Federal Republic of Nigeria

Federal Ministry of Works

Highway Manual Part 1: Design

Volume VII:

Environmental Management

2013

ENVIRONMENTAL MANAGEMENT

FOREWORD

The vision statement of the Federal Ministry of Works is to elevate Nigerian roads to a standard where they become National economic and socio-political assets, contributing to the Nation's rapid growth and development, and to make Federal roads functional, safe, pleasurable, and an avenue for redeeming Nigerians' trust and confidence in Government. This vision statement is in tune with the Transformation Agenda of the President of the Federal Republic of Nigeria, His Excellency, Dr Goodluck Ebele Jonathan, GCFR. Based on the foregoing, our mission is to use the intellectual, management and material resources available to the Ministry to make Nigerian roads functional all the time. The principal goal of the Ministry is to drive the transformation agenda by improving road transport infrastructure for the overall socio-economic derivable benefits and development of our great country, Nigeria.

In exercising this mission and in discharging its responsibilities, the Ministry identified the need for updated and locally relevant standards for the planning, design, construction, maintenance and operation of our roads, in a sustainable manner. One of the main reference documents for this purpose is the Highway Manual, which previously included Part 1: Design and Part 2: Maintenance. Both current parts of the Highway Manual were first published in 1973 and 1980 respectively and have been subjected to partial updating at various times since then. The passage of time, development in technology, and a need to capture locally relevant experience and information, in the context of global best practices, means that a comprehensive update is now warranted.

The purpose of the Highway Manual is to establish the policy of the Government of the Federal Republic of Nigeria with regard to the development and operation of roads, at the Federal, State and Local Government levels, respectively. In line with this objective, the Manual aims to guide members of staff of the Ministry and engineering practitioners, with regard to standards and procedures that the Government deem acceptable; to direct practitioners to other reference documents of established practice where the scope of the Manual is exceeded; to provide a nationally recognized standard reference document; and to provide a ready source of good practice for the development and operation of roads in a cost effective and environmentally sustainable manner.

The major benefits to be gained in applying the content of the Highway Manual include harmonization of professional practice and ensuring uniform application of appropriate levels of safety, health, economy and sustainability, with due consideration to the objective conditions and needs of our country.

The Manual has been expanded to include an overarching Code of Procedure and a series of Volumes within each Part that cover the various aspects of development and operation of highways. By their very nature, the Manual will require periodic updating from time to time, arising from the dynamic nature of technological development and changes in the field of Highway Engineering.

The Ministry therefore welcomes comments and suggestions from concerned bodies, groups or individuals, on all aspects of the document during the course of its implementation and use. All feed back received will be carefully reviewed by professional experts with a view to possible incorporation of amendments in future editions.

Arc. Mike Oziegbe Onolememen, FNIA, FNIM.
Honourable Minister
Federal Ministry of Works,
Abuja, Nigeria
May, 2013

ACKNOWLEDGEMENTS

The Highway Manual has been updated by the Road Sector Development Team (RSDT), of the Federal Ministry of Works, with credit assistance from the World Bank's Federal Roads Development Project (FRDP). This update draws upon the original Manual, which was compiled between 1973 and 1980. The new Manual reflects recent developments in Road Design and Maintenance, in addition to latest research findings and updated references. Furthermore, it includes accepted practices that have been developed with the extensive effort of numerous organisations and people involved in the road sector. The assistance of all who have contributed is hereby gratefully acknowledged. Special acknowledgement is due to the following persons, who have been particularly involved and provided specific input that has been incorporated into the Manual:

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Public Organisations

Federal Ministry of Works – Highway Departments
Federal Ministry of Environment
Federal Roads Maintenance Agency (FERMA)
Federal Capital Development Authority
Federal Road Safety Corps
Nigeria Meteorological Agency
Nigerian Geological Survey Agency
Nigeria Police Force (Traffic Division)
Nigeria Hydrological Services Agency
Nigerian Meteorological Agency
Nigerian Society of Engineers
Nigerian Institute of Civil Engineers
Council for the Regulation of Engineering in Nigeria

Private Organisations

AIM Consultants
Aurecon Nigeria Ltd
Axion Consult Engineering Resources Ltd
Ben Mose & Partners
Dantata & Sawoe Construction (Nigeria) Ltd
Enerco Ltd
Etteh Aro & Partners
FA Consulting Services Ltd
Intecon Partnership Ltd
Julius Berger Nigeria Plc
Keeman Ltd
Multiple Development Services Ltd
Mansion Consulting Ltd

Property Mart Ltd
RCC Ltd
Sanol Engineering Consultants Ltd
Setraco Nigeria Ltd
Siraj International Ltd
Yolas Consultants Ltd

This update of the Highway Manual was compiled by the Road Sector Development Team of the Federal Ministry of Works with the assistance of the consultants Royal HaskoningDHV.

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1 Introduction

1.1 Background and Manual General Information

1.1.1 Overview of the Volume

Volume VII of the Highway Manual Part 1: Design deals with the Environmental Management of road and highway planning, design, construction and maintenance.

1.1.2 Background and Purpose

The main purpose of this Volume is to give guidance on the procedures to be applied to ensure that roads and highways are planned, designed, constructed and maintained so as to maximise the positive benefits of improved transportation in a more sustainable manner that in turn helps protect the environment from long term degradation. Furthermore, the Manual provides highway developers, Government agencies and road designers and contractors involved with roads development with the following information:

- How to avoid and/or minimise environmental impacts;
- Information on the likely impacts of road construction activities on the environment; and
- Suggestions on best practice environmental design and mitigation measures.

1.1.3 Aims and Objectives of the Volume

The aims of the Volume are to provide advice which reflects both legislative and best practice requirements. It seeks to ensure that information about the environmental effects of road projects is collected, assessed and used to inform options around decision making on route alignments, road design and road construction and maintenance in a timely and cost effective manner.

The objectives of this Volume are to provide:

- Consistence in approach to environmental assessment and its reporting for road projects; and
- An approach by which overseeing organisations can be assured that they have complied with all relevant environmental laws and regulations as well as best practice policies and procedures in terms of environmental and social management.

To this end, this Volume has drawn on experience and similar guidelines developed for countries elsewhere in Africa, in developed countries across the world and by finance institutions such as the World Bank (see References cited at the end of the Manual).

1.1.4 Links to Other Volumes in the Manual

The Highway Manual for Nigeria comprises of two Parts. Each Part of the Highway Manual is divided into a number of Volumes that deal with different aspects of the design and maintenance of the Federal Highway network. Preceding the full Manual is a Highway Design Procedure, which contextualizes the road planning project cycle.

Highway Design Procedure

- Highway Manual Part 1: Design
  - Volume I: Geometric Design
  - Volume II: Secondary Design Elements
  - Volume III: Pavement and Materials Design
  - Volume IV: Drainage Design
  - Volume V: Structural Design
  - Volume VI: Road Traffic Signs and Road Markings
  - **Volume VII: Environmental Management**
- Highway Manual Part 2: Maintenance
  - Volume I: Highway Register
  - Volume II: Maintenance Works
  - Volume III: Cost Accounting for Highway Maintenance

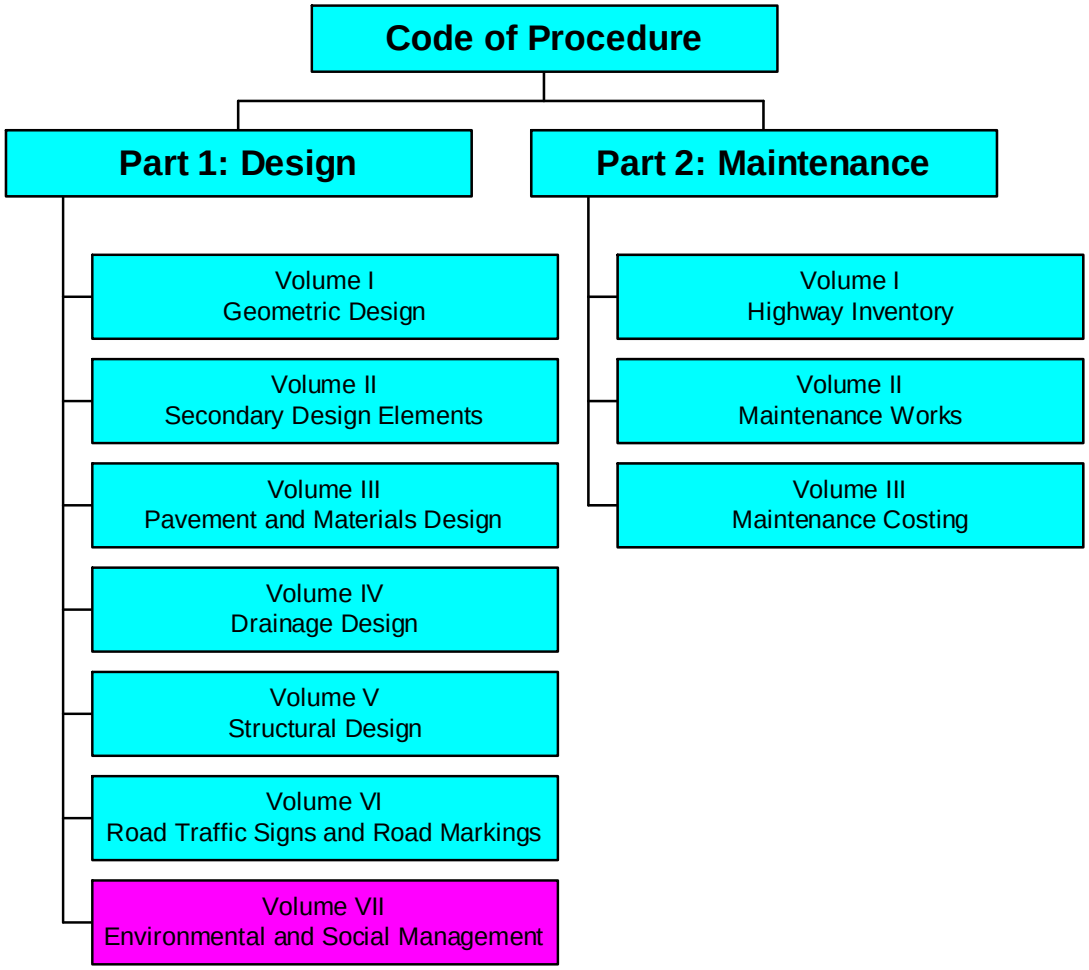

Figure 1.1: Arrangement of Volumes in the Highway Manual

2 Environmental Principles, Policies and Legislation

2.1 Definition of Environment

With regard to an all-inclusive definition, the term environment means the surroundings (biophysical and social) in which humans exist and that are made up of:

- The land, water and atmosphere of the earth;
- Micro-organisms, plant and animal life;
- Any part or combination of (i) and (ii) and the interrelationships among and between them; and
- The physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and wellbeing.

2.2 Environmental Best Practice and Planning

There is a growing awareness about the major impacts that can be caused by road developments worldwide. Some of the major environmental impacts of road projects include damage to sensitive ecosystems, loss of productive agricultural lands, resettlement of large numbers of people, permanent disruption of local economic activities, demographic change and accelerated urbanization. Since environmental and socio-economic impacts and/or benefits from road developments are quite common, such projects usually call for comprehensive environmental assessment studies, to be carried out.

Roads are a key element in modern economies, but with wide ranging implications. Planning for effective integration is therefore essential. The road designer should be aware of the constraints imposed by environmental legislation where a designer needs to preferably avoid or protect environmentally sensitive features. In carrying out their mandate to plan and design road systems, road designers should primarily aim to provide a safe and efficient transportation links to road users[(1).] All types of road projects can have potentially significant effects on the environment. Decision makers thus need to be able to understand these effects and the environmental assessment process provides a way of assessing and reporting on these effects [(2)]. The Guideline is applicable to road design, construction works and to road and bridge rehabilitation/upgrading works.

The impacts caused by new road projects, because of their linear nature, can be very complex in pattern with regards to the immediate surroundings. This potential complexity requires that every single project be examined individually for the significance of a variety of impacts. Furthermore, the interaction between the road project and other infrastructure projects should be carefully studied. The environmental impacts, which may be temporary, long term or permanent, created by road and highway projects include [3]:

- Deforestation;
- Destruction of natural habitat and modification of drainage systems;
- Disruption of animal migration patterns;
- Air pollution;
- Noise;
- Population migration; and
- Communal conflict; and community severance.

2.2.1 Project Planning and Prefeasibility Phase

Environmental impacts that may result from the development of roads need to be considered at the planning phase and throughout the project lifecycle (see the Highway Design Procedure). The following components need to form part of the planning phase [4]:

- Project description and road classification;
- Identification of the route corridor and alignment alternatives that will avoid sensitive environmental components (habitats and species);
- Conduct an initial site inspection to ground truth the route corridor and alternatives identified;
- Screen the alternatives to identify the significant environmentally sensitive areas and select a preferred alternative(s);
- Identify means to control secondary development in the project area;
- Conduct the Environmental Scoping Study;
- Consultations with the public; and
- Prepare Terms of Reference for the Environmental Impact Assessment.

A typical project plan checklist includes the following:

Table 2.1: Project Planning Checklist

Project Planning Checklist
▪ Project Description ▪ Expected Implementation and Timeframes ▪ Project Engineers Contact Details ▪ Date of Site Visit for Geometric Design ▪ Anticipated Funding Source and Estimated Costs ▪ Classification of the Road ▪ Type of Interventions ▪ Maps or Aerial Photographs of the Plotted Route Alignment ▪ List of Associated Activities (e.g. labour requirements, location of quarries/borrow pits, construction camps, access roads asphalt plants and waste disposal sites).

Source: [4]

There are other sources of good practises in the planning and prefeasibility phase of road projects which can be consulted and they include:

- South African Department of Environmental Affairs Integrated Environmental Management Information Series [5];
- Leopold Matrix for Evaluating Environmental Impacts;
- Hume Highway Upgrade-Woomargama Bypass Environmental Management Plan; and
- Project Checklist Road works [6]

2.3 Nigeria National Environmental Policy 1998

The Nigerian Government developed a National Environmental Policy in 1998 which commits to sustainable development based on the proper management of the environment. The main goals of the National Policy are to [7]:

- Secure a quality of environment adequate for good health and well-being;
- Conserve and use the environment and natural resources for the benefit of present and future generations;
- Restore, maintain and enhance the ecosystems and ecological processes essential for the functioning of the biosphere to preserve biological diversity and the principle of optimum sustainable yield in the use of living natural resources and ecosystems;
- Raise public awareness and promote understanding of the essential linkages between the environment, resources and development, and encourage individual and community participation in environmental improvement efforts; and
- Co-operate in good faith with other countries, international organisations and agencies to achieve optimal use of trans-boundary natural resources and effective prevention or abatement of trans-boundary environmental degradation.

The implementation of the National Policy on the environment depends on specific actions directed towards all sectors of the economy and problem areas of the environment. The proposed implementation strategies for the transportation and communication sectors are detailed below:

- Supporting an integrated transport policy that explores the full array of technical and management options and pays due attention to the needs of all population groups (e.g. the disabled, poor and the aged);
- Co-coordinating land-use, communication systems and transport planning in order to encourage spatial settlement patterns that facilitates access to such basic necessities as workplaces, schools, health care facilities, places of worship, goods and services and leisure destinations thereby reducing the need to travel;
- Encouraging the use of an optimal combination of modes of transport, including walking, cycling and public means of transportation, through appropriate pricing, spatial settlement policies and regulatory measures;
- Introducing disincentives that discourage the increasing growth of private motorized traffic and thus reduce congestion;
- Providing and or promoting an effective, affordable, physically accessible and environmentally sound public transport and communication system, giving priority to collective means of transport with adequate carrying capacity and frequency that support basic needs and the main traffic flows;

- Promoting, regulating and enforcing quiet, resource use-efficient and low-polluting technologies, including fuel-efficient engine and emissions controls and fuels with a low level of polluting emissions;
- Encouraging and promoting public access to electronic information services;
- Bringing the private sector into the process of managing environmental pollution in the transport sector as one aspect of a partnership in progress;
- Establishing and enforcing emission standards;
- Requiring new transport and communication projects to undergo environmental impact assessment; and
- Developing, where appropriate, criteria for maximum permitted and safe levels of noise exposure and promoting noise assessment control as part of environmental health programmes.

2.4 Environmental Impact Assessment (EIA) Act No 86 of 1992

The EIA Act No 86 of 1992 makes EIA a mandatory tool for all new public and private projects in Nigeria. The EIA Act sets out to [7]:

- Consider the likely impacts on the environment before embarking on any project or activity;
- Promote implementation of appropriate policy on all Federal Lands consistent with all laws and decision making processes through which the goal of this Decree may be realised; and
- Encourage the development of procedures for information exchange, notification and consultation between organisations and persons when the proposed activities are likely to have significant environmental effects on boundary or trans-state or on the environment of bordering towns and villages.

The Act gives specific powers to the Ministry of Environment in Nigeria to facilitate environmental assessment of projects. In September 1995, Federal Environmental Protection Agency (FEPA) published EIA Sectoral Guidelines for Infrastructure Projects (including roads). The Guidelines are intended to assist in the proper and detailed execution of EIA studies of projects involving infrastructure in line with the EIA Act of 1992.

2.4.1 The Federal Ministry of Environment

The Federal Ministry of Environment (FME) has the responsibility of environmental protection within Nigeria. The functions of the Ministry include:

- Routine liaison with different State Ministries of Environment in order to achieve the objectives of the National Policy on Environment;
- Co-operation with States Ministries of Environment and other relevant National Directories/Agencies in the promotion of environmental education of the citizenry;
- Responsibility for general environmental matters including managing the negative effects of soil degradation due to flooding and erosion, mineral and oil exploitation and exploration and deforestation; and
- Monitoring the implementation of the Environmental Impact Assessment (EIA) and Environmental Audit Report guidelines and procedures on all development policies and projects.

2.4.2 Project Specific Application

Specific conditions must influence the selection of detailed impact prevention and mitigation actions. These detailed area and project-specific mitigation actions must be derived from the Environmental Impact Assessments (EIAs) carried out for road and bridge construction and rehabilitation/upgrading projects [8]. The Nigerian EIA Sectoral Guidelines for Infrastructure Projects of 1995 describe the following steps which need to be undertaken for transportation development projects (roads and highways) by the project proponent prior to construction activities:

- Project justification;
- Project description;
- Description of the receiving environment;
- Public consultations;
- Description of the associated and potential environmental impacts (biophysical and social) including site selection during the construction, operation and maintenance phases of the project;
- Description of the mitigation measures for potential impacts identified;
- Environmental Management Plan for compliance monitoring of the mitigation measures identified for the project; and
- Remediation plans after decommissioning of the project, which describes both negative and positive impacts, which will result during the closure of the highways.

The EIA process as applied in Nigeria is shown in Figure 2.1.

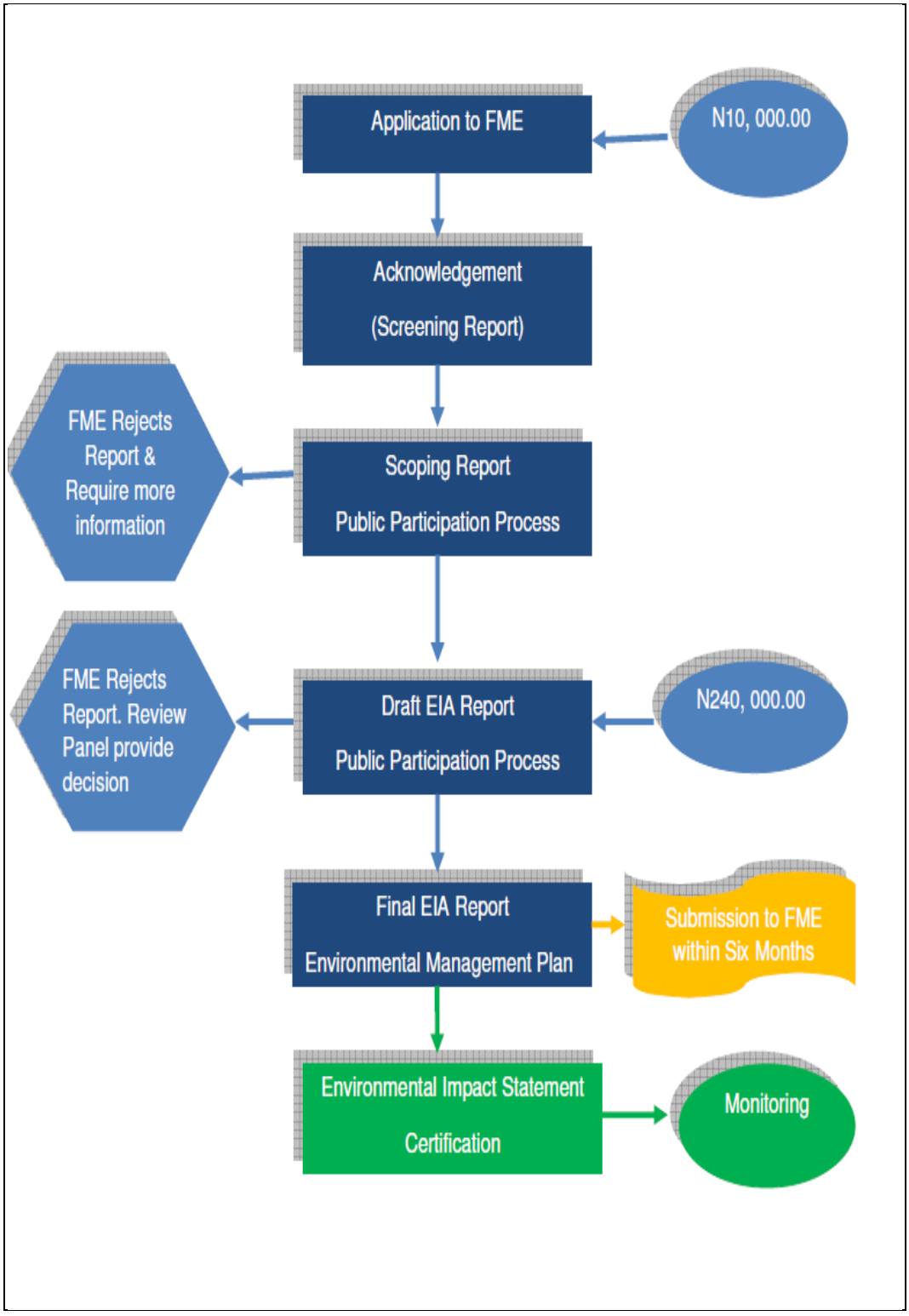

Figure 2.1: Nigeria EIA Process

2.4.3 Key Requirements of Environmental Control

Environmental issues must be investigated and monitored by the Federal Ministry of Environment on all road and bridge projects in Nigeria. A monitoring plan should be developed for the project which will assist with daily monitoring of activities taking place on site and easily identify the environmental risks and prevent/minimise environmental impacts (refer to Appendix C for a typical monitoring plan). The monitoring process should be carried out by an independent staff member appointed by the Ministry who can act in a permanent or part-time capacity as Environmental Control Officers (ECO). The duties to be carried out during the monitoring process of any specific project are listed below [8].

- **Adaptation to Guidelines**: The Environmental Control Officer should assist in the process of adapting these general environmental guidelines to project and area specific requirements. This should be done in conjunction with the environmental consultants or specialists appointed to carry out Environmental Impact Assessment (EIA) studies;
- **Facilitation of Environmental Impact Assessments and Environmental Management Plans**: The ECO should facilitate the Environmental Impact Assessment process and assist in the compilation of Environmental Management Plans (EMPs) for projects. The key objectives of the EMPs are listed below:
    - Identify a range of mitigation measures which could reduce and mitigate the potential significant impacts identified to minimal or insignificant levels;
    - Detail specific actions deemed necessary to assist in mitigating the environmental impacts of the project;
    - To identify measures that could optimize beneficial impacts;
    - To create management structures that address the concerns and complaints of Interested and Affected Parties with regards to the development;
    - To establish a method of monitoring and auditing environmental management practices during all phases of the activity;
    - Ensure that the construction and operational phases of the project continues within the principles of Integrated Environmental Management (IEM);
    - Ensure that safety recommendations are complied with; and
    - Specify time periods within which the measures contemplated in the final EMP shall be implemented where appropriate.

2.5 Relevant Environmental and Transportation Legislation, Polices and Standards

Table 2.1 lists relevant environmental and transportation legislation, policies and standards which might be applicable to transportation and highway projects in Nigeria. The list is not exhaustive and checks should be carried out to ensure new policies and legislation introduced at federal, state and local levels are not overlooked. International commitments to which Nigeria signs up should also be checked.

Table 2.2: Applicable Legislation and Policies

LEGISLATION/POLICIES/TREATIES AND CONVENTIONS	DESCRIPTION
Environmental Impact Assessment Act No 86 0f 1992	This Act provides the guideline for activities or development projects for which EIA is mandatory in Nigeria. Such developments include oil and gas fields, transportation, conversion of mangrove swamps covering area of 50 hectares or more for industrial use, land/coastal reclamation projects involving an area of 50 hectares or more. Pursuant to this, the EIA Act No 86 sets out the procedure for prior consideration of environmental issues in certain categories of public and private development projects.
National Environmental Policy 1998	The policy commits to a sustainable development based on the proper management of the environment.
Land Use Act No 202 of 1990	Deals with the management and protection of land.
Harmful Waste Act No 42 of 1988	The Act Relates to the management of waste and penalties imposed to waste offenders.
Water Resources Decree No 101 of 1993	The decree deals with the management of water resources in the country and the application process for water licences.
National Guideline and Standards for Environmental Pollution Control 1991	The regulation provides guidelines for the management of pollution control measures.
National Environmental Protection (Management of Solid and Hazardous Wastes) Regulation 1991	The regulations, regulates the collection, treatment and disposal of solid and hazardous wastes from municipal and industrial sources.
National Transport Policy 1993 as amended in 2010.	The policy aims at ensuring that transport infrastructures and services are adequate to meet social and economic goals of government in order to:- • Support existing and future needs for efficient movement • Serve as instrument of social and economic growth of the nation • Serve as an instrument of national integration and unity • Be affordable to the generality of Nigerians • Protection of the natural environment.
Master Plan for Integrated Transport infrastructure 2002.	The objectives of the plan are that transport infrastructure shall: • Provide efficient interregional connections between the major activity centers of the country • Support the government policy of regional and sectoral development. • Increase the average travel speeds and reduce trip duration • Support transport safety • Promote sustainable development and environmental protection.

LEGISLATION/POLICIES/TREATIES AND CONVENTIONS	DESCRIPTION
Draft National Transport Policy 2003	The strategies outlined in the Policy include: • Recognising the crisis situation in the transport system • Retain as fundamental objectives the provision of an adequate, safe, efficient and environmentally friendly transport system • Introduce discipline of the market economy into the transport sector of the country • Aims at attracting private sector investment and initiatives and transfers the responsibilities for the functioning of the transport system from direct government involvement.
Federal Road Maintenance Agency Bill 2001	The Bill established the Federal Road Maintenance Agency (FERMA) under the supervision of the Federal Ministry of Works to maintain all existing Federal trunk roads from time to time in Nigeria.
Federal Highway Act CAP 135 (revised 1990)	The Act vest the powers of management, direction and control of the Federal highways throughout Nigeria in the Minister of Works, Housing and Urban Development in respect of planning, construction and maintenance, supervision of highway users and regulation of traffic.
Draft Federal Highway Bill 2001	The bill amends the Act of 1990. The Minister and state highway authority may enter into an agreement in relation to highway specified in an agreement. State Governments many maintain and improve highways under such agreement. Every major project for the construction, improvement or maintenance of a Federal Highway shall be subject to an EIA in accordance with EIA Act of 1992.
Resettlement Policy Framework April 2006	The policy is a tool to enhance the quality of land efficiency of the works programme. It sets out terms which land need for the works is acquired, it outlines the steps needed before any occupied land whether part of existing rights of way or outside them, can be entered and used in construction and reconstruction tasks. It establishes a process for treating fairly and in a timely way what ever rights to occupy such space that individuals and interprices may have.
Vienna Convention for Ozone Layer Protection	The objectives of this Convention adopted in 1985 are to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the Ozone Layer and to adopt agreed measures to control human activities found to have adverse effects on the Ozone Layer.
Convention on the Conservation of Migratory Species of Wild Animals	The Bonn Convention adopted in 1979 aims at the conservation and management of migratory species (including waterfowl and other wetland species) and promotion of measures for their conservation, including habitat conservation.
Convention on Biological Diversity	The objectives of this Convention, which was opened for signature at the 1992 Rio Earth Summit and adopted in 1994, are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources by appropriate transfer of relevant technologies.
World Heritage Convention	This Convention adopted in 1972 defines cultural and natural heritage. The latter is defined as areas with outstanding universal value from the aesthetic and conservation points of view.

LEGISLATION/POLICIES/TREATIES AND CONVENTIONS	DESCRIPTION
Minerals and Mining Act (No 20 of 2007)	The act is administered by the Ministry of Mines and Steel Development. It describes the administration of the act, the functions of the Minister and the establishment mining cadastre offices, mine inspectorate department and environmental compliance department that will assist in the enactment of the act. Section 21 of the act gives the Ministers powers to make regulation in the fulfillment of the act.
Minerals and Mining Regulations 2011	The regulations list the activities that require permits, licences and leases. It also prescribes the procedures that are required for the mining and use of the minerals and the obligations of the applicant towards the environmental management. The types of mineral title applications which can be made include Reconnaissance Permit, Exploration Licence, Small Scale Mining Lease, Mining Lease, Quarry Lease and Water Use Permit.
OTHER CONVENTIONS	
The African Convention 1968	The African Convention on the Conservation of Nature and Natural Resources.
The Basel Convention 1989	Convention on the Control of Transboundary Movement of Hazardous Waste and Disposal.
Kyoto Protocol 1995	The Framework Convention on Climate Change.

3 General Environment of Nigeria

3.1 Study area

This section of the Volume provides an overview of the environment in Nigeria and acts as a backdrop to identifying important environmental issues, which may need to be considered on a project specific basis.

The country of Nigeria is situated in the west of the African Continent. It is bordered by Niger to the north, Chad to the northeast, Cameroon to the east and Benin to the west (Figure 3.1).

Figure 3.1: Location of Nigeria

3.1.1 Climate of the Country

The climatic conditions of the country vary from equatorial in the south, tropical in the centre and arid in the north [9]. Temperatures across the country are relatively high with a very narrow variation in seasonal and diurnal ranges. The average maximum temperature in the country is 33°C (February and March) with an average minimum temperature of 21°C in August. Nigeria receives an average rainfall of 1626mm. The month with the driest weather is January with 40mm of rain and the wet month is June with 336mm of rain. The mean humidity for an average year is 85% between March and October.

There are two basic seasons in Nigeria: the wet season which lasts from April to October; and the dry season which lasts from November till March. The dry season commences with the Harmattan, a dry, chilly weather condition that usually lasts till February and is associated with lower temperatures and a dusty and hazy atmosphere brought about by the North-Easterly winds blowing from the Arabian Peninsula across the Sahara. The second half of the dry season, February - March, is the hottest period of the year and high temperatures are experienced, especially in the northern part of the country.

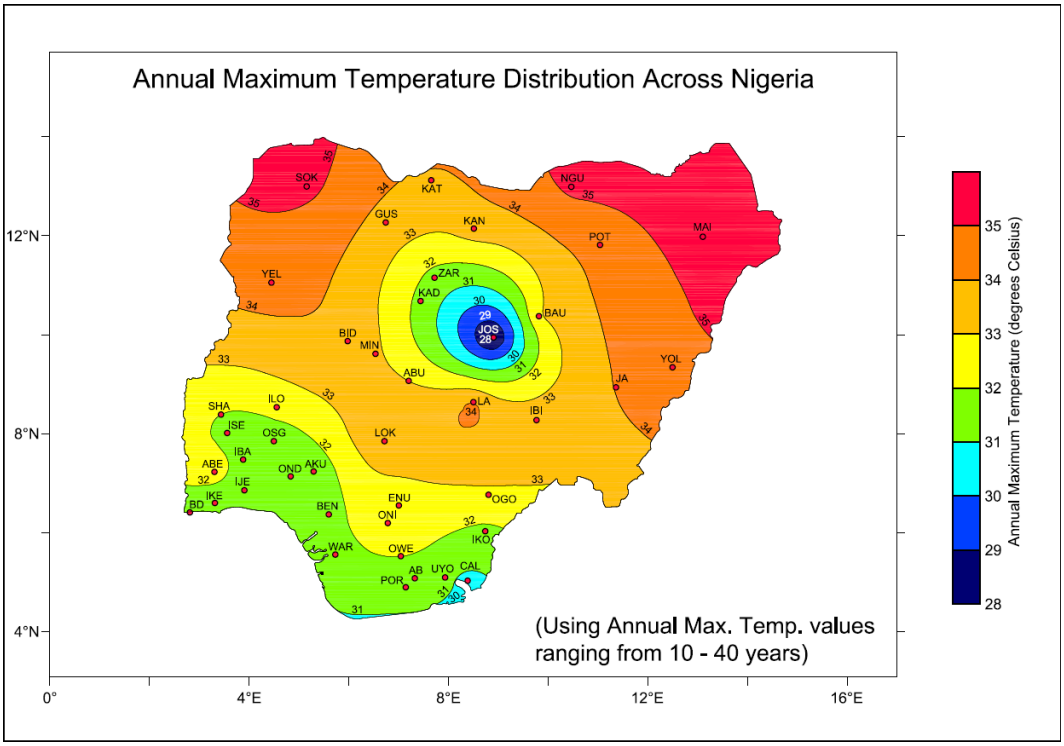

Figure 3.2: Annual Maximum Temperatures in Nigeria

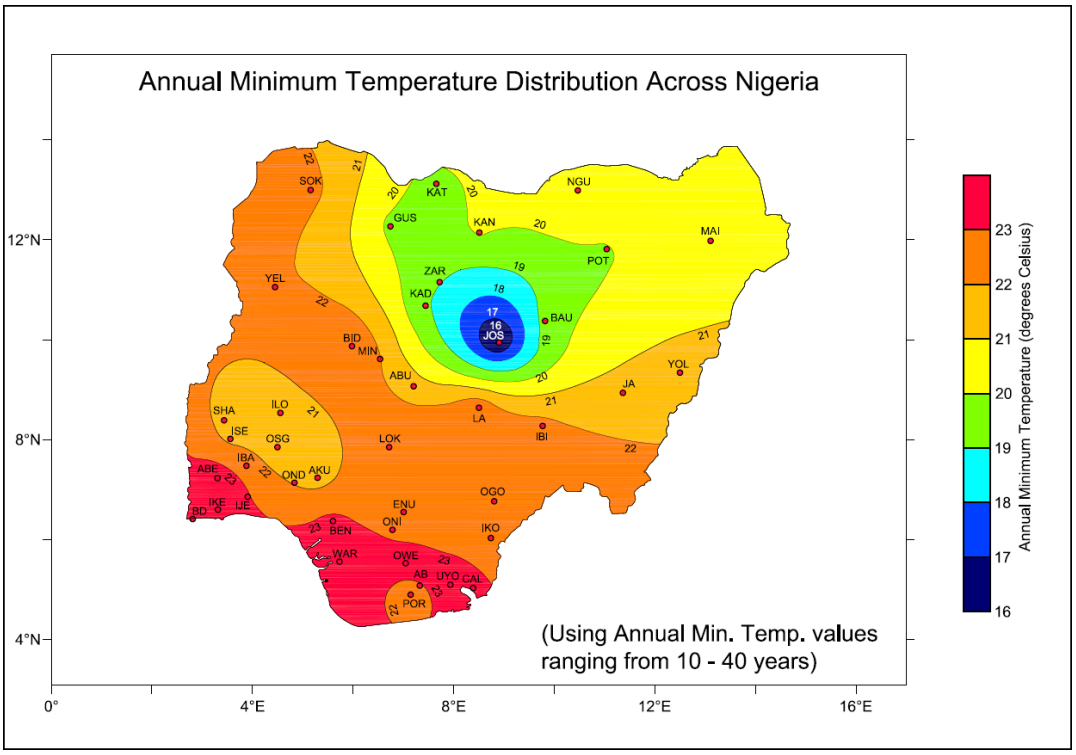

Figure 3.3: Annual Minimum Temperatures in Nigeria

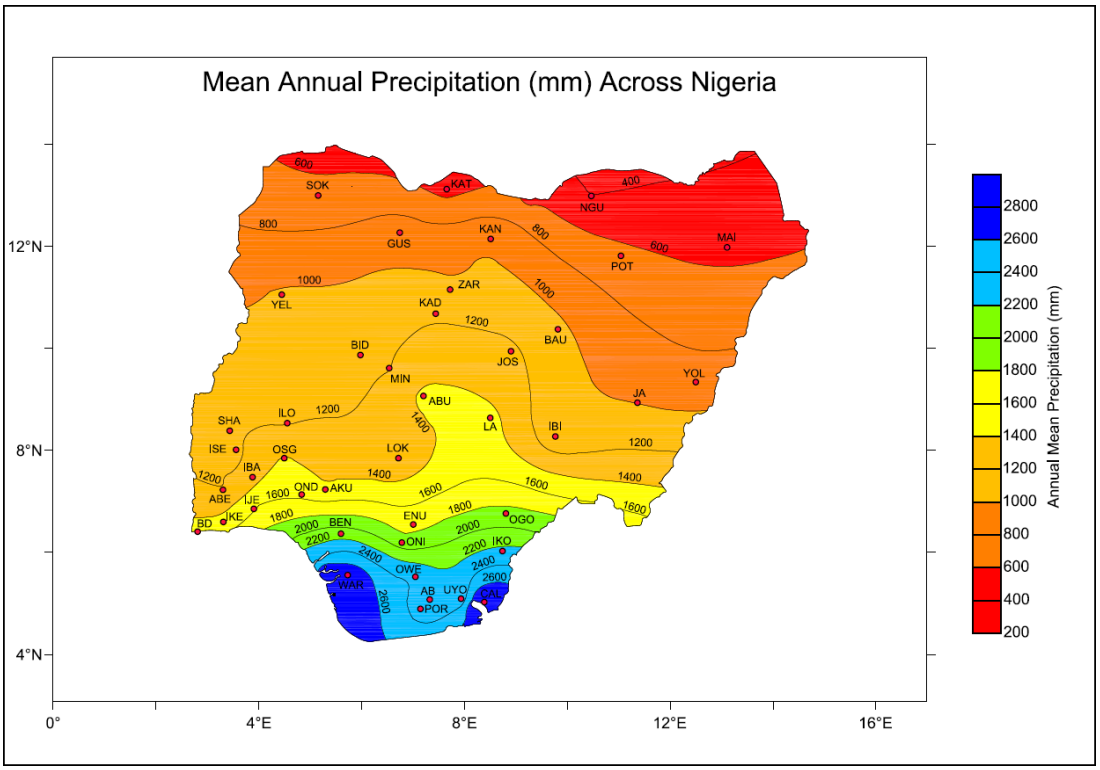

Figure 3.4: Annual Precipitation in Nigeria

3.1.2 Topography of the Country

The terrain varies from coastal swamps and tropical forest in the south, to savannah and semi-desert in the north. The highest points are the Jos Plateau in the centre (1,200-2,000 metres above sea level) and the mountains along the eastern border with Cameroon. The river Niger, the third longest river in Africa, traverses the country and reaches the sea in the south through an extensive delta of mangrove swamps.[10]

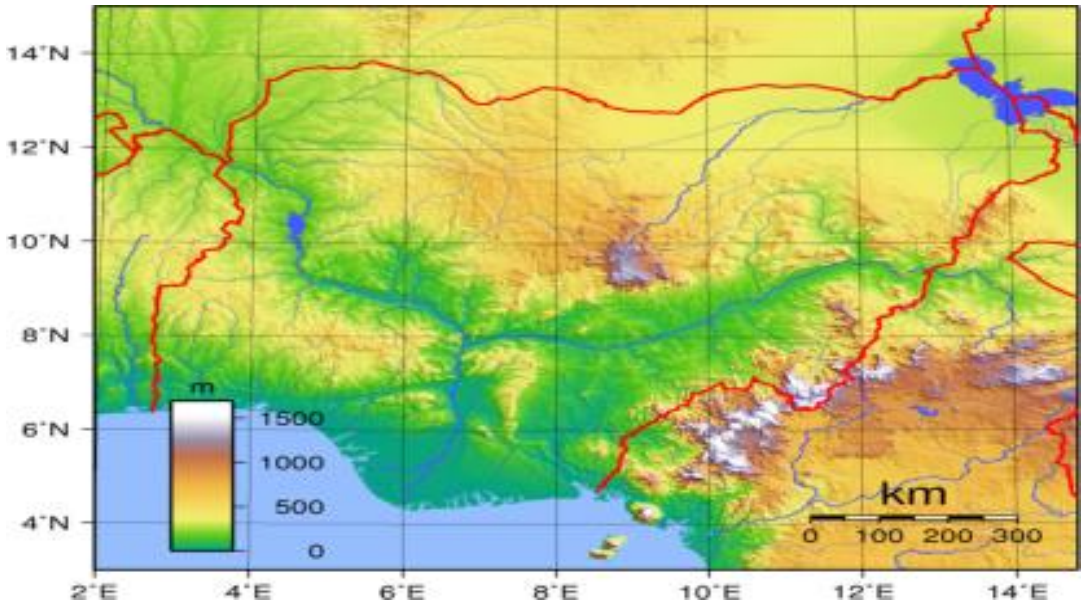

Figure 3.5: Topography of Nigeria

3.1.3 Geology of the Country

The geology of Nigeria is dominated by crystalline and sedimentary rocks both occurring in equal proportion. The crystalline rocks are made up of Precambrian basement complex and Phanerozoic rocks, which occur in the eastern and the north central regions of the country. The Precambrian basement consists of magnetite gneissic quartzite complex rocks dated Archean to Early Proterozoic. The schist belts and granitoid plutons of older granite, which dates from Late Proterozoic to Early Phanerozoic, are found in the western part of the country.

The Benue Trough extends for about 1000km in a north-easterly direction from the Bight of Benin to Lake Chad and forms part of the broader central African Rift system. The trough has its southern limit at the northern boundary of the Niger Delta, where it dips down and is overlaid with Tertiary and more recent sediments [11].

The south-western part of the country is underlain by amphibolites, migmatite gneisses, granites and pegmatites. The Niger delta, which is situated in the south of the country, contains a petroleum system, which is called the Tertiary Niger Delta Petroleum System and has 35 billion barrels of recoverable oil and natural gas [11].

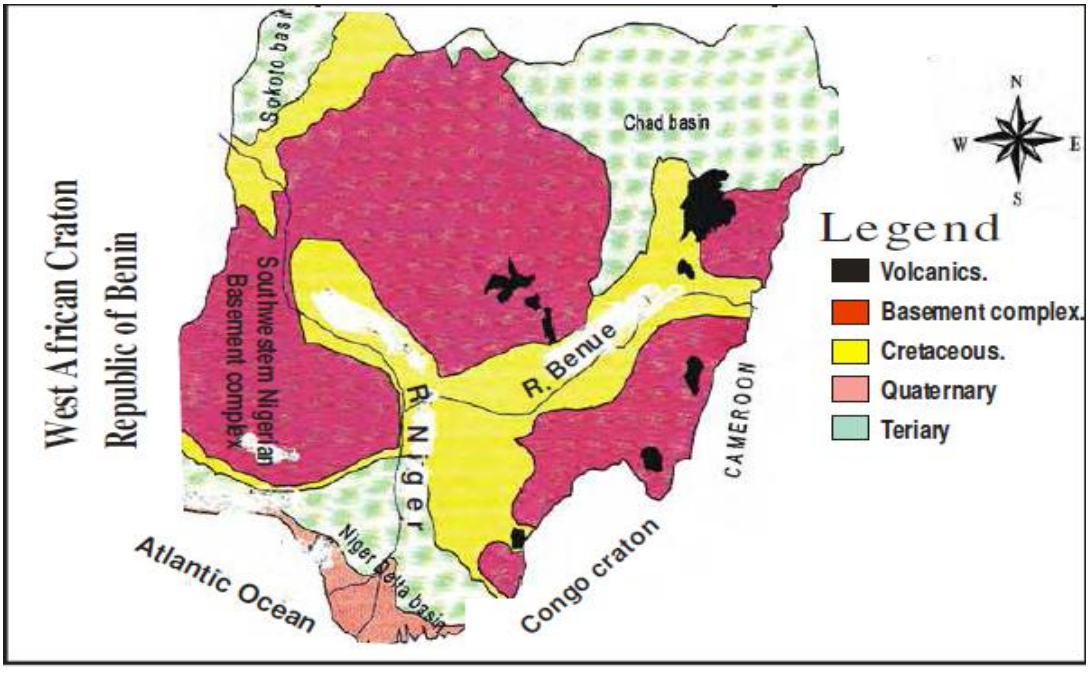

Figure 3.6: Geology of the south-western Nigeria

3.1.4 Hydrology of the Country

The Nigeria Hydrological Service Agency (NHSA) established eight hydrological areas across the country in 2009 [12]. Four principal surface basins drain these hydrological areas: the River Niger, Lake Chad, West Coast and West Central Coast with numerous minor tributaries[13].

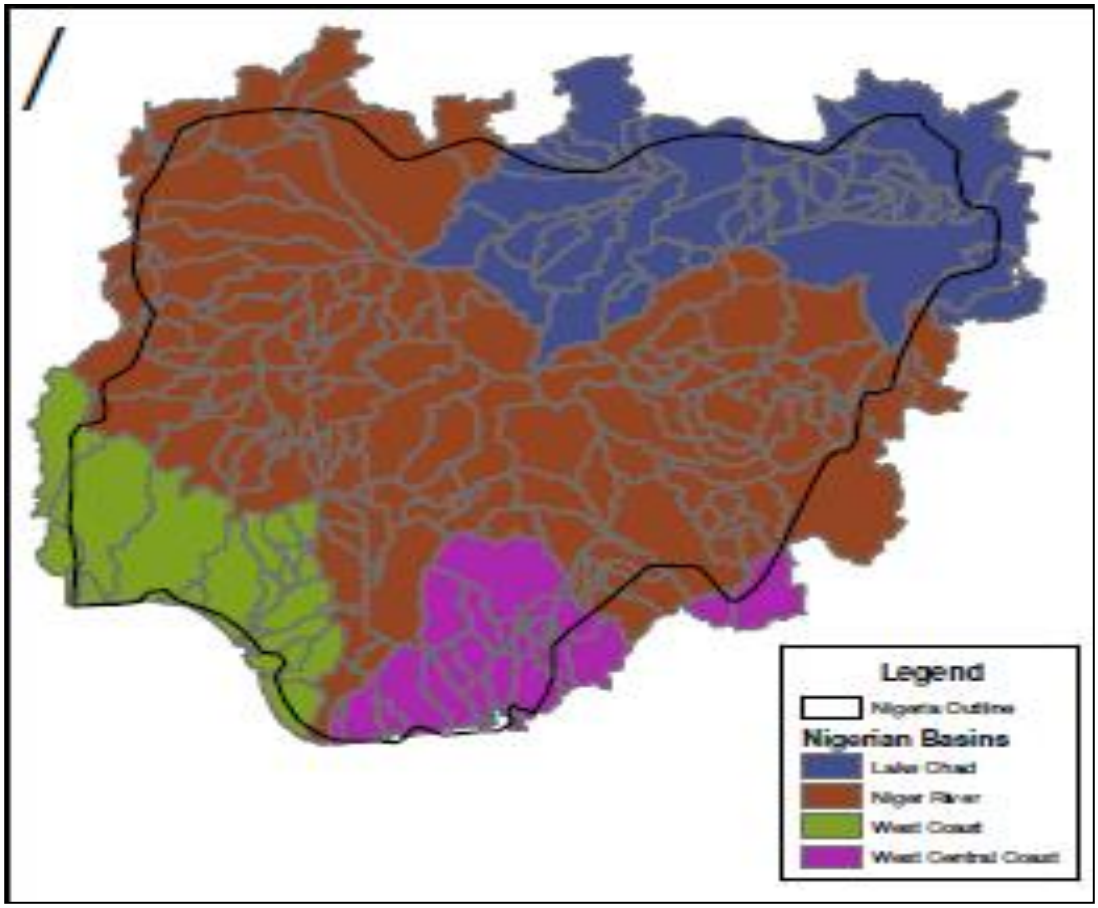

Figure 3.7: Major Basins of Nigeria[14]

There are several other major perennial rivers namely the Gongola, Hadejia-Jama'are, Kaduna, Zamfara and Yobe in the north, and the Ogun, Osun, Imo, Cross and Anambara rivers in the south.

The annual runoff on the River Niger has been recorded to be 165.80 billion cubic metres. The volume of available groundwater is also considerable in large sedimentary basins (the Chad and the Sokoto basins), which lie along the country's northern international boundaries with the latter representing Nigeria's segment of the internationally shared Iullemeden Aquifer System (IAS) [13].

There are also groundwater resources in the south of the country in particular on the trans-boundary coastal aquifers of the Gulf of Guinea Tano and Keta Aquifer Systems (TAKAS) (13).

a. Wetlands

Coastal wetlands are the most extensive. In the west, there are large lagoonal systems with mangrove swamps, palm-pandan swamps and reed swamps. In the east, the Niger Delta and Cross Estuary both carry large areas of mangrove forest and both permanent and seasonally inundated freshwater swamp forest. Inland, there are floodplains on many rivers, as a consequence of the increasing seasonality of the rainfall in passing northwards(15). The protected wetlands of the country are listed in Table 3.1 below.

Table 3.1: Protected Wetlands of Nigeria

Source: (www.Ramsar.wetlands.org)

Type	Name	Conservation Status
Riverine Wetlands	The Komadugu Yobe.	It consists of small Baturiya Wetlands Game Reserve, which includes 29 700 ha of floodplain near Hadejia.
	Ngadda Yedsardam & El Beid Rivers	A substantial area of the south western side of Lake Chad is protected in the Lake Chad Game Reserve.
Lake Chad	Lake Chad	The Lake Chad Game Reserve occupies 704 480 ha with a frontage of over 150 km along the western shore of the lake, which is more than half the shoreline of the lake in Nigeria.

3.1.5 Biodiversity of the Country

The biodiversity of Nigeria is rich with many different habitats that include savannahs, tropical forest, wetlands, lakes, rivers and coastal areas. The development of rainforest in the region is as a result high rainfalls in the coastal and south-eastern areas. However, the northern part of the country receives less rainfall and results in a drier vegetation zone.

There are three highland areas found in the country, namely the Jos plateau in the centre of the country, Yoruba in the west and the mountains bordering Cameroon towards the east[16].

a. Vegetation

There are seven types of vegetation found in the country namely marginal savannah, short grass savannah, woodlands and grass savannah, rain forest, freshwater swamps, mangrove and montane. The location of these vegetation types is depicted in Figure 3.8 and they are briefly described below [16].

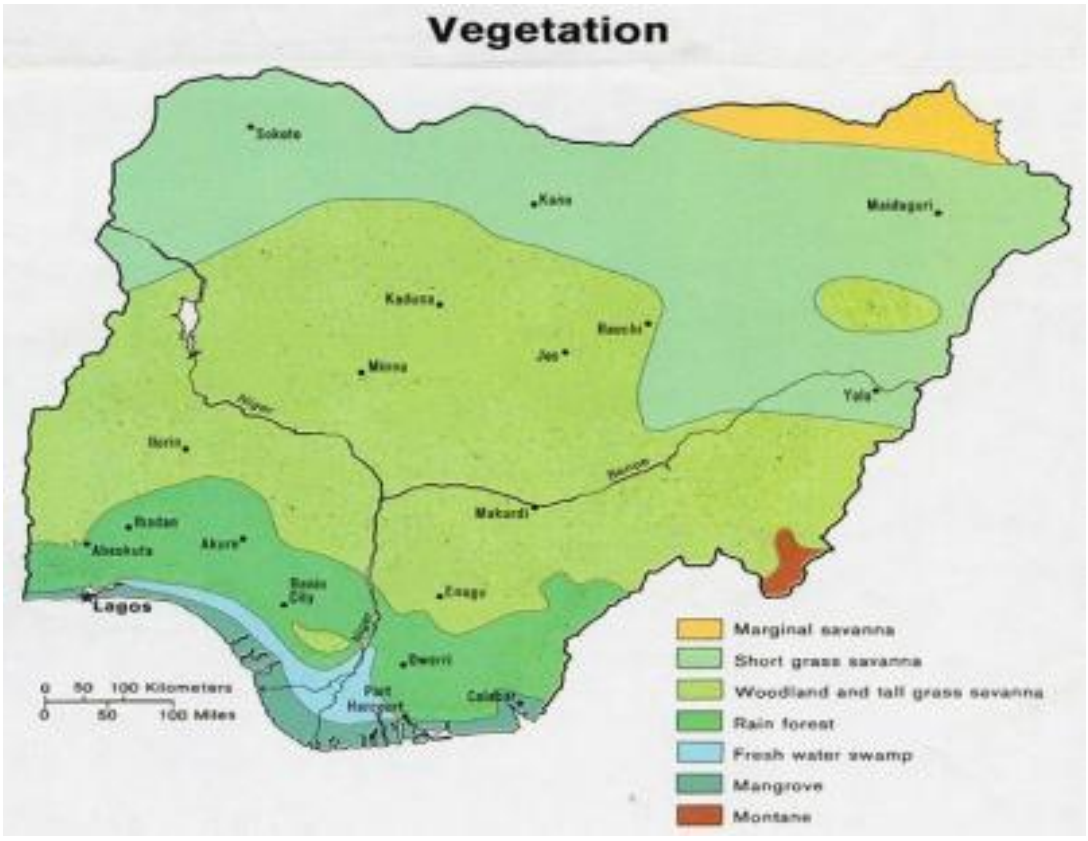

Figure 3.8: Distribution of Vegetation in Nigeria

(i) Savannah Grassland

The savannah grasslands are found in the north and central areas and often classified into four types, namely Sahel, Sudan, Guinea and derived savannah which range from north to south and are based on the amount of rainfall amount received and the seasons. Natural savannah is reducing and its animal's species are protected due to the numbers that have been reduced. However, there have

been initiatives to preserve the remaining species and habitats in game reserves such as Yankari and Lame Burra game reserves in Bauchi State.

(ii) **Lowland Rainforests**

Lowland rainforests are characterized by a great variety of plant species, which include mahoganies, African walnut (Lovoa) and Mansonia arranged in a complex vertical structure of forest canopies. There has been excessive exploitation of timber, agricultural encroachment, and other anthropogenic changes have greatly reduced these forests in extent and in biological diversity.

(iii) Mangrove Forests

The forest provides a number of ecological services, including habitat and nursery grounds for fish and mollusc species and firewood for residents. The first protected area to include mangroves was established as a forest reserve in Cross River State.

(iv) Freshwater Swamp Forests

Freshwater swamp forests are found in southern Nigeria on the landward side of the mangrove belt. Swamp forests are dominated by species of Raphia, Pandanus, Calamus, and Alchornea. They are characterised by climbing palms and a variety of other species that make the forest impenetrable. The swamps are threatened by saltwater intrusion due to the development of navigational canals that support the oil industry.

Figure 3.9: Lowland Forests

Source: Pat Foster Turley

(v) Freshwater Ecosystem

The country has a diversity of freshwater resources including seasonal and permanent rivers, lakes and wetlands, which provide breeding and feeding habitats for a diversity of bird and aquatic species. The Hadejia-Nguru Wetlands in the northwest has been protected for many years and forms part of a Ramsar site together with ten more Ramsar sites, which were added in 2008 for their global importance.

(vi) Coastal Areas

The coastline of Nigeria is approximately 853 km long, stretching from the western border with the Republic of Benin to the eastern border with Cameroon. The coastal shore consists of barrier islands, sandy beaches, lagoons, estuaries, mud beaches, and creeks and includes the Niger Delta. Mangroves and estuaries extend from 10-150 km inland. Further inland are freshwater swamp forests and other low-lying habitats, which are all, considered to be part of the coast.

The marine and coastal environment of Nigeria is rich in resources and species diversity. The mangroves found here are the largest remaining tract in Africa and the third largest in the world covering an area of about 9,723 km^2. The mangrove ecosystem provides a nursery and breeding ground for many of the commercial fishery species taken in the Gulf of Guinea [16].

b. Mammals, Birds and Invertebrates

There are a few large mammal species remaining in the country and these are found mostly in National Parks. Nigeria is a hot spot of bird species diversity and 906 species were recorded in 2003 and 12 were found to be threatened species and 3 were endemic and they include Anambra waxbill (Estrilda poplipaia), the Ibadan malimbe (Malimbus ibadanensis), and the Jos indigo-bird (Vidua maryae)[17].

According to Nigeria's National Biodiversity Strategy and Action Plan, there are 135 reptiles' species, 109 amphibian species and 247 non-marine fish species. Other threatened Fauna and Flora species of the country are listed in Appendix A.

Table 3.2: Biodiversity in Nigeria[18]

Species	Total number of species	Number of species threatened	Species found only in the Country
Plants	5103	171	-
Mammals	247	29	3
Birds	906	12	3
Reptiles	135	3	1
Amphibians	109	13	5
Fish	247	21	-
Invertebrates	More than 20000	1	-

c. National Parks and Game Reserves

There are eight national parks in Nigeria and they contain major ecosystems that include tropical montane forests, freshwater wetlands and lakes and savannahs [16].

Gashaka-Gumti National Park - is the largest national park in size and is adjacent to Tchabal Mbabo National Park in Cameroon, forming a significant trans-boundary protected area known for the great diversity of its primates, amphibians, butterflies, and plant species.

Cross River National Park -contains two sections which are Okwangwo and Oban. The Okwango section is one of the remaining places in the country to have a population of the critically endangered Cross River gorilla (Gorilla gorilla diehli).

Chad Basin National Park- contains the Hadejia-Nguru wetlands and is home to elephants and ostriches.

Kainji Lake National Park- contains wildlife, which is visible from man-made lakes.

Kamuku, Old Oyo and Okomu National Parks- contain important savannahs and forest habitats.

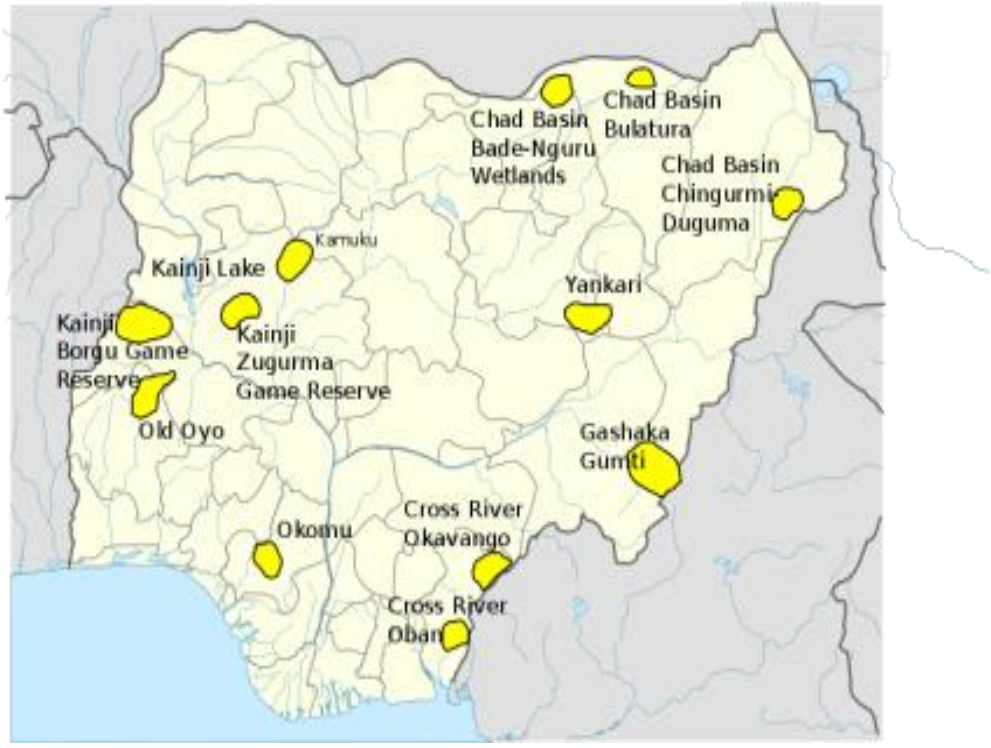

Figure 3.10: Location of the National Parks

3.1.6 Socio-Economic

a. Population

In 2012, the population of Nigeria was estimated to be 170 123 740 with a growth rate of 2.5%. The country has 250 ethnic groups including the Hausa and Fulani 29%, Yoruba 21%, Igbo (Ibo) 18%, Ijaw 10%, Kanuri 4%, Ibibio 3.5%, Tiv 2.5% [9]. The population of the country ranges from 100 people per km^2 in the northeast and west central regions to 500 per km² in the south and northwest regions.

There has been an increase in urbanisation over recent years in Nigeria. Lagos, the largest city of the country, was reported to have 12.5 million people in the year 2000 and is projected to increase to 25 million by 2015. There are 24 other main cities in the country having a population exceeding 100 000 [19]. Nigeria has 36 states with different population densities and they are depicted in Figure 3.11.

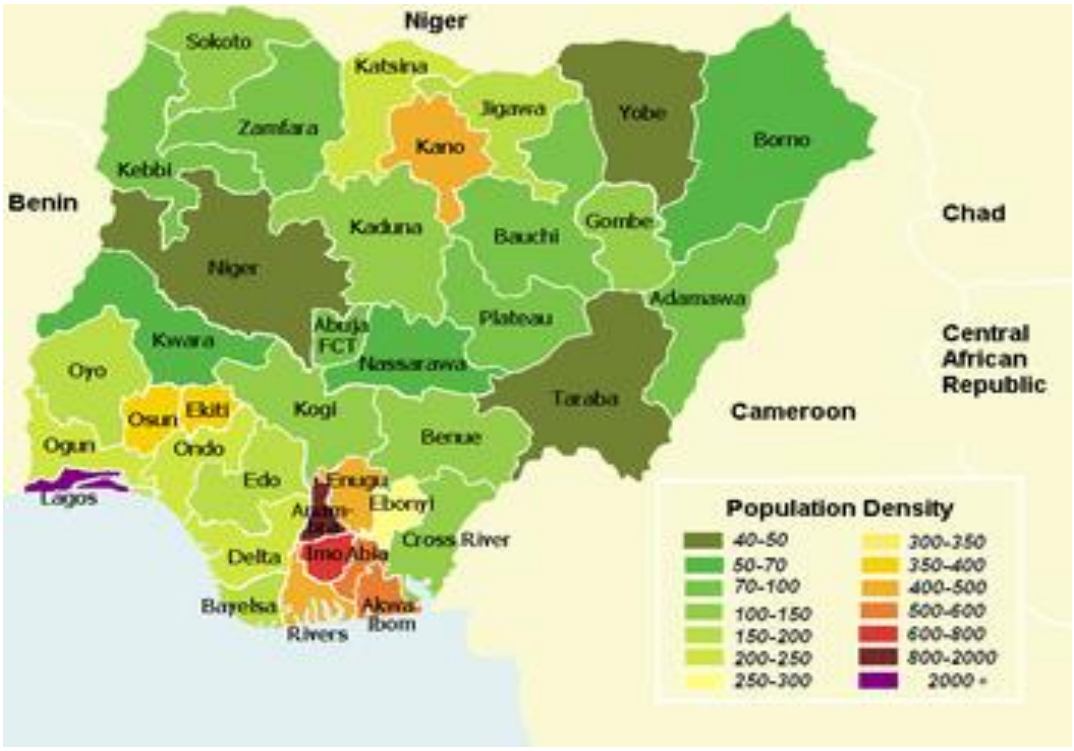

Figure 3.11: Population Density per State of the Country

In 2005, there were 57.2 million people employed and the employment by sector was 70% in agriculture, 20% in services and 10% in industry with a minimum wage of US$42.80 per month [11].

b. Settlement Patterns

About half of the population live in rural areas. Urban sprawl and urban expansion has extended into rural areas almost all over the country with little provision of basic infrastructure facilities and amenities. Densely populated settlements occur along the coast in Yoruba (south west), Hausa and Kanuri (north). The sparely populated areas are Igbo and Anang-Ibibio (south east) and Tiy (central region)[20]. Benue State is one of the underdeveloped parts of Nigeria with scattered settlements.

c. Economic Activities

Nigeria is a middle income and mixed economy country with emerging markets. The economic activities in of the country include agriculture, mining, industry and services. According to the 2012 Nigeria economic profile, the Gross Domestic Product (GDP) of the country in 2011 was 6.9% [9].

Nigeria produces oil which accounts for 2.7% of the world's supply. It accounts for 14% of GDP. The agricultural sector contributes about 26.8% with two thirds of employment. In the year 2000, the oil and gas industry accounted for 98% of the GDP. The banking sector has grown significantly in recent years. In 2007, 29% of the population did not own bank accounts.

d. Transport Sector

The road network of the country covers a distance of 80,500km and 15,000km are officially paved with the remaining poorly maintained. Government is gradually implementing construction of new roads and road repairs across the country. There are four main national airports in Nigeria located in Abuja, Lagos, Kano and Port Harcourt and they receive domestic and international flights daily. The aircraft are often poorly maintained and airlines are under pressure to meet world standards. The inland waterways cover a distance of 8,575km and they include the major rivers, which are the Benue and the Niger. The inland waterways provide an important transportation mode for goods and services across the country, as there are areas where roads are difficult to build [19]. The docking fees for freighters at major ports are, however, very expensive and a lack of investment in publicly owned transportation is a major constraint to economic development.

The rail system of the country covers a distance of approximately 3,557km and has two major rail lines - one connects Lagos on the Bight of Benin and Nguru in the northern state of Yobe and the other connects Port Hacourt in the Niger Delta and Maidiguri in the northern state of Bono [11].

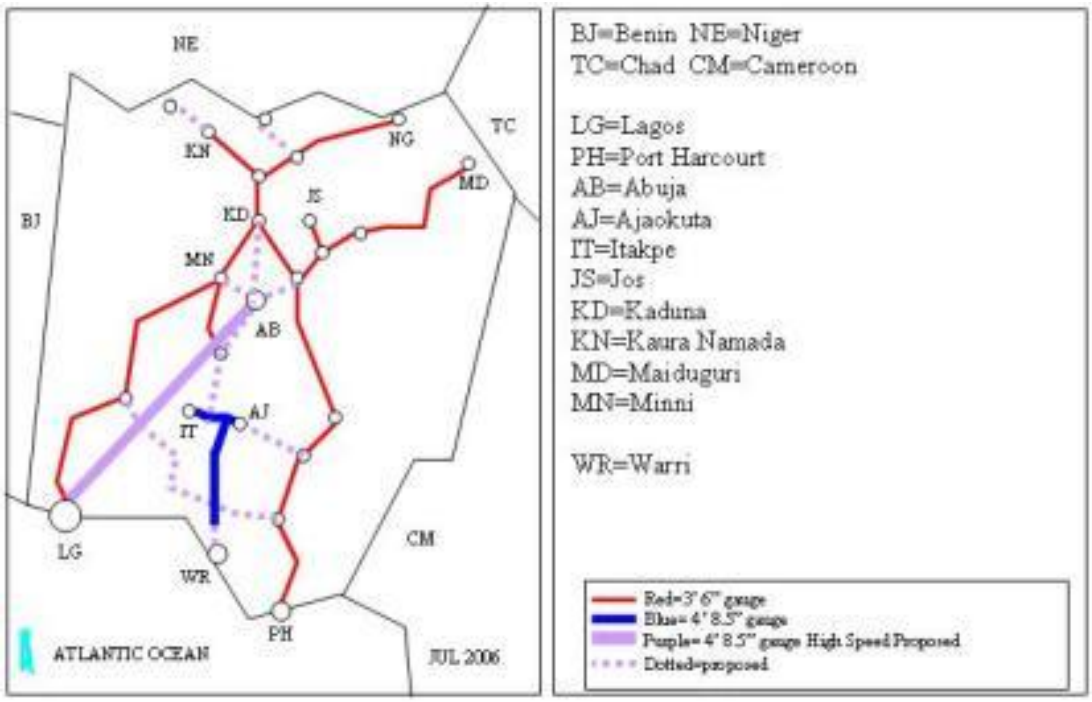

Figure 3.12: Railway system of Nigeria[11]

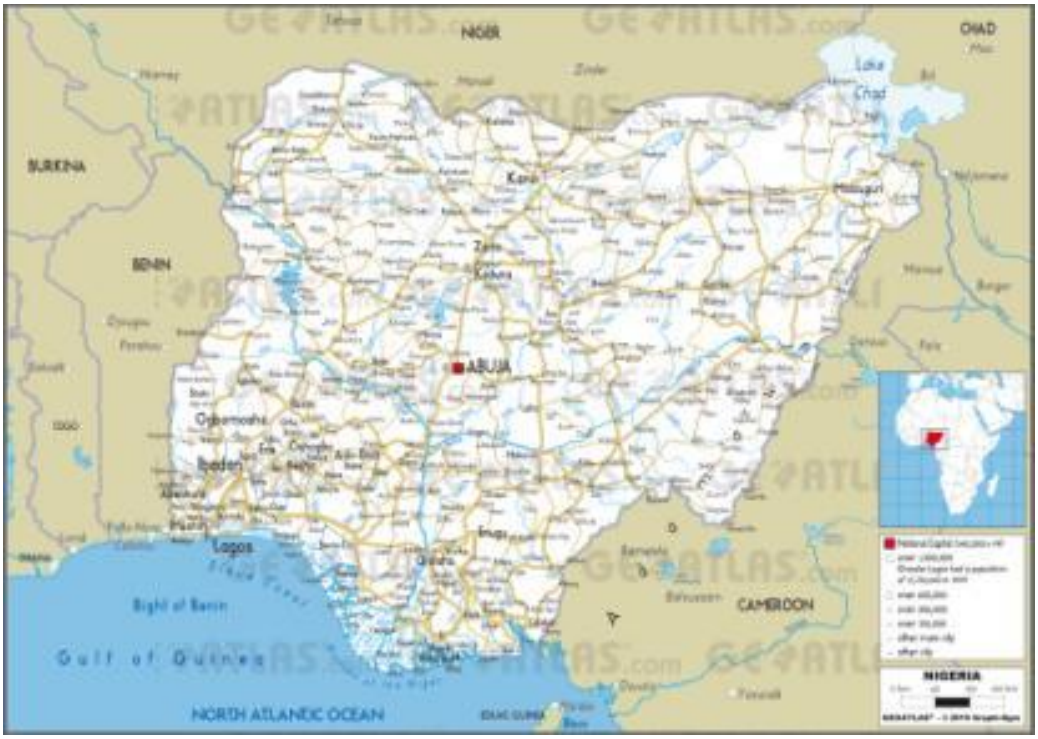

Figure 3.13: Major Road Networks of the Nigeria[21]

The sections (4-12) that follow in the Manual lists potential environmental impacts typically associated with the construction of roads and bridges and contain recommendations for mitigating and minimising the various impacts. As mentioned earlier, specific recommendations on a project basis will need to be identified by the EIA, the EMP and the Ministry of Environment.

4 Environmental Specialist area: Biodiversity

4.1 Impact Prevention

When planning new roads or changes in road width or road alignment, sensitive natural environments should be identified early in the planning process so that alternate routes and designs may be considered. Wherever possible, road developments should be located away from sensitive areas to avoid severe impacts on flora and fauna. Water crossings should be minimized, and buffer zones of approximately 500m of undisturbed vegetation should be left between roads and watercourses. Groundwater recharge areas should be avoided, and major roads should not be constructed through national parks or other protected areas. Advantage should be taken of opportunities to twin new road corridors with previously established transport rights of way, such as railway lines[(22)].

4.2 Protected areas

The following mitigation measures need to be implemented when roads are planned near National Parks or other protected areas:

- Enactment and enforcement of laws prohibiting hunting, transport of hazardous substances, and removal of plant materials from the areas by construction workers and the general public;
- Inspection of the contents of vehicles entering the areas, in order to discourage importation of potentially hazardous cargoes;
- Educational measures aimed at informing the travelling public about the reasons for not feeding wildlife, removing plants, littering, etc., and to instil a general appreciation of the desirability of conservation;
- Implementation of traffic control measures such as volume restrictions, lower speed limits, and forbidding vehicles to stop while crossing the areas; provision of rest areas with garbage cans and toilet facilities to discourage indiscriminate stopping along the roadside and littering; and
- Use of design features such as deep ditches, narrow shoulders, barriers to discourage roadside stops and removal of plant materials.

4.3 Protected Species

Protected species should not be interfered with or destroyed during the construction process. Prior to construction activities, a search and rescue survey needs to be conducted by a Biodiversity Specialist and representatives from the local Conservation Department, in

order to identify protected species occurring within the construction surroundings. The identified species need to be marked and fenced off and species which cannot be avoided by construction activities need to be removed from site and stored at a nearby nursery temporally until construction activities are completed. The species need to be returned to site after construction and rehabilitation activities have been completed.

4.4 Ecological Connectivity

A site specific wildlife assessment for the road project must be completed. The resulting impacts that the road has on the surrounding major ecosystems must be reported on. All non-human life that is impacted by the development according to the best scientific knowledge available for the ecosystem must be identified.

New dedicated wildlife crossing structures and protective fencing as recommended by the wildlife assessment should be provided. Existing alignments must replace in kind, retrofit or upgrade all existing culverts and fencing structures deemed structurally deficient, damaged, obsolete, insufficiently sized or inadequate[23].

4.5 Vegetation Management Measures

The following measures can be implemented for vegetation management:

- Design vegetation for effective long-term maintenance;
- Provide adequate conditions for plant growth through preparation of the soil to an appropriate depth (50-200mm);
- Recognise the limitation of prevailing conditions: e.g. large trees cannot be established on compacted steep embankments;
- Allow adequate areas for planting for specific purposes, e.g. a tall screening plant needs to be at least 10m deep. An eye level shrub screen can be achieved with a minimum width of 5m;
- It is essential to design planting around existing features to achieve screening in flat landscapes;
- Respect for existing patterns of vegetation and use native species in rural areas;
- Design earthworks with the type and extent of planting in mind; the shallower the gradient, the easier it is to establish vegetation;
- Grassland is often the right vegetation type to fit the existing landscape and must be established as a site specific type;

- Identify rapidly-dwindling vegetation types in a project area and consider this in landscaping;
- Landscaping can be varied, but uniform areas of common species are practical - careful appraisal of local conditions is needed; and
- Woodlands are products of either a long period of management of self-regenerating trees and shrubs or of deliberating planting. They do not have a natural distribution of species. New planting is an opportunity to create a more natural woodland type, which will give a special character to the area, and be of high wildlife interest [(2).]

4.6 Habitat Restoration

Conduct a biological assessment of the pre-development conditions of the project site and surrounding ecosystems or watershed sand implement a restoration plan that shall include the following [(23)]:

- Restoration of an area equal to the total disturbed surface area of the road way project;
- Describe the ecological design or engineering elements that are expected within a reasonable professional certainty;
- List responsible parties for restoration activities and monitoring efforts;
- List sources of funding for restoration activities prior to the roadway facility opening to traffic, ideally during project planning; and
- The plan must be signed and approved by the responsible parties or the project ecologist.

Figure 4.1: Depicts Vegetation Management along a Highway in the United Kingdom

5 Environmental Specialist Area: Topography and Visual Impacts

5.1 Impact Prevention

Designs should aim to achieve the best possible use of excavated materials, thus minimizing the need for off-site spoil disposal and borrow pits. If off-site works are necessary, they should be subject to the same good design principles as those used on site, achieved by liaison with the appropriate planning authority. Earthworks can only be integrated successfully if the new landform and its soil structure allow effective strategic rehabilitation. Restoration to agricultural use can be a particularly useful strategy. The objective of the design should be:

- To choose the route least damaging to the landscape and which respects existing landforms by avoiding disruption of major topographical features;
- To find an alignment that uses the existing landform to good effect and which minimizes the scale of earthworks;
- To design profiles which reflect existing natural slopes;
- To retain the least road footprint, by the return of land to its former use;
- To use existing landforms to minimize noise and visual intrusion: for example, placing a road in a cutting or behind rising ground to protect settlements;
- To develop new landforms, including mounds and false cuttings, to screen the road from settlements, and
- To achieve a balance between horizontal and vertical alignment [(1)].
- Map the existing topography and changes to the landform of each segment, as construction progresses. The map should identify critical areas for protection, which may be easily erodible, such as highly erodible soils, steep slopes, haul roads, or bare areas.
- Design a continuous and homogenous appearance and sudden breaks, kinks or abrupt changes in the alignment must be avoided.

Retaining existing topography wherever practical rather than undertaking major landscaping, for example, placing a road in a cutting or behind rising ground to protect settlements[(24)].

5.2 Mitigation of Visual Impacts

Aesthetic improvements can often be achieved without incurring additional costs, provided the designer approaches the subject in a sensitive manner. Alignments that are visually pleasing are usually less hazardous than other alignments.

On any roadway, creating a pleasing appearance is a worthwhile objective. Scenic values can be considered along with safety, utility, economy, and all the other factors considered in planning and design. This is particularly true of the many portions of a National Road system situated in areas of natural beauty. The location of the road, its alignment and profile, the cross section design, and other features should be in harmony with the setting. Economy consistent with traffic needs is of paramount importance, although a reasonable additional expenditure can be justified to enhance the beauty of the highway [(1)].

Where roadway lighting is provided, consideration should be given to preventing light intrusion and dispersion to the surrounding environment, especially if high mast lighting is utilised.

6 Environmental Specialist Area: Soils

6.1 Impact Prevention

The likelihood of serious environmental impacts on soil as a result of road projects can be reduced by the following measures [22]:

- Minimizing the area of ground clearance; avoiding sensitive alignments, such as those which include steep hillsides;
- Balancing filling and cutting requirements through route choice, so as to avoid the production of excess spoil material and to reduce the need for borrow pits;
- Avoiding previously contaminated sites;
- Avoiding the creation of cut slopes and embankments which are of an angle greater than the natural angle of repose for the local soil type; and
- Replanting disturbed areas immediately after disturbance has stopped, not after construction has been completed.

6.2 Management of Soil and Erosion Control

There is a wide range of techniques designed to reduce the risk of damaging the soil and to fit the project into its environment with minimal adverse effects. Removal of vegetation in a phased manner and to areas where construction will not be taking place should not be disturbed to limit the amount of soil exposed. Replanting cleared areas and slopes is the most effective action to be taken in reducing erosion and stability problems. It should be undertaken as early as possible in the construction process, before erosion becomes too advanced; to be most effective, it should be done immediately after the disturbance takes place. Vegetation should be selected to serve a specific engineering function. In some cases, a short-lived engineering structure, such as a woven wattle fence, is installed, along with vegetation that can take over the function of the structure in time. Engineering functions of vegetation include its abilities to [22]:

- Catch and retain material moving over the surface (stems);
- Armour the surface against erosion and abrasion by intercepting raindrops (leaves);
- Support the slope by propping from the base (tree and shrub boles and roots);
- Reinforce the soil profile by increasing its shear resistance (roots);
- Drain the soil profile by drawing water out through the roots and releasing it to the air by transpiration;

- Facilitate infiltration of water through the soil profile, thereby reducing the proportion of water flowing over the soil surface (roots);
- Store and reuse topsoil. This requires that topsoil be separated from subsoil during the initial excavation;
- The more fertile topsoil can later be deposited on the slopes to form a superficial layer conducive to seedling establishment;
- Shape the slope surface for maximum seedling survivability;
- Choose the right varieties, according to soil type, climate, ease of maintenance, and desired engineering function. Whenever possible, use local varieties for protecting against soil erosion; and
- Choose the right time of the year (for example, take advantage of the rainy season).

Sowing can be performed manually or mechanically, with farm machinery, for instance Hydroseeders (which use solutions of water, fertilizer, binder, and seeds) are of interest in areas where access is difficult, or as a labour saving practice where labour costs are high. Other products can also be applied to compensate for sterile soil and to promote seed germination. These may include mulch to protect the seed, covers, binders, and soil stabilizers. Shrubs and trees (woody plants) control erosion on slopes that are generally steeper; over 30 to 40 %, for instance [22].

6.2.1 Erosion Control Measures

Soil management measures [25] include:

- Increase vegetative cover, especially close to the soil surface; increase the content of soil organic matter which helps improve soil structure;
- Increase soil roughness;
- Plant windbreaks and shelter beds to reduce wind erosion;
- Use contour furrows, terraces, ploughed strips, and/or ridges to reduce or deflect runoff;
- Shrubs and shallow rooted plants can be used in areas with steep slopes;
- Matting in a biodegradable material can be used to prevent soil erosion and also allow plants to grow through it;
- Fertiliser and mulch can be used to reduce soil erosion and stabilise the soil; and
- Small walls can be built at the edges of the development or construction site to retain and prevent soil erosion.

6.2.2 Protection of Slopes

Slopes can be protected by implementing the following measures:

- Intercepting ditches at the top and bottom of the slope. Gutter and spillways are used to control the flow of water down a slope;
- Terraced and stepped slopes are used to reduce the steepness of the slope;
- Riprap or rock material embedded in the slope combined with planting;
- Retaining structures such as gabions, cribs and wooden barricades usually battered back against the slope;
- Retaining walls and more substantial engineering structures able to resist bending and with a footing designed to withstand pressures at the base of the slope;
- Reinforced earth embankment walls built up as earth fill is placed with anchors compacted into the fill material.

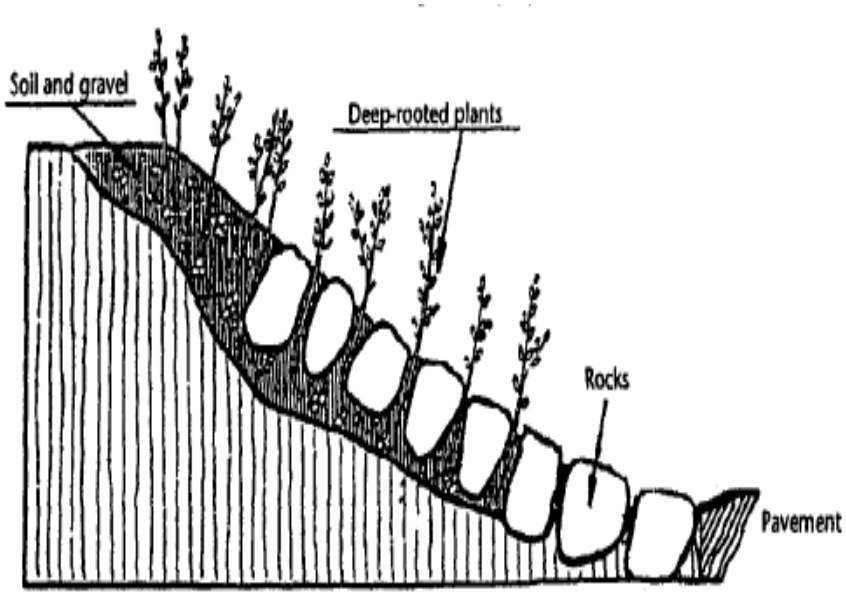

Figure 6.1: Combined Technique for Slope Protection[26]

6.3 Site Clearance

Site clearing shall take place in phased manner, as and when required. Areas which are not to be affected by construction shall not be disturbed or cleared in order to reduce erosion risks. The area to be cleared shall be clearly demarcated and this footprint strictly

maintained. Spoil that is removed from the site shall be removed to an approved spoil site or licensed landfill site. Silt fences and erosion control measures shall be implemented in areas where the risk is more prevalent. The areas include wetlands and steep slopes. Topsoil from the right of way shall be neatly stockpiled adjacent to the excavations ready for backfill when required. Coordinate the work schedules, if more than one contractor is working on a site, so that there are no delays in construction activities resulting in disturbed land remaining un-stabilised.

6.4 Topsoil and Subsoil Management and Stockpiling

- The full depth of topsoil should be stripped from areas affected by construction and related activities prior to the commencement of major earthworks. This should include the building footprints, working areas and storage areas;
- Topsoil shall be reused where possible to rehabilitate disturbed areas;
- Care shall be taken not to mix topsoil and subsoil during stripping;
- Polluted topsoil shall be disposed of at a licensed landfill site;
- Stockpiles should not be situated such that they obstruct natural water pathways and drainage channels;
- Stockpiles should not exceed 2m in height;
- If stockpiles are exposed to windy conditions or heavy rain, they should be covered either by vegetation or sackcloth. Stockpiles may further be protected by the construction of berms or low brick walls around their bases; and
- Stockpiles should be kept clear of weeds and alien vegetation growth by regular weeding.

6.5 Slope Stabilisation

Vegetation can help surface stability where it can penetrate into the bedrock. Brushwood can also be used with gabions or timber slope planting. Honeycomb biodegradable geotextile material or matting is appropriate where rapidly established dense grass is difficult. Hydro seeding is widely used to establish good grass cover. The choice of emulsion, organic matter and seed used as well as their proportions in the mix are crucial for good results. A precise specification chosen for the site and a properly qualified and specialist subcontractor are essential. Rock outcrops can vegetate naturally. This is usually the most effective method and also gives visual effect.

In order to avoid upslope run-off from the surrounding area causing erosion to the rehabilitation site, a geotextile should be used as a soft supporting structure that will assist in preventing this impact from occurring. The use of a geotextile cover is particularly important

where there is a slope, or where the soils are likely to remain exposed for any period of time while the new vegetation establishes itself. The geotextile is available in a range of types and materials with variable spacing in between threads. The lifespan of these materials should also last the length of the rehabilitation period (i.e. one year). The geotextile must be fixed by means of pegs or alternative structures such as duckbill anchors for example. The use of soft geotextiles is recommended in wetland areas.

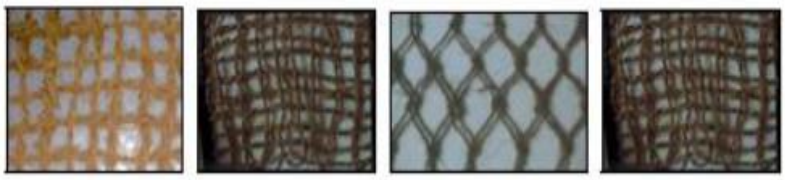

Figure 6.2: Examples of Geotextile that can be used

6.6 Soil Contamination and Prevention

- Where contamination of soil is expected or suspected, soil analysis should be done prior to disposal of excess soil to determine the appropriate disposal route;
- Topsoil and subsoil to be protected from contamination;
- Fuel and material storage shall be away from stockpiles;
- Cement, concrete and chemicals shall be mixed on an impermeable surface and provision should be made to contain spillages or overflows into the soil;
- Any storage tanks containing hazardous materials shall be placed in bounded containment areas with sealed surfaces. The bound walls shall be high enough to contain 110% of the total volume of the stored hazardous material;
- Contaminated soil shall be contained and disposed of off-site at an approved landfill site.

7 Environmental Specialist Area: Water Resource Management

7.1 Impact Prevention

Measures used to avoid severe impacts on the local hydrological environment may include [22]:

- Avoiding alignments which are susceptible to erosion, such as those crossing steep slopes;
- Minimizing the number of water crossings wherever possible;
- Using only clean fill materials around watercourses, such as quarried rock containing no fine soil; and
- Leaving buffer zones of undisturbed vegetation (width increased in proportion to slope) between road sites and bodies of water.

7.2 Water Resource Consumption

- Site staff should not be permitted to use any other open water body or natural water source adjacent to or within the designated site for the purposes such as washing of construction equipment or related activities;
- Municipal water or another source approved by the Project Manger should instead be used for all activities such as washing of equipment, dust suppression, concrete mixing, compacting, etc.; and
- Cement contaminated water should not enter the water system as this disturbs the natural acidity of the soil and affects plant growth.

7.3 Watercourse Management

- All watercourses should be recorded where they interface with or could be affected by the proposed or existing highway maintenance;
- Watercourse quality should be recorded by its River Ecosystem (RE) classification where this is available. If not, a General Quality Assessment (GQA) grade should be given. Data sets should identify which classification is used;
- Information on watercourse quality and fisheries can be obtained from the appropriate Department of Water Affairs;
- Groundwater resources must be protected from pollution from highway run-off.

7.4 Wetland Management

During the preliminary planning phase of projects, wetlands need to be identified and mapped by specialists and where possible be avoided by construction activities. If avoidance is not possible, licences or permits required need to be sourced from the regulatory Department of Water Affairs. The following mitigation measures need to be implemented to minimise impacts on wetlands[27].

- Size the culvert system to provide water level equalisation across fills similar to natural conditions;
- Design culverts to allow peak flows to dissipate at normal rates and prevent damming;
- Design culverts and structures that retain established circulatory patterns and minimise channelization. Carefully place culverts in areas that have a significant natural circulatory flow;
- Highway design must consider fill permeability and substrate compression requirements and make adequate passage of subsurface water. Where possible maintain diffuse drainage patterns;
- Highways are designed and constructed to reduce the areal extent of the footprint in the wetland;
- Appropriate buffer zones need to be created in areas of water bodies; and
- The construction of the development must not utilise heavy construction vehicles where possible in proximity to the wetlands.

7.5 Storm Water Management

a. Reduction of Storm Water on Site

If uncontaminated water enters part of the site that has been cleared, it will quickly pick up sediment and need to be treated. Additional water may also add to the erosion potential, increasing the risk of pollution. It is recommended that clean storm water be diverted away from those parts of the site where soil is to be exposed. This can be done by constructing diversion banks and intercept drains around the site while ensuring that the water discharging from such banks or drains is disposed of without causing erosion.

Wherever possible, the new storm water drainage system should be installed before any land disturbance activities commence. If possible, on-site inlets should not be connected until the site has been stabilised and rehabilitated. In this way, silt-laden storm water cannot escape the site via this route and pollute surface waters. It will have to be treated onsite.

b. Water Velocities

Installation of rock structures on the site to retard water flows is an effective measure to reduce erosion in areas where high water flows are expected. It is desirable to minimise continuous slopes where flowing water can scour. To prevent scouring, drainage lines may need to be lined or velocity-reducing structures, such as crushed rock or geotextiles, placed in the drainage line.

c. Steep Slopes

Any natural drainage lines that discharge water on to the top of a slope should be directed to grass areas by intercept drains. Perimeter banks or sediment fences should also be constructed at the toe of the slope to contain sediment run-off[28].

7.6 Other Mitigation Measures

7.6.1 Hazardous Material

- Use and storage of materials, fuels and chemicals which could potentially leak into the ground shall be controlled in a manner that prevents such occurrences;
- All storage tanks containing hazardous materials shall be placed in bounded containment areas with sealed surfaces; The bund wall shall be high enough to contain 110% of the total volume of the stored hazardous material with an additional allocation for potential stormwater events;
- Any hazardous substances shall be stored at least 100m from any of the water bodies on site. Contaminated wastewater shall be managed by the Contractor to ensure existing water resources on the site are not contaminated.
- The Contractor should be responsible for ensuring that potentially harmful materials are properly stored in a dry, secure, ventilated environment, with concrete or sealed flooring and a means of preventing unauthorised entry;
- Contaminated wastewater shall be managed by the Contractor to ensure existing water resources on the site are not contaminated. All wastewater from general activities in the camp shall be collected and removed from the site for appropriate disposal at a licensed commercial facility; and
- Temporary cut-off drains and berms may be required to capture storm water and promote infiltration.

7.6.2 Best Practice Measures

- There should not be any washing or servicing of vehicles on site;
- The site shall be managed in order to prevent pollution of drains, downstream watercourses or groundwater, due to suspended solids, silt or chemical pollutants;
- Silt fences should be used to prevent any soil entering the stormwater drains;
- Temporary cut off drains and berms may be required to capture storm water and promote infiltration;
- Promote a water saving mind set with construction workers in order to ensure less water wastage;
- New storm water infrastructure construction shall be developed strictly according to specifications from the Project Manager in order to ensure efficiency;
- The installation of the storm water system shall take place as soon as possible after commencement of the construction activities, to attenuate storm water from the construction as well as the operational phase;
- There should be a periodic checking of the site's drainage system to ensure that the water flow is unobstructed;
- If a batching plant is necessary, run-off should be managed effectively to avoid contamination of other areas of the site. Run-off from the batch plant shall not be allowed to get into the storm water system or nearby streams, rivers;
- Ensure that surface/storm water is diverted away from excavation trenches;
- If necessary, ensure that stream flow bypasses the construction area within drainage lines;
- **Flow speed control-**water speed reduction measures can substantially reduce potential impacts. Examples include grasses, riprap, and other devices in water channels, as well as dispersal structures in main drains;
- **Settling basins-** settling basins are sometimes used to remove silt, pollutants and debris from road runoff water before it is discharged to adjacent streams or rivers. They are most appropriate where the downstream environment is particularly sensitive or where the levels of silt or pollutants are particularly high. On-going maintenance may be required where large amounts of silt are deposited;
- **Paving**- sections of dirt and gravel roads prone to erosion and likely to be a source of sediment can be paved to reduce the amount of sediment produced. This is especially relevant near water crossings;
- **Infiltration ditches**- infiltration ditches can be used to reduce overland flow by encouraging the movement of runoff down through the soil profile. The volume of flow in downstream drain age structures is reduced, the flow of pollutants is localized, and groundwater is recharged; and

- **Water collection, control, and treatment**-this is a relatively expensive option for polluted runoff from pavements and slopes, but may be called for in particularly sensitive areas [22].

7.6.3 Compensation Measures

Compensatory measures should be considered if they prove more cost-effective than mitigation or if mitigation proves impossible; examples include [22]:

- Moving a bore hole away from an adversely affected site, provided the local ground water distribution permits this;
- Drilling wells for local residents who previously relied on surface water for drinking; and
- Creating a replacement habitat for wildlife.

7.6.4 Enhancement Measures

Road projects often provide an opportunity to improve some aspects of the hydrological environment. In very dry areas, road drainage can be designed to retain water in small dams or maintain a high water table for example, by raising the inlets to drainage culverts-which increases the availability of drinking water and the viability of many species of flora and fauna, and recharges local aquifers. In areas prone to flooding, road works can either incorporate retarding basins that reduce runoff peaks (and potentially save on drainage structures), or they can improve drainage in residential or farming areas that are excessively sensitive to flood damage. In some cases, a section of the road itself can be constructed as a dam, perhaps designed to operate as a spillway during peak floods (22).

8 Environmental Specialist Area: Waste Management, Quarries and Borrow Pits

8.1 Waste Management Plan

The contractor should establish, implement and maintain a formal Construction and Demolition Waste Management Plan (CDWMP) that encompasses all waste types (general waste, recyclable, construction waste and hazardous waste) during roadway construction. The CDWMP should be included in the project contract documents and identify at minimum the following items

- Type of construction waste (paving process waste such as asphalt, concrete), milling waste, metals, plastic (waste plastic pipes), excavated soil cuttings and boulders, land clearing debris, hazardous and general waste;
- Expected (or actual) tonnage of hazardous, general and building rubble;
- Costs and fees for landfills, recovery facilities and hauling;
- Contact information of responsible party for hauling;
- Handling method (re-use, recycle, salvage, landfill) including the container size and correct labelling;
- Destination of waste (e.g. recycling facility, landfill);
- Contact information of the responsible party for the disposal site;
- Certificates/receipts of disposal, recycling and salvage documents;
- Management strategy for waste generated from mobile office activities and personal worker (household) waste.

An example of a waste management plan is attached in **Appendix B**.

8.2 Best Practice

The management of waste for road construction activities should reflect the waste management hierarchy with waste prevention and minimisation being the first priority, succeeded by reuse and recycling. Examples of how the hierarchy can be implemented on the construction site are described below. The reuse and recycling of materials also reduces the quantities of waste, which needs to be disposed at landfill sites[29].

Waste can be minimised by using improved technology, recycled or reused on-site, or by making purchasing decisions that favour recycled products. Wherever possible, include performance measures and targets for reduction, reuse and recycling options in the Environmental Management Plan. Waste minimisation opportunities include [28]:

Figure 8.1: Waste Management Hierarchy[30]

8.2.1 Waste Prevention

Examples of waste prevention on construction sites are listed below.

- Construction materials should be ordered on a need basis to prevent oversupply to site;
- Purchasing coverings, panelling or other materials in a shape, dimension and form that minimises the creation of excessive scrap waste on site;
- Ensuring correct storage and handling of construction materials to minimise generation of damaged materials (keeping deliveries packaged until they are ready for use).
- Ensuring correct sequence of operations; and
- Assign a person who will be responsible for the purchase and control of materials required.

8.2.2 Reuse of Waste

Initiatives should be put in place to maximise the efficient use/reuse of materials. Examples of how waste can be reused on site are described below:

- Excavated spoil/topsoil can be carefully set aside and used as landscaping material in the completed development;
- Architectural features can be reused in the refurbishment of retained structures on the same site;
- The warehousing of salvaged material can facilitate its reuse on future projects.

8.2.3 Recycling of Waste

- Waste timber can be recycled as shuttering or hoarding or sent for reprocessing as medium density fibreboard;
- Waste concrete can be utilised as fill material for roads or in the manufacture of new concrete when arising at source;
- Asphalt and bitumen can be recycled.
- Obtaining construction materials, paints, lubricants and other liquids in reusable packaging or containers;
- Using noise barriers made from recycled materials;
- Using overburden to construct temporary noise barriers;
- Sending waste concrete from demolition activities to a concrete recycler instead of a landfill;
- Segregating and recycling solid wastes generated by construction activities, offices and mess-rooms;

- Collecting lubricating oil from the construction vehicle fleet and sending it to a recycler.

8.2.4 Treatment and Disposal

Construction materials which cannot be reused and recycled can be transported to the nearby municipal approved landfill site for disposal and disposal certificates obtained as a proof of correct disposal.

It should be noted that other waste management mitigation measures which can be incorporated into the waste management plan are included in the sections below.

8.3 Hazardous Waste Management

- Hazardous waste (such as chemicals and oil) should be recycled where possible;
- All hazardous waste materials should be temporarily stored in a bunded /lined area for a period of 90 calendar days and later disposed of at a licensed landfill site;
- Contaminants are to be stored safely to avoid spillage;
- Machinery shall be properly maintained to keep oil leaks in check;
- Labelled containers should be provided to store used oils, as well as hazardous waste containers for oily rags; oil filters etc. and shall be disposed of at a suitable approved registered landfill;
- The Contractor shall install mobile chemical toilets on the site;
- Staff shall be sensitised to the fact that they should use these facilities at all times;
- Ablution facilities shall be within 100m from workplaces but not closer than 100m from any natural water bodies and they shall be serviced regularly;
- Depending on the nature and extent of the spill, contaminated soil shall be either excavated or treated on-site;
- Excavation of contaminated soil shall involve careful removal of soil using appropriate tools/machinery to storage containers until treated or disposed of at a licensed hazardous landfill site;
- Spillages on site should be contained immediately;
- If a spill occurs on an impermeable surface such as cement or concrete, the surface spill shall be contained using oil absorbent materials; and
- Contaminated remediation materials shall be carefully removed from the area of the spill so as to prevent further release of petrochemicals to the environment, and stored in adequate containers until appropriate disposal.

8.4 Litter and General Waste Management

- The Contractor and it's workers should ensure that all litter and general waste is disposed of in a responsible manner, and is not released into the environment;
- Maintain a high quality of housekeeping and ensure that materials are not left where they can be washed or blown away to become litter;
- Provide sufficient waste bins on site for construction workers and staff at locations where they consume food. The refuse bins must be of different types for waste disposal and recycling purposes;
- Conduct ongoing awareness with staff of the need to avoid littering;
- Construction rubble which cannot be reused and recycled needs to be to be stockpiled temporarily and disposed to a landfill site;
- Refuse bins shall be placed at strategic positions to ensure that litter does not accumulate on site; and
- All waste shall be removed from the site and transported to a landfill site approved by authorities.

8.5 Quarry and Borrow Pit Planning

- The earliest possible recognition of the need for quarries or borrow pits is essential in order to produce a satisfactory design;
- The local planning authority should have the opportunity to provide information for tender bidders on potential sites and list the conditions which would apply for their design and after use;
- All necessary mining permits need to be sourced from the relevant Regulatory Authority prior to construction activities;
- Wherever possible, surpluses or shortfalls should be dealt with in the design of earthworks on site, i.e. by grading out embankments or cuttings;
- Where off-site works are required, it is usually better to tip or borrow close to the site to avoid the costs of hauling and the impact of moving materials on local roads and residents;
- The environmental impact of borrow and disposal sites should be assessed and the best sites used in the scheme design;
- Return to previous land use is often an appropriate objective. This is usually agricultural use. Alternatively, flooded borrow pits can sometimes be turned into features of landscape and nature conservation interest, provided safety considerations are taken into account.
- Borrow pits can be integrated into the surrounding environment and form the basis of a new public open space in a heavily developed area.

Borrow and quarry material should not be placed until all roadway excavation has first been placed in embankments and fill areas. If more borrow is placed than is required and causes a waste of excavation, the quantity of waste will be deducted from the volume measured in the borrow area. If more embankments are placed than is required, the excess embankment quantity will be deducted from the volume of borrow or excavation measured for payment[31].

8.5.1 Location of Borrowpits

According to the Irish Wind Energy Industry Best Practice Guideline, the following factors should be considered when planning the location of borrow pits:

- Proximity to existing or proposed roads;
- Access to material suitable for the required purpose;
- Minimum amount of excavation required to access the material;
- Borrow pits should not be established in environmentally sensitive areas such as near ground and surface water resources, sensitive biodiversity areas etc.;
- Borrow pits should be located 500m away from local communities for safety reasons and should be barricaded all the time for the duration of the construction activities.

8.6 Quarry and Borrow Pit Rehabilitation

Once borrow pits and quarries have been mined out, the following final rehabilitation actions should be implemented:

- The equipment and infrastructure should be removed from the site.
- During rehabilitation, the topography should be finished off so that the sides of the borrow area are no steeper than 1:5.
- The slope changes should be finished off so that flowing curves that blend with the surrounding landscape are formed in preference to sharp angles.
- Unused boulders should be placed back in the deepest areas of the excavated area and topsoil and vegetation stripped during site clearance should be spread evenly across the borrow pit area;
- Before placing topsoil, all visible weeds should be removed from the placement area and from the topsoil.
- The previously stripped and stockpiled topsoil should generally be spread evenly over the prepared surface to a depth of 75 to 150mm on slopes of 1:3 or steeper;
- For re-vegetation, it is best to establish fast growing locally indigenous grasses; this will help to establish a plant cover to bind the soil and create conditions favourable for the natural growth and prevent soil erosion; and

- The borrow pits should be fenced off to prohibit un authorised access from the general public

Before final acceptance by the Transportation Authorities, the highway, borrow pits, and all areas occupied by the Contractor in connection with the work shall be cleaned of all rubbish, excess materials, temporary structures, and equipment; and all parts of the construction work shall be left in a condition acceptable to the Engineer / ECO [31].

9 Environmental Specialist Area: Land Use and Socioeconomic Impacts

9.1 Land Use and Landscape Integration

The objective of route selection should be to choose a route that has both the minimum effect on landform and requires the smallest number of large earthworks. Designs should aim to achieve the best possible use of excavated materials, thus minimizing the need for off-site spoil or borrow pits. If off-site works are necessary, they should be subject to the same good design principles as those used on site, achieved by liaison with the appropriate planning authority. Earthworks can only be integrated successfully if the new landform and its soil structure allow effective strategic rehabilitation. Restoration to agricultural use can be a particularly effective strategy. The objective of the design should be:

- To choose the route least damaging to the landscape and which respects existing landforms best by avoiding disruption of major topographical features;
- To find an alignment that uses the existing landform to good effect and which minimizes the scale of earthworks;
- To design profiles which reflect existing natural slopes;
- To retain the least road footprint, by the return of land to its former use;
- To use existing landform to minimize noise and visual intrusion: for example, placing a road in a cutting or behind rising ground to protect settlements;
- To develop new landforms, including mounds and false cuttings, to screen the road from settlements, and
- To achieve a balance between horizontal and vertical alignment [(1)].

9.2 Heritage, Cultural and Historical Features Impact Prevention and Mitigation

- Where possible, road construction should avoid any alignment that cuts through known cultural sites;
- If an important site is uncovered during road works, work should stop immediately and the uncovered archaeological feature be reported to the nearest Museum for investigation or possible realignment of the road should be considered;
- In some unusual cases it is preferable to leave a cultural site buried beneath the road. This may involve raising the level of the road [(22)];

- Control water and soil erosion which will result in runoff that impacts or destroys historical and archaeological features;
- Avoidance of historical features by re-routing the construction works;
- If the features cannot be avoided, they must be relocated to a new site and a site management plan needs to be compiled detailing the relocation and salvage measures and the responsibility of the Contractor that uncovered/discovered the features/ sites. Other mitigation measures which can be implemented are outlined below [22]:

    - **Baseline data and potential environmental impacts:** the identification and prioritization of historical and archaeological sites should occur prior to route surveying. It should pinpoint highly sensitive areas, and archaeological soundings;

    - **Analysis of alternatives:** options for the avoidance of sensitive areas should be considered seriously;

    - **Mitigation plan:** such plan should include rules for the construction phase and archaeological supervision;

    - **Environmental specifications for contractors:** these should specify the actions required and the person responsible, and should define the nature and scope of any additional development work that may be called for;

    - **Legislation:** the analysis should focus on legislation that is in effect in the country or region, and the regulations regarding various classes of protected sites.

9.3 Land Acquisition, Resettlement of People/ Businesses

According to the Federal Republic of Nigeria Resettlement Policy Framework 2006, the individual design consultants to be contracted in the undertaking of highway/road construction process are to make recommendations as to which users of the road corridor and reserves will need to be displaced from their present locations. The principles which follow should guide their work, which should be oriented to causing the least displacement consistent with the road design goals, enabling displaced people or enterprises to be reinserted as close to their existing locations as possible, ensuring that those displaced can re-establish their income, and compensating some of those displaced for any reasonable losses they incur. Residential and business areas should be identified early in project

planning and considered as constraints in the choice of alternative routes, the planning of temporary traffic diversions, and the location of work-site camps [22].

Once road reserves have been proclaimed for planning purposes, steps should be put in place to prevent encroachment by new residents and traders.

9.3.1 Disruption and Resettlement of Businesses

Minimizing the loss of roadside business activity is best dealt with through on-going collaboration between the road agency and those local agencies responsible for the enforcement of encroachment regulations. The intent should be to ensure that the interests of both the road users and the community are served [22].

Where road improvements require removal of some local activities from the right-of-way, a common mitigation measure is to provide alternative space for these activities nearby. The covering of drains or the purchase of additional roadside land, for example, can permit continued operation of roadside stalls, customer parking, or pick-up areas for informal public transport services [22].

The effects of bypassing local businesses can be mitigated by providing service areas adjacent to the new routes and by encouraging local communities to make use of the new opportunities provided. However, care should be taken to discourage the migration of businesses that are not essential for the passing travellers since such movement can drain the existing roadside community of much of its vitality. In other cases, roads can be designed to encourage long-distance travellers to continue to use local businesses [22].

9.3.2 Disruption and Resettlement of Communities

The splitting of the community can be minimised by taking into account local movements at the road design stage and by making provision for improved crossings or alternative access routes. This can be achieved through the use of signals, intersections, pedestrian and bicycle underpasses and overpasses, service roads and alternative arrangement for local traffic circulation.

Resettlement and compensation may need to be considered for houses, land, welfare or livelihoods directly affected by road projects. Compensation may be provided through the restructuring of property layout and access arrangements disturbed by road construction. In addition, compensation can be provided through small landscaping and roadside improvement measures which take advantage of changes in road layout and operation to provide alternative spaces and facilities (roads, roadside market and bus parks) for community's social life [22].

9.4 Consultation and Compensation Processes

Consultation with affected people and other interested parties can assist planners in mitigating the impacts of land acquisition and resettlement actions by providing clear and timely information as well as opportunities for a complete discussion of options, preferences, and likely outcomes. Thus, by taking full account of the needs of those affected the design of implementation arrangements should be based on more solid information. In the event that displacement is necessary, or that disruptions to livelihoods will occur, a comprehensive assistance strategy is required. This should go beyond financial compensation to include social and commercial rehabilitation or replacement [(22)].

9.4.1 Resettlement Plan

Resettlement planning is a complex process and involves various disciplines. Its key elements include location, housing, infrastructure, institution building, social and economic development services and participation. A typical Resettlement Plan includes the following items listed in

Table 9.1 [(4)]

Table 9.1: Resettlement and Rehabilitation Plan[(4)]

Resettlement and Rehabilitation Plan Action Check List
▪ Objectives and Principles
▪ Project Description
▪ Project Benefits
▪ Project Impacts and Losses
▪ Linkages with Existing Laws and Guidelines
▪ Entitlement Framework
▪ Replacement Costs for Losses
▪ Income Restoration
▪ Choices and Options
▪ Consultation and Participation
▪ Targeting the Vulnerable Groups
▪ Resolution for Grievances
▪ Development of Proposals for Resettlement Sites
▪ Integration with Host Communities
▪ Institutional Arrangements

Resettlement and Rehabilitation Plan Action Check List

- Guidelines for Implementation
- Implementation Time Table and Budget

10 Environmental Specialist Area: Noise and Air Quality

10.1 Noise Impact Prevention

- Moving the road alignment or diverting traffic away from noise-sensitive areas using bypass roads can avoid noise problems.
- Choosing alignments, which minimize steep slopes and sharp corners, especially at sensitive locations, can also prevent noise problems.

10.2 Noise Pollution Management and Mitigation

All noise nuisances should be reduced wherever possible from vehicles, fixed machinery within the site, blasting, general construction activities, and from movements of vehicles servicing the site. The noise mitigation measures include the following (28):

- Fit and maintain appropriate mufflers on earth-moving and other vehicles on the site;
- Enclose noisy equipment;
- Provide noise attenuation screens, where appropriate;
- Where an activity is likely to cause a noise nuisance to nearby residents, restrict operating hours to between 7 am and 5 pm weekdays and 7 am to 1 pm on Saturday, except where, for practical reasons, the activity is unavoidable;
- Noise should not be above background levels inside any adjacent residence between 10 pm and 7 am. Advise local residents when unavoidable out-of-hours' work will occur;
- Schedule deliveries to the site so that disruption to local amenity and traffic are minimised; and
- Conduct a study on the impact of ground vibration from construction activities, where these operations occur within 50 metres of a building and take appropriate action. Minimise air vibrations.
- **Surface design and maintenance:** the application of a bituminous surface layer over worn concrete roadways is effective in reducing frictional noise. The use of open-graded asphalt and the avoidance of surface dressings may also be effective in reducing frictional noise in sensitive areas. Some jurisdictions are experimenting with asphalt made using discarded tires, which appears to reduce frictional noise as well. Generally, smooth, well-maintained surfaces such as freshly laid asphalt without grooves and cracks will keep noise to a minimum.

- **Road geometry:** Road design where possible should avoid steep grades and sharp corners to reduce noise resulting from acceleration, braking, gear changes, and the use of engine brakes by heavy trucks at critical locations.
- **Working hours:** the construction activities need to be conducted ideally between 07H00 and 17H00 to minimise nuisance in the neighbouring communities.

10.3 Air Quality Impact Prevention, Management and Mitigation.

Many of the measures taken to reduce dust problems are outlined below [28].

- Prevent the generation of dust in preference to applying dust suppression measures;
- Ensure in the project schedule, that the area of cleared land is minimised during the drier months of the year, when dust generation is at its greatest;
- Pave and water haul roads;
- The frequency of watering will be determined by weather conditions and the erodeability of the soil. If additives in the water are used to increase its dust suppression properties, the chemical should have no adverse environmental impact on adjacent water bodies;
- Construction vehicles should be serviced regularly and off site to prevent offensive gasses in the environment;
- Ensure that smooth surfaces are deep ripped and left rough and cloddy to reduce the wind velocity at the soil surface; a
- Construct wind fences if this is appropriate for the site.

11 Environmental Specialist Area: Construction Site Management

11.1 Site Establishment

The Contractor should establish his construction camps, offices, workshops and any other infrastructure as per the agreed site layout plan in a manner that does not adversely affect the environment (e.g. the camp should be located 100m away from any water resources to prevent the discharge of hazardous substances). The Contractor should submit to the Project Engineer for his approval, plans of the exact location, extent and construction details of these facilities and the impact mitigation measures the Contractor proposes to put in place. Site establishment shall take place in an orderly manner and all required amenities shall be installed at camp sites before the main workforce moves onto site.

11.2 Water, Wastewater, Energy and Waste Management

The Contractor shall arrange with the local service providers for the provision of portable water and power on site. Safe drinking water for human consumption shall be available at the site offices and at other convenient locations on site. All effluent water from the camp / office sites shall be disposed of in a properly designed and constructed system, situated so as not to adversely affect water sources (streams, rivers, pans dams etc.). The Contractor shall ensure that energy sources are available at all times for construction and supervision personnel for heating and cooking purposes. The Contractor shall supply waste collection bins where such is not available and all solid waste collected shall be disposed of at a registered landfill site. A certificate of disposal shall be obtained by the Contractor from the waste management service provider [27].

11.3 Site and Worker Health and Safety

- The site shall remain barricaded all the time with construction barricading tape and other construction fences;
- Potentially hazardous areas such as trenches are to be demarcated and clearly marked;
- Adequate warning signs of hazardous working areas shall be erected in suitable locations;
- Uncovered manholes and excavations shall be clearly demarcated;
- Emergency numbers for the local police and fire department shall be placed in a prominent area;

- Fire fighting equipment shall be placed in prominent positions across the site where it is easily accessible. This includes fire extinguishers, a fire blanket as well as a water tank;
- All flammable substances shall be stored in dry areas which do not pose an ignition risk to the said substances;
- Smoking may only be conducted in demarcated areas as agreed upon by the Contractor;
- A minimum speed limit of 40km/h shall be adhered to by all vehicles and machinery on site;
- Personal Protective Equipment (PPE) shall be made available to all workers and the wearing and use of PPE (safety boots, overalls, reflective vests, hardhats, gloves) shall be compulsory;
- Workers operating high level noise machinery and activities which generate high levels of dust need to be provided with earplugs and dust masks;
- No person is to enter the construction site without the necessary PPE;
- Health and Safety Officers must be appointed by the Contractor;
- Health and Safety Officers need to train the construction workers about health and safety issues on site such as the dangers of the equipment they will be using and diseases which can be easily contracted and spread among workers (e.g. measles and HIV Aids);
- A record of drugs administered on site needs to be kept. The record will assist the Contractor should there be claims lodged by workers; and
- The Contractor with the Ministry of Health/Local Health Authorities should arrange a mobile clinic at the construction site and the first aid kit should be easily accessible to construction workers.

11.3.1 Social Issues

- The Contractor and its workforce needs to be courteous at all times when they are in contact with the public;
- A food catering company should be arranged by the Contractor to supply food for workers for the duration of construction activities; and
- Eating areas need to be kept clean to ensure highest standards of hygiene.

11.4 Environmental Training

Periodic Environmental Training (PET) and continuous awareness programmes for the engineers will go a long way towards sustainable road projects in Nigeria. The Ministry of the

Environment will be willing to interact technically with their counterparts in the Ministry of Works for sustainable road projects.

- The appointed Contractor must ensure that all site personnel have a basic level of environmental awareness training. Topics covered should include:
  - The definition of term Environment;
  - Why the environment needs to be protected and conserved;
  - How construction activities can impact on the environment;
  - What can be done to mitigate against such impacts;
  - Awareness of emergency and spills response provisions;
  - Social responsibility during the construction of the road;
- Environmental Training should be provided to the staff members through toolbox talks. These should be relevant to a specific day's work or activity;
- Staff operating equipment (such as excavators, loaders, etc.) shall be adequately trained and sensitised to any potential hazards associated with their tasks. Proof of training to be kept on file; and
- The Contractor must be conversant with all legislation pertaining to the environment applicable to a road contract and must be appropriately trained in environmental management and must possess the skills necessary to impart environmental management skills to all personnel involved in the contract.

11.5 Environmental Monitoring and Compliance

A monitoring programme should be in place to monitor construction activities, environmental issues and the implementation of environmental mitigation measures. The appointed ECO shall monitor the construction activities and provide corrective actions to the Contractor where there are non-compliances on site for the duration of the construction and post construction activities. The monitoring programme should include:

- Weekly/Monthly site audits conducted by the ECO for the duration of the construction phase;
- Compilation of a weekly and monthly audit report which shall document findings and recommend corrective actions to be taken. Subsequent reports shall provide feedback on whether previous non-conformances raised have been resolved thereby ensuring continual improvement in the site's environmental performance.

12 Environmental Specialist Area: Road Maintenance

12.1 Protection of Physical Environment

Protection of the physical environment can be assisted by regular drain clearing, up keep of vegetation on slopes and exposed surface maintenance of flow speed reduction devices in drains, removal of waste material arising from road repair works, avoiding the use of herbicides and other toxic or polluting substances [(22).]

12.2 Protection of Social Environment

The impacts of the community and social environment can be mitigated through a well-designed traffic management plan; undertaking operational activities during daily periods of high ambient noise, focusing on the improvements of road signs and other features which contribute to safety and accessibility [(22).]

12.3 Road Resurfacing and Patching

Patching is undertaken to repair potholes, depressions, bumps and distorted surfaces on highways and several impacts can result from maintenance activities and below are the recommendations to mitigate the impacts [(27)]:

- The maintenance personnel are to minimise the volume of waste materials generation and arrange that service providers collect waste for proper disposal;
- The asphalt emulsion pumps, shovels and rakes, which require cleaning with diesel and other fuels, are to be cleaned at a maintenance depot. All used fuels shall be collected in a closed container and recycled or disposed of appropriately at a registered facility;
- Drum containers, which were used to carry fuels, should be disposed appropriately in an approved landfill site.

12.4 Vegetation Management

- All vegetative growth shall be controlled through manual and mechanical means. Herbicides shall not be permitted unless unavoidable.
- Within the 30m of a watercourse, mowing and brush-cutting shall not be conducted without a watercourse alteration permit;

- Burning shall be permitted only in rural areas where it does not create a nuisance, health hazard and does not restrict traffic vision [27].

12.5 Stormwater Drainage Management

Ditching is undertaken to effect drainage of the roadbed and correct deficiencies such as erosion, non-conformity in grade, line or cross section of ditch, water ponding on roadway and restrictive vegetation growth that impedes drainage of the road bed. To mitigate against the environmental impacts which will result from conducting this activity, the following mitigation measures are recommended and they include [27]:

- The Contractor shall obtain a Watercourse Alteration Permit in order to conduct maintenance activities in watercourses. A copy of the permit shall be kept on site and the Contractor should familiarise himself with the conditions stipulated in the permit;
- Where possible, a buffer zone of 30m shall be kept between the end of the ditching and all watercourses. Additional erosion control structures should be installed up the ditch as required;
- Side slopes should be as flat as possible within the limit of the terrain;
- Natural drainage should be maintained where practical;
- Ditches should be directed into surrounding vegetation where possible rather than emptying to nearby watercourses;
- Sediment deposited in the ditch should be removed when it reduces the capacity of the channel. Removed material should be disposed 30 m away from a watercourse.

12.6 Waste/ Litter Management

- The Contractor and its workers should ensure that all litter is disposed of in a responsible manner, and is not released into the environment;
- Maintain a high quality of housekeeping and ensure that materials are not left where they can be washed or blown away to become litter;
- Provide sufficient waste bins on site for construction workers and staff at locations where they consume food. The refuse bins must be of different types for waste disposal and recycling purposes;
- Conduct on-going awareness with staff of the need to avoid littering;
- Refuse bins shall be placed at strategic positions to ensure that litter does not accumulate on site; and
- All waste shall be removed from the site and transported to a landfill site approved by authorities.

13 Potential Gaps

In compiling the first edition of the Manual, attention has been focused on typical environmental aspects associated with road projects. However, input and comments from users especially on local environmental matters and content would assist in making future editions of the Manual both more user friendly and pertinent to local environmental practitioners and road design engineers.

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Appendix A

Threatened Flora and Fauna Species

FAMILY	NO OF ENDANGERED PLANT SPECIES
Acanthaceae	26
Adiantaceae	5
Agavaceae	2
Amarantaceae	1
Anacardiaceae	7
Annonaceae	15
Apocynaceae	19
Araceae	3
Araliaceae	1
Aristolochiaceae	3
Asclepiadaceae	2
Aspidiaceae	7
Aspleniaceae	6
Atwyriaceae	2
Balsaminaceae	1
Begoniaceae	2
Boraginaceae	4
Burseraceae	1
Butomaceae	11
Caesalpiniaceae	13
Capparidaceae	2
Caryophycaceae	2
Celastraceae	6
Combretaceae	9

FAMILY	NO OF ENDANGERED PLANT SPECIES
Commelinaceae	3
Compositae	36
Connaraceae	6
Convolvulaceae	3
Crucifereae	1
Cucurbitaceae	6
Cyaheaceae	1
Cyperaceae	21
Dennstaediaceae	1
Dichapetalaceae	11
Ebenaceae	7
Ericaceae	2
Eriocaulaceae	3
Euphorbiaceae	31
Flacourtiaceae	7
Gentianaceae	2
Geraniaceae	1
Gnetaceae	1
Goodeniaceae	1
Gramineae	19
Guttiferae	4
Hypmenophylaceae	4
Hypericaceae	3
Iccinaceae	2
Guttiferae	4

FAMILY	NO OF ENDANGERED PLANT SPECIES
Iridaceae	1
Labiatae	6
Lauraceae	2
Lecythidaceae	2
Lemnaceae	1
Lentibulariaceae	1
Liliaceae	2
Lobeliaceae	3
Loganiaceae	4
Lomariopsidaceae	2
Loranthaceae	1
Lycopodiaceae	1
Malvaceae	1
Marantaceae	1
Melastomataceae	10
Menispermaceae	2
Mimosaceae	3
Monimiaceae	2
Moraceae	9
Myristicaceae	2
Mrytaceae	1
Najadaceae	1
Ochnaceae	1
Obtoknemataceae	1
Olacaceae	1

FAMILY	NO OF ENDANGERED PLANT SPECIES
Oleaceae	1
Onagraceae	1
Opiliaceae	1
Orchidaceae	23
Orobanchaceae	1
Oxalidaceae	2
Papilionaceae	8
Pedaliaceae	1
Pittosporaceae	2
Plantaginaceae	1
Podostemaceae	2
Protaceae	1
Ranunculaceae	2
Rosaceae	3
Rubiaceae	16
Rutaceae	3
Salvadoraceae	1
Santalaceae	1
Sapindaceae	8
Sapotaceae	2
Scrophulariaceae	2
Scytopetalaceae	1
Selaginellaceae	1
Simargoubaceae	2
Solanaceae	1

FAMILY	NO OF ENDANGERED PLANT SPECIES
Sterculiaceae	4
Thelypteriodaceae	2
Thymelaeaceae	3
Tiliaceae	2
Ulmaceae	1
Umbelliferae	3
Urticaceae	2
Verbenaceae	2
Violaceae	2
Vittariaceae	2
Vochysiaceae	1
Xyridaceae	1
Zingiberaceae	2

THREATENED MAMMAL SPECIES	
ENDANGERED	
Species Name	Scientific Name
Chimpanzee	*Pan troglodytes*).
Crested Genet	(*Genetta cristata*).
Dama Gazelle	Gazella dama
Drill	*Mandrillus leucophaeus*).
Giant African Water Shrew	(*Potamogale velox*).
Western Gorilla	(*Gorilla gorilla*).
Hartweg's Soft-furred Mouse	*Praomys hartwigi*).
Preuss's Monkey	(*Cercopithecus preussi*).
Red-bellied Monkey	(*Cercopithecus erythrogaster*
Savanna Swamp Shrew	(*Crocidura longipes*). Endemic to Nigeria
Sclater's Guenon	(*Cercopithecus sclateri*). Endemi to Nigeria
Western Vlei Rat	(*Otomys occidentalis*).
Wild Dog	*Lycaon pictus*).
Vulnerable	
African Elephant	(*Loxodonta africana*)
African Pygmy Squirrel	*Myosciurus pumilio*).
Buettikofer's Epauletted Fruit Bat	*Epomops buettikoferi*
Cheetah	*Acinonyx jubatus*).
Dorcas Gazelle	(*Gazella dorcas*
Fox's Shrew	(*Crocidura foxi*)

Jackson's Fat Mouse	(*Steatomys jacksoni*).
Lagos Serotine (Bat	*Eptesicus platyops*
Lion	(*Panthera leo*).
Morris's Bat	(*Myotis morrisi*).
Pygmy Hippopotamus	(*Hexaprotodon liberiensis*)
Red-eared Guenon	(*Cercopithecus erythrotis*).
Red-fronted Gazelle	(*Gazella rufifrons*).
Spotted-necked Otter	*Lutra maculicollis*
West African Manatee	(*Trichechus senegalensis*

Appendix B

Waste Management Plan Report Form

Waste Management Plan Report Form

General Contractor:	
Project Name:	
Site Waste Coordinators:	
Phone:	
Waste Collection Agency:	
Date and Proof of Disposal, Recycling and Salvage Certificate	
Steps to inform contractors of Waste Management Plan Policies (Example)	
1. Waste prevention and recycling activities will be discussed at the beginning of each safety meeting.	
2. All waste containers will be clearly labelled.	

Construction Material Expected To Be Generated

Waste material type	**Quantity (units)**	**Haulage method**	**Disposed at municipal landfill**	**Diverted from landfill by recycling, salvage or reuse**		
				Reused	**Recycled**	**Salvage**
Total In Weight						

APPENDIX C

MONITORING PLAN

Monitoring & Auditing Plan

Project Name:	
Auditor/ECO Name:	
Contact Details:	
Contractor Name:	
Contact Details:	

Monitoring Objectives,

Potential Environmental Impacts Envisaged To Occur And Remedial Measures

The following table lists impacts expected to result from the project during construction and post construction activities.

CONSTRUCTION PHASE		
POTENTIAL ENVIRONMENTAL IMPACT	**REMEDIAL MEASURES**	**FREQUENCY OF MONITORING**

POST CONSTRUCTION PHASE		
POTENTIAL ENVIRONMENTAL IMPACT	**REMEDIAL MEASURES**	**FREQUENCY OF MINITORING**