ENVIRONMENTAL IMPACT ASSESSMENT FOR THE
ACQUISITION OF 2000 KM OF 2D LAND SEISMIC IN
NORTHERN SENEGAL

FOR THE
WORLD BANK / PETROSEN

FEBRUARY 2001

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EXECUTIVE SUMMARY

Introduction
As part of a national policy of promoting the potential for hydrocarbon development of the sedimentary basins within the Republic of Senegal, Petrosen, which is the responsible organisation, has negotiated part financing from the World Bank for the acquisition of a new land seismic survey. This seismic survey extends over the northern part of Senegal, from the Gambian border to the Senegal River at the Mauritania border. It will consist of approximately 2000 line km of 2D seismic recording. The acquisition is expected to start early in the year 2001 and to continue for 8-12 months.

In order to mitigate any environmental disturbance from the planned operation an environmental impact assessment (EIA) is required by the World Bank. Environmental and social aspects which may be affected shall be identified, and mitigation and remedial measures shall be recommended.

Seismic Acquisition Method and Activities
The seismic acquisition will employ a mechanical vibrating tool (Vibroseis) mounted on heavy, 15 tonnes, vehicles. Access to acquisition lines will be required by a number of vehicles and associated personnel, and for alignment of geophones and cables. The seismic survey team will consist of 60-80 people. In addition to the Vibroseis vehicles, 15-20 cars and trucks for transport of personnel and equipment will be required. The right-of-way (3-4 m) and access roads will be cleared by hand. Inspections of the planned seismic lines concluded that it is possible to clear the lines without using bulldozers and caterpillars. Seismic shot points will be established every 60-120 m along the seismic lines. The Vibroseis vehicles are equipped with geographical positioning systems (GPS), and minor deviations from the seismic line do not constitute a technical problem. A minimum of three camp sites will be established during the seismic survey, which is expected to take 8-12 months to complete.

Baseline data
The EIA includes a description of the physical, socio-cultural and eco-geographical environment, as well as the protected and sensitive areas in the seismic acquisition area. The description is based on written material, information obtained through a number of consultation meetings and a field survey carried out in Senegal.

The climate is dominated by the dry and the rainy seasons. The rainy season lasts from July-September in the northern part of the area, and from June-October in the southern parts. The topography of the area is largely flat, though fixed dunes occur in the northern parts. The soils are sandy and rich in iron. Saline flats occur in the Senegal River delta.

The southern part of the seismic acquisition area is intensively cultivated. Main crops are millet and groundnuts. Irrigated rice and sugar plantations are established on suitable soils in the Senegal River delta. The northern part of the area, with poor soils and low annual precipitation, is mainly unsuitable for agriculture, and vast areas are used for pasture for livestock during the rainy season.

The population in the seismic acquisition area is dominated by four larger groups; the Wolof, the Tukolor, the Peul and the Serer. The Peul people are traditionally semi-nomadic cattle herders. The remaining groups are traditionally traders and farmers.

Rapid increase of the population over the last 30 years has caused an increased pressure on agricultural land, and the agricultural zones have expanded to areas allocated for grazing and forest protection.
The vegetation in the area is mainly tree and bush savannah. The impact of desertification is most severe in large areas of the seismic acquisition area. The Senegalese Government has implemented extensive programs to plant and conserve trees in order to protect the dry sandy soils in agricultural areas.

A number of protected areas are located within the seismic acquisition area. These include Djoudj National Bird Sanctuary, Saloum Biosphere Reserve, Ndïët and Bao Bolon Special Wildlife Reserves, three classified pasture reserves (sylvo-pastoral reserves) and seven classified forests. Several tree species occurring in the seismic acquisition area are completely or partly protected.

The general hunting season is from September-December. Three important hunting areas are located within the seismic acquisition area, but hunting is generally performed everywhere in the area.

Historical sites located in the seismic acquisition area includes battlefields and grave mounds.

Malaria is widespread in the seismic acquisition area. The HIV-virus (aids) is widespread on the African continent, although the infection frequency in Senegal is less than in other West-African countries.

Environmental Impact Assessment and Proposed Mitigation Measures

Agricultural land
Seismic operations conducted during the main growing season of July-October would result in crop losses in areas of intensive agriculture. Extensive areas might be affected. Soil compaction from vehicle operations, which can inhibit crop growth, is most likely to occur during the wet season in moist areas.

The seismic survey should be conducted during the dry season in the intensively cultivated southern parts of the influence area to prevent damage on crops, and to reduce compensation payments and soil compaction. Cutting of trees shall be avoided, fences and other structures restored. Seismic operations in irrigated areas should only be performed on existing roads. Mechanisms to measure damage, assess compensation and distribute payments related to landowner/land user are established by The Ministry of Agriculture and will be implemented in the project. It is further important to consult and inform landowners and their organizations well in advance of the project.

Vegetation
Due to the impact of desertification large areas of the seismic acquisition area are exposed to wind and water erosion. The seismic survey should be acquired in such a manner that necessary measures are taken to protect the vegetation as far as possible. Cutting of trees should be avoided as far as possible, and the activity should take place in the dry season in order to avoid unnecessary removal of vegetation and topsoil layer, thus preventing wind and water erosion of the soils. The disposal of trees and bushes that are unavoidably cut should be carried out with the advice of local authorities.

Gallery forests, occurring along rivers and waterways in the southern part of the area, provide shelter for wildlife and are of importance for biodiversity. Seismic operations in these areas should be avoided.

Protected areas
General for protected areas and species: No seismic operations can take place in national parks, nature reserves, classified forests or sylvo-pastoral reserves without a permit from the authorities. No completely or partly protected tree species can be cut without permission.
Any activities in classified forests should be undertaken in co-operation with governmental and local officials. Any restoration measures shall be undertaken with direction from these officials.

The national parks and nature reserves located in the seismic acquisition area are of special importance for migratory and breeding birds. The most sensitive period is from September-December, but large numbers of migratory birds can be found in the reserves to March/April.

In order to avoid disturbances on the bird life the proposed seismic line in Djoudj National Bird Sanctuary is proposed to be moved to a location outside the park and the buffer zone. Operations should be performed in April-June.

It is further recommended that the proposed seismic lines that would cross Ndiâel Special Wildlife Reserve are terminated at the reserve’s boundaries.

Three of the proposed seismic lines will affect the outer zones of the Saloum Biosphere Reserve. It is recommended to move two of the lines to the north to prevent interference with the biosphere reserve. The third line should be terminated at the reserve boundary. No seismic operations should be carried out from June-December to avoid conflicts with hunting and agriculture.

Bao Bolon Special Wildlife Reserve is an important location for migratory birds. Open water may occur also in the dry season. Hunting is allowed in September-December. No seismic operations should be carried out in the reserve, and the seismic line should be terminated at the reserve boundary. No seismic activities should be carried out in the area from June-December to avoid conflicts with hunting.

The classified forests and sylvo-pastoral reserves in most of the area are sparsely vegetated, and severe negative impact can be prevented, provided that cutting of trees and removal of the topsoil layer is avoided. It is recommended to insert dog leg bends in the lines that affect Forêt de Boulierobe, Forêt de Mahekor and Forêt de Malka in order pass outside the forests if cutting of trees should be unavoidable.

Dense Acacia stands are found in Forêt de Djilor, Forêt de Velor and Forêt de Keur Maktar in the southern part of the area. Alternative routing of the proposed seismic lines is recommended in these areas.

Summary of proposed mitigating measures in protected areas

<table>
<thead>
<tr>
<th>Area</th>
<th>Proposed mitigating measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>National parks and reserves</td>
<td>No seismic activity in national parks or wildlife reserves.</td>
</tr>
<tr>
<td>Djoudj National Bird Sanctuary</td>
<td>Move the line to a location outside the park and the buffer zone. Work to be performed in April-June.</td>
</tr>
<tr>
<td>Ndiâel Special Wildlife Reserve</td>
<td>Terminate all lines at the reserve’s boundaries.</td>
</tr>
<tr>
<td>Saloum Biosphere Reserve</td>
<td>Move two of the lines to areas outside the reserve’s boundaries. Terminate one of the lines at the boundary. No seismic activities in June-December.</td>
</tr>
<tr>
<td>Bao Bolon Special Wildlife Reserve</td>
<td>Terminate the line at the reserve boundary. No seismic activity in June-December.</td>
</tr>
</tbody>
</table>
Cont.

<table>
<thead>
<tr>
<th>Area</th>
<th>Proposed mitigating measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Classified forests</strong></td>
<td>It is allowed to keep grazing livestock in classified forests. Land users should be consulted and informed well in advance of any seismic activity.</td>
</tr>
<tr>
<td>Foret de Boulierobe</td>
<td>Move the line to the south of the area by inserting dog leg bends if cutting of trees is unavoidable.</td>
</tr>
<tr>
<td>Foret de Malka</td>
<td>Move the line to the south of the area by inserting dog leg bends if cutting of trees is unavoidable.</td>
</tr>
<tr>
<td>Foret de Mehekor</td>
<td>Move the line to the west of the area by inserting dog leg bends if cutting of trees is unavoidable.</td>
</tr>
<tr>
<td>Foret de Birikelane</td>
<td>Move the line to the south of the area by inserting dog leg bends if cutting of trees is unavoidable.</td>
</tr>
<tr>
<td>Foret de Keur Mactar</td>
<td>Move the line to the south of the area by inserting dog leg bends.</td>
</tr>
<tr>
<td>Foret de Velor</td>
<td>Use existing roads.</td>
</tr>
<tr>
<td>Foret de Djilor</td>
<td>Use existing roads.</td>
</tr>
<tr>
<td><strong>Sylvopastoral reserves</strong></td>
<td>The Sylvopastoral reserves in the influence area are very sparsely vegetated, and the seismic survey can be performed without removing trees. The work should be performed in the dry season in order to minimize the damage on the vegetation and to avoid interference with foraging livestock.</td>
</tr>
<tr>
<td>Mpal Merinaghene</td>
<td>Seismic activities should be performed in May-July. The land users should be consulted and informed well in advance.</td>
</tr>
<tr>
<td>Boulel</td>
<td>Seismic activities should be performed in August-October. The land users should be consulted and informed well in advance.</td>
</tr>
<tr>
<td>Deali</td>
<td>Seismic activities should be performed in August-October. The land users should be consulted and informed well in advance.</td>
</tr>
</tbody>
</table>

**Waterways and landscape**
Activities in streams and waterways can have an impact on water quality by adding sediment to the stream, and by physically altering stream banks. No seismic operations, apart from crossings, should be conducted closer than 45 m from the banks of any watercourse or lake.

Fixed dunes are characteristic landscape elements in parts of the northern area. Necessary considerations should be taken to avoid damage on the dunes due to driving.

**Historical sites**
Local authorities shall be consulted prior to any seismic activities in, or close to, historical sites.

**Camp sites**
Driving, fuel handling, production of effluent water and waste production at the camp site may have a negative impact on the environment. Environmental operational procedures should be implemented and reviewed in order to mitigate these effects.

**Conflict with other activities**
Due to the fact that no seismic activities are carried out at the same place for an extensive period of time conflicts with other activities such as hunting and construction work could be prevented through planning and co-operation with local officials.

**Noise and dust**
The seismic operations will create noise and dust, which may cause annoyance for the local population as well as for the wildlife. The effects will be of a temporary character, as the seismic survey team moves minimum 8 km per day.

EIA
Infrastucture
The vibrations generated by the seismic acquisition may cause damages to wells and structures with a concrete base. Suggested restrictions for seismic operations close to wells, buildings and pipelines are established in the environmental management plan.

General measures
The right-of way should be kept at a minimum and existing roads and tracks should be used as far as possible for access for service vehicles. Local officials shall be consulted prior to the final alignment of the seismic lines.

Malaria and HIV/aids
The seismic crew will work on the site for extended periods. This might lead to a risk for exposure to malaria and HIV/aids. Recommended measures to prevent transfer of infectious diseases should be considered by the seismic contractor.

Environmental Management Plan (EMP)
An EMP for the project is developed as a separate document (Ledje 1999). The purpose of the EMP is to ensure that mitigation measures have been efficient, to provide a base for implementation of additional measures where necessary, and to collect and systemise experience data for use in the planning of future seismic projects. The EMP is based on the findings in the EIA and focuses on three areas: mitigation measures, environmental monitoring and institutional strengthening and training. The EMP includes a summary of the environmental impacts as described in the EIA.

Environmental operating procedures should be developed and implemented for alignment and access, terrain stabilisation and erosion control, fuel storage and handling, camp site operation and restoration work. All procedures should be developed by the contractor and approved by the operator.

Conclusions
The environmental impact of the proposed seismic survey is site-specific and reversible, provided that the proposed mitigation measurements are followed. It is not expected that the operations will cause any long term or irreversible impacts.

The activities associated with the proposed seismic project can be conducted with minimal impact to the environment and the lives of local people and their communities. Potential environmental impacts can be successfully mitigated through the adoption of environmental operating standards based on the recommendations given in the environmental management plan.

Opportunities exist to temporarily enhance the lives of the local population through local project employment and upgrading of dirt roads at very low costs.
1 INTRODUCTION

As part of a national policy of promoting the hydrocarbon potential of the sedimentary basins within the Republic of Senegal, the state oil company Petrosen, which is the responsible organisation, has negotiated part financing from the World Bank for the acquisition of a new land seismic survey. The seismic acquisition is planned to cover an area extending from the Gambian border to the border of Mauritania. It will consist of approximately 2000 line km of 2D seismic data. The acquisition is expected to start early in year 2000 and to continue for 11-14 months.

The seismic acquisition will employ a mechanical wave generating (Vibroseis) energy source which, although benign in its environmental impact, will require access to the line of acquisition by a number of heavy vehicles and associated personnel. In order to mitigate any environmental disturbance from the planned operation an environmental impact assessment (EIA) is required by the World Bank. The EIA identifies environmental and social aspects that may be affected. Mitigation and remedial measures to reduce the impacts are suggested.

2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

The following section describes the policy, legal and administrative framework which has governed the conduct of this environmental impact assessment.

2.1 World Bank’s Operational Policy

The World Bank requires environmental assessment of proposed projects for Bank financing to help ensure that they are environmentally sound and sustainable, and thus to improve decision making.

The Bank undertakes environmental screening of each project proposed for Bank financing to determine the appropriate extent and type of EIA. The proposed seismic acquisition has been assigned to Category B; the negative impact is supposed to be site-specific, reversible and/or mitigatory measurements are expected to be designed in an effective way. (Category A projects are likely to have significant adverse environmental impact. The impacts for Category B projects are expected to be less adverse).

The borrower is responsible for carrying out the EIA.

2.2 Senegal Legal and Administrative Framework

This section provides a brief description of relevant regulations and standards governing protection of sensitive areas and endangered species, land use control, environmental impact assessments and environmental aspects related to petroleum exploration activities.
2.2.1 International Legislation

Senegal has ratified the following international conventions concerning nature protection and management (Ministry of Environment, 1997):

- The African convention regarding the protection of nature and natural resources (Alger), ratified in 1972
- Protection of wetlands (Ramsar), ratified in 1977
- Protection of cultural and natural world heritage (Paris), ratified in 1975
- Protection of migratory species (Bonn), ratified in 1983
- Protection of species and habitats (Bern), ratified in 1987
- Convention on international trade in endangered species (Washington), ratified in 1977
- The conventions regarding sustainable development, climate changes, protection of the biodiversity, and the fight against desertification (Rio)

The area where the proposed seismic acquisition will be performed includes several sites that are protected under the Ramsar and Paris conventions, as well as important habitats for endangered native and migratory species.

2.2.2 National Legislation

The following law govern nature management in Senegal:

- The Environmental Law, with the Environmental Code (1983).

The law is currently being revised. It is assumed that the new law will enter into force in December 1999. The environmental law embraces national legislation concerning nature management and protection, soil, water and air pollution, noise, handling of hazardous substances and chemicals, waste management, and requirements and procedures related to environmental impact assessments.

Additional regional legislation applicable for nature management comprises:

- The Vegetation (flora) Law, with the Forest Code (1993)
- The Wildlife Law, with the Hunting Code (1986)

In addition, the Petroleum Code (1998) covers environmental aspects of petroleum exploration and production, related activity, and the "Loi Domanial", the Land Expropriation Law, regulates compensation issues for land expropriation and temporary land use.

Furthermore, a law aiming at achieving a higher degree of decentralisation and facilitation of transfer of nature management competence to the regional and communal levels, was implemented in 1996. This is of relevance for the seismic acquisition project, as co-operation with central, regional and local authorities, both at the planning and operational phases of the project, is important for the project execution.

2.2.2.1 The Environmental Code

Requirements for environmental impact assessments are described in Senegal's pending Environmental Code. This document will replace the Environmental Code from 1983.
The Environmental Code distinguish between three categories of projects:

- Projects that are likely to have significant adverse environmental impact. An extensive environmental assessment is required.
- Projects that have limited, site-specific or reversible environmental impact. These projects require an initial environmental impact assessment
- Projects that are not supposed to have a negative environmental impact. No impact assessment is required.

The type of projects that are potential subjects for an EIA are specified in the law.

The following phases are involved in the development of an EIA:

Phase 1. Announcement of the project
   Preparation and publication of a short document describing the project by the project owner.

Phase 2. First screening
   Classification of the project into one of the above three categories by the Ministry concerned. If the project is regarded unacceptable from an environmental point of view, it may be rejected at this stage.

Phase 3. Terms of reference
   Definition of the content of the EIA by a technical committee, appointed by the Ministry of Environment, in co-operation with the affected and involved parties.

The project owner is responsible for producing the EIA when the terms of reference are given. After completion, the EIA shall be sent to the technical committee for approval. Before the project is approved, it will be subject to internal and external evaluation. The internal evaluation will be done by the Directorate for Environment, the external by the public.

The public is to be involved in all phases of the EIA.

2.2.2.2 The Forest Code

Regulations regarding the management of protected areas and plant species are given in the Forest Code of 1998. The Code also gives a description of the responsible authorities and their field of responsibility.

The Directorate for National Parks and the Directorate for Water and Forest are responsible for the management of protected areas and species.

Protected areas
There are five major types of protected areas in Senegal:
- national parks
- integrated nature reserves (fauna reserves)
- special reserves
- forest reserves (classified forests)
- "reserve sylvo-pastoral", hereafter called sylvo-pastoral reserves
The management of national parks and integrated nature reserves is usually carried out in accordance to specific management plans for each area. Hunting, fishing, agricultural activities such as grazing or cultivation, or other exploratory activities are not allowed in nature reserves. Normally does the same restrictions apply to the national parks, but some adaptations might be made based on the specific conservational values in each area. National parks shall be open to the public for educational and recreational purposes.

Special reserves are areas that are protected for ecological or scientific reasons or because of values for tourism and recreation. These reserves can have temporary or permanent restrictions regarding hunting, fishing and agricultural activities.

Classified forests are divided in two groups: forest reserves and sylvo-pastoral reserves. The protection of the forest reserves is the stronger. Generally it is allowed to keep grazing cattle in the forests, but no other agricultural activities or cutting of live trees is allowed. The resources are managed based on a management plan specific for each forest reserve. Such a plan will include information on how much wood that can be taken out, and during what time period. For classified forests of regional and local interest the management responsibilities are delegated to local authorities at different levels. Permission must be sought for any extraordinary activities in classified forests.

The sylvo-pastoral reserves are set aside as grazing reserves, mainly for semi-nomadic cattle-herders. Grazing cattle and cultivation of millet for own consumption is allowed. Production of groundnuts is not allowed. Family camps are allowed.

Due to the severe desertification problems in Senegal, sustainable management of the classified forests is a highly focused issue in the country's environmental action plan.

Protected Species
The Forest Code includes a list of protected trees in Senegal. Apart from these species there are no other plants protected in Senegal.

2.2.2.3 The Hunting Code
The Law for Protection of Wildlife, with the Hunting Code, includes lists of protected animal species.

2.2.2.4 The Petroleum Code
The Petroleum Law, with the Petroleum Code, provides restrictions on exploration activities. The Code regulates activity in the vicinity of buildings or sites used for religious or cultural purposes, residences and infrastructure such as roads, railroads and pipelines and reservoirs as well as in land which is classified as a national forest (nature reserves, national park and hunting area).

2.2.3 Governmental organizations

2.2.3.1 National Level
The Ministry of Environment is divided into three technical directorates: the Directorate for Environment, the Directorate for Water and Forests and the Directorate for National Parks.

The Directorate for Environment is mainly responsible for issues related to pollution, noise and coastal management.
The Directorate for Water and Forest is responsible for the management of classified areas (reserves and forests), freshwater resources, soil conservation and endangered species/biodiversity.

The Directorate for National Parks is responsible for the management of Senegal’s six national parks. The Directorate is also responsible for the biosphere reserve(s).

2.2.3.2 Regional Level

Figure 2.1 gives a simplified overview of how the regional governmental units in Senegal are organised.

![Regional Governmental Structure in Senegal](image)

Figure 2.1. Regional governmental structure in Senegal

A directorate might have representatives at each level in the organisation. The Directorate for Water and Forest has an inspection department at level 1, a sector unit at level 2 and local agents at level 3 and sometimes also at level 4.

Section 3.3.3 describes how Petrosen will co-operate with the governmental levels during the project planning and execution.

2.2.3.3 Authorisations and permits

To obtain authorisation to perform any activities in classified areas (forests and reserves) a description of the planned activity must be sent to the Ministry of Environment, who will ensure that the right addressees are consulted.

It is also necessary to contact the Governor in regions that will be affected by the seismic survey. The Governor will facilitate the necessary contacts that have to be established in each region.

2.2.4 Other Organisations and Non Governmental Organisations (NGO's)

A number of different UN organisations including UNESCO, UNDP and IUCN are engaged in environmentally related projects in Senegal.
IUCN in Senegal are working with biodiversity, nature management, environmental training and local participation in environmental work. The organisation is involved in work related to the development and implementation of management plans for some of the national parks.

One of the most important NGO's is *L'Association de les Amis de la Nature*. This organisation has representatives in all regions in Senegal.
3. DESCRIPTION OF THE PROPOSED SEISMIC ACQUISITION PROJECT

3.1 Purpose of the seismic acquisition

Away from the vicinity of the Dakar Peninsular and the areas known as the Ties and Sebikhotane Blocks, onshore Senegal is very sparsely populated with seismic lines. Surveys have in the past been recorded by several companies in the northern part of Senegal (north of The Gambia). These data are confined to the most prospective zone, which lies within approximately 100 km of the coast (west of 16°E). Some 1500 line kilometres have been recorded in this area and this equates to about one line every 20 km. This density of seismic lines is termed “regional coverage”. Such coverage will provide indications of the stratigraphic morphology and structural style (of faulting) at best, and permit some educated guesses as to the hydrocarbon prospectivity, but is inadequate for any detailed reserve estimation or for siting wells and drilling activities.

The purpose of the current survey is twofold; 1) to provide more evenly distributed regional infill of existing lines and 2) to target several specific areas of geologic interest that have been observed on the existing data.

On the basis of the existing data it is not possible to measure, nor even estimate, the size and shape of the hydrocarbon traps. After processing and interpretation, the new seismic data will be used to confirm the existence of several hydrocarbon prospects, making Petrosen better able to attract international oil companies to invest and explore. It is not within Petrosens remit to carry the actual exploration operations further.

The survey will help interpreting and understanding several general questions on Senegalese geology, all of which are important to the evaluation of the potential for hydrocarbon generation and accumulation. This includes trapping mechanisms and ultimately, the production of hydrocarbons. For example, the regional extent, especially to the east, of the objective Palaeozoic strata, the identification of a number of important stratigraphic marker horizons and the understanding of the tectonics, the geologic evolution and the present structural configuration of the several sub basins within the area. The seismic study will assist in evaluating these factors and in predicting the distribution of possible hydrocarbons.

3.2 Location

Seismic data will be acquired over the northwestern part of Senegal, from the Gambia border to the Senegal River at the Mauritanian border. Figure 3.1 shows the location of the proposed seismic lines.

---

1 Shell, Elf, PetroCanada
3.3 Methods

3.3.1 The Vibroseis method

Acquisition of the seismic data will employ a vibrating energy source (Vibroseis) mounted on heavy, 15-20 tonnes, vehicles (see Fig. 3.2). A vibrator plate (maximum 1.2 m in diameter) is pressed firmly to the ground and a train of waves of progressively varying frequency is generated over a short period of time. The frequency generated by the vibrating plates varies between 10 and 70 Hz. Four vehicles will be used simultaneously during the acquisition (see Fig. 3.2 for normal disposition of the vehicles). The vehicles vibrate in phase and each vehicle vibrates for 12 seconds before moving to the next shot point along the seismic line. The shot points are located every 60-120 m. The vibrations generated do not reach far on the surface, and can normally not be registered by people standing 10-15 meters from the vehicles.
The vehicles will require a right of way of 3-4 meters. It is expected to acquire minimum 8 km seismic per day under normal conditions.

The Vibroseis method does not require any drilling operations or use of explosives.

![Seismic vehicle](image)

**Figure 3.2.** A seismic vibrating vehicle (photo), standard disposition of seismic vehicles during a land seismic survey (drawing).

### 3.3.2 Flexibility in line location

The optimum seismic line is straight and lies vertically above the subsurface feature that is to be sampled. However, although seismic lines are positioned with high accuracy (their location is normally known to within a few meters) the exact position normally has some flexibility before the purpose for which the line was designed is defeated. In the case of regional surveys, most lines are exploratory; they are designed to “see what is there” rather than to locate some particular feature. A rough rule of thumb for such exploratory lines is that they should be moved no more than 25% of their original separation distance.

Another factor is the angle and number of bends introduced into a line. Any bend introduces data positioning errors, reduces the effective subsurface sampling and increases the complexity and uncertainty in the interpretation process. The greater the bend, the greater are these negative effects and any bend should be kept below 20°.

### 3.3.3 Working activities and staffing

The following describes the main activities carried out in the field by the seismic contractor. Section 3.3.4 briefly describes Petrosen’s responsibilities before, during and after the seismic survey.

The seismic team for the planned acquisition will consist of 60-80 people divided into several smaller working groups/teams. It is assumed that 50-60% of the working crew will be local personnel, hired by the seismic contractor. It will take 8-12 months to complete the seismic acquisition. Normal working procedures are as follows:
Topographic/Survey Team
Initially, a Topographic Team consisting of 4-6 people in 2 cars, will establish the detailed acquisition routes adjusted for existing topography, vegetation and infrastructure. The work is completed 2-4 weeks ahead of the seismic recording.

Line Clearance Team
Following the Topographic Team the acquisition routes will be cleared by the Line Clearance Team to gain access for the vibrator vehicles. Minor adjustments on flat and sparsely vegetated land may be necessary by using a caterpillar to remove topsoil to create appropriate surfaces for the vibrating plates. In areas with dense forest or sand dunes the use of bulldozers may be necessary. The Line Clearance Team will consist of 2 people.

In this case the seismic lines have been surveyed in the field, and it has been concluded that the right-of-way can be cleared by hand. The lines intersect mainly flat and sparsely vegetated areas, thus there will be no need for using caterpillars or bulldozers.

The Recording team
The recording team consists of several working groups, in all about 30-35 people.

The Front Group aligns the cables and geophones along the lines in front of the seismic vehicles, and the Back Group removes them. In this case only one cable (consisting of 240 channels) will be used. Cables, geophones and other necessary equipment are provided by trucks that support the field teams continuously. The Front and the Back Group consists of 16-20 people. The trucks (2 of them) are managed by 4 people.

The Vibrator Group consists of 5 people working on the vibrator vehicles.

The whole seismic operation is co-ordinated by the team leader who is managing the Laboratory Group. This group, with 2 people, is responsible for the seismic recording. The recording equipment used in the field is placed in a field car that is connected to the cable in the right-of-way.

A small Mechanical and Maintenance Group, with 3 people, provides technical services to the Recording Team.

LVL Team
This is a small field laboratory that operates weight drop equipment for correlation of the shallow sections. They use two cars and engage 4-6 people.

Camp site Team
Most of the seismic team will reside in temporary camp sites. The camp will be located close to towns or villages. Acceptable driving time from the camp to the field site is approximately 1 hour. It is expected that three camp sites will be established during this survey. The camp will consist of either tents or trailers, and it is estimated that each camp will be used for approximately 3 months. The staff at the camp will consist of 15 people covering different functions such as drivers, mechanics, welders, cooks and housekeepers. 5-10 pick-up cars will be located at the camp for transportation of personnel back and forth to the site.

Fuel
It is estimated that the fuel consumption for all vehicles in operation will be about 500 litres per day. A tank car will be used in the field and supply the vehicles with fuel. Fuel tanks for diesel and petroleum will be located just outside the camp site. They will be designed to hold one week consumption (3 m³). Fuel will be bought locally, and transported to the camps on a weekly basis.
Required investments
All technological equipment will be shipped to Senegal tax free, and sent back when the project is finished. Services that will be bought locally are.

- fuel
- personnel (40-50 local persons will be engaged during the whole project period)
- services and consumables for the camp site

3.3.4 Petrosen’s responsibilities
Petrosen has the overall responsibility for the planned project execution. A representative from the organisation will be present at the working site at all times. Petrosen will be responsible for the following activities:

Planning and information, authority liaison
Petrosen will inform central and local authorities about the project plans. Applications for work in protected areas shall be sent to the Ministry of Environment with copies to the Ministry’s technical directorates.

Information meetings shall be arranged with the governors in the affected regions. The governors normally invite representatives for the concerned regional and local organisation to an introductory information meeting. Separate meetings for detailed planning of the project are to be held with the concerned regional and local authorities. Activities in classified areas shall be undertaken with approval of, and in co-operation with, governmental and local forestry officials.

Activities in agricultural areas shall be discussed with the concerned officials and representatives at regional and local level. Compensation issues shall be discussed and established well in advance of the operations. Land users shall be informed.

The Bureau d’Architecture des Monuments Historiques (BAMH) and the Ministry of Culture shall be contacted in order to localise the occurrence of ancient grave mounds, battlefields or other archaeological, cultural and historical site in the seismic lines. See also Appendix E.

Follow up function in the operation phase
Petrosen has the responsibility for following up and review the contractor’s health, safety and environmental (HSE) performance during the operational phase of the project. Petrosen is planning to engage an independent organisation or consultancy company to perform the field inspections. Operational procedures developed by the contractor shall be approved by Petrosen. An environmental management plan for the project is enclosed (see App. D).

Follow up of the environmental monitoring after project termination
An environmental monitoring plan for the project is developed (Ledje 1999). Petrosen will review the contractors work, probably be using an independent organisation or consultancy company, and participate in the monitoring surveys.
4. BASELINE DATA

This chapter provides a description of the relevant baseline data for the environmental impact assessment.

4.1 Influence area

The influence area is defined as the area that will be affected by the activities performed during the seismic acquisition. These activities include:

- clearing of the seismic acquisition lines
- seismic recordings
- transportation of personnel and equipment
- establishment of 3 camp sites

The influence area has been defined as a 12 m wide corridor along the seismic acquisition lines (see Fig. 3.1). The corridor includes the right-of-way (3-4 m) and a buffer strip of 4 meters on both sides of the line, to facilitate surveying and cable layout.

Traffic during the seismic operations will create noise. Due to the fact that the vehicles will move minimum 8 km per day, and that no work will be performed after dark, noise has not been used as a criteria for defining the influence area.

Traffic by supply vehicles will take place on existing roads and in the right-of-way. Existing roads will be used as far as possible.

The location and organisation of campsites for the seismic crew will be decided by the company responsible for the seismic survey. It is assumed that it will be necessary to establish 3 camp sites during the operational phase. The location of the camps has not been decided.

Measurements, routines and procedures to minimise the negative effect of supply traffic and from any temporary camp sites will be developed as a part of the Environmental Management Plan for the project.

The following baseline data describes the physical and eco-geographical environment, protected areas and species, socio-cultural conditions, infrastructure and historical sites in the seismic acquisition area, and is not restricted to the influence area (the seismic lines). The seismic acquisition area is outlined in Figure 4.2. The seismic acquisition lines are outlined in Figure 3.1.

4.2 Physical environment

4.2.1 Climate and meteorology

The climate in Senegal is dominated more by rainfall than by temperature. Generally the rainy season last from June to October, and the dry season is from November to May. The rainy season in the northern part of the seismic acquisition area is normally shorter, 2-3 months (July-August/September), than in the southern parts where it lasts for 4-5 months. The temperature in the rainy season is around or above 30°C, and somewhat cooler in the dry season (25-28°C).
Mean annual precipitation varies from 200-1000 mm, increasing towards the south.

Figure 4.1 shows the annual average rainfall in the period 1940-1994. There has been a general tendency towards reduced annual precipitation in most of the area during the last thirty years.

A dry trade wind, the Harmattan, fills the air with dust particles from the Sahara from December-February, and tends to colour the skies grey. The effects are most noticeable away from the coast (Else 1999).

4.2.2 Geology and topography

The topography in the area is largely flat, and the elevation in the influence area is mainly less than 50 meters.

The geology of the seismic acquisition area is uniform. The soils are dominated by sandy, brown and brown-red soils with a high content of iron. The soils change progressively from the north to the south as a function of the annual precipitation. Fixed dunes occur in the region of Cayor, Djolof and at the central Ferlo plateaux (Ministry of Environment 1998).

The soils in the Senegal River valley are dominated by hydro- and halomorphic fine sand and mud soils. Impermeable halomorphic soils form saline flats in the Senegal River delta.

A soil map is shown in Figure 4.2.
Figure 4.2. Soil map over Senegal. The seismic acquisition area is marked with white borders. The different soil types within this area are: Blue = hydromorphic soils, Yellow = red brown soils, Red = tropical ferruginous soils (Ministry of Environment 1998).

4.2.3 Rivers and waterways

Two of Senegal’s three major waterways, the Senegal River system (including Lac de Guiers and the Ferlo River valley) and the Saloum River system are located within the seismic acquisition area. A branch of the River Gambia, the Bao Bolon, is located in the southernmost part of the area.

During the dry season many branches of the main waterways are dry. Figure 4.3 shows the hydrology in the area.

Figure 4.3. Hydrological map. Dark blue lines= permanent water, light blue lines= temporary water (Ministry of Environment 1997).
4.3 Socio-cultural environment

4.3.1 Population

The population in Senegal consists of seven larger groups where the Wolof people is the dominant, occupying the central areas and the coast. Wolofs are traditionally traders and farmers.

Other large groups living in the seismic acquisition area are the Tukolor, the Peul (Fula) and the Serer people. The Tukolor people are predominately found in the northern part of the country, and in the Senegal River valley. The Tukolor are traditionally traders and farmers. The Peul are traditionally nomadic cattle herders, and live in the northern part of the country. The Serer are less widespread, and are concentrated in the Sine-Saloum region, across the border of north-west Gambia.

Islam is the dominating religion within all these groups.

The population in Senegal has grown from 3 millions in 1960 to just under 9 millions today (Ministry of Environment 1997).

The population density is 25-50 person/km$^2$ in the Senegal River valley and in the northern and south western part of the seismic acquisition area, and 50-200 person/km$^2$ in the central agricultural areas (Ministry of Environment 1997).

4.3.2 Infrastructure and Community Structure

The infrastructure in the seismic acquisition area is well developed, and most areas are easily accessible via roads. Large and small trucks and animal charts are most frequently used for local transportation, whereas cars, taxis and small buses transport people between centres on paved main roads and secondary roads. Dirt roads, accessible for four wheel drive are available to all small villages (Speller 1992).

Each village has one or more water wells, which may be shallow (15-30 m) or a deep water well (300 m) developed by the government. The deeper wells, located at larger villages, have pumps and, frequently, above ground water storage towers associated with them. Piped water supply systems in and between the large towns (Speller 1992). Communal organisations are responsible for the maintenance of the wells.

All but the smallest villages have electricity and telephone communications. In small and medium sized villages, houses are constructed of concrete blocks, mud bricks or woven bush. They are often surrounded by bush fences to keep animals out (Speller 1992).

The political community structure is described in Figure 2.1, Chapter 2. All communes and rural communities have a contingency organisation for the prevention of and fight against bush fires.

4.3.3 Land-use and Agriculture

The rapid increase of the population the last 30 years has caused increased pressure on agricultural land. Figure 4.4 shows how the agricultural zones have expanded the last 30 years.

Agriculture is mainly carried out by family farmers. The dominating crops are millet, sorghum, groundnuts, sweet potatoes and corn. Trees in agricultural areas are often pruned to...
facilitate fruit production. Areas with poorer soil quality are used for pasture for goats, sheep and cattle. In the dry season livestock is also foraging on the remnants of crops in the fields (Speller 1992). Rice and sugar are grown in irrigated areas along the rivers, mainly along the Senegal River.

Figure 4.4. Expansion of the agricultural zones since 1960 (Ministry of Environment 1997).

The pressure on classified forests is high, and although not permitted, classified forests are frequently cleared to provide areas for agriculture. This is very evident in the southern parts, where most of the classified forests in addition are small. Figure 4.5 shows the evolution of the condition of the forests in Senegal in the period 1965-1994.

Figure 4.5. Evolution of the condition of forests in Senegal, 1965-1994. Dark green= excellent condition, light green= slightly degraded, orange= rather degraded, red= very degraded (Ministry of Environment 1998).
Figure 4.6 shows the duration of the agricultural period in the different parts of the seismic acquisition area.

![Map of Senegal showing the duration of the agricultural period in different parts of the seismic acquisition area.](image)

**Figure 4.6.** Duration of the agricultural period in the seismic acquisition area (roughly marked with red lines). White= non agricultural zone, light blue= 60-70 days, light green= 70-80 days, green= 90-120 days, pinks >120 days. (CSE 1998).

The economy of Senegal is largely depending on the production of groundnuts (peanuts). The main groundnut growing region is east of Dakar, around the towns of Diourbel, Touba and Kaolack. The groundnuts are harvested after the rains, mainly in October to January, and transported to the crushing mills.

Although groundnuts contribute to the country’s economy, the large plantations have a devastating effect on the environment. The crops absorb nutrient from the soil, but replace very little. When the crop is harvested, the whole plant is removed leaving the loose, dry soil exposed and subject to wind erosion. The soil is exhausted and blown away, and new plantations are established in other areas. This has become a major environmental issue in Senegal as groundnut farmers expand eastward into the sylvo-pastorale reserves (grazing reserves), supposedly set aside for semi-nomadic people such as Peul (Else 1999).

### 4.3.4 Important hunting and fishing areas

The main hunting period is from September to December. The most important hunting area in the seismic acquisition area is in the surroundings of Foundioune (aquatic birds). Other important hunting areas are the Senegal River valley and the Bao Bolon River valley. Hunting is generally popular and widespread in the whole seismic acquisition area.

There are no fishing areas of importance in the seismic acquisition area.

### 4.3.5 Areas of recreational value

The most popular recreational areas in the seismic acquisition area are in connection with the National Parks of Djoudj and Saloum (see Sect. 4.5)
4.3.6 Historical sites

Important historical and archaeological sites in the seismic acquisition area are listed in Appendix E and include buildings, mosques and churches, battlefields, grave mounds and stone monuments.

4.4 Description of the Eco-Geographical Zones in the Influence Area

The vegetation types in the seismic acquisition area are shown in Figure 4.7. Dominating vegetation is bush and tree savannah. The central parts of the seismic program area are intensively cultivated.

![Figure 4.7. Vegetation types in the seismic program area.](image)

The vegetation cover varies during the year. Figure 4.8 shows the variation in the vegetation cover throughout the year.

The seismic acquisition area covers five different eco-geographical zones (see Fig. 4.9). These are, from north to south:

- The Senegal River valley zone
- The northern sandy, pastoral zone
- The central agricultural zone
- Saloum estuarine zone
- Saloum agricultural zone

The following sections give brief descriptions of the vegetation, agriculture and socio-cultural environment in the different eco-geographical zones.
Figure 4.8. Annual variations in the vegetation cover. The images are based on analyses of a large number of satellite photos taken in the period 1982-1995. The orange and yellow colours indicate sparse and poorly developed vegetation cover, whereas the green nuances indicate well developed vegetation cover. Data source CSE.

Figure 4.9. Eco-geographical zones in the seismic survey area. Dark brown= the Senegal River valley, yellow= the northern sandy, pastoral zone, beige= the central agricultural area, purple= the Saloum estuarine zone, light brown= the Saloum agricultural area (Ministry of Environment 1997).
4.4.1 The Senegal River valley zone

Vegetation
The vegetation in the flooded parts of the Senegal River valley zone reflects a low rainfall on unfavourable holomorphic soils. The Sahelian type savanna is dominated by spiny bushes, acacias such as Acacia nilotica, A. tortilis, A. seyal, tamarisk Tamarix senegalensis, and Balanites aegyptiaca. During the rainfall dense populations of Typha spp. and waterlily Nymphaea spp. appear in the flooded zones. Halophytic plants, particularly Salicornia spp., cover much of the area. Aquatic vegetation is dominated by Pistia stratiotes (World Conservation Monitoring Centre 1997).

Population
The dominating population groups in the Senegal river valley are Wolof and Tukulor. Commerce and agriculture are the main occupations.

Agriculture
Due to high salinity and acidity, parts of the river valley are unsuitable for agricultural purposes. On the hydromorphic soils sorghum, millet, groundnuts and some corn are grown. Rice and sugar is cultivated all year round in suitable, irrigated areas in the flood valley. Sugar fields are restricted to the area around Richard Toll.

Figures 4.10 gives an overview of the typical landscape in the river valley.

![View over the Lampsar river, a branch of the Senegal river. To the left can irrigated rice fields be seen. These are established on muddy soils deposited by the river. A bush step of the Sahelian type is established on the sandy, elevated soils to the right. These areas are never flooded (CSE 1996).](image)

4.4.2 The northern sandy, pastorale zone

Vegetation
The vegetation in the northern pastoral zone is characterized by spiny bushes and trees, Different Acacia species are the dominating trees. Other species typical for this area are
*Boscia senegalensis, Balanites aegyptiaca* and *Combretum glutinosum*. The herbs are dominated by grasses (*Graminidae*) with an annual life cycle. Dominating grass species are *Eragrostis tremula, Cenchrus biflorus* and *Schoenefeldia gracilis*.

**Population**

The dominant population group in the northern pastoral is the Peul (Fula). Both permanent and temporary villages occur in the area. Parts of the population follow the cattle to the southern sylvo-pastoral reserves during the dry season.

**Agriculture**

Sandy soils and small amounts of rain make most of this area unsuitable for commercial agricultural activities. Large herds of livestock graze in the area during the rainy season. Millet, grown for own consumption, is the main agricultural product.

Figures 4.11-4.12 gives an overview of typical landscapes in the northern sandy, pastoral area.

![Figure 4.11. A temporarily inhabited Peul settlement east of Lac de Guiers. The crop on the field is millet (CSE 1996).](image)
4.4.3 The central agricultural zone

Vegetation
The vegetation in the “groundnut basin”, as this area also is called, is characterised by a bush savannah, strongly influenced by agriculture. The herbal stratum is dominated by *Andropogon, Pennisetum* and *Zornia*.

The fields (called “parcs” in french) are characterised by the occurrence of scattered trees dominated by *Faidherbia, Borassus, Adonsonia, Cordyla, Sterculia* and *Combretum*. The trees contribute to soil fertilization and most of them produce fruits, fodder and other products.

Typical plants on the salt plains are the *Tamarix* bushes. *Borreria* dominates the herbal stratum on these areas.

Population
The dominant population group is the Wolof.

Agriculture
This is the most important district for groundnut production. Generally the area is intensively cultivated.

Figures 4.13-4.14 gives an overview of typical landscapes in the central agricultural zone.
Figure 4.13. An area in the northern part of the central agricultural zone (south of Kebemer). Natural forests have given place for agricultural land. Scattered Acacia trees grows on the fields (pares). A typical wolof village, with a large central public place, can also be seen (CSE 1996).

Figure 4.14. An area in the southern part of the central agricultural zone (east of Gossas). This area is the most ancient populated part of the “groundnut basin”, and is also one of the most densely populated areas in the country. Villages, typical of the Serer people with dispersed family settlements, can be seen (CSE 1996).

4.4.4 Saloum estuarine zone

Vegetation
The delta of the rivers Sine and Saloum contains extensive areas of mangrove forest dissected by numerous saline channels and interspersed with lagoons, islands and islets. The area also includes sand dunes with dry open woodlands.
Population and community structure
The dominant population groups in this area are Serer and Wolof. Agriculture, livestock rearing, hunting and fishing is carried out in or close to the estuarine zone.

Agriculture
Millet is the most important crop in this area.

Figure 4.15 gives an overview of a typical landscape in the Saloum estuarine zone.

Figure 4.15. A branch of the Saloum river east of Foundiougne. The flood plains are unvegetated. In the background, an agricultural area typical for the southern part of the central agricultural zone, can be seen (CSE 1996).

4.4.5 Saloum agricultural zone

Vegetation
The vegetation in the Saloum agricultural zone is similar to the vegetation in the central agricultural zone. The dominating species in the remaining forests is *Acacia seyal*.

Population
Wolof and Serer are the dominant population groups.

Agriculture
Different varieties of millet are the most important crop in this area.

Figures 4.16-4.17 give an overview of typical landscapes in the Saloum agricultural zone.
Figure 4.16. An intensively used agricultural area, almost without fallow land, east of Wack-N’Gouna (CSE 1996).

Figure 4.17. More and more of the original forests in the Saloum are eliminated due to agriculture and charcoal production. Fragments of pristine forests dominated by *Acacia seyal* forests still exists. The pictures shows a landscape north of Sokone (CSE 1996).

### 4.5 Protected areas and species

Figure 4.18 gives an overview over the national parks, nature reserves and classified forests in the influence area.
Figure 4.18. National parks, nature reserves and classified forests in the influence area. The seismic acquisition lines are marked with red.
4.5.1 National Parks

Senegal has six national parks, two of those are within or close to the influence area.

Djoudj National Bird Sanctuary

Djoudj National Bird Sanctuary is a national park, established in 1971. The park was declared a Ramsar site in 1980, and a World Heritage site in 1981.

Djoudj is an inland delta, set in a shallow depression in a generally flat, open landscape, with impermeable saline soils. The area is within the floodplain of the Senegal River, and contains an extensive complex of seasonally inundated brackish lakes and pools, linked by a network of channels stemming from the Djoudj River. It is located in a low valley, 60 km north-east of Saint Louis. The park covers 16,000 hectares, and is adjacent to Diawling national park in Mauritania.

Djoudj is part of a network of wetlands in West Africa south of the Sahara, and it is one of the first refuges for migrating water birds after the crossing of Sahara (Sylla & Balde 1999). A total of 366 species have been recorded in the area. From September to March/April, an estimated three million migrants pass through the park, and the area is of international importance for both breeding and wintering birds.

The park is managed by the government, and has more than 3,000 visitors annually. An integrated management plan for the site has been prepared and officially approved. The plan has been developed with the support of IUCN. The implementation of the plan focuses on an extensive co-operation between the park management and the local population.

Tourism has not indicated to have any negative impacts on the park. Hunting, by both tourists and villagers, in the vicinity of the park is tightly regulated.

Major threats to the area are related to changes of the habitat due to constructions of dikes and dams for promotion of the rice agriculture on the Senegal River valley.

Parc National du Delta du Saloum, Saloum Biosphere Reserve

The National Park of Delta du Saloum extends through 73,000 hectares of mangroves and small islands of white sand with dense vegetation. The site also includes dune areas with dry, open forest. It is the second largest national park in the country, located 80 km west of Kaolack. It was established in 1976. The park is designated under the Ramsar convention (1984). It is part of the Saloum biosphere reserve, included in the UNESCO’s management plan and the Biosphere Program, set up both to conserve genetic diversity and to promote conservation activities such as monitoring, research and training.

The park is especially important for migrating birds and a variety of other birds. Animal life includes deer, warthogs, antelopes, hyenas, monkeys. Dolphins and manatees can be observed. Four species of sea turtles breed within the National Park.

The biosphere reserve includes estuaries, agricultural land and forests.

Management problems in the park and the biosphere reserve include land pressure for agricultural purposes, erosion and impoverishment of the grounds, poaching and over-exploitation of the forest resource.
An integrated management plan for the area, supported by IUCN, is under development. It will be completed in December 1999. The plan will focus on sustainable management of the natural resources in the national park as well as in the biosphere reserve. The implementation of the plan will be based on extensive co-operation between the park management and the local population.

4.5.2 Nature Reserves

Ndiael Special Wildlife Reserve

Ndiael Special Wildlife Reserve is located about 50 km north-east of Saint Louis, 20 km south of Djoudj National park. The reserve was declared a Ramsar site in 1977, and covers an area of 46 550 hectares.

The reserve consists of an alluvial basin in the flood plain of the Senegal River, and was formerly fed by seasonal flooding from the river and from the nearby Lac de Guiers. Under natural conditions, the basin began to fill at the end of July, reached its maximum level in October, and receded gradually until reflooding next year. When flooded, the site used to attract very large number of water birds. No human activities were allowed in the site itself. Rice is cultivated in the surrounding areas. The natural hydrology of the region was transformed in the 1960s by major engineering works aimed at improving conditions for agriculture, and through road constructions (Jones 1999).

At a Ramsar Convention conference in 1987, Ndiael was declared one of the 29 most threatened Ramsar sites in the world. The Ramsar Monitoring Procedure Mission visited the site in 1988. Their report concluded that the site could not be considered to be of international importance in its present condition (Jones 1999).

A management plan for the area has recently been developed. One of the main purposes of the plan is to restore the hydrological conditions by 2001, pending sufficient financing.

Bao Bolon Special Reserve

The Bao Bolon is a river branch of the Gambia River. It is an important winter location for migratory birds, moving between this area and the Saloum national park. Hunting in the reserve is allowed at certain periods. The river branch is normally dry during the dry season, but areas with open water have been registered also in the dry season in some years.

4.5.3 Other protected natural habitats

The following classified forests and sylvo-pastoral reserves will be affected by the proposed seismic acquisition:

Classified forests:

- Forêt de Boulierobe
- Forêt de Maleka
- Forêt de Mahekor
- Forêt de Birkelane
- Forêt de Velor
- Forêt de Djilor
- Forêt de Keur Maktar
Sylvo-pastoral reserves (grazing reserves):
Reserve sylvo-pastorale de Mpal Merinaghene
Reserve sylvo-pastorale de Boulel
Reserve sylvo-pastorale de Deali

The vegetation in the woodlands and sylvo-pastoral reserves in the northern part of the seismic acquisition area is characterised as bush and tree savannah. The forests in the southern part of the area are more densely vegetated. Some of these forests are partly degraded due to human activities such as agriculture.

4.5.4 Protected species

Eleven species are totally protected for commercial use all over the country. Any damage on these species is formally forbidden. Authorisation for scientific or medical use can be given by the Directorate for Water and Forest. In addition, 17 species are partly protected. Permission must be obtained from the Directorate of Water and Forest before any of these species can be cut or in other ways damaged.

A list over the protected tree species is given in Appendix D.

Apart from the protected areas mentioned above no habitats of special importance for protected animal species have been identified within the seismic acquisition area.

4.5.5 Occurrence of malaria and HIV/AIDS

Malaria is widespread throughout Senegal. The diseased is transferred through mosquitoes, but can also be transferred by blood transfusion. The highest density of mosquitoes is found during the rainy season or in areas where fresh water is found all year round.

The HIV-virus is widespread on the African continent. Heterosexual activity is the main source of transfer of the virus in Africa. Blood transfusion is, due to poor screening of blood, another important infection source.

It is estimated that 1.8% of the Senegalese population is infected by the HIV-virus (Souhlal, pers. comm.). However, there are considerable uncertainties associated with the statistic material.
5. ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

The environmental evaluations presented in this Chapter are based on written material (see Appendix B), and on information gained during a fact finding mission to Senegal in October 1999. The background data used for the baseline description and for the environmental evaluations are considered to be sufficient, accurate and of high quality.

During the development of the EIA, a number of meetings with central and local authorities, as well as with other associations in Senegal, have been held. The purpose of these meetings was to inform the authorities of the project plans, to discuss concerns and to identify issues. Short minutes of these meetings are given in Appendix C.

A survey of the seismic acquisition area was carried out in October 1999 (at the end of the rainy season). All photos presented in this chapter were taken during this survey.

5.1 General impacts

Considerable activity along the acquisition lines will be necessary during the laying out and recording process, but is unlikely to cause any long term effects.

No drilling activity and limited soil removal or disturbance will take place. No chemical explosive energy source will be used, and there is no need for use of muds or other toxic chemicals. Engine lubricants and diesel and petroleum fuels will be used for the vehicles. All materials will be removed upon completion of the survey.

The right of way, along which the cables and geophones will be aligned and the Vibroesis vehicles will drive, will be 3-4 meters wide.

The environmental impact related to the seismic acquisition can be:

- damage on crops and property
- damage on forest and vegetation
- disturbance caused by noise and traffic
- environmental impact caused by the activity at the camp sites
- damage on historical sites
- conflicts with other interest, such as hunting

5.2 Potential Impact on Crops and Property

5.2.1 General issues

Agricultural land will be affected by the survey, both along the seismic acquisition lines and by the traffic necessary to transport personnel and equipment. The vibration may also have an impact on wells, buildings, soil structure and on the water regime in the soils. Soil compaction from vehicle operations, which can inhibit crop growth, is most likely to occur during the wet season in moist areas.

Seismic operations conducted during the main growing season of July-October would result in crop losses in areas of intensive agriculture. Extensive areas might be affected, both along the seismic lines and on any new access roads that will have to be constructed.

Damage to trees and structures such as fences can occur regardless of the operating season.
5.2.2 Mitigation measurements

*Compensation:* Compensation payments for crop losses and temporary damage to property and soil effectively mitigate losses to local farmers if they are administered fairly and efficiently. The Ministry of Agriculture in Senegal has implemented a system for compensation to landowners. The system is based on a fixed price list covering a number of issues. The farmer, a representative from the regional governmental agricultural agency and a representative from Petrosen will inspect the damages and agree on a compensation based on fixed price compensations for lost harvest, lost trees, mending of fences, breaking up compacted soil etc. Petrosen should consult with, and inform local farmers and their organization well in advance of the project in order to prevent unnecessary damages and controversies.

*Right-of-way and access:* The right-of-way should be kept at a minimum and existing roads and tracks to be used as far as possible for access for service vehicles. The Vibroseis vehicles are equipped with GPS (geographical positioning system), and minor deviations from the seismic line in order to avoid the cutting of trees do not constitute a technical problem. The GPS will give the correct co-ordinates for the shoot points at all times. The figures 5.1-5.3 show typical agricultural landscapes in the influence area. For a more detailed localisation of the sites of the pictures, see Figure 3.1 (page 16).

**Figure 5.1.** Agricultural area south of Louga in the northern part of the central agricultural zone (location ref. Fig. 3.1: where line E intersect the main road to Louga). Millet and groundnuts are grown in the field, the bush fence is planted to keep animals from the crops.

**Figure 5.2.** Agricultural area north of Gossas in the southern part of the central agricultural zone (location, ref Fig. 3.1: where line H intersect the main road to Gossas). Millet is grown in the field.
Figure 5.3. Agricultural area at Wack-N’Gouna in the Saloum agricultural zone (location, ref. Fig. 3.1: where line K intersect Wack-N’Gouna). Groundnuts are grown in the field.

Irrigated areas: Irrigated areas for rice and sugar production are found in the Senegal River valley. In order to avoid soil compaction and damages to the crops access to these areas should be gained by using existing roads in the fields. Permission to do this must be given by the plantation owners prior to any activities. Figures 5.4-5.5 shows rice fields and sugar plantations in the Senegal River valley.

Figure 5.4. Sugar plantation west of Richard Toll (location, ref. Fig. 3.1: line A). Seismic recording can be performed along the plantation road if permission is given.

Figure 5.5. Irrigated rice fields west of Richard Toll (location, ref. Fig. 3.1: where line A and line 2 intersect). Seismic recording in the rice field shall be avoided. Salt plains can be seen to the left in the picture.
Distance from buildings, wells etc.: No seismic shooting shall take place less than 50 meters from residences, buildings or water reservoirs. The closest allowed distance to wells is 120 meters.

Timing: To minimize damages on agricultural land the seismic survey should be carried out in the dry season in intensively cultivated areas. This would minimise damage to the crops, the need to remove the topsoil layer, soil compaction and the economical compensation.

The following timing is recommended (see Figure 4.6 for the duration of the agricultural periods in the seismic program area):

May-July: northern part of zone 1 (to avoid negative impact on areas protected for bird life, see section 5.3).
August-October: southern part of zone 1
November-January: zone 2
February-April: zone 3

For localisation of zone 1-3, see Figure 5.6 below.

![Figure 5.6. Zone 1= grey and blue areas, zone 2= green areas, zone 3= purple areas. The seismic acquisition area is roughly outlined in blue. For recommended timing of the seismic acquisition, see text above.](image)

5.3 Potential Impact on Vegetation and Protected Areas

5.3.1 General issues

As Senegal is located at the edge of the Sahara desert the impact of desertification in the seismic acquisition area is most severe. Decreased annual precipitation during the last 30 years, increased wind erosion due to increased activity by the Harmattan (the trade wind from Sahara) the last 15 years, as well as increased land utilisation for agricultural purposes, have amplified the desertification impact (Ministry of Environment 1998). The Government in Senegal has an ambitious, well advertised program to plant trees in poor soil areas, to conserve trees and to protect the ubiquitous dry, sandy soils in agricultural areas (Speller 1992).

Extensive cutting of trees, bushes and removal of perennial herbs and topsoil may lead to longterm environmental impact in sensitive areas or in areas exposed for erosion and desertification.
Apart from limited areas in the southern part of the influence area dense forest is not found anywhere outside the classified forests.

North of Kaolack the herbal strata is dominated by annual grasses that reproduce by wind borne seeds (Figures 5.7-5.9). Damages on this kind of vegetation cover will not have any longterm effects regarding revegetation, provided that the topsoil, which is rich in seeds, is not removed.

In the southern parts of the influence area a larger degree of perennial herbs binding the soils are found, but annual grasses are also here dominating the herbal stratum.

So called gallery forests occur along rivers and waterways in the southern part of the area (Figure 5.10). Gallery forests provide shelter and habitats for wildlife, and are important for the biodiversity in this intensively cultivated part of the seismic acquisition area. Gallery forests are considered to be sensitive habitats for physical disturbances.

The pictures (Figures 5.7-5.9) show examples of the vegetation types and landscapes found outside the agricultural and protected areas in the seismic acquisition area.

**Figure 5.7.** Uncultivated areas in the northern part of the central agricultural zone (location, ref. Fig. 3.1: where line D and line 1 intersect). Annual grasses dominate the herbal stratum.

**Figure 5.8.** Pastoral areas west of Lac de Guiers (location, ref. Fig. 3.1: where line B east of Ndial Reserve). A temporary Peul village is seen in the picture.
5.3.2. General mitigation measures

The seismic survey should be acquired in such a manner that necessary measures are taken to protect the vegetation as far as possible.

Cutting of trees shall be avoided, and the activity should take place in the dry season in order to avoid unnecessary removal of vegetation and topsoil layer, thus prevent wind and water erosion of the soils. It will be fully possible to adjust the major part of the seismic lines in order to avoid cutting of trees. The use of GPS at the seismic vehicles (see Sect. 5.2 above) allows a flexible localising of the shoot points.

A number of tree species are protected (see App. D). Authorisation to cut or damage protected species can be granted by the authorities. Local officials should be consulted prior to any seismic operations. The disposal of trees or bushes that are unavoidably cut should be carried out with the advice of local community leaders.

The work should be performed in the dry season, as the disturbance of vegetation and topsoil can be kept at a minimum. The recommended periods for activities in the different areas are given in figure 5.6 above.

5.3.3 Issues in protected areas

Protected areas located in the influence area of the seismic survey are shown in Figure 4.18. One national park, one biosphere reserve, 2 fauna reserves, 7 classified forests and 3 sylvo-pastoral reserves are affected by the proposed seismic acquisition lines. A more detailed description of the parks and reserves is given in Section 4.5.

The following text summarises the vulnerability and major environmental concerns in the different areas. Mitigation measures to reduce the environmental impact of the seismic activities are proposed.

5.3.3.1 Authorizations and consultations

No seismic activities can take place in national parks, nature reserve, classified forests or sylvo-pastoral reserves without a permit from the authorities. A letter describing the planned activities should be sent to the Ministry of Environment, with copies to the Directorate for
National Parks and the Directorate for Water and Forests. The central authorities will forward the information to their local representatives.

Any activities in classified forests should be undertaken with the approval of, and in cooperation with, governmental and local forestry officials. Any restoration measures shall be undertaken with direction from these officials.

The public should be consulted and informed well in advance of any activity in, or close to, classified forests or sylvopastorial reserves. The sylvopastorial reserves are used for grazing livestock during the rainy season. It is also allowed to keep grazing cattle in classified forests. The seismic activity will not last for more than 1-3 days in, or close to, any of these areas, but the landusers should be involved in the planning in order to avoid unnecessary inconvenience or controversies.

5.3.4 National Parks and Nature Reserves

Djoudj National Bird Sanctuary: Djoudj National Bird Sanctuary is a sensitive area with high international conservation value. The most sensitive period is from September to December. This is the breeding time for birds that breed in the park, as well as the most important staging period for migratory birds. The migration period stretches to March/April.

The park is surrounded by a buffer zone with a radius of 1 kilometre. No soil or sub-soil exploration activities are allowed in the national park or in the buffer zone.

According to the planned seismic program, one of the seismic lines will cross the park from east to west.

Proposed mitigation measures: The proposed seismic line should be moved, and preferably established south of the park, outside of the buffer zone. Activities in this area should be restricted to the period April-June, during the end of the dry season, which will facilitate access to the dry flood plains, and disturbance to the bird life will be kept at a minimum. Figure 5.10 shows the landscape and vegetation in the area of the proposed alternative route for the seismic line. The proposed alternative route can be seen in Figure 5.11.

Figure 5.11. Landscape and vegetation south of Djoudj National Bird Sanctuary. The picture is taken in the end of the rainy season (October).

Ndali Special Wildlife Reserve: Engineering work carried out in the 1960 lead to severe changes in the natural water regime in this reserve, and the number of breeding and wintering
birds has decreased drastically. The reserve is not considered to be of international importance in its present condition. It is not considered to be a wetland, but rather a part of the Sahelian desert. A new management plan for the area has recently been developed. It includes a plan for restoration of the water regime in the reserve. Reestablishment of the water level is planned to be done in the period 1999-2001, but the final restoration is pending financing of the project.

The most vulnerable period for wildlife in the reserve is from September to December, when migratory and breeding birds are found in areas with open water.

According to the planned seismic program three seismic lines will cross the park.

*Proposed mitigation measures:* From a geophysical point of view, moving the proposed lines that affect the Ndiaël reserve is not an alternative. There are two geological objectives, the most important being the structural rollover, seen on existing seismic data from previous acquisitions. The purpose of the proposed line B, is to complete existing data and determine how far north these interesting structural features continue. Moving the line north or south, out of the Reserve is therefore not an alternative.

Despite the fact that the seismic survey itself not is assumed to have a significant negative impact on the environmental values in Ndiaël, exploration activities in a Ramsar site is in conflict with the intentions of the protection and the World Banks Safeguard Policies regarding natural habitats. Recommended mitigation measure is to terminate the proposed seismic lines at the reserve boundaries.

If this is not feasible to the overall purpose of the survey, the Ramsar Secretariiate should be consulted for approval of any activities within the site. Specific terms and conditions for any possible exploration and production drilling should be defined already at this stage, in order to avoid future conflicts.

*Saloum Biosphere Reserve:* The Saloum Biosphere Reserve is divided into three management zones. Three seismic line will affect zone 3 (the outermost zone). Extensive human activity, including agriculture, fishing and hunting, is allowed in this zone. An important hunting area is located within the northern part of zone 3. The hunting period is from September-December.

*Proposed mitigation measure:* The objective of the seismic acquisition in this area is to survey a stratigraphic sequence, Palaeozoic but of unknown age, that subcrops the Mesozoic unconformity. Several seismic lines have been recorded through the Reserve area in the past, and the new proposed lines are localised in order to complete these data.

To avoid any unnecessary interference with the Biosphere reserve, the following changes for the proposed lines are recommended (see Fig. 5.11):

- The west end of Line I, from about the intersection with Line 1, should be bent northwards sufficiently to clear the northern extremity of the Reserve.

- The western part of Line J can be bent to the north, introducing the bend at the intersection with Line 1.

- The western end of Line K should be terminated at the Reserve boundary.

It is further recommended that the work is carried out in the period January/February-March in order to avoid conflicts with agricultural activities and the hunting period.
**Bao Bolon Special Reserve**: Bao Bolon River valley is an important wetland for migratory birds moving between Saloum National Park and this area. The most sensitive period is from September and as long as open water can be found. The river is normally dry in the dry season, but some years open water has been noted also in the dry period. Hunting is allowed in Bao Bolon from September-December. One seismic line is planned to cross the southern part of the reserve.

**Proposed mitigation measures**: To prevent any negative impact on the area it is recommended to terminate the line at the boundaries of the reserve (see Fig. 5.11). It is further recommended that all activities take place in the period January/February-March. Hunting in the area is terminated in December.

### 5.3.4.1 Classified forests and sylvo-pastoral reserves

The classified forests and reserves in the northern sandy, pastoral zone could be characterised as savannah. Trees are sparse, and dense forests do not occur in this part of the seismic acquisition area. In Saloum Agricultural zone the forests are more dense.

**Protected areas in the northern part of the seismic acquisition area**: One classified forest (Foret de Boulierobe) and three sylvo-pastoral reserves (Reserve sylvo-pastorale de Mpal Merinaghene, Reserve sylvo-pastorale de Boulel, Reserve sylvo-pastorale de Deali) might be affected by the seismic survey. Trees and bushes are sparsely distributed in these areas.

**Proposed mitigation measurements**: Due to the low density of trees in Foret de Boulierobe and the three sylvo-pastoral reserves, it will be possible to perform the seismic survey through these areas with a minimum of damage on the forests. It is assumed that cutting of trees is avoidable. However, should it be impossible to perform the seismic survey in Foret de Boulierobe without cutting of trees, line F (see Fig. 5.11) should be moved south of the classified area by inserting a dog leg bend in the line (three bends).

The work should be performed at the end of the dry season, when the vegetation cover on the ground is at a minimum. Due to this, removal of the top soil layer will be unnecessary. The livestock, kept by the semi-nomadic Peul people, graze the areas in the northern, sandy pastoral zone during the rain season. The herds are moved to the sylvo-pastoral reserves in the south east of the influence area in the dry season.

Figures 5.12-5.15 shows the landscape and vegetation in the Foret de Boulierobe and the sylvo-pastoral reserves of Merinaghene and Deali.

**Protected areas in the southern part of the seismic acquisition area**: Six classified forests (Foret de Malka, Foret de Mahekor, Foret de Birkelane, Foret de Velor, Foret de Djilor and Foret de Keur Maktar) may be affected by the seismic survey.

Foret de Makehor and Foret de Malka are not dense, and are similar to the forests in the northern part of the influence area. Foret de Birkelane is affected by the railroad in the southern part of the protected area. The seismic acquisition line is planned to be located in this part of the forest. The seismic survey will not have significant environmental impact in these areas, provided that it is carried out in accordance with the recommendations given in Section 5.3.2.

The vegetation in Foret de Velor, Foret de Djilor and Foret de Keur Maktar is dense, at least in the central parts. Seismic recording will require cutting of trees if work has to be done outside existing roads. Due to their limited size, and to a high pressure on these areas caused by exploitation for agricultural and charcoal production, the forests are considered to be sensitive for any additional damaging activities.
Figure 5.11. Proposed alternative routes of seismic lines that affect protected areas. Blue lines = proposed alternative routes, white lines = areas that should be excluded from the seismic survey, blue arrows = show the proposed direction for line movement.

Proposed mitigation measurements: Forêt de Malka and Forêt de Mahekor: These forests are not dense, and it is assumed that the seismic operations can take place with a minimum of destruction to the forests. Proposed working period is January/February-March.

Should it be impossible to perform the seismic survey without cutting trees in the classified forests, the following changes are recommended:

- Forêt de Makehor: insert a dog leg bend (three bends) in Line 1 (see Fig. 5.11) to pass the forest area to the west.
Foret de Malka: insert a dog leg bend (three bends) in Line 2 (see Fig. 5.11) to pass the forest area to the east.

*Foret de Birkelane.* The proposed seismic line affects the southern edge of Foret de Birkelane, an area where the forest is degraded due to the railroad and agricultural activities. It is not assumed that the seismic survey will have any significant environmental impact in this part of Foret de Birkelane. Proposed working period is January/February-March.

**Figure 5.12.** A sparsely vegetated area of the Foret de Boulirobe (location, ref. Fig. 5.11: where line F and line 3 intersect).

**Figure 5.13.** View of the sylvo-pastoral reserve of Merinaghene (location, ref. Fig. 5.11: line 2 south of Keu-Mornar-Sarr). The annual grass species *Schoenofeldia gracilis* is dominating the herbal stratum.

**Figure 5.14.** View of the sylvo-pastoral reserve of Merinaghene (location, ref. Fig. 3.1: where line C and line 2 intersect).
**Foret de Keur Maktar:** This is a small, dense Acacia forest, less influenced by tree cutting and agriculture than other forests in the southern part of the influence area. It will not be possible to perform seismic acquisition in the forest without cutting of trees. Because of its pristine character, limited size and the lack of existing roads through the forest, it is recommended that the seismic line is moved outside this forest. Proposed working period is January/February-March. Figure 5.16 shows the vegetation in Foret de Keur Maktar.

**Foret de Velor and Foret de Djilor:** These forests are small and strongly influenced by human activities. A road intersects Foret de Velor, and it is recommended that the seismic recordings are performed along this road. Any activities in the central, well preserved parts of the forest should be avoided. The same recommendations are also valid for Foret de Djilor, where roads are located on the western and eastern borders of the forest. Proposed working period is January/February-March.

Figure 5.17 describes the proposed alternative routes for the seismic lines that affect the forests of Keur Maktar, Velor and Djilor.
Figure 5.17. Originally proposed routes for the seismic lines (in red) that affect Foret de Djilor (to the left), Foret de Velor (in the middle) and Foret de Keur Maktar (to the right). For Foret de Velor it is proposed that the existing road through the forest is used. For Foret de Djilor it is recommended that the existing road east of the forest is used. The traffic on these roads is not dense. It is further proposed to move the seismic line in Foret de Keur Maktar to a location south of the forest.

For all work in protected and sensitive areas, it is required that fences or post signs are installed to limit the use of access roads. This should be determined in the planning stages, and through contact with the appropriate government land management agency.

5.4 Potential Impact on Waterways and Landscape, Mitigation Measures

Streams and waterways
Activities in streams and waterways can have an impact on water quality by adding sediment to the streams, and by physically altering the stream banks. Cuts in the river banks may lead to erosion.

No seismic activities shall be carried out in any stream bed or river with flowing water. Except for crossings, no seismic lines may be constructed closer than 45 m from the banks of any watercourse or lake.

The number of vehicular movements across a stream crossing should be kept at a minimum, and vehicles equipped with wide pads or flotation wheels should be used in sensitive areas.

Landscape
The landscape in the seismic acquisition area is generally flat. Fixed dunes constitute characteristic topographical elements in parts of the northern area (see Fig. 5.18). Despite the flat topography most of the area is sensitive to wind and water erosion. Activities in slope
terrain or sparsely vegetated areas might lead to erosion problems unless necessary precautions are taken.

Figure 5.18. Fixed dunes are found in the northern part of the seismic program area (location west of Lac de Guiers).

Erosion control measurements shall be taken in any slope terrain to prevent water erosion. Removal of vegetation shall be avoided in order to prevent wind erosion.

In areas with fixed dunes north of Louga detours shall be made to avoid traffic on the dune slopes.

5.5 Historical sites

A number of historical sites are located in the regions affected by the seismic survey. These are listed in Appendix E. Historical battlefields, archaeological grave mounds and other archaeological sites might be located in the influence area. Local authorities shall be contacted to inform the operator of the detailed locations of these historical sites, and to advice on mitigation measurements. The seismic lines should either be terminated or relocated at the historical sites.

5.6 Environmental issues related to the activity at the camp sites

The establishment and activities at the camp sites is not expected to have any significant or long term environmental impact, provided that the necessary procedures and actions are developed and implemented.

Procedures to ensure adequate health, safety and environmental performance at the camp sites shall be developed by the contractor and approved by Petrosen. The following environmental guidelines are based on the Environmental Operating Guidelines for International Geophysical Operations, developed by Petro-Canada, 1990.

Location

Positioning of campsites can be very important not to disturb wildlife. Mineral lick areas, denning sites and important nesting sites shall be avoided. The local governmental agency must be consulted prior to the selection of a camp site. All camp facilities shall be at least 100 m from the shore or banks of any watercourse.
Sewage effluent and wastewater treatment
Local authorities shall be contacted regarding standards for sewage treatment and disposal. Where feasible, camp wastewater should be hauled or discharged to an approved municipal wastewater system. No effluent should be discharged to the ground from an onsite system.

Waste disposal
Collection, storage, conveyance and disposal operations should be carried out to ensure that wind blown trash and odor emissions are minimized. Any landfill sites shall be developed in accordance with approved procedures. Putrescible wastes that might attract scavengers should be placed in tightly closed containers, and hauled to an approved disposal site on a daily basis. Any toxic waste shall be managed in a safe manner and transported to an approved destruction site.

Fuel storage and handling
Fuel storage areas shall be clearly marked or barricaded to ensure that they are not damaged by moving vehicles. Dykes shall be built around fuel tanks to contain accidental spills and leakages. The containment area shall be impermeable and designed to keep 110% of the volume of the largest tank being contained. Any fuel spills shall be handled in accordance to approved procedures, and be reported to the landowner/land user.

Restoration of landscape affected by camp facilities and activities
The landscape affected by the camp operations shall be restored as closely as possible to original conditions, unless otherwise requested by the local authorities. Restoration should include revegetation of the area with grasses, shrubs and, if necessary trees native to the area. Where required, compacted soils must be broken up prior to seeding.

5.7 Potential Conflicts with Other Activities
Due to the fact that no seismic acquisition activities are carried out at the same place for an extensive period of time, conflicts with other activities such as hunting and construction work could be prevented through planning and co-operation with local officials.

5.8 Potential Impact of Noise and Dust
The seismic operations will create noise and dust, which may cause annoyance for the local population as well as for the wildlife. The effects will be of a temporary character, as the seismic survey team moves minimum 8 km per day.

5.9 Potential Impact on Infrastructure
The vibrations generated by the seismic acquisition may cause damage to wells, pipelines and structures with a concrete base. Recommended restrictions for seismic operations close to buildings and other structures are as follows (Petro-Canada 1990):

- Residences, barns, cemetery and buildings or structures with a concrete base: 50 m
- Water wells: 120 m
- Driveways, gateways and buried water pipelines: 5 m
- Survey monument or buried telephone or telecommunication lines: 1 m
- Oil or gas pipelines: 15 m
5.10 Mitigation measures to prevent malaria and aids infections

The seismic crew will work on the site for extended periods. This might lead to a risk for exposure to malaria and HIV/aids. The management of the contractor is therefore recommended to take the following precautions:

Malaria:
- Non-senegalese seismic crew should receive proper malaria prophylaxis, prior to during and for a sufficient period after the mission.
- Distribute/ensure that the seismic crew has access to insect repellents.
- Install mosquito nets around all beds at the camp sites.
- Malaria can also be transferred through blood transfusions, see HIV/aids.

HIV/aids:
- All crew members should be informed about the risks and the infection ways for aids transfer. Information should be given well in advance of the departure to Senegal, both in writing and through information presented in meetings at the site.
- Non-Senegalese crew members should be employed on a rotation schedule that includes a free home travel minimum every third month.
- For Senegalese crew members living in the camp sites joining the project for longer periods, it is recommended to keep families together (e.g. by providing employment for both husband and wife).
- The camp site should be equipped with disposable syringes for medical treatment. Used syringes should be treated as special waste.
- Only HIV-screened blood can be used for blood transfusions.
- Condoms should be available for distribution/sale at the camp sites.
- Free aids tests should be provided by the contractor, prior to, during and after the mission.

5.11 Summary of significant negative and positive impacts

The environmental impact of the proposed seismic survey is site-specific and reversible, provided that the proposed mitigation measurements are followed. The seismic lines will be cleared by hand (without the use of caterpillars and bulldozers). It is not expected that the operations will cause any long term or irreversible impacts.

The activities associated with the proposed seismic project can be conducted with minimal impact to the environment and the lives of local people and their communities. Potential environmental impacts can be successfully mitigated through the adoption of environmental operating standards based on the environmental management plan outlined in Appendix F.

Opportunities exist to temporarily enhance the lives of the local population through local employment and upgrading of dirt roads at very low costs.

5.11 Summary of proposed mitigation measurements and analyses of alternatives

Technology selection

The Vibroseis technology selected for the project is considered to be a better alternative than technology which involves drilling and use of dynamite. It allows a high degree of flexibility for the positioning of the shoot points, and it is time efficient.
Siting
The planning phase of the project includes extensive co-operation with central and local authorities as well as with the local population. The operator must apply for permission to work in any protected areas. Final localisation of the seismic routes shall be done in cooperation with local authorities. For all work in protected and sensitive areas it is required that fences or post signs are installed to limit the use of access roads, and to ensure that the work is performed in accordance with the conditions given by the authorities.

Alternative localisation to the proposed seismic lines is recommended in five areas; the Djoudj National Bird Sanctuary, Saloum Bioshere Reserve, Foret de Djilor, Foret de Velor and Foret de Keur Maktar. It is further recommended to avoid any seismic activities in the Ndiaël Nature Reserve and in the Bao Bolon Nature Reserve. If cutting of trees is unavoidable in Foret de Boulierobe, Foret de Malka and Foret de Mahekor dog leg bends should be inserted in the in the seismic lines to avoid any interference with these areas.

Operating and maintenance procedures
The disposal of trees or bushes that are unavoidable should be carried out with the advice of local community leaders. No unnecessary removal of topsoil or vegetation shall be done.

No seismic activities shall be carried out in any stream beds, rivers with flowing water or on the banks of any watercourse or lake. Seismic shooting points and vehicle crossings shall be located outside of gallery forests.

No seismic recording shall be done closer than 120 meters from wells, or 50 metres from cemeteries, churches, mosques, or other buildings or sites used for religious or cultural purposes.

No seismic recordings shall be done closer than 50 meters from residences or buildings and, in general, in proximity of any public works or engineering structures.

No seismic recording shall be done, without permission and guidelines given by the authorities, in or close to any historical or archaeological sites listed in Appendix E.

Environmental operating procedures shall be developed and implemented for alignment and access, terrain stabilisation and erosion control, fuel storage and handling, camp site establishment, operation and restoration work. All procedures shall be developed by the contractor and approved by the operator.

Timing
The work should preferably be carried out in the dry season. Recommended periods for activities in the different areas are given in figure 5.6.

Compensation
Compensation payments for crop losses and temporary damage to property and soil shall be paid in accordance to the methods implemented by the Ministry of Agriculture. All sites shall be inspected by a representative from the regional governmental agricultural agency, a representative from Petrosen and the landowner in order to fix the compensation. Structures such as fences shall either be replaced or otherwise compensated.
6. ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

An environmental management plan for the project is developed as a separate document (Ledje 1999). The Environmental Management Plan (EMP) is based on the findings in the present EIA and focuses on three areas; mitigation measures, environmental monitoring and institutional strengthening and training. The EMP includes a summary of the environmental impacts as described in the EIA.

The purpose of the environmental monitoring plan is to ensure that mitigation measures have been efficient, to provide a base for implementation of additional measures where necessary, and to collect and systemise experience data for use in the planning of future seismic projects.

The environmental management plan is based on the working procedures that Petrosen has used for other land seismic projects. It is developed as a checklist, and covers the following areas:

The planning phase
- contact with authorities at the central level
- contact and meetings with authorities, organisations and the public at the local level
- compensation issues
- review of the environmental legislation, authority terms and conditions
- on-site planning

The operational phase
- list of necessary environmental procedures
- description of recommended mitigation measures
- checklist for environmental reviews/audits

The operational and post project phase
- checklist for environmental monitoring

Detailed operational procedures shall be developed by the contractor and approved by Petrosen before any field work is commenced. The procedures shall consider the recommendations given in this report and in the Environmental Management Plan.
7. APPENDICES

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Appendix A  List of Environmental Assessments Prepared

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Appendix B

Written material used in study preparation


Laws
- Projet de loi Portant Code de l'Environnement. Pending
- Decree No. 98-812 of October 6th, 1998, establishing the condition of the application of the Petroleum Code
Appendix C References Record of Interagency/Forum/Consultation Meetings

Minutes of Meetings

General comment to the Minutes of Meetings:

At all meetings the proposed seismic acquisition project was presented by a representative from Petrosen, or by one of the environmental consultants. The minutes of meetings summarise the concerns and issues related to the seismic acquisition project expressed by the attendees.

20/10 Meeting with the Directorate for Environment (Direction de l'Environnement), Dakar

Attendees: Mr. Pathe Balde, Environmental economist, The Directorate for Environment
Mr. Ernest Dione, Environmentalist, The Directorate for Environment
Mr. Mamadou Faye, Promotion Department Manager, Petrosen
Mr. Moussa Sall, Environmentalist, Centre de Suivi Ecologique
Ms. Ulla P. Ledje, Environmental consultant

The Directorate for Environment is a technical directorate under the Ministry of Environment. The Directorate's main responsibilities are related to pollution and coastal management. The content and major additions in the new, pending Environmental Law, with the Environmental Code was presented, and a copy of the draft was handed over to the consultant. The law is expected to be approved by the National Assembly in connection with the ongoing budget session. The presentation focused on the new legislation regarding environmental impact assessment.

The representatives from the Directorate emphasised that the following issues should be addressed in the environmental impact assessment for the seismic acquisition:

- noise and dust generated from the operations
- soil compaction
- damages on vegetation and agricultural land
- hindrance for traffic or other activities, caused by the operations

It was also mentioned that the final project plans/design shall be presented for the environmental authorities for further evaluation.

20/10 Meeting with the Directorate for National Parks (Direction de Parcs Nationales), Dakar

Attendees: Mr. Souleye Ndiaye, Director, The Directorate for National Parks
Mr. Mamadou Faye, Promotion Department Manager, Petrosen
Mr. Moussa Sall, Environmentalist, Centre de Suivi Ecologique
Ms. Ulla P. Ledje, Environmental consultant

Activities related to the seismic acquisition project in, or in the vicinity of, the Djoudj National Bird Sanctuary and Saloum National Park/ Biosphere Reserve were discussed. According to Mr. Ndiaye Djoudj is a very sensitive area, and no seismic activities will be allowed in the park. The sensitive period is from September to March/April, when large
numbers of migrating and breeding birds are present. It was recommended to move the proposed seismic acquisition line to an area outside of the park, and to schedule any seismic activities in the Djoudj area to the period April-June.

The proposed seismic acquisition lines in the Saloum area will only affect the outer zones of Saloum Biospere Reserve. The reserve is divided in three management zones. The affected part belongs to zone III. This zone is strongly influenced by agriculture and other human activities, and is not considered to be sensitive to the proposed acquisition, provided that the necessary mitigation measures are taken. The operations shall be planned and designed in cooperation with the authorities.

The Ndial Special Fauna Reserve is, in its present condition, not considered to be sensitive to the proposed activities, provided that the activities are scheduled to the dry season.

Mr. Ndiaye emphasised that an application regarding activities in protected areas has to be sent to the Directorate for National Park’s and to the Ministry of Environment for consideration, before an authorisation with working conditions can be given.

23/10 Meeting with the Conservator at Djoudj National Bird Sanctuary, Djoudj

Attendees: Mr. Sarra Diouf, Conservator, Djoudj National Bird Sanctuary
Mr. Joseph Medou, Geologist/Geophysist Engineer, Petrosen
Mr. Moussa Sall, Environmentalist, Centre de Suivi Ecologique
Ms. Ulla P. Ledje, Environmental consultant

The conservator recommended to move the proposed seismic acquisition line to an area outside of the park and its buffer zone. The buffer zone around the park is 1 km. The most important period for both migratory and breeding birds is September-March, and activities should be avoided in this period. It is not expected that seismic survey will have any negative impact on the flora or fauna in the park and its surroundings, provided that it is performed in the dry season (from April-June).

Mr. Diouf also expressed the need to apply for an authorisation to perform any activities in the vicinity of the National Park.

23/10 Meeting with the representative for Ndial Nature Reserve, Saint-Louis

Attendees: Mr. Mbaye Ndiaye, Responsible for the Management of Ndial Special Fauna Reserve
Mr. Joseph Medou, Geologist/Geophysist Engineer, Petrosen
Mr. Moussa Sall, Environmentalist, Centre de Suivi Ecologique
Ms. Ulla P. Ledje, Environmental consultant

Mr. Ndiaye presented the present status of the conditions in the reserve and the content of the new management plan. Feasibility studies will be carried out for three different alternatives to restore the hydrological conditions of the reserve. Water will be introduced either from the Lampsar river, from Neiti Yone or from Trois Marigots. The actual work will be conducted at the earliest in year 2001, pending necessary fundings.

The area is of importance for birds in the period September-December. Seismic activity in the dry period (April-June) is not supposed to have any negative impact on the environment.
Application for authorisation to perform work in the reserve has to be sent to the authorities for further evaluation.

25/10: The inspection for Water and Forest, Region Kaolack, Kaolack

Attendees: Mr. Serigne Mbacke Thioune, Inspector, The inspection for Water and Forest, Region Kaolack
          Mr. Joseph Medou, Geologist/Geophysicist Engineer, Petrosen
          Mr. Moussa Sall, Environmentalist, Centre de Suivi Ecologique
          Ms. Ulla P. Ledje, Environmental consultant

The Inspector gave a short report of the status for the forests that might be affected by the seismic acquisition:

The southern part of Forêt de Birkelane is partly degraded due to the railroad that is located within the forest limits. There are also some private agreements on use for agricultural purposes.

Forêt de Keur Maktar is conserved in a good condition.

Forêt de Velor is affected by agriculture in the outer zones, whereas the inner zone of the forest is conserved in a good state.

Mr. Mbacke Thioune emphasised the importance of considering the nature of the soils and the vegetation in the different areas, in order to ensure that local considerations are made. He also recommended that an environmental monitoring program is developed and implemented in order to minimise the environmental impact.

The management responsibility for the forests is divided between the local state agency (Water and Forest Inspection, Region Kaolack) and the local community. Both levels should be consulted before the seismic survey is started.

Forêt de Djilor is located in the Fatick region. The inspection for Water and Forest in Fatick should be consulted before planning any seismic activities in this area.

26/10: IUCN (International Union for Nature Conservation), Dakar

Attendees: Mr. Abdoulaye Kane, Chef de Mission, IUCN
          Mr. Aliou Faye, Program Officer, IUCN
          Mr. Moussa Sall, Environmentalist, Centre de Suivi Ecologique
          Ms. Ulla P. Ledje, Environmental consultant

IUCN have been responsible for developing the management plan for the Djoudj National Park, and is now heavily involved in the implementation of the plan. This work includes, amongst other things, environmental training of the local communities and development of eco-tourism for local communities. A management plan for the Saloum national park has been drafted, and will be finished in the end of 1999. The plan will be implemented in year 2000, and will include activities that involves the local communities. IUCN has good contacts with the local communities in Djoudj and Saloum. IUCN saw no conflicts with the planned seismic acquisition considered that the activity in the Djoudj area is carried out outside the park and in the dry season, and that only the outer zones of the Saloum Biosphere Reserve is affected. However, they also pointed out that the Bao Bolon is a nature reserve. This reserve is used by
the migratory birds moving between Bao Bolon and Saloum, and might have areas with open water also during the dry season. If this is the case when the seismic survey is carried out, disturbance of the wetlands should be avoided.

According to IUCN the proposed seismic acquisition lines will not affect other areas defined as important wildlife habitats.

27/10: Directorate for Water and Forest, Dakar

Attendees: Mr. Babacar Diakham, Directorate for Water and Forest
Mr. El hadj Ndiaye, Directorate for Water and Forest
Mr. Moussa Sall, Environmentalist, Centre de Suivi Ecologique
Ms. Ulla P. Ledje, Environmental consultant

Also at this meeting the need to apply for an authorisation for working in protected areas was emphasised. In addition to consult central authorities the Regional Inspector of Water and Forest, as well as the administration in the rural collectives, should be consulted before any work is performed.

The representatives from the Directorate pointed out that the Bao Bolon is an important hunting area during periods of the year.
### Appendix D  Protected tree species in Senegal

<table>
<thead>
<tr>
<th>Latin name</th>
<th>Local or French name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Albizia sassa</td>
<td>Banéto</td>
</tr>
<tr>
<td>2. Alstonia congensis</td>
<td>Emien</td>
</tr>
<tr>
<td>3. Butyrospermum Parkii</td>
<td>Karité</td>
</tr>
<tr>
<td>4. Celtis integriofolia</td>
<td>Mboul</td>
</tr>
<tr>
<td>5. Daniellia thurifera</td>
<td>Santanforo</td>
</tr>
<tr>
<td>6. Diospyros mespiliformis</td>
<td>Alom</td>
</tr>
<tr>
<td>7. Holarrhena africana</td>
<td>Séhoulou</td>
</tr>
<tr>
<td>8. Mitragyna stipulosa</td>
<td>Bahia</td>
</tr>
<tr>
<td>9. Piptadenia africana</td>
<td>Dabéma</td>
</tr>
<tr>
<td>10. Hyphaene thebaica</td>
<td>Palmier Doum</td>
</tr>
<tr>
<td>11. Dalbergia melanoxylon</td>
<td>Dialambane</td>
</tr>
</tbody>
</table>

### Partly protected tree species

<table>
<thead>
<tr>
<th>Latin name</th>
<th>Local or French name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Acacia raddiana</td>
<td>Seing</td>
</tr>
<tr>
<td>2. Acacia senegal</td>
<td>Vereck (gommier)</td>
</tr>
<tr>
<td>3. Adansonia digitata</td>
<td>Baobab</td>
</tr>
<tr>
<td>4. Afzelia africana</td>
<td>Linké</td>
</tr>
<tr>
<td>5. Borassus aethiopum</td>
<td>Rônier</td>
</tr>
<tr>
<td>6. Ceiba pentandra</td>
<td>Fromager</td>
</tr>
<tr>
<td>7. Chlorophora regia</td>
<td>Tomboire noir</td>
</tr>
<tr>
<td>8. Cordyla pimata</td>
<td>Dimb</td>
</tr>
<tr>
<td>9. Faidherbia albida</td>
<td>Cad</td>
</tr>
<tr>
<td>10. Khaya senegalensis</td>
<td>Caïlcédrat</td>
</tr>
<tr>
<td>11. Moringa oleifera</td>
<td>Nébédaay</td>
</tr>
<tr>
<td>12. Prosopis africana</td>
<td>Ir</td>
</tr>
<tr>
<td>13. Pierocarpus erinaceus</td>
<td>Vène</td>
</tr>
<tr>
<td>14. Sclerocarya birea</td>
<td>Béer</td>
</tr>
<tr>
<td>15. Tamarindus indica</td>
<td>Tamarinier</td>
</tr>
<tr>
<td>16. Ziziphus mauritiana</td>
<td>Sidem</td>
</tr>
<tr>
<td>17. Grewia bicolor</td>
<td>Kel</td>
</tr>
</tbody>
</table>
Appendix E  Historical sites in the seismic acquisition area

This list contains grave mounds and battlefields and other structures or ruins that are located in the terrain in the seismic acquisition area (CSE 1999). Larger, existing structures, such as mosques and other buildings are not included. Archaeological institutions and authorities should be contacted for a detailed localisation of the monuments and sites.

Dioubel Region

- Mbaanaars de Mambaye
- Battlefield of Ndiarème (*) close to Sindiane
- Battlefield of Téné Mbambey
- Battlefield of BOUNGHOYE
- Battlefield of Ndiaby

Saint-Louis Region

- Le Marigot de Rhant, prehistoric site
- Les Tumuli de Rao, prehistoric site
- Ruins of “Poste de la barré à Mouit”
- Fort of Dagana
- Makhana water plants
- Fort of Podot

Kaolack Region

- All prehistoric stone monuments
- “Les Hots de l’estuaire du Saloum, prehistoric site
- Tata de Maba Diakhou Ba at Nioro
- Mysterious huts (without windows and doors) at Mbouboune
- Mysterious wells/pits, village of Dabaly
- Wells/pits of Mame Drarra Bousso
- The long tomb at Village of Velingara-Nioro
- Tomb of matar Kalla DRA ME at Ndime DRA ME

Louga Region

- Fort of Mérina Guène FOSS
- Tata d’Alboury at Yang Yang
- The ruins of the Poste and the residence of Yang Yang
- The well of Kaloum near Ndande (12th century)
- Battlefield of Dékheulé
- Battlefield of Loro
- Battlefield of Giilé
- Tomb of Meissa Waly à Mbissel
- Tomb of Bour Sine Coumba Ndoffene Fa Maak
- The Ndramou-Badat graveyard, 1.4 km from Dionewar, 149 grave mounds
- Graveyard situated 1.2 km south-east of the Dionewar mosque, 11 grave mounds
- The Fandaga graveyard, 2 km south-east of the Mosque of Niodior, several grave mounds
- The Ndrouta-Boumak graveyard, 4.7 km south, south-east of the Mosque of Niodior, 26 grave mounds
- Ndafaté graveyard south-west of Falia, 12 grave mounds left
- The Tioupane-Boumak and Boudaw graveyards (neighbouring graveyards), 700 m east of Faha, 168 and 54 grave mounds respectively
- Mbar Fagnick graveyard, situated 75 km east the previous graveyards, 4 grave mounds
- Graveyard situated at the junction of Bolon Bakhalou, 6 grave mounds
- The Droron Boumak graveyard, 6 km from Toubkouta, by the river west of Bandaiala, 125 grave mounds
- Graveyard situated 350 km south-west of the previous graveyard, 14 grave mounds
- Graveyard situated by the river of the northern arm of the bon Bossinka junction, 63 grave mounds
- The Bandiokouta graveyard, south of the junction du bolon Bossinka, 30 grave mounds
- Graveyard situated by the river to the right of the balcon Oudiérin, 72 grave mounds
- The Soukouta graveyard at the mainland 1 km west of Bandrala, 33 grave mounds