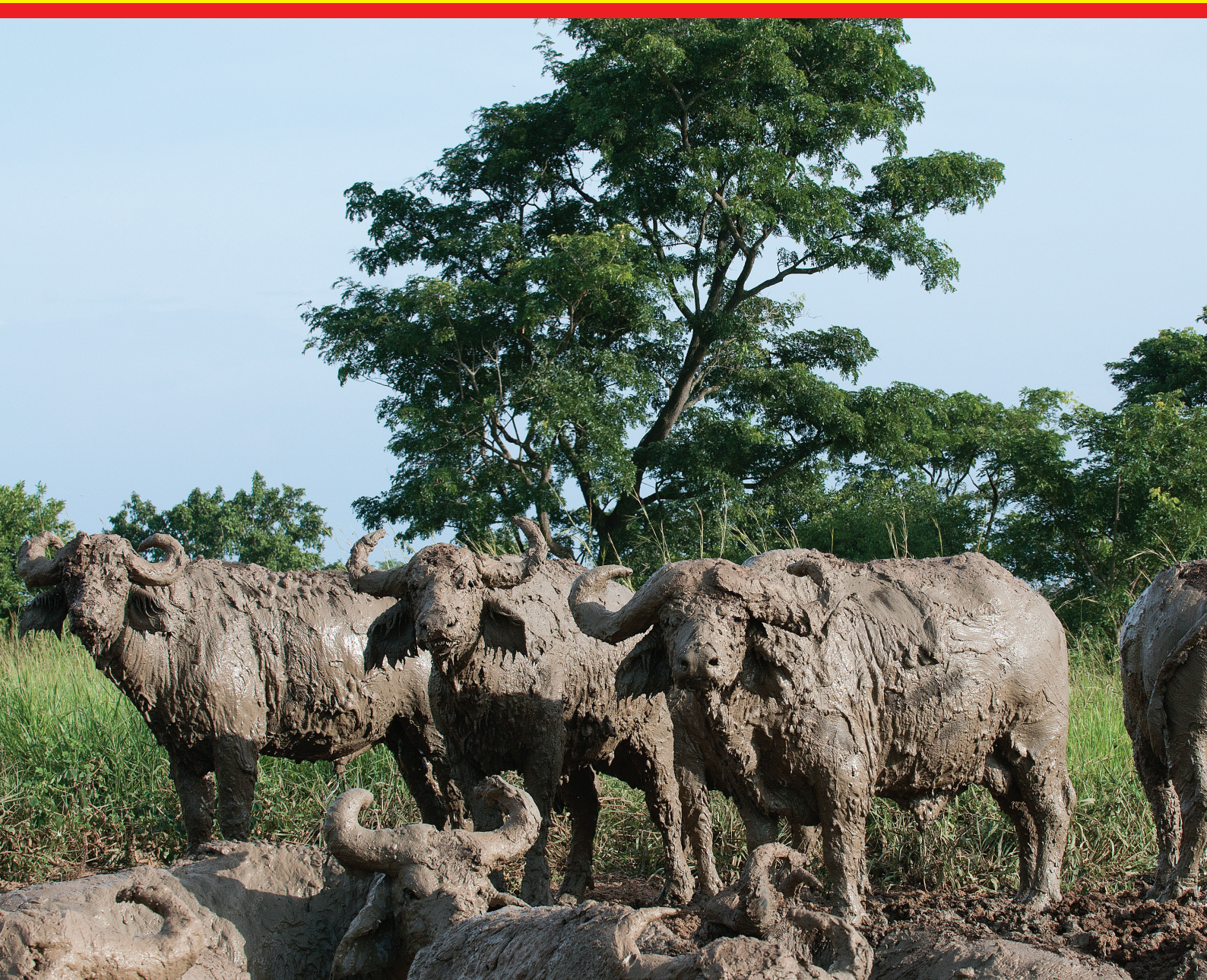
THE REPUBLIC OF UGANDA

MANUAL FOR DATA COLLECTION TO MONITOR ENVIRONMENTAL CHANGES IN THE ALBERTINE GRABEN 2012



MANUAL FOR DATA COLLECTION TO MONITOR ENVIRONMENTAL CHANGES IN THE ALBERTINE GRABEN

2012

ROYAL NORWEGIAN GOVERNMENT

Contents

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CHAPTER 1: BACKGROUND

1.1 Introduction

Discovery of commercially exploitable oil and gas reserves in the Albertine Graben presents both opportunities and challenges to economic development and human prosperity. Oil and gas resources in the Albertine Graben in Uganda overlap with other high value natural resources namely; wildlife, fisheries, wetlands, forests, water and soils which are likely to be negatively impacted upon by development of oil and gas sectors. While petroleum resources are finite and non-renewable; biodiversity assets are renewable and if managed well can continue supporting livelihoods and economic development indefinitely. The Albertine Graben Environmental Monitoring Program AGEMP that was prepared in 2011 with appropriate indicators will ensure that the exploitation of oil and gas does not compromise the integrity of important environmental resources. The monitoring of changes in the Albertine Graben will be done under five main themes namely, Aquatic, terrestrial, Physical and chemical, Society and Business and management. Terrestrial ecosystem includes flagship mammals, flagship birds, floral ecosystems (forests, wetlands and savanna) and below ground biodiversity. The aquatic theme is constituted by fish and wetlands. Business in this region revolves around tourism, agriculture, fisheries, transport, forestry, construction materials and land.

1.2 Objectives

Main objectives of Monitoring is to:

i. Establish a baseline on all the issues of interest in the Albertine region.
ii. Provide information to users on the service level they can expect;
iii. Provide data for an objective evaluation of services and activities;
iv. Provide data to identify problems in the supply chain;
v. Provide data to determine what measures are needed for improving services;
vi. Provide data to understand the need to increase or decrease resources; and
vii.Provide data to define parameters for the periodic review system

CHAPTER 2: AQUATIC THEME

2.1 Valued Ecosystem Component VECs Description

A Valued Ecosystem Component (VEC) is a resource or environmental feature that is important not only economically to a local human population, but has a national or international profile. Under Aquatic theme the prioritized Valued Ecosystem Components (VEC's) to be monitored under the AG EMP are fish and wetlands.

An aquatic ecosystem is a natural water environment in which plants and animals (biotic factors) interact with one another and non living components (abiotic factors) to result into a stable state Aquatic ecosystems can either be marine or freshwater. All aquatic ecosystems in the Albertine Graben are freshwater systems. Aquatic ecosystems are categorized into two environments with regard to the state of water, either as lotic environments – moving water - as in a river or stream or lentic environments - still water- as in lakes and wetlands. There are three zones within both of these environments:

i. Fringing zone – these areas are subject to irregular water cover;
ii. Benthic zone – bottom sediments and rocks; and
iii. Pelagic zone – the main water body.

Fish and wetlands of the Albertine Graben are so adapted to the aquatic environments and colonized all the zones mentioned above that when the natural conditions are altered particularly by human activities, they can be significantly affected. Monitoring the condition of Albertine Graben's aquatic ecosystems is vital for sustainable natural resources management.

2.1.1 Wetlands

The wetlands are very fragile ecosystems that are sensitive to any changes in the environment and therefore their integrity needs to be monitored on a regular basis. The oil and gas developments are likely to disrupt wetland ecosystem functioning thereby causing changes in size, quality and quantity of the physical and biological environment. The indicators that are set to monitor the changes in wetlands include water quality, vegetation cover, acreage, water flow, plant species richness and composition. The main drivers in environmental changes for wetlands related to oil and gas development include waste disposal, water abstraction, physical presence, noise and vibrations, access and foot print.

2.1.2 Fish

Fish in the Graben is found in lakes, rivers and wetlands aquatic systems. Lake Albert is the main water body in the graben and is recognized as an important hotspot for endemic fish species and rich in fish species diversity. Oil and gas development activities could threaten

the level of fish species endemism, biodiversity fish growth and fish production in the Lake Albert. The Sensitivity of fish to oil and gas industry development is associated with high frequency noise from seismic surveys, oil spills and pollution from hydrocarbon compounds and chemicals from mud cuttings which can cause changes in fish habitat conditions. An unpolluted aquatic environment is crucial for fish and other aquatic life. Fish requires good water quality which allows maximum penetration of sunlight, favorable temperatures and pH levels, as well as dissolved oxygen and nutrients in appropriate levels. These conditions support primary aquatic production on which fish is dependent.

2.1.3 Influencing Drivers

Drivers are impact factors or pressures which can affect the ecosystem and/or the society in one way or another. Under Aquatic theme the identified and prioritized drivers are waste disposal, oil spill, physical presence, noise/vibrations, access/foot print and water abstraction.

2.1.4 Parameters to Monitor

2.1.4.1 Wetlands

The parameters to be monitored under wetlands include water quality, vegetation cover, acreage, water flow, plant species richness and composition.

2.1.4.2 Fish

The parameters to be monitored on fish include biological data such as reproductive status, breeding seasons, habitat, diversity index (abundance and species composition), keystone fish species, condition factor, Gonado - Somatic Index (GSI), fecundity, size at first maturity and length frequency distributions of commercial fish species). catch rates (Catch per unit effort - CPUE), fishing effort (number of fishing vessel, number of fishing gears, number of fishers, and number of fish landing sites and socio-economic -facilities therein.

2.1.5 Methodology

2.1.5.1 Catch assessment surveys

Catch Assessment Surveys (CAS) estimate fish landed per fishing unit (Vessel, gear and crew) catch per unit and recorded values can be used to estimate fish production for the entire water body.

The CAS employs a two-stage stratified sampling design. Within each district, a sample of primary sampling units (PSUs – landing sites) is selected, and then, at each PSU, stratified samples of Secondary Sampling Units (SSUs- vessels) are randomly selected by the field enumerator for sampling.

Landing sites (LS) are the primary sampling unit (PSU) where a landing site is defined as

a location where more than 5 vessels routinely land. The vessel-gear type (VG) landing at each site is the secondary sampling unit (SSU).

Sampling Frequency

Randomly selected pairs of consecutive days are sampled monthly during week one and three giving a total of four sampling days per month per quarter. Sampling pairs of consecutive days allows the enumerator to adjust the estimates of the numbers of vessels belonging to each vessel-gear category that have landed during the sampling day but not during the sampling period (i.e. between 18:00 hrs and 24:00 hrs), on the following sampling day. This information should also be sought by the enumerator after the second sampling day. Sampling weeks 1 and 3 takes account of the variability in fishing activities determined by the lunar cycle.

A Sampling Proportion of 30% of the vessels routinely landing at sampled landing sites is applied across vessel types. Catch and Effort data is recorded on CAS Form (**Annex 1)**.

Equipment Required for CAS

GPS, Weighing scales of (100 kg, 20 kg and 1 kg or 1000g spring scales).
Fish weighing baskets, Clipboards, Sharpeners, Erasers.
Pencils, Water proof plastic bags, Data sheets, Measuring tape, at least 15 m long for measuring boat lengths, Basins, Polyethylene sheet, Life jackets, Gumboots, Raincoats, Hand gloves, Overall coats, Caps, Identification tags
Umbrellas

2.1.5.2 Fisheries frame surveys

Fisheries Frame Surveys (FS) are used to generate information required for monitoring changes in fishing effort, fisheries management and planning. It also provides a sampling frame for designing Catch Assessment Surveys (CAS).

Frame Surveys (FS) involve total enumeration (counting) of all fish landing sites number of landing sites and their location, number of fishers, number and types of fishing crafts, size and mode of propulsion, number of fishing gear and types, mode of operation and fish species targeted, Fishing related infrastructure/facilities on fish landing sites (toilets, banda, electricity, potable
water, cold room, fish store, accessibility to all weather road, designated net and boat repair, and pantoon/jetty) and markets.

FS is a step by step process, each step with clear outputs. The key activities undertaken in a fisheries FS cycle are:
National planning meetings, Identification of supervisors and enumerators, Training of

supervisors and enumerators Identification and Procurement of FS Materials, Publicity of the Frame Surveys, Conducting the Frame Survey, data entry and analysis Preparation of FS draft report, Stakeholders' Workshop to review the FS draft report, Finalization of FS report, FS Report Dissemination.

Sampling Frequency

FSs are conducted bi-ennially (after every two years) to track changes in fishing effort and other fisheries socio-economic parameters.

Equipment for Frame Surveys

The key equipment required during FS includes:

Stationery (paper, pencils, markers, and clipboards) Measuring equipment (tape measures), Polythene bags for protecting questionnaire forms, Protective clothing (gumboots, raincoats and umbrellas), Identification tags for supervisors and enumerators, Computers and accessories, GPS devices and binoculars, Whistles, Transport facilities (Water and land – vehicles, boats, outboard engines and life jackets.

Frame Survey data is recorded in FS Form **(Annex 2)**.

2.1.5.3 Bio-Monitoring: Macro-Invertebrates as Indicators Of Water Quality

Benthic macro-invertebrates are frequently used as biological water quality indicators because they are abundant, easier to capture than fish and to identify than either algae or protozoans.

Three separate samples of benthic invertebrates are taken with a Ponar grab sampler at each designated and geo-referenced sample site in the lake. Each sample is processed, preserved and stored separately. Elutriation may be used when the samples contain large amounts of sand, snail shells, or other debris that prevent sediment from quickly passing through a 500-µm mesh. This Standard operating procedure describes a method for collection and preservation of benthic invertebrates and sediment characterization samples from the soft sediment typical of water benthic habitats.

Equipment

i. 2 Full-size Ponar grab samplers.
ii. Elutriator, 500-µm mesh sleeve and deck stand.
iii. 500-µm mesh sieve bucket.
iv. Hose/pump for water supply.
v. Adjustable spray nozzle for hose.
vi. Funnel.
vii. 1-L plastic field sample bottles (3 per site).
viii. 500-mL plastic field sample bottles (1 per site).
ix. Labels and marking pens.

x. Benthos field sheet.

Reagents

i. 37 % Formaldehyde

ii. Rose Bengal stain (powder)

Reagent Preparation

Add approximately 1 g Rose Bengal stain per 20 L of 37% formaldehyde. This can be done prior to arrival at the first site.

2.1.5.4 On-station ponar sampler procedures

a) Sample Collection Sampling and Analytical Procedures

Cock the arms of the Ponar grab sampler to open position and insert the spring loaded safety pin. Lower the Ponar to the sediment surface. The grab sampler should be lowered slowly to within 5 m of the bottom, and then allowed to free fall to the bottom. The jaws will close automatically as the grab sampler is raised from the sediment surface. If the Ponar grab sampler descends too quickly, it creates a “bow wave” that can push animals out from under the sampler, as well as strike the bottom at an improper angle.

However, if it strikes the sediment without enough force, it will not penetrate deep enough for a good sample. Stopping the sampler during the descent may cause the trigger to release. The speed at which it is raised is not as critical as the speed of descent. Empty the grab sampler into a plastic tub.

Rinse the sediment and animals from the top screen and the interior of the Ponar. If the substrate at the site is hard packed clay, sand or bedrock, the grab sampler will come up empty. Because the sample sites were originally located in depositional areas, none of these situations should occur. If these problems do occur, the station should be relocated to deeper water (moving as short a distance as possible, less than 500 feet) and the procedure re-started. If the sediments are fine enough to quickly wash through the mesh, then use the sieve procedure. If the sediment contains rocks, snail shells, or other debris and is too coarse to pass through the mesh easily, it will be necessary to elutriate the sample.

b) Rinsing the Sample

Add water to the sample and mix gently with a spoon to break up lumps of sediment. Pour the sample slurry from the tub through a 500-µm sieve bucket which is placed over a second tub to catch the rinse water. Wash the sediment through the mesh with water at very low pressure. Excessive pressure will result in damage to organisms, in particular oligochaetes (water worms), and will therefore compromise taxonomic analysis of the sample. Gently agitate the sieve bucket to aid in rinsing the fine sediment out of the sample. It may be

necessary to sieve the slurry in small portions to prevent clogging of the mesh. The sample should be rinsed until no more than 750 ml of material is left. In other words, the sample bottle should be less than: full. If there is too much material to reduce to 750 mL, then two sample bottles should be used. The fact that there are two bottles for the sample should be indicated on both the sample bottle labels, and the Benthos Field Collection Worksheet. When rinsing is completed, concentrate the rinsed sample in one corner of the sieve bucket and wash it through a funnel into the sample collection bottle, and begin to process the next sample.

c) Elutriating the Sample

Use the elutriation method only when the sample contains too much large material to wash quickly through a 500-µm mesh sieve. Visually examine the sediments during the elutriation process and note on the field sheet if there are large numbers of live or dead snails shells. Place entire sample in the elutriator, fill it with water, and then gently stir the water and sediment together with your hand. This will suspend the animals and sediment in the elutriator. Agitating the water too vigorously will destroy a large number of animals (soft bodied oligochaetes are most susceptible) and compromise the laboratory results. Stop stirring and let the sample stand for a few seconds. This allows the largest/heaviest sediments to settle and the animals to be poured off with the water. Lift the handle edge of the elutriator and pour the water into the nozzle/net/field sample bottle GENTLY. This rinsing process should be repeated 8 times per sample. Release spent sediments over the side when finished. The efficiency of the elutriator separation step will vary somewhat with the sediment type at the site. The number of times a sample is rinsed will affect the number of animals recovered (more rinses = more animals recovered). All biologists MUST use the same number of rinses during the entire cruise, regardless of sediment type encountered. This means that samples with high percentages of large detritus may not separate well and two bottles per replicate may be needed to preserve the sample. Make sure both bottles are labeled the same and make a note how many bottles were used on the Benthos Field Collection Worksheet.

d) Sample Labeling

Field sample bottles should be labeled with water body name, date, sample site, and sediment type, Depth. Duplicate and triplicate benthos samples are designated by a D and T, respectively.

e) Preservation of Biological Samples

Add 50 to 100 ml of 37% formaldehyde with Rose Bengal to the sample. Top off the sample bottle with tap water. Invert 3 times. The final concentration will be 5 - 10% formaldehyde required for proper fixation and preservation. The higher concentration of formaldehyde should be used if there is more than 500 mL of organic material in the concentrated sample.

Wrap the top of the jar in parafilm to prevent leakage and store the sample in a designated cooler in the walk-in refrigerator.

f) Benthos Field Documentation

Notes should be made in the field log book to indicate any changes to the normal sampling procedure (e.g., more than one bottle used; unusual substrate encountered, etc.). The field technician should also complete the Ponar Grab Data sheet and enter the data into the computer database.

2.1.6 Quality Control

Precision of the sampling process is obtained by having all crew members follow the same steps in the same order during each monitoring field activity. New members or those who have not previously performed the procedures must read a copy of this SOP before embarking on the sampling activity. A copy will also be available whenever a monitoring activity in the field is going on.

The more experienced benthic sampler must closely supervise the new sampler for at least two stations after which the new sampler is expected to perform sampling unsupervised.

Macro invertebrates are identified and enumerated, and the number of organisms at each site is estimated from the average of three same size sample areas. Benthic macro invertebrate densities are reported as the total number of organisms per square meter of stream/lake bottom. In addition to the total number of those organisms, measures of diversity particularly at the taxonomic level of order such as mayflies, stoneflies, beetles, and other organisms should also be noted. The Shannon index and the EPT index measure the diversity and quality of an invertebrate community respectively.

2.1.6.1 Measurement of chlorophyll-a

Chlorophyll is a key biochemical component in the molecular apparatus that is responsible for photosynthesis, the critical process in which the energy from sunlight is used to produce life-sustaining oxygen.

In the photosynthetic reaction below, carbon dioxide is reduced by water, and chlorophyll assists this transfer.

$6\,CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

Chlorophyll is present in water plants mainly algae and some species of bacteria. Chlorophyll gives plants their green color. It exists in many forms coded a, b, c, and d, which augment the overall fluorescent signal. These types of chlorophyll, are present in all photosynthetic organisms but vary in concentrations.

2.1.6.2 The Importance of Chlorophyll as a Water Quality Parameter

The measurement and distribution of microscopic living plant matter commonly referred to as phytoplankton or algae, have been of interest to scientists, researchers, and aquatic resource managers for decades. An understanding of the phytoplankton population and its distribution enables us to draw conclusions about a water body's health, composition, and ecological status. For in-situ monitoring, the measured parameter is the chlorophyll contained within the phytoplankton. Chlorophyll is essential to the existence of phytoplankton. Phytoplankton can be used as an indicator organism for the health of a particular body of water. Monitoring chlorophyll levels is a direct way of tracking algal growth. Surface waters that have high chlorophyll conditions are typically high in nutrients, generally phosphorus and nitrogen. These nutrients cause the algae to grow or bloom. Thus, chlorophyll measurement can be utilized as an indirect indicator of nutrient levels.

2.1.6.3 Reasons to Measure Chlorophyll-a

Measurement of chlorophyll-a can be used for the indirect monitoring and detection of indicator pollutants, including phosphorus and nitrogen and direct measure the amount of phytoplankton in a water body. It is the biggest carbondioxide sink on earth. At NaFIRRI, a spectrophometric method is used to measure Chlorophyll-a.

2.1.6.4 Measurement of Chlorophyll-a

Spectrophotometry is the classical method of determining the quantity of chlorophyll in surface waters. It involves the collection of a fairly large water sample, filtration of the sample to concentrate the chlorophyll-containing organisms, mechanical rupturing of the collected cells, and extraction of the chlorophyll from the disrupted cells into the organic solvent acetone. The extract is then analyzed by either a spectrophotometric method (absorbance or fluorescence).

2.1.6.5 Filtration

A sample of water, using either a hose sampler, some sort of water sampling bottle, or by simply lowering the sample container over the side of the boat is collected. Once the sample is taken, it is usually filtered and preserved until delivered to the laboratory for analysis. An alternative to filtering, preservation, and storage would be to immediately deliver the whole water sample to the laboratory. Herve and Heinonen (1982) suggest that whole-water samples stored at 4oC in the dark can be kept up to 1 day without significant degradation of chlorophyll. Weber et al. (1986) found no change in refrigerated samples over 18 days, but if the samples were left at room temperature (20oC), 50% of the chlorophyll was lost in 5 days.

Filtration is accomplished using a filtration funnel and hand-held suction pump and this allows to filter large amounts of water in a relatively short time. This filtration technique does have the problem that the volunteer must measure the water in a separate, graduated

container and must handle the filter, both before and after the filtration.
Standard Methods (APHA, 1989) recommends an optical density of 0.1 to 1.0 at 664 nm if the trichromatic method is used.

2.1.6.6 Choice of Filters

Three factors have been considered: retention of particles, efficiency of extraction, and cost. Membrane filters such as Millipore HA□ or Gelman□ retain more particles (Lenz and Fritsche, 1980), but are more subject to clogging than are glass fiber filters.
Glass fiber filters have the advantage of being less expensive than membrane filters and, during grinding, the glass fibers aid in the homogenization of cells. The membrane filters can be ground in a tissue grinder, but not as efficiently as glass fiber filters.
Two types of glass fiber filters can be used. They are: Whatman GF/F (median retention size of 0.7 um) and GF/C (median retention size of approx 0.2 um) glass fiber filters. These can measure concentrations ranging from 2 - 175 µg/L. In oligotrophic waters, the choice of filter may be of more concern.

2.1.6.7 Preservation of the Chlorophylls

Once the chlorophylls are on the filter, they become highly susceptible to degradation as the cells die and decompose. They also become increasingly light and temperature labile. Some method must be used to keep the pigments from degrading. The problem is compounded for volunteer programs because the samples have to be transported to the laboratory for analysis. A simple mailing of the samples would be desirable, but there is the real possibility of degradation of the samples during the process.
The simplest method of preservation apparently is to freeze the samples. Several authors report that frozen samples showed no significant degradation even after 6 months (Lenz and Fritsche, 1980). Jones and Lee (1982), however, mention that they have encountered problems with freezing and recommend that samples should not be frozen unless investigation has shown that results from frozen samples are comparable to those from fresh samples. A problem with freezing the filters is that apparently the chlorophyll will begin to degrade as soon as it is unfrozen. This means that the samples must be brought to the laboratory in a frozen state. This would seem to preclude the use of the mails to get the samples to the laboratory if they are not kept frozen during shipment.
Another preservation method is to immediately submerse the filter in the solvent, seal and darken. Apparently the chlorophyll will not degrade as long as it is kept dark. This means, however, that the volunteer would have to be given the solvents and that transportation would have to be of a liquid chemical.
Others have found that as long as the filter is kept dry and in the dark, the chlorophyll will not degrade. More experimentation seems to be necessary before an adequate preservation technique can be recommended.

2.1.6.8 Laboratory Analysis for Chlorophyll

Several methods for chlorophyll analysis are available. The methods are carefully described in Standard Methods (APHA, 1991), and the methods will not be discussed in detail here. However, there is a great deal of confusion about which method should be used in limnological investigations, and this confusion has resulted in a number of different methods being used by various volunteer programs. Unfortunately, although all of these methods report their results as chlorophyll a, there is little evidence that the numbers derived by each method are necessarily similar. Because monitoring programs imply that the numbers generated are accurate as well as precise, the choice of a technique is important. A little background about chlorophyll analysis might help clarify the differences between the various chlorophyll methodologies used.

2.1.6.9 Choice of Solvents

Homogenization by grinding of the filter enhances the rupture of the algal cells and increases extraction efficiency of the solvent. Homogenization is an absolute necessity with an acetone solvent, but some have found that other extractants such as ethanol or methanol apparently do not need grinding to extract all the chlorophyll (Sartory and Grobbelaar, 1984). Others, however, have found that even methanol extractants do not extract as well without grinding. These other solvents are more efficient than acetone at extracting pigments from some green and blue-green algal cells. Methanol, however, is more toxic. Membrane filters can be ground but they lack the abrasiveness to produce a good extraction, and their extraction efficiencies are lowered (Long and Cooke, 1971).

2.1.6.10 Measuring Chlorophyll

$$TotalChlorophyll = 11.0\,(Abs_{665} - Abs_{750})\,\frac{v}{Vp}$$

where V is the volume filtered (L), v is the volume of extract (ml), and p is the path length (cm). Using values for total chlorophyll pigments rather than either the trichromatic equations or the acid-corrected equations gets around the problem of interference by ignoring it. It is simply a measure of absorbance at 665 nm.

The YSI 6025 chlorophyll sensor is designed for these in-situ applications, and its use allows the facile collection of large quantities of chlorophyll data in either spot sampling or continuous monitoring applications. It is important to remember, however, that the results of in-situ analysis will not be as accurate as results from the certified extractive analysis procedure. The limitations of the in-situ method should be carefully considered before making chlorophyll determinations with the YSI sonde and sensor. Some sources of inaccuracy can be minimized by combining extractive analysis of a few samples during a sampling or monitoring study with the YSI sensor data. The in-situ studies will never replace the standard procedure. The estimates of chlorophyll concentration from the easy-to-use YSI chlorophyll system are designed to complement the more accurate, but more difficult to obtain, results

from more traditional methods of chlorophyll determination.

2.1.6.11 Gillnet SOPs for obtaining indicators on the status of fish

Gillnets are well suited to sampling and monitoring the near-shore fish biota of Lake habitats. The SOPs describe procedures for the standardized design and implementation of gillnet surveys for various purposes on Lake Albert. They are intended to enable the standard application of survey and sampling methodologies across the lake. Gillnets have the potential to be used widely for inshore monitoring of parameters and information is of great value to the management of the lake fishery resources. However, to maximize the potential utility of the data collected by gillnet surveys, it is important to develop standard procedures that can be applied lake-wide.

2.1.6.12 Biological Sampling of fish

Biological sampling and analysis of resulting data provides biological and ecological information on fish species present in the lake and their habitats. There is a need to monitor trends in the biological parameters of fish stocks and examine factors influencing these trends, and to predict responses in fish populations to human interventions (fishing and non-fishing) and natural environmental change. Biological studies are the fundamental way of understanding the behavior of the individual species in the lake, the relationships between them and the environment in which they live. Biological information can be “absolute” in that it defines the characteristics of the species and “relative” in that changes in these characteristics are indicators of something happening in the lake either man made (pollution, overfishing etc) or natural (climatic; global warming, El Nino etc.).

Biological information on the fish, such as length frequency distributions, length-weight data and maturity stages provide data from which to indicators parameters like Condition Factor, Size at First Maturity can be derived. These parameters are used to assess the status of the stocks and to develop target and limit reference points for management. In addition, biological data can be used directly, in a precautionary sense, to indicate changes in fish populations that are indicative of overfishing, thereby prompting management action in advance of more complete information on the status of the stocks.

Table Regular sampling surveys

Output / Status **Indicators**	Gillnet survey 1: Multimesh in shallow water for species composition	Gillnet survey 2: Standardised CPUE as an abundance index
Species composition	Provides a good coverage of species with wide range of mesh size	Limited by narrow mesh size range
Diversity indices	Can be calculated from catch composition to indicate fish species diversity in near shore; survey undertaken regularly will show changes	Of limited value for studying biodiversity; aimed mainly at commercial fish stocks
Distribution and abundance of fishes	Provides good coverage of species distribution in shallow water and may support analyses of relative abundance, but catches per mesh size will be small	Provides an index of abundance of species within the range of selection.
Length frequency distributions	Will provide data on length distributions over a wide range of fish sizes and changes over time. Larger specimens of Nile perch may be underrepresented.	Will provide data on length distributions over a restricted range of fish sizes (similar to the commercial fishery) and changes over time.
Length at first maturity	Growth parameters derived from length distributions are an important pointer of how a fisheries is fairing either as stressed or healthy	Growth parameters derived from length distributions are an important
Length-weight relationships and **condition factor**	Will provide data for estimating length-weight and changes in condition factor over time. Length-weight is an important input into population models to provide outputs in catch limits by weight. Condition factor is an important indicator of the well-being of the fish (e.g. indicating food availability).	Will provide data for estimating length-weight and changes in condition factor over time, but size range of fish in samples will be limited. Length-weight is an important input into population models to provide outputs in catch limits by weight. Condition factor is an important indicator of the well-being of the fish (e.g. indicating food availability).
Reproductive biology: maturity Ogive, **Lm50, fecundity, sex ratios,** **GSI** etc.	Will provide an opportunity to collect maturity data by size across a range of sizes and species and also show changes over time. Sample sizes may be small.	

2.1.6.13 Regular monitoring: Rationale

Regular monitoring using gillnets can be used to collect data that address the following **Objectives**

1. Development of a fishery independent abundance index for key commercial species in the near-shore portion of the lake
2. Development of a time series of indicators of the composition and status of the near shore fish biota.
3. Provision of biological data inputs from the near-shore area for stock assessment of key commercial fish species on the lake.

All of these objectives can be achieved through a programme of constructing, setting and hauling gillnets in a standard way. Where they vary is in the sampling of the catch as the nets are hauled and in the subsequent treatment and analysis of the catch post sampling.

2.1.6.14 Construction of net fleets for regular monitoring

Regular sampling will be undertaken using a combination of multimesh fleets and fleets with a more restricted range of mesh sizes (called the “CPUE” fleet). There are two methods of fishing stations with passive gears such as gillnets: long-chain setting, where an extensive length of gillnets is set in a single continuous row and shortchain settings, where the gear is set as several relatively short chains (Hovgård and Lassen 2000). The former gives fewer replicates of larger sample size, whereas the latter gives more replicates of smaller sample size. One important factor in deciding on the size of the gillnet fleets to be used is the expected catch. It is important that the catches are large enough so that variations in cpue are detectable and also to provide enough specimens for biological sampling. Expected catch per net for gillnets suggest that the best approach would be to use long chain setting.

Table Characteristics of the gillnet fleets for regular monitoring

Fleet Characteristic	Multimesh fleet			
Colour of netting	Depends what is available from manufacturers, but needs to be standardized			
Hanging ratio	60%			
Mesh sizes (stretched mesh)	Mm	inches	**Ply**	**Number**
	25	1.0	3	2
	38.1	1.5	3	2
	50.8	2.0	3	2
	63.5	2.5	3	2
	76.2	3.0	3	2
	88.9	3.5	3	2
	101.6	4.0	6	2
	114.3	4.5	6	2
	127.0	5.0	6	2
	139.7	5.5	6	2
	152.4	6.0	15	2
	177.8	7.0	15	2
	203.2	8.0	15	2
	228.6	9.0	15	2
	254.0	10.0	15	2
Dimensions of each panel	Length: 54m Depth: 5m or less according to depth of sampling station			
Floats	one mounted every 3 meters			

The color of gillnets may be an important factor because of variable water clarity across the lake. The color will depend on what is available, but it should be standardized across the lake, and should be recorded as part of the survey. The 60% hanging ratio is the same as that currently used by fishermen and one used during previous gill net surveys.

2.1.7 Experimental design

2.1.7.1 Stratification

The regular surveys will be carried out to monitor species diversity, length distributions and relative abundance (CPUE) of major commercial fish species and biological characteristics of the catches of these species, and provide some measures of the precision of these estimates. The common approach to this type of sampling is stratification; i.e. to divide the total survey area into strata with common features regarding the species composition and their densities and age structures (Hovgård and Lassen 2000). Strata should be selected so as to give low variability within strata and clear differences between strata, thereby increasing the precision of the estimates (Cochran 1977). It is also important not to identify too many strata as this creates a large number of potential interactions, all of which would need to be sampled. The most efficient approach is to identify the major sources of variation in the variables being measured (for example CPUE) and base the sampling strata on

these. Other factors that may influence the variables in some way are then recorded in the data collection and used as co-variates in subsequent data analysis. The degree to which appropriate strata can be identified and an efficient allocation of sampling effort between strata can be achieved from the start depends greatly on the availability of knowledge a priori on the variables of interest. If there is little information available, it is necessary to use an adaptive sampling approach such that strata and stations are distributed more or less evenly throughout the survey area and the design is modified as information becomes available on the metrics of interest. Within each stratum the allocated stations are distributed randomly.

Table Lists of variables that have been identified as being potentially important for regular monitoring of stock status indicators.

Stratum type	**Strata**	**Details of relevance to regular monitoring using gillnets**
Temporal	Phases of the moon	Dark Moon, First quarter, Full Moon, Last quarter
	Seasons	The year is divided into dry and rainy seasons. It is possible to identify four seasons: e.g. Long dry season (1 December to 15 March; Main rainy season (16 March to 30 June); Short cool dry season (1 July to 15 September); Short rainy season (16 September to 30 November) (Balirwa, J. S. 1998. Lake Victoria wetlands and the ecology of the Nile Tilapia, *Oreochromis niloticus* Linné Phd Dissertation, Wageningen.
Spatial	Distance from shore	Multimesh fleets at intervals of 100m from shore
	Distance around the lake	It is expected that the abundance and composition of the near-shore fish fauna will vary around the lake, but there is little information available regarding the spatial scale of this variation. Sampling stations should be evenly spread around the lake until information is available to suggest a more efficient distribution. The zonation of the lake used will be Butiaba-Kaiso (Northern), Kaiso-Sebagolo (Central), Sebagolo-Ntoroko (Southern)
	Ecological habitat types	e.g. lagoons, sandy/muddy areas, rocky areas, shorelines with marginal macrophytes, river mouth, open shore, open water
Depth	Depth ranges	0-5m

2.1.7.2 Sampling capacity

An important consideration in the development of a sampling design is the amount of sampling that can reasonably be expected to be achievable in space and time with the available human and institutional resources; i.e. what is the likely maximum number of stations that can be sampled? This is an important constraint on what can be done and may preclude complex statistical designs (e.g. many strata) from the outset. The important capacity constraints for the gillnet surveys are set out below.

It is expected that a sampling team of about 4 to 6 people, capable of undertaking a single sampling trip of approximately eight days per month. Eight days should be sufficient to sample three sites with four gillnet fleets being fished at each site. Wherever possible, each site will be sampled twice – on two consecutive nights.

2.1.7.3 Sampling at each site

A sampling site will consist of four fleets of gillnets set parallel to the shoreline. There will be three multimesh fleets and one CPUE fleet. The fleets will be set at the following intervals from the shore:

Fleet	Location relative to shore
Multimesh 1	0-100 metres (as close to the shore as practicable)
Multimesh 2	100-200 metres (approximately 100 metres offshore of multimesh 1)
Multimesh 3	200-300 metres (approximately 100 metres offshore of multimesh 2)
Multmesh 4	500-1000 metres

Nets will be set in the evening and retrieved the following morning. Catch per net panel is expected to be in the region of 0 to 10 fish, giving a total catch in the range 0 to 300 fish per fleet per night.

2.1.7.4 Sampling frequency

One zone will be sampled each month over a period of three months, starting with the northern zone in the first month and continuing with the central in the second and the Southern in the third month. When completed, the cycle repeats, returning to the first Northern zone in the fourth month, the central zone in the fifth and so-on. The three sites within a zone will be sampled in one trip due to transport logistics. Due to logistics, it is unlikely to be possible to randomly spread the sampling days within the month. This is not necessarily a problem for the survey design, but it will need to be evaluated after an initial period of sampling. The particular issue is how well the sampling covers the phases of the moon (which will be recorded as a variable in the survey). Depending on the results of an analysis of data from an initial period (say, 1 year of data), it may become necessary (for example) to randomise the day in the month when the 6-8 day sampling trip starts.

2.1.7.5 Sampling with respect to the variables

The sampling scheme set out above means that every zone should be sampled in every season at some stage. Phases of the moon should be well covered by the random start times of the sampling period in each month. This scheme should provide coverage of a range of habitat types spread around the lake, however habitat type should not be one of the criteria used in the selection of sites suitable for sampling.

2.1.8 Data Handling

Data handling covers the processes of data entry, storage and retrieval

2.1.8.1 Data entry

All data from gillnet surveys should be entered into a purpose designed database as soon as possible after the conclusion of the experiment. Data entry is the process of transferring data the paper data sheets to an electronic database. Care should be taken to type the correct entries as the transfer is taking place. A data entry process should be designed that checks data on entry and/or upload and traps errors in data entry so they can be rectified prior to entering the main database.

2.1.8.2 Software for data entry and storage

A standard relational table structure for the database should be based on the design of the record sheets in Appendix 1. Researchers should avoid storing data in free-format Spread sheets as this is does not ensure long term data security. Common commercial database software such as Microsoft Access is suitable for this purpose. It is possible to design convenient data entry and upload procedures using
spreadsheets (e.g. Microsoft Excel), providing a familiar environment for researchers who are comfortable with this software platform, but spreadsheets are not a good solution for long term data storage or powerful statistical analyses. Range checks will be included either in primary data entry procedures or in data upload procedures. For example, when entering length data, routines will be included to validate the range of lengths that are acceptable within the range of the data.

2.1.8.3 Data retrieval: ownership and sharing

The data resulting from these surveys are the property of EIN, but should be made available to all researchers through a clearly defined data access policy. Data should be stored as paper copy deposited for storage with EIN, and on appropriate electronic media. Raw data should be stored at EIN and NaFIRRI in electronic format. The electronic database system should be designed to allow ready access to data by authorised persons to as to allow timely analysis or integrated datasets from across the graben.

2.1.9 Data Analysis and Reporting

2.1.9.1 Routine data reports

Routine data reports should be submitted for every survey summarizing:

i. sampling station characteristics (location,

ii. Total catch by species (weight and number) per net

iii. Catch per unit effort by species and in total (net)

iv. Length frequency of selected species (e.g. Nile perch and Nile tilapia)

v. spatial distribution of catches

vi. Condition factor

vii. Reproductive characteristics (sex ratios, maturity stage, GSI, fecundity)

Catch Per Unit Effort (CPUE) can be calculated in a number of ways. The most basic measures sometimes used for characterising the CPUE of the commercial fleet are catch per day or catch per boat. The measurement of CPUE for the gillnet survey, however, needs to be more precise than this. Several different measures will need to be investigated to see which is the most useful as an index of abundance. The most important condition is that the survey is carried our in a standard and systematic way so that as much of the variability observed between stations as possible can be attributed to changes in the abundance of fish, rather than to differences in construction and operation of the gear . With the data being collected during the survey it will be possible to calculate the catch per net panel within the fleet, and it should even be possible to trace a particular catch back to the panel from which it came. The physical dimensions of the panels will provide details on the dimensions of the panel and the size and hanging ratio of the meshes in the panel, therefore allowing calculation of the exact number of meshes in the panel, which is the most basic measure of fishing effort for a gillnet.

Biological data are recorded in Forms 1.1 – 1.5

CHAPTER 3: TERRESTRIAL ECOSYSTEMS

3.1 Flagship mammals

3.1.1 VEC description

Amongst the many species that are present in the Albertine Graben, four mammal species have been selected to be monitored. These include elephants, lions, Uganda kobs and small mammals. Elephants have been specifically selected because of their sensitivity to noise and vibrations caused by seismic surveys, drilling activities and transport. Lions were selected because of their tourism value, high sensitivity to light due to various oil and gas related activities that are carried out at night and their position in the food chain. The Uganda kobs were selected due to their high sensitivity to changes in an ecosystem which leads to their failure to breed.

3.1.2 Influencing drivers

Various drivers were identified during the scoping process. The prioritised ones include infrastructure, hazardous waste, poaching, human influx and vehicle traffic.

Table 3.1: Drivers of change in mammal population, diversity and health selected for monitoring

Table 3.1: Drivers of change in mammal population, diversity and health selected for monitoring

Drivers	Description of potential impact
Infrastructure (roads, seismic lines, camps, drill sites, airstrip)	Infrastructural development fragments wildlife habitats that interrupts migration patterns, increasing human-wildlife conflicts, animal stress, inbreeding and other behavioral changes that eventually lead to reduced wildlife productivity infrastructure
Hazardous waste	Mammals can be affected by hazardous waste through food chain. Plants accumulate heavy metals from the environment and the plants are eaten by herbivores which are in turn preyed by carnivorous mammals
Poaching	Poaching reduces animal populations and may cause species extinctions
Human Influx	Human influx increases human-wildlife conflicts, poaching and illegal trade in wildlife and wildlife products People have bought land around several petroleum development areas prospecting to be compensated at the time of petroleum production. Many people come to the petroleum areas seeking for gainful employment.
Vehicle traffic	Increases in vehicular traffic lead to increased wildlife kills and injury which affects animal behavior, ranging pattern and population

3.1.3 Methodology

Table 3.2: Parameters of each drivers of change that will be monitored in relation to mammals

Driver	Parameters to be monitored
Infrastructure	Mammal numbers and diversity, mammal ranges (area), infrastructure density, traffic volumes, Animal injuries and kills NB: Gene diversity and stress hormones should not be done frequently since they are intrusive on wildlife freedom
Hazardous waste	Number of spill incidences, heavy metal levels in the food chain, presence and level of heavy metals in water and soils
Poaching	Number and location of snares, poached animals, apprehended poachers, number of public awareness meetings
Human influx	Human and animal (livestock) demography (population, density, distribution, sex, age), , number of human-wildlife conflicts reported, Incidences of human and animal injuries or death, crop raids and animal poisoning
Vehicle Traffic	Number of animal kills or injuries, vehicle count, stress hormone levels should not be done frequently since they are intrusive on wildlife freedom
Noise and vibrations	Mammal behaviour Mammal movement

3.1.3.1 Geo-spatial design

Mammal surveys

Here both aerial survey and ground counts are carried out. Method used is based on the terrain of the landscape and the visibility of the desired species

Aerial surveys

For Systematic Reconnaissance Flights (SRF), grids/subunits of 2.5km X 2.5km will be used
For Total counts, transects of 1km X 1km will be used.
For Ground counts in savannah PAs, systematic segmented trackline sampling done using DISTANCE software will be carried out.
Ground counts in Forested PAs and Forest Reserves
A similar spatial design is used for mammals, birds and plants. Plot data for the three categories shares the center point of the plot.
i) Area to be surveyed is divided into blocks
ii) Transect lines are placed at regular intervals to cover the block
iii) Nested plots are placed at regular intervals along each transect
iv) Distance between transects – 500M.
v) Distance between plots – 250M. The size of the block will determine the number of transects that can be laid.

vi) Plot laying starts at point zero (0), which is an area outside the area of interest. A transect should have at least 10 plots.

3.1.3.2 Sampling design

Mammal numbers, diversity and range

Data collection within protected areas will be carried out periodically (every 2 years) while outside protected areas it should be collected according to need. Data collection on mammals will be by aerial surveys and ground counts. Aerial surveys will involve systematic reconnaissance flights along transects at 2.5 x 2.5km, and when funds are available, intensive data collection will be carried out. In this case, total aerial count will be done at 1km x 1km interval.

During ground counts, data will be collected within plots along a transect. Sampling intervals will be determined based on the dominant vegetation type found in the landscape. Distances between plots will range from 250m in closed tropical high forest to 1Km in open savannah landscapes. Plot size of 40m radius will be used. Outside protected areas, data will be collected along transects at intervals of 1 Km. However for lions, lure count method will be used to determine the lion population numbers.

For mammal ranges, data will be obtained from radio collared animals and using the camera traps for the shy animals.

Tissue sampling - Random sampling

Blood- random sampling

Ground counts in Forested Parks and Forest Reserves

For mammals, data is collected on several variables i.e. live mammals, dung and footprints. These counts are carried out all along the transect. For chimps, nest counts are carried out. The chimp nest count has to be done 3 times at the interval of 3 weeks between the count dates. This is to account for chimps that could have been missed in the previous counts.

3.1.4 Drivers

Table 3.3: Drivers of change that will be monitored and their respective variables that will be measured

Driver	How to measure
Infrastructure	Count and record the location and spatial extent of the various infrastructure facilities.
Hazardous waste and oil spills	Count and record the number of spill incidences An inventory of animal species that visit the waste pits will be carried out. Species occurring in the area and the abundance of each species will be recorded. In order to determine the level of waste contamination in the animals, tissue samples will be collected from selected species. water and soils sampling and analysis (transfer to physical)
Poaching	The current RBDC will be used to determine the number and location of snares as well as the different species poached. The number of apprehended poachers will be obtained from records of the courts of law. Public awareness among the surrounding communities around Protected Areas (PA) is an ongoing process, so records of these meetings will be extracted from the Protected Area management data. Where they do not exist, a system will be set up to start keeping such records.
Human influx	Count and record Incidences of human and animal injuries or death, crop raids and animal poisoning to determine the trend. Population census – human and animal, *(data will be collected under the society theme)* Livestock census *(data will be collected under the society theme)* Every 3 years a census will be conducted to determine number, density, distribution, sex, and age of the people living on the landscape. *(data will be collected under the society theme)*
Vehicle Traffic	Count and record number of vehicles passing specific roads or aeroplanes landing or taking off from a specific airstrip carried out for a specified period. Blood and tissue sampling/analysis
Noise and vibrations	Measure and record noise levels Measure and record vibrations
Domestic waste	Count and record number and species of animals, which visit the waste pits where food remains, are deposited. Sample and analyze animal tissues from selected species in order to determine the level of waste contamination. Assess Waste composition at waste disposal sites
Animal kills	Count and record number of species of animals killed along the road, drowned in the waste pits and those that may have massively died due to consumption of contaminated food will be collected. Sample and analyze animal tissues from selected species in order to determine the level of waste contamination in animals
Incidences of fires	Count and record fire incidences and sources. Measure and record extent of coverage and damage

Table 3.4: Description of the sampling gear/equipment required to measure the identified parameters for each driver of change

Driver	Priority indicators / parameters	Equipment/consumables
Infrastructure	Mammal numbers and diversity, mammal ranges (area), infrastructure density, traffic volumes, Animal injuries and kills	**Aerial surveys** Aircraft, GPS, digital cameras, streamers, tape recorders, **Ground counts** Vehicles Camera traps, GPSs, range finders, radio/ GPS collars and transmitters, Yagi antenna (animal tracer) **Infrastructure** GPSs, GIS/Remote Sensing software Computers **Traffic volumes** Numatic road tube (counter) **Animal injuries and kills** Gloves, dart gun, vehicles, mobile animal clinic, drugs
Hazardous waste	Number of spill incidences, heavy metal levels in the food chain, presence and level of heavy metals in water and soils (data to be collected under the physical chemical theme)	Mobile lab, gloves, apparatus, coolers, reagents, dart gun, tissue samplers,
Poaching	Number and location of snares, poached animals, apprehended poachers, number of public awareness meetings	GPSs, vehicles, camping gears (tents, sleeping bags) , food ration, water bottles
Human influx	Human and animal demography (population, density, distribution, sex, age)- data will be collected under the society theme Number of human-wildlife conflicts reported, Incidences of human and animal injuries or death, crop raids and animal poisoning	GPSs, vehicles, camera **Animal injuries and kills** Gloves, dart gun, vehicles, mobile animal clinic, drugs
Vehicle Traffic	Number of animal kills or injuries, vehicle count, stress hormone levels	**Animal injuries and kills** Gloves, dart gun, vehicles, mobile animal clinic, drugs
Noise and vibrations		Sound level meter, vibration meter/analyser(Richter scale)-static and mobile (data to be collected under the physical chemical theme)

3.1.5 Nomenclature/classification code list

Flagship Mammals

a) Elephants (Loxodonta africana)

b) Lions (Panthera leo)

c) Uganda kobs (Kobus kob)

d) Small mammals

3.1.6 Numerical and statistical analysis

3.1.6.1 Analysis methods

Animals: To generate the required information, collected data will be analyzed using standard data analysis methodologies e.g. biodiversity indices and total species counts used for species richness. Baseline data will be compared with data obtained during or after a specific activity. In addition to analysis of species variation, analysis of the impacts of the drivers of change on species will also be carried out.

3.1.6.2 Analysis of drivers of change

Infrastructure: With the availability of spatial layers of infrastructure coverage and the total area of the landscape, infrastructural density will be calculated using Geographic Information System (GIS).

Traffic volumes: The total number of vehicles counted after the determined period will be analyzed for an average number of vehicles per day. This will be related to the animal injuries or kills counted within the same period. The results obtained will provide a basis on how responsible institutions will guide the oil companies on the best way to reduce or manage traffic in order to minimize its impact on wildlife.

Number of spill incidences: analyze spill incidence records obtained from companies and protected area management to generate information on spill occurrence variation over specific periods.

Heavy metal levels in the food chain: Laboratory analysis of tissue samples will be carried out to determine the level of waste contamination in the animals. Information obtained will be compared with the standard minimum levels of the different heavy metals.

Number and location of snares, and poached animals: MIST and other analysis methods will be used for processing the RBDC data to determine the number and location of snares as well as the different species poached over a specific period.

Apprehended poachers: The number of apprehended poachers will be analyzed using standard statistical methods to obtain information on variation in number of poachers over

the determined period.
Number of public awareness meetings: For every area where awareness meetings have taken place, analysis of the impact of these meetings will be carried out.

Human demography: The census data will be analyzed using standard statistical analysis methods to determine population density, distribution and age segments. This will be done to identify variation in levels of human influx.

Number of human-wildlife conflicts reported: Incidences of human and animal injuries or death, crop raids, property destruction and animal poisoning will be analyzed using standard statistical tools.

Incidences of fire: Oil related fire incidence data will be analyzed and results compared to fire from other sources over the same period.

3.1.6.2 Monitoring of change

Mammals: Data collected in the subsequent phases will be analyzed using standard analysis methods and then compared to the previous data. Changes in areas where petroleum activities have taken place will be compared to those where there have not been any activities in order to establish the actual impact of the activities.

Infrastructure: Any added infrastructural layers over the period since the last data collection will be added to the already existing spatial layers of infrastructure. Infrastructure density analysis will then be calculated using GIS. The current infrastructure density will be compared to the density at the earlier date of analysis to obtain an estimate of infrastructure change over the area.

Traffic volumes: Roads where counts were made in the previous study will be revisited and vehicles counted. This should be either during the same season or when a similar activity is taking place. Data obtained will be analyzed and compared with the information of the previous survey. For the new roads that have been constructed since the last survey, a few will be selected for traffic volume survey.

Hazardous waste

Number of spill incidences and heavy metal levels in the food chain: Data obtained during this phase will be analyzed using the same standard methods and compared to the previous information.

Poaching

Number and location of snares, and poached animals: Data collected after the earlier survey

will be analyzed using MIST and other analysis methods and it will be compared to the results obtained from the earlier survey.

Apprehended poachers: Data collected will be analyzed and compared to information obtained from the previous survey.

Number of public awareness meetings: Current awareness impact levels will be compared to impact levels obtained in the previous survey.

For the rest of the indicators, obtained data in the subsequent surveys will be analyzed and compared to results obtained from the earlier survey analysis. Similar survey methods as used for each variable in the earlier surveys will be employed.

Relationships between change in animal numbers and change in driver variables will also be explored to identify possible impacts of the drivers on the animals.

3.2 Flagship birds

3.2.1 VEC description

The Albertine rift has 52% of all African bird species (1061 species). Of these, 25 birds species are considered highly threatened by extinction (Critically Endangered, Endangered or Vulnerable as classified by IUCN criteria). So far 41 endemic bird species have been identified in the region. Amongst the many species that are present in the Albertine Graben, five bird species/species groups have been selected to be monitored. These include African fish eagle, Crested crane, vultures, green breasted pitta and migratory birds. These bird species have been selected because they are sensitive to changes in the environment

3.2.2 Influencing drivers

Table 3.5: Drivers of change of birds population, diversity and health and a description of how their change may affect the birds species

Drivers	Description of potential impact
Infrastructure (roads, seismic lines, camps, drill sites, airstrip)	Infrastructural development fragments wildlife habitats that interrupts migration patterns, increasing human-wildlife conflicts, animal stress, inbreeding and other behavioral changes that eventually lead to reduced wildlife productivity infrastructure
Hazardous waste	Mammals can be affected by hazardous waste through food chain. Plants accumulate heavy metals from the environment and the plants are eaten by herbivores which are in turn preyed by carnivorous mammals
Poaching	Poaching reduces animal populations and may cause species extinctions
Human Influx	Human influx increases human-wildlife conflicts, poaching and illegal trade in wildlife and wildlife products People have bought land around several petroleum development areas prospecting to be compensated at the time of petroleum production. Many people come to the petroleum areas seeking for gainful employment.
Vehicle traffic	Increases in vehicular traffic lead to increased wildlife kills and injury which affects animal behavior, ranging pattern and population

3.2.3 Methodology

Parameters to monitor

Figure 3.6: Parameters that will be monitored in order to assess impact of oil and gas developments on birds

VECS	Driver	Priority indicators /parameters
Flagship birds (e.g. African fish eagle, vultures, forest birds, shoe bill etc.)	Infrastructure (plus refinery and power plants).	Birds numbers, diversity and range, infrastructure coverage and density, land cover change Gene diversity, stress hormone levels, Noise levels, light intensity, migratory patterns
	Hazardous waste and Oil spills	Number of spill incidences, Bird kills, Air quality, presence and level of heavy metals in water and soils, Incidences of fire
	Domestic Waste	Population, diversity, density, distribution, disease among birds communities

3.2.3.1 Geo-spatial design

a) Area to be surveyed is divided into blocks

b) Transect lines are placed at regular intervals to cover the entire block

c) Plots are placed at regular intervals along each transect

d) Distance between transects – 500M.

e) Distance between plots – 250M.

f) The size of the block will determine the number of transects

g) Plot laying starts at point zero (0), which is an area outside the area of interest. A transect should have at least 10 plots.

h) Ground counts- systematic segmented trackline sampling will be done using DISTANCE software

i) Tissue sampling - Random sampling

j) Blood- random sampling

k) Timers (timed counts)

3.2.3.2 Sampling design

Bird numbers, diversity and range

Every two years, data collection will be undertaken. Bird species diversity will be monitored using field surveys. Priority areas of focus will be the protected areas (UWA PAs and Forest Reserves). Other areas of interest will be relatively undisturbed areas outside protected areas e.g. local forests and wetlands.

Plots will be laid out based on the geo-spatial design indicated above. At each point, a plot of 10 cm radius will be laid out. The enumerators will take 10 minutes at each plot (5 minutes for settling down, 5 minutes for recording both observed birds and recognizable bird calls). In addition, birds observed along the transect as one moves from one plot to another will also be recorded. Also, the permanent plots in the Graben will be monitored regularly according to the established pattern.

3.2.3.4 Drivers

Table 3.7: Methods of obtaining information about each driver of change

Driver	How to measure
Infrastructure	Count and record the location and spatial extent of the various infrastructure facilities.
Hazardous waste and oil spills	Count and record the number of spill incidences An inventory of bird species and total individuals that visit the waste pits will be carried out. Species occurring in the area and the abundance of each species will be recorded. In order to determine the level of waste contamination in the birds, tissue samples will be collected from selected species. Water and soils sampling and analysis (*data to be collected under the physical chemical theme*)
Domestic waste	Count and record number and species of birds, which visit the waste pits where food remains are deposited. Sample and analyse bird tissues from selected species in order to determine the level of waste contamination. Assess Waste composition at waste disposal sites
Incidences of fires	Count and record fire incidences and sources. Measure and record extent of coverage and damage

Table 3.8: Description of sampling gear/equipment to be used to during the monitoring of birds species and the associated drivers of change.

Driver	Priority indicators /parameters	Equipment/consumables
Infrastructure (plus Refinery and power plants)	Birds numbers, diversity and range, infrastructure coverage and density, land cover change	**Ground counts** Vehicles, GPSs, range finders, binoculars, radio/GPS collars and transmitters, tape recorders **Infrastructure** GPSs, GIS and Remote Sensing software Computers
Hazardous waste and Oil spills	Number of spill incidences, Bird kills, Air quality, presence and level of heavy metals in water and soils, Incidences of fire	Mobile lab, gloves, apparatus, coolers, reagents, dart gun, tissue samplers,
Domestic Waste	population, diversity, density, disease among birds communities	Mobile lab, gloves, apparatus, coolers, reagents, dart gun, tissue samplers,
Fire incidences	Number of incidences, area covered and extent of damage.	GPSs, fire watch towers, GIS and Remote Sensing software, Computers, fire fighting equipment including aircraft.

3.2.3.5 Nomenclature/classification code list

Table 3.9: List of Flagship Birds that will be monitored.

Common Name	Scientific Name
African Fish Eagle	*Haliaeetus vocifer*
Grey Crowned Crane	*Balearica regulorum*
Vultures: • White Barked Vulture • Lappet-faced Vulture • Ruppels Vulture	 • *Gyps africanus* • *Aegypius tracheliotus* • *Gyps rueppellii*
Green Breasted Pitta	*Pitta reichenowi*
Migratory birds: • Yellow wagtail • Barn swallows • Abdim's stork	 • *Motacilla flava* • *Hirundo rustica* • *Ciconia abdimii*

3.2.3.6 Numerical and statistical analysis

Analysis methods

Birds: To generate the required information, collected data will be analyzed using standard data analysis methodologies e.g. biodiversity indices and total species counts used for species richness. Baseline data will be compared with data obtained during or after a specific activity. In addition to analysis of species variation, analysis of the impacts of the drivers of change on species will also be carried out.

Analysis of drivers of change

Infrastructure: With the availability of spatial layers of infrastructure coverage and the area of the landscape, infrastructural density will be calculated using Geographic Information System (GIS).

Number of spill incidences: Analysis of oil spill incidence records obtained from companies and protected area management will be carried out to generate information on spill occurrence variation over specific periods and the spatial area affected.

Heavy metal levels in the food chain: Laboratory analysis of tissue samples will be carried out to determine the level of waste contamination in the animals. Information obtained will be compared with the standard minimum levels of the different heavy metals.

Incidences of fire: Oil related fire incidence data will be analyzed and results compared to fire from other sources over the same period and fires in the periods when there were no oil and gas activities.

Monitoring change in birds diversity, abundance and health, and change in drivers of change variables

Birds: Data collected in the subsequent phases will be analyzed using standard analysis methods and then compared to the previous data. Changes in areas where petroleum activities have taken place will be compared to those where there have not been any activities in order to establish the impact of the oil and gass activities on birds.

Infrastructure: Any added infrastructural layers over the period since the last data collection will be added to the already existing spatial layers of infrastructure. Analysis will be carried out to establish change in infrastructure density over time.

Hazardous waste

Number of spill incidences and heavy metal levels in the food chain: Data obtained during this phase will be analyzed using the same standard methods and compared with the previous information.

Domestic Waste

The number of birds visiting the waste disposal sites counted and recorded. The data will be analyzed using standard analytical methods.

For the rest of the indicators, obtained data in the subsequent surveys will be analyzed and compared to results obtained from the earlier survey analysis.

Relationships between the birds diversity and abundance, and the drivers will also be explored to identify possible impacts of the drivers on the birds.

3.3 Flagship floral ecosystem components

3.3.1 VEC description

A variety of vegetation types are found in the Albertine Graben. They occur at different altitudes, for example, alpine vegetation (giant forms of plants that occur at lower altitudes such as giant Lobelias and Senecios), montane forest, lowland forest, savannah grasslands, woodlands, papyrus swamps, high altitude swamps.

The rich and varied floral ecosystems that occur in the region are also reflected in the high plant biodiversity found in the region. 6409 woody plant species have so far been identified in the region. 341 of them are endemic and 73 of them are considered threatened (Plumptre et al, 2007). There is, therefore, need to monitor the impact of oil and gas activities on these rich ecosystems.

The rich and varied flora of the region is key to the existence of a wide diversity of animal communities and species (both mammals and birds). The grasslands have great potential to support a high biomass of wild animals. For example, the short and medium height grassland

savannah is preferred by ungulates including the Uganda Kob. The swamps are well known for supporting a wide variety of water birds, including the Shoebill and the Grey Crowned Crane. Although most of the recorded biodiversity is within protected areas, a wealth of plant biodiversity exists outside the protected areas. Unfortunately, most of it is either already disturbed or threatened.

In order to assess the impact of oil and gas activities on the floral ecosystems, three ecosystem qualities will be monitored i.e. the spatial extent of each vegetation cover, biomass content and species diversity of these vegetation cover types. Whereas some drivers may mainly affect one ecosystem quality, others may affect all. For example, infrastructure development is often linked with land clearing leading to reduction of the spatial extent of some vegetation types. Human influx, on the other hand, may result in either selective logging of preferred species leading to species diversity reduction or complete clearing of land for agriculture leading to spatial reduction of the land cover/use in question.

3.3.2 Drivers

Table 4.10: Drivers of plants diversity and abundance change and how they may cause the change

Driver	Description
Infrastructure (roads, seismic lines, camps, drill sites, pipelines airstrip)	Infrastructural development takes a lot of land, increases the spread of invasive species, leads to habitat destruction, and increases human-wildlife conflicts, thus, affecting the floral ecosystem components. Petroleum developments may increase the spread of invasive species through vehicular movements, land-take and decommissioning of facilities.
Human influx	Human influx can cause land degradation which in turn causes deterioration of floral communities, and increases the spread of invasive species.
Oil spills, Hazardous & domestic waste	Oil spills will directly affect plant survival through blocking their respiratory and food absorption systems. Plants will bio-accumulate heavy metals in their tissues, which in turn may affect the health of herbivores.
Incidences of fires	Fire destroys vegetation cover and habitats, and species therein (flora and fauna).

3.3.3 Parameters to monitor

Table 3.11: Parameters of each driver of change that will be monitored

Driver	Priority indicator
Infrastructure (roads, seismic lines, camps, drill sites, pipelines airstrip)	Land take (spatial coverage of habitat destroyed/cleared), Area of Habitat destruction, Number (diversity) and coverage of invasive species, areas that have changed from one cover type to another, Incidences of human wildlife conflict (crop raids, human injuries), biodiversity change
Hazardous Waste, Domestic Waste and Oil Spills	Number and quantity of spills, spatial coverage of spill, Quantity of waste, Type of waste, area affected, plant tissue content
Human Influx	Area of land cover types, biomass stocking including regeneration, biodiversity, trade in timber and non-timber products
Fire incidences	Number of incidences, area covered and extent of damage.

3.3.4 Geo-spatial design

Vegetation mapping (spatial extent)

i) Field surveys (ground truthing)- stratified sampling will be used based on land cover. In each strata, systematic data collection points will be laid out. Intensity of points will be higher in areas that have high variation in vegetation cover.

ii) Satellite imagery (preferably high resolution) will be used in the mapping

Biodiversity surveys

a. Area to be surveyed is divided into blocks

b.Transect lines are placed at regular intervals to cover the entire block

c. Nested plots are placed at regular intervals along each transect

d. Distance between transects – 500M.

e. Distance between plots – 250M.

f. The size of the block will determine the number of transects

g. Plot laying starts at point zero (0), which is an area outside the area of interest. A transect should have at least 10 plots.

h. Along these same transects, mammal and bird counts are carried out.

Biomass measurement

The methodology used in biomass monitoring is given in detail in the Biomass Technical report, 2003.

i) A systematic sampling over a grid system will be used

ii) North-south plots laid at every intersection point

iii) Grid distance - 5km by 10km

iv) Distance from grid intersection – 300m north and 300m south

v) Sampling intensity based on ecological zones

High population has high impact on biomass and land cover. The country is stratified into 3 population zones. Greater biomass changes are expected in high population areas i.e. priority Zone I, than in priority zone II and priority III, a sampling intensity at a ratio of 3:2:1 was adopted. This means that three intersections (9 plots) are measured in Zone I, two intersections (6 plots) in Zone II, and one intersection (3 plots) in Zone III.

Priority Zone I - High population density (over 100 persons per square km covering approximately 64,013 km2)

Priority Zone II - Medium population density (50 – 100 persons per square km covering approximately 56,375 km2)

Priority Zone III - Low population density (Less than 50 persons per square Km covering approximately 76,708 km2)

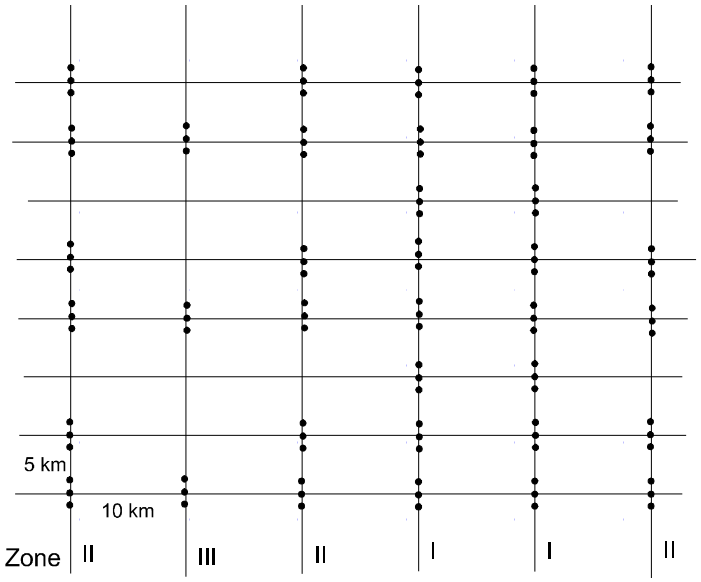

Figure 3.1: Grid layout and plot distribution at grid intersection points. Figure also shows plot variation based on ecological zoning

3.3.5 Sampling design

Vegetation mapping (spatial extent)

Floral ecosystems will be monitored through remote sensing, by means of land cover mapping using satellite images. Mapping will cover the whole Albertine Graben since all the parts of the Graben are likely to be affected by the oil and gas activities. Although wetlands are aquatic ecosystems, their extent will be mapped at this stage along other floral ecosystems. Satellite images will be interpreted to produce a land cover/use map based on the NBS methodology and classification. The land cover map will be ground truth to ensure that the interpreted map is accurate. Ground truthing will be carried out in those areas where land cover change is suspected to have taken place.

Biodiversity surveys

Biodiversity will be monitored using field surveys. First priority areas of focus will be the protected areas (UWA PAs and Forest Reserves). Other areas of interest will be relatively undisturbed areas outside protected areas e.g. local forests and wetlands.

Plots will be laid out based on the geo-spatial design indicated above. At each point, nested

circular plots will be laid out as follows

Table 3.12: Plot sizes variation over which data of woody plants of varied DBH is collected

Plot size	Woody species size	Category
Radius – 20 M	≥ 10 cm DBH	Trees
Radius – 10 M	< 10 cm DBH	Shrubs, saplings, climbers
2 cm plot		Herbs, grasses, forbs

In addition to recording species in the plot, woody species encountered while moving from one plot to another will be recorded. This will ensure that rare species that could have been missed at the plot can also be captured.

Biomass plot sampling design

Biomass growth is affected by soil types and climatic conditions. In determining biomass stocks and growth agro-ecological zones are used. Four main zones have been curved out of the 11 common ones.

Agro ecological zone 1, i.e. High altitude areas

Agro ecological zone 2, i.e. Pastoral dry to Semi Arid rangeland areas

Agro ecological zone 3, Semi-moist lowland Savannah areas

Agro ecological zone 4, i.e. Moist lowland and medium altitude areas

This agro ecological zoning is particularly important not only in ensuring that sample plots or the sampling intensity cover all ecological systems but also improves the precision of estimating the biomass stock.

Biomass monitoring plots measure 50m by 50m in all areas except in forest plantation. Plots are located on the ground using differential GPSs. Coordinates of all plots are known. The coordinate of the plot marks its south-western corner. Demarcation of the plot and tree measurement start from this corner. A plot is subdivided into five 10-meter wide strips running in the east-west direction and tree measurement is done systematically from one strip to another. Even tree numbering is based on the location of the tree in the strip (Figure 3.2) This is intended to make tree re-identification easier during subsequent visits.

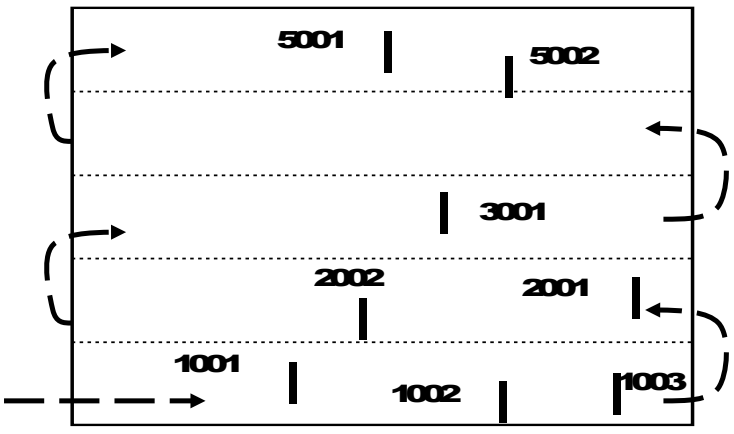

Figure 3.2: Strips in a 50x50 m plot. The arrows show the direction taken while measuring trees from strip to strip

In the plot, all trees equal or more than 3cm DBH (1.3m above the ground). Parameters recorded for every tree were:

1. DBH- diameter at breast height corrected to the nearest centimeter
2. Bole – height from the ground to the first major branching
3. Height – total height of the tree
4. Crown – width of the crown of the tree as distended on the ground
5. Species- the species of the tree is identified and recorded.

Stems growing on the same stump but forking below 1.3cm are measured as separate trees. If the visit to the plot was the second or more, there could be any of the following scenarios:

1. Recruits- trees which were below 3cm during the first visit and had attained 3cm DBH or more centimeters on the next visit
2. A tree no longer existed. It was either cut or it died a natural death.
3. Broken top- part of the crown of the tree had been removed. This could again be by man or by force of nature such as wind.
4. Plot class (land cover type) had completely changed
5. Access to the plot was denied

When all the trees have been measured, cover of the plot is assessed. Each land cover type or crop in the plot is given a percentage of the area it covers. Care is taken not to award more than 100%. Percentages are given to the nearest 5%. These parameters are recorded on a pre-designed field form.

Table 3.13: Description of sampling gear/equipment for acquiring and processing plants related data.

Driver	Priority indicator	Equipment/consumables
Infrastructure (roads, seismic lines, camps, drill sites, pipelines airstrip).	Land take, Area of Habitat destruction, Number and coverage of invasive species, areas that have changed from one cover type to another, Incidences of human wildlife conflict (crop raids, human injuries), biodiversity change.	GPSs, GIS and Remote sensing software, Yagi antenna, distance tape, satellite images and cameras.
Hazardous Waste, Domestic Waste and Oil Spills.	Number and quantity of spills, spatial coverage of spill, Quantity of waste, Type of waste, area affected, plant tissue sampling	Mobile lab, gloves, apparatus, coolers, reagents, tissue samplers
Human Influx.	Area of land cover types, biomass stocking including regeneration, biodiversity, trade in timber and non-timber products.	GPSs, compass, distance tape, Diameter tape, callipers, ranging poles, vehicles, camera, GIS/ Remote sensing software Satellite imagery.
Fire incidences	Number of incidences, area covered and extent of damage.	GPSs, fire watch towers, GIS/Remote Sensing software, Computers.

Nomenclature/classification code list of Flagship Floral ecosystems.

Table 3.14: List of selected floral ecosystems

Ecosystems	Vegetation types
Forests	Tropical forests Riverrine forests Swamp forests
woodlands	Open woodland Closed woodland
Bushland	Thickets
Savanna	Grassland Wooded grassland
Wetlands	Swamp forest Papyrus Marsh and bogs Sedges/reeds
Cropland	Subsistence Commercial

3.3.5 Numerical and statistical analysis

Analysis methods

Vegetation cover

To generate information on vegetation cover the generated land cover maps will be assessed for acreage of each vegetation cover. The current land cover data will be compared with data from previous years to generate rate of land cover change over a specific period.

Biodiversity analysis

To generate information on plant diversity status, data collected will be analyzed using standard data analysis methodologies e.g. vegetation indices and plant total species counts used for species richness. In addition, subsequent studies should also focus on the analysis of impacts of the drivers on plant species diversity and distribution variation.

3.3.6 Biomass Monitoring

3.3.6.1 Data Management and analysis

Field data are in two parts and are also entered into two separate files that could be linked. Plot data includes plot number, location, class, land cover types, coordinates of the plot, name of team leader and access to the plot. These are stored in a plot file. Tree data, which includes plot number, tree number and the tree parameters are stored in a tree file. The two files can be linked by plot number.

Tree volume is computed using one of 3 models depending on the diameter class the tree falls. The models are for 3 to 20cm, 21 to 50cm, and More than 50cm

Volume is converted to weight and trees of the same plot are summed up to give total weight of the plot. A 50 by 50m plot is 2,500 square meters which is a quarter of a hectare. To extrapolate plot data to a hectare, plot weight is multiplied by 4. After this, analysis can be done to extract various information such as average biomass stock per class, sub-strata, region etc.

Mean stocks per stratum

Biomass Stock was categorized in three major classes namely Low (LO), Medium (ME) and High (HI). Each land cover class had its own thresholds biomass stocking in terms of tons per hectare. That is, 6LO (bush-low stock) was not the same as 7LO (grassland low stock)

Determining Biomass Stock from LCCS Classification

In the NBS classification, classes 3, 4, 5, 6, 7 and 9 had a stock classifier of LO (Low) or ME (Medium) or HI (High). To introduce stock levels in the translated legend, mixed units were used. A major class followed by a second class of high biomass would take a stock level of high. For example, herbaceous crops with mixed class of open trees would become 9HI. In LCCS it would be written as HR3HQ47-x/2TO8. On the other hand, if a class of high biomass such as woodland is mixed with a class of low biomass such as grassland, its stock level would drop.

Linking Biomass to land cover

To display and analyze biomass data geographically, it must be linked to a land cover map. We can then query how much biomass we can expect to find in particular land cover type, in a particular agro ecological zone.

Biomass data is linked to a map by linking the biomass stock table and the attribute table of the land cover map. This was done by concatenating fields of agro ecological zone, class and stock into one code.

To get total biomass per polygon, the area of the polygon is multiplied with its mean stock. For convenience, area is converted into hectares by dividing by 10,000 and weight is converted into tons by dividing by 1000. Biomass of a specific area is therefore a sum of biomass from all polygons that make that area.

Analysis of drivers of change

Infrastructure: With the availability of spatial layers of infrastructure coverage and the area of the landscape, infrastructural density will be calculated using Geographic Information System (GIS).

Number of spill incidences: Analyze spill incidence records obtained from companies and protected area management to generate information on spill occurrence variation over specific periods.

Incidences of fire: Oil related fire incidence data will be analyzed and results compared to fire from other sources over the same period and oil and gas related fires in the previous periods.

Hazardous waste

Number of spill incidences and heavy metal levels in the food chain: Data obtained during this phase will be analyzed using the same standard methods and compared with data from the previous periods.

3.4 Below ground biodiversity

3.4.1. VEC description

The need to identify soil quality indicators for monitoring positive or negative soil changes due to land cover and use change has been emphasized by various authors. Soil invertebrate macrofauna communities are very sensitive to environmental changes (Lal, 1987), which results into a diminution in the diversity and abundance of macrofauna (Murphy, 1958; 1994; Lal, 1987). Infrastructural development and human influx affects the feeding and breeding sites of Below Ground Biodiversity (BGBD) species. It also directly destroys their habitats and increases mortality. Infrastructure and human influx affect the feeding and breeding sites of BGBD species. BGBD accumulates contaminants from wastes and oil. The BGBD is eaten by omnivores which are in turn preyed by carnivorous mammals.

Because of the relationship between soil quality and macrofauna, the diversity and abundance of macro invertebrates such as termites, ants, and earthworms has often been used as a measure of the quality and level of soil fertility (Stork and Eggleton, 1992). The diversity and abundance of soil invertebrate and vertebrate macrofauna can be an indicator of the intensity of disturbance and therefore a proxy indicator of soil quality.

3.4.2 Influencing drivers

Infrastructure (roads, camps, drill sites burrow pits) and human influx; Hazardous waste, domestic waste, oil spill

3.4.3 Methodology

3.4.3.1 Parameters to monitor

i) Species numbers
ii) Species distribution
iii) Species richness

3.4.3.2 Sampling design

Studies will be done in virgin and affected ecosystems. Sampling techniques will be based on the methodology recommended by the Tropical Soil Biology and Fertility programme (Anderson and Ingram, 1993). Sampling will be done at the initial stages of the dry season

and during the rainy season. The macro invertebrate will be identified among broad taxonomic units of orders or families, counted and further grouped in larger groups such as earthworms, termites, ants etc. (Anderson and Ingram, 1993).
Points of observation will be geo-referenced for both grid points or random points. A sampling plan similar to the soil quality assessment protocol should be used as BGBD sampling will be done at same soil sampling points. This allows correlation of BGBD to soil quality parameters thereby avoiding duplication of efforts.
At each observation point, plots measuring about 50 square meters will be marked out and a belt transect with a random origin and direction will be spaced out across each of these observation point. Sampling points will be marked out at intervals of 5m.

A wooden quadrant measuring 25cm x 25cm will be used to isolate soil monoliths at each of these stations. Litter within a 25cm quadrant will be removed and retained for sorting. Then by digging (using hoe and a spade) a 20cm by 30cm deep trench a few centimeters around the quadrant, the 25cm x 25cm by 30cm deep monolith will be isolated. Each of these monoliths will be hand sorted separately on a 4m x 4m wide polythene sheet. The soil will be placed at one end of the sheet and small amounts of soil material will be systematically examined manually. The invertebrates will be removed using forceps and brushes and then the sorted material further examined. Large aggregations of ants or termites in woody litter, or soil chambers exposed on the sides of the sample, will be collected as bulk material and sorted separately.

3.4.3.3 Numerical and statistical analysis

Analysis of Variance ANOVA and T-test will be employed to test for significant differences between means. A chi-square will be used to study the independence of species densities and agro-ecosystems. The diversity measures will consider: species richness, that is number of species, and evenness, that is how equally abundant the species are. Shannon's Index of diversity (Magurran, 1991) will be used to compare diversities and evenness of the agro-ecosystems. A T-test will be used test for the significance of the diversities. Geo-referencing of points will also allow the spatial analysis of data using spatial programs.

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CHAPTER 4: PHYSICAL/CHEMICAL ENVIRONMENT

4.1 Water

Fresh water resources and supplying enough water for the world's growing population are increasingly important issues. Today, water in rivers, lakes and wetlands only represents 0.3% of the world's freshwater. The loss of freshwater resources has a direct impact on food availability, water quality, public health, climate, and can lead to environmental disasters.
The water resources of the Albertine Graben consist of both surface water and groundwater. The surface water sources include L. Albert, L. Edward, L. George and their river systems. Groundwater on the other hand exists as shallow and deep aquifers.
The water resources in the Graben are subject to competing water uses such as domestic use, hydro power generation, industrial and irrigation. In addition the water resources are transboundary in nature and therefore likely to trigger conflict with downstream users.

4.1.1 Influencing drivers

Water resources availability in the Albertine Graben will be affected by the following drivers:
1. Waste disposal and storage - If drill cuttings and other waste is poorly disposed, it leads to pollution of water bodies. The contaminants infiltrate into groundwater and will infiltrate into water bodies thereby contaminating them.
2. Oil spillage - Affect surface water quality which will eventually affect aquatic life.
3. Water abstraction – The water resources in the Albertine Graben are likely to be subjected to competing water uses and therefore aspects of allocation of the water resources for the various uses is paramount depending on the risks levels if sustainability is to be ensured. High risk scenarios are likely to trigger conflicts over water use.
4. Land use practices – Clearing increases erosion and sedimentation of water bodies and reduces water quality.

4.1.2 Methodology

Parameters to be monitored
Water resources will be monitored for both quality and quantity.

a) Water Quality

Geo – spatial design for water quality analysis
Water will be sampled at collection, treatment, effluent discharge and receiving water bodies. Groundwater quality sampling will be carried out in areas around and down stream of waste consolidation areas.

Sampling Design

To ensure that sampling is consistent, and of good quality and traceability, samples need to be representative of the body from which they were taken. If the sample integrity is

altered, the information gained from analysis could be misleading and ultimately result in mismanagement of water resources and/or polluting of the resource.

The main processes that have the potential to affect the integrity of a sample are physical, chemical and biological changes. These processes are interlinked and a change in one may have a flow-on effect that will influence another, eg a change in temperature can cause chemical changes and in similar manner, Biological activity in a sample may affect both its physical and chemical characteristics.

Contamination of a sample occurs when foreign substances are introduced into it. This will lead to the sample having characteristics that are not representative of the in situ conditions. Contamination of a sample can occur at any stage of the sampling process from the collection of samples through to the final analysis, and will have a direct effect on the integrity of the sample. As many results are reported in fractions of grams, even extremely small volumes of contaminants can significantly affect results. Contamination can be very costly, especially if decisions are based on unrepresentative data
It is therefore important that samples should only be collected by personnel who have proper training and adequate experience.

Planning a sampling event
The following are issues to consider when planning a water quality sampling event.

Logistics
The basic steps for planning a sampling event are as follows:
1. Review the monitoring plan, including monitoring locations, number of samples required, sampling methods, and Occupational Health, Safety and Welfare (OHS&W) issues.

2. Inform the client or property owner of your intended schedule and be aware of any liabilities that you may incur.

3. Co-ordinate with the analytical laboratory. Obtain appropriate sample containers (i.e. containers of suitable material and volume that contain preservatives. Discuss any problems you foresee, for example, with procedures, containers or limitations of reporting.

4. Schedule the monitoring event, including planning how and when you will transport the samples back to the laboratory. The aim is to have all samples preserved and delivered to the laboratory as quickly as possible and within recommended holding times. This is especially relevant for samples with holding times of 24 hours or less.

5. Organize and review site maps and locations to determine logistics of sampling including

sampling order. Sampling order should be designed to avoid cross-contamination, i.e. as much as practical, move from samples with lowest pollutant concentrations to highest concentrations.

6. Check that you have all the equipment required for the sampling event. Test that the equipment is operational and calibrated. Ensure you are able to decontaminate equipment that is to be reused between samples. Fill out as much paperwork as practical before sampling such as preparation of labels.

Equipment

Major items of equipment likely to be needed are discussed as follows:

1. Paper work and record keeping: Good planning and record keeping is imperative. The sampling plan, or concise sampling schedule and map should provide all the required information such as location of monitoring points, the number and type of samples that need to be collected and container types. Records of observations and actions can be critical for future reference. A sampling data sheet ensures that a complete record of each sampling site and event is kept. Other required paperwork includes Chain of Custody forms.
2. Navigational aids: It is important to be able to accurately locate the sampling site for future reference. A modern Global Positioning System (GPS) can be a useful aid in accurately locating a sampling site. The sampling locations should also be recorded on site maps.
3. Field testing meters: Some analytes are most reliably determined at the point of sampling.
4. Sampling containers: As the wrong sampling equipment can affect the integrity of the sample, it is important to use appropriate sample containers for each of the various parameters. The analytical laboratory should be able to provide appropriate containers with required treatments.
5. Other sampling equipment: Other forms of sampling equipment may include sampling rods, bucket and rope, depth equipment or filtration equipment.
6. Decontamination of sampling equipment: All sampling equipment presents a risk of cross contamination and should be thoroughly cleaned between samples. Decontamination equipment may include detergents, ethanol, scrubbing brushes, tap water, distilled water and a receptacle for collecting waste rinse. A burner or 10% sodium hypochlorite solution may be required for microbiological samples.
7. Refrigeration: Most types of sample require chilling as a means of preservation. Samples can be stored on ice in an esky or in a car refrigerator, and the temperature should be maintained between 1°C and 4°C.
8. Camera: Photographs can show where the sample was taken and illustrate observations recorded on the field datasheet. It is good practice to take photographs on the first visit to a sampling location and when there are any unusual conditions at the site that may affect the sample.

Field filtration

Field filtration can be undertaken for a number of purposes:

1. To maximize a sample's integrity during transport from the sampling site to the laboratory—nutrients such as ammonia, nitrate and nitrite can have a short retention period in a sample and filtering can extend this significantly
2. To separate the total and the soluble portions of analytes (eg dissolved metals)—the soluble portion of an analyte is generally more bio-available, and therefore can have greater impact upon the ecosystem
3. To extract filtered material for biological analytes such as chlorophyll and algae to separate biomass when undertaking wastewater analysis.

Filtration equipment

1. Hand pump
2. Vacuum operated pump
3. Syringes

Always follow the operating instructions of your filtering equipment. Factors to consider when filtering include:

1. Filters may need to be decontaminated or preconditioned through washing or soaking prior to use. Check the requirements during planning of the sampling event as some decontamination/soaking procedures can take up to 24 hours.

2. The type and pore size of the filter will affect the results. Select the right type and size of filter for the job. A 0.45µm filter should be used, except where otherwise specified by criteria. be careful not to contaminate samples during the filtration process.

3. When filtering samples in the field minimize the chance of contamination with a clean work environment and by replacing caps on sample containers immediately. A plastic sheet on the ground is a good method of defining and maintaining a clean work area.

4. Samples with lots of suspended material can be difficult to filter in the field. Pre-filters may be needed for pressure filtration. For vacuum filtration it may be necessary to change the filters as they become clogged with sediment. Excessive force may rupture clogged filters requiring recommencement of the sampling.

5. For analysis of parameters such as chlorophyll and suspended solids retain the filter paper, not the filtrate. Record the volume of sample filtered, as this will be used later to calculate the concentration of the sample. When retaining the filter papers, fold the filters so the residue surfaces are against themselves and place them in a sample tube or opaque bottle. Appropriate preservation techniques must also be followed for filter paper such as

dark storage or refrigeration.

Decontamination

Decontamination is the cleaning of sampling equipment to remove trace analytes and avoid cross-contamination of samples. Reliance should not be placed solely on decontamination procedures. Minimize the chance and consequence of contamination with good sampling design and equipment.

The following methods should be used when decontaminating sampling equipment:

1.Decontaminate equipment away from sampling site. Use plastic sheets to prevent contamination from ground material

2. It is advisable to wear clean, sterile gloves and protective clothing when performing the decontamination process.

3. Prepare detergent solution1 in large container or bucket, place equipment into container and scrub clean. Detergents should be phosphate free. To clean hoses/pumps, pump decontamination solution through lines.

4. Rinse equipment thoroughly (preferably triple rinse). Distilled or deionized water should be used for rinsing.

5. Clean equipment with further decontamination solutions if required.

6. The cleaning solution will depend on the contaminants being investigated as follows:

i) for oil and grease, hydrocarbons, pesticides, PCBs or PAHs a solvent should be used. Rinse equipment with acetone then solvent such as methylated spirits.

ii) for metal analysis acid washing is recommended. Rinse equipment with 10% nitric acid, followed by distilled or de-ionized water rinse.

iv) microbiological sample containers should be further sterilized

Sampling Techniques

Grab samples

Depth sampler shall be used for most of the river sampling to abstract water for onsite analysis and for filling sample bottles. A dipper, submersible pump or any other method that may meet with the sample requirements shall be used where applicable. Disinfection of equipment shall be carried out when collecting a water sample for bacteriological analysis. Grab samples are also known as spot or snap samples.

Composite or integrated samples

Composite or integrated samples are samples made up of several different parts. Composite samples may be of the following types:

1. Depth integrated: made up of two or more equal parts collected at predetermined depth interval between the surface and the bottom. A flexible piece of plastic piping close at the upper end and hauling to the bottom with a weighted rope shall provide a simple method of

obtaining depth integrated sample. A submersible pump operated at a steady pumping rate while the pumping inlet is drawn up wards at a uniform speed also provides another method of obtaining a depth integrated sample.
2. Area integrated: made by combining a series of samples taken at various sampling points spatially distributed in the water body but usually at one depth or predetermined depth intervals.
3. Time integrated: made by mixing equal volumes of water collected at a sampling station at a regular time interval.
4. Discharge integrated: made by mixing equal volume of water collected at a sampling point at a regular interval and measured discharge over a period of time eg 24 hours

Samplers

Water samplers provide means of abstracting water, sediments or other materials from rivers, streams or reservoirs for analysis. Several types of samplers are available and may be designated for a specific purpose.

Depth samplers

Depth samplers or sometimes-called grab samplers are designed to retrieve a sample from any predetermined depth. Depth samplers are used in cases where sampling sites may not be easily accessed directly. In this case sampling is done over bridges using a submersible pump or other forms of depth samplers. Examples of depth sampler include;

Syndler or Vandon samplers

Consist of a tube, approximately 10cm in diameter and 30 cm in length, fastened along a frame along which it can slide. The end or ends of the tube are covered with spring loaded flaps which can be held in the fully open position by latches or magnet. The latches can be released by applying a small amount of pressure to a lever. To accomplish this weight (called a messenger) is dropped down the lowering rope, the latch is tripped and the ends of the tube close.

Procedure

a. Attach a guide rope to the 10kg weight (optional).
b. Attach the loose end of the rope to the Bridge railing or any fixed object e.g. vehicle, boat etc.
c. Disinfect sampler in appropriate disinfectant. This is only applicable if bacteriological samples are to be collected.
d. Attach the depth sampler to the guide rope with a suitable device.
e. Latch the end flaps into the open position.
f. Slowly and carefully lower the sampler into the lake, reservoir or river on the down streamside of the bridge to appropriate depth.
g. Hold the rope firmly and drop down the rope messenger weight to trip the latches and

close the end flaps.
h. Bring the sampler back to the surface and transfer the contents to the appropriate sample bottles.
i. Fill the bacteriological bottles first and then other bottles. Carry out the required on-site tests.
j. When sampling has been completed, retrieve the sampler and other associated equipment.
k. Clean the sampler with clean water ready for next sampling.

Sampling using a dipper

A dipper is a cup with an extended handle (1 – 3m in length) is lowered into a river, stream, dug well or spring from its banks or edges to obtain a sample. It is used in cases where sampling sites may not easily be accessible or may not be deep enough to warrant the use of submersible pump or depth sampler.

Procedure

a. Rinse the dipper several times with the sample and collect the sample.
b. Fill the sample bottles from the dipper.
c. Disinfect the dipper and all equipment, which have come in contact with the sample after sampling wastewater.
d. Rinse thoroughly with clean water before next sample is taken.

Sampling and Measurement Procedures for field analyzed parameters

Electrical Conductivity

Electrical conductivity (EC) is the measure of the ability of water to conduct an electric current and depends upon the number of ions or charged particles in the water, and is measured using conductivity meter placed into a sample of water. The EC of a water sample is expressed in either micro Siemens per centimeter (μS/cm) or milli Siemens per centimeter (mS/cm) depending on the amount of ionic particles in the sample.

Electrical conductivity determinations are useful in aquatic studies because they provide a direct measurement of dissolved ionic matter in the water. Low values are characteristic of high-quality, low-nutrient waters. High values of conductance can be indicative of salinity problems but also are observed in entropic water systems where plant nutrients are in greater abundance. Very high values are good indicators of possible polluted sites. A sudden change in electrical conductivity can indicate a direct discharge or other source of pollution into the water. However, electrical conductivity readings do not provide information on the specific ionic composition and concentrations in the water.

Field measurement and Sampling procedure for conductivity

In situ field measurement of conductivity	a. Carefully mount a probe onto the meter. b. Switch on the Meter and select conductivity. c. Deep the probe in water (approximately 10cm or mid water column), keep it in gentle motion through the water column while a reading is being taken. d. Allow time for the meter to stabilize before recording reading.
Sample collection technique for laboratory analysis at 25°C	a. Either sample directly into a bottle or transfer into a sample bottle from collection vessel. b. Ensure sample bottle is pre-rinsed three times with sample water (3 × 20 mL) before final collection. c. Excessive turbulence should be avoided to minimize presence of air bubbles in the sample. d. Fill container completely to the top to exclude air. e. The sample must be free of air bubbles and capped tightly.
Container	a. Plastic Bottle capable of conveying 125ml of sample. b. Cap must have a teflon liner. c. Use new or pre-cleaned bottles
Treatment/preservation required	a. Refrigerate at 1–4°C, do not freeze. b. No chemical preservative is required.
Maximum sample holding time and storage conditions	a. Analyze within 24 hours for samples of low conductivity, i.e. below 20 µS/cm. b. Other samples can be held for one month if sample is kept refrigerated at 1–4°C and stored in an airtight container. c. Laboratory procedure applies when samples are delivered for analysis.
Analysis method and calibration	a. Conductivity is measured electrometrically with (or without) temperature compensation. b. Calibrate meter against a standard solution of potassium Chloride, EC 1414µS/cm. (Note: use the equipment manual or procedure developed the particular meter)

Dissolved oxygen (DO)

Dissolved oxygen analysis measures the amount of gaseous oxygen (O2) dissolved in an aqueous solution. Oxygen dissolved in water by diffusion from the surrounding air, by aeration (rapid movement), and as a product of photosynthesis. The dissolved oxygen analysis should be performed immediately and in situ. This is a field test that should be performed on site.

Dissolved oxygen can be expressed either as a concentration (in mg/L), which is an absolute value, or as percentage saturation, which is an expression of the proportion of dissolved oxygen in the water relative to the maximum concentration of oxygen that water

at a particular temperature, pressure, and salinity can dissolve. The amount of dissolved oxygen in water is largely dependent upon the water temperature; colder water can carry more dissolved oxygen than warmer water. When in equilibrium with the atmosphere, at this maximum concentration the water is said to be saturated or at 100% saturation of dissolved oxygen.

In situ field measurement DO	a. Carefully mount a probe onto the meter. b.Switch on the Meter and select DO. c. Deep the probe in water (approximately 10cm or mid water column), keep it in gentle motion through the water column while a reading is being taken. d. Allow several minutes for the meter to stabilize before recording reading. e. Calibrate meter against before proceeding to use it(Note: use the equipment manual or procedure developed for the DO meter)
Comment	a. DO is measured directly without taking sample into a sampling container. b. Meter calibration is essential. Perform calibration according to equipment manual

pH

The pH of a solution is the concentration of hydrogen ions, expressed as a negative logarithm. It reflects the acidity or alkalinity of a solution, in this case water. Water with a pH of 7 is neutral; lower pH levels indicate increasing acidity, while pH levels higher than 7 indicate increasingly alkaline solutions. It is important to consider the effects of pH on other potential toxicants; e.g. the bioavailability of heavy metals.

Field measurement and Sampling procedure for pH

In situ field measurement of conductivity	a. Carefully mount a probe onto the meter. b. Switch on the Meter and select pH. c. Deep the probe in water (approximately 10cm or mid water column), keep it in gentle motion through the water column while a reading is being taken. d. Allow several minutes for the meter to stabilize before recording the meter reading. e. Calibrate meter against buffer solution pH 4, 7 and 10 solutions. f. Two point calibrations is normally sufficient for most pH meters. (Note: Follow instruction in the equipment manual or procedure developed the particular meter)
Sample collection technique for laboratory analysis at 25°C	a. Either sample directly into a bottle or transfer into a sample bottle from collection vessel. b. Ensure sample bottle is pre-rinsed three times with sample water (3 × 20 mL) before final collection. c. Excessive turbulence should be avoided to minimize presence of air bubbles in the sample. d. Fill container completely to the top to exclude air. e. The sample must be free of air bubbles and capped tightly.
Container	a. Plastic Bottle capable of conveying 125ml of sample. b. Cap must have a teflon liner. c. Use new or pre-cleaned bottles
Treatment/preservation required	a. Refrigerate at 1–4°C, do not freeze. b. No chemical preservative is required.
Maximum sample holding time and storage conditions	a. Analyze within 6 hours if sample is kept refrigerated at 1–4°C. b. In this case, the procedure for analysis in the laboratory will be used.

Salinity

Salinity is an indication of the concentration of dissolved salts in a body of water. The ions responsible for salinity include the major cations (calcium, Ca 2+, magnesium, Mg2+, sodium, Na+ and potassium, K+) and the major anions (carbonates, CO3 2- and HCO3 2- , sulphate, SO4 2- , and chloride, Cl-). The level of salinity in water systems is important to aquatic plants and animals as species can survive only within certain salinity range. Although some species are well-adapted to surviving in saline environments, growth and reproduction of many species can be hindered by increases in salinity

Water Classification according to Salinity

1. 0-450mg/L = Freshwater
2. 450 - 30 000 mg/L = Brackish water
3. 30 000 - 50 000 mg/L = Saline water
4. >50 000mg/l =Brine water

EC can be converted to TDS using the equation:
TDS = (0.548 -0.7 x EC) + (2.2 x 10-6 x EC2)
WhereTDS = Total Dissolved Solids (mg/L)
EC = Electrical conductivity (µS/cm)
Note: salinity measurement is done using a calibrated conductivity meter. Use the measurement protocol under EC and convert measurement using the formula above.

Turbidity

Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms. Turbidity is a measure of the clarity of a water body and is an optical measurement that compares the intensity of light scattered by a water sample with the intensity of light scattered by a standard reference suspension. It is commonly recorded in nephelometric turbidity units (NTUs).

Field measurement and Sampling procedure for turbidity

Field measurement of turbidity using hand held meter	a. Hand held turbidity meter function the same way as the bench meter. b. Switch on the meter and allow it to perform internal memory check. c. Check that no sample cell is kept in the cell holder. d. At this point, the meter gives a background reading which should indicate free light path. e. Perform calibration check using GELEX standards provided by the manufacturer. f. Ensure the readings fall within the set values before proceeding to take measurements. g. At the beginning of any measurement, run a standard solution (4NTU) prepared by diluting serially formazin stock (400NTU) into 1000, 200, 20 NTU. h. Fill sample cell with sample. i. Apply thin layer of silicon oil supplied with the meter onto the sample cell and gently wipe using cell cleaning cloth(also supplied) This should spread the oil uniformly all around the cell to create a thin film coating to ensure uniformity. j. Invert cell several times to ensure uniform distribution of any suspended materials in the sample. k. Insert into the cell holder and close l. Record the reading m. Do not filter sample

Sample collection technique for laboratory analysis at 25°C	n. When field measurement is not possible, collect sample for laboratory analysis. o. Collect sample directly into a bottle or transfer into a sample bottle from collection vessel. p. Ensure sample bottle is pre-rinsed three times with sample water (3 × 20 mL) before final collection. q. It is important not to increase the turbidity of the water while collecting a sample, so do not disturb the bottom or the aquatic plants
Container	r. Plastic Bottle capable of conveying 250ml of sample. s. Cap tightly (tap must have a teflon liner). t. Use new or pre-cleaned bottles
Treatment/ preservation required	u. Store in the dark. Refrigerate at 1–4C, v. Do not freeze. w. No chemical preservative is required.
Maximum sample holding time and storage conditions	x. Analyze directly as soon as possible after sample is collected and preferably in the field y. Analyze within 24 hours if the sample is refrigerated at 1–4°C.

Secchi disk depth

The Secchi disc is a simple device for measuring the depth of light penetration into a body of water for comparative purposes. Secchi disc depth gives a rough approximation of how turbid the water is. A Secchi disc consists of a circular white plate made of any non-corrosive rigid material, and is usually a diameter of 30 ± 1 cm. To reduce the effects of currents on the angle of view, a mass of 3.0 ± 0.5 kg is suspended below the centre of the disc on a rigid rod 15 cm long. The disc is painted with quadrants in flat black and flat white waterproof paints. The disc is normally attached to a non-stretch rope, which has been marked at appropriate intervals of depth with waterproof markings.

Field measurement procedure for secchi depth

Field measurement of Secchi depth using a circular plate.	a. Secchi depths measurement is done with vertical immersion of the disc. b. This is possible while on a platform (boat or bridge). c. After obtaining good position, lower the disc gradually into the water watching how the visibility is changing. d. Mark the point on the rope exactly where the disc became invisible e. Ensure the following , clear sky, sun directly overhead – if the sun is not directly overhead, make sure that the sun is at your back to minimize reflection from the sun on the water f. measurements to be taken on the protected side of the boat, with minimal waves or ripples g. the same person should record Secchi disc depth during the sampling day, to ensure consistency across the readings h. If the conditions vary from this ideal situation, record any differences infield notes on the field observations form.

	How to take a Secchi depth reading. a. The sampler must no ware sunglasses. b. Tie the end of the rope onto a float (e.g. a bucket) to prevent accidental loss of the disc. c. Lower the disc into the water in a position away from shadow and record the depth at which the black/white interface on the disc just disappears from sight. d. Raise the disc until it just becomes visible and record this depth to the nearest 10 cm as D1. e. Lower it just to the point where the disc disappears again (D2). f. The depths at disappearance and reappearance are averaged and referred to as the Secchi disc depth. g. Calculate Secchi depth (m) $\frac{D1 + D2}{2}$

Temperature

Temperature of a water body will vary throughout the day and at different depths. Water temperature will move towards ambient temperature as soon as a sample is removed from the water body. Thus, temperature should be measured in situ. Temperature can be measured using a liquid-in-glass thermometer or a digital meter. However, multimeters, pH meters, conductivity meters and DO meters will also often measure temperature. It is unlikely that a separate device is needed. The probe or thermometer needs to be left fully immersed until a stable reading is obtained. The time required for the thermometer to stabilize will vary according to the temperature of the water and the individual thermometer or probe. Insufficient time can lead to inaccurate readings.

Redox

Direct redox potential (or oxidation reduction potential, ORP) measurements determine the oxidizing or reducing capacity of waters. Redox must be measured in situ and it often varies substantially in a water body, especially with depth. Redox potential can be measured using an electronic meter or multimeter. ORP values are used much like pH values to determine water quality. Just as pH values indicate a system's relative state for receiving or donating hydrogen ions, ORP values characterize a system's relative state for gaining or losing electrons. ORP values are affected by all oxidizing and reducing agents, not just acids and bases that influence pH measurement

ORP Sensor

ORP sensor operation works similarly to that of a standard pH sensor. A two-electrode system makes a potentiometric measurement. The ORP electrode serves as an electron donor or electron acceptor, depending upon the test solution. A reference electrode supplies a constant stable output for comparison. Electrical contact is made with the solution using a saturated potassium chloride (KCl) solution.

For accurate sample measurements, check the ORP electrode performance against an ORP standard solution. The difference between the standard mV potential and the measured mV potential is called the offset. As long as the reference electrode is working properly, the ORP

standard potential should be within ±10 mV for ORP probes in routine use, at a defined temperature. If desired, this offset may be subtracted from the sample mV readings.

Maintenance

Refer to manufacturers manual

Sampling Procedures for Laboratory Analyzed Parameters

Total suspended solids (TSS)

TSS is defined as the portion of total solids in a water sample retained by a glass fibre (GF/C) filter of pore size 70mm□. This pore size can vary so please check with your analytical lab. Once the filter has been dried at 103–105°C and weighed, the amount of total suspended solids is recorded in units of mg/L.

Sampling Procedures for Total Suspended Solids

Sample requirement	Unfiltered sample
Sample collection technique	a. Direct collection into sample bottle or transfer into a sample bottle from collection vessel. b. Ensure sample bottle is pre-rinsed three times with sample water (3 × 20 mL) before final collection. c. It is important not to increase the turbidity of the water while collecting a sample, so do not disturb the bottom or the aquatic plants. d. Excessive turbulence should be avoided to minimize presence of air bubbles in the water. e. Fill to the shoulder of bottle. f. Take care not disturb bottom sediments or plants during collection.
Container	a. Plastic Bottle capable of conveying 1000ml of sample. b. Cap tightly. Cap must have a teflon liner. c. Use new or pre-cleaned bottles
Treatment/preservation required	a. Store in the dark. b. Refrigerate at 1–4°C, do not freeze. c. No chemical preservative is required.
Maximum sample holding time and storage conditions	a. Analyze directly as soon as possible after sample is collected b. Analyze within24 hours if the sample is refrigerated at 1–4°C. c. Do not hold samples longer than 7 days

Volatile suspended solids (VSS)

A volatile suspended solid is defined as the portion of total suspended solids (TSS) that are lost on ignition (heating to 550°C). This information is useful as it gives an approximation of the amount of organic matter present in the solid fraction of wastewater, activated sludge or industrial wastes. It is sometimes referred to as Loss on Ignition (LOI).

Sampling procedures for volatile suspended solids

Sample requirement	Unfiltered sample
Sample collection technique	a. Direct collection into sample bottle or transfer into a sample bottle from collection vessel. b. Ensure sample bottle is pre-rinsed three times with sample water (3 × 20 mL) before final collection. c. It is important not to increase the turbidity of the water while collecting a sample, so do not disturb the bottom or the aquatic plants. d. Excessive turbulence should be avoided to minimize presence of air bubbles in the water. e. Take care not disturb bottom sediments or plants during collection. f. VSS and TSS can be collected in the same 1 L container for analysis. g. Fill to the shoulder of bottle.
Container	a. Plastic Bottle capable of conveying 1000ml of sample. b. Cap tightly, cap must have teflon liner. c. Use new or pre-cleaned bottles
Treatment/preservation required	a. Store in the dark. Refrigerate at 1–4°C, do not freeze. b. No chemical preservative is required.
Maximum sample holding time and storage conditions	a. Analyze directly as soon as possible after sample is collected b. Analyze within24 hours if the sample is refrigerated at 1–4°C. c. Do not hold samples longer than 7 days

Total Nitrogen (TN)

Total Nitrogen includes all forms of nitrogen, such as (in order of decreasing oxidation state) nitrate, nitrite, ammonia and organic nitrogen. The concentration of nitrogen can be used to assess nutrient status in water systems. Enrichment by nitrogenous compounds may lead to related problems (such as nuisance or toxic algal blooms), although some water systems are naturally high in nitrogen and/or other key nutrients.

Sampling procedures for total nitrogen

Sample requirement	Unfiltered sample
Sample collection technique	a. Direct collection into sample bottle or transfer into a sample bottle from collection vessel. b. Ensure sample bottle is pre-rinsed three times with sample water (3 × 20 mL) before final collection. c. Fill to just below shoulder of the bottle d. Samples for TN and TP determination can be collected in the same 250 mL container.
Container	a. Plastic or glass bottle capable of conveying 250ml of sample. b. Cap must have a teflon liner. c. Use new or pre-cleaned bottles
Treatment/preservation required	a. Refrigerate at 1–4°C or freeze and store in the dark.
Maximum sample holding time and storage conditions	a. Analyze within 24 hours if sample is kept refrigerated at 1–4°C b. Analyze within 30 days if kept frozen below -20°

Total phosphorus (TP)

Phosphorus occurs in natural waters and in wastewaters almost solely as phosphates. These are classified as orthophosphates (PO43-), condensed phosphates (pyro-, meta-, and other polyphosphates), and organically bound phosphates. They occur in solution, in particle or detritus, or in the bodies of aquatic organisms. Sources of phosphorus enrichment may include some detergents, fertilizers (in both rural and urban areas), animal feaces (e.g. from farms and feedlots), sewage and some industrial wastes. High levels of phosphorus and/or other key nutrients may lead to related problems such as nuisance or toxic algal blooms, although some waterways are naturally eutrophic (nutrient enriched).

Sampling procedures for total phosphorus

Sample requirement	Unfiltered sample
Sample collection technique	a. Direct collection into sample bottle or transfer into a sample bottle from collection vessel. b. Ensure sample bottle is pre-rinsed three times with sample water (3 × 20mL) before final collection. c. Fill to just below shoulder of the bottle d. Samples for TN and TP determination can be collected in the same 250 mL container.

Container	a. Plastic or glass bottle capable of conveying 250ml of sample. b. Cap must have a teflon liner. c. Use new or pre-cleaned bottles
Treatment/ preservation required	a. Refrigerate at 1–4°C or freeze and store in the dark.
Maximum sample holding time and storage conditions	a. Immediate analysis is preferable, but analyze within 24 hours if sample iskept refrigerated at 1–4°C and stored in the dark. b. Analyze within 30 days if kept frozen below -20°C c. Alternative holding time is 7 days at 4°C

Total oxidized nitrogen (NOx-N), [Nitrate (NO3 -) +Nitrite (NO2-)]

Total oxidized nitrogen is the sum of the nitrate (NO3 -) and nitrite (NO2 -) expressed as concentrations in mg/L nitrogen. Additionally, the nitrate and nitrate species can be determined separately. Nitrite is an intermediate form of nitrogen and is generally short-lived as it is rapidly oxidised to nitrate. Nitrate is an essential plant nutrient and its levels in natural water systems are typically low (less than 1 mg/L). Excessive amounts of nitrate can cause water quality problems and accelerate eutrophication, altering the densities and types of aquatic plants found in affected water systems. Some bacteria mediate the conversion of nitrate into gaseous nitrogen through a process known as denitrification, and this can be a useful process reducing levels of nitrate in water systems.

Sampling procedures for total oxidised nitrogen

Sample requirement	Filtered sample A
Sample collection technique	a. The sample can be collected in a clean sample container prior to filtration. b. Filtered sample is placed into a different sample bottle, after rinsing. c. Ensure sample bottle is pre-rinsed three times with filtered sample water (3 × 20 mL) before final collection. d. Filter the sample through 0.45 µm pore diameter cellulose acetate (membrane) filter C. e. If determining nitrite species, the sample may be refrigerated (< 4°C) upon collection and analyzed as soon as possible thereafter. f. If the sample is frozen, the analysis must occur within 2 days of collection. g. Samples for determining NOx-N, NH4-N /NH3-N, soluble reactive phosphorus and dissolved organic nitrogen can be collected in the same 250 mL container. h. Fill to just below shoulder of the bottle
Container	a. Plastic or glass bottle capable of conveying 250ml of sample. b. Cap must have a teflon liner. c. Use new or pre-cleaned bottles

Treatment/ preservation required	a. Refrigerate at 1–4°C or freeze and store in the dark.
Maximum sample holding time and storage conditions	a. Analyze within 24 hours if sample is kept refrigerated at 1–4°C b. Analyze within 30 days if kept frozen below -20°C c. Alternative holding time is 1–3 days at 4°C

Soluble Reactive Phosphorus (SRP)

Soluble reactive phosphorus (SRP) describes the dissolved phosphates that respond to colorimetric tests without preliminary hydrolysis or oxidative digestion of the sample and are termed 'reactive phosphorus'. Reactive phosphorus is largely a measure of orthophosphate (PO4 3-); however, a small fraction of any condensed phosphate present is usually hydrolyzed unavoidably in the analytical procedure. Reactive phosphorus occurs as both dissolved and suspended phosphorus. Sources include natural cycling of phosphorus but also fertilizers, detergents and soil erosion, which can carry particulate bound phosphate into water systems.

Sampling procedures for soluble reactive phosphorus

Sample requirement	Filtered sample A
Sample collection technique	a. The sample can be collected in a clean sample container prior to filtration. b. Filtered sample is placed into a different sample bottle, after rinsing. c. Ensure sample bottle is pre-rinsed three times with filtered sample water (3 × 20 mL) before final collection. d. Filter the sample through 0.45 µm pore diameter cellulose acetate (membrane) filter C. e. If determining nitrite species, the sample may be refrigerated (< 4°C) upon collection and analyzed as soon as possible thereafter. If the sample is frozen, the analysis must occur within 2 days of collection. f. Samples for determining NOx-N, NH4-N /NH3-N, soluble reactive phosphorus and dissolved organic nitrogen can be collected in the same 250 mL container. g. Fill to just below shoulder of the bottle
Container	a. Plastic or glass bottle capable of conveying 250ml of sample. b. Cap must have a teflon liner. c. Use new or pre-cleaned bottles
Treatment/preservation required	a. Refrigerate at 1–4°C or freeze and store in the dark.
Maximum sample holding time and storage conditions	a. Analyze within 24 hours if sample is kept refrigerated at 1–4°C b. Analyze within 30 days if kept frozen below -20°C c. Alternative holding time is 1–3 days at 4°C

Total organic nitrogen (TON)

Total organic nitrogen may be calculated from the concentrations of total nitrogen, nitrite, nitrate and ammonium nitrogen, by subtracting the concentrations of inorganic fractions of nitrogen, namely nitrite and nitrate (NOx) and ammonium nitrogen (NH3- N/NH4-N) from the total nitrogen (TN) concentration:

i.e. TON = TN – (NOx + NH3-N/NH4-N).

Total Kjeldahl nitrogen (TKN)

The Kjeldahl nitrogen is a term used to describe all dissolved nitrogen in the tri-negative oxidation state (e.g. ammonium, ammonia, urea, amines, amides, etc) and therefore comprises all the dissolved nitrogen except for some inorganic species (nitrite and nitrate) and organic compounds (azo- compounds, nitriles, oximes, etc). The Kjeldahl method hydrolyses all the amino nitrogen to ammonium, which is then measured by the ammonium/ammonia method. Assuming that the concentrations of many of the other nitrogen species are very low, the TKN concentration is therefore approximately equal to the TN concentration less the nitrite and nitrate concentrations. Or alternatively the TKN concentration is approximately equal to the sum of the total organic nitrogen and ammonia/ammonium as nitrogen concentrations. Many analytical laboratories do not actually measure TKN using the Kjeldahl method (unless specifically requested); instead TKN (total) is calculated by subtracting nitrate and nitrite from total nitrogen (TN) on an unfiltered sample. The Kjeldahl determination is rarely used because it is not as precise as the persulphate digestion method used to calculate TN. It also uses mercuric sulphate–sulphuric acid digest, leaving mercury as an undesirable waste product.

If a value of TKN is necessary ask for it on the Chain Of Custody. Be sure to confirm beforehand with the lab that this is for the calculated value (which should be free, assuming you are already paying for TN and NOx (nitrite and nitrate) analyzes).

Dissolved organic nitrogen (DON)

Dissolved organic nitrogen (DON) is calculated by analysing TN in a filtered sample and then subtracting the NH3-N/NH4-N and NOx-N (i.e. the dissolved inorganic fractions of nitrogen) from the result. Until recently DON could not be accurately measured; it was calculated and therefore prone to greater error. Previously DON was not thought to be a significant portion of the total nitrogen in a system compared to inorganic fractions of nitrogen. However, research has shown that in fact DON is; and that it can be readily utilized by some nuisance algal species. In light of this, it is important that we quantify this previously ignored fraction of nitrogen.

Sampling procedures for dissolved organic nitrogen

Sample requirement	Filtered sample A
Sample collection technique	a. The sample can be collected in a clean sample container prior to filtration. b. Filtered sample is placed into a different sample bottle, after rinsing. c. Ensure sample bottle is pre-rinsed three times with filtered sample water (3 × 20 mL) before final collection. d. Filter the sample through 0.45 µm pore diameter cellulose acetate (membrane) filter C. e. If determining nitrite species, the sample may be refrigerated (< 4°C) upon collection and analyzed as soon as possible thereafter. If the sample is frozen, the analysis must occur within 2 days of collection. f. Samples for determining NOx-N, NH4-N /NH3-N, soluble reactive phosphorus and dissolved organic nitrogen can be collected in the same 250 mL container. g. Fill to just below shoulder of the bottle
Container	a. Plastic or glass bottle capable of conveying 250ml of sample. b. Cap must have a teflon liner. c. Use new or pre-cleaned bottles
Treatment/preservation required	a. Refrigerate at 1–4°C or freeze and store in the dark.
Maximum sample holding time and storage conditions	a. Analyze within 24 hours if sample is kept refrigerated at 1–4°C b. Analyze within 30 days if kept frozen below -20°C c. Alternative holding time is 1–3 days at 4°C

Total organic carbon (TOC)

The total organic carbon (TOC) concentration represents all the carbon covalently bonded in organic molecules and so is not filtered. Total organic carbon does not take into account the oxidation state of the organic matter, and does not measure other organically bound elements, such as nitrogen and hydrogen, and inorganics that can contribute to the oxygen demand measured by biological oxygen demand (BOD). Wastewaters may contain very high levels of organic carbon (>100mg/L).

Sampling procedures for total organic carbon

Sample requirement	Unfiltered sample A
Sample collection technique	a. Ensure sample bottle is pre-rinsed three times with sample water (3 ×20 mL) before final collection. b. Pre-rinse three times with sample water c. Fill container completely to the top to exclude air. The sample must be free of air bubbles. d. Ideally the sample is acidified by adding 10% sulphuric acid (H2SO4) in the field until the pH is < 2. This is often not possible in the field.
Container	a. Glass – brown (amber) container, Cap must have teflon-lined insert b. Use new pre-cleaned bottles that are free from organics
Treatment/preservation required	a. Refrigerate at 1–4°C, do not freeze b. Store in the dark
Maximum sample holding time and storage conditions	a. Test should be carried out as soon as possible after collection. Keep refrigerated at 1–4°C and stored in dark. b. If acidified, holding time is 7 days c. Alternative holding time is 3 days at 4°C (no acidification)

Dissolved organic carbon (DOC)

Dissolved organic carbon (DOC), represents all the soluble organic carbon (or carbon covalently bonded in organic molecules) that can pass through a 0.45 µm pore diameter filter. Dissolved total inorganic carbon (TIC, or DIC) represents the carbonate (CO_3^{2-}), bicarbonate (HCO_3^-) and dissolved carbon dioxide (CO_2) present in a sample. Interference of DIC in the measurement of DOC is removed by acidifying the sample to a pH of less than 2 thus converting all carbonates to CO_2. The CO_2 gas produced is purged from the sample prior to DOC analysis. In this process of CO_2 purging from the sample, volatile organic carbon present in the sample will also be removed; therefore, only non-purgeable organic carbon will be determined in the DOC measurement).

Sampling procedures for dissolved organic carbon

Sample requirement	Filtered sample A
Sample collection technique	a. The sample can be collected in a clean sample container prior to filtration. b. Filtered sample is placed into a different sample bottle, after rinsing. c. Ensure sample bottle is pre-rinsed three times with filtered sample water (3 × 20 mL) before final collection. d. Filter the sample through 0.45 µm pore diameter cellulose acetate (membrane) filter C. e. If determining nitrite species, the sample may be refrigerated (< 4°C) upon collection and analyzed as soon as possible thereafter. If the sample is frozen, the analysis must occur within 2 days of collection. f. Samples for determining NOx-N, NH4-N /NH3-N, soluble reactive phosphorus and dissolved organic nitrogen can be collected in the same 250 mL container. g. Fill to just below shoulder of the bottle
Container	a. Plastic or glass bottle capable of conveying 250ml of sample. b. Cap must have a teflon liner. c. Use new or pre-cleaned bottles
Treatment/preservation required	a. Refrigerate at 1–4°C or freeze and store in the dark.
Maximum sample holding time and storage conditions	a. Analyze within 24 hours if sample is kept refrigerated at 1–4°C b. Analyze within 30 days if kept frozen below -20°C c. Alternative holding time is 1–3 days at 4°C

Chemical Oxygen Demand (COD)

Chemical oxygen demand is defined as the amount of a specified oxidant that reacts with the sample under controlled conditions. The quantity of oxidant consumed is expressed in terms of its oxygen equivalence. Because of its unique chemical properties, the dichromate ion (Cr2O7=) is the specified oxidant, and is reduced to the chromic ion (Cr+3). Both organic and inorganic components of a sample are subject to oxidation, but in most cases the organic component predominates and is of the greater interest.

Sample requirement	Unfiltered sample
Sample collection technique	a. Do not pre-rinse container with sample a. Directly collect into sample bottle or transfer into a sample bottle from collection vessel. b. Fill bottle half way (250ml) to ensure the pH is kept below 2 a. Safety note: Use the appropriate personal protective equipment (e.g. safety glasses and gloves) when filling the sample bottles for dissolved metal analysis. Avoid contact or accidental splashing with the concentrated nitric acid preservative present in the bottles. Concentrated nitric acid is corrosive and care should be taken to avoid any eye or skin contact, or inhalation of fumes. If eyes or skin are exposed to the acid, wash thoroughly and with copious amounts of water and seek medical attention
Container	a. Collect samples in glass bottles. Use of plastic containers is permissible if it is known that no organic contaminants are present in the containers. b. Cap must have teflon-lined insert c. Use new pre-cleaned bottles that are free from organics
Treatment/preservation required	a. Pre-treat bottle by adding 10% sulphuric acid (H2SO4). b. Refrigerate at 1–4°C, do not freeze c. Store in the dark
Maximum sample holding time and storage conditions	a. Samples should be analyzed as soon as possible after collection. b. If storage is required, preserved samples maintained at 4°C may be held for up to 28 days prior to analysis

Biochemical oxygen demand (BOD)

Biochemical oxygen demand is a measure of the amount of biologically degradable organic material that is present in the water. It indicates the amount of oxygen that aerobic aquatic organisms could potentially consume in the process of metabolising all the organic matter available to them. The consequence of high BOD is low levels of dissolved oxygen in affected water systems resulting in aquatic organisms becoming stressed and in extreme cases, suffocating and dying.

Sampling procedures for biochemical oxygen demand

Sample requirement	Unfiltered sample
Sample collection technique	a. Do not pre-rinse container with sample b. Directly collect into sample bottle or transfer into a sample bottle from collection vessel. c. Keep samples at or below 4°C during compositing. Limit compositing period to 24 hrs after sample collection d. Fill container completely to the top to exclude air e. The sample must be free of air bubbles
Container	a. Plastic or glass – brown (amber) capable of conveying 1L of sample. BOD samples is normally in a separate bottle b. Use new pre-cleaned bottles only
Treatment/preservation required	a. Refrigerate at 1–4°C, do not freeze b. Store in the dark
Maximum sample holding time and storage conditions	a. Analyze directly as soon as possible after sample is collected, but within 24 hours if the sample is refrigerated at 1–4°C in the dark.

Metals — total and dissolved metals and metalloids

Many metals are toxic to aquatic animals. They can also bioaccumulate through food chains and this has implications for human health as well as environmental health.

Metals commonly determined include: aluminum (Al), silver (Ag), arsenic (As), boron (B), barium (Ba), beryllium (Be), calcium (Ca), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), mercury (Hg) , potassium (K), lithium (Li), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na), Nickel (Ni), lead (Pb), antimony (Sb), selenium (Se), tin (Sn), titanium (Ti), uranium (U), vanadium (V) and zinc (Zn).

Note that;

1. Total metals can be analyzed by digesting the sample using a concentrated nitric/ hydrochloric acid added to an unfiltered water sample prior to analysis

2. Dissolved metals are determined by analysing those metals in a filtered sample that passes through a 0.45 µm membrane filter]. Before analysis of a field-filtered, field-acidified sample, some extra dilute acid is added to the filtered sample, to ensure dissolution of any precipitates formed after filtration.

3. The sample must not be filtered when determining total metals (which include those metals bound to the particulate matter in the sample); otherwise, the same collection procedure is followed.

4. The specific metals that are required to be determined must be stated on the chain of custody form (COC).
5. Slightly different analysis techniques are also required if speciation is necessary to determine concentrations of ferrous iron [Fe (II)] and hexavalent chromium [Cr (VI)].

Sampling procedures for heavy metals

Metals (Dissolved or particulate)	Al, Ag, As (total, III, V), B, Ba, Be, Ca, Cd, Co, Cr (total, III), Cu, Fe (total), Hg, K, Li, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se (total, IV, VI), Sn (not including tributyl tin as Sn), Ti, U, V & Zn
Sample requirement	Filtered sample if analysis is required for dissolved metals. Do not filter if particulate metals are required.
Sample collection technique	a. Decant from collection vessel and filter immediately. b. Filtered sample is placed directly in sample bottle c. Filter sample through 0.45 µm pore diameter cellulose acetate (membrane) filter d. If the sample bottles contain acid do not pre rinse them, otherwise, prerinse bottle with filtered sample three times, then add filtered sample and add acid preservative. e. Fill to the shoulder of bottle. f. Samples for total metal concentrations are not filtered. g. Generally, all metals/metalloids can be analyzed from the same sample bottle, except for when the special Hg analysis or speciation analysis is required. ***Safety note***: Use the appropriate personal protective equipment (e.g. safety glasses and gloves) when filling the sample bottles for dissolved metal analysis. Avoid contact or accidental splashing with the concentrated nitricacid preservative present in the bottles. Concentrated nitric acid is corrosive and care should be taken to avoid any eye or skin contact, or inhalation of fumes. If eyes or skin are exposed to the acid, wash thoroughly and with copious amounts of water and seek medical attention

Dissolved hexavalent chromium [Cr (VI)]

A minimum volume of 100 mL of sample is required. The same sample treatment as above applies, except the sample should not be acidified. Rather, after filtration, the pH of the sample should be adjusted to > 8 with 1 M (4%) sodium hydroxide solution, and refrigerated at 1–4°C (do not freeze). Samples should be analyzed within 24 hours of collection.

Dissolved ferrous iron [Fe (II)]

A minimum volume of 100 mL of sample is required. The same sample treatment as above applies, except that the sample is acidified with concentrated hydrochloric acid to pH < 2,

and refrigerated at 1–4°C (do not freeze). Additionally, the sample container must be filled completely to exclude air from the container thus preventing conversion to ferric iron [Fe (III] and further hydrolysis to form insoluble hydrated ferric oxide. Samples should be analyzed within 24 hours of collection.

Total water hardness (as CaCO3)

Total hardness is defined as the sum of calcium and magnesium concentrations in water, expressed as calcium carbonate equivalents in milligrams per litre according to the following formula. Hardness equivalent CaCO3/L = 2.497 [Ca, mg/L] + 4.118 Mg, mg/L].

Sampling procedures for total water hardness

Sample requirement	Unfiltered sample
Sample collection technique	• Decant from collection vessel, ensuring sample bottle is pre-rinsed three times with sample water (3 × 20 mL) before final collection. • Pre-rinse bottle with sample water three times, then add sample water. • Fill to the shoulder of bottle
Container	a. Plastic capable of conveying 1L of sample b. Bottle cap must have a teflon liner c. Use new pre-cleaned acid rinsed bottles
Treatment/preservation required	a. Refrigerate at 1–4°C, do not freeze b. Store in the dark
Maximum sample holding time and storage conditions	7 days

Total acidity and total alkalinity (as CaCO3)

The total alkalinity of water is a measure of its acid-neutralising capacity to a designated pH. It is the sum of all titratable bases, including carbonates, bicarbonates, and hydroxides, and also borates, phosphates, silicates and other bases if they are present. Total acidity is a quantitative measure of the capacity of water to react with a strong base to a designated pH. For analysis of total alkalinity APHA, 1998 requires titration with a standard hydrochloric acid solution to an end-point pH of 3.7 (i.e. the methyl orange endpoint). To determine total acidity APHA, 1998 requires titration with a standard

Sodium hydroxide solution to an end-point pH 8.3 (i.e. the phenolphthalein end-point).

Sampling procedures for total acidity and total alkalinity

Sample requirement	Unfiltered sample
Sample collection technique	a. Direct collection into sample bottle or transfer into a sample bottle from collection vessel. b. Ensure sample bottle is pre-rinsed three times with sample water (3 × 20 mL) before final collection. c. Fill container completely to the top to exclude air. d. The sample must be free of air bubbles. Cap tightly
Container	a. Plastic capable of conveying 1L of sample b. Bottle cap must have a teflon liner c. Use new pre-cleaned acid rinsed bottles
Treatment/preservation required	a. Refrigerate at 1–4°C, do not freeze b. Store in the dark
Maximum sample holding time and storage conditions	c. Analyze within 1 day if sample is kept refrigerated at 1–4°C. d. Do not freeze

Total petroleum hydrocarbons (TPHs)

The C6 to C9 petroleum hydrocarbon fraction will predominantly consist of the BTEX compounds, so the same method described for BTEX (see section 5.21) is applied to the sample for this hydrocarbon fraction. The other molecular weight range fractions namely C10 to C14, C15 to C28, and C29 to C36 are estimates of the total petroleum hydrocarbons since:

Sampling procedures for total petroleum hydrocarbons

Sample requirement	Unfiltered sample
Sample collection technique	a. Do not pre-rinse container with sample b. Bottle must be used to collect sample directly c. No decanting d. Do not pre-rinse container with sample e. Do not completely fill sample container
Container	a. Glass – brown (amber) container capable of conveying 1L of sample b. Cap must have teflon-lined insert c. Use new pre-cleaned bottles that are free from volatile organics
Treatment/preservation required	a. Refrigerate at 1–4°C, do not freeze b. Store in the dark
Maximum sample holding time and storage conditions	a. Analyze within 14 days if refrigerated at 1–4°C and stored in the dark.

Polycyclic aromatic hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) have multiple aromatic rings in their chemical structure. They are also referred to as polynuclear aromatic hydrocarbons. PAHs are found in coal tar, crude oil, creosote, and roofing tar, but a few are used in medicines or to make dyes, plastics, and pesticides. They can be formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or char-broiled meat, and are typical components of asphalts, fuels, oils, and greases. Some PAHs are manufactured as colourless, white, or pale yellow-green solids. A suite of 16 individual PAHs, identified as priority pollutants by are usually determined in environmental samples. This suite comprises:

naphthalene,acenaphthylene,acenaphthene,anthracene,benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[ghi]perylene, benzo[a]pyrene, chrysene, dibenz[a,h]anthracene, fluoranthene, fluorene, indeno[1,2,3-cd]pyrene, phenanthrene&pyrene

Other alkylated PAHs, commonly found in petroleum, may also be targeted for example 1-methylnapthalene and 2-methylnapthalene.

Sampling procedures for total petroleum hydrocarbons

Sample requirement	Unfiltered sample
Sample collection technique	a. Do not pre-rinse container with sample. b. Bottle must be used to collect sample directly, no decanting c. Do not pre-rinse container with sample d. Do not completely fill sample container e. Detection limits and limits of reporting may be decreased for trace level analysis by increasing the volume of water to 1 litre. f. Decreasing the volume of water to 500mL increases the detection limits and limits of reporting.
Container	a. Glass – brown (amber) container capable of conveying 1L of sample b. Cap must have teflon-lined insert c. Use new pre-cleaned bottles that are free from volatile organics
Treatment/preservation required	a. Refrigerate at 1–4°C, do not freeze b. Store in the dark
Maximum sample holding time and storage conditions	a. Extract within 7 days and analyze within 40 days, if refrigerated at 1–4°C and stored in the dark

Volatile organic compounds (VOCs)

A suite of volatile organic compounds including benzene, toluene, ethyl benzene and xylene isomers (BTEX), other C6 to C9 petroleum hydrocarbons, other monocyclic aromatic compounds and halogenated compounds may be determined in water samples to investigate anthropogenic contamination. This suite might include some of the following compounds. Please note that these
lists are not exhaustive:

Examples of monocyclic aromatic hydrocarbons include

acrylamide, benzene, tert-butylbenzene, sec-butylbenzene, n-butylbenzene, dimethylamine, EDTA (ethylenediaminetetraacetic acid), epichlorohydrin, ethylacrylate, ethyl benzene, isopropylbezene [cumene], p-isopropyltoluene, npropylbenzene, styrene (vinyl benzene), toluene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, m-xylene, o-xylene, p-xylene & a-methylstyrene

Examples of chlorinated VOCs include

Bromobenzene, bromochloromethane, bromoform, carbon tetrachloride, chlorobenzene, chloroform, 2-chlorotoluene, 4-chlorotoluene, bromodichloromethane, dibromochloromethane, 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, dibromomethane, o-dichlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,1-dichloroethane, 1,2- dichloroethane, 1,1- dichloroethene, trans-1,2-dichloroethene, cis-1,2- dichloroethene, dichloromethane, 1,2-dichloropropane, 1,3-dichloropropane, 2,2- dichloropropane, 1,1-dichloropropene, cis-1,3-dichloropropene, trans-1,3- dichloropropene, hexachlorobutadiene, tetrachloroethene, 1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, trichlorobenzenes (total), 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, 1,1,1-trichlororethane, 1,1,2-trichloroethane, 1,2,3-trichloropropane, trichloroethene, trichlorofluoromethane, vinyl chloride, chloroacetic acid, cyanogen chloride (as cyanide), dichloroacetic acid, trichloroacetaldehyde (chloral hydrate), trichloroacetic acid &trihalomethanes
(THMs) (total)

Sampling procedures for total petroleum hydrocarbons

Sample requirement	Unfiltered sample
Sample collection technique	a. Do not pre-rinse container with sample b. Bottle must be used to directly collect sample. No decanting. c. However, if acid preservative is present in bottle prior to collection (as with preprepared laboratory bottles), decant sample from another collection vessel into sample vial. d. Sample should be collected such that there is minimum exposure of sample (in either the collection or sample container) to the atmosphere e. Completely fill sample container to capacity with a 'bulging meniscus' but not overflowing. Cap sample so that there are no air spaces or bubbles. f. Tightly seal sample bottles and store with the teflon-lined septum cap face down g. Sample must be free of air bubbles h. For chlorinated VOC determination, for each 40 mL of sample add either: (a) 3 mg of sodium thiosulphate (Na2S2O3); or (b) 25 mg ascorbic acid (vitamin C, C6H8O6); or (c) 3 mg sodium sulphite (Na2SO3); to container prior to sample collection for preservation ***Safety note*:** Take care and use the appropriate personal protective equipment (e.g. safety glasses and gloves) when filling the sample bottles for BTEX analysis, as there is a need to avoid contact or accidental splashing with the concentrated hydrochloric acid preservative in the bottles.
Container	a. Glass – brown (amber) container capable of conveying 1L of sample b. Cap must have teflon-lined insert c. Use new pre-cleaned bottles that are free from volatile organics
Treatment/preservation required	a. Bottles may come including a fixative, from the laboratory. Do not rinse these pre-prepared bottles. b. Refrigerate at 1–4°C but do not freeze
Maximum sample holding time and storage conditions	a. 7 days if refrigerated at 1–4°C and acidified, extract within 7 days, analyzewithin 40 days

Surfactants

A surfactant molecule contains a strongly hydrophobic portion, usually a hydrocarbon chain containing about 10 to 20 carbon atoms, and a hydrophilic portion. The hydrophilic part of the molecule is usually either ionic or uncharged. Ionic surfactants (i.e. the hydrophilic portion of the molecule is ionic) may be further categorised as cationic, where the ion retains a positive charge, and anionic where the charge is negative.

Surfactants often enter waters and water systems through the discharge of aqueous wastes from household laundering and other cleansing operations.

Anionic surfactants

These include linear alkylbenzenesulphonates (LAS), alkylsulphonates and alkylsulphates.

Sampling procedures for Anionic surfactants

Sample requirement	Unfiltered sample
Sample collection technique	a. Bottle must be used to directly collect sample, no decanting b. Fill container completely to exclude air
Container	c. Glass container d. Cap must have teflon-lined insert e. Use new pre-cleaned bottles that are free from detergent f. Do not wash glass sample bottle with detergent g. Bottle should be solvent washed with methanol h. For the analysis of methylene blue active substances (MBAS), do not acidify
Treatment/preservation required	a. Add 10% sulphuric acid (H2SO4) to pH < 2 (this is not necessary if analysing MBAS) b. Refrigerate at 1–4°C c. Do not freeze
Maximum sample holding time and storage conditions	a. Immediate analysis is preferable b. Analyze within 2 days if sample is kept refrigerated at 1–4°C c. Do not freeze.

Cationic surfactants

These include polyethoxylated tallow amine, commonly used as a wetting agent in herbicide formulations and alkylquarternanry ammonium salts, common ingredients in hair shampoos and conditioners.

Sampling procedures for cationic surfactants

Sample requirement	Unfiltered sample
Sample collection technique	a. Bottle must be used to directly collect sample, no decanting b. Fill container completely to exclude air
Container	a. Glass capable of conveying 1L of sample b. Cap must have teflon-lined insert c. Use new pre-cleaned bottles that are free from detergent d. Do not wash glass sample bottle with detergent e. Bottle should be solvent washed with methanol f. For the analysis of methylene blue active substances (MBAS) do not acidify
Treatment/preservation required	a. Add 40% (v/v) formaldehyde solution to give a 1% (v/v) final concentration b. Refrigerate at 1–4°C c. Do not freeze
Maximum sample holding time and storage conditions	a. Immediate analysis is preferable b. Analyze within 2 days if sample is kept refrigerated at 1–4°C

Sampling procedures for Non-ionic surfactants (NIS)

Sample requirement	Unfiltered sample
Sample collection technique	a. Bottle must be used to directly collect sample, no decanting b. Fill container completely to exclude air
Container	a. Glass capable of conveying 1L of sample b. Cap must have teflon-lined insert c. Use new pre-cleaned bottles that are free from detergent d. Do not wash glass sample bottle with detergent e. Bottle should be solvent washed with methanol f. For the analysis of methylene blue active substances (MBAS) do not acidify
Treatment/preservation required	a. Add 40% (v/v) formaldehyde solution to give a 1% (v/v) final concentration b. Refrigerate at 1–4°C c. Do not freeze
Maximum sample holding time and storage conditions	a. Analyze within 1 month if sample is kept refrigerated at 1–4°C

Oil and grease

In the determination of oil and grease specific substances are not quantified. Rather, groups of substances with similar physical characteristics are determined qualitatively on the basis of their common solubility in an organic extracting solvent. 'Oil and grease' is defined as any material recovered as a substance soluble in a particular solvent. It includes petroleum based fuels such as gasoline, diesel, and kerosene, emulsifiable oil, and petroleum hydrocarbons (C6–C9, C10–C14, C15–C28, and C29–C36). The organic solvent currently prescribed by standard methods is a mixture of 80% n-hexane and 20% methyl-tert-butyl ether (MTBE). Because the extraction is not specific for these petroleum products, other non petrogenic compounds are also determined. These include biological hydrocarbons and well as photosynthetic pigments. Volatile organic compounds are not recovered from this analysis.

Sampling procedures for oil and grease

Sample requirement	Unfiltered sample
Sample collection technique	a. Do not pre-rinse container with sample b. Bottle must be used to directly collect sample, no decanting c. Do not pre-rinse container with sample d. Do not completely fill sample container
Container	a. Glass – brown (amber) container capable of conveying 1L of sample b. Cap must have teflon-lined insert c. Use new pre-cleaned bottles that are free from volatile organics d. Bottle should be solvent washed (with acetone/hexane/methanol) and free of organics e. Extract on site where practical f. Extract sample container as part of the sample extraction procedure
Treatment/preservation required	a. Add 40% (v/v) formaldehyde solution to give a 1% (v/v) final concentration b. Refrigerate at 1–4°C c. Do not freeze
Maximum sample holding time and storage conditions	a. Analyze within 28 days if acidified, refrigerated at 1–4°C and stored in the dark. b. Analyze within 1 day if refrigerated at 1–4°C and stored in the dark, but not acidified.

Sampling procedures for Chloride (Cl-), Sulphate (SO42-)

Sample requirement	Filtered sample
Sample collection technique	a. The sample can be collected in a clean sample container prior to filtration. b. Filtered sample is placed into a sample bottle, after rinsing. c. Ensure sample bottle is pre-rinsed three times with filtered sample water (3 × 20 mL) before final collection. d. Filter sample through 0.45 µm pore diameter cellulose acetate (membrane) filter e. Fill to below shoulder of bottle if freezing
Container	a. Plastic or glass capable of conveying 500ml of sample b. Use new pre-cleaned bottles c. If necessary, bottles should be washed in phosphate-free detergent and rinsed three times with tap water and three times with deionised water.
Treatment/preservation required	a. Analyze within 1 month if sample is kept refrigerated at 1–4°CRefrigerate at 1–4°C b. Do not freeze
Maximum sample holding time and storage conditions	a. Analyze within 1 month if sample is kept refrigerated at 1–4°C

True colour

Colour in water samples can result form the presence of natural metallic ions (iron and manganese), humus and peat materials, plankton, weeds, and industrial wastes. Colour or true colour refers to the colour of water upon removal of suspended solids (i.e. once the sample has been filtered). Table 35 Sampling procedures for true colour

Sample requirement	**Filtered sample**
Sample collection technique	a. The sample can be collected in a clean sample container prior to The sample can be collected in a clean sample container prior to filtration. b. Filtered sample is placed into a sample bottle, after rinsing. c. Ensure sample bottle is pre-rinsed three times with filtered sample water (3 × 20 mL) before final collection. d. Fill to just below shoulder of the bottle; do not completely fill
Container	a. Plastic B or glass capable of conveying 500ml of sample b. Use new pre-cleaned bottles c. If necessary, bottles should be washed in phosphate-free detergent and rinsed three times with tap water and three times with deionised water d. Filter sample through 0.45µm pore diameter cellulose acetate (membrane) filter
Treatment/ preservation required	a. Refrigerate at 1–4°C and store/transport in the dark. b. Do not freeze
Maximum sample holding time and storage conditions	a. Analyze within 2 days if sample is kept refrigerated at 1–4°C in the dark.

Microbiological analyzes

Microbiological parameters include;

Total plate count (TPC), Total coliforms, faecal coliforms (or thermotolerant coliforms), E. coli. (Escherichia coli), Entercocci.

Sampling procedures for microbiological analysis

Sample requirement	Unfiltered sample
Sample collection technique	a. Keep sterilized sample bottle closed until it is ready to be filled b. Carefully remove container cap & do not contaminate inner surface of bottle and cap c. Do not rinse sample container with sample d. Direct collection into sample bottle or transfer into a sample bottle from collection vessel e. Fill to below shoulder of bottle to facilitate mixing by shaking. f. If composite samples are prepared, care must be to ensure that the samples remain homogeneous during transfer.
Container and volume	a. Sterilized plastic or glass containers b. Use new pre-cleaned sterilized bottles If necessary, bottles should be washed in phosphate-free detergent and rinsed three times with tap water and three times with deionized water, prior to sterilization c. For each parameter tested, at least 100 mL of sample is required (this does not include plate count); e.g. 200 mL is required for the AS method for coliforms and E. coli, and total plate count; and an additional 100 mL is required if sulphite reducing spore formers are also requested.
Treatment/preservation required	a. Store in the dark b. Refrigerate at 1–4°C c. Do not freeze
Maximum sample holding time and storage conditions	a. Immediate analysis is preferable. b. Analyze within 24 hours if sample is kept refrigerated at1–4°C

Benthic Macroinvertebrates

Benthic macro invertebrate sampling is conducted within the same 75m site used for other sampling. The intent of benthic sampling is to provide a representative sample of the community composition and relative abundance in favorable habitat (habitats supporting the greatest benthic diversity) within the site. In addition to representing the diversity at the sampling site, benthic macro invertebrate data collected are used to calculate the benthic macro invertebrate. The information on the abundance of species or absence can be used as an alternative pollution monitoring criteria complementary to physical chemical and or organic pollution loading in water systems.

D-net (450µ mesh), sieve bucket (450µ mesh sieve), and sample bucket are needed to collect benthic macro invertebrate sample.

Benthic Macro invertebrate Sampling Protocols

Benthic sample buckets must be labeled twice - on the external wall of the bucket and on the inside. The following information must be included on the label: date, time, and site identification. Verify the information on each label and indicate so on the Data Sheet. The external label should be covered with clear plastic tape to prevent smudging and/or label loss. Internal labels must be printed on waterproof paper. Both labels should be filled in with pencil. Benthic sample Chain-of-Custody forms should also be filled out with the name of the sampler, date, time, and sample site number.

In a riffle, start at the downstream edge and place the net firmly in the substrate. Aggressively disturb the substrate with hand and/or foot. Sampling typically disturbs riffle habitat about 5 to 8 34 cm below the substrate surface. Rub by hand any large sticks and/or stones from within the disturbed area to dislodge any organisms that may be clinging to these substrates. Repeat this process near the upstream edge of the riffle. Repeat as necessary until the desired number of square feet has been sampled. Samples should be taken from the range of substrate types and velocities found within the riffle to best represent the community of benthic macro invertebrates living within the riffle.

Log and snag substrates should be rubbed by hand or with a small brush. The D-net should be positioned with the stream current flowing into the net as the logs or snag substrates are rubbed.

The D-net should be used in a jabbing or sweeping motion to dislodge organisms from root mats, submerged macrophytes, or other habitats. Kicking the habitat prior to jabbing may also be done as needed to dislodge organisms. In soft substrates the net motion should be more gentle to minimize the collection of detritus. In all cases the D-net should be placed downstream of the sampled substrate following jabbing and sweeping to make sure that dislodged organisms are carried into the net

In some rare cases, (e.g. some large 3rd-4th order streams) a sufficient amount of potentially productive habitat may not be present within the 75m site to collect a 20 ft2 sample. If this is the case, moving out of the sample site in an upstream direction to find habitat that can be sampled using a D-net is permissible. This should only be done if it is not possible to collect a sufficient sample within the 75m site. If sampling is conducted upstream of the 75m site, a description of the habitats sampled and distance from the upstream end of the 75m must be recorded in the comments section of the Data Sheet.

When a complete 20 ft2 sample has been obtained, or when the D-net becomes filled to the point that water does not pass easily through it, the net should be washed into a sieve bucket that is partially submerged and in a shallow portion of a run or pool. While the sample is in the sieve bucket, all large stones (i.e., those greater than 3 cm in diameter), debris, leaves, etc., should be carefully washed, inspected for organisms, and discarded. If necessary, use

forceps to remove any animals remaining on the net. All vertebrates (e.g., herpetofauna and fish) should be removed from the sieve bucket at this time. To remove fine sediments from the sample, the sieve bucket may be gently "slapped" against the stream water surface and very slowly rotated while the bottom of the bucket is submerged. Do not rotate the sieve bucket quickly during this process, as this action may damage many soft-bodied macro invertebrates potentially rendering them unidentifiable. After processing the sample in the sieve bucket, the benthic net should be rinsed carefully in stream water to make sure that no benthic macroinvertebrates remain that may be transported to the next sample site.

Preservation

The processed composite sample should be transferred from the sieve bucket to an externally labeled sample bucket and preserved in 95% ethanol. Place the internal label atop the sample material and ensure that the lid to the sample bucket is tight. Gently mix the sample material and preservative and ready the sample for transport.

Delivery to Laboratory

A Benthic Macroinvertebrate Chain-of-Custody Sheet must accompany all samples taken to the benthic macroinvertebrate identification laboratory, which includes the sample identification codes for all samples being delivered, sampler name, date, and a signature from a laboratory representative upon transfer of samples to the laboratory.

Equipment and other field requirements/checklist

Depth Sampler 1400ml
Depth Sampler 1000ml
Dispensing reel and Rope 60m
Rope 15m
Sampling Dipper
Submersible pump, Rope and delivery hose
10kg Weight and rope
Multiprobe
Alkalinity Kit
Bucket, 5L(heavy duty with spout)
D-net (450µ mesh), sieve bucket (450µ mesh sieve), and sample bucket for benthic microvertabrates
GPS
Sechi disk
Hand net
Surber sampler
Grab sampler
Sediment corer

Bucket with lid
Plankton nets
Tarpaulin and ropes
Waste Bin(s)
Jerry can(s) 20litres
Turbidimeter
Distilled water
Filter Funnel with pump
Filter flask 1000ml
Wash Bottle
Conical Flask
Measuring cylinder(s)
GFC filter papers
Forceps (plastic)
280mm diameter funnel
Soft tissue, 3ply grade (Kimberly type)
Marker Pen (s)
Collilert vessels for Quanti trays
Quanti-trays
Quanti tray heat sealer and Cable
UV viewing cabinet
UV lamp
Sterile pipettes
Gas torch
Gas Lighter
Gas cylinders
Pipette Filler(s)
Incubator and Cables
Cool box
Generator
Reagents/Solutions
Collilert 18 reagent
Disinfectant(Hypochlorite)

Quality Controls
Dilution Water(lts)
Pseudomonas aurogenosa (negative)
Enterobacteraerogenes(Positive/ Negative)
Escherichia coli (Positive)
Blanks(sterile Water)

Sodium carbonate solution (200mg/l) for Alkalinity.
Turbidity standards (4000NTU)
pH buffer solutions, pH 7.00, 4.00, 10.0
Potassium Chloride (EC = 1414µS/cm)

Sample Bottles

Plastic or glass 1000ml , No preparation
500ml glass, Sulphuric acid
1000ml glass, amber, sulphuric acid
1000ml glass Hydrochloric acid
100ml sterilin, Nitric acid
100ml sterilin, No preparation
500ml Duran, Sterilised

Manuals/Forms/Logs

Field Sampling/Analysis record sheets (chain of custody)
Maps of relevant areas
Incident/Accident Forms

Field Safety/Protection

Disposable gloves
Marigold gloves
Particle masks
Overalls / Over coats
Day glow vests
Road Hazard warning Triangles
Traffic cones
Gumboots
Thigh waders
Life jackets
Umbrella(s)
Rain Coat(s)

Groundwater quality(monitoring site) and sampling

At suitable locations where oil and gas exploration and production activities are actively going on ground water wells need to be sunk from which periodically water samples will be collected and analyzed to provide data on status of the quality of the water resource. The number of wells on a site is determined by the size of the land coverage under use but also on the nature of the aquifer present. Wells are located at the outskirts of the pads or land were the activities or waste storage sites are located.

The purpose of groundwater sampling is to retrieve a water sample that represents the

characteristics of water below the ground surface. To obtain a representative sample, stagnant water is pumped out from the bore casing before a sample is taken. A process referred to as purging. Pump until such time as the pH, EC and temperature of the discharge water are observed to stabilise. Only then is the obtained sample considered to be representative of groundwater residing in the aquifer surrounding the bore screen. Then a sample can be collected using standard sampling bottles.

Equipment

1. Sampling bottles (1l glass bottle, 200ml glass bottle treated with Conc Nitric Acid)
2. Field potable devices (pH, Conductivity and Turbidity meters, GPS)
3. Cool box
4. Field record forms
5. Water Pump

a) Water quantity

Monitoring the fluctuation of water levels (surface and ground water) is very important since it is an indicator of the amount of water available for various uses in the Albertine Graben. The frequency of measurement of water levels in both ground and surface water bodies is done on a daily basis.

Geo spatial design for water quantity monitoring

Water quantity monitoring stations already exist along water bodies in the Albertine Graben. However additional stations will have to be constructed to enhance groundwater and wetlands to be monitored. Specific abstraction points will be monitored in order to ensure that abstractions are sustainable

Baseline will include inventory on all water users, water balance (methodology to be developed)

Surface Water monitoring

Surface water monitoring involves obtaining a continuous record of water levels, making periodic discharge measurements, establishing and maintaining a relation between the water levels and discharge, and applying the water level -discharge relation to the water level record to obtain a continuous record of discharge.

The configuration of the network and the makeup of the stations varies over time as stations are upgraded or damaged and as the need for data of a particular location changes. The current network in the Albertine Graben comprises primary stations which are equipped with automatic water level recorders and secondary stations which are read manually. The procedure highlighted below should be followed when one visits a monitoring station.

a. Visit the observers

i. Collect recorded water levels (wl)

ii. Pay for the work and give instructions

iii. Stress the importance of thorough and accurate work

b. Read the gauge, check the firmness of the installation, service the automatic water level recorder, check the gauge reader's past records and flush the stilling well if needed. (See Appendix I notes on reading staff gauges)

c. Make discharge measurement with current meter or ADCP.

d. Calculate the discharge and plot the result on the rating curve.

e. Take level checks

f. Carry out any maintenance

g. Carry out other necessary station surveys

h. Make field report

Discharge measurements

Discharge measurements are made to create a unique rating curve for each gauging station. Based on the rating curve, water levels are transformed to discharge. Without current meter measurements the recorded water level is of little value in rivers. During the first years of operation of the network, every effort must be made to make discharge measurements as often as possible, particularly in the wet season to measure peak flow. Once the rating curve (stage/discharge relationship) has been satisfactorily defined, the frequency of special measurements may be reduced to a level where the ongoing validity of the relationship is checked on a routine basis. For stations with no proper section or channel control, like stations in wetlands, a unique rating curve cannot be expected due to changes in vegetation and backwater effect. It is therefore essential that measurements are made synchronic revealing the water balance in the lake.

Choosing the Discharge Measurement site

The discharge measurement site must satisfy certain criteria.

The site must not be so far from the gauge plates that there is significant in flow or outflow of water between the two. In addition there should be no significant storage between the two, e.g. Large pools. Generally the discharge measurement site should be within 300m upstream or downstream of the river station.

The channel should be reasonably straight, for the distance upstream of at least 3 times the channel width with a regular cross-section and longitudinal profile. The cross section should be perpendicular to the general direction of the flow. Slight convergence of flow is preferred to divergence. There should be no major eddies or reverse flows. However, occasionally a case will occur where water in part of the cross section might reverse due to weed growth or some debris (logs etc.) which have fallen into the channel, when this occurs the reverse flow must be subtracted from the remainder of the flow.

The cross section shall be free from weed growth, large rocks, bridge pillars and other obstructions in and upstream the cross section for a distance that there is no turbulence in the measuring profile normally three times the width of the river. Therefore weed is cut

prior to a measurement, and all measurements are made upstream obstructions like pillars generating turbulence. For viaducts and culverts, measurements are made within the structure.

The minimum depth of moving water should be greater than the propeller.

The riverbanks must be sufficiently elevated above high flow levels. In case of wading is impossible; a cableway or a nearby bridge may be found from which the current meter may be suspended by relocation devise or bridge crane.

Measuring water velocity/Discharge measurements

On arrival at the station:

a) Write down the gauge height, time and date on discharge Form No. 1 (Appendix 1)

b) Select the proper instrument like current meter with propeller or ADCP. Normally use current meter with the propeller No. 1 (125mm diameter, 0.25m pitch) when the velocity is below 5.0m/s and propeller No.2 (125mm diameter, 0.5m pitch) when the velocity exceeds 5.0m/s. For shallow water select the “Small Current meter” with propeller No. 6 or 3. Note the instrument and propeller number on Form No. 1.

Water depth	OTT Instrument	Propeller type, examples	Velocity
≤ 10	Small current meter	No. 6 30mm Ø, 0.1m pitch	
≥ 10 - 30	Small current meter	No. 3 50mm Ø, 0.0.25m pitch	
> 20	Universal CM	A 100mm Ø	
> 30	Universal CM	1 125mm Ø, 0.25m pitch	V < 5.0m/s
> 30	Universal CM	2 125mm Ø, 0.25m pitch	V < 5.0m/s

c) Perform the spin test for the current meter to ensure it is performing well. Universal Current Meter with brass propeller shall spin for 110 sec until it comes to a standstill.

d) At low flows, stretch out the tag line across the channel at a right angle to the general direction of flowand make discharge measurement by wading. At high flows the portable cableway, or a tape measure across a bridge will replace a tag line.

e) Measure the total width of the water surface and write distance to banks. Normally Bank =0 but for a 20 cm vertical bank: Bank = 0/20.

f) It is preferable to select the same cross section and refer all distances to a fixed reference point. This will make QA easier when cross sections of two or more measurements are plotted for comparison.

g) Measure the water depth to the nearest 0.01m at intervals across the channel. In general no segment should be more than 10% of the total flow. The number of vertical used is a compromise: more verticals give higher accuracy but take longer. Beyond a certain number there may be no significant improvement in accuracy. The filed team leader will decide on

the technique for measurement and the number of verticals.

	Minimum number of verticals for a cross section
Cross section width in m	Minimum number of verticals
b < 0.5	3
0.5 < b < 1.0	4 - 5
1.0< b <3.0	5 – 8
3.0 < b <6.0	8 – 12
b > 6.0	12 or more

h) For each vertical measure the depth and calculate the vertical heights.

Minimum number of horizons in the vertical depending on water depth and propeller used	
Vertical Depth	Minimum number of horizons for universal current meter
d < 0.20 m	1
0.20 < d < 0.40	2
d > 0.40	3 or more

i) Calculate 0.2, 0.6 and 0.8 times the depth and tell the operator of the meter

j) Set the current meter below the water surface at 0.2, 0.6 and 0.8 times the depth. Make sure the current meter is connected to counter unit.

k) Switch on the counter unit. Always select 60 seconds on the mode switch.

l) Normally the operator will carry the counter and write the position and revolution in the discharge form which will allow him to evaluate the verticals. If a second person is doing the writing, the operator he should call START when the meter in position and he is ready and the assistant can press the switch.

m) Normally sample 3 horizons in each vertical and enter the number of revolutions (revs) on the Discharge form No.1. If the revolutions are not performing as expected (increasing number of revolutions from the bottom to surface): check the instrument and repeat the measurement.

n) At the end of each measuring interval write the next vertical

o) Remember to switch the counter unit off at the end of the measurement.

p) Note down the gauge height and time again at the end of the discharge measurement

q) Clean and dry the control unit as necessary

r) After every 3 measurements the oil in the current meter shall be changed. If the ball bearings are soiled with dirt they should be dismantled and cleaned in white spirit. The performance of the instrument is sensitive to any dirt in oil and ball bearing, therefore any cleaning is done under dust free conditions and certainly not along the roadside.

s) Make sure the current meter components and control box are secure and protected from vibration during transportation.

t) Any information pertaining to the discharge measurement unit which is not required to complete Discharge Form No. 1 but which you deem to be important should be recorded in the remarks column.

Calculating the discharge measurements

The calculation of discharge from the velocity measurements the propeller revolutions over 60 sec. are recorded on Discharge Form No. 3 (Appendix 2). To transform the revolutions to velocity, the calibration certificate from the manufacturer is used.

Equipment

1. Current meter
2. Electric Cables
3. Counter
4. Tape measure

Groundwater level measurements

Groundwater level measurements can provide information on lateral and vertical head distribution and hydraulic gradients within individual aquifers and between aquifers in layered aquifer systems. Long-term groundwater level measurement provides information on the temporal trends in groundwater levels (and therefore flow direction and rates) due to the effects of drought, high rainfall events and groundwater pumping.

When monitoring unequipped boreholes the first parameter to be measured is total depth (TD) of the borehole. When monitoring a borehole that has pumping equipment permanently installed and does not provide access to the borehole casing, the TD cannot be measured. Total depth should be obtained from the owner or custodian of the borehole and noted on the Borehole Information Sheet. Note that all depth measurements are conventionally taken from the top of the casing or borehole shield (at a marked point, such as the padlocking point). Hence, the height above the ground surface of this reference point should also be measured.

Over time, the base of the monitoring bores can silt up, and this can occur to the top of the slotted/screened interval. Comparing the measured total depth reading with the depth documented at the time of construction can be useful to determine the status of the borehole.

Groundwater level measurements are taken by dipping the water level meter into the borehole. The water level meter uses a probe attached to a permanently marked polyethylene tape, fitted on a reel. The probe detects the presence of a conductive liquid between its two electrodes and is powered by a standard 9 volt battery. When contact is made with water, the circuit is closed, sending a signal back to the reel. This activates a buzzer and a light. The water level is then determined by taking a reading directly from the tape, at the top of the bore casing or borehole.

Compliance Monitoring

Discharge and abstraction points for specific developments within the Graben are issued with permits with standard and site specific conditions as a mechanism for avoiding pollution occurrences and ensuring sustainability of the water resources. Monitoring involves;

a) Spot checks at discharge points to ensure compliance to permit and EIA Approval conditions.
b) In situ measurements of both water quality and quantity indicators are made as part of the conditions in the permits.
c) Self monitoring by permit holders for water quality and quantity and submission of the same quarterly.
d) Verification and analysis of self monitoring data submitted and providing feedback to permit holders with particular emphasis on areas of compliance and non-compliance with respect to the permit conditions with cautions for improvements.
Providing compliance assistance to permit holders in form of technical advice, demonstrations and support information.I**ndicator calculation and interpretation/Numerical and statistical analysis**
The above indicators will be analyzed using standard conventional water quality and hydrological analytical methods.

4.2 Soil

Soils are important components of the ecosystem and act as a major sink for various wastes. It is important that their buffer capacity for various constituents of the waste is not exceeded.

Soil monitoring is very important for sustaining soil quality and thus ecosystem sustainability. It involves soil sampling and analysis using international conventional methods. Field observations and tests will also be carried out to complement the soils chemical, biological and physical analysis. The results from these activities will enable assessment of the impact of the oil and gas activities on the soils ability to support plant growth and also perform essential ecosystem functions and services. This requires seasonal/annual sampling of soil and analyzing the parameters.

4.2.1 Influencing drivers

i. Oil Spills

Oil spills are known to affect soil permeability, porosity, water infiltration, aerations oil biota, availability of plant nutrients which will significantly affect soil quality hence reducing its productivity. Oil spills also pollute the soil and hence affect basic soil nutrients and soil biota.

ii. Waste storage and disposal

If waste is poorly disposed, it leads to pollution of soils through accumulation of heavy metals, chemical and other compounds to toxic levels. Soils are major sources of plant nutrients, heavy metals and other toxic compounds will be taken up by plants, thus entering the food chain with negative consequences.
Furthermore, some elements are toxic to plants when taken in excess, resulting in poor plant

growth thus affecting the productivity of the ecosystem.

iii. Vegetation clearance

As part of the oil development activities, vegetation is cleared in order to construct drilling pads, oil refinery, seismic surveys and other infrastructure. This leads to exposure of the soil to erosion and its related impacts. Additionally oil spills and drilling wastes can lead to soil pollution.

4.2.2 Methodology

Parameters to be monitored

The indicators that will be used for monitoring soil quality include area covered by the spill, magnitude and extent of oil traces, hydrocarbons, heavy metals, major and trace elements, porosity, friability, erodibility, composition, soils micro, meso and macro fauna, soil pH, soil organic matter, electro conductivity, base saturation, cation exchange capacity, and soil erosion. Monitoring of compliance to EIA conditions in regard to oil spill response strategy is also required.

Sampling design

A carefully designed sampling plan is required to provide reliable samples for the purpose of sampling. The plan will address the site selection, depth of sampling, type and number of samples, details of collection, and sampling and sub-sampling procedures to be followed.

Standard soil sample collection protocol (USDA-SSL, 2004) will be used to sample and analyse soil chemical and physical properties in the soil and plant laboratories. The protocol will be backed up by an intuitive and statistical sampling plan to collect representative samples. The intuitive sampling plan, is based on the judgment of the sampler, wherein general knowledge of ecosystem or landscapes, past experience, and present information about the Albertine Graben will be used. Geo referencing the sample points will allow spatial analysis to be done using appropriate spatial programs.

In the laboratory, the primary objectives of sample collection and preparation are to homogenize and obtain a representative soil sample to be used in chemical, physical, and mineralogical analyzes. Concerted effort is made to keep analytical variability small.

The geomorphological unit must be considered and addressed in the sampling plan. Special considerations should be given to soil landscape catenary relationships.

The extent of vegetation clearance will be assessed through the estimation of percentage vegetation cover based on the FAO methodology.

4.3 Air

The equipment used in oil exploration, production and processing generate noise, particulate matter and gaseous emissions which have the potential to pollute both indoor and ambient air. If the air quality is not controlled, it can affect both plant, animal life and human beings in the polluted area and areas outside the source of pollution as air pollution is trans-boundary.

Particulate matter primarily is dust, smoke, aerosols and haze - any finely divided airborne solid material. Particulates are aesthetically displeasing, can irritate the eyes and cause respiratory problems.
The common gaseous emissions from oil exploration and production activities are sulphur oxides (SOx) ,Sulphides, Nitrogen oxides (NOx) , volatile organic compounds (VOC) and carbon monoxide.

Sulphur oxides and Nitrogen oxides gases are primary pollutants i.e. Themselves are hazardous and can produce other dangerous substances after undergoing chemical reactions in the atmosphere. Being corrosive acidic gases, sulphur oxides, nitrogen oxides damages buildings and other materials, and can cause respiratory problems.

NOx reacts with any of a wide range of volatile organic compounds in the presence of sunlight to produce ground level ozone that can cause damage to sensitive plants and crops, eye and lung irritation, accelerated degradation of materials such as rubber, and a marked deterioration in atmospheric visibility.

Interaction of SO2 and N O2 with moisture and oxygen in the air forms acid rain (a mixture of nitric and sulphuric acids). Acid rain corrodes building materials and has harmful effects on plant and animal life.

Hydrogen sulphide (H 2S) is highly poisonous and because it initially anaesthetizes the sensory organs it can build up to high concentrations without warning and cause paralysis and then asphyxiation.

Carbon monoxide usually results from the combustion of petrol in the presence of insufficient oxygen. It is highly toxic gas that displaces oxygen in human blood, causing oxygen deprivation.

4.3.1 Influencing drivers

Oil development processes have a number of drivers which are likely to lead to atmospheric pollution. The main drivers that will impact air quality negatively are:
i) Drilling – During drilling, dust and gaseous emissions are generated that can pollute the air

ii) Motor Vehicles and other means of transport(railway and aero planes) – produce noise and emit gaseous emissions (exhausts) to the surrounding air.
iii) Power plant and Refinery – These processes generate hazardous smoke ,Oil fumes and noise from the inline machinery.
iv) Construction works - Generate both inhalable and non inhalable that ends up to the air.
v) Social activities- With the influx of human beings to the area, social activities such as church gatherings may generate nuisance noise.

4.3.3 Methodology

Parameters to be monitored

Air quality monitoring will mainly be focused on the primary air pollutants outlined below; Particulate matter, Nitrogen dioxide, Carbon monoxide, Sulphur dioxide, Hydrogen sulphide, Volatile organic compounds, Noise level

A wide range of methods is available for the measurement of air pollutants, from the very simple manual procedures to the instrumental methods.

The manual procedures are relatively labour intensive, and limited in the amount of information provided. For the purpose of monitoring air quality in the albertine Graben, Instrumental Monitoring Methods which give direct-reading in real time with high-resolution measurements of a range of pollutants at a single point will be adopted. The systems of these devices are based on photometric techniques.

Measurements will be taken at identified sites /locations within the workplaces, fields and in the neighboring settlements on 24 hour basis for each air pollutant. Results will be entered in the form shown in appendix.

Monitoring devices/ equipment for specific pollutant are outlined in the table below

Equipment	Pollutant
Non-Dispersive Infra-Red (NDIR) analyzer	Carbonmonoxide
Chemilunminenscence Detector	Nitrogen oxides
Portable GC	Volatile organic Compounds
Fluorescence Analyzer	Sulphur dioxide , hydrogen sulphide
Tapered-Element Oscillating Microbalance (TEOM) monitor	Particulate matter

Noise measurement

Measuring noise levels in the ambient air and workers' noise exposures is the most important part of a workplace hearing conservation and noise control program .However before taking field measurements, it is important to determine the type of information required. The person making the measurement must understand:

i) The purpose of measurement: compliance with noise regulations, hearing loss prevention, noise control, community annoyance etc.

ii) The sources of noise, and times when the sources are operating, the temporal pattern of noise - continuous, variable, intermittent, impulse.
iii) Locations of exposed persons.
The initial measurements are noise surveys to determine if
iv) Noise problem exists and
v) Further measurements are needed.
If noise survey indicates that noise problem exists then further measurements to determine personal noise exposure levels will be carried out i.e. the amount of noise to which individuals within the area of concern are exposed.
There are various instruments and techniques for noise measurement and all of them are based on measuring sound level pressure to determine noise exposures. For the purpose of noise monitoring at the Albertine Graben area, Sound Level Meter set for A-scale slow respond shall be used for noise Survey while Noise Dosimeter for personal noise exposures.
The Sound Level Meter (SLM) consists of a microphone, electronic circuits and a readout display. The microphone detects the small air pressure variations associated with sound and changes them into electrical signals. These signals are then processed by the electronic circuitry of the instrument. The readout displays the sound level in decibels. The SLM takes the sound pressure level at one instant in a particular location.
A noise dosimeter is a small, light sound level meter that clips to a person's belt with a small microphone that fastens to the person's collar, close to an ear. The dosimeter stores the noise level information and carries out an averaging process.
It is useful in areas where noise usually varies in duration and intensity, and where the person changes locations. Wearing the dosimeter over a complete work shift (8 hours) gives the average noise exposure or noise dose for that person. This is usually expressed as a percentage of the maximum permitted exposure.
A noise dosimeter required should be of the following settings:

(a) Criterion Level: exposure limit for 8 hours per day five days per week. Criterion level 85 dB(A)
(b) Exchange rate: 3 dB or 5 dB.
A noise survey involves measuring noise level at selected locations throughout the entire area. Selected locations (Measurement points) should clearly be located using Modern Global Positioning System (GPS) and marked on the sketch for further reference. Noise measurement results are entered in the form shown in appendix 2 and noise map is produced by drawing lines on the sketch between points of equal sound level.
Geo-spatial design
The coordinates of each of the data point will be taken using GPS and with the help of GIS analysis will be done to show spatial relationships
Indicator calculation and interpretation/Numerical and statistical analysis
Concentration of individual air pollutant obtained in the air for particular period of time will be

compared with the applicable National guidelines /Standards.

4.4 Micro Climate

The lift valley floor lies in the rain shadow of both the escarpment and the mountains and has the least amount of rainfall average of less than 875 mm per annum which is much lower than that of highland areas. The maximum temperatures are above 300C which can sometimes reach 380C. Average minimum temperatures are relatively consistent and vary between 160C and 180C. Wind speed and direction records indicate a high incidence of strong winds especially in the rift valley. The prevailing winds commonly blow along the valley floor in the north-east to south-west direction or vice versa. Winds also blow across the rift valley in an east to west direction.

4.4.1 Influencing drivers

The main driver influencing the micro climate of the area is land use/cover change through;

a) Land use

b) Urban and industrial development

4.4.2 Methodology

Parameters to be monitored

Rainfall, Temperature, Wind speed and direction, Atmospheric pressure, Evaporation, Solar radiation, Relative humidity

The weather parameters will be monitored using the department of meteorology standard manual

Sampling design

The data from the existing meteorological stations will be used to determine the baseline data, where possible non functional stations will be reinstated. In addition, possibilities of using available near real time satellite data will be explored. Specifically NEMA based AMESD will be evaluated for possible use in monitoring the micro climate.

Description of census methodology, sampling gear/equipment, etc.

Standard meteorological equipments and methods will be used as explained below. More details can be got from WMO Guide to Meteorological Instruments and Methods of Observation (WMO-No.8)

i. Rainfall

The standard instrument for measuring rainfall is the standard rain gauge which should be fixed firmly in level ground with the rim accurately horizontal and exactly 12 inches above the ground surface. The ground around the gauge should be covered by short grass or small gravel. Rain is measured in terms of depth of the liquid water which would accumulate in a specified period on a horizontal impermeable surface at a ground level, assuming that no water is lost either by evaporation or by runoff. The rain water collected is measured by a special measuring cylinder calibrated to indicate depth

ii. Temperature

Atmospheric temperature is measured by the thermometers installed in a Stevenson screen at a height between 1.25m to 2m. The screen is designed to ensure that:

i. Instruments within it are effectively shielded from radiation from all sources

ii. There is a gentle flow of air in and out of the screen and around the instruments

iii. Instruments are protected from precipitation

With effective design of the screen, the temperature of the thermometer exposed inside will agree closely with the temperature of the air circulating just outside at the level of the thermometer bulb.

iii. Wind speed and direction

When we consider measurement of surface wind we have to look at as a vector whereby we measure it`s magnitude as well as its direction. The standard instrument for measuring wind direction is the wind vane while that of wind speed is Anemometer.

iv. Atmospheric pressure

The instrument used for measuring atmospheric pressure is a Barometer. For synoptic purposes the barometer used is the ordinary mercury-in glass tube type.

v. Evaporation

Evaporation loss is measured in the same units as rainfall depth using the standard evaporation pan.

vi. Solar radiation

Solar radiation is measured by the Gunn-Bellani Radiometer. The instrument should be exposed in an open situation similar to that required for the sunshine recorder. It should have an unobstructed view of a sun and a sky throughout the day and at all seasons of the year.

vii. Relative humidity

Relative humidity is computed from the readings of the dry- bulb and wet-bulb thermometers. The bulb of the wet-bulb thermometer is kept moist by a wrapping of a wet cotton cloth. Water is regularly supplied to the cloth to replace that which has evaporated by means of the capillary action of a number of cotton strands dipped into a specially designed container.

Sampling design (approach and protocols)

The data from the existing meteorological stations will be used to determine the baseline data, where possible non functional stations will be reinstated. In addition, possibilities of using available near real time satellite data will be explored. Specifically NEMA based AMESD will be evaluated for possible use in monitoring the micro climate.

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Hydrometric field procedures. Practical Manual II, WRAP Report Nr PRAC-02, December 2004

USDA-SSL 2004. Soil Survey Laboratory Methods Manual Soil Survey Investigations Report, No. 42, Version 4.0, November 2004

CHAPTER 5: SOCIETY

5.1 Introduction

The discovery and subsequent development of petroleum resources will have both positive and negative impacts on the environment and society in the both the short and long-term. If they are not appropriately managed, negative impacts may outweigh the positive impacts. A good monitoring system of societal changes enables the stakeholders to easily understand, predict, minimize, prevent and/or mitigate adverse impacts. It will also help to provide insight into the nature of positive impacts, how these can be scaled up as well as establishing the state of the environment and society during the petroleum development process.

Monitoring society parameters will provide information about the status and trends of society or communities thus; this will be an effective means of checking on progress as well as a tool for improvement. Without monitoring, there would be difficulty in knowing if management actions are working and how they should be changed to be more effective. In addition, monitoring of society indicators provides the first early warning signs and a baseline for any remedial measures that may need to be undertaken.

Valued Ecosystem Components (VECs) are resource, environmental or society features that are important (not only economically) to a local human population, or has a national or international profile or if altered from their existing status, will be important for the evaluation of environmental impacts of industrial developments, and the focusing of administrative e□orts (Hansson et al.1990). The following VECs have been prioritized for the monitoring societal issues;

i. Settlement
ii. Agriculture
iii. Water and Sanitation
iv. Health
v. Energy
vi. Infrastructure
vii. Education
viii. Culture
ix. Archaeological and cultural sites

5.2 Objectives

With a focus on the valuable ecosystem components outlined above, this Society Monitoring Manual seeks to address the following objectives;

1. To provide reliable information about the status and trends of society or community wellbeing;

2. To assess the progress of socio-economic development activities vis a vis petroleum development as well as document associated impacts;
3. To provide early warning information (indicators) with respect to the interaction between indicators of social wellbeing and petroleum development processes in order to undertake remedial measures;
4. To provide recommendations for improving the outcomes of petroleum development processes regarding social wellbeing in the Albertine Graben.
5. To establish a database relating to key socio-economic indicators of relevance to petroleum development in the Albertine Graben.

5.3 Valued Ecosystem Components (VECs)

Below are the monitoring arrangements for the Society VECs. This section among others covers the following; VEC description, influencing drivers, parameters to be monitored, sampling design among others.

5.3.1 Settlements

The term human settlements is an integrative concept that comprises: (a) physical components of shelter and infrastructure; and (b) services to which the physical elements provide support, that is to say, community services such as education, health, culture, welfare, recreation and nutrition.
Human settlements in the Albertine Graben will be influenced by changes in population due to migration of people in search of labour or business opportunities in and out of the Graben. Below is a description of key drivers that will affect human settlements;

5.3.1.1 Influencing Drivers

The main drivers of settlement as identified include migration and labour. People move in search for labour/employment opportunities, ease of communication-access to a road, search for greener pastures in terms of space say for farming or relocation due on oil works in their areas of residence. Increase in oil and gas activities in the region will allow for population movement into and out of the areas.

5.3.1.2 Methodology

Parameters to be monitored

In monitoring settlements, the following parameters will be measured: type of dwelling unit, tenure status of dwelling unit, construction material for dwelling unit, floor material of dwelling unit, type, amount and source of domestic energy.

These are physical structures of different shapes, size, type and materials erected by mankind for security, privacy and protection from the elements and for his singularity within a community
Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997.

Sampling design

For information required at household level, households will be selected using a two stage sampling procedure. The Population and Housing Census of 2002 will be used for the sampling Frame. A two stage stratified sampling design will be used. At the first stage Enumeration Areas will be selected using probability proportional size. At the second stage, households will be selected using a systematic sampling.

Data sources and collection methods.

Settlements data will be obtained from mainly surveys and administrative records and the following methods will be used to collect the information:

1. Questionnaires: Using questionnaires, selected households will be visited where a legible adult will be interviewed.
2. Observation: Still photographs will be taken to collect information related to the settlements
3. Focus group discussions (FGDs): FGDs will be used to collect settlement related information at community level.

Equipment.

Global Position System (GPS) will be used to map the location of the household marked for enumeration, Archaeological and culture sites.

Recorders will be used during the FGDs.

Cameras will be used to take still photographs for these sites.

4.2.1.4 Data Processing and Statistical analysis

Raw data obtained from the field will be edited in the office to ensure consistence within the questionnaires. It will be captured using a double entry system to ensure good quality data and then cleaned. Using statistical packages, statistics will be generated using statistical methods.

5.3.2 Agriculture

The Food VEC originally identified in the NINA report was changed to agriculture in order to accommodate crops and livestock. Agriculture refers to the growing of crops and the rearing of animals. Agriculture is Uganda's main economic activity engaging 66% of total working population and contributed 22.9% to Gross Domestic Product at current market prices in 2011 (UBOS- Statistical Abstract , 2012). In Uganda, Agriculture is mainly rain fed with two major agricultural seasons in year; mainly depends on family labour; and is mostly subsistence.

5.3.2.1 Influencing drivers

The growing of crops and rearing of animals is influenced by a number of factors and these include: Climate, Soil properties, Availability of land, Prevailing market prices for the

agricultural products, Availability of labour, Infrastructure, Storage facilities etc. In the NINA report, Production, Storage and Infrastructure development were identified as the drivers for Agriculture.

5.3.2.2 Methodology

Parameters to be monitored

Under the agriculture VEC, the following parameters will be monitored: Proportion of households(HH) engaged in agriculture as the Main activity, Proportion of HHs with a storage facility, For specific crops: Crop Area, Production and Yield, Livestock Numbers by Type, Number/ proportion of HHs that are food insecure, Land available to HHs, and Tenure system.

Sampling design

For information required at household level, households will be selected using a two stage sampling procedure. The Population and Housing Census of 2002 will be used for the sampling Frame. A two stage stratified sampling design will be used. At the first stage Enumeration Areas will be selected using probability proportional size. At the second stage, households will be selected using a systematic sampling.

Data sources and collection methods

Agriculture data will be obtained from mainly surveys and administrative records and the following methods will be used to collect the information:

1. Questionnaires: Using questionnaires, selected households will be visited where a legible adult will be interviewed.
2. Observation: Still photographs will be taken to collect information related to the Agriculture
3. Focus group discussions (FGDs): FGDs will be used to collect Agriculture related information at community level.

Equipment

Global Position System (GPS) will be used to map the location of the household marked for enumeration, agriculture.

Recorders will be used during the FGDs.

Cameras will be used to take still photographs for these sites.

Data Processing and Statistical analysis

Raw data obtained from the field will be edited in the office to ensure consistence within the questionnaires. It will be captured using a double entry system to ensure good quality data and then cleaned. Using statistical packages, statistics will be generated using statistical methods.

5.3.3 Water and Sanitation

Water is essential for life. The amount of fresh water on earth is limited, and its quality is under constant pressure. Uganda is blessed with about 80% of its water as fresh with a number of water sources namely: Wells, springs, rain water, boreholes, tapped water, lakes and rivers. According to Uganda National Household Survey (UNHS- 2009/10), 74 % of households had access to improved water sources yet Water plays a major role in the sanitation and hygiene of the people.

Sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and faeces. The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal .

Water and sanitation information is of much importance in informing policy formulation and decision making. It is also useful to monitor progress toward achieving national and international targets, and allows for informed investment into the sector where there is need.

During the monitoring, emphasis will go to access to safe drinking water. Safe drinking water refers to water that is safe to drink and available in sufficient quantities for hygiene purposes. Sanitation will focus on basic sanitation which is defined as basic sanitation as the lowest-cost option for securing sustainable access to safe, hygienic and convenient facilities and services for excreta and sewage disposal that provide privacy and dignity while ensuring a clean and health environment both at home and in the neighbourhood of users (Lenton R, Wright AM, Lewis K. Health, dignity and development: what will it take? New York, UNDP, 2005

5.3.3.1 Influencing drivers

The quality, availability and use of water and beliefs and culture greatly influence sanitation. Increasing population, say through migration, poses a challenge especially in the urban centers as those in authority need to commensurately increase safe drinking water and sanitation services in the specific area of immigration since it puts pressure on resources such as water. If the population increases and the supply/quantity of water does not increase proportionately, hygiene will be affected negatively.

5.3.3.2 Methodology

Parameters to be monitored

During the five years of monitoring the Albertine Graben, the following parameters will be measured: Number of HH using a specific source of drinking water, Distance and Time to the nearest drinking water source, Treatment of water at home, Number of HHs with sanitation facilities (latrines by type, garbage collection facilities and hand washing), Number of cases reported due to water borne diseases

Sampling design

For information required at household level, households will be selected using a two stage sampling procedure. The Population and Housing Census of 2002 will be used for the sampling Frame. A two stage stratified sampling design will be used. At the first stage Enumeration Areas will be selected using probability proportional size. At the second stage, households will be selected using a systematic sampling.

Data sources and collection methods.

Water and sanitation data will be obtained from mainly surveys and administrative records and the following methods will be used to collect the information:

1. Questionnaires: Using questionnaires, selected households will be visited where a legible adult will be interviewed.
2. Observation: Still photographs will be taken to collect information related to the water and sanitation
3. Focus group discussions (FGDs): FGDs will be used to collect water and sanitation related information at community level.

Equipment

1. Global Position System (GPS) will be used to map the location of the household marked for enumeration, water and sanitation.
2. Recorders will be used during the FGDs.
3. Cameras will be used to take still photographs for these sites.

Data Processing and Statistical analysis

Raw data obtained from the field will be edited in the office to ensure consistence within the questionnaires. It will be captured using a double entry system to ensure good quality data and then cleaned. Using statistical packages, statistics will be generated using statistical methods.

5.3.4 Health

Human Health is the general condition of the body or mind with reference to soundness and vigor. The state of health is influenced by a number of drivers and these include: population, infrastructure development, and occupational hazards.

5.3.4.1 Influencing Drivers

The soundness and vigor of the body or mind is influenced by a number of things and these may include: population changes which impact on demand for the health services, pollution (of say water or air) causing increased cases of sick people, and availability of health related infrastructure like hospitals, health centres etc.

5.3.4.2 Methodology

Parameters to be monitored

In monitoring the health of people and the sector in general, in the Albertine Graben, the following indicators will be measured: Availability and Number of Health facilities by level, Staffing level by skill , Distance to the nearest health facility, Availability of laboratory, Ambulance, Safe water and sanitation facilities, Waste disposal facilities, Number of beds for in patients, Number of in and out patients handled by facility, Occupational hazards, and Waste disposal facilities, prevalence rates of illnesses by type of illness.

Sampling design

For information required at household level, households will be selected using a two stage sampling procedure. The Population and Housing Census of 2002 will be used for the sampling Frame. A two stage stratified sampling design will be used. At the first stage Enumeration Areas will be selected using probability proportional size. At the second stage, households will be selected using a systematic sampling.

Data sources and collection methods

Health data will be obtained from mainly surveys and administrative records and the following methods will be used to collect the information:

1. Questionnaires: Using questionnaires, selected households will be visited where a legible adult will be interviewed.
2. Observation: Still photographs will be taken to collect information related health
3. Focus group discussions (FGDs): FGDs will be used to collect health related information at community level.

Equipment

1. Global Position System (GPS) will be used to map the location of the household marked for enumeration, health.
2. Recorders will be used during the FGDs.
3. Cameras will be used to take still photographs for these sites.

Data Processing and Statistical analysis

Raw data obtained from the field will be edited in the office to ensure consistence within the questionnaires. It will be captured using a double entry system to ensure good quality data and then cleaned. Using statistical packages, statistics will be generated using statistical methods.

5.3.5 Infrastructure

Infrastructures are fundamental facilities and systems serving an area e.g. Transport and communication (Roads, telecommunication etc), Power plants, schools, Health facilities,

Recreational centers, Industrial facilities, and Banking facilities etc. Efficient infrastructure is an enabling environment that facilitates the growth of other sectors. For example, the existence of a good tarmac road will enable the trade of goods and services as they easily transported to the market hence promoting the business and social sectors.

5.3.5.1 Influencing drivers

Infrastructure development is influenced by population size, availability and development of viable natural resources (e.g. Oil and gas, high value minerals like gold), Individual decision-beliefs and culture of the people in the area, and government policy. The availability and development of natural resources demands for infrastructure say roads for transportation of the mineral(s). This demand causes the need by government to construct a road(s).

5.3.5.2 Methodology

Parameters to be monitored

In order to monitor the infrastructure in the region, the following parameters will be monitored: Availability of and distance to(roads, air railway and water), Source and Type of information, Mobile Network and Internet coverage, availability of Social facilities(church, recreation centres, hotels), number of industries in the region , Access to information(Newspapers,)

Sampling design

For information required at household level, households will be selected using a two stage sampling procedure. The Population and Housing Census of 2002 will be used for the sampling Frame. A two stage stratified sampling design will be used. At the first stage Enumeration Areas will be selected using probability proportional size. At the second stage, households will be selected using a systematic sampling.

Data sources and collection methods

Infrastructure data will be obtained from mainly surveys and administrative records and the following methods will be used to collect the information:

1.Questionnaires: Using questionnaires, selected households will be visited where a legible adult will be interviewed.

2. Observation: Still photographs will be taken to collect information related to Infrastructure

3. Focus group discussions (FGDs): FGDs will be used to collect Infrastructure related information at community level.

Equipment

1. Global Position System (GPS) will be used to map the location of the household marked for enumeration, Infrastructure.

2. Recorders will be used during the FGDs.

3. Cameras will be used to take still photographs for these sites.

Data Processing and Statistical analysis

Raw data obtained from the field will be edited in the office to ensure consistence within the questionnaires. It will be captured using a double entry system to ensure good quality data and then cleaned. Using statistical packages, statistics will be generated using statistical methods.

5.3.6 Education

Education refers to the acquisition of knowledge and skills through formal, informal and non-formal activities. The government of Uganda (GoU) has indicated education as one investment priorities for the purpose of human resources development for the period 2010/11 to 2014/15. Education is instrumental for social transformation and sustained economic growth.

5.3.6.1 Influencing driver

Education is influenced by population, human resource, infrastructural development, attitudes, scholastic and instruction materials, and cultural beliefs in any given area. Availability of school infrastructure in an area, for example, increases the chance of a child going to school than where there isn't one. Increasing population causes a demand for social services, like schools, and if the schools or institutions of learning are provided these influences the education levels of people in the region.

5.3.6.2 Methodology

Parameters to be monitored

In order to monitor progress in education, the following parameters will be monitored: Education attainment, Literacy rate, School enrolment (primary and secondary), Reason for not attending school, and Average distance to an education facility.

Sampling design

The Population and Housing Census of 2002 will be used for the sampling Frame. A two stage stratified sampling design will be used. At the first stage Enumeration Areas will be selected using probability proportional size. At the second stage, households will be selected using a systematic sampling.

Data sources and collection methods

Education data will be obtained from mainly surveys and administrative records and the following methods will be used to collect the information:

1. Questionnaires: Using questionnaires, selected households will be visited where a legible adult will be interviewed.
2. Focus group discussions (FGDs): FGDs will be used to collect education related information at community level.
3. Observations will be made for information/ data that cannot be obtained directly from the

household as in is the case of population in a class room.

Equipment

1. Global Position System (GPS) will be used to map the location of schools and the household marked for enumeration.
2. Recorders will be used during the FGDs.
3. Cameras will be used in case of observation to take still photos.

Data Processing and Statistical analysis

Raw data obtained from the field will be edited in the office to ensure consistence within the questionnaires. It will be captured using a double entry system to ensure good quality data and then cleaned. Using statistical packages, statistics will be generated using statistical methods.

5.3.7 Culture

Culture is defined as the sum total of the ways in which a society preserves, identifies, organizes, sustains and expresses itself. Culture includes both the tangible and intangible heritage. The tangible include monuments or architecture, visual arts and handicrafts, cultural sites, manuscripts, cultural industries, linguistics and literary and other objects of artistic and historical interest. The intangible heritage comprises language, oral traditions, performing arts, music, festive events, cultural beliefs, organization culture, values and social practices, traditional craftsmanship, indigenous knowledge and practices concerning nature (NDP, 2010).

5.3.7.1 Influencing Drivers

The set of beliefs, moral values, traditions, language of a people group are influenced by a number of drivers and some these include: Existing related country laws, Migration, Development Methodology

Parameters to be monitored

In order to monitor changes in culture, the following parameters will be monitored: Languages spoken Existing tribes, Music, Staple food, Festive events, cultural beliefs, Existing religions, Reading culture, and Cultural products.

Sampling design

The Population and Housing Census of 2002 will be used for the sampling Frame. A two stage stratified sampling design will be used. At the first stage Enumeration Areas will be selected using probability proportional size. At the second stage, households will be selected using a systematic sampling.

Data sources and collection methods

Culture data will be obtained from mainly surveys and administrative records and the

following methods will be used to collect the information:
1. Questionnaires: Using questionnaires, selected households will be visited where a legible adult will be interviewed.
2. Observation: Still photographs will be taken to collect information related to the existing art crafts and other tangible culture
3. Focus group discussions (FGDs): FGDs will be used to collect culture related information at community level.

Equipment
1. Global Position System (GPS) will be used to map the location of the household marked for enumeration.
2. Recorders will be used during the FGDs.
3. Cameras will be used in case of observation to take still photos.

Data Processing and Statistical analysis
Raw data obtained from the field will be edited in the office to ensure consistence within the questionnaires. It will be captured using a double entry system to ensure good quality data and then cleaned. Using statistical packages, statistics will be generated using statistical methods.

5.3.8 Archaeological and cultural sites
Archaeological site is a place in which evidence of past activity is preserved (pre-historic, historic or contemporary). Cultural site is the legacy of physical artifacts (cultural property) and intangible attributes of a group or society that are inherited from past generations, maintained in the present and bestowed for the benefit of future generations.

5.3.8.1 Influencing drivers
The existence of Archaeological and cultural sites is influenced by immigration, education, level of development, and urbanization. Immigrants, who are of different ethnic group than the natives, will have less attachment to the existing Archaeological and/or Cultural sites. In such circumstances, the preservation of the cultural /archaeological sites is not a priority leading to the destruction of the same. It's also expected that as people get more educated, there is tendency to move away from preserving traditional cultures, values, beliefs due to change in attitude and hence a change in culture.

5.3.8.2 Methodology
Parameters to be monitored
In monitoring Archaeological and Cultural sites, the following parameters will be measured: Existence of known Archaeological/ Cultural sites, Number of Archaeological and Cultural sites, Purpose of site, and location of sites.

Sampling design

For information required at household level, households will be selected using a two stage sampling procedure. The Population and Housing Census of 2002 will be used for the sampling Frame. A two stage stratified sampling design will be used. At the first stage Enumeration Areas will be selected using probability proportional size. At the second stage, households will be selected using a systematic sampling.

Data sources and collection methods

Archaeological and culture sites data will be obtained from mainly surveys and administrative records and the following methods will be used to collect the information:

1. Questionnaires: Using questionnaires, selected households will be visited where a legible adult will be interviewed.
2. Observation: Still photographs will be taken to collect information related to the Archaeological and culture sites
3. Focus group discussions (FGDs): FGDs will be used to collect Archaeological and culture site related information at community level.

Equipment

1. Global Position System (GPS) will be used to map the location of the household marked for enumeration, Archaeological and culture sites.
2. Recorders will be used during the FGDs.
3. Cameras will be used to take still photographs for these sites.

Data Processing and Statistical analysis

Raw data obtained from the field will be edited in the office to ensure consistence within the questionnaires. It will be captured using a double entry system to ensure good quality data and then cleaned. Using statistical packages, statistics will be generated using statistical methods.

5.3.9 Energy

Energy refers to the Source of power .There are different sources of energy at the household level and these include: biomass, solar, wind, and electricity. According to Uganda National Household Survey (UNHS, 2009/10), 95% of the households in Uganda used wood fuels (Firewood, and charcoal) as main source of energy for cooking, while 80.2 % used 'Tadooba' and Lanterns for lighting (UBOS-UNHS, 2009/10) . Although affordable and reliable energy is essential to the long-term health of the Ugandan economy, this exploitation pattern is not sustainable because it heavily relies on none renewable energy that is costly, untimely, limited and has serious environmental effects (NDP, 2010).

5.3.9.1 Influencing drivers

The source of energy used at household is influenced by a number of factors and these may include: Population increase, Level of education, infrastructural/technological development for example installation of a grid, and change in attitudes. As people get higher education it's expected life style changes and this may cause a move from use of say fire wood to electricity.

5.3.9.2 Methodology

Parameters to be monitored

To monitor energy the following parameters will be measured: Proportion of HHs using energy source, Quantity of energy, Source of energy, Distance to source of energy, Energy demand, and Energy demand.

Sampling design

For information required at household level, households will be selected using a two stage sampling procedure. The Population and Housing Census of 2002 will be used for the sampling Frame. A two stage stratified sampling design will be used. At the first stage Enumeration Areas will be selected using probability proportional size. At the second stage, households will be selected using a systematic sampling.

Data sources and collection methods

Archaeological and culture sites data will be obtained from mainly surveys and administrative records and the following methods will be used to collect the information:

1. Questionnaires: Using questionnaires, selected households will be visited where a legible adult will be interviewed.
2. Observation: Still photographs will be taken to collect information related to the energy sources.
3. Focus group discussions (FGDs): FGDs will be used to collect energy related information at community level.

Equipment

1. Global Position System (GPS) will be used to map the location of the household marked for enumeration.
2. Recorders will be used during the FGDs.
3. Cameras will be used to take still photographs for these energy sources.

Data Processing and Statistical analysis

Raw data obtained from the field will be edited in the office to ensure consistence within the questionnaires. It will be captured using a double entry system to ensure good quality data and then cleaned. Using statistical packages, statistics will be generated using statistical methods.

CHAPTER 6: BUSINESS AND MANAGEMENT

6.1 Tourism

The Albertine Graben is a high tourism potential area with a number of Protected Areas. The Graben and surrounding areas have about 160 protected areas. Uganda's tourism is nature based with about 80% of tourists coming to look at the wildlife and scenery. This area has high biodiversity and indeed great scenery and yet it is also rich in Oil deposits

The discovery of commercially viable oil in this high biodiversity and a prime tourism area, poses new challenges on management of the environment. Oil activities may negatively impact on tourism through among others land take that reduces habitat for animals, increase in infrastructure, increase in pollution and visual intrusion.

6.1.1 Influencing drivers

With these economic developments, a number of drivers are likely to emerge that might affect Tourism activities; namely

i. Land takes

ii. Clearance

iii. Infrastructure increases

iv. Visual intrusion.

These will result into Land clearance within PAs for oil and gas activities leading to wildlife migration, reducing wildlife numbers and impacting on landscape/ scenery which will reduce visitors' experience hence reducing visitor numbers impacting on tourism.

6.1.2 Methodology

i. Quantitative methods; where a questionnaire tool will be designed together data on tourism such as tourist demography, arrivals, perception and visual intrusion. The survey will also be used to assess tourist attitudes towards oil activities in protected areas. This survey will be done annually. Data on tourists will be compiled from Uganda Wildlife Authority.

ii. Field Inspections; this will be used to find out the number of facilities, tourist sites, room occupancy and quality of the facilities. Number of tourists not registered by UWA will also be estimated.

iii. Collect data on revenue generation from tourism by service providers

Parameters to monitor

In order to assess the impacts of oil activities on tourism, the following parameters will be monitored;

i. Number of tourists

ii. Number of tourism sites

iii. Number tourism facilities

iv. Tourism revenue and

v. Quality of facilities

Geospatial design

The survey will cover the whole of the Albertine graben as defined by the EIN. Information will be obtained from various tourist facilities including, lodges, hotels, guest houses, camping sites, National parks and Forest Reserves, tour operators, exits and entries.

Sampling design

Data will be collected using questionnaires, interviews or direct counts.

Description of census methodology, sampling gear/equipment

i. Cameras
ii. Computer
iii. Stationary
iv. Topographic Maps
v. GPS devices and
vi. Binoculars

Nomenclature/classification codes

i. Accommodation facilities(Capacities of Lodges, Hotels, Guest Houses, Camping Sites)
ii. Other tourist facilities (Stopovers plus information centres , Gates, Viewing Platforms, Boat cruises)

Indicator Calculation and Interpretation/Numerical and Statistical Analysis

Periodic statistics on tourism, tourism sites, tourism facilities and revenue generated from tourism. This will help determine trends in tourism development in and around the Albertine Graben.

6.2 Fisheries

There are several fresh water bodies in the region namely Lake Albert, L. George, L. Edward, L Bunyonyi, several crater lakes and the Albert Nile which are important sources of fish. For instance, Lake Albert fishery is the third largest in Uganda and it is distinctive in being a multi-species fishery. Shallow water areas are much more productive and critical to fisheries but also limited in extent. Numerous fishing villages are located along the shores of Lake Albert whose inhabitants directly depend on the lake for subsistence fishing and water for domestic use.

The major factors affecting productivity of fisheries resources are fishing capacity and ecological condition of the water body. Other important factors include aquatic environmental conditions which may partly be influenced by shoreline /catchment based activities.

As oil and gas development activities become prominent in the Albertine Graben, there is a risk of water pollution in water bodies through oil spills or inadequate waste management. There will also be interruptions in fishing schedules due to physical presence of oil and gas exploration operations in the fishing grounds. Furthermore, activities like offshore seismic

surveys and drilling will generate noise and vibration which can scare fish and alter spatial fish distribution patterns.
For these reasons, fishing capacity and fish catch rates need to be monitored to assess the likely socio-economic dynamics associated with oil and gas development in the Albertine.

6.2.1 Influencing drivers

With these economic developments, a number of drivers are likely to emerge that might affect the fisheries activities; namely
i. Aquatic disturbances,
ii. Oil spills and
iii. Blow outs.
These may result in destroying breeding grounds leading to fish migration, and mortality hence reduction in fish stocks affecting the fisheries business. Therefore it is important to find out the aquatic impact on livelihood and incomes for the society & economy.

6.2.2 Methodology

Catch Assessment Surveys (CAS) and Fisheries Frame survey (Total count) appendix II will be carried out.

Parameters to monitor

In order to assess the impacts of oil activities on fisheries business, the following parameters will be monitored;
i. Quantity of fish
ii. Catch rates (catch per unit of effort)
iii. Fishing inputs (gears, boats)
iv. Fishing facilities (landing sites, storage and transport facilities)
v. Fish Prices
vi. Fishing efforts

Geospatial design

Fishing capacity (effort) will be monitored by conducting bi-annual frame surveys, which will involve direct and total enumeration of fishing factors and facilities at landing sites of all water bodies in the Albertine graben.

Sampling design

See CAS methodology

Description of census methodology, sampling gear/

i. GPS
ii. Three weighing scales (1 kg, 10 kg and 50 or 100 kg spring balances)

iii. Fish weighing baskets
iv. Tape measure, at least 1.5m long with a millimetre scale for measuring the
v. length of fish larger than 100 cm total length
vi. Clipboards
vii. Sharpeners
viii. Erasers
ix.Pencils
x. Water proof bags
xi. Data sheets
xii. measuring tape, at least 15 m long for measuring boat lengths
xiii. Basins
xiv. Polyethylene sheet (about 2 m)
xv. Life jackets
xvi. Gumboots
xvii. Raincoats
xviii. Hand gloves
xix. Overalls
xx. Caps
xxi. Umbrellas
Indicator Calculation And Interpretation/Numerical And Statistical Analysis
Fish quantities in relation to;
i. Catch
ii. Facilities

6.3 Agriculture

Agriculture is the backbone of Uganda's economy; it employs and feeds the country's entire population. Food and Agriculture census is carried out every 10 years covering the entire country. So to ensure food security, one will have to monitor the demand for food, food production and the area under agriculture.

6.3.1 Influencing drivers

With these economic developments, there is a likelihood of shifts in economic activities. The oil and gas activities will provide alternative economic activities causing shifts from agriculture resulting into reduced food production. This will reduce food security, causing escalation of food prices and affecting the agricultural business.

6.3.2 Methodology

i. Quantitative method (Questionnaires)
ii. Field Inspections and
iii. Remote sensing

Parameters to monitor

In order to assess the impacts of oil and gas activities on agriculture, the following parameters will be monitored;

i. Change in area cultivated (acreage)

ii. Type of crop and

iii. Volume of agricultural output (volume of crops and animals)

Geospatial design

Mapping areas under agriculture will cover the whole Albertine graben while data on crop and volume of agricultural output will be collected from randomly selected areas.

Sampling design

Agriculture parameters will be monitored by conducting seasonal frame surveys, involving direct collection of data from; markets, storage facilities, District Agricultural Officer (DAO), households and type of crops and animals. Acreage will be determined through study of regular satellite imagery and visual sampling.

Description of census methodology, sampling gear/equipment

Stationary, Camera, GPS

Nomenclature/classification codes

i. Commercial outlets(markets, roadside stalls, abattoirs and storage facilities

ii. Crops types

Indicator Calculation and Interpretation/Numerical and Statistical Analysis

Agriculture output in relation to;

i. Crop and animal types

ii. Quantities and

iii. Quality of harvest

iv. Change in area under agriculture

6.4 Transport

The oil exploration will require transport infrastructure in form of roads, pipelines, airstrips and railways. Also production facilities have to be linked to major road networks for access during routine maintenance and monitoring. Development of the Albertine petroleum will require importation of heavy machinery into the country. Finished products may also have to be transported by road before pipelines are built.

All these developments are potential sources of business and management impacts. Thus the need for monitoring the indicators developed to track changes in the business and management environments of the region.

6.4.1 Influencing drivers

With these economic developments, a number of drivers are likely to emerge that might affect business and management activities like Settlements and infrastructural development. These will result into oil and gas activities which will increase traffic load and volumes likely to cause increase in accidents and maintenance costs that can affect the transport business.

6.4.2 Methodology

Information will be obtained on national/ district urban and community access roads, airstrips, landing sites and railway stations in the Albertine graben. Data will be obtained by digitising transport features such as roads from satellite images or tracking them using a GPS. Tracked data will be downloaded and converted into shapefiles. Physical counts of vehicles will be conducted on strategic locations such as entry into the graben. Type of vehicle and load will be recorded on forms.

Parameters to monitor

In order to assess the impacts of oil activities on transport infrastructure the following parameters will be monitored;

i. Traffic volumes
ii. Loads
iii. Type of infrastructure (air, road, water, railway) and
iv. Sites

Geo-spatial design

Mapping transport infrastructure will cover the entire Albertine Graben. Vehicle counts will be done at entry or exit points of the Albertine graben.

Sampling design

GPS will be used to mark point features or track linear features.

Physical counts of vehicular traffic and their load will be done and recorded on forms.

i. Description of census methodology, sampling gear/equipmentStationary
ii. GPS
iii. Car
iv. Computer

Nomenclature/classification codes

i. Transport infrastructure(Road types, airstrips, landing sites, vehicle parks)
ii. Transport facilities (aeroplanes, vehicles, bicycles, ferries, boats, motorcycles)

Indicator Calculation and Interpretation/Numerical and Statistical Analysis

Traffic flow in relation to;

i. Number of vehicle, planes, boats, roads
ii. Capacity carriage
iii. Means of arrivals and interest
iv. Mileage

6.5 Forestry

Infrastructure development, population increase and urbanization are likely to increase demand for timber and non timber forest products. Increased extraction of these products can impact on the environmental health of forests in and around the Albertine Graben. It is important therefore to monitor trade in these products.

6.5.1 Influencing drivers

With these economic developments, trade in Forest products and non-forest products is likely to increase due to increased demand and should therefore be monitored. Oil and gas activities will involve settlements and infrastructure developments that may require land clearance/ taking causing destruction of forests reducing the supply of forest products and ecological functions hence increasing prices. Timber is itself required in construction.

6.5.2 Methodology

Utilisation of forest products will be monitored through licensing records kept by responsible bodies namely National Forestry Authority and Forest Sector Support Department/District Forest Office. Licenses for timber production will also be recorded. Timber and charcoal selling points in major trading centres will be counted and volumes of the forest product recorded. Prices of the products will also be recorded. The number of persons involved in the business will be counted to know the number of people depending on forestry business.

Parameters to monitor

In order to assess the impacts of oil activities on forestry the following parameters will be monitored;
i. Timber volumes
ii. Timber prices
iii. Number of loggers within and surrounding areas of the AG and
iv. Demand and supply of fuel wood
v. Timber shades
vi. Carpentries

Geo-spatial design

The study will cover the entire Albertine Graben and surrounding areas. Surveys will mostly be done in major trading centres in and around the Albertine graben.
Sampling design

Data will be collected from licensing records from NFA and FSSD/DFO. Field surveys will be conducted in major towns and data recorded on forms
Description of census methodology, sampling gear/equipment, Nomenclature/classification codes
Equipment required is:
i. Stationary
ii.Camera,
iii. GPS
iv. Car
Items that will be classified are:
i. Type of forest products- Timber, charcoal firewood, fencing poles transmission poles
ii. Type of forest industry-Timber shade, saw mill, carpentry,

Numerical and Statistical Analysis
Analysis will be done to determine trends in the trade of forest products; specifically:
i. Change in Timber volume
ii. Change in Prices
iii. Number of loggers
iv. Trend of Licenses issued
v. Wood based industries

6.6 Construction materials

Oil and gas exploration in the Albertine Graben is likely to result into increased demand for housing and construction materials to cater for the increasing settlements, materials for road construction and oil and gas infrastructure.

6.6.1 Influencing drivers

With these economic developments, consumption of construction material as an indicator should be monitored.Oil and gas activities will involve settlements and infrastructure developments that may require more building materials that will deplete or reduce the availability of these materials thus increasing the prices for these materials.

6.6.2 Methodology

The number of quarries for sand, stones and murram will be mapped and their area measured using a GPS. Where possible, the depth will be measured to estimate the volume extracted. The volume may also be estimated by counting truck loads per day. Brick making sites will also be mapped using a GPS and their production determined in terms of number of bricks per month. Consumption of wood products will be estimated from the number of building sites in town and from the timber survey.
Parameters to monitor

In order to assess the impacts of oil activities on construction materials the following parameters will be monitored;

i. Timber
ii. Sand
iii. Stone
iv. Bricks
v. Murram
vi. Gravel
vii. Number of sites
viii. Number and type of structures constructed

Geo-spatial design

The study will cover major trading centres in the Albertine Graben and surrounding areas

Sampling design

Walking around sites with a GPS
Measure depth of quarries
Estimate the number of bricks in kilns
Estimate volume of wood at building sites
Get data on licensing records from local government.

Description of census methodology, sampling gear/equipment, Nomenclature/ classification codes

To use:

i. GPS
ii. Measuring tape
iii. Stationery

Indicator Calculation and Interpretation/Numerical and Statistical Analysis

Figures on construction materials will be analysed for consumption per year and also expressed in total accumulative units.

i. Material volume of :
a. Timber
b. Sand
c. Stone
d. Bricks
e. Murram
f. Gravel
ii. Prices
iii. Licenses issued

iv. Commercial Outlets

6.7 Land Commodity

The oil and gas exploration in the Albertine Graben brings another land use activity that will increase the demand for land as a commodity yet its supply is static. The demand increase will be due to land for settlement, infrastructural development and agriculture among others. Increase inland prices and demand is already evident.

6.7.1 Influencing drivers

Following the discovery of oil and gas in the Albertine Graben, land as a resource has gained value in the region. Land use activities like settlements, infrastructure development and agriculture will increase demand for land as a commodity. Oil and gas activities will impact on the value of land.

6.7.2 Methodology

i. Market survey
ii. Land use analysis

Parameters to monitor

In order to assess the impacts of oil activities on land as a commoditythe parameter that will be monitored is
i. Land transfers
ii. Price of land

Geo-spatial design

The study will cover the entire Albertine Graben

Sampling design

Market surveys will be done within land management structures (MLHUD, District Land Board, Uganda Land Commission, land brokers) this will be done bi- annually.

Description of census methodology, sampling gear/equipment

i. Stationary

Nomenclature/classification codes

ii. Land tenure(free hold, mailo land, lease hold, customary land)
iii. Land use (settlement, infrastructure, agriculture and oil exploration, grasslands, forests shrub land)

Indicator Calculation and Interpretation/Numerical and Statistical Analysis

Trends in land demand in relation to;
i. Number of registered land titles
ii. Change in price of land
iii. Change in land use.

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Annexes

Annex 1: Catch Assessment Survey Data Form

Part A – Document Identification

Date : .....(dd/mm/yy)

Country : .....

District :.....

Sub-County/Division:.....

Parish/Location:.....

Landing site:.....

Enumerators' Name :.....

Part B –Vessels Landing and Sampling Targets

Number of vessels (all types) that landed at the site during the sampling day (00:00 – 24:00) 60

Maximum number of vessels that can be sampled 20

Sampling Proportion 30%

Example:

Number of vessels (all types) that routinely land at the site during the sampling day (00:00 hrs – 24:00 hrs) = 60

	Gear Type (Main)			
Vessel Type	**SS/SN**	**GN**	**LL**	**Other**
Parachute	5			
Sesse (Motorised or sail)		20	15	
Sesse (paddled)	10			5
Other		5		

Numbers of vessels to be sampled

	Gear Type (Main)			
Vessel Type	**SS/SN**	**GN**	**LL**	**Other**
Parachute	2			
Sesse flat at one end		7	5	
Sesse pointed at both ends	3			2
Other		2		

Part C: Form Codes

Vessel Type CodeDescription	Description	Propulsion Code
SMS Sesse Motor	Motorised or Sail O	Outboard
SP Paddled	Sesse Paddled	P
PA Paracute	S	Sail
OT	Other	

Gear	Type Code	Mode of Operation
GN Gill Net	A	Active
LL Long Line	D	Drift
SS Small mesh seine	S	Stationery
HL Hand line		
LN Lift net	Construction Code	
CN Cast net	MO	Monofilament
TR Trap	MU	Multifilament
OT Other		

Part D – Fishing Operations and Catch

Form Number: Enter Pre-assigned serial number from Part A
Date : dd/mm/yy
Country : Uganda
District : Hoima
Landing Site Name or Code: Kigorobya
Enumerators Name ; Bagonza Ateenyi

VESSEL DETAILS GEAR AND EFFORT DETAILS

SN	Reg. No.	Vessel Type Code	Length (m)	Crew	Propulsion Code	Gear Type Code	Construction Code	Number of net panels	No. of Units	Size	Mode of Operation Code	Hours Fished	Number of lamps	Total Catch Weight (kg)
1	1230	SMS	6.5	2	O	GN	MU	1	50	5”	S	6		30
2	1236	SMS	6	2	O	GN	MU	1	60	5”	S	6		25
3	1239	PA	3	1	P	GN	MO	1	25	8”	D	6		80
4	1240	SP	5.5	2	P	LL			600	9		5		15
4	1240	SP	5.6	2	P	CN			1		A	3		54

Part D – Species Information

VESSEL DETAILS GEAR AND EFFORT DETAILS Price / kg

SN **(from Part C)**	Reg. No.	Vessel Type Code	Gear Type Code	Species Code	Catch Weight of Species (kg)	Number of fish in sample	
1	**1230**	**SMS**	**GN**	**LN**	**30**	**17**	**7000**
2	**1236**	**SMS**	**GN**	**LN**	**25**	**18**	**7000**
3	**1239**	**PA**	**GN**	**ON**	**80**	**67**	**5000**
4	**1240**	**SP**	**LL**	**LN**	**15**	**9**	**7000**
4	**1240**	**SP**	**CN**	**ON**	**54**	**24**	**6000**

Vessel Type Descriptions

Boat type	Description
1. Dugout boat 	• Curved out of a whole log of a tree. • Common size, 4 to 5 m long • Entirely propelled by paddle • Operated exclusively in the littoral areas targeting Nile tilapia • The main fishing gears used are • gillnets and basket traps • Constructed from several planks of • timber • Flat bottomed • Common size, 4 to 6 m long
2. Parachute 	• Entirely propelled by paddle • Operated exclusively in the littoral • areas targeting Nile tilapia • The main gears used are gillnets,cast nets and basket traps • Constructed from several planks oftimber • V-shaped bottom with a keel • Common size, 6 to 10 m long • Propelled by paddle or sails • Operated in the littoral and sublittoral • areas, up to about 3 km from the shore • Predominantly used in the
3. Sesse pointed at both ends 	• Dagaa/Omena/Mukene fishery with small seines • Constructed from many planks of timber • V-shaped bottom with a keel • Common size, 5 to 12 m long • Propelled by paddle, sail or outboard motor Largely unspecialised, i.e. used in the Dagaa/Omena /Mukene fishery with small seines; in the Nile tilapia fishery with gillnets, cast nets and basket traps; and in the Nile perchfishery with gillnets, beach seines, long lines and hand lines

Annex 2: Frame questionnaire/data form sheet 1:

Water Body ……..... (year)…….....…

NOTES ON CRAFT

1.

Fishing craft	=	all crafts that are fishing
Derelict craft	=	all damaged craft not repaired for one year or more
Fish carrier	=	all crafts solely for transporting fish
Transport craft	=	craft used for transport only (and never for fishing)

EXPLANATION OF CODING

CRAFT TYPE

1. Sesse flat at one end	**SF**
2. Sesse pointed at both ends	**SP**
3. Parachute	**P**
4. Dugout	**DO**
5. Rafts	**R**
6. Congobaki (CB)	**CB**
7. Foot Fisher	**FF**

Length: Measured in metres using a tape measure or a rope with knots tied at 1 metre intervals

PROPULSION: Method of propulsion: - State main type

1. Outboard motor	**O**
2. Paddles	**P**
3. Sail	**S**

HP: If PROPULSION is inboard or outboard engine state the Horse power, e.g. 15

CREW: Number of crew who normally accompany the boat on a fishing trip

MO: Mode of operation of gillnets A-Active, P- Passive, D- Drift (Tembea)

GEAR TYPES

GN	Gill Net: State number per mesh size in inches
LL	Long Lines: State number of hooks
BS	Beach seine: state number of complete sets
CN	Cast net: State number
HL	Hook and Line: State number of lines
TR	Traps: State number
MF	Monofilament: state number of complete sets
SN	Scoop net: State number
SS	Small seine / Lampara targeting Muzuri: State number of complete sets by

mesh size range (mm)

Others Other gear not specified above: State type and Number

SPECIES TARGETED

1. Lates (Mputa, Peti)
2.Neobola(Muziri)
3. Tilapines (Ngege)
4. Clarias (Male)
5. Protopterus(Mamba)
6. Synodontis (Nkolongo)
7. Haplochromines (Nkejje)
8. Labeo (Ningu)
9. Barbus (Kisinja)
10. Schilbe
11. Malapterurus
12.Alestes (Angara)
13.Brycinus (Ragoogi)
14. Bagrus (Ssemutundu/Munama)
15. Mormyrus (Kasulu)
16. Distichodus
17. Hydrocynus (Ngassia)
18. Auchenoglanis
19. Polypterus
20. Others

Annex 3: FRAME SURVEY DATA FORM

Water Body…….....…Year…….....

SUMMARY OF NUMBERS OF CRAFT ON BEACH AND OTHER FACILITIES

1. NAME OF RECORDER (AS IN ID) .....TeL.....	1	
2. STATUS/ RANK OF RESPONDENT.....	2	
3. DATE	3	
4. DISTRICT	4	
5. SUB-COUNTY/ DIVISION	5	
6. PARISH/WARD	6	
7. NAME OF LANDING SITE	7	
Latitude.....Longitude.....	8	
8. NAME OF BMU.....	9	
CRAFT SUMMARY	10	
9 DERELICT CRAFTS.....	11	
10 FISH CARRIER	12	
11 TRANSPORT CRAFTS (NON-FISHING)	13	
12 FISHING CRAFTS WITH OUTBOARD ENGINE	14	
13 FISHING CRAFTS WITH IN-BOARD ENGINE	15	
14 FISHING CRAFTS USING PADDLES ONLY	16	
15 FISHING CRAFTS USING SAILS ----------	17	
FACILITIES SUMMARY	18	
16 FISH WEIGHING SLAB [1] YES [2] NO	19	
17 COLD ROOM [1] WORKING [2] NOT-WORKING	20	
[3] NONE	21	
18. JETTY [1] YES [2] NO		
19. ICE BOX [1] WORKING [2] NOT-WORKING		
20. FISH STORE [1] YES [2] NO		
21. ELECTRICITY SUPPLY [1] YES [2] NO		

22. IF “NO” HOW FAR TO NEAREST SUPPLY (KM)?

[1] <1 [2] 1-5 [3] 6 - 10 [4] > 10

23. TOILET FACILITY [1] YES [2] NO

24. POTABLE WATER [1] YES [2] NO

IF “YES” SPECIFY SOURCE

25. IS BEACH ACCESSIBLE BY ALL WEATHER ROAD? [1] YES [2] NO

26. IF “NO” HOW FAR TO NEAREST ALL WEATHER ROAD (KM)

[1] <1 [2] 1-5 [3] 6 - 10 [4] > 10

27. DESIGNATED NET REPAIR FACILITY [1] YES [2] NO 27

28. DESIGNATED BOAT REPAIR FACILITY [1] YES [2] NO 28

29(a) IS FISHERIES STAFF RESIDENT? [1] YES [2] NO

29(b) If YES, what is the name of the fisheries staff i/c of S/County

.....

30. IS THE BMU BASED AT THE LANDINGBEACH? [1] YES [2] NO

3

ADDITIONAL INFORMATION

31 NAME THE NEAREST MARKET (WHERE MOST OF THE FISH IS FIRST SOLD)

---

32 (a) DO FISHERMENLAND AT THIS BEACH FOR MORE THAN 5 MONTHS IN A YEAR [1] YES [2] NO

32 (b) If NO why.....

.....

22	
23	
24	
25	
26	
27	
28	
29	
30	
31	
32	

FRAME SURVEY: LAKE ALBERT/ALBERT NILE – MONTH ---------- Year-------

DEPARTMENT OF FISHERIES RESOURCES (DFR)

SHEET 3: DETAILS OF EACH FISHING CRAFT AND THE FISHING GEARS IT USES

Name of Landing site (Beach) ----------

33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
CRAFT DETAILS								GEAR TYPE							
				PROPULSION					GN - MESH SIZES (inches)						
S/N	Reg. No.	Craft Type	Length (m) Type	HP if Engine		Crew	Target Fish Species <2.5	Gill net **MO/*Panel*** 2.5	3	3.5	4	4.5	5	5.5	6
1															
2															
3															
4															
5															
6															
7															
8															
9															

49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
									OTHER GEARS								SS-mesh size (mm)			Other gears specify
6.5	7	7.5	8	9	10	>10	LL	BS	CN	HL	TR	MF	LN	SN	<5	6-9	≥10			

Data forms

Plant datasheet

Observer…..……

Date……..

	2m		10m		20m							
Plot	**Herbs**	**Lians**	**Tree**	**2.5-10cm**	**10-30cm**	**30-50cm**	**>50cm**	**GPS EW**	**GPS NS**	**Altitude**	**Habitat**	**Topo**
								Canopy cover				
								Canopy height				
								Notes				
Habitat:	THFO	SFC	SFO	Wood	Grass-L	Grass-H	Swamp	Shamba	Fern	BOMB	B-Mix	B-Grass

Bird Plot Counts

Point no.	Bird species	No. seen	Distance Key species	GPS EW	GPS NS	Alt	Habitat	EPE

Data Sheet for chimp survey.

Time	Animal species	Age	Group size	Perpendicular Dist.	GPS W	GPS N	EPE	Habitat

Dung Count.

Plot no./sector	Dung Plot	Species	No. of Piles	Age	EW	NS

Threats Plot Sheet

Plot no.	Human sign	Number	Age	EW	NS	Altitude

Appendix

– Data forms

SUPPORT TO WATER RESOURCES MANAGEMENT DEPARTMENT
DIRECTORATE OF WATER DEVELOPMENT
P.O. Box 19, Entebbe

DISCHARGE FORM No. 1
CURRENT METER OBSERVATION SHEET

Date.....
Site.....
No. and type of instrument.....
Discharge No. .....
Observer.....
Work started at.....
Finished at .....

Gauge ..... Reading..... at.....
Gauge ..... Reading..... at.....
Water Level at Site.....at.....
" " " " Us. .....at.....
" " " " Ds. .....at.....
Weather and remarks: Enter in Margin end on Form 3.

	Distance from datum	Sounding observed	Revs, per minute at Half Depth						Weather and remarks
			1st	2nd	3rd	4th	5th	Mean	

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Results of air Quality Monitoring		
Measurement point reference----------		
Pollutant	Concentration	Time period
Total particulate matter		
Nitrogen dioxide		
Carbon monoxide		
Sulphur dioxide		
Hydrogen sulphide		
Volatile organic compounds		
Measurements taken by----------		

Land Cover Classification

NBS Class	NBS Code	LCCS Classes
1	Broad leaved plantations	Broad leaved trees
2	Coniferous plantation	Needle leaved trees
3	TropicalHighForest well stocked	Closed multi-storied high trees
4	Tropical high forest low stock	Open high trees
5	Woodland	Closed trees, Open trees, generally open trees, very open trees, woody areas
6	Bush	Closed, Open or very open shrubs
7	Grassland	Graminoids and herbaceous areas
8	Wetland	Permanently wet Graminoids and herbaceous areas
9	Small scale farmland	Shrub and herbaceous crops on small fields
10	Commercial farmland	Shrub or herbaceous crops on Medium or large size fields
11	Built up area	Artificial surfaces- urban, airport, refugee camp
12	Open Water	Standing and flowing waterand water dams
13	Impediments	Bare soil and bare rocks, quarry, snow

Tourist Site Form

Observer:.....

District:.....

Date:.....

ID	Name of Site	Nature of Tourism	District	x-coord	y-coord
1					
2					
3					
4					

Tourism Facility Form

Observer:.....

District:.....

Date:.....

ID	Name of Facility	Type of Facility	No of Rooms	Self Contained	Suites	Double	Single	Lowest cost of room	Occupancy	Conference Halls	Fitness facilities	X-coord	Y-coord	Residents/ non-residents in last month
1	**xxx**	Hotel	30	30	5	15	10	60,000	40%	4	0			
2														
3														
4														

Building Materials form

Observer:.....

District:.....

Date:.....

ID	Site Name	Type	Eastings	Northings	Avg length (m)	Avg with (m)	Avg depth (m)	Volume
1	Name of site	Sand Quarry			32	20	4	
2		Stone quarry						
3		Murram						
4		Gravel						
5								

Timber Inventory Form

Observer:.....

District:.....

Date:.....

ID	Type of Business	Easting	Northing	Dimensions	Species	No of pcs	Volume	Source of timber
1	Timber shade			6x2x14				
2	Carpentry							
3								
4								

Transport Form

Observer:.....

District:.....

Date:.....

					Name of Location			
					x-coord		y-coord	
	ID	Type vehicle	Tare	Cargo type	Cargo-ton	passenger-Nos	In/Out	Time
	1	Station wagon	2000	Passengers	0.3	3	in	10:30am
	2							
	3							
	4							

NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY (NEMA)

NEMA House Plot 17/19/21 Jinja Road, P.O. Box 22255 Kampala Uganda

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