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Environmental Inspection and Monitoring Manual

(developed for petroleum industry)

Document Revision Draft 2.0
Date of Issue: [October 2020]

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Revision Matrix

Revision	Date	Purpose	Prepared by	Reviewed/Approved
Draft	26/06/2020	Issued for review	IHS Markit/ESAL	NEMA/KEPTAP/WB
Revised	18/06/2020	Realigned with Phase 2 deliverables	IHS Markit/ESAL	NEMA/KEPTAP/WB
Final Draft	11/09/2020	Revised to address Client's comments	IHS Markit/ESAL	NEMA/KEPTAP/WB
Final Draft	24/09/2020	Revised to address outstanding Client's comments	IHS Markit/ESAL	NEMA/KEPTAP/WB
Final	22/10/2020	Final Document	IHS Markit/ESAL	NEMA/KEPTAP/WB

Document History

This chart contains a history of the revisions made to this document by NEMA (to be used by NEMA once NEMA starts using this manual)

Revision Number	Date of Issue	Author(s)	Brief Description of Change
		Last, First	
		Last, First	
		Last, First	
		Last, First	

Document Location

This is an on-line document. Paper copies are valid only on the day they are printed. Refer to the author if you are in any doubt about the accuracy of this document.

Approvals

This document requires the following approvals:

Name	Title	Signature	Date
[NEMA to update this]			

Distribution

Title	Department
[NEMA to update this]	

Table of Contents

Acronyms

BTEX – Benzene, Toluene, Ethylbenzene, and Xylene
BOD - Biological Oxygen Demand
CEO – Chief Executive Officer
CO_2 - Carbon dioxide
CVSA – Commercial Vehicle Safety Alliance
DCE – Director of Compliance and Enforcement
DDE – Deputy Director Enforcement
DOSHS – Directorate of Occupational Safety and Health Services
EA – Environmental Audit
EIA – Environmental Impact Assessment
EM – Environmental Monitoring
EMCA - Environmental Management and Compliance Act
EMR – Emissions Monitoring Report
E&P – Exploration and Production
EPA – Environment Protection Agency
EPC – Engineering, Procurement and Construction
EPRC – Energy Petroleum and Regulatory Commission
ESDV – Emergency Shut Down Valve
GC – Gas-chromatography
GBSS – Gravity Base Structure
GPA – Gas Processor Association
H_2S - Hydrogen sulfide
HDPE – High-density polyethylene
HEIA – Health Equity Impact Assessment
HELCOM – Baltic Marine Environment Protection Commission
HIS – Head of Inspectorate Section
HNO_3 – Nitric acid
HPU – Health Protection Unit
HPLC – High Performance Liquid Chromatography
HSE – Health and Safety Executive
HWMS – Hazardous Waste Management System
HWQS – Hydrologic and Water Quality System
ISO- International Standard Organization
IT – Inspection Team
IPCC – International Panel on Climate Control
Kg/m^3 - Kilogram per cubic metre
KPI – Key Performance Indicator
LDPE – Low density polyethylene
LNG – Liquefied Natural Gas
mg/l – milligrams per litre
ml – millilitres
NEMA – National Environment Management Authority (of Kenya)
NIST – National Institute of Standards and Technology
NH_4 – Ammonia
NO_2 - Nitrogen dioxide
NO_3 - Nitrate
NOx – Nitrogen Oxide
NORM – Naturally occurring radioactive materials
NPDES – National Pollutant Discharge Elimination System
OGP – Oil & Gas Producer

O&G - Oil and Gas
OSPAR – Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic)
PLETS – Pipeline End Termination
PLONOR – Pose Little or No Risk to the Environment
psi – Pounds per square inch
QA – Quality Assurance
QC – Quality Control
ROV – Remotely Operated Vehicles
SOP – Standard Operating Procedure
SOx – Sulphur oxides
THC – Total Hydrocarbon Content
TL – Team Leader
TSS – Total Suspended Solids
Ug/m^3 - Micrograms per Cubic Meter of Aid
VOC – Volatile Organic Compound(s)

Volume 1

Section 1 – General Provisions

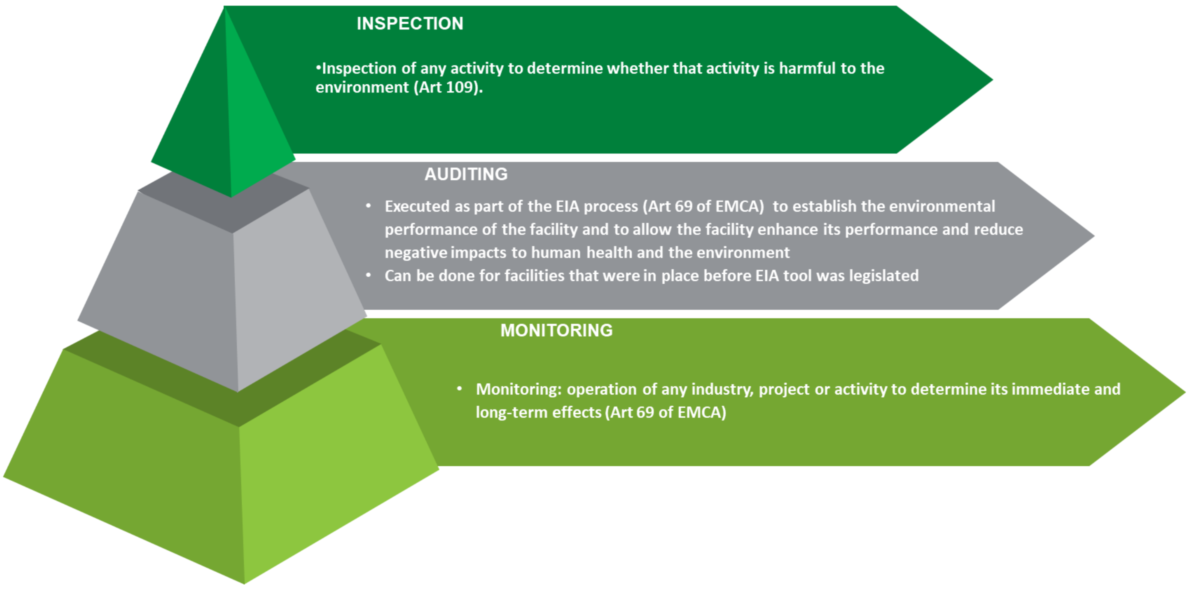
1. Introduction

1.1 Purpose and objective of the manual

The purpose of this manual is to establish and document the processes and procedures developed and adopted by NEMA in execution of its compliance and enforcement function in the form of Environmental Monitoring, Auditing and Inspection process of petroleum industry facilities and operations, as prescribed by Environmental Management and Compliance Act as revised, (further referred to as EMCA) and its underlying regulations.

This manual establishes the process of environmental monitoring to be executed by NEMA and/or Lead Agencies, control audits by NEMA auditors and NEMA inspections processes of upstream, midstream and downstream operations and facilities as provided in Figure 1 aimed at achieving compliance with applicable Kenyan environmental legislation.

Figure 1 – Kenya compliance and enforcement processes



The objective of this manual is to provide clear and comprehensive information on the processes and procedures to be uniformly followed by authorized NEMA inspectors, auditors and other representatives of NEMA or Lead Agencies to provide for consistent execution of compliance monitoring activities of petroleum operations in Kenya.

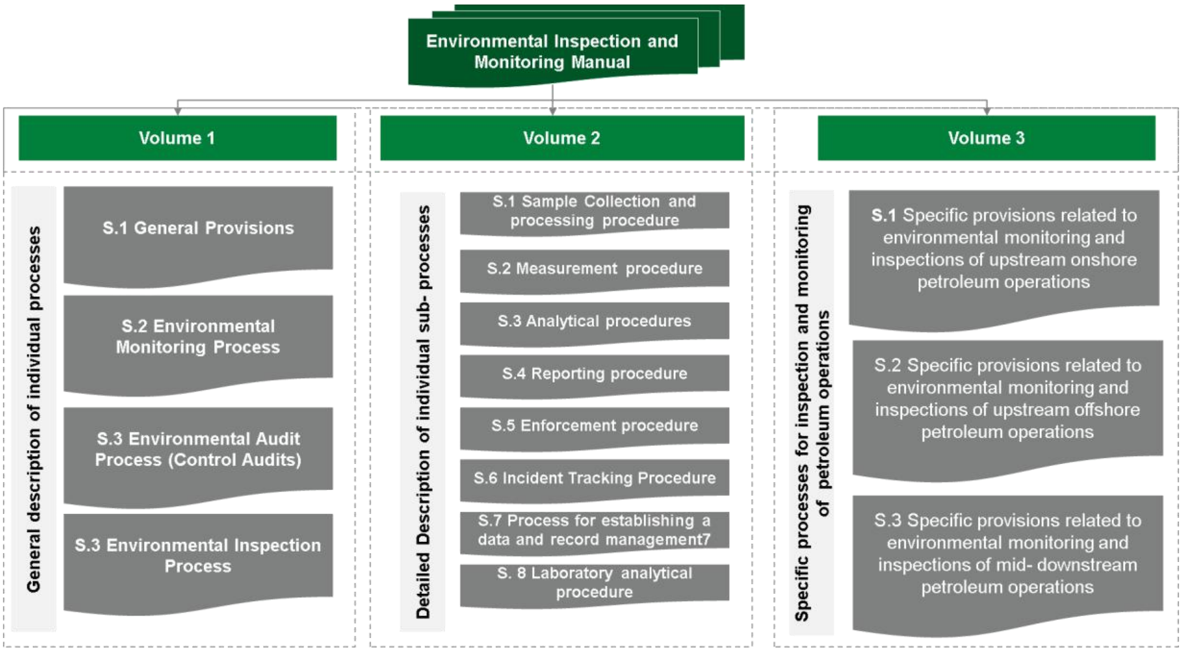
This Manual shall serve as a reference guide for NEMA, or those granted authority by NEMA, to undertake government led environmental Monitoring, Auditing and Inspection activities of oil and gas operations and facilities in Kenya.

2. Document Structure and content

2.1 Document Structure

This manual is arranged in a number of volumes and subordinate sections to assist NEMA personnel in executing of a specific compliance and enforcement activity. The manual structure is provided in the Figure 2.

Figure 2 – Manual Structure



The structure of the manual allows and facilitates:

- A clear definition of general compliance and enforcement processes used in Kenya that apply to the petroleum industry,
- Detailing sub-processes that form each compliance and enforcement process,
- Provision of specifics that apply to upstream onshore, upstream offshore and mid-downstream petroleum activities and facilities.

2.2 Document Contents

For the ease of reference and understanding, the content of each Volume is summarised below.

- **Volume 1, S.2-4**

Except for this general section S.1 which aims to provide general information, sections 2-4 of Volume 1 of this manual are drafted with the following structure:

1	**Introduction**
1.1	Purpose and Objective
1.2	Scope
1.3	Roles and Responsibilities
2	**Process Mapping**
2.1	Process Map
2.2	Inputs
2.3	Outputs
2.4	Tools, Forms and Templates
2.5	Metrics (KPIs)

3	**Procedure (steps detailing process activities)**
4	**Qualifications and Training**
4.1	Qualifications
4.2	Training
	Appendixes detailing applicable forms, etc.

- **Volume 2**

All sections of Volume 2 of this manual are drafted with the following structure:

1	**Introduction**
1.1	Purpose and Objective
1.2	Scope
1.3	Roles and Responsibilities
2	**Process Mapping and Procedure**
2.1	Process Map
2.2	Inputs
2.3	Outputs
2.4	Tools, Forms and Templates
2.5	Procedure (steps detailing process activities)
	Appendixes detailing applicable forms, etc.

- **Volume 3**

All sections of Volume 3 of this manual are drafted with the following structure:

1	Description of activities and facilities involved in upstream onshore oil and operations
2	Sources of key impacts of onshore oil and gas operations and impact categorization
3	Sources of environmental pollutions/emissions from onshore oil and gas operations
4	Parameters for environmental monitoring
5	Specific procedures distinctive from Volumes 1 and 2 as it relates to onshore oil and gas operations

3. Description of Environmental Monitoring, Auditing, Inspections

3.1 Environmental Monitoring by NEMA and Lead Agencies

Environmental monitoring is a continuous or periodic determination of actual and potential effects of any activity or phenomenon on the environment whether short-term or long-term.

NEMA in consultation with the relevant lead agencies, as needed, has authority to monitor the operation of any industry, project or activity with a view to determining its immediate and long-term effects on the environment. An environmental inspector appointed under this Act may enter upon any land or premises for the purposes of monitoring the effects upon the environment of any activities carried out on that land or premises.

Furthermore, all projects for petroleum operations are required to have an environmental impact assessment (EIA) study license. Each EIA includes an environmental management plan that includes monitoring activities executed by oil and gas companies. Such monitoring is undertaken to determine the actual and potential effects of the given activity on the environment in the short and long term. As part of its monitoring function NEMA in consultation with the relevant lead agencies, as needed, may request and verify results of monitoring carried out by oil and gas company against baseline parameters.

This manual makes provisions for NEMA leading environmental monitoring activities of petroleum operations.

3.2 Audits

Environmental audit is the systematic, documented, periodic and objective evaluation of how well environmental organisation, management and equipment are performing in conserving or preserving the environment. An environmental inspector may enter any land or premises for the purposes of determining how far the activities carried out on that land or premises conform with the statements made in the environmental impact assessment study report.

EMCA distinguishes between three types of audit activities: environmental audit studies, self audits and control audits.

Environmental Audit Studies are required for projects that have been undertaken after completion of an environmental impact assessment study.

Initial audits provide baseline information upon which subsequent control audit studies shall be based. An initial environmental audit must be within 12 months of the commencement of operations and not more than 24 months after completion of project. If project life is shorter, the audit may be required earlier. Additional audits will be required on a regular basis to verify compliance with the environmental management plan and regulations.

Self audits are the primary method of auditing. Companies will prepare a detailed audit of their facility using a third-party auditor from a register maintained by NEMA. Self-audits are then reviewed by the NEMA technical staff. NEMA classifies self-audits for review in terms of risks. Low risk facilities require self-audits only when there is an incident or if NEMA would like to understand the practice within the facilities. Medium risk facilities must submit self-audits every three years. High risk facilities must submit audits annually. Improvement notices may be issued where needed. If satisfied with the report, NEMA issues a compliance letter to the facility.

Control Audits are used when NEMA deems it necessary to check compliance with environmental parameters set for a project or in order to verify information in a self-audit report. Control audits intend to verify compliance with a project's environmental management plan and that the plan is sufficient to mitigate any negative impacts of the project. Control audits will be initiated when there are concerns voiced by NEMA, the public, parliament, or other stakeholders.

This manual makes provisions for NEMA lead control audits of petroleum operations. For processes related to self audits and environmental audit studies please refer to NEMA Standard Operating Procedures for Compliance and Enforcement.

3.3 Inspections

Environmental inspections are undertaken by NEMA, or its representatives, through the powers granted by EMCA. Inspections are periodic events that are undertaken in response to incidents, complaints, or issues raised by the public, Parliament, or other stakeholders. An inspector may, at reasonable times, enter on any land, premises or facility of a project for the purposes of inspection, to examine records and to make enquiries on the project.

Inspections consist of a site visit that includes a thorough review of licenses and other documents at the facility by NEMA compliance staff, observation of environmental management practices in place at the facility, and discussions with relevant employees. Upon completion of the inspection, findings will be shared with the responsible authority of the facility and any improvement orders or enforcement actions will be issued.

This manual makes provisions for NEMA inspectors to lead environmental inspections of petroleum operations.

4. General Roles and Responsibilities

This section makes provision for general definition of parties involved in environmental monitoring, audits and inspection and description of their roles:

Name of party	Responsibilities
National Environment Management Authority (NEMA)	Responsible for exercising general supervision and co-ordination over all matters relating to the environment and to be the principal instrument of the Government of Kenya in the implementation of all policies relating to the environment. Assumes general responsibility to execute environmental monitoring, control audits and environmental inspections.
Chief Enforcement Officer, NEMA	Responsible for review of Inspection Reports for enforcement actions Improvement Orders.
Head of Environmental Audit Section, NEMA	Initiates Audit reports, coordinates review of environmental audits by NEMA staff, verifies reviewed EA reports, prepares and issue improvement notices, evaluate responses to improvement notices, and issue compliance letters.
Registered Expert	Performs environmental audits. Must be qualified and registered with NEMA
Directorate of Occupational Safety and Health Services (DOSHS)	Provides assistance to NEMA during audits, inspections, and monitoring activities as a "lead agency" with specialization in occupational health and safety
Energy and Petroleum Regulatory Authority (Petroleum & Natural Gas Directorate)	Provide assistance to NEMA during audits, inspections, and monitoring activities as a "lead agency" with specialization in the midstream and downstream oil and gas industry (i.e. pipelines, petroleum storage depots and tanks, import/export facilities, retailers, refineries, etc.) Identifies, reviews, and enhances standards relating to EHS activities in the midstream and downstream petroleum sectors.
Oil & Gas Operator	Respond to NEMA or authorized inspector inquiries; undertake environmental self audits as needed; provide details of incidents to Compliance Unit.
Lead Agency	Any Government ministry, department, parastatal, state corporation or local authority, in which any law vests functions of control or management of any element of the environment or natural resources.

5. Legal References

The following is a list of all major Kenya environmental laws and regulations applicable to inspection, monitoring and auditing petroleum facilities and operations at the time of writing.

- Environmental Management and Co-Ordination Act, 1999
- Land Act, 2012
- National Land Commission Act, 2012
- Climate Change Act, 2016
- Energy Act of 2019
- Petroleum (Exploration, Development, and Production) Act of 2019
- Environmental (Impact Assessment and Audit) Regulations, 2003
- Environmental Management and Coordination (Air Quality) Regulations, 2014
- Environmental Management and Co-ordination (Water Quality) Regulations, 2006
- Environmental Management and Coordination (Waste Management) Regulations, 2006

- Environmental Management and Coordination (Controlled Substances) Regulations, 2007
- Environment Management and Co-ordination (Noise and Excessive Vibration Pollution Control) Regulations, 2009
- NEMA Standard Operating Procedures for Compliance and Enforcement. REF No. NEMA/SOP/C&E/01-11

6. Quality assurance and quality control measures

Quality assurance/quality control measures are activities undertaken by NEMA and lead agencies, required to demonstrate the accuracy and precision of environmental monitoring, audits and inspections.

Quality Assurance (QA) generally refers to a broad plan for maintaining quality in all aspects of a program, including all quality control measure, sample collection, sample analysis, data management, evaluation, etc.

Quality Control (QC) consists of the steps, including measurements, calibration and standardization practices required to be taken to assure quality of specific sampling and analytical procedures.

Quality Assurance is essential in environmental monitoring, auditing and inspections to promote, achieve and maintain adequate data quality. Quality Assurance and Quality Control procedures are incorporated into all aspects of the monitoring programs including:

- **Sampling** (equipment preparation, sample collection, sample storage and transportation) – this is achieved via compliance with sampling standards defined in this manual or alternative de-facto international best practice standards.
- **Laboratory analysis** – this is achieved through the designation of laboratories by NEMA laboratory , internal laboratory QA/QC procedures independently verified and audit and analysis of control samples carried out to maintain laboratory accreditation. It is anticipated that NEMA designated laboratories are to follow good laboratory practices.
- **Data management** – this is achieved via use, maintenance, issue and storage of data in compliance with applicable regulations and this manual.
- **Reporting** – this is achieved through consistent reporting and tracking of results of monitoring activities in compliance with applicable regulations and this manual.

Additional measures that improve the quality of environmental monitoring, audits and inspections of petroleum operations include, amongst others:

- Adherence to NEMA internal QA/QC corporate procedures and other procedures required by ISO 18091:2019 (Guidelines for the application of ISO 9001 in local government);
- Adequate training of NEMA inspectors/auditors in execution of environmental monitoring, audits and inspection of petroleum operations as specified in this manual;
- Internal audits of NEMA enforcement and compliance activities.

S. 2 Environmental Monitoring Process

1. Introduction

1.1. Purpose and Objective

Environmental monitoring is the continuous or periodic determination of actual and potential effects of any activity or phenomenon on the environment whether short-term or long-term. NEMA identifies projects and programmes or types of projects and programmes, plans and policies for which environmental audit or environmental monitoring must be conducted under EMCA.

Environmental monitoring programs for petroleum industry should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during normal operations and emergency conditions.

Industrial activity, such as oil and gas operations, can impact the environment in many different ways over the short- and long-term. Environmental monitoring indicates whether the environmental status is stable, deteriorating or improving, due to operators' activities. In addition to identifying trends, the results should as far as possible provide a basis for projections for future developments.

Environmental monitoring of petroleum operations should take into account any impacts on:

- air quality,
- water quality,
- soil and land uses,
- and biodiversity.

Specific parameters are identified as part of the baseline survey. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project.

Objectives of environmental monitoring include:

- Evaluating short/medium/long term impacts of petroleum operations,
- Provide government agencies with data to evaluate any impacts and to contribute to environmental impact assessments, audits, and inspections,
- Assist in the evaluation of environmental goals and programs,
- Comparison of environmental data to baseline data measured in EIA process,
- Verify that environmental mitigation measures are sufficient to maintain desired outcomes
- Provide early warning for potential environmental damage.

Environmental monitoring of petroleum operations can be executed in two main forms:

- **Through NEMA verification carried out as part of control audit of the adequacy of the environmental management plan in mitigating the negative impacts of a project submitted and approved as part of the EIA process (see S. 3 of this Manual);**
- **By NEMA inspectors or jointly by NEMA and /or Lead Agency.**

Effective environmental monitoring should accomplish the following:

- Carefully determine the indicators to be used in monitoring activities,
- Collect meaningful and relevant information,
- Apply measurable criteria in relation to chosen indicators,
- Pass objective judgements on the information collected,
- Draw tangible conclusions based on the processing of information and objective judgements,
- Facilitate rational decision-making on the conclusions drawn.

1.2. Scope

The scope of environmental monitoring executed by NEMA and /or lead agency in monitoring of operations of petroleum industry projects with a view to determining its immediate and long-term effect on the environment.

The environmental monitoring by NEMA and/or a lead agency is executed by measuring environmental changes that have occurred during project implementation by comparing actual parameters against the baseline parameters identified as part of the baseline survey.

Appropriate environmental indicators/parameters for future environmental monitoring can be identified as part of individual EIA preparation and approval process for petroleum operations and facilities.

1.3. Roles and Responsibilities

NEMA is responsible for determining the parameters and measurable indicators to be used in monitoring of projects as part of the EIA review and approval process.

NEMA and/or a Lead Agency is responsible for conducting measurement of environmental changes that have occurred during implementation of petroleum projects.

NEMA must take all necessary measures to provide feedback through improvement orders to operators that will correct and improve the environmental performance of the project. NEMA should also compile, compare, and evaluate the data collected against regional, national, and international environmental goals and commitments.

Operators are required to complete a monitoring report that includes project details, information on the monitoring process and metrics, and the results of the monitoring activities. Once the monitoring report has been reviewed and feedback provided by NEMA, the operator must then take actions to make the suggested improvements in the orders to bring the facility into compliance.

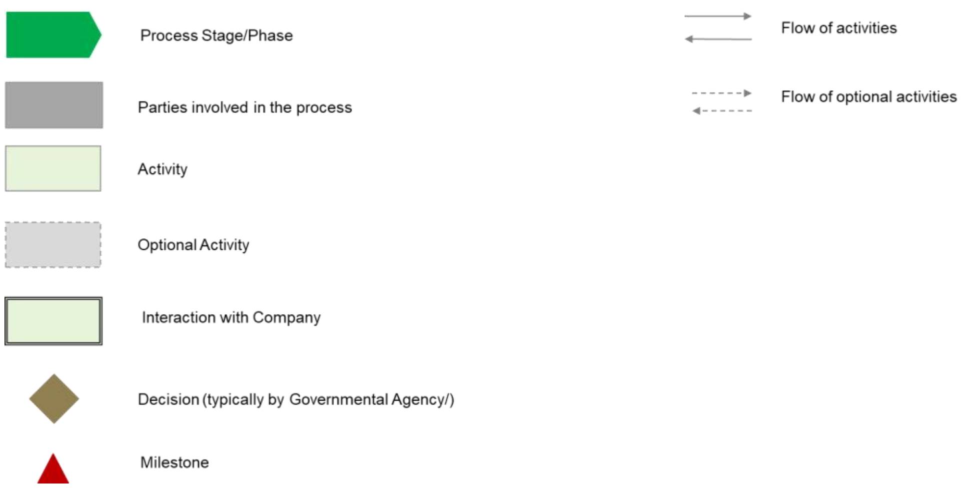
Operators must also designate in its EIA the specific employees or positions responsible for management of its monitoring program.

Operators shall grant access and facilities environmental monitoring executed by NEMA and/or a Lead Agency.

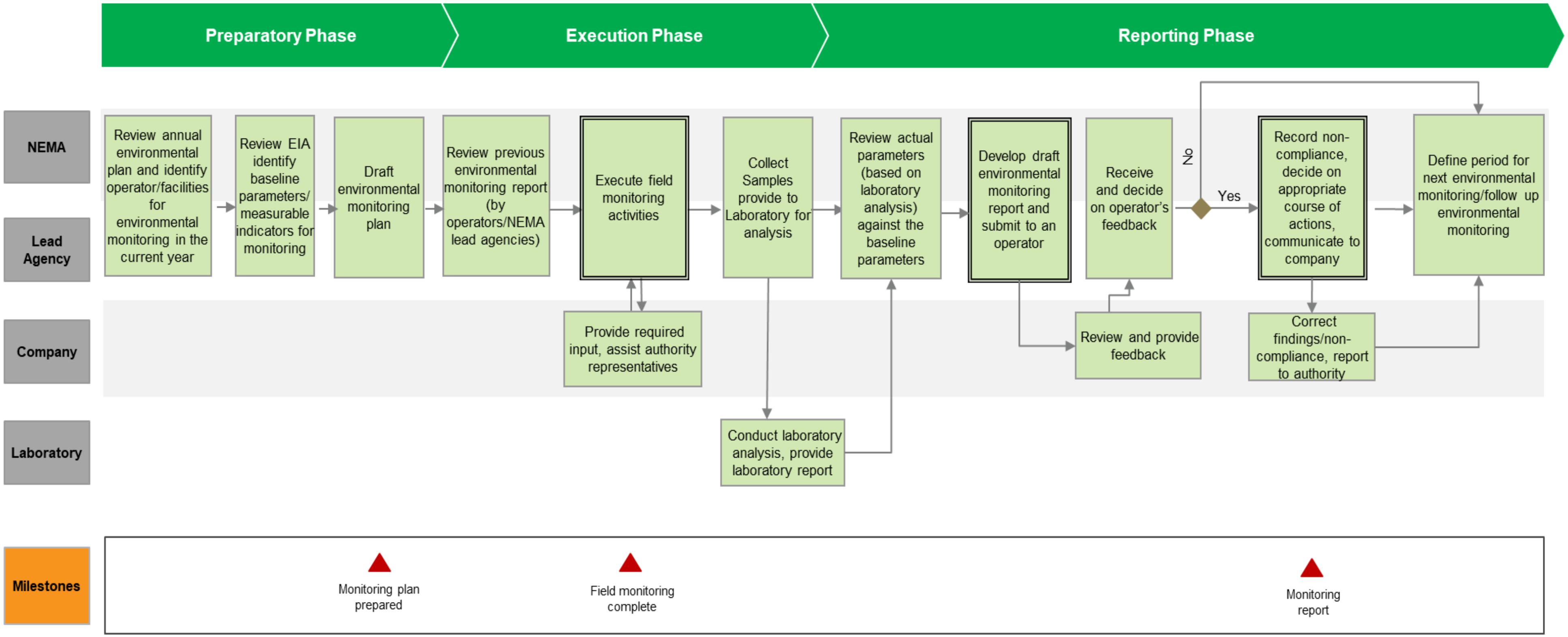
2. Process Mapping

2.1 Process Map

Process Map legend:



Environmental Monitoring Process



2.2 Inputs

Input	Detail of Inputs and remarks	Ref.
List of projects/facilities subject to environmental monitoring by NEMA and/or Lead Agency	NEMA to develop, approve and maintain such list. This list includes oil and gas projects and facilities	
Approved EIA report for individual petroleum project	This report developed by an operator shall contain a baseline survey to identify basic environmental parameters in the project area before implementation	
Baseline survey	For projects where a baseline survey was not carried out as part of EIA or for projects, that commenced prior to EIA requirements adoption	
Parameters and measurable indicators	Typically, these parameters and indicators are approved as part of EIA report	
Environmental Management Plan	Developed by an operator as a part of the EIA	
Previous/Earlier Monitoring report	Reports summarising results of previous environmental monitoring conducted by NEMA and/or Lead Agency	
Remedial action	Actions raised deriving from previous environmental audit activity	

2.3 Outputs

Output	Detail of Outputs and remarks	Ref.
Environmental Monitoring Report	Report detailing results of environmental monitoring of petroleum operations/facilities	EM – Form 3 - Environmental Monitoring Report EM (
Improvement Orders	When corrective action is needed, corrective orders will be issued	

2.4 Tools, Forms and Templates

2.4.1 Tools

The following tools shall be used in the Environmental Monitoring process

- Air Quality Sensors
- Soil quality testing equipment
- Water quality/effluent testing equipment
- Internal correspondence guide
- External correspondence guide
- User manual
- NEMA compliance database

2.4.2 Forms and Templates

The following templates shall be used in the Environmental Monitoring process:

Form & template	Objectives	Usage
EM – Form 1 - Environmental Monitoring Plan	• Standardized method for planning environmental monitoring of petroleum facility	• To be completed by the head of the monitoring team of NEMA and /or Lead Agencies in preparation of the monitoring activities
EM – Form 2 - Environmental Monitoring Compliance Checklist	• Standardized method to check that all environmental monitoring activities are complete	• To be completed by a monitoring team member (inspector) of NEMA and /or Lead Agencies in preparation of the monitoring activities
EM – Form 3 - Environmental Monitoring Report EM	• Standardized method to report on results of environmental monitoring	• To be completed by a monitoring team to report on results of the environmental monitoring

Templates and manuals for each of the forms are included in Appendix to this schedule.

2.5 Metrics (KPIs)

The following Key Performance Indicators (KPIs) shall be used in evaluating effectiveness and efficiency of the environmental monitoring process:

- **Internal KPIs:**

No	KPI	Metric
1	Completion of environmental monitoring	>85% of annually scheduled activities (carried out by NEMA, lead agencies, jointly NEMA & lead agency) are completed on time (according with an annual plan and timeframe defined in the manual)
2	Inspectors/auditors/NEMA & Lead Agency personnel engaged in environmental monitoring	>80% of personnel engaged in preparation, execution and monitoring of environmental monitoring are trained in line with requirements of this manual, other NEMA and lead agencies requirements
3	Report Quality	>80% of monitoring report receives a score of 3.0 (see Annex of this section - Audit Reports Quality Scoring) This KPI is repeated in the environmental inspection section
4	Closure of findings/actions	>90% of findings closed in the timeframe agreed/stipulated in the monitoring report
5	Repeated non-compliances	<10% of repeated findings during the next environmental monitoring

3. Procedure (steps detailing process activities)

The following procedures must be followed to accomplish outcome of Audit process. Each step will lead to the logical next ste p unless otherwise indicated.

Activities, Steps, Description		Roles				Timeframe	Reference
Process Activity/	Description	NEMA	Laboratory	Company	Lead Agency		
Activity 1 - Preparatory Phase							
Step 1	Review annual environmental plan and identify an operator/facilities subject to environmental monitoring in the current year	X			X	0.5 day	• NEMA annual activity plan • NEMA environmental monitoring annual plan • NEMA list of petroleum facilities/operations subject to Authority led environmental audit
Step 2	Review EIA report and identify baseline parameters and measurable indicators for environmental monitoring	X			X	1 day	• EIA report of a petroleum facility or operations
Step 3	Define scope of environmental monitoring (parameters and performance indicators as provided in Vol 2 & 3 of this manual)	X			X	2 days	• Environmental monitoring plan (Form EM-1)
Step 4	Identify procedures for environmental monitoring (refer to Vol 2 & 3 of the manual)	X			X	2 days	• Environmental monitoring plan (Form EM-1)
Step 5	Define environmental monitoring team	X			X	1 day	• Environmental monitoring plan (Form EM-1)
Step 6	Draft environmental monitoring plan	X			X	5 days	• Environmental monitoring plan (Form EM-1)
Activity 2 - Execution Phase							

Step 1	Review previous environmental monitoring report prepared by operators	**X**			**X**	2 days	• Operator's Environmental Monitoring Report • Environmental Monitoring Compliance Checklist (Form EM-2)
Step 2	Review previous environmental monitoring reports prepared by NEMA and/or Lead Agency	**X**			**X**	2 days	• NEMA/Lead Agency Environmental Monitoring Report • Environmental Monitoring Compliance Checklist (Form EM-2)
Step 3	Execute field monitoring activities	**X**		**X**	**X**	Up to 1 week	• Environmental Monitoring Compliance Checklist (Form EM-2) • Sample procedure
Step 3.1	Set a start date, adjust all following dates to fit the monitoring schedule						
Step 3.2	Review locations, monitoring parameter lists and activities						
Step 3.3	Clearly mark the monitoring locations on site plans						
Step 3.4	Conduct (or supervise) the required sampling and analysis						
Step 3.5	Record any site remarks and observations						
Step 4	Deliver samples for analysis to dedicated laboratory for analysis	**X**	**X**		**X**	Up to 1 week	• Environmental Monitoring Compliance Checklist (Form EM-2) • Sample handling and transportation procedure
Activity 3- Reporting Phase							
Step 1	Review actual parameters (based on laboratory analysis) against the baseline parameters	**X**			**X**	3 days	• Environmental Monitoring Compliance Checklist (Form EM-2) • Laboratory analysis report
Step 2	Develop draft environmental monitoring report and submit to an operator	**X**		**X**	**X**	2 weeks from receipt of laboratory analysis report	• Environmental Monitoring Report (Form EM-3)
Step 3	Receive and decide on operator's feedback	**X**		**X**	**X**	2 weeks from receipt of report	• Environmental Monitoring Report (Form EM-3) • Comments/feedback from Operator

Step 4	Record findings and decide on appropriate course of actions	**X**			**X**		• Environmental Monitoring Report (Form EM-3) • Remediation action
Step 5	Communicate these actions to the operator for remediation	**X**		**X**	**X**		• Remediation actions • NEMA non-compliance database • NEMA web-site • NEMA environmental monitoring database
Step 6	Define period for next environmental monitoring/follow up environmental monitoring	**X**		**X**	**X**		• NEMA annual activity plan • NEMA environmental monitoring annual plan

4. Qualifications and Training

4.1 Qualifications

NEMA and/or lead agency personnel involved in the environmental monitoring process should satisfy the following minimum requirements:

- Bachelor's (or Master's Degree for higher level positions) in any of the following disciplines: Environmental Science, Natural Resource Management, Natural Science, Project Planning/Management, Monitoring & Evaluation, Statistics, Economics, or any other relevant field from a recognized institution.
- Knowledge of upstream, midstream and downstream petroleum industry,
- Knowledge on environmental impacts of petroleum operations,
- Knowledge of processes and procedures required to be utilised to execute environmental monitoring of petroleum facilities,
- Ability to develop work plans for monitoring unit,
- Ability to develop and coordinate reports using appropriate monitoring and evaluation equipment and methods,
- Willingness to travel for onsite inspections as needed,
- Experience with interpretation of outputs from monitoring equipment,
- Experience of interpretation of laboratory reports.

4.2 Training

- Degree (Bachelor's or higher) in any of the following disciplines: Environmental Science, Natural Resource Management, Natural Science, Project Planning/Management, Monitoring & Evaluation, Statistics, Economics, or any other relevant field from a recognized institution,
- Post-graduate qualification in the Environmental field,
- Course on Petroleum Industry Fundamentals, including Environmental Protection,
- Knowledge of Computer applications,
- Qualification of environmental inspector.

Appendixes

EM - Form 1 - Environmental Monitoring Plan Template

Note : This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Ref:
Date:

Name of authority	
Name of operator	
Name of project/facilities	
Location [physical, postal and GPS coordinates]	

Information about previous environmental monitoring:

Previous operator's environmental monitoring report:	
Previous NEMA/Lead Agency environmental monitoring report:	
Previous findings	
How findings were addressed	

Objectives of environmental monitoring:

- 1.
- 2.
- 3.

Environmental monitoring team:

State body:	Name, Title

Baseline parameters selected for environmental monitoring:

Parameter	Reference value

Monitoring locations:

Parameter	Location description

Sampling and analytical work plan:

A. Sampling frequency and parameters

Sampling locations are shown on Figure 1 and listed in Table 1. Samples are collected at each location [specify frequency, e.g., “once annually”, “in the spring and fall each year”] and tested for the field and laboratory parameters listed in Table 2.

B. Sample collection and handling

Samples will be collected in accordance with the procedures ____ in and for parameters analyzed in the laboratory will include one field duplicate per every twenty sample events (5%). Any deviations from the SOPs will be noted by field personnel and documented in the Environmental Monitoring Report.

C. Laboratory analysis and reporting

All samples will be analyzed by an accredited environmental laboratory designated by NEMA.

The laboratory will be required to provide a narrative report that includes:

- Date and time each analysis was completed (to verify holding times);
- Title of the analysis method used with reference;
- The percent recoveries of matrix spikes as specified in the analytical methodology;
- Corrections made for interferences, if any;
- Sample pre-treatments, if any; and

The laboratory report also will specify the detection limits of each procedure and the practical quantitation limits for each parameter. The analysts performing the work and the laboratory technical director will be required to certify the results.

Data validation

Upon receipt of the laboratory report, the results will be validated to ensure the data is reliable. The data will be deemed complete if:

- all analyses for a particular sample have been completed and the results reported in writing by those involved in the analyses; and
- all required sample documentation has been provided.

Other methods for data validation:

- 1.
- 2.
- 3.

FIGURE 1: site plan with sampling locations

(Include a copy of the site plan and identify locations for sampling)

Figure 2 Sampling Locations

Location ID	Type

Figure 3 - Detection Parameters

[This list is a starting point for development of a site-specific parameter list]

Laboratory parameter	Recommended Method	Reporting Limit

EM - Form 2 - Monitoring Compliance Checklist Template

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Environment Monitoring - Checklist			
Name of operator			
Name of project/facilities			
Location (postal, physical address and GPS coordinates)			
Name(s) of Inspector			
Signature(s)		**Date of Environmental Monitoring**	

Subject/Topic	**Ref.**	**Comment**	**YES**	**NO**	**Observation/Comment**
Baseline survey		Does EIA contain baseline survey and baseline parameters to be used for environmental monitoring?			
Previous Environmental Monitoring activities		Can it be demonstrated that the Operator carries out monitoring operations in line with approved Environmental Management Plan?			
		Does operator submit environmental monitoring reports to NEMA?			
		Does findings of previous NEMA/Lead agency environmental monitoring were addressed by an Operator?			
Environmental Monitoring		Does NEMA/Lead Authority led environmental monitoring plan contains all elements defined in Form EM1?			
		Has NEMA/Lead Authority environmental monitoring been executed in line with the plan?			
		Has NEMA/Lead Authority environmental monitoring report been prepared, reviewed and approved in line with SoP?			
		Have findings of NEMA/Lead Authority environmental monitoring report been communicated to an Operator and entered NEMA compliance database?			

EM - Form 3 - Environmental Monitoring Report Template

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Ref:
Date:

Name of authority	
Name of operator	
Name of project/facilities	
Location/address (postal, physical address and GPS coordinates)	
Date of implementation of proposed project	

Previous environmental monitoring:

Ref:	**Date & Name of previous monitoring report**	**Report findings**	**Actions taken**	**Results**
1				
2				
3				

Environmental parameters subject to current environmental monitoring:

Parameter	**Baseline value**

Results of current environmental monitoring:

Parameter:	**Reported Value/Limit**	**Compliant/Non-compliant**

Summary of Technical Findings:

Findings:	**Action required/Type of Action**	**Timeline for closing finding**	**Follow-up time**

Summary of a Non-Technical Findings, conclusions and recommendations

Findings:	**Action required/Type of Action**	**Timeline for closing finding**	**Follow-up time**

List of appendixes:

1.
2.
3.

Signature box:

For NEMA/Lead Agency	
Full Name and Title	
Signature	
For Operator:	
Full Name and Title	
Signature	

Methodology for Scoring Environmental Monitoring, Audit or Inspection Reports

An exceptional environmental monitoring, audit or inspection can be compromised by a poorly crafted and poorly written audit report. Reports must be of exceptional quality in order to both protect the integrity of the program and to assure that the true meaning of the findings and observations are understood by those who shall implement the corrective actions. In most organizations, audit reports receive one or more peer reviews. However, there often is no formal, overall quality assurance program for these reports, and there should be one.

The following ten criteria are to be used consistently in the evaluations over a five-year period:

- **Timeliness** – Was the report submitted on time? If late, how late?
- **Team Identified** – Was the activity team identified in the report?
- **Background** – Did the report include a facility description, activity scope, date, and duration of activity? Was sufficient background information provided?
- **Executive Summary** – Was an executive summary included? Was it concise (e.g., one to two pages) and focused on the right issues?
- **Protocols Used** – Did the report describe the activity protocols that were used by the team? Did the protocols cover company requirements and applicable requirements?
- **Findings Descriptions** – Were the findings well written and to the point? Did they accurately describe the actual deficiency?
- **Findings Citations** – For findings based on a deviation from corporate standards or regulations were the appropriate citations provided?
- **Findings Types** – Were the findings appropriately classified as regulatory, company standard, or other finding type? Did each classification make sense?
- **Findings Risk Levels** – Were the assigned risk levels for each finding appropriate based on the written description?
- **Recommendations** – Did the recommendations flow logically from the findings' descriptions? Was there a focus on both corrective and preventive actions?

For the evaluations, the criteria were entered onto the form shown in Table 3 below. The normalized score ranges from zero to 4.0 for each report; a scoring system that most people can relate to quite easily. This is a process that could be readily adapted in other organizations.

Annual Performance Metric: >80% of reports receive a score of >3.0 on a scale of 0 to 4.0.

Example of Report Scoring Protocol

Criteria	Score				
	0 Does not meet	1 Largely deficient/often does not meet	2 Generally meets	3 Meet substantially/ consistently	4 Meets fully/ universally
Timeliness					
Team identified					
Audit Background					
Executive Summary					
Protocols Used					
Findings Descriptions					
Findings Citations					
Findings Types					
Findings Risk Level					
Recommendations					
Total Score (max 40)					
Normalised Score (maximum 4.0)					

Section 3 - Environmental Audit (Control Audits) Process

1. Introduction

1.1 Purpose and Objective

Environmental audit is a systematic, documented, periodic and objective evaluation of how well environmental organisation, management and equipment are performing in conserving or preserving the environment.

The goals of an environmental audit are to assess the actual environmental impact, verify the accuracy of predictions, test the effectiveness of the environmental impact mitigation measures, and evaluate the functioning of the environmental monitoring mechanism.

A control audit shall be carried out by NEMA, whenever NEMA deems it necessary to check compliance with the environmental parameters set for the project or to verify self-auditing reports.

The objectives of the control audit include:

- A confirmation that the environmental management plan of the project is being adhered to;
- A verification of the adequacy of the environmental management plan in mitigating the negative impacts of a project.

1.2 Scope

Environmental audits are based on baseline data generated during the Environmental Impact Assessment (EIA) process and are intended to verify compliance with the project's environmental management plan, consider the effectiveness of programs in protecting the environment, evaluate the agencies' performance in monitoring, evaluating predictive tools, and identifying potential modifications to the EMP.

The environmental audit is driven by the audit plan developed by the operator in consultation with NEMA. The audit plan specifies the objectives, scope, and criteria of the audit, which includes the timeframe, organizational and functional units under audit, identification of personnel and business functions and responsibilities. The audit plan also specifies the contents of the audit report and its format.

Control audits are executed by NEMA. A control audit shall be carried out by the Authority whenever the Authority deems it's necessary:

- to check compliance with the environmental parameters set for the project or
- to verify self-auditing reports.

<u>**To check compliance with the environmental parameters set for the project – please follow the procedure for environmental monitoring stipulated in this manual (Volume 1 S.2)**</u>

<u>**To verify self-auditing reports - please follow the procedure stipulated in S. 2.12 of the NEMA SOP FOR COMPLIANCE AND ENFORCEMENT (No. NEMA/SOP/C&E/01-11).**</u>

Section 4 – Environmental Inspection Process

1. Introduction

1.1 Purpose and Objective

Environmental inspections are used by NEMA to identify cases of non-compliance by operators and to implement actions to bring the facilities back into compliance. Enforcement takes place through inspection orders, which include cessation orders, notice of improvement, etc.

The objectives of environmental inspections include:

- Identification of non-compliance,
- Correction of non-compliance,
- Identification of non-compliance trends on the industry and county level,
- Investigate complaints about a facility issued by stakeholders or government agencies.

1.2 Scope

Inspections provide an opportunity for NEMA officials to become familiar with the facilities on a first-hand basis. Initial planning for an inspection begins with a review of the files for a facility to evaluate compliance status.

Environmental inspections conducted by NEMA include a variety of activities on-site at the facility including:

- meetings with personnel and owners,
- review of all licenses and documents,
- a walk-through of the facility,
- observation of environmental management processes,
- and a preliminary review of the inspection findings.

Following the inspection, a formal inspection report is created that includes the inspection findings, describes any offenses, and presents any formal corrective actions needed.

NEMA identifies and schedules inspections into an annual inspection plan which is updated on a quarterly basis. Planning of inspections in the upstream sector is undertaken using a risk-based approach in conjunction with the consideration of other relevant factors. This approach is summarised in Appendix A to this section.

NEMA executes tree main types of inspections:

- **Integrated inspections** - inspections in which all environmental laws and rules including the environmental licence are checked applicable to petroleum company/facility.
- **Specific inspections** that may concern only a specific topic, such as for example the extent of soil pollution, or the inspection of a specific installation, such as, for example, the effluent treatment facilities.
- **"As needs" inspections** - inspections carried out on an 'as needs' basis, where information obtained indicates a more immediate need to inspect oil and gas facilities.

1.3 Roles and Responsibilities

NEMA coordinates inspections with the Head of the Inspection Section (HIS) identifying the facilities to be inspected on a quarterly basis. HIS identifies the team and team leader for all inspections. Team leaders coordinates the logistics of the inspection site visit and develops a pre-inspection workbook in preparation for the site visit.

Operators must provide the inspection team access to facilities, provide relevant licenses and documents for inspection, and allow inspectors to meet with relevant personnel at the facility. Following the inspection, operators should perform any requested modifications or provide responses to adequately close inspection findings.

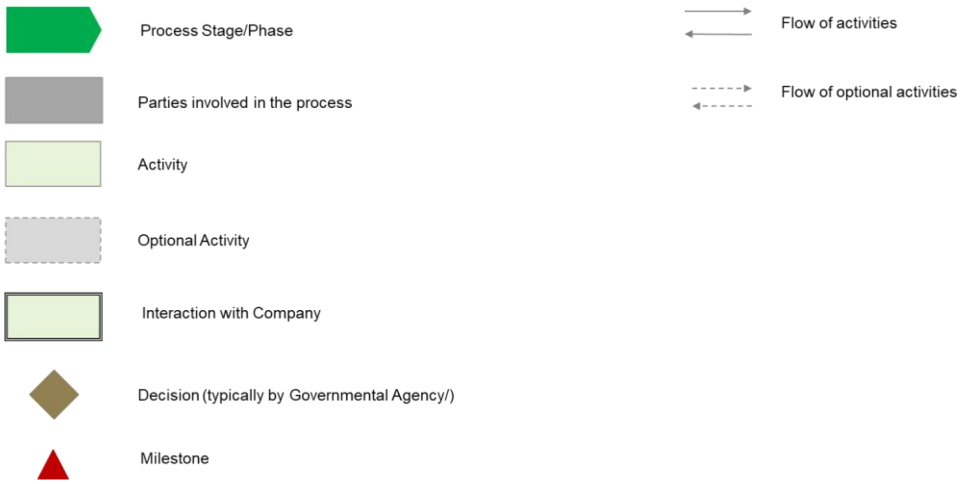
Inspectors have the rights to enter the land, premises, vessels, or motor vehicles related to inspections in order to evaluate compliance with the regulations and licenses.

NEMA is responsible for issuing any improvement orders for the carrying out of corrective measures for mitigating the environmental degradations revealed during any audit study. Improvement orders are based on suggestions from inspectors and reviewed by NEMA Compliance staff.

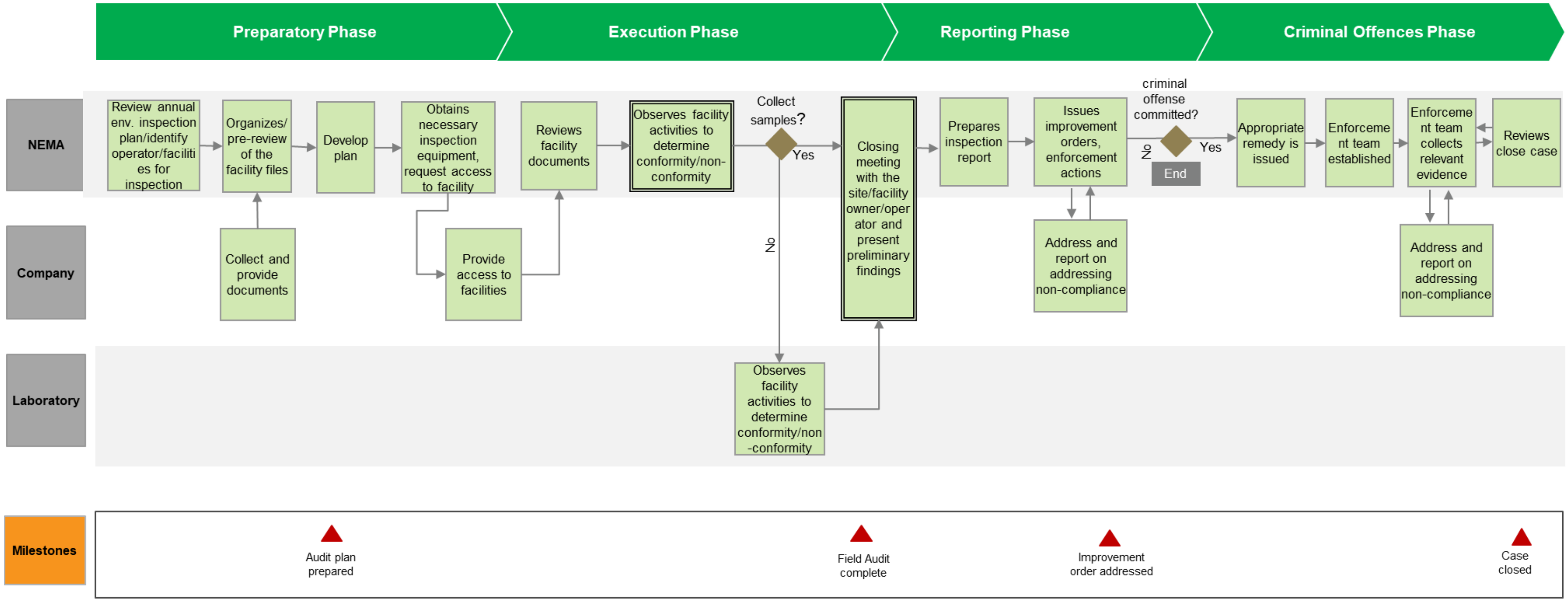
2. Process Mapping

2.1 Process Map

Process Map legend:



Environmental Inspection Process Map



2.3 Inputs

Input	Detail of Inputs and remarks	Ref.
Incident Register	• Register of Incidents as recorded by the Incident desk officer	• Developed and maintained by NEMA
Risk register of petroleum industry facilities	• A list of petroleum facilities and their list level (low, medium, high)	• Developed and maintained by NEMA
List of operators, contracts, facilities	• Include list of operators and contracts to be inspected	• Operator, contract list and status, including phase of operations (exploration, development, production) among others
Facilities File	• Includes all details on the facility.	• Will be compiled in a database of the
Environmental Management Plan	• A plan submitted as a part of the EIA license report. • Details the programs in place	
Environmental Audits Register	• A register is maintained by Head EA of all compliance letters.	
Environmental Monitoring Register	• A register is maintained by Head EA of all compliance letters.	
Copies of Licenses (EIA, Hazardous/Industrial Waste, waste transportation, effluent discharge)	Registers of licenses maintained by the relevant departments, HEIA/EO, HWMS, HWQS)	

2.4 Outputs

Output	Detail of Outputs and remarks	Ref.
Inspection Report	• Report detailing results of environmental inspection of petroleum operations/facilities	EI- Form 5
Enforcement Actions (Environmental restoration orders, notices, warning letters)	• Actions prescribed by NEMA in response to inspection findings	
Case File	• If criminal prosecution is deemed appropriate, a case file will be developed and forwarded to DLS.	

2.5 Tools, Forms and Templates

2.4.1 Tools

The following tools shall be used in the inspection process:

- Testing equipment
- Compliance documents/register
- Glossary
- Incident Register
- Inspection manual

2.4.2 Forms and Templates

The following templates shall be used in the environmental inspection process:

Form & template	Objectives	Usage
EI - Form 1, Annual Inspection Schedule of Petroleum Facilities	• Provides a list of planned inspection of petroleum operations. Build on the risk-based approach	• Used for inspection planning purpose
EI – Form 2a, Pre-inspection checklist for inspectorate **EI – Form 2b, Pre-inspection checklist for inspectors**	• Provides for a checklist for inspection	• Used for inspection planning purpose
EI – Form 3, Inspection Plan	• Developed by inspection team leader and reviewed by HIS	• Used for inspection planning purpose
EI – Form 4, Field Inspection Checklist	• Provides for a checklist for field inspection	• Used during the course of inspection
EI – Form 5, Inspector 's Workbook	• File on site inspection	• Used during the course of inspection
EI – Form 6, Inspection Report	• Report of the inspection of petroleum industry facilities	• Used after site visit inspection complete
EI – Form 7, Inspection Follow Up Checklist	• Provides a template to record how inspection non-compliances/findings were closed and if a follow up inspection is required	• Used after inspection report is issued

2.6 Metrics (KPIs)

The following KPIs shall be used in evaluating effectiveness and efficiency of the environmental inspection process:

- **Internal KPIs:**

No	KPI	Metric
1	Completion of environmental inspections	>85% of annually scheduled activities (carried out by NEMA) are completed on time (according with an annual inspection plan and timeframe defined in this manual)
2	Inspectors executing environmental inspections	>80% of personnel engaged in preparation, execution and monitoring of environmental inspections are trained in line with requirements of this manual
3	Report Quality	>80% of inspection report receives a score of 3.0
4	Closure of inspection findings/actions	>90% of findings closed in the timeframe agreed/stipulated in the inspection report
5	Repeated non-compliances	<10% of repeated findings during the next environmental inspection

3. Procedure (steps detailing process activities)

The following procedures must be followed to accomplish outcome of Audit process. Each step will lead to the logical next step un less otherwise indicated.

Activities, Steps, Description		Roles			Timeframe	Reference
Process Activity/	Description	NEMA	Inspected Company	Laboratory		
Activity 1 – Inspection Preparation						
Step 1	Review annual environmental inspection plan and identify an operator/facilities subject to environmental inspection in the current year	X			0.5 day	• NEMA annual activity plan • NEMA environmental inspection annual plan • NEMA list of petroleum facilities/operations subject to Authority led environmental audit • Risk register of petroleum industry facilities
Step 2	Develop inspection schedule	X			2 days	• Schedule shall be sufficient to allow getting access to the facility and all other actions
Step 3	Identify inspection team members & appoint inspection Team Leader	X			3 days	• Site inspectors shall be accredited by NEMA
Step 4	Organizes and pre-review of the facility files	X			5 days	• File can comprise of all the necessary information maintained by NEMA related to the facility that is subject to inspection
Step 5	Develop an inspection plan that covers inspection purpose, scope	X			5 days	• Develop a robust plan for inspection execution
Step 6	Develop inspection workbook/pre-inspection checklist	X				• Checklist to assist with execution of inspection activities
Step 7	Identify and obtains necessary inspection equipment	X			3 days	
Activity 2 - Inspection Execution						

Step 8	Obtains access to facility for inspection	X	X			
Step 9	If access not granted, warning letter is issued to facility, which includes request for explanation of denial of access.	X	X			
Step 10	Explain the scope and purpose of the inspection to facility management and employees	X	X			• Share inspection plan
Step 11	Inspection team reviews facility documents for compliance	X				
Step 12	Inspection team makes walk-through inspection of facility.	X				
Step 13	Inspection team observes facility activities to determine conformity/non-conformity with environmental management practices.	X				
Step 14	Inspection team has closing meeting with the site/facility owner/operator and present preliminary findings	X	X			
Activity 3 - Reporting						
Step 15	Team leader prepares an inspection report	X				
Step 16	Team leader prepares and issues improvement orders, where necessary.	X				
Step 17	Team Leader issues appropriate enforcement actions, if warranted.	X				
Step 18	Enter all enforcement actions into a database to monitor action closure by petroleum operators	X				
Step 19	HIS discusses with CEO appropriate follow-up enforcement actions.	X				

Activity 4- Criminal Offences						
Step 20	CEO determine if criminal offense has been committed.	**X**				
Step 21	If criminal offense committed, the appropriate remedy is issued.					
Step 22	CEO develops an enforcement team (HIS, inspection team, HPU)					
Step 23	Enforcement team collects relevant evidence					
Step 24	Enforcement team compiles case file					
Step 25	Case file is presented to DCE and/or DDE for decision-making					
Step 26	If case file is adequate, DCE forwards case file to DLS for action					
Step 27	If not adequate, enforcement team must revise					

4. Qualifications and Training

4.1 Qualifications

Inspection team will be developed prior to inspections by the Inspection Section. Only NEMA qualified inspection may take part in the onsite inspection of petroleum facilities.

Inspectors must have the following:

- Bachelor's (or Master's Degree for higher level positions) in any of the following disciplines: Environmental Science, Natural Resource Management, Natural Science, Project Planning/Management, Monitoring & Evaluation, Statistics, Economics, or any other relevant field from a recognized institution.
- To be a gazetted inspector
- Knowledge of upstream, midstream and downstream petroleum industry.
- Knowledge on environmental impacts of petroleum operations.
- Familiarity with the relevant Kenyan regulations (I.e., EMCA, air quality regulations, waste regulations, etc.)
- Training in environmental impact assessments and/or auditing/inspections
- Be comfortable working in an industrial or outdoor setting, including areas where field activities will take place.
- Ability to write detailed inspection summaries and reports on technical and environmental matters
- Knowledge of sampling and monitoring techniques and specifically these stipulated in this manual

The personnel should also ideally demonstrate the following skill sets

- Attention to detail and quality control
- Ability to work in a team with related agencies, operators, and vendors
- Ability to communicate well in foreign languages especially priority languages
- Ability to manage multiple stakeholders

4.2 Training

Training curriculum is designed around key qualification requirements:

- Obtain oil and gas industry certifications as needed
- Petroleum technical knowledge
- Finance, accounting and auditing knowledge
- Language knowledge

Appendixes

Appendix A – Risk Based approach to planning and executing environmental inspections of petroleum facilities

NEMA scopes, schedules and conducts inspections of petroleum industry facilities using a risk-based methodology that considers the following factors:

- relevant risk factors
- previous performance and compliance history, informed by inspections, investigations, incident history and other environmental and safety performance factors
- industry incident trends
- responses to recommendations from previous inspections.

This risk-based approach has allowed NEMA to establish the following guiding targets for inspection frequency as outlined in the Table below:

Inspection category	Definition	Target
New petroleum right holders	Inspections specific to a right holder with limited or no experience in undertaking an activity in Kenya and who may be undertaking a petroleum activity for the first time.	1. All new rightsholders undertaking an exploration or development activity - frequency: • At least once prior to or during the first activity.
Development activities	Activities that involve the production of hydrocarbons (including construction, installation, commissioning and decommissioning stages), and may include onshore processing facilities, offshore fixed platforms floating facilities, pipelines and associated infrastructure.	2(a) All rightsholders undertaking a development activity involving the production of oil and gas - frequency: • At least once in a 12-month period. 2(b) Opportunistically, as informed by the risk-based approach outlined in this section, for all other development activities not inspected under target 2(a).
Drilling activities	Inspection of production and exploration drilling activities.	3(a) All rightsholders undertaking drilling activities-frequency: • Prior to or during the activity. 3(b) Opportunistically, as informed by the risk-based approach outlined in this section, for all other drilling activities not inspected under target 3(a)
Seismic and other surveys	Inspection of survey activities that involve the acquisition of geophysical / geotechnical data using acoustic energy.	4(a) All rightsholders undertaking a seismic activity that overlaps habitat critical to survival or biologically important areas during an important life cycle stage for migratory or threatened species - frequency: • At least once prior to or during the activity. 4(b) All titleholders undertaking seismic activities where specific controls, as defined in an accepted environmental management plan, are required to manage interactions with a particular socioeconomic value or sensitivity - frequency: • At least once prior to or during the activity. 4(c) Opportunistically, as informed by the risk-based approach outlined in this section, for all other survey activities that are not inspected under targets 4(a) or 4(b).

EI - Form 1, Annual Inspection Schedule of Petroleum Facilities

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Developed by:
Revision:
Date:

Petroleum sector	Phase	Company Name/Operator	Facility/Project Title	Location (onshore/offshore)	Risk level (high, medium, low)	Last inspection date	20 _ _ year											
							Jan	Feb	Mar	Apr	Jun	Jul	Aug	Sep	Oct	Nov	Dec	comments
Upstream																		
	Exploration																	
	Development																	
	Production																	
Midstream																		
Downstream																		

Name:
Signature:

In developing an annual inspection plan the following priorities shall be taken into account.

- number of inspections identified to be required;
- number of complaints;
- polluting capability or risk caused by an installation;
- emission type (single media inspection);
- recipient type - air, soil, water;
- branch or installation type;
- geographical area;
- intensity of natural resources used;
- season of the year;
- availability of Environmental (or other) Management System;
- operator self-monitoring;
- other inspection programmes, like the co-operation with other inspection
- programmes of other authorities (national monitoring programmes;
- programmes on voluntary agreements or other environmental contracts);
- agreements/conventions in Africa or other (inter)national governments;
- special (or new) environmental laws;
- information about changes, supplied by the installation;
- environmental performance;
- environmental contracts.

EI – Form 2a, Pre-inspection checklist for inspectorate

Note : This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Environment Inspection – Checklist for Inspectorate			
Name of operator			
Name of project/facilities			
Location (postal, physical and GPS coordinates)			
Name(s)/title of NEMA personnel who completed the checklist			
Signature(s)		**Date**	

Question **Source of information**		**YES**	**NO**	**Observation/Comment**
Do you have an overview of petroleum facilities and operation? If yes, it was compiled by/information collected by				
1	from the Ministry of Petroleum, Energy and Petroleum Regulatory Authority, other state bodies			
2	from the register of the county government			
3	Other, if any			
Is the information verified? If so, the date of the last update is noted, and the following of the listed methods were used				
1	a location survey (drive by visit to all the companies registered)			
2	visiting (actually entering the facility premises) all facilities to match the petroleum operations against the registered data			
3	sending a letter to the facility, in which an overview of the present activities or an upgrade of the details is requested			
Is an update required of the available information? If so, because				
1	the owner of the potential polluting facility provided information about changes in processes or equipment			
2	revision works were completed, and a facility starts operating according to a revised licence			
3	an (environmental) accident happened			
4	complaints were received or a situation of non-compliance is suspected			
5	a regular visit was carried out by an inspector			
6	a follow up visit is required			
Were priorities for inspection set? If so, by using the following criteria				
1	polluting capability or risk			
2	emission type (single media inspection)			
3	recipient type - air, soil, water			
4	branch or installation type			
5	geographical area			
6	number of complaints			
7	natural resources consuming criteria			
8	season of the year			
9	availability of Environmental Management System in relation to quality and/or health and safety management system			
10	other inspection programmes, agreements / conventions: EC / international / county government, branch, special environmental laws, special subjects (air, soil, water, energy, waste, risks)			
11	notifications by the polluter			
12	former non-compliance			
13	specific / integral			
14	inspection themes			

EI – Form 2b, Pre-inspection checklist for inspector

Note : This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Environment Inspection – Checklist for Inspector			
Name of operator			
Name of project/facilities			
Location(Postal, physical & GPS coordinates)			
Name(s)/title of NEMA personnel who completed the checklist			
Signature(s)		**Date**	

Question **Source of information**		**YES**	**NO**	**Observation/Comment**
Did you check the completeness of the facility dossier? If so, check:				
1	Licence(s) of the facility and details of the conditions, application procedure, including operator self monitoring programme, EMAS etc and reports from the operator to NEMA			
2	Up to date information about petroleum best industry practices			
3	New Kenya environmental regulations, standards, guidelines that are of importance to the facility			
4	Technical drawings of the facility			
5	Map of the facility premises			
6	Descriptions of eventual new processes, expansions, modifications etc. in the facility that have been subjected to recent change (this should have resulted in issuing a revised licence)			
7	Diagrams of the processes in the facility			
8	Reports, letters, notifications etc. from previous inspections			
9	Notices sent to the facility (depending on the character of the on-site visit (announced versus unannounced))			
10	Seasonal influences that are of importance for the outcome of the visit			
11	Essential environmental facts			
12	Incidents which have taken place in the past			
13	Earlier infringements			
14	Aspects of the facility's operations which have not been thoroughly investigated and approved during a previous inspection			
15	Notifications of environmental incidents			
16	Research reports or environmental reports			
Did you co-ordinate your activities with other (non environmental) inspectors. If so, by				
1	Deciding whether the inspection will have an integrated or a single media character			
2	Contacting other lead agencies to find out which facilities in their juridical area they will inspect in the near future. Ask them to send a list of those facilities			
3	Sending those lists to the officers of other lead agencies (e.g. the water quality board) to find out which facilities have an adequate licence			
4	Trying to find out whether some facilities will be visited by more inspectors within short notice. Try to plan the on-site visit together with them			
5	Contacting the police-officer(s) or other state bodies/representative in charge of environmental affairs and the			

	public prosecutor to know about complaints of the public, former prosecutions, sentences, reports etc.			
6	Having meetings with the above-mentioned inspectors			
7	You are accompanied by a colleague (in case of a serious incident). This in order to collect corroborated legal evidence (if necessary) and to question a person simultaneously			
Which of the listed inspection tools are needed for the site visit?				
1	Checklists (either site-specific or branch specific)			
2	Information to hand out, e.g. about the inspectorate and the Ministry of Environment etc.			
3	Information on the regulations on the items of inspection			
4	Laptop computer			
5	Inquiry forms			
6	The licence of the facility and details of the application procedure			
7	Technical drawings of the premises and the plant Process diagrams			
8	Reports and letters, etc. from previous inspections			
9	Notices sent to facility			
10	Equipment to take samples of the soil, air-emissions noise-emissions etc.			
11	Mobile phone (permission might be needed to take the phone during certain parts of the visit)			
12	Photo camera			
13	Personal protection equipment: safety glasses safety shoes/boots special clothing safety gloves safety helmet overall ear protection face protection			
14	Other items			

EI – Form 3, Inspection Plan

Note : This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Ref:
Date:

Name of authority	
Name of operator	
Name of project/facilities	
Location **(Postal, physical & GPS coordinates)**	

Inspection Purpose:

No	Details of Inspection Purpose and what is to be accomplished
1	
2	
3	
4	

Inspection Scope:

No	Details of Inspection Scope: identifies the functional areas, assessment topics, and level of inspection.
1	
2	
3	
4	

Inspection Team:

No	Team member name, title and qualification
1	
2	
3	
4	

Inspection Schedule:

No	Activity	Timeframe
1		
2		
3		
4		

Inspection procedures and associated rationales:

No	procedure

Field and analytic techniques will be used to collect what information (select specific procedure appropriate to the scope of inspection from Volume 2 & 3 of the manual)	
1	
2	
3	
4	
Recordkeeping systems will be reviewed (What records, files, licences will be inspected)?	
1	
2	
3	
4	
Personnel to be interviewed (specify relevant positions and scope of responsibility)	
1	
2	
3	
4	
Samples to be collected (select specific procedure appropriate to the scope of inspection from Volume 2 & 3 of the manual)	
1	
2	
3	
4	
What co-ordination with laboratories, other State or local authorities is required?	
1	
2	
3	

Evidences to be collected:

No	Details of evidences to be collected
1	
2	
3	
4	

Safety contingency plan, where required:

No	Detail contingency plan actions
1	
2	
3	
4	

Report prepared by: ______________________

Report signed off by: ________________

Date:

Date:

EI – Form 4, Field Inspection Checklist

Note : This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Environment Inspection – Checklist for Inspector			
Name of operator			
Name of project/facilities			
Location (Postal, physical & GPS coordinates)			
Name(s)/title of NEMA personnel who completed the checklist			
Signature(s)		**Date**	

Question **Source of information**		**YES**	**NO**	**Observation/ Comment**
What character will the inspection have (integrated versus single medium)?				
1	an integrated inspection will be executed			
2	a single medium (air, water, solid wastes etc.) inspection will be executed			
3	a specific target inspection (targeting specific facilities/equipment on petroleum facility)			
In case of a single medium inspection, which of the following media are you going to inspect?				
1	water			
2	Soil			
3	Air			
4	waste			
5	noise			
6	hazardous waste			
7	radiation			
Which of the following aspects will be included in your inspection?				
1	the environmental media			
2	the environmental equipment			
3	the administration and the log books			
Is the visit a routine site inspection? If so, make sure that				
1	the responsible contact at the location is notified			
2	the purpose and the procedure of the inspection is explained			
Did you ensure that the licence of the facility is matched against the actual situation? If so, check the following				
1	environmental provisions are present in the licence			
2	the provisions are well maintained			
3	the provisions are properly used			
4	the staff follows the instructions included in the licence			
5	the log books and administrative records (stated in the licence) are up to date			
6	is there compliance with the provisions of the license			
7	the required periodic tests have been carried out, and the results are……………………………			
Are you taking samples and do you carry out measurements? If so, which samples were taken				

1	discharged waste water			
2	soil			
3	Air			
4	waste materials			
5	other media / substances			
6	emissions			
7	noise			
8	radiation			
Are you familiar with the options that are available for immediate action? If so, which of the following options was used				
1	shut down (parts of) the process			
2	sealing of (parts of) the process or specific equipment			
3	other			
Did you ensure that the operator is in compliance with the self-monitoring programme?				
Did you co-operate with other authorities involved?				
Is the inspection a response to a pollution incident? If so, make sure that				
1	the visit is co-ordinated with the emergency services			
2	the facility's responsible person is present			
3	the purpose of the visit is explained			
4	the site contact and other site operators / staff are questioned in order to establish the exact details of on-site operations and potential problems which might have resulted in the incident			
5	you are accompanied by a colleague (in case of a serious incident). This is in order to collect corroborated legal evidence (if necessary) and to question a person simultaneously			
6	all relevant areas of the process site are inspected. This must be the case unless the inspector must follow the site safety requirements			
7	the contact person is given the opportunity to accompany the inspector on the inspection (in some large process sites etc. the inspector should not enter the site unless accompanied by a site representative)			
8	appropriate samples of discharges etc. are taken (if necessary as legal samples in accordance with the legal procedures) for use as evidence			
9	all statements made by the contact person are written down			
10	appropriate photographs or video recordings are made as information or as evidence			
11	information and advice is given to the site operator (if appropriate) regarding action which may stop an ongoing incident, prevent a recurrence, or remedy damage caused (In some circumstances the inspector may strongly recommend or insist that certain action is taken to stop an incident and / or prevent further pollution).			
	the site contact/management is aware of any further action required on their part, and of further action, before leaving the site			
Which of the listed items should be available at completion of the on-site visit?				

1	a summary of inspection results including a list of infringements and noncompliance items, as well as a list of positive observations / improvements			
2	a summary of required actions and measures, including time limits to improve the situation. (It is essential that the facility gains insight in the legal consequences of its environmental behaviour and possible follow-up actions)			
3	a list with the consequences of repeated non-compliance in case of a follow-up inspection (e.g. proposed fines).(It is essential that the facility gains insight in the legal consequences of its environmental behaviour and possible follow-up actions).			
4	additional information on possibilities to implement cleaner technology / waste minimising techniques / precautionary activities and / or the provision of information on self-monitoring possibilities and related items?			
5	the official inspection report (The report can vary from a point by point indication whether a regulation in the licence is met, to a full report including all the steps taken).			

EI – Form 5, Inspector Workbook (Field Notes)

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

(These notes may be subject to discovery and disclosed to the opposing side and may be entered as evidence in a trial.)

N.B. this workbook shall contain accurate and inclusive documentation of all inspection activities.
For detailed form please see form RP-Form 1

Indicative Content of the Workbook:

- **Documents;**
- **Unusual Conditions and Problems;**
- **Interview Notes;**
- **General Information;**
- **Other Incidents; Administrative Data.**

EI – Form 6, Inspection Report

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Inspection reports should contain only the facts about the inspection. The report to the inspection management should be objective and complete

Ref:
Date:

Name of authority	
Name of operator	
Name of project/facilities	
Location postal, physical address and GPS coordinates)	

1. Introduction

1.1 General information:
- purpose of the inspection
- participants in the inspection

1.2 Summary of Findings:
- brief summary of the inspection findings
- names and titles of facility officials interviewed

1.3 History of Facility
- status of the facility
- size of the organisation
- related firms, subsidiaries, branches, etc.
- type of operations performed at the facility under inspection

2. Inspection Activities

2.1 Opening Meeting:
- procedures used at arrival, including presentation of credentials and written Notice of Inspection (the latter only if required)
- special problems or observations if there was reluctance on the part of facility officials to give consent, or if consent was withdrawn or denied
- topics discussed during the opening meeting; what is the inspector's objective?

2.2 Records
- types of records reviewed
- any inadequacies in record-keeping procedures, or if any required information was unavailable or incomplete
- note if record-keeping requirements were being met

2.3 Evidence Collection
- statements taken during the inspection
- photographs taken during the inspection
- drawings, maps, charts, or other documents made or taken during the inspection

2.4 Physical Samples
- purpose for which samples were obtained
- exact location from which they were obtained
- sampling techniques used
- physical aspects of the sample

- custody procedures used in sample handling
- results of laboratory analysis

2.5 Closing Meeting

- receipts for samples and documents given to facility officials
- procedures taken to confirm claims of confidentiality
- recommendations made to facility officials

3. Attachments

3.1 List of Attachments

- list of all documents, analytical results, photographs, and other supporting information attached to the report

3.2 Documents

- copies of all documents and other evidence collected during the inspection. All documents should be clearly identified.

3.3 Analytical Results

- sample data and quality assurance data

Report prepared by: ______________________	Report signed off by: ________________
Date:	Date:

EI – Form 7, Inspection Follow Up Checklist

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Ref:
Date:

Name of authority	
Name of operator	
Name of project/facilities	
Location (postal, physical address and GPS coordinates)	
Inspection report Number	

Findings:

Finding/non-compliance description (as stated in the inspection report)	**Measures taken by petroleum company to address non-compliance/finding**	**Evidence provided by petroleum company/finding**	**Finding closed? Yes/No**
Further inspection required?			

Checklist prepared by: ______________________

Date:

Checklist signed off by: ________________

Date:

Volume 2

The purpose of Volume 2 of this manual is to document detailed sub-processes and procedures that are an integral part of environmental monitoring and environmental inspection processes and to provide further guidance to NEMA personnel in planning, execution and reporting results of environmental monitoring and environmental inspections of petroleum industry facilities.

S. 1 - Sample collection and processing

1. Introduction

Kenya regulation requires companies conducting petroleum operations to meet certain maximum levels of pollutants released to the environment through air emissions, water effluents, and waste, as well as to ensure that measurement of such emissions is conducted in accordance with test methods established in local legislation.[1] NEMA has a duty to verify compliance with the aforementioned requirements and to conduct environmental monitoring to determine actual and potential effects of petroleum operations on the environment.

1.1 Purpose and Objective

This section establishes a process and a procedure, as part of the environmental monitoring process, for NEMA and lead agencies to execute sample collection and processing to verify compliance with environmental standards and to ensure true and objective results.

NOTE: This process is a sub-process of either an environmental monitoring or inspection process and shall be read in conjunction with the processes' description stipulated in Volume 1 S. 2 and 4 of this manual.

1.2 Scope

This section provides for a clear guidance to NEMA personnel and the personnel of other lead agencies, where engaged, on how to take samples and process data on:

- air emissions,
- liquid effluents,
- and soil.

generated by companies operating in the up-, mid-, and downstream sectors of petroleum industry. It is based on Kenyan legislation and guidelines, as well as on best international practices.

1.3 Roles and Responsibilities

Sampling of air emissions, effluents, and waste generated by oil and gas facilities require the participation of a number of stakeholders. These include specifically:

- **NEMA HIS**: Head Inspectorate Section:
- **NEMA IT**: Inspection Team
- **NEMA TL**: Team Leader
- **NEMA DCE**: Director of Compliance and Enforcement
- Lead agencies
- NEMA designated laboratories
- Petroleum Company (operating in the up-, mid-, and downstream sectors of the petroleum industry)

[1] The Environmental Management and Coordination (Air Quality) Regulations, 2009 §§ 8(1), 52(1); The Environmental Management and Coordination (Water Quality) Regulations, 2006 §§11-14.

2. Process Mapping and Procedure

2.1 Inputs

Input	Detail of Inputs and remarks	Ref.
NEMA Inspection or Monitoring Schedule	Annual and Quarterly inspection or monitoring schedule developed by HIS	• NEMA, *Standard Operating Procedure for Compliance and Enforcement*, § 2.6.3. • EI - Form 1, Annual Inspection Schedule of Petroleum Facilities of this Manual
Documents in support of license application	Documents on the characteristics of effluents discharged from a facility, and on the facility's infrastructure, equipment used for sampling.	• The Environmental Management and Coordination (Air Quality) Regulations, 2009, §§ 61-64; • The Environmental Management and Coordination (Water Quality) Regulations, 2006, § 16.
Initial emissions assessment report(*)	Report submitted to NEMA by company on facility emissions and best available technology.	• The Environmental Management and Coordination (Air Quality) Regulations, 2009, § 66(a).
Emissions/effluents monitoring report (EMR)	Emissions/effluents monitoring report developed by company and submitted to NEMA quarterly	• The Environmental Management and Coordination (Air Quality) Regulations, 2009, §§ 65(1), 68(1); • The Environmental Management and Coordination (Water Quality) Regulations, 2006, § 14.
NEMA's response to EMR	NEMA's written feedback on EMR.	• The Environmental Management and Coordination (Air Quality) Regulations, 2009, § 68(1); The Environmental Management and Coordination (Water Quality) Regulations, 2006, § 15.
Reports on contingencies	If applicable, atmospheric impact report, malfunctions report, and emission limit exceedance report.	• The Environmental Management and Coordination (Air Quality) Regulations, 2009, §§ 67(1), 69(1).
Environmental monitoring plan	Provides a detailed plan for environmental monitoring of specific petroleum operations/facilities	• Form EM1 - Environmental Monitoring Plan Template (Vol 1, S. 2 of the Manual)
Environmental Inspection plan	Provides a detailed plan for environmental monitoring of specific petroleum operations/facilities	• Form EI3, Inspection Plan Template (Vol 1, S. 3 of the Manual)
Sampling Strategy Template	General outline of the plan for sampling operations, including, objective, scope, action, equipment, roles, among others	• Sampling and processing form 1
Sampling protocol	Document provided by corresponding laboratory detailing steps to collect, handle, store, and transport samples[2].	

(*) Applicable only to sampling of air emissions.

[2] Certified laboratories are required to determine the sampling procedure as they vary depending on the analytical methods the laboratory will use to analyze specific parameters. .

2.2 Outputs

Output	Detail of Inputs and remarks	Ref.
Sampling strategy	Document detailing plan for sampling operations, including, objective, scope, action, equipment, roles, among others.	• Sampling and processing form 1
Test Report	Report detailing action taken during sampling and obtained results.	• Fifth Schedule, Part XIII, The Environmental Management and Coordination (Air Quality) Regulations; • Sixth Schedule of Environmental Management and Coordination (Water Quality) Regulations.

2.3 Tools, Forms and Templates

2.3.1 Tools

- Document checklist
- Action checklist
- Equipment checklist
- Applicable sampling protocol
- Chain of custody record

2.3.2 Forms and Templates

The following templates shall be used in the sampling process:

Form & template	Objectives	Usage
Form SCP 1 - Model Checklist for planning and implementation of sampling	The checklist provides assistance in planning and implementation of sampling. Checklists help to ensure that the sampling is conducted in a systematic and comprehensive manner, and the proper evidence and documentation are obtained.	Documents, actions, and equipment.
Form SCP 2 - Model Sampling Strategy	Documenting planning of sampling activities.	Preparation for sampling.
Form SCP 3.1- Air Emissions Test Report	Reporting results in standardized manner, in accordance with Kenyan regulation.	Report used for results of air emissions sampling and analysis.
Form SCP 3.2- Effluents Test Report	Reporting results in standardized manner, in accordance with Kenyan regulation.	Report used for results of sampling and analysis of discharged treated effluents.
Form SCP 3.3 - Model Soil Test Report	Reporting results in standardized manner, in accordance with Kenyan regulation.	Report used for results of soil sampling and analysis.
Form SCP 4- Chain of Custody Record	Verification of integrity of sample management.	Verification of identity of people handling samples.

2.4 *Procedure (steps detailing process activities)*

The following procedures must be followed to accomplish the required outcome of the Audit , Inspection or Monitoring process. Each step will lead to the logical next step unless otherwise indicated.

Activities, Steps, Description		Roles						Reference
Process Activity/	**Description**	**HIS**	**Team Leader**	**Inspection Team**	**DCE**	**Company**	**Laboratory**	
Step 1	Prepare and coordinate inspection/monitoring plan for planned inspections/monitoring activities on quarterly basis.	X						Form EM1 - Environmental Monitoring Plan Template (Vol 1, S. 2 of the Manual) Form EI3, Inspection Plan Template (Vol 1, S. 3 of the Manual)
Step 2	Appointment of inspection team and team leader.	X						
Step 3	Determine specific facility subject to inspection/monitoring based on inspection schedule developed by HIS.	X	X	X				
Step 4	Revise documents on emissions/effluents, generated by facility to be inspected or baseline parameter to be monitored		X	X				**Documents:** • Documents submitted with license application on the characteristics of effluents discharged from a facility, and on the facility's infrastructure, equipment used for sampling. • Initial emissions assessment report (*) • Quarterly effluents/emissions monitoring report (EMR) • NEMA's response to EMR • Reports on contingencies
Step 5	Develop specific sample strategy		X	X				See appendix 2.1.3 below.
5.1	Determination of objective, scope and sample size		X					For further guidance see: Environment Canada's "The Inspector's Field Sampling Manual, Second Edition (2005)". http://publications.gc.ca/collections/Collection-R/En40-498-2005-1E.pdf

								For further guidance on air emissions sampling see: • BS EN 15259:2007 Air quality. Measurement of stationary source emissions. Requirements for measurement sections and sites and for the measurement objective, plan and report • Applicable standards listed in Eleventh Schedule of the Environmental Management and Coordination (Air Quality) Regulations. For further guidance on effluents sampling see: • Chapter 5 of US EPA's, NPDES Compliance Inspection Manual (2017), https://www.epa.gov/sites/production/files/2017-01/documents/npdesinspect.pdf • Part D of British Columbia's Field Sampling Manual (2013), https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual For further guidance on soil sampling see: • *Alberta Environmental Site Assessment Standard* (2016), https://open.alberta.ca/dataset/3acc7cff-8c50-44e8-8a33-f4b710d9859a/resource/579321b7-5b66-4022-9796-31b1ad094635/download/environmentsiteassessstandard-mar01-2016.pdf • Canadian Council of Ministers of the Environment, *Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment,* Volume 1 (2016), https://www.ccme.ca/en/files/Resources/csm/Volume%201-Guidance%20Manual-Environmental%20Site%20Characterization_e%20PN%201551.pdf • State of Washington, *Guidance for Remediation of Petroleum Contaminated Sites* (2016), https://fortress.wa.gov/ecy/publications/documents/1009057.pdf

5.2	Identify and select NEMA designated laboratory(ies) to analyze specific parameters within scope of sampling.		**X**				**X**	NEMA designated list of laboratories:
5.3	Identify and select sampling protocol, based on substances and parameters established in scope.		**X**				**X**	For further guidance see: Environment Canada's "The Inspector's Field Sampling Manual, Second Edition (2005)". For further guidance on air emissions sampling see: • EPA Victoria's "A Guide to the Sampling and Analysis of Air Emissions and Air Quality (2002)"; or • Applicable standards listed in Eleventh Schedule of the Environmental Management and Coordination (Air Quality) Regulations. For further guidance on effluents sampling see: • Chapter 5 of US EPA's, NPDES Compliance Inspection Manual (2017), https://www.epa.gov/sites/production/files/2017-01/documents/npdesinspect.pdf • Part D of British Columbia's Field Sampling Manual (2013), https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual • Environment Canada's "The Inspector's Field Sampling Manual, Second Edition (2005)", http://publications.gc.ca/collections/Collection-R/En40-498-2005-1E.pdf For further guidance on soil sampling see: • *Alberta Environmental Site Assessment Standard* (2016), https://open.alberta.ca/dataset/3acc7cff-8c50-44e8-8a33-f4b710d9859a/resource/579321b7-5b66-4022-9796-31b1ad094635/download/environmentsiteassessstandard-mar01-2016.pdf • Canadian Council of Ministers of the Environment, *Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment,* Volume 1 (2016),

								https://www.ccme.ca/en/files/Resources/csm/Volume%201-Guidance%20Manual-Environmental%20Site%20Characterization_e%20PN%201551.pdf • State of Washington, *Guidance for Remediation of Petroleum Contaminated Sites* (2016), https://fortress.wa.gov/ecy/publications/documents/1009057.pdf • US EPA, *Soil Sampling Operating Procedure* (2014), https://www.epa.gov/sites/production/files/2015-06/documents/Soil-Sampling.pdf
5.3.1	Determine equipment required for sampling, which shall i consider: • • Why and how will the equipment be used • What are the performance characteristics of the instruments • Are there any safety issues associated with the use of equipment • Decision how the equipment will be shipped to and from the sampling site		X				X	For further guidance see: Environment Canada's "The Inspector's Field Sampling Manual, Second Edition (2005)". For further guidance on air emissions sampling see: • Alberta's Stack Sampling Code, https://open.alberta.ca/publications/alberta-stack-sampling-code • Alberta's Air Monitoring Directive, https://open.alberta.ca/publications/air-monitoring-directive-2016 • Applicable standards listed in Eleventh Schedule of the Environmental Management and Coordination (Air Quality) Regulations. • Environment Canada's "The Inspector's Field Sampling Manual, Second Edition (2005)", http://publications.gc.ca/collections/Collection-R/En40-498-2005-1E.pdf For further guidance on effluents sampling see: • Chapter 5 of US EPA's, NPDES Compliance Inspection Manual (2017), https://www.epa.gov/sites/production/files/2017-01/documents/npdesinspect.pdf • Part D of British Columbia's Field Sampling Manual (2013), https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual

								For further guidance on soil sampling see: • *Alberta Environmental Site Assessment Standard* (2016), https://open.alberta.ca/dataset/3acc7cff-8c50-44e8-8a33-f4b710d9859a/resource/579321b7-5b66-4022-9796-31b1ad094635/download/environmentsiteassessstandard-mar01-2016.pdf • Canadian Council of Ministers of the Environment, *Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment,* Volume 1 (2016), https://www.ccme.ca/en/files/Resources/csm/Volume%201-Guidance%20Manual-Environmental%20Site%20Characterization_e%20PN%201551.pdf • State of Washington, *Guidance for Remediation of Petroleum Contaminated Sites* (2016), https://fortress.wa.gov/ecy/publications/documents/1009057.pdf • US EPA, *Soil Sampling Operating Procedure* (2014), https://www.epa.gov/sites/production/files/2015-06/documents/Soil-Sampling.pdf
5.3.2	Develop checklist for necessary equipment considering the following parameters: ○ sturdiness ○ the sample medium (liquid, solid, gas) ○ possible contamination of the sample ○ compatibility or chemical reactivity with the sample ○ possible sample degradation by light, oxidation, etc.		**X**					
5.4	Determine steps for collection, storage, and transport samples, which may include		**X**				**X**	For further guidance see: • Environment Canada's "The Inspector's Field Sampling Manual, Second Edition (2005)".

	1. Sample collection methods may include, for example among others: a grab sample, a composite sample. 2. Procedural steps may include requirements for samples to be securely stored, protected from light, in specific storage and transportation containers suitable for a sampling medium.							• US EPA, *Sample and Evidence Management* (2013), https://www.epa.gov/sites/production/files/2015-06/documents/Sample-and-Evidence-Management.pdf For further guidance on air emissions sampling see: • BS EN 15259:2007 Air quality. Measurement of stationary source emissions. Requirements for measurement sections and sites and for the measurement objective, plan and report. • Applicable standards listed in Eleventh Schedule of the Environmental Management and Coordination (Air Quality) Regulations. For further guidance on effluents sampling see: • Chapter 5 of US EPA's, NPDES Compliance Inspection Manual (2017), https://www.epa.gov/sites/production/files/2017-01/documents/npdesinspect.pdf • Part D of British Columbia's Field Sampling Manual (2013), https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual • Environment Canada's "The Inspector's Field Sampling Manual, Second Edition (2005)", http://publications.gc.ca/collections/Collection-R/En40-498-2005-1E.pdf For further guidance on soil sampling see: • *Alberta Environmental Site Assessment Standard* (2016), https://open.alberta.ca/dataset/3acc7cff-8c50-44e8-8a33-f4b710d9859a/resource/579321b7-5b66-4022-9796-31b1ad094635/download/environmentsiteassessstandard-mar01-2016.pdf • Canadian Council of Ministers of the Environment, *Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment,* Volume 1 (2016), https://www.ccme.ca/en/files/Resources/csm/Volume%201-

								Guidance%20Manual-Environmental%20Site%20Characterization_e%20PN%201551.pdf • State of Washington, *Guidance for Remediation of Petroleum Contaminated Sites* (2016), https://fortress.wa.gov/ecy/publications/documents/1009057.pdf • US EPA, *Soil Sampling Operating Procedure* (2014), https://www.epa.gov/sites/production/files/2015-06/documents/Soil-Sampling.pdf
5.4.1	Develop checklist on steps to follow during sampling.		**X**				**X**	
5.4.2	Develop and keep chain-of-custody records		**X**					For further guidance see: • US EPA, *Sample and Evidence Management* (2013), https://www.epa.gov/sites/production/files/2015-06/documents/Sample-and-Evidence-Management.pdf • Form SCP 4 - Chain of Custody Record This form is used to ensure the integrity of samples by identifying all the persons responsible for handling, storing, analyzing samples at all times.
Step 6	Conduct sampling in accordance to sampling protocol and checklists.			**X**				
6.1	Arrange access to facilities							
6.2	Collect samples in line with defined strategy							
Step 7	Provide samples to identified, accredited laboratory for analysis, and complete chain of custody record.		**X**	**X**				• Form SCP 4 - Chain of Custody Record This form is used to ensure the integrity of samples by identifying all the persons responsible for handling, storing, analyzing samples at all times.
Step 8	Analyze samples according to sampling scope/objective developed by team leader.						**X**	
Step 9	Develop test report following regulatory guidance.		**X**	**X**			**X**	For further guidance see Appendix 2.1.2 below, and Fifth Schedule, Part XIII, The Environmental Management and Coordination (Air Quality) Regulations. Form SCP 3.1 Air Emissions Test Report or Form SCP 3.2 – Effluents Test Report
Step 10	Submit test report to HIS and DCE.		**X**					
Step 11	Follow next steps of the environmental monitoring/environmental inspection process.	**X**			**X**			For more information see Volume 1, S. 2 & S.4 of this manual

(*) Applicable only to sampling of air emissions.

Appendices

Form SCP 1- Model Checklist for planning and implementation of sampling

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Ref:
Date:

Name of authority	
Name of operator	
Name of project/facilities	

1. Location

Approval of test report being true, accurate, and in compliance with Kenyan regulation, by the people responsible for conducting the emissions sampling and test.

Name of NEM. Official	
Date	Signature

Name of Lab. Official	
Date	Signature

Form SCP 3.2 - Model Effluents Test Report

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Ref:
Date:

Name of authority	
Name of operator	
Name of project/facilities	

1. Location

Approval of test report being true, accurate, and in compliance with Kenyan regulation, by the people responsible for conducting sampling and testing.

Name of NEMA Official	
Date	Signature

Name of Lab. Official	
Date	Signature

Form SCP 3.3 - Model Soil Test Report

Note : This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Ref:
Date:

Name of authority	
Name of operator	
Name of project/facilities	
Location (postal & physical address, GPS coordinates)	

1. Details of Facilities

Description of facility, including activity and processes conducted therein.

2. Sample Management

Sample No.
Description of Sample
Date and Time Sample Received in Lab
Date and Time Sample was Examined

3. Results

Parameter	Results
...	
...	

4. Approval

Approval of test report being true, accurate, and in compliance with Kenyan regulation, by the people responsible for conducting the sampling and testing.

Name of NEMA. Official	
Date	Signature

Name of Lab. Official	
Date	Signature

Form SCP 4 -Chain of Custody Record

This form is used to ensure the integrity of samples by identifying all the persons responsible for handling, storing, analyzing samples at all times.

<table>
<tr><th colspan="7">Samplers' Name</th></tr>
<tr><th colspan="4">Date</th><th colspan="3">Signature</th></tr>
<tr><th>Sample No.</th><th>Date</th><th>Time</th><th>Collection Type</th><th>Collection Station/Site</th><th>No. of Containers</th><th>Remarks</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Relinquished by:</td><td>Date/Time</td><td>Signature</td><td>Received by:</td><td>Date/Time</td><td colspan="2">Signature</td></tr>
<tr><td>Relinquished by:</td><td>Date/Time</td><td>Signature</td><td>Received by:</td><td>Date/Time</td><td colspan="2">Signature</td></tr>
<tr><th colspan="7">Space Reserved for Laboratory</th></tr>
<tr><td colspan="3">Received by:</td><td colspan="2">Date/Time</td><td colspan="2">Remarks</td></tr>
</table>

FORM SCP 5 -Sampling Protocols Lists

General	Air	Effluents	Soil
Environment Canada's "The Inspector's Field Sampling Manual, Second Edition (2005)". **http://publications.gc.ca/collections/Collection-R/En40-498-2005-1E.pdf** **British Columbia's Field Sampling Manual (2013),** **https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual** **US EPA, *Sample and Evidence Management* (2013),** **https://www.epa.gov/sites/production/files/2015-06/documents/Sample-and-Evidence-Management.pdf**	EPA Victoria's "A Guide to the Sampling and Analysis of Air Emissions and Air Quality (2002)"; Alberta's Stack Sampling Code, https://open.alberta.ca/publications/alberta-stack-sampling-code Alberta's Air Monitoring Directive, https://open.alberta.ca/publications/air-monitoring-directive-2016	NPDES Compliance Inspection Manual (2017), https://www.epa.gov/sites/production/files/2017-01/documents/npdesinspect.pdf	*Alberta Environmental Site Assessment Standard* (2016), https://open.alberta.ca/dataset/3acc7cff-8c50-44e8-8a33-f4b710d9859a/resource/579321b7-5b66-4022-9796-31b1ad094635/download/environmentsiteassessstandard-mar01-2016.pdf Canadian Council of Ministers of the Environment, *Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment,* Volume 1 (2016), https://www.ccme.ca/en/files/Resources/csm/Volume%201-Guidance%20Manual-Environmental%20Site%20Characterization_e%20PN%201551.pdf State of Washington, *Guidance for Remediation of Petroleum Contaminated Sites* (2016), https://fortress.wa.gov/ecy/publications/documents/1009057.pdf US EPA, *Soil Sampling Operating Procedure* (2014), https://www.epa.gov/sites/production/files/2015-06/documents/Soil-Sampling.pdf

S.2 - Measurement Procedures

1. Introduction

Kenyan law establishes ambient air quality levels.[3] In order to meet such levels, local regulations prohibit companies from exceeding certain maximum levels of pollutants released to the environment through air emissions.[4] In turn, NEMA has a duty to verify compliance with the aforementioned requirements, by conducting measurements of ambient air quality levels in accordance with methods established in the Ambient Air Quality Regulations.[5]

1.1 Purpose and Objective

This section of the manual providing NEMA, lead agencies, and designated accredited laboratories, with the process and procedure for selection of measurement procedures, following implementation of the corresponding sampling procedures.

NOTE: This process is a sub-process of either an environmental monitoring or inspection process and shall be read in conjunction with the processes' description stipulated in Volume 1 S. 2 and 4 of this manual.

1.2 Scope

The scope of this section is limited to selection of measurement procedures to detect ambient air quality levels.

1.3 Roles and Responsibilities

HIS: Head Inspectorate Section - Leader of the inspection section of NEMA.
IT: Inspection Team - NEMA appointed team, responsible for conducting on- and off-site inspections.
TL: Team Leader - Team Leader – Head of inspection team.
DCE: Director of Compliance and Enforcement
Lead agencies – Agencies, including NEMA, responsible for monitoring compliance with Kenyan law.
Designated laboratories

2. Process Mapping and Procedure

2.1 Inputs

Input	Detail of Inputs and remarks	Ref.
Initial emissions assessment report	Report submitted to NEMA by company on facility emissions and best available technology.	The Environmental Management and Coordination (Air Quality) Regulations, 2009, § 66(a).
Emissions monitoring report (EMR)	Emissions monitoring report developed by company and submitted to NEMA quarterly.	The Environmental Management and Coordination (Air Quality) Regulations, 2009, §§ 65(1), 68(1).
NEMA's response to EMR	NEMA's written feedback on EMR.	The Environmental Management and Coordination (Air Quality) Regulations, 2009, § 68(1).

[3] The Environmental Management and Coordination (Air Quality) Regulations, 2014 §7.
[4] Id. at 8(1).
[5] Id. at 53, 58, 60(1), Eleventh Schedule.

Reports on contingencies	If applicable, atmospheric impact report, malfunctions report, and emission limit exceedance report.	The Environmental Management and Coordination (Air Quality) Regulations, 2009, §§ 67(1), 69(1).
Environmental monitoring plan	Provides a detailed plan for environmental monitoring of specific petroleum operations/facilities	Form EM1 - Environmental Monitoring Plan Template (Vol 1, S. 2 of the Manual)
Environmental inspection plan	Provides a detailed plan for environmental monitoring of specific petroleum operations/facilities	Form EI3, Inspection Plan Template (Vol 1, S. 3 of the Manual)
Sampling strategy template	General outline of the plan for sampling operations, including, objective, scope, action, equipment, roles, among others	Sampling and processing form 1
Test report	Report detailing action taken during sampling and generating the results.	• Fifth Schedule, Part XIII, The Environmental Management and Coordination (Air Quality) Regulations.

2.2 Outputs

Output	Detail of Inputs and remarks	Ref.
Air quality monitoring report.	Report containing air quality data, and factors potentially affecting such data.	See appendix 3.2 below.

2.3 Tools, Forms, and Templates

2.3.1 Tools

- Air quality monitoring report
- Matrix on Parameters, Limits, and Analytical Procedures for Substances Frequently Released by Petroleum Industry.

2.3.2 Templates

The following templates shall be used in sampling process:

Form & template	Objectives	Usage
MP – Form 1 - Matrix on Parameters, Limits, and Analytical Procedures for Substances Frequently Released by Petroleum Industry	Provide a baseline for Parameters, Limits, and Analytical Procedures	To be used in preparation and execution of environmental monitoring
MP – Form 2 - Air quality monitoring report	Provides a template of measurement report	To be used at reporting phase

2.4 Procedure

Activities, Steps, Description		Roles					Reference
Process Activity/	Description	HIS	Team Leader	Inspection Team	DCE	Laboratory	
Step 1	Identify facilities subject to environmental monitoring. Review documents on air quality generated by licensed facilities	**X**			**X**		NEMA annual environmental monitoring plan
1.1	Initial emissions assessment reports	**X**			**X**		The Environmental Management and Coordination (Air Quality) Regulations, 2014, § 66(a).
1.2	Quarterly emissions monitoring report (EMR)	**X**			**X**		The Environmental Management and Coordination (Air Quality) Regulations, 2014, §§ 65(1), 68(1).
1.3	NEMA's response to EMR	**X**			**X**		The Environmental Management and Coordination (Air Quality) Regulations, 2014, § 68(1).
1.4	Reports on contingencies	**X**			**X**		The Environmental Management and Coordination (Air Quality) Regulations, 2014, §§ 67(1), 69(1).
1.5	Test Report detailing action taken during sampling and generating results.	**X**			**X**		
Step 2	Based on review of documents listed above, and on air quality goals established in local law, develop air monitoring plan.	**X**			**X**		• EM – Form 1 - Environmental Monitoring Plan • The Environmental Management and Coordination (Air Quality) Regulations, First and Second Schedule. • Appendix 3.1 Matrix on Parameters, Limits, and Analytical Procedures for Substances Frequently Released by Petroleum Industry.

2.1	Create list of substances to be monitored under the strategy.	**X**			**X**		
2.2	Select measurement methods.	**X**			**X**		For further reference see: • Environment Canada, National Air Pollution Surveillance Network Quality Assurance and Quality Control Guidelines (1995), Chapter 5, • Canadian Council of Ministers of the Environment, Ambient Air Monitoring Protocol (2011), Chapter 6. • Appendix 3.1 Matrix on Parameters, Limits, and Analytical Procedures for Substances Frequently Released by Petroleum Industry.
2.3	Select measurement equipment.	**X**			**X**		Id.
2.4	Select site and location of monitoring stations.	**X**			**X**		For further reference see: • Environment Canada, National Air Pollution Surveillance Network Quality Assurance and Quality Control Guidelines (1995), Chapter 5. • Canadian Council of Ministers of the Environment, Ambient Air Monitoring Protocol (2011), Chapter 4, https://urlzs.com/gea9h • Canadian Council of Ministers of the Environment, Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone (2012), Chapter 3, https://urlzs.com/vjT5m
2.5	Select design of sampling system, considering, amongst others, siting criteria, temperature stability of the station, length and composition of sample lines, and the composition of filters and fittings	**X**			**X**		For further reference see: • Environment Canada, National Air Pollution Surveillance Network Quality Assurance and Quality Control Guidelines (1995), Chapter 5.
2.6	Develop equipment maintenance program, including station visits, instrument zero and span verifications, calibrations, preventive maintenance.	**X**			**X**		For further reference see: • Equipment user’s manuals

							• Environment Canada, National Air Pollution Surveillance Network Quality Assurance and Quality Control Guidelines (1995), Chapter 5.
2.6.1	Develop logbook on implementation of maintenance program.		**X**	**X**			
2.7	Provide training to all employees engaged in the monitoring process.	**X**			**X**		
Step 3	Development of monitoring results per monitoring station.		**X**	**X**		**X**	See appendix 3.2 Air quality monitoring report. • EM – Form 2 - Environmental Monitoring Compliance Checklist
Step 4	Submit air quality reports to HIS and DCE.		**X**	**X**		**X**	
Step 5	Archive air quality reports in accordance with NEMA's Record Management Policy	**X**	**X**	**X**	**X**		• EM – Form 3 - Environmental Monitoring Report EM

Appendices

MP – Form 1- Matrix on Parameters, Limits, and Analytical Procedures for Substances Frequently Released by Petroleum Industry

Please refer to Appendix AP – Form 1 – Comparative Matrix on Parameters, Limits, and Analytical Procedures for Substances Frequently Released by Petroleum Upstream Industry (Vol 2, S. 3)

MP – Form 1 - Air quality monitoring report.

Note : This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Station identification
Station name and address
City, including the borough or municipality
Analyzer type and ownership
DATE OF INSPECTION

1. Air Quality Data

Provide ambient air quality levels read by measurement equipment.

2. Site Description

- Provide site description including scale of representativeness, land use, elevation, average building height, air flow restrictions, manifold, and the nearest meteorological station.
- Describe site influences including localized sources, roadway influences and major point sources.
- Provide site map or aerial photograph of the area.
- Provide photographs from the manifold inlet showing the north, east, south and west directions.
- Describe any activity at the site or events and occurrences that may affect the air quality data.

3. Equipment Records

Provide information on the implementation of the equipment maintenance program.

Date	Responsible Person
Signature	

S 3 - Analytical procedures

1. *Introduction*

1.1 *Purpose and Objective*

In line with best international practices, most environmental legal frameworks impose maximum permissible limits on the substances companies are allowed to release to the environment. In order for permissible limits to be enforceable, an approved analytical method—a test procedure to measure the parameter (substance)—must be available. This section aims at providing guidance to NEMA personnel, the personnel of other lead agencies, and designated laboratories, in the selection of analytical procedures, following implementation of the corresponding sampling procedures.

NOTE: This process is a sub-process of either an environmental monitoring or inspection process and shall be read in conjunction with the processes' description stipulated in Volume 1 S. 2 and 4 of this manual.

1.2 *Scope*

The scope of this section is limited to selection of analytical procedures to detect polluting substances in soil and water effluents, as opposed to air emissions measurement, which is covered in Vol 2 S. 2 above. *Roles and Responsibilities*

- **HIS**: Head Inspectorate Section - Leader of the inspection section of NEMA.
- **IT**: Inspection Team – NEMA appointed team, responsible for conducting on- and off-site inspections.
- **TL**: Team Leader – Head of inspection team.
- **DCE**: Director of Compliance and Enforcement – Lead of compliance and enforcement, responsible for prosecuting and sanctioning companies in breach
- Designated laboratories

2. *Process Mapping and Procedure*

2.1 *Inputs*

Input	Detail of Inputs and remarks	Ref.
Documents in support of license application	Documents on the characteristics of effluents discharged from a facility.	The Environmental Management and Coordination (Water Quality) Regulations, 2006, § 16.
Effluents monitoring report (EMR)	Effluents monitoring report developed by company and submitted to NEMA quarterly.	The Environmental Management and Coordination (Water Quality) Regulations, 2006, § 14.
NEMA's response to EMR	NEMA's written feedback on EMR.	The Environmental Management and Coordination (Water Quality) Regulations, 2006, § 15.
Test Report	Report detailing action taken during sampling and obtained results.	Sixth Schedule of Environmental Management and Coordination (Water Quality) Regulations.

2.2 *Outputs*

Output	Detail of Inputs and remarks	Ref.
Final Test Result	Results on presence and level of polluting substances in soil and water, following conduction of analytical procedures.	

2.3 Tools, Forms, and Templates

2.3.1 Tools

- Matrix on Parameters, Limits, and Analytical Procedures for Substances Frequently Released by Petroleum Industry.

2.3.2 Templates

The following templates shall be used in sampling process:

Form & template	Objectives	Usage
AP – Form 1 - Matrix on Parameters, Limits, and Analytical Procedures for Substances Frequently Released by Petroleum Industry	Provide a baseline for Parameters, Limits, and Analytical Procedures	To be used in preparation and execution of environmental monitoring

2.4 *Procedure*

Activities, Steps, Description		Roles					Reference
Process Activity/	**Description**	**HIS**	**Team Leader**	**Inspection Team**	**DCE**	**Laboratory**	
Step 1	Revise documents on emissions/effluents generated by facility to be inspected		**X**	**X**			
1.1	Documents submitted with license application on the characteristics of effluents discharged from a facility.		**X**	**X**			The Environmental Management and Coordination (Water Quality) Regulations, 2006, § 16.
1.2	Quarterly effluents monitoring report (EMR)		**X**	**X**			Environmental Management and Coordination (Water Quality) Regulations, 2006, § 14.
1.3	NEMA's response to EMR		**X**	**X**			Environmental Management and Coordination (Water Quality) Regulations, 2006, § 15.
1.4	Test Report detailing action taken during sampling and generating results.		**X**	**X**			
1.5	Other relevant documents		**X**	**X**			
Step 2	Based on review of documents listed above, determine the substances for the test.		**X**	**X**			
Step 3	Based on substances to be tested, select and implement proper analytical method[6].		**X**	**X**			For further guidance see: • Appendix 4.1 below; • Washington State Department of Ecology, *Analytical Methods for Petroleum Hydrocarbons* (1997), https://urlzs.com/TBx9b • Canadian Council of Ministers of the Environment, *Guidance Manual for*

[6] The relevant analytical methods are typically selected and applied by the test laboratory

							Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment Volume 2 Checklists (2016) https://bit.ly/2DlJQLn • Laboratory Services Branch Ministry of the Environment, *Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act* (2011), https://urlzs.com/FPdxU • US Code of Federal Regulations, Title 40, Chapter I, Subchapter D, Part 136, *Guidelines Establishing Test Procedures for the Analysis of Pollutants*, https://urlzs.com/xCSWp • USA EPA, *Clean Water Act Analytical Methods*, https://www.epa.gov/cwa-methods
Step 4	Obtain field samples for test and provide them to laboratories for tests		**X**	**X**			• Follow procedures in Volume 2, S. 1 of of this manual • Follow procedures set in Volume 1 S. 2 and S. 4.
Step 5	Receive samples, conduct test and report final test results on presence and level of polluting substances in soil and water, following conduction of analytical procedures.		**X**	**X**		**X**	• Follow an appropriate analytical method for analysis
Step 5	Develop test report following regulatory guidance. Typically done by a laboratory only		**X**	**X**		**X**	
Step 7	Submit test report to HIS and DCE.		**X**				
Step 8	Proceed with further phases required as part of environmental monitoring or environmental inspection process	**X**			**X**		Follow procedures set in Vol.1 S.2 & 4 of this manual

Appendices

AP – Form 1 – Comparative Matrix on Parameters, Limits, and Analytical Procedures for Substances Frequently Released by Petroleum Upstream Industry

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Parameter	Permissible Limits under Kenyan Law[7]	Permissible Limits Best Practices (onshore)[8]	Monitoring (frequency)[9]	Measurement Protocol[10]
Air Quality[11]				
Sulphur oxides (SO_X)	80 µg/m^3 (annual average).	500 µg/m3 (10-minute average) (for SO_2)	Annual / Quarterly (refineries)	• KS ISO 11632: Stationary source emissions -- Determination of mass concentration of sulfur dioxide --Ion chromatography method • KS ISO 6767: Ambient air --Determination of the mass concentration of sulfur dioxide -- Tetrachloromercurate (TCM)/pararosaniline method • KS ISO 4219: Air quality -Determination of gaseous Sulphur compounds in ambient air - Sampling equipment • KS ISO 4221: Air quality -Determination of a mass concentration of Sulphur dioxide in ambient air -Thorin spectrophotometric method • KS ISO 7934: Stationary source emissions - Determination of the mass concentration of Sulphur dioxide -Hydrogen peroxide / barium perchlorate –Thorin method
Oxides of Nitrogen (NO_X)	80 µg/m^3 (annual average).	40 µg/m^3 (annual average) (for nitrogen dioxide)	Annual / Quarterly (refineries)	KS ISO 7996: Ambient air --Determination of the mass concentration of nitrogen oxides -- Chemiluminescence method
Nitrogen Dioxide	150 µg/m^3 (annual average).	40 µg/m^3 (annual average)	Annual / Quarterly (refineries)	• KS ISO 10849: Stationary source emissions -- Determination of the mass concentration of nitrogen oxides --Performance characteristics of automated measuring systems • KS ISO 11564: Stationary source emissions -- Determination of the mass concentration of nitrogen oxides --Naphthylethylenediamine photometric method

[7] Water Quality Regulations, Third and Fourth Schedule; Air Quality Regulations, Arts. 5-7, First Schedule.

[8] https://www.ifc.org/wps/wcm/connect/4504dd0048855253ab44fb6a6515bb18/Final%2B-%2BOnshore%2BOil%2Band%2BGas%2BDevelopment.pdf?MOD=AJPERES&id=1323153172270 ; https://www.ecfr.gov/cgi-bin/text-idx?SID=6b51273d47e8dc451e0aac10f60cdfee&mc=true&node=pt40.31.419&rgn=div5#se40.31.419_150 ; NAAQS Table, https://www.epa.gov/criteria-air-pollutants/naaqs-table

[9] Water Quality Regulations § 14; Air Quality Regulations, § 19, 68, Fourteenth Schedule.

[10] https://www.concawe.eu/wp-content/uploads/2017/01/report-no.-4_13.pdf ; Air Quality Regulations, Eleventh Schedule.

[11] Permissible limits refer to Ambient Air Quality Guidelines, in accordance to IFC's Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development, IFC's General EHS Guidelines, and US National Ambient Air Quality Standards. However, Kenya law also imposes specific limits to refineries, Air Quality Regulations. Third Schedule.

Suspended Particulate matter (SPM)	360 µg/m³ (annual average).	X	Annual / Quarterly (refineries)	ISO 9835:1993(en) Ambient air - Determination of a black smoke index
PM_{10}	70 µg/m³ (annual average).	20 µg/m³ (annual average)	Annual / Quarterly (refineries)	KS ISO 12141: Stationary source emissions -- Determination of mass concentration of Particulate matter (dust) at low concentrations --Manual gravimetric method
$PM_{2.5}$	35 µg/m³ (annual average).	10 µg/m³ (annual average).	Annual / Quarterly (refineries)	KS ISO 12141: Stationary source emissions -- Determination of mass concentration of Particulate matter (dust) at low concentrations --Manual gravimetric method
Lead (Pb)	1.0 µg/m³ (annual average).	0.15 µg/m³ (3-month average).	Annual / Quarterly (refineries)	KS ISO 9855: Ambient air -Determination of the particulate lead content of aerosols collected on filters -Atomic absorption spectrometric method
Carbon monoxide (CO)/carbon dioxide (CO2)	5 µg/m³ (annual average).	9 ppm (8-hour average)	Annual / Quarterly (refineries)	• KS ISO 12039: Stationary source emissions -- Determination of carbon monoxide, carbon dioxide and oxygen --Performance characteristics and calibration of automated measuring systems. • KS ISO 8186: Ambient air --Determination of the mass concentration of carbon monoxide -- Gas chromatographic method.
Hydrogen Sulphide	150 µg/m3 (24 hours).	X	Annual / Quarterly (refineries)	KS ISO 4219: Air quality -Determination of gaseous Sulphur compounds in ambient air - Sampling equipment
Non-methane hydrocarbons	700ppb (instant peak)	X	Annual / Quarterly (refineries)	• ISO 14965:2000: Air quality -- Determination of total non-methane organic compounds -- Cryogenic pre-concentration and direct flame ionization detection method • US EPA, Ambient Air Non-Methane Hydrocarbon Monitor
Total VOC	600 µg/m3 (24 hours).	X	Annual / Quarterly (refineries)	• KS ISO 16200-1: Workplace air quality -- Sampling and analysis of volatile organic compounds by solvent desorption/gas chromatography --Part1: Pumped sampling method • KS ISO 16200-2: Workplace air quality -- Sampling and analysis of volatile organic compounds by solvent desorption/gas chromatography --Part2: Diffusive sampling method • KS ISO 16000-5: Indoor air --Part5: Sampling strategy for volatile organic compounds (VOCs) • KS ISO 16000-6: Indoor air --Part6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS/FID • KS ISO 16000-9: Indoor air --Part9: Determination of the emission of volatile organic compounds from building products and furnishing --Emission test chamber method

				• KS ISO 16000 -10: Indoor air --Part10: Determination of the emission of volatile organic compounds from building products and furnishing --Emission test cell method • KS ISO 16000-11: Indoor air --Part11: Determination of the emission of volatile organic compounds from building products and furnishing --Sampling, storage of samples and preparation of test specimens • KS ISO 16017-1: Indoor, ambient and workplace air –Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography --Part1: Pumped sampling • KS ISO 16017-2: Indoor, ambient and workplace air --Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography --Part2: Diffusive sampling
Ozone	200 µg/m3 (1 hour).	100 µg/m^3 (8-hour maximum).	Annual / Quarterly (refineries)	• KS ISO 10313: Ambient air --Determination of the mass concentration of ozone --Chemiluminescence method • KS ISO 13964: Air quality --Determination of ozone in ambient air --Ultraviolet photometric method
Water Quality (Effluents)				
Biochemical Oxygen Demand, BOD	1.0 mg/L	25 mg/L	Quarterly	• ISO 5815: 2003(en) Water quality — Determination of biochemical oxygen demand after n days (BODn)
Chemical Oxygen Demand, COD	50 mg/L *(refining only)*	125 mg/L	Quarterly	• ISO 6060: Water Quality – Determination of the chemical oxygen demand. • ISO 15705: Water Quality – Determination of the chemical oxygen demand index (ST-COD) – Small-scale sealed-tube method.
Total Suspended Solids, TSS	30 mg/L	35 mg/L	Quarterly	ISO 11923:1997 Water quality -- Determination of suspended solids by filtration through glass-fiber filters
pH	6-9	6-9	Quarterly	ISO 10523:2008(en) Water quality — Determination of pH
Oil & Grease	Nil	10mg/L	Quarterly	ASTM D8193 – 18 Standard Test Method for Total Oil and Grease (TOG) and Total Petroleum Hydrocarbon (TPH) in Water and Wastewater with Solvent Extraction Using Non-Dispersive Mid-IR Transmission Spectroscopy
Total hydrocarbon content	X	10 mg/L	Quarterly	ASTM D8193 – 18 Standard Test Method for Total Oil and Grease (TOG) and Total Petroleum Hydrocarbon (TPH) in Water and Wastewater with Solvent Extraction Using Non-Dispersive Mid-IR Transmission Spectroscopy
Temperature	± 3 (in degrees Celsius) based on	X	Quarterly	US EPA, SESDPROC-102-R3, Field Temperature Measurement.

	ambient temperature			
Chloride	X	600 mg/l (average), 1200 mg/L (maximum)	Quarterly	ISO 15682: Water Quality – Determination of chloride by flow analysis (CFA and FIA) and photometric or potentiometric detection
Color/Dye/Pigment	15 Hazen units (H.U.)	X	Quarterly	• ISO 787-3:2000 General methods of test for pigments and extenders -- Part 3: Determination of matter soluble in water -- Hot extraction method • ISO 787-8:2000 General methods of test for pigments and extenders -- Part 8: Determination of matter soluble in water -- Cold extraction method
Heavy Metals[12]	X	5 mg/L	Quarterly	• APHA 3113: Metals by electrothermal atomic absorption spectrometry. • EN ISO 11885: Water Quality – Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP – OES) • EN ISO 12846: Water Quality – Determination of mercury. Method using atomic absorption spectrometry (AAS) with and without enrichment • EN ISO 11885: Water Quality - Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP - OES) • EN ISO 15586: Water Quality - Determination of trace elements using atomic absorption spectrometry with graphite furnace • ISO 17294: Water Quality - Application of inductively coupled plasma mass spectrometry (ICP-MS) - Part 2: Determination of 62 elements • EN ISO 11885: Water Quality - Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP - OES) • ISO 17294: Water Quality - Application of inductively coupled plasma mass spectrometry (ICP-MS) - Part 2: Determination of 62 elements
Phenols	0.001 mg/L *(refining only)*	0.5 mg/L	Quarterly	• ISO 6439: Water Quality – Determination of phenol index – 4-aminoantipyrine spectrometric methods after distillation • ISO 8165-2: Water Quality – Determination of selected monovalent phenols – Part 2: Method by derivatization and gas chromatography
Total Chromium	2 mg/L *(refining only)*	5 mg/L	Quarterly	ISO 9174: Water Quality – Determination of chromium – Atomic absorption spectrometric methods

12 Heavy metals include: Arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, vanadium, and zinc.

Chromium VI *(refining only)*	0.05 mg/L	32 mg/L	Quarterly	• ISO 11083: Water Quality – Determination of chromium(VI) – Spectrometric method using 1,5-diphenylcarbazide. • ISO 11885: Water Quality – Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP-OES).
Ammonia (as N) *(refining only)*	100 (mg/L)	10.6 kg/m3	Quarterly	EN ISO 11732: Water Quality – Determination of ammonium nitrogen – Method by flow analysis (CFA and FIA) and spectrometric detection
Sulphide *(refining only)*	0.1 mg/L	158 mg/L	Quarterly	ISO 10530: Water Quality – Determination of dissolved sulfide – Photometric method using methylene blue
Soil[13]				
pH	X	6-8 µg/g	As soon as possible in face of substance release.[14]	• CCME Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment Volume 1 Guidance Manual (2016) • CCME Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment Volume 2 Checklists (2016).
Electrical conductivity	X	2 µg/g	*Id.*	*Id.*
Sodium adsorption ratio SAR	X	5 µg/g	*Id.*	*Id.*
Total extractable hydrocarbons	X	1000 µg/g	*Id.*	*Id.*
Benzene	X	0.5 µg/g	*Id.*	*Id.*
Toluene	X	3 µg/g	*Id.*	*Id.*
Ethyl benzene	X	5 µg/g	*Id.*	*Id.*
Xylene	X	5 µg/g	*Id.*	*Id.*
Ethylene glycol (EG)	X	97 (grazing); 410 (no grazing) µg/g	*Id.*	*Id.*
Polychlorinated biphenyl (PCB)	X	0.5 µg/g	*Id.*	*Id.*
Barium	X	750 µg/g	*Id.*	*Id.*

[13] Soil remediation parameters diverge based on the use of the land following remediation. The limits/values provided herein assume eventual agricultural use. Saskatchewan Upstream Petroleum Sites Remediation Guidelines, http://publications.gov.sk.ca/documents/310/84469-PDB%20ENV%2007%20SPIGEC4%20Upstream%20Contaminated%20Sites%20Remediation%20Guidelines%202016.pdf

[14] Alberta Remediation Regulation, §2.2(1).

Cadmium	X	1.4 µg/g	*Id.*	*Id.*
Chromium	X	64 µg/g	*Id.*	*Id.*
Copper	X	63 µg/g	*Id.*	*Id.*
Lead	X	375 µg/g	*Id.*	*Id.*
Mercury	X	6.6 µg/g	*Id.*	*Id.*
Nickel	X	150 µg/g	*Id.*	*Id.*
Vanadium	X	130 µg/g	*Id.*	*Id.*
Zinc	X	200 µg/g	*Id.*	*Id.*

S. 4 - Reporting procedure (for field operations)

1. Introduction

1.1 Purpose and Objective

This section aims to establish and document the process and procedures NEMA inspectors and other NEMA personnel as well as lead agencies should follow to report their business activities, as well as quantitative, qualitative, factual, and/or technical information collected or observed during environmental monitoring and environmental inspections.

NOTE: This process is a sub-process of either an environmental monitoring or inspection process and shall be read in conjunction with the processes' description stipulated in Volume 1 S. 2 and 4 of this manual.

1.2 Scope

This section applies to all reports generated by NEMA inspectors and other NEMA personnel as well as lead agencies.

1.3 Roles and Responsibilities

- **HIS**: Head Inspectorate Section - Leader of the inspection section of NEMA.
- **IT**: Inspection Team - NEMA appointed team, responsible for conducting on- and off-site inspections.
- **TL**: Team Leader - Team Leader – Head of inspection team.
- **Lead agencies – Agencies, including NEMA, responsible for monitoring compliance with Kenyan law.**

2. Process Mapping and Procedure

2.1 Inputs

Input	Detail of Inputs and remarks	Ref.
Records management policy	NEMA policy for handling records	
Documents collected and generated in the course of inspection or monitoring activity	See all relevant forms and documents identified in this manual	multiple

2.2 Outputs

Output	Detail of Inputs and remarks	Ref.
Filled NEMA-generated forms	Forms generated by NEMA and lead agency personnel during field visits	
Field Inspection Logbook		

2.3 Tools, Forms, and Templates

2.3.1 Tools

- Detailed Field Inspection Logbook

2.4.2 Templates

The following templates shall be used in sampling process:

Form & template	Objectives	Usage
RP – Form 1- Detailed Field Inspection Logbook	Provides a record of field activities executed by inspectors	

2.4 *Procedure*

Activities, Steps, Description		Roles			Reference
Process Activity/	Description	HIS	Team Leader	Inspection Team	
Step 1	Preparation in anticipation of investigation, audit, or report drafting.		**X**	**X**	
1.1	Review NEMA's Record Management Policy.				For further reference see section on Data Management above.
1.2	Review project's Record Creation and Collection Strategy.				For further reference see section on Data Management above.
1.3	Review and select NEMA-generated forms required to report.				
Step 2	Prepare selected NEMA-generated forms		**X**	**X**	
2.1	Forms must be bound prior to use; If unfeasible, approval must be obtained from Inspection Team Leader.				
Step 3	When developing a field report, assure field data integrity and accountability		**X**	**X**	For further reference see: US EPA, *Operating Procedure for Logbooks* (2013), https://www.epa.gov/sites/production/files/2015-06/documents/Logbooks.pdf
3.1	The project's unique identifier or reference number must be included on each page.				
3.2	Field personnel will date and number each page. Numbering will be conducted by utilizing a format that incorporates both the current page number and the total number of pages.				
3.3	Observations, data and calculations must be recorded at the time they are made				
3.4	Pens with permanent ink will be used to record all data.				
3.4.1.	If unfeasible entries should be made using a non-smear lead pencil, upon returning from the field, the team leader will photocopy the				

	penciled section of the logbook and certify, in writing, that the photocopied record is a true copy of the original entry. The photocopy will be included in the project file.				
3.5	Entries will be legible and contain pertinent, accurate and inclusive documentation of project activities.				
3.6	Upon completion of the field investigation, the end of project entries in the logbook and/or bound forms will be clearly indicated.				
3.6.1	This may be accomplished by noting "End" or "End of Notes" on the last page of notes and dating and initialing the notation. Field investigators will draw a diagonal line through blank or unused portions of pages/forms that are located prior to the "End of Notes" entry and initial them.				
3.7	Pages and NEMA-generated forms should not be removed from bound logbooks.				
3.8	Data or other information that has been entered incorrectly will be corrected by drawing a line through the incorrect entry and initialing and dating the lined through entry. Under no circumstances should the incorrect material be erased, made illegible or obscured so that it cannot be read.				
3.9	If pre-printed adhesive labels are used in logbooks or bound forms, the inspector who is responsible for taking notes will sign the label with the signature beginning on the label and ending on the page of the logbook such that the label cannot be removed without detection.				
3.10	Logbook entries that may be considered privileged or confidential information will be handled in accordance with Kenya's intellectual property legislation.				For further reference see section on Data Management section
3.11	Comply with instructions established in NEMA-generated model forms.				
Step 4	Reports must be submitted to the project requestor, e.g., HIS, DCE.		**X**	**X**	
Step 5	Following submission of report, document must be placed in project filed, and stored in accordance with NEMA's Record Management Policy	**X**	**X**	**X**	

Appendices

RP – Form 1- Detailed Field Inspection Logbook

Note : This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Name of Industry
Business Reg. No.
Name and Position of Contact Person
Address
Telephone No.
Reference

Participant NEMA Staff	
Name	**Role**
Name	**Role**

1. Information Required for Sampling Collection

Including:

- Applicable operating procedures for field sampling
- Date and time of collection
- Station identification
- Sample identification
- Method of collection
- Number and type of containers
- Sample collection equipment
- Equipment identification number, if applicable
- Physical description of sample
- Matrix sampled
- Sample team member duties (calibration, collection, deployment, etc.)
- Sample preservation (including ice), if applicable
- Conditions that may adversely impact quality of samples, if applicable (rain, wind, smoke, dust, extreme temperature, etc.)
- GPS coordinates (Non-logging GPS units), if applicable
- Location of electronic data file backups, if applicable
- Monitoring of condition of ice in coolers or sampler
- Other pertinent information.

2. Information Required for Field Measurements

Including:

- Applicable operating procedures for field measurement
- Date and time of measurement or deployment

- Sample identification, if appropriate
- Station identification
- Sample measurement equipment
- Sample measurement equipment identification number
- Manufacturer name, lot number and expiration date of all buffers and standards
- Calibration information, including before and after calibration readings
- Meter end check information
- Deployment depth and total depth, if applicable
- Pinger identification number and frequency for deployed equipment, if applicable
- Time of retrieval for deployed equipment, if applicable
- Physical description of matrix
- Sample team member duties (calibration, collection, deployment, etc.)
- Measurement values for non-logging equipment
- GPS coordinates (non-logging GPS units), if applicable
- Location of electronic data file backups, if applicable
- Ambient air temperature, where applicable
- Conditions that may adversely impact quality of measurement (Ex. temperature extremes)
- Maintenance performed, if applicable

3. Other Relevant Observations

4. Appendices

The following information may be included in logbooks as appropriate:

- Maps/sketches
- Photographic or videographic log
- Process diagrams

Name of Responsible Official	
Date	**Signature**

Name of Team Leader	
Date	**Signature**

S. 5 Enforcement procedure

1. Introduction

Following the identification of a noncompliance incident by NEMA, Kenya's law entitles the agency to take a number of measures. Specifically, NEMA is entitled to issue *Improvement Orders* directing the implementation of corrective measures for mitigating the environmental degradations revealed during any audit study.[15] Additionally, the law also entitled NEMA to, at any time, issue *environmental restoration orders.*[16] Such orders are issued to:

- require the person on whom it is served to restore the environment as near as it may be to the state in which it was before the taking of the action which is the subject of the order;
- prevent the person on whom it is served from taking any action which would or is reasonably likely to cause harm to the environment;
- award compensation to be paid by the person on whom it is served to other persons whose environment or livelihood has been harmed by the action which is the subject of the order;
- levy a charge on the person on whom it is served which in the opinion of the Authority represents a reasonable estimate of the costs of any action taken by an authorized person or organization to restore the environment to the state in which it was before the taking of the action which is the subject of the order;
- require a person on whom it is served to:
    - take such action as will prevent the commencement or continuation or cause of pollution;
    - restore land, including the replacement of soil, the replanting of trees and other flora and the restoration as far as may be, of outstanding geological, archaeological or historical features of the land or the area contiguous to the land or sea as may be specified in the particular order;
    - take such action to prevent the commencement or continuation or cause of environmental hazard;
    - cease to take any action which is causing or may contribute to causing pollution or an environmental hazard;
    - remove or alleviate any injury to land or the environment or to the amenities of the area;
    - prevent damage to the land or the environment, aquifers beneath the land and flora and fauna in, on or under or about the land or sea specified in the order or land or the environment contiguous to the land or sea specified in the order;
    - remove any waste or refuse deposited on the land or sea specified in the order and dispose of the same in accordance with the provisions of the order;
    - pay any compensation specified in the order. [17]

1.1 Purpose and Objective

This section aims at ensuring fairness and consistency in the assessment of and response to noncompliance.

[15] The Environmental (Impact Assessment and Audit) Regulations, 2003 (EIA Regulation), section 37.

[16] Environment Management and Co-ordination Act (EMCA), section 108(1).

[17] *Id.*, section 108(2), (4).

NOTE: This process is a sub-process of either an environmental monitoring or inspection process and shall be read in conjunction with the processes' description stipulated in Volume 1 S. 2 and 4 of this manual.

1.2 Scope

This section provides a clear guidance to NEMA personnel and the personnel of other lead agencies, where engaged, on the steps to be taken following the identification of a non-compliance in the up-, mid-, and downstream sectors of petroleum industry.

1.3 Roles and Responsibilities

- **HIS**: Head Inspectorate Section - Leader of the inspection section of NEMA.
- **IT**: Inspection Team - NEMA appointed team, responsible for conducting on- and off-site inspections.
- **TL**: Team Leader - Team Leader – Head of inspection team.
- **DCE**: Director of Compliance and Enforcement - Lead of compliance and enforcement, responsible for prosecuting and sanctioning companies in breach
- **CEO**: County Environment Officer – NEMA, regional environmental law enforcement officer.
- **DDE**: Deputy Director Enforcement – Officer responsible for prosecuting and sanctioning companies in breach

2. Process Mapping and Procedure

2.1 Inputs

Input	Detail of Inputs and remarks	Ref.
Environmental Inspection Report	Report identifying an incident following an inspection. Report identifying non-compliance following an inspection	NEMA, Standard Operating Procedure for Compliance and Enforcement, § 2.6.2.10 EI - Form 6 - Environmental Inspection Report Template
Environmental Monitoring Report		EM - Form 3 - Environmental Monitoring Report Template
Audit Report	Report from baseline audit conducted to verify compliance with environmental legislation.	EIA Regulations, regulation 36.
Self-audit Report	Report from self audit conducted to verify compliance with environmental management program.	EIA Regulations, regulation 34(1)(b).
Incidents Register	Record kept by NEMA's Compliance and Enforcement Team on incidents reported to the Incident Desk	
Reports on contingencies	If applicable, atmospheric impact report, malfunctions report, and emission limit exceedance report.	The Environmental Management and Coordination (Air Quality) Regulations, 2009, §§ 67(1), 69(1).
Other relevant documents	Documents in NEMA's possession containing information of the facility where the incident took place, and the process taking place therein.	

2.2 Outputs

Output	Detail of Inputs and remarks	Ref.
Caution Notice	Document issued during site visit to notify company in writing that they are in noncompliance with a specific regulatory requirement and to recommend a course of action that is expected to achieve compliance.	NEMA, Standard Operating Procedure for Compliance and Enforcement, § 2.6.2.12
Warning Letter	Document issued following an investigation to notify company in writing that they are in noncompliance with a specific regulatory requirement and to recommend a course of action that is expected to achieve compliance.	NEMA, Standard Operating Procedure for Compliance and Enforcement, § 2.6.2.12
Restoration Order	Document to create a requirement to undertake specific, time-bound actions or to stop specific actions, to outline the consequences for failing to comply with the requirements, and to impose administrative sanctions.	NEMA, Standard Operating Procedure for Compliance and Enforcement, § 2.6.2.12
Follow-up Report	Report verifying compliance with corrective orders issued by NEMA in response to environmental noncompliance.	See Appendix 6.1
Investigation Report	Report on inspection conducted after identification of an noncompliance specifying the causes of the incident, whether regulation has been broken, identifying responsible parties, and ways to prevent future similar incidents.	

2.3 Tools, Forms, and Templates

2.3.1 Tools

- Follow-up Report

2.4.2 Templates

The following templates shall be used in sampling process:

Form & template	Objectives	Usage
EP – Form 1- Follow-up Incident/Non-compliance Report	Provides a template for the follow up report	To be used in follow-up inspections or environmental monitoring

2.4 Procedure

Activities, Steps, Description		Roles						Reference
Process Activity/	Description	HIS	Team Leader	Inspection Team	DCE	DDE	CEO	
Step 1	Identification of noncompliance through site visit, inspection report, audit report, environmental monitoring report, self-reporting, or the Incident Register.	X	X	X	X		X	For further reference see: • NEMA, Standard Operating Procedure for Compliance and Enforcement, § 2.6.2.10 • EIA Regulations, regulation 36, and 34(1)(b).
Step 2	Assessment and classification of noncompliance, based on its actual and potential impact.	X			X			
Step 3	Determine whether an investigation is needed. If so, follow procedure in Volume 1 of this manual, and in section 5 above.	X			X		X	
Step 4	Review of applicable legislation on possible sanctions under the law.				X		X	For further reference see EMCA.
Step 5	Select compliance and enforcement tool best suited to address noncompliance.						X	NEMA, Standard Operating Procedure for Compliance and Enforcement, § 2.6.2.12
5.1	If noncompliance is identified during site visit, issue caution notice to notify company in writing that they are in noncompliance with a specific regulatory requirement and to recommend a course of action that is expected to achieve compliance. Terms of compliance can be negotiated.		X	X				
5.2	Issue a warning letter to notify company in writing that they are in noncompliance with a specific regulatory requirement and to recommend a course of action that is						X	

	expected to achieve compliance. Terms of compliance can be negotiated.							
5.3	Issue restoration order to create a requirement to undertake specific, time-bound actions or to stop specific actions, and to outline the consequences for failing to comply with the requirements							
5.3.1.	If applicable, impose administrative sanctions, such as closures, fines, payment of compensation to third parties, refund restoration costs.						**X**	EMCA, sections 108, 143.
5.4	Based on investigation report, decide whether company's conduct might entail criminal responsibility.						**X**	
5.4.1	If so, constitute enforcement team to gather information and compile case.	**X**	**X**	**X**			**X**	NEMA, Standard Operating Procedure for Compliance and Enforcement, § 2.6.2.13
5.4.2	Make decision on prosecution of company.				**X**	**X**		For further reference see: • NEMA, Standard Operating Procedure for Compliance and Enforcement, § 2.6.2.14-16 • EMCA, section 118
Step 6	Follow-up on company's compliance with caution notice, warning letter, or restoration order.	**X**					**X**	
6.1	Conduct follow-up inspection, if deemed necessary.		**X**	**X**				
6.1.1	Appointment of inspection team and team leader	**X**						
6.2	Review applicable documentation, if applicable.		**X**	**X**				
6.3	Conduct follow-up report.		**X**	**X**				See EP – Form 1- Follow-up Incident/Non-compliance Report
6.4	Submit report to HIS, DCE, and CEO		**X**					
6.5	Archive investigation and follow-up report in accordance with NEMA's Record Management Policy	**X**			**X**			

Step 7	Make incidents, investigation report, compliance and enforcement actions, and follow-up report available to the public.				**X**			For further reference see Alberta's Compliance Dashboard. The AER's compliance dashboard reports incidents and provides Albertans with information about energy incidents in the province. The information is based on initial incident information reported to the AER. The AER posts information as soon as possible following its receipt. The information is subject to change as more details become available. http://www1.aer.ca/compliancedashboard/index.html

Appendices

EP Form 1 – Incident/Non-Compliance Follow-Up Report Form

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Name of Industry	
Business Reg. No.	
Name and Position of Contact Person	
Address and GPS Coordinates	**Phone No.**
Date of Inspection	
Reference	

1. Purpose and Scope

- Provide a brief summary and make reference to the enforcement tool preceding follow-up report.
- Specify whether follow-up will entail on-site inspection and document review, or just the latter. Provide rationale for this decision.

2. NEMA'S Inspection Team

Name	Position	E-mail address

3. List of Reviewed Documents

No.	Document Title	Description

4. List of Interviewed People, if applicable.

Name	Position	Subject	Annex No.

5. Analysis

Include the following information:

- Whether corrective actions have been taken.
- The date corrective actions were taken.
- The inspector's analysis for determining that compliance was obtained.
- The reason the non-compliance was closed.
- When compliance was achieved.

Date	Name of Team Leader
Signature	

S.6 - Incident Tracking Procedure

1. *Introduction*

1.1 *Purpose and Objective*

This section aims at providing guidance to NEMA officers on the steps to take following the identification of an environmental incident.

1.2 *Scope*

This section provides a clear guidance to NEMA personnel and the personnel of other lead agencies, where engaged, on the steps to take following the identification of an environmental incident in the up-, mid-, and downstream sectors of petroleum industry.

NOTE: This process is a sub-process of an inspection process and shall be read in conjunction with the processes' description stipulated in Volume 1 S. 2 and 4 of this manual.

1.3 *Roles and Responsibilities*

- **HIS**: Head Inspectorate Section - Leader of the inspection section of NEMA.
- **IT**: Inspection Team - NEMA appointed team, responsible for conducting on- and off-site inspections.
- **TL**: Team Leader - Team Leader – Head of inspection team.
- **DCE**: Director of Compliance and Enforcement - Lead of compliance and enforcement, responsible for prosecuting and sanctioning companies in breach
- **CEO**: County Environment Officer – NEMA, regional environmental law enforcement officer.
- **DDE**: Deputy Director Enforcement – Officer responsible for prosecuting and sanctioning companies in breach

2. *Process Mapping and Procedure*

2.1 *Inputs*

Input	Detail of Inputs and remarks	Ref.
Inspection Report	Report identifying an incident following an inspection.	NEMA, Standard Operating Procedure for Compliance and Enforcement, § 2.6.2.10
Audit Report	Report from baseline audit conducted to verify compliance with environmental legislation.	EIA Regulations, regulation 36.
Self-audit Report	Report from self-audit conducted to verify compliance with environmental management program.	EIA Regulations, regulation 34(1)(b).
Incidents Register	Record kept by NEMA's Compliance and Enforcement Team on incidents reported to the Incident Desk	
Reports on contingencies	If applicable, atmospheric impact report, malfunctions report, and emission limit exceedance report.	The Environmental Management and Coordination (Air Quality) Regulations, 2009, §§ 67(1), 69(1).

Other relevant documents	Documents in NEMA's possession containing information of the facility where the incident took place, and the process taking place therein.	

2.2 *Outputs*

Output	Detail of Inputs and remarks	Ref.
Investigation Report	Report on inspection conducted after identification of an incident specifying the causes of the incident, whether regulation has been broken, identifying responsible parties, and ways to prevent future similar incidents.	See Appendix 5.1
Follow-up Report	Report verifying compliance with corrective orders issued by NEMA in response to environmental incidents	See Appendix 5.2

2.3 *Tools, Forms, and Templates*

Form & template	Objectives	Usage
IT – Form 1 – Investigation report	Report on inspection conducted after identification of an incident	To be used in the process of report drafting
IT – Form 1 - Follow-up Report	Report verifying compliance with corrective orders issued by NEMA	To be used in follow-up inspection

2.4 Procedure

Activities, Steps, Description		Roles						Reference
Process Activity/	**Description**	**HIS**	**Team Leader**	**Inspection Team**	**DCE**	**DDE**	**CEO**	
Step 1	Identification of incident through inspection report, audit report, self-reporting, or the Incident Register.	**X**					**X**	For further reference see: • NEMA, Standard Operating Procedure for Compliance and Enforcement, § 2.6.2.10 • EIA Regulations, regulation 36, and 34(1)(b).
Step 2	Appointment of inspection team and team leader	**X**						
Step 3	Classification of incident according to Kenya's National Incident Classification Scheme	**X**					**X**	
Step 4	Within the boundaries of NEMA's inspection powers, conduct an investigation on incident and its causes.		**X**	**X**				For further reference see: • EMCA, section 117(3).
4.1	Gather all the information about the incident and examine the root cause of the incident.		**X**	**X**				
4.1.1	Gather historical and background information, if necessary.		**X**	**X**				See Input section above.
4.1.2	Conduct site visits, if necessary.		**X**	**X**				
4.1.3	Assess incident response activities, if necessary.		**X**	**X**				
4.1.4	Interview key people, if necessary.		**X**	**X**				
4.1.5	Determine whether a regulation has been broken		**X**	**X**				

4.1.6	Identify the responsible parties		**X**	**X**				
4.1.7	Identify ways to improve industry practices to prevent the incident from happening again		**X**	**X**				
Step 5	Develop and submit report on results of investigation		**X**					See appendix 5.1 below
Step 6	Decide on and conduct compliance and enforcement action.	**X**			**X**	**X**	**X**	For further reference see: • NEMA, Standard Operating Procedure for Compliance and Enforcement, § 2.6.2.11 • Section S.5 below.
Step 7	Follow-up on company's compliance with HIS' enforcement decision, if applicable.							
7.1	Conduct follow-up inspection, if deemed necessary.		**X**	**X**				
7.1.1	Appointment of inspection team and team leader	**X**						
7.2	Review applicable documentation, if applicable.		**X**	**X**				
7.3	Conduct follow-up report.		**X**	**X**				See appendix 5.2 below
7.4	Submit report to HIS, DCE, and CEO		**X**					
7.5	Archive investigation and follow-up report in accordance with NEMA's Record Management Policy	**X**			**X**			
Step 8	Make incidents, investigation report, compliance and enforcement actions, and follow-up report available to the public.				**X**			For further reference see Alberta's Compliance Dashboard.

Appendices

IT-Form 1- Investigation Report Form

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Name of Industry	
Business Reg. No.	
Name and Position of Contact Person	
Address (postal, physical address and GPS coordinates)	**Phone No.**
Date of Inspection	
Reference	

1. Rationale and Scope

- Include information on the reasons behind the inspection, e.g., the incident occurring on-site, the incident's classification, it's known and potential effects, the goal of the inspection team.
- Include information on the scope of the inspection, e.g., location of the premises, size of the premises, description of the facility, the types of activities conducted therein, incidents to be analyzed, etc.

2. NEMA's Inspection Team

Name	Position	E-mail address

3. Description of facility and summary of regulatory requirements applicable to facility

- Describe type of facility, e.g., pipeline, well, oil rig, refinery.
- Summarize regulatory requirements applicable to facility and activities conducted therein, including technical standards, and conditions included in operating license.

4. List of Reviewed Documents

No.	Document Title	Description

5. List of Interviewed People

Name	Position	Subject	Annex No.

6. **Observations**

Include:

- Observations made by the officer on the scope and impact of incident, included location, date and time of the observation.
- Assess incident response activities for each observation

7. **Analysis**

- Identify breached regulations
- Identify potentially responsible parties
- Identify ways to improve industry practices to prevent the incident from happening again

8. **Compliance and Enforcement**

- Identify compliance or enforcement tool to meet the regulatory requirement, e.g., improvement order.
- Identify corrective action(s).
- Set corrective action due date.

Date	**Name of Team Leader**
Signature	

IT-Form2 - Incident Follow-Up Report Form

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Name of Industry	
Business Reg. No.	
Name and Position of Contact Person	
Address (postal, physical address and GPS coordinates)	**Phone No.**
Date of Inspection	
Reference	

1. Purpose and Scope

- Provide a brief summary and make reference to the investigation report preceding follow-up report.
- Specify whether follow-up will entail on-site inspection and document review, or just the latter. Provide rationale for this decision.

2. NEMA'S Inspection Team

Name	**Position**	**E-mail address**

3. List of Reviewed Documents

No.	**Document Title**	**Description**

4. List of Interviewed People, if applicable.

Name	**Position**	**Subject**	**Annex No.**

5. Analysis

Include the following information:

- Whether corrective actions have been taken.
- The date corrective actions were taken.
- The inspector's analysis for determining that compliance was obtained.

- The reason the non-compliance was closed.
- When compliance was achieved.

Date	Name of Team Leader
Signature	

S.7 Process for establishing a data and record management process

1. Introduction

Kenya legislation imposes a number of record-keeping obligations on companies in the petroleum industry. Documents recorded and kept by such companies are transmitted to NEMA either via an annual submission[18] or at the request of NEMA personnel during inspections, audits, or other enforcement mechanisms.[19] In turn, NEMA is required to keep such documents and make them available to the public, unless they contain restricted information under Kenyan law.[20] Failing to meet the aforementioned obligations can be punished with up to 4 years of imprisonment, and/or a fine of up to four million shillings.[21]

It is critical that NEMA establishes a comprehensive process for data and record management in line with best practices.

1.1 Purpose and Objective

This section aims to describe the process and procedure that NEMA should implement to identify, collect, index, access, file, store, maintain, protect, back-up and dispose of quality and technical records. Such process, once fully developed and documented, will be used for generating, keeping and managing data and records deriving from NEMA activities related to environmental monitoring and inspection.

1.2 Scope

This procedure applies to all quality and technical records generated by NEMA in preparation, execution, reporting and following up of environmental monitoring and inspection.

1.3 Roles and Responsibilities

Data management requires the participation of a number of stakeholders. Specifically:

- **HIS**: Head Inspectorate Section - Leader of the inspection section of NEMA.
- **IT**: Inspection Team - NEMA appointed team, responsible for conducting on- and off-site inspections.
- **TL**: Team Leader - Head of inspection team.

1.4 Definitions

Records management: The planning, controlling, directing, organizing, training, promoting and other managerial activities involved with respect to records creation, records maintenance and use, and records disposition in order to achieve adequate and proper documentation of the policies and transactions conducted and implemented by NEMA.

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[18] The Environmental Management and Coordination Act, 2018, §122

[19] *Id.* at 121.

[20] *Id.* at 123.

[21] *Id.* at 139.

2. *Process Mapping and Procedure*

2.1 *Inputs*

Input	Detail of Inputs and remarks	Ref.
Records management policy	This policy shall determine how records are created, handled, maintained and disposed of.	

2.2 *Outputs*

Output	Detail of Inputs and remarks	Ref.
Protocol for creating and receiving documents	Guidance for NEMA employees on the creation of records related to the agency's business activities, e.g., checklists, strategies, reports, among others.	
Protocol for record management	Guidance for NEMA employees on the process and persons involved in the handling of records.	
Protocol for records filing, and maintenance	Guidance for NEMA employees on the storage of records.	
Protocol for records accessibility	Guidance for NEMA employees on personnel authorized to access certain sensitive records.	
Protocol for record disposal	Guidance for NEMA employees on the situations, time, manner in which it is appropriate to dispose of records stored by the agency.	

2.3 *Tools, Forms, and Templates*

- not available for this sub-process

2.4 Procedure

Activities, Steps, Description		Roles				Reference
Process Activity/	**Description**	**HIS**	**Team Leader**	**Inspection Team**	**County Offices**	
Step 1	Develop Record Management Policy (a planned, coordinated set of policies, procedures and activities needed to manage its recorded information).	**X**				For further reference see: • US EPA, *Interim Records Management Policy* (2018). • US EPA, *Control of Records Operating Procedure* (2014). • ISO 15489-1:2016 (E): Information and documentation – Records management - Part 1: Concepts and principles.
1.1	Develop protocol for creating and receiving documents.	**X**				For further reference see: US EPA, *Interim Records Management Policy* (2018), https://www.epa.gov/sites/production/files/2018-09/documents/interim-records-mgmt-policy-20180822.pdf
1.2	Develop protocol for record management.	**X**				For further reference see: US EPA, *Interim Records Management Policy* (2018), https://www.epa.gov/sites/production/files/2018-09/documents/interim-records-mgmt-policy-20180822.pdf
1.3	Develop protocol for filing, and maintenance of records.	**X**				For further reference see: US EPA, *Control of Records Operating Procedure* (2014), https://www.epa.gov/sites/production/files/2015-06/documents/Control-of-Records.pdf
1.4	Develop protocol for accessibility of documents, including restrictions applicable to confidential information.	**X**				For further reference see: US EPA, *Control of Records Operating Procedure* (2014),

						https://www.epa.gov/sites/production/files/2015-06/documents/Control-of-Records.pdf
1.4.1.	Develop and implement training program on restricted access to confidential information based on Kenya's intellectual property legislation.	**X**				For further reference see: • US EPA, *Control of Records Operating Procedure* (2014), https://www.epa.gov/sites/production/files/2015-06/documents/Control-of-Records.pdf • Act No. 3 of 2001 on Industrial Property.
1.5	Develop protocol on disposal of information.	**X**				For further reference see: US EPA, *Control of Records Operating Procedure* (2014), https://www.epa.gov/sites/production/files/2015-06/documents/Control-of-Records.pdf
1.6	Implementation of Record Management Policy in central and county offices.	**X**			**X**	For further reference see: US EPA, *Interim Records Management Policy* (2018), https://www.epa.gov/sites/production/files/2018-09/documents/interim-records-mgmt-policy-20180822.pdf
Step 2	Appointment of inspection team and team leader.	**X**				
Step 3	Determine specific facility subject to inspection based on inspection schedule developed by HIS.	**X**	**X**	**X**		
Step 4	Review of Record Management Policy		**X**	**X**		
Step 5	Develop Record Creation and Collection Strategy, in line with Record Management Policy		**X**			For further reference see: US EPA, *Control of Records Operating Procedure* (2014), https://www.epa.gov/sites/production/files/2015-06/documents/Control-of-Records.pdf
5.1	Assignment of Roles		**X**			
5.2	Development of log books for field observations		**X**	**X**		For further reference see: • US EPA, *Operating Procedure for Logbooks* (2013), https://www.epa.gov/sites/production/files/2015-06/documents/Logbooks.pdf • Appendix 2.7.1
Step 6	Implementation of Record Creation and Collection Strategy		**X**	**X**		
Step 7	Filing collected date in accordance with Record Management Policy		**X**	**X**		

Appendices[22]

DESIGNING SPECIALISED DATABASES AND SOFTWARE

The databases related to environmental regulatory management and compliance assurance should help organise, analyse or produce the following types of information:

- Laws and regulations;
- Facility-specific data;
- Inspection reports;
- Non-compliance reports;
- Incidents and accidents;
- Sampling reports and information on the rest of steps in the data production chain;
- Self-monitoring reports;
- Reports on compliance assistance activities;
- Complaints and data requests from the general public;
- Non-compliance cases and responses;
- Correspondence with the regulated community;
- Correspondence with partners;
- Resources used to conduct activities;
- Publishing activity and sub-contracts;
- Performance data.

The software designed to handle this information can have the following functions:

- Facilitate tracking any information that is relevant for the profiling of the regulated community and compliance assurance;
- Enable the analysis of performance and sharing of data on violators and non-compliance responses in different regions;
- Provide for automatic calculation of fees, fines and damage compensations, where possible;
- Make the link to the existing information systems of other state agencies, especially other enforcers (e.g. for identifying new facilities, recently registered, or check the financial status of enterprises and their fiscal discipline);
- Identify the resource-intensity of any activity and facilitate a better budgeting and expense;
- monitoring within the Inspectorate;
- Decrease the amount of paperwork and optimize reporting.

Several interfaces need to be available, including: (1) input and transfer interface and (2) reporting interface(s). Through the input and transfer interface, the employees of competent authorities should be able to record new enterprises and their characteristics, open folders for storing data from regulated community, input data from any reports and transfer data, which have been send electronically by permit holders to authorities, etc.

[22] It is understood that under the Kenyan Public Archieve Law, no agency can destroy records unless they have auhtorisation from the Director of the Public Archive Services agency.

At a minimum, data sets should be searchable by region, by chemical or pollutant of concern, by business sector, and by individual enterprises. The preference, however, should be given to search possibilities by any key word or combination of key words.

The reporting interface(s) should offer the possibility to view data in various combinations and time perspectives. They have to be tailored to different categories of users (high level officials, managers, and inspectors).

Given the nature of stored information, the access to some data sets should be restricted to authorised employees.

The following minimum technical criteria should be respected when designing the software:

- The database can be operated from one server computer and will be accessible from personal
- computers in the LAN in accordance to permissions set by the IT administrator;
- New data from regions can be uploaded into the main database only by staff working in the regions
- or in the head office;
- There should be the possibility to add new modules/databases;
- The databases and the applications will be compatible with other computer tools available within the Ministry of Environment, as well as other governmental authorities, in particular the Ministry of Interior.

S.8 Laboratory analytical procedure

1. Introduction

Kenyan law imposes a number of restrictions on the release of substances to the environment, e.g. air and water. Such restrictions consist -for example- of the imposition of maximum permissible levels of pollutants emission. NEMA has a duty to verify compliance with the aforementioned requirements, by conducting corresponding measurements and monitoring. EMCA provides the tools enabling NEMA to accomplish such task. On one hand, it enables the agency to take samples from regulated facilities; and, on the other hand, it authorizes NEMA to designate such number of laboratories at it considers necessary to analyze such samples. EMCA, furthermore, requires NEMA to state the specific functions of each designated laboratory, as well as the subject matter which the laboratory shall serve.

When NEMA commissions the analysis of any sample/substance to one of its designated laboratories, the latter is required to conduct such analysis and, subsequently, issue a certificate of analysis stating the results of the analysis, the methods of analysis followed, and the names of the personnel involved in the procedures.

1.1 Purpose and Objective

The objective of this section is to provides processes and procedures to deliver accuracy and precision of the tests results executed and reported by designated laboratories and to meet reliability requirements, i.e. to assure laboratory quality. Quality assurance (QA) ensures reliability of data by utilizing administrative and technical procedures and policies regarding personnel, resources, and facilities.

1.2 Scope

This section establishes and document processes and procedures implemented by NEMA employees to guarantee the reliability of analyses conducted by designated laboratories.

1.3 Roles and Responsibilities

- **HIS**: Head Inspectorate Section - Leader of the inspection section of NEMA.
- **IT**: Inspection Team - NEMA appointed team, responsible for conducting on- and off-site inspections.
- **TL**: Team Leader- Head of inspection team.
- Designated laboratories – Laboratories selected by NEMA to analyze determined parameters.
- Lead agencies (in case of environmental monitoring) – Agencies, including NEMA, responsible for enforcing Kenyan law.

2. Process Mapping and Procedure

2.1 Process Map

The following process map outlines the process of sample collection and processing:

2.2 Inputs

Input	Detail of Inputs and remarks	Ref.
Laboratory Manual for Quality Assurance and Quality Control	The manual must clearly identify the individuals involved in the QA program and document their responsibilities.	
Laboratory Quality Assurance Checklist	Checklist with issues inspectors must address to verify quality assurance.	•
NEMA's Record Management Policy	NEMA's policy on the management of agency records	•

2.3 Outputs

	Detail of Inputs and remarks	Ref.
Laboratory Quality Assurance Checklist	Checklist with issues inspectors must address to verify quality assurance.	•
Report on the implementation of laboratory quality assurance measures		•

2.4 Tools, Forms, and Templates

2.4.1 Tools

- Laboratory Quality Assurance Checklist
- Report on the implementation of laboratory quality assurance measures

2.4.2 Templates

The following templates shall be used in the sampling process:

Form & template	Objectives	Usage
LAP – Form 1, Laboratory Quality Assurance Checklist	Provide a checklist in preparation and execution of laboratory inspection	In planning and execution of laboratory inspection
LAP – Form 2- Report on the Implementation of Laboratory Quality Assurance Measures	Provides a template for laboratory inspection report	Reporting phase

2.5 Procedure

Activities, Steps, Description		Roles				Reference
Process Activity/	Description	HIS	Team Leader	Inspection Team	Laboratory	
Step 1	Determine laboratory to be inspected	X				
Step 2	Establishment an inspection team and team leader.	X				
Step 3	Revision of selected laboratory's Manual for Quality Assurance and Quality Control		X	X		
Step 4	Establishment of inspection strategy based on the following steps.		X			
Step 5	Evaluation of sample handling procedures. Including verifying the following:		X	X		
5.1	The laboratory area is secure and restricts entry to authorized personnel only.					
5.2	The laboratory has a sample security area that is dry, clean, and isolated; has sufficient refrigerated space; and can be locked securely.					
5.3	The laboratory has a sample custodian and a back-up custodian.					
5.4	The custodian receives all incoming samples, signs the chain-of-custody record sheet accompanying the samples, and locks the samples in the sample security area refrigerator.					
5.5	The custodian ensures that samples are properly stored.					
5.6	The custodian performs or analyzes checks of proper preservation, container type, and holding times and documents the results.					
5.7	The custodian distributes and retrieves samples to and from personnel who perform the analyses (i.e., analysts) and documents					

	the transfer of the samples in the chain-of custody record, which is retained as a permanent record.					
5.8	The custodian and analysts ensure the minimum possible number of people handle the samples.					
5.9	The custodian only disposes of samples and records upon direction from the laboratory director, in consultation with previously designated enforcement officials, when it is certain that the information is no longer required or that the samples have deteriorated.					
Step 6	Evaluation of laboratory analytical procedures. Including, verifying the following:		**X**	**X**		
6.1	The laboratory personnel follow analytical methods approved by NEMA.					
6.2	The laboratory personnel properly perform any deviations allowed by NEMA and maintain documentation of any NEMA-approved deviation from specified procedures					
6.3	The laboratory personnel follow QA/QC procedures that conform to the procedures specified in the QA Manual, and respective analytical method.					
6.4	The laboratory personnel conduct QA/QC checks on materials, supplies, equipment, instrument calibration and maintenance, facilities, analyses, standard solutions, and temperature.					
Step 7	Evaluation of laboratory facilities and equipment. Including, verifying the following:		**X**	**X**		
7.1	Laboratory Services					
7.1.1	Adequate supply of laboratory pure water, free from chemical interferences and other undesirable contaminants. The laboratory personnel should check water quality routinely and document it.					
7.1.2	Adequate bench, instrumentation, storage, and recordkeeping space.					
7.1.3	Clean and orderly work area to help avoid contamination.					
7.1.4	Adequate circulation and egress.					
7.1.5	Adequate humidity and temperature control.					
7.1.6	Adequate lighting and ventilation.					

7.1.7	Dry, uncontaminated compressed air when required.					
7.1.8	Efficient fume hood systems.					
7.1.9	Necessary equipment					
7.1.10	Electrical power for routine laboratory use and, if appropriate, voltage-regulated sources for delicate electronic instruments					
7.1.11	Vibration-free area for accurate weighing.					
7.1.12	Use proper safety equipment					
7.2	Instruments and Equipment					
7.2.1	The laboratory personnel follow standard and specific procedures for selecting and cleaning glassware and containers.					Chapter 2, section 2.7.4 of EPA's NPDES Compliance Monitoring Inspector Training Module: Laboratory Analysis (EPA, 1990), https://urlzs.com/4gH2c
7.2.2	The laboratory personnel follow written requirements (e.g., standard operating procedures) for daily operation of instruments and equipment.					
7.2.3	The laboratory contains emergency equipment such as a fire extinguisher, eye wash station, shower, first aid kit, lab coats, gloves, and goggles.					
7.2.4	Standards and appropriate blanks are available from suppliers to perform standard calibration procedures.					
7.2.5	The laboratory personnel maintain records of each set of analyses performed including the order in which calibration, QA/QC, and samples were analyzed (i.e., analysis run logs or instrument run logs).					
7.2.6	The laboratory personnel follow written troubleshooting procedures to identify common equipment malfunctions.					
7.2.7	The laboratory personnel follow written schedules for replacement, cleaning, checking, and/or adjustment by service personnel.					
7.2.8	The laboratory personnel maintain documentation on equipment maintenance and service checks.					
7.3	Supplies					

7.3.1	Check the accuracy of purchased solutions as per method requirements.					
7.3.2	Prepare stock solutions and standards using volumetric glassware.					
7.3.3	Prepare and standardize reagents against reliable primary standards.					
7.3.4	Use the required reagent purity for the specific analytical method.					
7.3.5	Check working standards frequently to determine changes in concentration or composition.					
7.3.6	Verify concentrations of stock solutions before being used to prepare new working standards.					
7.3.7	Label standards and reagents properly including the preparation date, concentration, the analyst's identification, storage requirements, and discard date.					
7.3.8	Store standards, reagents, and solvents in appropriate containers and under required method conditions and manufacturer's directions.					
7.3.9	Store standards, reagents and solvents using clean containers of suitable composition with tight-fitting stoppers.					
7.3.10	Discard standards and reagents after recommended shelf-life has expired or when signs of discoloration, formation of precipitates, or significant changes in concentrations are observed.					
Step 8	Evaluation of the precision and accuracy of the laboratory. Including, verifying the following:		**X**	**X**		The precision of laboratory findings refers to the reproducibility or degree of agreement among replicate measurements of the same quantity. Accuracy refers to the degree of difference between observed values and known or actual values.
8.1	Precision					
8.1.1	Introduce duplicate samples into the train of actual samples at least 10 percent of the time to monitor the performance of the analytical system.					
8.1.2	Prepare and use precision control charts or other statistical techniques for each analytical procedure. Develop precision control charts by collecting data from a minimum of 15 to 20 duplicate samples (run in controlled conditions) over an extended					

	period (e.g., 10 to 20 days). Statistical methods include calculation of mean, standard deviation, and variance to define the range and variability of the data.					
8.1.3	Take corrective actions when data fall outside the warning and control limits.					
8.1.4	Document out-of-control data, the situation, and the corrective action taken.					
8.2	Accuracy					
8.2.1	Introduce spiked samples into the train of actual samples at least 10 percent of the time to monitor the performance of the analytical system. In the spiked samples, the amount of additive is appropriate to the detection limit and sample concentration.					
8.2.2	Prepare and use accuracy control charts for each analytical procedure. Develop accuracy control charts by collecting data from a minimum of 15 to 20 spiked samples (run in controlled conditions) over an extended period.					
8.2.2.1	Establish accuracy limits (as percent recovery) based on standard deviations whose upper and lower control limits are three times the standard deviation above and below the central line.					
8.2.2.2	Establish the upper and lower warning limits at twice the standard deviation above and below the central line.					
8.2.3	Take corrective actions when data fall outside the warning and control limits.					
8.2.4	Document out-of-control data, the situation, and the corrective action taken.					
Step 9	Evaluation of data handling and reporting. Including, verifying the following:		**X**	**X**		
9.1	Use correct formulas to calculate the final results.					
9.2	Apply round-off rules uniformly.					
9.3	Establish significant figures for each analysis.					
9.4	Provide data in the form/units required for reporting.					
9.5	Ensure cross-checking calculations provisions are available.					

9.6	Determine control chart approaches and statistical calculations for the purposes of QA/QC and reporting.					
9.7	Maintain laboratory report forms that provide complete data documentation and facilitate data processing.					
9.8	Keep permanently bound laboratory notebooks or pre-printed data forms to document the procedures performed and the details of the analysis, such as the original value recorded, correction factors applied, blanks used, data values reported, personnel that performed the tests, and any abnormalities that occurred during the testing procedure.					
9.9	Define procedures for correction of data entry errors. Original data entries can be read and the individual(s) making the corrections are clearly identified.					
9.10	Back up computer data with duplicate copies (i.e., electronic and hardcopy).					
9.11	Maintain data records that allow the recalculation of all results reported by the laboratory(ies) from the original unprocessed results (i.e., raw data) to the final results sent to NEMA and other regulatory authorities for a minimum of three years.					
Step 10	Evaluation of laboratory personnel. Including, verifying the following:		**X**	**X**		
10.1	Adequacy of training.					
10.2	Skill and diligence in following procedures.					
10.3	Skill and knowledge in using equipment and analytical methods					
10.4	Precision and accuracy in performing analytical tasks.					
10.5	Assignment of clearly defined tasks and responsibilities.					
Step 11	Develop report on implementation of quality assurance measures		**X**	**X**		
Step 12	Submit report mentioned above to HIS and store copy, in accordance with Record Management Policy.		**X**	**X**		

Appendices

LAP – Form 1, Laboratory Quality Assurance Checklist

Note: This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Name of Industry	
Business Reg. No.	
Name and Position of Contact Person	
Address (postal, physical address and GPS coordinates)	
Telephone No.	
Reference	

GENERAL			
YES	NO	N/A	Laboratory maintains a written QA/QC manual.
SAMPLE HANDLING PROCEDURE			
			Access to laboratory area restricted to authorized personnel only.
			Sample security area available within laboratory that is dry, clean, and isolated; has sufficient refrigerated space; and can be locked securely.
			Laboratory refrigerator utilizes a thermometer with NIST certification or that is annually calibrated against another NIST-certified thermometer and documented using certification tags.
			Laboratory has a sample custodian and a back-up custodian.
			Custodian receives and logs in all incoming samples.
			Custodian properly stores samples.
			Custodian performs checks of proper preservation, container type, and holding times performed and documents the results.
			Custodian distributes and retrieves samples to and from the analysts.
			Custodian maintains chain-of-custody documentation.
			Custodian and analysts ensure the minimum possible number of people handles the samples.
			Custodian disposes of the samples and records upon direction of the laboratory director.
LABORATORY PROCEDURES			
			NEMA-approved written analytical testing procedures used and protocols are easily accessible by laboratory personnel.
			If alternate analytical procedures used, proper written approval obtained.
			Calibration and maintenance of instruments and equipment satisfactory.

			QA procedures used.
			QC procedures adequate.
			Duplicate samples are analyzed _______________ % of time.
			Spiked samples are used _________________ % of time.
Laboratory Facilities and Equipment			
			Adequate supply of laboratory pure water available for specific analysis.
			Adequate bench, instrumentation, storage, and recordkeeping space available.
			Clean and orderly work area available to help avoid contamination.
			Adequate circulation and egress.
			Adequate humidity and temperature control.
			Adequate lighting and ventilation.
			Dry, uncontaminated compressed air available.
			Efficient fume hood systems available.
			Adequate electrical sources available.
			Instruments/equipment available and in good condition.
			Vibration-free area for accurate weighing available.
			Proper safety equipment (lab coats, gloves, safety glasses, goggles, and fume hoods) used when necessary.
			Proper volumetric glassware used.
			Glassware properly cleaned.
			Written requirements for daily operation of instruments/equipment available.
			Standards and appropriate blanks available to perform daily check procedures.
			Sources of standards documented.
			Records of each set of analysis including order in which calibration, QA/QC, and samples were analyzed are available.
			Written troubleshooting procedures for instruments/equipment are available.
			Written schedules for required maintenance are available.
			Check the accuracy of purchased solutions as per method requirements.
			Prepare stock solutions and standards using volumetric glassware.
			Prepare and standardize reagents against reliable primary standards.
			Use the required reagent purity for the specific analytical method.
			Frequently checked working standards to determine changes in concentration or composition.
			Verify concentrations of stock solutions before being used to prepare new working standards.
			Background reagents and solvents run with every series of samples.
			Label standards and reagents properly, including the preparation date, concentration, the analyst's identification, storage requirements, and discard date.

			Store standards, reagents, and solvents in appropriate containers and under required method conditions and manufacturer's directions.
			Store standards, reagents, and solvents using clean containers.
			Replace gas cylinders at 100-200 psi.
			Written procedures exist for cleanup, hazard response methods, and applications of correction methods for reagents and solvents.
			Discard standards after recommended shelf-life has expired or when signs of discoloration, formation of precipitates, or significant changes in concentrations are observed.
LABORATORY PRECISION, ACCURACY, AND CONTROL PROCEDURES			
			Analyzed multiple control samples (i.e., blanks, standards, duplicates, and spikes) for each type of QA/QC check and recorded information. Every tenth sample should have been followed by a duplicate and a spike.
			Plotted precision and accuracy control methods used to determine whether valid, questionable, or invalid data are being generated throughout the analysis.
			Taken corrective actions when data fall outside the warning and control limits.
			Recorded out-of-control data, the situation, and the corrective action taken.
DATA HANDLING AND REPORTING			
			Used correct formulas to calculate final results.
			Applied round-off rules uniformly.
			Established significant figures for each analysis.
			Recorded data in the proper form and units for reporting.
			Ensured cross-checking calculations provisions are available.
			Developed and followed control chart approaches and statistical calculations for QA/QC.
			Laboratory report forms developed to provide complete data documentation and to facilitate data processing.
			Laboratory notebooks or pre-printed data forms bound permanently utilized to provide good documentation.
			Procedures for correction of data entry errors are defined.
			Backed up computer data with duplicate copies (i.e., electronic and hardcopy).
			Efficient filing system exists, enabling prompt retrieval of information and channeling of report copies.
			Data records allow recalculation of all results reported by the laboratory(ies) from the original unprocessed results (raw data) to the final results sent to NEMA and the regulatory authority for a minimum of three years.
LABORATORY PERSONNEL			
			Enough analysts present to perform the analyses necessary.
			Analysts have on hand the necessary references for procedures being used.
			Analysts trained in procedures performed through formal or informal training or certification programs.

Observations	
Date	Name of Responsible Officer
Signature	

LAP – Form 2- Report on the Implementation of Laboratory Quality Assurance Measures

Note : This form is designed for general use and may not be exhaustive. Modifications and additions may be necessary to suit individual projects and to address specific environmental issues and associated mitigation measures.

Name of Laboratory	
Business Reg. No./Accreditation number	
Name and Position of Contact Person	
Address	**Phone No.**
Date of Inspection	
Reference	

1. Executive Summary

2. Evaluation of sample handling procedures.

Include inspectors' findings on whether:

- The laboratory area is secure and restricts entry to authorized personnel only.
- The laboratory has a sample security area that is dry, clean, and isolated; has sufficient refrigerated space; and can be locked securely.
- The laboratory has a sample custodian and a back-up custodian.
- The custodian receives all incoming samples, signs the chain-of-custody record sheet accompanying the samples, and locks the samples in the sample security area refrigerator.
- The custodian ensures that samples are properly stored.
- The custodian performs or analyzes checks of proper preservation, container type, and holding times and documents the results.
- The custodian distributes and retrieves samples to and from personnel who perform the analyses (i.e., analysts) and documents the transfer of the samples in the chain-of custody record, which is retained as a permanent record.
- The custodian and analysts ensure the minimum possible number of people handle the samples.
- The custodian only disposes of samples and records upon direction from the laboratory director, in consultation with previously designated enforcement officials, when it is certain that the information is no longer required or that the samples have deteriorated.

3. Evaluation of laboratory analytical procedures.

Include inspectors' findings on whether:

- The laboratory personnel follow analytical methods approved by NEMA.
- The laboratory personnel properly perform any deviations allowed by NEMA and maintain documentation of any NEMA-approved deviation from specified procedures.
- The laboratory personnel follow QA/QC procedures that conform to the procedures specified in the QA Manual, and respective analytical method.
- The laboratory personnel conduct QA/QC checks on materials, supplies, equipment, instrument calibration and maintenance, facilities, analyses, standard solutions, and temperature.

4. Evaluation of laboratory facilities and equipment.

<u>Laboratory Services</u>

Include inspectors' findings on whether:

- Adequate supply of laboratory pure water, free from chemical interferences and other undesirable contaminants. The laboratory personnel should check water quality routinely and document it.
- Adequate bench, instrumentation, storage, and recordkeeping space.
- Clean and orderly work area to help avoid contamination.
- Adequate circulation and egress.
- Adequate humidity and temperature control.
- Adequate lighting and ventilation.
- Dry, uncontaminated compressed air when required.
- Efficient fume hood systems.
- Necessary equipment
- Electrical power for routine laboratory use and, if appropriate, voltage-regulated sources for delicate electronic instruments
- Vibration-free area for accurate weighing.
- Use proper safety equipment

Instruments and Equipment

Include inspectors' findings on whether:

- The laboratory personnel follow standard and specific procedures for selecting and cleaning glassware and containers.
- The laboratory personnel follow written requirements (e.g., standard operating procedures) for daily operation of instruments and equipment.
- The laboratory contains emergency equipment such as a fire extinguisher, eye wash
- station, shower, first aid kit, lab coats, gloves, and goggles.
- Standards and appropriate blanks are available from suppliers to perform standard calibration procedures.
- The laboratory personnel maintain records of each set of analyses performed including the order in which calibration, QA/QC, and samples were analyzed (i.e., analysis run logs or instrument run logs).
- The laboratory personnel follow written troubleshooting procedures to identify common equipment malfunctions.
- The laboratory personnel follow written schedules for replacement, cleaning, checking, and/or adjustment by service personnel.
- The laboratory personnel maintain documentation on equipment maintenance and service checks.

Supplies

Include inspectors' findings on whether:

- Check the accuracy of purchased solutions as per method requirements.
- Prepare stock solutions and standards using volumetric glassware.
- Prepare and standardize reagents against reliable primary standards.
- Use the required reagent purity for the specific analytical method.
- Check working standards frequently to determine changes in concentration or composition.
- Verify concentrations of stock solutions before being used to prepare new working standards.
- Label standards and reagents properly including the preparation date, concentration, the analyst's identification, storage requirements, and discard date.
- Store standards, reagents, and solvents in appropriate containers and under required method conditions and manufacturer's directions.
- Store standards, reagents and solvents using clean containers of suitable composition with tight-fitting stoppers.

- Discard standards and reagents after recommended shelf-life has expired or when signs of discoloration, formation of precipitates, or significant changes in concentrations are observed.

5. Evaluation of the precision and accuracy of the laboratory.

Precision

Include inspectors' findings on whether to:

- Introduce duplicate samples into the train of actual samples at least 10 percent of the time to monitor the performance of the analytical system.
- Prepare and use precision control charts or other statistical techniques for each analytical procedure. Develop precision control charts by collecting data from a minimum of 15 to 20 duplicate samples (run in controlled conditions) over an extended period (e.g., 10 to 20 days). Statistical methods include calculation of mean, standard deviation, and variance to define the range and variability of the data.
- Take corrective actions when data fall outside the warning and control limits.
- Document out-of-control data, the situation, and the corrective action taken.

Accuracy

Include inspectors' findings on whether to:

- Introduce spiked samples into the train of actual samples at least 10 percent of the time to monitor the performance of the analytical system. In the spiked samples, the amount of additive is appropriate to the detection limit and sample concentration.
- Prepare and use accuracy control charts for each analytical procedure. Develop accuracy control charts by collecting data from a minimum of 15 to 20 spiked samples (run in controlled conditions) over an extended period.
    - Establish accuracy limits (as percent recovery) based on standard deviations whose upper and lower control limits are three times the standard deviation above and below the central line.
    - Establish the upper and lower warning limits at twice the standard deviation above and below the central line.
- Take corrective actions when data fall outside the warning and control limits.
- Document out-of-control data, the situation, and the corrective action taken.

6. Evaluation of data handling and reporting.

Include inspectors' findings on whether to:

- Use correct formulas to calculate the final results.
- Apply round-off rules uniformly.
- Establish significant figures for each analysis.
- Provide data in the form/units required for reporting.
- Ensure cross-checking calculations provisions are available.
- Determine control chart approaches and statistical calculations for the purposes of QA/QC and reporting.
- Maintain laboratory report forms that provide complete data documentation and facilitate data processing.
- Keep permanently bound laboratory notebooks or pre-printed data forms to document the procedures performed and the details of the analysis, such as the original value recorded, correction factors applied, blanks used, data values reported, personnel that performed the tests, and any abnormalities that occurred during the testing procedure.
- Define procedures for correction of data entry errors. Original data entries can be read and the individual(s) making the corrections are clearly identified.
- Back up computer data with duplicate copies (i.e., electronic and hardcopy).

- Maintain data records that allow the recalculation of all results reported by the laboratory(ies) from the original unprocessed results (i.e., raw data) to the final results sent to NEMA and other regulatory authorities for a minimum of three years.

7. Evaluation of laboratory personnel.

Include inspectors' findings on whether to:

- Adequacy of training.
- Skill and diligence in following procedures.
- Skill and knowledge in using equipment and analytical methods
- Precision and accuracy in performing analytical tasks.
- Assignment of clearly defined tasks and responsibilities.

8. Observations

9. Certification

Certification of test report being true, accurate, and in compliance with Kenyan regulation, by the people responsible for conducting the emissions sampling and test.

Name of NEMA Official	
Date	Signature

Volume 3

This volume of the manual details specific aspects of environmental monitoring and inspection of onshore, offshore and up-, mid- and downstream petroleum operations. It shall be read and used in conjunction with Volumes 1 and 2 of this Manual.

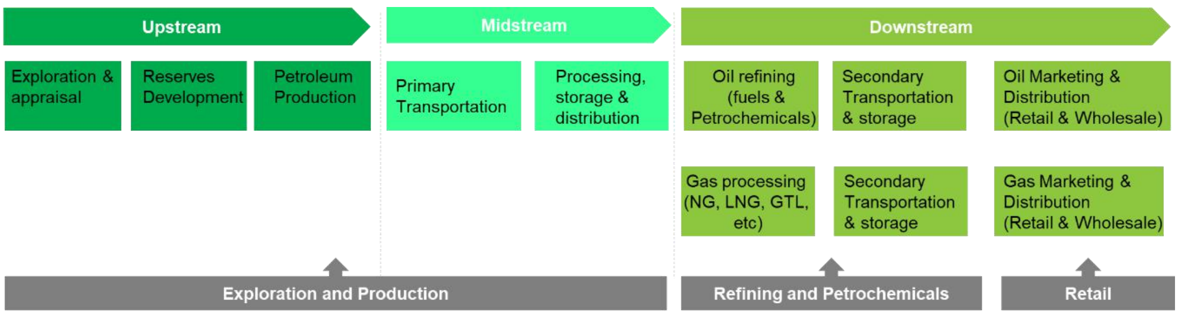
S. 1 Specific provisions related to environmental monitoring and inspection of upstream onshore petroleum operations

1.1. Description of activities and facilities involved in upstream onshore petroleum operations

The main purpose of the petroleum industry is to find and bring above ground natural gas and crude oil, to process it into products and to distribute petroleum derivatives to customers. A major factor, which determines the importance, ease of processing, quality of final products, and the environmental impact of the petroleum industry, is the composition of crude oil and natural gas.

The oil and gas industry is usually divided into three major sectors: upstream exploration and production (E&P), midstream and downstream. It should be noted, however, that some authors categorize midstream either as part of the upstream or downstream operations.

The diagram below is a high-level graphical representation of the sequence of petroleum industry activities:



The upstream sector includes searching for potential onshore and offshore crude oil and natural gas fields, drilling exploratory wells, and subsequently drilling and operating the wells to recover and bring the crude oil or raw natural gas to the surface. In recent years, there has been a significant shift toward including unconventional gas as a part of the upstream sector, and corresponding developments in liquefied natural gas (LNG) processing and transportation.

The following table represents the life-cycle, processes and technologies for onshore conventional upstream oil and gas E&P.

Main Stages	Sub-stages	Processes/technologies
Stage 1 - Site identification and preparation	1. Identification of resource (desk study)	**Desk studies** of target area to establish geological conditions and hydrocarbon potential
		Licensing
	2. Surveys and conceptual model	**General investigation:** - Aerial survey of land features e.g. satellite imagery, aircrafts, etc.
		Geophysical testing/investigations: - Land based seismic
		Development of conceptual model
	3. Exploratory drilling	**Baseline surveys** (ecology, hydrology, groundwater, community impact, etc.)
		Mobilisation of drilling rig and equipment and people to the drill location
		Site preparation (e.g. site clearing, accessibility, infrastructure)
		Support camp (outside boundary)
Stage 2 - Well design, construction and completion	4. Exploration well construction	**Well pad construction**
		Rig installation
		Drilling of vertical or deviated wells
		Drill cuttings management – Management of cuttings generated during drilling operations
		Cementing and casing
		Well stabilisation
	5. Well testing	**Well testing** (some preliminary testing may be carried out before the well is plugged temporarily)
		Management and treatment of produced water from exploratory wells
		Revised conceptual model and resource estimate
		Assessment (evaluate technical and economic viability for the whole project and develop plans for production)
	6. Well completion	**Well completion** (screens, valves, etc.)
Stage 3 – Development and Production	7. Field development design (not all necessarily required)	**Field development** (planning and design): - Field development concept - Front-end engineering design
	8. Construction and installation	**Implementation of development plan** - Site clearing - Access infrastructure(i.e. roads, infrastructure)
	9. Hook-up and commissioning	- Well hook-up to production system - Pre-commissioning - Commissioning

	10 Development drilling- if required, once field development in place	**Development drilling** (if required) - Small drilling field - Large drilling field
	11. Hydrocarbon production - hydrocarbon production and processing	**Crude oil and gas processing** - operation of plant and process equipment and maintenance activities
		Well workover – well maintenance, etc.
		Process treatment systems - produced water collection and management
		Utility systems - wastewater and sewage collection and treatment
		Waste handling - waste handling, storage, collection and transport
		Hydrocarbon offtakes - product export
		onshore pipelines/road tankers **Enhanced recovery (water flooding)** – water flooding to boost production **Enhanced recovery (substance injection)** – steam/miscible gas/polymer injection to boost production **Well stimulation (low volume hydraulic fracturing)** – fracturing to boost production
Stage 4 Project cessation, well closure and decommissioning	12. Decommissioning and rehabilitation planning	**Project cessation, well closure and decommissioning**
	13. Decommissioning of equipment and reclamation	**Plugging of wells, Removal of well pads, Waste management**
	14. Rehabilitation	**Site restoration**
Stage 5 Project post closure and abandonment	15. Project closure and abandonment	**Long-term well integrity and monitoring. License relinquishment**

1.2. Sources of key impacts of onshore oil and gas operations and impact categorization

In order to manage the health, safety and operational integrity risks associated with onshore petroleum activities, best practice is to implement a risk characterisation approach which involves the use of a risk matrix by which to qualitatively rank the risks identified[23]. A qualitative approach is typically used due to the lack of quantitative data available across the range of stages and activities that might be involved.

A risk matrix based on King (2012), was developed and agreed as part of the study 'Technical Support for the Risk Management of Unconventional Hydrocarbon Extraction' and is illustrated as Figure 3.

[23] Final report. Study on the assessment and management of environmental impacts and risks resulting from the exploration and production of hydrocarbons. Prepared by Amec Foster Wheeler Environment & Infrastructure UK Ltd October 2016

Figure 3- Risk matrix

<table>
<tr><td rowspan="8">Likelihood of Incident</td><td rowspan="3"></td><td rowspan="3"></td><td colspan="6">Consequence of Incident</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td></td></tr>
<tr><td>Slight</td><td>Minor</td><td>Moderate</td><td>Major</td><td>Catastrophic</td><td>No data</td></tr>
<tr><td>1</td><td>Extremely Rare</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td rowspan="6">Not classifiable</td></tr>
<tr><td>2</td><td>Rare</td><td>2</td><td>4</td><td>6</td><td>8</td><td>10</td></tr>
<tr><td>3</td><td>Occasional</td><td>3</td><td>6</td><td>9</td><td>12</td><td>15</td></tr>
<tr><td>4</td><td>Likely</td><td>4</td><td>8</td><td>12</td><td>16</td><td>20</td></tr>
<tr><td>5</td><td>Highly Likely</td><td>5</td><td>10</td><td>15</td><td>20</td><td>25</td></tr>
<tr><td></td><td></td><td>No data</td><td colspan="5">Not classifiable</td></tr>
</table>

Key

Colour	Level of Risk	Score
Green	Low	1 – 4
Yellow	Moderate	5 – 8
Orange	High	9 – 12
Red	Very High	15 – 25

This approach and methodology is used to identify and document sources of impact and their categorisation for upstream onshore and offshore petroleum operations, as provided for in this section and Vol. 3 S.2.2.

1.2.1 Risk and impacts of ground investigations (aerial surveys)

Overall environmental risk characteristics of aerial surveys are considered low with respect to releases to air and noise impacts, as summarised in the table below.

Environmental Aspects	Impacts	Risk Level
Release to air (local air quality)	Based on the consumption of fuel, emissions to air would be expected from aircraft. Despite the potential impacts to air quality, the frequency of the occurrences will be minimal and therefore are generally considered to have low impact.	4 low
Release to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality; the emissions of greenhouse gases will also have a contribution towards climate change.	5 moderate
Noise	Low flying aircraft over the study area may have sensitive receptors in the vicinity or could potentially cause very short-term disturbance to migrating birds.	4 low

1.2.2 Risk and impacts of seismic surveys

Risk to the environment from seismic activities are considered, generally, to be reasonably low. However, this may vary on a site-by-site basis. Based on how current land-based seismic testing is carried out and due to the short term and transient nature of the activity, a low level of impact may be generally expected. Land clearing is required to enable the vibrator unit to survey the identified area, which can cause heightened impacts if in sensitive areas.

Environmental Aspects	Impacts	Risk Level
Surface water contamination	Intrusive surveys such as shotgun method (dynamite) may have an impact to surface from surface runoff. Impact in the event of a spill or release of potentially contaminative material from seismic machines and vehicle engines can lead to surface runoff to nearby surface water bodies. Site clearing from seismic activities may expose more land which would be more susceptible to surface run off in wet weather.	4 low
Releases to air (local air quality)	Dust and vehicle exhaust emissions will be emitted from vibroseis or shot hole surveys. The latter method can generate a larger quantity of dust due to hole preparation. Otherwise generally gases such as carbon dioxide and nitrogen oxides emitted from engines and machinery and dust from vibrator movements during the survey can contribute to air emissions although generally in low quantities.	4 low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality; the emissions of greenhouse gases will also contribute towards climate change.	5 moderate
Land take	Land and vegetation clearing and land acquisition to enable vibrator unit to survey the identified area. Damage to local infrastructure and archaeological sites (from vibrations)	4 low
Biodiversity impacts	Seismic surveys could disturb flora and fauna where shot gun methods (e.g. dynamite) are adopted. Improvements, creation or maintenance of access routes can potentially be responsible for geomorphologic damage or disturbance. Destabilising the soil structure during access road preparation (or by driving off-track) will expose the finer grained materials that are present beneath the surface layer, leading to scarring and increased erosion.	2 low
Traffic	Localised increase in traffic to site to perform investigative work.	4 low
Seismic	Shot hole drilling and testing or acoustic sources (vibrations, explosions) may generate disturbance to human and wildlife.	4 low

1.2.3 Risk and impacts of mobilising drilling rig, equipment and people to drill location

Compared to construction and drilling activities, the impact and risk for mobilising drilling rig, equipment and people to the drill site may generally be considered to be low, since the scale of works is not as extensive. Impacts arise primarily from vehicles and machinery.

Environmental Aspects	Impacts	Risk Level
Surface water contamination	Water contamination from surface runoff or stormwater runoff. Impact in the event of a spill or release of potentially contaminative material from engines, spillages, leakages, sewage, camp grey water, etc. Vegetation cleared; possible erosion and changes in surface hydrology; emissions from earth moving equipment leading to potential disturbance of local population and wildlife. Potential long-term impacts from access route construction.	2 low
Releases to air (local air quality)	Dust emissions from use of dirt tracks. Exhaust emissions from vehicles and generators.	4 low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality; the emissions of greenhouse gases will also contribution to climate change.	5 moderate

Noise	Mobilisation would involve low level noise from camp activities therefore generating disturbance to local environment. This is considered short term and transient. Vibration and noise from earth moving equipment can lead to potential disturbance of local population and wildlife. Potential long-term impacts from access construction.	4 low
Traffic	Development of an oil and gas field would result in the need to construct and/or improve access roads and would result in an increase in industrial traffic. Overweight and oversized loads could cause temporary disruptions and could require extensive modifications to roads or bridges (e.g. widening roads or fortifying bridges). Increased traffic would also result in a potential for increased accidents within the project area. The locations at which accidents are most likely to occur are intersections used by project-related vehicles to turn onto or off of highways from access roads. Conflicts between industrial traffic and other traffic are likely to occur, especially on weekends and holidays.	4 low

1.2.4 Risk and impacts of site preparation

Although the environmental footprint for site preparation is considered larger than that of the other processes of oil and gas exploration, overall risk levels for site preparation are generally assessed to be reasonably low once risk management measures are implemented and adopted such as limiting the sources of air emissions. However, land take is identified as generally presenting a moderate level of risk, as its impact is attributed to land clearing and preparation for vehicular and pedestrian traffic, construction and installation of facilities to make way for well drilling activities. Potentially, the land may be required for a considerable period of time depending on whether, following the exploration phase, the site is deemed commercially viable and therefore moves into the production phase. Impact would then be ongoing for the duration of the project lifetime and recovery of the land and natural habitats would be delayed. As a result, the same impact for land take is considered repeated across the subsequent processes and technologies, the assessment is conducted once here in the table below for the site preparation stage to cover both the exploration and production stages.

Environmental Aspects	Impacts	Risk Level
Surface water contamination	Soils compacted on existing roads, new access roads, and well pads generate more runoff than undisturbed sites. The increased runoff could lead to slightly higher peak storm flows into streams, potentially increasing erosion of the channel banks. Impact in the event of a spill or release of potentially contaminative material from engines, spillages, leakages, sewage, camp grey water, etc.	4 low
Releases to air (local air quality)	Dust emissions from use of dirt tracks. Exhaust emissions from vehicles and generators. Dust generated from exposed land clearing and poor housekeeping practices.	4 low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality; the emissions of greenhouse gases will also contribute to climate change.	5 moderate
Land take	The acquisition of land may have a moderate impact although in more extreme cases may require community displacement to make way for exploration. Site preparation will result in further vegetation clearing in preparation for the site well pad.	8 moderate
Visual impact	Low level light from camp activities would be observed and therefore can disturb local environment. However, this is considered short term during the exploration stage. The addition of wells, pipelines, access roads, and other ancillary facilities during the production phase would result in an industrial landscape in the oil or gas field area.	4 low

Biodiversity impacts	Surface disturbance, fragmentation or damage to ecological habitat is proportional to the total area of the site cleared prior to well pad construction. Vegetation and topsoil would be removed for the development of well pads, access roads, pipelines, and other ancillary facilities. This would lead to a loss of wildlife habitat, reduction in plant diversity and potential for increased erosion. These access roads and seismic lines may pass through a variety of environments. The activities associated with the improvement, creation or maintenance of access routes are the main activities that can potentially be responsible for geomorphologic damage or disturbance. Destabilising the soil structure during access road preparation (or even by simply driving off-track) will expose the finer grained materials that are present beneath the surface layer, leading to scarring and increased erosion.	4 low
Noise	Primary sources of noise during the drilling/development phase would be equipment (bulldozers, drill rigs, and diesel engines). Other sources of noise include vehicular traffic and blasting (blasting activities typically would be limited to areas where the terrain is hilly and bedrock shallow). Vibration and noise from earth moving equipment can lead to potential disturbance of local population and wildlife. Potential long-term impacts from access construction.	4 low
Traffic	Access and footprint impact with increased number of vehicles accessing the site adding further traffic burden to local infrastructure if near any settlement. Mainly short-term with potential long-term impact from newly formed access.	4 low

1.2.5 Risk and impacts of well pad construction

With adequate risk management measures in place, environmental hazards associated with well pad construction may generally be considered relatively low. However, risks to groundwater, surface water and air are expected to be moderate, due to their potentially more significant consequences. The risk of air releases are also deemed generally moderate, but impacts would depend upon the amount, duration, location, and characteristics of the emissions and the meteorological conditions (e.g. wind speed and direction, precipitation, and relative humidity).

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	Poor management practices during construction may have the potential for contaminants to be released into groundwater which is dependent on the depth to groundwater and the permeability of the intervening material.	6 moderate
Surface water contamination	Contamination and soils compacted on construction site can generate surface runoff if not appropriately managed. This increased runoff could lead to slightly higher peak storm flows into streams, potentially increasing pollution impact to surface water bodies.	6 moderate
Releases to air (local air quality)	Dust emissions from exposed construction materials. Exhaust emissions from vehicles and generators and poor housekeeping practices during construction	8 moderate
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality; the emissions of greenhouse gases will also contribute to climate change.	5 moderate
Biodiversity impacts	Low level lighting at night and disturbance of fauna and impacts on flora from construction activities.	5 moderate

Visual impact	The well pad construction and associated activities would introduce an industrial site for oil or gas exploration.	5 moderate
Noise	Disturbance of local residents and fauna by noise from generators, machinery and vehicles. Increased traffic will be expected contributing to further background noise.	4 low
Traffic	Traffic from increased number of construction vehicles.	4 low

1.2.6 Risk and impacts of rig installation

Overall environmental risk characteristics of rig installation are generally considered relatively low with respect to releases to air, noise and traffic impacts.

Environmental Aspects	Impacts	Risk Level
Releases to air (local air quality)	Dust emissions from exposed construction materials, exhaust emissions from vehicles and generators and poor housekeeping practices during construction.	4 low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality; the emissions of greenhouse gases will also contribute to climate change.	5 moderate
Noise	Noise from increased traffic and vehicle operating on site for the installation of the rigs. More transportation activity is expected if the rig is constructed in modules.	4 low
Traffic	Vehicles to transport the rig part(s) and equipment on site.	4 low

1.2.7 Risk and impacts of drilling of vertical or deviated wells

Generally, environmental risk from oil and gas drilling operations is considered moderate for groundwater, surface water and emissions to air (local and globally), as summarised in the table below.

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	There may be leakages from subsurface formations if well casing and (triple) cement do not fully seal the well. Aquifers can be impacted by other non-potable formation waters seeping out. In addition, the well may provide a path for surface contaminants (e.g. drilling fluids, chemicals, drill cuttings) to come into contact with groundwater. Inadequate housekeeping practices on a site can lead to leaks, improper storage facilities and increased risk of spills.	6 moderate

Surface water contamination	Drilling and well development often remove large quantities of water that is held in the same formation as the hydrocarbons. This is referred to as produced water. The generation of produced water can create several problems: • Exploratory wellbores may decrease the pressure in water wells and affect their quality; • Produced water that is saline or contaminated with drilling fluids can contaminate soils or surface waters, if not correctly managed; and • Produced water may also contain organic acids, alkalis, diesel oil, crankcase oils, and acidic stimulation fluids (e.g. hydrochloric and hydrofluoric acids). Insufficient treatment of discharged produced water can result in contamination of surface water. Produced water is typically managed through processes such as recycling, reinjection into the original formation or an alternative formation with suitable containment properties (with pre-treatment only to increase injectivity), treatment and discharge, evaporation or infiltration. Leakage or discharge of drainage water may result in pollution of groundwater. In the event of a spillage during well drilling or testing, produced water may leak into surface water bodies and contaminate them. Depending on the geology of the area, the characteristics of produced water may vary. Produced water may contain salt, oil and grease, various inorganic and organic chemicals and naturally occurring radioactive material (NORM).	6 moderate
Water resource depletion	Depletion of water resources will depend on the scale of drilling required. Increased pressure on localised water resources may result; this effect due to water scarity is expected to be moderate due to the small scale activity of the exploration stage.	6 moderate
Releases to air (local air quality)	Release of trapped gas, VOCs, dust from drilling and emissions from flaring of gas or oil. Principal pollutants emitted from oil production include nitrogen oxides, sulphur oxides, carbon monoxide and particulates. Additional pollutants can include: hydrogen sulphide (H_2S); volatile organic compounds (e.g. methane and ethane, benzene, ethyl benzene, toluene and xylenes (BTEX), glycols and polycyclic aromatic hydrocarbons. Dust emissions from exposed construction materials, exhaust emissions from vehicles and generators.	6 moderate
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also contribute to climate change. Whereas past data have indicated that emissions from exploration and production activities can contribute up to 1% of global CO2 emissions, according to a report conducted by Rhodium Group, the best currently available data show that around 3.6 trillion cubic feet (Tcf) of natural gas escaped into the atmosphere in 2012 from global oil and gas operations. Methane escaping from oil and gas operations was estimated to be approximately equal to1,680 million metric tonnes of carbon dioxide equivalent (MtCO2e) in 2012.	5 moderate
Biodiversity impacts	Risks to habitats and species due to drilling and associated activities disturbing the natural environment. Contaminating substances associated with drilling fluids and petroleum products may leak and soil contamination from these sources can be widespread and persistent but generally localised in the immediate vicinity of drilling and production activity. Contamination can be variable depending on methods and materials used and the occurrence of isolated spills and materials misuse.	5 moderate

Noise	The highest noise levels would occur from drilling and the flaring of gas. Drilling noise would occur continuously for a period of time depending on the depth of the formation. Exploratory wells that become production wells would continue to generate noise during the production phase.	4 low
Traffic	An overall increase in heavy truck traffic would accelerate the deterioration of roads, requiring county government agencies to schedule road repair or replacement more frequently than under the existing traffic conditions. Increased traffic would also result in a potential for increased accidents within the project area. The locations at which accidents are most likely to occur are intersections used by project-related vehicles to turn onto or off of highways from access roads. Conflicts between industrial traffic and other traffic are likely to occur, especially on weekends, holidays, and seasons of high use by recreationists.	4 low

1.2.8 Drill cutting management

With adequate risk management measures in place such as a comprehensive waste management plan, environmental hazards are generally low. However, risks to surface water and air are judged generally moderate. Impacts would depend upon the storage, treatment and disposal method of the drill cuttings. Otherwise, the amount, duration, location, and characteristics of the emissions and the meteorological conditions (e.g. wind speed and direction, precipitation, and relative humidity) would typically vary the impact on the environment, as summarised in the Table below.

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	Poor construction practices for drill cutting storage or disposal may have the potential for contaminants such as chemicals, additives and oil contaminant to be released into groundwater through long-term seepage. This is very much dependent on the depth to groundwater and the permeability of the intervening material.	5 moderate
Surface water contamination	Poor storage and/or disposal of contaminated drill cuttings (likely contaminated with oil based muds, chemicals and additives used for drilling operations, etc.) on site can generate surface runoff of contaminated efflunet if not appropriately managed. This increased runoff could lead to higher peak storm flows into streams, potentially increasing pollution impact to surface water bodies.	6 moderate
Releases to air (local air quality)	Air and dust emissions from exposed storage of drill cuttings. Exhaust emissions from vehicles and generators and poor housekeeping practices.	6 moderate
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also contribute to climate change.	6 moderate
Traffic	Traffic from increased number of waste management vehicles.	4 low

1.2.9 Risk and impacts of casing installation

With casing installed and with risk management measures in place impacts to groundwater and surface water are judged to generally be moderate as, although the likelihood of the impact occurring for groundwater and surface water is ‘rare’, the consequence is ‘high’, reflecting the difficulty in remediating contaminated land, groundwater and water bodies. In general, few data exist in the public domain for the failure rates of onshore wells in Europe. Nonetheless, it is thought that well barrier failure can and will occur in a small number of wells and this could in some instances lead to environmental contamination. In addition, some wells in the UK and Europe will become “orphaned” (well with no responsible party) in the future. It is important therefore that the appropriate financial and monitoring processes are in place, particularly after well abandonment.

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	Ineffective casing due to poor cement job or damage to the casing may have an impact on groundwater. The circulation of cement on production casing prevents monitoring of the space between the casing strings for changes in pressure which could indicate leakage through the casing or cement sheath. There are examples of steel and plastic casings widely used due to high resistance to corrosion. However, groundwater reaction to steel casing can potentially raise the pH of the water. Sources of issues include: • Chemical attack on the casing material; • Sorption and desorption; • Leaching of the casing material; and • Microbial colonisation and attack. If a well is completed improperly such that subsurface formations are not sealed off by the well casing and cement, aquifers could be impacted by migration of formation water into aquifers along the well.	6 moderate
Surface water contamination	The interaction between surface water and groundwater may also be affected if the two are hydrologically connected, potentially resulting in unwanted dewatering or recharging and impacts on surface water.	6 moderate
Releases to air (local air quality)	Emissions from vehicles and machines can be expected. Impact would depend on the duration of the cementing work.	4 low
Releases to air (contribution to global warming	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also have a contribution towards climate change.	5 moderate
Water resource depletion	Use of water for water based fluid during drilling and during cementing application may have some impact on the local water resource.	4 low

1.2.10 Risk and impacts of well stabilisation

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	Exploratory well bores may provide a path for surface contaminants to come into contact with groundwater or for waters from subsurface formations to co-mingle.	6 moderate
Surface water contamination	Exploratory well bores may provide a path for surface contaminants to come into contact with waters from subsurface formations to commingle.	5 moderate
Releases to air (local air quality)	Flaring of any trapped gas or emission of VOCs, dust, from exploratory well.	8 moderate
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also have a contribution towards climate change.	5 moderate

1.2.11 Risk and impacts of well testing

During well-testing, the main potential impact, release to air due to flaring during well testing, is generally expected to be moderate in risk level.

Environmental Aspects	Impacts	Risk Level

Releases to air (local air quality)	Flaring of any trapped gas or emission of VOCs, dust, from exploratory well.	8 moderate
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also contribute to climate change. However, the overall effects are likely to be slight.	5 moderate

1.2.12 Risk and impacts of treatment of produced water from exploratory wells

A relatively low risk level is generally expected from the management of produced water with expected risk management measures in place, as summarised below.

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	In the event of a spillage produced water may leak into groundwater water bodies	5 moderate
Surface water contamination	Potential leakage to surface water bodies of produced water containing contaminants such as salt, oil and grease, various inorganic and organic chemicals and NORM. Produced water is typically managed through processes such as recycling, treatment and discharge, evaporation or infiltration, and deep well injection. Impact could arise from inadequate management of produced water such as overflows from storage tanks, improper disposal and accidental release of untreated produced water from tanks. If stored and treated appropriately, the risk is minimal.	5 moderate
Releases to air (local air quality)	Any VOCs or light hydrocarbons contained in the produced water may be released into the atmosphere.	5 moderate
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also contribute to climate change.	5 moderate
Biodiversity impacts	Land contaminated by produced water may change the characteristics of the sediment and therefore will impact biodiversity. Produced water may contain high salt, oil and grease, chemicals and NORM all of which have the potential to adversely affect local fauna and flora.	5 moderate
Noise	Noise from power generator and treatment facility	4 low
Traffic	Some traffic would be generated from transportation of produced water for storage or for treatment. The amount of produced water varies greatly depending on the formation. Typical water cut ranges from 25% or lower at the start of production (1 barrel of water produced per 3 barrels of oil) to 75% or higher later in production (3 barrels of water produced per 1 barrel of oil).	4 low

1.2.13 Risk and impacts of well completion

If appropriate risk management steps are taken, impacts associated with well completion are generally judged to be low. Although incidents may be considered rare with assumed risk management practices in place, the consequence of leakages and contamination particularly into groundwater would be a moderate risk.

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	There is a potential for leakage from subsurface formations if well casing and (triple) cement do not fully seal the well. Groundwater aquifers can be impacted by other non-potable formation waters seeping out. Accidental leakage of completion fluids (e.g. corrosion inhibitor, biocide, oxygen scavenger) through inadequate well completions.	6 moderate
Surface water contamination	Leaks from insufficient well completion works can lead to contamination of surface water bodies. Accidental discharge of completion fluids (e.g. corrosion inhibitor, biocide, oxygen scavenger) resulting from loss of containment.	2 Low
Releases to air (local air quality)	Flaring or venting of gas to the atmosphere. Fugitive emissions of methane and other trace gases from routing gas generated during completion via small diameter pipeline to the main pipeline or gas treatment plant.	3 Low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also contribute to climate change.	5 moderate
Noise	Potential impact but installation of completed items for the well is expected to be short and transient.	4 low

1.2.14 Risk and impacts of development plan implementation

The overall environmental risk once the development plan is implemented with risk management measures in place is generally considered low, with the exception of land take. The impact for land take is significant, depending on the scale of operations. The land previously employed for the exploration phase is now used for production phase and would potentially be subjected to a longer term use (20-30 years for a typical conventional well, depending on market conditions). The impact is attributed to additional infrastructure and systems needed to put in place to extract oil or gas, as summarised below.

Environmental Aspects	Impacts	Risk Level
Surface water contamination	Water contamination from surface runoff or storm-water runoff from contaminated soil. Soil contamination may occur from leaching from mud pits, chemical spillages and leakages from e.g. sewage, camp grey water etc.	4 low
Releases to air (local air quality)	Dust emissions from use of dirt tracks. Exhaust emissions from vehicles and generators.	4 low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also contribute to climate change.	5 moderate
Land take	Further impact similar to those as set out for the site preparation sub-stage above. Depending on the scale of the development plan, increased number of facilities and more permanent equipment would mean more land would be further converted for industrial use.	12 High

Biodiversity impacts	Refer to site preparation sub-stage. More vegetation cleared; possible erosion and changes in surface hydrology; emissions, vibration and noise from earth moving equipment leading to potential disturbance of local population and wildlife. Potential long-term impacts from access construction. Low level noise from camp activities; disturbance to local environment. Short term, transient.	2 low
Visual impact	Refer to site preparation sub-stage. Further expansion of the site will require construction and/or improved access roads and would result in an increased industrial landscape.	4 low
Noise	Increased duration of construction usage and operation resulting in longer term impact of noise from vehicles and equipment.	4 low
Traffic	Refer to site preparation sub-stage. Further expansion of the site will require construction and/or improved access roads and would result in an increase in traffic. Overweight and oversized loads could cause temporary disruptions and could require extensive modifications to roads or bridges (e.g. widening roads or fortifying bridges). Increased traffic would also result in a potential for increased accidents within the project area. Conflicts between industrial traffic and other traffic are likely to occur, especially on weekends and holidays.	4 low

1.2.15 Risk and impacts of hook up and well commissioning

The risk levels for hook up and commissioning activities are judged as generally low apart from risks to groundwater and surface water which are thought to be generally moderate due to the potential for persistent contamination leading to gradual seepage and leakage into groundwater (if the event occurred). Effective treatment of contaminated groundwater may be challenging.

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	Minimal impact expected during hook-up, pre-commissioning and commissioning. However, if the well were constructed inadequately or poorly, there is significant potential to contaminate groundwater by hazardous chemicals (e.g. hydrostatic testing, chemical dosing, etc.).	6 moderate
Surface water contamination	Pre-commissioning stage will have the most significant potential for impacts as this activity involves hydrostatic testing water availability, chemical dosing and water disposal. If handled inappropriately or in case of spillage or accident, this can result in surface runoff of harmful chemicals released into surface water bodies. Erosion and sedimentation at discharge point of testing liquids.	4 low
Releases to air (local air quality)	Flaring as a safety measure during start up, maintenance or emergency during normal processing operations. Emissions can include carbon dioxide, carbon monoxide, methane, VOCs, NOx, SOx, hydrogen sulphide.	3 low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also contribute to climate change.	5 moderate
Water resource depletion	Water is required for the hydrostatic testing of the well during pre-commissioning. The quantity of water needed is expected to be relatively small and only required when undertaking the test.	2 low
Biodiversity impacts	Toxic chemical spill from hydrostatic testing can lead to permanent loss of plant and habitat.	2 low

Noise	Noise from machinery, power plant and equipment.	4 low

1.2.16 Risk and impacts of development drilling

The risk levels for land take and visual impacts are considered generally high due to increased land area required for further drilling development and changes to more widespread 'industrial' land use. As indicated in previous processes and technologies, due to the difficulty of treating contaminated groundwater, the risk to groundwater would be moderate.

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	Refer to drilling activities in exploration for related impacts. Risks to groundwater are mainly those posed by inadequate design or poor construction of well completion leading to potential aquifer contamination. Of most concern are the naturally occurring substances such as heavy metals, natural gas, dosing chemicals used to maintain the well, etc. from production processes. Production may open an exposure route for surface contaminants to leak into groundwater if the well is not correctly constructed.	6 moderate
Surface water contamination	Refer to drilling activities in exploration for related impacts.	4 low
Releases to air (local air quality)	The main sources of carbon dioxide emissions are from production operations. Other releases to air include methane arising from process vents and potentially from leaks, flaring and combustion. Principal pollutants from combustion processes include nitrogen oxides, sulphur oxides, carbon monoxide and particulates. Additional pollutants from flaring and leakages can include: hydrogen sulphide (H2S); volatile organic compounds (e.g. methane and ethane), benzene, ethyl benzene, toluene and xylenes (BTEX), glycols and polycyclic aromatic hydrocarbons.	3 low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also contribute to climate change.	5 moderate
Water resource depletion	Refer to drilling activities in exploration for related impacts	4 low
Land take	Refer to drilling activities in exploration for related impacts	10 high
Biodiversity impacts	Contaminating substances associated with petroleum products may leak and contaminate soil. Impacts, if occurring, can be persistent but are generally in the immediate vicinity of the drilling and production activity. Contamination can be variable depending on methods and materials used and the occurrence of spills. The levels of contaminating agents may not represent immediate environmental threats, but there may be long-term cumulative effects of soil alteration and toxicants on organisms.	4 low
Noise	Refer to drilling activities in exploration. Scale of impacts (geographical) is expected to be larger than that of exploration phase.	4 low
Visual impact	Additional components that would adversely affect the visual character of the landscape are overland pipelines leading off the site, pumping units, compressor stations, equipment storage areas, and, if required, nearby worker housing units and airstrips.	15 very high
Traffic	Refer to drilling activities in exploration	4 low

1.2.17 Risk and impacts of crude oil & gas processing

Frequent flaring of gas or VOC releases would have an impact on local air. Contaminated groundwater is expected to generally have a moderate risk level due to the potential difficulty of treating contaminated groundwater (if this occurred).

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	Long term contamination of the surface by accidental spills, etc. may contaminate soil in the immediate vicinity leading to contamination of groundwater bodies.	6 moderate
Surface water contamination	Surface runoff of any spillages and leakages not cleaned up or detected during crude oil and gas processing.	4 low
Releases to air (local air quality)	Flaring of gas. Emissions from machinery, equipment, power plant, etc.	6 moderate
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also contribute to climate change. For oil and gas processing the related emissions are potentially greater than in other processes covered under the life-cycle, but are expected to be periodic	9 high
Noise	Noise from treatment machinery, power plant and equipment.	3 low
Traffic	Impact is expected to be minimal from vehicles.	4 low

1.2.18 Risk and impacts of crude oil & gas processing

Frequent flaring of gas or VOC releases would have an impact on local air. Contaminated groundwater is expected to generally have a moderate risk level due to the potential difficulty of treating contaminated groundwater (if this occurred).

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	Long term contamination of the surface by accidental spills, etc. may contaminate soil in the immediate vicinity leading to contamination of groundwater bodies.	6 moderate
Surface water contamination	Surface runoff of any spillages and leakages not cleaned up or detected during crude oil and gas processing.	4 low
Releases to air (local air quality)	Flaring of gas. Emissions from machinery, equipment, power plant, etc.	6 moderate
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also have a contribution towards climate change. For oil and gas processing the related emissions are potentially greater than in other processes covered under the life-cycle, but are expected to be periodic	9 high
Noise	Noise from treatment machinery, power plant and equipment.	3 low
Traffic	Impact is expected to be minimal from vehicles.	4 low

1.2.19 Risk and impacts of minor accidental events from oil & gas processing

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	If contamination of the ground surface occurs through spillages or accidents (e.g. loss of containment of fuel storage; loss of containment of chemicals; smaller hydrocarbon releases) this may lead to contamination of groundwater bodies.	8 moderate

Surface water contamination	Surface runoff and storm water runoff contaminated by a minor spill (e.g. loss of containment of fuel storage; loss of containment of chemicals; smaller hydrocarbon releases) can reach rivers, resulting in the pollution of a water source that serves both humans, flora and fauna.	8 moderate
Releases to air (local air quality)	Emissions of large quantities of fugitive hydrocarbon gas or volatile chemicals can result in the degradation of local air quality.	4 low
Impacts to biodiversity	Releases of toxic substances can potentially result in adverse effects on surrounding environments such as local habitats and flora and fauna.	8 moderate

1.2.20 Risk and impacts of well workover

Environmental Aspects	Impacts	Risk Level
Surface water contamination	Surface runoff and stormwater runoff contaminated.	4 low

1.2.21 Risk and impacts of process treatment systems

With proper risk management measures in place ensuring proper containment or management of produced water, the environmental risk is considered to be low in general for surface water, releases to air and noise impacts. Groundwater contamination is assessed as generally moderate as any resulting impact (contamination) is difficult to remediate.

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	If contamination of the ground surface occurs through spillages or accidents, etc., this may lead to contamination of groundwater bodies.	6 moderate
Surface water contamination	Surface runoff and storm water runoff contaminated by produced water. Produced water (from the target formation) is recovered during well development. Generation can be an issue during the development phase, although it usually becomes a greater waste management concern over the long-term operation of an oil or gas field because water production typically increases with the age of the production well. Typical watercuts (proportion of produced water to oil) range from 25% or lower at the start of production (1 barrel of water produced per 3 barrels of oil) to 75% or higher later in production (3 barrels of water produced per 1 barrel of oil)	4 low
Releases to air (local air quality)	Dust emissions from use of dirt tracks. Exhaust emissions from vehicles and generators.	2 low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will contribute to climate change.	2 low
Noise	Noise from treatment machinery and equipment. Engines and vehicles transporting and running the waste facility plant.	4 low

1.2.22 Risk and impacts of utility systems

With risk management measures in place ensuring containment or management of the utility systems, the environmental risk is considered to be low in general for surface water, releases to air and noise impacts. Groundwater contamination risk is assessed as generally moderate as any resulting impact (contamination) is difficult to remediate. Waste from the utility system will require further treatment and disposal offsite and require transport.

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	If contamination of the ground surface occurs through spillages or accidents, etc., this may lead to contamination of groundwater bodies.	6 moderate
Surface water contamination	Surface runoff and storm-water runoff contaminated by sewage	4 low
Releases to air (local air quality)	VOCs from oily sludge and drill cuttings. Emissions from plant machinery, power plant, engines and vehicles transporting the waste.	2 low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also have a contribution towards climate change. However, the overall effects are likely to be slight.	2 low
Noise	Noise from machinery and equipment and engines and vehicles transporting and powering facilities.	4 low
Traffic	Impact may be minimal; however, some traffic would be generated from transportation of wastewater for treatment.	4 low

1.2.23 Risk and impacts of waste handling

With risk management measures in place ensuring containment or management of waste, environmental risks are considered to be generally low. Groundwater contamination risk is assessed as moderate as any resulting impact (contamination) is difficult to remediate. Wastes require further treatment and disposal and are therefore transported off site.

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	If contamination of the ground surface occurs through spillages or accidents, etc., this may lead to contamination of groundwater bodies.	6 moderate
Surface water contamination	Surface runoff and storm-water runoff that may be contaminated by spills and unplanned releases of wastes, oily mud, etc.	4 low
Releases to air (local air quality)	VOCs from oily sludge, drill cuttings. Emissions from plant machinery, power plant, engines and vehicles transporting the waste.	3 low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also contribute to climate change. However, the overall effects are likely to be slight.	3 low
Noise	Noise from machinery and equipment and engines and vehicles transporting and powering facilities.	4 low
Traffic	Impact may be expected from traffic associated with transportation of waste for treatment and disposal. The quantity of waste transported varies greatly depending on site-specific factors.	4 low

1.2.24 Risk and impacts of hydrocarbon offtakes

Risks are considered to be generally relatively low for the outlined environmental aspects.

Environmental Aspects	Impacts	Risk Level
Surface water contamination	Surface runoff and storm-water runoff that may be contaminated by waste chemicals, oily mud, etc. due to accidental spills or leakage.	4 low
Releases to air (local air quality)	Emissions from plant machinery, valve leakage, power plant, engines and vehicles transporting the waste.	2low

Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also have a contribution towards climate change.	5 moderate
Noise	Noise from machinery and equipment and engines and vehicles transporting and powering facilities.	4 low
Traffic	Impact may be expected from traffic where transportation of hydrocarbon offtakes off-site takes place by tanker.	4 low

1.2.25 Risks and impacts of substance injection

The risks associated with substance injection are generally considered to be relatively low, as summarised in the table below:

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	Chemicals penetrating subsurface groundwater due to the proximity of the wellbore to groundwater.	6 moderate
Surface water contamination	Surface or storm-water runoff may be contaminated with injection chemicals.	6 moderate
Releases to air (local air quality)	Emissions of SO_2, NOx and dust from the equipment and vehicles used to transport, pressurise and injection substances (and/or heat steam).	4 low
Releases to air (contribution to global warming)	Emissions of CO_2 from the equipment used to pressurise and inject substances / heat steam.	3 low
Water resource depletion	Polymers and gases are often injected alongside water, additionally steam is produced using local water resources. This presents a slight risk of depleting local water resources.	2 low
Land take	Increased land take resulting from the need to store large quantities of gas/chemicals above ground, in addition to the equipment required for pressurisation and injection.	8 moderate
Noise	Noise resulting from equipment used to pressurise and inject the substance	4 low
Visual impact	Visual impact due to physical presence of fluid storage and injection equipment	2 low
Traffic	Increased traffic required to transport equipment and materials for the injection.	4 low
Seismicity	Small risk of induced seismicity from the pressures applied during injection (Rubinstein & Mahani, 2015).	2 low

1.2.26 Risk and impacts of plugging of wells, removal of well pads and waste management

Similar to activities from exploration and production, controls applied in the same way during decommissioning and aftercare will mitigate many of the risks. Risk levels are therefore thought to be low in general with the exception of those for groundwater. Any spillages and leakages onto the ground could result in long-term impact. Land take and visual impact are considered as part of environmental hazards due to the equipment potentially remaining on site permanently. Nevertheless, impact is assessed as generally being relatively low, in view of the small scale of the equipment.

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	Risk of migrating dissolved constituents from long term spillages or leakages to aquifers. Volatilisation of VOCs into vadose zone, infiltration of groundwater to basements, wetlands and surface water or into soils. Improper controls, accidents and spillages can result in soil and water contamination.	6 moderate
Surface water contamination	Improper controls can result in soil and water contamination and erosion and changes in surface hydrology from decommissioning activities. Potential leaks leading to staining, smells, sheens on water surfaces.	4 Low
Release to air (local air quality)	Risk of odours from accidental leaks of waste chemicals and hydrocarbons from decommissioning the well and associated facilities or from vehicles and deconstructed area. Migration of contaminated soil vapours into air. Potential methane seepage to occur in the long-term if seals or liners breakdown.	4 Low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also have a contribution towards climate change.	4 Low
Land take	It may not be possible to return the entire site to beneficial use following abandonment (e.g. due to concerns regarding public safety). Over a wider area this could result in loss of land and/or fragmentation of land area.	4 Low
Visual impact	Not all of wellhead equipment may be removed from site.	4 Low
Biodiversity impacts	Soil contamination by VOCs. Wetlands, wildlife, livestock, fish, amphibians, birds, agricultural areas, surface and drinking water and parks or recreational facilities can all be affected. Soil is a significant concern; texture, consistency, pH, salinity, organic matter, nutrients and TPH (total petroleum hydrocarbon) can all impact the biodiversity of the site and should be monitored Improper controls can result in soil and water contamination; erosion and changes in surface hydrology; wildlife disturbance; loss of habitat; impacts to biodiversity; human and cultural disturbances; changes in land and resource use.	4 Low
Noise	Noise from decommissioning machinery and equipment, vehicle engines and power plant. Impact would be short term and transient.	4 Low
Traffic	Vehicle activity will increase as equipment and infrastructure is removed. (Marathon, Undated)	4 Low

1.2.27 Risk and impacts of site restoration

Noise and traffic impact are expected to be generally relatively low in risk level. This is because the nature of the site restoration activity is expected to be short and transient and on a much lower scale than those observed during site exploration and production.

Environmental Aspects	Impacts	Risk Level
Noise	Vehicles to transport equipment and machinery for site restoration activities.	3 Low
Traffic	Vehicles to transport equipment and machinery for site restoration activities.	3 Low

Release to air (local air quality)	Potential local air quality effects from vehicle emissions and increased traffic to and from site. However, this is expected to be of lower volumes than in other parts of the life-cycle.	4 Low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will contribute to climate change.	4 Low

1.2.28 Impacts and risks of long term well integrity failure

The environmental risks associated with well-integrity failure are generally considered to be low on account of the lower pressure gradients within the well as opposed to that of the adjacent formations, as summarised below.

Environmental Aspects	Impacts	Risk Level
Groundwater contamination	Subsurface leaks of hydrocarbon fluids can occur, which result in fluids penetrating groundwater reserves. King & King (2013) found that if the well failure is in the subsurface, an outward leak is uncommon because of lower pressure gradient in the well than in outside formations. Subsurface leaks in oil and gas wells are therefore rare and generally result in exterior-formation salt water leaking into the well toward the lower pressure in the well, rather than hydrocarbons leaking out and penetrating groundwater.	2 low
Surface water contamination	Liquid hydrocarbons may leak from the mouth of the well bore, resulting in a contamination of surface waters.	4 low
Releases to air (contribution to global warming)	Well integrity failure can result in hydrocarbon gases (incl. methane) being released to the atmosphere and contributing to climate change. King & King (2013) found that when total well-integrity failures occurs, gas is the most common fluid lost.	4 low

1.3 Sources of environmental pollutions/emissions from onshore oil and gas operations

- **Water**

The oil and gas industry consumes and produces water. Water is used to drill and hydraulically fracture ("frack") wells, refine and process oil and gas, and produce electricity in some natural gas power plants. Water is also naturally present in the rocks that contain oil and gas and is extracted along with the oil and gas as "produced water", sometimes in large quantities. The quantity and quality of water used, produced, and disposed of or re-used varies enormously depending on local geology, financial constraints, and regulations, with implications for the environmental impacts of oil and gas production. Water used in the production of oil and gas is often locally sourced from groundwater, rivers, or lakes (both natural and artificial).

Water produced along with oil and gas is often naturally salty and may contain oil residues, chemicals from hydraulic fracturing and drilling fluids, and natural contaminants from the rocks themselves. The amount of water produced by a well can vary from almost none to over 100 barrels of water per barrel of oil, depending on the maturity of the field and other factors.

Produced water must be either re-used or disposed of. Re-use typically requires some treatment to remove oil residues, salts, and other chemicals, depending on how the water will be reused. In some cases, produced water is temporarily stored in surface pits to evaporate off some of the water. This can affect local air quality, and if pits leak, can contaminate groundwater supplies. In many places, large amounts of produced water are disposed of through deep underground injection wells. This has triggered earthquakes in certain locations.

Hydraulic Fracturing

Hydraulically fracturing a modern well can require millions of gallons of water for the initial fracturing process. This is a potential problem in arid regions with competing demands for fresh water and/or implications for a high level of road-use associated with trucking water to the well-site.

Groundwater

Hydraulic fracturing chemicals - Hydraulic fracturing fluid is roughly 99% water. The remaining 1% typically consists of 3 to 12 chemical additives that improve the effectiveness of the fluid during hydraulic fracturing operations.5 Some of these additives are toxic, and because a single hydraulically fractured well may use several million gallons of fluid, even a small leak may pose a risk to local groundwater supplies.

Drilling fluids – used to lubricate drills, remove rock chips, and maintain pressure in the well during drilling, usually consist of mud and water with smaller amounts of minerals and chemicals that change the physical properties of the fluid to improve its function. Most of the substances in drilling fluids are not harmful to humans, and jurisdictions typically impose restrictions on additives that can be used when drilling through freshwater aquifers. However, there have been rare cases in which unauthorized use of drilling fluid additives while drilling through freshwater aquifers has been found to contaminate groundwater.

Methane – methane is a naturally occurring, flammable gas that is non-toxic but explosive at high concentrations. It is also a potent greenhouse gas. Methane is the main component of natural gas but it is also produced by microbes in sediments and wetlands, so methane found associated with groundwater may come from nearby oil and gas operations, natural microbes, or both. Methane may also be sourced from natural leakage from coal or gas-rich rocks.

Oil and produced water – any fluid that can enter a well also has the potential to leak out of it if the well is compromised. This may include natural gas (see above), oil, or the often-salty water that coexists with oil and gas in many rocks (called "produced water" when it is extracted along with oil and gas). Oil and saltwater leaks are rare but are of greater risk in improperly abandoned or "orphaned" wells than in active ones.

Overall, there are three main ways in which oil and gas wells may contaminate groundwater: (1) if a well leaks; (2) if oil or other fluids are spilled at the surface; or (3) if a hydraulic fracturing operation generates cracks in the overlying rocks it is theoretically possible for fluids and/or gas to move up through the rocks and into an aquifer.

- **Air**

Oil and gas production, processing, and use release large quantities of greenhouse gases, especially methane and carbon dioxide.

Methane is the main component of natural gas, a cheap, abundant, and versatile source of energy that produces less carbon dioxide than other fossil fuels when burned. However, methane itself is a approximately twenty times more potent a greenhouse gas than carbon dioxide. Methane leaks from wells, pipelines, or processing equipment can substantially increase the greenhouse gas emissions of the natural gas sector, while also wasting resources as methane escapes into the atmosphere.

Oil- and gas-producing areas may have high levels of volatile organic compounds (VOC) that contribute to harmful ozone formation in the lower atmosphere. VOCs are emitted by vehicles and equipment used in oil operations as well as in surrounding roads and communities. VOCs also evaporate directly from the oil and gas being extracted, stored, and transported around the oilfield. Storage tanks, certain types of pumps and compressors, and leaky valves and fittings may allow VOCs to escape into the atmosphere.

Waste

In addition to common waste produced by any industrial undertaking, e.g., sewage, sanitary and domestic waste, petroleum operations also generate solid and liquid waste that is specific to the industry. The most relevant include:

- **Cuttings**, i.e., the small pieces of formation rock and subsurface materials that break away because of the action of drill bit teeth as a well or direction borehole is being drilled.[24]
- **Drilling muds**, i.e., a suspension, usually in water but sometimes in oil (natural, synthetic and diesel), used in rotary drilling, consisting of various substances in a finely divided state (commonly bentonitic clays and chemical additives), introduced continuously down the drill pipe under pressure and through openings in the drill bit and transported back up in the annular space between the pipe and the walls of the hole to a surface pit or tank where it is conditioned and reintroduced into the wellbore. It is used to lubricate and cool the bit, carry the cuttings up from the bottom, and prevent blowouts and cave-ins.[25]
- **Drilling fluids**, i.e., the fluid portion of drilling wastes consisting to water, drilling muds, fine cuttings, and additives.[26]
- **Naturally occurring radioactive materials (NORM)**, i.e., materials typically found in certain types of barium or strontium scales that may be deposited in the wellbore or production tubulars.[27]
- **Produced water**, i.e., water - naturally present in a reservoir - that is produced along with hydrocarbons (oil, gas, and crude bitumen) from a well.[28]
- **Used Oil**, i.e., any semi-solid or liquid product consisting totally or partially of mineral oil or synthesized hydrocarbons (synthetic oils) that has been used and because of such use is contaminated by impurities rendering it unsuitable for its original use and includes oily residues from tanks, oil-water mixtures, and emulsions.[29]
- **Sludge**, i.e., an accumulated free settling wet solid typically consisting of hydrocarbon, water, and inorganic sediments (i.e. sands, silts, etc.).[30]
- **Wastewater**, e.g., oily water, pipeline test water or waste fluids/solids generated from the cleaning of a pipeline (pipeline pigging water).[31]
- **Contaminated soil,** i.e., hydrocarbon-bearing soil that must be either remediated or removed.
- **Oily debris**, i.e., oil-contaminated soil, rags and other absorbent materials, such as filters.

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[24] Alberta Energy Regulator, *Directive 050: Drilling Waste Management*, pg. 153 (2016).
[25] *Id.*
[26] *Id.*
[27] Schlumberger, *Oilfield Glossary*.
[28] Canada-Newfoundland and Labrador Offshore Petroleum Board, *Offshore Waste Treatment Guidelines*, pg. 8 (2010).
[29] National Environment Management Authority, *Technical Guidelines on the Management of Used Oil and Oil Sludge in Kenya*, pg. 10 (2016).
[30] Alberta Energy Regulator, *Directive 058: Oilfield Waste Management Requirements for the Upstream Petroleum Industry*, pg. 148 (2006).
[31] State of Louisiana Department of Natural Resources, *E&P Waste, Disposal Technique, and Facility Type Codes and Descriptions* (2011).

- **Flowback water**, i.e., the fluids and entrained solids that emerge from a well during the flowback process. The flowback process allows fluids and entrained solids to flow from a well following a treatment, either in preparation for a subsequent phase of treatment or in preparation for cleanup and returning the well to production.[32]

- **Spills**

Oilfield spills can harm wildlife and pose a risk to human health if they reach fresh water sources or contaminate soil or air. The enormous size of the oil and gas industry and the huge volumes of oil and produced water that are handled, stored, and transported result in thousands of spills every year.

Spills occur in two main settings: at or near the well site, or in transit between the oilfield, refineries, and consumers. Spills in the oilfield are usually smaller and easier to clean up than those related to bulk transportation: drill sites are purpose-built "pads" made of gravel and other materials designed to deter spills from reaching soil or groundwater; additional containment measures are used around liquid storage tanks or pits to help contain spills; and equipment and personnel are commonly on hand to address spills quickly.

The most commonly spilled fluid is produced water (sometimes including flow-back of hydraulic fracturing fluid). Other commonly spilled fluids include crude oil, fluids to be used for hydraulic fracturing, and drilling waste (slurries of rock chips and drilling mud produced during drilling).

The environmental impact of a spill depends strongly on the size, location, type of fluid, and spread of the spill, including whether it contaminates ground- or surface water, which allows it to spread further and makes cleanup more difficult:

- Spilled oil or refined fuel can coat plants, soils, microbes, and animals. Oil prevents plant growth and hinders the movement of water, oxygen, and nutrients through soils. Some components of oils and liquid fuels are toxic to plants, animals, and humans.
- Some light oils and refined fuels such as gasoline or diesel may evaporate, releasing toxic fumes that may degrade air quality or pose a fire hazard.
- Highly saline produced water (up to 15 times saltier than seawater) can kill vegetation and prevent plants from growing in contaminated soil.

- **Induced Seismicity**

Any activity that significantly changes the pressure on or fluid content of rocks has the potential to trigger earthquakes. This includes geothermal energy production, water storage in large reservoirs, groundwater extraction, underground injection of water for enhanced oil recovery, and large-scale underground disposal of waste liquids.

- **Abandoned wells**

Orphaned wells are often abandoned without any plugging or cleanup, but even plugged wells may leak, especially those plugged in the past, when plugging procedures were less rigorous and used less durable materials. Unplugged or poorly plugged wells may affect:

[32] 40 CFR 60.5430.

Groundwater – old wells may have degraded well casing or cement that can allow oil, gas, or salty water to leak into freshwater aquifers (although see above for comments regarding pressure gradient differences).

Methane emissions – a study of 138 abandoned wells in Wyoming, Colorado, Utah, and Ohio found that over 40% of unplugged wells leaked methane, compared to less than 1% of plugged wells. This study estimated that abandoned wells account for 2-4% of the methane emissions from oil and gas activity.

The surface environment – orphaned sites may still have old equipment, contaminated soil from small spills, and other waste at the surface. In some unplugged or poorly plugged wells, oil, gas, drilling mud, or salty water can rise the well and spill at the ground surface.

Source: Edith Allison and Ben Mandler, The American Geosciences Institute, *Petroleum and the Environment* (2018), https://www.americangeosciences.org/sites/default/files/AGI_PetroleumEnvironment_web.pdf

1.4 *Parameters for environmental monitoring*

Environmental monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during normal operations and upset conditions. Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project.

Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken.

The following table provides a list of the parameters most frequently monitored for upstream oil and gas operations. It consists of a list of substances released to the air, water, and soil by upstream, petroleum companies; Kenya's maximum emission limits for such substances; as well as emission limits and monitoring procedures under best international practices.

Parameter	Permissible Limits under Kenyan Law[33]	Permissible Limits Best Practices (onshore)[34]	Monitoring (frequency)[35]	Measurement Protocol[36]
Air Quality[37]				
Sulphur oxides (SO_X)	80 µg/m^3 (annual average).	500 µg/m^3 (10-minute average) (for SO_2)	Annual / Quarterly (refineries)	**Under Kenyan Law** • KS ISO 11632: Stationary source emissions --Determination of mass concentration of sulfur dioxide --Ion chromatography method • KS ISO 6767: Ambient air --Determination of the mass concentration of sulfur dioxide --Tetrachloromercurate (TCM)/pararosaniline method • KS ISO 4219: Air quality -Determination of gaseous Sulphur compounds in ambient air -Sampling equipment • KS ISO 4221: Air quality -Determination of a mass concentration of Sulphur dioxide in ambient air -Thorin spectrophotometric method

[33] Water Quality Regulations, Third and Fourth Schedule; Air Quality Regulations, Arts. 5-7, First Schedule.

[34] https://www.ifc.org/wps/wcm/connect/4504dd0048855253ab44fb6a6515bb18/Final%2B-%2BOnshore%2BOil%2Band%2BGas%2BDevelopment.pdf?MOD=AJPERES&id=1323153172270 ; https://www.ecfr.gov/cgi-bin/text-idx?SID=6b51273d47e8dc451e0aac10f60cdfee&mc=true&node=pt40.31.419&rgn=div5#se40.31.419_150 ; NAAQS Table, https://www.epa.gov/criteria-air-pollutants/naaqs-table

[35] Water Quality Regulations § 14; Air Quality Regulations, § 19, 68, Fourteenth Schedule.

[36] https://www.concawe.eu/wp-content/uploads/2017/01/report-no.-4_13.pdf ; Air Quality Regulations, Eleventh Schedule.

[37] Permissible limits refer to Ambient Air Quality Guidelines, in accordance to IFC's Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development, IFC's General EHS Guidelines, and US National Ambient Air Quality Standards. However, Kenya law also imposes specific limits to refineries, Air Quality Regulations. Third Schedule.

				• KS ISO 7934: Stationary source emissions -Determination of the mass concentration of Sulphur dioxide -Hydrogen peroxide / barium perchlorate –Thorin method
				Under best practices In addition to the ones listed above, the following: • BS EN 14212:2012 Ambient air. Standard method for the measurement of the concentration of sulphur dioxide by ultraviolet fluorescence • Alaska Department of Environmental Conservation, *Standard Procedures for Sulfur Dioxide (SO_2) Monitoring by Ultraviolet Fluorescence* (2012). • Canadian Council of Ministers, *Ambient Air Monitoring Protocol for* $PM_{2.5}$ *and Ozone* (2011) • McLinden et al, *Space-based detection of missing sulfur dioxide sources of global air pollution* (2016).
Oxides of Nitrogen (NO_X)	80 µg/m³ (annual average).	40 µg/m³ (annual average) (for nitrogen dioxide)	Annual / Quarterly (refineries)	**Under Kenyan Law** • KS ISO 7996: Ambient air --Determination of the mass concentration of nitrogen oxides --Chemiluminescence method
				Under best practices In addition to the ones listed above, the following: • Canadian Council of Ministers, *Ambient Air Monitoring Protocol for PM2.5 and Ozone* (2011) • BS EN 14211:2012 Ambient air. Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence (2012)
Nitrogen Dioxide	150 µg/m³ (annual average).	40 µg/m³ (annual average)	Annual / Quarterly (refineries)	**Under Kenyan Law** • KS ISO 10849: Stationary source emissions --Determination of the mass concentration of nitrogen oxides --Performance characteristics of automated measuring systems • KS ISO 11564: Stationary source emissions --Determination of the mass concentration of nitrogen oxides --Naphthylethylenediamine photometric method
				Under best practices In addition to the ones listed above, the following: • Canadian Council of Ministers, *Ambient Air Monitoring Protocol for PM2.5 and Ozone* (2011)

				• BS EN 14211:2012 Ambient air. Standard method for the measurement of the concentration of nitrogen dioxide and nitrogen monoxide by chemiluminescence (2012)
Suspended Particulate matter (SPM)	360 µg/m³ (annual average).	X	Annual / Quarterly (refineries)	**Under Kenyan Law** Kenyan law provides no reference.
				Under best practices ISO 9835:1993(en) Ambient air - Determination of a black smoke index
PM_{10}	70 µg/m³ (annual average).	20 µg/m³ (annual average)	Annual / Quarterly (refineries)	**Under Kenyan Law** KS ISO 12141: Stationary source emissions --Determination of mass concentration of Particulate matter (dust) at low concentrations --Manual gravimetric method
				Under best practices In addition to the ones listed above, the following: • EN 12341:2014 Ambient air - Standard gravimetric measurement method for the determination of the PM10 or PM2,5 mass concentration of suspended particulate matter
$PM_{2.5}$	35 µg/m³ (annual average).	10 µg/m³ (annual average).	Annual / Quarterly (refineries)	**Under Kenyan Law** KS ISO 12141: Stationary source emissions --Determination of mass concentration of Particulate matter (dust) at low concentrations --Manual gravimetric method
				Under best practices In addition to the references listed above, the following: • Canadian Council of Ministers, *Ambient Air Monitoring Protocol for PM2.5 and Ozone* (2011) • EN 12341:2014 Ambient air - Standard gravimetric measurement method for the determination of the PM10 or PM2,5 mass concentration of suspended particulate matter.
Lead (Pb)	1.0 µg/m³ (annual average).	0.15 µg/m³ (3-month average).	Annual / Quarterly (refineries)	**Under Kenyan Law** KS ISO 9855: Ambient air -Determination of the particulate lead content of aerosols collected on filters -Atomic absorption spectrometric method
				Under best practices

				In addition to the ones listed above, the following: • US Code of Federal Regulations, Tittle 40, Chapter I, Subchapter C, Part 50, Appendix G Reference Method for the Determination of Lead in Total Suspended Particulate Matter
Carbon monoxide (CO)/carbon dioxide (CO2)	5 µg/m³ (annual average).	9 ppm (8-hour average, not to be exceeded more than once per year)	Annual / Quarterly (refineries)	**Under Kenyan Law** • KS ISO 12039: Stationary source emissions --Determination of carbon monoxide, carbon dioxide and oxygen --Performance characteristics and calibration of automated measuring systems. • KS ISO 8186: Ambient air --Determination of the mass concentration of carbon monoxide --Gas chromatographic method.
				Under best practices In addition to the ones listed above, the following: • BS EN 14626:2012 Ambient air. Standard method for the measurement of the concentration of carbon monoxide by non-dispersive infrared spectroscopy • Canadian Council of Ministers, Ambient Air Monitoring Protocol for PM2.5 and Ozone (2011)
Hydrogen Sulphide	150 µg/m³ (24 hours).	X	Annual / Quarterly (refineries)	**Under Kenyan Law** KS ISO 4219: Air quality -Determination of gaseous Sulphur compounds in ambient air -Sampling equipment
				Under best practices In addition to the ones listed above, the following: • Canadian Association of Petroleum Producers, *Guideline on H_2S Release Rate Assessment and Audit Forms* (2012). • *Hydrogen Sulfide in Gases by the Tutweiler Method*, UOP Method 9-59, Universal Oil Products Company, Des Plaines, Illinois, USA, 1959. • *Test for Hydrogen Sulfide in LPG and Gases (Tutweiler Method)*, Plant Operations Test Manual, Gas Processor's Association (GPA), 1812 First Place, Tulsa, Oklahoma. • *Tentative Method of Test for Hydrogen Sulfide in Natural Gas Using Length of Stain Tubes*, Adopted as a tentative standard in 1997 by the Gas Processors Association, GPA publication 2377-77. • *Standard Test Method for Hydrogen Sulfide in Natural Gas Using Length of Stain Detector Tubes*, ASTM Designation D 4810-88 (re-approved 1994).

				• *Influence of Containers on Sour Gas Samples*, J.G.W. Price & D.K. Cromer, Petroleum Engineer International, March, 1980.
Non-methane hydrocarbons	700ppb (instant peak)	X	Annual / Quarterly (refineries)	**Under Kenyan Law** Kenyan law provides no reference.
				Under best practices • ISO 14965:2000: Air quality -- Determination of total non-methane organic compounds -- Cryogenic pre-concentration and direct flame ionization detection method • US EPA, Ambient Air Non-Methane Hydrocarbon Monitor
Total VOC	600 µg/m³ (24 hours).	X	Annual / Quarterly (refineries)	**Under Kenyan Law** • KS ISO 16200-1: Workplace air quality --Sampling and analysis of volatile organic compounds by solvent desorption/gas chromatography --Part1: Pumped sampling method • KS ISO 16200-2: Workplace air quality --Sampling and analysis of volatile organic compounds by solvent desorption/gas chromatography --Part2: Diffusive sampling method • KS ISO 16000-5: Indoor air --Part5: Sampling strategy for volatile organic compounds (VOCs) • KS ISO 16000-6: Indoor air --Part6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS/FID • KS ISO 16000-9: Indoor air --Part9: Determination of the emission of volatile organic compounds from building products and furnishing -- Emission test chamber method • KS ISO 16000 -10: Indoor air --Part10: Determination of the emission of volatile organic compounds from building products and furnishing -- Emission test cell method • KS ISO 16000-11: Indoor air --Part11: Determination of the emission of volatile organic compounds from building products and furnishing -- Sampling, storage of samples and preparation of test specimens • KS ISO 16017-1: Indoor, ambient and workplace air –Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography --Part1: Pumped sampling • KS ISO 16017-2: Indoor, ambient and workplace air --Sampling and analysis of volatile organic compounds by sorbent tube/thermal desorption/capillary gas chromatography --Part2: Diffusive sampling

				Under best practices In addition to the ones listed above, the following: • Canadian Council of Ministers, Ambient Air Monitoring Protocol for PM2.5 and Ozone (2011) • US EPA, Method 18 - Volatile Organic Compounds by Gas Chromatography • US EPA, Method TO-17 Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes
Ozone	200 µg/m³ (1 hour).	100 µg/m³ (8-hour maximum).	Annual / Quarterly (refineries)	**Under Kenyan Law** • KS ISO 10313: Ambient air --Determination of the mass concentration of ozone --Chemiluminescence method • KS ISO 13964: Air quality --Determination of ozone in ambient air -- Ultraviolet photometric method
				Under best practices In addition to the ones listed above, the following: • BS EN 14625:2012 Ambient air. Standard method for the measurement of the concentration of ozone by ultraviolet photometry • Canadian Council of Ministers, Ambient Air Monitoring Protocol for PM2.5 and Ozone (2011)
Water Quality (Effluents) – produced water				
Biochemical Oxygen Demand, BOD	1.0 mg/L	25 mg/L	Quarterly	• ISO 5815: 2003(en) Water quality — Determination of biochemical oxygen demand after n days (BODn)
Chemical Oxygen Demand, COD	50 mg/L *(refining only)*	125 mg/L	Quarterly	• ISO 6060: Water Quality – Determination of the chemical oxygen demand. • ISO 15705: Water Quality – Determination of the chemical oxygen demand index (ST-COD) – Small-scale sealed-tube method.
Total Suspended Solids, TSS	30 mg/L	35 mg/L	Quarterly	ISO 11923:1997 Water quality -- Determination of suspended solids by filtration through glass-fiber filters
pH	6-9	6-9	Quarterly	ISO 10523:2008(en) Water quality — Determination of pH
Oil & Grease	Nil	10mg/L	Quarterly	ASTM D8193 – 18 Standard Test Method for Total Oil and Grease (TOG) and Total Petroleum Hydrocarbon (TPH) in Water and Wastewater with Solvent Extraction Using Non-Dispersive Mid-IR Transmission Spectroscopy
Total hydrocarbon content	X	10 mg/L	Quarterly	ASTM D8193 – 18 Standard Test Method for Total Oil and Grease (TOG) and Total Petroleum Hydrocarbon (TPH) in Water and Wastewater with Solvent Extraction Using Non-Dispersive Mid-IR Transmission Spectroscopy
Temperature	± 3 (in degrees Celsius) based on	X	Quarterly	US EPA, SESDPROC-102-R3, Field Temperature Measurement.

	ambient temperature			
Chloride	X	600 mg/l (average), 1200 mg/L (maximum)	Quarterly	ISO 15682: Water Quality – Determination of chloride by flow analysis (CFA and FIA) and photometric or potentiometric detection
Color/Dye/Pigment	15 Hazen units (H.U.)	X	Quarterly	• ISO 787-3:2000 General methods of test for pigments and extenders -- Part 3: Determination of matter soluble in water -- Hot extraction method • ISO 787-8:2000 General methods of test for pigments and extenders -- Part 8: Determination of matter soluble in water -- Cold extraction method
Heavy Metals[38]	X	5 mg/L	Quarterly	• APHA 3113: Metals by electrothermal atomic absorption spectrometry. • EN ISO 11885: Water Quality – Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP – OES) • EN ISO 12846: Water Quality – Determination of mercury. Method using atomic absorption spectrometry (AAS) with and without enrichment • EN ISO 11885: Water Quality - Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP - OES) • EN ISO 15586: Water Quality - Determination of trace elements using atomic absorption spectrometry with graphite furnace • ISO 17294: Water Quality - Application of inductively coupled plasma mass spectrometry (ICP-MS) - Part 2: Determination of 62 elements • EN ISO 11885: Water Quality - Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP - OES) • ISO 17294: Water Quality - Application of inductively coupled plasma mass spectrometry (ICP-MS) - Part 2: Determination of 62 elements
Phenols	0.001 mg/L *(refining only)*	0.5 mg/L	Quarterly	• ISO 6439: Water Quality – Determination of phenol index – 4-aminoantipyrine spectrometric methods after distillation • ISO 8165-2: Water Quality – Determination of selected monovalent phenols – Part 2: Method by derivatization and gas chromatography
Total Chromium	2 mg/L *(refining only)*	5 mg/L	Quarterly	ISO 9174: Water Quality – Determination of chromium – Atomic absorption spectrometric methods
Chromium VI *(refining only)*	0.05 mg/L	32 mg/L	Quarterly	• ISO 11083: Water Quality – Determination of chromium (VI) – Spectrometric method using 1,5-diphenylcarbazide. • ISO 11885: Water Quality – Determination of selected elements by inductively coupled plasma optical emission spectrometry (ICP-OES).

[38] Heavy metals include: Arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, vanadium, and zinc.

Ammonia (as N) *(refining only)*	100 (mg/L)	10.6 kg/m3	Quarterly	EN ISO 11732: Water Quality – Determination of ammonium nitrogen – Method by flow analysis (CFA and FIA) and spectrometric detection
Sulphide *(refining only)*	0.1 mg/L	158 mg/L	Quarterly	ISO 10530: Water Quality – Determination of dissolved sulfide – Photometric method using methylene blue
Soil[39]				
pH	X	6-8 µg/g	As soon as possible in face of substance release.[40]	• CCME Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment Volume 1 Guidance Manual (2016) • CCME Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment Volume 2 Checklists (2016
Electrical conductivity	X	2 µg/g	*Id.*	*Id.*
sodium adsorption ratio SAR	X	5 µg/g	*Id.*	*Id.*
Total extractable hydrocarbons	X	1000 µg/g	*Id.*	*Id.*
Benzene	X	0.5 µg/g	*Id.*	*Id.*
Toluene	X	3 µg/g	*Id.*	*Id.*
Ethyl benzene	X	5 µg/g	*Id.*	*Id.*
Xylene	X	5 µg/g	*Id.*	*Id.*
Ethylene glycol (EG)	X	97 (grazing); 410 (no grazing) µg/g	*Id.*	*Id.*
Polychlorinated biphenyl (PCB)	X	0.5 µg/g	*Id.*	*Id.*
Barium	X	750 µg/g	*Id.*	*Id.*
Cadmium	X	1.4 µg/g	*Id.*	*Id.*
Chromium	X	64 µg/g	*Id.*	*Id.*
Copper	X	63 µg/g	*Id.*	*Id.*
Lead	X	375 µg/g	*Id.*	*Id.*
Mercury	X	6.6 µg/g	*Id.*	*Id.*
Nickel	X	150 µg/g	*Id.*	*Id.*
Vanadium	X	130 µg/g	*Id.*	*Id.*
Zinc	X	200 µg/g	*Id.*	*Id.*

[39] Soil remediation parameters diverge based on the use of the land following remediation. The limits/values provided herein assume eventual agricultural use. Saskatchewan Upstream Petroleum Sites Remediation Guidelines, http://publications.gov.sk.ca/documents/310/84469-PDB%20ENV%2007%20SPIGEC4%20Upstream%20Contaminated%20Sites%20Remediation%20Guidelines%202016.pdf
[40] Alberta Remediation Regulation, §2.2(1).

1.5 Onshore oil and gas-specific monitoring procedures distinct from those defined in Volumes 1 and 2

1.5.1 Methodologies used for onshore environmental monitoring

Environmental monitoring programs for this sector should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during normal operations and emergency conditions.

Environmental monitoring activities should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project. Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrections may be made.

The table in section 1.4 above provides a list of the substances most frequently released to the environment during onshore oil and gas operation, as well as methodologies used to monitor their release into the air, water and soil.

1.5.2 Procedures for air quality and effluent sampling and analytical methods

Information for this and the following section is provided in the following sections of Volume 2:

- S.1 Sample collection and processing;
- S.2 Measurement procedures; and,
- S.3 Analytical procedures.

1.5.3 Solid and particulate sampling and measurement

Please see information on S. 1.5.1 above

1.5.4 Procedures for sample storage and preservation

To get the best quality analytical results, the correct handling of sample collection and its prompt delivery to the laboratory is crucial. Samples should be delivered to the laboratory as soon as possible to ensure the analytical results are representative of the collection site. Sample storage and preservation varies depending on the type of sample (e.g., soil or water), as well as the type of parameter to be analyzed.

The British Columbia B.C. Environmental Laboratory Technical Advisory Committee, in cooperation with the provincial Ministry of Environment has produced the 2015 edition of the British Columbia Environmental Laboratory Manual. Section A of the manual provides information on “Laboratory Quality Assurance / Quality Control”, and it provides a table (Table 1) on sample preservation and hold time requirements. The table contains a list of frequently analyzed parameters, containers that must be used to store samples, storage temperature, preservation techniques, holding times, and references to best international practices per parameter.

Parameter Name	Sample Container	Storage Temp$^{(3>}$	Preservation	Holding Time$^{(4)}$ (days)	References
Water					
Bromide	Plastic. Glass	no requirement	none	28 days	EPA 300.1
Chloride	Plastic. Glass	no requirement	none	28 days	APHA EPA 300.1
Chlorate. Bromate	Plastic. Glass	S6^{B}C	50 mg L EDA	28 days	EPA 317.0
Chlorine. Total Residual (Free Chlorine)	Plastic. Glass	none	none	15 minutes	APHA
Chlorite	Plastic. Amber Glass	S6'C	50 mg/L EDA	14 days	EPA 317.0
Cyanide (SAD. WAD)	Plastic. Glass	S6*C	field NaOH. store in dark	14 days	APHA
			none	24 hours	APHA
Dissolved Oxygen (Winkler Method)	Glass BOD bottle	S6°C	Winkler kit. store in dark	8 hours	APHA
Fluoride	Plastic	no requirement	none	28 days	APHA EPA 300.1
Nitrogen. Nitrate Nitrite	Plastic. Glass	S6°C	H2SO4	28 days	APHA
			none	3 days	BC MOE
Nitrogen. Ammonia	Plastic. Glass	S6°C	H2SO4	28 days	APHA
			none	3 days	BC MOE
Nitrogen. Nitrate	Plastic. Glass	S6^{9}C. do not freeze	none	3 days	APHA / BC MOE
Nitrogen. Nitrite	Plastic. Glass	S6*C. do not freeze	none	3 days	APHA / BC MOE
Nitrogen. Total Kjeldahl	Plastic. Glass	S6^{B}C	H2SO4	28 days	APHA
			none	3 days	BC MOE
Nitrogen. Total. Persulfate Method	Plastic. Glass	S6^{9}C	H2SO4	28 days	APHA
			none	3 days	BC MOE
Nitrogen. Total. Combustion Method	Plastic. Glass	<6-C	HCI	28 days	APHA
			none	3 days	BCMOE
Phosphorus. Dissolved (Orthophosphate)	Plastic, Glass	S6«C	filter (field or lab)	3 days	EPA 40CFR 2012 / BC MOE
Phosphorus. Total Reactive (Orthophosphate)	Plastic. Glass	S6«C	none	3 days	APHA / BC MOE
Phosphorus. Total Dissolved	Plastic. Glass	S6^{9}C	filter. H2SO4	28 days	APHA
			none	3 days	BC MOE
Phosphorus. Total	Plastic. Glass	<6-C	H2SO4	28 days	APHA
			none	3 days	BCMOE
Silica. Reactive	Plastic	S6®C. do not freeze	none	28 days	APHA
Sulfate	Plastic. Glass	S6^{9}C	none	28 days	APHA SW846 Ch3 2007
Sulfide	Plastic, Glass	S6«C	ZnAc / NaOH to pH >9	7 days	APHA
Physical & Aggregate Properties					
Acidity	Plastic. Glass	S6'C	none	14 days	APHA
Alkalinity	Plastic, Glass	S6^{4}C	none	14 days	APHA
Colour	Plastic. Glass	S6^{9}C	none	3 days	APHA BC MOE
Conductivity	Plastic. Glass	S6'C	none	28 days	APHA
PH	Plastic. Glass	S6°C	none	15 minutes	APHA
Solids (Total. TSS. TDS. Fixed. Volatile, etc.)	Plastic. Glass	S6'C	none	7 days	APHA
Turbidity	Plastic. Glass	S6^{9}C	none	3 days	EPA 40CFR 2012 BC MOE
UV Transmittance	Plastic. Glass	S6^{9}C	none	3 days	APHA BCMOE
Inorganic Non-metallics					
Metals					
Hexavalent Chromium	Plastic. Glass	<6^{S}C	1 mL 50% NaOH per 125 mL	30 days	EPA 1669
			none	24 hours	APHA
Metals. Total	Plastic. Glass	no requirement	HNO3	180 days	APHA / EPA 200.2

Metals. Dissolved	Plastic. Glass	no requirement	field filter 0.45 urn HNO3. quakfy if lab-filtered[171]	180 days	APHA
Mercury. Total	Glass. PTFE	no requirement	HCI or BrCI	28 days	APHA/EPA 1631E
Mercury. Dissolved	Glass. PTFE	no requirement	field filter 0.45 urn HCI or BrCI. quahfy if lab-filtered[181]	28 days	APHA/EPA 1631E
Aggregate Organics					
Adsorbable Organic Halides (AOX)	Amber Glass	S6°C	HNO3. store in dark, sodium sulfite it chlorinated, collect with no headspace	14 days	APHA 5320
Biochemical Oxygen Demand (BOD)	Plastic. Glass	S6°C. do not freeze	none	3 days	APHA BC MOE
Carbonaceous Biochemical Oxyqen Demand (CBOD)	Plastic. Glass	S6⁴C. do not freeze	none	3 days	APHA BC MOE
Carbon. Dissolved Organic	Plastic. Glass	S6°C	filter. H2SO4 or HCI	28 days	APHA
			none	3 days	BCMOE
Carbon. Dissolved Inorganic^	Plastic. Glass	S6*C	field filter	14 days	APHA (alkalinity)
Carbon. Total Organic	Plastic. Glass	S6°C	H2SO4 or HCI	28 days	APHA
Carbon. Total Inorganic	Plastic. Glass	S6°C	none	14 days	APHA (alkalinity)
Chemical Oxygen Demand (COD)	Plastic. Glass	S6°C	H2SO4 (field or lab)	28 days	APHA
			none	3 days	BC MOE
Chlorophyll *a* and Phaeophytin	Filter	Filters: freeze	field filter, store in dark	Filters: 28 days	APHA
	Dark Plastic. Amber Glass	$6°C	unfiltered, store in dark	2 days	
Surfactants (Methylene Blue Active Substances)	Plastic. Glass	S6°C	none	3 days	APHA / BC MOE
Total Phenols (4AAP)	Plastic. Glass	S6°C	H2SO4	28 days	APHA
Extractable Hydrocarbons					
Extractable Hydrocarbons (LEPH. HEPH. EPH)	Amber Glass	S6°C	NaHSO4. HCI. or H2SO4	14/40 days	EPA 3511
			none	7 / 40 days	SW846 Ch4 2007
Oil and Grease / Mineral Oil and Grease	Amber Glass	S6°C	HCI or H2SO4	28 days	EPA 40CFR 2012
Waste Oil Content	Amber Glass	S6°C	none	28 days	BCMOE
Carbamate Pesticides	Amber Glass	S6°C	Potassium Dihydrogen Citrate (solid), -pH	28 days	EPA 531.2. APHA 661 OB
			ChlorAC buffer. -pH 3. 1.8mL / 60 mL	28 days	EPA 531.1
			none. 100 mg-L Na2S2O3 it chlorinated	7 days	EPA 8321A
Chlorinated and Non-chlorinated Phenolics	Amber Glass	S6C	0.5g Ascorbic Acid / L NaHSO4 or H2SO4	14/40 days	Alberta Env AE130
			none	7 / 40 days	SW846 Ch4 2007
Dioxins / Furans	Amber Glass	e6'C	none	unlimited	SW846 Ch4 2007
Glyphosate / AM PA	Amber Glass or Polypropylene	S6°C	100 mg-L Na2S2O3 if chlorinated	14 days	APHA 6651B
Glycols	Glass	S6°C	NaHSO4. HCI. or H2SO4	14 / 40 days	EPA 3511
			none	7 / 40 days	SW846 Ch4 2007
Halogenated Hydrocarbons (Semi-Volatile)	Amber Glass	<6°C	100 mg! Na2S2O3 it chlorinated	7 / 40 days	SW846 Ch4 2007
Herbicides. Acid Extractable	Amber Glass	S6°C	HCI (optional), store in dark. 50 mg L	14/21 days	APHA 6640A APHA 6640A

Paraquat / Diquat	Dark Plastic (protect from light)	S&C	100 mg-L Na2S2O3 if chlorinated	7121 days	EPA 549.2
Pesticides (NP. OP. OC)	Amber Glass	S6⁹C	none	7 / 40 days	SW846 Ch4 2007
Polychlorinated Biphenyls (PCBs)	Amber Glass	S6"C	none	unlimited	SW846 Ch4 2007
Polycyclic Aromatic Hydrocarbons (PAHs)	Amber Glass	S6⁹C	NaHSCM. HCI. or H2SO4	14 40 days	EPA 3511
			none	7 / 40 days	SW846 Ch4 2007
Resin Acids, Fatty Acids	Amber Glass	S6⁹C	0.5g Ascorbic Acid 4 0.4g NaOH) / L	M/40 days	Alberta Env AE129
			none	7 / 40 days	SW846 Ch4 2007
Volatile Organic Compounds (Trihalomethanes)	43mL Glass VOC Vials (2-3}	S6®C	3 mg Na2S2O3 (see BC Lab Manual method for more	14 days	BC MOE
Volatile Organic Compounds (VOC. BTEX.VH	43mL Glass VOC Vials	S6C	200 mg NaHSO4, or 3 mg Na2S2O3 if	14 days	BC MOE
Microbiological Parameters					
Coliforms, Total. Fecal, and Ecoli	Sterile Glass or Plastic	n8ˢC. do rot freeze	Na2S2O3	30 hours	BC CDC / APHA 9060B
Cryptosporidium, Giardia	Sterile Glass or Plastic	<8-C, do not freeze	Na2S2O3	96 hours	EPA 1623 /APHA 9060B
Enterococcus	Sterile Glass or Plastic	<8*C. do not freeze	Na2S2O3	30 hours [151]	APHA 9060B
Heterotrophic Plate Count	Sterile Glass or Plastic	«8ˢC. do not freeze	Na2S2O3	24 hours	APHA 9215
Toxicity					
Daphnia, Chronic 21 day / Chronic EC25	Plastic. Glass (non - toxic)	4±2*C	collect with no headspace	5 days	EC EPS 1/RM/14 8 11
Daph na. LC50 / LT50	Plastic, Glass (non-toxic)	4±2®C	collect with no headspace	5 days	EC EPS 1/RM/14 8 11
MicroCox	Plastic. Glass (non-toxic)	4±2*C	collect with no headspace	3 days	EC EPS 1-RM-24
Trout, LC50	Plastic. Glass (non-toxic)	4±2*C	collect with no headspace	5 days	EC EPS 1/RM/13 8 9
Trout. LT5O	Plastic. Glass (nontoxic)	4+2'C	collect with no headspace	5 days	EC EPS 1/RM/13 8 9
Soil and Sediment					
Inorganics					
Bromide / Chloride / Fluoride	Plastic. Glass	no requirement	none	unlimited	Carter (Table 4,1)
Cyanide (WAD /SAD)	Plastic. Glass	S6«C	store in dark, field moist	14 days	SW846 Ch3 2007
Hexavalent Chromium	Plastic. Glass	£6'C	store field moist	30/7 days	SW846 Ch3 2007 / EPA 3060A
Metals. Total	Plastic, Glass	no requirement	none	180 days	SW846 Ch3 2007
Mercury. Total	Plastic. Glass	no requirement	none	28 days	SW846 Ch3 2007
Moisture	Plastic. Glass	s6⁹C	none	14 days	Puget Sound Protocols
pH	Plastic. Glass	no requirement	none	365 days	Carter
Sulfide	Plastic, Glass	S6ˢC	store field moist	7 days	Puget Sound Protocols
TCLP - Mercury	Plastic. Glass	no requirement	sample: none TCLP extract: HNO3, HCI. or BrCI	28 / 28 days	EPA 1311
TCLP - Metals	Plastic, Glass	no requirement	sample: none TCLP extract: HNO3	180 / 180 days	EPA 1311
Organics					
Carbons (TC. TOC)	Plastic. Glass	S6⁹C	none	28 days	SW846 Ch3 2007
	Plastic Glass	no requirement	dried state	unlimited	Carter (Table 4, 1)
Chlorinated and Non-chlorinated phenolics	Glass	S6⁹C	none	14 / 40 days	SW846 Ch4 2007

Dioxins / Furans	Glass	S6°C	none	unlimited	SW846 Ch4 2007
Extractable Hydrocarbons (LEPH, HEPH, EPH)	Glass	S6°C	none	14 / 40 days	SW846 Ch4 2007
Glycols	Glass	S6°C	none	14 / 40 days	SW846 Ch4 2007
Herbicides. Acid Extractable	Glass	S6°C	none	14 / 40 days	SW846 Ch4 2007
Oil and Grease / Mineral Oil	Glass	S6C	none	28 days	SW846 Ch3 2007,
Pesticides (NP. OP. OCl	Glass	S6°C	none	14 / 40 days	SW846 Ch4 2007
Polychlorinated Biphenyls (PCBs)	Glass	S6°C	none	unlimited	SW846 Ch4 2007
Polycyclic Aromatic Hydrocarbons (PAHs)	Glass	S6°C	none	14 / 40 days	SW846 Ch4 2007
Resin Acids, Fatty Acids	Glass	S6°C	none	14 / 40 days	SW846 Ch4 2007
TCLP - Volatile Organic Compounds	Glass	S6C	sample: none TCLP extract:	14/14 days	EPA 1311
TCLP - Semi-Volatile Organic Compounds	Glass	S6°C	none	14 /7 / 40 days	CPA 1311
Volatile Organic Compounds (VOC. BTEX. VH. THM)	Pre-weighed sealed glass vial charged with	S6°C	methanol (exact volume, e.g. 10.0 mL)	40 days	EPA 5035A / CCME
	Hermetic sampler gtass SOI[1] jar lor mo^ure'[81]	S6°C	none	48 hours[1,1] / 40 days	EPA 5035A / CCME/ ASTM D6418-09
Biota					
Metals. Total	Plastic. Glass	freeze (S -18C)	none	2 years	Puget Sound Protocols
Mercury. Total	Plastic. Glass	freeze (3 -18C)	none	1 year”	EPA 1631 Appendix
Organics					
Semi-Volatile Organic Compounds	Glass. PTFE	freeze (s -18C)	none	365 / 40 days	Puget Sound Protocols
Volatile Organic Compounds	Glass. PTFE	freeze (s -18C)	none	14 days	Puget Sound Protocols
Air (Vapours)					
VOCs by Canister Sampling	SS canister	ambient	none	30 days	EPATO15
VOCs by Thermal Desorgttion	thermal desorption tube	S6°C	none	30 days	EPA TO17
VOCs and other Volatile Substances by Charcoal and	see BC Lab Manual Method	S6°C (or as per applicable	none	30 days	see BC Lab Manual Method

3 Storage temperature applies to storage at the laboratory. For all tests where refrigeration at *s* 6°C is required at the laboratory, samples should be packed with ice or cold packs to maintain a temperature of ≤1O°C during transport to the laboratory. The storage of <8°C for microbiological samples applies during storage at the laboratory and during transport to the laboratory. To prevent breakage, water samples stored in glass should not be frozen. Except where indicated by *do not freeze*. test results need not be qualified for frozen samples. Labs may apply a 'Cooling Initiated* qualifier on reports to indicate where samples were received above specified storage temperature. but where sampling occurred < 8 hours before arrival at the lab. and where samples were packed appropriately in coolers with ice or cold packs to initiate the cooling process.

4 Hold Times: Single values refer to hold time from sampling to analysis. Where 2 values are given, the first is hold time from sampling to extraction. and the second is hold lime from extraction to analysis. 3 values are given for TCLP semi-volatiles (1st is from collection to TCLP extraction; 2nd is from TCLP extraction to preparative extraction; 3rd is from preparative extraction to analysis).

5 Samples received from remote locations more than 48 hours after collection must not be tested.

6 Methanol extracts are stable for 40 days from sampling. Hermetic samples must be methanol-extracted within 48 hours of sampling or may be frozen at s -7°C within 48 hours of sampling to extend hold time to 7 days from sampling. Frozen hermetic samples must be extruded into methanol while still predominantly or partially frozen.

7 It not field-preserved, water samples for metals analysis must be acidified at the lab in their original containers by

addition of HNO3 (within 14 days of sampling). then equilibrated at least 16 hours prior to sub-sampling or analysis (otherwise, quality as 'received unpreserved*). This approach is also applicable to dissolved metals if field filtered. Not applicable to mercury.

8 Use only glass or PTFE containers to collect water samples for total or dissolved mercury. For total mercury, field-preserve with HCI or BrCl. For dissolved mercury, field filter and then preserve with HCI or BrCl . Adding BrCl to original sample container at the laboratory within 28 days of sampling is an acceptable alternative for total mercury and for dissolved mercury (if field filtered), if samples are oxidized for 24 hours prior to sub-sampling or analysis. Dissolved mercury should not be lab-filtered. Qualify lab-filtered results for dissolved mercury as *lab filtered*.

9 Freezing is optional for freeze dried tissue samples and for vegetation that is dried prior to digestion and reported on a dry weight basis: in these cases, samples may be stored at ambient temperature, with a hold time of 28 days for mercury and 6 months for other metals (based on BC MOE soil guidelines).

1.5.5 Quality assurance and quality control measures

Please refer to Vol. 1 S.1 of this manual for general Quality Assurance and Quality Control measures to be followed.

The typical goal of QA/QC system is to ensure that all monitoring-related data are scientifically sound and of known and documented quality. The implementation of QA/QC procedures into monitoring activities concern the collection and storage of sample materials, analysis of samples, validation of measurements as well as interpretation, reporting and storage of data. This can be achieved through:

- the establishment of standardized procedures,
- adequate documentation,
- and appropriate training of personnel.

The general result of a good QA/QC policy is more trustworthy investigations and data. By this it becomes easier to compare data between studies and to discover real trends of change within the monitoring areas. The monitoring consultant's QA/QC system should be presented in the tender as well as in the final report of the monitoring program, and the industrial operator must before awarding contracts to environmental monitoring work assess the sufficiency of the described quality system. The quality

- The quality system should include:
- verification of sample collection procedures,
- a plan for using reference samples in connection with analyses,
- reviewing the quality of analytical methods and results and performing of quality control of the report.

Optimally, a standard QA-system should be used, for example ISO 9000. Type and frequency of QA inspections of analyses should be presented as part of the method description in the report. Analyses should be verified against reference samples run in the same test series as the real samples. Presentation of results from the reference samples would be a natural part of result interpretation. The suppliers of services for monitoring programmes (analyses, fieldwork) should preferably be accredited (e.g. ISO 17025 or an equivalent) for the methods they use.

S2. Specific provisions related to environmental monitoring and inspections of upstream offshore petroleum operations

2.1 Description of activities and facilities involved in upstream offshore oil and operations

Upstream oil and natural gas activity take place in four unique stages:

- exploration,
- development,
- production and
- decommissioning.

Below is an overview of how each stage works specifically related to the offshore oil and natural gas industry to another.

Exploration

Exploration is the process of locating oil and natural gas resources. Companies may begin their exploration process by reviewing existing geological and geophysical data to learn more about potential reservoirs. Once the data is compiled and analyzed, companies make an economic calculation which factors in elements such as geological risk, financial returns that might be earned, taxes and royalties etc., to determine whether a geological prospect is worth exploring.

<u>Seismic Surveys</u>

Conducting a marine seismic survey is typically the next step in exploring an offshore area as precise information is needed before investing in drilling an exploratory well given the high cost of drilling in the offshore. A marine seismic survey involves survey vessels using a compressed air gun to send a sound waves through the water at regular intervals along a predefined path. Seismic vessels tow streamers behind them containing hydrophones which record the reflected energy. Hydrophones may also be placed on the seabed in more shallow waters.

The result of a seismic survey is essentially a picture of the various rock layers underneath the seabed. This data is used to identify geological structures that may contain oil and natural gas resources.

<u>Exploration Drilling</u>

If an analysis of seismic data shows a geological structure that could contain oil and natural gas resources, a company may decide to drill an exploration well. Exploration wells are drilled to confirm whether geological formations identified in seismic surveys contain oil or natural gas. Each well has four major parts:

- The sections of drill pipe joined together to form the drill string
- The drill bit used to cut through the rock
- The equipment that rotates the drill string and the drill bit
- The drilling fluid that circulates between the drilling platform and the drill bit.

To begin drilling, a surface hole is drilled a few hundred meters into the sea floor. A continuous steel pipe called a surface casing is lowered into the hole and cemented in place. A blowout preventer (BOP) is installed on the top of the surface casing to prevent water or hydrocarbons from escaping into the environment in the unlikely event of an emergency or equipment failure. Once the BOP is pressure tested, the next section of the well is drilled by lowering the drill bit and string through the BOP into the surface hole for drilling. Extra joints are added to the drill string as the drill bit cuts deeper into the rock. When a section of well is completed, the drill string is pulled out and sections of the casing are joined together, lowered into the well and cemented in place.

Once the drilling is complete, it is ready to become the conduit for the oil or natural gas in the reservoir if the reservoir contains hydrocarbons. The company may use the pressure in the reservoir, pumps or other stimulation methods to bring hydrocarbons to surface. A series of valves control the flow of the hydrocarbons in a safe and controlled manner.

The drilling process is the same for all types of wells drilled offshore – exploration wells, delineation wells (used to help determine the size and shape of a reservoir), production wells (used to actually produce the oil and natural gas from a reservoir) and re-injection wells.

All of the drilling activity takes place on a special offshore drilling platform which can be fixed or floating. Drilling an offshore well can take three to four months and can cost $150 - 200 million per well, depending on water depth and other factors.

Development

Should a company decide that it wants to proceed to oil and natural gas production, the next step is development. During the development phase, the company develops a series of plans which outline exactly how it will produce the oil and natural gas from a particular reservoir, the environmental protection measures that will be put in place to minimize any environmental impact, the safety measures that will be used on the project, and the benefits of the project to the relevant communities (including employment, revenues, contracts, etc.). During development planning, the company will typically hold a series of consultations with key stakeholders and the general public to explain the project and its benefits. If the plan is approved by the appropriate regulatory body and relevant governments, the company will then proceed with construction of the production facilities and any other infrastructure required, as outlined in the development plan.

The offshore development phase can take five to 10 years, depending on the size of the project.

Production

Producing oil and natural gas offshore is a complex process due to the challenges of operating in a remote and sometimes harsh environment. Production facilities are built to withstand the offshore environment and its challenges.

Several key activities happen on a production facility:

- Drilling and maintaining the wells used to produce oil and natural gas and, where required, injecting water, chemicals and possibly gas, depending on the project, back into the formation;
- Processing and separating the produced mixture of oil and natural gas, and removing any water and sand from the hydrocarbons;
- Storing produced liquids for transport to markets or to a transshipment terminal; and
- Gathering and processing gas and natural gas liquids, and sending them through a subsea pipeline to shore (or, if not processed at the platform, the raw gas and liquids are sent to shore through a pipeline for processing at a shore-based facility)

These functions may be combined in one structure or carried out using separate facilities or at a separate location.

Although there are different types of offshore production facilities, all are made up of two parts:

- The platform supporting the upper, or "topsides", facilities; it may float or sit on the seabed and may contain silos for storage of crude oil;
- The "topsides", where all the operating and support functions of the producing operations are housed.

The type of production facilities used in offshore production depends on many factors, including water depth, environmental conditions, proximity to land, the depth and extent of the oil and natural gas field, and anticipated production rates. Three common types are:

- A gravity base structure (GBS): a concrete-based structure which sits on the sea floor and may contain tanks in the base that are used to store oil before it is shipped to shore.
- A floating system: a vessel, which can contain production, oil storage and transshipment facilities, and which is connected to the producing wells through an internal turret that is anchored in position. The structure then rotates around the turret in response to local winds and currents.
- An anchored structure with legs: sometimes called a "jacket", this type of structure has steel or concrete legs that are floated by barge to the desired location and then lowered to the seabed in an upright position. The legs are anchored to the bottom with steel piles driven into the seafloor.

Decommissioning

An offshore oil and natural gas field can produce for decades, depending on its size. Once all of the accessible oil and natural gas reserves in a field have been produced, the project can be decommissioned, meaning that wells are plugged and abandoned, infrastructure is removed and the site is cleared to remove any debris. Decommissioning also involves test trawling to verify that the area is free of any potential obstructions. These activities are monitored by the regulator

A life-cycle and processes and technologies for offshore conventional oil and gas is presented in the table below.

Stages (AEA)	Main stages	Processes/technologies
Stage 1 - Site identification and preparation	1. Desk studies and licensing	**Desk studies** of target area for favourable geological conditions **Licensing**
	2.Exploratory Surveys	**General investigation:** Gravity and magnetic surveys by boat to capture geological information and identify 'leads' for further exploration. **Geophysical testing/investigations:** Seismic surveys – shock waves are sent into the subsea geological formations and response times monitored for returned waves to further identify and define reservoirs.
Stage 2 - Well design and construction	3. Well design	**Desk studies** for well design, planning and logistics
	4. Transport of drilling rig	**Transport of drilling rig** – vessels,
	5. Well drilling	**Positioning of drilling apparatus** – Seabed activities **Drilling of vertical or deviated wells** – Drilling with water based mud (WBM)/ Oil Based Mud (OBM)/Synthetic Based Mud (SBM) **Drill Cuttings Management** – Management of cuttings generated
		Cementing and Casing– Cementing of well casings

	6. Well completion	**Well bore clean-up** - handling potentially contaminated wastewater and solids/cuttings **Introduction of completion fluids –** Introduction of chemicals to protect the well including corrosion inhibitors and biocides
Stage 3 - Production	7. Platform installation	**Engineering, Procurement and Construction (EPC) – facility design and construction –** Onshore/nearshore activities to prepare platform for particular drilling site. **Transport of platform** – shipping vessels **Piling for jacket foundations/anchor points**- seabed activities to permanently install fixed platforms and/or floating production facilities **Rock dumping** - depending on rig type may be necessary to use rock dumping as part of foundation design. **Hydrostatic testing –** leak and pressure testing of production and utility systems **Subsea infrastructure –** installation of subsea equipment as necessary including Includes ESPs, hydraulically-powered pumps, FLETS, PLETS, ESDVs, pigging equipment, manifolds, and X-trees. Also includes in-field flowlines, injection lines and umbilicals, but excludes piling **Pre-commissioning** – Pressure testing, hydro-static leak testing
	8. Platform operations	Platform operations are divided into three categories: i) Production, ii) Topside utility systems and iii) Export systems **I Production:** **Chemical injection** – Use of chemicals to maintain well bore. **Subsea production systems –** For larger networks tie-backs and sub-sea equipment has to be installed and maintained. **Oil/gas processing and handling** – processing of extracted material to separate oil, water and gas **Produced water management –** Treatment and processing of the water generated from reservoir fluid separation processes. **Produced sand management –** Washing and cleaning of contaminated sand before return to sea or return to shore **Off-gas management – flaring –** management of gas generated from separation processes **Enhanced recovery (water flooding)** – water flooding using seawater to boost production **Enhanced recovery (miscible gas injection)** – injection of miscible produced HC gas to boost production. **Well stimulation (low volume hydraulic fracturing)** – fracturing to boost production **II Topside utility systems:** **Power generation and combustion equipment** - Main energy generation units for power on the platform, auxiliary power generation for process equipment **Hydrocarbon and chemical Storage –** Includes both bunkered fuel for power generation and processed oil **Diesel/chemical deliveries/loading** – Includes all receiving shipments of goods to the installation **Open loop sea water cooling –** Seawater cooling systems for all thermal processes carried out on the platform **HVAC systems –** air conditioning systems for accommodation block equipment **Topside drainage systems** – Covers sewers fir grey and black water, closed systems for process equipment and open systems for drainage on deck **Waste management –** Covers all waste aspects not detailed already, principally drainage, solid waste management and return of material to shore **III Export systems:** **Off-take – vessels –** Off-take of oil to shuttle tankers **Gas/oil export pipelines** – off-take of gas/oil via pipeline
Stage 4 Project cessation and	9. Well closure	**Well Plugging –** Closure of the well bore at multiple points using cement plugs **Conductor recovery** – Recovery of the conductor from the well and return to the surface, may require cutting operations as necessary.

well closure	10. Management of cuttings piles	Leave in place – Management options for leaving cuttings in place. Excavate to surface – Remove of cuttings piles to surface for return to shore Excavate and redistribute on seabed – Options for redistribution of cuttings across the seabed
Stage 5 Post closure and abandonment	11. Topside and jacket decommissioning	**Preparation of topside for removal** – All clean down and removal processes to prepare topside for decommissioning and removal. **Dismantling of structures** – Dismantling of structures in preparation for removal of topside structures **Cutting of leg structures** – Cutting of platform legs to remove the topside structure. **Leave in-situ components** – Footings and base structures to be left in place
	12. Decommissioning seabed infrastructure, e.g. pipelines/bundles	**Leave in place** – Option to leave pipelines in place, may require further rock dumping. **Partial removal** – Removal of concrete mattresses and non-vital support structures **Full removal** – full removal of pipelines using jet washers to untrench pipelines
	13. Shipping	**All decommissioning activities** – Multiple shipping activities as required for decommissioning processes
	14. Long-term well integrity	**Monitoring** - the risks of long-term well integrity failure

2.2 Sources of key impacts of offshore oil and gas operations and impact categorization

The main pressures on the marine environment from oil and gas activities include operational and accidental discharges of chemicals, crude oil and produced water containing substances such as oil components, polycyclic aromatic hydrocarbons, alkyl phenols and heavy metals. In addition, there could be concerns related to atmospheric emissions, low level naturally occurring radioactive material, noise, and the placement of installations and pipelines on the seabed.

2.2.1 Risks and impacts of marine transport

Environmental Aspects	Impacts	Risk Level
Releases to air (local air quality)	The use of shipping for offshore oil and gas installations is a necessity, which will generate emissions to air from fuel use of vessels. The effects on local air quality and concentrations within the air and deposition to surface water are affected by a number of variables, including weather conditions. The measures outlined to maintain low sulphur content and limit shipping to a minimum will help mitigate this risk.	3 low
Releases to air (contribution to international greenhouse gas emissions)	The use of shipping for offshore oil and gas installations is a necessity, which will generate emissions to air from fuel use of vessels. While oil and gas operations will only make up a proportion of all international shipping that occurs, the contribution from this sector to international greenhouse gas emissions should not be under-estimated. The IPCC (2007) comments on energy-saving equipment measures that can be introduced to cut emissions significantly. However the same reference also recognises that market penetration of such measures into the shipping fleet is still relatively low and that more needs to be done to ensure uptake of these options.	5 moderate

2.2.2 Risk and impacts of seismic surveys

Environmental Aspects	Impacts	Risk Level
Underwater noise in the marine environment (potential to cause physical injury)	Seismic surveys require the use of compressed air guns to fire pulses into the seabed to gather information about subsea geology. The equipment used can generate noise 100,000 times louder than air craft (Oceana, 2013), so the potential to cause physical injury to marine mammals and fish is real. DNV (2007) estimate that harm is caused to creatures <5m from the gun and serious injuries at <1.5m. Fish in the early stage of life are particularly vulnerable. However, this issue is well recognised internationally and a large range of measures are in place to control the risk including the JNCC guidelines (2010) and advice from ACCOBAMS (2013) and ASCOBANS (2010. Assuming the measures quoted are adopted the potential to cause physical injury is greatly reduced.	4 low
Underwater noise in the marine environment (potential to cause disturbance to marine life)	The distinction between physical injury and disturbance that potentially causes behavioural change is important. A number of organisations question the impact of seismic surveys on effecting cetacean populations (Oceana 2013 and NRDC, 2010); evidence linking activity such as 'beaching' of whales with seismic surveys is still the subject of ongoing investigation. It has been documented that adult fish demonstrate reactions to soundwaves distances of up to 30km, which have the potential to interfere with spawning cycles (DNV, 2007). Again the risks of seismic surveys to marine populations are well recognised internationally and a variety of measures are available to control the risk.	4 low

2.2.3 Risk and impacts of transporting the drilling rig to the well site

Environmental Aspects	Impacts	Risk Level
Releases to air (local air quality)	The use of shipping for offshore oil and gas installations is a necessity, which will generate emissions to air from fuel use of vessels. The effects on local air quality and concentrations within the air and deposition to surface water are affected by a variety of variables, including weather conditions. The measures outlined to maintain low sulphur content and limit shipping to a minimum will help mitigate this risk.	3 low
Releases to air (contribution to international greenhouse gas emissions)	The use of shipping for offshore oil and gas installations is a necessity, which will generate emissions to air from fuel use of vessels. While oil and gas operations will only make up a proportion of all international shipping that occurs, the contribution from this sector to international greenhouse gas emissions should not be under-estimated. The IPCC (2007) comments on energy-saving equipment measures that can be introduced to cut emissions significantly. However the same reference also recognises that market penetration of such measures into the shipping fleet is still relatively low and that more needs to be done to ensure uptake of these options.	5 moderate
Discharges to sea (containment failure on shipping)	Transport of the drilling rig will be carried out using multiple shipping vessels which will carry cargoes of bunkered oil for fuel use on the vessel. The identified risk relates to the loss of containment either through collision or loss of containment for the storage vessel on-board. The measures identified go some way to prevent the risk of discharge to sea, but based on shipping more generally the	6 moderate

	potential for loss of bunkered oil to sea has been ranked as 'occasional'.	
Discharges to sea (containment failure on rig)	The drilling rig itself, depending on the choice of rig selected will carry a combination of chemicals and oil based materials such as hydraulic fluids. However the likely quantity involved compared to shipping vessels is likely to be lower, and the potential for collision / loss of containment would also be lower on the basis of 1 drilling rig versus up to 4 tug boats towing the rig.	2 Low

2.2.4 Risk and impacts of positioning apparatus on the seabed.

Environmental Aspects	Impacts	Risk Level
Seabed disturbance	Seabed disturbance from the placing of drilling rigs and equipment on the seabed, drill vessel anchorage and the discharge of drill cutting is inevitable. However measures are in place to help limit the scale of the impact and to protect sensitive areas of seabed from damage. Due to the highly likely basis of the potential impact the overall risk rating is generally deemed to be moderate. Sensitive biota such as sponge or cold water coral communities are expected to take some time to recover from disturbances.	5 moderate
Underwater noise in the marine environment (potential to cause disturbance to marine life)	The distinction between physical injury and disturbance that potentially causes behavioural change is important. Seismic surveys within stage 1 have been identified as having the greatest potential to cause physical injury to marine life from noise across the whole off-shore installation life cycle. However activities such as piling and rock dumping still have the potential create sufficient noise levels as to have effects on marine species. The risk ranking of generally low is awarded on the basis that all of the measures identified in stage 1 and 2 are in use.	4 low
Marine biodiversity impacts (introduce foreign species)	The consequences of introducing foreign species into new waters can have significant impacts depending on how quickly and aggressively the foreign species takes hold of a new environment. Care is needed to avoid introduction of foreign species for managing water in ballast tanks and species attached to the rig itself if moved from one location to another. Due to the potential severity of the consequence of introducing foreign species the risk ranking is judged as generally moderate.	6 moderate

2.2.5 Risk and impacts of drilling

Environmental Aspects	Impacts	Risk Level
Seabed disturbance	The main impact identified within this process is impact upon the seabed from the drilling operation itself. The likely affected area will be small based on the size of the well bore. Secondary issues could relate to any loss of drilling muds smothering the sea-bed. However, the contained nature of drilling means the risk of losing drilling muds should be limited.	3 low
Releases to air (local air quality)	The use of shipping for offshore oil and gas installations is a necessity, which will generate emissions to air from fuel use of vessels. The effects on local air quality and concentrations within the air and deposition to surface water are affected by a number of variables, including weather conditions. The measures outlined to maintain low sulphur content and limit shipping to a minimum will help mitigate this risk.	3 low
Releases to air (contribution to	The use of shipping for offshore oil and gas installations is a necessity, which will generate emissions to air from fuel	4 low

international greenhouse gas emissions)	use of vessels. While oil and gas operations will only make up a proportion of all international shipping that occurs, the contribution from this sector to international greenhouse gas emissions should not be under-estimated. The IPCC (2007) comments on energy-saving equipment measures that can be introduced to cut emissions significantly. However the same reference also recognises that market penetration of such measures into the shipping fleet is still relatively low and that more needs to be done to ensure uptake of these options.	
Underwater noise in the marine environment (potential to cause disturbance to marine life)	Underwater noise generated during the drilling phase relates to the 'humming' noise generated by pumping equipment and drill machinery. Noise generation from these sources will have less impact than piling and rock dumping during installation and significantly less impact than seismic surveys .	2 low
Discharges to sea (planned) damage to marine ecosystems	The use of the measures identified including use of low hazard/risk chemicals, limits on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials towards marine life. The further dilution of these materials within sea water will continue to reduce the risk of impact in the short term.	3 low
Discharges to sea (planned) damage Main Environmental Aspects to water quality	The use of the measures identified including use of low hazard/risk chemicals, limits on hydrocarbon content of Impacts released materials and oil and water separation systems should also reduce the hazard of the released materials into sea-water. The further dilution57 of these materials within sea water will reduce concentrations affecting water quality	3 low
Discharges to sea (planned) seabed fouling	The main impacts on seabed fouling is where solid material such as drilling muds and cuttings smothers the sea bed affecting the benthic species that live in the surface layers of the seabed. Effects can be significant killing all life in the surface layers. However, on completion of the process the affected area is expected to recover quickly with re-population from surrounding areas.	6 moderate
Impacts to marine ecosystems (accidental) Tier III	Accidental release of large quantities of oil to sea would be likely to have severe impact on marine species. The severity would be such that it could be foreseen that the impact would take a significant amount of time spanning years for the full recovery of the affected marine ecosystems. According to OGP (2010), the probability of a blowout occurring during exploration/development drilling is between 6.0x10-5 and 1.9x10-3 per well drilled. For this reason, the frequency of a tier III event occurring during drilling was judged to be 'rare'. During production, the annual blowout frequency per producing well (inclusive of all well intervention) is 4.28×10^{-5} (Sintef Blowout database - Scandpower, 2013). This corroborates with estimate given in OGP (2010) that the probability of a blowout occurring from a producing well is 3.9×10^{-5} per well. For this reason, the frequency of a tier III event occurring during production was judged to be 'Rare'.	10 high

Impacts to coastal environments (accidental) Tier III	The accidental release of large quantities of oil to sea would have a high potential for those materials to reach the coastline where the impacts would be extremely severe for not only marine species but avian and terrestrial species within the near shore. The potential damaged caused could have long term (years) effect along the affected coastline with recovery of ecosystems expected to be slow. In some cases, such damage may mean that ecosystems do not fully recover to pre-incident conditions. According to OGP (2010), the probability of a blowout occurring during exploration/development drilling is between 6.0x10-5 and 1.9x10-3 per well drilled. For this reason, the frequency of a tier III event occurring during drilling was judged to be 'rare'. During production, the annual blowout frequency per producing well (inclusive all well intervention) is 4.28×10^{-5} (Sintef Blowout database - Scandpower, 2013). This corroborates with estimate given in OGP (2010) that the probability of a blowout occurring from a producing well is 3.9×10^{-5} per well. For this reason, the frequency of a tier III event occurring during production was judged to be 'Rare'. Due to the large quantities of oil involved in a tier III spill, damage to the coastline is unavoidable, particularly as some rigs in Europe are located close to the shore. For this reason, the likelihood of this aspect is judged to be the same as impacts to marine systems and water quality.	10 high
Impacts to water quality (accidental) Tier III	While hydrocarbons will emulsify and degrade within marine conditions for a tier III event the quantities of oil involved would have severe impact upon the general water quality within the marine environment. The degradation and breakdown of hydrocarbons would be expected to have a strongly negative affect for chemical oxygen demand affecting the ability of seawater to support marine life. According to OGP (2010), the probability of a blowout occurring during exploration/development drilling is between 6.0x10-5 and 1.9x10-3 per well drilled. For this reason, the frequency of a tier III event occurring during drilling was judged to be 'rare'. During production, the annual blowout frequency per producing well (inclusive all well intervention) is 4.28×10^{-5} (Sintef Blowout database - Scandpower, 2013). This corroborates with estimate given in OGP (2010) that the probability of a blowout occurring from a producing well is 3.9×10^{-5} per well. For this reason, the frequency of a tier III event occurring during production was judged to be 'Rare'.	10 high
Seabed fouling (accidental) Tier III	The potential for hydrocarbon spillages to reach the seabed is less clear, but given the quantities involved the potential for seabed fouling should be considered a risk. This would include contamination of marine sediments which have knock-on effects for benthic species that live within them. According to OGP (2010), the probability of a blowout occurring during *exploration/development drilling* is between 6.0×10^{-5} and 1.9×10^{-3} per well drilled. For this reason the frequency of a tier III event occurring during drilling was judged to be 'rare'. During *production*, the annual blowout frequency per producing well (inclusive all well intervention) is 4.28×10^{-5} (Sintef Blowout database - Scandpower, 2013). This corroborates with estimate given in OGP (2010) that the probability of a blowout occurring from a producing well is 3.9×10^{-5} per well. For this reason, the frequency of a tier III event occurring during production was judged to be 'Rare'. Due to the large quantities of oil involved in a tier III spill, damage to the seabed is unavoidable, particularly where rigs are located in shallower waters. For this reason, the likelihood of this aspect is judged to be the same as impacts to marine systems and water quality.	6 moderate

Impacts to marine ecosystems (accidental) Tier II	The IPIECA definition states that Tier II accidents will cover a more diverse set of incidents which have lower severity than Tier III. In practice for drilling the greatest risk is related to a critical failure if the well releases thousands of litres of oil to the sea. A Tier II incident may cover a similar incident but one that is brought under control more quickly resulting in a smaller quantity lost. However, at Tier II level the impacts for marine species would be severe with both short term impact and longer term (months/years) effects to fully recover. According to OGP (2010), the probability of a blowout occurring during exploration/development drilling is between 6.0x10-5 and 1.9x10-3 per well drilled. For this reason, the frequency of a tier II event occurring during drilling was judged to be 'rare'. During production, the annual blowout frequency per producing well (inclusive all well intervention) is 4.28 x 10^{-5} (Sintef Blowout database - Scandpower, 2013). This corroborates with estimate given in OGP (2010) that the probability of a blowout occurring from a producing well is 3.9x10^{-5} per well. For this reason, the frequency of a tier II event occurring during production was judged to be 'Rare'.	8 moderate
Impacts to coastal environments (accidental) Tier II	For Tier II incidents the quantity of hydrocarbons lost are still sufficient to make the possibility of reaching coastline possible. The impact on marine, avian and terrestrial species at the near shore would be severe, with long term impacts and ecosystems likely to be slow to recover from the consequence of the incident. According to OGP (2010), the probability of a blowout occurring during exploration/development drilling is between 6.0x10-5 and 1.9x10-3 per well drilled. For this reason, the frequency of a tier II event occurring during drilling was judged to be 'rare'. During production, the annual blowout frequency per producing well (inclusive all well intervention) is 4.28 x 10^{-5} (Sintef Blowout database - Scandpower, 2013). This corroborates with estimate given in OGP (2010) that the probability of a blowout occurring from a producing well is 3.9x10^{-5} per well. For this reason, the frequency of a tier II event occurring during production was judged to be 'Rare'. Due to the large quantities of oil involved in a tier II spill, damage to the coastline is likely, particularly as some rigs may be located close to the shore. For this reason, the likelihood of this aspect is judged to be the same as impacts to marine systems and water quality.	8 moderate
Impacts to water Quality (accidental) Tier II	While hydrocarbons will emulsify and degrade within marine conditions for a tier II event the quantities of oil involved would have moderate impact upon the general water quality within the marine environment. The degradation and breakdown of hydrocarbons would be expected to have a strongly negative affect for chemical oxygen demand affecting the ability of seawater to support marine life. According to OGP (2010), the probability of a blowout occurring during exploration/development drilling is between 6.0x10-5 and 1.9x10-3 per well drilled. For this reason, the frequency of a tier II event occurring during drilling was judged to be 'rare'. During production, the annual blowout frequency per producing well (inclusive all well intervention) is 4.28 x 10^{-5} (Sintef Blowout database - Scandpower, 2013). This corroborates with estimate given in OGP (2010) that the probability of a blowout occurring from a producing well is 3.9x10^{-5} per well. For this reason, the frequency of a tier II event occurring during production was judged to be 'Rare'.	8 moderate

Seabed fouling (accidental) Tier II	The fouling of seabed relates to the smothering of surface layers which affect benthic communities as well as potential toxic effects from the material discharged. At tier II level the potential for quantities of discharged oil reaching the seabed are more limited with the greatest quantities remaining in the water column. Impacts for seabed fouling are considered to be more limited with a risk rating of generally low. According to OGP (2010), the probability of a blowout occurring during exploration/development drilling is between 6.0x10-5 and 1.9x10-3 per well drilled. For this reason, the frequency of a tier II event occurring during drilling was judged to be 'rare'. During production, the annual blowout frequency per producing well (inclusive all well intervention) is 4.28 x 10^{-5} (Sintef Blowout database - Scandpower, 2013). This corroborates with estimate given in OGP (2010) that the probability of a blowout occurring from a producing well is 3.9x10^{-5} per well. For this reason, the frequency of a tier II event occurring during production was judged to be 'Rare'. Due to the large quantities of oil involved in a tier II spill, damage to the seabed is unavoidable, particularly as some rigs in Europe are located in shallower waters. For this reason, the likelihood of this aspect is judged to be the same as impacts to marine systems and water quality.	4 low
Impacts to marine ecosystems (accidental) Tier I	Tier I accidents represent those with the highest frequency but lowest severity. The accidental discharge of drainage systems in this case may include waters contaminated with hydrocarbons or production chemicals. The quantities involved would be expected to be more limited but have the potential to still cause significant impact on marine species. According to OGP (2010), the probability of a well release occurring during exploration/development drilling is between 4.9x10^{-4} and 1.6x10^{-2} per well drilled. For this reason, the frequency of a tier I event occurring during drilling was judged to be 'occasional'. During production, the OGP (2010) estimate that the probability of a well release occurring is between 2.9x10^{-6} and 1.1x10^{-5} per well. For this reason, the frequency of a tier I event occurring during production was judged to be 'Rare'.	6 moderate
Impacts to coastal environments (accidental) Tier I	For Tier I accidents the quantities of material involved would be expected to be smaller than the major spillages described in earlier processes. The potential for discharged material to reach the coastline is more limited, while impact would be expected to be more significant. However the because the frequency and consequence of the incident would be lower than in the Tier II case. According to OGP (2010), the probability of a well release occurring during exploration/development drilling is between 4.9x10^{-4} and 1.6x10^{-2} per well drilled. For this reason, the frequency of a tier I event occurring during drilling was judged to be 'occasional'. However, due to the small quantities of fluid involved in a Tier I spill, the chances of the spill reaching the shoreline are reduced, the likelihood of coastal impacts during drilling are therefore judged to be 'rare'. During production, the OGP (2010) estimate that the probability of a well release occurring is between 2.9x10^{-6} and 1.1x10^{-5} per well. For this reason, the frequency of a tier I event occurring during production was judged to be 'Rare'. However, due to the small quantities of fluid involved in a Tier I spill, the chances of the spill reaching the shoreline are reduced, the likelihood of coastal impacts during production are judged to be 'extremely rare'.	4 low

Impacts to water quality (accidental) Tier I	For Tier I accidents the quantities of material involved would be expected to be smaller than the major spillages described in earlier processes. The effects on water quality would be expected to be short lived with minor impact. According to OGP (2010), the probability of a well release occurring during exploration/development drilling is between $4.9x10^{-4}$ and $1.6x10^{-2}$ per well drilled. For this reason, the frequency of a tier I event occurring during drilling was judged to be 'occasional'. During production, the OGP (2010) estimate that the probability of a well release occurring is between $2.9x10^{-6}$ and $1.1x10^{-5}$ per well. For this reason, the frequency of a tier I event occurring during production was judged to be 'Rare'.	3 low
Seabed fouling (accidental) Tier I	The impact for seabed fouling relates to smothering of surface layers where benthic species live. For tier I accidents where the likely discharged material is drainage waters contaminated with hydrocarbons or chemical wastes, the likelihood for seabed fouling is relatively low. According to OGP (2010), the probability of a well release occurring during exploration/development drilling is between $4.9x10^{-4}$ and $1.6x10^{-2}$ per well drilled. For this reason, the frequency of a tier I event occurring during drilling was judged to be 'occasional'. However, due to the small quantities of fluid involved in a Tier I spill, the chances of the oil reaching the seabed are reduced, the likelihood of seabed fouling during drilling is therefore judged to be 'rare'. During production, the OGP (2010) estimate that the probability of a well	2 low

2.2.6 Risk and impacts of handling cuttings contaminated with oil based muds

Environmental Aspects	Impacts	Risk Level
Discharges to sea (planned) damage to marine ecosystems	The use of the measures identified including the use of low hazard/risk chemicals and avoided use of high risk chemicals (e.g. PLONOR chemicals under OSPAR, the zero discharge principle under HELCOM), limits on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials towards marine life. The further dilution of these materials within sea water will continue to reduce the risk of impact.	3 low
Discharges to sea (planned) damage to water quality	The use of the measures identified including the use of low hazard/risk chemicals and avoided use of high risk chemicals (e.g. PLONOR chemicals under OSPAR, the zero-discharge principle under HELCOM or the prohibition of harmful substances under Annex I of the Barcelona Convention[55]), limits on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials into sea-water. The further dilution[59] of these materials within sea water will reduce concentrations affecting water quality.	3 low
Discharges to sea (planned) seabed fouling	The main impacts on seabed fouling is where solid material such as drilling muds and cuttings smothers the sea bed affecting the benthic species that live in the surface layers of the seabed. Effects can be significant killing all life in the surface layers. However, on completion of the process the affected area is expected to recover quickly with re-population from surrounding areas.	6 moderate

2.2.7 Risk and impacts of cementing of well casing

Environmental Aspects	Impacts	Risk Level
Discharges to sea (planned) damage to marine	The use of the measures identified including the use of low hazard/risk chemicals and avoided use of high risk chemicals (e.g. PLONOR chemicals under OSPAR, the zero	3 low

ecosystems	discharge principle under HELCOM), limits on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials towards marine life. The further dilution[60] of these materials within sea water will continue to reduce the risk of impact.	
Discharges to sea (planned) damage to water quality	The use of the measures identified including the use of low hazard/risk chemicals and avoided use of high risk chemicals (e.g. PLONOR chemicals under OSPAR, the zero discharge principle under HELCOM) limits on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials into sea-water. The further dilution[61] of these materials within sea water will reduce concentrations affecting water quality.	3 low
Discharges to sea (planned) seabed fouling	The risk management measures in place are intended to reduce the quantity of any material discharged to sea, however as this will likely be solid matter, the potential for any discharged material to reach the seabed is greater. The main impact here would be from smothering the surface layers of seabed where benthic species exist. The likely impact would be moderate in the short term, but affected areas would be expected to recover quickly from benthic species repopulating affected area.	6 moderate
Underwater noise in the marine environment (potential to cause disturbance to marine life)	Underwater noise generated during the cementing phase relates to the 'humming' noise generated by pumping equipment and drill machinery. Noise generation from these sources will have less impact than piling and rock dumping during installation and significantly less impact than seismic surveys during life cycle stage 1.	2 low

2.2.8 *Risk and impacts of well-bore clean-up*

Environmental Aspects	Impacts	Risk Level
Releases to air - flaring (local air quality)	Impact to local air quality would result from the flaring of gases potentially generating air quality pollutants such as NOx, SOx and VOCs. For gas flows particulate matter is probably less of an issue. These emissions will vary with the quantity of gas flared, but are judged as generally being relatively low.	4 low
Releases to air - flaring (contribution to international greenhouse gas emissions)	Combustion of fossil fuels will generate carbon dioxide and greenhouse gases. These emissions contribute to climate change and will vary with the quantity of gas flared, but are judged as generally being relatively low risk.	4 low
Discharges to sea (accidental) – flaring drop-out damage to marine ecosystems	OSPAR/HELCOM limits (see 2.4.2.3) on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials towards marine life. The further dilution[62] of these materials within sea water will continue to reduce the risk of impact.	3 low
Discharges to sea (accidental) – flaring drop-out damage to water quality	OSPAR/HELCOM limits (see 2.4.2.3) on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials into sea-water. The further dilution[63] of these materials within sea water will reduce concentrations affecting water quality.	3 low
Discharges to sea (accidental) – flaring drop-out seabed fouling	The gas generated during this phase will also contain a certain amount of condensate (light liquid hydrocarbon fraction). This has the potential to impact the marine environment. However, measures such as 'knock out' drums can be used to reduce the amount of condensate in the gas flow before flaring.	6 moderate
Discharges to sea	The use of the measures identified including the use of low	3 low

(accidental) – well leakage damage to marine ecosystems	hazard/risk chemicals and avoided use of high risk chemicals (e.g. PLONOR chemicals under OSPAR, the zero discharge principle under HELCOM), limits on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials towards marine life. The further dilution of these materials within sea water will continue to reduce the risk of impact.	
Discharges to sea (accidental) – well leakage damage to water quality	The use of the measures identified including the use of low hazard/risk chemicals and avoided use of high risk chemicals (e.g. PLONOR chemicals under OSPAR, the zero discharge principle under HELCOM), limits on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials into sea-water. The further dilution[65] of these materials within sea water will reduce concentrations affecting water quality.	3 low
Discharges to sea (accidental) – well leakage seabed fouling	The process of wellbore clean-up is intended to remove any final cuttings, drilling muds or residues of chemicals used in drilling prior to production. The potential release of solid matter the potential for any discharged material to reach the seabed is greater. The main impact here would be from smothering the surface layers of seabed where benthic species exist. The likely impact would be moderate in the short term, but affected areas would be expected to recover quickly from benthic species repopulating affected area.	6 moderate

2.2.9 Risk and impacts of introduction of completion fluids

Environmental Aspects	Impacts	Risk Level
Discharges to sea (accidental) damage to marine ecosystems	The use of the measures identified including the use of low hazard/risk chemicals and avoided use of high risk chemicals (e.g. PLONOR chemicals under OSPAR, the zero-discharge principle under HELCOM), limits on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials towards marine life. The further dilution of these materials within sea water will continue to reduce the risk of impact.	3 low
Discharges to sea (accidental) damage to water quality	The use of the measures identified including the use of low hazard/risk chemicals and avoided use of high risk chemicals (e.g. PLONOR chemicals under OSPAR, the zero-discharge principle under HELCOM), limits on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials into sea-water. The further dilution of these materials within sea water will reduce concentrations affecting water quality.	3 low
Discharges to sea (accidental) seabed fouling	The main impacts on seabed fouling is where solid material such as residual drilling muds and cuttings smothers the sea bed affecting the benthic species that live in the surface layers of the seabed. These materials can be released as a result of completion fluids dislodging any remaining material in the well. Effects can be significant killing all life in the surface layers. However' on completion of the process the affected area is expected to recover quickly with re-population from surrounding areas. Sensitive biota such as sponge or cold-water coral communities are expected to take additional time to recover from accidental seabed fouling compared to other biota. However, the damage to these species caused by small quantities of accidentally discharged drill cuttings and/or muds will not be as severe as that caused by positioning apparatus on the seabed.	3 low

2.2.10 Risk and impacts of piling for jacket foundations and/or mooring line anchors

Environmental Aspects	Impacts	Risk Level
Visual impact – lighting from rig attracts birds and causes 'birdstrike'	The OSPAR (2012a) review into the effects of oil rig lighting on bird-strike in the North Sea area highlights a key issue in that the majority of birds affected are not sea birds, but migrating garden birds. The reports state that 75% of the birds killed come from the thrush family. This suggested that the potential consequence for the garden bird populations (particularly thrush) could be particularly serious. Moreover the issue of bird-strike within the offshore oil and gas sector is likely to be an area where measures to avoid bird-strike are less fully adopted.	5 moderate
Visual impact – Lost fishing areas increases burden elsewhere	The placement of oil rig equipment at sea and necessary use of exclusion zones to avoid collision with oil rig platforms means that fishing vessels are no longer able to trawl in these specific areas. The loss fishing areas and relocating of fishing vessels potentially increases burden elsewhere. In practice the competing needs of space and resources are managed through permitting and regulatory control such as 'consent to locate'. Overall risk ranking is judged as generally moderate due to likely frequency of issues arising and potential impact which is expected to be relatively minor.	5 moderate

2.2.11 Risks and impacts of pre-commissioning

Environmental Aspects	Impacts	Risk Level
Discharges to sea (accidental) – hydrostatic leak testing damage to marine ecosystems	The use of limits on hydrocarbon content of released materials and separation systems should also reduce the hazard of the released materials towards marine life. The further dilution[83] of these materials within sea water will continue to reduce the risk of impact in the short term.	3 low
Discharges to sea (accidental) – hydrostatic leak testing damage to water quality	The use of the measures identified including use of limits on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials into sea-water. The further dilution[84] of these materials within sea water will reduce concentrations affecting water quality.	3 low
Discharges to sea (accidental) – hydrostatic leak testing seabed fouling	The main impacts on seabed fouling is where solid material such as drilling muds and cuttings smothers the sea bed affecting the benthic species that live in the surface layers of the seabed. These materials can be released as a result of pressure testing dislodging any remaining material in the well. Effects can be significant killing all life in the surface layers. However, on completion of the process the affected area is expected to recover quickly with re-population from surrounding areas.	6 moderate

2.2.12 Risks and impacts of processing of gas production

Environmental Aspects	Impacts	Risk Level
Releases to air – (accidental) – loss of containment	The release of hydrocarbons to air which includes both air quality pollutants and greenhouse gases will have impacts for local air quality as well as contribution to greenhouse gas emissions.	6 moderate
Releases to air – (accidental) – unplanned need to vent or flare gas during production	Venting or combustion of fossil fuels will generate carbon dioxide and greenhouse gases. These emissions contribute to climate change However the management of gases on the installation is generally tightly controlled and managed. The likely frequency of needing to vent or flare within unplanned conditions should be rare. Due to the expected low frequency of this activity the overall risk rating is judged as generally low.	2 low
Releases to air – (planned) – planned venting or flaring as per permit	Venting or combustion of fossil fuels will generate carbon dioxide and greenhouse gases. These emissions contribute to climate change. Management of gas flows on the installation are generally tightly controlled with planned flaring controlled by permit. However, the quantity of gas flared and frequency in needing to flare or vent means the risk rating for this set of impacts is rated as relatively high.	9 high

2.2.13 Risks and impacts of processing produced water

Environmental Aspects	Impacts	Risk Level
Discharges to sea (accidental) Marine biodiversity	Impacts from the accidental discharge of produced water on marine environments assumes that the water produced has not been fully treated and will exceed the safe limits set under OSPAR, HELCOM or the Barcelona Convention (noting that these limits vary). Dependent on the quantity of produced water discharged to sea, the impacts could be more significant. Assuming this is the case the overall risk rating for this risk is judged to be generally moderate.	6 moderate
Discharges to sea (accidental) Coastal biodiversity	The impact detailed from this risk involves the discharged material to sea reaching coastal environments and then causing impact for coastal species both within the marine environment and to avian and terrestrial species in the near-shore. Based on the measures in place the potential to cause impact is considered minor based on the risk matrix, and likely occurrence of coastal impacts would be rare.	4 low
Discharges to sea (accidental) Deterioration in water quality	The main issue with accidental loss of produced water will be that it is still contaminated by hydrocarbons. The use of separation tanks will greatly reduce hydrocarbon concentration but use of technologies such as hydrocyclones are needed to reduce hydrocarbon content below the safe thresholds set by OSPAR, HELCOM or the Barcelona Convention (noting that these limits vary). Direct impacts on water quality as a result of accidentally discharged produced water are expected to be short lived as oil readily degrades in the marine environment.	2 low
Discharges to sea (accidental) Sediment fouling	The main issue with accidental loss of produced water will be that it is still contaminated by hydrocarbons. This material will likely remain on the sea surface and form emulsion, with the risk of then sinking down to the sea bed.	2 low

Discharges to sea (planned) Marine biodiversity	The measures detailed are intended to reduce the hydrocarbon content below the safe limits set out by OSPAR, HELCOM or the Barcelona Convention. However full removal of quantities of hydrocarbons is difficult and costly to achieve. Planned release of produced water will still contain trace quantities of hydrocarbons which have the potential to negatively affect marine populations. Risk rating is still moderate, but ranked score is higher for accidental release than for planned releases.	5 moderate
Discharges to sea (planned) Coastal biodiversity	The impact detailed from this risk involves the material discharged to sea reaching coastal environments and then causing impact for coastal species both within the marine environment but avian and terrestrial species in the near- shore. Based on the measures in place the potential to cause impact is considered minor based on the risk matrix, and likely occurrence of coastal impacts would be rare.	2 low
Discharges to sea (planned) Deterioration in water quality	The use of the measures detailed will reduce the hydrocarbon content of produced water below the threshold set by OSPAR, HELCOM or the Barcelona Convention. Direct impacts on water quality as a result of planned discharged produced water are expected to be limited and short lived due to low concentrations and the fact that oil readily degrades when in low concentrations in the marine environment.	2 low

2.2.14 Risk and impacts of produced sand management

Environmental Aspects	Impacts	Risk Level
Discharges to sea (accidental) Marine biodiversity	Produced sand will be treated to remove hydrocarbon content as far as possible. Return of produced sand to sea will make use of a sub-sea caisson to avoid impact from suspended sand increasing turbidity and blocking sunlight to surface layers. The impact on marine species is likely to be limited.	3 low
Discharges to sea (accidental) Deterioration in water quality	The introduction of produced sand back to sea which increases the quantity of suspended sediment within the water column can impact water quality. However, these effects would be expected to be short lived with sediment quickly settling out of the water column.	3 low
Discharges to sea (accidental) Sediment fouling	The main impact from return of produced sand to sea will be the smothering of the seabed which negatively affects benthic species. The quantity of sand generated and lost during an accidental release is less clear. However, the dispersion of sand across a wider area will limit the impact with seabed species expected to recover quickly	6 moderate
Discharges to sea (planned) Marine biodiversity	Produced sand will be treated to remove hydrocarbon content as far as possible. Return of produced sand to sea will make use of a sub-sea caisson to avoid impact from suspended sand increasing turbidity and blocking sunlight to surface layers. The impact on marine species is likely to be limited.	3 low
Discharges to sea (planned) Deterioration in water quality	The introduction of produced sand back to sea which increases the quantity of suspended sediment within the water column can impact water quality. However, these effects would be expected to be short lived with sediment quickly settling out of the water column.	3 low
Discharges to sea (planned) Sediment fouling	The main impact from return of produced sand to sea will be the smothering of the seabed which negatively affects benthic species. Unlike the accidental release, planned returned of produced sand to sea would be expected to involve greater quantities which would have more significant potential to affect benthic species through sea- bed smothering. These environments are expected to recover quickly and repopulate from surrounding areas once the process completes.	6 moderate

2.2.15 *Risk and impacts of oil storage*

Environmental Aspects	Impacts	Risk Level
Impacts to marine ecosystems (accidental) Tier III	Accidental release of large quantities of oil to sea would be likely to have severe impact on marine species. The severity would be such that it could be foreseen that the impact would take a significant amount of time spanning years for the full recovery of the affected marine ecosystems. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a catastrophic release from a large storage vessel for use in a risk assessment is $5x10^{-6}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a catastrophic rupture occurring in an offshore atmospheric storage tank to be $3x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.7x10^{-7}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low
Impacts to coastal environments (accidental) Tier III	The accidental release of large quantities of oil to sea would have a high potential for those materials to reach the coastline where the impacts would be extremely severe for not only marine species but avian and terrestrial species within the near shore. The potential damaged caused could have long term (years) effect along the affected coastline with recovery of ecosystems expected to be slow. In some cases, such damage may mean that ecosystems do not fully recover to pre-incident conditions. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a catastrophic release from a large storage vessel for use in a risk assessment is $5x10^{-6}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a catastrophic rupture occurring in an offshore atmospheric storage tank to be $3x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.7x10^{-7}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	5 moderate
Impacts to water quality (accidental) Tier III	While hydrocarbons will emulsify and degrade within marine conditions for a tier III event the quantities of oil involved would have severe impact upon the general water quality within the marine environment. The degradation and breakdown of hydrocarbons would be expected to have a strongly negative affect for chemical oxygen demand affecting the ability of seawater to support marine life. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a catastrophic release from a large storage vessel for use in a risk assessment is $5x10^{-6}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a catastrophic rupture occurring in an offshore atmospheric storage tank to be $3x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.7x10^{-7}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low

Seabed fouling (accidental) Tier III	The potential for hydrocarbon spillages to reach the seabed is less clear, but given the quantities involved the potential for seabed fouling should be considered a risk. This would include contamination of marine sediments which have knock-on effects for benthic species that live within them. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a catastrophic release from a large storage vessel for use in a risk assessment is $5x10^{-6}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a catastrophic rupture occurring in an offshore atmospheric storage tank to be $3x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.7x10^{-7}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low
Impacts to marine ecosystems (accidental) Tier II	Accidental release of large quantities of oil to sea would be likely to have an impact on marine species. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a major release from a large storage vessel for use in a risk assessment is $1x10^{-4}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a major spill occurring in an offshore atmospheric storage tank to be between $1.6x10^{-6}$ and $2.8x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.3x10^{-6}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low
Impacts to coastal environments (accidental) Tier II	The accidental release of large quantities of oil to sea would have a high potential for those materials to reach the coastline, the impacts would be for not only marine species but avian and terrestrial species within the near shore. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a major release from a large storage vessel for use in a risk assessment is $1x10^{-4}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a major spill occurring in an offshore atmospheric storage tank to be between $1.6x10^{-6}$ and $2.8x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.3x10^{-6}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low
Impacts to water quality (accidental) Tier II	While hydrocarbons will emulsify and degrade within marine conditions for a tier II event the quantities of oil involved would have an impact upon the general water quality within the marine environment. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a major release from a large storage vessel for use in a risk assessment is $1x10^{-4}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a major spill occurring in an offshore atmospheric storage tank to be between $1.6x10^{-6}$ and $2.8x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.3x10^{-6}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low

Seabed fouling (accidental) Tier II	The potential for hydrocarbon spillages to reach the seabed is less clear, but given the quantities involved the potential for seabed fouling should be considered a risk. This would include contamination of marine sediments which have knock-on effects for benthic species that live within them. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a major release from a large storage vessel for use in a risk assessment is $1x10^{-4}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a major spill occurring in an offshore atmospheric storage tank to be between $1.6x10^{-6}$ and $2.8x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.3x10^{-6}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low

2.2.16 *Risk and impacts of diesel/chemical deliveries*

Environmental Aspects	Impacts	Risk Level
Impacts to marine ecosystems (accidental) Tier I	Accidental releases of diesel or chemicals oil to sea would be likely to have an impact on marine species. The severity would be limited due to the small quantities involved and rapid dilution[85]. In their risk assessment data directory, the OGP (2010a) estimate that the probability of an offshore diesel storage tank rupturing to be $3.0x10^{-5}$ per tank per year. On this basis, the likelihood of spillage involving diesel or chemicals is judged as 'rare'.	6 moderate
Impacts to coastal environments (accidental) Tier I	The accidental release of diesel or chemicals to sea would have some potential for those materials to reach the coastline, where the impacts would be amplified due to the avian and terrestrial species within the near shore. In their risk assessment data directory, the OGP (2010a) estimate that the probability of an offshore diesel storage tank rupturing to be $3.0x10^{-5}$ per tank per year. On this basis, the likelihood of spillage involving diesel or chemicals is judged as 'rare'.	8 moderate
Impacts to water quality (accidental) Tier I	Hydrocarbons will emulsify and degrade within marine conditions, therefore for a tier I even the quantities of diesel/chemicals involved would have a limited impact upon the general water quality within the marine environment. In their risk assessment data directory, the OGP (2010a) estimate that the probability of an offshore diesel storage tank rupturing to be $3.0x10^{-5}$ per tank per year. On this basis, the likelihood of spillage involving diesel or chemicals is judged as 'rare'.	4 low
Seabed fouling (accidental) Tier I	The potential for hydrocarbon spillages to reach the seabed is less clear; given the quantities involved the potential for seabed fouling should be considered a small risk. In their risk assessment data directory, the OGP (2010a) estimate that the probability of an offshore diesel storage tank rupturing to be $3.0x10^{-5}$ per tank per year. On this basis, the likelihood of spillage involving diesel or chemicals is judged as 'rare'.	4 low

2.2.17 *Risk and impacts of open loop cooling systems*

Environmental Aspects	Impacts	Risk Level
Discharges to sea (planned) – Thermal affects -	The effects of returning water to sea which is thermally different to surrounding conditions can have both negative and positive effects on the marine species and biodiversity	4 low

Marine biodiversity	of receiving ecosystem. However, the effects would be expected to be short lived and confined to the area immediately around the release pipe.	
Discharges to sea (accidental) – residual antifoulant - Marine biodiversity	Anti-foulant chemicals are required to maintain the integrity of the cooling system. The quantities and nature of the chemicals used will typically be selected according to chemical use approval requirements under international conventions (e.g. PLONOR list of chemicals under OSPAR, the zero-discharge principle under HELCOM), although requirements vary across the EU. Concentrations within released water would be expected to be of a concentration where effects were limited, with further dilution quickly reducing any potential impact[86].	4 low

2.2.18 Risk and impacts of HVAC cooling systems

Environmental Aspects	Impacts	Risk Level
Releases to air (unplanned) – leaking air conditioning equipment	Fluorinated gases have significantly greater global warming potential than carbon dioxide (per kg). The EU F-gas regulation is intended to put in place measures to limit the impact of these substances through better control and maintenance and the use of gases with lower potentials. The overall contribution of fluorinated gases to air from offshore installations is generally expected to be relatively low and less greenhouse gas intense than other activities . flaring.	4 low

2.2.19 Risk and impacts of top side drainage systems cooling systems

Environmental Aspects	Impacts	Risk Level
Discharges to sea (accidental) – Tier I – Minor incident – damage to marine environment	Tier I accidents represent those with the highest frequency but lowest severity. The accidental discharge of drainage systems in this case may include waters contaminated with hydrocarbons or production chemicals. The quantities involved would be expected to be more limited but have the potential to still cause significant impact on marine species.	8 moderate
Discharges to sea (accidental) – Tier I – Minor incident – damage to coastal environment	For Tier I accidents the quantities of material involved would be expected to be smaller than the major spillages described in earlier processes. The potential for discharged material to reach the coastline is also more limited. However, because the frequency of the incident is rare the overall risk ranking is judged to be generally low.	4 low
Discharges to sea (accidental) – Tier I – Moderate incident – damage to water quality	For Tier I accidents the quantities of material involved would be expected to be smaller than the major spillages described in earlier processes. The effects on water quality would be expected to be short lived with minor impact.	3 low
Discharges to sea (accidental) – Tier I – Minor incident – fouling seabed marine environment	The impact for seabed fouling relates to smothering of surface layers where benthic species live. For tier I accidents where the likely discharged material is drainage waters contaminated with hydrocarbons or chemical wastes, the likelihood for seabed fouling is lower.	2 low

2.2.20 *Risk and impacts of waste management*

Environmental Aspects	Impacts	Risk Level
Discharges to sea (accidental) – Liquid wastes - Marine biodiversity	The accidental discharge of liquid wastes may include waters contaminated with hydrocarbons or production chemicals. The quantities involved would be expected to be limited but have the potential to still cause impact on marine species. However, the effects would be expected to be short lived.	2 low
Discharges to sea (accidental) – Liquid wastes - Deterioration in water quality	The accidental discharge of liquid wastes may include waters contaminated with hydrocarbons or production chemicals. The quantities involved would be expected to be limited but have the potential to still cause impact on water quality. However, the effects would be expected to be short lived.	2 low
Discharges to sea (accidental) – Liquid wastes - Sediment fouling	The quantity discharged and nature (liquid) of the waste lost to sea mean the potential to reach the seabed could be expected to be a minor issue. Quantities reaching the seabed would have only limited impact.	2 low
Discharges to sea (accidental) – solid waste - Marine biodiversity	The accidental discharge of solid wastes would be likely to include drilling muds, oil contaminated cuttings or solid waste. These materials will have impacts on marine species both from the physical effects on water (turbidity) and the chemical effects of the contaminated materials. Depending on the quantities involved the impact for marine species could be significant.	6 moderate
Discharges to sea (accidental) – solid waste - Sediment fouling	The accidental discharge of solid wastes would be likely to include drilling muds, oil contaminated cuttings or solid waste. These materials will have the potential for seabed smothering affecting benthic species as well as toxic effects from the contaminated material itself. The potential impact for this risk is potential significant depending on quantities involved.	6 moderate

2.2.21 *Risk and impacts of off take by shipping vessels*

Environmental Aspects	Impacts	Risk Level
Impacts to marine ecosystems (accidental) Tier III	With expected risk management measures in place, an accidental release of large quantities of oil to sea would still have a serious impact on marine species, but more catastrophic impacts would be adverted. Additionally, the likelihood of this incident would be very low with measures in place. A tier III spill from a shuttle tanker has never occurred and Therefore, the likelihood is judged to be 'extremely rare'.	4 low
Impacts to coastal environments (accidental) Tier III	With measures in place, the chances of an accidental release of large quantities of oil to sea occurring would be greatly reduced and in the event of a spill the quantity of fluid leaked to the ocean would also be reduced by response measures. However, if even small quantities of hydrocarbons were to reach the coastline, the impacts would be significant for not only marine species but also avian and terrestrial species within the near shore. The potential damaged caused could also have prolonged effects along the affected coastline. A tier III spill from a shuttle tanker has never occurred and	5 moderate

	Therefore, the likelihood is judged to be 'extremely rare'.	
Impacts to water quality (accidental) Tier III	Hydrocarbons will emulsify and degrade within marine conditions. With measures in place, the quantities of oil involved would therefore not have a great effect on general water quality within the marine environment. The likelihood of a spill occurring is also very low when measures are in place. A tier III spill from a shuttle tanker has never occurred and therefore the likelihood is judged to be 'extremely rare'.	3 low
Seabed fouling (accidental) Tier III	The potential for hydrocarbon spillages to reach the seabed is less clear, but given the small quantities involved with measures in place, and the low likelihood of a spill, the potential for seabed fouling should be considered a great risk. A tier III spill from a shuttle tanker has never occurred and therefore the likelihood is judged to be 'extremely rare'.	3 low

2.2.22 Risk and impacts of off take of oil by pipeline

Environmental Aspects	Impacts	Risk Level
Impacts to marine ecosystems (accidental) Tier III	Accidental release of large quantities of oil to sea would be likely to have severe impact on marine species. The severity would be such that it could be foreseen that the impact would take a significant amount of time spanning years for the full recovery of the affected marine ecosystems. According to the OGP's (2010a) Risk Assessment Data Directory for riser and pipeline release frequencies, the probability of a subsea pipeline failure in open sea is between $1.4x10^{-5}$ and $5.0x10^{-4}$ per km-year. On this basis, the likelihood of a tier III spill from a pipeline is deemed to be 'rare'.	8 moderate
Impacts to coastal environments (accidental) Tier III	The accidental release of large quantities of oil to sea would have a high potential for those materials to reach the coastline where the impacts would be extremely severe for not only marine species but avian and terrestrial species within the near shore. The potential damaged caused could have long term (years) effect along the affected coastline with recovery of ecosystems expected to be slow. In some cases such damage may mean that ecosystems do not fully recover to pre-incident conditions. According to the OGP's (2010b) Risk Assessment Data Directory for riser and pipeline release frequencies, the probability of a subsea pipeline failure in open sea is between $1.4x10^{-5}$ and $5.0x10^{-4}$ per km-year. On this basis, the likelihood of a tier III spill from a pipeline is deemed to be 'rare'.	10 high
Impacts to water quality (accidental) Tier III	While hydrocarbons will emulsify and degrade within marine conditions for a tier III event the quantities of oil involved would have severe impact upon the general water quality within the marine environment. The degradation and breakdown of hydrocarbons would be expected to have a strongly negative affect for chemical oxygen demand affecting the ability of seawater to support marine life. According to the OGP's (2010b) Risk Assessment Data Directory for riser and pipeline release frequencies, the probability of a subsea pipeline failure in open sea is	6 moderate

	between 1.4x10^{-5} and 5.0x10^{-4} per km-year. On this basis, the likelihood of a tier III spill from a pipeline is deemed to be 'rare'.	
Seabed fouling (accidental) Tier III	The potential for hydrocarbon spillages to reach the seabed is less clear, but given the quantities involved the potential for seabed fouling should be considered a risk. This would include contamination of marine sediments which have knock-on effects for benthic species that live within them. According to the OGP's (2010b) Risk Assessment Data Directory for riser and pipeline release frequencies, the probability of a subsea pipeline failure in open sea is between 1.4x10^{-5} and 5.0x10^{-4} per km-year. On this basis, the likelihood of a tier III spill from a pipeline is deemed to be 'rare'.	6 moderate

2.2.23 Risk and impacts of off take of gas by pipeline

Environmental Aspects	Impacts	Risk Level
Releases to air (accidental) – containment failure in pipeline (contribution to global emissions for greenhouse gas)	Rupture of pipelines or loss of containment will cause hydrocarbon gases to vent to the surface of the sea and then to the atmosphere. These gases will contain substances will contribute to climate change. Depending on where the rupture occurs the quantities of gas released could be significant but the likely frequency of such an event is rare.	4 low

2.2.24 Risk levels of water flooding using seawater

Environmental Aspects	Impacts	Risk Level
Releases to air (local air quality) – injection equipment	Emissions of SO_2, NOx and dust from the equipment and vehicles used to clean, pressurise and inject water	4 low
Releases to air (contribution to global warming) – injection equipment	Emissions of CO_2 from the equipment used to pressurise and clean injection water.	3 low
Underwater noise in the marine environment resulting from induced seismicity (disturbance to animals)	As with onshore water flooding, there is a small risk of induced seismicity (Rubinstein & Mahani, 2015). This is due to the pressures applied in order to inject the water. This may result in low levels of underwater noise.	2 low

2.2.25 Risk levels for enhanced recovery (miscible gas injection)

Environmental Aspects	Impacts	Risk Level
Releases to air (local air quality) - injection equipment	Emissions of SO_2, NOx and dust from the equipment and vehicles used to clean, pressurise and inject gas	4 low
Releases to air (contribution to	Emissions of CO_2 from the equipment used to pressurise clean and inject gas.	3 low

global warming) - injection equipment		
Underwater noise	Underwater noise in the marine environment resulting from induced seismicity affecting marine fauna.	4 low

2.2.26 Risk and impacts of well plugging

Environmental Aspects	Impacts	Risk Level
Discharges to sea (accidental) damage to marine ecosystems	The use of the measures identified including limits on hydrocarbon content of released materials which should also reduce the hazard of the released materials towards marine life. The further dilution[92] of these materials within sea water will continue to reduce the risk of impact.	1 low
Underwater noise in the marine environment (disturbance to animals)	The distinction between physical injury and disturbance that potentially causes behavioural change is important. Seismic surveys within stage 1 have been identified as having the greatest potential to cause physical injury to marine life from noise across the whole off-shore installation life cycle. However, activities using heavy equipment (such as cutting tools) have the potential create sufficient noise levels as to have effects on marine species. The risk ranking of generally low is awarded on the basis that relevant measures identified in stage 1 and 2 are deployed.	4 low
Seabed disturbance	Any redistribution of the cuttings pile may cause seabed disturbance. However, measures are typically in place to help limit the occurrence of the impact and to protect sensitive areas of seabed from damage. Furthermore, on completion of this process, the majority of seabed communities are expected to recover quickly. Sensitive biota such as sponge or cold-water coral communities are expected to take additional time to recover from these disturbances compared to other biota. However, with measures in place damage to these species is expected to be minimised.	3 low

2.2.27 : Risk and impacts of management of cuttings pile – leave in situ

Environmental Aspects	Impacts	Risk Level
Discharges to sea	The cuttings pile released to sea during well drilling would have been required to not exceed maximum concentrations of hydrocarbons (at least since introduction of limits in the OSPAR and HELCOM regions). However this does not mean it is hydrocarbon free. Any remaining residual concentrations have the potential to be released over time into the seawater with potential impacts for marine species and water quality.	6 moderate

2.2.28 Risk and impacts of management of cuttings pile – excavate to surface/redistribute across seabed

Environmental Aspects	Impacts	Risk Level
Releases to air – main power generation units (local air quality impacts)	The use of diesel driven engines to power heavy equipment used for movement of cuttings pile will generate exhaust emissions that potentially affect local air quality. The management of use equipment to ensure that it meets BAT will help limit the impact of such emissions.	2 low
Releases to air –	The use of diesel driven engines to power heavy equipment	4 low

main power generation units (emissions of greenhouse gas)	used for movement of cuttings pile will generate exhaust emissions that include greenhouse gases and contribute to the overall international emissions of greenhouse gases which contribute to global warming. The management of use equipment to ensure that it meets BAT will help limit the impact of such emissions	
Seabed disturbance - Physical disturbance to the seabed (redistribution only)	Fouling of sediments and potential smothering of benthic communities and habitat as a result of redistribution the cuttings pile across a large area of seabed.	6 moderate

2.2.29 *Risk and impacts of topside preparation for removal using hot cutting, welding etc.*

Environmental Aspects	Impacts	Risk Level
Discharges to sea	The use of the measures identified including the use of low hazard/risk chemicals and avoided use of high risk chemicals (e.g. PLONOR chemicals under OSPAR, the zero-discharge principle under HELCOM), limits on hydrocarbon content of released materials and oil and water separation systems should also reduce the hazard of the released materials towards marine life. The further dilution[97] of these materials within sea water will continue to reduce the risk of impact.	2 Low
Seabed disturbance	This environmental aspect relates to the physical disturbance to the seabed and cuttings pile, if present from dropped objects (e.g. Module loss during lifting and transportation, loss of metal debris) during the dismantlement of topside structures. These kinds of incidents can be avoided in part through training and management plans which are supported in part by accident logs from other decommissioning projects	3 low
Underwater noise	Underwater noise: cutting of jacket/topside to facilitate removal may generate some noise which can carry into the marine environment with potential impacts on marine species, especially cetaceans. However, the levels of activity detailed are likely to be equivalent to or lower than noise generated during well design and production life cycle stages.	2 low

2.2.30 *Risk and impacts of long-term well integrity failure*

Environmental Aspects	Impacts	Risk Level
Discharges to sea – leaked hydrocarbons	Over time, liquid hydrocarbons may penetrate the cement casing and leak from the well bore, resulting in contamination of sea water.	4 Low
Releases to air (contributions to climate change)	Well integrity failure can result in hydrocarbon gases (incl. methane) being released to the atmosphere and contributing to climate change. King & King (2013) found that when a total well-integrity failure occurs, gas is the most common fluid lost.	4 low

2.3 *Sources of environmental pollutions/emissions from offshore oil and gas operations*

- **Exploration**

Fish species are sensitive to sound and, at close range, larval fish might even be killed by seismic sources. Seismic surveys might therefore disturb spawning fish away.

- **Drilling**

During drilling, a drilling mud is continuously circulated between the well and the platform through a 'riser pipe'. Mud is used to maintain well pressure and wall stability, to cool and lubricate the drill bit and to carry the rock chips (cuttings) generated during the drilling process away from the cutting head to the platform. Drilled cuttings removed from the wellbore and spent drilling fluids are typically the largest waste streams, by volume and weight, generated during oil and gas drilling activities.

Though various drilling fluids are available, they can generally be categorized into the following:

- Water-based drilling fluids (WBDF): Fluids for which the continuous phase and suspending medium for solids is seawater or a water-miscible fluid. There are many WBDF variations, including gel, salt-polymer, salt-glycol, and salt-silicate fluids.
- Non-Aqueous Drilling Fluids (NADF): The continuous phase and suspending medium for solids is a water-immiscible fluid that is oil based, enhanced mineral oil based, or synthetic based.

In the solids removal system, the drilling fluids are separated from the cuttings so that they may be recirculated downhole, leaving the cuttings behind for collection or disposal. The volume of cuttings produced will depend on the depth of the well and the diameter of the hole sections drilled. The cuttings contain residual drilling fluid.

In the past, the bulk of cleaned cuttings were discharged to the seabed along with their residual oily mud contamination. Extensive monitoring studies showed that this caused changes to the seabed via a combination of smothering, organic enrichment and toxicity effects. These were seen to be most severe close to discharging platforms where the 'pile proper' formed, but they commonly extended up to distance of 1 or 2 km. Disposal of spent NADF by discharge to the sea must be avoided. Instead, NADF should be transferred to shore for recycling or treatment and disposal.

Feasible alternatives for the disposal of spent WBDF and drilled cuttings from well sections drilled with either WBDF or NADF should be evaluated. Options include injection into a dedicated disposal well offshore, injection into the annular space of a well, and containment and transfer to shore for treatment and disposal. When no alternative options are available, residual WBDF might be discharged to sea at the end of a drilling program, provided that the overall EIA conducted for the site has considered this scenario, demonstrating the environmental acceptability of this practice.

Completion and well work-over fluids (including intervention fluids and service fluids) can include solid material, residual drilling fluids, weighted brines or acids, hydrocarbons, methanol and glycols, and other types of performance-enhancing additives. These fluids are used to clean the wellbore and stimulate the flow of hydrocarbons or may be used to maintain downhole pressure. Once used, these fluids may contain contaminants including solid material, oil, and chemical additives.

- **Production**

During production, large amounts of produced water (PW)are recovered with the hydrocarbons. This is cleaned to very stringent standards and some is re-injected to maintain reservoir pressure.

Produced water contains a complex mixture of inorganic (dissolved salts, trace concentrations of certain metals, suspended particles), organic (suspended and dissolved hydrocarbons, traces of fatty acids and other organic compounds), and in some cases residual trace concentrations of chemical additives (for example, scale and corrosion inhibitors, hydrate inhibitors), which are sometimes used to enhance the hydrocarbon production process.

Depending on the field reservoir characteristics, Naturally Occurring Radioactive Materials (NORM) may be present in the produced fluids. NORM may precipitate as scale or sludge in process piping and production vessels in which the concentration of NORM can be higher than in the fluid.

- **Atmospheric emissions**

The main sources of air emissions (continuous or intermittent) from offshore activities include:

- combustion sources (boilers, turbines) for power and heat generation;
- the use of compressors, pumps, and reciprocating
- and other engines on offshore facilities, including support and supply vessels and helicopters;
- emissions resulting from flaring and venting of hydrocarbons;
- intermittent emissions (e.g., well-testing emissions, safety flaring, engine exhaust, etc.) and
- fugitive emissions.

The two major sources accounting for over seventy percent of total non-methane hydrocarbon emissions are:

- oil storage; and
- storage tanks on board the platforms and vents which discharge intermittently during gas processing.

Power generation during production operations is the largest source of essentially continuous emissions of oxides of nitrogen, sulfur oxides, carbon monoxide and particulates, but accounts for only about ten percent of total non-methane hydrocarbon emissions.

- **Decommissioning**

The principal source of environmental pollution in the context of decommissioning is related to the management of waste. The most obvious manifestation of waste will probably be the structure itself, including the topside, deck, jacket, and footings. There may also be pipelines and other associated subsea installations. On the platform, there may be redundant chemicals and other wastes. Some plant and equipment may be radioactively contaminated, and there may be debris on the sea bed along with piles of drill cuttings. Radioactive scales and sludges can form in production systems during offshore operations.

2.4 Parameters for environmental monitoring

Effluent levels from offshore oil and gas development[41]:

Parameter	Guideline
Drilling Fluids and Cuttings – NADF	1) NADF: Reinject or ship-to-shore, no discharge to sea 2) Drilled cuttings: Reinject or ship-to-shore, no discharge to sea except: • Facilities located beyond 3 miles (4.8 km) from shore; • For new facilities:[a] Organic Phase Drilling Fluid[b] concentration lower than 1% by weight on dry cuttings;

[41] IFC, Environmental Health and Safety Guidelines for Offshore Oil and Gas Development (2015)

	• For existing facilities[c]: Use of non-aqueous base fluids and treatment in cutting dryers. Maximum residual Non-Aqueous Phase Drilling Fluid[d] (NAF) 6.9% (C16 - C18 internal olefins) or 9.4% (C12-C14 ester or C8 esters) on wet cuttings; • Mercury (Hg): max 1 mg/kg dry weight in stock barite • Cadmium (Cd): max 3 mg/kg dry weight in stock barite • Discharge via a caisson (at least 15 m below surface is recommended whenever applicable; in any case, a good dispersion of the solids on the seabed should be demonstrated)
Drilling Fluids and Cuttings – WBDF	1) WBDF: Reinject or ship-to-shore, no discharge to sea except: • In compliance with 96 hr. LC-50 of Suspended Particulate Phase (SPP)-3% vol. toxicity test first for drilling fluids or alternatively testing based on standard toxicity assessment species[e] (preferably site-specific species) 2) WBDF cuttings: Reinject or ship-to-shore, no discharge to sea except: • Facilities located beyond 3 miles (4.8 km) from shore; • Hg: 1 mg/kg dry weight in stock barite • Cd: 3 mg/kg dry weight in stock barite • Maximum chloride concentration must be less than four times the ambient concentration of fresh or brackish receiving water • Discharge via a caisson (at least 15 m below sea surface is recommended whenever applicable; in any case, a good dispersion of the solids on the seabed should be demonstrated)
Produced Water	Reinject. Discharge to sea is allowed if oil and grease content does not exceed 42 mg/l daily maximum; 29 mg/L monthly average
Flow-Back Water	Reinject or reuse. Discharge to sea is allowed if oil and grease content does not exceed 42 mg/L daily maximum; 29 mg/L monthly average. An environmental risk assessment to determine the maximum site-specific allowable concentrations should be conducted for all other chemicals
Completion and Well Work-Over Fluids	Ship-to-shore or reinject. No discharge to sea except: • Oil and grease content does not exceed 42 mg/L daily maximum; 29 mg/L monthly average • Neutralize to attain a pH of 5 or more • In compliance with 96 hr. LC-50 of SPP-3% vol. toxicity test first for drilling fluids[f] or alternatively testing based on standard toxicity assessment species (preferably site-specific species)
Produced Sand	Ship-to-shore or reinject: No discharge to sea except when oil concentration lower than 1% by weight on dry sand
Hydrotest Water	• Send to shore for treatment and disposal. • Discharge offshore following environmental risk analysis, careful selection of chemicals • Reduce use of chemicals.

Cooling Water	The effluent should result in a temperature increase of no more than 3°C at edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 m from point of discharge.
Desalination Brine	Mix with other discharge waste streams, if feasible.
Sewage	Compliance with MARPOL 73/78[h]
Food Waste	Compliance with MARPOL 73/78[h]
Storage Displacement Water	Compliance with MARPOL 73/78[h]
Bilgewater	Compliance with MARPOL 73/78[h]
Deck Drainage (nonhazardous and hazardous drains)	Compliance with MARPOL 73/78[h]

a New facilities include offshore drilling rigs which have been newly designed or structurally modified for the project.

b As defined by OSPAR (2000) Decision 2000/3.

c Applicable to existing offshore drilling rigs deployed for development well drilling programs. Applicable to exploratory well drilling programs. Technically and financially feasible techniques, including installation of thermo-mechanical cutting cleaning systems, to meet the guidelines for new facilities should be considered for implementation, in relation to the number of wells (including producers and injectors) included in development drilling programs, and/or to potential impacts on critical habitats.

d As defined in US EPA (2013a).

e 96-hr LC-50: Concentration in parts per million or percent of the SPP from sample that is lethal to 50 percent of the test organism exposed to that concentration for a continuous period of 96 hours. See also: http://www.epa.gov/nrmrl/std/qsar/TEST-user-guide-v41.pdf.

f Consistent with US EPA (2013a); OSPAR (2011); IOGP (2005).

g In accordance with OSPAR (2010a) “Recommendation 2010/4 on a Harmonized Pre-screening Scheme for Offshore Chemicals” or other applicable process

h In nearshore waters, carefully select discharge location based on environmental sensitivities and assimilative capacity of receiving waters.

2.5 Specifics procedures relevant to offshore upstream oil and gas operations

2.5.1 Methodologies used for offshore environmental monitoring

The following appendix contains references to analytical methods and standards applicable for use in analyses of samples taken for offshore monitoring. Other methods and standards may also be available and suitable for laboratory analysis of samples taken as part of an offshore monitoring program.

The methods described in the tables below range from classical monitoring techniques, such as water column and sediment analyses, to more advanced analyses of biological tissues such as fish muscle, blood and liver bile. While water column and sediment analyses are generally part of an offshore monitoring program, the chemical analysis of tissues and analysis of biomarkers are relatively new techniques that have been applied almost exclusively in Norway.

Analytical methods and standards for water analyses

Parameters	Methods	Standards
Suspended solids	Filtering then weighing Centrifugation	ISO 11923 T 90-105-2 EPA 160
Nitrates, nitrites, orthophosphates	Ionic Chromatography	EN ISO 10304-2 EPA 300 EPA 353 EPA 365
Chlorophyll pigments and phaeopigments	Extraction then spectrophotometry or fluorescence	NF T 90-117 EPA 445
Dissolved Oxygen- pH-Temperature- Salinity-Electrical Conductivity- Turbidity- Visibility	Simple procedures and equipment by using probes	SM 4500
Metals	Metals analysis with nitric acid	OSPAR/ICES 2002 EPA 6010 EPA 6020
Hg	Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry	EPA 1631
Ba, Cd, Cr, Cu, Pb, Ni, Co, Sn, Zn	Inductively Coupled Plasma Atomic Emission Spectrometer (ICP-AES	EN ISO 11885 EPA 6010
Hydrocarbons	Three possible approaches 1. Direct sampling – difficult because HC concentrations are very low. Integrating samplers: 2. passive (SPMD) 3. living (caged bivalves	
Total Hydrocarbon Content (THC) THC can be measured to understand the hydrocarbons in the water column. These can also be used to further understand the composition of aliphatics, aromatics and PAHs in the water sample.	Gas-chromatography (GC)/FID Internal reference standard for quantification	X 31-410 EPA 8015 EPA 8021 ISO 11046
Aliphatic Hydrocarbons (if THC > 0.01 mg/L)	Gas-chromatography (GC)/FID Internal reference standard for quantification	X 31-410 method B EPA 8015 EPA 8021 ISO 11046
Polycyclic Aromatic Hydrocarbons (PAH16*)	Gas-chromatography (GC)/MS High Performance Liquid Chromatography (HPLC) Internal reference standard for quantification.	X 31-410 EPA 8270 ISO 11046 EPA 8310 EPA 610
Mono Aromatic Hydrocarbons (BTEX)	Gas chromatography (GC)	NF ISO 11423-1 EPA 8015 EPA 8021

Source: *OGP, Offshore environmental monitoring for the oil & gas industry (2012)*

Analytical methods and standards for sediment analyses

Physical-chemical analysis		
Parameter/activity	**Procedure principle**	**Standard**
Planning of field work for sediment monitoring	General planning of activity and adjoined QA-QC routines	Norsk Standard NS 9420 EPA 823/R-92-006
Sediment sampling	Sampling by use of grab or box corer. Preferred grab type is long-armed van Veen	Norsk Standard NS-EN ISO 5667-19:2004 EPA 823/B-01-002
Sample handling, subsampling, storage	Provides guidelines for sampling equipment and sample treatment in the field, sorting and species identification, storage of collected and processed material. Guidelines generally focus on macro-fauna retained on a 0.5mm sieve, though deepwater assessments may also include organisms collected on a 0.3mm sieve	Norsk Standard NS-EN ISO 5667-19:2004 (chemical parameters) NS-EN ISO 16665:2005 (fauna) EPA 823/R-92-006
Total organic matter, TOM (also called total organic carbon, TOC)	Analysis as loss on ignition. Maximum ignition temperature 480°C to prevent loss of inorganic carbonate	NS 4764 EPA 415
Sediment grain size distribution	Sifting through different meshes of sieves	Buchanan (1984)
Total hydrocarbons, THC	KOH/methanol saponification, followed by pentane extraction and determination by GC/FID of the C12-C35 molecular interval. Reference oil: HDF 200	IOC 1982 EPA 8015 EPA 8021
Aromatic HC: NPD	Internal standards. Saponification and extraction as above. Determination by GC/MS	NS 9810 NS 9815 EPA 8270
Aromatic HC: PAH_{16}	Internal standards. Saponification and extraction as above. Determination by GC/MS	NS 9810 NS 9815. EPA 8270
Barium, Cadmium, Chromium, Copper, Lead, Zinc	Freeze dried <0.5mg sample fraction eluted with nitric acid. Determination by ICP-AES	NS-EN ISO 11885 EPA 6010
Mercury	Freeze dried <0.5mg sample fraction treated to the cold vapor technique: Reduction with $SnCl_2$ followed by spectrophotometric quantification	NS-EN 1483:2007 EPA 7471
Biological analysis of sediments: Benthic macro-fauna	Sample washed with water in a 1mm sieve to remove formalin, all macro-fauna individuals[1] sorted out under a dissecting microscope and preserved in ethanol	NS-EN ISO 16665:2005 EPA 823/R-92-006

	prior to species identification and enumeration. N.B. There is a miniaturizing effect on macro-fauna in deep water thus 0.5mm and 0.3mm sieves may be required	
Limit of significant contamination	Statistical difference in concentrations relative to reference stations	None applicable. Procedure described in Annex 1
Statistical analysis of biological data: Univariate characteristics of macrobenthos per station	Calculation of number of taxa[2], total number of individuals, Shannon-Wiener diversity index, Pielou evenness, expected number of species per 100 individuals, 10 numerically dominant taxa.	Shannon & Weaver 1963, Pielou 1966, Hurlbert 1971, Sanders 1968
Statistical analysis of biological data: Station similarity in macrofauna structure	Cluster analysis and nonparametric MDS ordination analysis based on Bray-Curtis similarity index	Gray et al. 1988

1: Taxonomic groups omitted: nematoda, colony forming hydrozoa, bryozoa, porifera, harpacticoida, zooplankton, hyperbenthos, fish.

2: Species or higher-level groups.

Source: *OGP, Offshore environmental monitoring for the oil & gas industry (2012)*

Sampling methods and preparation for analysis

Physical-chemical analysis		
Parameter/activity	**Procedure principle**	**Standard**
Planning of offshore field work	General planning of activity and adjoined QA-QC routines	Norsk Standard NS 9420
Fish Sampling and sample handling	Sampling of selected open sea fish species by standard commercial fishing methods (trawling)	OSPAR 1999 Norsk Standard NS 9420
Field studies using caged fish	Field deployment of mussel and cod fish cages in the Norwegian OCS. N.B. Cod are used in the North Sea but, for other regions, this method may also be applicable to other fish species	Hylland et al. 2006
Sampling of fish (cod)	Determination of length, weight, sex and condition. Extraction of subsamples of liver, bile, and blood for analysis	OSPAR 1997 OSPAR 2003
Sampling of mussels	Determination of length. Extraction of subsamples of haemolymph, haemocytes, gills, hepatopancreas, digestive gland, and soft tissues for analysis	OSPAR 1997 OSPAR 2003

Source: OGP, Offshore environmental monitoring for the oil & gas industry (2012)

Methods for the performance of biomarker and PAH analyses in marine organisms

Physical-chemical analysis		
Parameter/activity	**Procedure principle**	**Standard**
Cytochrome P4501A (CYP1A) in cod liver	Elevation relative to controls maybe indicative of PAH exposure	Goksøyr 199

Vitellogenin in cod blood	Elevation relative to controls maybe indicative of exposure to endocrine disruptors	Hylland et al. 1998 Biosense Laboratories AS, Kit V0100640
Zona radiata protein (ZRP) in cod blood	Biomarker for exposure to xenoesterogens (hormone disruptors). Exposure increases the levels of ZRP which are important in the formation of eggshell. This prevents polyspermy and provides mechanical protection for the developing embryo.	Arukwe at al. 1997
DNA adducts in cod liver	Elevation relative to controls maybe indicative of PAH exposure.	Ericson and Balk 2000
B(a)P hydroxylase activity in bivalve hepatopancreas	Elevation relative to controls maybe indicative of PAH exposure	Michel et al. 1994
Immunocompetence in mussel haemolymph	This is generally suppressed by exposure to various contaminants, so this is a biomarker expressing general stress	Pipe and Coles 1995
Lysosomal membrane stability in mussel haemolymph	Indicator of organism stress	Lowe and Pipe 199
Micronucleus formation in mussel haemolymph	This is among the most widely used tool in eco-genotoxicology. It reveals a time-integrated response to complex mixtures of pollutants by an increase in number of micronuclei	Burgeot et al. 2006
Aromatic HC: PAH16/NPD 4 in fish liver and muscle	Internal standards added. KOH/methanol saponification of wet sample followed by cyclohexane extraction, extract reduction and determination by GC/MS	NS 9810 NS 9815 EPA 8270
PAH-metabolites and Alkylphenol metabolites (B only) in fish liver bile	A: Methanol:Water diluted bile is directly analyzed by fixed fluorescence. B: Internal standards. Extraction with ethyl acetate, conversion to ethers and determination by GC/MS.	A: Aas et al. 2000 OSPAR 2003 B: Krahn et al. 1992, Johnsson et al. 2003 EPA 8270
PAHs in mussels	Internal standards. Extraction of wet sample with n-pentane, cleaning, re-extraction with cyclohexane and determination by GC/MS	NS 9810 NS 9815 EPA 8270

Source: OGP, Offshore environmental monitoring for the oil & gas industry (2012)

Standards referenced above

- Norsk Standard NS-EN 1483. Vannundersøkelse. Bestemmelse av kvikksølv. Norges Standardiseringsforbund. (Water investigations. Determination of mercury).
- Norsk Standard NS 4764. Vannundersøkelse. Tørrstoff og gløderest i vann, slam og sedimenter. Norges Standardiseringsforbund. (Water investigations. Dry weight and loss on ignition of water, sludge and sediments).
- Norsk Standard NS 9420. Retningslinjer for feltarbeid i forbindelse med miljøovervåking og –kartlegging. Norges Standardiseringsforbund. (Guidelines for field work in environmental monitoring and mapping).
- Norsk Standard NS-EN ISO 5667-19:2004. Water quality – sampling – Part 19: Guidance on sampling in marine sediments.
- Norsk Standard NS 9810. Opparbeiding av prøvemateriale for bestemmelse av PAH. Norges Standardiseringsforbund. (Preparation of samples for determination of PAH).

- Norsk Standard NS 9815. Gasskromatografisk analyse for bestemmelse av PAH. Norges Standardiseringsforbund. (Gas chromatography analysis for determination of PAH).
- Norsk Standard NS-EN ISO 11885. Water quality. Determination of 33 elements by inductively coupled plasma atomic emission spectroscopy. International Organization for Standardization 11885:19 98.
- Norsk Standard NS-EN ISO 16665. Water Quality – Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna. International Organization for Standardization 16665:2005.
- SM 4500. Standard Methods for the Examination of Water and Wastewater, Method 4500.
- US Environmental Protection Agency Method 160. Residue, Non-Filterable & Total Suspended Solids.
- US Environmental Protection Agency Method 300. Determination of Inorganic Anions by Ion Chromatography.
- US Environmental Protection Agency Method 353. Nitrate-Nitrite (as N) - Colorimetric/Cadmium.
- US Environmental Protection Agency Method 365. Phosphorus, All Forms Colorimetric/Automated.
- US Environmental Protection Agency Method 415. Organic Carbon, Total - Combustion or Oxidation.
- US Environmental Protection Agency Method 445. In Vitro Chlorophyll & Pheophytin by fluorescence.
- US Environmental Protection Agency Method 610. Polynuclear Aromatic Hydrocarbons.
- US Environmental Protection Agency Method 1631, Revision E: Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry.
- US Environmental Protection Agency Method 6010. Inorganics by ICP – AES.
- US Environmental Protection Agency Method 6020. Metals by ICP/MS.
- US Environmental Protection Agency Method 7471. Mercury in Solid or Semisolid Waste.
- US Environmental Protection Agency Method 8015. Nonhalogenated Organics Using GC/FID.
- US Environmental Protection Agency Method 8021. Halogenated Volatiles by GC+ Cap Column.
- US Environmental Protection Agency Method 8270. Semi volatile Organic Compounds by GC/MS.
- US Environmental Protection Agency Method 8310. Polynuclear Aromatic Hydrocarbons (PAH) – HPLC.
- US Environmental Protection Agency Report #823/B-01-002. Field sample sediments & interstitial water.
- US Environmental Protection Agency Report #823/R-92-006. Sediment Classification Methods Compendium.

Source: *OGP, Offshore environmental monitoring for the oil & gas industry (2012)*

2.5.2 Procedure for preparation of a site sampling plan offshore for marine sediment and water column

One of the first steps in conducting an offshore environmental sampling study is to develop a site sampling plan. The plan identifies location and number of stations, sampling methodologies and analytes to be measured. Please refer to Volume 2, S.1 – Sample collection and processing of this manual.

The location and number of stations should also be related to the project objective, the activity and size of the development. When available, bathymetry and metocean data should be used to define sampling locations. Dispersion modelling may also be useful in selecting sampling sites by predicting the deposition of constituents. Attention should be given to understanding previous and current activities in and around the study area, and how these activities may influence the results that are obtained.

A typical sampling program should include at least one reference station, measurement stations that reflect presumed gradients and stations that reflect potential near-field and far-field impacts. This type of program should allow comparison between affected and unaffected sites, and to discern between project-related impacts and natural variation. When possible, the sampling design should be adequately robust to allow for statistical analysis of the data.

For more specific information to consider prior to initiating field work and to aid in planning a successful sampling effort and/or data gathering activity, see *Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound* (1997), prepared for the US EPA, available at the EPA's National Library.

2.5.3 Procedure for sampling and measuring of bulk water column parameters and benthic habitats

When conducting oil and gas operations, there is a risk of impacting the marine environment. Therefore, environmental authorities in general set up guidelines to monitor the environmental conditions around oil and gas production platforms.

Typically, the water column and benthic habitats are the two main ecosystem compartments that are addressed in offshore environmental monitoring studies. Operators in a region where monitoring is planned are responsible for drawing up draft programmes for monitoring of the water column and of the benthic habitats in the region. The operators are required to build their environmental monitoring programmes on the requirements of the regulations and on the instructions to content given in sector specific guidelines which are developed or approved by the Competent Regulatory Authority.

Using results from a long-term survey programme, it is normally assessed:

- the environmental state around the platforms compared with a reference station spatial and
- temporal changes in the environmental state of the seabed around the platform

As part of the monitoring surveys, several samples of sediment at different monitoring stations can be collected in order to carry out:

- physical and chemical analyses the identification and
- quantification of benthic fauna

Physical and chemical analyses on the samples can include:

- grain size analysis and determination of the median grain size and the silt/clay fraction of the sediment
- dry matter, loss on ignition and total organic carbon
- metals – Barium (Ba), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Zinc (Zn), Mercury (Hg) and Aluminium (Al) total hydrocarbons and polycyclic aromatic hydrocarbons/ alkylated aromatic hydrocarbons (PAH/NPD)

Analyses of the collected benthic fauna can include:

- species identification
- biodiversity and abundance analyses
- biomass of all major taxonomic groups (as total wet weight and total dry weight)
- precisely determining the biomass of the brittle star Amphiura filiformis, which is known to be sensitive to drilling activities

Water Column

As a general rule, field surveys in a water column monitoring programme are required at three-year intervals. Typically, they are executed by a specialised consultant.

Which areas are to be monitored is to be described in the monitoring programme together with the planned station network and sampling design. The study site(s) shall be chosen based on knowledge regarding the discharges and their dispersal and on the expected risk as a result of these discharges.

Monitoring of the water column must look at relevant components in the discharges, including added chemicals. The monitoring survey must include at least one suitable reference area; both in cases when wild caught organisms are used and in cases when rigs for caged organisms or monitoring instruments (e.g. passive samplers) are used. In cases when rigs for caged organisms or monitoring instruments (e.g. passive samplers) are used, the positioning of the in a particular area must be decided upon based on knowledge of the physical characteristics of the area and on dispersal models for relevant discharge components, including added chemicals. The basis for the selection of rig positions must be explained in the survey report.

Measurements of bulk water column variables such as temperature, turbidity, conductivity/ salinity and dissolved oxygen may be carried out on discreet samples but can also be measured using multiparameter probes.

Sensor technology has advanced so many parameters can now be continuously measured by specialized instruments deployed at the seafloor. Measurement of concentrations of substances of presumed concern, for example trace metals, frequently pose significant analytical challenges due to their occurrence at trace levels. However, sensitive analytical methods have been established that allow for accurate detection of these substances both in sediments and the water column. In some environmental research projects, semi permeable membrane devices (SPMDs) or baskets containing live bivalves have been deployed around offshore facilities to assess the presence of polyaromatic hydrocarbons in the receiving water. SPMDs and bivalves accumulate (concentrate) the lipophilic hydrocarbons, which allow for chemical analysis below conventional analytical detection limits.

The suite of analytes to be measured is determined by the objectives of the monitoring program. Examples of monitoring parameters are included in section 2.5.9 below.

For more specific information on water column sample collection, processing, and storage see OSPAR Commission's:

- Joint Assessment & Monitoring Program (JAMP) Guidelines for Monitoring Contaminants in Biota (JAMP 1999-02); http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2008/Special%20Requests/OSPAR%20JAMP%20Guidelines%20for%20monitoring%20contaminants%20in%20biota%20and%20sediments.pdf and,
- JAMP Guidelines for Contaminant-Specific Biological Effects (JAMP 2008–09).

The choice of marine species (fin-fish and mussel shellfish) that are suitable for water column monitoring is a key decision and the species selection process should be described in the monitoring program. The selected fish species (one or several species) should fulfil a set of selection criteria, such as:

- It is common along the whole Kenyan coast
- It is commonly caught as seafood by local fishermen
- It has a non-migratory behaviour
- It is typically size is suitable (e.g. 100-400 g for fin-fish, ca. 7-10 cm shell-length for mussels)
- It is quite easy to collect (e.g. for fin-fish by use of baited traps)
- It is reasonably easy to catch in suitable numbers
- It is robust in the sense that it rather easily can be kept alive after catch (e.g. in suitable seawater holding tanks)
- It can tolerate transplant caging (e.g. stay alive in cages)
- It is easy to keep alive in culture and in the lab

- **Parameters determined in biological materials**

The monitoring programme should address a selected set of chemical and biological effect parameters in mussels and fish. The selection of which parameters to include in the monitoring is a key decision and should be based on a judgement of the kind of contamination issue which is targeted by the monitoring programme as well as on practical criteria such as the availability of the necessary analysis infrastructure and analysis competence for the given methods. In cases when analysis infrastructure and analysis competence is limited, it is strongly recommended that the monitoring-responsible consultant initiate collaboration with international expert laboratories on the performance of analyses and data-interpretation. Collaboration may also include method training activities to enable the development of method competence in Sudan for future monitoring activities. The basis/rationale for parameter selection must be described in the monitoring plan. Initial sets of chemical and biological effect parameters to choose from are provided in the tables below. In addition to the suggested chemical parameters, one should consider analysing for other chemical components in cases when this can be considered as relevant as based on data from discharge, spreading analyses and risk assessments.

The chemical analyses of mussels are to be done using four composite samples at each station. All other effect analyses in mussels are to be done on 15 mussel specimens from each station. General procedures for collection and processing of biological samples from mussels are described in the JAMP Guidelines for Monitoring Contaminants in Biota, edition 2010 (OSPARCOM, 2010).

In fin-fish, 30 individual fish from each species and from each area/station are to be analysed, with the exception of DNA-adducts, which are to be analysed on 15 female fish from each species and from each area/station. The most important samples to collect from fish specimens are liver tissue, muscle tissue, bile fluid and gill samples. Procedures for the necropsy and sample collection of individual fish are described in OSPARCOM (2010).

Animals used for preparation of biological effect samples must be kept alive until the biological samples are taken. This is an important point, as the quality of the biological samples rapidly decreases after the study organism dies. The fish and mussels may after the capture, and prior to the sampling, be kept alive by means of suitable seawater holding tanks (sufficiently ventilated with fresh seawater), or by means of holding-nets that are hanging into the water. For the mussels it may be sufficient to keep the animals alive by use of suitable cooling containers with ice (at least for some hours). All sample processing procedures on board the survey vessel or in laboratory facilities must take place in clean (i.e. uncontaminated) environments. The samples must in general be handled in such a way that the risk of sample contamination is minimised. The sample processing procedures must be described in the survey report. A standard set of sampling data must be registered in a sampling form; including the species, date, location (geographic co-ordinates), fishing depth and fishing gear used.

Suggested inventory of parameters to record/analyse in mussels in water column monitoring.

Parameter	Method	Type of tissue/matrix	Method-relevant references
Size	Total mass and length, soft tissue mass/volume of the mussel	Whole mussel	(OSPARCOM, 2010)
Spawning status	Histological	Gills/gonad	(OSPARCOM, 2010)
General health state	Clearance rate and respiration or <<stress on stress>>	Whole mussel	(Al-Subiai et a., 2011; Hellous and Law, 2003; Viarengo et al., 1995)
PAH/NPD	GC-MS	Soft tissue	(OSPARCOM, 2010)
Metals (Hg, Pb, Cd, Ba)	ICP	Soft tissue	(OSPARCOM, 2010)
Chromosome damage	Micronucleus formation	Haemocytes	(Venier et al., 1997)
Lysosomal membrane stability (LMS)	Histological	Digestive gland or haemocytes	(Castro et al., 2004; Garmendia et al., 2011; Regoli, 1992)
Acetylchlinesterase inhibition (AChE)	Enzymatic	Gills	(Escartin and Porte, 1997)

Suggested inventory of parameters to record/analyse in fin-fish in water column monitoring.

Parameter	Method	Type of tissue/matrix	Method-relevant references
Size and condition index (CI)	Weight (without intestines and gonad)/length	Whole animal	(Lloret et al., 2002)
Liver somatic index (LSI)	Liver mass/body mass (without intestines and gonad)	Liver	(Lloret et al., 2002)

Gender and Gonad somatic index (GSI)	Gonad mass/body mass (without intestines and gonad)	Gonad	(Corsi et al., 2002)
PAH/NPD and metals	GC-MS (for PAH/NPD), ICP (for metals)	Filet	(OSPARCOM, 2010)
Concentration of PAH metabolites	GC-MS/LC-FD	Bile	(Aas et al., 2000; Beyer et al., 2010)
Fish gill ultrastructure and histopathology	Histology	Gill	(Afifi et al., 2014), (Hesni et al., 2011)
Fish skin ultrastructure and histopathology	Histology	Skin	(Afifi et al., 2014)
Tissue changes, including lysosomal changes	Histology	Liver	(Bilbao et al., 2010)
DNA damage	DNA address	Liver	(Lyons et al., 2004; Myers et al., 1998)
DNA damage	DNA strand breaks (comet)	Lymphocytes	(Mitchelmore and Chipman, 1998; Nagarani et al., 2012)
Chromosome damage	Micronucleus formation	Red blood cells	(Barsiene et al., 2013; Bombail et al., 2001)

Benthic Habitats

The term benthic refers to anything associated with or occurring on the bottom of a body of water. The animals and plants that live on or in the bottom are known as the benthos.

For baseline surveys of soft-bottom habitats, there should be chosen appropriate quantitative sampling equipment that can be used for the collection of both biological and chemical samples. The equipment must sample a minimum area of $0.1m^2$. Benthic samples should be taken with suitable equipment to avoid sediment compression. The equipment used to subtract subsamples for metal and hydrocarbon/drilling fluid analysis should not contaminate the samples (see ISO 5667-19:2004 Water quality - Sampling - Part 19: Guidance on sampling of marine sediments).

In shallow areas (<500 meters) one should as a rule use a modified van Veen grab[42]. Heavier equipment such as boxcorer can be used in deep sea areas. The most important is that the same type of equipment is used in subsequent surveys.

Separate samples should be taken from the upper 0–1 cm of the sediment (optionally from several depths) in each grab sample for analysis of metals and hydrocarbons/drilling fluid. Each sample is to be packaged, stored and analyzed separately. Samples for chemical and biological analyses are to be taken from separate grab loads, collected in accordance with ISO 16665 Water quality - Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna. This does however not exclude the use of modified van Veen grab sampler because chemical and biological samples taken with such devices are to be regarded as separate samples. For sieving of macrofauna samples in the field, see the same standard. Sieves should have round openings and a mesh opening of 1mm. It is

[42] The **Van Veen Grab Sampler** is an instrument to sample sediment in water environments. Usually it is a clamshell bucket made of stainless steel. Up to 20 cm deep samples of roughly 0.1 m^2 can be extracted with this instrument. It can be light-weight (roughly 5 kg) and low-tech.

preferable to take separate core samples, but it is also possible to collect partial samples from the grab loads for such analyses.

For more specific information on sampling and measuring of benthic habitats, please refer to the following international standards:

- ISO 16665:2014 Water quality -- Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna
- EN 16260:2012 Water quality. Visual seabed surveys using remotely operated and/or towed observation gear for collection of environmental data

2.5.4 Procedure for sampling and measurement of biological water column

Marine organisms may be sampled to assess possible adverse effects to their health. These organisms can either be feral or caged. Sampling can also be performed to measure the fitness of marine products for human consumption. For more information on the aforementioned subjects, *see* US EPA, Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis, Third Edition. Office of Water, EPA 823-B-00-07.

The biological indicators most employed in river quality investigations are large visible invertebrates (macroinvertebrates), while the biological indicators most employed in lake and coastal water investigations are studies of phytoplankton (algae) and zoobenthos.

The sampling frequency differs substantially depending on the purpose of the monitoring programme and the variables to be measured. Frequent samples are generally taken when the purpose of a monitoring programme is to observe trends, while programmes and surveys with the purpose of assessing the general state of many waterbodies generally are based on low sampling frequency. Some monitoring programmes include continuous registration of basic variables such as pH, conductivity, salinity and dissolved oxygen, while in most monitoring programmes measuring the quality and pollution in the water column, a number of annual samples are taken. Investigation of biological organisms such as macroinvertebrates in rivers and zoobenthos in lakes and marine areas is usually based on few annual samples. A large proportion of the costs of operating a monitoring programme is directly related to the sampling frequency.

The sampling frequency can be described by the total number of annual samples, for example

- 12/yr: twelve samples a year; or
- 2/5 yr: two samples every five years.

Information on the timing of sampling may also be important, if sampling is evenly spread throughout the year (e.g. monthly, weekly samples) or if stratified sampling is used (e.g. sampling during summer, pesticide spraying seasons or peak flow periods; monthly sampling every fifth year).

2.5.5 Sample storage and preservation procedures

Sampling plans should specify as a minimum the following:

- the type of container,
- storage conditions and
- maximum holding times for each type of analysis.

Sample containers should be clean and properly stored to avoid contamination.

For the water column monitoring, the tissue samples must be taken and prepared on board the boat immediately after the organisms are brought onboard.

Sediments sub-sampled for chemical analyses are stored in containers appropriate for the type of measurement e.g., glass jars for organic compound analyses and plastic jars for metals analyses. Biota samples should be appropriately preserved and stained to facilitate later analyses.

A frequently used approach is to chemically preserve the organisms and stain them with 'Rose Bengal (Rose Bengal, 4,5,6,7-tetrachloro-2',4',5',7'-tetraiodofluorescein, is used to dye or stain.)'. Storage and preservation conditions e.g. refrigeration and maximum holding times should be specified based on the target analyte and method.

- **Sediment sampling preservation**

Preservation of sediment samples is generally limited to specified storage conditions such as refrigeration or freezing. Depending on the parameter to be analyzed, some samples will require addition of chemical preservatives. Preservation techniques are summarized in the table below. Care should be taken to avoid exposure to acid gases which might be released when chemical preservatives are added to sediment samples in the field.

Recommended Sample Sizes, Containers, Preservation Techniques, and Holding Times for Sediment

Parameter	Minimum Sample Size (g)[a] (wet wt.)	Container	Preservation Technique	Holding Time
Particle size	100 to 150[b]	Glass or Polyethylene	Refrigerate, 4°C	6 months
Total solids	50	Glass or Polyethylene	Freeze, -18°C Refrigerate, 4°C	6 Months 14 Days
Total volatile solids	50	Glass or Polyethylene	Freeze, -18°C Refrigerate, 4°C	6 Months 14 Days
Total organic carbon	25	Glass or Polyethylene	Freeze, -18°C Refrigerate, 4°C	6 Months 14 Days
Oil and grease	100	Glass	Freeze, -18°C Refrigerate, 4°C	6 Months 28 Days
Total sulfides	50 (a 250 ml sample for 5 ml Zn Acetate)	Glass or Polyethylene	Refrigerate, 4°C (2 N Zn Acetate - 5 ml)	7 days
Acid volatile sulfides	50	Glass (no headspace protect from O2)	Refrigerate, 4°C	14 days
Total nitrogen	25	Glass or Polyethylene	Refrigerate, 4°C	28 days
Biochemical oxygen demand	50	Glass or Polyethylene	Refrigerate, 4°C	7 days
Chemical oxygen demand	50	Glass or Polyethylene	Refrigerate, 4°C	7 days
Volatile organics	50	Glass (no headspace)	Refrigerate, 4°C	14 days
Semivolatile organics	100	Glass	Freeze, -18°C Refrigerate, 4°C	1 Year[c] 14 Days[c]

Organotins	100	Glass	Freeze, -18°C Refrigerate, 4°C	1 Year[c] 14 Days[c]
Methyl mercury	100	Teflon™ or Glass	Freeze, -18°C	28 days
Mercury	50	Polyethylene, Glass (LDPE) or Teflon™	Freeze, -18°C Refrigerate, 4°C	28 Days[d] 28 Days
Metals	50	Polyethylene (LDPE)	Freeze, -18°C Refrigerate, 4°C	2 Years 6 Months
Microbiology	100	HDPE (Autoclaved)	Refrigerate, 4°C	24 hours
Bioassay	7 liters	Glass or Polyethylene	Refrigerate Protect from light	2 weeks

Notes:

a. Minimum field sample size for one laboratory analysis. If additional QC analyses are required, the field sample size should be adjusted accordingly.

b. Sandier sediments require larger sample sizes than do muddier sediments.

c. Holding time to extraction. After extraction, holding time is 40 days to analysis.

d. A number of unpublished studies have demonstrated that freezing sediment samples may extend the holding time for mercury analysis up to 6 months.

Source: *Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound (1997), prepared for the US EPA, available at the EPA's National Library.*

- **Marine water sampling preservation**

The following table summarizes recommended sample volumes, containers, preservation techniques, and holding times for water samples.

Recommended Sample Sizes, Containers, Preservation Techniques, and Holding Times for Water

Parameter	Minimum Sample Size (ml)[a]	Container	Preservation Technique	Holding Time
Alkalinity	100	Glass or Polyethylene	Refrigerate, 4°C	14 days
Total hardness	100	Glass or Polyethylene	Refrigerate, 4°C HNO_3 to pH<2	6 months
Total phosphorus	50	Glass or Polyethylene	Refrigerate, 4°C H_2SO_4 to pH<2	28 days
Orthophosphate	50	Glass or Polyethylene	Refrigerate, 4°Cg Filter on Site	48 hours
Ph	25	Glass or Polyethylene	None	Analyze Immediately [b]
Salinity	200	Glass or Polyethylene	None	28 days
Turbidity	100	Glass or Polyethylene	Refrigerate, 4°C	48 hours
Total suspended solids	1000 to 4000[d]	Glass or Polyethylene	Refrigerate, 4°C	7 days
Dissolved oxygen winkler	125	Glass Bottle with Glass Top	Fix with MnCl2 and Alk. Iod. (2 ml ea.)	8 Hours (store in the dark)
Dissolved oxygen probe	125	Glass Bottle with	None	Analyze

		Glass Top		Immediately [b]
Ammonia -N	100	Glass or Polyethylene	Refrigerate, 4°C H_2SO_4 to pH<2[g]	28 days
Nitrite -N	100	Glass or Polyethylene	Refrigerate, 4°C [g]	48 hours
Nitrate -N	100	Glass or Polyethylene	Refrigerate, 4°C [g]	48 hours
Silica	100	Polyethylene	Refrigerate, 4°C [g]	28 days
Chlorophyll a	25 to 1000[d]	Glass or Polyethylene (Dark)	Store filters frozen (-20°C) in the dark[f]	28 days [f]
Volatile organics	80	Glass -2 40 ml vials No Headspace	Refrigerate, 4°C HCl to pH<2	14 days
Semivolatile organics	1000 to 2000	Glass	Refrigerate, 4°C	7 days [e]
Total mercury and diss. Mercury	500	Teflon™ or Glass with Teflon™ Cap	Refrigerate, 4°C HNO_3 to pH<2[g h]	28 days
Total metals and diss. Metals	1000	Polyethylene or Teflon™	Refrigerate, 4°C HNO_3 to pH<2[g]	6 months
Microbiology	500	HDPE (Autoclaved)	Refrigerate, 4°C	24 hours

Notes

a. Minimum field sample size for one laboratory analysis. If additional QC analyses are required, the field sample size should be adjusted accordingly.

b. Immediately means as soon as possible after the sample is collected, generally within 15 minutes. These parameters should, ideally, be measured in the field.

c. After filtration.

d. The volumes specified are only estimates; the actual volume collected and filtered depends on concentration and analytical methodology used and may be larger than those presented in the Table.

e. Holding time to extraction. After extraction, holding time is 40 days to analysis.

f. Samples collected for the analysis of chlorophyll a must be kept cold until sample filtration. Filtration should occur as soon as possible after sampling. The filter may be immersed in 90 percent acetone solution and frozen which may significantly the holding time, however, this method is not approved for use on projects that come under regulatory scrutiny. Prolonged exposure of the filter to air can result is a loss of chlorophyll a.

g. Samples for analysis of total mercury and total metals should be preserved within 24 hours of sample collection, preferably in the field immediately following sample collection. Samples for analysis of dissolved mercury and dissolved metals must be preserved after filtration. Filtration and/or preservation of metals samples and the nutrients orthophosphate, ammonia nitrogen, nitrate, nitrite, and silica must occur within 24 hours of sample collection, preferably in the field immediately following sample collection. Holding times for nutrient samples may be extended up to 60 days by freezing but this methodology may not be allowed if samples are collected under certain regulatory programs.

h. Samples collected for analysis of very low levels of mercury or for mercury speciation should be preserved with HCl rather than HNO_3.

Source: *Recommended guidelines for sampling marine sediment, water column, and tissue in Puget Sound (1997), prepared for the US EPA, available at the EPA's National Library.*

2.5.6 Approaches for establishing and storing biological reference material

Accurate species identification is of fundamental importance for the reliability of the statistical analyses of the fauna. Experience has shown that quality control of species identification of the macrofauna needs to be improved.

One way of improving the situation is to build up a reference collection by retaining selected biological material from the surveys (specimens of genus and species). External taxonomists should validate the reference collection at regular intervals. It is important that the contractors/institutions carrying out the surveys use the services of the same external taxonomists. It is also important to be aware of the fact that reference collections and specimen samples from the surveys have different purposes and shall not include the same material. It would be best to assign the responsibility for the storage and curation of the material to experts, for example within natural history museums.

2.5.7 Parameters and procedures for sediment sampling and analytical methods

The choice of methods for sediment sampling is influenced by the sediment characteristics (where known), the type of measurement(s) to be made on the sample, the water depth (size of macrofauna relative to water depth may affect sieve size), and the amount of sediment needed for the analyses of interest. Surface deployed equipment for collecting sediment samplings includes various grab-type, box or multicore samplers. The multicorer can be used to take undisrupted sediment samples from the seabed.

Sediment cores can also be obtained using remotely operated vehicles (ROV). This approach provides the advantage that the location to be sampled can be selected with precision, e.g. pre- and post-drill sampling. The required amount of sediments varies according to the type of measurement being made. Physiochemical analyses require approximately 0.1m2 of sediment (to a depth of 10cm) per sample whereas analyses of the community structure of macrofauna require a larger sample, e.g. 0.3-0.5m2to a depth of 10cm, to ensure that sufficient biomass of organisms is collected to provide the basis for a representative count.

For more specific information on sediment sampling, see ISO 5667-19:2004 Water quality -- Sampling -- Part 19: Guidance on sampling of marine sediments.

For more specific information on analytical methods and standards for sediment analyses, see section 2.5.9 below.

2.5.8 Quality assurance and quality control measures

Please refer to Vol. 1 S.1 of this manual for general Quality Assurance and Quality Control measures to be followed.

The typical goal of QA/QC system is to ensure that all monitoring-related data are scientifically sound and of known and documented quality. The implementation of QA/QC procedures into monitoring activities concern the collection and storage of sample materials, analysis of samples, validation of measurements as well as interpretation, reporting and storage of data. This can be achieved through:

- the establishment of standardized procedures,
- adequate documentation,
- and appropriate training of personnel.

The general result of a good QA/QC policy is more trustworthy investigations and data. By this it becomes easier to compare data between studies and to discover real trends of change within the monitoring areas. The monitoring consultant’s QA/QC system should be presented in the tender as well as in the final report of the monitoring program, and the industrial operator must before awarding contracts to environmental monitoring work assess the sufficiency of the described quality system. The quality

- The quality system should include:
- verification of sample collection procedures,
- a plan for using reference samples in connection with analyses,
- reviewing the quality of analytical methods and results and performing of quality control of the report.

Optimally, a standard QA-system should be used, for example ISO 9000 or OSPAR (2002-15). Type and frequency of QA inspections of analyses should be presented as part of the method description in the report. Analyses should be verified against reference samples run in the same test series as the real samples. Presentation of results from the reference samples would be a natural part of result interpretation. The suppliers of services for monitoring programmes (analyses, fieldwork) should preferably be accredited (e.g. ISO 17025 or an equivalent) for the methods they use.

2.5.9 Sub-sea monitoring technologies

Water column analyses and physical, chemical and biological analyses of sediments compose the basic elements of an environmental monitoring program. These analyses are often coupled with dispersion modeling assessments that estimate the spatial footprint of drilling and production discharges, both within the water column and on the sea floor. New technologies are becoming part of the environmental monitoring toolbox, including subsea chemical and physical sensors attached to subsea landers, remote observational vehicles equipped with video, sensor and sampling capabilities, whole effluent toxicity testing, and biomarkers in organisms caught or caged within the oilfield environment.

The International Association of Oil and Gas Producers (OGP) Offshore Environmental Monitoring Task Force has developed a compendium of guidance and best practices for offshore environmental monitoring. The study remarks lander systems (or multi-sensor platforms), and remotely operated vehicles (ROVs) as examples of surveillance technologies. It states that they are increasingly employed by marine scientists and industry to couple traditional environmental data gathering with multi-sensor probes, computing and communication instrumentation. They also often include photographic and video capabilities.

Landers and ROVs are normally equipped with cameras and bathymetric monitoring equipment. Landers can also carry physical/chemical sensors that measure parameters such as temperature, salinity, turbidity, oxygen, and chlorophyll-a. Some ROVs are also capable of taking sediment core samples.

Some of the key advantages of these technologies include:

- Allow a large number of assessments to be made over a wide temporal and spatial area and are able to track natural seasonal and global changes.
- Possibility for real-time measurements, depending on the set-up
- Photographic surveys are non-invasive and provide material that is both useful to scientist and understandable by public audiences.

S.3 Specifics related to midstream and downstream petroleum operations

3.1 Description of activities, facilities, and equipment involved in midstream and downstream oil and gas operations

3.1.1 Midstream Oil & Gas Operations

The midstream sector involves the transportation (by pipeline, rail, barge, oil tanker or truck), storage, and wholesale marketing of crude or refined petroleum products. Pipelines and other transport systems can be used to move crude oil from production sites to refineries and deliver the various refined products to downstream distributors. Natural gas pipeline networks aggregate gas from natural gas purification plants and deliver it to downstream customers, such as local utilities. The midstream operations are often taken to include some elements of the upstream and downstream sectors. For example, the midstream sector may include natural gas processing plants that purify the raw natural gas as well as removing and producing elemental sulfur and natural gas liquids (NGL) as finished end-products.

Pipelines – Pipelines transmit oil and gas from the wellhead to market. Pipeline transportation is the safest, most efficient method of transporting crude oil and only method for transportation of natural gas. Development of pipelines requires extensive planning that includes acquisition of the right of way, significant construction costs, and establishment of users. Once pipelines are in place, they may be used for decades with some maintenance required.

Gathering pipelines connect the wellhead to centralized hubs and larger transmission pipelines that bring the oil and gas to market. Transmission pipelines require the oil or gas to meet certain specifications; thus, impurities must be removed.

Pipelines must be constructed of higher quality steel with extensive pre-operations testing that includes welds that are inspected by x-ray to verify defects are not in place. Regular maintenance and monitoring as well as installation of anti-corrosion measures are standard requirements to prevent and identify any leaks.

Compressors - Natural gas pipelines will require compression facilities in order to maintain the necessary pressure to keep the natural gas flowing through the pipeline. The number of compression stations required depends on the region and conditions, but they are generally located every 65-110 km along the pipeline. The level of required compression also depends on the region, elevation, size of pipeline, and supply and demand. Compressors are large engines that can be fueled by natural gas or electricity. Because of the noise emitted by the compressors, mufflers may be added to compressor stations to reduce the noise levels.

Compressor stations typically include scrubbers, strainers or filter separators which remove liquids, dirt, particles, and other impurities from the natural gas. These impurities, such as water and other hydrocarbons, may condense out of the gas as it travels. “Pigs” may also be launched or received into the pipeline at compression stations. Pigs are used to clean and maintain the pipeline. “Smart pigs” are used to inspect the pipelines for damage.

Storage Facilities– Fuel is normally received at bulk fuel storage facilities by pipeline, tank truck, tank car, barge, or ship. These components include pipeline receiving facilities, tank truck and tank car receiving facilities, pipeline dispensing (pumping) facilities, tank truck and tank car loading facilities, and all related piping and equipment.

Loading/Offloading facilities - Rail spurs, barge and/or truck docks located at a Facility, and all loading and unloading equipment and facilities with respect thereto located at such Facility, including, but not limited to, all conveyors, lifts and elevators used in connection with movement of materials and products.

Truck and Rail Transport – When crude oil pipelines are not available, operators may transport crude oil to market using trucks or rail transportation. Natural gas cannot be transported by truck or rail.

3.1.2 Downstream Oil & Gas Operations

The downstream sector is the refining of petroleum crude oil and the processing and purifying of raw natural gas, as well as the marketing and distribution of products derived from crude oil and natural gas. The downstream sector reaches consumers through products such as gasoline or petrol, kerosene, jet fuel, diesel oil, heating oil, fuel oils, lubricants, waxes, asphalt, natural gas, and liquified petroleum gas (LPG) as well as hundreds of petrochemicals. Midstream operations are often included in the downstream category and are considered to be a part of the downstream sector.

The purpose of refining is to convert crude oil and natural gas into useful saleable products. Crude oil and natural gas are naturally occurring hydrocarbons found in many areas of the world, in varying quantities and compositions. In refineries, these are transformed into different products such as:

- Transportation fuels
- Combustion fuels for the generation of heat and power for industry and commercial and domestic use;
- Raw materials for the petrochemical and chemical industries;
- Specialty products such as lubricating oils, paraffins/waxes and bitumen;
- Energy as a by-product in the form of heat (steam) and power (electricity).

Multiple processing units convert the crude oil and natural gas into products. The market demand for the type of products, the available crude quality and certain requirements set by authorities influence the size, configuration and complexity of a refinery. As these factors vary from location to location, no two refineries are identical.

The refining of crude oil into usable petroleum products can be separated into two phases and a number of supporting operations. The first phase is the desalting of crude oil and the subsequent distillation into its various components or ‘fractions’. The second phase involves several processes where the molecular structure of the hydrocarbon molecule is chemically changed into marketable products. These processes include breaking molecules into smaller molecules, combining them to form larger molecules, or reshaping them into higher quality molecules. Supporting operations include energy generation, waste water treatment, sulphur recovery, additive production, waste gas treatment, blowdown systems, handling and blending of products and the storage of products.

The following processes will produce pollution at refineries:

Alkylation is used to yield high quality motor fuel after blending. The process uses a catalyst, usually hydrogen fluoride (HF) or sulfuric acid, to transform the feedstocks. HF is particularly hazardous and may require the use of additives to improve safety.

Catalytic Cracking is the most widely used conversion process for upgrading heavier hydrocarbons into more valuable lower boiling hydrocarbons. It uses heat and a catalyst to break larger hydrocarbon molecules into smaller, lighter molecules.

Coking processes are used to transform low-value residual fuel oils into transportation fuels. A by-product of this process is petroleum coke, which is essentially solid carbon with various impurities. A coke calciner may be used to further process the “green” coke so that it may be used by other industries, notably the metals industry.

Cooling Systems are required to allow refinery process operations to take place at the right temperatures, and to bring products to their appropriate storage temperature. Water or air may be used for cooling purposes. During the cooling process, water may take on impurities or hydrocarbon fractions, which must be removed prior to return of the water into natural water bodies or for other uses.

Desalting is used to wash the crude oil or heavy residues with water at high temperature and pressure to dissolve, separate, and remove the salts and other water extractable components. These impurities may contaminate or corrode components or impact the effectiveness of catalysts. Contaminated water is a by-product of desalting and will need to have impurities removed before it can be reused or released.

Distillation units separate the various hydrocarbon fractions by their boiling range. Atmospheric and vacuum distillation processes are employed.

Energy and heat production is essential for the various refinery processes to take place. Heat requirements are provided by fuel combustion (heaters & furnaces) directly or indirectly via steam. Most air emissions at refineries are due to fuel combustion. Steam used in turbines and heaters after cooling is usually recovered as condensate and will need contaminants to be removed from the water and the temperature to be normalized prior to release into natural water bodies or for other uses.

Gas separation processes are used to separate the C_1-C_5 and higher compounds from various refinery off-gases by distillation. Feed gas for these gas plants comes from the various crude distillation, cat crackers, catalytic reformers, alkylation, desulfurization, and other units at the refinery. Gases are usually separated into different fractions for sale, use as a refinery fuel gas, LPG, or gasoline.

Hydrotreating and hydroprocessing is used to remove impurities such as sulfur, nitrogen, oxygen, halides, and trace minerals that may impact the use of catalysts. Some solid deposits may be formed in the process and will need to be removed by water wash.

Natural gas plants are used to remove contaminants from the wellhead stream to make sure the gas meets contractual and statutory specifications. Contaminants that may be removed include sands, clay scale, sulfates, water/brine, hydrocarbons, chemicals added at the wellhead, acid gases, CO_2, H_2S, nitrogen, mercury, or other gases.

Product treatments are used to remove or change the undesirable properties associated with sulfur, nitrogen, or oxygen compound contaminants in petroleum products. Treatments are either done through extraction or oxidation (sweetening) depending on the product. H2S or other acids may need to be removed from the product stream.

Storage and handling of materials at the refinery are necessary so that products can be blended and prepared for market. Leaks and spills from tanks, valves, flanges, and other connections may occur which release contaminants into the water, soil, or air.

Visbreaking is a well-established non-catalytic thermal process that converts atmospheric or vacuum residues to gas, naphtha, distillates and tar. It uses heat and pressure to break large hydrocarbon molecules into smaller, lighter molecules. A significant quantity of gas is produced and all distillate products need further treatment and upgrading prior to running them to storage.

3.2 Sources of key impacts of midstream and downstream oil and gas operations and impact categorization

3.2.1 Midstream Oil & Gas Operations

Air emissions or spills from storage facilities occur either during normal operations, such as the transferring of substances in and out of the facility and cleaning or during an incident. Emissions from pipelines will occur at by equipment during normal operations, at loading/unloading points, or if the pipeline is damaged due to an accident or mechanical failure.

Air Emissions

Air emissions may be fugitive emissions (i.e. leaks from valves, seals, etc), from tank breathing (due to temperature changes), and during entry and evacuation. Most air emissions from storage facilities are VOCs.

Emissions of Volatile Organic Compounds (VOCs) may result from evaporative losses during storage (typically referred to as "breathing, storage, or flash losses"), from operational activities such as filling, withdrawal, additive blending, and loading / unloading of transport links (referred to as "working losses"), and due to leaks from seals, flanges, and other types of equipment connections (known as "fugitive losses"). Additional emissions may occur from vapor combustion units and vapor recovery units. Recommendations to prevent and control the emission of VOCs from storage and working losses which apply to most bulk fuel storage tanks, as well as above-ground piping and pump systems, include the following:

- Maintaining stable tank pressure and vapor space by:
    - Coordinating filling and withdrawal schedules, and implementing vapor balancing between tanks (a process whereby vapour displaced during filling activities is transferred to the vapor space of the tank being emptied or to other containment in preparation for vapor recovery);
    - Reducing breathing losses by using white or other reflective color paints with low heat absorption properties on exteriors of storage tanks for lighter distillates (e.g. gasoline, ethanol, and methanol) or by insulating tanks. The potential for visual impacts from tank colors should be considered;
- Where vapour emissions contribute or result in ambient air quality levels in excess of health-based standards, installation of secondary emissions controls such as vapor condensing and recovery units, catalytic oxidizers, vapour combustion units, or gas adsorption media;
- Use of gasoline supply and return systems, vapour recovery hoses, and vapour tight trucks / railcars / vessels during loading and unloading of transport vehicles;
- Use of bottom loading truck / rail car filling systems;
- Establishing a procedure for periodic monitoring of fugitive emissions from pipes, valves, seals, tanks and other infrastructure components with vapour detection equipment, and with subsequent maintenance or replacement of components as needed. The procedure should specify the monitoring frequency and locations, as well as the trigger levels for repairs.

Tank cleaning and degassing can also generate significant quantities of VOCs. Tank degassing vapors should be routed to an appropriate emissions control device. Other practices include restricting activities to a season when the potential for ozone formation is reduced or to a time of the day when the potential for ozone formation is less.

Air emissions from pipelines are primarily at compressor stations from two main sources –fugitive emissions and combustion engines. Engines at the compression stations may be powered by electricity or gas and are subject to those regulations. Pipeline compressor stations are a significant source of fugitive emissions

Water Emissions

Emissions to water by tanks may occur from cleaning, discharge from drainage facilities, fire-fighting water, storm-water runoff (i.e., spills collected in secondary containment areas), or waste water from tanks. Tanks should be designed with secondary containment capabilities that are capable of holding the at least the contents of the primary system.

Emissions to water from pipelines only occur due to leaks or if water separates from the product. Water may separate from the crude oil or natural gas during the transportation process. Compressor stations and loading/unloading facilities will have equipment designed to remove any contaminants, such as water, to maintain product quality.

Operators should have spill prevention emergency plans in place to limit and contain emissions during an emergency at storage facilities. Spill prevention plans should evaluate failure of the primary and secondary containment systems. Plans should be required for facilities that transfer from vessels over water, are located in environmentally sensitive areas, could impact local drinking water supplies, have a history of oil spills in past 5 years, or have oil storage capacity greater than 1 million gallons.

Inspectors must verify that the following information is available for the response plan.

- A copy of the response plan must be maintained at the facility and include any plan updates
- Log of response drills and training exercises
- Records of inspections for response equipment (past 5 years)

Specific detail risks and impacts are summarized below:

- ***Risk and impacts of offshore oil storage***

Environmental Aspects	Impacts	Risk Level
Impacts to marine ecosystems (accidental) Tier III	Accidental release of large quantities of oil to sea would be likely to have severe impact on marine species. The severity would be such that it could be foreseen that the impact would take a significant amount of time spanning years for the full recovery of the affected marine ecosystems. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a catastrophic release from a large storage vessel for use in a risk assessment is $5x10^{-6}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a catastrophic rupture occurring in an offshore atmospheric storage tank to be $3x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.7x10^{-7}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low

Impacts to coastal environments (accidental) Tier III	The accidental release of large quantities of oil to sea would have a high potential for those materials to reach the coastline where the impacts would be extremely severe for not only marine species but avian and terrestrial species within the near shore. The potential damaged caused could have long term (years) effect along the affected coastline with recovery of ecosystems expected to be slow. In some cases, such damage may mean that ecosystems do not fully recover to pre-incident conditions. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a catastrophic release from a large storage vessel for use in a risk assessment is $5x10^{-6}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a catastrophic rupture occurring in an offshore atmospheric storage tank to be $3x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.7x10^{-7}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	5 moderate
Impacts to water quality (accidental) Tier III	While hydrocarbons will emulsify and degrade within marine conditions for a tier III event the quantities of oil involved would have severe impact upon the general water quality within the marine environment. The degradation and breakdown of hydrocarbons would be expected to have a strongly negative affect for chemical oxygen demand affecting the ability of seawater to support marine life. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a catastrophic release from a large storage vessel for use in a risk assessment is $5x10^{-6}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a catastrophic rupture occurring in an offshore atmospheric storage tank to be $3x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.7x10^{-7}$ per vessel per year. For this reason, the likelihood of a Tier III	4 low
Seabed fouling (accidental) Tier III	The potential for hydrocarbon spillages to reach the seabed is less clear, but given the quantities involved the potential for seabed fouling should be considered a risk. This would include contamination of marine sediments which have knock-on effects for benthic species that live within them. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a catastrophic release from a large storage vessel for use in a risk assessment is $5x10^{-6}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a catastrophic rupture occurring in an offshore atmospheric storage tank to be $3x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.7x10^{-7}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low
Impacts to marine ecosystems (accidental) Tier II	Accidental release of large quantities of oil to sea would be likely to have impact on marine species. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a major release from a large storage vessel for use in a risk assessment is $1x10^{-4}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a major spill occurring in an offshore atmospheric storage tank to be between $1.6x10^{-6}$ and $2.8x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.3x10^{-6}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low

Impacts to coastal environments (accidental) Tier II	The accidental release of large quantities of oil to sea would have a high potential for those materials to reach the coastline, the impacts would be for not only marine species but avian and terrestrial species within the near shore. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a major release from a large storage vessel for use in a risk assessment is $1x10^{-4}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a major spill occurring in an offshore atmospheric storage tank to be between $1.6x10^{-6}$ and $2.8x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.3x10^{-6}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low
Impacts to water quality (accidental) Tier II	While hydrocarbons will emulsify and degrade within marine conditions for a tier II event the quantities of oil involved would have an impact upon the general water quality within the marine environment. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a major release from a large storage vessel for use in a risk assessment is $1x10^{-4}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a major spill occurring in an offshore atmospheric storage tank to be between $1.6x10^{-6}$ and $2.8x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.3x10^{-6}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low
Seabed fouling (accidental) Tier II	The potential for hydrocarbon spillages to reach the seabed is less clear, but given the quantities involved the potential for seabed fouling should be considered a risk. This would include contamination of marine sediments which have knock-on effects for benthic species that live within them. According to the UK Health and Safety Executive (HSE) (2012), the recommended rate of a major release from a large storage vessel for use in a risk assessment is $1x10^{-4}$ per vessel year. This corroborates with data from the OGP (2010a), which estimate the probability of a major spill occurring in an offshore atmospheric storage tank to be between $1.6x10^{-6}$ and $2.8x10^{-6}$ per tank per year and for a pressurised storage vessel to be $4.3x10^{-6}$ per vessel per year. For this reason, the likelihood of a Tier III event from this source is judged as 'extremely rare'.	4 low

- ***Risk and impacts of offshore diesel/chemical deliveries***

Environmental Aspects	Impacts	Risk Level
Impacts to marine ecosystems (accidental) Tier I	Accidental releases of diesel or chemicals oil to sea would be likely to have an impact on marine species. The severity would be limited due to the small quantities involved and rapid dilution[85]. In their risk assessment data directory, the OGP (2010a) estimate that the probability of an offshore diesel storage tank rupturing to be $3.0x10^{-5}$ per tank per year. On this basis, the likelihood of spillage involving diesel or chemicals is judged as 'rare'.	6 moderate

Impacts to coastal environments (accidental) Tier I	The accidental release of diesel or chemicals to sea would have some potential for those materials to reach the coastline, where the impacts would be amplified due to the avian and terrestrial species within the near shore. In their risk assessment data directory, the OGP (2010a) estimate that the probability of an offshore diesel storage tank rupturing to be $3.0x10^{-5}$ per tank per year. On this basis, the likelihood of spillage involving diesel or chemicals is judged as 'rare'.	8 moderate
Impacts to water quality (accidental) Tier I	Hydrocarbons will emulsify and degrade within marine conditions, therefore for a tier I even the quantities of diesel/chemicals involved would have a limited impact upon the general water quality within the marine environment. In their risk assessment data directory, the OGP (2010a) estimate that the probability of an offshore diesel storage tank rupturing to be $3.0x10^{-5}$ per tank per year. On this basis, the likelihood of spillage involving diesel or chemicals is judged as 'rare'.	4 low
Seabed fouling (accidental) Tier I	The potential for hydrocarbon spillages to reach the seabed is less clear; given the quantities involved the potential for seabed fouling should be considered a small risk. In their risk assessment data directory, the OGP (2010a) estimate that the probability of an offshore diesel storage tank rupturing to be $3.0x10^{-5}$ per tank per year. On this basis, the likelihood of spillage involving diesel or chemicals is judged as 'rare'.	4 low

Hydrocarbon offtakes - product export, onshore pipelines / road tankers within the production process boundary

- ***Risk and impacts of onshore hydrocarbon offtakes (via pipelines and road tankers)***

Environmental Aspects	Impacts	Risk Level
Surface water contamination	Surface runoff and storm-water runoff that may be contaminated by waste chemicals, oily mud, etc. due to accidental spills or leakage.	4 low
Releases to air (local air quality)	Emissions from plant machinery, valve leakage, power plant, engines and vehicles transporting the waste. (UNEP/O&G, 1997)	2low
Releases to air (contribution to global warming)	Along with fuel related emissions that have the potential to affect local air quality, the emissions of greenhouse gases will also have a contribution towards climate change.	5 Moderate
Noise	Noise from machinery and equipment (UNEP/O&G, 1997) and engines and vehicles transporting and powering facilities.	4 low
Traffic	Impact may be expected from traffic where transportation of hydrocarbon offtakes off-site takes place by tanker.	4 low

Risks are considered to be generally relatively low for the outlined environmental aspects.

- ***Risk and impacts of off take of oil by pipeline***

Environmental Aspects	Impacts	Risk Level
Impacts to marine ecosystems (accidental) Tier III	Accidental release of large quantities of oil to sea would be likely to have severe impact on marine species. The severity would be such that it could be foreseen that the impact would take a significant amount of time spanning years for the full recovery of the affected marine	8 moderate

	ecosystems. According to the OGP's (2010a) Risk Assessment Data Directory for riser and pipeline release frequencies, the probability of a subsea pipeline failure in open sea is between $1.4x10^{-5}$ and $5.0x10^{-4}$ per km-year. On this basis, the likelihood of a tier III spill from a pipeline is deemed to be 'rare'.	
Impacts to coastal environments (accidental) Tier III	The accidental release of large quantities of oil to sea would have a high potential for those materials to reach the coastline where the impacts would be extremely severe for not only marine species but avian and terrestrial species within the near shore. The potential damaged caused could have long term (years) effect along the affected coastline with recovery of ecosystems expected to be slow. In some cases such damage may mean that ecosystems do not fully recover to pre-incident conditions. According to the OGP's (2010b) Risk Assessment Data Directory for riser and pipeline release frequencies, the probability of a subsea pipeline failure in open sea is between $1.4x10^{-5}$ and $5.0x10^{-4}$ per km-year. On this basis, the likelihood of a tier III spill from a pipeline is deemed to be 'rare'.	10 high
Impacts to water quality (accidental) Tier III	While hydrocarbons will emulsify and degrade within marine conditions for a tier III event the quantities of oil involved would have severe impact upon the general water quality within the marine environment. The degradation and breakdown of hydrocarbons would be expected to have a strongly negative affect for chemical oxygen demand affecting the ability of seawater to support marine life. According to the OGP's (2010b) Risk Assessment Data Directory for riser and pipeline release frequencies, the probability of a subsea pipeline failure in open sea is between $1.4x10^{-5}$ and $5.0x10^{-4}$ per km-year. On this basis, the likelihood of a tier III spill from a pipeline is deemed to be 'rare'.	6 moderate
Seabed fouling (accidental) Tier III	The potential for hydrocarbon spillages to reach the seabed is less clear, but given the quantities involved the potential for seabed fouling should be considered a risk. This would include contamination of marine sediments which have knock-on effects for benthic species that live within them. According to the OGP's (2010b) Risk Assessment Data Directory for riser and pipeline release frequencies, the probability of a subsea pipeline failure in open sea is between $1.4x10^{-5}$ and $5.0x10^{-4}$ per km-year. On this basis, the likelihood of a tier III spill from a pipeline is deemed to be 'rare'.	6 moderate

- ***Risk and impacts of off take of gas by pipeline***

Environmental Aspects	Impacts	Risk Level
Releases to air (accidental) – containment failure in pipeline (contribution to global emissions for greenhouse gas)	Rupture of pipelines or loss of containment will cause hydrocarbon gases to vent to the surface of the sea and then to the atmosphere. These gases will contain substances will contribute to climate change. Depending on where the rupture occurs the quantities of gas released could be significant but the likely frequency of such an event is rare.	4 low

3.2.2 Downstream Oil & Gas Operations

Air Emissions

Oil refining is responsible for a significant contribution to air emissions by industrial activities. Primary sources of emissions are from power plants, boilers, heaters, and catalytic cracking units. Refining processes require a significant amount of energy, and the production of energy is the source of over 60% of air emissions at refineries.[43] Carbon dioxide, carbon monoxide, nitrogen oxides (NOx), and sulphur oxides (SOx) emissions are primarily caused by combustion processes. To a lesser degree, SOx is emitted as flue gas from sulfur recovery units. There is a direct relation between the sulphur in the feed to a combustion process and the sulphur oxides in its flue-gas.

Volatile Organic Compounds (VOCs) arise from evaporation and leakage of hydrocarbons fractions associated with all refining activities. VOCs can react with NOx in the presence of sunlight to form low-level atmospheric ozone. VOC emissions come from sulphur recovery units, storage facilities, waste water treatment plants, loading and unloading facilities, vents, flanges, and valves. Petroleum refineries are a major source of the VOCs benzene, toluene, ethylbenzene, and xylene (BTEX) as these chemicals all naturally occur in crude oil and natural gas.

Particulate matter is caused by the combustion of fuel oils or may be released from catalyst changeovers and cokers. Particulates from refineries may include may include some hazardous compounds, such as heavy metals or polycyclic aromatic hydrocarbons.

The table below shows the sources of various air emissions at refineries.

Source	CO_2	CO	NOx	N_20	PM	SOx	VOCs
Process furnaces, boilers, gas turbines	x	x	x		x	x	
Fluidised catalytic cracking regenerators	x	x	x	x	x	x	
CO boilers	x	x	x		x	x	
Flare systems	x	x	x			x	x
Incinerators	x	x	x		x	x	
LNG plant CO2 separation	x						
Sulphur recovery units		x				x	
Coke calcinators			x			x	
Coke plants					x		
Storage and handling facilities							x
Gas separation units							x
Oil/water separation systems							x
Fugitive emissions (valves, flanges, etc)							x
Vents							x

Air emissions can be reduced through preventative techniques, implementing primary measures, or through end-of-pipe techniques such as scrubbers.

Water emissions

Refineries consume water on a continuous basis for use as steam, cooling water, utility service water, and as an emergency water supply for fires. Water used as steam in processing systems or for other processing purposes comes into direct contact with hydrocarbon fractions and other substances. Nearly all refinery processes have steam injection to enhance the distillation or separation processes, which leads to the production of sour water, which will require stripping. The condensates generated by steam will need to be separated and extracted from the processing system followed by a process that strips and extracts contaminants such as hydrogen sulfide (H_2S) and ammonia (NH3). Waste water

[43] BREF page 29

may also created from maintenance activities, firefighting, sanitary usage, ballast water from loading/offloading vessels, rainwater, etc. Water treatment techniques at refineries are directed at reducing the amount of pollutants and the oxygen demand exerted on the wastewater before it is released.

The table below shows the various waste water sources at refineries.

Source	Oil	H2S	NH3 (NH4+)	Phenols	Organic Chemicals (BOD, COD, TOC)	CN	Amines Compounds	TSS
Distillation Units	x	x	x	x	x			x
Hydrotreatment	x	x	x		x			
Visbreaker	x	x	x	x	x	x		x
Catalytic cracking	x	x	x	x	x	x		x
Hydrocracking	x	x	x		x			x
Lube oil	x	x	x		x			
Spent caustic	x	x		x	x	x		
Ballast water	x			x	x	x		x
Utilities (rain)	x				x			
Sanitary blocks			x		x			x
CO2 removal in LNG Plants							x	

Waste waters are generally treated in on-site waste water treatment facilities or sometimes by external waste water treatment plants and then discharged. Depending on the origin of the waste water, these can be contaminated with hydrocarbons, inorganics, metals and salts that may have the potential to impact the receiving environment. The effect of rainwater on both the amount and the quality of the effluent water and the problems that the water discharges to either fresh continental waters or to the sea must be considered. Furthermore, sanitary waste water and firefighting water are waste water streams that need attention and quality control prior to deciding on treatment, direct discharge and/or potential reuse.

Other Wastes

The amount of wastes generated by refineries is small in comparison to the amount of raw materials used and products produced.

Oil refinery waste normally covers three categories of materials:

- sludges, both oily (e.g. from tank bottoms) and non-oily (e.g. from waste water treatment facilities);
- other refinery wastes, including miscellaneous liquid, semi-liquid or solid wastes (e.g. contaminated soil, spent catalysts from conversion processes, oily wastes, incinerator ash, spent caustic, spent clay, spent chemicals, acid tar) and;
- non-refining wastes, e.g. domestic, demolition and construction.

Refinery operators are motivated to limit wastes for several reasons. Oil retained in sludges or other types of waste represents a loss of product and, thus, efforts are generally undertaken to recover the oil. Furthermore, waste disposal has high operating costs, so minimization of wastes is given a priority. Wastes may also be recycled off-site, re-refined, or used as a feedstock.

Changes in technologies have reduced oily sludge production, but biological sludge production due to the biotreatment of refinery effluent and spent catalyst production has increased. Third party waste contractors are typically used to treat and dispose of these wastes off-site.

Soil and groundwater contamination may occur from spills. Most spills occur during the storage, transfer, and transport of hydrocarbons.

Other environmental issues

Refineries may also cause environmental nuisances that will impact the neighboring communities. These include:

- Noise
- Light
- Flaring
- Odours
- Heat discharge

Flaring and light pollution may cause concerns during the nighttime hours. Many of these may occur in emergency situations causing concern in the neighboring communities. Design of refinery installations and process control systems should include provisions for safe shutdowns in an emergency with minimum emissions from the units involved.

3.3 Parameters for environmental monitoring

The present emission and effluent guidelines for the Petroleum Refining sector.

Guideline values for process emissions (such as FCCU, SRU, and combustion units) and effluents in this sector are indicative of good international industry practice, as reflected in relevant standards of countries with recognized regulatory frameworks. The guideline values are assumed to be achievable under normal operating conditions in appropriately designed and operated facilities through the application of pollution prevention and control techniques discussed in the preceding sections of this document.

Air Emissions Levels for Petroleum Refining Facilities a		
Pollutant	Units	Guideline Value
NOX b	mg/Nm^3	300 100 for FCCU
SOX c	mg/Nm^3	150 for SRU; 300 for FCCU 500
Particulate Matter (PM10) d	mg/Nm^3	25
Vanadium e	mg/Nm^3	5
Nickel	mg/Nm^3	1
H_2S e	mg/Nm^3	5

a. Dry gas at 3 percent O2.
b. NOx means NO+NO2 expressed in NO2 equivalent. Guideline value from European Commission Joint Research Center (EC JRC), “Best Available Techniques Reference (BREF) Document for the Refining of Mineral Oil and Gas” (2015).
c. SOx means SO2 + SO3 expressed in SO2 equivalent.
d. Guideline value from EC JRC, “BREF Document for the Refining of Mineral Oil and Gas” (2015). Particulate matter guideline value is also valid for FCCU.
e. From G.S.R. 186(E) and 820(E), India Ministry of Environment and Forests Notification http://envfor.nic.in/legis/env_stand.htm

To improve the management of fugitive emissions from the entire petroleum refinery and to protect human health in affected communities fence line monitoring of benzene concentration should be carried out. Where annual average benzene concentrations associated with refinery emissions exceed the guideline value below, corrective actions should be taken to reduce benzene emissions from refinery. Corrective actions and monitoring results should be reported.

Fence Line Monitoring Action Level	
Pollutant Guideline	Value
Benzene	9 μg/m³ a

a. Annual average concentration that is corrected for background contribution. Guideline value from U.S. EPA 40CFR63 Subpart CC—National Emission Standards for Hazardous Air Pollutants from Petroleum Refineries (2015).

Effluent guidelines are applicable to direct discharges of treated effluents to surface waters for general use. Site-specific discharge levels may be established based on the availability and conditions in use of publicly operated sewage collection and treatment systems or, if discharged directly to surface waters, on the receiving water use classification, as described in the General EHS Guidelines.

Liquid Effluents Levels for Petroleum Refining Facilities a

Pollutant	Units	Guideline Value
pH	S.U.	6 – 9
BOD5	mg/L	30 b
COD	mg/L	125 c
Total Suspended Solids (TSS)	mg/L	30
Oil and Grease	mg/L	10
Chromium (total)	mg/L	0.5
Chromium (hexavalent)	mg/L	0.05
Copper	mg/L	0.5
Iron	mg/L	3
Cyanide	mg/L	
Total		1
Free		0.1
Lead	mg/L	0.1
Nickel	mg/L	0.5
Mercury	mg/L	0.003 d
Arsenic	mg/L	0.1
Vanadium	mg/L	1
Phenol	mg/L	0.2
Benzene	mg/L	0.05 e
Benzo(a)pyrene	mg/L	0.05
Sulfides	mg/L	0.2
Total Nitrogen	mg/L	10 f
Total Phosphorus	mg/L	2
Temperature increase	°C	<3g

Notes:
a. Assumes an integrated petroleum refining facility.
b. Guideline value from EC JRC, BREF (2015) Table 3.16; National legislations may have lower values such as China: 20 mg/L.
c. Guideline value from EC JRC, BREF (2015); National legislations may have lower values such as China: 120 mg/L.
d. EC JRC, BREF (2015) Table 3.16.
e. Guideline value from EC JRC, BREF (2015).
f. The effluent concentration of nitrogen (total) may be up to 40 mg/l in processes that include hydrogenation.
g. At the edge of a scientifically established mixing zone, which takes into account ambient water quality, receiving water use, potential receptors, and assimilative capacity. EC JRC, BREF (2015) Table 3.16

Emission/waste quantities generated per million tons of processed crude oil are provided below. Industry benchmark values are provided for comparative purposes only, and individual projects should target continuous improvement in these areas.

Emission and Waste Generation		
Parameter	Unit	Industry Benchmark
Wastewater	m^3 /metric ton crude oil	0.1–1.51
Emissions		
CO_2 [2]		105,000–276,000
NOx [3]	Metric ton /million metric tons of processed crude oil	70–450
Particulate matter		60–150
SOx [4]		60–300
VOC		65–300
Solid waste		10–100

Notes:
1. Based on European Commission Joint Research Center (EC JRC), "Best Available Techniques Reference (BREF) Document for the Refining of Mineral Oil and Gas" (2015).
2. Not all GHGs, only total CO2. Based on EC JRC, "BREF Document for the Refining of Mineral Oil and Gas" (2015).
3. NO+NO2 expressed in NO2 equivalent.
4. SO2+SO3 expressed in SO2 equivalent.

3.4 Specific environmental monitoring procedures relating to mid- downstream oil and gas operations, distinct from procedures defined in Volumes 1 and 2

3.4.1 Methodologies for environmental monitoring and inspection in the midstream and downstream facilities

Pipelines

Regulators should ensure that the environmental monitoring programs should include corrosion protection systems, regular inspection using "smart pigs," visual inspections of the pipelines.

Visual inspection of the pipelines may be undertaken through on-site visits to the rights of way, compression stations, or hubs. Inspections of rights of way may also be done by airplanes, helicopters, or drones.

Regulators should do a regular review of emergency response and crisis management plans for the pipelines. The plans should include preparations (personnel and equipment) to respond to a worst-case discharge scenario.

Pipeline operator monitor pipelines from central control centers 24 hours a day, 7 days a week, 365 days a year. Monitoring takes place electronically and in person. Specially trained controllers monitor pipeline pressure, flow and volume and can shut down a pipeline if a potential leak is detected. Sensors along the pipeline route can detect a drop in pressure, which can indicate a leak. Flow gauges monitor product passing through the pipeline ensuring everything remains inside the pipe. Pipeline sensors and gauges feed their data into central control rooms where operator personnel constantly monitor operations on computer displays.[44] Additionally, operator personnel patrol along the pipeline route and personnel in airplanes or helicopters travel overhead the length of the pipeline on a regular schedule looking for signs of leaks.

Inspection tools called "smart pigs" travel inside the pipes scanning the pipe wall for signs of dents, corrosion or possible cracking. Smart pigs are inserted into the pipeline and pushed along by the flowing product and use technology similar to an ultrasound or an MRIs to detect any restrictions, deformations, or metal loss. Hand held imaging tools, such as ultrasonic imaging technology, in the field can be used to confirm previous smart pig internal inspections. If maintenance is needed, the specific action is prescribed and performed before returning the pipe to service.

[44] http://www.aopl.org/wp-content/uploads/2018/05/Pipeline-Questions-Answered-Detecting-Leaks-s.pdf

Corrosion protection systems, also known as cathodic protection, use a small direct current (DC) to flow through the soil and water to identify any corrosion in the pipelines. These systems should be regularly inspected (~every 2 months).

Inspectors should verify pigging operations are undertaken and that regular maintenance operations are undertaken and based on these results.

Screening for leaks can be undertaken in the following methods

- **Soap bubble screening** – spraying a soap solution on small accessible components, such as threaded connections. Soaping is effective for locating loose fittings and connections, which can be tightened on the spot to fix the leak, and for quickly checking the tightness of a repair.
- **Electronic Screening** using small hand-held gas detectors or "sniffing" devices that are equipped with catalytic oxidation and thermal conductivity sensors designed to detect the presence of specific gases. Electronic gas detectors can be used on larger openings where soaping does not work.
- **Organic Vapor Analyzers (OVAs) and Toxic Vapor Analyzers (TVAs)** are portable hydrocarbon detectors that can also be used to identify leaks. An OVA is a flame ionization detector (FID), which measures the concentration of organic vapors over a range of 9 to 10,000 parts per million (ppm). A TVA combines both an FID and a photoionization detector (PID) and can measure organic vapors at concentrations exceeding 10,000 ppm. TVAs and OVAs measure the concentration of methane in the area around a leak.
- **Infrared Cameras** detect the presence of gas emissions from equipment by converting the scanned area into a moving image in real time such that the gas plumes are visible due their absorption of the Infrared light. This method works best to screen inaccessible locations within viewing distance or larger areas. They may be also mounted on aircraft, trucks, or other vehicles.
- **Acoustic Leak Detection** uses portable acoustic screening devices designed to detect the acoustic signal that results when pressurized gas escapes through an orifice. Leak rates can not be measured, but higher intensity or "loud" signals may indicate a greater leak rate.
    - *High frequency acoustic detection* can be applied in noisy environments where leaking components are accessible to a handheld sensor.
    - *Ultrasound Leak Detection* is an acoustic screening method that detects airborne ultrasonic signals in the frequency range of 20 kHz to 100 kHz. Leaks are pinpointed by listening for an increase in sound intensity through headphones. Tuning capabilities can be tuned to a specific leak in a noisy environment.

Measurement of leaks can be undertaken using the following methods:

- **Toxic Vapor Analyzers (TVAs)** can be used to estimate mass leak rate. The TVA-measured concentration in ppm is converted to a mass emissions rate by using a correlation equation. A major drawback to TVAs for methane leak measurement is that the correlation equations are typically not site-specific.
- **Bagging Techniques** measure mass emissions from equipment leaks. The leaking component or leak opening is enclosed in a "bag" or tent. An inert carrier gas such as nitrogen is conveyed through the bag at a known flow rate. Once the carrier gas attains equilibrium, a gas sample is collected from the bag and the methane concentration of the sample is measured. Leak rate measurement is fairly accurate, but slow and may be impossible for equipment components that are very large, inaccessible, and unusually shaped.

- **High Volume Samplers** capture all of the emissions from a leaking component to accurately quantify leak emissions rates. Leak emissions, plus a large volume sample of the air around the leaking component, are pulled into the instrument through a vacuum sampling hose.
- **Rotameters** and other flow meters are used to measure extremely large leaks that would overwhelm other instruments. Flow meters typically channel gas flow from a leak source through a calibrated tube where the flow lifts a "float bob" within the tube, indicating the leak rate. These instruments work best for open-ended lines and similar components, where the entire flow can be channeled through the meter.

In addition to emissions from leaks, engines and turbines used at compressor stations will have emit pollutants. Monitoring of this equipment should follow procedures used for engines and turbines for all industrial operations.

Storage Tanks

Monitoring for VOC emissions is typically done on a monthly basis rather than a continuous basis for storage tanks. Tanks should be periodically inspected internally, and establishing an inspection frequency based on the condition of the tank at the previous internal inspection (typically 10 years or less).

Storage tanks and components should meet international standards for structural design integrity and operational performance to avoid catastrophic failures during normal operation and during exposure to natural hazards and to prevent fires and explosions. Applicable international standards typically include provisions for

- overfill protection,
- metering and flow control,
- fire protection (including flame arresting devises), and
- grounding (to prevent electrostatic charge).

Storage tanks and components (e.g. roofs and seals) should undergo periodic inspection for corrosion and structural integrity and be subject to regular maintenance and replacement of equipment (e.g. pipes, seals, connectors, and valves). Several types of inspections should be undertaken.

- Visual inspection – reveals cracks and leaks in tanks
- X-ray or ultrasound analysis – measures wall thickness and can pinpoint crack locations
- Hydrostatic testing – indicates leaks cause by pressure
- Magnetic flux eddy current and ultrasonic analysis (in combination) detects pitting.

Spill prevention plans should be verified and should include the following:

- Scenario analysis
- Analysis of various magnitudes of releases
- Details of training and available resources

Loading/Unloading activities

Loading / unloading activities should be conducted by properly trained personnel according to preestablished formal procedures to prevent accidental releases and fire / explosion hazards. Procedures should include all aspects of the delivery or loading operation from arrival to departure, including wheel blocking to avoid vehicle movement, connection of grounding systems, verification of proper hose connection and disconnection, adherence to no-smoking and no-naked light policies for visiting drivers;

For unloading / loading activities involving marine vessels and terminals, preparing and implementing spill prevention procedures for tanker loading and off-loading according to applicable international standards and guidelines which specifically address advance communications and planning with the receiving terminal.

Facilities should develop a spill prevention and control plan that addresses significant scenarios and magnitudes of releases. The plan should be supported by the necessary resources and training.

Downstream oil and gas activities
Monitoring should be undertaken during commissioning, start-up, normal operation, and shutdown unless it is agreed that it would be inappropriate to do so. The monitoring system should allow adequate processing and emission control. A monitoring system in a refinery generally includes:

- continuous monitoring of pollutants for high volume flows with high variability in pollutant concentrations;
- periodic monitoring or the use of emission relevant parameters for flows with a low variability and calculation based on high-quality emission factors;
- regular calibrating of measurement equipment;
- periodic verification of measurement by simultaneous comparative measurements.

3.4.2 Procedures for air quality measurement, effluent sampling, suspended particulate matter sampling and measurement, sample storage and preservation and standard analytical methods

Information for this and the following section is already provided in the following sections of Volume 2:

- S.1 Sample collection and processing;
- S.2 Measurement procedures; and,
- S.3 Analytical procedures.

Air Emissions

The most common air emissions monitoring at refineries is for the following pollutants:

- carbon dioxide
- nitrous oxide
- volatile organic compounds (VOCs)
- heavy metals
- hydrogen fluoride
- halide compounds
- ammonia (NH_3)
- hydrocarbons (as unburnt hydrocarbons, UHC)
- dioxins and/or POPs.

SO_2, NO_X, particulate matter and CO are typically continuously monitored (on-line or predictively) in the refineries. Records of the volumes are also required for the calculation of the load (tonnes of pollutant per year) or for the application of the bubble concept. The Table below shows the locations where the main air pollutants are typically monitored in a refinery.

The most common air emissions monitoring at oil refineries is shown in the table below.

Parameter[45]	Example of Monitoring	Location where measurement occurs
Sulfur dioxide	Continuous if P>30 MW (except for natural gas) Continuous if P>20 MW and desulphurisation unit (elsewhere, daily estimation) or P >100 MW	FCC unit regenerators Sulphur recovery units (i.e. from tail gas incinerators) Incinerators or furnaces used to burn sour gas or liquid fuels Bitumen production units Gasification units Coking processes Oxides
Oxides of Nitrogen	Continuous if >30 MW (except for natural gas) Continuous if P>20 MW and abatement unit or P >100 MW	Combustion processes FCC unit regenerators Gasification units Coking processes
Carbon monoxide	Continuous if P >10 MW Continuous if P >50 MW	FCC unit regenerators (for partial combustion type units if CO release is significant). Combustion processes
Particulate matter	Continuous for solid and liquid fuels if >10 MWюNot relevant for natural gas or RFG Continuous if P >50 MW (Examples from France – P expressed as MW th)	Combustion processes burning fuel oil FCC unit regenerators Coking processes and petroleum coke calciners and coolers Gasification units Catalyst regeneration (e.g. reforming)

Sulphur – Sulphur balances are typically computed over appropriate time periods, which may vary according to the circumstances (e.g. how often feedstocks change) but could typically be quarterly. SOX balances from combustion processes may be calculated from the analysis of the fuel being burnt.

VOCs – VOC emissions from refineries come mainly from diffuse emissions, which makes monitoring and quantification of emissions somewhat challenging. VOS may be passively or actively measured.

- *Passive measurement* – Badges or tubes that absorb or collect VOCs at known rates are set at monitoring sites and then collected later. The samples are then sent to labs where concentrations are identified using ion chromatography or plasma mass spectrometry.
- *Active measurement* – Gas chromatograph mass spectrometers are installed at facilities to collect air samples. These systems can identify total VOC emission concentrations as well as concentrations of individual compounds in a matter of minutes. However, these systems are much more sophisticated and therefore much more expensive.

There are four methods used at refineries for monitoring VOC emissions.

- *Sniffing (EN 15446):* Hand-held VOC analysers measure atmospheric VOC concentrations adjacent to equipment. The most frequently used measuring techniques are the flame ionisation (FID) and the photo-ionisation (PID), calibrated to operate in the range of 10 – 100 000 ppmv. The probe is characterised by a 'response factor' which takes into account the sensitivity to the actual VOC mixture measured compared to a reference gas, and a 'response time' defined as the time needed to register 90 % of a concentration step change. For mass flow quantification, the source may be bagged to capture a direct measurement directly from the source. This method is highly burdensome and requires a large number of prior measurements.
- *Optical gas imaging techniques (OGI):* Use of small lightweight handheld cameras to enable the visualization of gas leaks in real time so that they appear as "smoke" on the video recording. This method best identifies significant VOC leaks, but has limitations on quantification and may be impacted by temperature, distance from the leak, and wind speeds.

[45] European Commission Joint Research Center (EC JRC), "Best Available Techniques Reference (BREF) Document for the Refining of Mineral Oil and Gas" (2015).

- *Differential absorption lidar (DIAL)* : A laser-based technique using differential adsorption LIDAR (light detection and ranging) which is the optical analogue of radio wave-based RADAR. Wind data availability, accuracy and representativeness are essential for reducing quantification uncertainties. The overall uncertainty in industrial field conditions is evaluated at around 30 – 50 %, most of it from wind speed evaluation, and extrapolation of the data to annual emissions values may lead to inaccuracies.
- *Solar occultation flux (SOF)*: The technique is based on the recording and spectrometric Fourier Transform analysis of a broadband IR or UV/Visible sunlight spectra along a given geographical itinerary, crossing the wind direction and cutting through VOC plumes. This method requires sunny weather and may not capture all data.

- ***Odour* Emissions**

Odour emissions from refineries is potentially related to the emission of a large number of chemical substances and compounds such as

- sulfur compounds (e.g. hydrogen sulfide, mercaptans, sulfides, disulfides); ·
- nitrogen compounds (e.g. ammonia, amines);
- hydrocarbons (e.g. aromatics).

Methods to undertake odour monitoring may be by a panel of trained, human assessors or panelists or by a committee of residents via questionnaire.

Refineries should have an odour management plan as a well identified part of their environmental management system with the following elements:

- an odour management strategy;
- protocols for conducting odour monitoring;
- a protocol for response to identified odour events;
- an ongoing odour prevention and elimination programme designed to identify the location, nature, emission and dispersion of on-site odours, to characterise the odours, and to implement elimination and/or reduction measures in relation to these odours;
- an implementation timetable for all actions to be taken within this programme;
- reporting procedures to regularly advise management on the results of the plan;
- a review programme for regularly updating the plan.

Full compliance evaluations should be conducted once every 2-3 years, but annual compliance certifications, monitoring reports, and other reports should be reviewed on an annual basis. If a site visit has been determined by the regulator to be not necessary for the full compliance evaluation, the site should nonetheless be visited at least once every five years to verify records, observe any modifications or new construction, and to identify any permit deviations.

- ***Water Emissions***

The water effluent quality parameters to be considered relevant for refining activities are mainly the pH, total suspended solids (TSS), total organic carbon (TOC) or COD, total nitrogen and its various forms (organic $R\text{-}NH_2$, ammonium NH_4+, reduced or Kjeldahl NTK, nitrite NO_2, and nitrate NO_3), total phosphorus, BOD, Total Petroleum Hydrocarbons (TPH), aromatics (BTEX), phenols, PAH, metals, temperature.

Continuous monitoring and flow-proportional sampling for releases to water are always preferable but the use of a fixed interval or time-proportional sampler for low flow rates (less than 1 litre per second) may be acceptable. The monitoring of process effluents released to controlled waters and sewers will commonly be carried out for the following: flow rate, pH, temperature, and TOC (surrogate for COD/BOD). Samples are also being monitored for other appropriate parameters such as COD, BOD, Total Petroleum Hydrocarbons, suspended solids, nitrogen compounds, phenols, benzene, metals (typically Cd, Hg, Ni, and Pb). The periodicity can be typically daily, weekly or monthly, depending on the risk assessment and on local circumstances.

One problem with effluent discharge monitoring from refineries is related to the analytical method. For example, for the analysis of petroleum hydrocarbons (oil) there are many different methods (e.g. GC-MS, IR one wavelength, IR two wavelengths, gravimetric) which give completely different results which prohibit a clear comparison. Unification of analytical methods or calibration against a standard preferred method can circumvent this issue.

- ***Solid Wastes***

A recording of the quantity and composition (including prescribed substances) of residues generated should be carried out. Operators have written procedures which ensure that releases are handled, treated and disposed of in an approved manner, and which specify how the accumulation and storage of waste are to be controlled. The frequency of analysis of the waste is site-and/or process-specific.

Groundwater and soil at and near the refinery should be monitored for contamination regularly to prevent and identify any potential contamination. Monitoring should include Benzene, Toluene, Ethylbenzene and Xylenes (BTEX), Polycyclic aromatic hydrocarbon (PAH), Total Petroleum Hydrocarbons, pH, temperature and conductivity.

Groundwater should be tested using sampling wells at and near the refinery. Well construction materials (PVC or HDPE) should be selected in order not to interact with contaminants or modify the composition of the groundwater. On sites with aged contamination, multilevel sampling wells can be used for sampling, in order to be able to draw a detailed three-dimensional groundwater contamination profile (e.g. DNAPL).

Laboratories performing the analyses should be accredited for each substance analyzed and must achieve the analytical performances set (i.e. limit of quantification). Quality control procedures should also cover the prevention of drilling and sampling equipment contamination.[46] Results from the testing should be shown on a map with the refinery footprint outlined and the groundwater flows identified.

Soil sampling at refinery site should be done in a zigzag pattern from multiple locations and include soil from the depth of 50cm. Samples should be placed in plastic bags and transported to the laboratory for testing as soon as possible. Atypical areas, such as eroded knolls, depressions, saline areas, fence lines, old road ways and yards, water channels, and field edges, should be avoided in the sampling.

3.4.3 International Best Practices in monitoring and inspection of petroleum supply operations and facilities, construction of such facilities and incidents tracking

Tankers and Railcars

Tank cars that transport crude oil are required to be inspected and qualified at least once every ten years and after any accident, fire, or if defects are noted. The types of tests and inspections include a

[46] 'Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells' (US EPA, March 1991). ISO 5667 – 11 'Guidance on sampling of groundwater'.

visual inspection, structural integrity inspection, thickness test, safety systems test, internal coating or lining test, leakage pressure test, and service equipment test.

Inspections of shipments of crude oil by rail can also be undertaken to determine if the crude oil in transit is classified properly for transport. Shippers should meet all hazardous material transportation and labelling requirements. Classification should include gas content, vapor pressure, flash point and boiling point, which correlates to ignitability and flammability.[47] [48]

Petroleum tanker trucks should undergo inspection and testing annually. This includes internal and external visual inspections, lining inspections, leakage testing, pressure testing, and thickness testing. Inspections must include testing of all valves, inspection for corrosion and damage, and verification the liner is intact. Trucks may not be filled and offered for transportation or transported until the test or inspection has been successfully completed.

Terminal facilities

Environmental monitoring programs for terminals should be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during normal operations and upset conditions. Activities include monitoring for fugitive emissions from tanks, treatment of wastewaters including stormwater, tank bottom water, water from secondary containment, management of wastes such as tank bottom sludge, and decommissioning activities.

Environmental monitoring activities at terminals should be based on direct or indirect indicators of emissions, effluents, and resource use applicable to the particular project. Monitoring frequency should be sufficient to provide representative data for the parameter being monitored. Monitoring should be conducted by trained individuals following monitoring and record-keeping procedures and using properly calibrated and maintained equipment. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken.[49]

Removal of tanks requires the removal of all residual fuel from the tank and associated pipelines. Tanks should be inerted to eliminate the risk of explosion and all vent pipes and risers should be dismantled and/or capped off and clearly labelled. If tanks or pipes are left in situ, closure should include inerting, cleaning and removal of contents, filling with sand or cement slurry, hydrophobic foams, or foamed concrete.

Traffic and road use concerns typically do not fall under the jurisdiction of the oil and gas regulator, but rather under the jurisdiction of municipalities, regional governments, or the Department of Transportation.

Local roadways in most areas with developments are designed for low volume and lightweight traffic with many secondary roads made of gravel or asphalt. Developments require heavy machinery and equipment (water trucks, rigs, sand, pipes, etc.) that will cause excess wear on the roads. Excessive delays and poor road conditions may drive up operator costs and may discourage investment.

Counties and municipalities with oil and gas activity have modest tax revenues at the beginning of these developments, although the road damage and traffic is prevalent in the drilling and completion phase. A lag exists between when the damage occurs and when the municipalities will receive any monetary benefit from oil and gas production in the region. Traffic congestion is also an issue in these

[47] https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/docs/07_23_14_Operation_Safe_Delivery_Report_final_clean.pdf
[48] ASTM 4057, "Standard Practice for Manual Sampling of Petroleum and Petroleum Products
[49] https://www.ifc.org/wps/wcm/connect/81def8804885543ab1fcf36a6515bb18/Final+-+Crude+Oil+and+Petroleum+Product+Terminals.pdf?MOD=AJPERES

regions. In 2012 in the midst of the shale boom, Texas saw a 6% increase in crashes and a 13% increase in fatalities in the five major shale areas.

In DeWitt County, Texas, which overlays the Eagle Ford Shale, costs for road repairs and maintenance are estimated at $133,000 per well. Local officials in the county negotiated a $8000 fee per well to help repair county roads. To offset road damage by heavy haulers, Pennsylvania signs maintenance agreements with heavy users and haulers. These agreements include a bond requirement, submission of a maintenance plan, regular inspections of road conditions, and timely repairs as hazards arise. Both Pennsylvania and Texas have targeted energy producing regions to receive funds collected from growing oil and gas revenue. The Texas Legislature has also dedicated a portion of the oil and gas severance tax revenue to road repair and maintenance in areas with increased energy production. Pennsylvania's Impact Fee, which is charged on all unconventional wells, provides a portion of funds back to localities in the Marcellus Shale to help mitigate the impacts of drilling on the community. In 2016, most spending by these counties and municipalities was on public infrastructure, emergency preparedness, and public safety programs.

Other governments have used new developments to connect remote areas to transportation hubs. In British Colombia, oil and gas operations are in remote areas, many without direct roads. Specific Road Permits are required to modify or construct roads and the permit conveys an obligation to maintain or to operate the road safely. BC also has several programs targeting rural road development. The Oil and Gas Rural Roads Improvement Program (OGRRIP) funds road infrastructure projects and helps industry to explore and extract natural gas by building strong roads that can handle the industrial traffic. Since 2001, the OGRRIP program has upgraded about 2500 kilometers of roads and bridges that are used extensively by the oil and gas industry in northeastern BC. The program also helps mitigate the negative impacts of the industrial use of roads, such as dust concerns and increasingly rough surfaces to local residents. In 2004, BC also entered into a public private partnership for the construction of a major 188 km road in northeast BC to be used primarily by oil and gas users but open to the public.

BC also has an Infrastructure Royalty Credit program where road and pipeline projects are selected through a competitive bidding process where projects are evaluated on the ability to open new areas of oil and gas exploration. The projects must be fully funded and completed within three years of the agreement before the royalty deduction can be applied. Deductions can be as much as 50% of the total costs of construction.

In Argentina, road damage caused by the development of the Vaca Muerta play caused significant damage and traffic for the region. The National and provincial governments established the Ruta del Petroleo project to upgrade, construct, and repair 630km of roadways in the Vaca Muerta region at a cost of US$208 million. Additionally, the National Government and several oil companies entered into a Public Private Partnership to upgrade the rail connection to the Atlantic Coast at a cost of $1.2 billion.

Northern Territory in Australia has acknowledged the potential road use and traffic problems associated with oil and gas developments. The recent report on Hydraulic Fracturing suggested that any shale development should be coupled with plans to upgrade the road and rail networks if traffic volumes begin to impede other users in the province. The NT Government suggestions include an assessment of the heavy-vehicle traffic on the transportation system and the development of a management plan to mitigate any negative impacts. Forecasted traffic patterns, potential use of existing rail lines, and upgrades should be a part of the management plan. It was also recommended that the traffic and infrastructure impacts be addressed in the social impact assessment that would be required for any application. Road maintenance and road repair costs on this shared infrastructure would be assessed on a tonnage basis for companies engaging in shale developments. Safety considerations and monitoring programs would be established through road use agreements with the territorial government.

In the UK, the planning application Cuadrilla Resources submitted for its unconventional sites was originally turned down because of its traffic management plan. It initially planned to limit traffic levels to a maximum of 25 heavy goods vehicles (HGVs) per day for peak periods with the average number of HGVs over the drilling and fracturing operational period being just 5 HGVs per day. The revised and approved Traffic Management Plan was approved in late 2017 after appeal to the Secretary of State and included three routes for access to minimize disruptions to the community.

Incidents Tracking

The Alberta government follows a comprehensive strategy that was designed to reduce traffic-related deaths and injuries in the province. Alberta Transportation contributes to these road safety initiatives by monitoring the safety of commercial carriers travelling on Alberta's highways.

The Carrier Services section of Alberta Transportation monitors Alberta's carriers using their Carrier Profile, including information on:

- Convictions;
- Commercial Vehicle Safety Alliance (CVSA) inspections;
- Collisions.

Carrier Profile information is used to identify carriers who pose an unacceptable safety risk. The Carrier Profile is a "Report Card" of the carrier's compliance to "On-Road" and "Administrative" requirements and performance based on information collected from across Canada and the United States. Every carrier operating commercial vehicles registered in Alberta has a Carrier Profile.

The standard Alberta Carrier Profile includes information regarding:

- A carrier's safety fitness rating
- A carrier's operating status (federal or provincial)
- 12 months of events involving commercial vehicles registered in the carrier's name and the persons driving those vehicles. Events include;
- Convictions,
- Inspections, and
- Reportable collisions from all Canadian jurisdictions, and
- Violations identified in Alberta where no charges were laid.

The Alberta government may take intervention actions against a carrier if they continue to pose a risk to the motoring public. Specifically, information on the Carrier Profile is used to determine a carrier's Risk Factor score. A carrier's Risk Factor Score is shown as a number. The lower the number, the better the score and the less likely a collision is to occur.

Alberta's carrier monitoring program was designed to identify and intervene with the 5% of carriers who pose the greatest risk to the public. These carriers appear on the Carrier Services Monitoring Report and are compared with others that have a similar fleet type and fleet range. Carriers on the Monitoring Report are then assigned a monitoring stage of 1 - 4 based on their Risk Factor score. Carriers at monitoring stage 4 represent the greatest risk to the public, however any monitoring stage is considered to be unacceptable. The Alberta government will intervene with carriers on the Monitoring Report in an effort to create positive change within their operation. This may include the suspension or cancellation of the carrier's permit.

3.4.4 Quality assurance and quality control measures

Please refer to Vol. 1 S.1 of this manual for general Quality Assurance and Quality Control measures to be followed.

The typical goal of QA/QC system is to ensure that all monitoring-related data are scientifically sound and of known and documented quality. The implementation of QA/QC procedures into monitoring activities concern the collection and storage of sample materials, analysis of samples, validation of measurements as well as interpretation, reporting and storage of data. This can be achieved through:

- the establishment of standardized procedures,
- adequate documentation,
- and appropriate training of personnel.

The general result of a good QA/QC policy is more trustworthy investigations and data. By this it becomes easier to compare data between studies and to discover real trends of change within the monitoring areas. The monitoring consultant's QA/QC system should be presented in the tender as well as in the final report of the monitoring program, and the industrial operator must before awarding contracts to environmental monitoring work assess the sufficiency of the described quality system. The quality

- The quality system should include:
- verification of sample collection procedures,
- a plan for using reference samples in connection with analyses,
- reviewing the quality of analytical methods and results and performing of quality control of the report.

Optimally, a standard QA-system should be used, for example ISO 9000 or OSPAR (2002-15). Type and frequency of QA inspections of analyses should be presented as part of the method description in the report. Analyses should be verified against reference samples run in the same test series as the real samples. Presentation of results from the reference samples would be a natural part of result interpretation. The suppliers of services for monitoring programmes (analyses, fieldwork) should preferably be accredited (e.g. ISO 17025 or an equivalent) for the methods they use.