 2002 was the beginning of a new post-war era, with high investment and growth in the national economy lasting to the present. However, it remains plagued by high rates of poverty and ranks low in the Human Development Index (HDI) of the United Nations[6]. With high levels of illiteracy and unemployment, as well as infrastructural and bureaucratic problems, the socio-economic reality in Angola is rife with inequality and difficulty. **Table 6-1** below presents some basic economic and social indicators of Angola.

Table 6-1: Selected Economic and Social indicators for Angola.

Indicator	Year	Value
Real Gross Domestic Product (GDP)	2009*	$75.5 billion USD 10.2% Agriculture, 59 % Industry, 30.8% Services
GDP Annual Growth	2009* 2008	0.7% (29% Agriculture, 0.4% Industry, 9.2% Services) 13.3%
Principal Exports	2009*	Total Value $34.3 billion USD Crude Oil $32.4 billion USD Diamonds $1.3 billion USD Manufactures $156 million USD
Inflation	2009	13.7%
Urban Population (% of total)	2003-2009**	58%
Life Expectancy	2003-2009	47 years
Access to an improved water source	2003-2009**	50% of population
Literacy (% of population age 15+)	2003-2009**	70%
Percent of Population below the international poverty line of $1.25 USD per day	1992-2008	54%

[6] The HDI is calculated each year for countries around the world by considering statistics of health, education and income. In 2010, Angola's rating was 0.403 out of 1, ranking 146 out of 169 countries studied. The regional average for Sub-Saharan Africa is lower than Angola's, with a 2010 score of 0.389 (UNDP, 2010).

Notes: *2009 figures are estimates from the World Bank.; **Data from the latest year available, unspecified by UNICEF report.

Source: World Bank 2009; UNICEF 2009.

Angola is divided into 18 provinces. The nation's capital is Luanda, the most densely inhabited province in Angola – home to about one-third of the country's population. It is estimated that there are 18.5 million inhabitants in Angola with a 3.2% population growth rate per year (UNICEF 2009).

The coastal region nearest to Block 15/06 falls within the Province of Zaire. The province covers an area of approximately 40,130km² and shares a border with the Democratic Republic of Congo (DRC) to the north and the Angolan provinces of Uíge and Bengo to east and south. The Atlantic Ocean lies on the western side of the province with 250km of coastline and the River Congo defines the international border to the north (see **Figure 6-1**).

Figure 6-1: Zaire Province and municipalities along the coastline.
Source: ALNG, 2006.

Zaire Province has a total of six municipalities, divided into 24 *comunas* (community-level administrative/political divisions), as listed in **Table 6-2** below. The capital of the province is M'Banza Congo which lies 481km north of Luanda and is farther inland.

On the northwest corner of Zaire Province, the municipality of Soyo is located. Within the municipality there are five *comunas*, the largest and most important being Soyo. Though not the political capital of the Province, Soyo serves as the commercial hub of the region as the port and offshore oil exploration bring activity to the area.

Table 6-2: Municipalities and towns of Zaire Province.

Municipality	*Comunas*	Municipality	Community
M'Banza-Congo	M'Banza-Congo Luvo Madimba Kiende Kaluka Kalambata	Tomboco	Tomboco Kinzau Kiximba
Soyo	**Soyo** **Pedro do Feitiço** **Sumba** **Kelo** **Mangue Grande**	Noqui	Noqui Lufico Mpala
N'Zeto	N'zeto Kindege Mussera	Kuimba (Cuimba)	Kuimba Buela Kanda Luvaca

Source: INE, Zaire, 1995.

6.2 Demography

6.2.1 Population

The population of Zaire Province is estimated to be 313,000 with the most populous areas being Soyo and M'Banza-Congo (MAT 2010). Within the province, more than 50% of the population are under the age of 18 and slightly more than 3.5% are over the age of 65. About 47% of the total provincial population is of working age (Velose 2010). Up to a third of the population is made up of immigrants from the DRC to the north. Considering the size of the Province as 40,130km², the population density for the whole of Zaire is about 7.8 inhabitants per square kilometre.

The Soyo Municipality currently has a population of 116,000 amongst its five *comunas*, resulting in a municipal population density of 22.3 inhabitants per km². Soyo, the most densely populated of the five *comunas*, has a total of 65,340 residents amongst its 39 communities/villages. As the size of the *comuna* is 1,036.86km², the population density of Soyo is 63 inhabitants per km² (Administration 2011).

Of the five larger towns in Soyo Municipality, Soyo town has an estimated 89,000 residents living within 36 smaller villages. Previous studies show that the average age in Soyo is 21 years. Though officially data about the gender ratio is not available, surveys suggest that within the age group of 20-40, there is a higher amount of women than men. This is likely related to the loss of young men during the civil war (ARC/SRK 2007). The most populated area within Soyo Town is its more urban centre, with population density reducing farther out from the town. In Figure 6-2 below, satellite imagery highlights the locations of the communities identified and visited by ARC during field research.

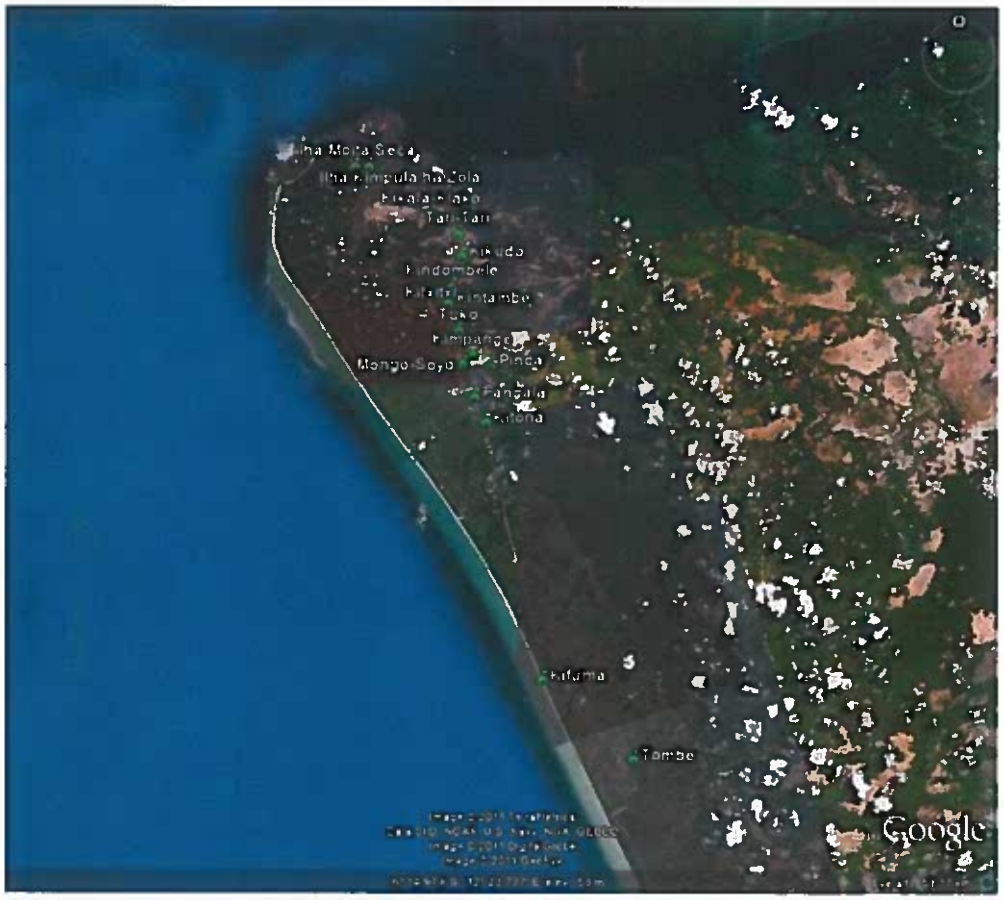

Figure 6-2: Communities located in Soyo *Comuna*.

The communities of Soyo are shown in Table 6-3 below, along with their population and household numbers, and if available, percentage of inhabitants living in urban versus rural areas. Data used in this table sources from questionnaires conducted in June 2011 for local *sobas* (elected community representatives), along with statistical data available from previous work in the area in 2005. Note that a dash represents the unavailability of the data both from local *sobas* and from the administration.

Table 6-3: Population statistics for communities in Soyo.

Community	Population (2005 HH Survey)	Population (2011 *Soba* Questionnaire)	# of HH (2005)	Rural (%) (2005)	Urban (%) (2005)
Bairro Fina (Pangala Fina)	755	-	98	-	100
Bocolo*	724	150	94	100	-
Conde	1679	2500	218	100	-
Down Town Soyo	1686	-	219		100
Figo*	339	-	44	100	-
Fundao*	-	-	-	-	-
Gande Soyo (Yenga)	909	-	118	100	-
Ilha M'Bubu*	431	-	56	100	-
Kami	685	-	89	100	-
Kifuma	-	800	-	-	-
Kikala Kiako	4650	6800	604	1	99

Community	Population (2005 HH Survey)	Population (2011 *Soba* Questionnaire)	# of HH (2005)	Rural (%) (2005)	Urban (%) (2005)
Kikudo	9171	-	1191	100	-
Kikumbo	1648	-	214	100	-
Kilumbo	7585	-	985	100	-
Kimpange	1940	-	252	100	-
Kimpondo	1925	-	250	100	-
Kimpula*	524	-	68	100	-
Kinganga Mavakala	439	-	57	100	-
Kinmianganga	916	446	119		100
Kintambi	1656	530	215	100	-
Kitona	2218	1800	288	100	-
Kitxitxi	531	894	69	100	-
Kungueyenguele	11350	12000	1474	13	87
Libi*	-	-	-	-	-
M'Pungo	2556	6000	332	100	-
Moita Seca*	-	213	-	-	-
Mongo Soyo	2680	8000	348	97	3
Mpangala	3126	-	406	93	7
Nona (Terra Nova)	10626	-	1380	2	98
Nsandi Kembo (Nsadi)	801	-	104	100	-
Ntampa	-	-	-	-	-
Pinda (Evata)	839	-	109	-	100
Quindombele/Kindembele	963	-	125	63	37
Tari-Tari (Zona B)	11458	-	1488	-	-
Tombe	-	7000	-	-	-
Tuko	1247	2000	162	100	-
Tulombo*	-	-	-	-	-
Wolo	685	-	89	100	-
Zola*	354	467	46	100	-
Zulu	1224	-	159	100	-

Source: Soba interviews 2011 and Household Survey 2005 as quoted in ARC/SRK 2007.
**fishing community accessible only by boat*

6.2.2 Ethnicity

Within Zaire Province the ethnic groups are mainly the Mussurongos and Sorongos on the coast and Muxicongos in the interior, all three part of the ethnic-linguistic group Bakongo (see **Figure 6-3** below) (INE 1995). Bakongo roots are linked to the historic Congo Kingdom, to which Soyo was once a part. In Soyo, 85-90% of the inhabitants are Basulongo, also a subgroup of the Bakongo. Another small portion of the inhabitants, roughly 6 percent, are of the Mbinda people originating from Cabinda (Ministério de Cultura). *Sobas* in Soyo confirmed these ratios, stating that 95-100% of their communities´ inhabitants are of Bakongo origin.

Figure 6-3: Map of Angola highlighting the Socio-cultural area of the Bakongo in the north-western region.

Source: Ministério de Cultura, not dated.

6.2.3 Language

Though the national language is Portuguese, the most widely-spoken language in Zaire Province is Kikongo. After Portuguese and Kikongo, both Lingala and French are spoken as a result of the influence and migration from neighbouring DRC. In Soyo, locals speak Kissolongo amongst themselves, a language closely related to Kikongo. Some Lingala and Ibinda (or Fiote) is spoken due to migrants from the Cabinda Province to the north. Table 6-4 below shows the various languages and the percentages of surveyed communities speaking each language. For written communication, Portuguese is the most common language – though some write in Kikongo and a selected few in English.

Table 6-4: Languages Spoken in communities of Soyo.

Language	Portuguese	Kikongo	Kissolongo	Lingala	Ibinda/Fiote
Percentage of communities where spoken	100%	43%	100%	22%	4%

6.2.4 Family Structure

The composition of a typical family in the Soyo area includes extended family alongside the nuclear one. When asked about the members of a family during site interviews, community members listed father, mother, children, aunts and uncles and grandparents. Often a family will live within one or two houses, though in each case it varies slightly who remains in each home. The number of families per community was often known whereas the number of people was not. In terms of the family head, 95% of the respondents listed the father; however, women are said to run the household.

Because polygamy is a fairly common practice in the area, the number of children per family is less useful than the number of children per woman. In the interviews with 74 local women between ages 20-60 from different communities, every single one had children. The majority had between 3 and 5; though almost a quarter had over 6 (see Figure 6-4 below).

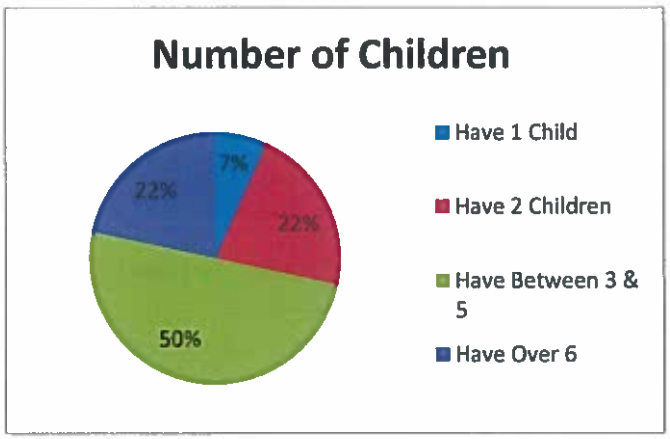

Figure 6-4: Number of children per woman.

6.2.5 Migration

Migration issues are relevant in Soyo due to the proximity of the border with the Democratic Republic of Congo (DRC) to the north. Throughout history, migration has been a relevant theme in the region particularly with the presence of conflict in the last half century in both the DRC and Angola. Migration flows have been heavier in one direction and later reversed, depending on the political and economic conditions within countries. According to the United Nations, there were 12,000 refugees from the DRC in Angola in January 2010. In addition, the thousands of Angolans who fled to the DRC during Angola´s civil war and are now returning either by choice or by force. The UN reports that in the autumn of 2009, about 54,000 Angolans were expelled from the DRC, causing severe social and logistical problems (UNHCR 2009). At present, there is an overall net in-migration of both Angolan nationals and foreigners to the Province.

In Soyo, an estimated 70% of the foreign immigrants originate from the DRC to the north. As some enter illegally, immigration authorities and locals share some concern about their legal status. However, in general, the population remains fairly homogenous as returning refugees and migrants share similar social and cultural backgrounds, resulting in little to no ethnic conflict in the area (ARC/SRK 2007).

In addition, a rural exodus is taking place in Soyo where in the last year, an estimated 2000 people have moved from rural areas to the city. Attraction is drawn to the Soyo area largely due to the oil industry activities at Kwanda Base, including the construction of the Angola Liquefied Natural Gas (ALNG) plant. Expatriated workers are also present in Soyo for limited or rotational schedules for work related to construction and the oil industry. Soyo serves as the support centre for many offshore exploration blocks off the northern shore of Angola.

Acceptance of foreigners is generally high; as long as they have legal papers, they are accepted by the local peoples. Congolese are accepted more easily than other nationalities due to their linked cultures and ethnic background. The Congolese people were also helpful to local Angolans during the Angolan civil war, resulting in a certain level of trust and camaraderie between the peoples.

Government efforts to control immigration are enacted via the Foreign Migration Services (*Serviços de Migração de Estrangeiros* or *SME*). Filipe José Pemba, the head of SME in Soyo, stated that they are currently building a retention centre for illegal immigrants order to support immigration enforcement in Soyo. On a policy level, the Triparty Accord between Angola, Congo Brazzaville and the DRC serves as an international treaty regarding immigration between the three countries (Pemba 2011).

6.3 Economy

6.3.1 National Economy

Angola's booming economy is reflected in the recent GDP annual growth rates. Despite the dip in 2009 and 2010 caused by the global recession, growth rates in Angola are returning to pre-recession values with an expected 7.75% in 2011 and 10.5% in 2012. Total GDP in current prices was $75.5 billion USD in 2009 and $85.3 billion USD in 2010. The principal exports in Angola are crude oil, diamonds and manufactures. Investments as a percentage of Angolan GDP were 15.2% in 2009 and 10.3% in 2010 (IMF 2011).

In 2009, the Angolan export of goods and services was $52.2 billion USD and the import was $46.2 billion USD (World Bank 2011b). Data specifying the various sectors of goods and services making up these sums is not currently available. In the municipality of Soyo, recent tax value for the region was 90,353,387,035kz or approximately $968,418,867 USD, a value that has increased within the last 5 years.

In Zaire Province, the local economy mirrors the national situation: as the second-most oil rich province, the oil industry has a large influence over the economic activities in the area. Situated to the west of Soyo Town, Kwanda Base provides the logistical support for onshore and offshore oil activities located in Cabinda and the Congo Basin. Soyo Town is the main commercial centre for the Zaire Province. Investments in the province from the central government included approximately $69 million USD for Zaire in 2007, totally 0.37% of its budget for the provinces (Ministério das Finanças 2007). There are no other big industries in Soyo besides the oil and gas sectors.

In Soyo, as in most coastal areas in Angola, the principle sources of employment are subsistence agriculture with some animal husbandry and fishing. Informal trading takes places in the streets as well as at the two markets in the *comuna*. Though there has been a general increase in economic activities in the area within recent years, these work areas still occupy the majority of the population. Employment is discussed further in the section below.

6.3.2 Employment

In Angola, it is estimated that 7.97 million people are within the economically active population (2010 est.). Of those in the labour force, about 85% are involved in agriculture and about 15% in industry and services (2003 est.; source CIA World Factbook 2011). Employment figures from 2006 show 25.2% unemployment in Angola, a 4% decrease from the previous year. The sectors creating the most jobs are the construction, fishing and non-market services. The oil industry alone in Angola provides 5% of the total country's employment (Jornal de Angola 2010). Most of the people seeking jobs in Angola are unskilled.

Field research in Soyo *Comuna* included interviews with several key entities who revealed data on employment and income in Soyo. Ferreira António José, the Director of Professional Training for the Ministry of Public Administration, Employment and Social Security (MAPESS), provided data useful to understanding the employment situation in Soyo. According to MAPESS statistics, there are currently 6356 people working in the private sector in Soyo, only 388 of which are women. Women, José noted, are little involved in the formal labour force, decision making and politics. Youth are more involved in the workforce than women, and minorities at an even higher rate (José 2011).

The unemployment rate in Soyo is 60%, with no overall data available for women, children or minorities. According to the Soyo Administration, 70% of the inhabitants work in informal commerce which they conduct daily (Arménia 2011). Women interviewed during field research were of the following professions: fish processing and selling (17%), agriculture (56%), sales/vending (4%) and housekeeper (23%), as depicted in **Figure 6-5** below.

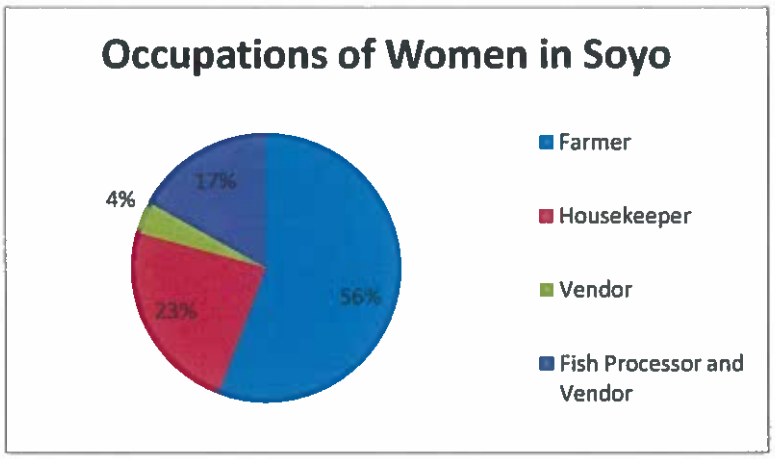

Figure 6-5: Occupations of Women interviewed in Soyo.

In the past 5 years, there has been a general increase in economic activities in the areas of formal and informal business, petroleum and gas, services and hospitality. A number of jobs have been created in the oil and gas sector, as highlighted in Table 6-5 below by company.

Table 6-5: New Jobs Created in the Past 5 Years within the Oil/Gas Sector.

Company	SNL Dist.	Somoil	Sondagens Angola	ALNG	Preciosa Angola	Spie oil
Number of Posts Created in Past 5 years	54	78	37	264	42	30

Source: José 2011.

In terms of training, MAPESS statistics show some students currently taking Level Three technical courses (ages 14-18) in Soyo focusing in the following areas: Computer Science (145 students), Electricity for Buildings (45 students), Industrial Electricity (32 students), Air conditioning (51 students), Welding (32 students), and Locksmithing (36 students).

When in the field in Soyo, ARC interviewed community leaders – called *sobas* – who indicated the following areas of employment relevant to their communities. Of the 23 communities surveyed, 78% listed fishing as a source of employment, 74% listed agriculture, 43% listed hunting, 39% listed wage labour with a private company, and 35% listed informal commerce. Other, less common jobs in the surveyed communities include woodworking, production of canoes and the public service. Reliable data on the exact numbers of people working in each sector or profession was not available. It was however noted that professions include professors, plumbers, locksmiths, cooks, divers, electricians, domestic workers, masons, doctors and nurses, mechanics, carpenters amongst others.

Similarly, data from a 2007 household survey in Soyo town shows employment divisions mirroring some of the data ARC acquired during its field work.The following diagram, Figure 6-6, demonstrates employment in percentages of the population divided into various professions, the majority of which are peasant farmers. The higher concentration of professionals (especially teachers and medical staff) in this case can be attributed to the sample area, as this survey in 2007 focused on the more urban area of Soyo and did not include the more rural communities that covered in this report.

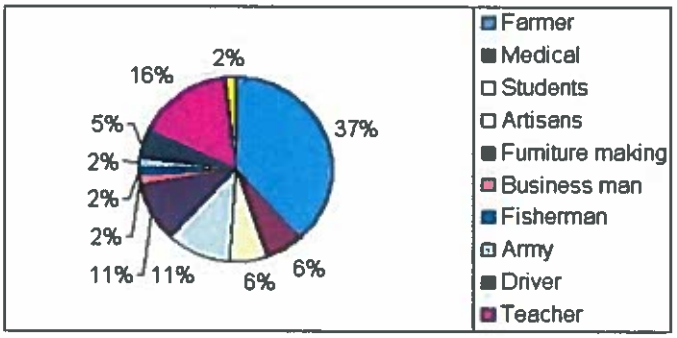

Figure 6-6: Employment in Soyo.

Source: Household Survey AEC, 2007 quoted in ARC/SRK 2007.

6.3.3 Income and Equity

In Angola, income levels vary significantly between fields as well as those with qualifications and those without. As such, inequity is a major issue in the country; with some industries generating enormous profits and providing mammoth salaries, an enormous gap exists between the rich and the poor. In Angola, an estimated 40.5% of the population is below the international poverty line of $1.25 USD per day (2006 est). Those with the resources to consume a variety of goods and services do so in large quantities: in Angola, the highest 10% of income earners consume 44.7% of the country's goods and services, whereas the lowest 10% only consume 0.6% (2000 data; CIA World Factbook 2011).

In Soyo, the top three wage employers are the extractive industries (14 percent), civil engineering (12 percent) and health care and social services (11 percent). Of the self-employed non-wage earners, the majority (close to 59 percent) worked in agriculture in 2005, followed by 11.9 percent in informal trading and then transport and communications at 6.2 percent (ARC/SRK 2007). In general, salaries are low and unemployment rampant. A minimum salary for individuals working in the public sector is only 10,030kz per month (Approx. $100 USD). According to the Administration, 71-90% of the population is living behind the national food poverty limit and 41-70% live below the national poverty line. In addition, prostitution levels are considerably high as many women do not have other income options (Arménia 2011).

Based on the 2005 Household Survey referenced in this report, an average monthly income based on profession is indicated in **Table 6-6** below.

Table 6-6: Average Monthly Income in Soyo by economic sector

Economic sector	Formally Employed	Self Employed
	US Dollar	US Dollar
Vehicle repair	531	53
Light industry	512	304
Mining	450	484
Retail trade	370	185
Real Estate services	340	1,195
Health care and social services	339	375
Transports and communications	277	94
Others	241	158
Hotels and restaurants	226	84
Finance	225	-
Civil engineering	186	196
Gross trade	179	2,077
Petty trading	175	228
Education	170	78

Economic sector	Formally Employed	Self Employed
	US Dollar	US Dollar
Agriculture	144	88
Fishing	113	323

Source: Household Survey, 2005 quoted in ARC/SRK 2007.

By referencing the table above, one can see that there is an extremely high incidence of poverty in Soyo. The Household Survey in 2005 revealed that approximately 57.2 percent of the population is living in poverty, of which approximately 20.2 percent live in extreme poverty. The fishing communities were found to have the highest proportion of non-poor individuals (based on expenditure rather than income), followed by communities located adjacent to Kwanda Base. In comparison, communities dependent primarily on agriculture were found to have the highest proportion of extremely poor residents. This is primarily due to low returns and the small scale nature of agricultural activities.

In a 2005 Household Survey in Soyo, researchers found that very few of the unemployed were educated beyond secondary level, and that the majority have not been educated beyond supplementary primary school. Individuals with higher education levels were found to be less likely to work in agriculture and informal commerce and are more likely to work in skilled employment – like construction (Household Survey 2005 quoted in ARC/SRK 2007). In 2007, ARC conducted a household survey which reaffirmed this trend around Mongo Soyo, M'Pungo and Kintambi. The results revealed twenty-two percent of respondents involved in the health and teaching professions, indicating a higher academic attainment and the ability to secure permanent wage labor, and presumably higher income levels than those who do not have the same qualifications (ARC/SRK 2007).

6.3.4 Subsistence Agriculture and Livestock Rearing

In Soyo, subsistence agriculture, together with artisanal fishing, has a large role in supporting the livelihood of the majority of the population. Depending on the community within the *comuna* of Soyo, a percentage of the inhabitants are involved in subsistence agriculture. In more rural communities, 80-100% of the residents are involved, whereas in the more urban or island communities, involvement rates are only 0-50%. According to the local Department of Agriculture, there are 60,000 people involved in subsistence agriculture in the *comuna*, consuming or selling their goods themselves. All of those involved in subsistence agriculture are dependent on it for their livelihood. The average distance that Soyo residents have to travel is 15-20km in order to arrive on agricultural lands, providing a transportation burden due to little or no public services available (Faustino 2011).

Overall in Soyo within the past five years, the number of families dependant on agriculture has increased, as has productivity. The most productive time of year is during the months of November – January, with the least productive being May-June. In Soyo, the principle crops cultivated at present are peanuts, cassava, sesame, maize, sweet potato and black-eyed peas. By far the most important crop to the local people is cassava (*mandioca*), which is consumed in many different manners every day.

Some crops have faced a sharp reduction in yield in recent years, as over half the communities surveyed citing complete loss of cashew and coconut trees attributed to heavy atmospheric pollution. Locals attribute this loss to oil exploration offshore and its subsequent air pollution, though the source of the contamination has not been proven. From the total land area planted, 75% of the production is consumed by the subsistence farmers, whereas 20% is lost to natural factors and 5% is sold. Some agricultural products are transformed after harvest and some are sold directly whole (Faustino 2011).

While most of the communities interviewed stated that there was sufficient agricultural land for all, a small portion said no (13%). Accessing available lands is not restricted for locals as long as the local *soba* is in agreement. Some agricultural production does occur on marginal lands.

Only some communities practice livestock cultivation and the scale is very small and dispersed; 35% of the communities surveyed mentioned some cultivation of pigs, chicken, goats and ducks.

It is common in Soyo to join agricultural cooperatives in order to gain access to resources. In the municipality of Soyo, there are 20 agricultural cooperatives and 53 agricultural associations. Considering Table 6-7 below, the majority of cooperatives and associations are located in both the *comunas* of Sumba and Kelo, with less activity in Soyo. In terms of local administration, there are 15 public functionaries currently allocated to agriculture in Soyo (Faustino, 2011).

Table 6-7: Agricultural Cooperatives and Associations in Soyo Municipality.

Comuna	Soyo	Sumba	Mangue Grande	Kelo	Pedra do Feitiço
Cooperative	1	12	0	7	0
Association	8	13	7	20	5

6.3.5 Artisanal Fishing

Small-scale fishing is a central activity for many small communities in the Soyo Municipality due to its location on the shores of the Atlantic Ocean to the west and the Congo River to the north. Those involved in artisanal fishing are typically from small communities with limited resources; fishing is part of the local culture but also a necessity for food supply and income. While the capture of fish is reserved only for men, women play an active role in processing and then selling the fish onshore when the catch arrives.

Vessels used by artisanal fishermen are typically handmade out of wood and vary slightly in size. The smaller rowing crafts are called *canoas* or *chatas* and the more scarce *catrongas* are inboard diesel-powered vessels 7-10m in length. In Zaire, canoes make up 48% of the fleet, compared to 90% in northern Cabinda. Very few of the approximately 115 canoes and nearly 80% of the *chatas* in Zaire Province have motors, which enable fisherman to get farther out at sea (Duarte et al. 2005). In Soyo, there are 72 *chatas* and 3 *catrongas*, according to the Institute of Artisanal Fishing (*Instituto das Pescas Artesanais* ou IPA). *Chatas* hold 3-4 men at a time while *catrongas* hold up to 6, making their capacity for capture higher (Pereira 2011). In Figure 6-7 below, typical wooden boats used for artisanal fishing are depicted; in Figure 6-8, local fishermen construct a wooden vessel to take offshore in Soyo.

Figure 6-7: Boats used by artisanal fishermen in Soyo.

Figure 6-8: Fishermen in the island communities near Soyo town crafting fishing boat by hand.

Due to the fact that most boats used by artisanal fisherman do not have motors, their zone of access is limited to relatively near shore, as well as the Baía de Diogo Cão and the nearby channels like Pululu and Moita Seca. Most fishermen stay within the legal boundary of 8 nautical miles off the coast, a distance defined by the Angolan government to be reserved for artisanal fishing. A popular fishing area in the *comuna* is the zone between Ponta do Padrão and Lombo Este. Though officially anybody with an Angolan fishing license can fish in the coastal areas, it is common practice to first have permission from the local *soba*. Typically a trip will last 2-4 days, with an average catch ranging from 50-100 kilograms.

Fishing gear used by artisanal fishermen includes beach seine nets (*banda banda*), seine nets modified to catch demersal fish (*rapa*), gill nets, and hook and line. The most common fish captured in the Soyo region are listed in Table 6-8 below.

Table 6-8: Commonly captured fish in Soyo.

Species	Common name	Angolan Name
Plectorhinchus mediterraneus	Rubberlips grunt	Peixe Burro
Pelates quadrilineatus *Pseudotolithus typus* *Pseudotolithus senegalensis* *Pseudotolithus elongates* *Miracorvina agolensis*	Croaker	Corvina
Dentex + Sparus spp	Large-eye dentex + other sparids	Cachucho
n/a	Shark spp	Tubarão
Argyrosomus hololepidotus	Southern meagre/Kob	Pungo
Various spp. grouper	Rockcods	Garoupa
Arius spp.	Catfish	Bagre
Galeoides decadactylus	African threadfin	Barbudo
Raiidae	Ray spp.	Raia

Species	Common name	Angolan Name
Solene dorsalis	African lookdown fish	Galo
n/a	*n/a*	Taco Taco
/a	*n/a*	Enchada

Source: Personal Interviews; Duarte et al 2006.

Productivity depends on the time of year. Although there are generally more fish in the rainy season (October to May), the most productive fishing season is the dry season *(cacimbo)* (June to September) when weather conditions are more favorable. According to local fisherman, within the last five years, catch of the following fish have reduced significantly: *pescada, mataco, roncador, pungos, piazete* and *calafate*. The zones with reduced yield are Mangue Grande and Lombo Este, as well as Block 2. Reasons for the reduction in yield are thought to be related with petroleum exploration and dredging activities in the area.

In **Table 6-9** below, the monthly catch for the coastal municipalities of Zaire Province are listed for the second quarter of 2009. This table allows one to compare the quantity of capture related to the activity levels in each municipality; as is evident, Soyo has the most significant artisanal fishing industry in the region.

Table 6-9: Monthly catch (kg) for the second quarter of 2009, for each coastal municipality of Zaire province.

Municipality	April	May	June	Total
Soyo	2.757.895	2.097	1.107.467	3.867.459
Tomboco	79.800	4.620	781.620	866.040
N'Zeto	732.651	173.746	961.446	1.867.843
Total	**3.570.346**	**180.463**	**2.850.533**	**6.601.342**

Source: INIP 2009

Once the fishermen arrive on shore after each trip, the catch is divided; typically 30% of the capture is kept by the fisherman, while 70% goes to the owner of the boat (Pereira 2011). The majority of fish is sold to local women at landing sites. Price does not vary between seasons but does vary between fresh or preserved fish, as salted or dried fish is more expensive. In Figure 6-9 below, a small amount of fish is dried in the traditional manner. Fish is also a key component of the diet for fishing communities, and approximately half of all fish is set aside for consumption by the household.

Figure 6-9: Processing of fish in fishing villages along the coast.

Participation in fishing cooperatives is common for local fishermen, as grouping allows access to joint resources and a unified voice to communicate with the Institute of Artisanal Fishing (*Instituto de Desenvolvimento da Pesca Artesanal* or IPA). There are currently 20 fishing cooperatives in the municipality of Soyo, with a total of 545 active fishermen. Of these 545, a total of 375 (68%) are from the *comuna* of Soyo (Pereira 2011).

Due to the relatively low catches and the minimal infrastructure for the artisanal fishing industry, fishermen struggle to sustain themselves and their families. Additionally, as most of the effort is focused in shallow waters near the shore, much of the catch consists of immature fish which use these areas as nursery grounds. This affects recruitment to breeding populations and is probably unsustainable over any appreciable length of time (decades). These two facts highlight the lack of long-term sustainability of the local industry as it is currently functioning.

6.3.6 Industry

The key industry in Soyo and all of Zaire Province is the oil and gas sector. Since 1965, the petroleum industry has made large investments in Soyo due to significant reserves offshore from the area. Activities are currently located on Kwanda Base, the logistical centre in Soyo (see **Figure 6-10** below).

The petroleum sector, along with its support economy, generates the largest part of revenue in the region, causing a ripple effect on small businesses in town (INE 1995). To date, there are no other big industries in Soyo outside of oil and gas. This sector alone supports a series of small and medium enterprises (SMEs) in the area both directly and indirectly by stimulating commerce. There are 16 SMEs in the Soyo Municipality linked to the oil industry, and 78 other SMEs that extend to other commercial sectors.

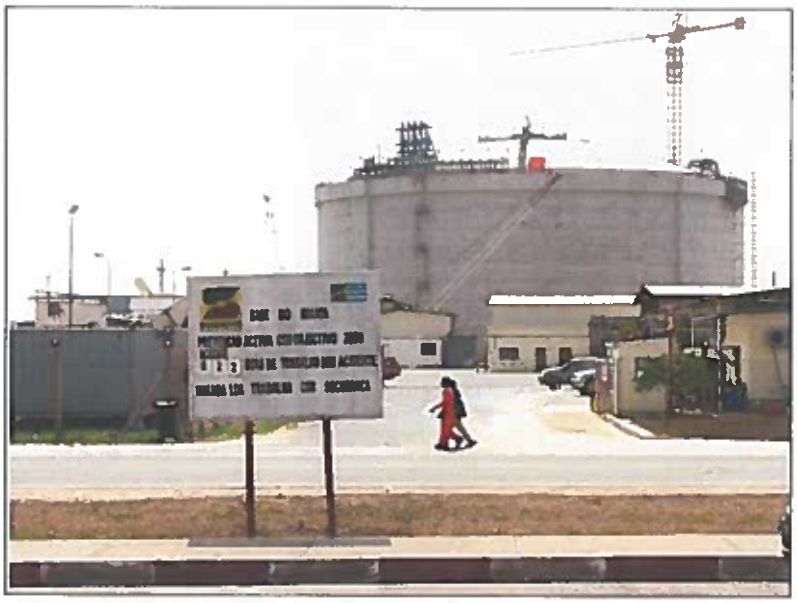

Figure 6-10: Kwanda Base in Soyo, the centre point for the oil industry in the region.

Within the last five years, the Angola Liquefied Natural Gas Project (ALNG) has spurred new economic stimulus in the area. During this time there has been an increase in demand and spending by the private sector, though there has been no notable increase in the public sector. Formal and informal commerce has augmented, especially those related to the oil and gas sector but also including the hospitality and services sectors.

The principle types of economic activities in Soyo relate to construction, transport, communication, trading, banking and finances, public sector establishments and governmental institutions. Beyond these fields, many locals are involved in informal trading that takes place in the streets or the one market in the Soyo *comuna* (Agriar, 2011).

It is notable that Soyo has been designated by the Government of Angola as one of six industrial growth centres in the country. With the ALNG Project as a catalyst, it is predicted that other possible industries will establish in the area including power generation, metal and chemical plants and related secondary industries (Angola LNG, 2006).

6.4 Political and Institutional Context

6.4.1 Political Structure

The institutional context the proposed project within the Soyo *comuna* can be understood in terms of international, national and local levels. At the national level, legislative framework exists to protect social and environmental standards and many relate to this proposed development project. These laws are discussed in the legal section of this ESHIA. Luanda, Angola´s capital, serves as the governmental headquarters for law-making.

At the regional level, Zaire Province has a total of 7.010 public functionaries, with no corresponding data available for Soyo specifically (MAPESS, 2010). The highest authority at the provincial level is the Provincial Government of Zaire based the provincial capital, M´Banza Congo, inland from Soyo. Soyo Town serves as the base for both Soyo Municipality and Soyo *comuna*. Administrative structures for both levels are located in the town centre where ARC consultants visited (see Figure 6-11 below).

Figure 6-11: Close-up Map of Soyo Town highlighting Administrative Offices.

6.4.2 Political Participation

Decision-making traditionally is allocated to the community leader, called the s*oba*, guided by his Deputy Soba and Adviser. Depending on the gravity of the issue at hand, the Soba may decide to call a community meeting where all are able to vote and voice their opinions. Respondents indicated that both women and men are included in community decision-making processes, yet women less so than men. On average, 74% of women participate, as do 81% of youth. Only one respondent mentioned the political participation of minorities, stating that 100% are involved in community discussions.

6.4.3 Community Vulnerability

A community's vulnerability can include its exposure to conflict and natural disasters as well as oil spills. Based on interviews with community representatives, ARC consultants found that 87% of communities did not have any inner conflicts and 91% did not have any conflicts with outside groups or entities. An estimated 39% of the communities were located near military zones, though there is no war in Angola or involving Angola at this time. Thus, none were located near conflict zones. In addition, about one-third of the communities responded that they were prone to natural disasters, namely strong winds that occur annually and destroy some housing and trees. One community stated their previous exposure to an oil spill.

6.4.4 Transparency and Corruption

In terms of transparency in Angola, corruption is still relatively high and significant barriers exist for citizens. Since the end of the war in 2002, the government has taken several measures to introduce financial transparency regarding the management of its petroleum and mineral wealth, however, reforms are seen as incomplete and obstacles still abound. The Extractive Industries Transparency

Initiative (EITI) has still not been signed by the Angolan government (Revenue Watch 2011). In Soyo, a series of key stakeholders were asked to comment on corruption in the region. Most commented that corruption levels were medium-high and answers varied from pinpointing the areas of corruption to just business while others included politics.

6.5 Community Resources and Social Infrastructure

The social resources and infrastructures in the province relate to health, education, transportation and roads, amenities like gas, water, electricity and waste management, communications, and housing. The social services in Soyo are listed in Table 6-11 below. As the health portion is covered in the Health Baseline Study in the following section, the topic will not be discussed in this portion of the Social Baseline Study.

6.5.1 Education

Educational standards in Soyo are slightly higher on average than in other parts of the province, though huge challenges still exist. According to António José Mpemba of the Department of Education for the Soyo Administration, the literacy rate in Soyo Municipality is 70%. Women tend to have lower levels of literacy as local social norms still place slightly more emphasis on boys' education over girls'. Questionnaires with local women revealed a 56% literacy rate for women.

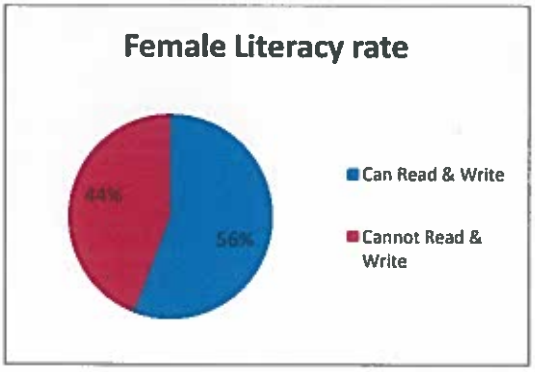

Figure 6-12: Literacy Rate of Women in Soyo based on interviews.

Site visits confirmed the locations of many of the educational facilities in the area, as highlighted by Figure 6-13 below. Note that most communities are located nearby the main road heading southwards from the airport and urban centre. Schools are commonly located along this main throughway.

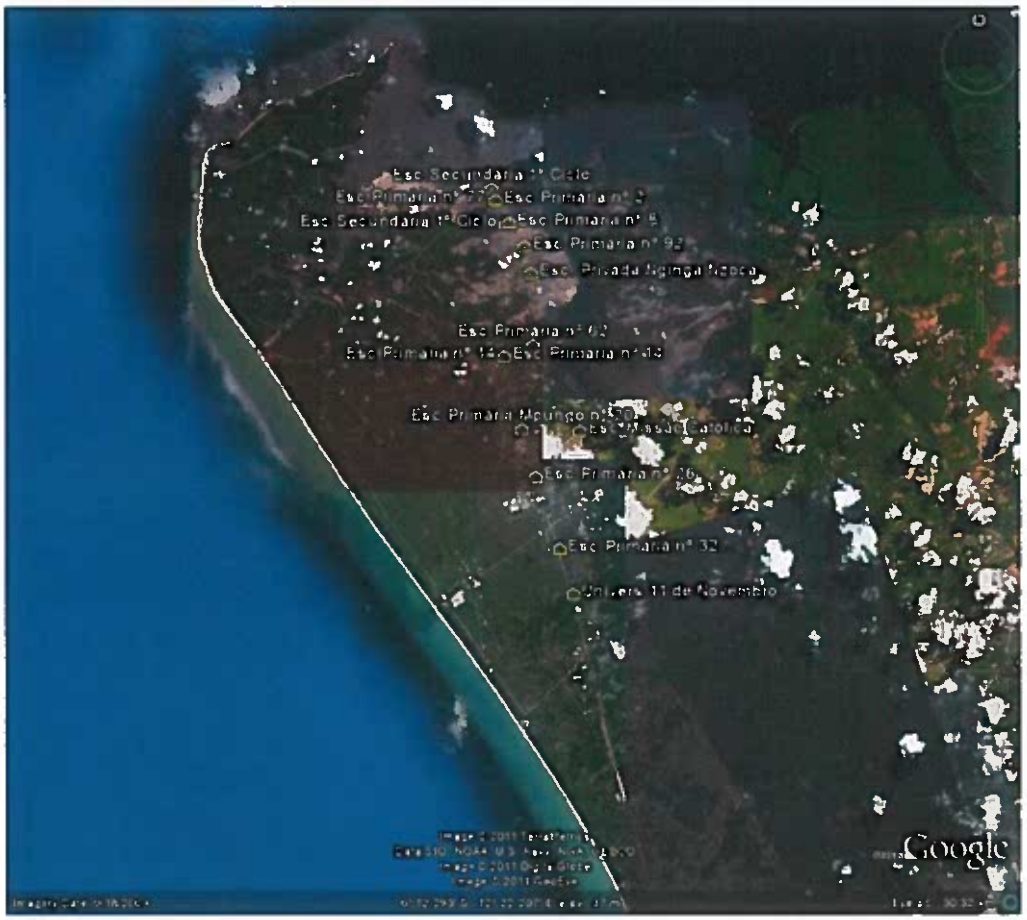

Figure 6-13: Map of Schools in Soyo *Comuna*.

Most schools are public and sponsored by the state. The large majority of the schools in Soyo Municipality are primary level and are located in the *comuna* of Soyo (see Table 6-10 below). There is only one university. The lack of education beyond primary level was noted as a major concern for locals.

Table 6-10: Number of schools in Soyo.

Type of School	Primary	Secondary	Tertiary	University	Other
Soyo *Comuna*	26	6	3	1	n/a
Soyo Municipality	59	9	4	1	n/a

Currently, 17,348 children in Soyo have access to school and 12,179 do not. Of those lacking access to school, 7,416 children are of primary school age (6-10), 3,763 of secondary school age (10-14), and 1,000 are of tertiary school age (14-18). In Soyo *Comuna*, the student-teacher ratio is 36-1 in primary schools, 24-1 in secondary schools, and 43-1 in tertiary schools. The ratio for university is not known. No data available about how many children are economically active, or the average cost of sending a child to school.

There is no public transportation for students in Soyo at this time. As such, children walk on average 1-2km each way to get to school. For some, the distance is too far and they do not attend. The island communities, for example, do not have a single school and students are obligated to take a long boat ride into Soyo Town in order to study.

Infrastructure for schools is in need of repair and many children still lack facilities with adequate classroom space to learn. Class sizes on average range from forty to sixty students. Educational needs include new classrooms and schools, access to water and electricity for the facilities and learning materials. Despite some government efforts to improve the educational system by building some new schools, large deficiencies still persist. Figure 6-14 below depicts a typical structure of an old colonial school building in Soyo as well as a newly-constructed facility nearby yet to be utilized.

Figure 6-14: Primary school in a community south of Soyo town centre (left); new school yet to be inaugurated near Soyo.

6.5.2 Transportation

As in the rest of Angola, the civil war destroyed or severely damaged much of the physical infrastructure in Soyo. Roads in the Municipality are generally in poor condition, with few of them asphalted outside of Kwanda Base and Soyo Town. The 15km section of the main Soyo road running from Kwanda Base to Pangala in the south is tarred, but does not have sidewalks. Public transportation via busses is limited, as busses are highly irregular, of poor quality, and do not reach many communities outside of the immediate urban area. Interviews with community members in the rural communities farther south revealed that public busses do not reach the area and private buses (called *taxis*) are prohibitively expensive (approximately $10 USD for an hour drive to the City).

One domestic airport is based in the center of Soyo, servicing regular flights to and from Luanda, M'Banza Congo and Cabinda. There are two ports in Soyo, a commercial port on Kwanda Base and the other on Bubu peninsula.

6.5.3 Utilities

Regular access to utilities like water, gas, electricity and waste services is rare. In Zaire Province, only 15% of the population has piped water, whereas 25% use a fountain and 32% an unprotected well for their primary water source (INE, 2007). Potable water is obtained in the Soyo Municipality from inlets of the Congo River, some of which is treated prior to distribution at the filtration plant east of Pinda Mission that opened in 2000. Water is delivered via trucks to inhabitants in certain parts of Soyo Town center and the houses of close by communities; however, supply is irregular due to limited tank capacity among other factors.

According to the local administration, 4,000 families are served by the public water supply. Others use fountains located approximately every 500 m along the main road between Soyo and Kitona; otherwise wells, lakes and rivers supply the freshwater for locals (Komba, 2011). Interviews with 74 local women showed that 35% use a public well, 28% buy water, and the rest collect rain, use the river or borrow from a neighbor; only 1% claimed use of municipal water. The time they take each day to fetch water for their families ranges from less than 1 hour to more than 2, as seen in Figure 6-15 below.

Figure 6-16 depicts young women along the main road in Soyo collecting water in plastic buckets from a public faucet.

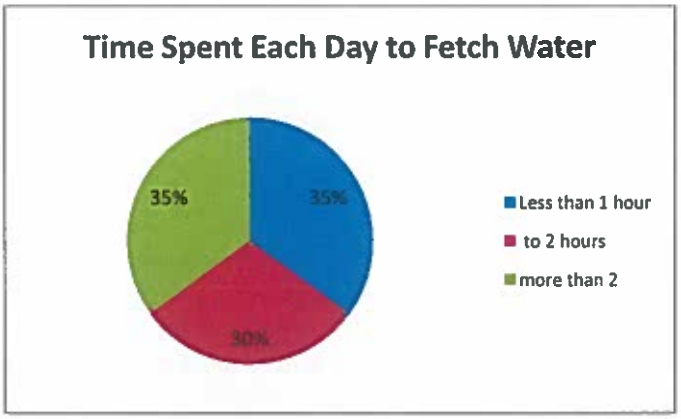

Figure 6-15: Graph of women´s daily time spent on fetching water.

Figure 6-16: Young women in Soyo municipality collect water from a public faucet in buckets.

Sanitation facilities are very limited in the area. In Zaire Province, only 11% of inhabitants have access to a WC, 4.1% to a sceptical tank, and 66% to a basic latrine (INE, 2007). No sewage treatment plant exists in the Soyo Municipality. About two thirds of the households surveyed in 2005 revealed that they did not have access to improved facilities[7] and depended on open air latrines or traditional latrines. Households in Kikala Kiako and Soyo Town communities have the highest percentages of households with access to improved facilities, whereas more rural parts of the Soyo, notably fishing and then agricultural and fishing communities have the lowest (ERM, 2005 quoted in ARC/SRK, 2007).

Energy sources in Zaire for lighting and cooking vary. Most households in the region use petroleum for lighting and firewood for cooking. Only 22.5% of households in Zaire Province use electricity for illuminating their homes (INE, 2007). In Soyo, 3500 homes have access to electricity through the municipal network, covering only the centre of the city. Energy comes from a gas plant in Pangala

[7] According to UNICEF and WHO (2004) improved sanitation facilities are those ensuring privacy and hygiene use i.e. indoor facilities connected to a sewer and improved latrines. Open air and traditional latrines are not improved.

community run by the company Somoil (Komba 2011). As the majority of Soyo residents are left outside of the electrical system, few manage by purchasing generators while some others make illegal connections for access.

Waste collection services are very limited for Soyo, most residents either burn or bury their household trash. Of the communities surveyed, about one-quarter listed the use of public or private dump for disposing of their solid waste, whereas others burn, bury or even throw their waste in the ravine or river.

6.5.4 Communications

Communication in Soyo is restricted due to infrastructural limitations. The most common form of communication is via cellular phone, though networks do not reach many areas. Landlines telephone connections are scarce, and postal services are minimal if not absent. Internet use is limited to those urban areas with network and to those with electricity and means for a computer. Statistics on communications are currently only available at the national level. In Angola 3.3% of the population are internet users, 44% cellular phone users, and there are 2 telephone lines per 100 people (World Bank 2009).

6.5.5 Housing

In Zaire province, 64.9% of the houses are owned, 21.5% are rented, 12.3% are property of family or friends, and 1.3% are occupied. The majority of the homes are simple with only one or two bedrooms. Most commonly houses are made out of adobe from local earth (82.4% of homes in the province) with dirt floors (77.4%) and galvanized metal sheet or grass roofs (65.3% and 25.9%). Within Soyo, housing can be divided into five types: architect-designed apartments, conventional houses, traditional houses/huts, annexed compartments and *barraca*/shacks (see Figure 6-17 below). A higher proportion of communities on Kwanda Island and Soyo Town live in apartments and conventional dwellings. Traditional houses are the most common overall in Soyo (ARC/SRK, 2007).

Most families build their own home within the community's terrain and add to it over time. There is little to no help from the government in supplying materials or connecting homes to water, electricity or sewage systems, which as aforementioned, are scarce. Some recent government efforts to provide housing, like the youth housing complex below, show improvements in the sector.

Figure 6-17: Housing in communities south of Soyo town centre. Typical cement blocks home (left); newly constructed houses for young couples (right).

6.5.6 Social Services and Resources

Within Soyo there are a range of social services, including accommodation, administration, education, entertainment, government, industry, emergency (fire and police), medical, recreational, religious, and retail services. A summary of these services is provided in the Table 6-11 below. It should be noted

that most of these services are based within Soyo Town, and the farther out from the nucleus of the town, the less quantity of services are available.

Table 6-11: Social services in Soyo.

Type of Service	Description
Accommodation	A few hotels and guesthouses are available for travelers in the Soyo Town area, including Hotel Porto Rico and the new 4-star Hotel Nempanzu.
Administrative	Administrative services include an employment centre (MAPESS), a local newspaper, banks, a library, and government offices (such as traffic and the municipal administration offices).
Education	Education services include a primary school, a secondary school and also a school for pre-university. In 1995, there were approximately 25 schools in the Soyo Area. Most of these (22 schools) provided basic education up to Level 3.
Entertainment	Entertainment services include several restaurants/bars, a number of coffee shops and discos/bars.
Emergency Services	*Fire Services*. There is one fire station in the Soyo. *Police Services*. There are two police stations including the station for the Municipal police (*Comando da Policia Nacional Municipal*).
Medical	There are 29 medical services in the Soyo area, with a total of 255 hospital beds and 16 doctors. Refer to the Section on Health for more information.
Government	There are two municipal buildings including the Department of Fishery and Environmental Ministry and the Municipal Court.
Industry	There are a number of industry services including construction companies, a furniture factory and petrol stations.

Source: Celeste and Virgilio (2005) quoted in ARC/SRK 2007.

6.5.7 Culture and Lifestyle

Cultural life in Soyo includes religious practices, cultural sites, leisure activities and typical diet. Data that is not available for Soyo specifically is substituted by data for data relating to Zaire Province or in some cases to Angola.

Religious Practices

In Angola, religion is an important part of life. The majority (70.1%) of people claim to be Catholic or Protestant, with most of the rest of the population practicing various tribal religions (IPAD). In Soyo as in much of the country, these two religious systems, traditional ancestral worship and Christian practices, are combined. Beliefs are expressed by respect for sacred sites, including graves and cemeteries, as well as the practice of traditional music, dance and rituals. Ninety-five percent of communities have at least one church within their boundaries. Structures range from old colonial architecture to newer and more colourful buildings (see Figure 6-19). These churches are located mostly along the main road heading south from Soyo Town towards the communities of Kitona and Tombe (see Figure 6-18 below).

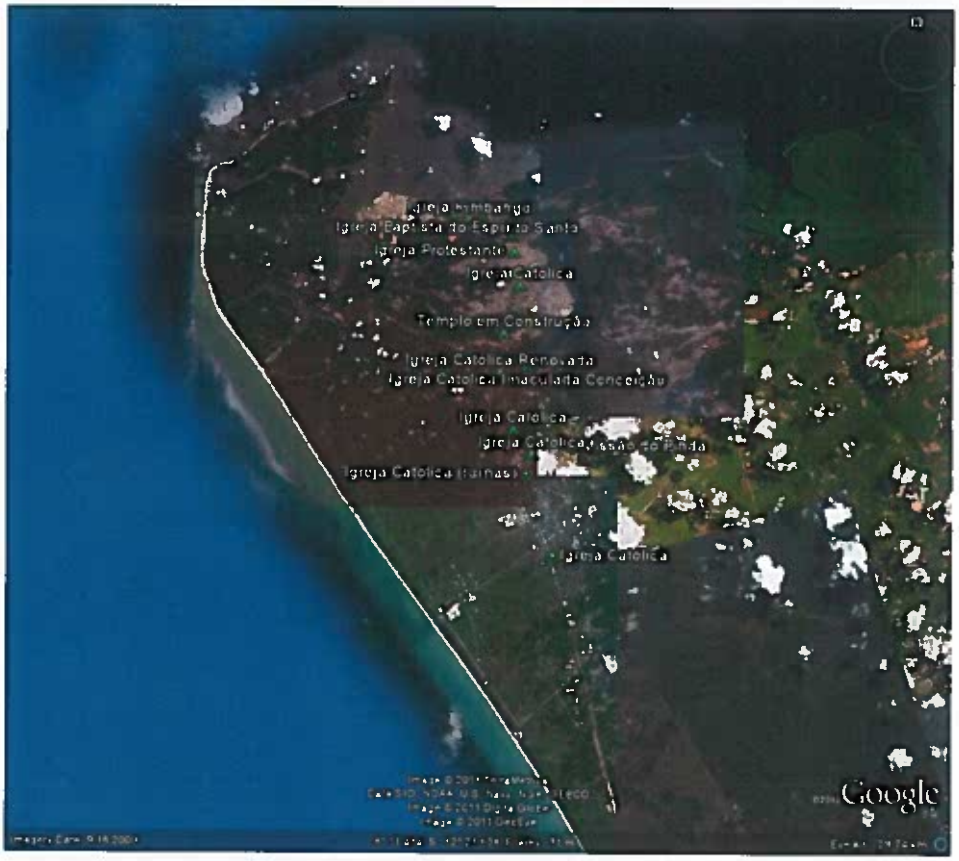

Figure 6-18: Map of Church locations in Soyo.

The major churches in Soyo are the Roman Catholic, Baptist, Kimbanguist[8] and Tocoist,[9] where religious leadership structures of priests, nuns and pastors, are well defined. A total of 46 Christian churches are registered with the local government, and it is estimated that over 80 percent of the Soyo population belong to a church such as the Catholic (53 percent), Evangelical (30 percent), Kimbanguist (11 percent) and Tocoist (4 percent) churches. There is a small Islamic community in Soyo (Household Survey 2005 quoted by ARC/SRK, 2007).

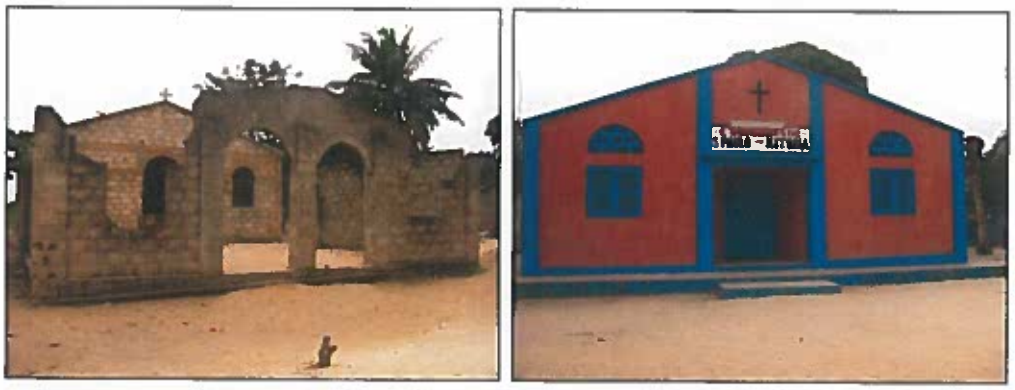

Figure 6-19: Local churches in Soyo *Comuna*.

[8] One of the newer churches in Angola founded in Nigeria.
[9] An Angolan church founded perhaps 100 years ago by Simão Toco, regarded as a prophet by his own people and seen as a threat by the colonial state. He was imprisoned and exiled in southern Angola, where he died. His followers were persecuted by the colonial state for a period of time.

Religion also serves as a social forum, especially for women. It is common for women to be involved with the running of the church and to join women´s church groups. In Figure 6-20 below, women from one church gather with their matching head scarves and wrapped-fabric skirts (*panos*).

Figure 6-20: Women belonging to a local church group in Soyo.

Cultural Sites

Soyo is rich with cultural heritage as the number of sites can attest. Surveys suggest that there are 52 cultural sites throughout the Soyo municipal area (Table 6-12). An important symbol to the local peoples is the *Sereia*, a mermaid closely associated with the history and cultural identity of the area. Each year in September during the dry season, a group of *sobas* and community members visit the *Sereia* in the Holy Forest (*Finda a Mvemba Pangui*) near Kindombele to pray for rain. Other sites of major cultural significance include:

- Mermaid's Sanctuary –marked by a miniature building of reeds and wood (*Vela Kiam Pangui)* and a site near Pangala *(Vela Kia Soyo*), one of the main areas in Soyo where prayers are offered to the mermaid.
- Graveyard of the Kings (*Cemeterio dos Reis*) –a holy burial site of two kings and a queen who lived in the region prior to the arrival of the Portuguese in the area of land belonging to the Kindombele alde. Situated north of the Mermaid Sanctuary, this site is also visited at the same time the Mermaid Sanctuary is visited.
- Grave of the Messenger (*Dokuta Die Kunka/Sukama*) –located between the Graveyard of the Kings and the inhabitants of the Soyo, representing the messenger or go-between the Kings and the people. Marked by a mound of earth on the Kindombele road, the grave is found in the area of land belonging to the Kilumbo community.
- Sacred Mermaid Areas –situated in land belonging to the Wolo (*Vela Kia Mabumina* and *Vemba Suama Suama*) and the Kilumbio (*Vela Kia Kime Yundo, Vela Kian Kuampi* and *Vela Kya Kuzo*). The Sacred Mermaid Area called *Vela Kia Kime Yundo* is a simple wooden shelter located close to the village of Kintambi. These areas are visited by people from Soyo to evoke the spirits and make requests or pray for rain.

- Sacred Mermaid Bush (*Vela Kie Ekakata*) –an area of bush, about 240m² in extent, where the Mermaid is believed to reside. The area is situated in the land belonging to the Kikudo community near the settlement of Kintambi.

Table 6-12: Cultural sites by village owning site, Soyo

	Village Owning Site	Type of site	Local Name
1	Kindombele	Mermaid's Forest	*N'Finda a Mvemba Pangui*
2	Kindombele	Mermaid's Sanctuary	*Vela Kiam Pangui*
3	Kikudo	Cemetery of the Kings	*Cemeterio dos Reis*
4	Wolo	Sacred Mermaid Area	*Vela Kia Mabumina*
5	Wolo	Sacred Mermaid Area	*Vemba Suama*
6	Kilumbo	Sacred Mermaid Area	*Vela Kime Kya Yundo*
7	Kindombele	Burial Ground of the Messenger	*Dokuta Die Kunka/ Sukama*
8	Kilumbo	Sacred Area	*Vela Kya N'Kuampi*
9	Kilumbo	Sacred Mermaid Area	*Vela Kya Kuzo*
10	Kikudo	Sacred Mermaid Area	*Vela Kya Ekakata*
11	Songo e Tona	Grave of one of the great grandfathers of the community	*(With no particular name)*
12	Kinganga Mavakala (abandoned village)	Cemetery	*Antigo cemiterio do Kinganga Mavakala*
13	Mongo Soyo	Sereia Area (one of the main areas where prayers are made)	*Vela Kia-e-Soyo*
14	Kitona	Historical site	*Vemba Kóndo-Kóndo (Kondo-Kondo is a subarea of Kitona)*
15	Kitona	Cemetery	*Jiamy-Kia-Kitona*
16	Kitona	Historical site	*Vela Kian N'Dundo*
17	Pinda (Evata)	Cemetery	*Pinda Evata Ceemetery*
18	Pinda (Evata	Historical site where ancestors of Mpinda Evata lived	*Vela Kya Nvuembanga*
19	Pinda (Evata)	Historical site (where Virgin Mary was seen by a village resident) many years ago.	*Historically known as Malu-Ma-Madya (visited widely by many historians)*
20	Pinda (Evata)*	Historical site	*Vela Kia Nkanka*
21	Mongo Soyo*	Historical site	*Vela Kia Kinjimba*
22	Mongo Soyo*	Historical site	*Vela Kia Biugu*
23	Kimpange*	Cultural site	*Vela Kie Ekakata*
24	Mongo Soyo*	Historical site	*Vela Kia Kinjimba*
25	Mongo Soyo*	Historical site	*Vela Kia Biugu*
26	M'Pungo**	Historical	*Ximby Kya-M'Pungo (*)*
27	M'Pungo**	Cultural	*Jami Kiamabala*
28	Kimpange**	Historical	*N'Ximba Yo-N'Zuzu*
29	Pangala**	Historical	*N'zo-a-N'Kixi*
31	Pangala**	Historical	*Jiamy Kia Akukulu*
32	Pangala**	Historical	*Vela Kya Esoyo*
33	Pangala**	Historical	*N'Finda Esoyo*
34	Pinda**	Cultural	*Lendo Kikanoa*
35	Pinda**	Historical	*Porto do Pinda (Port of Pinda)*
36	Pinda**	Historical	*Missao Catolica*
37	Kinganga**	Historical	*Vela Kia-Mavakala*

	Village Owning Site	Type of site	Local Name
38	Kinganga**	Cultural	*Kilolo*
39	Kukala Kiako**	Cemetery	*Ancient cemetery (since 1955)*
40	Tuko**	Historical site	*Vela Kia Sambi a Kumbi*
41	Tuko**	Cemetery	*Segue dia Massanga*
42	Tuko**	Cemetery	*Kingalo Kia Pungui*
43	Tuko**	Cemetery	*Kissambo*
44	Tuko**	Cemetery	*Kindembi*
45	Tuko**	Cemetery	*Kimpungui*
46	Tuko**	Cemetery	*Banza*
47	Tuko**	Cemetery	*Vela Kia Sambi Ankumbo*
48	Wolo**	Cemetery	*Wembua*
49	Wolo**	Cemetery	*'Wolo'*
50	Kikudo**	Cultural site	*Vela Kya Kuampe*
51	Kungueyengele**	Historical site	*Kumbo Nganga*
52	Tari-Tari**	Historical site	*Tumulo do soldado desconhecido*

Notes: *The Rei do Povo (People's King), four advisors (one of whom is also a *soba*) and 20 other *sobas* identified some of the major sites in Soyo Municipality during the first Soba consultation meeting during site selection; **New sites identified in survey work undertaken in November 2005.

Source: Comerford (2005) quoted in ARC/SRK 2007.

Leisure Activities

Recreational activities in the Soyo area are typically centered on youth. About half of the communities in the *comuna* have their own sports field, where football is played daily. Though fields are made of dirt and little to no infrastructure exists to support the game, these fields are an important site for communities. In addition, almost all communities have some type of recreation centre, typically a simple building that serves for meetings, parties and other festivities. Not a single community surveyed had an organization that promoted arts, culture or sports. Adults are likely to pass their free time visiting with each other and sharing a local drink called *samba*, made from the fermented sap of the palm tree.

Typical Diet

The typical diet in the area varies slightly depending on the location of the community, as coastal residents, for example, consume higher amounts of fish. Foods commonly consumed include fish and some meat, cassava and sweet potato, beans and some vegetables. In addition, sesame seeds (*gergelim*) are commonly consumed as well as fruits like oranges and bananas. When interviewed, almost all respondents said the typical dish in their communities was fish accompanied by *funge* – a starch made of fermented cassava flour and water. The leaves of the cassava plant are also commonly consumed in a cooked dish called *kizaca*.

7 Health Baseline

7.1 Introduction

The objective of this baseline health study is to give an overview of the status of the community health in the Soyo region. In order to gather these results, desk-based research was utilized including literature searches via Pubmed and Google. Information was collected on prevalence and incidence of diseases (countrywide, Zaire Province, Soyo region), aetiology and transmission, disease presentation and diagnosis, treatment, prevention and interaction with other diseases. In addition, primary data was collected by means of 3 personal interviews: one with Dr. Mariano and J. Pedro from the Municipal Department of Health (Mariano and Pedro 2011); one with Dr. G. Diwampovessa (clinical director) and Dr. M. Mpemba (general director) from the Muncipal Hospital in Soyo (Diwampovessa and Mpemba 2011); and one with I.P. Malila (nurse) from the health centre in Pinda (Malila 2011). Although these data were collected by means of a primary data collection technique (interviews), some of the responses on the questions might actually be based on secondary data (reports, statistics), although the respondents did not disclose the sources for these. In addition to the interviews with the health professionals, a group of 77 women was interviewed individually on several issues, including health issues (prenatal care, birth, postnatal care, malaria and health care seeking). All of the women interviewed were from small communities in Soyo *Comuna*.

The diseases included in this baseline health assessment comprised those diseases identified for the Soyo region as the key health issues through a health study conducted by ERM in 2005 and through our primary data collection. Furthermore protein-energy malnutrition and road traffic accidents were included because of their high burden of disease in Angola, in terms of mortality and/or morbidity. In addition viral haemorrhagic fevers and poliomyelitis were added because of recent outbreaks, as well as injury due to violence, alcohol and other drug abuse and dependence as these are important issues in areas with high economic development.

Key limitations of this study relate to the nature of the desk-research as well as the scarce, often self-reported, information available on the Soyo region in the literature. In the primary data collection: a lot of the information requested by the interviewers could not be given by the respondents – probably because the information is not available. Despite these limitations, this document gives the most recent information currently available and of importance to establishing the health status of the communities in the Soyo region, and serves as a baseline for a Health Impact Assessment for this region.

7.2 Health System

7.2.1 Health Service Indicators Angola

The quality and effectiveness of a country's health care system can be understood in terms in government spending on the sector. In Angola, health expenditure is considerably lower than that of the average for Sub-Saharan African countries, with 3.3% of total GDP compared to a regional average of 6.1% (Table 2-2). However, in contrast to the region, public sector financing dominates (85%) and Angola is less dependent on out of pocket (15%) and donor funds (3%).

In terms of effectiveness of health care, some indicators Angola scores better than the average for Sub-Saharan Africa: access to improved sanitation facilities, immunisation rate, TB case detection rate, antenatal care, births attended by skilled health staff. However, for others it scores worse: number of health staff, access to an improved water source, malaria prevention and treatment, TB success rate, Vitamin A supplementation. Table 7-1 below highlights these comparisons.

An attempt was made to collect information on these indicators on the level of Soyo municipality in the primary data-collection. However, most information was not retrieved and the available information

was in general not in the same format (expressed per population) hampering direct comparison with (inter)national level. Therefore, the information collected on these issues will be presented at the relevant sections throughout this health baseline chapter.

Table 7-1: Health service indicators.

Indicator [year]	Angola	Sub-Saharan Africa
Health system		
Health expenditure: total % of Gross Domestic Product [2008]	3.3	6.1
Public % of total [2008]	85.0	42.9
Out of pocket % of total [2008]	15.0	36.5
External resources % of total [2008]	3.0	9.3
Physicians per 1000 people [2004-2009]	0.1	0.2
Nurses and midwives per 1000 people [2004-2009]	0.4	1.0
Hospital beds per 1,000 people [2004-2009]	0.8	-
Disease prevention coverage and quality		
Access to an improved water source: % of population [2008]	50	60
Access to improved sanitation facilities: % of population [2008]	57	31
Measles immunisation rate: % of children 12-23 months [2009]	77	68
DTP-3 immunisation rate: % of children 12-23 months [2009]	73	70
% of new-borns protected against tetanus [2009]	88	-
% of children <5 sleeping under treated nets [2004-2009]	17.7	20.2
% of children <5 with fever receiving antimalarial drugs [2004-2009]	29.3	34.4
TB treatment success rate: % of new registered cases [2008]	70	79
TB case detection rate: % of new registered cases [2008]	75	48
Reproductive health		
% of pregnant women receiving prenatal care [2004-2009]	80	71
% of births attended by skilled health staff [2004-2009]	47	44
% of births attended by skilled health staff ratio of richest 20% to poorest 20% [2000-2009]	3	-
Nutrition		
Vitamin A supplementation: % of children 6-59 months	28	81

Indicator [year]	Angola	Sub-Saharan Africa
% of children exclusively breastfed (<6 months) [2005-2009]	11	-

Note: Components may not sum to 100% because of rounding.

Sources: World Bank 2011a, UNICEF 2011.

7.2.2 Health System Assessment Angola

In 2005 the Partners for Health Reform*plus* project (PHR*plus*) – the predecessor to the Health Systems 20/20 project (HS 20/20) – conducted a Health System Assessment (HSA) in Angola to inform USAID/Angola's health sector programming (Connor, Rajkotia *et al.* 2005). In 2010 this exercise was repeated. Information from the 2010 study is used in this report.

The national health system consists of the Ministry of Health (MINSA) and the national service delivery network of both public and private providers which include for-profit and non-for-profit organizations. In 2001, the Government of Angola officially launched a policy of political and administrative decentralization. MINSA has taken this policy a step further through its district health strategy that calls for shifting more management responsibility to Angola's 164 districts and resources to the primary health care system.

Health service delivery is divided into three levels of care with the corresponding levels of government responsible for their delivery included **Table 7-2** below.

Table 7-2: Levels of health care and responsible governmental level.

Level of health care	Government level	Responsible for
Primary	Municipal	Municipal hospitals Health centres Health posts Company health units
Secondary	Provincial	Provincial hospitals Private (mainly religious) hospitals
Tertiary	National government	National and specialized hospitals

Source: Connor, Rajkotia et al. 2005.

7.2.2.1 Health Service Delivery

Coverage of basic health services increased from 30 to 42% since 2005. Public funding of primary care facilities grew faster than any other category. Geographic access has increased thanks to the renovation and construction of health centres, in many cases based on the provincial health maps, and some experience using private sector services to reach populations. The application of health system regulations and introduction of provincial health maps clarified standards for levels of care, services, and facility types that allowed objective evaluation of facility performance. Quality of service delivery is being addressed through development of clinical standards, and evolving experiences with facility accreditation. Service delivery is still afflicted by human resource issues, stock-outs of essential products, and uneven funding of recurrent costs.

7.2.2.2 Health Financing

Angola spends an estimated US$ 72 per capita on health per year, about the same as the regional average. In contrast to the region, public sector financing dominates (85%) and Angola is less dependent on donor funds (only 3% of total health expenditures compared to the regional average of 9.3%). Public financing for primary care increased dramatically (415%) from 2000 to 2005. However public spending on health overall remains low at five percent of total public spending, far below the regional average of 9.6%. Management of health financing is in transition as the country implements the decentralization strategy that will shift responsibility for planning and spending health budgets to the districts. Provincial health maps are now guiding infrastructure investment and operational decisions, though one was not found for Soyo. Public primary care facilities no longer charge user fees, but funding to replace user fee revenue has been uneven. Private health insurance options have emerged since 2005 targeting companies and upper income households. The major challenge is financing of non-salary recurrent costs (drugs, water, fuel, and supplies) at the primary care level in the face of rapid decentralization. These inputs are critical to improve service quality and avoid out-of-pocket expenditures.

7.2.2.3 Human Resources in the Health Care Sector

The same human resource issues originally highlighted in 2005 are cited as major constraints in 2010: low and/or narrow clinical skills, underserved rural areas, doctor shortage, few medical schools, limited quality supervision, and few community-based health workers. Progress since 2005 includes tripling the number of doctors (up to 2,956 in 2009), building several new medical schools (though staffing is a challenge), establishing a functional payroll system (public employees generally paid on time), and including community health workers in MINSA's district health strategy. Lack of funds for recurrent costs (e.g., fuel) and vertical programming, hamper integrated supervision and training of primary care staff, and ultimately limit opportunities to increase efficiencies and address clinical realities.

7.2.2.4 Medicines and Medical Products

The National Medicines Policy was adopted in 2010 indicating the opportunity for significant improvement in medicines management. Stock-outs of medicines and commodities in the public sector to support service delivery remain a challenge. Currently, MINSA still manages the procurement and distribution, including the essential-medicines-kit program, but problems include poor information systems, delayed national procurements, lack of an operational registration system, and limited quality assurance. In the face of these challenges, provinces are increasingly managing their own medicines outside of the kits system and at least one donor has resorted to a private distribution system.

7.2.2.5 Health Information System

Angola has acquired new and valuable heath information in the form of studies of priority health issues and the provincial health maps. MINSA and donors have worked closely to build provincial and facility capacity to use data and improve data quality. MINSA is championing birth registration and maternal death audits. However, there are significant delays and restrictions on the release of public health information, and one-way flow of information hinders data use and quality. For example, annual health statistics reports are not available since 2007. Individual patient records are a rarity at the primary care level, making it an obstacle to ensure clinical quality. A notable gap is the lack of a national census since the 1970s. Since 2001, MINSA has endeavoured to establish a single harmonized Health Information System (HIS) and database for routine health system data. The Health Metrics Network's recently completed assessment and the district health strategy represent fresh opportunities to build a harmonized, integrated, well-used HIS.

7.2.2.6 Health care in the Soyo municipality

An extensive situational analysis of the healthcare system in the Soyo region conducted by ERM in 2005, supports the findings of the USAID assessment (ERM 2006). Key findings from the ERM analysis were:

- Local public healthcare providers are under capacity in terms of equipment, facilities, training opportunities and staff.
- Limited availability of transportation hampers access to healthcare facilities, especially for communities located south of Soyo.
- Overall, there is a high number of beds available and trained staff in the area relative to other areas in Angola. However, these figures include staff and bed availability in the private sector which are not available to all members of the public. The municipal hospital operated by the state is the main referral hospital in the area where specialist care is available. However, the hospital staff report that medicine is scarce and equipment old. There is no isolation room for contagious patients. As there is no ambulance in the municipality, transport to the hospital is dependent on the patient and their family.

The following information was retrieved from the interviews conducted with the staff members of the Municipal Department of Health and health institutions (Mariano and Pedro 2011, Diwampovessa and Mpemba 2011, Malila 2011). The health services that are available in Soyo municipality, by sector, type of facility and service provision are presented in the table below. Below Table 7-3 , a map shows the location of health centres in Soyo *Comuna* (Figure 7-1).

Table 7-3: Health services in the Soyo *Comuna* and municipality.

Sector	Types of facility	Number in *comuna*	Number in municipality	Provision
State (open)	Municipal Hospital	1	1	Secondary and tertiary care, paediatric care, laboratory facilities
	Health Centres	6	10	Primary care, antenatal care, paediatric care, nutrition, laboratory facilities
	Health Posts	2	20	Primary care
	Nurse posts	17	17	-
Private (restricted)	Clinics	6	6	Primary and secondary care, paediatric care
	Health Centres	8	8	-

Source: Mariano and Pedro, 2011.

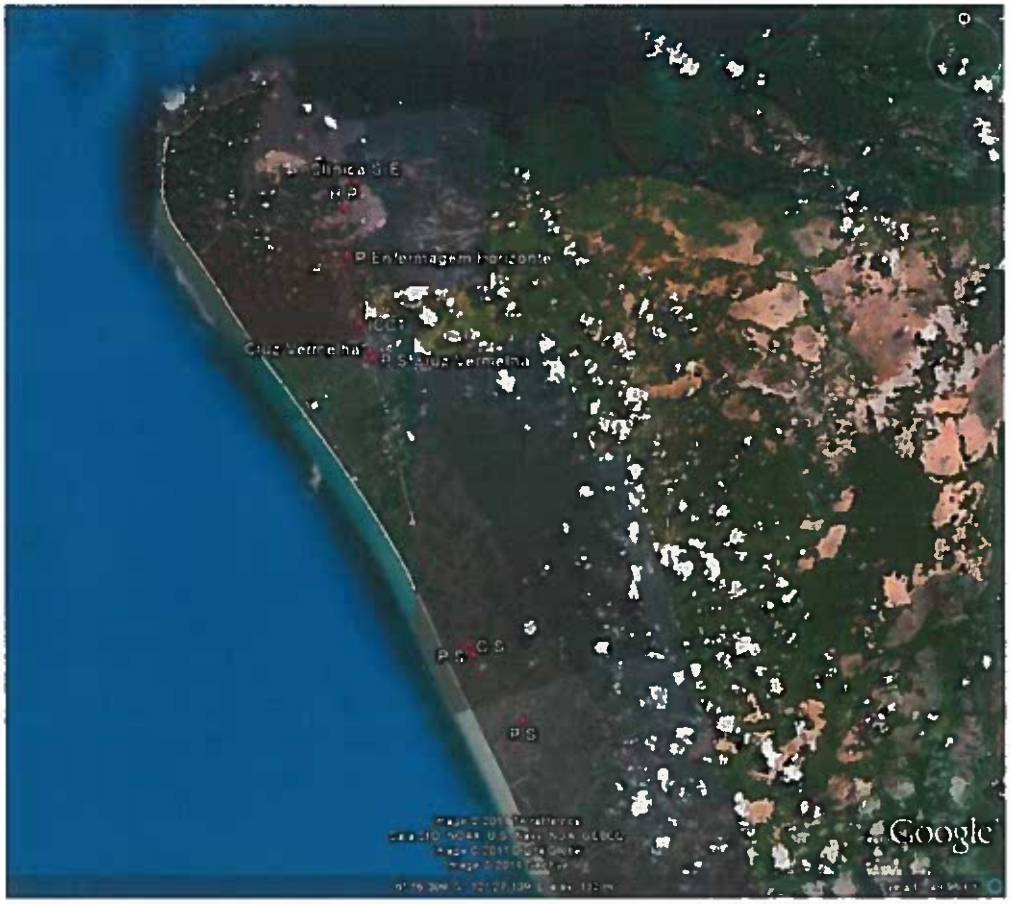

Figure 7-1: Map of Health Centres identified during Field Research.

It was noted that when people have health problems there preferences are to go to the church first, then to the pharmacy, then to the traditional healer and finally to the hospital. However, of the 68 women that answered the question where they accessed health care, 65 (96%) indicated to seek medical help at the hospital, and only 3 (4%) elsewhere (catholic mission, health centre). Traditional healers are reported to often provide health care to members of the community. Community members are said to be encouraged to use government facilities by the fact that there is a doctor or nurse present and because they are treated well in the hospital. Illiteracy is mentioned as an aspect that discourages members of the community to use these facilities, as well as the distance and lack of transport, and the costs of treatment. The private facilities are not considered to be better than the public facilities, although in private facilities they provide better customer service. None of the public health units had stock out of indicator drugs at the moment of the interview. And the cost of medical care is thought to be affordable to most members of the community. Drugs are free, which is made possible through a Drug Revolving Fund financed by government in the Soyo municipality hospital, and through the support of various organizations in the Pinda health centre.

Regarding prenatal health care, local women responded that 56 (85%) had some form of care whereas (10) 15% did not. The provider of this prenatal care, for those who responded affirmatively, was in most cases the Soyo hospital; others attended smaller health clinics, the catholic church or mission, the central hospital in Cabinda or M´Banza Congo. Few visited traditional midwives or the catholic church (see Figure 7-2 below).

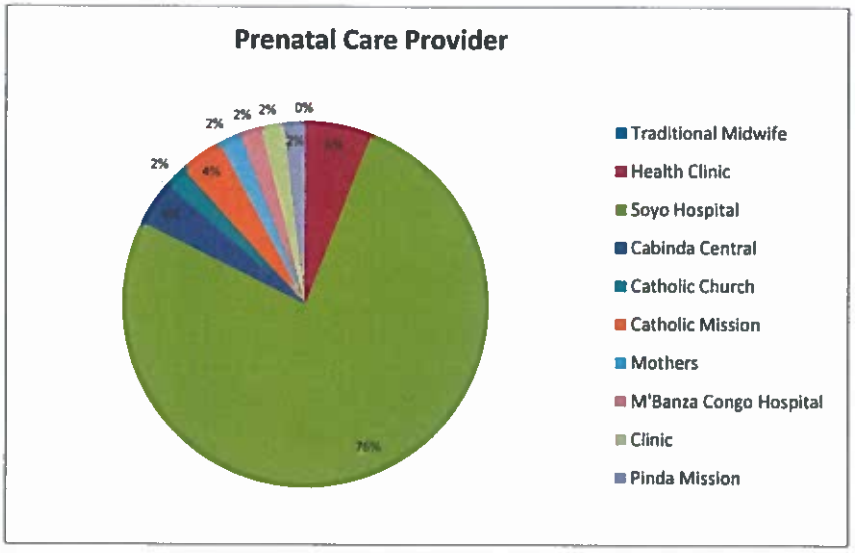

Figure 7-2: Graph of prenatal care providers to local women in Soyo.

The following numbers of health staff are available in Soyo municipality: 16 registered doctors, 226 registered nurses, 50 registered midwives, 132 traditional birth attendants and 30 community health workers. When this is expressed per 1000 population (assuming that the population number is correct), the ratio for doctors is 0.5 and that for nurses and midwives 2.3, both figures being higher than the country average. Despite this, the number of doctors, nurses and midwives are not considered enough to satisfy the health care demand.

In addition to the health services indicated above, there are local organizations/NGOs (community investment department of the ALNG project, SOS Cedia) in the area with activities focussing on health (mainly general health care including malaria and HIV/AIDS) and development: awareness, voluntary HIV testing, malaria diagnosis and treatment and supply of bed nets.

There are awareness, education and/or prevention programmes present in Soyo. But no (general) health issues awareness studies, Knowledge, Attitudes and Practices (KAP) studies and studies on sexual behaviour have been conducted. However, some information on sexual behaviour was provided by the health professionals: Premarital sex is common and so is polygamy. Abortion is not socially acceptable, but common in the Soyo hospital area, although not common in the area of the Pinda health centre. People are aware of how HIV is transmitted, but condoms to prevent HIV and other sexually transmitted infections are seldom used, although they are available at any health unit for free.

7.3 Health status

7.3.1 Health Indicators Angola

The estimated average life expectancy in Angola is only 48, less than the average for other Sub-Saharan African countries (Table 7-4). Infant and under-five mortality rates are high at 98 per 1000 and 161 per 1000, higher than the average for other Sub-Saharan African countries. Adult mortality rate is 406 for males and 350 for females, and the maternal mortality rate 610 per 100,000. Both the female mortality rate and the maternal mortality rate seem so be somewhat lower than the average for other Sub-Saharan African countries. Again an attempt was made to collect information on these indicators on the level of Soyo municipality in the primary data collection. However, not all information was retrieved and the available information differed considerably between the interviews and from what would be expected when looking at the national level, so these data were not considered valid.

Table 7-4: Health status indicators.

Indicator [year]	Angola	Sub-Saharan Africa
Life expectancy at birth (years) [2009]	48	53
Healthy life expectancy at birth (m/f)	32/36	-
Neonatal mortality rate [2009]	42	-
Infant mortality rate (per 1000 live births) [2009]	98	81
Under five mortality rate (per 1000) [2009]	161	130
Adult mortality rate (per 1000) [2005-2009]	406 (males) 350 (females)	390 (males) 358 (females)
Maternal mortality rate (per 100,000 live births) [modelled, 2008]	610	650

Source: World Bank 2011a, UNICEF 2011.

These poor health indicators reflect a series of contributing factors such as a lack of access to health services, clean water, means of excreta disposal, personal and food hygiene, food security, housing, household income and health care knowledge and practices in communities and households (Connor, Rajkotia *et al.* 2005).

7.3.2 Burden of Disease

The WHO compiles a Burden of Disease Report which is updated regularly (WHO, 2008a). The most recent data is from the year 2004 and for Angola is almost exclusively based on estimates due to a lack of available country-level data.

For *mortality* the top ten causes of death (per 100,000 population) are:

Lower respiratory infections	484.4
Diarrhoeal diseases	345.2
Malaria	137.4
Neonatal infections and other conditions	88.8
Protein-energy malnutrition	74.0
Maternal conditions	70.0
Prematurity and low birth weight	67.8
HIV/AIDS	66.3
Birth asphyxia and birth trauma	64.4
Cerebrovascular disease	63.6

Morbidity is measured by Disability Adjusted Life Years (DALYs). The DALY is a health gap measure that extends the concept of potential years of life lost due to premature death to include equivalent years of 'healthy' life lost by virtue of being in states of poor health or disability. The DALY combines in one measure the time lived with disability and the time lost due to premature mortality. One DALY can be thought of as one lost year of 'healthy' life and the burden of disease as a measurement of the gap between current health status and an ideal situation where everyone lives into old age free of disease and disability. For *morbidity* the top ten causes of DALYs lost per 100,000 of the Angolan population are:

Lower respiratory infections	15,709
Diarrhoeal diseases	11,364
Malaria	5,012
Maternal conditions	3,294
Neonatal infections and other conditions	3,099
Protein-energy malnutrition	3,070
Birth asphyxia and birth trauma	2,960
Prematurity and low birth weight	2,481
Road traffic accidents	2,020
HIV/AIDS	1,972

Both mortality and morbidity data show that communicable diseases including lower respiratory infections, diarrhoeal diseases, malaria and HIV/AIDS, are significant causes of both death and disability in Angola. The same can be said for the non-communicable diseases protein-energy malnutrition, maternal conditions and perinatal conditions (prematurity and low birth weight, birth asphyxia and birth trauma, neonatal infections and other conditions).

7.3.3 National Health Priorities

The Angolan government has identified a number of national priority health issues and the following programmes have been developed to address these:

- National Strategic Plan for Sexually Transmitted Infections and HIV/AIDS 2007-2010;
- National Malaria Control Strategic Plan 2008-2012;
- National Tuberculosis and Leprosy control programme;
- 2011 Expanded programme on immunization - operational plan;
- Integrated management of childhood illness;
- National programme for trypanosomiasis control;
- National plan for road accident prevention (in development).

In 2005 ERM conducted a household survey in the Soyo region to identify the key health issues for those who were sick in the 90 days before the survey (ERM, 2006). The key health issues identified for the Soyo region were:

- Respiratory illness;
- HIV/AIDS;
- Sexually Transmitted Infections;
- Malaria;
- Tuberculosis;
- Diarrhoea;
- Sleeping sickness.

The key health issues (in terms of mortality) in Soyo municipality were the following according to the interviews with the health professionals (Diwampovessa and Mpemba 2011, Malila 2011):

- Malaria;
- Diarrhoeal diseases (including dysentery);
- Pneumonia (respiratory infections);
- Typhoid fever;
- Chickenpox;
- Cancer;
- Tetanus;
- Tuberculosis;
- HIV/AIDS; and
- Cerebrovascular accident (stroke).

7.3.4 Diseases

The diseases included in this baseline health assessment include those diseases identified for the Soyo region as the key health issues. Furthermore protein-energy malnutrition and road traffic accidents were included because of their high burden of disease in Angola, in terms of mortality and/or morbidity. In addition viral haemorrhagic fevers and poliomyelitis were added because of recent outbreaks, as well as injury due to violence, alcohol and other drug abuse and dependence as these are important issues in areas with high economic development. Note that cancer, the maternal conditions and the perinatal conditions were not included as these are very broad.

Questions on other health problems (e.g. illnesses caused by chemical and physical agents, mental and physical disability) and some health risk factors (e.g. tobacco and alcohol consumption) were included in the primary data collection tool, but no information was retrieved on these issues.

The information presented below is primarily based on the desk-based research and where applicable data from the primary data collection is added.

7.3.4.1 HIV/AIDS

Aetiology and transmission

The Human Immunodeficiency Virus (HIV), a retrovirus, is the causative agent in the Acquired Immunodeficiency Syndrome (AIDS). HIV is transmitted sexually (75%), via infected blood and intravenous drug abuse, and perinatally (from mother-to-child during pregnancy, labour and breastfeeding) (Longmore, Wilkinson et al. 2007). In Angola, HIV-1 is the viral type responsible for most, if not all, cases. Heterosexual transmission is the predominant route of infection in the country, with a male-to-female ratio of 0.8:1, indicating that women are more likely to be infected than men (UNAIDS 2004). Contaminated needles, medical devices, and blood transfusions are the second largest spreader of HIV/AIDS, although more specific research in this area is needed. Mother-to-child transmission currently accounts for approximately 15% of HIV cases.

Prevalence and incidence

Countrywide

The Global Report (The UNAIDS report on the Global AIDS epidemic 2010) shows that the AIDS epidemic in Angola is stable (UNAIDS, WHO 2010). In 2001 the incidence rate among adults 15-49 years was 0.22% (0.17-0.28%) and in 2009 this was 0.21% (0.14-0.28%). The prevalence rate among adults in this age group was 1.9% (1.4-2.4%) in 2001 and 2.0% (1.6-2.4%) in 2009. The total estimated number of people (adults and children) living with HIV was 140,000 (110,000 – 190,000) in 2001 and

200,000 (160,000 – 250,000) in 2009. In 2001 the number of AIDS related deaths among adults and children was 10,000 (6,500 – 14,000) and this was 11,000 (7,700 – 16,000) in 2009.

The Burden of Disease study indicates that there were 66.3 AIDS deaths per 100,000 and 1,972 DALYs lost per 100,000 in 2004 (WHO 2008a). In 2008 2% of deaths in children under 5 were due to malaria (Countdown to 2015, 2010).

The World Development Indicators report that for 2009 the prevalence of HIV (15-49 years) was 2.0%, of which 60% were females (World Bank 2011a). Prevalence among youth (15-24 years) was 0.6% among males and 1.6% among females. These prevalence figures are lower than for the average of the Sub-Saharan countries (5.4, 1.5 and 3.8% respectively).

Zaire Province

Data collected from women attending antenatal clinics suggests the intensity of the HIV epidemic varies among Angola's different provinces (USAID 2011). Zaire province is not among the 5 provinces mentioned as having the highest prevalence rates in the country. A press release reporting on the year report of the provincial programme of AIDS states that in 2010 444 cases of HIV/AIDS were recorded and 22 deaths (ANGOP 2011a). According to the document, these numbers were 459 and 22 respectively in 2009.

Soyo region

Data is limited on HIV prevalence/incidence in Soyo. Press releases on the year reports of the provincial programme of AIDS state that in 2009 144 cases of HIV/AIDS were recorded in Soyo and in 2010 276 cases (ANGOP 2010a, ANGOP 2011a). Furthermore, health professionals working in the area report that there are 'high levels' of HIV/AIDS (ERM 2006).

Disease presentation and diagnosis

Acute infection with HIV is often asymptomatic and is followed by seroconversion which may be accompanied by a transient illness of 2 to 6 weeks (Longmore, Wilkinson et al. 2007). Later, progression to AIDS occurs when the immune system fails and the CD4 (immune cells) count drops to below 200 X 10^6/litres. AIDS is characterised by indicator diseases caused by opportunistic infections (infections that a healthy immune system can prevent). Diagnosis is confirmed by a blood test to detect anti-HIV antibodies. Saliva test-kits are also available but false-positive results tend to be relatively common. The Centres for Disease Control and Prevention is currently assisting the national laboratory systems in Angola to validate reapid HIV tests (CDC 2010d)

USAID, in partnership with the Angolan Ministry of Health and the Associação do Bloco 15, including Esso Angola, inaugurated an HIV/AIDS Voluntary Counselling and Testing (VCT) clinic in Soyo, Zaire province, on July 10th, 2006 (USAID 2006). This clinic, which is a new addition to Soyo's Regional Hospital, is the first facility of its kind in the Zaire province. Its purpose is to help the people of Soyo know their HIV seroprevalence status, and make decisions and lifestyle choices based on that information.

According to the HAMSET project, in 2010 their were 547 VCT centres functional in the country and 200 centres that offered prevention of mother to child transmission services (World Bank 2011).

Treatment

Untreated, death from AIDS will follow within approximately two years (Longmore, Wilkinson et al. 2007). Highly active anti-retroviral treatment (HAART) significantly slows the progression to AIDS, allowing the HIV-positive individual to remain well and, importantly, economically productive for considerably longer periods of time. The 2010 WHO guidelines for resource-constrained settings recommend beginning HAART once the CD4 count drops to 350 or below (WHO 2010a). Angola took

over this recommendation as well as is actively shifting from Stavudine based to Zidovidine- or Tenofovir-containing regimens as recommended by the WHO (WHO, UNAIDS, UNICEF 2010). The Estimated ART coverage based on WHO 2010 guidelines was 24% (19-32%) in 2009. In the country there are 133 centres that provide HAART to adults, 120 to children and 209 deal with prevention of vertical transmission (ANGOP 2011d).

Although the number of people receiving ARV therapy in 2009 has increased eightfold from 2004, only 53% of the estimated number that would need treatment by 2007 was actually on treatment in 2009 (UNDP 2009). With the new guidelines on ARV treatment that were released on November 30th 2009, it can be expected that the number of people needing ARVs is going to increase substantially. The new guidelines recommend that ARVs be started at the higher CD4 threshold of 350 cells/mm^3; earlier in the pregnancy at 14 weeks, and continue through to the end of the breastfeeding period. This is inevitably going to increase the estimates of the need and demand for ARVs in the country.

Prevention

Strategies to prevent transmission of the virus are based on the biological, social and environmental factors driving the epidemic. Current WHO recommendations for prevention, based on the best evidence, include:

- The A, B, C triad: Abstinence, Be Faithful, Condomise;
- Promotion of Voluntary Counselling and Testing (VCT);
- Treatment of other Sexually transmitted Infections;
- Reduction in alcohol and drug use (disinhibition results in risky behaviours).

According to the 2005–2006 Knowledge, Attitudes and Practices (KAP) study among young people (15 to 24 years old) in six provinces, found younger and more educated youth were more likely to use condoms than older and less educated youth (USAID 2011). According to the 2009 KAP study, 53.5% of men and women aged 15-24 reported use of condom in their last act of sexual intercourse with a non regular sexual partner during the previous 12 months (World Bank 2011c).

PSI started its HIV/AIDS prevention program in 2000 by promoting risk-reduction and safer sexual behaviours (PSI 2011). By 2001, PSI launched Legal brand condoms and in 2004 added a second branded male condom, Sensual. To date, more than 61 million condoms have been sold between the two brands. PSI has also produced numerous behavior change campaigns and materials and has provided technical assistance and training to over 20 national partner nonprofit organizations (NGOs) in implementing community-based interpersonal communications activities with high-risk groups such as commercial sex workers, truckers, police and youth. In 2011, PSI/Angola launched two new HIV prevention projects – one continuing to cater to Most At Risk Populations (MARPs) and the other focusing on HIV prevention among members of the General Population, including youth. The MARPs project will continue to promote risk-reduction and safer behaviours among target high risk groups such as commercial sex workers and their clients, truckers and, for the first time in Angola, men who have sex with men. HIV prevention among members of the general population, including youth, will also include prevention work with mobile men with money, workplace training programs to promote safer behaviours within the general population as well as a radio program promoting the reduction of risky behaviours among youth.

Interaction with other diseases

Tuberculosis

An individual who is HIV-positive and infected with TB bacilli is many times more likely to become sick with TB than someone infected with TB bacilli who is HIV-negative (WHO 2010b). TB is a leading

cause of death among people who are HIV-positive. In Africa, HIV is the single most important factor contributing to the increase in the incidence of TB since 1990.

In Angola, tuberculosis (TB) co-infection with HIV is a major concern (USAID 2011). TB is the leading cause of death among people who are HIV positive. Nineteen percent of newly diagnosed TB patients are also HIV positive.

Sexually Transmitted Infections

There is an association between STIs and both the acquisition and transmission of HIV infection. As a result of immunosuppression, HIV may increase the duration and severity of other STIs, particularly Herpes Simplex Virus-2 (HSV-2). STIs enhance the likelihood of HIV acquisition due to the presence of genital lesions, as well as increasing HIV transmission as a result of increased viral shedding (Ward and Rönn 2010).

Malaria

Malaria is more common and severe in adults with HIV, pregnant women, and children (Reithinger, Kamya, et al. 2009). HIV viral load is greater in women with placental malaria, and infants born to women with both HIV and placental malaria are of greater risk of premature delivery, low birth weight, or death compared with infants born to women with HIV infection alone. Malaria causes increased HIV viral load in blood and breast milk and reduced CD4 cell count. Malaria treatment is less effective in non-pregnant adults with HIV.

Malnutrition

Poor nutrition compromises the body's immune system, reducing the ability to fight infection. In HIV-positive individuals poor nutrition promotes progression to AIDS. Treatment with HAART is most effective when coupled with a healthy diet.

7.3.4.2 Malaria

Aetiology and transmission

Malaria is a parasitic infection caused by a plasmodium protozoa, injected by the Anopheles mosquito into humans (Longmore, Wilkinson et al. 2007). Plasmodium falciparum is the parasite responsible for more than 90 percent of malaria infections in Angola (AMIS 2007). Malaria transmission is greatest during the rainy season and peaks between January and May. The three vector species most involved in transmission are *Anopheles gambiae*, *A. funestus*, and *A. melas*.

Prevalence and incidence

Countrywide

In 2009 there were 3,726,606 suspected malaria cases reported, 2,221,076 probable and confirmed cases, and 10,530 malaria attributed deaths (WHO 2010c). According to data from the Angola Malaria Indicator Survey which was conducted in 2006-2007, 19.5% of children between 6 months and five years were positive for malaria; 28.8% in hyperendemic areas (including Zaire province) (COSEP Lda. *et al.* 2007). For pregnant women these figures were 14.2% and 17.9% respectively.

The 2004 Burden of Disease data report 137.4 malaria deaths per 100,000 and 5,012 DALYs lost per 100,000 (WHO 2008a). In 2008 8% of deaths in children under 5 were due to malaria (Countdown to 2015, 2010).

Zaire Province

Malaria is hyper-endemic in the Zaire province. According to a model based on the AMIS data, the percentage of children under five with malaria parasites is 20.92 (country figure 23.38) (Gosoniu, Veta et al. 2010). A press release reports that according to the provincial malaria supervisor Zaire province

had 20,604 cases and 98 deaths in the first quarter of 2010, 4,628 cases more than in the same period in 2009 (ANGOP, 2010b).

Soyo region

According to the ERM report, malaria is the key cause of mortality and morbidity in the Soyo region. In 2003, there were 13,268 suspected cases of malaria, with 589 considered serious. No information is provided on the definition of 'serious' but it is assumed that these cases may have been of the cerebral form (ERM, 2006). The ERM report also provides data specific to 2003 hospital admissions with 25 deaths reported from malaria, all in children aged less than five years. These figures are likely to be a significant under-estimation due both to the likelihood of poor record-keeping and that deaths would occur prior to hospitalisation or in areas where access to healthcare is limited. These figures are supported by the 2005 household survey conducted in the Soyo region by ERM which found malaria to be the biggest cause for respondents to report being sick in the 90 days preceding the survey (ERM, 2006).

Out of the 77 women that were interviewed, 76 (99%) indicated that they had malaria (see Figure 7-3 below).

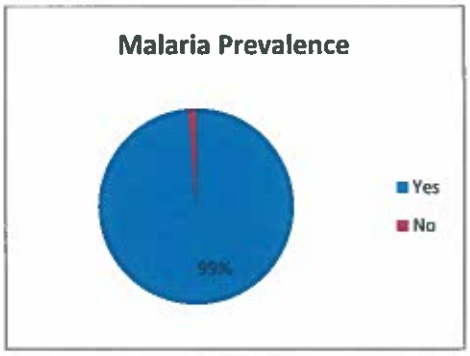

Figure 7-3: Prevalence of Malaria amongst women interviewed in Soyo.

Disease presentation and diagnosis

Acute infection with P. falciparum malaria follows 7 to 10 days after injection and presents with non-specific flu-like symptoms including headache, malaise, fatigue, muscle aches, loss of weight, fever and chills (Longmore, Wilkinson *et al.* 2007). The symptoms recur 36 to 48 hourly. Cerebral malaria is the most serious complication leading to confusion, coma and fits. Diagnosis is confirmed by a blood test to detect the parasite, but requires skill. Rapid tests are now available and are currently being implemented in Angola (ANGOP 2011e).

Treatment

Nearly all falciparum malaria is now resistant to chloroquine and increasingly resistance is developing to Fansidar (pyrimethamine and sulfadoxine) (Longmore, Wilkinson *et al.* 2007). The WHO recommends artemisinin-based combination therapies for treatment of uncomplicated P. Falciparum, which can also be used in children and during the 2nd and 3rd trimester of pregnancy (WHO 2010d). This treatment was introduced in 2006 in Angola (Africa news 2006). According to the AMIS data (which are from 2006/2007), among children age 0-59 months who were sick with fever, 29 percent received antimalarial drugs, and 18 percent were treated promptly (AMIS 2007). The vast majority of children given antimalarial drugs for fever received either chloroquine or amodiaquine (14 percent and 11 percent of children with fever, respectively).

All women (also the one that never had malaria) indicated where they would get malaria treatment: 71 (92%) in Soyo hospital, 4 (5%) in a health centre and 2 (3%) at the Catholic mission.

The goal of Angola's National Malaria Control Program (NMCP) strategic plan 2008-2012 is to reduce by 60% the impact of malaria by 2012 (WHO 2008e). Specifically, it focuses on the following interventions:

Artemisinin Combination Therapy (ACTs

Insecticide Treated Nets (ITNs)

Behavior Change Communication and Community Outreach

Health System Strengthening (Human Resources & Monitoring and Evaluation).

Prevention

The Roll Back Malaria (RBM) Initiative was launched by the WHO in 1998 to coordinate global actions against malaria (WHO 2006a). The RBM goal is to reduce the global malaria burden by half by 2010 as compared to 2000 and reaching near zero deaths from malaria by 2015.The RBM endorsed the Global Malaria Control Strategy which includes the following four objectives:

1. To provide early diagnosis and prompt treatment of malaria;
2. To plan and implement selective and sustainable preventive measures, including vector control;
3. To detect early, contain or prevent epidemics; and
4. To strengthen local capabilities in basic and applied research to permit and promote the regular assessment of a country's malaria situation, in particular the ecological, social and economic determinants of the disease.

Early diagnosis and treatment requires the local community and health professionals to have a high level of suspicion that flu-like symptoms could be malaria. Education and information is therefore essential to prevention efforts as prompt treatment reduces the pool of transmissible cases.

Vector control remains the key strategy to malaria prevention. Table 7-5 below highlights the control measures outlined by the RBM Global Malaria Control Strategy (WHO, 2006a).

Table 7-5: Malaria vector control measures.

Action	For individual and family protection	For community protection
Reduction of human-mosquito contact	Insecticide-treated nets, repellents, protective clothing, screening of houses	Insecticide-treated nets, zooprophylaxis
Destruction of adult mosquitoes		Insecticide-treated nets, indoor residual spraying, space spraying, ultra low-volume sprays
Destruction of mosquito larvae	Peri-domestic sanitation	Larviciding of water surfaces, intermittent irrigation, sluicing, biological control
Source reduction	Small-scale drainage	Environmental sanitation, water management,

Action	For individual and family protection	For community protection
		drainage
Social participation	Motivation for personal and family protection	Health education, community participation

Source: WHO 2006a.

Indoor residual spraying is an important component of efforts to control malaria transmission In Angola (AMIS 2007). From the households interviewed in the 2006-07 AMIS only 2 percent reported that the interior walls of their dwelling had been sprayed in the past year, principally as part of a government program (67 percent of sprayed households). The same study showed that one-third of households in Angola have at least one mosquito net, whether treated or untreated, and 14 percent have more than one net. 21 percent of children under 5 slept under some kind of net, 18 percent under an ever-treated net, and 18 percent under an ITN. Among pregnant women age 15-49 years, 25 percent slept under a mosquito net during the night before the survey, most under an ever-treated net (23 percent) or ITN (22 percent). The Multi Indicator Cluster Survey (MICS) which was conducted in 2008/2009 showed that only 16.4% of children under five slept under and ITN the previous night, however, the number of household with at least one ITN was found to be 66.7% (World Bank 2011c).

Of the 77 women that were interviewed, (35%) indicated that they used a mosquito net at home, whereas 65% indicated that they did not (see Figure 7-4 below).

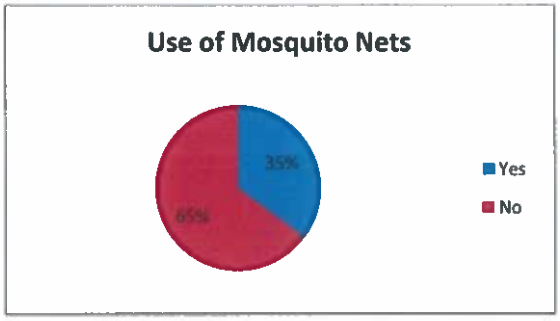

Figure 7-4: Use of Mosquito Nets based on Women's Survey in Soyo.

Interaction with other diseases

Malaria is more common and severe in adults with HIV, pregnant women, and children (Reithinger, Kamya et al. 2009). HIV viral load is greater in women with placental malaria, and infants born to women with both HIV and placental malaria are of greater risk of premature delivery, low birth weight, or death compared with infants born to women with HIV infection alone. Malaria causes increased HIV viral load in blood and breast milk and reduced CD4 cell count. Malaria treatment is less effective in non-pregnant adults with HIV.

7.3.4.3 Tuberculosis

Aetiology and transmission

Tuberculosis (TB) is a disease caused by the *Mycobacterium Tuberculosis* and is transmitted via the aerosol route. It is a disease of poverty, and transmission is encouraged by over-crowding living conditions. Left untreated, each person with active TB disease will infect on average between 10 and 15 people every year (WHO 2010b).

Prevalence and incidence

Countrywide

The incidence (new cases) of TB in Angola was 287 per 100,000 population per year in 2007, the prevalence 294 per 100,000, and the mortality rate 33 per 100,000 (WHO 2009a). The HIV prevalence in new TB cases was 19%. According to the World Development Indicators the incidence was 298 per 100,000 in 2009 (World Bank 2011a). According to the Burden of Disease Study, in 2004 TB was responsible for 26.4 deaths per 100,000 population, and 749 DALYs lost (WHO 2008a).

Zaire Province

A press release indicated that in the first quarter of 2007 Zaire province recorded 292 cases of TB, three of them resulting in death according to the supervisor of the TB and Leprosy Control Programme (ANGOP 2007a). The figure represents a rise of 22 cases in comparison to the same period in 2006. In the second quarter of 2007 766 cases were recorded, including three deaths, a decrease of 50 cases compared to 2006 (ANGOP 2007b).

Soyo region

From the 766 cases reported in the second quarter of 2007, 156 were recorded in Soyo (ANGOP 2007b).

Disease presentation and diagnosis

TB occurs as a primary infection in infants and children and then as a reactivation of disease in adults. It usually presents as a pulmonary (lung) disease with coughing (often blood-stained sputum), fever, night sweats, malaise and loss of weight and appetite (CDC 2010a). In HIV-positive patients, TB may occur in other organs and systems of the body (such as TB meningitis) and can be more difficult to diagnose.

Diagnosis of TB is based on a high degree of clinical suspicion and is confirmed by obtaining multiple sputum samples (in the case of pulmonary TB) and identifying the TB organism under the microscope ('smear-positive') (CDC 2010a). Skin tests and chest X-ray do not provide definitive diagnoses. Non-pulmonary TB requires identification of the TB organism in the relevant clinical samples. Definitive diagnosis can be difficult.

Treatment

Recommended first line drugs for treating TB are: Isoniazid, Rifampicin, Yrazinamide, Ethambutol and Streptomycin. The WHO guidelines for the treatment of TB recommend that new patients with pulmonary TB should receive a regimen containing 6 months of Rifampicin (WHO 2010e). Multidrug-resistant TB (MDR TB) is TB that is resistant to at least Isoniazid and Rifampicin (CDC 2010b). Extensively drug resistant TB (XDR TB) is defined as TB which is resistant to Isoniazid and Rifampin, plus resistant to any fluoroquinolone and at least one of three injectable second-line drugs (i.e., Amikacin, Kanamycin, or Capreomycin). Because XDR TB is resistant to first-line and secondline drugs, patients are left with treatment options that are much less effective. XDR TB is of special concern for persons with HIV infection or other conditions that can weaken the immune system.

According to the World Health Organization's (WHO's) Global Tuberculosis Control Report 2009, treatment success rates were between 68 and 74 percent between 2002 and 2005, and national data for 2007 show that the success rate is still within that range, still below the WHO target of 85 percent (USAID 2009). According to national data fewer than 1,000 cases of multidrug-resistant (MDR) TB have been detected in Angola; however, the actual prevalence is not known.

Prevention

Completing a full course of treatment under the WHO Directly Observed Treatment - Short course (DOTS) programme remains central to the public health approach to TB control (Heller, Gemmell et al. 2006). This is now presented as the Stop TB Strategy. The DOTS programme incorporates five elements: political commitment; case detection by sputum microscopy; standardized short-course chemotherapy; a sustained drug supply and a standardised recording and reporting system (Heller, Gemmell et al. 2006). Despite a global advocacy campaign for DOTS, a recent Cochrane systematic review of the results of clinical trials on the subject concluded that directly observed therapy compared with self-administered treatment had no quantitatively important effect on cure or treatment completion in people receiving treatment for tuberculosis (Volmink and Garner 2007). Although the research community is divided over this, the WHO has not altered their recommendations and continue to promote DOTS as the best preventive tool.

Regarding prevention of TB in HIV-positive people, another recent Cochrane review found that treatment of latent tuberculosis infection with Isoniazid prophylaxis reduces the risk of active TB in HIV positive individuals especially in those with a positive tuberculin skin test (Akolo, Adetifa et al. 2010).

Angola established the National Program for the Control of Tuberculosis (NPCT) in 1981 (USAID 2009). However, an analysis by the Ministry of Health (MOH) in 2007 found that the national program was implemented in only 8.6 percent of health units. However, according to the National Tuberculosis Control Program Report 2009, 100% of the 59 municipalities included in the study were implementing TB control activities (World Bank 2011c).

As of August 2009, 77% of the 112 municipalities had at least one DOTS facility (UNDP 2009). Furthermore, all the provinces in Angola now have at least one DOTS facility. There are a total of 197 DOTS facilities, which are distributed in 119 of the 164 municipalities of the country.

Vaccination with the BCG vaccine is also an option for TB prevention, although its effectiveness is decreasing. In Angola children are either vaccinated at birth or during a campaign (ANGOP 2009b).

Interaction with other diseases

An individual who is HIV-positive and infected with TB bacilli is many times more likely to become sick with TB than someone infected with TB bacilli who is HIV-negative (WHO 2010b). TB is a leading cause of death among people who are HIV-positive. In Africa, HIV is the single most important factor contributing to the increase in the incidence of TB since 1990.

In Angola, tuberculosis (TB) co-infection with HIV is a major concern (USAID 2011). TB is the leading cause of death among people who are HIV positive. Nineteen percent of newly diagnosed TB patients are also HIV positive.

7.3.4.4 Respiratory infections

Aetiology and transmission

Respiratory infections are transmitted via the aerosol (droplet) route and are caused by a variety of organisms including viruses, bacteria and fungi. Upper respiratory tract infections such as the common cold are primarily due to rhinoviruses whereas lower respiratory infections of the lungs (pneumonia) are usually due to bacteria (Kumar and Clarke 2009). In the case of community-acquired pneumonia, the responsible bacteria is most likely to be a *Streptococcus pneumoniae*. Other organisms causing pneumonia (responsible for 20% of cases) include *Mycoplasma*, influenza A virus, *Chlamydia* and *Coxiella Burnetti* (Kumar and Clarke 2009). TB is an important cause of pneumonia but is discussed separately as its mode of presentation and treatment are very different.

Close personal contact, overcrowding and poor ventilation facilitates the spread of respiratory infections (Kumar and Clarke 2009).

Prevalence and incidence

Countrywide

Respiratory infections account for significant mortality and morbidity in Angola, which reflects the global burden. Overall respiratory infections account for 491.7 deaths per 100,000 people with lower respiratory infections accounting for the bulk of this. DALYs lost due to respiratory infections account for over 15,969 DALYs lost per 100,000, again with lower respiratory tract infections making up most of this burden (WHO 2008a).

Zaire Province

No data was available specific to the province.

Soyo region

In the household survey conducted in Soyo, 3.5% of the respondents reported cold or flu symptoms in the 90 days preceding the survey (ERM 2006). This was the fifth most common symptom reported. Although pneumonic symptoms were not recorded in the survey, the investigators noted from interviews with healthcare providers in the area that respiratory infections are an important cause of ill-health in the area.

Disease presentation and diagnosis

Symptoms of respiratory infections depend on the location of the infection site with upper respiratory infections presenting with nasal symptoms and low fever (if any) and lower respiratory infections presenting with a high fever, pleuritic pain and cough (Kumar and Clarke 2009). Pneumonia is very often preceded by a viral infection. Incubation periods differ according to causative agents, but in the case of the common cold the period is less than 5 days (Kumar and Clarke 2009).

Diagnosis is made clinically and pneumonia is confirmed by chest X-Ray and blood tests, including blood culture. Sputum should be sent for microscopy and blood culture if possible (Kumar and Clarke 2009).

Treatment

Treatment of the common cold is supportive. Treatment of community-acquired pneumonia will require the administration of the correct antibiotic depending on the causative agent and should begin immediately without awaiting results of investigations (Kumar and Clarke 2009). In more than 20% of cases more than one organism is involved. A combination of bactericidal antibiotics that cover the commonest organisms should be used due to the high degree of resistance to Penicillin in many organisms (Kumar and Clarke 2009). For mild community-acquired pneumonia, oral treatment can be sufficient. Severe pneumonia will require hospitalisation with intra-venous antibiotics.

Angola is one of countries with the highest pneumonia burden. Despite this there is a large treatment gap (48 000 cases per year are not treated each year) (Marsh 2008). Furthermore, there is no community case management of pneumonia in place, i.e. management of respiratory infections and prescription of antibiotic by community health care workers, and also no permissive policy that allows community health care workers to do so.

And although pneumonia accounts for 18% of the deaths of children under-five in Angola, no data are available on the percentage of children under 5 with suspected pneumonia taken to appropriate health provider nor the percentage of children receiving antiobiotica, according to the Countdown to 2015 initiative (Countdown to 2015, 2010). This initiative tracks coverage levels for health interventions proven to reduce maternal, newborn and child mortality. It calls on governments and development

partners to be accountable, identifies knowledge gaps and proposes new actions to reach Millennium Development Goals 4 and 5, to reduce child mortality and improve maternal health.

Prevention

Prevention of respiratory infections depends on avoidance of contact with infected droplets. Hand-washing, disposal of tissues and handkerchiefs, adequate ventilation and avoidance of over-crowding are all important preventive measures.

Interaction with other diseases

People with advanced HIV infection are vulnerable to infections and malignancies that are called 'opportunistic infections' because they take advantage of the opportunity offered by a weakened immune system. One of these is bacterial pneumonia.

7.3.4.5 Sexually Transmitted Infections

Aetiology and transmission

Sexually Transmitted Infections (STIs) are transmitted through unprotected vaginal, anal or oral sexual intercourse. Both the receptive and penetrating partners are at risk of acquiring disease. Many organisms are transmitted sexually and common STIs include syphilis, gonorrhoea, chlamydia, HSV-2 and human papilloma virus (HPV) (WHO 2003). Hepatitis B (and C) is sexually transmitted, but can also be transmitted by infected blood or blood products (for example, by sharing of needles between intravenous drug users or through transfusions of unscreened blood) (WHO 2008b). Despite being considered an STI, the major clinical manifestations of hepatitis B (and C) are not in the reproductive tract. Unlike the others above, therefore, they are not termed reproductive tract infections (RTIs) (WHO 2005a).

Prevalence and incidence

Countrywide

Accurate statistics on STIs in Angola are difficult to come by. WHO estimates that, excluding HIV, STIs are responsible for 5.7 deaths per 100,000 people countrywide. Syphilis, gonorrhoea and chlamydia account for most of these, with syphilis alone accounting for 4.2 deaths per 100,000 (WHO 2008a). Hepatitis B is estimated to cause 3.5 deaths per 100,000 while hepatitis C is estimated to be responsible for 1.6 deaths per 100,000 (WHO 2008a).

With regards to morbidity, excluding HIV, STIs in general are estimated to be responsible for 461 DALYs lost per 100,000. Of these, syphilis accounts for 158, gonorrhoea 169 and chlamydia 112 (WHO 2008a).

Hepatitis B is estimated to cause 102 DALYs lost per 100,000 and hepatitis C 46 DALYs per 100,000 which is not very high, but the real impact of disability may be 'hidden' in other indicators such a chronic liver conditions, which is an endpoint of Hepatitis B and C.

A study conducted in Luanda showed that among pregnant women showed that 8.1% were infected by hepatitis B and 5.4% by syphilis (WHO, 2003).

Zaire Province

No data are available for Zaire Province.

Soyo region

In the household survey where participants reported their symptoms in the previous 90 days, no STI-related symptoms were reported to the investigators. This may reflect the stigma attached to such diseases and the fact that the survey was based on self-report rather than actual genital examination.

The same survey reveals that only a 122 out of over 12,000 people in the area reported experiencing hepatitis or jaundice in the 90 days preceding the survey (ERM 2006).

Disease presentation and diagnosis

Apart from the hepatitis infections, which are discussed in more detail below, most common STIs will manifest with genital lesions or symptoms.

Primary syphillis presents with an ulcer or chancre on the genitals at the site of inoculation. Secondary syphilis manifestations include a skin rash, condylomata lata (warts), mucocutaneous lesions (e.g. in the mouth) and generalised lymphadenopathy (swollen glands) (WHO 2005a). If these relatively early syphilis syndromes are missed, the disease can present up to decades later as late syphilis, usually with cardiovascular or neurological signs. Simple blood tests, like the RPR (rapid plasma reagin), exist for diagnosing latent syphilis (WHO 2005a).

Gonorrhoea is characterised by urethral discharge and pain on urination in the male and vaginal discharge in the female (Goering, Dockrell et al. 2007).

Chlamydia is most commonly asymptomatic but can cause urethritis or penile discharge in the male and cervicitis in the female (Goering, Dockrell et al. 2007).

Herpes Simplex Virus-2 causes vesicles on the penis or vulva that break down to form ulcers. Associated local lymph glands are swollen and fever, headache and malaise might be experienced (Goering, Dockrell et al. 2007).

Human Papilloma Virus causes warts in the penis, vulva or perianal regions (Goering, Dockrell et al. 2007).

Hepatitis B infections cause an acute disease with symptoms lasting several weeks. Signs of illness include: yellowing of the skin and eyes (jaundice); dark urine; extreme fatigue; nausea; vomiting and abdominal pain. Following acute infection it can take from several months to a year to regain normal health (WHO 2008b). Hepatitis B virus can cause chronic hepatitis which can progress to cirrhosis of the liver or liver cancer. Globally, it is estimated that about 17% of those infected with hepatitis B have progressed to chronic disease (WHO 2008b).

With hepatitis C the most common symptoms are fatigue and jaundice. The majority of cases (between 60% and 70%) are asymptomatic however (CDC 2010c).

The National Strategic Plan (NSP) for Sexually Transmitted Infections and HIV/AIDS 2007-2010 states that one of the strategies to improve the care for STIs is the compilation and dissemination of protocols for the diagnosis and treatment of these diseases (INLS 2006).

Treatment

Because of concerns about: a) the cost of confirming a diagnosis, b) human resource constraints and c) the fact that a laboratory diagnosis necessitates a repeat visit from the patient for a result and treatment, the WHO advocates syndromic management of sexually transmitted infections (WHO 2003).

Excellent guidelines for STI management exist (WHO 2003) and treatment is designed to cover the likely causative organisms of the major syndromes observed, namely:

- Urethral discharge;
- Genital ulcers;
- Scrotal swelling;
- Vaginal discharge; and

- Lower abdominal pain.

Acute hepatitis B and C do not have specific treatment and are managed conservatively. Chronic hepatitis B (or C) can be managed with antiviral therapy or immune-therapy but this is unlikely to apply in developing country settings (WHO 2008b).

Specific Aim 2 of the NSP is to reduce sexually transmitted infections (INLS 2006). This should be achieved by training of health staff in the treatment of STIs, standardization of the treatment and making sure that medication is in stock. Furthermore it is considered that the care for STIs, HIV and AIDS are integrated in a Program of Reproductive Health.

Prevention

Although not 100% effective, regular and consistent condom use is associated with statistically significant protection of men and women against several types of STIs, including Chlamydia infection, gonorrhoea, herpes simplex virus type 2, and syphilis (Holms, Levine et al. 2004).

A hepatitis B vaccine exists and is 95% effective in preventing the development of chronic infection in those who have not previously been exposed (WHO 2008b). There is no vaccine against hepatitis C (CDC 2010c).

The NSP highlights that there should be an intensification of the action of social mobilization and prevention of STIs in the form of massive interventions (INLS 2006).

Interaction with other diseases

There is an association between STIs and both the acquisition and transmission of HIV infection. As a result of immunosuppression, HIV may increase the duration and severity of other STIs, particularly HSV-2. STIs enhance the likelihood of HIV acquisition due to the presence of genital lesions, as well as increasing HIV transmission as a result of increased viral shedding (Ward and Rönn 2010).

7.3.4.6 Diarrhoeal diseases

Aetiology and transmission

Many organisms cause diarrhoeal symptoms. However, most of the severe outbreaks in Angola are caused by *Vibrio cholerae* (causing cholera) and *Shigella dysenteriae* (causing bacillary dysentery/shigellosis) (WHO 2005b). Other organisms responsible for diarrhoea include bacteria like *Escherichia coli* and *Salmonella spp*, protozoa like *Entamoeba histolytica* (causing amoebiasis) and *Giardia lamblia* (causing giardiasis) and viruses such as rotavirus and Norwalk virus (WHO 2005b).

All of the above organisms are spread via the faecal-oral route, particularly through drinking contaminated water or eating contaminated foods. It is also possible, and is especially relevant with respect to cholera, for an organism to be transmitted by direct person-to-person contact. Examples of such transmission would include nursing cholera patients or washing bodies of people who have died from cholera (WHO 2005b).

Cholera has a short incubation period, from a few hours to 5 days. It can be transmitted during the symptomatic phase and up to 3 days after recovery (WHO 2005b). Dysentery has an incubation period of between 1 to 6 days and can be transmitted during the diarrhoeal phase and up to 4 weeks thereafter. Appropriate treatment shortens this period to 2-3 days.

Prevalence and incidence

There is limited data on the distribution of these diseases. According to the Burden of Disease data there were 345.2 deaths due to diarrhoeal diseases per 100,000 and 11,364 DALYs lost per 100,000 in 2004 (WHO 2008a). In 2008 25% of all deaths in children under 5 were due to diarrhoea and 2% of all neonatal deaths were due to diarrhoea (Countdown to 2015, 2010).

The most extensive and probably most relevant data available refers to cholera. The section immediately below relates to cholera specifically.

Countrywide

Parts of Angola, especially around Luanda, have been subject to a recurrent cholera epidemic for at least the last thirty years (Colombo, Francisco et al. 1993; WHO 2005b). The most recent outbreak was mid-2006 when 46,758 cases, and 1,895 deaths, had been reported by June 19 (Sack, Sack et al. 2006). Fourteen out of eighteen provinces were affected but almost half the cases came from Luanda. The overall case fatality rate was 4% but reached 30% in some provinces (Sack, Sack et al. 2006). Since then the cholera incidence has been reduced. In 2010 about 1630 cases of cholera were recorded countrywide (ANGOP 2011b).

Zaire Province

During the 2006 outbreak, the number of reported cases of cholera in Zaire province was between 50 and 499 (WHO 2006b).

Soyo region

Soyo city recorded the first case of cholera on 30 May 2006 (International Society for Infectious Diseases 2006) and in total reported 61 cases (Doctor's Diary 2007).

Disease presentation and diagnosis

Cholera is defined clinically as a person of more than 5 years of age who develops severe dehydration or dies from acute watery diarrhoea or defined epidemiologically as a sudden increase in the daily number of patients with acute watery diarrhoea, especially if the patients pass 'rice water' diarrhoea typical of cholera (WHO 2005b). A case is confirmed by laboratory isolation of *Vibrio cholerae* O1 or O139 from a patient with diarrhoea. It is recommended that at least 10 cases are used to confirm an outbreak situation and to acquire antibiotic sensitivity. Once this has been done it is not necessary to proceed with laboratory identification from other cases in the outbreak (WHO 2005b).

Dysentery is a clinical definition of diarrhoea with visible blood in the stools (WHO 2005b). Confirmation of the diagnosis is by isolation of *Shigella* from the stools of a clinical case. There is no clearly identifiable epidemic threshold, but one should be suspected if there is (WHO 2005b):

- An unusual and sudden rise in the number of new cases or deaths due to bloody diarrhoea;
- An increase in the proportion of bloody diarrhoea among diarrhoeal cases; and
- Five or more linked cases of bloody diarrhoea.

Treatment

The principle for treatment of all types of diarrhoea, regardless of causative organism, is adequate and early treatment of dehydration. This can be with oral or intravenous fluids which can be achieved in the primary healthcare setting, with intravenous rehydration requiring hospitalisation reserved for severe cases only (WHO 2005b).

A study on diarrhoea prevention and management practices conducted in Cuanza Sul, showed that ORS (oral rehydration solution) or other appropriate medical treatment is not commonly used, largely because of cost (Save the children 1998). Mothers do not believe in withholding fluids or foods during diarrhoea, but the amounts ingested during diarrhea episodes are usually reduced due to diminished appetite or vomiting. Common fluids given during diarrhea are uala (or garapa - used nationally) and breastmilk. Common foods given during diarrhea are matete (a porridge made from corn meal) and funge (a dense mash of boiled corn meal or cassava). The most common home treatments for diarrhea are teas made from specific roots, tree barks and leaves.

For cholera, antibiotics (doxycycline or tetracycline) are not essential but can reduce the volume of diarrhoea and shorten the period of transmission (WHO 2005b). Sensitivity to the appropriate antibiotics should be confirmed before treatment.

For bacillary dysentery, effective antibiotics can reduce severity and duration of disease. There is concern about rapid acquisition of drug resistance by *Shigella* species and drug sensitivity needs to be established before prescribing a course of antibiotics. The currently recommended first-line choice for treatment of *Shigella dysenterae* type 1 is ciprofloxacin (WHO 2005b).

Prevention

The principles of diarrhoea prevention are 1) the provision and use of safe water, 2) adequate sanitation and 3) health education (WHO 2005b).

The provision of safe water is a concern in the country. In a recent press release a project official of UNICEF in Angola said that the lack of potable water in some localities of the country is worrying because it has been the main source of diseases such as diarrhoea, cholera, hepatitis and other problems related to basic hygiene (ANGOP 2011f). The Ministries of Health, Energy and Waters, Education, provincial health department of Luanda and UNICEF have been working in a multi-sectorial programme so as to reduce faecal and oral transmission, through a campaign that promotes measures of water treatment and hygiene. This campaign for treatment of drinking water with bleach was launched in April 2011 (ANGOP 2011g).

Interaction with other diseases

Any illness that worsens immunity will result in increased susceptibility to diarrhoeal disease and increased likelihood of an adverse outcome. Diarrhoeal disease is often associated with malnutrition, especially with regard to prevalence in children. Areas affected by cholera have a greater probability of being affected by polio as well (ANGOP 2011b).

7.3.4.7 Typhoid fever

Aetiology and transmission

Typhoid fever is a bacterial disease, caused by *Salmonella typhi* (Initiative for vaccine research (IVR) 2009). The disease is spread by the faecal-oral route and closely associated with poor hygiene, lack of clean drinking water and inadequate sanitation. The disease is almost exclusively transmitted by food and water contaminated by the faeces and urine of patients and carriers. Polluted water is the most common source of typhoid transmission and can cause outbreaks of the disease. In addition, shellfish taken from sewage-contaminated beds, vegetables fertilized with night-soil and eaten raw, contaminated milk and milk products have been shown to be a source of infection.

A recent study from the Catholic University of Angola shows that well over 50% of Angola's population lacks access to safe water and sanitation (Angola Rising 2011). The study was carried out by experts from the Center for Studies and Scientific Research in Angola in partnership with the Open Society Foundation. The study reveals that some 38-42 % of the population has an 'access to water' while 25-40% have access to appropriate sanitation. The lack of clean water for those living in the country's poorest neighbourhoods, coupled with the still-common practice of open-air defecation, means there is a high risk of diseases like cholera and typhoid, especially during the rainy season.

Prevalence and incidence

No data could be found on the occurrence of this disease; no information regarding mortality/morbidity is included in the Burden of Disease data from the WHO (WHO 2008a) and no information could be found on prevalence/incidence in the country, Zaire province or Soyo region. This is not surprising as

most developing countries are uncertain of their true typhoid fever disease burden, due to lack of rapid diagnostic tools, infrequency of laboratory testing and poor reporting system (IVR 2009).

Disease presentation and diagnosis

Symptoms usually develop 1–3 weeks after exposure, and may be mild or severe (IVR 2009). They include high fever, malaise, headache, constipation or diarrhoea, rose-coloured spots on the chest, and enlarged spleen and liver. The illness can last for several weeks and even months. Healthy carrier state may follow acute illness. The most frequent complications, which arise with a frequency of 1% to 4%, include gastro-intestinal bleeding and intestinal perforation. Severe neurological forms also have been described with mental dullness, stupor, delirium and shock.

Treatment

Typhoid fever can be treated with antibiotics (IVR 2009). Hospitalization of cases varies from 10% to 40% of cases and usually lasts for 10-15 days or more. Case-fatality rates, which varied from 10% to 30% before the advent of antibiotics, have now been reduced to about 1%-4% with appropriate antibiotic therapy. However, resistance to common antimicrobials is widespread. Healthy carriers should be excluded from handling food.

Prevention

Three vaccines are currently in use: the old heat-killed, phenol-preserved, injectable whole-cell S. typhi vaccine and two new vaccines, a subunit (Vi PS) vaccine administered by the intramuscular route and a live attenuated S typhi strain (Ty21a) for oral immunization (IVR 2009).

Vaccination against Typhoid is recommended for travellers; no data is available on the vaccination rate within the country itself.

Interaction with other diseases/factors

There are no known interactions of typhoid fever with other diseases, but it is strongly related to hygienic practices as the virus is transmitted through contaminated food and water.

7.3.4.8 Varicella (Chickenpox)

Aetiology and transmission

Varicella or chickenpox is a disease caused by infection with the varicella zoster virus (CDC 2009). It is spread by coughing and sneezing (highly contagious), by direct contact, and by aerosolization of virus from skin lesions.

Prevalence and incidence

No data could be found on the occurrence of this disease; no information regarding mortality/morbidity is included in the Burden of Disease data from the WHO (WHO 2008a) and no information could be found on prevalence/incidence in the country, Zaire province or Soyo region.

Disease presentation and diagnosis

The diagnosis of varicella is primarily clinical: A skin rash of blister-like lesions, covering the body but usually more concentrated on the face, scalp, and trunk (CDC 2009). Most, but not all, infected individuals have fever, which develops just before or when the rash appears. If exposed, persons who have been vaccinated against the disease may get a milder illness, with less severe rash (sometimes involving only a few red bumps that look similar to insect bites) and mild or no fever. Complications can be bacterial infection of the skin, swelling of the brain, and pneumonia. Adolescents and adults are more at risk for severe disease.

Treatment

Varicella treatment mainly consists of easing the symptoms (anti-itching creams and lotions) as there is no actual cure of the condition (CDC 2009). Also, staying in a cold surrounding can help in easing the itching as heat and sweat makes it worse. The condition resolves by itself within a couple of weeks.

Prevention

Varicella vaccine can prevent the disease (CDC 2009). Currently, two doses of vaccine are recommended for children, adolescents, and adults.

Vaccination against Varicella is recommend for travellers; no data is available on the vaccination rate within the country itself.

Interaction with other diseases/factors

Severe chickenpox symptoms are more common in those people whose immune system does not work well (e.g. due to HIV/AIDS, or medicines such as steroids).

7.3.4.9 Tetanus

Aetiology and transmission

Tetanus is caused by the bacterium *Clostridium tetani*, the spores of which are widespread in the environment (soil) (WHO 2008c). Tetanus is acquired when the spores infect a wound or the umbilical stump. The disease is caused by the action of a neurotoxin, produced by the bacteria when they grow in the absence of oxygen. People of all ages can get tetanus but the disease is particularly common and serious in newborn babies ("neonatal tetanus"). Tetanus is not transmitted from person to person.

Prevalence and incidence

Limited data was found on the occurrence of this disease. In 2009, 17 cases were reported throughout the country (Republic of Angola 2010). Between January and October 2010, only 13 cases were reported. Despite its surveillance being integrated with that of polio and measles, suspected cases of tetanus continue to be under-reported. In the last two years, the majority of cases have been reported in the provinces of Luanda and Benguela. The Burden of Disease data from the WHO indicate that there were 7.6 deaths and 254 DALYs lost per 100,000 due to tetanus in 2004 (WHO 2008a). No information could be found on tetanus occurrence in Zaire province or Soyo region.

Disease presentation and diagnosis

Tetanus is characterized by muscle spasms, initially in the jaw muscles (WHO 2008c). As the disease progresses, mild stimuli may trigger generalized tetanic seizure-like activity, which contributes to serious complications (bone fractures, abnormal heart rhythm) and eventually death unless supportive treatment is given.

Treatment

Treatment may include:

- Antibiotics, including penicillin, clindamycin, erythromycin, or metronidazole (metronidazole has been most successful);
- Bedrest with a nonstimulating environment (dim light, reduced noise, and stable temperature);
- Medicine to reverse the poison (tetanus immune globulin);
- Muscle relaxers such as diazepam;
- Sedatives; and

- Surgery to clean the wound and remove the source of the poison (debridement).

Breathing support with oxygen, a breathing tube, and a breathing machine may be necessary.

Prevention

Tetanus can be prevented through immunization with tetanus-toxoid (TT) -containing vaccines (WHO 2008c). Neonatal tetanus can be prevented by immunizing women of childbearing age with tetanus toxoid, either during pregnancy or outside of pregnancy. This protects the mother and - through a transfer of tetanus antibodies to the fetus - also her baby. Additionally, clean practices when a mother is delivering a child are also important to prevent neonatal and maternal tetanus. People who recover from tetanus do not have natural immunity and can be infected again and therefore need to be immunized. To be protected throughout life, an individual should receive 3 doses of DTP in infancy, followed by a TT-containing booster at school-entry age (4-7 years), in adolescence (12-15 years), and in early adulthood.

In 2009 88% of newborns were protected against tetanus, and 73% of children aged 12-23 months received DTP3 immunisation (World Bank 2011a). In 2008 these figures were 79% and 81%, respectively (Countdown to 2015, 2010).

Interaction with other diseases/factors

Clean practices when a mother is delivering a child are important to prevent neonatal and maternal tetanus.

7.3.4.10 Sleeping sickness (Human African Trypanosomiasis)

Aetiology and transmission

Human African Trypanosomiasis (HAT) is caused by infection with a protozoan of the genus *Trypanosoma* (WHO 2010f). In West and Central Africa the causative organism is *Trypanosoma brucei gambiense* and is transmitted to humans through bites by flies of the *Glossina* genus (Tsetse flies). Tsetse flies are mainly found in vegetation near rivers and lakes, in gallery-forests and in wooded savannah (WHO, 2010f). Mother to child transmission can occur via the placenta and it is possible to become infected through exposure to contaminated blood (WHO, 2005b).

Prevalence and incidence

Countrywide

Trypanosomiasis is endemic in northern Angola but for a number of reasons, including the recent history of conflict, accurate epidemiological information is limited. In some provinces the prevalence is between 20%-50%, putting it ahead of HIV/AIDS in terms of burden of disease (WHO 2005b). WHO estimated that in 1995 there were more than 100,000 cases in Angola (WHO 2005b). Of the approximately 13.5 million people in the country, about 4 million are estimated to be exposed and at risk of contracting the disease (WHO 2005b). Recently a representative of the Institute of Combat and Control of Trypanosomiasis (ICTT) indicated that about 6 million are at risk in the endemic regions (ANGOP, 2011). Between 1998 and 2001, 44.1% of people surveyed in the Lucala district in Kuanza Norte province had serological proof of contact with the parasite and 10.1% had the parasite in their blood (Abel, Kiala et al. 2004).

According to the Burden of Disease, in 2004 there were 16.1 deaths due to Trypanosomiasis per 100,000 and 520 DALYs lost (WHO 2008a).

Zaire Province

The WHO communicable diseases toolkit (WHO 2005b) supplies the following information about the screening and prevalence of HAT in Zaire Province (see Table 7-6 below).

Table 7-6: HAT in Zaire Province, Angola.

Year	Number screened for HAT	Number (%) confirmed cases of HAT
2004	58 760	193
2003	45 798	338
2002	11 979	359
2001	18 459	359

Source: WHO 2005b.

More recently the Institute of Combat and Control of Trypanosomiasis (ICCT) conducted a screening campaign from October 15 to November 7 2009 (ANGOP 2009). At least 11,855 residents of northern Zaire province were found to suffer from sleeping sickness.

Soyo region

Although no data on the number of people affected by Trypanosomiasis are known for Soyo, the campaign discussed above covered included this area (ANGOP 2009). Furthermore, a report from the WHO HAT surveillance and control programme indicated that Soyo was one of the areas in Angola affected by sleeping sickness (WHO 2006c).

Disease presentation and diagnosis

Following a bite from an infected tsetse fly, incubation can last from months to years. Classical signs and symptoms are divided into two stages, the first stage, of haemolymphatic involvement and the second stage of neurological involvement.

First stage symptoms can include fever, intense headache, insomnia, painless swollen glands, anaemia, local oedema (swelling) and rash (WHO 2005b).

Second stage symptoms give rise to the "sleeping sickness" name and can occur years after the initial bite. The signs include cachexia (wasting), sleepiness and other signs of central nervous system involvement. The disease is fatal without treatment and will invariably progress to coma and death (WHO 2005b).

A serological test (Card agglutination trypanosomiasis test - CATT) exists specific for *Trypanosoma brucei gambiense* disease only. A negative CATT result indicates no disease; a positive result indicates that further tests are required. Disease confirmation is by microscopic identification of the organism in blood, lymph nodes or cerebrospinal fluid (WHO 2005b).

In 2001 an observational study was conducted in Angola to assess the operational feasibility of detecting human African trypanosomiasis by active and passive case finding using the card agglutination test with serial dilution of serum to guide treatment (Inojosa 2006). The study found that the card agglutination test is useful for initial screening in active detection of cases with human African trypanosomiasis but, given the toxicity of the drugs, serology using the card agglutination test should be not used alone to guide treatment after active case finding. A second confirmatory test is needed.

Treatment

Treatment depends on the stage of disease. Drugs used in the first stage are less toxic and easier to administer, while drugs used in the second stage need to be able to cross the blood-brain barrier (WHO 2010f). The earlier the disease is identified therefore, the better the prospects of a cure. Four drugs are registered for treatment of HAT and are provided free of charge to endemic countries through a WHO public-private partnership.

1. First stage treatment: Pentamidine and suramin.
2. Second stage treatment: Melarsoprol and eflornithine.

Apart from stage determination itself, the follow-up of patients after treatment, needed to verify if therapy has been successful, is cumbersome (ITM 2011). Historically, about 5% of second stage sleeping sickness patients are not cured. Recently, in different endemic countries including Angola, alarming relapse rates of up to 50% have been observed.

The strategy of the National Program in Angola combines activities against the parasite reservoir by active screening and treating patients with antivector campaigns against tsetse flies (Stanghellini 2001). Case detection is simultaneously based on passive surveillance by stationary diagnostic and treatment facilities, and on active screening of the population by mobile screening teams. Primary screening comprises CATT-testing of the complete population visited by the teams or of those who are spontaneously present for consultation. Those who are serologically positive undergo parasitological examination. In serologically positive cases which cannot be confirmed parasitologically, a titration of serum with the CATT is performed: those with a titre equal to or higher than 1/8 are considered infected with trypanosomes. All new cases so detected have a lumbar puncture for staging of the disease.

Cases with up to 20 white blood cells (WBC) per mm3 in the cerebrospinal fluid (CSF) are considered to be at an early stage and are treated with pentamidine. Those with more than 20 WBC/mm3 or trypanosomes, independent of the number of WBC, are considered to be in late-stage and are treated with melarsoprol. The cut-off for the definition of late-stage used to be 5 WBC/mm3 , but was changed to 20 WBC/mm3 at the beginning of 1999. All patients are treated in health centers which are responsible for treatment and follow-up examinations. All late-stage cases receive melarsoprol following a protocol of three series of four injections (the injections spaced by 24 h, the series being spaced by 7 days). First-stage cases are treated ambulatorily with a total of seven injections of pentamidine isethionate (4 mg/kg) every other day.

Prevention

Routine prevention measures recommended by the WHO include (WHO 2005b):

- Avoidance of known areas of sleeping sickness infestation.
- Wearing of long sleeves and long trousers;
- Routine use of insect repellents and nets; and
- Prohibit blood donations from those living in, or who have visited, endemic areas.

Vector control management of tsetse fly populations should also be instituted where possible by the following activities:

- Use of insecticide-impregnated traps and screens; and
- Destruction of tsetse habitat by selective clearing of vegetation, especially around villages. Indiscriminate destruction of vegetation is not recommended.

The cornerstone of disease control remains case detection and treatment through population screening. Because of the long asymptomatic periods active-case finding by means of CATT tests, performed by "screening teams", is the best option with identified cases promptly treated (WHO 2010f).

Combating tsetse flies by constant trapping (Lancien type) in targeted areas with active community participation is the second measure of the National Program to cut the transmission chain (Stanghellini 2001). More recently an ICCT official indicated that a spray operation is being conducted in the

southern region of the country and in the endemic provinces, including ongoing research (ANGOP 2011).

Interaction with other diseases

Little is known about the interaction of Trypanosomiasis with other diseases, but it can be presumed that diseases that worsen host immunity, like HIV/AIDS, will probably result in an accelerated course of the parasitic disease.

7.3.4.11 Viral haemorrhagic fevers

Aetiology and transmission

"Viral haemorraghic fever" refers to a group of diseases that are caused by a number of distinct families of viruses and result in excessive bleeding. Ebola virus and Marburg virus originate from the same family, *Filoviridae,* and have an almost identical clinical presentation (WHO 2005c). Both diseases are rare but tend to occur in outbreaks and carry a high associated mortality (WHO 2005c). An animal reservoir (or other environmental source) of either disease has yet to be identified, but epidemiological links point towards African rain-forests (WHO 2008d). Marburg is transmitted through close human contact and infection results from contact with blood or other body fluids. Ebola virus is similarly transmitted (WHO 2008d). For both diseases infection through casual contact is thought to be extremely rare (WHO 2005c).

In addition, transmission can occur in hospitals lacking adequate equipment and supplies for infection control and training in their proper use as is the case in Angola (WHO 2005f). Several cases of Marburg haemorrhagic fever have occurred in health care staff exposed during the treatment of patients.

Prevalence and incidence

Countrywide

Outbreaks and sporadic cases of Marburg virus have been reported in Angola, DRC, Kenya and South Africa (WHO 2005c). An outbreak of Marburg is believed to have begun in the Uige Province, adjacent to Zaire province, in January 2005. By August 2005, a total of 374 cases, including 329 deaths (CFR 88%) were reported countrywide (WHO 2005d).

Since monitoring first began in 1976, Ebola virus cases have been reported in the Sudan, Cote d'Ivoire, DRC, Gabon, South Africa and Uganda but no documentation of cases in Angola has occurred (WHO 2008d). However, in order to avoid spread of the 2009 Ebola epidemic in the DRC, Angola closed its north-eastern border (News24 2009).

Zaire Province

In the Marburg outbreak discussed above, Zaire Province had reported 6 cases (WHO 2005e). No documentation is available for Ebola with respect to Zaire province.

Soyo region

No documentation is available for either disease with respect to Soyo Municipality.

Disease presentation and diagnosis

As mentioned above, the clinical presentation of both diseases is virtually identical and specialised laboratory tests are required to distinguish between the two. For laboratory work, Marburg virus has been classified as an extremely hazardous pathogen and can be handled safely only in specialized high-containment laboratories. WHO has established an international network of expert laboratories for the diagnosis of Marburg and other viral haemorrhagic fevers. During the Angolan outbreak diagnostic support was provided by laboratories within this network (WHO 2005h).

The incubation period for Ebola is about 2 to 21 days (WHO 2005c) and for Marburg is about 3 to 9 days (WHO 2008c). Usually there is a sudden onset of fever, weakness, muscle pain and headache. This is often followed with diarrhoea, nausea and vomiting, abdominal pain and cramping within about three days. Haemorrhagic signs occur around days 5 to 7 and manifest as bleeding from multiple mucous membrane sites, externally and internally. When fatal, death usually occurs between 8 or 9 days after symptom onset (WHO 2005c).

Treatment

No specific treatment or vaccine is available for either disease. Medical management would be largely supportive and revolve around adequate fluid and blood product replacement.

Prevention

To reduce the risk of transmission in the community, priority activities include intensive social mobilization and health education. Identified cases should be isolated and all contacts must be traced. All people who have had close contact with contaminated blood; secretions or body fluids should be kept under strict surveillance and monitored regularly for signs of fever. Medical staff attending patients should wear barrier nursing attire (WHO 2008d). The US Centre for Disease Control and Prevention (CDC) in partnership with the WHO has developed a manual, *Infection Control for Viral Haemorrhagic fevers in the African Health Care Setting* which should be available to medical personnel in risk areas (CDC and WHO 1998).

Almost three decades of civil unrest have left Angola with a severely weakened health infrastructure, a hospital system in dire need of basic equipment and supplies, inadequate communication and transportation systems, and a population weakened by economic hardship (WHO 2005g). These weaknesses hampered the containment efforts in the 2005 outbreak, as these depend on active surveillance for cases, rapid detection and isolation in specially designated and equipped facilities, and rapid tracing of contacts.

Interaction with other diseases

Very little information is available with regard to interaction between viral haemorrhagic fevers and other diseases. This is presumably because of the rapid progression of the disease and the high case fatality rate. Ebola case fatality is estimated at between 50% to 90% (WHO 2008d) and Marburg case fatality rates in the Angolan outbreak were 88% (WHO 2005d).

7.3.4.12 Poliomyelitis

Aetiology and transmission

Poliomyelitis (polio) is a highly infectious viral disease, which mainly affects young children (WHO 2010g). The virus is transmitted through contaminated food and water so enters the body through the mouth, and multiplies in the intestine, from where it can invade the nervous system. Many infected people have no symptoms, but do excrete the virus in their faeces, hence transmitting infection to others.

Experts say that Angola's lack of clean water and poor sanitation is a major driver for the recent resurgence of polio that is now spreading northward into the neighbouring country of Congo (Angola Rising 2011).

Prevalence and incidence

Countrywide

In Angola, circulation of an imported wild poliovirus A polio outbreak began in 2007 and poliovirus transmission was highly concentrated in the Luanda-Benguela corridor along the Atlantic coast (Global

Polio Eradication Initiative 2011). In 2009, re-established polioviruses re-infected other, previously polio-free provinces, as well as neighbouring DRC. As the outbreak has persisted for more than 12 months, the country is classified as having re-established transmission. The total number of cases for 2011 (up to mid-April) remains two, in 2010 33 cases were reported, in 2009 and 2008 each 29 cases and in 2007 8 cases.

According to the Burden of Disease data of 2004, 0.1 deaths per 100,000 were due to polio and 2 DALYs lost per 100,000 (WHO 2008a).

Zaire Province

Zaire province was not reported to have had cases during the outbreak.

Soyo region

The Soyo region probably did not have any cased during the outbreak. During the vaccination campaign 23,068 children were vaccinated (ANGOP 2011c).

Disease presentation and diagnosis

Most infected people (90%) have no symptoms or very mild symptoms and usually go unrecognised (WHO 2010g). In others, initial symptoms include fever, fatigue, headache, vomiting, stiffness in the neck and pain in the limbs. One in 200 infections leads to irreversible paralysis, usually in the legs. This is caused by the virus entering the blood stream and invading the central nervous system. As it multiplies, the virus destroys the nerve cells that activate muscles. The affected muscles are no longer functional and the limb becomes floppy and lifeless – a condition known as acute flaccid paralysis (AFP). More extensive paralysis, involving the trunk and muscles of the thorax and abdomen, can result in quadriplegia. In the most severe cases (bulbar polio), poliovirus attacks the nerve cells of the brain stem, reducing breathing capacity and causing difficulty in swallowing and speaking. Among those paralysed, 5% to 10% die when their breathing muscles become immobilized.

Laboratory diagnosis includes recovery from poliovirus from the stool or pharynx of a person with poliomyelitis (CDC 2011). If poliovirus is isolated from a person with acute flaccid paralysis, it must be tested further, using oligonucleotide mapping (fingerprinting) or genomic sequencing, to determine if the virus is "wild type" (that is, the virus that causes polio disease) or vaccine type (virus that could derive from a vaccine strain). In poliovirus infection, the cerebrospinal fluid usually contains an increased number of white blood cells (10–200 cells/mm3, primarily lymphocytes) and a mildly elevated protein (40–50 mg/100 mL).

Treatment

There is no cure for polio, only treatment to alleviate the symptoms (WHO 2010g). Heat and physical therapy is used to stimulate the muscles and antispasmodic drugs are given to relax the muscles. While this can improve mobility, it cannot reverse permanent polio paralysis.

Prevention

Polio can only be prevented by immunization (WHO 2010g). There are two types of polio vaccine in use: the oral polio vaccine (OPV) and the inactivated polio vaccine (IPV). Polio vaccine, given multiple times, can protect a child for life. In 1988, the forty-first World Health Assembly, consisting then of delegates from 166 Member States, adopted a resolution for the worldwide eradication of polio. It marked the launch of the Global Polio Eradication Initiative. Overall, since the Global Polio Eradication Initiative was launched, the number of cases has fallen by over 99%.

The objectives of the Global Polio Eradication Initiative are:

- To interrupt transmission of the wild poliovirus as soon as possible;

- To achieve certification of global polio eradication;
- To contribute to health systems development and strengthening routine immunization and surveillance for communicable diseases in a systematic way.
- There are four core strategies to stop transmission of the wild poliovirus in areas that are affected by the disease or considered at high risk of re-infection:
- High infant immunization coverage with four doses of oral poliovirus vaccine (OPV) in the first year of life;
- Supplementary doses of OPV to all children under five years of age;
- Surveillance for wild poliovirus through reporting and laboratory testing of all acute flaccid paralysis (AFP) cases among children under fifteen years of age; and
- Targeted "mop-up" campaigns once wild poliovirus transmission is limited to a specific focal area.

In 2009 73% of children aged 12-23 months received DTP3 immunisation (World Bank 2011a). In 2008 these figures were 79% and 81%, respectively (Countdown to 2015, 2010). The outbreak that started in 2007 has lead to a national vaccination campaign in Angola against the disease held in March 2011(Global Polio Eradication Initiative 2011). During the national vaccination campaign at least 77,419 children from zero to five years old have been vaccinated in Zaire province (of which 23,068 children in Soyo) (ANGOP 2011c).

Interaction with other diseases/factors

There are no known interactions of poliomyelitis with other diseases, but it is strongly related to hygienic practices as the virus is transmitted through contaminated food and water. Areas affected by cholera have a greater probability of being affected by polio as well (ANGOP 2011b).

7.3.4.13 Asthma and Chronic Obstructive Pulmonary Disease

Although patients usually have either asthma *or* Chronic Obstructive Pulmonary Disease (COPD) rather than both entities together (Longmore, Wilkinson et al. 2007), the diagnosis can be confused and as a result data for both diseases are presented here as there may be considerable overlap.

Aetiology

Both asthma and COPD are caused by an interaction between genetic predisposition and environmental factors. Asthma can affect children and adults and an acute episode can be triggered by many environmental factors including allergens (such as dust and pollen), infection, drugs, emotion and cold air (Longmore, Wilkinson et al. 2007). COPD is primarily caused by smoking and is a disease of adults, usually aged over 35 years of age (Longmore, Wilkinson et al. 2007).

No data was found on the prevalence of smoking in Angola.

Prevalence and incidence

Countrywide

In Angola, asthma is estimated to be responsible for 9.7 deaths per 100,000 people and COPD for 17.9 deaths per 100,000 people (WHO 2008a). Estimated rates for DALYs due to both diseases reported by the WHO are 419 per 100,000 for asthma and 284 for COPD.

Zaire Province

No data are available on asthma and COPD specifically for Zaire Province.

Soyo region

In the household survey conducted in the area in 2005, ERM report that in the 90 days before the survey, 3% of the survey participants reported being sick due to 'bronchitis' (ERM 2006). This classification is likely to provide some indication of the prevalence of asthma and COPD in the area (Longmore, Wilkinson et al. 2007).

Disease presentation and diagnosis

Asthma is due to reversible airway obstruction and is characterized by recurrent episodes of shortness of breath, cough and wheeze. COPD is a progressive disorder of airway obstruction with little or no reversibility and presents as chronic bronchitis or emphysema (Longmore, Wilkinson et al. 2007). Diagnosis for both diseases can be done in a primary healthcare setting with lung function tests using a peak flow meter. No information was found about whether these diagnostic techniques are available in Angola.

Treatment

Treatment of acute severe asthma and COPD require hospitalization. Both asthma and COPD require long-term monitoring and drug and behavioural measures which can be implemented in the primary health care setting. No information was found about whether these treatment options are available in Angola.

Prevention

Primary prevention of asthma and COPD is focussed on reducing the level of exposure of individuals and populations to common risk factors, particularly tobacco, poor nutrition, frequent lower respiratory infections during childhood, and environmental air pollution (indoor, outdoor, and occupational) (WHO 2002).

In July 2009 the Angolan Cabinet Council approved the decree establishing a ban on smoking in public places (ANGOP 2009c).

Indoor and outdoor air pollution in Angola cause serious concern. Angola is among the 20 worst-affected countries with respect to the number of deaths and DALYs due to indoor air pollution (WHO 2002b). According to 2004 data, indoor air pollution affects 95% of houses causing 33,500 deaths a year, and outdoor air pollution in urban areas causes an additional 2,700 (WHO 2009c).

Interaction with other diseases and factors

Smoking, poor nutrition, lower respiratory infections during childhood and environmental air pollution (indoor, outdoor, and occupational) all contribute to the development of asthma and COPD (WHO 2002).

7.3.4.14 Cerebrovascular accident (stroke)

Aetiology

A stroke happens when blood flow to a part of the brain is interrupted because a blood vessel in the brain is blocked or bursts open (Pubmed Health 2010). If blood flow is stopped for longer than a few seconds, the brain cannot get blood and oxygen. Brain cells can die, causing permanent damage. There are two major types of stroke: ischemic stroke and hemorrhagic stroke. Ischemic stroke occurs when a blood vessel that supplies blood to the brain is blocked by a blood clot. Hemorrhagic stroke occurs when a blood vessel in the brain becomes weak and bursts open, causing blood to leak into the brain. The flow of blood that occurs after the blood vessel ruptures damages brain cells.

Prevalence and incidence

There is limited data available. In Angola, cerebrovascular disease is estimated to be responsible for 63.6 deaths per 100,000 people and 943 DALYs lost (WHO 2008a). No information is available specifically for Zaire province or the Soyo region.

Disease presentation and diagnosis

The symptoms of stroke depend on what part of the brain is damaged (e.g. muscle weakness on one side of the body) (Pubmed Health 2010). In some cases, a person may not even be aware that he or she has had a stroke. Symptoms usually develop suddenly and without warning, or they may occur on and off for the first day or two. Symptoms are usually most severe when the stroke first happens, but they may slowly get worse. A headache may occur, especially if the stroke is caused by bleeding in the brain. A complete physical and neurological exam should be performed.

Treatment

A stroke is a medical emergency (Pubmed Health 2010). Immediate treatment can save lives and reduce disability. If the stroke is caused by a blood clot, a clot-busting drug may be given to dissolve the clot. Treatment depends on the severity and cause of the stroke. A hospital stay is required for most strokes.

In Luanda in August 2011 in Luanda a Scientific Meeting on Cardiology and Cardiovascular Surgery was held (ANGOP 2011i). The local and foreign specialists e.g. discussed matters linked to high blood pressure (as stroke is) including the treatment.

Prevention

The following behavioural interventions can help prevent a stroke: low-fat diet, limited alcohol intake, regular exercise, treatment of high blood pressure, treatment high cholesterol level, and quitting smoking (Pubmed Health 2010).

In August 2011 the Angolan Health Minister announced that a legislative package is being prepared that will help to make chronic diseases like diabetes and high blood pressure more easily treatable through a subsidy from the government, since this type of patients often need to be on lifetime medication (ANGOP 2011j).

In July 2009 the Angolan Cabinet Council approved the decree establishing a ban on smoking in public places (ANGOP 2009c).

Interaction with other diseases and factors

The following are risk factors for strokes: high blood pressure, atrial fibrillation, diabetes, family history of stroke, heart disease, high cholesterol and increasing age (Pubmed Health 2010).

7.3.4.15 Protein-energy malnutrition

Aetiology

Protein-energy malnutrition (PEM) occurs as a result of a poor or limited nutritional intake. In children, classic kwashiorkor was previously attributed to a severe deficiency of proteins and marasmus due to a severe deficiency of calories but the aetiology of each type is complex and there is protein depletion in both groups (Kumar and Clarke 2009). Both kwashiorkor and marasmus are the extreme end of a cycle of progressively poor or absent nutritional intake. Stunted growth is an earlier indication that nutrition is not optimal. A host of other disorders arise from specific vitamin or mineral deficiencies e.g. beri-beri due to a lack of thiamine (vitamin B_1) which can affect both adults and children (Longmore, Wilkinson et al. 2007).

Prevalence and incidence

Countrywide

The WHO Burden of Disease Report estimates that nutritional deficiencies are highly prevalent in Angola. Nutritional deficiencies cause 83.8 deaths per 100,000 people and are responsible for 3,675 DALYs lost per 100,000 people, with protein-energy malnutrition accounting for the bulk of this burden (WHO 2008a). In 2009 41% of the population of Angola were estimated to be undernourished in the period 2005-2009 (World Bank 2011a).

Of the children below 5, 49.0% in urban areas and 55.1% in rural areas was found to be stunted (low height for age) in 2001 according to the WHO Global Database on Child Growth and Malnutrition (WHO 2007). In 2007 29% of children under 5 were moderately/severely stunted, 16% underweight (low weight for age) and 8% moderately/severely wasted (low weight for height) (Countdown to 2015, 2010).

Zaire Province

The WHO Global Database on Child Growth and Malnutrition only presents the 2001 data per region. North Angola (which includes Zaire province) had a stunting percentage of 49.3 (WHO 2007). Older data from the same source indicated that in 1996 the percentage of stunted children (aged between 6 months and 5 years) was 50.1 in Zaire Province.

Soyo region

No nutritional data specific to Soyo were available.

Disease presentation and diagnosis

Stunted growth as well as wasting and underweight are early indications that nutrition is not optimal (Longmore, Wilkinson et al. 2007).

Treatment

Treatment of severe malnutrition may require hospitalisation with gradual introduction of feeding. Less severe forms can be addressed in the primary healthcare setting if food security is guaranteed and staff is experienced.

As no data existed concerning the management of severe malnutrition in Angola, a study has been conducted to measure the impact of practice review and in-service supervision based on WHO guidelines on the outcomes of severely malnourished children admitted to a therapeutic feeding centre in Bailundo, a rural municipality in Angola (Giugliani 2010). The study showed that this intervention in a setting of limited resources apparently contributed to a reduction in fatality rates. These findings support the view that such guidelines can be effectively implemented in under-resourced facilities in Angola and similar settings if they are introduced using an interactive approach and if in-service supervision continues to be provided.

Prevention

Prevention of malnutrition and under nutrition through an accessible and nutritious diet is key to reducing the prevalence of these highly preventable diseases. Prevention depends not only on adequate nutrients being available but also on education of governments and individuals of the importance of good nutrition (Kumar and Clarke 2009). This was highlighted by the Health Department of Huamba province, which after several children had died due to malnutrition, urged traditional authorities, religious entities and the civil society in general to promote awareness campaigns in rural communities on healthy nourishment, taking into account that there is no hunger in these localities,

but there is a lack of knowledge on the composition of a healthy meal (ANGOP 2011m). General good health care with treatment of infections is particularly beneficial in alleviating severe PEM.

Interaction with other diseases

Poor nutrition can weaken the immune system and increase susceptibility to illness (Kumar and Clarke 2009). Drug treatments for diseases such as HIV/AIDS require the patient to take tablets on full stomachs which can be hard to achieve if food is not available.

7.3.4.16 Road Traffic Injury

Aetiology

The cause of Road Traffic Injury (RTI) is multifactorial and depends on an interplay between the traffic environment and driving and pedestrian behaviours (Peden, Krug et al. 2001). Reasons behind RTIs differ depending on the development of a country or region. For example, in well-resourced countries, behaviours such as not wearing a seat-belt may account for more RTIs than a dangerous driving environment. The WHO predicts that RTIs will rise in the future with rapid urbanization and motorization in developing countries accounting for much of this predicted increase (Peden, Krug et al. 2001). A lack of appropriate road engineering and injury prevention programmes in the public health sector in such countries contributes to the problem. RTIs disproportionately affect the poor and vulnerable worldwide.

Driving in a state of intoxication, over speeding, the lack of respect for traffic regulations, poor street lighting and carelessness on the part of pedestrians and drivers are the main causes of accidents in Angola according to the police in Luanda (Stead 2010).

Prevalence and incidence

Countrywide

Based on data published in the Global Status Report on Road Safety published by the WHO in 2009, Angola was listed as 7th in the world in accordance to the rate of traffic deaths (No author 2009). Angola has experienced 2,358 traffic deaths, a rate of 37.7 deaths per 100,000 people. The Angola Traffic Department indicated that at least 2,867 were killed in the country in 2009 due to road accidents (ANGOP 2010c).

According to the Burden of Disease data 2004, road traffic accidents account for 56.7 deaths per 100,000 and 2,020 DALYs lost per 100,000 (WHO 2008a).

Zaire Province

According to the Angola Traffic Department 47 people were killed in Zaire province in 2009 due to road accidents (ANGOP 2010c).

Soyo region

No data are available on road traffic injuries specifically for the Soyo region. Given the increasing growth of the economy and road development it seems prudent to assume that the risk of RTI will become higher in the Soyo municipality.

Disease presentation and treatment

Treatment of an individual who has been hit by a vehicle, a driver or passenger who has been injured in a RTI will depend on the nature and extent of that injury. This could range from mild shock to multiple injuries requiring extensive specialist orthopaedic and rehabilitative care in hospital.

Prevention

The UN Road Safety Collaboration has developed a Global Plan for the Decade of Action for Road Safety 2011-2020 with input from many partners through an extensive consultation process through meetings and the Internet (WHO 2011a). The Plan provides an overall framework for activities which may take place in the context of the Decade. The categories or "pillars" of activities are:

- Building road safety management capacity;
- Improving the safety of road infrastructure and broader transport networks;
- Further developing the safety of vehicles;
- Enhancing the behaviour of road users; and
- Improving post-crash care.

Indicators have been developed to measure progress in each of these areas. Governments, international agencies, civil society organizations, the private sector and other stakeholders are invited to make use of the Plan as a guiding document for the events and activities they will support as part of the Decade.

In order to combat the growing trend of road accidents, the Angolan government issued a new Highway Code in 2009, which has divided society (Angola Rising 2010). On one hand, the new code is seen as a good measure taken by the Government as it will educate some of the drivers who are less attached to life. Nevertheless, the legislation contains costs that not everyone is able to meet. The compulsory use of seats for children under twelve, may be an example. There are now well informed thieves who have begun stealing these items each of which costs around 30 thousand Cuanza (approximately 385 USD at the date this piece was published). The new highway code also imposes the use of seat belts and child seats as well as dictating the mandatory use of helmets for motorcycle drivers (laws normally applied in most all western societies). Fines applied tend to be heavy. However, most drivers choose to ignore the law. This fact, coupled with the country's poor road conditions in some areas, is causing congestion and situations of risk for those using public roads.

During the festive season of 2010-2011, the Special Brigade of Traffic (BET) held a campaign of road prevention and safety in national roads linking the various provinces (ANGOP 2010). This included fixed posts with radars to control speed and alcohol test devices, backed by helicopters and patrol car (vehicles and motorbikes).

Interaction with other factors

Alcohol use and abuse is responsible for a large proportion of RTIs (Peden, Krug et al. 2001). Driving while under the influence of alcohol (or indeed other drugs) significantly increases the risk of causing or being involved in a road traffic collision. Pedestrians who are inebriated are also at risk of being involved in a collision and sustaining a RTI.

The above has been emphasized by the Provincial Director of Family and Woman Promotion in Uije (ANGOP 2011). In her opinion the excessive consumption of alcohol and drugs among young people and teenagers has been causing the increase in juvenile delinquency, road accidents, vandalism acts, as well as domestic violence.

7.3.4.17 Injury due to violence

Aetiology

The WHO defines violence as the intentional use of physical force or power, threatened or actual, against oneself, another person, or against a group or community, that either results in or has a high

Treatment

Treatment for alcohol and other drug abuse requires detoxification which may be done under medical supervision, followed by long-term behavioural interventions (Longmore, Wilkinson et al. 2007).

In 2008 prevention and sensitization campaigns were held against the use of drugs and these included detoxification sessions (ANGOP 2008).

Prevention

Macro-level development (indirect strategies) such as job creation, establishment of better recreation facilities, improvement of literacy and the provision of education opportunities are recognised as essential to the primary prevention of alcohol and drug abuse use (Riley and Marshall 1999). Direct prevention strategies include establishment of the necessary policy and regulatory environments and processes directed at the alcohol and drug markets, as well as community education and health promotion (Riley and Marshall 1999).

The 2008 drug prevention and sensitization campaigns included television and radio debates (ANGOP 2008).

In April 2011 an awareness campaign on the use and abuse of alcohol and drugs was held throughout the country (ANGOP 2011k). The event was part of celebrations of Angolan National Youth Day, marked on April 14, and the aim was to combat excessive use of alcohol and drugs in young people at the country level.

An health expert of Youth Counselling Centre (CAJ) indicated that excessive publicities on alcoholic drinks, related to the facility of purchasing the product, contributes to the consumption of alcoholic drinks by the youths and therefore the access of alcoholic drinks should be made difficult (ANGOP 2011l). Furthermore, the development and support of education programs or health in the areas of alcohol should include development of public information and campaigns.

Interaction with other illnesses

Alcohol is a contributing factor in many other diseases: liver cirrhosis, pancreatitis, RTIs, injuries due to violence, schizophrenia (Longmore, Wilkinson *et al.* 2007).

7.4 Health risk factors

Based on the information available from the desk-based research and the primary data collection on the Soyo community – the health, social and environmental data - the following potential risk factors for health can be identified:

A. The social and economic environment

There is a lot of population movement in the area: returning refugees from the war, refugees from neighbouring countries, in-migration for work due to economic development in the region which has various effects:

Import of diseases: Those coming in the area could import diseases like HIV/AIDS, malaria, tuberculosis, sleeping sickness and viral haemorrhagic fevers from elsewhere.

High risk behaviour (see below).

B. The physical environment

There is limited access to clean drinking water and sanitation (sewage and other waste) facilities in the area: If contaminated water or food is consumed, diarrhoeal diseases and e.g. poliomyelitis and typhoid fever will occur.

Poor roads in combination with a large amount of traffic: Due to the economic development, the risk for road traffic injuries – especially in the poor condition the roads are - is high (especially between the traffic and pedestrians).

The climate in the area and the proximity to a river (the swamps) makes the area very susceptible to e.g. malaria.

For those outside the Soyo *Comuna*, there is limited access to medical facilitates: Most facilities (hospital, health centres, nurse posts, private facilities) are based within the boundaries of the *Comuna*, implying long(er) travel distances and costs for those living outside the *comuna*. Furthermore, medical staff is considered insufficient for the needs. As a consequence people might become more severely sick and/or will transmit disease for a longer period of time.

C. The person's individual characteristics and behaviours

The high levels of poverty and the low levels of education as present in the area will lead to poorer health.

There is poor / limited nutritional intake with subsistence agriculture and fishing forming the mainstay of the local diet. Many households live on a basic traditional diet of manioc and its products, edible herbs, peanuts and their products, corn and beans. This results in e.g. (protein-energy) malnutrition and hence a higher susceptibility for disease (progression) e.g. progression from HIV to AIDS.

There is the potential for high health risk behaviour in the area: Due to population movement, especially influx of (male) workers related to the oil industry activities at Kwanda Base, there is the potential of high risk sexual behaviour e.g. multiple sex partners, commercial sex workers leading to transmission of HIV/AIDS and other sexually transmitted infections. Also other health risk behaviours might be stimulated by an influx of workers in the area e.g. alcohol and drug abuse. Besides the direct health consequence of this abuse this leads to road traffic accidents, injuries due to violence.

There is poor health seeking behaviour. From the interviews became clear that many community members first visit other media (church, pharmacy, traditional healer) before turning to the hospital [although the women mainly indicated to seek medical care at the hospital]. As a consequence they might become more severely sick and/or will transmit disease for a longer period of time.

There is poor preventive health behaviour. It has been indicated that there is a low uptake of prevention measures like insecticide-treated nets (malaria, sleeping sickness), condoms (HIV/AIDS, sexually transmitted infections), and vaccination (Hepatitis B, poliomyelitis, typhoid fever, varicella, tetanus). The interviews with the women indeed indicated that only 65% used bed nets, but 99% vaccinated their child(ren).

D. Project related risk-factors

As this is an offshore project, in normal circumstances, no negative health impacts for the community members are expected. There will be no influx of workers or materials (traffic) via land. Possible side-effects of the project activities (noise/vibration, air pollutants, waste) will be managed by the project so that these will stay below the limits set. There will be systems in place to avoid (and respond to) spills.

7.5 Health Needs

From the health baseline it becomes clear that the most important issues in the Soyo region are infectious diseases (HIV/AIDS, malaria, tuberculosis, respiratory infections, sexually transmitted infections, diarrhoeal diseases, sleeping sickness, viral haemorrhagic fevers, poliomyelitis typhoid fever, varicella, tetanus) and behaviour related diseases (protein-energy malnutrition, road traffic injury, injury due to violence, alcohol and other drug abuse and dependence), and to a lesser extent

non-communicable diseases (asthma and chronic obstructive pulmonary disease, cerebrovascular accident).

Based on the diseases above, the following health needs can be identified, divided into prevention measures, diagnostic tests and treatment options:

Prevention measures: e.g. awareness and education (all diseases), condoms (HIV/AIDS, sexually transmitted infections), insecticide-treated nets and repellants (malaria, sleeping sickness), vaccines (hepatitis B, poliomyelitis, typhoid fever, varicella, tetanus).

Diagnostic tests: e.g. HIV test, rapid test (malaria), skin and sputum test (TB).

Treatment options: e.g. HAART (HIV/AIDS), artemisinin-based combination therapies (malaria), drugs for TB treatment, antibiotics (respiratory infections, diarrhoeal diseases, typhoid fever, tetanus), oral fluids (diarrhoeal diseases), drugs for sleeping sickness, drugs for asthma and COPD, treatment for stroke.

In addition, general medical facilities (including staff) are needed: primary/secondary/tertiary care, antenatal care, paediatric care, laboratory facilities, and essential medicines.

It is difficult to exactly indicate where the gaps in the above health needs lie. Awareness and education programmes are indicated to be available, but details on the content of these programmes are not obtainable. Condoms are available, but seldom used. Bed nets are e.g. distributed by development organisations (but only 65% of the women used nets), which also provide testing for HIV and malaria. It was indicated that there was not stock out of medication, but it is unclear whether this includes medication for all diseases mentioned. And although the ratio of doctors, nurses and midwives seems to be high in the municipality, it was indicated not be enough to cater for the need.

8 Environmental, Social and Health Impacts Assessment and Mitigation

The present chapter analyses the associated and potential impacts that the proposed Angola Block 15/06 West Hub Development Project activities could have on the biophysical and anthropic environment. As described in Chapter 3 Project Description, the project essentially involves well drilling operations, to be performed using a "Semisubmersible Drilling Unit", Installation, operation and removal of well heads; Laying and operation of Transport Systems (flowlines); and Installation and operation of FPSO and mooring systems.

The chapter describes the impact identification and assessment methodology, identifies the potential impacts and assesses the significance of the identified potential impacts on the various environmental, social and health components. The assessment approach generally involves matching the various activities of the proposed project (as described earlier in this report) with the components of the existing biophysical and anthropic environment.

8.1 Impact Assessment Methodology

8.1.1 Potential Impacts Identification and Characterisation

The environmental, social and health impacts potentially generated by the development of Block 15-06 were identified via the elaboration of impact pathways. An impact pathway is substantially a process tool which allows for the identification of the main impacts on the surrounding physical environment and the host communities' society, economy and health, induced during the execution of the Block 15-06 West Hub project, from the initial phase, through to Operation and Production, and ultimately Decommissioning.

The process begins with an impact identification matrix, which involves the listing of the main project activities carried out during the various project phase on one side and the baseline biophysical and anthropic profile components (i.e. environmental, socio-economic and health components) on the other, so as to highlight the relationships between project activities and potential direct impacts. In some cases the components are expressible by means of specific *indicator parameters* (see next paragraph).

Characterisation refers to the *types* of impact generated by the Project; i.e. any project can generate a wide range of potential impacts, some of which will be direct, whilst others will be more complex and difficult to identify (see box below).

Types of Impact

Direct (or primary) Impacts that result from a direct interaction between a planned project activity and the receiving natural or socio-economic environment.

Indirect Impacts that follow on from the primary interactions between the project and its natural and socio-economic environment as a result of subsequent interactions.

Cumulative Impacts that act together with other impacts (including those from concurrent or planned future third party activities) to affect the same resources and/or receptors as the project.

Perceived Changes that may be unconnected to, but blamed on, the project. These are usually identified and assessed through stakeholder engagement and consultation.

Therefore, once the direct impacts are established, the next step is to complete the impact pathway by determining the indirect impacts of these direct changes to the environmental, social and health components, as well as any subsequent cumulative and perceived impacts.

8.1.2 Potential impacts indicator parameters

The next step in the impact assessment methodology consists in selecting the parameters/indicators of each ESH component that are "sensitive" to the changes triggered by the potential impacts identified. Their sensitivity renders them capable of describing and/or quantifying the potential impacts caused by project activities, as well as providing a clear picture of the potential impacts' boundaries and characteristics.

The identification of indicator parameters therefore serves the purpose of translating the identified potential impacts into measurable (qualitatively and/or quantitatively) terms, in order to proceed to their evaluation via the qualitative assessment method hereby described and/or specific *ad hoc* modelling/simulation techniques

8.1.3 Assessment of Impact Significance

Once identified, the significance of the potential impacts must be assessed in order to determine requirements for impact mitigation (or enhancement of benefits) and management measures to be implemented during the project.

Where feasible, in relation to certain components the potential impacts identified were assessed quantitatively via modelling techniques. These modelling techniques put into correlation the values of the single indicator parameters of each component before and after the project's activities, thus allowing quantifying their relative potential disturbing effect.

While in the case of other components the assessment is solely qualitative and is limited to a series of considerations on the possible natural and/or anthropic sources of disturbance, their status within the marine environment and their effects on the biophysical and/or anthropic ecosystems. Here, in assessing the significance of each potential impact (positive or negative), the following criteria of consequence were applied:

Duration: The temporal scale of the impact, ranging from 1 year or less to 10 years or more/irreversible, which, however, also takes into consideration frequency, i.e. continuous or intermittent nature, of the impact;

Extent: The geographical scope of the impact, ranging from local scale (the proposed operating area and immediate environs) through to international trans-boundary scale effects;

Magnitude: This is composed of three elements, namely:

- extent of the change induced with respect to the baseline,
- sensitivity/resilience of the receptor, i.e. its ability to recover or adapt to the change induced (1 implies good adaptability/resilience or low sensitivity while 4 means poor adaptability/capacity to recover or high sensitivity),
- importance/persistence of cumulative effects derived from the impact; and

No. of Elements: includes individuals, households, enterprises, species and habitats that could be affected by the impact.

Each criterion is assigned a rating, and the consequence (severity) score is the sum total of the criteria ratings (ranging from 4 to 16) (see Table 8-1).

Table 8-1: Ranking of evaluation criteria.

Ranking	Evaluation Criteria			
	Duration	Extent	Importance / resilience of receptor / resource	No. of elements involved
Low 1	Less than 1 year / Temporary	Local scale: the proposed operating site and its immediate environs	Low value/sensitivity of receptors or resources, able to recover or adapt to the change without interventions	Affecting small no. of individuals, households, individual enterprises and/or small no. of species
Medium 2	Between 1 and 5 years	Regional scale: as determined by country's administrative boundaries	Moderate value/sensitivity of receptors or resources, able to adapt with some difficulty and which may require interventions	Affecting small number of individuals, communities or administrative and/or higher no. of species and habitats
High 3	Between 5 and 10 years	National scale: Entire country	High value/sensitivity of receptors or resources, poorly able to adapt to changes with strong interventions	Affecting great no. of individuals, households and/or medium/large enterprises and/or habitats and ecosystems
Critical 4	Over 10 years / Irreversible	International scale: trans-boundary	Extreme value/sensitivity of receptors or resources, resulting in permanent changes	Affecting huge no. of individuals, households and/or large enterprises and/or habitats structure and ecosystems functions
Score	1 – 4	1 – 4	1 – 4	1 – 4

Alongside impact consequence, it is necessary to establish the impact's probability of occurrence. Probability is divided into four, almost equally weighted, categories:

Unlikely: Unlikely to occur in normal operating conditions but may occur in exceptional circumstances;

Possible: May occur under normal operating conditions, but not likely;

Probable: Likely to occur under normal operating conditions; and

Definite: Will occur under normal operating conditions.

Once consequence and probability have been established, the significance (Low, Medium or High) can be determined (see Table 8-2). Consequence and probability can be established quantitatively or qualitatively, on the basis of an analysis of the information contained in the baseline data report, project data and other relevant (international) literature.

Table 8-2: Significance ratings.

Consequence Score	Probability			
	Unlikely	Possible	Probable	Definite
4 – 6	Low	Low	Low	Low
7 – 9	Low	Low	Medium	Medium
10 – 12	Low	Medium	Medium	High
13 – 16	Medium	Medium	High	Critical

8.1.4 Approaches to impact mitigation

Finally, having assessed potential impacts, appropriate control and management measures should be defined and undertaken according to the significance rating of each impact.

The approaches to the mitigation measures include enhancement (for the positive impacts), prevention, reduction, avoidance and compensation (for the significant negative impacts). The mitigation measures for each (significant and adverse) impact of the proposed Project activities were

generally identified, basing on the associated effect to the environment. The significance of the impact, probability or likelihood that the impact would occur and the severities of its consequence (as determined from the risk assessment matrix) were indices used for determining the mitigation requirements as illustrated in Table 8-3 and Figure 8-1. Moreover subsequently, the specific mitigation measures satisfying the mitigation requirement were established putting into consideration available resources and competencies, on-site conditions, public concerns and technology.

Table 8-3: Impact significance, control and management actions.

Ranking	Impact level	Control and Management Actions	
4 – 6	Low	Actions in the short term	Ensure that policy and control measures are adequate to control the impact
		Actions in the long terms	Verify that monitoring and reporting activities are properly established to guarantee the correct application of policy and ensure that control measures remain adequate
7 – 9	Medium	Actions in the short term	Check if current policy and control measures are adequate, and revise them according to set appropriate objectives for improvement
		Actions in the long terms	Develop adequate plans and activities for control measures, ensuring that they are approved and implemented with timescales set and resources (budget and personnel) allocated.
10 – 12	High	Actions in the short term	Plans and activities are implemented to mitigate the impact as soon as possible. Interim reduction measures are established.
		Actions in the long terms	Long-term plans and activities are developed. parameters and KPIs are set and properly measured, monitored, reported and verified. Targets are set for improvement and feedback used for corrective actions.
13 – 16	Critical	Actions in the short term	Immediate emergency measures to reduce impact. Align the current level of control and implemented measures to best available practices to address the issue. Parameters and KPIs are measures, monitored, reported and verified. Targets are set for improvement and feedback used for continuous improvement.
		Actions in the long terms	The company demonstrates the delivery of continuously improved performance through Research and Development, technology and innovation, training of the personnel, strategic partnership and input and feedback from internal and external stakeholders.

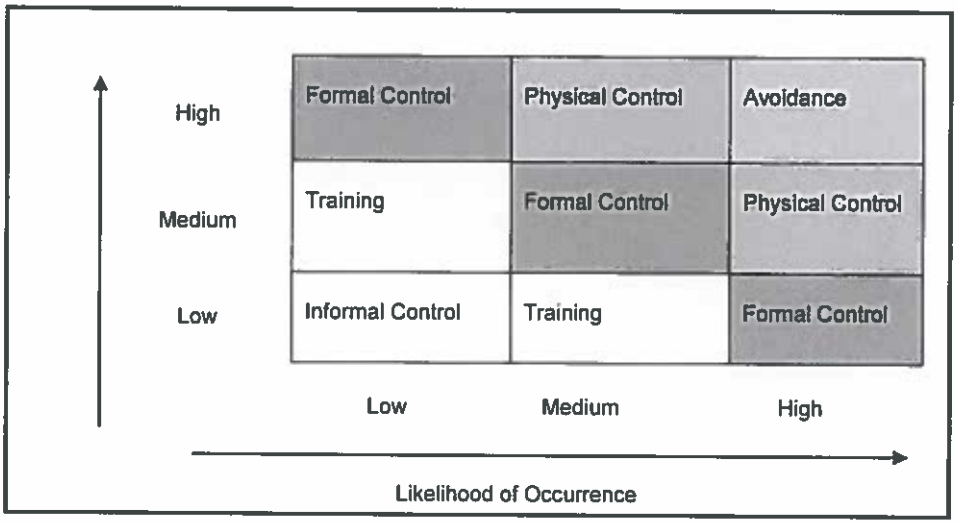

Figure 8-1: Matrix for determination of mitigation measures.

The definitions of the various approaches to impact mitigation considered are presented below.

Enhancement: These are measures proffered to ensure that significant beneficial impacts of the existing facilities and proposed project are encouraged.

Prevention: These are measures proffered to ensure that significant and adverse potential impacts and risks do not occur.

Reduction: These are measures proffered to ensure that the effects or consequences of those significant associated and potential impacts that cannot be prevented are reduced to a level as low as reasonably practicable.

Formal control: This involves the application of documented policy, process or procedure in mitigating the impacts of the project activities.

Informal Control: This involves the application of sound judgment and best practice in mitigating the impacts of project activities.

Physical control: This involves the application of physical processes or instruments (pegs, flags, sign post etc), not necessarily requiring any special technology, in order to mitigate the impacts of a project or impacts.

Avoidance: This involves the modification of plans, designs or schedules in order to prevent the occurrence of an impact or impacts.

Training: This involves personnel awareness in specific / specialized areas.

Management Procedure for Mitigation Measures

The management procedures employed for the establishment of mitigation measures for the identified impacts is presented in Figure 8-2. Mitigation measures were subsequently proffered for adverse significant potential impacts. These measures (prevention, reduction, control strategies) were developed for the adverse impacts through review of industry experience (past project experience), consultations and expert discussions with multi-disciplinary team of engineers and scientists.

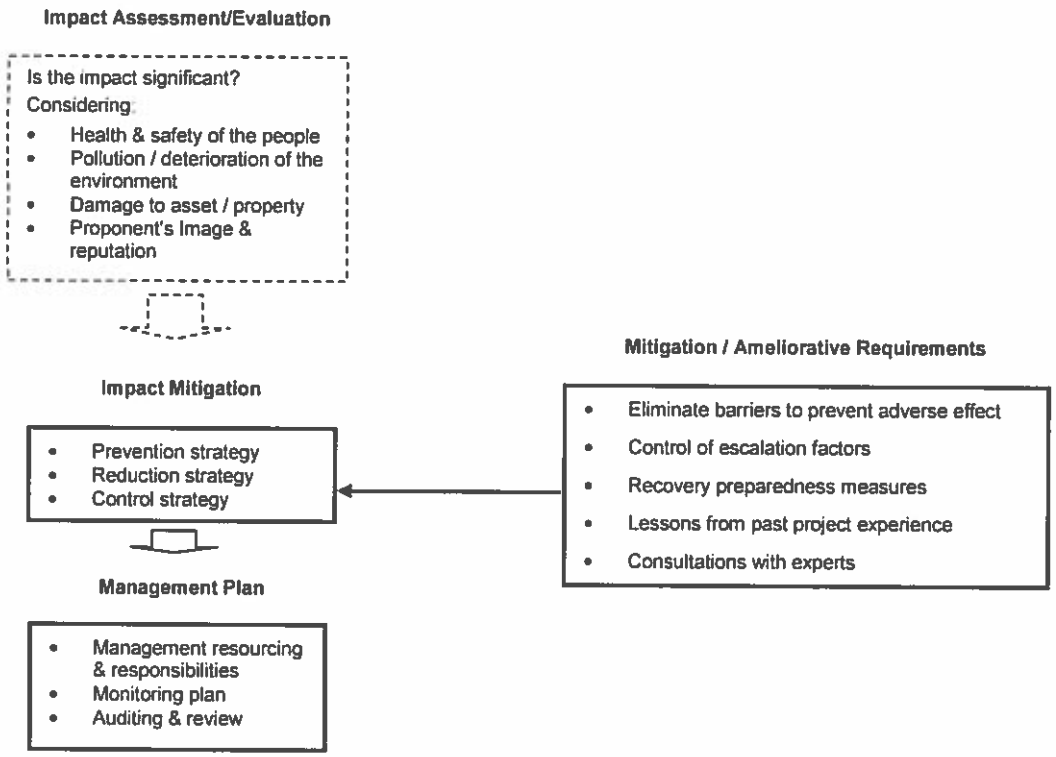

Figure 8-2: Management Procedure for Mitigation Measures.

8.2 Potential Impact Identification and Characterisation

As mentioned in order to identify all of the potential impacts of a project, all proposed project activities must be analysed in relation to the environmental, social and health components of the natural and socio-economic environment that may be affected by the project.

The procedure applied for the impact analysis of the project and the analysis of the environment conducted in the study has involved the breakdown of the project into operating stages:

- Drilling;
- Well heads installation/removal;
- Transport Systems;
- FPSO mooring system;
- FPSO process commissioning/operation; and
- Overhead (i.e. comprises activities which are cross-cutting to all stages, affecting the socio-economic and health components).

Next, for each individual project stage considered, different project sublevels have been identified leading to identification of the project actions (see Table 8-4 to Table 8-9).

While the environmental, social and health components considered were:

- Atmosphere;
- Water environment (characteristics of the water column);
- Sea bed and marine subsoil (characteristics of the sea bed sediments);

- Vegetation, flora and fauna (characteristics of the animal and plant associations of the water column and sea bed);
- Coastal economic resources;
- Population dynamics;
- Local economy;
- Services and Infrastructure;
- Community health and safety; and
- Community relations.

The interactions between project actions and ESH components affected result in the following impact identification matrices, organised by Project Stage:

Table 8-4: Matrix to identify potential environmental, socio-economic and health impacts – Well Drilling Stage.

ENVIRONMENTAL, SOCIO-ECONOMIC & HEALTH COMPONENTS												
STAGE	**ACTIVITY**	**ACTION**	**Atmosphere**	**Water Environment**	**Sea bed & Marine Subsoil**	**Vegetation, Flora, Fauna**	**Coastal economic resources**	**Population Dynamics**	**Local economy**	**Services & Infrastructure**	**Community Health & Safety**	**Community Relations**
WELLS DRILLING	Drilling activities	Drilling system installation and removal			Damages to morphological structures and benthic biocenoses	Damages to morphological structures and benthic biocenoses	Impact on fishing resources					
				Mobilisation and resuspension of sediments	Mobilisation and resuspension of sediments	Mobilisation and resuspension of sediments						
		Drilling system operation	Emission of pollutants into the atmosphere			Generation of noise in the water	Impact on fishing resources				Potential for fire and explosion (safety hazards)	
		Drilling cuttings discharge			Damages to morphological structures and benthic biocenoses	Damages to morphological structures and benthic biocenoses				Pressure on onshore waste disposal / treatment plants		
		Production test	Emission of pollutants into the atmosphere									
	Drilling support	Use of support vessels	Emission of pollutants into the atmosphere	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Impact on fishing resources		Increase in marine traffic	Pressure on local ports & related infrastructure		
				Release of pollutants and metals in solution		Release of pollutants and metals in solution						
				Discharge of engine cooling water into the sea – Hot waste water	Release of pollutants and metals in solution	Discharge of cooling engine water into the sea – Hot waste water						
						Generation of noise in the water						

Table 8-5: Matrix to identify potential environmental, socio-economic and health impacts – Well Heads Installation, Operation and Removal Stages.

ENVIRONMENTAL, SOCIO-ECONOMIC & HEALTH COMPONENTS												
STAGE	**ACTIVITY**	**ACTION**	**Atmosphere**	**Water Environment**	**Sea bed & Marine Subsoil**	**Vegetation, Flora, Fauna**	**Coastal economic resources**	**Population Dynamics**	**Local economy**	**Services & Infrastructure**	**Community Health & Safety**	**Community Relations**
WELL HEADS INSTALLATION AND REMOVAL	Well heads installation and removal	Installation/removal activities		Mobilisation and resuspension of sediments	Damages to morphological structures and benthic biocenoses	Damages to morphological structures and benthic biocenoses	Impact on marine resources			Pressure on onshore waste disposal / treatment plants		
					Mobilisation and resuspension of sediments	Mobilisation and resuspension of sediments						
						Generation of noise in the water						
		use of support vessels	Emission of pollutants into the atmosphere	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Impact on marine resources			Pressure on local ports & related infrastructure		
				Release of pollutants and metals in solution		Release of pollutants and metals in solution						
				Discharge of engine cooling water into the sea – Hot waste water	Release of pollutants and metals in solution	Discharge of engine cooling water into the sea – Hot waste water	Increase in marine traffic					
						Generation of noise in the water						
WELL HEADS OPERATION	Normal operating procedures	presence of production structures		Mobilisation and resuspension of sediments	Mobilisation and resuspension of sediments	Mobilisation and resuspension of sediments						
				Increased availability of organic matter	Increased availability of organic matter	Increased availability of organic matter						
					Physical presence of structures	Physical presence of structures						
		protection of structures against corrosion (anodes)		Release of pollutants and metals in solution	Release of pollutants and metals in solution	Release of pollutants and metals in solution						
	Production, support, maintenance	Use of support vessels	Emission of pollutants into the atmosphere	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Impact on marine resources			Pressure on local ports & related infrastructure		
				Release of pollutants and metals in solution		Release of pollutants and metals in solution						
				Discharge of engine cooling water into the sea – Hot waste water	Release of pollutants and metals in solution	Discharge of engine cooling water into the sea – Hot waste water	Increase in marine traffic					
						Generation of noise in the water						

Table 8-6: Matrix to identify potential environmental, socio-economic and health impacts – Transport Systems Construction and Operation Stages.

ENVIRONMENTAL, SOCIO-ECONOMIC & HEALTH COMPONENTS												
STAGE	**ACTIVITY**	**ACTION**	**Atmosphere**	**Water Environment**	**Sea bed & Marine Subsoil**	**Vegetation, Flora, Fauna**	**Coastal economic resources**	**Population Dynamics**	**Local economy**	**Services & Infrastructure**	**Community Health & Safety**	**Community Relations**
TRANSPORT SYSTEMS CONSTRUCTION	Laying of flowlines	Use of support vessels	Emission of pollutants into the atmosphere	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Impact on marine resources			Pressure on local ports & related infrastructure		
				Release of pollutants and metals in solution		Release of pollutants and metals in solution						
				Discharge of engine cooling water into the sea – Hot waste water	Release of pollutants and metals in solution	Discharge of engine cooling water into the sea – Hot waste water	Increase in marine traffic					
						Generation of noise in the water						
		Laying of flowlines		Mobilisation and resuspension of sediments	Damages to morphological structures and benthic biocenoses	Damages to morphological structures and benthic biocenoses						
					Mobilisation and resuspension of sediments	Mobilisation and resuspension of sediments						
TRANSPORT SYSTEMS OPERATION	Flowlines operations	Protection of structures against corrosion (anodes)		Release of pollutants and metals in solution	Release of pollutants and metals in solution	Release of pollutants and metals in solution						
		Presence of flowlines		Mobilisation and resuspension of sediments	Mobilisation and resuspension of sediments	Mobilisation and resuspension of sediments						
				Increased availability of organic matter	Increased availability of organic matter	Increased availability of organic matter						
					Physical presence of structures	Physical presence of structures						

Table 8-7: Matrix to identify potential environmental, socio-economic and health impacts – FPSO Mooring System Installation Stage.

ENVIRONMENTAL, SOCIO-ECONOMIC & HEALTH COMPONENTS												
STAGE	**ACTIVITY**	**ACTION**	**Atmosphere**	**Water Environment**	**Sea bed & Marine Subsoil**	**Vegetation, Flora, Fauna**	**Coastal economic resources**	**Population Dynamics**	**Local economy**	**Services & Infrastructure**	**Community Health & Safety**	**Community Relations**
FPSO MOORING SYSTEM INSTALLATION	Installation activities	Mooring system installation activities					Impact on marine resources					
		use of support vessels	Emission of pollutants into the atmosphere	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Impact on marine resources			Pressure on local ports & related infrastructure		
				Release of pollutants and metals in solution		Release of pollutants and metals in solution						
				Discharge of engine cooling water into the sea – Hot waste water	Release of pollutants and metals in solution	Discharge of engine cooling water into the sea – Hot waste water	Increase in marine traffic					
						Generation of noise in the water						
	Structures normal operating conditions	protection of structures against corrosion (anodes)		Release of pollutants and metals in solution	Release of pollutants and metals in solution	Release of pollutants and metals in solution						
		Presence of mooring system		Mobilisation and resuspension of sediments	Mobilisation and resuspension of sediments	Mobilisation and resuspension of sediments						
				Increased availability of organic matter	Increased availability of organic matter	Increased availability of organic matter						
					Physical presence of structures	Physical presence of structures						
		Use of support vessels	Emission of pollutants into the atmosphere	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Impact on marine resources			Pressure on local ports & related infrastructure		
				Release of pollutants and metals in solution		Release of pollutants and metals in solution						
				Discharge of engine cooling water into the sea – Hot waste water	Release of pollutants and metals in solution	Discharge of engine cooling water into the sea – Hot waste water	Increase in marine traffic					
						Generation of noise in the water						

Table 8-8: Matrix to identify potential environmental, socio-economic and health impacts –FPSO Process Commissioning and Operation Stage

ENVIRONMENTAL, SOCIO-ECONOMIC & HEALTH COMPONENTS												
STAGE	**ACTIVITY**	**ACTION**	**Atmosphere**	**Water Environment**	**Sea bed & Marine Subsoil**	**Vegetation, Flora, Fauna**	**Coastal economic resources**	**Population Dynamics**	**Local economy**	**Services & Infrastructure**	**Community Health & Safety**	**Community Relations**
FPSO PROCESS COMMISSIONING AND OPERATION	Commissioning	Commissioning procedures, hydrotest		Release of pollutants and biocides in solution	Release of pollutants and biocides in solution	Release of pollutants and biocides in solution						
	Process normal operating conditions	Process operation	Emission of pollutants into the atmosphere	Discharge of cooling water – Hot waste water	Release of pollutants and biocides in solution	Discharge of cooling water – Hot waste water						
				Release of pollutants and biocides in solution		Release of pollutants and biocides in solution						
		Production water discharge		Release of pollutants and biocides in solution	Release of pollutants and biocides in solution	Release of pollutants and biocides in solution						
		Off-loading activities	Emission of pollutants into the atmosphere	Release of pollutants and metals in solution	Release of pollutants and metals in solution	Release of pollutants and metals in solution						
				Discharge of engine cooling water into the sea – Hot waste water	Discharge of nutrients and organic matter from civil sewage	Discharge of engine cooling water into the sea – Hot waste water						
				Discharge of nutrients and organic matter from civil sewage		Discharge of nutrients and organic matter from civil sewage						
	Production support, maintenance	Use of support vessels	Emission of pollutants into the atmosphere	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Discharge of nutrients and organic matter from civil sewage	Impact on marine resources			Pressure on local ports & related infrastructure		
				Release of pollutants and metals in solution		Release of pollutants and metals in solution						
				Discharge of engine cooling water into the sea – Hot waste water	Release of pollutants and metals in solution	Discharge of engine cooling water into the sea – Hot waste water	Increase in marine traffic					
						Generation of noise in the water						

Table 8-9: Matrix to identify potential environmental, socio-economic and health impacts – Onshore site and General Activities Stages

ENVIRONMENTAL, SOCIO-ECONOMIC & HEALTH COMPONENTS												
STAGE	**ACTIVITY**	**ACTION**	**Atmosphere**	**Water Environment**	**Sea bed & Marine Subsoil**	**Vegetation, Flora, Fauna**	**Coastal economic resources**	**Population Dynamics**	**Local economy**	**Services & Infrastructure**	**Community Health & Safety**	**Community Relations**
OVERHEAD	Onshore activities	Onshore activities (waste management, water collection for consumption, electricity & fuel consumption, loading/off-loading, etc.)					Increased natural & other resource use (fuel, water, electricity)	Influx of employees and work seekers	Increased employment levels and income generation	Increased natural & other resource use (fuel, water, electricity)	Potential for fire and explosion (safety hazards)	Alteration in expectations of local communities
	Employment of personnel and contractors	Employment of personnel and contractors						Influx of employees and work seekers	Increased employment levels and income generation			Increase in GDP Alteration in expectations of local communities
	Procurement of goods and services	Procurement of goods and services										Increase in GDP
	Payment of taxes, royalties and fees to Government	Payment of taxes, royalties and fees to Government										Increase in GDP

The matrices above underline the relationship of cause and effect between the operations related to the project and the impacts on the various environmental components generated in the different contexts. This has been followed by a thorough examination of the impacts of the various operations, the different types of effect, and the processes which might potentially be triggered.

The Potential Impacts selected are those potentially capable of shifting the balances of environmental systems in the marine context, or interacting with on-going environmental processes. For example, the project action "use of support vessels", which takes place during installation of the sub-sea well heads and laying of the flowlines, has the corresponding Potential Impact of the emission of atmospheric pollutants arising from the generators installed on board the craft.

Our scrutiny of the project's characteristics arising from the available technical design, thus enabled us to identify and select the main Potential Impacts potentially capable of creating interferences with the marine, coastal and anthropic environment and the relative components identified.

To this regard Table 8-10 represents, for the different ESH components, the summary list of all the potential direct impacts caused by the Project, as identified in the Activity/potential Impacts (or Impact Identification) matrix. The table also allows to represent how each component may be disturbed by a synergy of potential impacts.

Table 8-10: ESH Components/Potential Impacts.

Environmental, social & health components / Potential Impacts	Atmosphere	Water environment	Soil - Subsoil	Vegetation Flora Fauna	Coastal Economic Resources	Population Dynamics	Local economy	Services & Infrastructure	Community Health & Safety	Community Relations
Emission of pollutants into the atmosphere	■									
Generation of noise in the water				■						
Discharge of cooling water into the sea - Hot waste Water		■		■						
Discharge/availability of Nutrients and Organic Matter		■	■	■						
Damages to morphological structures and benthic biocenoses			■	■						
Mobilisation and Resuspension of sediments		■	■	■						
Physical Presence of Structures			■	■						
Release of pollutants, biocides and metals in Solution		■	■	■						
Impacts on marines resources	■			■	■		■			
Increased natural and other resource use (fuel, water, electricity)					■					
Influx of employees and work seekers						■				
Increased employment levels and income generation							■			
Pressure on local ports & related infrastructures								■		
Pressure on onshore waste disposal/treatment plants								■		
Potential for fire and explosion (safety hazards)									■	
Increase in marine traffic							■			

Environmental, social & health components / Potential Impacts	Atmosphere	Water environment	Soil - Subsoil	Vegetation Flora Fauna	Coastal Economic Resources	Population Dynamics	Local economy	Services & Infrastructure	Community Health & Safety	Community Relations
Alteration in expectations of local communities										
Increase in GDP										

Once the direct impacts are established, the next step is to determine the impact pathway to identify the further socio-economic and health implications (indirect impacts) of these changes, as well as any subsequent cumulative and perceived effects (Table 8-11).

Table 8-11: Impact pathway to identify *indirect* (as well as cumulative and perceived) socio-economic and health impacts (both positive and negative).

Direct	Indirect		Cumulative	Perceived
Increased employment levels and income generation	Increased capacity to access services such as schooling and health	Improved education levels, health status, etc		Expectations regarding new opportunities for employment and public services
Influx of employees and work seekers	Increased competition for available accommodation	Inflation in housing costs	Depletion of previous living standards	
		Mushrooming of slum/inadequate housing[10]		
	Increased pressure on existing sanitation systems	Increase in inadequate housing & living standards		
		Favouring additional breeding of disease vectors (water and animal)	Increased pressure on health care system	
	Water resource use	Reduced access to potable water	Increased health risks and demand on Health Services	Expectations regarding new opportunities for safe water supply
	Introduction of novel diseases, capacity for disease spread and disease vectors	Changes in epidemiological pattern	Increased workload for some health services	Expectations regarding new opportunities for health services
	Sex workers & other dysfunctional behaviour (crime) increase	STIs and blood borne viruses diffusion	Reduced productivity of the population	
		Reduced security of local population		
	Mixing of cultures & disruption of traditional family and community cohesion	Cultural integration		
		Loss of traditions, rites, beliefs		
Biophysical impacts on marine resources	Interruption or disturbance to fishing activities	Loss of income and decreased food security	Impacts to local economy	Marine pollution will harm fish and coastal communities, especially in the case of an oil spill
Increase in marine traffic	Hazards to and disruption of navigation	Potential emergency situation from vessel collision		Increased trawling in the Soyo Area & hence damage to fishing nets and erosion of the islands

[10] According to UN standards poor housing/slums have at least one of the following four characteristics: lack of access to improved water supply, lack of access to improved sanitation, overcrowding (more than 3 persons per room), and dwellings made of non-durable materials.

Direct	Indirect		Cumulative	Perceived
Pressure on local ports & related infrastructures	Increased safety risks for local users		Increase in noise emissions; psychological disturbance of local population	
Pressure on onshore waste disposal / treatment plants	Health problems due to biological, chemical, physical factors		Risk of pollution from waste mismanagement	
	Diffusion of safety risks to humans and livestock		Impoverished health conditions	
Degradation of air quality	Increase of respiratory disease	Increased health risks, impoverished health conditions and pressure on local health services		
	Health problems due to biological, chemical, physical factors			
Increased natural and other resource use (fuel, water, electricity)	Drop in town supply potable water		Loss of natural resources/reduced resource availability	Expectations regarding new opportunities for infrastructural services improvement & provision
	Increased competition in access to energy resources (price increases, lower capacity per capita)	Pressure on economic activities dependent on electrical supply	Impacts on local economy	
Potential for fire and explosion (safety hazards)	Increased safety hazards/risks	Inadequate occupational health and safety	Increased pressure on health care system	
Alteration in expectations of local communities	Risk of unmet expectations		Company sector reputational damage	Expectations regarding new opportunities for employment, improved infrastructural conditions like water, electricity, public transport, health centres and schools, new lands to cultivate and the donation of new construction materials
Increase in GDP	Increased public investment in infrastructure & services provision (education, health, etc.)		Improved standards of living	

8.3 Potential Impacts Indicator Parameters

As mentioned it is possible to express the ESH components by means of specific indicator parameters (see Table 8-12). This table of INDICATOR PARAMETERS against POTENTIAL IMPACTS illustrates which environmental, social and health (ESH) parameters are potentially affected by the Potential Impacts. The latter modify the parameters more or less significantly, directly and/or indirectly, by causing a change in the control value of the indicator associated to each parameter before the start of the project operations.

The chosen Parameters/Indicators are "sensitive" to the changes triggered by the Potential Impacts, and are therefore capable of describing and quantifying the impacts caused, and providing a clear picture of their boundaries and characteristics, even where the Potential Impacts interact with each other to generate more complex forms of environmental/social stress, involving a variety of interconnected components.

The table is therefore intended as a tool which provides an overview of the environmental, social and health sensitivity factors and the current or potential criticalities, in relation to the specific, often synergetic, agents of impact identified and arising from the project operations.

For example, the parameter of the T.O.C. of the sediments and/or water column is clearly influenced by the discharge of organic effluents, but less explicitly, it is also strongly affected by the physical presence of a hard substrate in the sea (permanent structure), due to bio-fouling.

Table 8-12: Relationships between Indicator Parameters and Potential Impacts.

POTENTIAL IMPACTS / PARAMETERS/ Indicators	Discharge of Nutrients and Organic Matter	Emission of pollutants into the atmosphere	Generation of noise in the water	Discharge of cooling water, hot waste water	Damage to morphological structures and benthic biocenoses	Mobilisation and resuspension of sediments	Physical Presence of Structure	Release of pollutants, Biocides and Metals in Solution	Biophysical impacts on marines resources	Increased natural and other resource use (fuel, water, electricity)	Influx of employees and work seekers	Increased employment levels and income generation	Pressure on local ports & related infrastructures	Pressure on onshore waste disposal/treatment plants	Potential for fire and explosion (safety hazards)	Increase in marine traffic	Alteration in expectations of local communities	Increase in GDP
Ammoniacal Nitrogen Concentration	■																	
Orthophosphate Phosphorus Conc.	■																	
Nitrate Concentration	■																	
Nitrite Concentration	■																	
Total Hydrocarbons								■										
Oxygen Concentration/BOD	■			■														
Temperature				■														
Transparency	■			■		■	■											
Bioaccumulation of Lead								■										
Bioaccumulation of Aluminium								■										
Bioaccumulation of hydrocarbons (IPA)								■										
Sulphur Dioxide Concentration		■																
Aromatic Hydrocarbon Concentration		■																
Nitrogen Oxide Concentration		■																
Carbon Oxide Concentration		■																
Dust Concentration		■																
Organic Carbon Concentration TOC	■						■											
Lead Concentration								■										
Aluminium Concentration								■										
Chlorine concentration								■										
Particle Size						■												
Sediment Thickness						■												
Chlorophyll "a"	■			■														
Fishing Yield	■						■		■									
Reduction in Fishing Grounds							■									■		
Average Number of Species	■				■	■			■									
Specific Diversity Index					■	■												
Average Low Frequency Noise			■															
Zone Affected by noise			■															
Water consumption / % pop. access to safe water										■	■							
Electricity consumption										■	■							
Malnutrition/Food insecurity									■	■	■	■						
Population											■							
Employment											■	■	■	■				
Infrastructure and services capacity											■	■	■	■	■	■		
Fires and explosions															■			
Community relations											■	■					■	■
GDP																		■

8.4 Potential Impacts Evaluation

Once identified and characterised, potential impacts need to be assessed in order to determine the significance of each impact, as well as any required mitigation/enhancement and/or management measures to ensure that impacts are of acceptable levels of significance. The significance of an impact is qualitatively established on the basis of clearly defined criteria that describe each impact's Consequence and Probability, using a methodology developed by Eni and defined in the Eni ESHIA Standard (Eni doc. no. 1.3.1.47). In relation to some affected components impacts are also assessed quantitatively through the application of modelling techniques.

This section presents more detailed discussions on the environmental, social and health aspects as well as the associated and potential impacts of the proposed projects. As already indicated in the previous section, these impacts have been assessed (characterized and evaluated) and the results presented in Table 8-4 to Table 8-9. The discussions presented in this section are intended to provide insight into the nature and magnitude as well as duration of identified impacts of the various project activities.

8.4.1 Environmental Impacts Evaluation

Environmental Effects of Potential Impacts

As previously illustrated in Table 8-10 (ESH Components/Potential Impacts) each environmental component may be affected by a synergy of potential impacts, which stem one from the other. For example, the component Seabed and Marine Subsoil is potentially affected by 5 different types of impact, and these impacts in turn may be generated by one or more project actions. Moving towards the impact evaluation it is therefore necessary to first provide a description of the environmental effects of each potential impact, as well as which project actions give rise to these same potential impacts.

The presence of the vessels supporting the installation and operation of the drilling system and the installation of the sub-sea well heads, the construction of the mooring system and the positioning of the FPSO, its operation and offloading activities, and the support vessels which lay the flowlines linking the sub-sea well heads and install the connections and protective systems causes the **emission of pollutants into the atmosphere** as a result of operation of the engines and power generators. However, these emissions are small in quantity, temporary, and partly restricted to the installation site and partly occurring along the route of the flowlines.

The presence of the support vessels necessary for the operations leads to an **increase of the low frequency underwater noise level** which may drive fish species away, although only temporarily and within the small area where the noise is heard, and may also interfere with the normal physiological functions and behaviour of some species.

The presence of the support vessels and the operation of FPSO including offloading activities will also cause the discharge of engine cooling water into the sea; the main effect of the **discharge of engine cooling water** is a possible local increase in temperature, with possible consequences for primary production.

The **discharge of treated sewage** from the support vessels, the FPSO and the offloading vessels involves the discharge both of dissolved substances (e.g. nutrients easily assimilated into the primary production cycle) and **suspended matter** (which causes an increase in turbidity and the consumption of significant amounts of oxygen to degrade the matter through the affected column of water, also triggering an increase in primary production). In the event that this discharged material reaches the

sea bed (this might not occur in the zone concerned, where the water is very deep) there is an **increase in organic matter** and thus a reduction in the amount of oxygen at the interface.

Treated sewage will be discharged for the time for which the support vessels are required for drilling operation, well heads installation, FPSO installation and operation, offloading activities and flowlines laying operations, and this will take place in the installation sites and along the route of the flowlines.

The operations for installation, laying of the flowlines and anchoring of the lay barge and mooring system construction may cause small, localised morphological changes, which may lead to **interference with morphological structures** (formed by sediments or biological processes) and **benthic biocenoses** with damages depending on the vulnerability of involved ecosystems.

Given the absence of light capable of illuminating the seabed (water depth in project area is over 1500m) the benthic communities present in the area potentially affected by the project are decidedly poor both in terms of number of individuals and specific biodiversity.

Morphological variations are filled, levelled and returned to their previous conditions by the currents and hydrodynamics, at varying speeds which depend on the sedimentation rate and hydrodynamics of the areas where the installation site and flowlines route are located.

During drilling operations, a solid waste processing system will be in operation at the point where the mud flows out of the well. It will comprise equipment such as a vibrating screen, desilter, desander, centrifuges, etc., which will separate the mud from the drilling cuttings, which will be collected and discharged into the sea.

The discharge into the sea of the drilling cuttings contaminated with the water-based muds used in the drilling operations will tend to **bury the benthonic biocenoses,** temporarily damaging a small area of habitat in the immediate vicinity of the discharge point.

The drilling fluids used consist of a basic liquid (water in this case) rendered colloidal and weighted through the addition of specific products. The colloidal properties provided by special clays (bentonite) and enhanced by special compounds such as carboxyl methyl cellulose give the mud the rheological properties needed to keep the weighting materials and cuttings in suspension, even when the circulation is at a standstill, with the formation of a gel.

In the light of the chemical-physical characteristics of the drilling muds, briefly described above, there are no grounds for envisaging contamination of the seawater or changes to the quality of the marine sediments due to the discharge of the drilling cuttings into the sea.

Another consequence of the operations to install the drilling and the production system, and to install the mooring system and lay the flowlines is the **mobilisation and resuspension of sediments** from the sea bed. This leads to a temporary increase in the turbidity of the water over a small area, the size of which depends on the local hydrodynamics, and the particle size and cohesiveness of the sediment. The degree of turbidity decreases as the particle size increases is greater in specific hydrodynamic conditions, such as where there is stratification of the water column, and leads to a reduction in the level of light penetration. If this reduction in light levels continues for some time, there may be a decrease in the amount of oxygen in the water due to a reduction in the rate of photosynthesis and the activation of degradation/oxidation processes only; primary production is thus directly affected.

The positioning of the drilling and production structures and their presence leads to burying of the organisms and benthic biocenoses, and the removal of a small area of habitat; this removal is temporary in the case of the drilling system and restricted to drilling period and much longer in the case of well heads and flowlines laying activities.

The temporary physical presence on the sea bottom of drilling structures and the much longer presence of the sub-sea well heads, the flowlines and the mooring system, produces an

amplification/modification of the local hydrodynamics and the normal sediment resuspension and erosion phenomena, with negligible effects on the local particle size and local changes to the typical percentage of sand, clay and silt, and consequent negligible variations in the numbers and types of macrobenthic species (especially polychaetes and molluscs), which depend to a considerable extent on the types of sediment found on the sea bed.

An increase in the organic matter both in suspension and on the sea bed, with a possible reduction in the amount of oxygen near the sea bed and an increase in the turbidity, with potential direct and indirect effects on the area's biology, may arise as a result of the physical presence of the sub-sea structures (well head, flowlines, FPSO positioning system).These cause an increase in the availability of the organic matter in the area, thanks to the F.A.D. (Fish Aggregating Device) effect, creating a new community of fauna different from that typically found in the waters around the well heads. This will also have beneficial effects on fishing in the zones close to these sub-sea structures.

Changes in the trophism (increase in organic matter available during installation due to the treated sewage discharges, and during normal operation due to the F.A.D. effect) may modify the concentration of chlorophyll a, linked in turn to the algal biomass.

Since during normal operation the subsea structure will discharge no nutrients into the sea (no treated sewage), the variations in chlorophyll concentrations derive essentially from the normal seasonal fluctuations, indirectly influenced by the presence of the offshore structure, which creates a microhabitat where biological activity is amplified compared to the surrounding environment.

There will be a de facto **reduction in the area available for commercial fishing** due to the presence of the production structures and the flowlines, or operations related to them. The operations may also temporarily chase the fish stock available for commercial fishing away from the involved areas and could partially modify the migratory routes for the young of some species. However, this will not in any way compromise survival or create any significant impact on commercial fishing conducted in the vast area.

The minor fishing performed by coastal communities will not be affected in any way because such fishing does not involve the area covered by the proposed project which is at a quite some distance from the coast.

The presence of the vessels needed to lay the flowlines and support installation, operation and offloading activities may generate an increase in the lead concentration in the water column and sediments, since this element is present in the fuels used to power the craft.

The quantities of relatively heavy aliphatic compounds (from C10 to C15) and the concentration of IPA (generally of the order of ppb) can be considered quite low, since the only emission source is the exhaust water of Diesel-powered vessels used for support activities. The highest levels of hydrocarbons (and lead) in sediments occur generally along the routes followed by the vessels which travel to and from the offshore structure, allowing us to assume that their presence is caused by the passage of the craft.

The resuspension of sediments may trigger a limited **release into the water column of** any **pollutants** in the sediments themselves, and in the final analysis indirect effects on the biology of the area arising from the possible burying of organisms and biocenoses due to the re-sedimentation of material placed in suspension during operations.

The use of sacrificial anodes to protect the submerged structures against corrosion has negligible effects on the water column and sediments, and marginally also on the biocenoses. The anodes (which contain no mercury) **shed metals**, especially Aluminium, causing a slight increase in the concentration of these elements in the water column and in the sediment, to which they are confined, unable to significantly affect the biocenoses.

The bibliography on the effects of the presence of Aluminium in marine sediments or the water column is very limited. However, there are no reports of cases in which this element has been toxic to marine organisms, and apparently sea-dwelling filtering organisms are not capable of bio-accumulating Aluminium.

Substantially, the extent of the effects of a given disturbance varies depending on the stage in the operations, but the processes triggered on the sea bed or through the water column are generally the same.

The types of change on which attention has been focused have basically been:

- Anomalies in the morphology, sediments and macro-fauna caused by the physical impact of installation of drilling structures, mooring system and the well heads, and the presence of the sub-sea structures (mooring system, well head and flowlines), in terms of both a physical obstacle interfering with the waves and currents, and occupation of the sea bed;
- Physical and biological effects (changes in the morphology, sediments, and burying of benthic organisms) caused by the material suspended as a result of the installation operations and subsequently re-sediment, and by the treated sewage discharged from the offshore structure during activities;
- Chemical, chemical-physical and biological anomalies in the water column and sea bed caused by the possible release of any toxic substances or elements present in the sediment disturbed, with effects on the planktonic and benthic organisms; and
- Chemical, chemical-physical and biological anomalies of the atmosphere, water column or sea bed caused by the possible release of any organic and inorganic pollutants and the disturbance caused by the presence of the vessels involved in the activities and by process operation.

Hence, to allow a more effective assessment of the environmental impact of the activities on each individual sector, it is necessary to make a detailed analysis of the project actions, the relative disturbances, and the processes with which they interact. To simplify this analysis, the project actions were subdivided into groups on the basis of the type of effect induced, and the relative forms of disturbance, i.e. the ways in which they interact with and change the environment, were identified for each group. This is illustrated in Table 8-13. Finally, the impacts' evaluation is presented by environmental component and relative parameters affected.

Table 8-13: Effects of project actions and potential impacts identified.

Effects of the project actions		Potential impacts
Modification of primary production and phytoplankton population density	Actions which may affect the level of trophism	Discharge of Nutrients and Organic Matter
Increase of organic particulate in suspension		Physical presence of structures with increase in organic matter availability
Changes in oxygen consumption with variation in compensation point		
Variation in the quantity of organic matter in the sediment		
Change in the level of microbic decomposition		Discharge of cooling water, hot waste water, production water, potentially containing hydrocarbons
Increase in resources of debris-eating animals		
Modification in thickness of the oxidised layer of the sediment		
Increase in sedimentation of particulate on sea bed		Damage to morphological structures and benthic biocenoses fron sea

Effects of the project actions		Potential impacts
Shifting of sediments and increase in organic particulate in suspension	Actions which cause mechanical and physical disturbance to the substrate	bottom activities and cuttings discharge
Increase in hydrodynamic energy on sea bed		Mobilisation, distribution and re-depositing of sediments
Increase in sedimentary instability of sea bed		
Clogging of breathing surfaces		Physical presence of structures and interference with the sea bed
Release of metals in solution and their incorporation into sediments	Actions causing inorganic pollution	Release of pollutants and metals in solution from sacrificial anodes, and as a result of shifting of any contaminated sediments
Bioaccumulation and bio-magnification		Discharge of pollutants and biocides from process operation
Modification of the physiological functions of organisms	Actions which disturb physical parameters (not on sea bed)	Generation of noise in the water
Driving away of fish and breeding stock and interference with routes used by fry		Physical Presence of Structure
Attraction of fish species (FAD effect)		Emission of pollutants into the atmosphere

Eutrophying disturbing actions

This first group includes the actions which cause disturbances capable of directly or indirectly increasing the level of nutrients or the level of organic enrichment of the water column and sediment.

This class of disturbance includes:

- Discharge into the sea of hot water from the cooling of the engines of the vessels present during installation, operations and offloading activities, and the system power generators;
- Discharge into the sea of cooling hot water from FPSO production process;
- Discharge into the sea of hot production water containing hydrocarbons and salts,
- Discharge of nitrogen and phosphorus compounds (treated sewage) or other organic substances, and the actual presence of the sub-sea structures which may indirectly cause an enrichment of the organic matter due to the variations triggered in the circulation near the sea bed.
- The physical presence of the sub-sea structures causes an increase in the availability of organic matter due to the colonisation of the structures by filtering bivalves, algae and other organisms as a result of what is known as the F.A.D. (Fish Aggregating Device) effect, thus creating a new fauna community different from that typically found on the soft sea beds around the well heads, with beneficial effects for fishing around the zones close to the sub-sea structures themselves.

Eutrophying disturbances lead to temporary interferences of the kind described, closely correlated to the increase in primary production, and significant over a limited area, negligible and fading into nothing along the route of the flowlines in the open sea.

The eutrophying actions cause an increase in the concentration of chlorophyll in the water column, due to the increase in the densities of the phytoplankton population; the increase of organic particles in suspension may lead to reduction in the transparency of the water column and a raising of the depth below which respiration predominates over production, while within the sediment it may cause an increase in organic matter and thus in the resources for debris-eating animals and microbic

decomposition, causing a rise in oxygen consumption and a reduction in the depth of the oxidised layer.

Mechanical and physical disturbing actions

This category includes all forms of disturbance, which, while their impact on the chemical characteristics of the water column and sea bed is low, have a mainly physical disturbing action, for example by modifying the hydrodynamics, particle size breakdown and morphology of the sea bed. They comprise the discharge of particulate inorganic matter (production water, treated sewage etc.), movements of sea bed sediments due for example to the laying of the flowlines, discharge of drilling cuttings and burying of portion of the sea bed, hydrodynamic variations caused mainly by the continuing presence of the sub-sea structures, which interfere with the waves and currents to cause turbulence and local erosion-sedimentation, as well as instability of the sedimentation mechanisms.

The presence of the well heads, the mooring system and the flowlines laid on the sea bed may lead to some level of distortion of the current field, and local changes of sediment distribution; however, the results of hydrodynamic models applied to similar structures have revealed that the variation only affects a very small volume of water around the structures, which can therefore be considered to have no significant effects. The interference occurs over a band just a few metres wide around the structures; moreover, in the case of the flowlines, the effects will diminish over time as the line gradually becomes covered with sediments.

The interferences caused by mechanical and physical changes to the substrate relate also to the transparency of the water column and a variation in the sedimentation of the sea bed. The effects vary depending on the type of the sea bed and the communities to which it is home, and are particularly severe only on rocky sea beds or organogenic substrates, which are not found in the areas affected by mooring system, the well heads and laying of the flowlines.

The physical presence of the structures, and the operations which may interact with the sea bed to cause erosion/resuspension of sediments in general, together with the emission of fine material, organic matter and nutrients from the treated sewage from the FPSO and the vessels providing support for the drilling activities, discharge of production water containing particulate matter, FPSO operation and offloading and flowlines laying operations, cause a variation in the transparency of the water and a local alteration in the typical percentages of sand, clay and silt, although this is limited in both time and space.

Although affecting only a limited area, the reduction in transparency is particularly noticeable in the deepest layers of the water column, due to the movement and resuspension of the sediments caused by the operations too.

A variation in the average number of polychaete and mollusc species and the specific diversity, equidistribution and abundance indicators of the benthic biocenoses arises as a result of the installation and laying of the flowlines, and in general from the operations or activities which affect the sea bed, although this is of fairly short duration and only occurs in the area immediately around the operating zones.

The physical presence of the structures and the shifting and re-depositing of the sediments caused by the operations, the discharge of drilling cuttings and their deposition on the sea bed may lead to habitat loss and changes in the type of the sediment and thus in the number and type of the macro-benthic species which depend to a large extent on the characteristics of the sea bed sediments.

Over the long term, the flowlines and the sub-sea structures of the well heads and mooring system may encourage colonisation by sessile organisms, leading to habitat conditions different from those in the surrounding area. There is also the possibility of species enrichment or the appearance of new species, especially since the surrounding sea beds are mobile and not hard.

However, it must be remembered that once the flowlines have been laid, its effects will only be felt for a few metres either side of it, and thus the loss of habitats caused by its presence and that of the other sub-sea structures is negligible.

Shifting of the sea bed and the changes in its physical and chemical composition caused by the operations may lead to local, temporary disturbances in the microbiology of the sediment.

Actions causing inorganic pollution

This is chemical pollution, originating both from the sub-sea structures and the cathodic protection systems (sacrificial anodes), and from the shifting and resuspension of any sediments contaminated with heavy metals, which are thus put back into circulation; the release of ions into the water column by support vessels is another form of pollution in this category.

The release of hydrocarbons and ions into the water column by the FPSO (production water) and by support and offloading vessels, and the discharge into the sea of the biocides or anticorrosion substances (probably chlorine) contained in the cooling water used during the production process and in the production water, are other forms of disturbance in this category.

The potential interaction between these forms of disturbance and the biological entombment arises from the bioaccumulation (incorporation by organisms).

Al is used in the construction of the anodes which protect sub-sea structures from corrosion. This cathodic protection is provided by applying a certain number of mercury-free strap-on sacrificial anodes consisting of an alloy containing about 95% aluminium.

The purpose of these anodes is to form batteries with an electromotive force which depends on the potential difference between the anode and the cathode. They thus wear at a rate calculated on the basis of a number of environmental parameters, such as the percentage of oxygen, the exposed surface area, the salinity and the temperature, all factors which affect the normal corrosion of submerged metal structures.

Apart from Al, the mercury-free anodes contain variable amounts of other elements including Mg, Mn and Zn, and also In (0.02-0.05 %), Cu (0-0.006%) etc., and during their lifetime, they release positive ions of these elements.

The presence of the anodes leads to an increase in the concentration of aluminium in the sediments around the flowlines, where it remains without causing changes to the biocenoses, and Al in ionic form in the water column. The presence of Al may lead to co-precipitation with silica (if concentrations of 0.5 ppm of Al, water temperature of 2° C and 0.5 ppm of Si all occur), and further to this event zeolitic formations may be deposited on the sea bed in the affected areas.

These substances are not considered harmful or pollutant, and it must also be underlined that Al is not bioaccumulated by organisms but rather tends to be eliminated by clearance. A slight increase in the level of the element in filtering organisms may be due to the presence of Al in the intravalvular liquids.

There may be an increase in the concentration of lead in the water column and sediment as a result of secondary activities relating to the management of the FPSO production process, the installation of well heads and flowlines laying activities, such as navigation and the presence of vessels.

From the bibliography available it is clear, for example, that higher lead concentrations are found in sediments along the routes used by the vessels which visit offshore structures on a regular basis, appearing to point to an origin linked to the presence of these craft.

The presence of vessels therefore generally leads to an increase in the concentration of Pb in solution, since it is found in the fuels used; lead is bioaccumulated by filtering organisms.

Hydrocarbons (Polycyclic Aromatic Hidrocarbons (PAH) in particular) are bioaccumulated by organisms; the data point to negligible bioaccumulation of hydrocarbons on organisms taken from the legs of offshore structures during operation (the offshore structure does not discharge PAH), but reveal that mussels are affected to a greater extent by the presence of the aromatic hydrocarbons derived from the ship traffic.

Some of the chlorine discharged into the sea with the water from the FPSO operation is rapidly consumed by oxidation reactions with a number of inorganic ions (bromide and ammonium); another part of this element reacts more slowly, especially with the dissolved organic substances, but also with the particulate organic matter.

The difference between the chlorine discharged and the residual chlorine is known as the "chlorine demand", which depends on the amount of chlorine discharged, the contact time and the characteristics of the water, which themselves vary depending on the time of year, as a consequence of the water's level of oxygenation and phytoplankton blooms. During hypoxic or anoxic phases, considerable amounts of ammonium are produced and interfere with the chlorine due to the formation of chloramines, increasing the chlorine demand. Similarly, a larger amount of plankton in suspension means a higher chlorine demand.

The chlorine discharged into the sea water mainly leads to the formation of organic halogen compounds (mainly bromine compounds) such as trihalomethanes (especially bromoform), haloacetic acids, haloacetonytriles and halophenols, compounds with a certain degree of toxicity.

The quantities produced depend on the quantities of chlorine discharged and the concentration of organic matter present in solution and as particulate; in general terms, it can be assumed that 1% of the chlorine consumed bonds to the organic matter to form halogen compounds with varying degrees of toxicity.

Actions which disturb physical parameters

This category includes all physical disturbing actions which do not specifically affect the sea bed, such as the generation of noise in the water or the discharge into the sea of hot production water, and hot water used to cool the engines of the vessels operating in the area or during the FPSO operation process.

These disturbances, especially those related to water-borne noise emissions, may cause modifications of organisms' physiological functions at various levels, or may simply temporarily drive fish away, interfering with the movements of the fry of many species, which come close to the coast at some times of year.

The heat discharged through the production water and the cooling water of the engines of vessels and the power generators and of the FPSO process is only capable of causing a marginal, local variation in the temperatures of the zone, since the homoeothermic properties of the open sea rapidly cool the discharges to the temperature of the surrounding area.

The presence of permanent structures on the sea bed, combined with the relative bans on shipping and fishing, may cause conflict between the wells and fishing activities; the Harbourmaster's Office generally establishes protection zones along the flowlines and around the well heads, with restrictions on fishing and mooring.

In fact, it should be pointed out that while there will be a small reduction in the area available for fishing, the provision of shelter for benthic and pelagic life forms, the increase in the biomass and the number of fish species attracted to the structures, together with the prevention of trawling on an area of the sea bed, will generate considerable benefits for the surrounding environment (fishermen included).

Analysis of Impacts/Effects on Environmental Components

Based on analyses of the previous sections a detailed assessment of the expected impacts on the individual components of the environment has been carried out; these evaluations are presented in the following parts of this document.

The estimated values of the impacts produced by the perturbance factors, whose behaviour can be predicted by a simulation model, were obtained through the use of mathematical tools capable of calculating the variation of the value of a given parameter (e.g. the concentration of a pollutant in the atmosphere or the concentration level of the metals released from the anodes into the water column) caused by the changes induced by the specific perturbation considered.

The formulation of reliable and significant quantitative estimates of the disturbing effects caused by certain activities on selected indicators is not necessarily easy. The difficulties are linked to the substantial lack of data due to the small number of studies conducted in this sense.

From a statistical point of view, it is therefore necessary to have a consistent data base to obtain meaningful results. And the use of mathematical simulation models does not solve in a comprehensive way the existing problems in impact estimation. Especially in cases like this, where the impacting actions are actually of modest quantitative significance in relation to the quality and capacity of the receiving body; given that the project area's water depth is more than 1500m and distance from the coast is some 120 km, chances that the impacts arising from the project should affect in any way the sea bed or the coast are very slim. Moreover, the dilution capacity of the receiving body renders virtually negligible impacts on the water column and on the biological component.

Despite these limitations, the findings made and the estimates given in this chapter are considered sufficient to focus on the real extent of the impacts of the project, which overall are very low.

Hereby follows an assessment of the impacts identified, i.e. of the alterations in the indicator parameters. In more general terms an assessment of the interaction between the Project and the receptor environment, emphasizing and taking into account:

- The characteristics of sensitivity and thus the vulnerability of the environment;
- The duration and extent of the perturbation; and
- The number of elements involved.

The sensitivity of the project activities is crucial in influencing the real effect of the impacts identified.

8.4.2 Impact on Air Quality

During the proposed project execution, modest levels of emissions will be generated from different sources such as helicopter movement, sea going and supply vessels and generators. The effects of the emissions are expected to be low as their effects will be mitigated in addition to atmospheric dynamics observed in the study area. Under most offshore meteorological (winds, gales, etc.) conditions, concentration of air quality pollutants would be well below their maximum predicted values due to the effect of dispersion / dilution leading to very negligible effect.

During well drilling, installation of FPSO, laying of flowlines and well heads activities, atmospheric emissions are essentially linked to exhaust gases from the engines. Other emissions are related to gas flaring in production tests. Considering that the activities in question are short-lived and that the weather conditions in the open sea present such features as the nearly constant wind of varying direction and intensity, it is clear that the pollutants in question are disposed of quite rapidly.

The position of the rig and other facilities allow a greater spread of the plume formed in the atmosphere, permitting the dispersion due to the higher probability of winds; previous studies of atmospheric dispersion, show a complete diffusion of pollutant emitted from the fuel combustion. As

regards the atmospheric component, the results reported above indicate that emissions cannot in any way modify the pre-existing air quality in the offshore area involved in the operations. Moreover, the project area is located quite far from the coast; so its impact on the shoreline will be minimal. Therefore, it is possible to underline that the project impacts on the atmosphere due to emissions produced by the project is totally negligible.

In Table 8-14 data about greenhouse gases (GHG) emissions is reported, calculating the Global Warming Potentials (GWP) according to IPPC (2007) characterization factor.

Table 8-14: Global warming potential of project activities

POLLUTANT	CO_2 (Kg)	CH_4 (Kg)	GWP (Kg CO_2 eq.)
Drilling unit	51.601.204,34	2.794,47	51.671.066,19
Supply vessel	26.182.154,20	1699,25	26.224.635,45
Gas flared in production tests	2.175.119,15	222,6285	2.180.684,86
Oil burned in production tests	8.393.647,50	290,19	8.400.902,25
TOTAL	88.352.125,19	5.006,54	88.477.288,75

The potential impact of air emissions on air quality is therefore assessed to be of low significance (see Table 8-15).

Table 8-15: Significance of impact of air emissions.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Medium term 2	Local 1	Low 1	Very small 1	5	Definite	LOW -

8.4.3 Impact on Water Quality

During project execution, there will be temporary re-suspension of sediment particles including organic matter within the water column. This will be low in magnitude and short term hence not envisaged to have pronounced significant effect on water quality. The following project activities are likely to contribute to the quality of seawater:

The project's activities require the presence of some vessels in the surrounding waters to support the various phases of the work. All vessels have mechanical seals which prevent any leaking of oily bilge water and thus the physiological hydrocarbon leaks can be deemed negligible. During the drilling phase, vessels are envisaged to transport personnel and a supply-vessel (for ordinary maintenance and for loading and unloading other materials).

The presence of naval vessels means the emission of hot water as the engine cooling water is discharged, water which may contain hydrocarbon residues and trace metals.

The presence of the drilling structure, submerged well-heads, flowlines and FPSO mooring system may lead to some level of distortion in the current field. However, the results of hydrodynamic models applied to similar structures have revealed that the variation only affects a very small volume of water around the infrastructure and, therefore, its effect can be considered insignificant as compared to waves and currents motion.

During the drilling and completion phases, the FPSO and well heads installation, and FPSO operations, effluents from the crew quarters and service areas of the drilling unit, the FPSO and the vessels, are discharged into the sea after adequate treatment. These discharges contain nitrogen and phosphorous compounds and organic substances in general, substances which can raise the BOD level, the level of water trophism and reduce transparency.

The presence of vessels can lead to increases in the lead concentration in the water when leaded fuels are used. On the other hand, the drilling system and well head are not expected to release lead into the sea.

Definition of the Indicator Parameters

- Transparency;
- Temperature;
- Nutrients;
- Organic substances, TOC;
- Chlorophyll "a";
- Total Hydrocarbons;
- Oxygen concentration; and
- Heavy metals.

Change in Indicator Parameters due to Production Water and Cooling Water Discharge

The project envisages the discharge of the **production water in the sea**. Associated with oil and gas deposits, these waters are brought to the surface along with the hydrocarbons produced. The quantity and quality of the production water generated during cultivation activities depends on the type of well, the nature of the geological formation and the extent to which the well is exploited.

In some cases chemical compounds can be added to the production waters. The amounts of such additives - e.g. corrosion inhibitors, biocides, de-emulsifiers, etc. - found in production water does not generally exceed a few parts per million (ppm).

The production waters typically contain i) an inorganic component - essentially composed of chlorides, bicarbonates and ions of sodium, potassium, calcium, barium and strontium, with concentrations increasing as depth increases - and ii) an organic component - alkanes from C7 to C31, aromatic compounds and polycyclic hydrocarbons.

The volatile hydrocarbon liquids (VHLs) - including light aromatics and, in particular, compounds ranging from benzene to naphthalene of ecotoxicological interest since they are most highly soluble in water - are those most commonly found in the production water.

The fraction of petroleum insoluble in water is, above all, composed of high molecular weight aliphatic hydrocarbons (HMW-HC) and cyclical and aromatic hydrocarbons, again with high molecular weight: only small amounts of polycyclical aromatic hydrocarbons, PAH, are present in the production waters.

The temperature of the production water increases as the production zone deepens (in shallow wells the temperature ranges from 30 to 50°C while it can even reach 250°C in the deepest wells).

The solid content suspended in the production water can vary quite significantly; the presence of major amounts of suspended solids can lead to a significant decrease in the transparency of the discharge water column. However, that it could have repercussions on the photosynthetic community on the sea floor is ruled out because of its great depth; thus can be assumed that the consequence for phytoplankton would be negligible.

The discharge of volumes of hot water and sea water (production water, process water) containing pollutants, biocides and anti-corrosion substances from the production process and FPSO and flowlines hydrotest into a large and deep basin like the one under consideration may trigger environmental interferences of negligible intensity.

There is little knowledge of the type and gravity of the consequences of these discharges on the biological community, which will depend to a large degree on the size of the area affected to varying extents by the discharge of the cold sea water.

Different environmental scenarios can be considered possible depending on the hydrodynamic conditions present, whether there is a thermocline with stratification of the temperature gradient and variation in density at different depths, whether a vertical/horizontal flow is established, etc.

In this context, it is important to consider the limited size of the discharges compared to the volume of the receptor body and the system and procedures by which the water is discharged along the water column, in order to ensure a good level of mixing.

The presence of materials suspended in the water column directly reduces transparency (and thus light penetration) and this can interfere with the variation in euphotic zones and, in turn, photosynthesis of the plant organisms present, both in the water column and on the sea bed. Generally, fine materials are a direct result of the increase in particulate substances present in the sea. However, reduced transparency is often the result of increased numbers of phytoplanktonic organisms or organic substances present as a result of the increased availability of nutrients.

Change in Indicator Parameters due to Sewage Waste Discharge

The concentration in the water of a series of characteristic indicators is considered, all of which are linked to the treated sewage discharged. These indicators are the nitrogen and phosphorous compounds detected in the water - i.e. ammoniacal nitrogen $N\text{-}NH_3$, nitric nitrogen $N\text{-}NO_3$, nitrous nitrogen $N\text{-}NO_2$ and phosphorous from orthophosphates $P\text{-}PO_4$.

The presence of nutrients directly affects the level of water trophism, making a substrate available to the primary producers for the synthesis of organic molecules. The phosphates are considered the limiting factor in the development of phytoplankton and any significant increase in the water phosphate concentration can, in some cases, lead to extensive algal bloom. The presence of organic substances in the sea can indirectly affect the level of trophism since it stimulates heterotrophic micro-organisms, mineralizing and placing inorganic ions into circulation.

These parameters are linked solely to the sewage discharged from the vessels and platform and are thus related to the installation and drilling operations. The sewage is treated and it is not possible to determine the individual nutrient concentrations. An overall estimate of the impact can be made considering the Biochemical Oxygen Demand (BOD), the reference parameter for controlling sewage treatment. The sewage discharges are, in fact, treated so as to achieve a BOD within the 40 mg/l limit.

Evaluation of the dispersion of the treated sewage is performed using the DISP3D model that can determine the primary dispersion of pollutants and the secondary dispersion due to currents. The model is a two-stage process: primary dispersion is evaluated using a jet formation while secondary dispersion is calculated using a 3-D dispersion model that takes the initial concentration from the primary dispersion model and operates over a rectangular domain; in other words it applies the approximation that the sea bed is flat and that there are no impediments in the domain calculation - i.e. structures, coast, etc. The current values must be supplied by the user as input for the model.

From the indications available, the overall extent of sewage discharged from the vessels and systems during installation and drilling is approximately 12 m^3/day which means approximately 13.9x10-5 m^3/s. In subsequent simulations, this was considered the average emission value but, to verify the process, a dispersion simulation was also performed considering peak emissions arbitrarily set at 10 times the average value.

For simulation purposes, current speed was set at 5, 10 and 20 cm/s; low current speeds correspond to lower pollutant dispersion and thus the concentration will be higher.

The digital simulations were performed over an 800 x 400 m domain, horizontal resolution 20 m, vertical resolution variable. Since discharges are made near the surface and, in the sea, vertical exchange is reduced, a rather tight resolution was adopted near sea level - variable from 1 to 4 m - and was progressively eased toward the bottom.

Figure 8-3 shows the BOD iso-concentration curve calculated with average sewage emissions and an environmental current of 5 cm/s. The calculation assumed a sewage BOD concentration of 40 mg/l and emission levels were set at approximately 4 m below sea level. The figure refers to the calculation level falling between 3 and 7 m below the surface, the zone where maximum concentration was recorded. Digital simulation showed a concentration peak of 1.9 x 10-3 ppm which was reduced by one order of magnitude at just 100 m from the emission point. Therefore the values obtained were 2000- 20,000 times lower than the BOD concentration limit of 4 ppm, set as acceptable.

Similar considerations can be made regarding the results obtained with stationary current levels of 0.10 m/s (Figure 8-4) and 0.20 m/s (Figure 8-5).

It is worth noting that even assuming peak emission values an order of magnitude higher than the average emissions (Figure 8-6), the peak concentration - 7.0 x 10-3 mg/l - is more than 500 times lower than the above-mentioned limit and it drops to more than 3000 times lower at a distance of around 200 m from the point of emission.

Therefore we can conclude that the increase in nutrient concentration is negligible, even in the immediate vicinity of the point of emission.

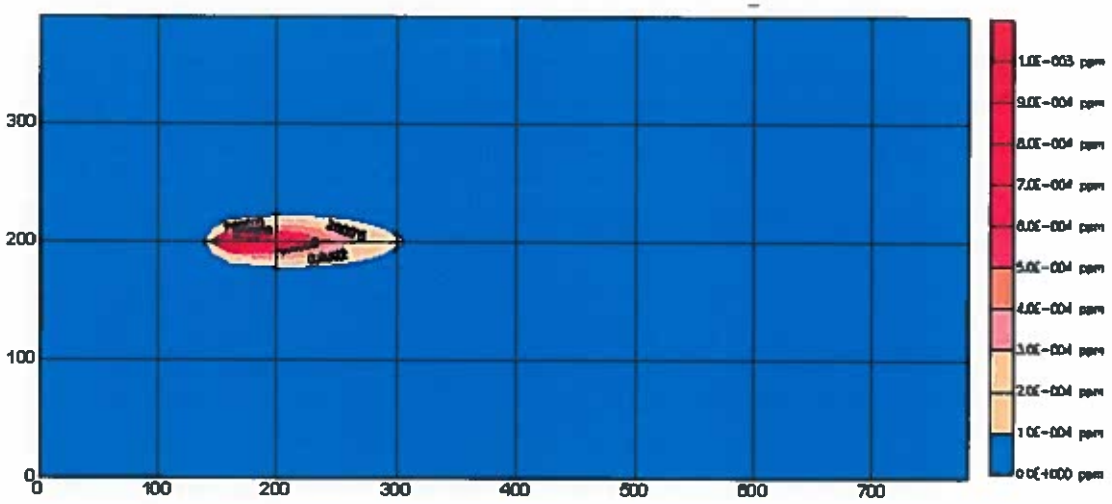

Figure 8-3: Analysis of the water dispersion of sewage – BOD concentrations (ppm) – V=0.05 m/s – Average emission capacity: 6.94x10^{-5} m^3/s.

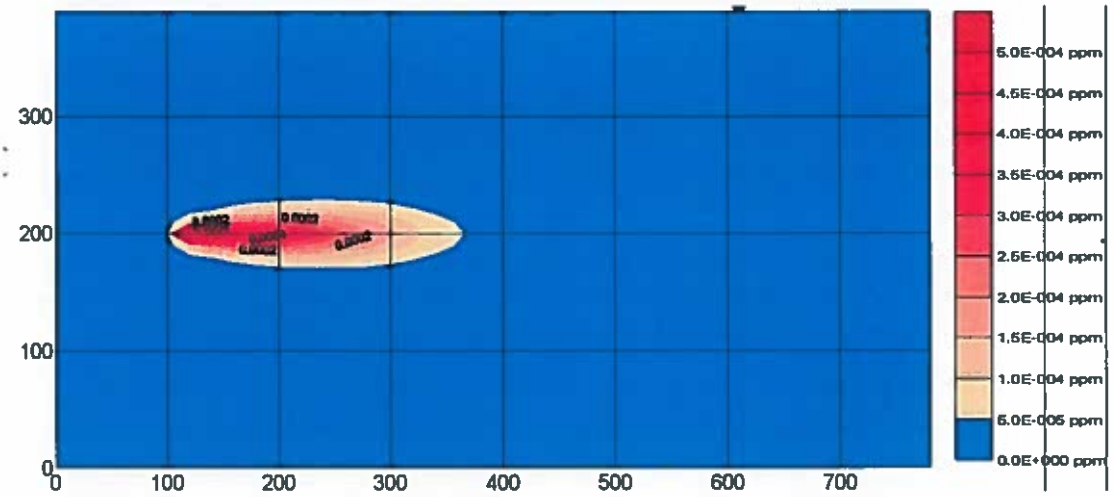

Figure 8-4: Analysis of the water dispersion of sewage – BOD concentrations (ppm) – V=0.10 m/s – Average emission capacity: $6.94x10^{-5}$ m^3/s.

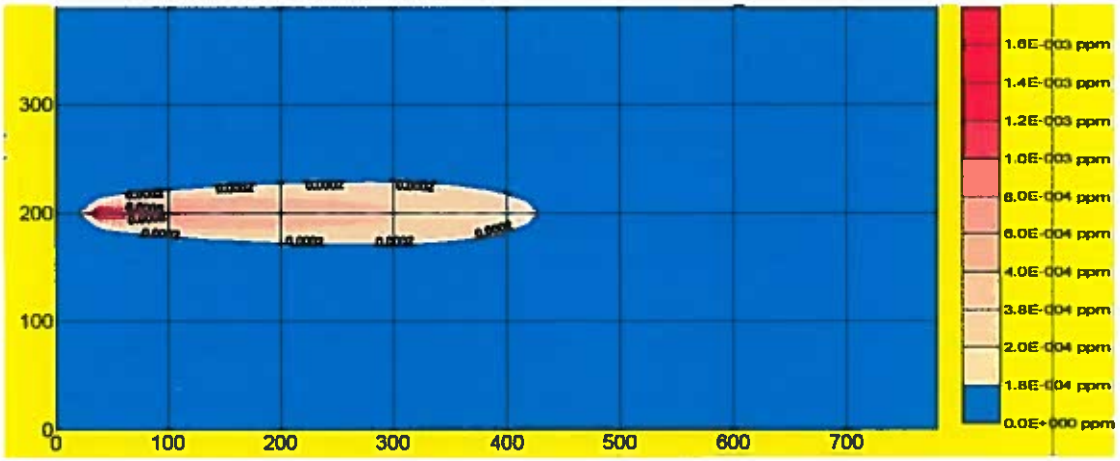

Figure 8-5: Analysis of the water dispersion of sewage – BOD concentrations (ppm) – V=0.20 m/s – Average emission capacity: $6.94x10^{-5}$ m^3/s.

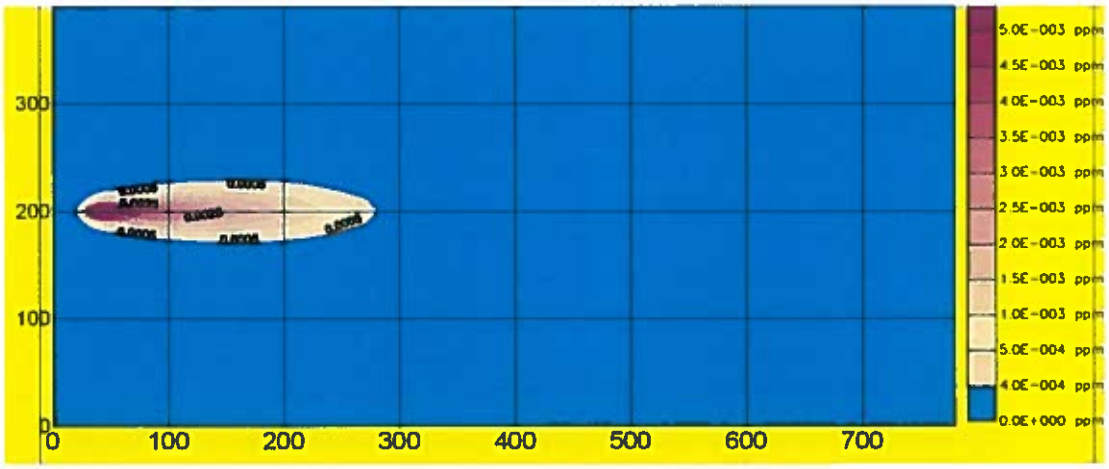

Figure 8-6: Analysis of the water dispersion of sewage – BOD concentrations (ppm) – V=0.20 m/s – Average emission capacity: $6.94x10^{-4}$ m^3/s.

Organic substances, TOC

In this case, the organic substance is expressed as the concentration of total organic carbon (TOC). The Total Organic Carbon is the sum of the carbon dissolved (DOC) and the particulate carbon (POC). The concentration is linked to the natural processes inherent to the biogeochemical cycle of this element and to any allochthonous sources (transport of solids from rivers, algae and discharge bloom, sewage).

It is more commonly interpreted as a BOD indicator that quantifies the oxygen demand and thus provides an indirect measurement of the concentration of organic substances present in the water directly relating them to the real site conditions. Also see dissolved Oxygen and BOD.

Chlorophyll "a"

This is an indicator of the trophic state of the offshore environment since it is directly linked to the amount of phytoplankton which, in turn, may increase as a result of sewage discharges.

Total hydrocarbons

The presence of hydrocarbons in the aromatic and aliphatic fractions leads directly to an increase in their concentration and indirectly to an accumulation in organisms at various points along the food chain. The aromatic component (PAH — benzene, toluene, xylene, naphthalene, phenanthrene, etc. general formula: CnH2n-6 with n>6) plays an important environmental role since it also includes the light aromatic hydrocarbons considered among the most highly toxic compounds for the environment (the acute effects and toxicity of PAHs with 2- and 3-rings have been demonstrated while the effects of those with greater numbers of rings has yet to be clarified).

In general, sediments containing the highest concentrations of Polycyclical Aromatic Hydrocarbons (in particular those with high molecular weight) are relatively more stable in water.

The sediment PAH level is related to human activities while the concentration of PAHs with a low number of rings quickly drops in the sediments (since they are highly water soluble).

In general, the presence of abundant levels of 3- and 4-ring compounds indicates that the source is spent oils, lubricants and crude oil while 4 or more rings indicate that the input is combustion.

The increase in the seaborne hydrocarbon concentration is generally related to shipping traffic, and this is more intense during installation of the well drilling structures.

The higher molecular weight aliphatic and aromatic hydrocarbons are characterized by low volatility and low solubility in water and thus tend to accumulate selectively in the biota and marine sediments.

Dissolved Oxygen

The amount of oxygen dissolved in the water depends on the solubility of this gas in the aqueous medium at a given salinity and temperature. It varies on the basis of a complex series of factors, including in particular, such biotic processes as algal photosynthesis (oxygen production) and bacterial organic substance mineralization (oxygen consumption). This parameter is affected by the input of nutrients through sewage discharge, even if the area of influence in open sea is very narrow.

The variability of this parameter is an indicator of the trophic state of the water and thus depends mainly on the increase in the autotrophic biomass in suspension. In fact, there is a clear-cut relationship between the chlorophyll "a" concentration and the fluctuation in dissolved oxygen.

The fluctuations around the value of physical saturation are mainly the result of oxygen derived from photosynthesis; subsaturation values are seen when the microalgal concentrations increase.

The dissolved oxygen value varies greatly from zone to zone and between surface and deep waters.

Metals

Alterations in the concentration of heavy metals in the water column are related to their release from platform sacrificial anodes and the transiting naval support vessels. Metals considered indicative to environmental conditions of the area are aluminium and lead. The former, in as much as it is the main constituent of the sacrificial anodes, the latter given its being the principal substance present in naval vessel fuel.

Modelling was used to evaluate of the effects of heavy metal dispersion in water, released by the sacrificial anodes.

The sacrificial anodes are composed of an aluminium-based alloy, which constitutes 95% of the total composition, as well as of Magnesium, Manganese, Zinc, Indium and Copper.

Considering that the rate of the anodes' dissolution can be estimated at c. 3kg/Amp/yr. and that residual current variability can be estimated in an interval of 80-300 mAmp, the release of metals should result between c. 250g/yr. and 900g/yr.

Nevertheless in the dispersion simulations a notably more conservative approach was opted for, assuming a release accrual equalling 5kg/yr.

Notwithstanding the notably conservative assumptions, the values calculated for metal release concentration in the marine environment surrounding the pipeline, prove very low, with a maximal in immediate proximity of the pipeline of 4 $\mu g/m^3$.

Furthermore, concentration levels decrease to almost negligible amounts at a 1 metre distance from the structure; also considering the spacing of the anodes along the structure it is possible to exclude the juxtaposition of adjoining anodes.

Figure 8-7 and Figure 8-8 respectively represent the calculation domain and grid adopted for simulations. The calculation domain is 20 m in length, 3m high and 1m deep, i.e. roughly the estimated dimension of the anodes. It should be observed that this domain description leads to the disregard of longitudinal dispersion phenomena, introducing an ulterior element of conservativeness in the evaluation of metals concentration in the marine environment.

The computational grid's meshes are subjected to densification in proximity of the seabed so as to obtain a better description of phenomena associated with the turbulent boundary layer.

Simulations were carried out considering 3 possible scenarios for marine current velocity in proximity of the seafloor, all assumed to flow perpendicularly to the structure:

- 5cm/s current
- 10cm/s current
- 40cm/s current

The first two cases correspond to climatic conditions with weak currents and therefore reduced dispersive effects, while the third scenario corresponds to an estimate of expected currents in case of storms of medium intensity (return period of c. 1 year), and therefore describes a situation characterised by a greater efficiency of released metals' dispersion.

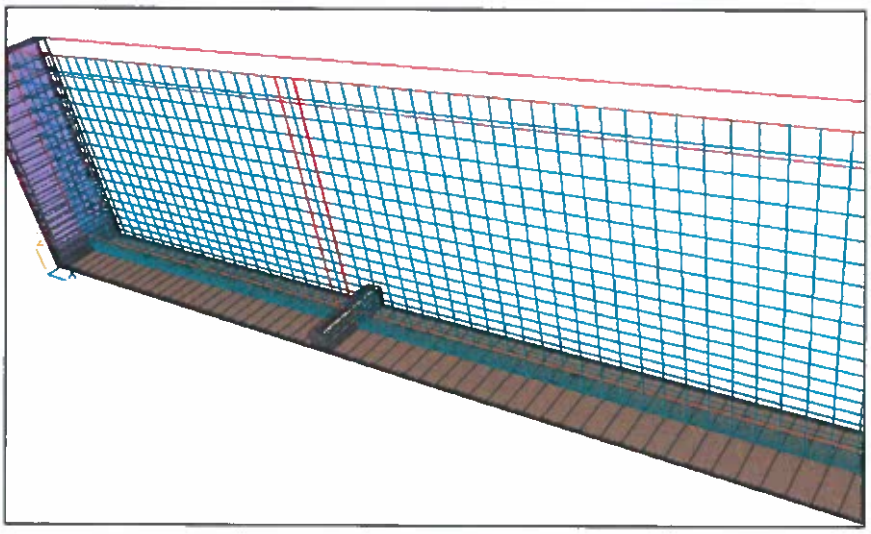

Figure 8-7: Calculation domain and grid.

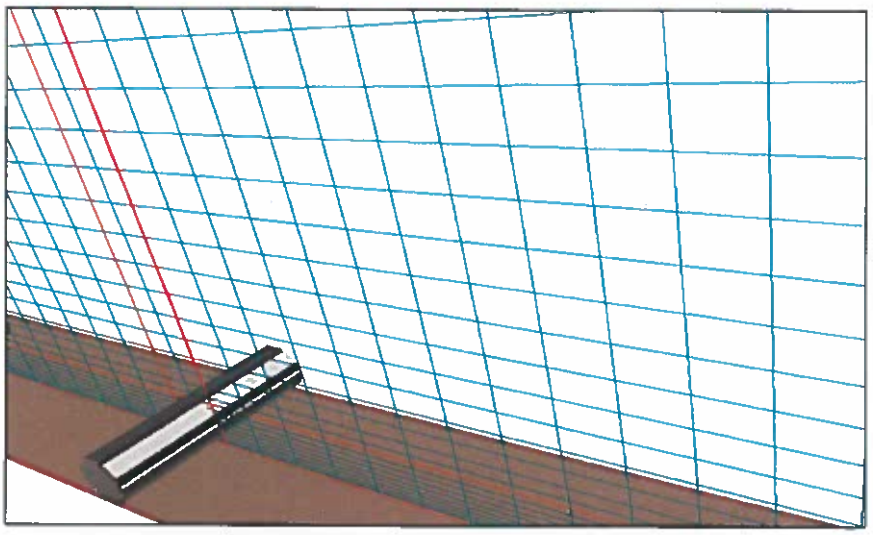

Figure 8-8: Calculation domain and grid – Detail in proximity of the pipeline.

Results

Figure 8-9 illustrates the current velocity calculated around the structure for the undisturbed current scenario equal to 5cm/s. As foreseeable on the basis of hydrodynamic considerations, the iso-speed lines substantially highlight 3 regions: a region of flux amplification in correspondence of the pipeline's top-side, a limited region of stagnation upstream and a wider region of stagnation and recirculation downstream. Flux amplification is nevertheless rather contained: maximum current velocity calculated is only 30% greater to the undisturbed value. Moreover, the effects caused by the pipeline's presence in the hydrodynamic field disappear over brief enough distances; at only 1.5m downstream from the pipeline, the flux resumes its undisturbed conditions.

Figure 8-9: Hydrodynamic field around the pipeline – V=0.05 m/s & velocity scale (m/s).

The iso-concentration curves of released metals (Figure 8-10) indicate rather low values: in proximity of the pipeline it is possible to observe maximum concentrations of 4µg/m3, while at only 0.5m from the pipeline values decrease to 1µg/m3 and records completely negligible values at distances beyond 1m. in order to obtain a metric comparison, the structure + anode system is represented, for a total diameter of c. 25cm. To this regard it is also possible to observe that anodes are spaced at roughly 100-120m intervals along the linear structures. Therefore, considering that metals release concentration is in fact negligible within a few metres of the pipeline, phenomena regarding adjoining anodes' emissions juxtaposition may be ruled out.

Figure 8-10: Metals concentration around the pipeline (µg/m³) – V=0.05 m/s.

Calculations carried out for undisturbed currents equal to 10 cm/s (Figure 8-11) indicate notably more extensive downstream phenomena, while again the maximum flux amplification on the top-side of the pipeline stands at 30%. A detailed view of the hydrodynamics in proximity of the pipeline is represented in Figure 8-12. The iso-concentration curves of released metals (Figure 8-13) indicate a greater extension of appreciable concentration zones, even though for extremely low values as well as lower maximums with respect to the 5cm/s scenario. Indeed, in proximity of the pipeline maximum values stand at 2µg/m³ with respect to the 4µg/m³ of the previous scenario, while concentrations decrease to values below 1µg/m³ for distances at 50-60cm from the pipeline.

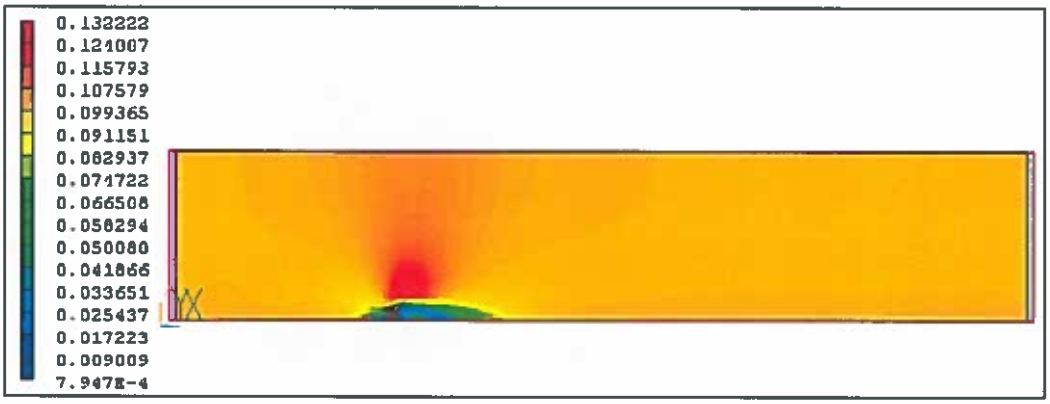

Figure 8-11: Hydrodynamic field around the pipeline – V=0.10 m/s.

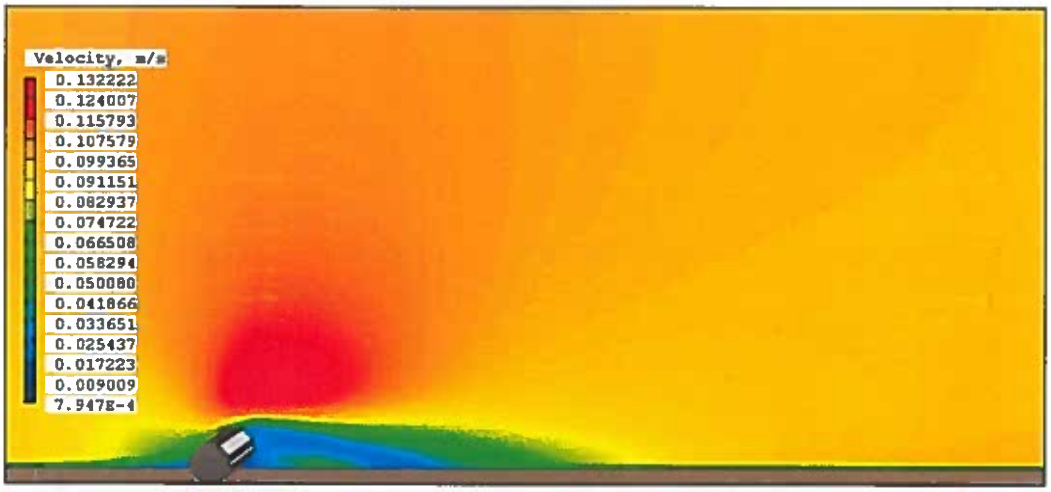

Figure 8-12: Hydrodynamic field around the pipeline – V=0.10 m/s – Detail.

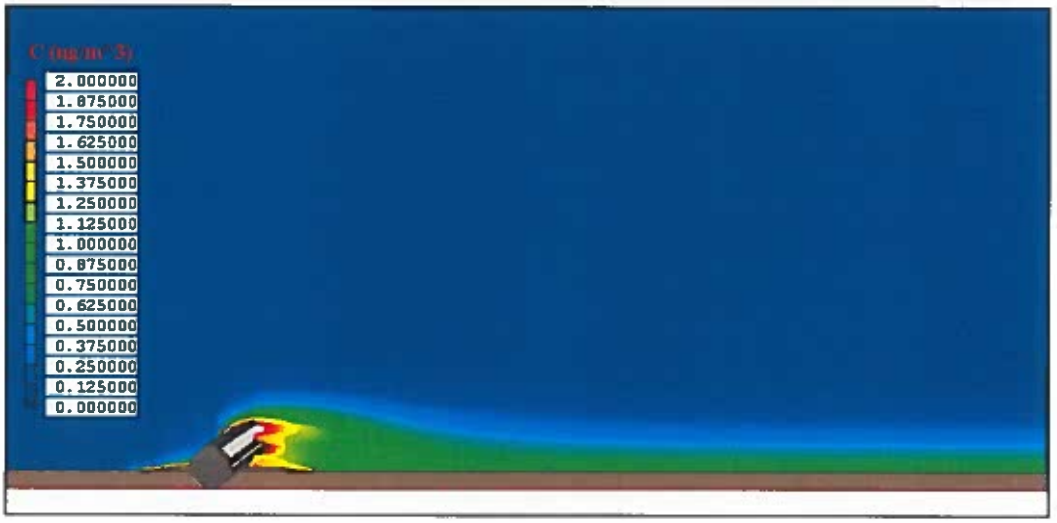

Figure 8-13: Metals concentrations around the pipeline (µg/m³) – V=0.10 m/s.

The 40cm/s current velocity scenario indicates a greater extension of the area manifesting conditions of flux disturbance and ulterior amplification of downstream phenomena (Figure 8-14), which are perceivable up to at least 3.5m from the pipeline. Nevertheless, the greater flux velocity also entails a

greater efficiency in the phenomena of contaminants' dispersion. Coherently, the iso-concentration curves of released metals indicate extremely low levels of concentration, with maximums in proximity of the pipeline well below 1µg/m³ (Figure 8-15), and concentration levels below 0.3µg/m³ at a 0.5m distance from the pipeline.

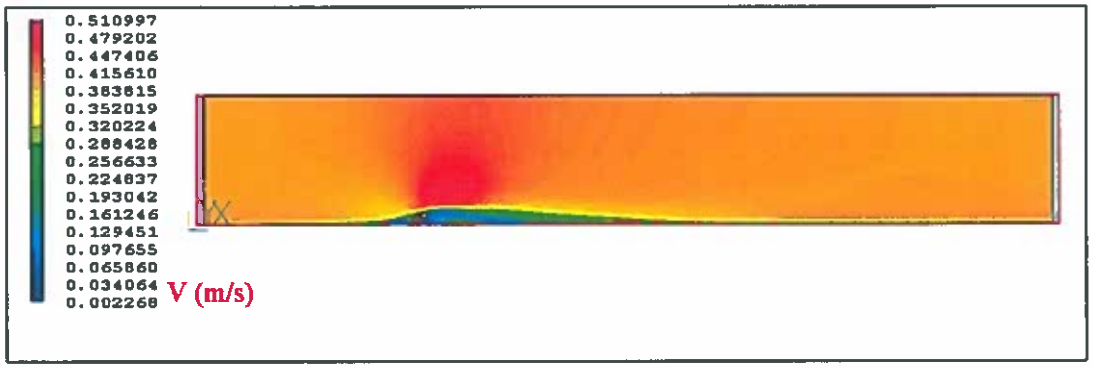

Figure 8-14: Hydrodynamic field around the pipeline – V=0.40 m/s.

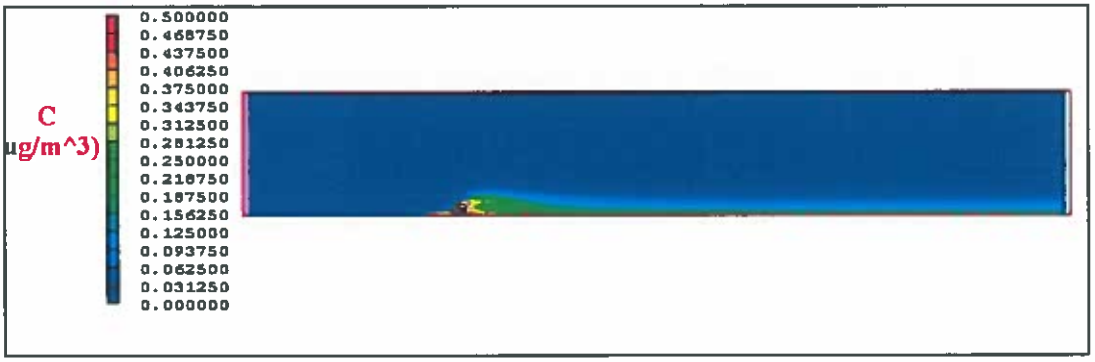

Figure 8-15: Metals concentrations around the pipeline (µg/m³) – V=0.40 m/s.

In synthesis the numerical simulations of metals dispersion, consequential to the corrosion of the submerged structures' sacrificial anodes, were carried out for 3 scenarios typical of hydrodynamic conditions within the Bonaccia area. With regards to fractioning of the anodes' dissolution, notably conservative assumptions were adopted for the calculations. Nevertheless, values calculated for concentration levels of metals released into the surrounding marine environment proved to be distinctly low, with maximums in immediate proximity of the pipeline standing at 4 µg/m³.

Furthermore, concentration levels decrease to almost negligible amounts at distances just over 1m from the pipeline. Hence, considering the effective spacing of the anodes it is possible to exclude the effect of emissions juxtaposition between adjoining anodes.

Summary Evaluation

Changes in sea water quality as a result of installation of the various permanent sub-sea structures (well-heads, pipelines, flowlines, etc.) and routine operational discharges from the vessels and drilling unit will be small and limited to the immediate vicinity of the discharge points. The dynamic nature of the water column environment as a result of waves and currents means that any pollution resulting from these activities would rapidly disperse in the environment. The potential impact of changes in sea water quality is therefore assessed to be of **low significance** (see Table 8-16).

Table 8-16: Significance of impact on sea water quality.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Medium term 2	Local 1	Low 1	Very small 1	5	Definite	LOW -

8.4.4 Impact on Seabed and Marine Subsoil

The used drilling unit has a dynamic positioning system, so the interference between the drilling structure and the sea bed are limited to the riser. The physical presence of the structures and the shifting and re-depositing of the sediments caused by the operations, the discharge of drilling cuttings and their deposition on the sea bed may lead to habitat loss and changes in the type of the sediment and thus in the number and type of the macro-benthic species which depend to a large extent on the characteristics of the sea bed sediments.

Over the long term, the flowlines and the sub-sea structures of the well heads and mooring system may encourage colonisation by sessile organisms, leading to habitat conditions different from those in the surrounding area. There is also the possibility of species enrichment or the appearance of new species, especially since the surrounding sea beds are mobile and not hard.

These effects could be qualitatively similar to that of the permanent production structures, but widely quantitatively lower. Since the sub-sea structures cause a localized variation in the current field, they indirectly affect the sedimentation process which, in turn, modifies the sea bed morphology. Nevertheless, this only occurs in a limited area on the sea bed in the immediate vicinity of the risers.

Likewise emission of the fine material resulting from sewage discharged during drilling can produce imperceptible variations in the characteristics of the sediments on the sea bed. Discharging sewage directly emits nutrients and organic substances that can settle on the sea bed. This occurs during the installation and drilling phases when personnel are present at the site. Of course, this effect is very displaced because of the water depth.

Definition of the Indicator Parameters

The following parameters were used to define the quality and assess the impact the activities have on the sediments.

- Variation in particle size distribution;
- Organic substances – TOC;
- Total Hydrocarbons – PAH; and
- Heavy metals.

Variation in particle size distribution

In the absence of any outside disturbance, the particle size characteristics of the site are generally an index of the hydrodynamics typical of the zone and source of the sediments. Alteration in the main particle size classes in a limited area can therefore be due to external disturbance.

Organic substances - TOC

The percentage of organic carbon in the overall weight of the sample is an index of the organic content of the sediments. Organic substances are a major source of nutrients for the benthic fauna and can be decomposed by the bacterial flora present in the sediment. However, the presence of large amounts of organic carbon per unit of surface and the resulting bacterial oxidation leads to high

consumption of oxygen and this, in turn, generally results in hypoxia or oxygen depletion of the substrate.

Nevertheless, one must recall that the concentrations of organic substances and organic carbon are linked to the particle size composition of the sediment. In general, the higher the percentage of sand, the lower the carbon content and thus it is difficult to compare TOC concentrations in sediments with different particle size distributions.

Total hydrocarbons

The increase in the concentration of hydrocarbons in the water, and thus in the sediments, is generally related to shipping traffic, and this could be particularly intense while the well drilling structures are being installed.

Metals

As previously discussed for the sea environment, lead is deemed most meaningful indicator of alterations because it is linked to shipping traffic.

A small increase of Aluminium in sediments can derive from the re-deposit on the seabed of the metals released from platform sacrificial anodes (see section 8.4.3).

Summary Evaluation

Changes in sea bed morphology and sediments as a result of installation of the various units and routine operational discharges from the vessels and drilling unit will therefore be small and limited to the immediate vicinity of the discharge points, but result in long-term changes in sediment particle size in areas affected by drill cutting discharge. The potential impact of changes in sea water quality is therefore assessed to be of **low significance** (see Table 8-17).

Table 8-17: Significance of impact on sea bed and marine subsoil.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	Local 1	Low 1	Very small 1	6	Definite	LOW -

8.4.5 Impacts on vegetation, flora, fauna and ecosystems

The project activities trigger different types of disturbances in the biological environment and they affect individual biological components differently.

The disturbances affect all levels - planktonic, nektonic and benthic - since the systems are mutually dependent.

In zones with mobile sea beds, artificial sub-sea structures attract numerous pelagic and demersal species. The physical presence of the well heads in the open sea for relatively long periods of time (average operation: approx. 20 years) serves to aggregate numerous sea species, some of which are characteristic of hard substrates which, under normal conditions, would be absent or poorly represented in the area. These changes could cause an increase in the availability of organic matter in the water column, promoting the phyto- and zooplankton in the immediate vicinity of the structures.

As regards the soil and subsoil, the increase in organic substances and nutrients during installation and drilling is related to sewage discharges. The duration is limited to a few months. The same considerations also hold for the particulate matter contained in these discharges. The metal ions (Pb) emitted into the water column can be bioaccumulated by filter feeding organisms (Mauri et al., 1998). During the drilling and installation phases, to ensure operations and safety, the area is lit all night.

Such lighting can attract marine organisms in the surface-most portion of the water column. However, this interference cannot be quantified with any clearly defined parameters.

Definition of the Indicator Parameters

- Average number of species present;
- Specific diversity index;
- Metal bioaccumulation; and
- Bioaccumulation of hydrocarbons (PAH).

The biological world is a complex, dynamic system sensitive to even minimal changes in the environment. Even under normal conditions, the marine environment is subject to significant variations linked to the water mass dynamics, the contribution of continental waters, seasonal variations, etc. Thus it is difficult to establish what parameters are indicators of the disturbance created and, above all, to identify what contribution each individual form of disturbance makes to changes in these parameters.

Interference with the benthic populations

The composition of the benthic communities analyzed plays a role as biological indicators, understood as providing indication of the complex environmental conditions ensuing from the interaction of a multitude of biotic and abiotic parameters that are difficult to measure individually. This type of approach is based on the concept of biotic community (the series of populations that live in a given area or physical habitat and which make up an organized unit the characteristics of which go above and beyond those of the component individuals and populations) and thus assumes a series of interactions between organisms and between the organisms and the environment. Each community presents the so-called homeostasis - i.e. the ability to maintain a steady state by using feedback control processes to respond to various stimuli. When these stimuli exceed the homeostasis capacity of the individual organisms, the community is no longer able to return to a state of equilibrium and its structure undergoes both qualitative and quantitative modifications. Thus the role of indicator attributed to the community as a whole given its ability to adapt to overall environmental situations.

Among the zoobenthic communities, the macroinvertebrates (organisms that can be trapped in a 1 mm mesh sieve) have, for various practical reasons, proved to be the best suited to this type of survey. In the marine benthic communities, the systematic groups (Taxa) most highly represented, both in terms of number of species and number of individuals, are the Annelids, Molluscs, Crustacea and Echinoderms. In particular, it has been shown that, since polychaetes occupy significantly diversified niches in the food chain and are found at various trophic levels in the macrobenthic communities, they are effective indicators, both functional and structural. Molluscs have been found to be effective indicators of the overall ecological conditions in coastal marine ecosystems. On the other hands, the Crustaceans, amphipods particular, have proved to be an important component of the mobile fauna in various environments.

As indicator parameters, the average number of species present and the specific diversity index are taken into consideration since they reveal changes in the population. Indeed they are good indicators because i) they reflect both the reduction and survival of the most representative or most resistant species and ii) they show the increase in some species as a result of the variation in environmental conditions or through repopulation.

Metal bioaccumulation (Pb)

A part of the metal ions released into the water are bioaccumulated in filter feeding organisms. Lead is considered the prime indicator because it is linked to shipping and installation activities.

Given their reactivity and the various processes involved in their removal, heavy metals do not remain in the water column for permanently; they tend to accumulate in the fine sediments and, in some cases, in the tissues of marine organisms. In this case, they can be detrimental to the growth, reproduction and species composition of the animal and plant communities (UNESCO, 1980).

Hydrocarbon bioaccumulation

The increase in the concentration of hydrocarbons in the water, and thus in the sediments, is generally related to shipping traffic, and this is particularly intense while the well drilling structures are being installed. The presence of hydrocarbons and the increase in hydrocarbon concentrations in the water indirectly leads to bioaccumulation in filter feeding organisms which are highly sensitive to Polycyclical Aromatic hydrocarbons (PAH - benzene, toluene, xylene, naphthalene, phenanthrene, etc.), undoubtedly the most highly toxic hydrocarbons.

Many invertebrates tend to concentrate PAH drawn from the water, generally the result of the lipid-water separation balance, thus establishing a direct correlation with the surrounding waters.

The damage to marine organisms can be acute, sub-lethal or chronic since many organisms are able to concentrate petroleum-based products.

Given the variety of petroleum products, it is not possible to establish an acceptable minimum level. In particular, benzene and toluene are simple aromatic compounds belonging to the category of solvents, substances of great environmental importance. These compounds are not very biodegradable and are often found in the marine environment; they tend to accumulate in the fatty tissues of animals.

Summary

Changes in the marine biota and ecosystems as a result of the installation and presence of the subsea structures, drilling unit, well heads and support vessels, as well as normal operation discharges will be limited to the immediate vicinity of these activities. The potential impact is assessed to be of **low significance** and may even be positive if the subsea structures and exclusion zones attract and provide shelter to a wide variety of species (see Table 8-18).

Table 8-18: Significance of impact on vegetation, flora, fauna and ecosystems.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Medium term 2	1	Low 1	Very small 1	5	Definite	LOW -/+

8.4.6 Underwater noise-generated impacts

Underwater sound allows marine animals to gather information and communicate at great distances and from all directions. The speed of sound determines the delay between when a sound is made and when it is heard. The speed of underwater sound is five times faster than sounds travelling in air, thus marine animals can perceive sound coming from much further distances than terrestrial animals. Because the sound travels faster, they also receive the sounds after much shorter delays (for the same distance). It is not a surprise that marine mammals have evolved many different uses for sounds.

Marine animals rely on sound to acoustically sense their surroundings, communicate, locate food, and protect themselves underwater. Marine mammals, such as whales, use sound to identify objects such as food, obstacles, and other whales. By emitting clicks, or short pulses of sound, marine mammals can listen for echoes and detect prey items, or navigate around objects. This animal sense functions just like the sonar systems on navy ships. It is clear that producing and hearing sound is vital to marine mammal survival. Sound is also important to fishes. They produce various sounds, including grunts,

croaks, clicks, and snaps, that are used to attract mates as well as ward off predators. Marine invertebrates also rely on sound for mating and protection. Little research has been done on marine invertebrates that produce sounds, but for those that do, like shrimp and lobsters, sound is very important for survival against predators.

Sound propagation

Sound is essentially generated when a vibrating object sets molecules in a medium adjacent to that object into motion. Sound amplitude or what is perceived as loudness is directly related to the amount of pressure generated by the vibrating object. In a compressible medium, the motion of molecules produces positive pressure where there is condensation and negative pressure where there is rarefaction of molecules. The intervals of condensation and rarefaction typically occur in a cyclical fashion. In a plane progressive wave of sound (when the acoustic pressure is the same in all planes perpendicular to the direction of propagation), the instantaneous pressure, p, generated in a compressible fluid can be described by:

$$p = \rho c u$$

where ρ equals the fluid density, c equals the speed of sound, and u equals the particle velocity.

Acoustic pressure is typically measured as the root-mean-square (RMS) pressure average over the duration of the sound. For impulsive sound such as pile driving strikes or biosonar clicks, peak sound pressure (the range from zero to the greatest pressure of the signal) or peak-to-peak sound pressure (the range of the most positive to the most negative pressure of the signal) are often reported instead, since it is difficult to define an appropriate duration over which to average the signal's pressure (Madsen, 2005). Pressure is typically reported in units of pascals (Pa) or micropascals (µPa). In a plane progressive wave, sound intensity is described by the sound power per unit area and is a product of the sound pressure and particle velocity by

$$I = pu$$

and substituting u from first equation, intensity of the sound, I, is related to p by

$$I = p(p/\rho c) = p2/\rho c$$

where p is the RMS pressure average over the duration of the sound. Intensity is typically reported in units of watts per square meter. Sound levels are most often described in units of decibel (dB), which is traditionally defined as a power or intensity ratio. Sound intensity level in decibels is as follows:

$$dB = 10 \log10 (I1/I2)$$

where I is the intensity of the sound of interest and I2 is a reference intensity. In the case of a plane wave, sound pressure which is typically what is measured by a microphone or hydrophone may also be used to measure the sound's magnitude in dB. Because sound intensity is proportional to pressure squared, sound pressure level (SPL) in dB is given by

$$dB = 10 \log10 (p12)/(p22) = 20 \log10 (p1/ p2)$$

where p1 is the pressure of the sound of interest and p2 is typically the standard reference pressure for a given medium. In water the reference is usually 1 µPa. SPLs in this document are referenced to the underwater convention (re 1 µPa) based on RMS measurements unless otherwise noted. This reference pressure is different from the standard used to measure sound pressure levels in air. Thus a dB (re 1 µPa) underwater is not equivalent to a dB (re 20 µPa) measured in air. Pulsed sounds such as explosions, seismic air gun pulses, or pile driving impacts are often measured in terms of their energy and not just pressure or intensity. Energy measures include time as a dimension and are also used to quantify sound exposure when both amplitude and duration of exposure is important. Energy

is proportional to the time integral of the pressure squared and in dB sound exposure levels (SELs) has the units of dB re 1 μPa2s.

Comparison of sound intensities measured in air and water

Direct comparisons of sound intensity levels measured in air and water cannot be made, unless levels are adjusted to take into account:

- The differences in acoustic impedance between air and water (cwater =1.5x106 and cair =4.15x102) and the differences in reference pressures used for air and water (pref water = 1μPa and pref air = 20μPa).

However, although the physics behind these adjustments is correct it may not reflect the complexities of marine mammal hearing.

The difference between a Sound Intensity Level (SIL) measured in water and in air is:

26dB + 36dB = 62dB

Therefore if a SIL is measured in air it has been proposed that its equivalent SIL underwater might be achieved by adding 62 dB, and, conversely if a SIL is measured in water, subtract 62dB from its value to get its equivalent value in air.

However, this may be a risky comparison because the mechanisms leading to damage in the ear underwater may be significantly different to those in the air.

Model Description

The acoustic modelling approach is based on the equations of propagation of underwater noise and the simplistic model published by WDCS in Ocean of noise. The model called Source Math Receiver Model where

The basic parameters of this model are:

- *Source*: the noise source, e.g. ship, sonar etc. Parameter of interest = source level (SL);
- *Path or medium*: the water column. Parameters of interest include transmission loss (TL), and ambient noise level (NL);
- *Receiver*: e.g. whale, hydrophone etc. Parameters of interest include signal to noise ratio (SNR), received sound intensity level (RL) and detection threshold (DT). A simple model of sound propagation is:

RL = SL –TL

Where RL is the received level, SL is the source level and TL is the transmission loss.

Model parameters

Transmission Loss (TL)

Transmission loss is the decrease in intensity of a sound as it propagates through a medium, and is the result of spreading, absorption, scattering, reflection and rarefaction. Transmission loss can also be estimated by adding the effects of geometrical spreading (TLsp), absorption (TLa) and the transmission loss anomaly (A). The transmission loss anomaly includes scattering loss and losses due to reflection and rarefaction at boundary interfaces.

$$TL = Tl_{spreading} + TL_{absorbitio\ n} + A$$

For simplicity we'll only deal with spreading (TLsp) and absorption loss (TLa):

$$TL = Tl_{spreading} + TL_{absorbtio\ n}$$

$Tl_{spreading}$ is a major component of transmission loss and is range (distance) dependent. Two forms of spreading loss are common underwater:

- Spherical or Geometrical spreading loss (TLg); and
- Cylindrical spreading loss (TLcy).

Spherical or Geometrical spreading loss (TLg)

Spherical spreading loss assumes a uniform or homogenous environment that is typical of deep waters (>2000m). Sound from a point source will spread outward as spherical waves, and intensity varies inversely with the square of the distance from the source:

$$Tl_g = 20\log\left(\frac{R}{R_o}\right) \quad R < R_1$$

Where R is the range in metres of the receiver from the source and R0 is a reference range, usually 1m.

With spherical spreading, sound levels decrease by 6dB if distance is doubled and by 20dB when distance increases by a factor of 10. R1 is the range in metres at which spherical spreading stops and cylindrical spreading begins.

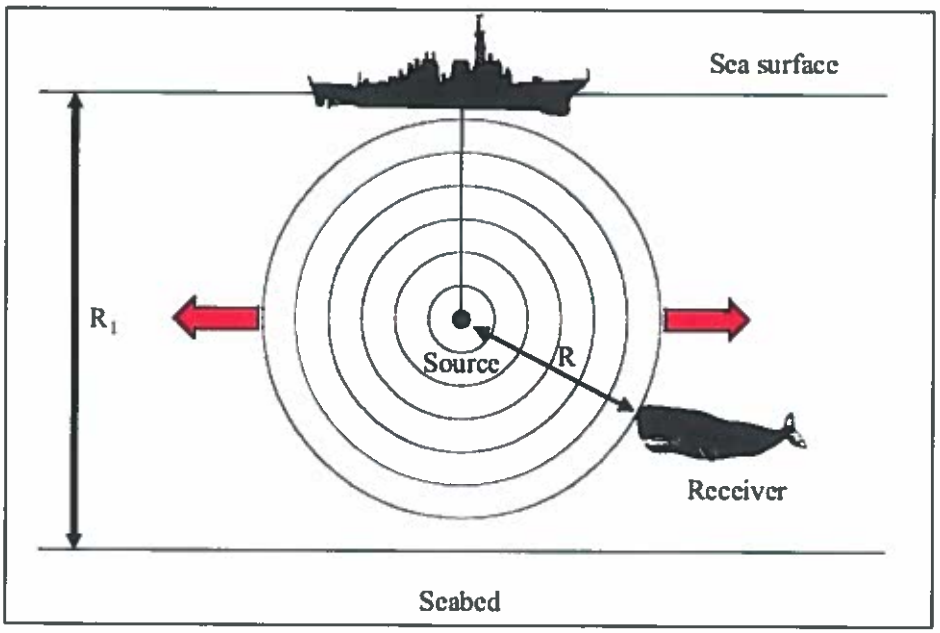

Figure 8-16: Spherical spreading.

Note that for spherical spreading to occur R1>R (from Oceans of Noise, WDCS 2004)

Cylindrical spreading loss

Cylindrical spreading is appropriate when the medium is non-homogenous. Non-homogenous mediums are typical of stratified or shallow coastal waters (<200m), where sound is reflected or refracted off the sea surface and seabed or off different density layers according to Snell's Law.

At a given distance from the source, which is long in comparison to the water depth, various reflected waves combine constructively to form a cylindrical wave front. Where cylindrical spreading occurs, sound intensity varies inversely with distance from the source:

$$TL_{cy} = 20 \log R_1 + 10 \log \left(\frac{R}{R_0} \right) \qquad R > R_1$$

Cylindrical spreading is applicable where the range of the receiver from the source is greater than the depth of the water column or density layer, i.e. for R > R1. Where R1 is the range in metres at which spherical spreading stops and cylindrical spreading begins. For ranges R< R1, TL is spherical. Spreading loss for cylindrical spreading (R>R1) is less than for spherical spreading (R< R1), and sound intensity decreases by 3dB if distance doubles and by 10dB when distance increases by a factor of 10. Therefore, a sound source generated in shallow coastal waters or estuaries travels twice the distance of an equal sound source in the open ocean.

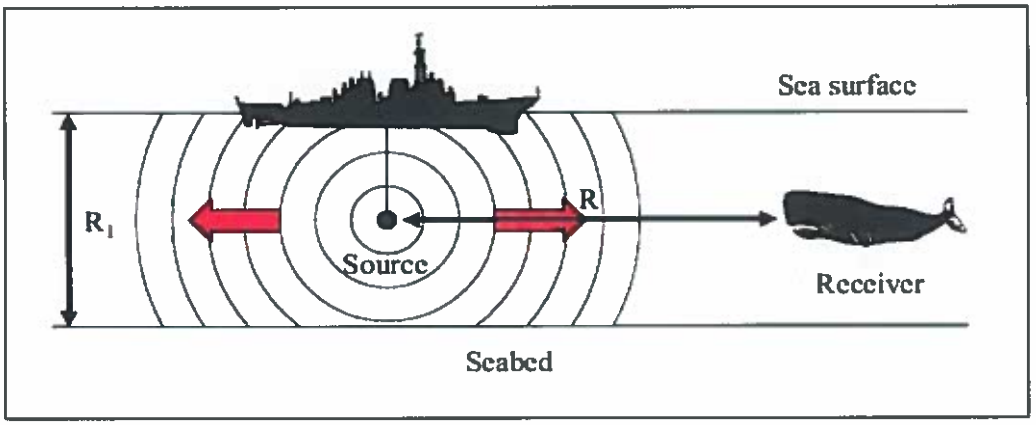

Figure 8-17: Cylindrical spreading.

Note that for spherical spreading to occur, R1< R. (from Oceans of Noise ,WDCS 2004).

Sources Definition

The design of the drilling rig and local oceanochartic conditions will affect both the path of the sound into the water column and how much sound is transmitted.

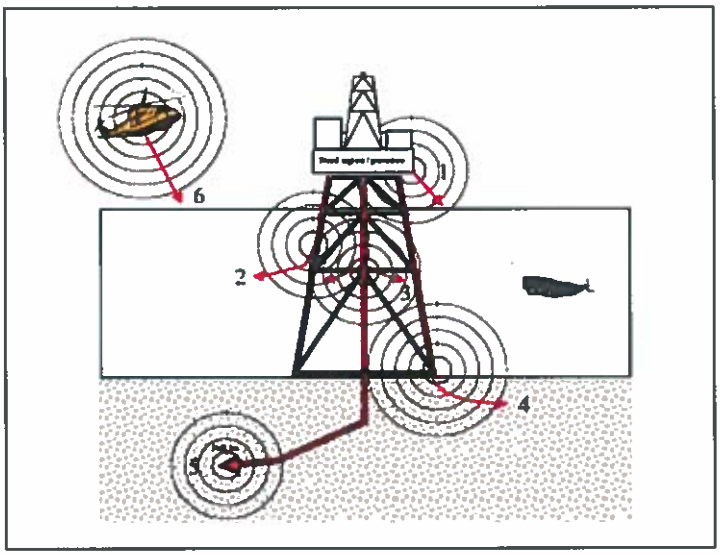

Figure 8-18: Sound transmission pathways associated with a fixed platform

Note: (1) Diesel engine /generator exhaust port, (2) Vibration through legs into the water, (3) Vibration through drill string and casing, (4) Vibration into the seabed, (5) Vibration of drill bit, (6) Noise from helicopters and vessels (Oceans of noise, WDCS 2004).

The following sources of underwater noise have been identified as potentially important:

- 2 support vessel;
- 1 semisubmersible drilling rig.

The present study will simulate noise emissions during the drilling activities considering the ones generating higher emissions for a defined time period. Data on noise emissions of semisubmersible drilling rig are not available, as for data for jack up unit. Anyway according to Richardson et al. (1995), noise emissions of semisubmersible rig have an intensity lower than supply vessels, so that the assumption of using data of jack up rig shall not affect the whole results.

Table 8-19: Construction activities noise sources (Ocean of Noise WDCS 2006).

	LeqA dB re 1 µPa-m						
	broad band	1/3rd octave band centre frequencies (KHz)					
	0.045-7.07	0.05	0.1	0.2	0.5	1	2
Supply ship	181	162	174	170	166	164	159
Jack up rig during drilling	59	55.9	54	55.6	46.9	-	-

Noise source have been considered in deep waters (1500 meters). These assumptions allow the use of spherical propagation described above for assessing impacts on receptors located at distances greater than the depth of the sea floor (1500) meters from the source) R> R1. The transmission loss assumes the trend showed in the following chart (Spence, 2006).

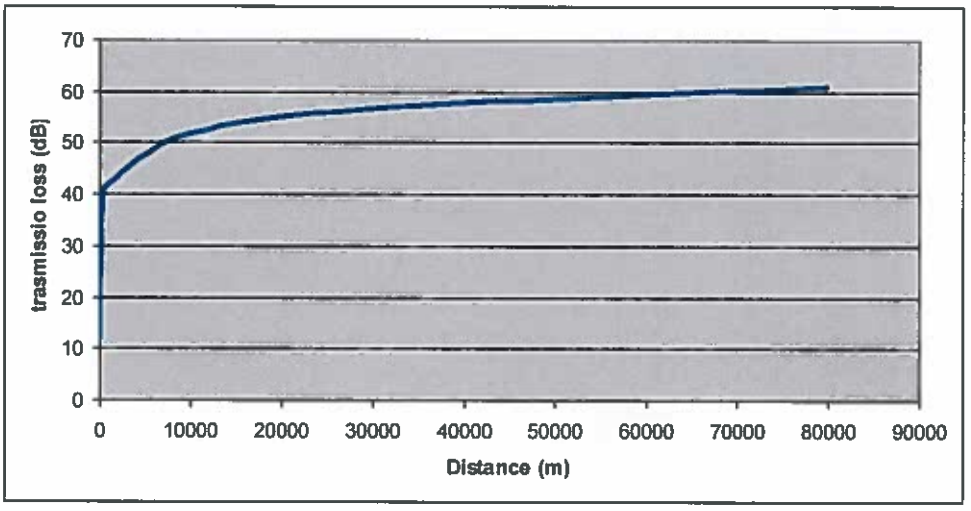

Figure 8-19: Transmission loss of trends depending of source distance.

Noise sources have been represented like a unique point source that emits in "shallow waters" (>2000 meters). Noise sources have been represented like a unique point source that emits the sum of the single emissions of the 2 Supply ship and the Jack up rig during drilling.

Table 8-20 presents the level of the emission sources, and the level assumed for the calculation (logarithmic sum of the levels).

Table 8-20: Level of the noise emission assumed for calculation.

	broadband	0.05	0.1	0.2	0.5	1	2
Jack up rig	59	55.9	54	55.6	46.9	0	0
supply ship	181	162	174	170	166	164	159
model source	184.0	165.0	177.0	173.0	169.0	167.0	162.0

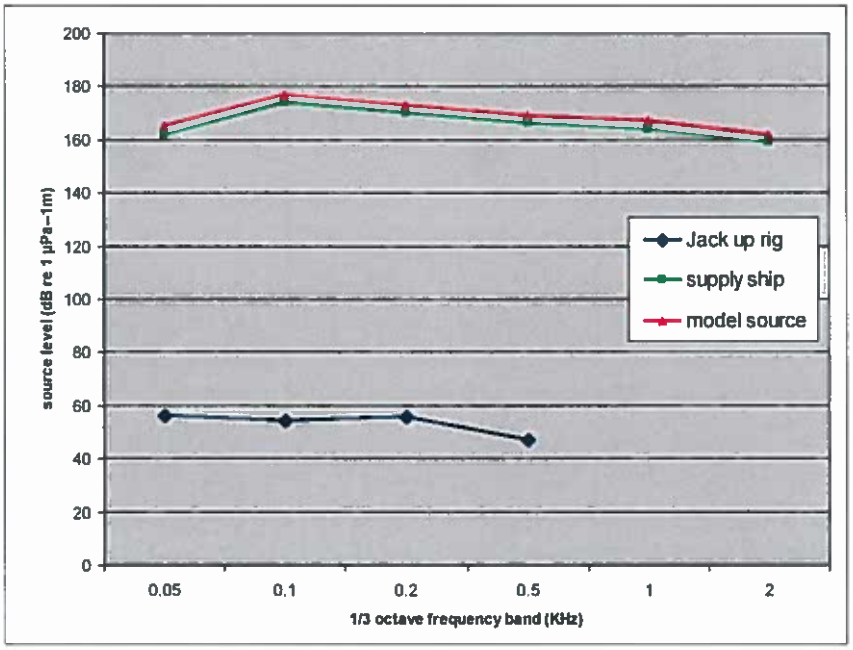

Figure 8-20: Sources as defined for the simulation.

It is be clear that the contribution of the jack up rig to the total noise is negligible.

The model applied considers the following equation for $TL_{absorbtion}$ (Richardson et al. 1995):

$$TL_{absorbtion} = \alpha R = 0.036 f^{1.5} R$$

where α is absorption coefficient

R distance from the source.

Simulation Results

Model results are represented in Figure 8-21 below.

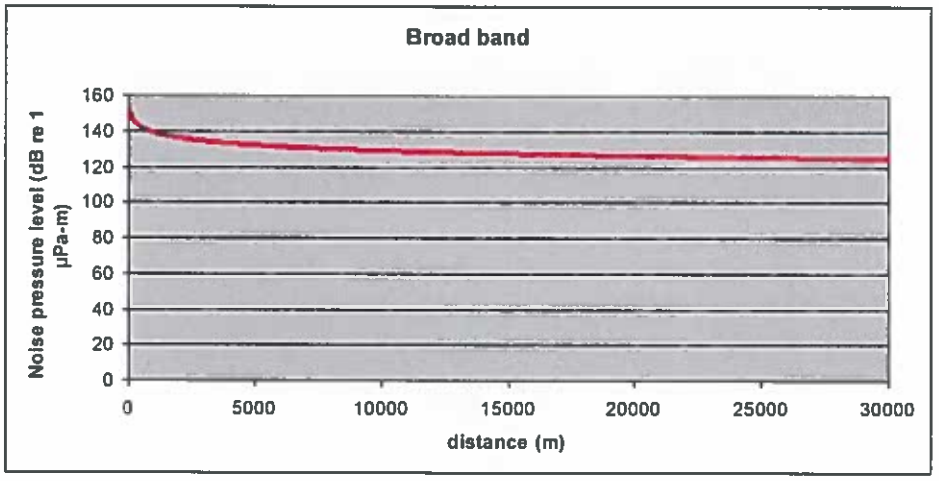

Figure 8-21: Absorption loss for broad band frequencies.

Considering broad band emission equal to 184 dB re 1 mPa pressure levels fall below the 130 dB re 1 mPa at about 7 km from the source. This issue, however, is the sum of the contributions of each frequency over the entire frequency band. In order to evaluate the impacts on marine life it is necessary to study the levels of pressure in the frequency range of hearing of the species analysed.

Figure 8-22 shows the pressure levels versus distance from the source in terms of emissions for different frequencies in the band of 1 / 3 octave considering the attenuation due to absorption.

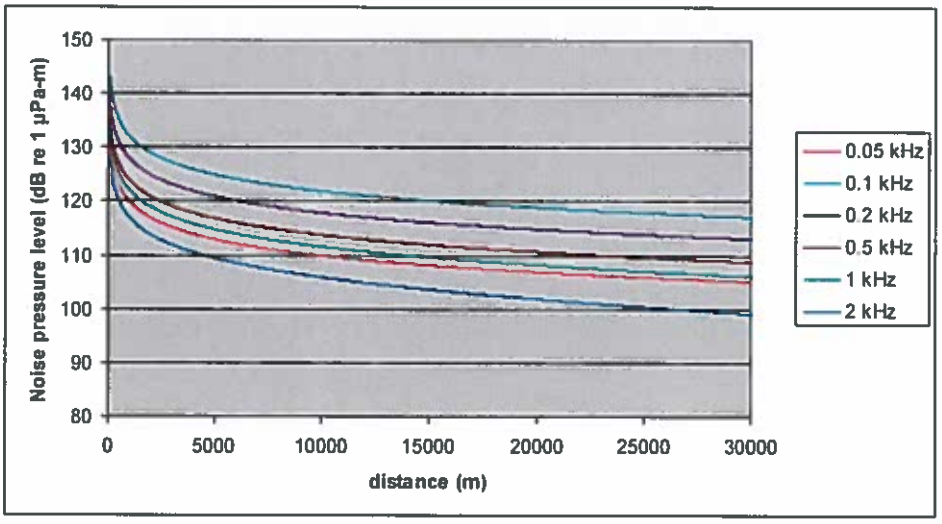

Figure 8-22: Pressure levels versus distance from the source in terms of emissions.

An analysis of the chart shows that the levels of 130 dB re 1 mPa are achieved at much lower distances from the source, even at 3000 meters all the pressure levels at frequencies of reference remain below 120 dB. In parachart estimation of the impacts will be addressed further the contribution of each frequency on the disorder of the main marine species present in the study.

Marine Mammal Use of and Responses to Sound

Marine mammals produce a variety of sounds and use hearing for communication, individual recognition, predator avoidance, prey detection and capture, orientation, navigation, mate selection, and mother-offspring bonding. At most frequencies, the ear is the most sensitive detector of acoustic energy although some evidence indicates that humans are affected by low-frequency sounds below their hearing threshold In most marine mammals that have been tested, the best hearing sensitivity

appears to correspond to the presumed primordial ocean background noise at any given frequency. This seems a reasonable limit because greater sensitivity may not convey an additional advantage. Beluga whales can detect the return of their echolocation signals when they are only 1 dB above background and grey whales can detect the calls of predatory killer whales at 0 dB above background Whether anthropogenic sounds are detected at the low levels associated with detection of prey and predators is not known and likely varies with factors such as species and habitat. Marine mammals have adapted to varying levels of natural sound, and the adaptive mechanisms may allow them to function normally in the presence of many anthropogenic sounds. The key question is when; because of its level, frequency, duration, location, or some other characteristic introduced sound exceeds the adaptive capacity of marine mammals, causing physical injury or eliciting physiological reactions, behavioural responses, masking, or other effects, and thereby posing a threat to individual animals or their populations.

Richardson et al. (1995) define four zones of noise influences, depending on the distance between source and receiver. The zone of audibility is defined as the area within which the animal is able to detect the sound. The zone of responsiveness is the region in which the animal reacts behaviourally or physiologically. This zone is usually smaller than the zone of audibility. The zone of masking is highly variable, usually somewhere between audibility and responsiveness and defines the region within which noise is strong enough to interfere with detection of other sounds, such as communication signals or echolocation clicks. The zone of hearing loss is the area near the noise source where the received sound level is high enough to cause tissue damage resulting in either temporary threshold shift (TTS) or permanent threshold shift (PTS) or even more severe damage. The different zones are illustrated in Figure 8-23 below:

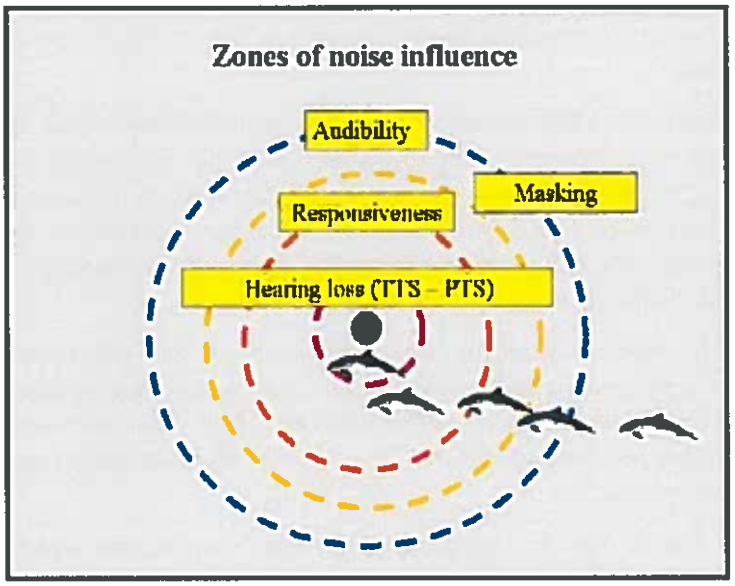

Figure 8-23: Zones of noise influence (Richardson *et al.* 1995).

Behavioural Responses - At the detection threshold, or at some level above that, sound may evoke a behavioural response. Examples of behavioural responses include changes in habitat use to avoid areas of higher sound levels; diving and surfacing patterns or direction of movement; and vocalization intensity, frequency, repetition and duration (Richardson et al. 1995). Some of these behavioural responses may affect vital functions (for example, reproduction, feeding). It is often not

clear whether such changes are significant (where significance is defined as having a measurable impact on either an animal's reproduction or survival or a population's status).

Masking - Masking occurs when a sound is more difficult to hear because of added noise (Southall et al. 2000). In this case, an animal's behaviour may be affected because it is not able to detect, interpret, and respond to biologically relevant sounds. Masking may occur at received levels less than those required to stimulate observable responses and therefore may affect marine mammals at greater distances from the sound source than those at which the animal shows a behavioural response.

Physiological Reactions - Exposure to sound energy may result in a range of physiological effects in marine mammals. The auditory system is thought to be the most sensitive to sound exposure, but sound exposure also may cause non-auditory physiological effects such as stress and tissue injury.

Exposure of marine mammals to high intensity sound may cause a temporary threshold shift, or a temporary loss of hearing sensitivity. A reduction in sensitivity is the usual response of a mammalian sensor exposed to an intense or prolonged stimulus and, within limits, is reversible. Nonetheless, because of the importance of sound in the daily lives of marine mammals, even temporary threshold shifts have the potential to increase an animal's vulnerability to predation, reduce its foraging efficiency, or impede its communication.

Physical Injury - Permanent threshold shifts - or permanent loss of hearing sensitivity - can result when animals are exposed even briefly to very intense sounds, over a longer duration to moderately intense sounds, or intermittently but repeatedly to sounds sufficient to cause temporary threshold shifts. Permanent threshold shifts result in the loss of sensory cells and nerve fibers. In terrestrial animals, temporary reductions in sensitivity of about 40 dB have been required to cause permanent threshold shifts. To date, temporary shifts of only about 20 dB have been induced experimentally in marine mammals, which is much less than required for a permanent shift if marine mammals respond similarly to terrestrial animals.

Ecological Effects - Ecological (indirect) effects may occur if ecologically related species are affected by anthropogenic sound, thereby changing the nature of their relationship with marine mammals or the structure of the affected ecosystem. The best-studied indirect effects suggest that, in some cases, seismic activity may cause a decrease in the number of fish in the survey region. If and when such effects occur, they may reduce the foraging efficiency of marine mammals, potentially compromising their growth, condition, reproduction, and survival.

Population Effects - The effects of sound on marine mammal populations are uncertain. Sound has not been considered a factor in several major declines over the past few decades involving pinnipeds and sea otters, species more easily monitored than cetaceans. Abundance and trends of cetacean populations often are poorly known and difficult to monitor; many populations could decline by half without such loss being detected

Cumulative Effects - Effects that are individually insignificant may become significant when repeated over time or combined with the effects of other sound sources. Baleen whales, for example, use low-frequency sound for communication and therefore may be affected by both seismic airguns and shipping noise. Similarly, the effects of sound may interact additively or synergistically with the effects of other risk factors. Beluga whales, for example, may be compromised in their ability to survive and reproduce if climate change has altered the distribution and availability of their prey, persistent organochlorine contaminants have altered their immune function and made them susceptible to disease and parasites, and noise from oil and gas operations, icebreakers, or commercial vessels has caused them to abandon important habitat.

Effect of the identified sound sources on marine mammals

Odontocetes produce rapid series of whistles and high-frequency clicks. Clicks individuals are generally used for echolocation, while groups of clicks and whistles are used for communication. The sounds are produced by passing air through a structure present in the head, similar to the human nasal cavity, called the phonic lips. When air passes through this narrow passage, the membranes of the phonic lips are sucked together, causing the vibration of the surrounding tissues.

These vibrations can, like those in the human larynx, be unconsciously controlled with great sensitivity. The vibrations pass through the fabric of the head to the melon, which shapes and directs the sound into a ray of sound used for echolocation. All toothed whales except the sperm whale have two sets of phonic lips and are therefore able to produce two sounds independently. Once the air is passed through the phonic lips, enters the buccal pouch. Hence the air can be recycled at the bottom of the complex nasal, ready to be used to produce other sounds, or expelled through the blowhole. Nedwell et al., (2003). The mysticetes have instead a larynx that appears to play a major role in the production of sound, but lacking the vocal cords. Scientists therefore remain uncertain about the exact functioning of the mechanism. The process however, cannot be completely comparable to that of man, as the baleen whales do not have to breathe out to produce sounds. It is likely that recycle the air in the body for this purpose. Even the cranial sinuses can be used to create the sounds, but again, the researchers cannot explain how.

Odontocetes have a valid biosonar or system of echolocation by which they intercept the prey, mates and any obstacles in total darkness with the sound being able to feel the presence, distance, shape, size, texture and direction of movement. Some species can produce sounds of frequencies up to 300,000 Hz. Mysticetes do not have biosonars but produce signals which are very intense but with low frequency around 20-100 Hz, similar to the "bellows". The signals keep individuals in touch with each other even at a distance of tens or hundreds of kilometres. The threshold of hearing is represented through the audiograms, the track that shows the weakest sound that can be perceived with varying frequency.

Figure 8-24 shows the audiograms of the species odontocetes.

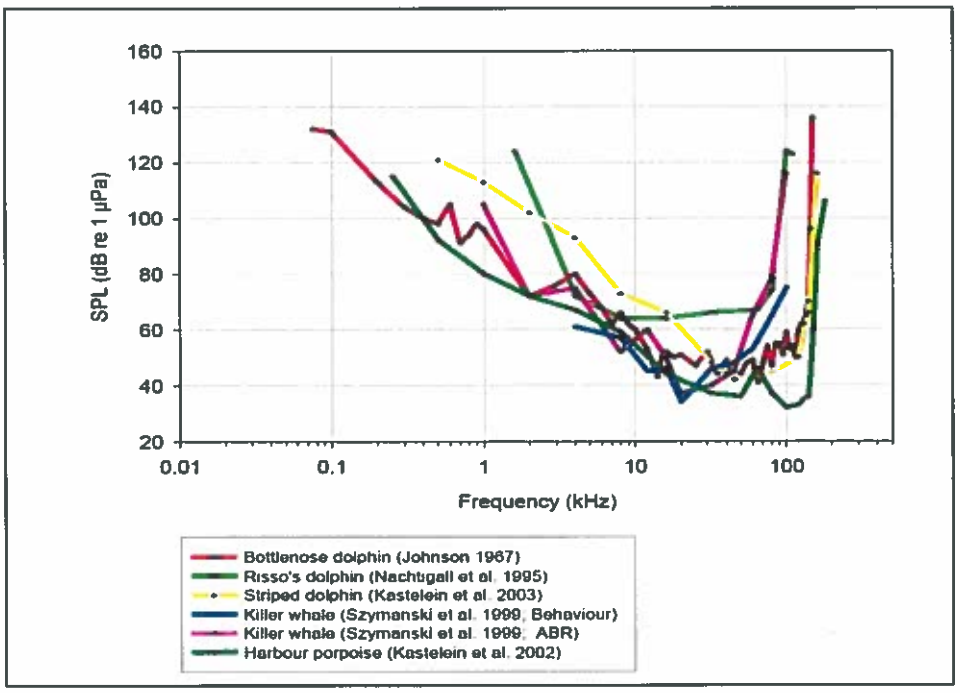

Figure 8-24: Audiograms of odontocetes species.

All audiogram exhibit the characteristic U-shape form with relatively high threshold above 1 kHz and with the area of better perception of ultrasound in the frequency (> 20kHz).

Comparing the audiogram values with the emission levels at known distances from the source it is possible to identify the area of audibility of the source. **Table 8-21** shows the results of the model adopted as the SPL at 1 / 3 octave set at distances from the source.

Table 8-21: Results of the model adopted as the SPL at 1/3 octave set at distances from the source.

Distance (m)	Broad band	0.05 kHz	0.1 kHz	0.2 kHz	0.5 kHz	1 kHz	2 kHz	0.05 kHz
1	172	153	165	161	157	155	150	145
100	152	133	145	141	137	135	130	125
400	146	127	139	135	131	129	124	119
1000	142	123	135	131	127	125	120	115
10000	132	113	125	121	117	115	110	105
30000	127	108	120	116	112	110	105	100
80000	123	104	116	112	108	106	101	96

The chart below (Figure 8-25) shows the attenuation values of noise produced sources at different distances compared with an odontocete audiogram produced from the previous figure (Figure 8-24).

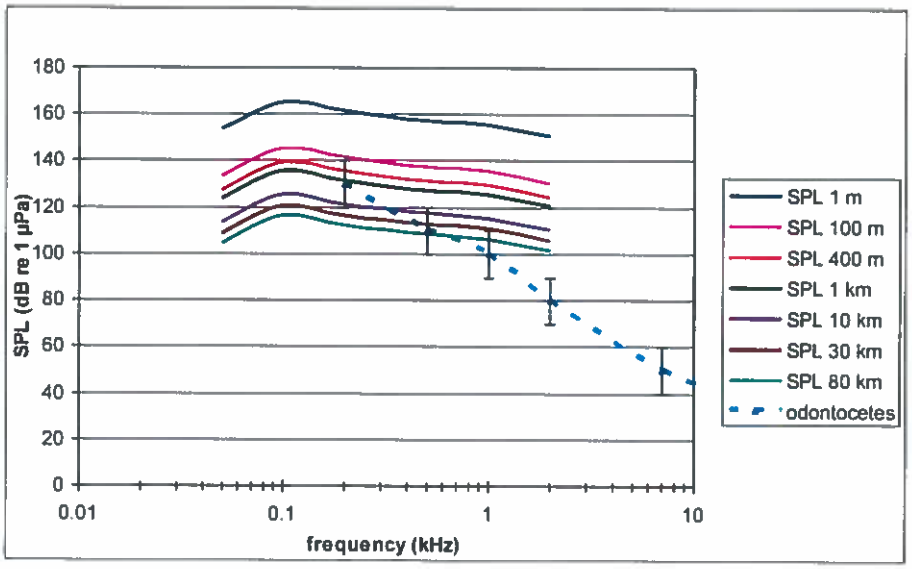

Figure 8-25: Attenuation values of the noise produced by the noise sources at different distances compared with an odontocete audiogram.

SPL on the source simulated at various distances from the source compared with the odontocete species audiogram. Comparing simulation results and odontocetes audiogram it is gather that the noise emitted from the source may have an impact on the species because the levels inputted into the environment are above their threshold of hearing for frequencies of reference.

From these considerations, we also need to identify the levels at which noise becomes a cause of disturbance (area response) or even damage (TTS). Several studies describe levels of SPL-related behavioural responses of different species of cetaceans. In particular Nedwell et al (2003) define the threshold of hearing dBht, the value for which are made of behavioural responses in cetaceans are at a higher level of the threshold of hearing of 75 dB for small responses and 90 for strong reactions.

Referring to these considerations parameter, you can locate the area of response by adding 75 dB, and the area of damage by adding 90 dB at the audiogram previously estimated. It should be emphasized that this analysis is completely deterministic because the threshold for listening dBht was

postulated from studies on humans and fish, and on which the authors have declared a need for further assessment and analysis, supported by empirical evidence that the time of the study were not available.

Figure 8-26 shows an indication threshold levels of listening to low noise and high noise according to the criterion defined by Nedwell et al (2003) to get the results of the model based on an evaluation criterion.

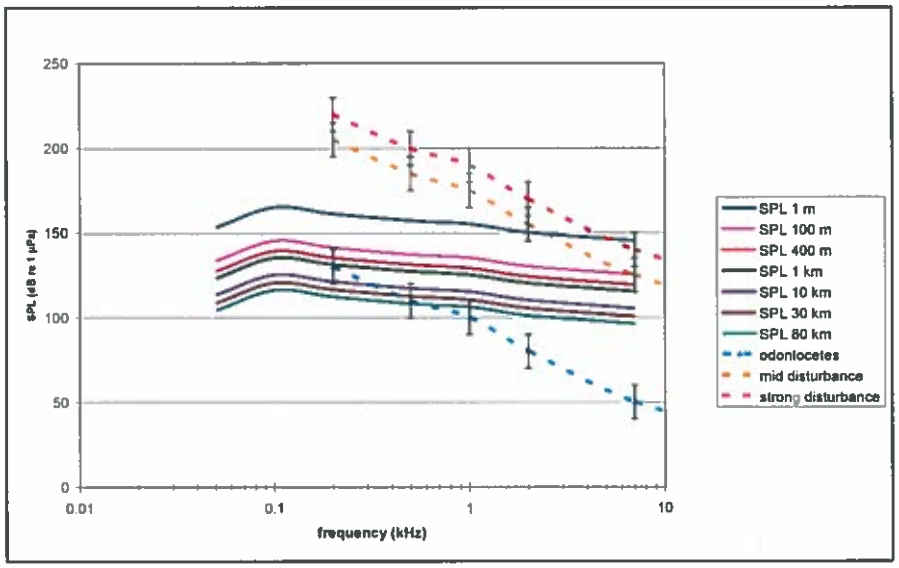

Figure 8-26: Indication threshold levels of listening to low noise and high noise frequencies.

An analysis of the figure shows that following the criterion of dBht, odontocetes are not disturbed by the source. The levels of SPL at 1 / 3 octave are all below audiograms of mid disturbance and the hypothesis of damage is therefore skirt. More information can be deduced by analysing in detail the single species such as bottlenose truncatus wide-spread in the Gulf of Guinea.

Truncatus Bottlenose dolphins, whose audiogram is shown in below has the ability, typical of dolphins, to perceive the signals covered by a background noise The ability of dolphins to detect signals embedded in noise is measured using two parameters: masking band (MB) and critical ratio (CR).

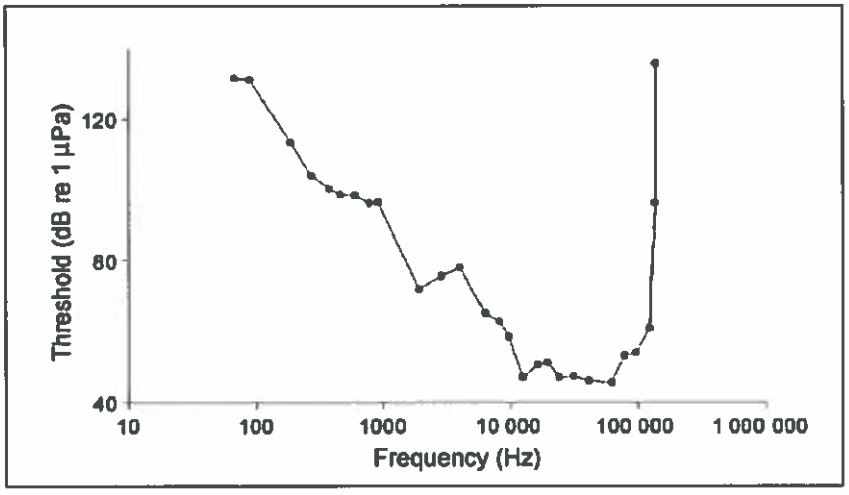

Figure 8-27: Audiogram of Tursiope truncatus (Johnson, 1967).

MB defines the frequency range able to mask a pure tone. Noise at frequencies outside the MB will have little effect on the detection of the tone.

The frequencies of communication (Tursiope truncatus) Bottlenose dolphin are shown in Table 8-22 below.

Table 8-22: Dolphin vocalisations (MCIWEM 2006).

Sound type	Frequency range (kHz	Dominant Frequencies (kHz)	Source level (dB re 1 mPa at 1m)
Barks	0.20-16.0		
Whistles	0.80-24.0	3.5-14.5	125-173
Clicks	0.10-300	15.0-130	218-228

CR is a comparison of the signal power required for target detection versus noise power. MBs tend to be a constant function of the CR throughout an animal's functional hearing range.

Based on CR and masking bandwidth data, odontocetes, including bottlenose dolphins, are better than most mammals at detecting signals in noise. Johnson (1968) estimated masking bandwidths from the CRs of bottlenose dolphins. Between 5 and 100 kHz, MBs appeared to be less than 1/6-octave width and rose to approximately 1/3-octave width at 150 kHz. Source noise has the potential to mask dolphin vocalizations over a significant distance. Both these sounds will attenuate over distance, and masking will be determined by their levels relative to each other.

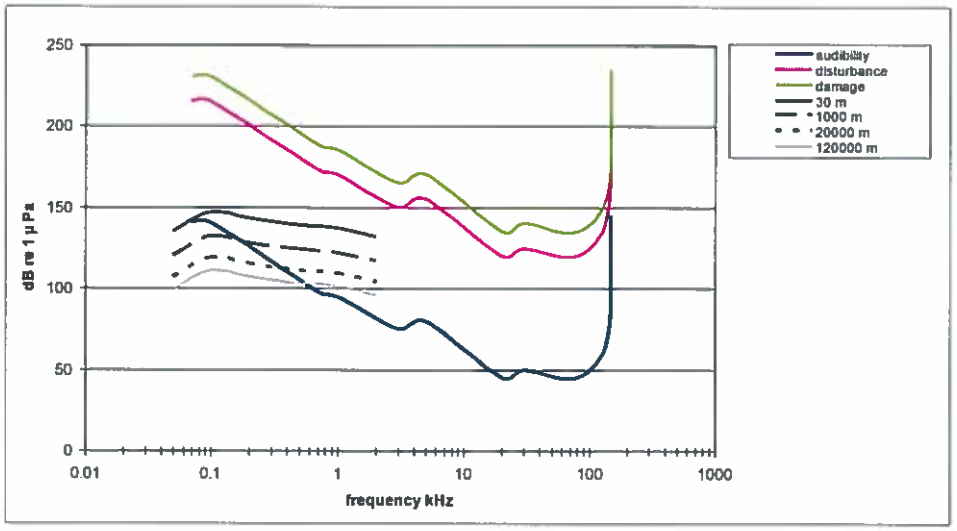

Figure 8-28: SPL in function of distance compared with Bottlenose dolphin audiogram.

Summary

It is difficult to predict which species will be most vulnerable to man-made noise because of the wide range of individual and population sensitivities as well as differences in wariness or motivation. Currently, it may only be possible to make generalizations about the vulnerability of species groups based on behavioural observations of responses to manmade sounds, habits and what is known about a species' auditory sensitivity or vocal range.

The potential impact of underwater noise as a result of the proposed drilling activities on marine mammals is therefore assessed to be of medium significance (see Table 8-23).

Table 8-23: Significance of impact of underwater noise on marine mammals.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Medium term 2	Local 1	Medium 2	Small 2	7	Definite	MEDIUM

8.4.7 Evaluation of Impacts on Social and Health Components

Limitations Encountered

The identification and assessment of socio-economic (and health) impacts have specific limitations which deserve due notice. Some of these are:

- Socio-economic and health impacts are not easily objectively measured and therefore often need to be inferred rather than measured. A combination of insight into social processes in general and a thorough knowledge of the affected communities are important in order to draw valid inferences;
- Communities are dynamic and often in a continual process of change. The proposed Block 15/06 West Hub project is one factor contributing to this change, but it is often difficult to identify when an impact is solely attributable to the Project or to other factors (or a combination thereof);
- Human beings are naturally continuously adapting to changes in their environment, including project impacts. As such, over time these impacts change in significance for those affected;
- Social impacts are often unavoidable for a given project design or approach, and as such, mitigation strategies should be regarded as strategies to manage change rather than as a means to avoid an impact; and
- Appropriate management of a potential negative impact may change the impact into a positive impact, i.e. an opportunity may be realised as a result of predicted changes as long as suitable measures are put in place to take advantage of that change, without which the change may result in negative impacts.

8.4.8 Employment and Procurement of Goods and Services

It is estimated that Eni's project team for the Block 15/06 West Hub development project will comprise of 200 people, with 125 people working full-time on the project at the peak of execution. These employees will be based in Luanda, at Eni's headquarters in Milan, as well as in various engineering and fabrication sites in Angola, Europe and the Far East. It is not known how many of these positions will be filled by Angolan nationals, but the number is likely to be small. Furthermore, it is likely that most positions will be filled by individuals already employed by Eni or their existing contractors.

An increase in local (Angolan) employment, either through direct employment in the project or in secondary businesses (suppliers and services providers), has the potential to improve the socio-economic well-being of employees and their dependants.

Assessment

While the oil and gas industry and projects such as the proposed Block 15/06 West Hub development is known to create very few direct employment opportunities, the oil and gas industry employs the services of other sectors such as finance and retail, and will require a wide range of services during the lifetime of the project. The use of such services, from the provision of materials and equipment to catering and cleaning services and supplies, will result in the creation of additional employment opportunities in these industries (indirect employment). Furthermore, spending by Eni's Angolan

employees in the country will also result in employment opportunities being created in the communities where this spending takes place (induced employment).

The oil and gas industry is generally regarded as having a relatively high employment multiplier[11] when compared to other industries (e.g. in the US the industry is considered to have the highest multiplier at 6.9). In Angola, the industry contributes 5% of total employment in the country. It is not possible to accurately predict the number of indirect and induced employment opportunities that will be created by the Block 15/06 West Hub development project, as the number of local (direct) employment opportunities and the Angolan industry employment multiplier are not known. However, if it is conservatively assumed that 50% of the 125 people employed by the project at the peak of execution will be Angolan nationals, and it is assumed that the Angolan oil and gas industry has a similar employment multiplier to the US (6.9), it can be estimated that the project will result in approximately 430 direct, indirect and induced employment opportunities in the Angolan economy, with only a portion of this anticipated to be created in the Soyo region in particular.

Therefore, although there are expectations amongst the local community in Soyo with regards to employment opportunities as a result of the project, it is not anticipated that the project will result in a significant number of opportunities. In addition, it is expected that most of the jobs created by the project (in particular direct employment opportunities) will most probably be skilled/professional level jobs and it is highly unlikely that these skills will be available in the local community. Despite the extremely high unemployment levels in Soyo (at 60%), which means that the creation of any employment opportunities in the Soyo region is highly desirable, the Block 15/06 West Hub project is not expected to create many new employment opportunities (direct, indirect or induced) in the Angolan economy.

Nevertheless, formal employment is generally speaking more lucrative than many of the economic activities on which the local communities (particularly in the Soyo region) currently relies and a reliable regular income would increase financial security and material wealth, and improve the ability of the employees to better their standards of living, invest in their future and access better health care and education.

The **positive impacts** of anticipated employment and procurement of goods and services by the proposed Block 15/06 West Hub development is assessed to be of **low significance** (Table 8-24).

Table 8-24: Significance assessment of employment and procurement of goods and services.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	National 3	Low 1	Very small 1	8	Possible	LOW +

8.4.9 Influx of Employees and Work Seekers into the Soyo Region

Labour demand generated by a new development project often necessitates the in-migration of employees and work seekers, attracted to the area by perceived employment or business opportunities, creating a boom effect in the local demography. In turn, rapid population growth can lead to a range of socio-economic and health implications for the local communities, e.g. increased pressure on existing social services and infrastructure (from housing through to schooling, electricity, water, sanitation and health structures) and an increase in socio-cultural conflicts (Note: health implications of an influx of employees and work seekers are addressed in section 8.4.11 below).

[11] An employment multiplier measures the total number of employment opportunities (direct, indirect and induced jobs) created (or lost) for every direct job created in a specific industry.

Assessment

Increased housing demand can lead to an increased demand of construction materials and hence in relative pricing. A resulting inflation of rental costs may lead to the mushrooming of makeshift houses, and hence poor housing conditions.

Access to sanitation and clean water is crucial to the health of the local population. There may be a fuelling in the increase of mosquitoes (and other animal vectors). For instance, disturbing drainage systems can cause environmental changes or disclose natural areas with low water evaporation, thus creating areas for the breeding of vectors. Settled and re-settled workers may exacerbate these conditions, especially where water and sanitation conditions are poor.

An influx of employees and work seekers and subsequent mixing of populations often poses an increased risk of antisocial behaviour (e.g. alcohol and drug abuse), crime as well as socio-cultural conflicts resulting from the mixing of cultures. The latter may lead to a positive cultural integration but also to a loss of traditions, rites and beliefs. Local people may also experience a loss in sense of place and belonging. The social and health baseline study conducted as part of the ESHIA identified that alcohol and drug abuse and crime (mostly robbery) are existing and major concerns in the local communities in Soyo, and that prostitution levels are high (mainly due to a lack of income options for women), an influx of employees and work seekers as a result of the proposed Block 15/06 West Hub development may exacerbate this situation.

Increased pressure on education facilities in the form of classroom overcrowding and lowering pupil-teacher ratios can lead to reduced education levels. Baseline data about education indicators in rural Angola indicates that this potential impact is of key concern. However, the Government is intending to invest in the restructuring of school buildings in certain provinces.

Based on experience, the potential impacts discussed above are realistic expectations for most large new development projects. However, the proposed Block 15/06 West Hub project is unlikely to be a significant source of these impacts, based on the small number of employment opportunities that will be created. In addition, offshore project employees work on a rotational shift basis (e.g. 12-hour shifts for 7, 14, 21 or 28 days at a time) and few if any of these employees will need to reside in the Soyo region in between their offshore rotation, as the would be able to return home. In addition, it is anticipated that any direct employees and those of contractors requiring temporary housing in Soyo would utilize existing accommodation facilities on Kwanda Base or in the urban areas of Soyo town.

Of greater concern than an influx of workers employed on the project would be that local people from outside Soyo might migrate into the region upon hearing of the proposed project, prompted by an expectation of increased job demands from the industry as well as other linked work opportunities.

However, it should be noted that the Soyo region already experiences a high level of in-migration, partly due to its proximity to the border with the DRC to the north: by far the largest proportion of foreign immigrants originate from the DRC (up to a third of the population of Zaire Province is made up of immigrants from the DRC to the north). In addition, large numbers of people continuously migrate from the rural areas to the city where there are more employment opportunities. Soyo is particularly attractive because of the oil industry activities at Kwanda Base and specifically large projects such as the Angola LNG project currently under construction. Furthermore, large numbers of expatriated workers already settle in the Soyo region temporarily or on rotational schedules for work related to the construction or oil industries. In addition, Angolan communities, particularly in oil-rich areas such as Soyo, are already exposed to oil industry activities and it is likely to assume that they are familiar with

the fact that industry projects, particularly offshore developments, present very limited employment opportunities.

Furthermore, the social and health baseline study found that acceptance of (legal) foreigners into the local communities is generally high, indicating a relatively high level of tolerance of local communities and little socio-cultural conflict between local inhabitants and newcomers.

While the proposed Block 15/06 West Hub development may therefore exacerbate the problems created as a result of an influx of people into the area, the actual influx is likely to be negligible when seen within the context of the existing situation in Soyo discussed above.

The **negative** impacts of a potential influx of employees and work seekers into the region due to the Block 15/06 West Hub Project are therefore assessed to be of **low significance** (Table 8-25).

Table 8-25: Significance assessment of influx of employees and work seekers into the Soyo region.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	Regional 2	Low 1	Small 2	8	Possible	LOW -

8.4.10 Disruption of Fishing Activities and Offshore Navigation

The presence of and exclusions zones in effect around the drilling unit and FPSO, and the movements of the two supply vessels, crew boat and unspecified number of shuttle tankers between the FPSO and the onshore base at Soyo, may impede access to fishing areas and disrupt navigation by fishing vessels and other vessels (e.g. cargo carriers, etc.) utilising the offshore region in the vicinity of the offshore development.

While the exclusion zones around fixed-position vessels involved in the oilfield development (i.e. drilling units, FPSO) are intended to prevent collisions and reduce risks, the movement of support and service vessels between the offshore location and the onshore logistics base could present hazards to other vessels that cross their paths, increasing the risks of collisions that could cause damage and/or injury. The exclusion zones and increase in marine traffic associated with the proposed development may necessitate any vessels that may pass through the area to re-route to avoid it. This is essential for safety of life at sea, but this could marginally affect commercial activities and livelihoods of vessels utilising the areas in the vicinity of the offshore development and the Kwanda Base.

Both industrial (commercial) and artisanal (subsistence) fishing takes place off the coast of Zaire Province. While larger cargo vessels travelling along the coast towards West Africa or Europe would tend to travel in deeper waters and would be unlikely to be affected, smaller vessels utilising the coastal regions and Congo River mouth may be affected. These activities could all be disrupted by the physical presence and movements of vessels associated with the proposed Block 15/06 West Hub development, and would be exposed to a higher risk of collisions and other hazards associated with increased marine traffic. In addition, the biophysical impacts of pollution at sea as a result of routine operational discharges (e.g. drilling cuttings and mud, production water, etc.) could affect fish populations and therefore catches, while subsea infrastructure and any equipment overboard could become obstacles to bottom trawlers and pose a risk of injury and/or damage to gear.

Any impacts on the ability of fishing and other vessels to operate normally may lead to a loss of income or indirect financial costs (in the case of damaged gear) and, for artisanal fisherman in particular, decreased food security, which is of concern in the Soyo region where coastal communities are reliant on subsistence fishing. Interviews with local stakeholders, including the Institute for Artisanal Fishing (IPA) and fishing cooperatives, revealed that fishing catches have decreased in recent years and the

causes were believed to be due to trawling, dredging and oil industry activities already existing in the region.

Assessment

The proposed Block 15/06 West Hub development is located well offshore of the known distributions of species targeted by commercial fishing activities in Angolan waters, and any interference would be limited to that caused by vessels travelling between the offshore development and the Kwanda Base at Soyo. Based on information gathered during the environmental (biophysical) baseline study for this ESHIA, such vessels may cross the northern extent of the known distributions of small pelagic species (sardinella and horse mackerel), demersal seabreams, deepwater rose and striped red prawn, as well as the northern extent of fishing effort for large pelagic species. It should be noted however that the extent of the distribution of the species targeted by these fisheries discussed above is vast, compared to the limited areas that may be affected by the movement of vessels between the Block 15/06 West Hub offshore development and the Kwanda Base.

The Angolan government has imposed an 8 nautical mile (nm) offshore limit on artisanal fishing. Most artisanal fishing by coastal communities would therefore be undertaken well inshore of the proposed Block 15/06 West Hub development (>70nm offshore). In addition, the type of gear used by artisanal fishing would limit their ability to venture further from shore. However, movement of vessels in the nearshore regions (within 8 nm offshore) and in the Congo River mouth may interfere with artisanal fishing activities. In the case of the latter, popular areas frequented by artisanal fisherman include the Baía de Diogo Cão, where the Kwanda Base is located, as well as canals and channels leading off from the bay, including Pululu and Moita Seca.

The extent of the habitat occupied by the species targeted by all of the fisheries discussed above is vast relative to the areas anticipated to be affected. In addition, the offshore activities associated with the proposed Block 15/06 West Hub development will take place in a region with extensive historical and current oilfield development, and existing (relatively) high levels of marine traffic travelling between the offshore developments and the Kwanda Base at Soyo. It can therefore be assumed that all non-related offshore traffic is well-adapted to the presence of oilfield development vessels in the area and would already be avoiding the area and/or familiar with safety procedures in this regard. In addition, as Zaire Province develops and the Angola LNG plant takes effect, shipping activity will likely increase out of the Port of Soyo.

Standard communication (constant bridge watch and radio contact) and navigation systems (lighting and signalling systems) will be in use on the vessels and Notices to Mariners would be used to warn other users of the sea of the presence of oilfield development vessels. The physical hazard posed by the vessels should therefore have little effect on other vessels. As no bottom trawling is known to take place in the deep waters where the Block 15/06 West Hub development is to take place, protruding well casings and items left on the seafloor are unlikely to present a hazard to such fishing activities.

The **negative** impacts of a potential disruption of fishing activities and offshore navigation is assessed to be of **low significance** (Table 8-26).

Table 8-26: Significance Assessment of disruption of fishing activities and offshore navigation.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	National 3	Low 1	Very small 1	8	Possible	LOW -

8.4.11 Community Health and Safety

The proposed Block 15/06 West Hub development can affect the health and safety of the local communities in the Soyo region in various ways, e.g. through the degradation of air quality, noise

emissions, waste generation and increased pressure on water and sanitation systems. Increased pressure on local health care systems as are result of an influx of employees and work seekers into the region may also affect service quality and local communities' access to these systems.

Increased contact between members of the local communities and newcomers (employees and work seekers) to the Soyo area may increase the incidence of communicable diseases in these communities. Of particular importance is the possible increase of Sexually Transmitted Infections (STIs) such as HIV/AIDS as well as other communicable diseases such as tuberculosis and respiratory tract infections (pneumonia). The increase in urban waste generation, (with relevant increase of vectors breeding sites) and poorer water supply and sanitation can also result in an increase of malaria transmission as well as all other arthropod and water borne diseases.

Noise associated to offshore site activities and onshore operations at Kwanda Base would create nuisance impacts (noise can lead to hearing loss in extreme cases).

The use of hazardous materials in the development of the Block 15/06 West Hub project could pose the risk of uncontrolled fires and explosions, which can cause injuries and even fatalities.

Assessment

Emissions and discharges as a result of onshore activities during the Block 15/06 West Hub development may reduce air and water quality and increase noise levels, which may affect the health of the local communities in which it operates. Pollutants from air emissions, if persistent and quantitatively appreciable, could potentially result in increased health problems such as respiratory diseases and decreased respiratory functions. Access to clean water is crucial for the health of the local population and decreased quality and stagnant water could encourage the breeding disease vectors and result in poor sanitation conditions.

Waste generated offshore will be taken to shore for storage, disposal and/or transfer. This may increase pressure on the local waste management systems, which can lead to further pollution incidents and may affect community health (through disease vectors, exposure to hazardous chemicals, etc.). However, onshore activities will take place on the Kwanda Base, which is equipped to provide the relevant services such as waste management to the oil and gas industry.

Employees on the offshore facilities and at the onshore base are most at risk of the effects of the health impacts discussed above, but the implementation of standard occupation health and safety standards, including the use of personal protective equipment (PPE), and adequate training would reduce these risks.

Although data on HIV/AIDS prevalence in the Soyo region is limited, indications show relatively high levels of infection with particular regard to some at-risk social groups. Malaria is considered the key cause of morbidity and mortality in the Soyo region, with high numbers of local inhabitants reporting to have experienced malaria, and numerous deaths resulting from the disease. Actually Tuberculosis is also considered a leading cause of mortality in the Soyo region (which may indirectly indicate a rampant HIV infection), while respiratory infections are reportedly an important cause of ill-health in the area. The existing health situation is already poor and a potential increase in communicable diseases in the Soyo region could have a potential impact on population. However, as noted above, any influx component of newcomers into the Soyo area as a specific result of the proposed Block 15/06 West Hub development is anticipated to be minimal and considered unable to produce a marked increase in the incidence of communicable diseases in the local communities.

Usually, any increase in health risks and decline in the health conditions in any region would increase pressure on the local health care system. The baseline study conducted for this ESHIA found that local healthcare providers in the Soyo area are currently under capacity in terms of equipment, facilities, training opportunities and staff and have limited access to medicines. This dramatic picture

implies that also minimal additional pressure on the local health care system as a result of the proposed Block 15/06 West Hub development impact on population influx could reduce local communities' access to the weak services.

The **negative** impacts on community health and safety although considered minimal, because of the critical existing situation, is assessed to be of **medium significance** (Table 8-27).

Table 8-27: Significance assessment of impacts on community health and safety.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	Regional 2	Medium 2	Great 3	10	Possible	MEDIUM -

8.4.12 Natural and Other Resource Use

The proposed Block 15/06 West Hub development will require resources such as water and electricity, which may reduce access to these resources by the local communities.

Assessment

No information is available with regard to the water, energy or other resource needs of the proposed Block 15/06 West Hub development. Nevertheless, it is known that the local communities have limited access to these resources. Very few of the inhabitants of the Soyo region are served by the public potable water supply, which is delivered by truck to certain parts of Soyo town and nearby communities, although supply is unreliable.Those inhabitants not served in this way have to collect/purchase their water elsewhere and spend up to two hours every day to do so. Water use by the project that exceeds local availability may result in a lack of adequate access to potable water. The same applies to electricity consumption; an uncontrolled use with respect to local capacity. Similarly, very few of the homes in Soyo have access to electricity through the municipal network, which covers only the centre of the city and petroleum gas and firewood are used as fuel for cooking and lighting. This may be of detriment to communities and local businesses dependent on these sources. In addition, competition for use of these resources may also lead to an increase in the price of the affected resources, which may further affect the local communities' access.

Use of local resources, such as water, electricity and other energy sources, by the project must be sustainably planned so as to avoid competing with local communities for scarce resources in the area. While the consumption of other fuel such as diesel and marine fuel is an operational necessity, fuel consumption can be minimised through a regular programme of servicing and maintenance.

The potential **negative** impacts of natural and other resource use by the project on the local communities are assessed to be of **medium significance** (Table 8-28).

Table 8-28: Significance assessment of impacts on natural and other resources use by the project.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	Regional 2	Medium 2	Great 3	10	Possible	MEDIUM -

8.4.13 Contribution to Angolan Economy

Oil production from the proposed Block 15/06 West Hub project will contribute to Angola's economy through taxes, royalties and other fees that Eni would have to pay to the government of Angola, the procurement of local goods and services, employment and income generation, government's share of

revenue received, etc. This would contribute to Angola's oil revenue, increase Gross Domestic Product (GDP) and generally benefit the economy at a national scale.

Assessment

The high growth rate in Angola's economy in recent years was largely due to high international prices for its oil: oil production and associated activities contribute approximately 85% to Angola's GDP.

Oil production from the Block 15/06 West Hub project is expected to commence in early 2014, reaching a peak of nearly 100 000 bbl/day in early 2016. The Block 15/06 West Hub project will therefore produce about 6.25% of Angola's production in 2016, which is estimated at approximately 1 600 000 bbl/day (see Figure 8-29). After 2016 production will continue at a decreasing rate until at least in early 2034, with an estimated total of nearly 200 million barrels of oil recovered over the 20-year period[12].

While the project would therefore not comprise a very large part of the upstream oil industry's contribution to Angola's economy, it will nevertheless make a valuable contribution.

The use of revenue received as a result of projects such as the proposed Block 15/06 West Hub development is the responsibility of the government. However, the increased availability of finance could facilitate the government's investment in the country's socio-economic development, including the development of much-needed infrastructure and provision of social, education and health services, which would be of great benefit to the affected communities.

The **positive** impact of a contribution to Angola's economy as a result of the project is assessed to be of **medium significance** (Table 8-29).

Table 8-29: Significance assessment of the contribution to the Angolan economy.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	National 3	Low 1	Small 2	9	Definite	**MEDIUM +**

[12] By comparison, BP Angola's PSVM Project currently under development in Block 31, is expected to produce 500 million bbl of oil by 2030 (ERM, 2008).

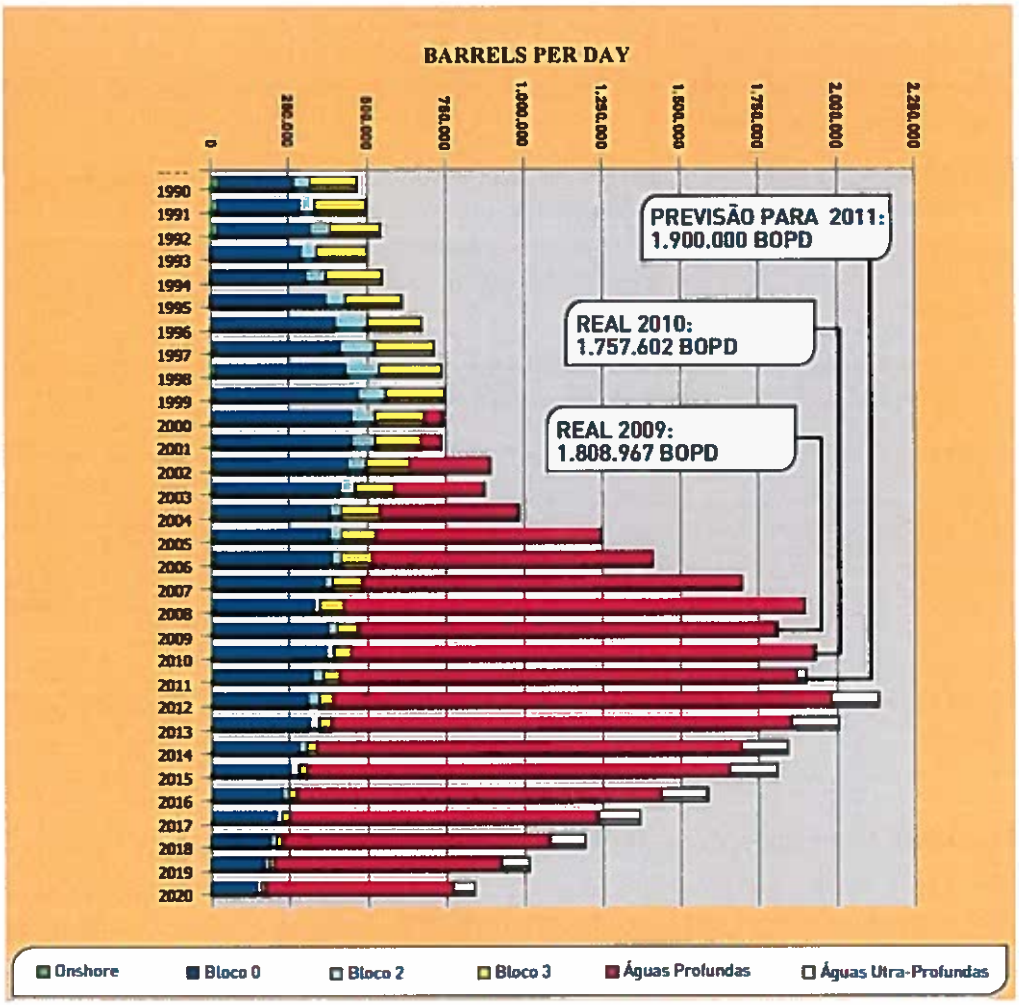

Figure 8-29: Angola's oil production history (1990 to present) and predicted (to 2020).

Source: adapted from www.sonangol.co.ao

8.4.14 Perceptions and Expectations of Local Communities

With most large development projects, and particularly in the case of offshore oil and gas developments, expectations from local communities with regard to economic opportunities (employment or business opportunities) typically far exceed the actual opportunities that will be created by the project. In addition, while local communities usually bear the brunt of the negative direct and indirect impacts (such as those discussed above) of a project, the socio-economic benefits (in the form of contribution to the national economy) rarely filter down to tangible or perceptible socio-economic benefits to the local communities. This may lead to a negative opinion of a project proponent in the local communities within which it operates, and even to damage to the reputation of the oil and gas industry as a whole.

Assessment

When asked about the principal problems affecting their communities, stakeholders consulted during the social and health baseline conducted for this ESHIA identified unemployment, HIV/AIDS and TB, alcohol and drug abuse, prostitution, crime (mainly in the form of robbery), lack of access to natural resources and human and economic losses due to natural disasters as the key concerns of the local

communities. As illustrated by the discussions in this section, projects such as the Block 15/06 West Hub development can result in impacts that raise or exacerbate these concerns. Local communities may therefore perceive these concerns as attributable to the project, whether they can be directly linked to the project or not.

Furthermore, stakeholders consulted for this ESHIA listed employment opportunities, improved utilities, health and educational infrastructure, access to new cultivation areas and new construction materials, etc. as anticipated socio-economic benefits that would accrue to the local communities as a result of oil and gas development in the region, and the Block 15/06 West Hub development in particular.

The potential **negative** impacts as a result of the perceptions and expectations of local communities are assessed to be of **low significance** (Table 8-30).

Table 8-30: Significance assessment of perceptions and expectations of local communities.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	Local 1	Medium 3	Great 3	8	Possible	LOW -

The summary results of this impact assessment exercise as just described are presented in Table 8-40: **Evaluation of the potential environmental, social and health impacts of the proposed project.**

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8.4.15 Impacts of an Accidental Release of Hydrocarbons

From the modelling undertaken, the areas of potential impact are predicted to extend to the coastline of Gabon and Sao Tome Island, and over Angolan, DRC, Congo and Gabon's Territorial Waters and Exclusive Economic Zones and the High Seas (**Figures 8.30 to 8.33**).

The nature of the impact is that oil can have toxic and/or smothering effects on organisms in the path of a spill. The environmental receptors/components that are considered vulnerable to the potential effects of a hydrocarbon spill at sea are:

- Seabird populations;
- Marine turtle populations;
- Cetaceans;
- Manatees
- Open coastal habitats;
- Estuarine and lagoon habitats;
- Coastal conservation areas;
- Fishing activities; and
- Tourism and recreation activities.

An assessment of the potential impacts on these receptors/components is presented below. It should be noted that the assessment is based on the premise that a hydrocarbon spill does occur, although this is considered highly unlikely. In other words, the probability ratings as presented in the assessment tables below are of the probability of the effects described occurring *should a spill take place*, and not of the probability of a spill occurring.

Key recommended mitigation measures designed to assist in preventing a spill from occurring, and in minimising the extent of a spill should it occur, include the following:

- Regularly test the BOP during drilling operations;
- Use reinforced hosing for crude oil transfers and use weak links and associated shut-off valves to reduce losses to sea should a rupture occur;
- Inform MinPet of any spills and deploy oil protection booms when possible;
- Inform the Angolan Ministry of Environment and Ministry of Foreign Affairs to advise the governments of Gabon and the Democratic Republic of Sao Tome and Principe.
- Apply biodegradable dispersants only after consultation with MinPet; and
- Implement the Oil Spill Emergency Response Plan.

8.4.15.1 Oil Spill Modelling Results

Oil spill modelling was undertaken by ENI E&P (EMERG unit) to predict spill trajectories for a blowout of crude oil (a 34.9°API, pour point 6°C, wax content 3.90%) likely to most closely represent the oil from the Sangos Field. Stochastic and deterministic model outputs were used to predict results[13].

The spill location modelled was 8°29.5760'E 6°8.3417'S, in the Sangos Field of the West Hub development area in Block 15/06.

The scenarios modeled were of a spill of 17 850 m³ or ~112 000 US bbl /day of oil for 30 days, and using 5 years of current and wind data, from Sat-Ocean, collected over the period 2007 to 2011.

Behaviour of the discharged oil as predicted by MEMW (OSCAR) software by Sintef was used to identify the possible environmental consequences that may be generated by accidental discharges.

Stochastic Modelling Results

Stochastic simulations were performed using data from the whole 5 year period of weather records.

Figure 8-30 shows the sea surface at risk from oiling as a contoured probability plot, and **Figure 2-2** the predicted time from release for oil to reach areas within the overall footprint. The coastal areas at risk from an oil spill at the Sangos4 site extend from Libreville, the capital city of Gabon, in the north to the coast off Gamba which is ~270 km south of Port-Gentil, and also reaching the island of Sao Tome (**Figure 8-30**). The predicted periods for oil to reach these shores range from 14 to 30 days (**Figure 8-31**).

[13] *Stochastic Modelling uses random variables, and is intrinsically non-deterministic. Deterministic modelling means behaviour determined by particular initial state and inputs, and which is not random or stochastic!*

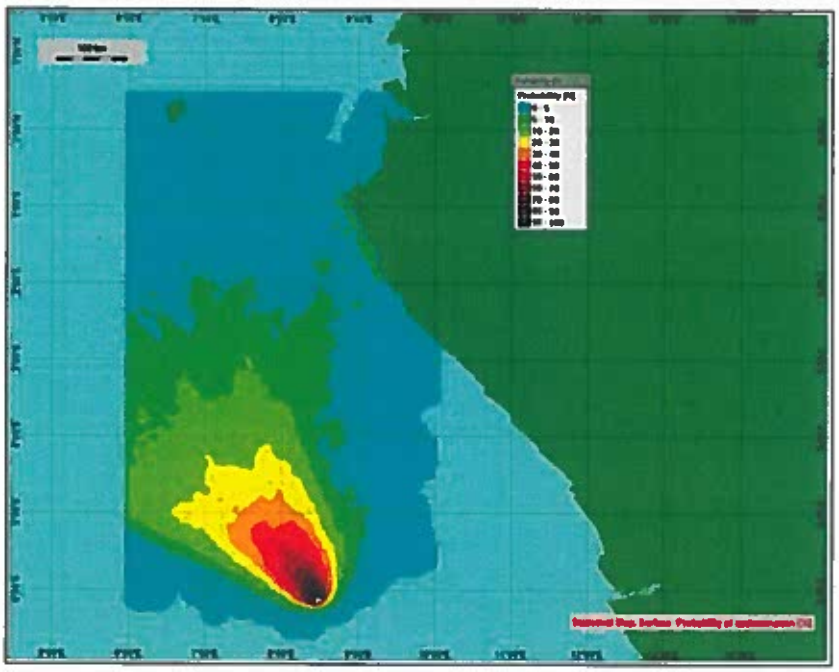

Figure 8-30: A stochastic output of the probability of oil contaminating the sea, on the basis of all the simulations performed (ENI, 2013).

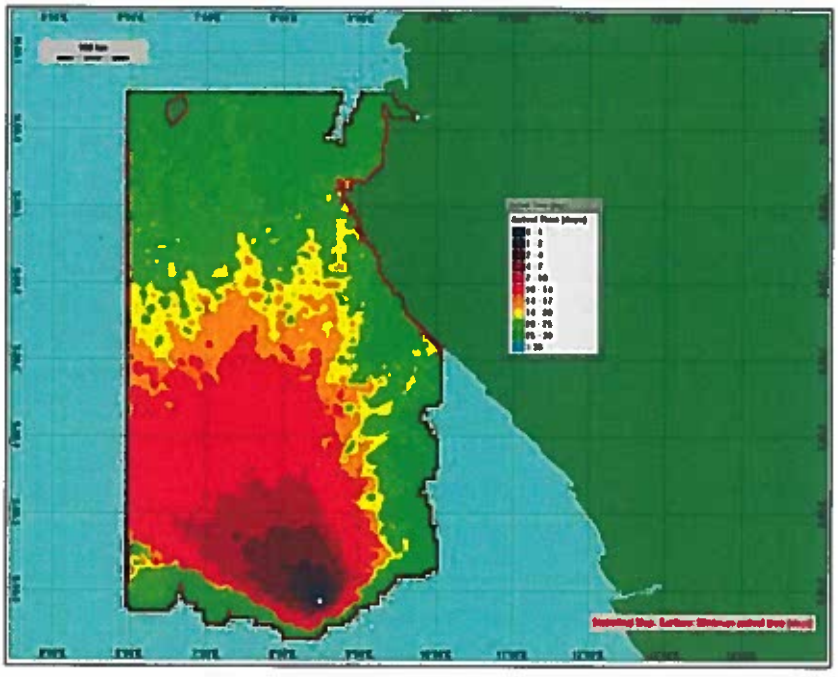

Figure 8-31: Sea surface. Predicted minimum arrival time of oil within the overall oil spill footprint as shown in Figure 8-30 (ENI, 2013).

The oiling of the shore may be intense with 'thick' oil (>100 µm layer thickness) predicted to affect the coast over the 150 km between Port Gentil in the north and Iguela in the south (**Figure 8-32**). The oil spill modelling indicates that the oil may reach these shorelines 7-10 days post spill (**Figure 8-33**), and the data indicate it may continue to be washed ashore for more than 25 days after release.

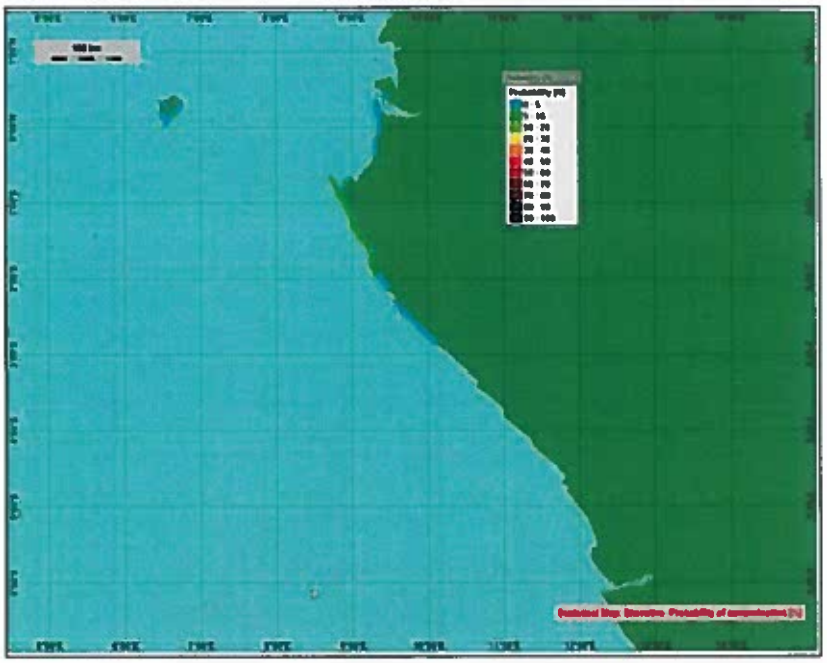

Figure 8-32: A stochastic output of the probability of oil contaminating the coastline, on the basis of all the simulations performed (ENI, 2013).

Figure 8-33: Predicted minimum arrival times for oil reaching the shore, derived from stochastic modelling (ENI, 2013).

Deterministic Modelling Results

Deterministic simulations, for particular cases, used scenarios which evolved in the worst weather conditions occurring over the period of data collection. Two worst case scenarios are given:

- Weather conditions resulting in the minimum time for oil to get ashore (starting at Oct. 11 2010 at 04:00 a.m.); this indicates the shortest time that would be available to organize a proper response to prevent oiling the coast; and
- Weather conditions resulting in the maximum amount of oil reaching the shore (starting at Sept. 20th 2009 at 11:00 p.m.); this indicates the greatest potential threat to biodiversity and cost to clean up.

An example of predicted behaviour in terms of trajectories and fates for the modelled scenarios is shown in **Figure 8-34** below which illustrates the expected track of the oil to eventual deposition on the shoreline. The mass balance (**Figure 8-36**) predictions show that, after the 30 day spill duration 53% of the oil will be on the sea surface, 40% would have evaporated and 2% would have been cast ashore. Minor amounts would have left the model domain or be entrained in the water column.

Under the worst case scenario ~150 km of the Gabon coastline between Port Gentil and Iguela is predicted to be oiled. Transit times of the oil are predicted to be short at 6.75 days for first arrival although oiling is expected to continue over at least 30 days following first arrival on the shore.

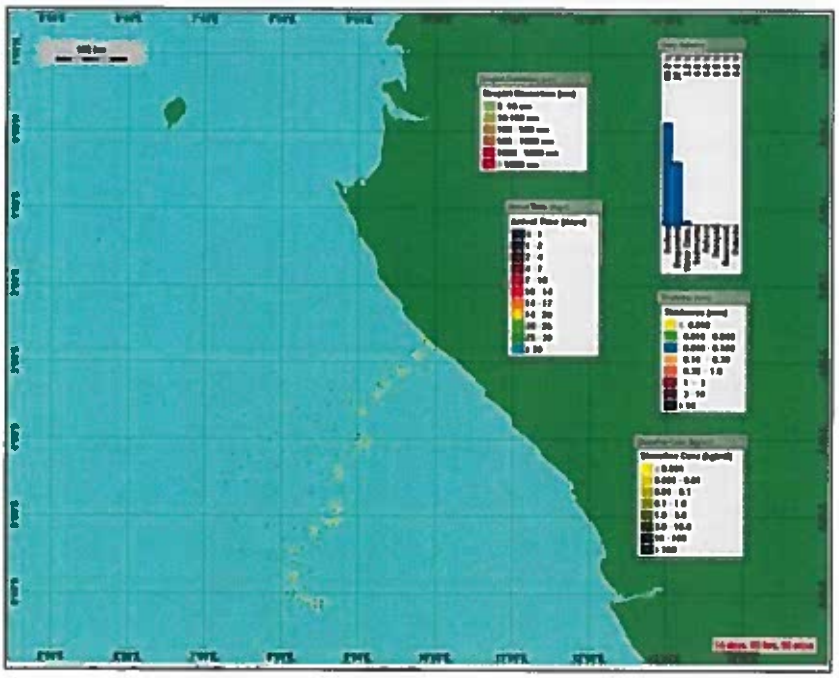

Figure 8-34: Min arrival time (+14days): a particular case, the one in all those performed which brings oil ashore in the minimum time, so that there is less time to respond to the spill appropriately; this snapshot is taken after 6 days and 18 hours from the beginning of the spill, when oil first hit the shore (ENI, 2013).

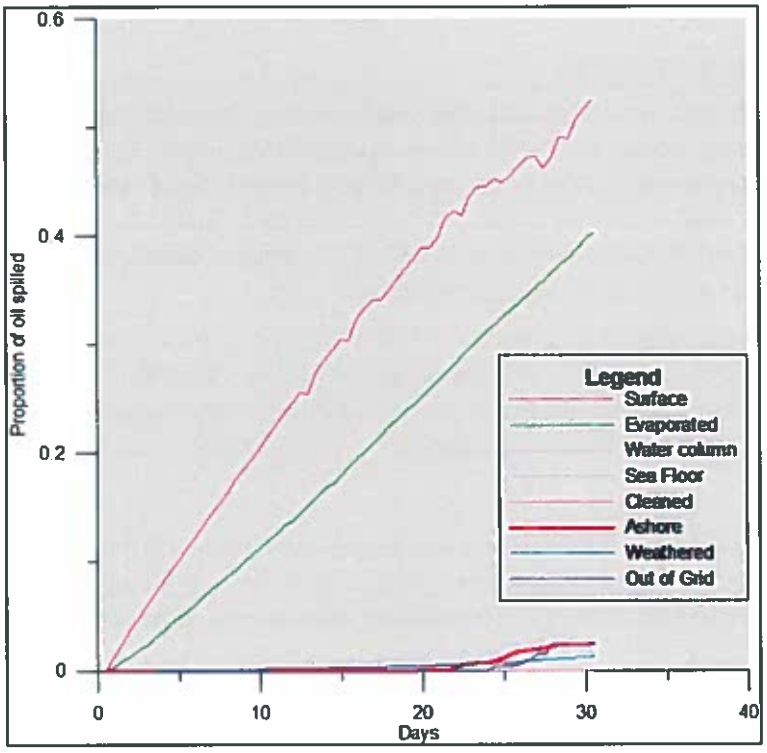

Figure 8-35: Plot showing the mass balances of the oil over time. The bulk of the oil evaporates or remains on the sea surface where it is exposed to weathering. A minor proportion is washed ashore but this is still equivalent to 11 000 metric tonnes of oil.

8.4.15.2 Potential Impacts on Seabird Populations

The species that may be at risk from spilt crude oil include pursuit diving and/or surface swimming birds such as terns, gannets and cormorants although the latter two are generally sparsely distributed in this region.

Although most of the coastal wetlands provide unique ecological conditions and habitats for Palaearctic migratory birds which overwinter in West Africa annually (GCLME, 2010), and there may be a temporary contraction in habitat, they would not readily be affected because these birds would escape to unaffected areas.

Assessment

Given their large natural ranges, if oiling of these inshore bird species were to occur the effects at the population level should be unlikely. Damara terns have been recorded from the region and do nest on the upper portions of sandy beaches, generally on or in dune slacks behind the primary dune. Due to their location, nests should not be affected by crude oil that may come ashore. Although any impact on seabirds would of *regional* extent, the impact would be of *low intensity* and *short-term duration*. The potential impact on seabird populations is assessed to be *insignificant*. The impact assessment is summarised in the table below.

Table 8-31: Significance of potential impact of a hydrocarbon spill on seabird populations.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Short term 1	International 3	Low 1	Medium 2	7	Possible	LOW -

8.4.15.3 Potential Impacts on Turtles

Olive ridley, green, hawksbill and leatherback turtles nest throughout the length of the Gabon coast with 18 known nesting sites (Fretey 2001). The region is particularly important for leatherbacks and currently supports the largest aggregation of this species in the world. Aerial surveys indicate that 15 730-41 373 females may nest in the region with important areas being Corisco Bay and the protected areas south of Port Gentil (Witt et al. 2009). All of the recorded species occur in the areas that may be affected by an accidental release of hydrocarbons.

The primary agents for lethal effects on turtles are complete covering by thick oil for juveniles or the ingestion of tar balls (Milton *et al* 2008). Sublethal effects may occur, as turtles do not appear to demonstrate avoidance effects for oil slicks. Prolonged exposure (days) may thus generate respiratory-linked pathologies such as reduced dive times and foraging success, with increased risks of starvation.

Assessment

Given the stated timing of the proposed exploration drilling activities (from mid-2013 over three years) which will extend through three sets of turtle hatching and mating periods, a spill may affect them. The relatively long period during which crude oil slicks may exist increases the probability of at least sub-lethal effects on turtles.

The proportion of the regional population that may be affected is unknown but, in the unlikely event of a major spill, it would have an impact of *medium-term duration* because of the volumes and density of crude oil involved. Furthermore, there is a high likelihood of turtles encountering a crude oil spill because of the appreciable area that may be affected this would result in an impact of *medium* intensity. The potential impact of a crude oil spill on marine turtle populations is therefore assessed to be of *high* significance without mitigation. Implementation of the recommended mitigation measures would reduce the likelihood of a spill occurring, and, should a spill occur, would reduce the intensity of the impact on marine turtle populations, resulting in a residual impact of *medium* significance.

Table 8-32: Significance of potential impact of a crude oil spill on marine turtle populations.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Medium term 2	International 3	Medium 2	High 3	10	Possible	MEDIUM -

8.4.15.4 Potential Impacts on Cetaceans

Whales and dolphins may be affected by a spill either by effects on their mating/courting behaviour or their food sources (e.g. fish for dolphins). In most cases these species will tend to move away from the oiled area and would not suffer long-term effects. Because of the conservation status of these fauna, even chronic level impacts are considered to be of *international* importance.

Assessment

An extensive area of sea surface may be affected by spilt crude oil with a high potential likelihood of whales being affected. Despite this fact, because whales are strong swimmers they will be able to avoid the area of the oil spill therefore the potential impact is assessed to be of *low significance*.

Table 8-33: Significance of potential impact of a crude oil spill on cetaceans.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Short term 1	International 3	Low 1	Medium 2	7	Probable	MEDIUM -

Implementation of the recommended mitigation measures is not expected to reduce the impact significance further, but would assist in preventing a spill from occurring.

8.4.15.5 Potential Impacts on Manatees

Manatees occur in the coastal areas of Gabon and extend inland in the larger rivers (IUCN 2012). These animals graze seagrass in shallow marine waters and algae and river bank vegetation in river mouths and rivers. Similar to whales and dolphins it is expected that manatees would retreat from their range polluted by oil and return once the physical and biological effects of the oil had been reduced by natural weathering processes.

Because of the conservation status of these fauna, even minor disturbances are considered to be of *international* importance. There is an extensive area of coastline that may be oiled and a high potential likelihood of manatees being affected. Despite this fact, manatees will be able to avoid the area of the oil spill therefore the potential impact is assessed to be of *low significance*.

Table 8-34: Significance of potential impact of a crude oil spill on manatees.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Short term 1	International 3	Low 1	Low 1	6	Probable	LOW -

8.4.15.6 Potential Impacts on Open Coastal Habitats

Sao Tome is a 1 536 km² volcanic island with a crenulated coastline with cliffs and sandy beaches. Gabon has an 885 km long coastline with long stretches of sandy beach, and cliff-backed coastline. Spilled crude oil is predicted to impact extensive lengths of these coastlines, particularly Gabon's, as illustrated in **Figure 8-36** below, and the formation of tar balls or asphalt pavements is considered to be likely and persistent. Effects may extend for more than a year before extensive weathering takes place and, due to formation of pavements, may be of high intensity. The potential impact of a crude oil spill on open coastal habitats would be of *medium-term* duration and is assessed to be of *very high* significance.

Table 8-35: Significance of potential impact of a crude oil spill on open coastal habitats.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Medium term 2	International 3	High 3	High 3	11	Definite	HIGH -

Implementation of the recommended mitigation measures would not reduce the significance of the impacts, but would assist in preventing a spill from occurring.

Figure 8-36: Satellite imagery of coastal areas predicted to be at risk of impacts from oil spilled in the Sangos Field in Angola. The orange dotted line between Port Gentil and Iguela indicates a 5-10% probability of 'thick' oil reaching the coast, and the white dotted lines north to Libreville, south to Gamba, and around the island of Sao Tome a <5% probability.

8.4.15.7 Potential Impacts on Estuaries and Lagoons

As evident in **Figure 8-30** above, spilt crude oil may affect the Gabon coast extending from Libreville in the north to Gamba in the south at a <10% probability (stochastic distributions). Within this area are a substantial number of estuary/lagoon systems, and mangroves (Gabon has a total of 1606 km^2 of mangrove cover (GCLME 2010). The two estuary/lagoon systems which could be most at risk of being affected, in the unlikely event of a major spill from Sangos4 in Block 15/06 in Angola, are at the Ogooue River mouth and the Nkomi lagoon at the northern end of the Loango National Park (**Figure 8-31**).

Figure 8-37: Satellite image showing the two estuary/lagoon systems predicted to be most at risk from a major spill from Sangos4 in Block 15/06 in Angola.

Effects, and their duration, would depend on the amount of oil that penetrates the systems. A small amount would mean recovery periods of salt marsh areas and mangroves could be relatively short, about 5 years, but if the salt marshes and mangroves and the substrates in which they grow were thickly covered in oil then recovery of the full biological diversity associated with these habitats would only occur over decades (IPIECA, 1994a and 1994b). This may have important implications for the functions of these estuary systems in terms of provision of fish nursery and foraging areas for coastal birds.

Because of the extent and trans-boundary nature of the area predicted by the modelling to be affected, the impact would be *international* and could be at a *high intensity* with a *long term duration*, mainly because of the length of time it would take mangrove habitats, especially, to recover. The potential impact of an accidental release of hydrocarbons on estuarine and lagoon habitats is therefore assessed to be of *high significance* without mitigation. Implementation of the recommended mitigation measures may reduce the volume of crude oil that may enter the estuary and lagoon habitats and but the significance rating of the impact would remain the same.

Table 8-36: Significance of potential impact of a crude oil spill on estuarine and lagoon habitats.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Long term 3	International 3	High 3	High 3	11	Possible	MEDIUM -

8.4.15.8 Potential Impacts on Conservation Areas

There are a number of declared coastal conservation areas within the trajectory predicted by deterministic modelling for an accidental release of hydrocarbons from the Sangos Oil Field in Block 15/06.

Figure 8-38: National parks and protected areas in Gabon (base map from WCS, viewed 1 February 2013). The red block shows the area of 5-10% probability of oiling, blue blocks show 0-5% probability.

In 2002 Gabon established west-central Africa's first marine national park, Mayumba, which the Sangos4 modelling predicts is unlikely to be affected, but the coastal parks of Loango (no 4 in **Figure 3-3**) and Pongara (no. 12 in **Figure 3-3**) fall within the predicted 0-5% probability of being affected in a worst case scenario by a major spill. The Sao Tome islands (santomean archipelago) are renowned as an important biodiversity area, which includes coral reef systems and turtle nesting beaches. The Islands have recently designated a number of protected reserve areas to be known as the Obo Natural Park.

Gabon's coastline is also an important nesting ground for threatened leatherback turtles. Humpback whales migrate to Gabon's near-shore waters to breed during the Southern Hemisphere's winter. The rare Atlantic humpback dolphin occurs in near-shore and estuarine environments. Gabon is believed to host a significant population of West African manatees and recent studies have found that manatee meat is routinely available in Gabonese marketplaces (WCS, 2013).

Loango National Park is situated between the Nkomi and Ndogo Lagoons. Habitats include marine, seashore, coastal lagoons, mangroves, salt marsh and coastal forest. The 220 km² Iguéla Lagoon is the only significant example of a typical western African lagoon system that is protected within a national park. The Loango area has over 100 kilometres of uninhabited coastline and humpback and killer whales are observed here from mid-July to mid-September.

Stochastic modelling indicates that coastlines of conservation areas in Sao Tome and Gabon have a <5% chance of being oiled, except in south-central Gabon (and a small area of Sao Tome?) which could be affected by crude oil spills with a higher probability of 5-10%. If this were to occur then coastal

conservation efforts may be compromised. Notwithstanding, if oiling was to occur large volumes may be involved and weathering periods would be comparatively long (months to year); effects would be of *high intensity*, *long duration*, as all of the areas contain estuaries, but with a *low probability* of oil reaching these areas. Again, because of the trans-boundary nature of impacts the extent is *international*. Impacts on conservation areas may therefore be of *high* significance without mitigation. The implementation of the recommended mitigation measures would reduce the intensity of the potential impact and its significance to *low*.

Table 8-37: Significance of potential impact of spilled hydrocarbons on conservation areas.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Medium term 2	International 3	High 3	High 3	11	Possible	MEDIUM -

8.4.15.9 Potential Impacts on Fishing Activities

The oil spill trajectory area passes through the Exclusive Economic Zones of Angola, Congo, Gabon and the Democratic Republic of Sao Tome and Principe, and would cross through all commercial fishing areas which are dispersed along these coastlines in specific depth ranges. Purse seine fishing could be affected most through gear fouling. Artisanal fishing occurs in Gabon and Sao Tome and could also be affected by spilt oil. Therefore, if a spill does occur, disruptions to commercial fishing (oiling of gear) may extend for >30 days as this is the predicted period of time that thick oil will be on the sea surface for the worst case trajectory and fate analysis.

Accordingly the potential impact of a crude oil spill on fishing activities is rated to be of *international extent* at a *medium intensity* but with a *short term* duration, and is assessed to be of *low significance*. The only mitigation possible would be compensation to artisanal fishers for missed catches as their mobility is limited. Boats fishing for large pelagic species should be able to avoid any oil spill that may occur.

Table 8-38: Significance of potential impact of a crude oil spill on fishing.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Short term 1	International 3	Medium 2	Medium 2	8	Possible	LOW -

8.4.15.10 Potential Impacts on Tourism and Recreation

Tourism infrastructure in Gabon and Sao Tome is reported to have expanded in recent years although not on an extensive scale in Gabon, particularly. Accordingly, within the time period of the envisaged drilling activities, disruption of tourism by an accidental release of hydrocarbons is *possible*. It is also possible that local people, particularly in San Tome, visit beaches in the region for recreation, but evidence of population and development densities appears to be low, from satellite imagery.

The potential impact of a crude oil spill on tourism and recreation would be *international* in extent but of a *low intensity* and with a relatively *short term* duration, it is therefore rated as of *very low significance*. There does not appear to be any practical mitigation for this.

Table 8-39: Significance of potential impact of a hydrocarbon spill on tourism and recreation.

Consequence					Probability	Significance
Duration	Extent	Magnitude	No. of elements involved	Score		
Short term 1	International 3	Low 1	Low 1	6	Possible	LOW -

8.4.15.11 Potential cumulative impacts

Insufficient monitoring and research has been done to determine the cumulative effects of oil/hydrocarbon spills on organisms at sea and on the coast in the Gulf of Guinea area.

Table 8-40: Evaluation of the potential environmental, social and health impacts of the proposed project.

Potential Impact Identified	Impact Characterisation	Significance Evaluation Criteria						Impact Significance
		Consequence					Probability	
		Duration	Extent	Magnitude	N° of elements involved	Score		
Air quality	Direct	Medium term 2	Local 1	Low 1	Very small 1	5	Definite	LOW -
Water quality	Direct	Medium term 2	Local 1	Low 1	Very small 1	5	Definite	LOW -
Sea bed and marine subsoil	Direct	Long term 3	Local 1	Low 1	Very small 1	6	Definite	LOW -
Sea bed Ecosystems and vegetation, flora & fauna	Direct	Medium term 2	Local 1	Low 1	Very small 1	5	Definite	LOW -/+
Noise	Direct	Medium term 2	Local 1	Medium 2	Small 2	7	Definite	MEDIUM -
Employment and procurement of goods and services	Direct	Long term 3	National 3	Low 1	Very small 1	8	Possible	LOW +
Influx of employees and Work Seekers into Soyo Region	Direct	Long term 3	Regional 2	Low 1	Small 2	8	Possible	LOW -
Disruption of fishing activities	Indirect, Perceived	Long term 3	National 3	Low 1	Very small 1	8	Possible	LOW -
Natural and other resources use	Direct Indirect Cumulative	Long term 3	Regional 2	Medium 2	Great 3	10	Possible	MEDIUM -
Community Health and Safety	Indirect Cumulative Perceived	Long term 3	Regional 2	Medium 2	Great 3	10	Possible	MEDIUM -
Contribution to Angolan economy	Indirect Cumulative Perceived	Long term 3	National 3	Low 1	Small 2	9	Definite	MEDIUM -
Perceptions and expectations of local communities	Direct Perceived	Long term 3	Local 1	Medium 3	Great 3	8	Possible	LOW -

Impacts of an Accidental Release of Hydrocarbons								
Significance of potential impact of a hydrocarbon spill on seabird populations	Direct	Short term 1	International 3	Low 1	Medium 2	7	Possible	LOW -
Significance of potential impact of a crude oil spill on marine turtle populations.	Direct	Medium term 2	International 3	Medium 2	High 3	10	Possible	MEDIUM -
Significance of potential impact of a crude oil spill on cetaceans	Direct	Short term 1	International 3	Low 1	Medium 2	7	Probable	MEDIUM -
Significance of potential impact of a crude oil spill on manatees	Direct	Short term 1	International 3	Low 1	Low 1	6	Probable	LOW -
Significance of potential impact of a crude oil spill on open coastal habitats	Direct	Medium term 2	International 3	High 3	High 3	11	Definite	HIGH -
Significance of potential impact of a crude oil spill on estuarine and lagoon habitats.	Direct	Long term 3	International 3	High 3	High 3	11	Possible	MEDIUM -
Significance of potential impact of spilled hydrocarbons on conservation areas	Direct	Medium term 2	International 3	High 3	High 3	11	Possible	MEDIUM -
Significance of potential impact of a crude oil spill on fishing	Direct	Short term 1	International 3	Medium 2	Medium 2	8	Possible	LOW -
Significance of potential impact of a hydrocarbon spill on tourism and recreation	Direct	Short term 1	International 3	Low 1	Low 1	6	Possible	LOW -

8.5 Impact Assessment Recommended Mitigation Measures

This section of the report regarding mitigation present the mitigation (preventive, reduction and control) measures and alternatives considered to ensure that the associated and potential impacts of the proposed well drilling, completion and production testing, laying of flowlines, installation of FPSO and installation of well heads and umbilicals on the ecological and socio-economic environment are eliminated or reduced to as low as reasonably practicable (ALARP), thus preserving the ecological and social integrity of the existing environment. These cost effective measures have been proffered with reference to best industry practice and ESH considerations.

Based on the impact assessment matrix in the previous section, the overall ratings of impact significance High, significance High, Medium or Low were established for each identified impact. The proffered mitigation measures for the identified potential significant impacts are presented in Table 8-41: **Environmental, Social and Health potential impacts' significance and key mitigation measures.**

below.

Table 8-41: Environmental, Social and Health potential impacts' significance and key mitigation measures.

Potential Impact	Key recommended mitigation measures
Emission of pollutants into atmosphere	• Ensure generators, barges etc are maintained at optimal working condition in accordance with operating manual. • Encourage the use of mufflers on equipment manifold where necessary to filter particulates and thus reduce its emission into the air.
Generation of noise	• Ensure all noise generating work equipment and vessels are maintained at optimal conditions as stated in the equipment operating manual. • Encourage the use of equipment with low noise ratings. • Encourage the use of mufflers on equipment manifold.
Discharge of cooling water into the sea – Hot waste water	• Discharge of cooling waters only in surface waters. • Limit to minimum necessary the amounts of anti-biofouling used in cooling waters.
Discharge/availability of nutrients and organic matter	• Develop an appropriate Waste Management Plan before project commencement. • As a minimum all operational waste shall be separated at source to enhance efficiency in waste handling and disposal. • Also, training on waste management will be conducted for project site personnel.
Damages to morphological structures and benthic biocenoses	• The pipeline laying technology is such that will reduce bottom sediments disturbance and possible loss of benthic organisms. • The procurement of a drilling rig with dynamic positioning and offline activity for drilling activities will reduce bottom sediments disturbance and possible loss of benthic organisms. • Develop an appropriate Waste Management Plan before project commencement. • Also, training on waste management will be conducted for project site personnel. • Treat and discharge all effluents (spent mud, cement, cuttings, etc.) in accordance with regulatory requirements. • The water-depth and density of organisms present in the area are such that render the impact negligible.
Mobilisation and resuspension of sediments	• The pipeline laying technology is such that will reduce bottom sediments disturbance and possible loss of benthic organisms. • The water-depth and density of organisms present in the area are such that render the impact negligible.
Physical presence of structures	• Ensure that abandoned well head is properly capped. • Post demobilization checks shall be carried out prior to commencement of development operations in the area to check incidence of well leaks. • Ensure that pipeline is protected.
Release of pollutants, biocides and metals in solution	• Develop an appropriate Waste Management Plan before project commencement. • Ensure adequate implementation of the Waste Management Plan. • Also, training on waste management will be conducted for project site personnel. • Operators shall be trained on safe handling practice. • Ensure proper handling of chemicals. • Employ chemicals with lowest toxicity levels in all its operations. • Material safety data sheets (MSDS) shall be provided for chemicals on site. • Treat and discharge all effluents (spent mud, cement, cuttings, etc.) in accordance with regulatory requirements.

Potential Impact	Key recommended mitigation measures
Employment and procurement of goods and services	• Preferentially employ Angolan nationals to fill available positions in the Block 15/06 West Hub project. Give preference to Angolan nationals from the Soyo region with the appropriate skills. Formalise this policy in Eni HR guidelines and contractors' agreements. • Train Angolan nationals currently employed by Eni so that they can eventually assume positions/functions in the Block 15/06 West Hub project initially or currently undertaken by employees of other nationalities. • Preferentially procure goods and services from Angolan sources, where possible and subject to reasonable financial criteria. • Procure resources (such as food supplies) at a local level (Soyo region), if available. Formalise this policy in Eni's procurement guidelines and contractors' agreements. • Effectively communicate available employment opportunities, required skills and resources and training programmes to the local communities in the Soyo region.
Influx of employees and work seekers into the Soyo Region	• Develop and implement, in consultation with local communities, Corporate Social Responsibility (CSR) initiatives that consider, evaluate and select a range of opportunities to address the potential impact of an influx of employees and work seekers into the Soyo region, which could include: – Development of a community interaction policy for migrant workers and suppliers; – Organising of crime awareness and prevention initiatives to assist local communities to deal with an increased risk of crime; – Investment in local education facilities; etc. • Acknowledge the authority of the local sobas in all activities, particularly in eni's CSR initiatives. • Ensure a transparent and appropriate grievance mechanism is in place, whereby local communities communicate incidents with eni personnel and or contractors/suppliers visiting the communities. • Develop or implement a clear HIV/AIDS policy for eni workers and contractors/ suppliers, including issues relating to interactions between employees and the local communities. • Enforce an alcohol and drug policy for eni employees and contractors/ suppliers when on duty. • Work with the local communities and government to identify local infrastructure needs, including housing, and support initiatives to improve such infrastructure.
Disruption of fishing activities and offshore navigation	• Inform local fishermen from the coastal communities of Zaire Province of the offshore activities, locations, vessel movements routes and timing. • Inform other users of the sea about the timing and location of offshore activities through the issuing of Notices to Mariners. • Develop, in consultation with the relevant coastal communities, a grievance mechanism through which fishermen can raise concerns with regard to activities and their grievances can be addressed. • Comply with international safety standards with regards to offshore navigation on all project-related vessels. • Intercept and redirect any vessels potentially entering designated exclusion zones. • Ensure potential conflicts between project-related vessels and other users of the sea are addressed in emergency response planning. • Implement mechanisms to compensate individuals who can demonstrate loss of income due to project activities. • Implement measures to mitigate the potential negative impacts on the biophysical environment, particularly impacts that could negatively impact on the resources targeted by fisheries operating in the area.

Potential Impact	Key recommended mitigation measures
Community health and safety	For local Communities • Develop and implement, in consultation with local communities and relevant local authorities and as part of Corporate Social Responsibility (CSR), the needed Community Health (CH) initiatives that identify, evaluate and select a range of opportunities to support or invest in increasing the capacity of local health care systems in the Soyo region through capacity building, infrastructure revamping, equipment top up and monitoring/evaluating activities. • Provide support to health awareness programmes and an education programme on HIV/AIDS and STIs within the communities (IEC). • Undertake routine monitoring of the municipal water supply to ensure that the project does not affect the quantity and quality of water available to the communities. • Provide support to cultural activities and sporting activities within the local communities in Soyo, in consultation with local community representatives. • Ensure all hazardous materials are correctly packed, labelled, stored and transported. Within the fence (in house) • Ensure that there is adequate housing, with adequate access to clean water and sanitation facilities for employees and contractors in the Soyo region. Provide or ensure the availability of mosquito nets or screened windows/doors for all employee/contractor accommodation in the Soyo region. • Initiate in house health promotion activities in terms of voluntary counselling and testing programme for HIV/AIDS and STIs and make such services available to all project personnel. • Monitor the prevalence of communicable diseases among employees and contractors, and work with local health care providers if additional measures to deal with the possible increased risk of communicable diseases to local communities are required. • Ensure emergency response plans are in place to deal with all potential emergencies, including support vessel (and helicopter) and onshore facilities emergency plans. • Prevent/Mitigate the potential impacts of pollution as a result of emissions, discharge of effluent and waste disposal. • Provide and enforce use of appropriate PPE by worksite personnel at all times.
Natural and other resource use	• Implement measures to minimise resource use (water, electricity, fuel, etc.) during on- and offshore activities. • Monitor resource use and local resource capacity (e.g. water, electricity and fuel supply) and implement additional measures to minimise resources during times of low local availability. • Implement mitigation measures to avoid/minimise pollution of local water resources in the Soyo region. • Develop and implement, in consultation with local communities and relevant local authorities, Corporate Social Responsibility (CSR) initiatives that consider, evaluate and select a range of opportunities to support or invest in increased access to municipal water and electricity supply for local communities in the Soyo region.
Contribution to Angolan economy	• Implement mitigation measures to maximise employment of Angolan nationals and procurement of Angolan goods and services. • Encourage and lobby for the responsible investment by the government of oil-generated revenue, particularly in the Soyo region.
Perceptions and expectation of local communities	• Develop and implement, in consultation with local authorities, sectoral institutions and communities, Corporate Social Responsibility (CSR) initiatives that identify, evaluate and select a range of opportunities to address the key concerns of the local communities in line with existing sectoral policies and plans. • Effectively communicate available employment opportunities, required skills and resources and training programmes to the local communities in the Soyo region. • Ensure on-going consultation with local communities with regard to progress with the project and changing community needs.

Potential Impact	Key recommended mitigation measures
Impacts of an Accidental Release of Hydrocarbons	• Regularly test the BOP during drilling operations; • Use reinforced hosing for crude oil transfers and use weak links and associated shut-off valves to reduce losses to sea should a rupture occur; • Inform MinPet of any spills and deploy oil protection booms when possible; • Inform the Angolan Ministry of Environment and Ministry of Foreign Affairs to advise the governments of Gabon and the Democratic Republic of Sao Tome and Principe. • Apply biodegradable dispersants only after consultation with MinPet; and • Implement the Oil Spill Emergency Response Plan.
Impact of a hydrocarbon spill on seabird populations	• Save, capture and rehabilitate any oiled birds if possible

9 Environmental Management Plan

This chapter presents the Environmental Management Plan (EMP) developed for the proposed activities in Angolan Block 15/06 West Hub Project. An environmental management plan (EMP) is essentially a management tool and standalone component of an EIA that provides the assurance that the mitigation measures developed for the significant impacts of a proposed project are implemented and maintained throughout the project lifecycle. It outlines management strategies for safety, health and environment stewardship in the proposed project implementation. It states in specific terms how the project proponent's commitments will be implemented to ensure sound environmental practice.

ENI Angola has designed the EMP of the proposed project in line with its Health, Safety and Environment (HSE) policy and in accordance with ISO 14001 Environmental Management System specifications. The EMP for the proposed Block 15/06 drilling project, installation of flowlines, installation of FPSO and installation of well and heads and umbilicals systems shall be a "life document" which shall be reviewed periodically with the incorporation of various mitigation measures for potential impacts and shall form the basis for the actual project implementation.

Compliance with the legal standards on safety and environment is regarded as the minimum requirement, and must be satisfied during all phases of the Project development. In order to reduce the risk of an adverse effect on the environment to the lowest level that is reasonably practicable, an objective of the engineering design will be to apply the ALARP principle. Figure 9-1 illustrates this principle graphically.

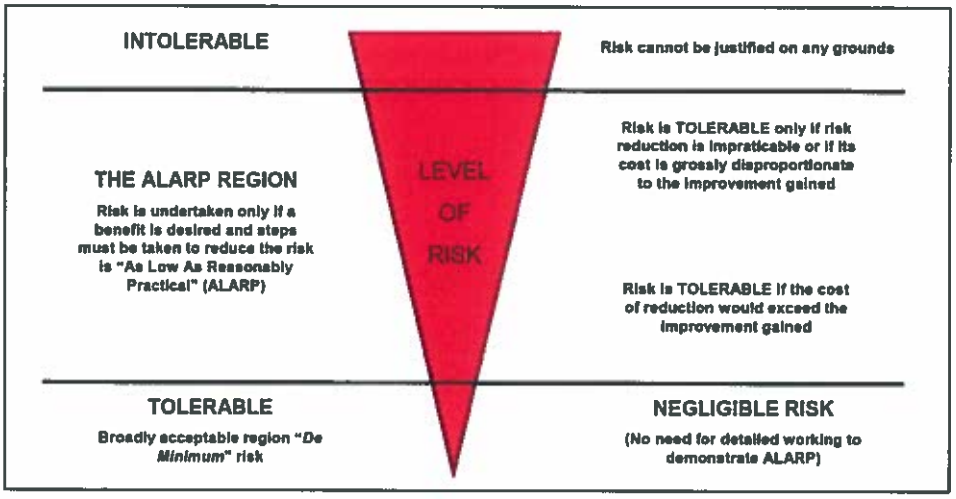

Figure 9-1: Level of Risk and ALARP.

9.1 EMP Objectives

The EMP is designed to:

- Ensure that all mitigation measures prescribed in the ESHIA document for eliminating, minimizing, and enhancing the projects adverse and beneficial impacts are fully implemented; and

- Provide part of the basis and standards needed for overall planning, monitoring, auditing and review of environmental and socio-economic performance throughout the project activities.

This has been developed to manage negative impacts/effects, enhance benefits and ensure good standards of practice are used throughout the project. These objectives shall be achieved by:

- Ensuring compliance with all stipulated legislation on protection of the biophysical and socio-economic environment and ENI HSE policy;
- Integrating environmental and socio-economic issues fully into the project development and operational philosophies;
- Promoting awareness on the management of the biophysical and socio-economic environment among workers;
- Rationalizing and streamlining existing environmental activities to add value to efficiency and effectiveness;
- Ensuring that only environmentally and socially sound procedures are employed during the project implementation; and
- Continuous consultations with the relevant regulatory bodies, community leaders (local heads/chiefs, clan heads, landlords, etc), youth leaders, Community Based Organizations (CBOs), and other stakeholders throughout the project lifecycle.

9.2 Structure and Responsibility

The implementation of the project EMP will be achieved through a management structure described in the Organizational chart shown in Figure 9-2.

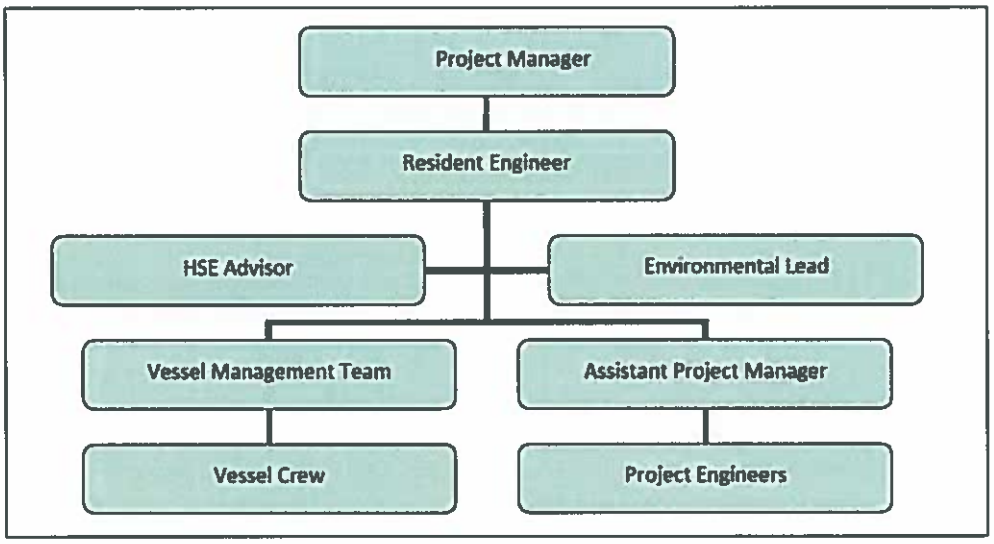

Figure 9-2: Environmental Management Schematic of Block 15/06 Development Project.

9.3 EMP Implementation Framework

The framework for the implementation of this EMP is strongly based on a repeated process of continuous improvement which comprises of eleven (11) elements, each with underlying principle and set expectations.

Overview of each of the eleven primary elements is presented as follows.

- Management Leadership, Commitment, and Accountability: Ensures that the workers understand the goals and management commitment to excellence in safety, health, environment, and operational integrity.
- Risk Assessment and Management: Ensures that risks involved in operations are recognized so that they can be appropriately addressed through facility design and/or operating practices.
- Facilities Design and Construction: Ensures elements for the protection of people and the environment are incorporated into the design of facilities and the plans for installation and operation.
- Process and Facilities Information/Documentation: Ensures that the systems designed to protect people and the environments are appropriately documented.
- Personnel and Training: Ensures that personnel understand the systems that are in place and are appropriately trained to perform required roles with respect to their functions.
- Operations and Maintenance: Ensures that facilities are maintained and operated in ways that ensure the protection of people and the environment.
- Management of Change: Ensures that new personnel are informed of existing systems that all affected personnel are informed of changes in the systems, and that safety and environmental aspects are considered when making changes.
- Third Party Services: Through contract, oversight and other mechanisms, third party contractors are held to the same standards as Eni Angola.
- Incident Investigation and Analysis: Seeks to understand the causes of any incidents so that effective controls or systems can be implemented to prevent recurrence.
- Community Awareness and Emergency Preparedness: Though not highly applicable in offshore project far removed from communities, ensures appropriate outreach and awareness programmes are implemented to establish effective emergency procedures and to allay concerns.
- Operations Integrity Assessment and Improvement: Ensures that the safety and environmental performance is monitored against targets to ensure Eni Angola is meeting its goals to protect people and the environment and seeks the means to improve the systems and processes, particularly when goals are not being met.

9.4 Core Elements of the EMP

In line with the objectives summarized in section 9.1 above, the main elements of this EMP are:

- Overall project organizational chart (including HSE) organogram;
- Preliminary EMP guidelines;

- Guidelines for waste management;
- Overall safety philosophy/guidelines;
- Contingency plan for oil spills;
- Environmental monitoring plan;
- Guidelines for audit and review;
- Guidelines on maintenance and facility management; and
- Guidelines for decommissioning and abandonment.

9.5 Guidelines for Mitigation Measures

The guidelines covering the various project phases, activities/aspects and impacts, mitigation measures and designation of responsibilities for implementation, were presented in chapter five and give detailed information on waste management, safety, emergency response/contingency. A detailed environmental monitoring plan, audit and review as well as decommissioning and abandonment are presented in sections 9.5.1 to 9.5.11.

9.5.1 Roles and Responsibilities

The roles and responsibilities (HSE) for the proposed Block 15/06 >Development project include:

Resident Engineer

- HSE management on the project.
- Provide visible leadership, systems and resources for environmental management.
- Initiate action to maintain compliance with requirements.
- Specify and participate in project audits/reviews as required.

Assistant Project Manager(s)

- Review procedures for environmental aspects.
- Follow up actions from project risk assessments and environmental reviews.
- Be focal point for environmental matters with subcontractors as required.
- Participate in project audits/review as required.

HSE Advisor

- Be pro-active in promoting HSE.
- Follow-up /monitor requirements with responsible parties.
- Provide specialist HSE advice.
- Facilitate project risk assessment as required.
- Lead/participate in audits, as required.
- Maintain HSE Activities matrix and monitor close out of Project Environmental Review.
- Development of Project HSE documentation.

Environmental Lead

- Provide specialist environmental advice.
- Jointly monitor project Environmental aspects with Project Team.
- Review relevant project documentation on circulation by Project Team.
- Facilitate project environmental review.
- Lead / participate in audits and inspections as required.
- Review project environmental documentation.

9.5.2 Training and Awareness – Site Induction

All Contractor employees and subcontractors involved in the project will be given a comprehensive induction before they start work. This environmental training will take place in conjunction with safety awareness training.

The environmental aspects will include:

- An overview of the Environmental Management Plan, goals and objectives.
- Awareness in relation to the risk, consequences and methods of avoiding noise pollution, oil/diesel spills, disturbance to wildlife and disturbance to fisher-folk on the high sea.
- Awareness of individual environmental responsibilities and environmental constraints to specific jobs.
- Location and sensitivity of the proposed Block 15/06 project.

All personnel who have attended the Environmental Induction will sign a Register which will be kept on the Project Files. Toolbox talks, based on the specific activities being carried out, will be given to personnel by the nominated project representative. These will be based on the specific activities being carried out. These talks will take place either on the appropriate off-shore vessel or on-site and will include environmental issues particular to the proposed Block 15/06 project, namely:

- Oil/Diesel spill prevention offshore including safe refuelling practice.
- Emergency response procedures used to deal with an oil/diesel spill.
- Minimising disturbance to wildlife such as cetaceans.

9.5.3 Communications

Environmental issues will be communicated to the workforce on a regular basis. Daily project meetings, which follow a set agenda incorporating Health, Safety and Environmental issues will be held on-board the project vessels and a daily report will be generated and distributed.

All staff and sub-contractors involved in all phases of the project will be encouraged to report environmental issues.

Environmental Reporting

The contractor will report the status of project environmental activities to Eni on a regular basis. These reports will summarize the key environmental issues in the period and identify any non-conformances and the status of corrective actions.

Communication of Initiatives and Project Information

Communication of initiatives and project information will be developed as the project progresses. Typically, these will include campaigns to raise environmental awareness, circulars to inform staff of key environmental issues such as lessons learnt from incidents or accidents and the impact of any new legislation.

Subcontractor Environmental Reporting

All external communications with local interest groups, external agencies and also the response to any complaints will be conducted by Eni. Contractors shall notify the onsite Eni representative if any communications are received from external stakeholders.

9.5.4 ENI Environmental Policy Objectives

Operations have a direct impact on the natural and built environment as such environmental management is an integral part of this project. All project personnel will be accountable for the environmental performance of the project.

Environmental performance will be managed, monitored and improved through the implementation of this Sustainable Environmental Management Plan and associated Operational Control Procedures in accordance with ISO 14001:2004 standard.

Eni's environmental policy is personally endorsed by Eni's Managing Director and is well documented and circulated within the system and requires all contractors to manage HSE in line with this policy.

In line with the Eni HSE Policy commitment to 'Protect the environment', ENI and their subcontractors shall ensure that:

- Impact on watercourses, the aquatic environment, terrestrial habitats and all species therein are minimized.
- Emissions to the atmosphere will be minimized.
- Environmental legislation applicable to activities undertaken is complied with and contractual obligations are met.
- Performance is monitored and procedures are reviewed to ensure continual improvement.
- Companywide awareness of environmental issues is raised.

9.5.5 Environmental Control & Monitoring

Environmental Control Procedures

Operational control is required to ensure the management of all operations and activities associated with significant environmental aspects, policies, objectives and targets. The required level of control is achieved through the implementation of approved project procedures which document the methodology for executing the works. As part of the procedures development and approval, the methodology is subject to peer review and risk assessment processes which considers environmental impacts and required mitigation measures. The internal audit process will check that these procedures are being implemented correctly and that they are effective.

Although project procedures, execution plans and method statements represent the most significant control mechanism, controls also include communication of company requirements

particularly to subcontractors and suppliers, the provision of health, safety and environmental training, and carrying out effective checking and monitoring. Project procedures will be reviewed and amended as necessary. The amended procedure will be reviewed to ensure that any new regulation or training requirements are identified and acted upon.

All activities are required to demonstrate that the Project Team have considered the requirements of Eni Environmental Policy in the design, construction and installation of the project. The key environmental goal set for the Block 15/06 Development project is that "Discharges and emissions associated with the development and subsequent production of hydrocarbons from the proposed Block 15/06 project shall be minimized as far as reasonably practicable, and the disturbance to the environment shall be kept to a minimum". For the project, this environment goal means minimizing the impact on Seabed community, marine community (fish, mammals), sensitive uses (fishing etc.), seawater quality, air quality, etc.

The stated goal shall be achieved primarily through minimizing pollution ('reduction at source') by the effective control of all operations and the monitoring of the potential sources of impact to ensure that the legislative and regulatory limits are maintained and also to track the progress towards the environmental targets.

Monitoring and Reporting

Environmental monitoring is essentially a process aimed at detecting negative impacts of a project on the environment early enough to take remedial actions. Eni representatives on-board each Contractors vessel will be responsible for routine day-to-day monitoring of environmental compliance and shall submit the environmental data for all HSE and community relations aspects.

Environmental Performance Monitoring

The environmental concerns identified will be controlled through adherence to the Environmental Operational Control Procedures, Method Statements and recommendations. The project will be monitored by inspections of work activities and internal auditing. The HSE Advisor shall work with ENI to assess the need for further monitoring.

Monitoring Objectives

The activities of the proposed project have such characteristics:

- The water depth (mostly above 1000 m) make little or non-significant the protocols frequently used for the physical examination, chemical, biological and sediment monitoring.
- benthic community at those depths is very simplified and uniform and according to both a temporal and spatial point of view; the distance from the surface and the currents along the water column (potentially very large and not known) does not ensure that the benthic community located near the means of drilling is the most affected by the discharge of water, cuttings or other contaminants.
- Regarding to the water column, an examination of the physico-chemical and biological parameters do not provide useful assessment of the state nor the quality of the water column itself (the change is very fast) nor induced impacts from activities project (for the same reasons described above, the effects could be spread in huge areas currently not identified).

For these reasons, the post-operation monitoring shall not involve the quality of environmental media involved, but a check of the implementation of the EMP on the environmental performance of facilities (waste management, wastewater systems, oil consumption and atmospheric emissions, etc.), via audits and inspections.

Monitoring Impact Indicators

Table 9-1 shows the parameter monitored in audits and the relative performance indicators are provided.

Table 9-1: Monitoring Impact Indicators.

Parameter	Unit of measure	Performance Indicator
Diesel consumption	Kg	
Electricity generated	kWh	Kg diesel / kWh
CO_2 emission	Kg	Kg CO_2 / kWh
CH_4 emission	Kg	Kg CH_4 / kWh Kg CO_2eq. / kWh (Global Warming Potential)
SOx emissions	Kg	Kg SOx / kWh
NOx emissions	Kg	Kg NOx / kWh Kg SOx eq. (Acidification Potential)
Waste generation	Kg	
Water consumption	Litre	

9.5.6 Environmental Audit

Eni Angola shall conduct periodic HSE audits (monthly / quarterly / annually, etc) of the oil wells activities in the Block 15/06 Development project Area in order to ascertain extent of compliance with policy and regulatory requirements. The audits shall be carried out by certified auditors and in accordance with ISO 14001 guidelines. The scope of the audits must include the following, as a minimum:

- Compliance with all necessary codes, standards and procedures;
- Examine line management systems, plant operations, monitoring practices etc.;
- Identify current and potential environmental problems especially during the operational phase of the project;
- Check the predictions in EIA and assure implementations and application of recommended practices and procedures;
- Make recommendation for the improvement of the management system of the operation; and
- After every audit exercise, the environmental auditor shall produce an Environmental Audit Report (EAR) which shall be submitted to Eni Angola and the operating contractor.

The audit and inspection frequencies will be established by Eni Angola, and may be increased or decreased according to the findings and degree of confidence arising from the on-going audit program.

All audit findings will be reviewed by the HSE and Community Relations teams and where corrective actions are deemed necessary, specific plans (with designated responsibility and timing) will be developed aimed at achieving continuous improvement in performance. In fact, in addition to assessing operational aspects and monitoring, audits will also assess the

effectiveness of the EMP and its implementation. The EMP will therefore be subject to ongoing review and development to ensure that it remains appropriate for all aspects of the Project.

9.5.7 Waste Management

Waste Management Strategy

All on-board waste discharge, from construction vessels, will follow the guidelines from MARPOL 73 / 78 for domestic waste discharges to the environment.

Solid and Chemical Waste will be treated on-board and recycling will take place wherever practicable. Incineration of combustible, non-hazardous waste will take place wherever an approved on-board incinerator is available. Bilge water will be treated to MARPOL standards prior to discharge on board all construction vessels. All waste discharge will be monitored & recorded as per vessel procedures. Compliance to this EMP will be monitored throughout the duration of the project through the project monitoring process.

ENI Policy on waste management

It is the policy of to:

- Adopt effective and responsible measures to minimize the generation of solid and liquid waste as well as reduce emissions into the air;
- Track and maintain records of the full life cycle of waste streams and provide an auditable trail as to its management and disposal; and
- Manage and dispose all waste in line with relevant regulatory requirements and environmentally responsible manner.

Solid Waste Discharge

No solid waste, other than food waste will be disposed of into the sea. Food waste will only be disposed into the sea, at least 12 nautical miles from the nearest land, after passing through a dedicated grinder and in accordance with MARPOL 73/78 standards. Any other solid waste that cannot be incinerated on-board shall be brought to shore for disposal and a record will be kept on the type and quantities of waste brought to the shore for disposal.

Waste Identification

ENI Marine Wastes Management plan (MWMP) and the Environmental Aspects and Impacts Register for this project summarize the primary types of waste streams encountered during vessel operations. Descriptions for typical waste stream, main sources and possible environmentally significant constituents are also given.

The physical, chemical and toxicological properties of hazardous wastes shall be identified via Material Safety Data Sheets (MSDS), manufacturer information, process knowledge, and historical information or lab analysis. Wastes can be grouped according to their health and environmental hazards.

Waste Minimization

To minimize the quantity of waste to be disposed of onshore, construction vessels where possible, will be equipped with a food grinder / waste compactor.

On a monthly basis, project vessels will report the amounts of hazardous and non-hazardous waste generated by the vessels, as per the vessel operators environmental management system. This data will be used to establish baseline data and targets for improvement.

Onshore Waste Management and Disposal Options

A local contractor / agent will arrange onshore transport and disposal of waste arising from the project vessels. Any waste that cannot be processed on-board of the vessels will be transported to the quayside for transport by a permitted waste handler to a permitted/licensed facility, which may be a Landfill Site or a Transfer Station. Scrap metals and chemical wastes will be transported to port for reprocessing through approved recycling facilities.

9.5.8 Waste Water Management

Ballast Water Discharge

Ballast tanks will be separated from any hydrocarbon storage areas on board the vessels and no potentially contaminated drain systems will be routed to the ballast tanks. De-ballasting shall be undertaken offshore in accordance with IMO guidelines and away from sensitive environmental areas to prevent introducing marine organisms from outside the project location.

Bilge Water Discharge

All construction vessels will be equipped with oil-water separation systems in accordance with MARPOL requirements.

Deck Run-Off Water

Any spills on deck will be contained and controlled using absorbing materials. This will be collected in dedicated drums to avoid contamination of deck run-off water.

Sewage Discharge

Construction vessels will be equipped with a sewage treatment system. If a vessel does not have a sewage treatment system it will have a suitable holding tank, waste water will then be brought back to shore for treatment by a licensed contractor.

9.5.9 Oil Spill Contingency Plan

Some of Eni's most important objectives include: enhancing safety, reducing health risks and protecting the environment. In light of this, Eni has developed a structured and comprehensive oil spill contingency plan to cover activities in Block 15/06 Project area.

The oil spill contingency plan outlines coordinated and integrated response actions to be implemented in the event of an oil spill. It highlights the roles and responsibilities of key personnel in Eni operations and lists equipment and materials available to combat oil spills. The plan is designed to cover the control and removal of any oil spill occurring at any of the facilities operated by Eni. It is a generic plan to be used in conjunction with a separately designed specific operational annex applicable to the particular project area. The main components of the contingency plan are namely spill categorization, offshore response action plans, reporting and notification guidelines.

Pollution Emergency Procedures

On board procedures for pollution prevention and emergency response are laid down in each vessel Shipboard Oil Pollution and Emergency Plan (SOPEP). Details on project specific (oil) pollution combat equipment will be available on-board along with locations of equipment, availability, and contact details for support personnel / services. Each individual vessel will have regard to Eni Oil Spill Contingency Plan, which contains detailed procedures to be followed in the event of a pollution emergency.

9.5.10 Safety Philosophy

The Project shall incorporate an Integrated Control and Safety System (ICSS) that shall provide an integrated monitoring, control, protection and safety system for the entire production, topsides, marine, and subsea facilities. The safety systems shall be separate from the Process Control System (PCS).

Fire and Gas Detection

The overall goal of the Fire and Gas System shall be to:

- Continuously monitor all areas of the installation where either a fire hazard may exist or an accumulation of flammable gas may occur;
- Alert personnel at the CCR to the presence, location and nature of the fire or gas emergency;
- Alert personnel on board to the hazard via the PA/GA system;
- Automatically activate fixed fire protection systems; and
- Reduce the risk to personnel by implementing executive control actions and/or shutdown events.

Lifeboats and Life Rafts

The rig will be provided with life boats on either side of the accommodation having a capacity each for 100% of the complement. Two 100-persons Totally Enclosed Self Propelled Survival Crafts (TEMPSC) are installed, one on the port side and the other on the on starboard side. The rig will also be equipped with a fast rescue boat. The crafts are located and arranged such that boarding of the units in stowed position will be in accordance with the latest SOLAS requirements. On the forward main deck area near the turret, on either side, life rafts will be installed in case crew members cannot return to the accommodation in case of emergency. The number and capacity of the life rafts will be established by an Escape, Evacuation and Rescue Analysis performed during detailed design.

Safety Shutdown System

In the event that the primary control system fails to keep the process within specified operating limits, separate, dedicated safety systems shall be provided for the safe shutdown of equipment and/or process units. The purpose of these systems shall be; first, to protect personnel from an abnormal condition; second, to protect the environment and equipment from damage; and third, to safely isolate problem areas.

Active Fire Protection

The rig shall be sufficiently equipped with fixed automatic, manual and portable fire fighting equipment. Mechanisms for release of fixed automatic systems shall be:

- Pneumatic fusible plugs for each fire/deluge area;
- F&G input (for inside enclosures);
- Manual buttons in the CCR;
- Manual buttons in local area;
- Remote trips for diesel oil valves; and

- Manual buttons for rotating equipment shutdown and manual released fixed fire fighting systems.

Accommodation

The living quarters for the rig have a sprinkler system that shall be charged with fresh water and backup seawater from the ring main.

Helideck

The helideck for the rig shall be provided with two foam hose reels with 0.23 m^3 (60 gallons) of foam for each reel and deliver foam for a period of 20 minutes.

Electrical Rooms

Rooms containing electrical equipment [transformer room, battery room, high voltage/low voltage (HV/LV) switchboard rooms and instrument rooms] shall be protected with automatically actuated non-halon, gaseous fire suppression systems. In addition, portable CO_2 extinguishers will be provided.

Hull Equipment Spaces

None of the hull equipment spaces have oil fuelled machinery and they shall be, therefore, not 'Category A spaces' according to safety of life at sea (SOLAS). These compartments shall be provided with a sufficient number of portable extinguishers and hose reels.

Deluge System

A pressurized fire water system shall be installed to cover the firewater demand for foam generation systems, deluge systems and hydrants located throughout the rig.

Water Mist Systems

Fixed self-contained automatic water mist systems shall be used in gas turbine enclosure hoods.

Escape Routes

The general requirement for number and location of escape routes on the rig shall follow the requirements of specification 'Facilities Layout and General Operational and Safety Systems. The EER Analysis contains a more detailed description of the arrangements, which include:

- Main escape routes shall have a minimum height of 2.39 m (7.8') and a minimum width of 1.525 m (5');
- Secondary escape routes shall have a minimum height of 2.1 m and minimum width of 1.0 m (3'-3");
- Dedicated routes shall be provided to both the helicopter deck and the lifeboats that allow the transportation of an injured adult on a stretcher from every manned area;
- Two paths of escape shall be provided from every area on the facilities that may be normally manned. This requirement also applies to enclosed areas and rooms that will not be continuously manned. However, this does not apply to tanks where normal tank entry procedure is assigned around tank access. Each tank shall be fitted with a second access hatch which can be fitted with ladders and access in the event there is major work required in that space. Smaller rooms/areas where the distance from any location to the exit will be less than 5 m (16') may have a single exit, however, all electrical rooms will have at least two exits; and

- Stairs shall be installed to ensure proper and easy access between all levels of the facilities. Wherever access shall be needed to a platform or any level below base, access will, as far as possible, also be performed via stairs.

Means of Evacuation

The primary means of emergency evacuation shall be lifeboats. Escape to sea via life rafts shall be considered the secondary means of evacuation. If helicopters shall be in the vicinity of the field, it shall be the decision of the Emergency Incident Coordinator to determine the best means by which helicopters may be used. The Emergency Incident Coordinator may also instruct the standby vessel(s) to assist with the evacuation of personnel via the boat landing area or via tertiary means of evacuation.

Equipment Room Evacuation

Machinery spaces can be evacuated by using the main stairways leading into the space from the main deck from both the east and west sides. The stairs drop down to the first level of the machinery space. Escape from the lower levels of each machinery space will also be by stairways.

Deck Escape Routes

There shall be two unobstructed longitudinal escape routes on the main deck. One will be located on each side of centreline at the outboard edge of the main deck. There shall be also five east-west or transverse escape routes that join with the longitudinal escape routes at almost equally spaced intervals. The transverse routes offer at least 7 feet of clearance under the centreline pipe rack and do not crossover any piping. There shall be one other longitudinal escape route that shall be provided on the topsides deck near centreline and can be used for escape along the entire length of the topsides deck. Stairs shall be provided at intervals along both sides of the deck for access between the main deck and the process deck.

Personnel caught on deck during a fire can proceed east to west through one of the east-west escape routes into one of the longitudinal escape routes located farthest away from the fire. The route taken through the longitudinal escape route shall be either north or south, whichever takes the trapped persons farther away from the fire or to the closest life boat. Protection against blast and fire can be provided (for at least 60 minutes) in the North TSR, in the LQ or behind the main deck blast wall under the LQ.

Each escape route shall be clearly marked, including arrows showing direction of the nearest life boat.

Muster Areas

The primary muster area on the rig shall have direct access to the life boats and requires a minimum area of 0.56m^2 (6ft^2) per person, per specification 'Facilities Layout and General Operational and Safety Systems'. Arrangements/location of the muster areas for rig shall be detailed in the EER Analysis. The study considers the location for the muster area for the rig. The extent of protection required for personnel mustering will be defined in, based on the hazard scenarios to which personnel could be exposed; however, the intention will be to use the same size of lifeboat.

An alternative (backup) muster area will be provided on the rig. The location/size basis will be based on an analysis of the hazard scenarios for which it may be required. This will be located

at the flare end of the rig. The alternative muster area will be protected from flare radiation and from the effects of any process hazard scenarios that could impair the muster area.

Based on predicted evacuation times for the rig, primary muster areas will remain intact for a minimum of 45 minutes in order to allow an orderly evacuation. Protection will be required for this period from the effects of fire, explosion, un-ignited gas/smoke ingress and excessive heat.

Muster areas will be considered to be impaired if:

- Heat radiation exceeds 1.6 kW/m2 (500 BTU/ft2);
- Blast overpressure exceeds 0.3 barg;
- Smoke levels lead to visibility below 5 m; or
- Un-ignited gas concentrations exceed 50% of the gas lower flammable limit (LFL).

An emergency control centre shall be provided on the rig in close proximity to the primary muster areas. Telephone and radio communication will be provided to enable coordination of emergency response actions between the primary and alternative muster areas. The emergency control centre will be protected to the same extent as the accommodation. The location will be in the central control room (Rig). It will be possible to initiate ESD from the muster areas.

Life Saving Equipment

Safety and information signs shall be provided in accordance with relevant regulations and operational requirements.

Helicopter Crash Equipment

Appropriate helicopter crash equipment shall be provided adjacent to the helideck of the rig. Personnel going offshore shall undergo mandatory helicopter ditching and water survival training.

Lifeboats/Liferafts

Two (2) lifeboats of the free fall type shall be installed at the Primary Muster Area and one (1) at the Secondary Muster Area. Each of these free fall lifeboats will be rated for 60 persons minimum. Sufficient life rafts will be provided to comply with the applicable regulations.

Fast Rescue Boat

A line boat shall be used as the fast rescue craft for the proposed Development Wells Drilling in Area. This boat shall be mounted on the Westside adjacent to the workshop in Module C on the process deck. However, this is the windward side for squalls. The boat will be used for rescuing any personnel who have fallen overboard from the rig, from the export tanker, or if a helicopter goes down. In a major emergency, the boat can be used to gather and tow life rafts after launching into the water. The boat can carry up to six persons and will be equipped with a Hamilton water jet propulsion engine. The engine will be capable of sustaining a speed of twenty knots.

Miscellaneous Safety and Lifesaving Equipment

In the accommodation cabins, for each occupant there shall be provided one lifejacket and also a grab bag containing flashlight, heat resistant gloves and a smoke hood. The provision of additional equipment items such as safety equipment cabinets, emergency showers and lifejackets will be determined in detailed design based on the findings of the updated EER

Analysis. An emergency shower will be located adjacent to the chemical usage areas, battery rooms, etc. Self-contained eye bath bottles and stretchers will be located at strategic points. Emergency response equipment lockers will be located adjacent to the primary muster area for rig and for other areas will be determined in detailed design as defined by the updated EER analysis.

Vessel Security

The vessel shall have suitable arrangements to prevent unauthorized personnel access to the vessel and reduce the risk of sabotage.

Gangway Access

All access ladders on the rig shall have alarms to identify people boarding the ladders and gates at the top of the ladders.

Riser Support and Protection Security

The riser areas shall have means of preventing unauthorized personnel access to the riser valves and the vessel. Access ladders to the riser valve platforms will have means to be secured.

9.5.11 Decommissioning and Abandonment Guidelines

Eni Angola shall ensure that all assets (including wells, production facilities, flowlines/risers, pipelines etc.), which have reached the end of their useful life span, shall be decommissioned and either dismantled and removed or abandoned, in accordance with statutory requirements and standards. This will entail the following scope of work.

Eni shall develop a sound and acceptable plan, which will describe how all assets are to be decommissioned and their planned state after abandonment. The plan will consider all technically feasible options for decommissioning and abandonment, including alternative uses for the assets, in accordance with ENI policy and government regulations.

Well suspension or abandonment operations will be carried out in accordance with the regulatory guidelines and best Industry practice. Once drilling activity has been completed, the well will either be producing or suspended and may be later abandoned, depending on production. During abandonment, an abandonment programme will ensure the isolation of the various zones from each other and from the surface in accord with the regulatory guidelines. Casing and wellhead equipment will be recovered from the well and the well will be capped at least 3 meters below seabed.

Following equipment recovery, a recorded site survey will be carried out using an ROV around the previous wellhead position and a hundred meter radius around the position as debris and dropped object survey. In the event the well is suspended for future entry for any purpose, down hole formations will be isolated from each other and from the surface using cement and mechanical plugs as required. Once the BOP and riser assembly has been removed, corrosion cap will be installed on the subsea wellhead.

A recorded site survey will be carried out using the ROV as debris and dropped object survey will be completed over a 50 meter radius around the wellhead locations.

Abandonment Report

ENI shall also prepare final report on condition of all assets abandoned prior to relinquishment. The Abandonment Report will include as a minimum:

- Operating and Technical Data (data on the asset thorough its operating life; e.g., location, repairs, etc.);
- Financial Data on the Abandoned Asset; and
- Final Abandoned Condition.

10 Stakeholder Consultation

10.1 Purpose and Scope

The following chapter, the Stakeholder Management Plan (SMP), describes the methodology, process and results of consultation with local stakeholders as part of the Environmental, Social and Health Impact Assessment (ESHIA) for the ENI development project of Block 15/06 West Hub field deep offshore. The key informative document for the creation of this SMP was the *Annex 1 Stakeholder Management Process*, ENI´s internal corporate guide for stakeholder engagement and reporting.

Identifying and consulting with stakeholders during the ESHIA process is an essential component to the project. Stakeholders are individuals, groups, organizations or institutions having an interest (a rightful stake) in the project´s outcome. These entities may be negatively or positively affected by the project, may be able to influence the project, or may have an interested in the outcomes of the project.[14] Stakeholder consultation is important to promote participation of people who are in some way involved in the project, and to address potential and actual environmental and socioeconomic impacts caused by it. The stakeholder management process ultimately seeks to define strategies on how to address the identified third party stakeholders and their requirements so as to avoid negative impacts and promote positive effects of the project.

This document includes the identification and categorization of stakeholders, the requirements and relative impacts for the project, the stakeholder interests and objectives, risk assessment, and the strategy and action plan.

10.2 Methodology

The first step of the stakeholder management process is the identification of stakeholders relevant to the project. Before visiting Soyo, ARC identified a preliminary list of individuals and organizations in the area that are considered stakeholders. The following step included site visits to Soyo *Comuna*[15], where ARC met with the identified stakeholders. Research tools used to gather baseline data as well as reactions to the project include interviews with guiding questionnaires.

ARC identified and met with key stakeholders in Soyo *Comuna*. Their aspirations and concerns for the project are discussed in this section, along with their perceived capacities and limitations.

The assessment of the stakeholders influence was conducted using terms defined by ARC where the disposition and requirements were quantified to create an influence rating. These ratings are expressed in the Stakeholder Assessment Matrix in Par. **Error! Reference source not found.** below.

10.3 Stakeholder Identification and Categorization

The first step in the stakeholder management process was the identification of the relevant individuals or entities related to the project). Recognizing and categorizing the key stakeholders for the project from the initial phases was important to the execution of the field work. Table

[14] Definition from ENI document *Best Practice Annex 1 – Stakeholders Management Plan* which quotes *Stakeholders Engagement on Corporate Social Responsibility, September 2005, ENI*.
[15] *Comuna* is the third level of administrative units in Angola. A municipality is constituted by several *comunas*.

10-1 demonstrates the updated data after field research and contact with the key entities, with stakeholders listed in order of their influence over the project´s execution.

Table 10-1: Key Stakeholders for Project.

Category	Sub-category	Name of Contact and Title
Local Government Offices	Municipal administration – Soyo	Sr. Manuel António, Administrador
		Sr. Lourenço Komba, Chefe de Secção dos Serviços Comunitários
		Dra. Arménia, Área da Estatística
		António José Mpemba, Chefe da Repartição da Educação Cultura e Desporto
	Agriculture and Rural Development Offices in Soyo	Luís Maria Faustino, Chefe da Área da Agricultura
	Municipal Health Department	Dr. Mariano, Chefe de Repartição da Saúde
	Financial Department	Sr. Gomes, Head of Department
	Soyo Department of Commerce, Industry and Tourism	Gerónimo Aguiar, Head of Municipal Commerce Section
	MAPESS (Municipal Education Section)	Sr. José Ferreira, Director do Centro de Formação Profissional
	Representative of the Artisanal Fisheries Institute (IPA)	Álvaro Maria Jorge, Representative of IPA
		Saldanha Joaquim, Head of Communities Section
	Immigration Services (SME)	Filipe José Mpemba, Head of SME
Health	Soyo General Hospital	Dr. Garcia Diwampovessa, Director Clínico
		Dr. Miguel Pemba, Director Geral
	Pinda Health Centre	Irmã Pascalina, Director of Clinic
NGO's	Local NGOs	Sr. Luvando, Director of ADPP
		Irmã Pascalina, Director of Cáritas
		Dr. Fernando Cazadi Paulo, Executive Director of SOS- CEDIA
Industry	Kwanda Base Administration	Sr. Giuliano Nobiloni, Vice-Gerente da Base
		Sr. Damião da Costa, Head of Human Resources
		Sr.Inácio José, Deputy Head
		Sr. Artur Lemos, Head of Kwanda Base
Organizations/Cooperatives/Associations	Fishermen representatives	Eliseu Tai-Tai, President of Fishing Cooperative of Kibuculo
Communities	*Sobas* (Representatives of the community)	Cardoso André, *Soba* Adjunto of Kikala Kiako
		António Juliano, Advisor of Kikala Kiako
		Manuel António, *Soba* of Tari-Tari

Category	Sub-category	Name of Contact and Title
		Pedro Tona Beu, *Soba* of Kikumbo, Kami and Kimbumba
		Manuel Domingos, *Soba* of Kilumbo and Kikudo
		David Txitxi, *Soba* of Nkungo-Yenguele
		Manuel Simba, Deputy *Soba* of Kitxitxi
		António Domingos, *Soba* of Kinimianganga
		João Kianga Pemba, *Soba* of Kintambi
		António Pemba, *Soba* of Conde
		João Kambi Olo, *Soba* of Tuko
		Rodrigo Congo, *Soba* of Mongo Soyo
		Francisco Casimiro, *Soba* of Pangala
		Sebastião Maria, *Soba* of Kitona
		Sebastião Kilombo, *Soba* of Kifuma
		Alfredo Francisco, *Soba* of Tombe
		Lúcio Nelumbo, *Soba* of Bocolo Island
		Filipe Moabi, Deputy *Soba* of Bocolo Island
		António Sebastião Joana, Deputy *Soba* of Kimpula Island
		José Canga Kombo, *Soba* of Kimpula Island
		Miguel Kilombo, Secretary of the *Soba* of Kimpula Island
		Enrique Massebo, Secretary of the *Soba* of Moita Seca Island
		António Dangua, Deputy *Soba* of Moita Seca Island
		Francisco Simba Rosa, *Soba* of Zola Island
		José David Rosa, Secretary of the *Soba* of Zola Island
		Abílio António Maria, *Soba* of Pinda
		André Vemba, *Soba* of Kinpange
		Manuel Mavunge Lau, *Soba* of Mpungo
		Garcia Isabel Sebastião, *Soba* of Kindombele
Communities (continued)	Women (members of various communities)	Isabel Dembe, Kikudo Community
		Sara Rosa, Kikudo Community
		Delfina Zau, Kikudo Community
		Helena Maria, Kikudo Community
		Maria da Conceição, Kikudo Community

Category	Sub-category	Name of Contact and Title
		Paulina Ramos, Kikudo Community
		Enriquieta Sunda, Kikudo Community
		Maria Mpemba, Kikudo Community
		Juliana Paulo Isabel, Kikudo Community
		Liliana Fernando, Kikudo Community
		Madalena Zau, Kikudo Community
		Isabel Dembe, Kikudo Community
		Adelian Ximba Manuel, Bocolo Island
		Josefina Nsimba, Bocolo Island
		Xtimba Zombo, Bocolo Island
		Paulina Mbatshi, Bocolo Island
		Afonsina Vela Kombo, Bocolo Island
		Afocina Moabi, Bocolo Island
		Joana Tabita Sumba, Bocolo Island
		Maria da Graça António, Kindombele Community
		Suzana Catarina Longa Kioni, Kindombele Community
		Pascalina Luísa, Pinda Community
		Amélia Francisco Cristina, Pinda Community
		Beatriz Mbundi Sieta, Pinda Community
		Bela Kigalo, Moita Seca Island
		Júlia Francisco, Moita Seca Island
		Teresa Lene, Moita Seca Island
		Jacinta Bartolomeu Maria, Moita Seca Island
		Ermélia António Calunga, Moita Seca Island
		Manuela Suzana Alberto, Moita Seca Island
		Emília Mayomona José Paulo, Kikala-Kiako Community
		Margarida Daniel Jõao, Kikala-Kiako Community
		Rosa José, Kikala-Kiako Community
		Arlete Onor, Kikala-Kiako Community
		Maria Paulo dos Santos, Kikala-Kiako Community
		Graça Diadi Carlos, Kikala-Kiako Community
		Adelina Formosa, Kikala-Kiako Community
		Simba António, Kikala-Kiako Community
		Inês Faustino, Conde Community

Category	Sub-category	Name of Contact and Title
		Juliana Pedro, Conde Community
		Adelaide Kenge, Conde Community
		Ana Ndango Eduardo, Conde Community
		Cecília Domingos, Conde Community
		Adelina Pedro Isabel, Conde Community
		Angelina Batista, Conde Community
		Josefina Pedro Suzana, Conde Community
		Teresa Conceição, Conde Community
		Juliana Bingo Nkutxi, Conde Community
		Rosa José Justina, Conde Community
		Esperança Serafina, Conde Community
		Isabel José Isabel, Conde Community
		Maria Francisco, Conde Community
		Lilita Miguel Joana, Conde Community
		Delfina Eduardo Alberto , Conde Community
		Josefina José, Conde Community
		Laura António Rita, Conde Community
		Domingas Faustino Maria, Conde Community
		Micaela Manuel Benigna, Conde Community
		Madalena Afonso Adelina, Conde Community
		Delfina Sebastião Isabel, Conde Community
		Suzana Serafina Daniel, Conde Community
		Elisa Faustina, Conde Community
		Isabel António Isabel, Conde Community
		Albertina Joana, Conde Community
		Celina Eurico Helena, Conde Community
		Juliana Vunda Domingos, Conde Community
		Madalena Juliana Pedro, Conde Community
		Cárida João, Conde Community
		Adelaide Francisco, Conde Community
		Cristina Boa-Ventura, Conde Community
		Maria José Isabel, Conde Community
		Maria da Conceição Nzozi, Conde Community
		Juliana Bernardo Albertino, Conde Community

Category	Sub-category	Name of Contact and Title
		Conceição Geral de Joana, Conde Community
		Beatriz Mpemba Vitorino, Conde Community
		Celestina Joana Pedro, Conde Community
		Maria Pascoal Isabel, Conde Community
		Maria da Comceição Jerónimo, Conde Community

10.4 Objectives of the Stakeholder Meetings

The purpose of meeting with the aforementioned stakeholders was to complete the following list of objectives:

- Inform them about the proposed project and the EIA process;
- Provide them the opportunity to identify any concerns or aspirations they have related to the project;
- Identify the baseline social and health conditions of the stakeholders, including their perceived capacities and constraints;
- Identify the impacts to be evaluated in the EIA; and
- Gain a sense of the acceptance level of the proposed project.

10.5 Consultation Process

In order to conduct the consultations with identified stakeholders, a team of ARC consultants travelled to Soyo over three consecutive weeks starting on June 8th, 2011. During the meetings with stakeholders, a questionnaire was utilized to record responses and gather important data related to the stakeholder. As the questionnaires were conducted as a guided conversation, ARC was able to gain a larger sense about stakeholders' perspectives beyond the limits of the questionnaire.

Table 10-1 above highlights the stakeholders who were contacted for baseline information within their area and also for their comments on the proposed projects. Though all of the stakeholders listed were consulted, not all were able to respond fully to the questions due to either lack of education or knowledge amongst other factors.

After receiving all the data, the ARC team summarized the main issues that arose during the consultation process. These points are discussed in Section 10.6 below.

10.6 Principle Issues Identified During Consultation

Meetings with stakeholders (see **Figure 10-1** below) revealed several key themes of concerns and aspirations relating to the Project. A short synopsis of each theme is presented below.

These issues identified include:

- **Marine Pollution and Oil Spills** - there was overall concern that the Project would result in marine pollution that would harm fish and coastal communities, especially in the case of an oil spill;
- **Trawlers** - many community representatives expressed concern that the proposed Project would increase trawling in the Soyo Area and would damage their fishing nets and cause erosion to the Islands;
- **Benefits** - respondents listed the benefits that they expect from the Project, including new opportunities relating to employment, improved infrastructural conditions like water, electricity, public transport, health centres and schools, new lands to cultivate and the donation of new construction materials. Few expected any individual benefits.

Not one stakeholder answered yes when asked if the Project will separate families or communities.

Figure 10-1: Stakeholder Consultation in Kitona, Soyo.

When asked about the major problems in their communities, stakeholders answered the following:

- Almost all stakeholders responded that **unemployment** was a serious problem;
- 11 of the 23 communities consulted named the **diseases of HIV/AIDS and Tuberculosis** as concerning social problems;
- All 23 communities listed **alcohol/drug abuse** was a big problem; and
- Other major problems were **crime (mostly robbery), lack of access to land and other natural resources, prostitution and natural disasters (strong winds and erosion).**

Following the question about social problems relevant to their communities, stakeholders were then asked to provide their priority actions relevant to infrastructure and quality of life. A summary of the results follow:

- **Health Services** – more health centres and improvement of existing infrastructures and services, including full-time, qualified doctors or nurses and sufficient supplies;
- **Education** – new or improved schools, both primary and secondary, with quality professors, and professional training centres;
- **Transport** – an improved, affordable public transport system including busses and boats for the island communities;
- **Communication** – a communication centre for the community including a fixed telephone line, a functioning postal services reaching everyone;
- **Water** – installation of piped water to communities, installation of public fountains and improvement of existing ones that have degraded;
- **Housing** – support with construction materials for housing including cement blocks and metal sheets for roofs, provision of land for building houses, construction of housing for youths and the elderly;

- **Waste** – better distribution of waste containers and increase of the number of trucks that collect waste reaching all communities; and
- **Employment and Salaries** – provision of more jobs and increased salaries.

10.7 Stakeholder Assessment Matrix

The purpose of the Stakeholder Assessment Matrix is to organize and visually represent the reaction (disposition) as well as the degree of influence that each stakeholder has on the proposed project.

10.7.1 Methodology

The first step that must be taken is to identify the stakeholders and place them into relevant groups. The group can be based on profession, social role, or another significant category such as reaction to the project including stated requirements.

In order to determine a stakeholder group´s disposition, the requirements for each stakeholder group is taken into consideration as well as potential behaviours that could impact on the project objectives. Requirements can include formal request like permits, public consultations mandated by law, licenses, inspections, reporting, compensation, etc. Less formal requirements can also mean the stakeholders´ interests, needs, and expectations, including non-compulsory investments such as local socioeconomic development.

Once requirements and behaviour have been noted, the disposition is then defined. **Disposition** of each stakeholder group can be considered positive, negative, or neutral according to the following definitions:

- **Positive**: positive reaction to the project or whose requirements could be probably satisfied meeting the project objectives;
- **Negative**: negative reaction to the project or whose requirements could likely not be satisfied without impacting project objectives; and
- **Neutral**: no notable reaction to the project or no requirements made.

After rating stakeholder disposition, their influence is then assessed. Stakeholder influence (or power) on the project can be classified as high, medium or low. The categories are defined as the following for assessing **influence**:

- **High**: direct actions influencing the project´s objectives could be expected;
- **Low**: no actions influencing the project´s objectives are expected; and
- **Medium**: indirect actions influencing the project´s objectives could be expected.

A table is then made representing the stakeholders' requirements and behaviours, disposition and influence (see Table 10.2 below). Using this information, the disposition and influence can then be graphed into a matrix. The matrix provides a visual representation where high influence third-parties with negative dispositions can be easily noticed and addressed.

The following is a key stakeholder assessment matrix. The results from stakeholder consultations should be applied to this matrix revealing the priority areas; those with negative dispositions should be addressed in order to move opinions towards the positive category. High influence and negative disposition stakeholder groups will likely take top priority as they present a potential risk to the project´s realization.

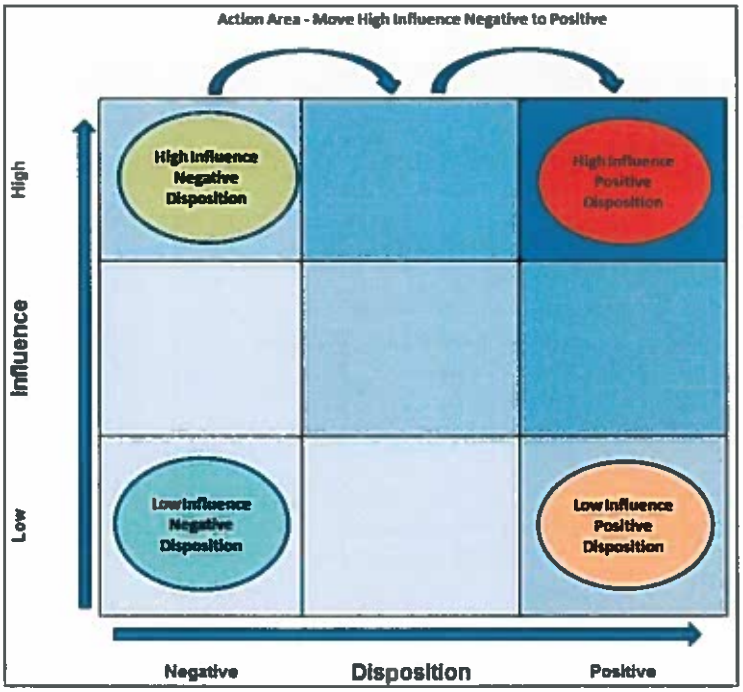

Figure 10-2: Stakeholder Assessment Matrix Model.

The table and matrix are depicted below using the information relevant to the project.

10.7.2 Application to Project

In order to first demonstrate the results from each stakeholder group, the following table brings together ARC´s assessment in Table 10-2 below.

Table 10-2: Stakeholder Engagement Results and Rating.

Stakeholder Group	Requirements / Behaviour	Disposition	Influence
Local Government Offices	None	Neutral	Medium
Health Sector	None	Neutral	Low
NGOs	Support to Health Centres and Infrastructure in area (electricity, piped water, roads, schools, employment)	Positive	Low
Industry	None	Neutral	Low
Associations/Cooperatives	Fishing cooperatives concerned about oil spills	Neutral	Low
Sobas	No requirements; behaviour showing approval of project but some expressed concern of possible oil spills	Positive	Low
Women	None	Neutral	Low

Taking into account that the requirements and behaviour determine the influence rating, the following matrix highlights the disposition and influence in a way to easily identify priority stakeholders. Those with high influence on the project should be considered the key stakeholders and those high influence stakeholders with negative dispositions the top focus of future engagement efforts.

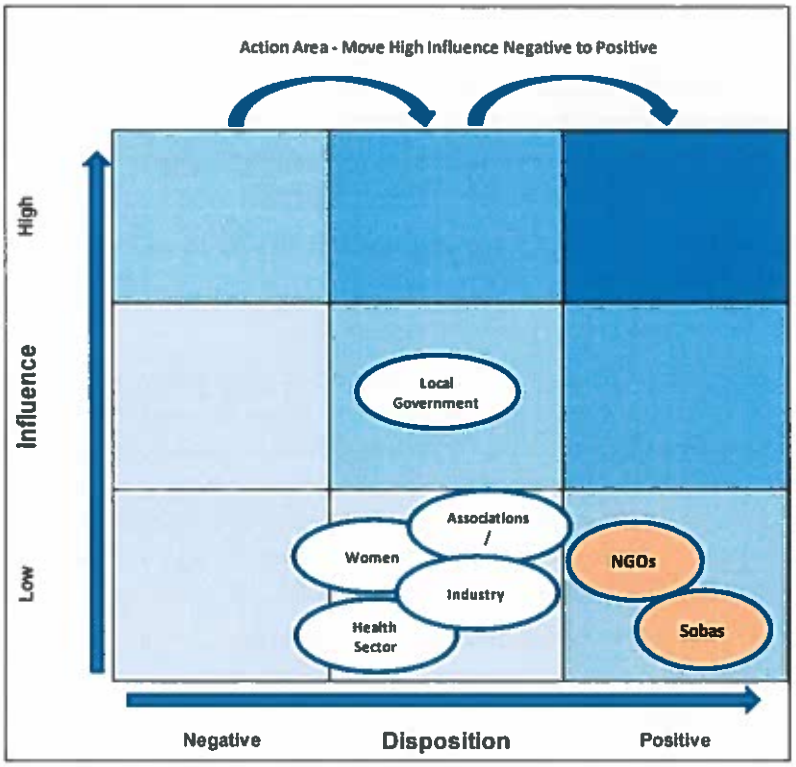

Figure 10-3: Stakeholder Assessment Matrix Applied.

10.7.3 Results

By applying the stakeholder assessment methodology to the data gathered from stakeholder consultations in Soyo, ARC was able to plot the results on the above matrix. Results reveal no high influence stakeholders or negative dispositions to the project; most stakeholders held a neutral disposition and some a slightly positive one. Neutral reactions likely had to do with the abstractness of the project and distance from shore; many respondents found it difficult to relate the project to their daily lives as it takes place far away in the deep ocean. Despite this, some comments and positive reactions were expressed in relation to the possibility of health and socioeconomic conditions improving onshore in their communities. There were some notable concerns, especially from stakeholders with some relationship to artisanal fishing, about marine pollution, though the overall reaction of these individuals to the project was not considered negative. Though no specific requirements were made, many stakeholders expressed optimism for improvements through development projects funded by the company.

Due to lack of stakeholders with negative dispositions, future stakeholder engagement should centre around the maintenance of communications on shore and the implementation of a chosen social project indicated as potential priority areas below.

10.8 Potential Intervention Areas

ENI, in recognition of its Corporate Social Responsibility (CSR), seeks to identify opportunities to engage in Community Investment Programmes where its projects are located. As such, ARC has highlighted key areas of potential intervention based on research of the social and health baseline conditions of the local community.

By first understanding the key problems of the communities in focus as well as community member's identified priority actions, an idea of potential intervention areas becomes clear. ARC combined both stakeholder suggestions with professional analysis of onsite observations to prioritize the areas placed into a final list. It should be noted that some further research may be necessary when implementation of a specific project begins as certain identified gaps in available information may slightly affect the company's execution plans.

The following analysis on potential implementation can also be found in the Health Social Baseline Analysis report:

- **Health Awareness and Education Programmes**

  In the health sector, HIV/AIDS, STIs, protein-energy malnutrition, RTIs, injuries due to violence, alcohol and other drug abuse could mainly be prevented by changes in human behaviour (e.g. by means of awareness and education). However, resources are also needed, such as the availability of condoms, food with adequate nutrients, safe roads and vehicles, as well as job creation, etc. These diseases are also of special importance to areas with high economic development and urbanization (e.g. in-migration of predominantly males, increase in traffic).

- **Resource Support in Health, Fishing and Agriculture**

  In addition to the items mentioned above, other health resources that are needed include prevention and treatment supplies for community members; malaria, tuberculosis, respiratory infections, sleeping sickness, asthma and COPD are a continuous threat, while diarrhoea due to cholera, viral hemorrhagic fevers and poliomyelitis are prone to outbreaks. Prevention and treatment for these diseases is available, although this is very reliant on the health care provision and resources for prevention (e.g. bed nets, adequate housing, clean water and sanitation facilities). Resource support for the fishing sector includes provision of supplies like nets, line, and even boats with motors. Refrigeration and other fish processing equipment would also benefit the local fishing communities. The agriculture sector requires supplies like tools and seeds, equipment like fencing and water pumps, and agricultural machinery.

- **Infrastructural Support**

  Areas for intervention in the social services sector cover almost all types of basic infrastructure, particularly for the communities located farther from the Soyo Town centre. Priority areas include the provision of health services, the building and running of local schools at all levels, transportation especially for schoolchildren, the supply of water and electricity to communities, and the creation of employment. Though needs also exist in the areas of housing and waste, amongst others, the aforementioned areas of intervention were recognized as key pieces to supporting the sustainable development of the local population.

10.9 Risk Assessment

Identifying risks within stakeholder management is important to the process so that ENI understands the potential issues associated with the public and its view of the project. Considering the stakeholders' requirements, as well as their drivers, actions, behaviours and dispositions upon consultation, ARC did not identify any adverse stakeholders who presented opposition to the project's undertaking. Therefore, a full risk assessment, classifying the levels of risk present was not necessary.

Should any new stakeholders with adverse reactions to the project emerge, a risk assessment will then be advisable so as to properly assess the situation and determine priority actions for addressing the concerns raised.

10.10 Strategy and Action Plan

Though the future steps for handling stakeholders will be determined by ENI, a suggested strategy and action plan was developed by ARC as a starting point for future interactions with locals.

The following diagram from the World Bank provides a useful overlay of the key components necessary for good stakeholder engagement (see Figure 10-4 below). These steps include:

- Stakeholder Identification and Analysis;
- Information Disclosure;
- Stakeholder Consultation;
- Negotiation and Partnerships;
- Grievance Management;
- Stakeholder Involvement in Project Monitoring;
- Reporting to Stakeholders; and
- Management Functions.

ARC, in its fulfillment of the ESHIA requirements, has begun the first three steps, which comprise the identification and analysis of the stakeholders relevant to the project, as well as the disclosure of information and the consultation of stakeholders. ENI´s role in maintaining engagement with stakeholders includes the continual disclosure of information when relevant, continual meetings with key stakeholders, and the creation of key partnerships based on the selected social project(s) ENI seeks to implement. In the case of the proposed project offshore, grievance management is not assumed to be necessary as well as stakeholder involvement in project monitoring. However, it is important for establishing the trust of local stakeholders that ENI maintain communication and follow through with stakeholders and project developments.

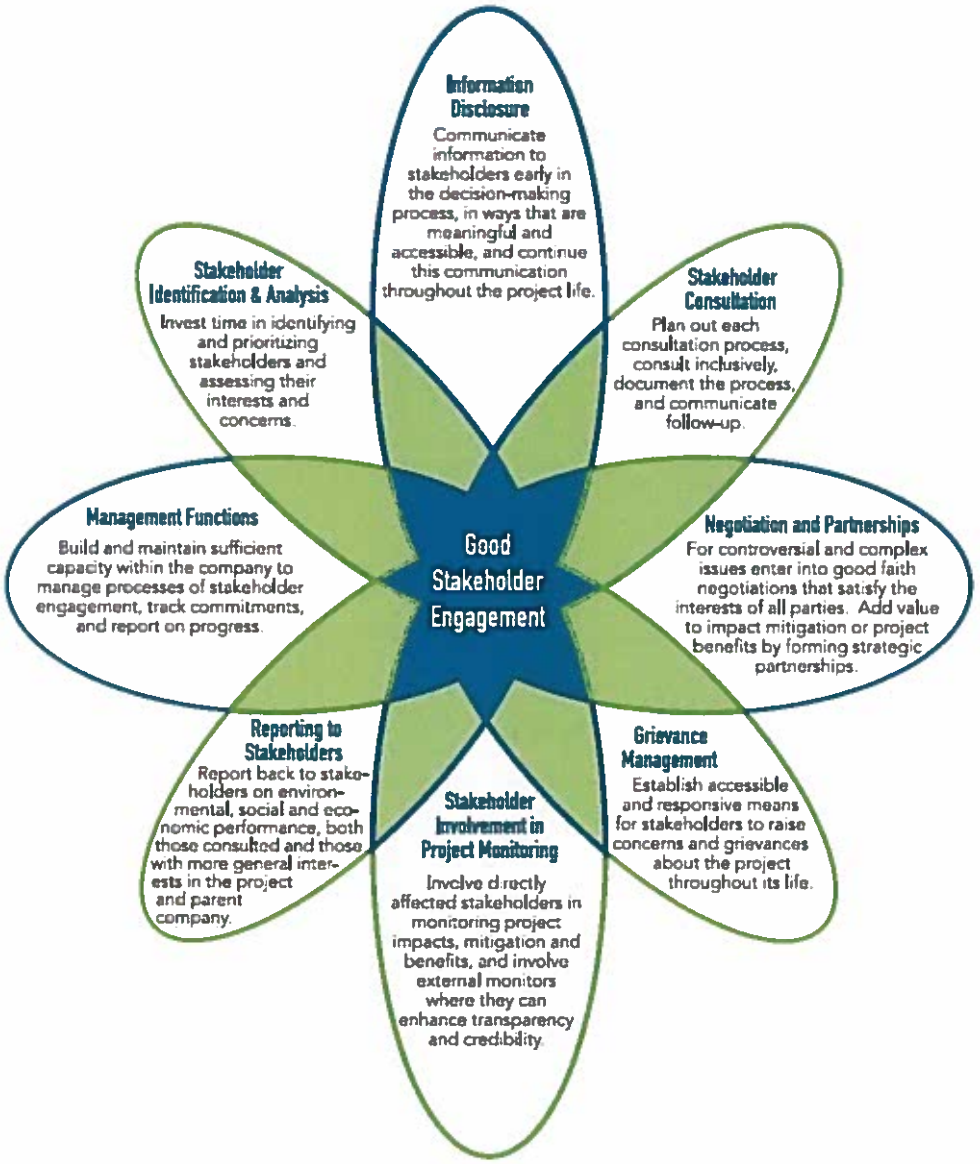

Figure 10-4: Components of Stakeholder Engagement.

Source: International Finance Corporation, World Bank Group, 2007

ENI´s Action Plan for dealing with stakeholder requirements and behaviours should address the stakeholder´s concerns that are listed above. However, since the requests made were community-based, similar for all consulted stakeholders, it is considered unnecessary for ENI to create a separate action list for each stakeholder.

Recognizing the requirements – or requested benefits – that stakeholders identified for this project, ARC recommends that the following actions are taken:

1. ENI to establish a solid relationship with the Administrator of Soyo Municipality, Sr. Manuel António along with his cabinet;

2. ENI to decide if and which social project it wants to create and then develop an initial plan;
3. Meet with relevant stakeholders to project (a health centre would imply meeting with indicated health contacts in stakeholder list as well as sobas and community members in the area);
4. Maintain contact and communications with community whenever a change to the project could affect them, including information about the developing social project.

11 Conclusion

The ESHIA of the proposed drilling, Installation/ Operation of FPSO and Mooring System. Installation and Operation of Well Heads and Umbilicals in Angolan Block 15/06 West Hub, has been a combination of data obtained from literature review and existing EIA reports as well as execution of field studies. The overall goal of the ESHIA is to ensure that potential impacts of the proposed project are identified, evaluated and adequate mitigation measures are proffered for significant impacts, while the positive impacts are enhanced. This will consequently, provide necessary data/evidence that will ensure the issuance of an environmental impact statement (EIS) for the proposed project.

The proposed project may significantly impact the national economy as well as the overall well-being of the people. It should also increase Angola's total hydrocarbon reserve, production capacity and ultimately enhance the country's present image and position in OPEC. It would also result in the provision of direct and indirect employment opportunities for Angolans as well as increased derivation funds to local and state governments and other government agencies/commissions.

The adverse impacts of the project would be in the form of injury/loss of life from operational accidents/incidents, chronic/acute health condition for onsite personnel due to exposure to hazardous chemicals and harsh weather, degradation of air quality from emissions from topsides, degradation of seawater column quality and loss of biodiversity resulting from disturbance of the seabed, oil spills/leaks, and wastes/effluents disposal. These adverse impacts can be prevented, reduced or controlled following implementation of the recommended mitigation measures.

Consequently, an EMP has been developed to ensure effective implementation of prescribed mitigation measures and for proactive environmental management throughout the project's life span. The EMP shall be implemented within the framework of ENI's Environmental Management System (EMS).

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Annex A

Statistical Sampling Methodology

ENI Block 15/06 West Hub Second Exploratory Drilling Campaign - Angola

Environmental Social & Health Impact Assessment

Statistical Sampling Methodology

Introduction

Pre-sample size selection for the undertaking of the survey was not possible as the total population of the target area was not known. The target area is the Soyo *Comuna* and includes the Soyo Town and surrounding areas. In a letter from the Municipal Administration dated on the 6th June 2011, the population of the comuna is declared as approximately 65,340. In the same letter it is indicated that there are 39 communities within Soyo *Comuna*.

Application to Study

In the ARC study, researchers interviewed 24 sobas representing 26 communities and an estimated population of 60,070. The reported population of the ERM study of 2005 was 88,320. There are three results in our study that are not justifiable in comparison to the ERM report. With these results being adjusted to allow for 3% per annum population increase the new population representation of the sobas interviewed would be 50,970 which would represent approximately 58% of the higher ERM reported figure.

The table below shows the target groups interviewed during the survey.

Table 1: Number of Stakeholders Interviewed During Survey.

Questionnaire	Stakeholder Category	Number
Q1	Sobas	31
Q2	Education Organisations	1
Q3	Formal Organisations	1
Q4	Administrators	1
Q5	Health Organisations/Installations	3
Q6	Non-Government Organisations	2
Q7	Civil Protection	
Q8	Justice Departments	
Q9	Agricultural Public Departments	1
Q10	Agricultural Cooperatives	2
Q11	Fishing Government Departments	1
Q12	Fishing Cooperatives	2
Q13	Commercial, Industrial & Tourism	1
Q14	Local Environment	
Q15	Energy Representatives	1
Q16	Waste Water Institutions	1
Q17	Immigration Authorities	1

Questionnaire	Stakeholder Category	Number
Q18	Oil Industry	1
Q19	Business Organisations	
Q20	Police	
Q21	Women	77
	TOTAL NUMBER INTERVIEWED	127

The difference between the ERM study population estimate of 88,320 and the figure indicated by the Administrator of the area in 2011 (65,340) is 22,980 or 35%. This is a large discrepancy and highlights the difficulty in arriving at statistical reporting confidence levels.

The mathematics of probability proves the size of the population is irrelevant unless the size of the sample exceeds a few percent of the total population under examination. This means that a sample of 500 people is equally useful in examining the opinions of a state of 15,000,000 as it would a city of 100,000[16].

Equation

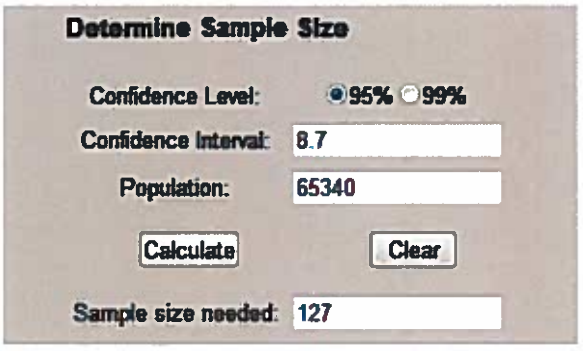
Using the Survey System calculations, assuming that:

Sample Size (ss)

$$= \frac{Z\ 2 * (p) * (1-p)}{c\ 2}$$

Where:

Z = Z value (e.g. 1.96 for 95% confidence level)
p = percentage picking a choice, expressed as decimal (.5 used for sample size needed)
c = confidence interval, expressed as decimal (e.g., .04 = ±4)



Results

[16] Population Size. http://www.surveysystem.com/sscalc.htm

Using ARC´s sample size of 127 in this equation results in a confidence level of 95% with a confidence interval or margin of error of 8.7%.

Annex B

Key Data Gaps

Table 1 - Identified key data gaps.

(✓) data available and collected; (±) some data was available and collected but not fully sufficient from ESHIA purposes; (×) data not available/found

Data Items	National	Regional/Provincial	Municipal/Communal
Cause/disease-specific mortality rate per 100,000 population	✓	×	×
Cause/disease-specific morbidity rate per 100,000 population	✓	×	×
Health issues awareness and KAPs	×	×	±
Immunisation rates	✓	×	±
ITN-use	✓	×	±
Sexual behaviour	×	×	±
Tobacco and alcohol consumption rates	×	×	×
# of registered cases of illnesses caused by chemical agents (e.g. respiratory, skin & eye diseases, poisoning, allergy, cancer & malignant blood diseases, etc.)	×	×	×
Prevalence of physical disability per 100,000 population	×	×	×
# registered cases of illnesses caused by physical agents (e.g. musculoskeletal & nervous system disorders, skin & eye diseases. Noise-induced hearing loss, cancer & malignant blood diseases, etc.)	×	×	×
# registered cases of illnesses caused by biological agents (e.g. infections & preventable diseaeses, animal vector diseases, cancer & malignant blood diseases, etc.)	✓	±	±
Weight for age, weight for height (nutritional status)	✓	±	×
Respiratory diseases mortality & morbidity rates	✓	×	±
Prevalence rate of mental disability per 100,000 population	×	×	×
% households with access to safe drinking water	✓	×	×

Data Items	National	Regional/Provincial	Municipal/Communal
% households with access to safe water for domestic use	✓	×	×
% households with adequate sanitation facilities (sewage & other waste treatment)	✓	×	×
# individuals affected by water-borne diseases	✓	±	±
# individuals affected by animal vector diseases	✓	±	±
% individuals water secure	×	×	×
% individuals food secure	×	×	×
# of health facilities by type and services offered	×	×	✓
Population per health facility	×	×	×
Number of registred doctor, nurse & midwife	×	×	✓
Population per registered doctor, nurse & mid-wife	✓	×	±
# of health units without stock out of indicator drugs	×	×	±
Frequency of alcohol abuse	✓	×	±
Frequency of drug abuse & trafficking	✓	×	±
# of newly registered HIV/AIDS cases	✓	±	±
Presence & frequency of law enforcement	±	±	±
Average property value (€ or $)	×	×	×
Pupil-teacher ratio	×	✓	✓
Structure, operations & influence of formal & informal judicial institutions	±	±	±
Budget transparency of Local Authorities	±	±	±
Share of income poorest 10%	±	×	×
Share of income poorest 20%	±	×	×

Data Items	National	Regional/Provincial	Municipal/Communal
Share of income richest 20%	±	×	×
Share of income richest 10%	±	×	×
Participation rates of women, youth and minority groups (ethnicities, tribes, etc.) in labour-force, decision-making & politics	×	×	±
# & activities of organisms that address safety issues & concerns (existence & implementation awareness programmes & safety practices)	×	×	×
Presence & frequency of criminal activties & organised crime	×	×	±
Population of formal and informal settlement (size and as % of total)	×	×	×
Δ cost of food (typical food basket) & other goods	×	×	±
# of new activities started-up in the area (indirect and induced effect) linked to oil & gas industry	×	±	✓
Informal sector employment: unregistered employment as a % of total employment (urban/rural/both)	±	×	±
Local/regional unemployment & participation rates of women	×	×	±
Local/regional unemployment & participation rates of youth	×	×	±
Local/regional unemployment & participation rates of minority groups	×	×	×
Population of Soyo & Δ			±
Population density per sq km & Δ	✓	±	±
Population distribution by gender & age	✓	×	×
Population distribution by ethnicity, religious group	×	×	±
Overall in-migration rate for the area	×	×	±