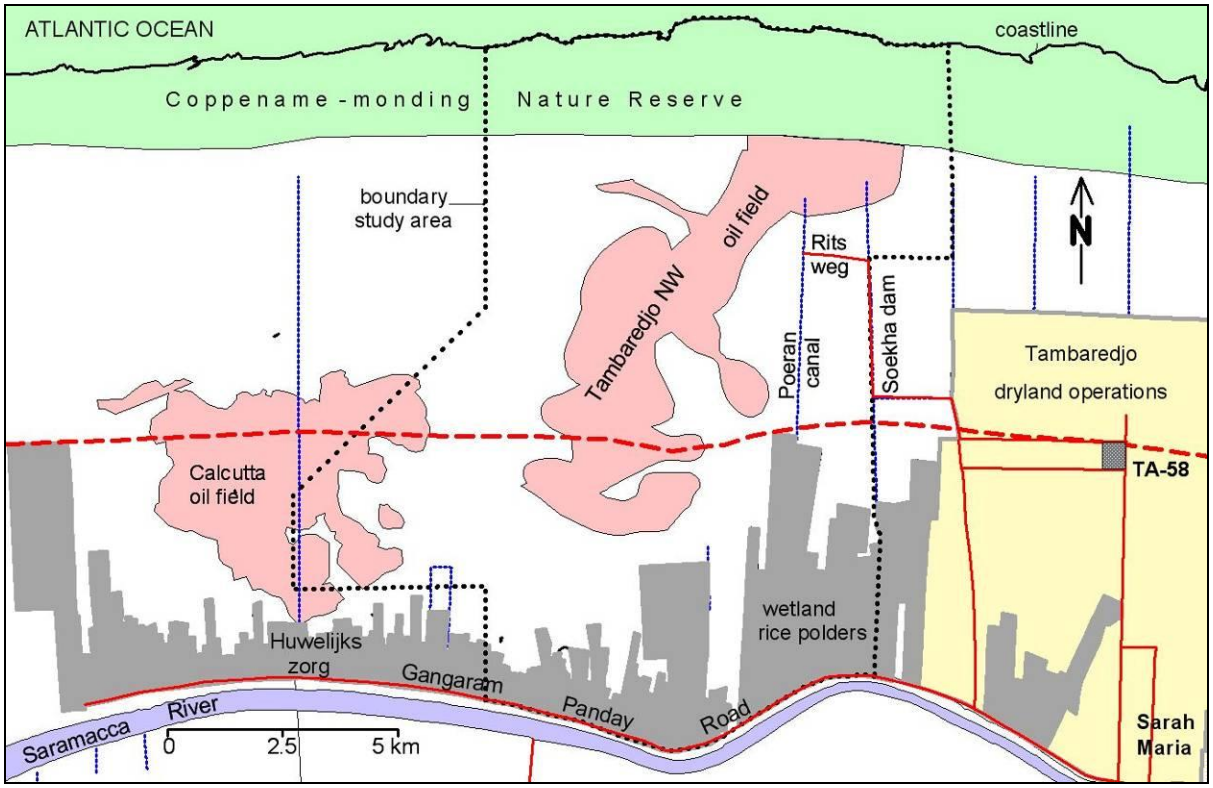
ENVIRONMENTAL IMPACT ASSESSMENT OF PRODUCTION DEVELOPMENT OF THE TAMBAREDJO NORTH-WEST OIL FIELD IN SURINAME



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EXECUTIVE SUMMARY

Background to the project

In 2005, commercial oil occurrences were encountered in the Tambaredjo Northwest (NW) area. In order to expand and maintain Staatsolie's crude production, the new Tambaredjo NW oil field must be taken into production. The production development will start in end May 2010 by practicing "wet operations" based on a two-rig operation. Currently it is assumed that the conventional drilling techniques, entailing the drilling of vertical wells, will be applied in this oil field. A transfer station will be constructed at Soekhadam, from where the crude oil will be transferred to the treatment facilities of TA-58.
This report presents the results of the Environmental Impact Assessment (EIA) for production development in the Tambaredjo NW oil field.
This EIA for the project has been prepared to conform to the guidelines of the National Institute for Environment and Development in Suriname (NIMOS).
The preparation and acceptance of the EIA report should ensure that environmental obligations are met as well as other relevant guidelines and regulations, so that the project will be conducted in an environmentally sustainable manner to meet both national and international accepted standards.

The current report does not deal with the construction, operation and abandonment/closure of the transfer station, which activities were discussed in a previous report (Noordam & Teunissen, 2009).

Brief project description

The Tambaredjo NW oil field is situated in the Buru Swamp in between the existing Tambaredjo and Calcutta oil fields. The Tambaredjo NW oil field project area covers 23 sq km. The northern part of the oil field borders the Coppename-monding Nature Reserve, while the complete oil field is situated within the North Saramacca Multiple-Use Management Area (MUMA).

The production development project entails the preparation and implementation of required facilities to accommodate production from the Tambaredjo NW oil field, its production and the decommissioning of the area.
This production development project will be executed by Staatsolie Maatschappij Suriname N.V. (hereafter shortly indicated as 'Staatsolie') which company aims to start full-scale production development in end May 2010. The oil field will be developed over a period of 5 years and crude production is currently foreseen to last at least 20 years.
From year 5 onwards the oil field will only be a crude production field and activities will be limited to monitoring, maintenance and servicing. Once the oil is depleted the field will be decommissioned.
In the construction phase the oil field will be prepared for crude production activities. The following activities will be undertaken:

1. Construction of the Transfer Station.
2. Construction of access and equipment trails.
3. Construction of the header dam
4. Construction of sub-header and flow-line dams
5. Construction of the sub stations within the oil field.
6. Preparation of the drilling wells (~50 x 50 m)

All transport takes place through the swamp and for that purpose trails are constructed. This construction comprises the removal of vegetation and peat (locally known as ‘pegasse’) in order to create open water for airboats, swamp carriers and rigs.
Dams are constructed to lay out a network of electricity grid and pipelines. Dams are constructed by excavating clay from the neighbouring swamp after the vegetation has been cleared. At regular distances the dams are supplied by openings so that no swamp water obstruction will take place.
The drilling locations will be cleared of vegetation and peat will be removed.
All clearing and digging activities are performed by excavators.

Drilling will start once above activities have been finalized. For the period 2010-2015, a maximum of 346 production wells will be drilled with 200 m spacing for the vertically drilled wells.
The production wells will be drilled with swamp rigs that are suitable for operations in the coastal swamps. Two types of rigs will be employed for drilling: the so-called caterpillar mounted rig and the Hover rig. The essential difference regarding impact is that the caterpillar-mounted rig requires a trail of 12 m, while the Hover rig needs a width of 38 meter.

Drilling is done to a depth of about 1500 feet. During drilling, drilling fluid (also known as "mud") is pumped down the inside of the drill pipe and exits at the drill bit. Particular functions of the drilling mud include cooling of the bit, preventing destabilization of the walls of the well hole and overcoming the pressure of fluids inside the sediment so that these fluids do not enter the well hole. For the Saramacca Operations water-based drilling mud is used, mainly composed of water, Drispac and clay (Bentonite).

During drilling “cuttings” are generated, for the Saramacca Operations consisting of clay, sand and shell fragments. These "cuttings" will be brought to surface through the mud circulation system. The cuttings are separated from the mud in the mud treatment system and at regular depth intervals sampled.
The drilling mud will be re-used as much as possible and only minimal amounts will be dumped. For the current wetland operations in the Calcutta oil field, the excess cuttings and the remaining drilling mud are dumped at the drill site, since no significant impacts were predicted because of this practice.

When the oil sands are found, initial well tests are conducted to establish the production capacity of the well.
After drilling and casing the well, it must be 'completed'. Completion is the process in which the well is enabled to produce oil or gas. During this process completion fluid is used to avoid swelling of clays, which may cause the drill string to be stuck in the hole. For the current wetland operations in the Calcutta oil field, the brine consisting of chemicals and cuttings is dumped at the drill site, since no significant impacts were predicted because of this practice.

The production hole is first closed with preliminary tubing, after which a small electrical pump is placed to pump up the crude.
The produced crude will be transported through a system of flow lines, sub-headers and headers to the Transfer Station at Soekha Dam. From there the oil fluid will be routed to the TA-58 crude treatment Plant through a high-pressure pipeline.

In case the well is considered a 'dry hole', meaning not capable of producing commercial amounts of petroleum, the well is plugged with cement and abandoned.

Production data of each producing well is needed for efficient production optimization purposes and for reservoir/geological modeling. Therefore all production needs to be tested. Test units will be established at a number of locations within the field. For the first year five test units are projected. During the testing period oil is collected in the test tank from which samples are collected for laboratory analysis.

Field and well inspection and maintenance of production facilities will be conducted throughout the production phase of the oil field. Inspections are conducted at least 2 times a day with the objective to identify unsafe and potentially risky situations, and defects and failures of production facilities (including oil spills and leaks). Any unsafe and dangerous situation and all defects and failures are reported immediately and prompt action is taken.
During field inspection also corrosion measurements are performed. Based on the results pipe replacements can be made timely, thus avoiding spills due to corrosion.
Maintenance of the wells is done according to schedule by a maintenance crew with an airboat. It includes lubrication and replacement of broken or worn-out parts.
In certain wells a work-over may be necessary, especially in older wells. Such remedial work comprises pulling and replacement of tubing and screens. Work-over jobs on average have to be performed 10 times per year in a new field. After the first year this number will increase, due to the increasing number of wells.
During maintenance and work-over a boom is placed in the water around the well in order to contain any leaked oil. In case of leakage the leaked oil is removed according to the “oil spill clean-up guidelines”.

The current reserves of the Tambaredjo NW oil field are estimated to last until 2031, but wells will start to be closed earlier when they reach their economical limits. At that point they will be dismantled and abandoned. In this process, tubing is removed from the well and sections of well bore are filled with cement to isolate the flow path between gas and water zones from each other, as well as the surface. The casing of the well will be sealed 1.5 meters below ground level.
When the economic limit of the field is reached the remaining wells and the supporting facilities will be dismantled.

With respect to future use of the abandoned oil field there are two possible scenarios:

1. The area is abandoned and returned to nature, with or without intervention
2. There is a follow-up land use, meaning that part of the infrastructure can be maintained to be used by the next entrepreneur.

The latter is unlikely given that fact that no land allocation is permitted in most of the oil field. However, there may be a possibility for touristic, recreational or educational uses.

In case of abandonment all facilities will have to be removed and dams and roads will need to be breached in order to allow free flow of water.
Buildings, offices, steel and iron hardware and the electrical grid will be removed or demolished and all waste will be removed.

In case of future use parts of the infrastructure could be maintained, but this cannot be decided at this point.

Apart from activities that are included in the design and operation of the project, some unforeseen events could occur in relation to the project. The events that can be considered as risks that should be managed through appropriate emergency response procedures in the Staatsolie Emergency Response Plan or other regulations.
These events comprise:
1) Spills and leakages from tanks and pipelines and from equipment
2) Vegetation and peat fires
3) Boat collisions

Legislative framework

The northern part of the Tambaredjo NW oil field area is bounding the Coppename monding Nature Reserve, a listed Wetland of International Importance (RAMSAR site).
According to the Nature Conservation Act, for all human activities in nature reserves, a written permit is needed from the Head of the Suriname Forest Service. This act does not offer much space for activities that cause damage to or harm nature reserves.
By joining the RAMSAR Convention, the Coppename-monding Nature Reserve received the status of a Wetland of International Importance (RAMSAR-site). Internationally, the Government of Suriname committed itself to maintain the ecological character of the RAMSAR site, through a wise management approach.

The whole Tambaredjo-NW oil field is situated in the North Saramacca Multiple-Use Management Area (MUMA), an area that can also be considered as a buffer zone to the Nature Reserve.
One of the recommendations in the Integrated Coastal Zone Management (ICZM) Plan for North Saramacca is the requirement of an Environmental Impact Assessment (EIA) for all large-scale and/or high-impact developments in the vulnerable parts of the MUMA. Special (regional) MUMA management legislation in that respect has not been developed as a national EIA legislation has already been prepared by the National Institute for Environment and Development in Suriname (NIMOS). It is currently anticipated that it will receive presidential assent and be promulgated during 2010.

Although EIA legislation is not yet in place, this EIA was voluntarily initiated by Staatsolie and the project will be undertaken in accordance with the requirements of the Suriname environmental permitting process.

The notification and permitting process

The Tambaredjo-NW oil field is situated in the North Saramacca Multiple-Use Management Area (MUMA), an area that is considered as a buffer zone to the Nature Reserve.
Staatsolie has discussed the project activities and the terms of reference of the Tambaredjo NW EIA with the head of the Suriname Forest Service (LBB) and the head of the Nature Conservation Division (NB) of LBB.

One of the recommendations in the Integrated Coastal Zone Management (ICZM) Plan for North Saramacca is the requirement of an Environmental Impact Assessment (EIA) for all large-scale and/or high-impact developments in the vulnerable parts of the MUMA. Special

(regional) MUMA management legislation in that respect has not been developed because a national EIA legislation has not yet been promulgated.
By carrying out this EIA this recommended requirement is being effectuated.

The Tambaredjo NW production development project is a Category A project being a project whose impact may be sensitive, irreversible and diverse (NIMOS 2005). A full EIA is required.

The head of the Suriname Forest Service (LBB) and the head of the Nature Conservation Division (NB) of LBB will be further involved during the review of the EIA.

Brief description of the affected environment

The physical environment

Like in most parts of Suriname, consistently high temperatures and a high humidity characterize the study area with the main variation being rainfall and the associated cloud cover. The mean annual air temperature at Paramaribo is 27.3 º C, with a daily range of 7-10 ºC and with an annual range of about 2ºC.

The average annual rainfall in the northern part of Suriname predominantly ranges between 2,000 and 2,500 mm, which apply for most of the study area. However, in the northern part of the oil field the total rainfall is slightly lower. There are four seasons, based upon rainfall distribution.

Related to air quality, the study area is still in its natural state as hardly any sources of relevant air emissions are found in its vicinity.
Potential air pollution sources like the Staatsolie TA-58 Operations, vehicles, roads and rice farms are all at a considerable distance from the study area, while their air pollution is minimal and/or incidental. Within the planned oil field there are few small emission sources, like two test tanks and incidental airboat and swamp carrier passages. But generally speaking the air quality of the study area is good.

Except for an occasional airboat or swamp carrier passing through the center of the planned oil field, there are no man-made sources of noise in or near the area and noise levels under the pre-project conditions will hardly ever exceed unacceptable levels.

The study area is located in the Coastal Plain, which together with the Coastal Plains of French Guiana and of Guyana constitutes the margin of the large Guiana Basin. The study area is located in the flat and very low-lying Young Coastal Plain in an area dominated by clayflats. Some discontinuous, very narrow and usually very low ridges indicate former coastlines.

The study area is located in the zone with recent to very recent marine deposits. Sedimentation is currently active along the coast near the study area and predominantly accretion has occurred during the last decades.
The dominant soil type is a gray, half ripe to nearly unripe (soft) clay; the soils are nearly fresh to brackish in the subsoil. A thick layer (40-80 cm) of peat (pegasse) is present in most

of the oil field, except for the mangrove forest where only thin (<30 cm) layers of peat are found.

The study area is dominated by a zone of saline to brackish wetlands (4 -5 km wide) along the coast with extensive freshwater wetlands south of it. This freshwater swamp is known as the Buru Swamp (or Duivelsbroek Swamp). Most of the swamp area of the oil field is draining towards the sea, because the polders and the Gangaram Panday road block the water flow towards the Saramacca River in the south.
Only a minor portion of the swamp water is (indirectly) drained into the Saramacca River after having been taken in by rice farmers for irrigation of their crop and subsequent drainage.
For management purposes, the so-called "red line" has been created to serve as an arbitrary watershed boundary. In the study area, this line has been drawn halfway between the ocean and the Saramacca River.
The flow of clean fresh water from the Buru Swamp adds to the brackish environment in which mangrove forests along the coast (and in and outside the Coppename-monding Nature Reserve) flourish. Significant water flow only occurs during the peak of the rainy season.

Swamp water depths vary from 20-70 cm in the dry season to 90-120 cm in the rainy season. The deepest swamps are found within the Typha zone and the shallowest in the parwa zone.
Water flow is generally very slow due to the high hydrological resistivity of the vegetation and the peat. Within the trails and canals, flow can be much faster.

West of the TA-58 field two so-called "fish holes" have been dug up to the southern edge of the mangrove zone, the Poeran-canal and the Soekha-canal (that have created Poeran-dam and Soekha-dam). In the same area Staatsolie has constructed roads on top of the local low ridges. To some extent these structures will block the S-N water movement, but its impact is considered as to be minor.

Most of the project area has neutral to slightly acid water, with a low (oligohalinous) to moderate salinity (mesohalinous).

The biological environment

The study area is characterized by a vegetation succession from a saline mangrove to a freshwater environment. Along the coast, young Black Mangrove (parwa) develops as soon as mudflats are silted up above mean sea level. With the prevailing net coastal accretion a closed to open Black Mangrove belt has been developed. Within this belt some relatively small salt to brackish water lagoons have formed under specific conditions. The mangrove in the project area is of the blocked type, meaning that there is no longer an influence from the sea water. However, in the rainy season there is an outflow from this zone toward the northern mangrove forest.
South of the Black Mangrove belt, an herbaceous brackish water swamp (with or without scattered Black Mangrove trees) has developed on firmer soils on which a peat layer develops.
In the study area, Cat tails (Langagrasi) dominates these swamps. Grass and peat fires, which may occur during dry seasons, may prevent the development of any woody vegetation here.
Further inland, grass swamps become fresh and richer in species. Gradually a low to high, species-rich swamp wood may develop.
The oil field area is dominated by freshwater swamps with mostly mixed herbaceous swamps, interspersed with low to high swampwood, and herbaceous brackish water swamps.

The northern section of the oil field is covered by closed to open Black Mangrove forest. This covers only a small part of the oil field.

Two vegetation types with (potential) high international conservation value are present in the project area:

1) the black mangrove forest (parwa forest)
2) the high swampwood that forms an intergrade toward high swamp forest

At a national level, the mangrove vegetation along the coast contributes to the many goods and services the estuarine zone has to offer. Conversion of mangrove forest means loss of free coastal protection and reducing the high primary production of mangrove forest. Loss of mangrove forest reduces the secondary production of fauna, including ocean fish and shrimp.
Virtually all plant species in the area are confined to the Surinamese brackish water region, which means that they are found only in 1 % of the Surinamese land area, where many human activities are taking place and even are increasing.

The mudflats and the mangrove zone between the Coppename and the Suriname River are important feeding and nesting areas for residential coastal birds and the most important feeding and wintering ground for migratory birds from the north (including from Canada). The Saramacca coast hosts 13 bird species of international importance.
Almost every year breeding colonies of scarlet ibises and heron species are present in the young Black Mangrove forests along the Saramacca coast. The breeding seasons start between March and April and ends between August and September.
Seafood abundance is directly related to the extent of the local mangroves. Up to 90 % of marine fish and shrimp species are found in and near mangrove areas during one or more periods of their life cycle. High production of seafood is found in the near-shore habitats where small-scale fisheries are practiced: in the shallow sea, the river estuaries, tidal creeks, lagoons and brackish swamps. In Suriname, these ecosystems provide the local market with fish and shrimp. Also large-scale industrial deep-sea fisheries benefit from the nursery function of these ecosystems.
The ecosystems of the coastal zone of Suriname, with their abundant bird and fish life, contribute to the increase of local and international nature tourism and outdoor recreation and attract international and local researchers and students.
The national, regional and international importance of the coastal zone north of the Tambaredjo NW oil field can be summarized as follows:

- between 1955 and 1966 the area had the status of a local “Bird Sanctuary”.
- in 1966 the same area became a national “Nature Reserve” (Coppename-monding Nature Reserve);
- in 1989 it received the regional status of "Western Hemispheric Reserve" within the Western Hemisphere Shorebird Reserve Network (WHSRN). As such, the area is twinned with two protected areas in the Bay of Fundy in Canada;
- in 1985 it was declared a RAMSAR Convention Wetland of International Importance;
- in 2002 the area has been embedded in the North Saramacca Multiple-Use Management Area (MUMA) that may be considered as a buffer zone.

The mangrove forest in the northern project area is of the blocked type, which does not, or to a much lesser extent, contribute to above-mentioned goods and services. However, most of the Tambaredjo NW oil field is located in the buffer zone.

Within the studied parts of the area, swamp fishes are dominating. No unique, rare, endangered, vulnerable or biogeographically important fish species are present.
The same holds for the birds.

The socio-economic environment

The only inhabited areas on the right bank of the Lower Saramacca River are located along (parts of) the Gangaram Panday Road. The population here lives far from the Tambaredjo NW area.

Except for the activities of Staatsolie, other human presence in the project area is absent.

All agricultural land is situated in the southern half of the Buru Swamp, with paddy rice being the dominant crop. In the past the agricultural activities have been affected by Staatsolie activities, but all problems have been solved.

Management of protected areas (nature reserves and MUMA's) with a natural protection and/or natural production function can be considered as the only form of land use in the study area.

Two so-called "fish holes" are present east of the study area, the Poeran-canal and the Soekha-canal. These canals are connected to the northern edge of the Poeran and Soekha rice farms in the south, and they are used to provide irrigation water for rice production. These canals are also used to catch fish in the dry season. Also other farmers catch swamp fish in the dry season along the northern edge of their farms and in their farm canals.
The canals are crossing the project area, but as it is not allowed to withdraw water from the swamp north of the "red line" they can not officially be used to supply irrigation water.

No archaeological sites are known within the study area.

No places of special historical interest are found within the study area.

Summary of key impacts

An overview of all impacts, including those of low significance, has been presented in the main report.
The major and moderate impacts and their prevention and mitigation measures are listed in below tables.

Summary of the potential major impacts

COMPO-NENT	DESCRIPTION	PREVENTION AND MITIGATION MEASURES	RESIDUAL IMPACT
Noise	Noise impacts on breeding colonies	• Select the quietest and most effective equipment available, also for the drilling rig. • When possible: use the Gator-tail boats instead of airboats. • When using airboats: operate at a moderate speed (2500 RPM) to reduce noise levels, if conditions allow such. • Plan activities in the northern section of the oil field in the October – March period, when the likelihood of breeding colonies is lowest. • In case work in the northern part of the oil field is planned for the May-September breeding season an aerial survey should be conducted in early May[1], to determine the locations of eventual breeding colonies in and near (within 1 km of the boundary) the project area. This survey should be conducted every year once this section is developed. • In case breeding colonies are present within 1 km from the oil field boundary no development activities in this zone should be conducted during the breeding period and monitoring and maintenance activities should be conducted with Gator-tails at a low noise-level. • Furthermore the number of transportation trips in the area in a radius of 1 to 2 km from breeding colonies should be limited to the minimum during the breeding season	negligible
Surface water resources	Changes in the hydrology of the Buru Swamp due to blockage of water	• See measures proposed for <u>Vegetation changes due to changes in hydrology</u> (below)	negligible
Vegetation	Loss of Black Mangrove (Avicennia) forest	• Limit the footprint of disturbance to the minimum through optimized planning and the use of the smaller caterpillar rig instead of the Hover rig. The required clearing for these rigs is respectively 29% versus 47% of the development areas.	moderate
	Loss of High Swampwood		moderate
	Vegetation changes due to changes in hydrology	<u>Construction phase:</u> • Provide dams with sufficient and adequately openings (cuts) in between. The current practice at the Calcutta oil field appears to be adequate and can be maintained, unless monitoring proves differently. The current practice is the creation of a 1 meter wide opening every 500-1000 m and a number of larger openings (up to 70 meters) at places where other trails are connecting.	negligible

[1] By then most breeding colonies will have settled; a survey in April is too early.

		Operation phase: • Conduct monitoring to the functioning of the system, as openings may easily be clogged by vegetation or caving in. Conduct more frequent monitoring directly after heavy rainfall, when the chance of increased water levels is highest. Preferably, the monitoring should be automated. • In case water flow blockage is occurring: check whether the dam openings are properly functioning and clear when necessary. In case water blockage is not caused by clogging: double the number of openings in the dams. Closure phase: • level or breach the dams, unless management is taken over by another party (e.g. tourism development)	
	Loss of ridge wood and ridge forest, also as a habitat	• do not project large trails and infrastructure on top of, or near ridges; keep a distance of 50 meters at least • in case of south-north dams: project such trails, as much as possible, in open spots in between ridges • if passage of a ridge cannot be avoided: keep the clearing width limited to the bare minimum	negligible
	Damage to ecosystems and to the Tambaredjo NW development project, due to fires	• develop a fire contingency plan • develop and implement strict fire control procedures and measures; measures could include that the vegetation of the Poeran and Soekha dams is kept low and that in the dry season all debris are removed, thus creating a fire break • implement a fire risk awareness program for Staatsolie personnel and contractors working in the Tambaredjo NW area • discuss the risks of vegetation and peat fires to Staatsolie personnel, materials and equipment in stakeholders meetings and organize special meetings during extremely dry periods to point out the fire risk again • conduct fire patrols in extremely dry periods	negligible
Nature conser-vation	Disturbance or damage to the Coppename monding Nature Reserve	• See all above proposed measures	negligible

Summary of the potential moderate impacts

COMPO-NENT	DESCRIPTION	PREVENTION AND MITIGATION MEASURES	RESIDUAL IMPACT
POTENTIAL MODERATE NEGATIVE IMPACTS			
Visual	Loss of visual quality due to project	• No mitigation measures possible	moderate
Vegetation	Loss of herbaceous swamp vegetation	• No mitigation measures possible	moderate
Fauna	Decrease of animal abundance.	• Minimize the footprint of disturbance of the project. • Develop the forested areas in such a way that fragmentation is minimal and inter-connection of residual parts optimum. An ecologist should be consulted during planning. • Impose the Calcutta Waterway Regulations also for the Tambaredjo NW oil field. • Restrict access to non-working areas within the project area to authorized personnel only. • Continue to impose a ban on wildlife harvesting at the Tambaredjo NW oil field for all Staatsolie personnel, contractors and authorized visitors. • Undertake a continuous environmental awareness and education program for Staatsolie employees focusing on the importance of minimizing harm to the environment.	minor
Surface water resources	Changes in the hydrology of the Buru Swamp due to increased discharge	• Limit the number of south-north trails in the mangrove forest zone • Limit the width and depth of trails in the mangrove forest zone to the minimum • Plan east-west trails in the northern section of the field preferably in zones with herbaceous vegetation (Typha) which provides a buffer for rapid water flow • In case trails are constructed in the mangrove forest where open outflow is possible, these should be provided with low clay dams along the sides and a closing dam at the northern end. These dams will prevent that water from the trail network to the south is flowing directly into the mangrove. No dams should be made where herbaceous vegetation (Typha) is present. • These measures are only applicable for the zone with a mixture of closed and open parwa forest interspersed with Typha swamp.	negligible

Land use	Loss of rice yield due to impact on the irrigation water supply and/or quality	• Locate trails in such a way that no water pollution, including increased turbidity, of canals is possible. In practice this means that there should be no open connection between the project trails and the canals. A vegetated strip of 50 meter[2] between the Poeran Canal and nearby trails is considered sufficient to block potential pollution with suspended solids (turbidity) and oil.	negligible
POTENTIAL MAJOR POSITIVE IMPACTS			
Vegetation	Return of vegetation during and after closure	• No enhancement measures are yet to be foreseen, as this development will only take place over 20 years from now.	moderate
POTENTIAL MODERATE POSITIVE IMPACTS			
Visual	Improvement of visual quality after closure	• No further enhancement possible	
Socio-economics	Increased employment opportunities	• No further enhancement possible	moderate

[2] During the current study it has been observed that suspended solids penetrate 25 m at most in the vegetation along trails with turbid water.

An Environmental Management Plan (EMP) has been drafted which includes above management measures, but apart from that also other measures are presented for minor impacts aiming at further improvement of environmental management.

As part of the EMP a framework for environmental monitoring has been drafted. This program presents monitoring requirements in addition to already existing Staatsolie monitoring activities and inspections. The program is shown below.

Based on the above framework a separate EMP was prepared, to be used for environmental project management.

Aspect	Parameters	Frequency	Monitoring locations
Noise	Check on proper maintenance of transport vehicles and equipment	Monthly	
	Sound measurements equipment and drilling (repeat baseline measurements)	Once	On location
	Check on use of airboat and speed level	Daily	Noise buffer zone, once northern oil field developed
Hydro-logy	Swamp level by staff gauges that have been adjusted to the same level – no essential differences should be present N and S of dams (automated recording should be considered)	Weekly in the rainy season; daily after heavy rainfall (>20 mm)	North and south of all E-W running dams
	Swamp water level reference monitoring with divers	Continuous	To be decided after field lay-out is known in detail.
	Swamp water flow velocity (to be conducted by WLA - Hydraulic Research Department)	Every long rainy season	All trails in the northern section of the oil field (2km from boundary), once developed
Water quality	EC or chlorides[3], TSS	Monthly	1. Poeran Canal, south of the oil field 2. At three locations along the boundary of the NR[4]. 3. Mangrove forest north of the oil field (e.g. sampling point 17 in existing trail) 4. Soekha dam landing 5. Wells drilled in this months – edge of drilling location and 10 meter into surrounding swamp
	Check for oil spills and oil films	Daily	Oil field
Vegeta-tion	Width and location of trails in forested parts – according to design	Directly upon completion of trails	Mangrove forest, high swampwood and ridge vegetation
Bird colonies	Location in early May (aerial survey) – with proper planning this could possibly be included in the routine program of the Nature Conservation Division of LBB	Once every year	Mangrove zone of the oil field and to the north of the oil field up to the ocean
Waste	Check if landing sites and station yards are clean Check proper storage of waste Check proper disposal of waste Log on waste	Daily weekly weekly daily	All working locations

[3] For the water of the Buru Swamp the following relation has been found: EC [µS] = 2.95 x Cl [mg/l]. The standards for chloride are 600 mg/l (average), 1200 mg/L (maximum). Expressed into EC this becomes 1765 and 3540 µS respectively. For the Typha swamp and the Parwa zone higher figures are allowed (see Ch. 2.4.3.4).

[4] Only after the northern oil field section has been developed. Before that time monitoring can take place at 3 of the most northern locations that is accessible (e.g. near test tanks and north of the Ritsweg).

ENVIRONMENTAL

IMPACT ASSESSMENT

1 INTRODUCTION

1.1 GENERAL

This report presents the results of the Environmental Impact Assessment (EIA) for production development in the Tambaredjo North-West (NW) oil field. The Tambaredjo NW oil field is located within the area where concession rights for petroleum activities are granted to Staatsolie.
The production development project entails the preparation and implementation of required facilities to accommodate production from the Tambaredjo NW oil field, its production and the decommissioning of the area.
Staatsolie Maatschappij Suriname N.V. (hereafter shortly indicated as 'Staatsolie' will execute this production development project. This company aims to start full-scale production development in end May 2010. The oil field will be developed over a period of 5 years and crude production is currently foreseen to last at least 16 years.

One of the required production facilities is a Transfer Station that will route the oil emulsion from the Tambaredjo NW oil field to the TA-58 crude treatment plant through a high-pressure pipeline. The construction of this facility and ancillary works has started in mid 2009 in order to be completed in time when crude oil production starts. Therefore, a separate environmental assessment was prepared for the construction of this Transfer Station and a permit was granted by NIMOS on April 27, 2009.
The current EIA deals with the remaining project as described below in Ch. 4.

This EIA for the project has been prepared to conform to the EA guidelines of the National Institute for Environment and Development in Suriname (NIMOS, 2005).

1.2 BACKGROUND

Staatsolie has the right to explore for and produce hydrocarbons in Suriname. Currently all crude oil production activities are executed within the Tambaredjo and the Calcutta oil fields (Figure 1).

The Tambaredjo oil field is situated in the district of Saramacca about 55 km west of Paramaribo and about 15 km inland from the coastline. In the Tambaredjo oil field, "dryland operations" are practiced. This type of operations mainly refers to the reclamation of the swamp whereby the area is drained before drilling and production activities can take place.
The Calcutta oil field is situated north of the former plantation Huwelijkszorg, about 20 km west of the Tambaredjo oil field. The Calcutta oil field is a "wet operation", which takes place without impoundment of the area.

All produced crude oil from both oil fields is treated and stored at treatment facilities of Catharina Sophia, Josikreek and TA-58. After treatment, the oil is transported by means of a 14-inch pipeline to the refinery and sales terminals at Tout Lui Faut. Part of the refinery production is transported by pipeline to the SURALCO aluminum refinery at Paranam.

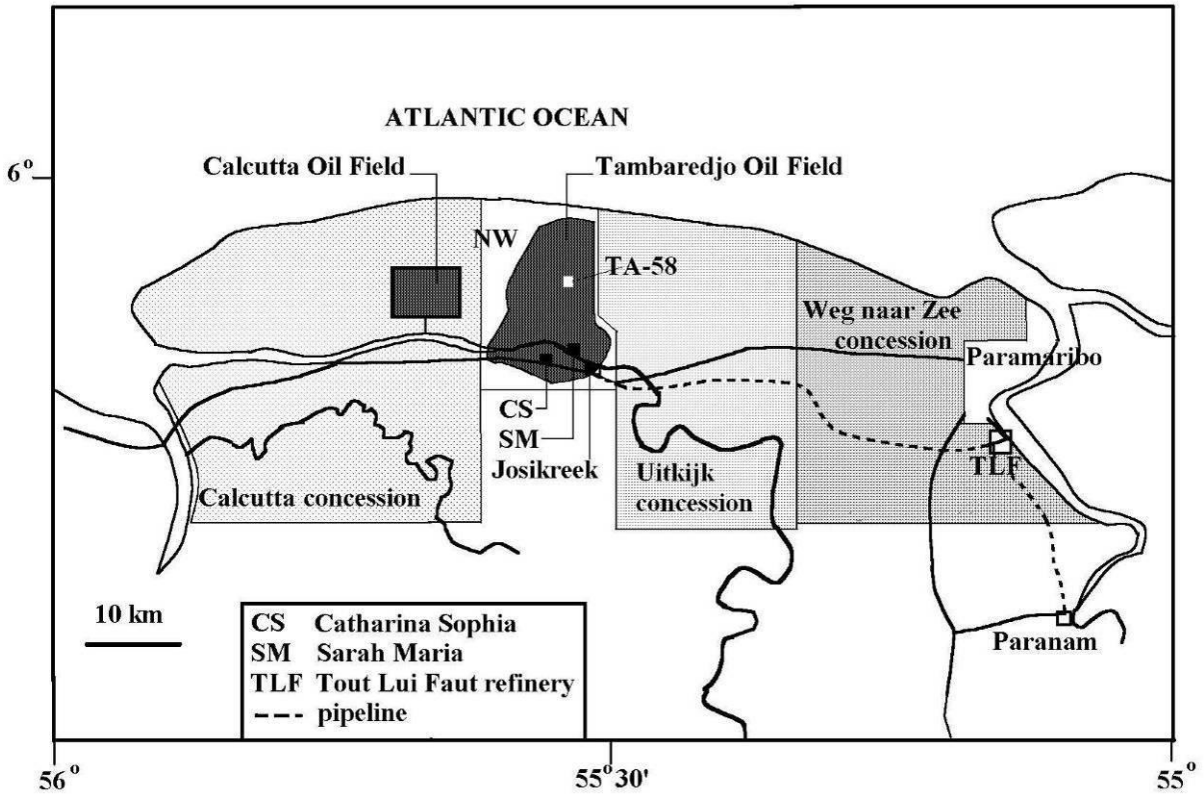

Figure 1: Location of Staatsolie production, treatment and delivery activities

In 2005, commercial oil occurrences were encountered in the Tambaredjo NW area. In order to expand Staatsolie's crude production, the new Tambaredjo NW oil field must be taken into production. The full-scale production development will start in end May 2010 by practicing "wet operations" based on a two-rig operation. Conventional drilling techniques will be applied, entailing the drilling of vertical wells. A Transfer Station will be constructed at the corner of the Noorddamweg and Soekhadamweg, from where the crude oil will be transferred to the treatment facilities of TA-58.

1.3 THE TAMBAREDJO NW PROJECT AND STUDY AREA

The description of the project area is based on the drawing "Field lay-out of the Tambaredjo NW oil field", dated October 10, 2008. This drawing shows the actual planned oil field and ancillary facilities. The oil field and the location of the ancillary facilities form the project area.
Certain impacts like noise, air- and water pollution, and hydrological changes could extend beyond the boundaries of the project area and therefore the study area is more extensive than the project area. The project and study area are shown in Figure 2. The boundary of the study cannot be precisely determined and has been chosen arbitrarily, but with wide enough margins to ensure that impacts will not extend beyond the area. A part of the Calcutta oil field has been included because here several measurements are being done to obtain baseline information on wetland oil field characteristics, as these will be applicable for the Tambaredjo NW oil field. The Tambaredjo NW oil field project area covers 23 sq km and the study area has a surface of approximately 150 sq km.

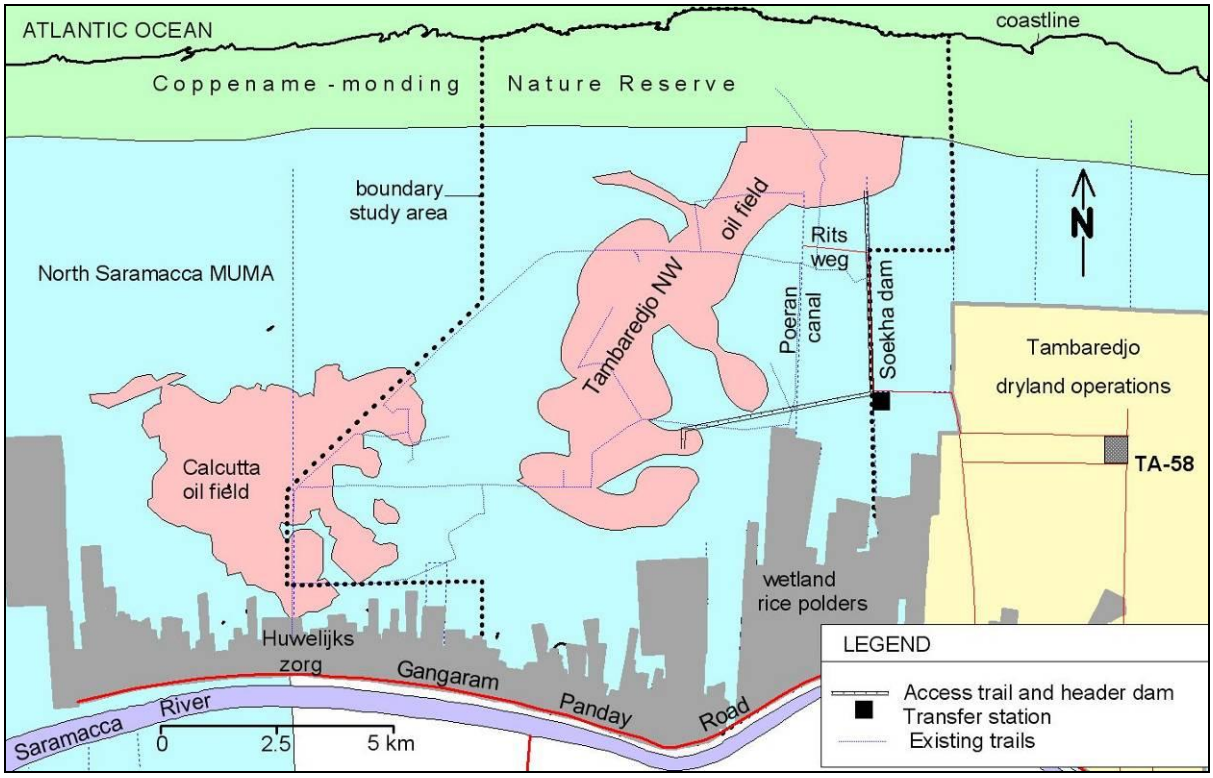

Figure 2: The Tambaredjo NW project and study area

1.4 EIA OBJECTIVES

The main objectives of the Tambaredjo NW Environmental (and Social) Impact Assessment (EIA) are:

1. to identify potential environmental and socio-economic impacts associated with oil production activities in the Tambaredjo NW area including:
    - construction of landing stages, facility grounds, roads, dams, equipment trails, drilling sites and the Transfer Station in the project area
    - exploitation drilling activities
    - crude oil production and transportation
    - monitoring and inspection activities
    - abandonment of the project area

2. to provide preventive, mitigation and decommissioning measures for these impacts

3. to assess residual environmental and socio-economic impacts after implementation of proposed mitigation measures

The preparation and acceptance of the EIA report should ensure that environmental obligations are met as well as other relevant guidelines and regulations, so that the project will be conducted in an environmentally sustainable manner to meet both national and international accepted standards.
In the absence of national legislation regulations, the "Environmental Assessment Guidelines" set out by NIMOS (National Institute for Environment and Development in Suriname), the Ramsar guidelines for Environmental Impact Assessment for activities within

wetlands and the World Bank Source Book for Environmental Assessment are used as guidance documents.

The current report does not deal with the construction, operation and abandonment of the Transfer Station, which activities have already been discussed in a separate report (Noordam & Teunissen, 2009).

1.5 METHODOLOGY

A Preliminary EIA has already been prepared for oil exploration in the Tambaredjo NW area (Noordam & Teunissen, 2006). This study included a baseline study that was based upon existing sources and additional field information collected in the study area. The existing information comprised data collected in the neighboring swamps of Tambaredjo (IBT, 1999) and Wayambo (E2 Canada et al., 2000; Teunissen et al., 2000; Teunissen & Noordam, 2001).

NIMOS has used the Tambaredjo NW PEIA to screen and scope the production development project. In April 2008, Staatsolie placed a public announcement in the local newspapers inviting stakeholders to submit their concerns and to add any other issues that should be addressed by the EIA. Following this stage, the Terms of Reference for the current EIA have been formulated and approved by NIMOS on May 30, 2008.

For the description of the baseline, information from the Tambaredjo NW PEIA has been used, supplemented by information that has been collected during baseline studies for the Tambaredjo NW production development EIA. Details will be provided in the respective chapters.

The methodology for impact assessment as well as the methods used to gather baseline data have been approved by NIMOS on July 29, 2008.

Some of the sub studies have gathered much detail during the baseline phase. In order to keep the main report readable, it was decided to present separate reports on:

Water resources – M.A. Amatali, 2009
Aquatic resources – J.H. Mol, 2009
Noise – B. Tan, 2009

These reports should be available together with the EIA report for consultation on background details.

2 LEGISLATIVE AND REGULATORY CONSIDERATIONS

2.1 NATIONAL ENVIRONMENTAL LEGISLATION AND GUIDELINES

Although Suriname has not yet promulgated an Environmental Act as such, elements of environmental protection and the conservation of biological resources can be found in other legislation.

General environmental rules and regulations for undertakings are provided by the Hindrance Act.
Current environmental rules and regulations, directly relating to the project, are found in the Mining Decree and the Petroleum Act. Because the Tambaredjo NW area is located within the North Saramacca Multiple Use Management Area and directly south of the Coppename-monding Nature Reserve, also the Resolution "Establishment North Saramacca Multiple-Use Management Area" and the Nature Preservation Act are applicable.

2.1.1 The Hindrance Act

(G.B. 1930 no. 64, lastly amended in G.B. 1972 no. 96)

The aim of this act is to prevent the cause of danger, damage or hindrance caused by undertakings (enterprises) to the outside-fence surrounding environment. According to the Hindrance Act, all new undertakings need a written 'Hindrance Act Permit' ('Hinderwet-vergunning') issued by the District Commissioner who has to seek advice from the Bureau for Public Health, the Department of Labor Inspection, the Head of the Fire Department, NIMOS etc. A permit is given on terms that may include environmental requirements. In case of outside-fence hindrance caused by air pollution and noise, soil and water pollution and generation of solid or liquid waste, this act can be enforced. However, the act does not include detailed regulations and/or standards for these components.
This act could be applicable for the construction of certain fixed facilities like the transfer C&T) station and sub-stations, but an EIA procedure provides better guarantees that no hindrance is caused by the activity. The issue has already been dealt with in the EIA for the C&T station.

2.1.2 Mining Decree, E-58

Environment-related articles in the Mining Decree are:

- *Article 4, sub. 1: "during the mining operation all mining activities should be carried out ... applying the most modern international techniques ...professionally making use of advanced technology and appropriate materials taking into account current requirements regarding safety and health... including requirements to protect the ecosystems".*

- *Article 16, sub 1: "after closure of the mining concession the holder of the right will, to the satisfaction of the Minister (of Natural Resources) take all necessary measures in the interest of public safety, the conservation of the deposit, the rehabilitation of the land concerned and the protection of the environment".*

- *Article 30 sub 2: "the application for a mining concession should be accompanied by a Plan of Operations for the rehabilitation of mined out land". This article is also covered by the Petroleum Act, Article 7 sub 2 (see below).*

2.1.3 Petroleum Act

(S.B. 1991 no. 7, lastly amended in S.B. 2001 no. 58)

Environment-related articles in the Petroleum Act are:

- Article 7, sub 1, states: "*for the performance of petroleum activities, due account should be given to the prevailing legal regulations, to build, establish, maintain and use all facilities that are necessary or advantageous for the proper performance of the petroleum activities*". This suggests, that due account should be given to all the existing regulations dealing with the environmental aspects of building, establishment and maintenance of all such facilities.

- Article 7, sub 2, states: "*upon termination of the petroleum activities on state land the land should return to its original condition insofar as reasonably possible*".

- Article 28, sub c, states that further rules may be laid down by means of State Decrees (which do not exist).

2.1.4 Nature Conservation Act

The Nature Conservation Act of 1954 provides the legal basis to protect wildlife and important natural areas on state-owned land by means of designating them as nature reserves. Since then, 11 nature reserves and 1 nature park were established, covering some 10% of the land surface of Suriname.

By Resolution (GB 1966, no 59) the "bird sanctuary", established in 1953 east of the Coppename River mouth, received the status of 'nature reserve" and was named "Coppename-monding Nature Reserve". The reserve has been established for the purpose of research, nature education and tourism.

The northern boundary of the Tambaredjo NW area is directly bordering the Coppename-monding Nature Reserve.
Due to the short distance between the projected oil field and the nature reserve, the following articles of the Nature Conservation Act could become relevant:

- Article 3 states: *The general management and control over the nature reserves rest in the hands of the Head of the Suriname Forest Service, who in turn gets advice from the Nature Preservation Commission. This Commission consists of at least 7 members. In official capacity the following members sit on the Commission:*
  1° The Director of Agriculture;
  2° The Head of the Suriname Forest Service;
  3° The Entomologist of the Agricultural experimental station;

4° The Head of the Geological Mining Service.
The remaining members, from which at least one is a District Commissioner, are appointed and dismissed by the President. The President chooses the Chairman and the Secretary from among the members. As far as it is needed, a local manager is appointed for every nature reserve.

- Article 5 states: *In a nature reserve it is forbidden:*
  a. To either deliberately, or through negligence, damage the soil conditions, the natural beauty, the flora and fauna, or to perform any action which destroys the value of the reserve;
  b. To camp, to light fires, cut trees or burn coal, except with the written permission from the Head of the Suriname Forest Service, and with due observance of the therein stated conditions;
  c. To hunt, fish or to have in possession, except with a license from the Head of Suriname Forest Service, a dog, a firearm, or other hunting or capturing equipment.

- Article 7 states: *The Head of the Suriname Forest Service can give written permission to special persons corresponding to a plan approved by him to carry out a business in an area of the nature reserve which is not closed off, or to co-operate with the establishment of a business concern, with explicit conditions that no damage or detriment whatsoever is done to the nature reserve by these people or their businesses.*
  The Head of the Suriname Forest Service can give a written license to certain persons under certain explicit conditions laid down by him in certain specific areas of the nature reserve to gather forest and forestry by-products, put cattle out to pasture, or to fish.

It is clear that the law does not offer space for activities that cause damage to or harm nature reserves.

2.1.5 Resolution Establishment North Saramacca MUMA

Along the coast of the Coppename-monding Nature Reserve, economic activities such as shipping and navigation, oil exploitation, fisheries, hunting and recreation are increasingly threatening the integrity of the reserve. South of the reserve, wetlands exist that provide the mangrove belt with the freshwater necessary for its vitality. In that southern area, economic activities are increasingly taking place, such as the extraction of irrigation water for rice cultivation, extension of polders into the wetlands for rice cultivation and oil field development (Teunissen, 1995). With the improved accessibility of the southern area, also hunting, fishing and poaching are increasing.

As all mentioned developments became a serious threat to the coastal zone, the Ministry of Natural Resources requested the Forest Service to design Integrated Coastal Zone Management (ICZM) Plans for the entire coast, including the North Saramacca area. The proposed Management Plan for North Saramacca (Teunissen, 2000) recommends (among others) embedding of the Coppename-monding Nature Reserve in a Multiple-Use Management Area (MUMA), where special rules and measures can prevent destruction of the protective and productive functions of the vulnerable coastal ecosystems. In 2001, the management plan for the North Saramacca MUMA was approved by the Nature

Conservation Division of the Suriname Forest Service and in 2002, the Ministerial Resolution to establish the MUMA was published in the State Gazette (Staatsblad 2002, no 88). By this Resolution, all state-owned land of the North Saramacca area was placed at the disposal of the Minister of Natural Resources. Mandate was give to Nature Conservation Division (NB) of the Suriname Forest Service (LBB) to manage the area as a Special Management Area ("Bijzonder Beheersgebied"). Since the establishment of a new Ministry of Spatial Planning, Land and Forest Management (RGB) in 2005, the Forest Service resorts under this Ministry.

The Coppename-monding Nature Reserve and the North Saramacca MUMA are both shown on the Map of the State Surveyor, attached to the above-mentioned Resolution (see Figure 3).

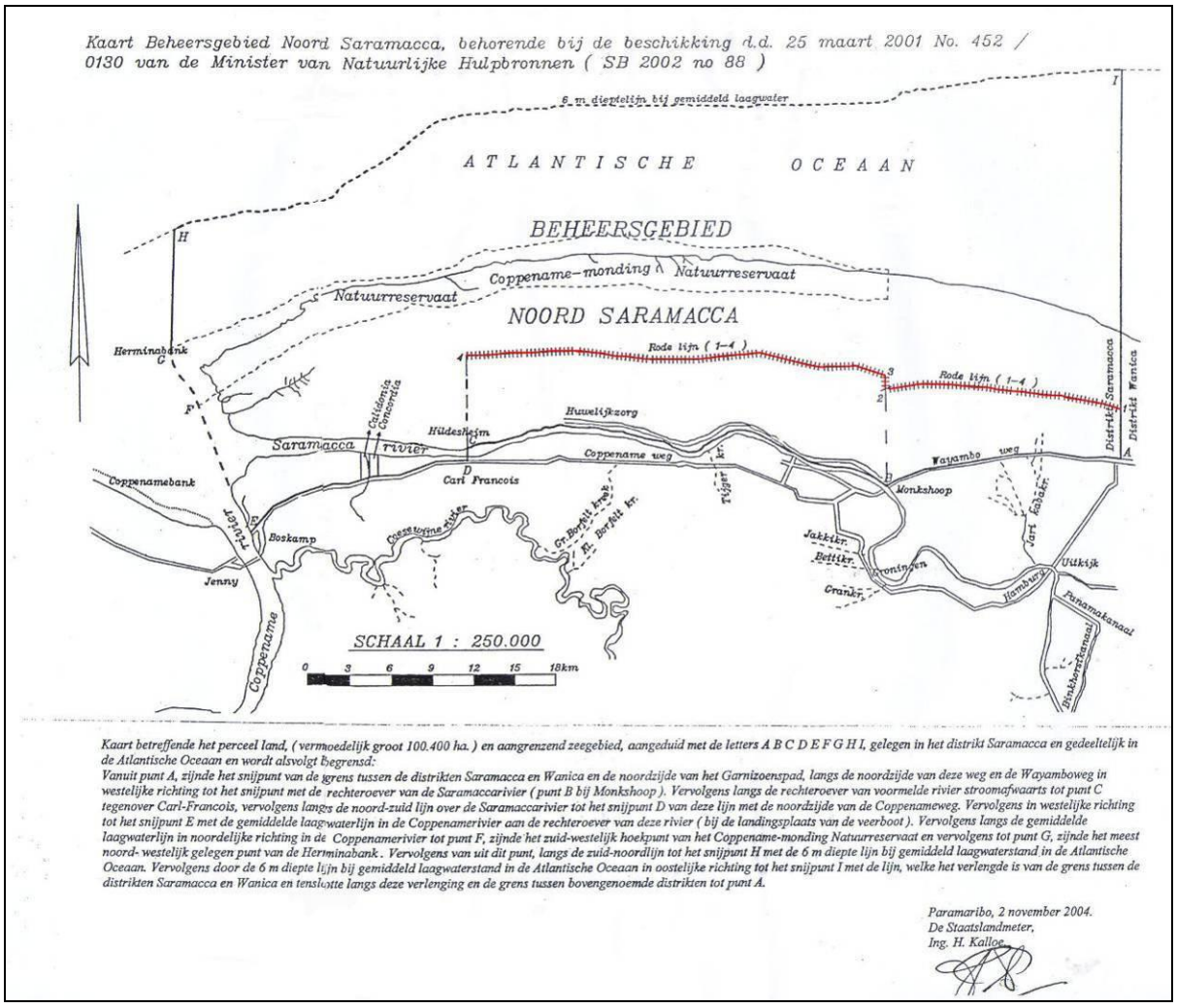

Figure 3: State Surveyor Map of the North Saramacca MUMA and Coppename-monding Nature Reserve

2.1.6 Resolution Land Allocation in Coastal Zone Management Areas

The first measure to accomplish Integrated Coastal Zone Management (ICZM) is the issuance of the Ministerial Order “Land Allocation in Coastal Zone Management Areas”, published in

the State Gazette (S.B. 2005, no 16). According to this Resolution, in the area between the Atlantic Ocean and the Lower Saramacca River, land allocation is not longer[5] possible in the northern part of the area, between the ocean and the (defined and mapped, "red line" ("rode lijn"; see Figure 3), being the imaginary boundary line between the seaside and the riverside drainage basins. Apart from coastal protection and sustainable production, the area is also acting as a buffer zone of the Coppename-monding Nature Reserve.
This buffer zone was first indicated in a letter of December 4, 1973 of the Director of the Ministry of LVV. In this letter, he advised the Head of the Bureau of Lands not to grant requests for land and concessions beyond the watershed boundary between the Saramacca Right Bank Drainage Basin and the Ocean Drainage Basin in order to prevent destruction of the estuarine ecosystems along the coast. Since that time, this boundary line is marked in red ("red line") on the maps of the Bureau of Lands.
Land allocation is still allowed in the southern part of the area, south of the "red line', but with the restrictions that (1) water extraction from the seaside drainage basin is not longer allowed, and (2) excess rainwater should be drained into the Saramacca River. The projected Tambaredjo NW oil field is within the North Saramacca MUMA with the major part north of the "red line" (Figure 11). In article 1B of the Ministerial Order "North Saramacca Special Management Area" it is stated that the Ministerial Order Land Allocation in Coastal Zone Management Areas" is not applicable for concession areas. As can be deduced from above restrictions, the purpose of the buffer zone is mainly to make sure that activities in the southern area do not affect the hydrology and the water quality of the estuarine zone along the coast.
It will be clear that also activities within the oil concession area should not influence hydrology and water quality of the buffer zone.
Figure 4 presents the above described.

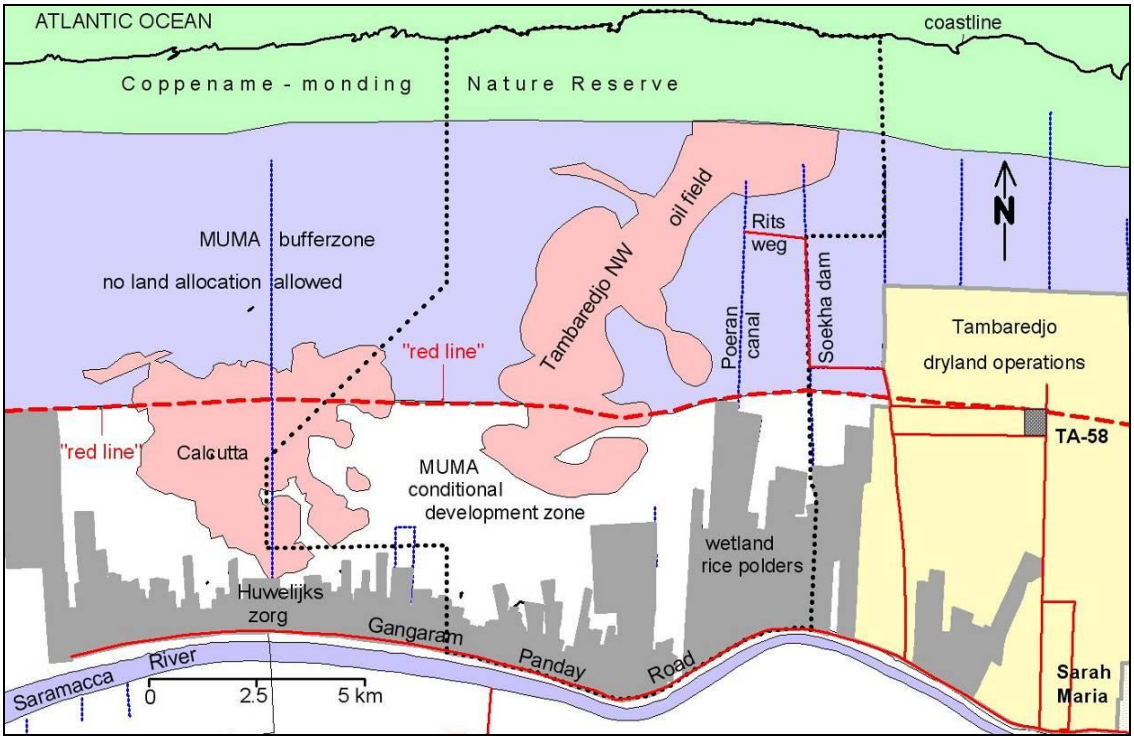

Figure 4: Zones according to the Resolution Land Allocation in Coastal Zone Management Areas

[5] Land that was already issued at the date that this Resolution came into force, is not part of this Resolution

2.2 LEGISLATION DRAFTED BY NIMOS

By Presidential Decree of March 1998, the "Nationaal Instituut voor Milieu en Ontwikkeling in Suriname" (National Institute for Environment and Development in Suriname, or NIMOS) was established as an autonomous government entity (a "Foundation") and since May 1999 NIMOS has been operating with a General Director and staff.

NIMOS is responsible for the preparation of national policy and legislation designed to protect the environment, and to monitor compliance with national environmental laws and regulations.

The General Director of NIMOS implements his/her responsibilities through five Offices, one being the Director's and Administration Office, and the other four being technical offices of a cross-sectoral nature: (1) Environmental and Social Assessments; (2) Legal Services; and (3) Environmental Monitoring and Enforcement; and (4) Education and Public Outreach.

NIMOS is a technical working arm of the Ministry of Labor, Technological Development and Environment (ATM).

2.2.1 Draft Environmental Act

NIMOS drafted an Environmental Act in 2002 to lay down rules for the conservation, management and protection of a sound environment within the framework of sustainable development. The Act has been prepared in draft and has already twice received comments from the Council of Ministers. The comments concern ministerial responsibilities in the context of the Act, but they do not affect the issues discussed below. The Act is now before the Council of Ministers and upon approval it will go to the Council of State and the National Assembly, the principal governing bodies of Suriname.

The Environmental Act has a number of key provisions, which:

- allow for the creation and implementation of a comprehensive environmental policy and planning process
- establish the importance of environmental protection and parity with all other considerations
- establish an Environmental Authority, which will become the primary environmental agency in Suriname; NIMOS will be the Environmental Authority
- give effect within Suriname to many internationally-accepted principles of Environmental Law, including the principle of precaution, the polluter pays principle and the concept of environmental impact assessment
- introduce and give effect to the Environmental Impact Assessment Guidelines (see below)
- enshrine the principles of access to information, participation and legal protection for the Surinamese public
- allow for the introduction of suitable regulations to address specific issues of environmental protection; and establish a framework for enforcement of environmental legislation and regulations, together with penalties

2.2.2 Environmental Impact Assessment Guidelines

In July 2003, the Office of Environmental and Social Assessment of NIMOS published draft guidelines to Environmental Impact Assessment in Suriname, referred to hereafter as the EA Guidelines. Following consultation with interested parties (including Staatsolie) and review of comments, these guidelines were finalized in early 2004 and approved on March 2005. The EA Guidelines will be given effect by the Environmental Act, once it has been promulgated.

The EA Guidelines were prepared as a guide for project sponsors, but are also intended to provide Surinamese Government officials with advice on evaluating and assessing the adequacy and suitability of EIA reports submitted in support of project permit applications.

The EA Guidelines cover the following aspects:

- project screening;
- classification of Projects;
- scoping guidelines;
- structure of EIA reports; and
- EIA report review process, including criteria for review and compliance checklist.

Although neither the Environmental Act nor the EA guidelines have any legal status yet, project developers are expected to comply within the spirit of the guidelines.

The guidelines allow for classification of projects into several categories, dependent on the adjudged potential for environmental damage:

Category A
Projects having adverse effects that may be sensitive, irreversible and diverse. The extent and scale of the environmental impacts can only be determined after thorough environmental assessment. Mitigation measures can only be taken after the results of the assessment are known.

Category B
Projects where the severity of potential impacts depends on the sensitivity of the location, scale and predictability.

Category C
Projects that have no significant impacts or where the effects are well known, predictable, are small in scale and can be mitigated.

Although NIMOS did not yet develop guidelines for oil and gas exploration and production, the Tambaredjo NW oil field development project can be considered as a Category A project, being a project whose impact may be sensitive, irreversible and diverse (NIMOS 2005).

2.3 INTERNATIONAL CONVENTIONS AND TREATIES

Suriname is party to a number of international conventions. Although these international conventions are not always incorporated in national legislation, they have been and still are significant drivers behind the development and promulgation of dedicated environmental legislation. Some relevant conventions will be briefly discussed below.

2.3.1 The Convention on Biological Diversity

The Convention on Biological Diversity, known informally as the Biodiversity Convention, is an international treaty that was adopted at the United Nations Conference on Environment and Development (UNCED), informally known as the Earth Summit, in Rio de Janeiro in June 1992. The convention has been ratified by Suriname in 1996. In 2006, a National Biodiversity Strategy has been compiled as framework for a National Biodiversity Action Plan.
The Convention has three main goals:

- conservation of biological diversity (or biodiversity)
- sustainable use of its components; and
- fair and equitable sharing of benefits arising from genetic resources

In other words, its objective is to develop national strategies for the conservation and sustainable use of biological diversity. It is often seen as the key document regarding sustainable development.
One of the many issues dealt with under the convention includes the execution of environmental impact assessments.

2.3.2 Convention on Wetlands of International Importance

(also indicated as the RAMSAR Convention)

On March 18, 1985, the Republic of Suriname became a contracting party to the Convention on Wetlands, signed in Ramsar, Iran, in 1971. The RAMSAR Convention is an intergovernmental treaty, which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 150 Contracting Parties to the Convention, with 1590 wetland sites, totaling 134 million hectares, designated for inclusion in the RAMSAR List of Wetlands of International Importance.

By joining the RAMSAR Convention, the Government of Suriname committed itself among others to:

- maintain the ecological character of (potential) RAMSAR sites, through a wise management approach
- include wetland conservation within its national land-use planning, so as to promote the wise use of all wetlands within its territory
- establish nature reserves as wetlands, whether or not they are included in the "RAMSAR List of Wetlands of International Importance"

- arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference

At the occasion of joining the RAMSAR Convention, the National Nature Conservation Commission (NBC) of Suriname was assigned as the Scientific Authority for the RAMSAR Convention, while the Head of the Suriname Forest Service (LBB) was assigned as the Management or Administrative Authority. LBB's Nature Conservation Division (NB) was then appointed as responsible for the implementation of last mentioned function. At the same time, the Coppename-monding Nature Reserve became the first Surinamese "RAMSAR site" that was included in the "RAMSAR List of Wetlands of International Importance", further quoted as the "RAMSAR List" (see http://www.ramsar.org).

In case an adverse change in ecological character or damage has occurred, is occurring, or is likely to occur in a listed "Wetlands of International Importance" (like the Coppename-monding Nature Reserve), the Surinamese RAMSAR Authorities may request inclusion of the site in the Montreux Record, in order to draw attention to the need for support from experts. The Montreux Record is the principal tool of the RAMSAR Convention for highlighting those sites in need of priority conservation attention.

Alternatively, the RAMSAR Bureau, on receipt of information on actual or possible adverse change from partner organizations, other international or national NGOs, or other interested bodies, may draw the attention of the Surinamese RAMSAR authorities to this information and enquire whether the RAMSAR site should be included in the Montreux Record.

2.3.3 Western Hemisphere Shorebird Reserve Network

On March 4, 1989, the Coppename-monding Nature Reserve (together with the Wia-Wia Nature Reserve and the Bigi Pan MUMA[6]) also received the status of "Hemispheric Reserves" within the Western Hemisphere Shorebird Reserve Network (WHSRN). The areas mentioned were subsequently twinned with two nature reserves in the Bay of Fundy, Canada: the Minas Basin at Nova Scotia and the Shepody Bay at New Brunswick. The flyway populations of Ne-arctic shorebirds that visit Suriname during northern winters use these Canadian protected areas as breeding area.

[6] MUMA: areas where integrated management by or on behalf of the Government is needed for a rational use of its natural resources, which includes the conservation of the protective and productive functions of vulnerable ecosystems.

2.4 ENVIRONMENTAL MANAGEMENT REQUIREMENTS AND STANDARDS

No national environmental standards have yet been developed for Suriname.
This section provides an overview of the national and international legal requirements, regulatory approvals, and permitting requirements that may apply to the project, and it identifies the key aspects of the route that must be followed to advance the project to the award of an environmental permit.

2.4.1 Oil Concession Conditions

Staatsolie was founded on December 13, 1980, as a company with limited liability under Surinamese Law. The Republic of Suriname owns all shares. The company has the right to explore for and produce hydrocarbons in Suriname (Decree E-8, E8-A, E-8B, E-8C, SB 1980 no. 128, SB 1981, no. 37, SB 1981 no. 59). It can exercise this right as an independent operator or in cooperation with other oil companies.

Within the concession agreement, it is stated that the contractor should take all reasonable measures in agreement with good oil field practices for safe working and for adequate treatment for the discharge of waste oils (article 11, sub 1 and 2). "Good oil field practices" could be translated as "to comply, at a minimum, with applicable laws, regulations, standards and guidelines for the protection of the environment and in their absence adopt the best practicable means to prevent or minimize adverse environmental impacts".

2.4.2 International requirements

For this EIA, a number of international environmental requirements for onshore oil operations are available.

2.4.2.1 ARPEL

The Regional Association of Oil and Natural Gas Companies in Latin America and the Caribbean (ARPEL) have developed environmental policies, codes, and guidelines for protection of the environment. ARPEL has published its own guidelines for conducting environmental audits.

In ARPEL's Code of Environmental Conduct, the following is stated:

"*ARPEL Member Companies are fully conscious that the self-sustained development (of Latin America in general and of its hydrocarbons industry in particular) can and must be accompanied with actions aimed at environmental protection, in compliance with the regulatory framework in force in each country, based on scientific grounds and respect for the community, as well as on risk analyses and environmental cost/benefit. Consequently, ARPEL Member Companies have established as an objective to continuously improve their environmental management systems and to develop their operations under principles that reflect the adequate application of the highest level of environmental practices*".

2.4.2.2 International Association of Oil and Gas Producers

In the international oil exploration and production industry, the guidelines and standards of the International Association of Oil and Gas Producers (OGP – formerly the Oil Industry International Exploration and Production Forum) are particularly influential. The OGP represents oil and gas companies from around the world.

The OGP has prepared several guidelines regarding onshore oil operations, on its own and in conjunction with organizations such as UNEP and IUCN. The OGP has recommended the use of EIA in a number of its guidelines. These guidelines, which represent "internationally acceptable operating practices" and "internationally acceptable goals and guidance on environmental protection during oil and gas exploration and production operations", fully endorse the EIA process, and provide recommendations and guidance to oil companies on the EIA process. A key development in the EIA process as it applies to oil and gas companies is the expectation that companies will assess the impacts of oil and gas development not merely on the physical environment, but also on local and indigenous peoples.
Among others special guidelines have been developed addressing oil operations in tropical rainforests and exploration and production operations in mangrove areas, and decommissioning for onshore exploration and production sites.

2.4.2.3 World Bank Group

Staatsolie has indicated that World Bank Source Book for Environmental Assessment should be used as a guidance document for this study.
The Sourcebook is a reference document that provides practical guidance for identifying and addressing negative environmental impacts of development projects. The Sourcebook aims to collect all of the different World Bank policies, procedures, guidelines, precedents and best practice that reside in different World Bank publications into a single source. The document is continually updated and covers a wide range of subjects. Included are guidelines for addressing specific ecological, socio-economic and other issues that may arise during an environmental assessment process, sectoral guidelines for environmental assessment and guidelines for the involvement of communities and NGOs in the process.
Another publication by the World Bank Environment Department is the Pollution Prevention and Abatement Handbook that focuses specific attention on pollution control (WB, 1999). The handbook among others contains General Environmental Guidelines (GEG) used for general applications, but also sector-related guidelines, e.g. for the onshore oil and gas development.

Recently (April 2006) the International Finance Corporation (IFC), the private sector arm of the World Bank Group, has developed Performance Standards (PS) aimed at specific industries or types of projects. These are used by the IFC to monitor a project s performance and set minimal acceptable environmental requirements in the case of IFC financed investment projects. These IFC Performance Standards have become a benchmark for large private sector projects, especially in developing countries.

The Performance Standards (PS) applicable for the current project are:

- PS 1: Social and Environmental Assessment and Management Systems
- PS 2: Labor and Working Conditions
- PS 3: Pollution Prevention and Abatement
- PS 6: Biodiversity Conservation and Sustainable Natural Resource Management

Corresponding to the Performance Standards IFC has prepared a set of Guidance Notes. These Guidance Notes offer helpful guidance on the requirements contained in the Performance Standards, including reference materials, and on good sustainability practices to improve project performance. These Guidance Notes are not intended to establish policy by themselves; instead, they explain the requirements in the Performance Standards.

The Performance Standards will be read along with their corresponding EHS Guidelines as published by the IFC. The EHS Guidelines contain the performance levels and measures that are normally acceptable to IFC and are generally considered achievable in new facilities at reasonable costs by existing technology.
Apart from the environmental guidelines for ambient air quality, noise and water quality (IFC, 2007a), also the EHS guidelines for onshore oil and gas development (IFC, 2007b) will be used as guidance for the project.

2.4.2.4 The Ramsar Convention

The Ramsar Convention (RC) has long recognized the importance of applying impact assessment techniques to situations where the ecological character of Ramsar sites and other wetlands may be threatened by developments or broader policies and strategies.
Based on the *Guidelines for incorporating biodiversity-related issues into environmental impact assessment legislation and/or processes and in strategic environmental assessment,* developed by the Convention on Biological Diversity (CBD), the CBD/Ramsar guidelines have been elaborated, which cover whether, when and how to consider biodiversity in both project-level and strategic-level impact assessments.

The objective of the draft guidelines (Ramsar Convention, 2007) is to provide general advice on incorporation of biodiversity considerations into new or existing environmental impact assessment procedures, noting that existing procedures consider biodiversity in different ways. A draft framework has been developed to address the screening and scoping phases of environmental impact assessment. Further development of the framework will be required to address the incorporation of biodiversity into subsequent stages of the environmental impact assessment process, including impact assessment, mitigation, evaluation and monitoring.

During the preparation of the current EIA, the following appendices of Handbook 13 of the Ramsar Convention (2007) have been consulted and used, where appropriate:

Appendix 1: Questions pertinent to screening on biological diversity impacts
Appendix 2: The screening criteria
Appendix 3: Indicative list (non-exhaustive) of examples of functions of the natural environment that are directly (flora and fauna) or indirectly (services provided by ecosystems such as water supply) derived from biological diversity
Appendix 4: Biodiversity checklist on scoping for the identification of the impacts of proposed projects on components of biodiversity (Not exhaustive)

2.4.3 Environmental Standards and Guidelines

2.4.3.1 Introduction

National legislated standards for emissions and the ambient environment have not yet been developed for Suriname. In their absence the internationally recognized World Bank (WB, 1999) and IFC guidelines (IFC, 2007a,b,c) have been adopted as project guidelines (standards). It is noted that some parts of the World Bank Pollution Prevention and Abatement Handbook (Worldbank, 1999) are not in use anymore, as they are replaced by the IFC Guidelines (2007a,b,c).

2.4.3.2 Ambient air quality

Among the main sources of air emissions are mobile equipment (combustion gases from airboat, carrier, excavators, drilling rig) and fugitive emissions from leaks and evaporation. There are no fixed sources of continuous air emissions. Virtually all emissions are non-continuous.

Recently Staatsolie has set ambient air quality criteria/standards (based on World Health Organization ambient air quality guidelines) for the proposed expanded refinery (SRK Consulting, 2009). Although there will be no relevant odor nuisance or human health effects from air emissions (see Ch. 5.2), logically these criteria/standards should be applicable for all Staatsolie Operations, including the Tambaredjo NW oil field.

2.4.3.3 Noise

Both the World Bank (WB, 1999) and IFC (2007a) have the same noise standards (Table 1). The levels in Table 1, or a maximum increase in background levels of 3 decibels, (measured on the A scale) [dB(A)] should not be exceeded. Measurements are to be taken at noise receptors located outside the project boundary.

Table 1: Noise level guidelines for the Tambaredjo NW project

	One hour LAeq [dB(A)]	
Receptor	**Daytime (07.00-22.00h)**	**Night time (22.00-07.00h)**
Residential, institutional, educational	55	45
Industrial, commercial	70	70

2.4.3.4 Wastewater

Drilling operation

No specific guidelines exist for wastewater disposal to the surrounding swamp during wetland operations such as that will be applied in the Tambaredjo NW Swamp. The IFC only distinguishes between onshore (being dryland) and offshore operations. The waste stream disposed to surface water during wetland operations comprises water-based drilling fluids and drilled cuttings, completion and well work-over fluids, and produced water. It is suggested here that the drilling area (~50 x 50 m) is considered as the drilling activity area, with the border towards the surrounding swamp as the activity boundary. This would

implicate that the several water quality parameters of the swamp water at the boundary of the drilling location should comply with the effluent levels for mentioned wastes.
Given the expected composition of above-mentioned wastes, the IFC guideline values (IFC, 2007c) for produced water (Table 2) will be used as guideline levels for waste disposed during drilling.

Table 2: Effluent levels for drilling waste water for discharge to surface waters (adapted from the levels proposed for production water)

Parameter	Guideline value
Total hydrocarbon content	10 mg/L
pH	6-9
BOD	25 mg/L
COD	125 mg/L
TSS	35 mg/L
Phenols	0.5 mg/L
Sulfides	1 mg/L
Heavy metals (total)[a]	5 mg/L
Chlorides	600 mg/l (average), 1200 mg/L (maximum) [b]

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

[b] The typha and the parwa swamps have maximum measured baseline figures up to 650 and 2000 mg chloride/liter respectively. The addition of salts from drilling waste will not have a significant effect in these environments that are adapted to relatively high salinity levels. For both ecosystems, a level up to 10,000 mg Cl/l (mesohalinous water) is acceptable (see Ch. 3.2.1; Amatali, 2009). It is possible that very high chloride levels are measured here in a very severe dry period. For practical reasons it is proposed that in these two environments the chloride monitoring levels should not exceed the local background level (mg Cl/l) +1,000 mg Cl/l, with a maximum at 10,000 mg Cl/l. For instance: when the background chloride level, measured in the nearby swamp, is 3,000 mg/l, the guideline value should be 4,000 mg/l.

Water pollution with hydrocarbons

Water pollution with hydrocarbon is not the result of a structural process, but of the occurrence of oil leakages and spills. As such, it is not rational to include monitoring of hydrocarbon in ambient surface water, because such spills or leakages would only be detected by monitoring when samples are taken at the locations where these events have taken place. A more appropriate method to trace hydrocarbon pollution of surface water is by visual inspection. The Dutch standards for surface water (fish and swimming) only require analysis for oil, when an oil film is visible or when oil is present on the bottom (VROM, 1983). In the case of Tambaredjo NW, such oil film indicates a spill or leakages that should be taken care of as soon as possible. The effect of the cleanup operation can again be measures by visible observation for oil films and no water sampling and analysis will be required.

2.4.3.5 Soil

Soil and/or groundwater pollution could occur because of an oil spill or leakages on dry land. A cleanup operation is part of Staatsolie's contingency planning and all polluted soil will be removed to be treated at the landfarm site. No additional soil testing is required for such occasions.

Soil testing is however part of the decommissioning procedures for tank areas and other potentially polluted areas.
The soil is clean, when values are below the Background Value (Table 3). Soil remediation is necessary in case the Intervention values are surpassed. For soils with pollution levels in between the Background and Intervention Values several 'use functions' are possible, depending upon the level of the various parameters (VROM, 2009).

Table 3: Background and Intervention Values for soil remediation (for standard soil with 25% clay and 10% organic matter).

Parameter	Background Value (mg/kg dry matter)	Intervention Value (mg/kg dry matter)
Arsenic	20	76
Barium	190	920
Cadmium	0.6	13
Chromium	55	180
Cobalt	15	190
Copper	40	190
Mercury	0.15	36
Lead	50	530
Nickel	35	100
Zinc	140	720
PAH (Polycyclic Aromatic Hydrocarbons)	1.5	40
Mineral oil	190	5000
EOX	0.3*	-*

* When above 0.3 mg/kg dm (the trigger value), detailed study is required

2.4.4 Staatsolie Policy

The EIA will meet the Health, Safety and Environmental principles as outlined in the HSE policy of Staatsolie, which aspires:

- prevention of all incidents
- compliance with all applicable health, safety and environmental legislative requirements
- continual improvement of the company's health, safety and environmental performance
- prevention of environmental pollution

Staatsolie is member of ARPEL and further emphasizes the importance of working to internationally recognized oil and gas standards like those of OGP, and relevant standards and guidelines of the World Bank. Staatsolie is fully involving local communities and reporting progress to all interested and affected parties. The environmental study will hence be structured to follow the principles as stipulated above.

Staatsolie is in the process of developing an Environmental Management System (EMS) in accordance with the requirements of the international standard ISO 14001. The EMS comprises procedures that specify the way that environmental issues are to be managed in normal activities.

2.4.5 Permitting process

2.4.5.1 Permit for study activities in the Coppename-monding Nature Reserve

The northern boundary of the projected Tambaredjo NW oil field corresponds with the southern boundary of the Coppename-monding Nature Reserve, a listed Wetland of International Importance (RAMSAR site). Due to the close proximity, there is a risk that certain oil field activities result in an impact that could affect the Nature Reserve. Therefore, it is necessary that baseline conditions in the neighboring Nature Reserve area are determined, so that eventual impacts can be assessed.

According to the Nature Conservation Act, a written permit is needed from the Head of the Suriname Forest Service, for all human activities in nature reserves.

During the preparation phase of the Tambaredjo NW project, Staatsolie has already communicated the project activities and the terms of reference of the EIA with the head of the Suriname Forest Service (LBB) and the head of the Nature Conservation Division (NB) of LBB. A research permit has been requested at head NB.

2.4.5.2 Notification for oil field activities in the North Saramacca MUMA

The Tambaredjo NW area is situated in the North Saramacca Multiple-Use Management Area (MUMA). The projected oil field is found almost completely to the north of the “red line’ in the area that is considered as a buffer zone to the Coppename-monding Nature Reserve.

By resolution, all state-owned land of the North Saramacca area was placed at the disposal of the Minister of Natural Resources. Mandate was give to Nature Conservation Division (NB) of the Suriname Forest Service (LBB) to manage the area as a Special Management Area ("Bijzonder Beheersgebied"). As indicated above, Staatsolie has discussed the project activities and the terms of reference of the Tambaredjo NW EIA with the head of the Suriname Forest Service (LBB) and the head of the Nature Conservation Division (NB) of LBB.

One of the recommendations in the Integrated Coastal Zone Management (ICZM) Plan for North Saramacca is the requirement of an Environmental Impact Assessment (EIA) for all large-scale and/or high-impact developments in the vulnerable parts of the MUMA. Special (regional) MUMA management legislation in that respect has not been developed because a national EIA legislation has not yet been promulgated.

By carrying out this EIA this recommended requirement is being effectuated.

3 DESCRIPTION OF THE IMPACTED ENVIRONMENT

3.1 CLIMATE

3.1.1 Methodology

For the description of the climate conditions, use has been made of already existing sources of information (see Appendix G: References) and records held by government agencies or others. Baseline climatic data have been acquired from published sources within Suriname, and from record held by the Meteorological Service.
For the study area, no meteorological data are available, except for few data gathered by Staatsolie at Calcutta and TA-58 for a period of respectively 14 and 18 days in 2006 and 2007.
Rainfall data for the study period were downloaded from the website of the Meteorological Service (www.meteosur.sr) for three selected stations (Kwatta, Groningen and Cultuurtuin).

3.1.2 General climate conditions

Most of Northern Suriname has a Tropical Rainforest Climate (Af-climate in Köppen's classification). The average rainfall exceeds 60 mm in the driest month(s). A narrow strip along the coast, which has drier conditions, forms an exception. The average annual rainfall in the northern part of Suriname predominantly ranges between 2,000 and 2,500 mm, but in the narrow coastal strip it is between 1,500 and 2,000 mm, and in some parts even less than 1,500 mm.

Like in most parts of Suriname, consistently high temperatures and a high humidity characterize the study area with the main variation being rainfall and the associated cloud cover. The mean annual air temperature at Paramaribo is 27.3 º C, with a daily range of 7-10 ºC and with an annual range of about 2ºC.

The weather of Suriname is dictated mainly by the northeast and southeast trade wind system called the Inter-Tropical Convergence Zone ("ITC" zone also known as the "Equatorial Trough").

The ITC zone passes over Suriname two times per year and results in four seasons based upon rainfall distribution (Scherpenzeel, 1977).

- Long Rainy Season End April-Mid August
- Long Dry season Mid August-Early December
- Short Rainy season Early December-Early February
- Short Dry season Early February-End April

Northern Suriname has a northeast to southeast wind direction, with the first dominating in the February-April and the latter during the July-September period. The other months show directions mostly ranging between northeast and southeast.
Calm winds, *i.e.* winds with hourly average speeds less than 0.5 m/s, are very frequent. During the night and early morning, it is usually calm. During the day, the wind speed may increase to about 5 m/s, and in some seasons to 5-8 m/s, in particular in the February-April

and the September-October periods. In the coastal zone, wind speeds are usually higher than further inland.
Wind speeds of 20-30 m/s have been occasionally recorded during thunderstorms, but only for a very short period (locally known as 'sibibusi'). Suriname is free of hurricanes.

3.1.3 Specific conditions for the study area and the study period

From swamp water level readings made for the surface water resources study (Amatali, 2009) it is concluded that during the observation period a narrow strip of the northern Tambaredjo NW oil field is receiving slightly less total rainfall than the remaining project area. This could point to the influence of the coastal effect that causes a dryer zone along the coast.
The readings further indicate the occurrence of local rain shower and considerable differences in rainfall between locations in the Buru Swamp. During one shower, certain parts of the swamp receive more rainfall than others and sometimes certain parts do not receive rain, while others are subjected to heavy rainfall. A clear pattern in the distribution of rainfall in time could not be established. Overall, there is no reason to believe that the climatic conditions in the project area differ significantly from the conditions in Northern Suriname.

Figure 5 presents the rainfall during the study period for three stations closest to the zone of the study area. The total rainfall between these stations does not differ much, but Groningen has slightly less rainfall than the other two stations. Also is the total rainfall about the same as the long-year total for Cultuurtuin.

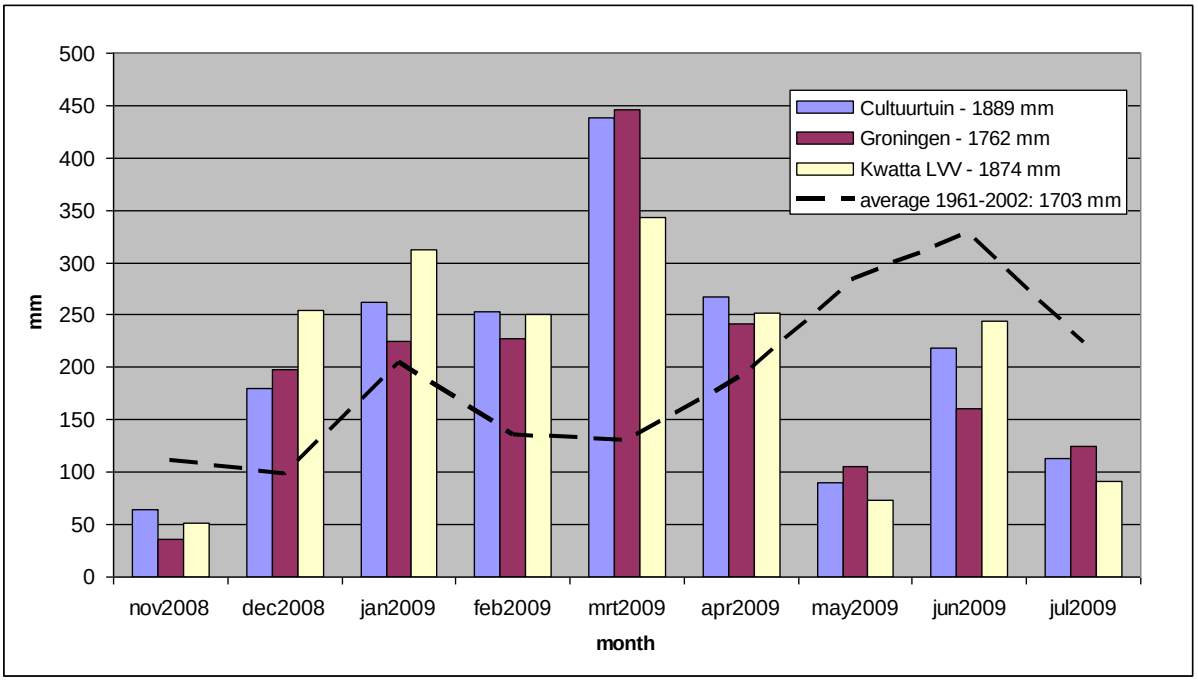

Figure 5: Monthly precipitation for the period November 2008-July 2009

However, the rainfall distribution during the study period is completely different from the yearlong average distribution. The Short Rainy Season during the study period is wetter than normal, the Short Dry Season of February-April 2009 is characterized by considerable rainfall – especially in March - and the Long Rainy Season is much dryer than normal. The rains of the Long Rainy Season were delayed in northern Suriname apparently because the

Inter Tropical Convergence Zone (associated with rainfall) was prevented to move in northern direction because of the presence of a high-pressure cell above the Atlantic Ocean. It rained very little during the whole month of May.
The consequences of this will be discussed where relevant, but the overall impact on the results of the study is not considered significant.

Wind speed and direction are available for Calcutta and TA-58 for two short periods only (December 2006 and June 2007). Notwithstanding the brief observation period, the data provided useful information because the only long-term wind data are from Zanderij, some 60 km from the coast. Comparison of the Staatsolie data with available data from Zanderij (1961-70) indicates that wind directions between the two locations do not significantly differ for the months June and December (Figure 6). June has dominating wind directions between NE and S, while in December NE winds are dominating with a range between NE and SE. This is in line with the general picture sketched above.

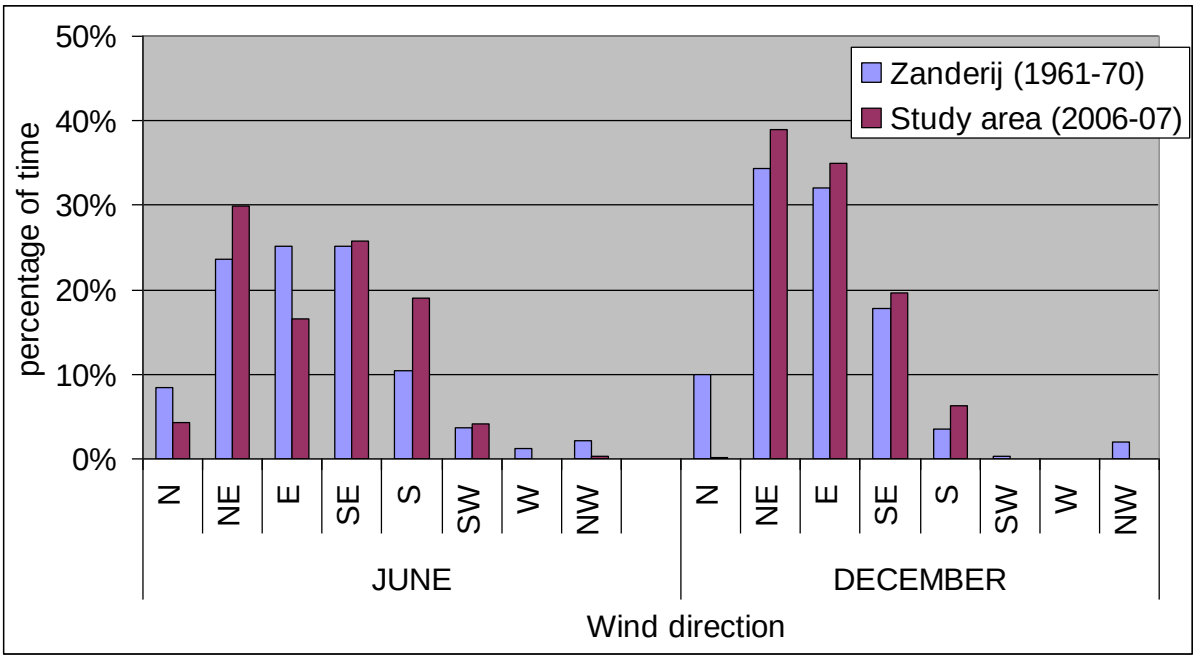

Figure 6: Wind direction compared for the months June and December

Regarding wind speed there are a number of differences though. The coastal location of the study area has far less calm winds than the inland location of Zanderij (Figure 7).
However, if there is wind, the general wind speed at Zanderij is higher than the one in the study area. However, wind speed at Zanderij has been measured at a height of 10 m, while the wind speed data at Staatsolie have been measured at an elevation of 1.5 m, so that no proper comparison between wind speeds can be made.

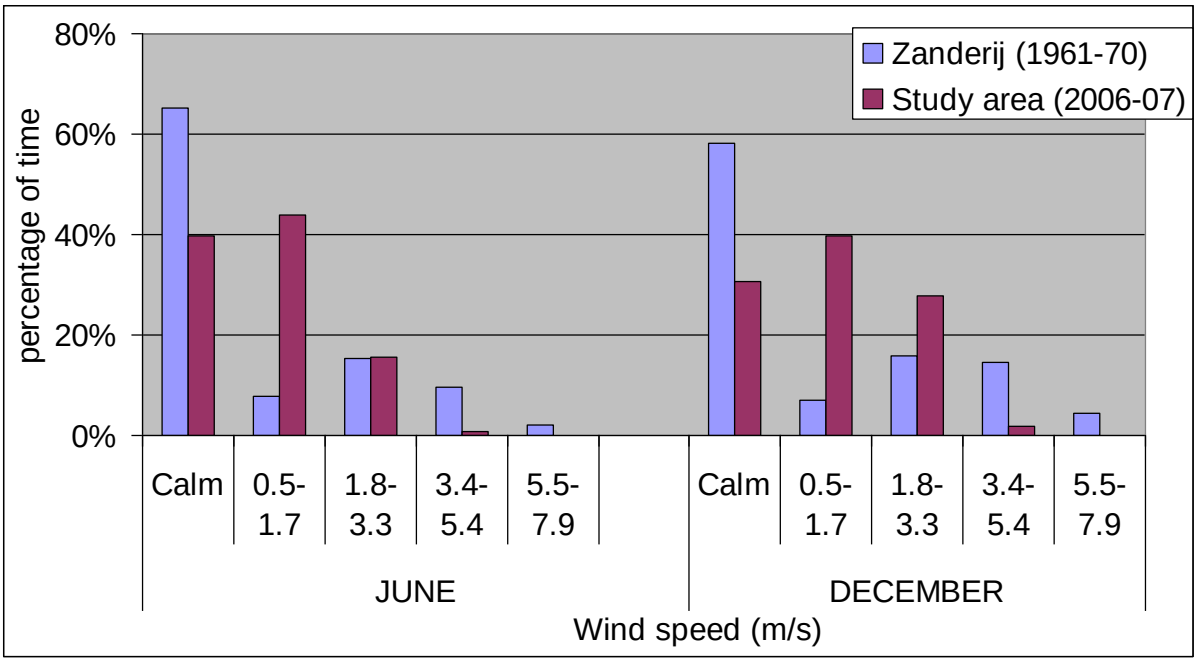

Figure 7: Wind speed compared for the months June and December

3.2 AIR QUALITY

3.2.1 Methodology

No background data on air quality are available for Suriname and the collection of reliable baseline data will require a very lengthy and expensive investigation, far beyond the scope and the requirements of the current project. Normally projections of air quality impacts of projects are being made based upon the expected emissions (type, temperature, height and speed), area characteristics like relief and vegetation type, height and structure, and meteorological parameters, in particular wind speed and wind direction. Based upon the following considerations no such exercise has been conducted for the current activity:

- There are no relevant point or line sources of emissions. Collection tanks will not be employed in the project.
- Main sources of emissions are those from equipment and vehicles which work across an extensive area (larger than the center of Paramaribo), but the number of equipment and vehicles is limited (Table 14) and their combined emission will be only a tiny fraction of that of all vehicles and equipment present in central Paramaribo at workdays.
- The majority of equipment will only be active during working hours. Only drilling and associated activities is a continuous process.
- All equipment and vehicles will be well maintained and no essential reduction of emissions is possible by additional measures (see Ch. 9.3.6).
- All activities take place at least 4 km - and most of the time much farther - from the closest receptors and these receptors could only be affected during NW and N winds that only occur during ⅓ of the time.

From these observations, it has been concluded that a qualitative description and assessment of air quality is justified for the purpose of the current study.

3.2.2 Air quality in the study area

There are very few sources of man-made air emissions that affect the air quality of the project area. Related to the dominating wind directions the only stationary source of air emissions outside the area is the TA-58 facility at 8-10 km east of Tambaredjo NW.
Air quality could be affected by the release of gases from this location:

- combustion gases of generators and vehicles
- fugitive emissions, like dust from the roads

At TA-58, associated gasses are removed from the crude. The gas is used for oil heating with gas burners. The total level of emissions at TA-58 will be relatively low and emissions will not significantly affect the air quality at Tambaredjo NW.

During southeastern winds, fugitive emissions from rice fields and from the Gangaram Panday road could reach the southern part of the project area. However, stubble burning on rice field is a very incidental activity (only once or twice a year), while dust emissions from the road are too far away (>5 km) to have an effect in the project area.

Sources of air emissions within the project area are the test tanks that are present at two locations within the Tambaredjo NW area. Associated gasses are released to the atmosphere from these tanks during testing. The release of the two tanks is intermittent, because only one tank is tested every day and only a small amount of gas is released. The tanks are found near the Ritsweg, which is over 10 km north of the Gangaram Pandayweg.

Mobile sources of air emissions within the project area are the airboats and carriers that pass through the area. However, frequency is very low with on average 1-2 passages per day at most, and the emissions are fugitive and will be spread over a large area.

Given the location and the scale of existing emissions around and within the project area it can be stated that the air quality in project area is still close to its natural state as very few sources of relevant air emissions affect the air quality in the project area.
Generally speaking, the air quality of the study area is good with hardly any air pollution.

3.3 NOISE AND ASSOCIATED EFFECTS

3.3.1 Introduction

No specific noise legislation or guidelines currently exist for Suriname, so international guidelines were considered (WHO, World Bank/IFC) in this study. Noise is recognized as a potential pollutant or nuisance, but no human receptors are present within 4 km of the nearest project activities. Therefore, no noise measurements were conducted along the Gangaram Panday Road. The existing standards apply for residential and industrial areas, but the WHO and IFC guidelines do not have a category for remote, uninhabited sites such as Tambaredjo

NW. As said impacts of ambient noise to human receptors have not been considered and the noise study focuses on potential effects of project-related ambient noise to animals, and in particular to birds.
Because noise specifications for the equipment used for project development are not available, a number of measurements were conducted on the commonly used equipment under field conditions.
However, no noise contours could be determined because all noisy equipment is mobile, without a fixed location and conditions differ for every working position.

3.3.2 Methodology

Noise measurements were performed with a sound level meter and analyzer SVAN 957 (Nr. 15357) mounted on a tripod. The 7052H prepolarised microphone was provided with a SA22 windscreen. The measurements were made with the microphone at 1.5 m above the surface.
The noise measurements were done with Type 1 IEC 61672:2002 accuracy in the frequency range 10 Hz ÷ 20 kHz with ACO 7052H microphone. A FAST detector was used for the measurements with A, C and Z filters. Also an 1/1 OCTAVE analysis with 15 filters with centre frequencies 1 Hz ÷ 16 kHz, Type 1 – IEC 1260 was logged.
Before each measuring period, a calibration was done with SV 31 Acoustic calibrator (serial No 17687) with IEC 60942:2003 standard, Type 1 accuracy.

Although the baseline noise conditions across the study area were expected to be very homogeneous, noise monitoring has been conducted at a number of sites within the area.

Measurements covered the daytime (06h00-19h00) and night-time (19h00-06h00) periods and measurements were only undertaken under favorable weather conditions;

Noise – distance relationships have been determined for all equipment that will be utilized for the project:

a) Excavator
b) Swamp carrier
c) Airboat and small boat (outboard engine)
d) Drilling
e) Moving of the rig

The conditions in the field have dictated the measuring procedures and no standard procedure could be applied. Virtually all measurements had to be made within the open trails, so that the attenuating effect of the vegetation could not be determined. In addition, it was not always possible to conduct upwind and downwind measurements.

3.3.3 Baseline conditions in the Tambaredjo NW area

Noise levels in the Tambaredjo NW area are typical of a remote nature area, where the natural sounds completely dominate the noise climate. Aside from the occasional passage of an airboat or a swamp carrier, there are no non–natural dispersed- or point-sources of noise.
Table 4 presents the average daytime and nighttime noise level. The daytime noise level is low at 39 dB(A). Unlike most environments, noise levels in the humid tropics actually

increase at night, largely as a result of insect and amphibian activity, e.g. frog calls. Natural nighttime noise levels (49 dB(A)) considerably exceed the daytime levels.
Exceptionally high natural sound levels of 54 dB(A) have been measured at location 17, where measurements have been made at a moment that frogs and insects were very active. But at all other occasions (14 times) that this location has been visited, the noise level was much lower, similar to the average natural noise level.

Table 4: Summary of noise levels in the Tambaredjo NW area

	Locations #	Measure	Average baseline noise level (dB(A)) of measured sites
Daytime – normal conditions	2, 10, 14, 25	Average LAeq	39
		Average L_{90}	33
Daytime – exceptional animal noises	17	Average LAeq	54
		Average L_{90}	53
Night time	22a	Average LAeq	49
		Average L_{90}	41

Noise level measurements have been made of all large equipment that will be used for the Tambaredjo NW production development.

In order to obtain a good impression of noise levels of the equipment, the distance has been determined that is needed to meet a selected noise level of the equipment under different measuring conditions (Table 5).

Table 5: Equipment noise pressure levels at various distances

Equipment	Measuring conditions	Approximated required distance (m) to meet noise level: [dB(A)]			LAeq [dB(A)] at distance of 25 m	Exposition period
		60	55	50		
Airboat	Mostly open trail – upwind/down wind – high speed	520	700	950	115	daytime-short
Airboat	Mostly open trail – upwind – slow speed	170	230	300	99	daytime-short
Airboat	Mostly open trail – downwind – slow speed	240	320	500	99	daytime-short
Moving rig – excavator pulling	Open trail	150 [b]	200 [b]	250 [b]	88[b]	daytime – hour (once per 1-2 weeks)
Carrier	Open trail – downwind	300	560	1040	80	daytime
Drilling (front)	Open terrain – front	120	160	220	76	day-night
Gator tail	Open trail			125[a]	75	daytime-short
Excavator– digging	Open trail – downwind	140	400	1130	72	daytime
Drilling (back)	Open terrain – back	80	150	260	69	day-night

[a] assuming speed of 30 km/h
[b] distances are difficult to determine because of the size of the sound source

From Table 5 the following can be concluded:

1) Noisy are the airboat, the moving of the rig and the carrier.
2) The sound of the airboat (at full speed), the carrier and the excavator carries far and only at a distance of ~1000-1100 m the noise level of this equipment drops below 50dB(A).
3) The noise level of the airboat can be significantly reduced by a reduction of the speed.
4) The position relative to the wind plays an important part. In Table 5 this effect is clearly visible for the airboat, but it has also been found for the carrier (Tan, 2009).
5) Drilling, the only continuous activity that also takes place at night, generates a relatively low noise level, which is at a distance of ~ 250 m, does slightly exceed nighttime background levels.
6) The gator tail boats produce a significantly lower noise level than the airboats, even when the latter are operated at a low speed.

3.4 GEOLOGY

3.4.1 Methodology

The description of the geology of the area is entirely based on available publications, maps and reports.

3.4.2 Geology of the study area

The study area is located in the Coastal Plain, which together with the Coastal Plains of French Guiana and of Guyana constitutes the margin of the large Guiana Basin.
The Coastal Plain can be divided into the Young Coastal Plain and the Old Coastal Plain. The study area is found in the Young Coastal Plain, and has developed on Holocene deposits of the Coronie Formation. According to the classification by Brinkman and Pons (1968), the area is formed on sediments of the Comowine phase, which are not older than 1,000 years. Throughout the area, predominantly marine clays have been deposited. The Comowine phase is characterized by extensive clay flats and the presence of relatively few sand ridges. In the study area, only discontinuous, very narrow and usually very low ridges indicate former coastlines.

Sedimentation is currently active along the coast near the study area and a considerable accretion has occurred during the last decades (Figure 8).

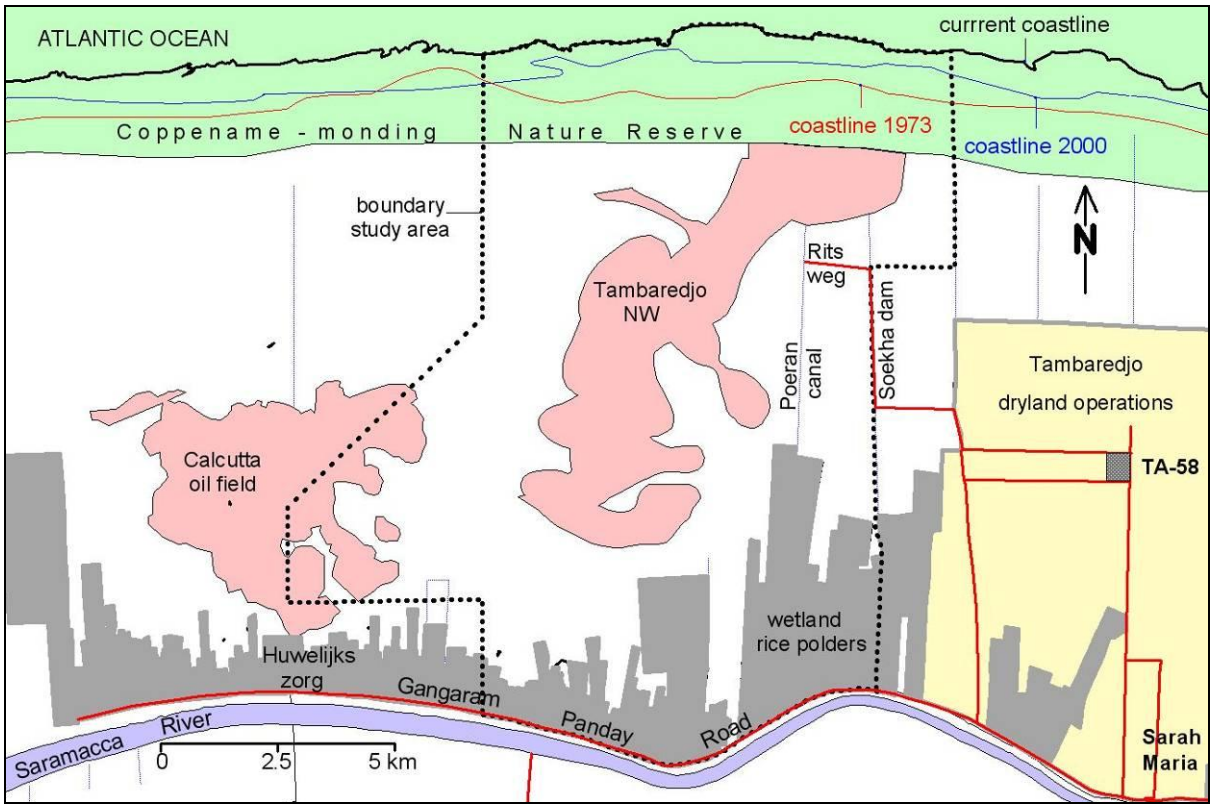

Figure 8: The changes in the coastline in the period 1973 to present

3.5 GEO-HYDROLOGY

3.5.1 Methodology

The description of the geology of the area is entirely based on available publications, maps and reports.

3.5.2 Geohydrology of the study area

In the coastal plain of Suriname drinking water is withdrawn from three major aquifers: the A-sand aquifer, the Coesewijne aquifer and the Zanderij aquifer, found in the formations of the same respective names (note: the A-Sand Formation in which the aquifer is found has been renamed Burnside Formation; Wong, 1989). The oil-bearing reservoir sand is found below these aquifers. It forms the basal unit of the Saramacca Formation, which was deposited on top of an erosional surface that marks the transition from the Cretaceous to the Tertiary (Paleocene).
No water for drinking purposes is extracted from the aquifers present in the area north of the Saramacca River, because their water is brackish. But at Sarah Maria and at the Calcutta oil field water from the Zanderij Formation (at about 160 m) is used to feed process water to production activities.
In areas south of the river, such as in Tijgerkreek, Tambaredjo and Groningen, the Coesewijne aquifer is exploited for drinking water supply. The Staatsolie Saramacca Operations, including Sarah Maria and TA-58 emplacements, withdraw their potable water from the water production plant at Tijgerkreek by means of a pipeline across the Saramacca River.

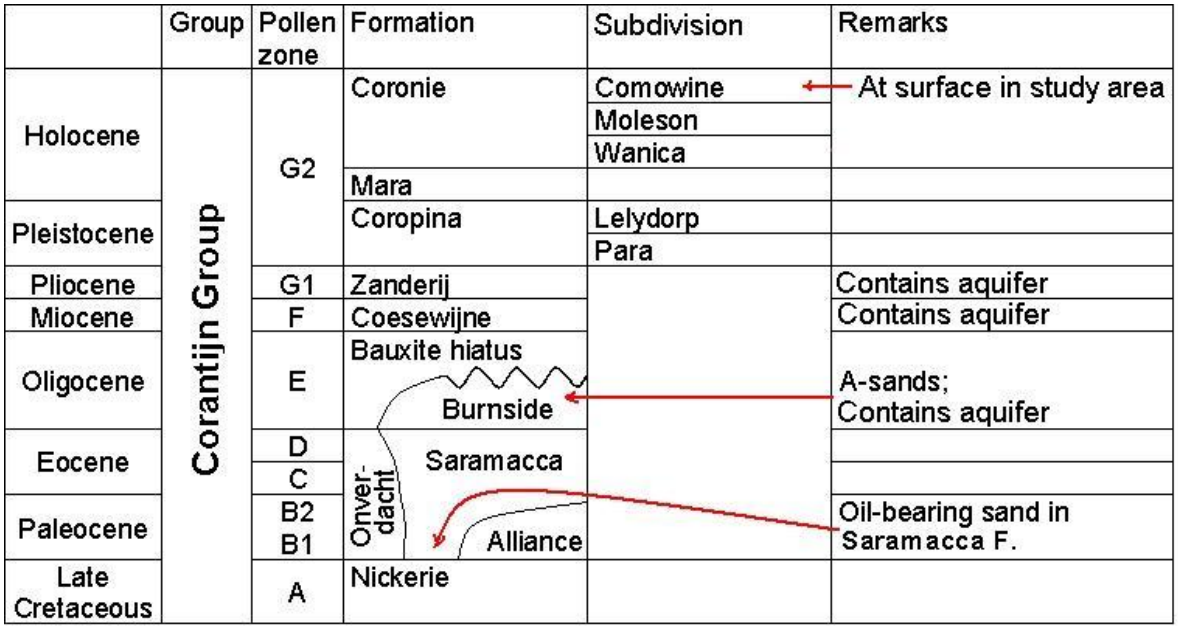

Figure 9: Stratigraphy of the Corantijn Group

3.6 GEOMORPHOLOGY AND SOILS

3.6.1 Methodology

As a basis for the description of landscape and soils of the Tambaredjo NW project area the Reconnaissance Soil Map of Northern Suriname, scale 1:100 000 (Soil Survey Department, 1977) is used. In addition to this map, use has been made of field data of seven survey lines of the Soil Survey Department (unpublished data, 1984). One of these lines covers the whole stretch from the river to the sea (14.4 km), the other 7 vary in length between 2.5 and 5.8 km from the Lareco road (survey conducted in the Short Dry Season of 1984).
Use is also made of soil information of the area east of Tambaredjo NW that was gathered as part of the Wayombo EIS (E2 Environmental Alliance Inc, 2000).
Finally, for the current study field checks of soil conditions have been made at all sampling stations.

3.6.2 General

The Tambaredjo NW area is situated in the northern part of the Young Coastal Plain. This plain is found throughout northern Suriname; in the east it has a width of 5 km, which increases towards the west, finally reaching a width of over 100 km along the western boundary of the country.
The Young Coastal Plain is dominated by flat and low-lying swamps and marshes with clay soils (at 1.0-1.5 m above mean sea level), on which a peat layer has developed. The thickness of the peat varies between some centimeters to several meters, mainly depending upon the water depth, frequency and duration of inundation and the occurrence of peat fires. The swamps are bisected by approximately east-west running ridges that were formed by former coastlines. These ridges form elongated bodies, which rise a few meters (1-3 m) above the neighboring clayflats. They are narrow (10-20 m) single ridges to rather broad (several hundreds of meters) for compound ridges; sometimes the ridges are discontinuous.
Generally speaking, ridges are most abundant in the east of the coastal plain; in the west few ridges are found. This is the result of the decreasing sand supply from east to west. Besides this trend, there are also clear differences in abundancy and form of ridges between the different sedimentation phases, with a decrease in ridges from the older to the younger deposits. Sand, shells, shell fragments or a mixture of these materials may build up ridges.
From north to south the sediments become progressively older, which is expressed in the increase in the degree of ripening of the marine clay soils. This shows in a firmer consistency, increasing depth of soil formation, increasing depth of desalinization, increasing intensity and depth of mottling and in a decrease of base saturation, resulting in a lower pH.
Ripening also results in some subsidence. Depending on the degree of ripening, clayey sediment may show a subsidence between 22 and 70 cm compared with the original deposit. A very rough estimate by Kamerling (1974) indicates that young (nearly unripe) sediments may show a subsidence of approximately 22 cm once they become nearly ripe. Further ripening (e.g., by artificial drainage) may add up to 34 cm of subsidence. It is to be expected that the polder clay soils show some subsidence, depending upon the current degree of ripening.
The soils of the Young Coastal Plain are the most important resource for development of agriculture, animal husbandry and aquaculture in Suriname. The ridges also serve as

important locations for the development of buildings and infrastructure, while they also form an important source for building and construction materials.

3.6.3 Landscape and soil conditions in the project area

The project area is dominated by clay flats. The area where the Tambaredjo NW oil field is located is found in a brackish to freshwater swamp of the Nickerie landscape.
This landscape is dominated by extensive clay flats with an occasional occurrence of discontinuous, low and narrow sand and/or shell ridges. The elevation of the clay flats is estimated at 1.0 -1.5 meters above mean sea level (+MSL) and the ridges are up to 1 meter higher. Ridges indicate former coastlines. Swamps have formed on the clay flats, due to their low elevation and flatness. These swamps become increasingly fresh going from the coast to the south.
The soils of the project area are shown in Figure 10.
The soil conditions of the clay soils in the area are rather homogeneous, with slight differences in degree of ripening and soil salinity level as the only significant difference between soil mapping units.

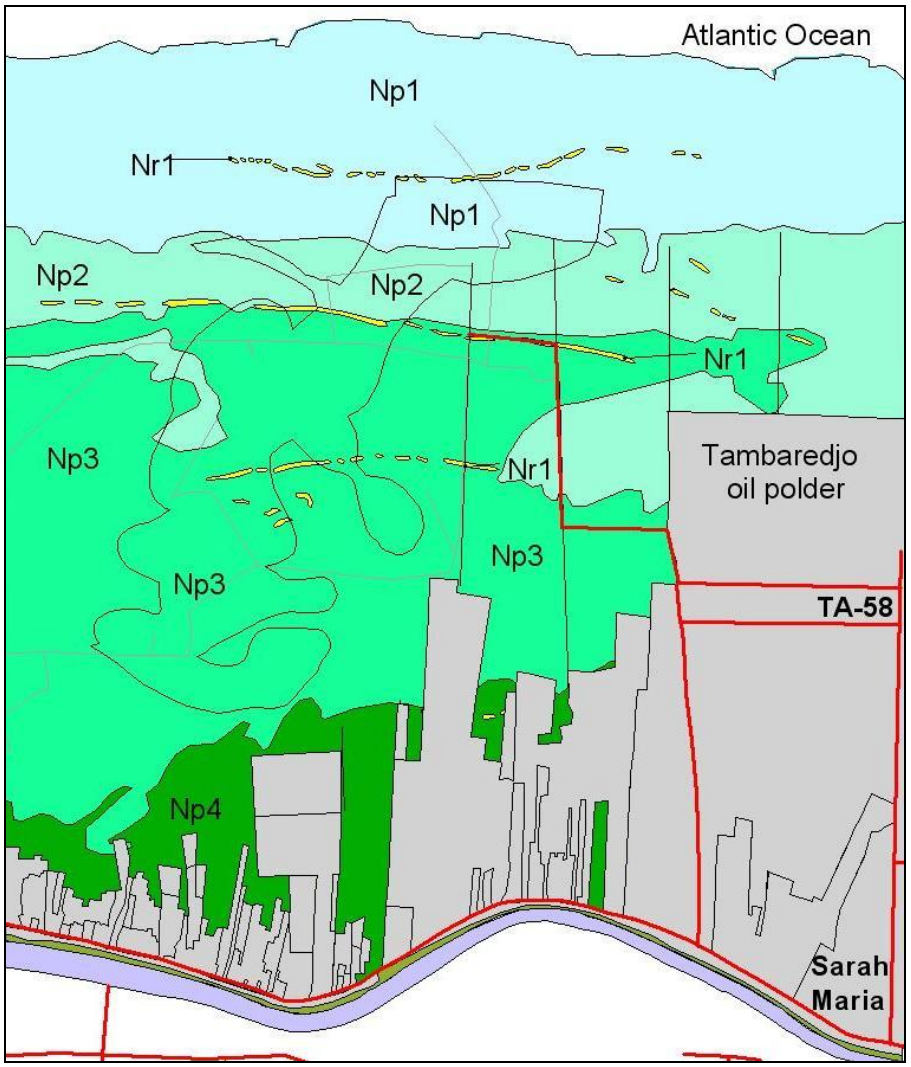

Figure 10: Soil map of the project area and surroundings

LEGEND OF THE SOIL MAP

Nickerie landscape

Np *Clayflats*

Np1 Very poorly drained, saline to brackish, nearly unripe clays over saline, nearly unripe clays; without a peat layer, or with a thin to moderately thick peat layer up to 30 cm

Np2 Very poorly drained, brackish, nearly unripe and half ripe clays over brackish to saline, nearly unripe clays; usually with a thick peat layer of about 40-50 cm

Np3 Very poorly drained, nearly fresh to slightly brackish, half ripe clays over brackish, nearly unripe to half ripe clays; usually with a thick peat layer of 50-75 cm

Np4 Very poorly drained, nearly ripe clays over slightly brackish to fresh, half ripe clays; usually with a moderately thick peat layer of 20-40 cm

Nr *Ridges*

Nr1 Imperfectly to very poorly drained, medium and fine sands and shell sands, often over nearly unripe clay within 100 cm; within unit Np1 with brackish groundwater

3.6.4 Soil properties

The clay soils of the Young Coastal Plain have a high fertility, due to their high mineral (clay soils) or organic (peat soils) reserve, they have a high Cation Exchange Capacity (CEC) and they are normally slightly acid (unit Np1) to acid (unit Np4).
Their physical properties are moderate to poor. Permeability and aeration are usually moderate to low and workability with machines is difficult. The bearing capacity will be a problem on the half ripe to nearly unripe clay soils as well as on the peat soils.

The soils have a decreasing salinity going from north to south. The clay soils can be classified as follows (Pons, 1964):

Soil unit	Classification
Np1	Saline soils
Np2	Brackish soils
Np3	Non-saline soils with brackish to saline subsoil
Np4	Non-saline soils with brackish subsoil

The ridges are too small and scattered to be taken into consideration.

3.6.5 Soil suitability

The project area is located within the North Saramacca MUMA. MUMA's have been established to protect the multiple values and functions of coastal ecosystems. One of the most critical factors to ensure the proper functioning of these ecosystems is the hydrology of an extensive area along the coast. The hydrological processes and pathways involved are not yet fully understood and any impact in the area may have unforeseen effects. Therefore, no land allocation is allowed to the north of the "red line" (Figure 4). Soil suitability will only be discussed for the southern part of the area, south of the "red line".

The soils in southern part of the project area are potentially suitable for paddy rice cultivation, cattle grazing and small-scale cultivation of certain dryland crops on cambered beds. But the extension of the rice area on unused land in the southern study area is very unlikely because of the limited availability of irrigation water from the Saramacca River and the ban to use swamp water from the northern swamps. For dry cropping sufficient reclaimed land is still available along the Gangaram Panday Road, where access and drainage are optimal. Use of land more to the north, e.g. within the project area would require new access roads and improved drainage facilities and therefore agricultural development here is unlikely. But more importantly, this part of the swamp is serving as a water reservoir and agricultural use will be conflicting with this function.

3.7 HYDROLOGY

3.7.1 Baseline description hydrology

3.7.1.1 General

The Surinamese coastal region has about 2,000 sq km of brackish wetlands with mangrove forest, salt water lagoons and herbaceous brackish swamps, and 12,000 sq km of freshwater wetlands (Teunissen, 1988). In the Saramacca district in which the study area is located, about 3,320 sq km of coastal wetland is found, of which about 370 sq km is mangrove forest (Noordam and Teunissen, 1999).

Most of the wetlands consist of swamplands with poorly to very poorly drained soils, which are inundated either permanently or at least during the greater part of the year (Teunissen, 1993). Exceptions are the areas bordering the ocean or tidal river sections, where the land is inundated twice a day during high tide, followed by discharge of the water back to the sea.

Swamps are formed because the low-lying and level clay flats have a very slow drainage due to the small hydraulic gradient and the very low permeability of the soil, combined with a dense layer of vegetation and peat on top of the soil. Watercourses (creeks running either to a river or to the sea) are usually only found along the edges of these swamps where both velocity and discharge are relatively high. Although drainage through peat and vegetation is very slow, a considerable amount of water is discharged due to the large areas over which the process takes place.
Still, in the rainy season, the water level of swamps usually is higher in the center than along the edges giving the swamp water level a convex form. This is especially pronounced in extensive swamp areas, like the Coronie swamp.

In the middle of the rainy season, a swamp is permanently draining towards the edges, with preference for sections with creeks. With diminishing rainfall at the end of the rainy season the discharge also decreases, as the water level very gradually lowers. At a certain water level, the drainage from the swamp will virtually stop and water will mostly be depleted by evapo-transpiration.

A slightly different situation exists in the near-coastal swamps, where seawater inundates the land twice a day. The incoming floodwater will block the drainage water from the back swamps at high tide and to a certain extent, seawater will mix with freshwater.
Due to a slight soil subsidence, some areas south of the mangroves may have a lower elevation than the land of the mangrove zone and seawater will remain here after springtide, when tidal creeks are absent. After evaporation, the water in this zone may become extremely saline.

Human activities like deforestation and land reclamation, construction of dams, dykes, roads and canals through swamps, and the withdrawal of swamp water for irrigation have seriously affected the hydrology of wetlands in many locations in Suriname. These activities have resulted in either increased or lowered water levels, and in changes in drainage patterns and consequently in more or less drastic changes in the vegetation (and related fauna) and in the water quality. In some parts along the coast and lower rivers courses, it has resulted in increased coastal erosion.

3.7.1.2 Hydrology of the Buru Swamp

The study area is dominated by a zone of saline to brackish wetlands (4-5 km wide) along the coast with extensive freshwater wetlands south of it. This freshwater swamp is known as the Buru Swamp (or Duivelsbroek Swamp). Before man settled in the area, the northern part of this swamp was draining towards the sea, while the southern part drained towards the Saramacca River in the south. In the absence of distinct height differences, no clear boundary between these two catchments can be determined, while it is also to be expected that the boundary will shift depending upon the season. For practical reasons the so-called "red line" has been created to serve as the watershed. Where continuous ridges are found, more or less blocking S-N water movement, the "red line" follows these ridges, but where they are lacking or discontinuous, the "red line" is drawn arbitrarily. In the study area this line has been drawn halfway between the ocean and the Saramacca River (see Figure 11).
The estuarine zone north of the "red line" provides many important goods and services. In order to enable this zone to continue to function as such, it is essential that the hydrology (and the water quality) north of the "red line" is not disturbed in one way or another. This means that no water should be withdrawn from the swamps over there, nor should water be discharged there. The first action would reduce the flow of freshwater towards the mangroves, while the latter could affect the water quality when the discharged water is contaminated.

The natural hydrological conditions of the southern study area have been affected by human activities since several hundreds of years ago, starting when the first plantations were developed along the Lower Saramacca River. In the early days dryland cropping has been practiced. At a later stage, the Lareco Road (later re-named to (Pandit) Gangaram Panday Road) has been constructed and rice polders have been developed, some of which stretch several kilometers towards the north.
In the early 1990s hydrological conditions in the northern part of the study area have also been affected by human activities when Staatsolie created a polder in the Sarah Maria/TA-58 area in order to carry out dryland operations (in below text indicated as the Tambaredjo oil polder), which polder now also reaches near the brackish wetland zone, crossing the "red line". Roads have also been constructed and trails established in the area to the NW and W of the TA-58 field.
All these activities have resulted in a change of hydrological conditions, which will be described below.

The development of polders along the Saramacca River has resulted in the obstruction of the flow of swamp water to the Saramacca River in the south. The water levels in the southern swamps will have increased compared to pre-polder conditions. However, since the introduction of rice cultivation in the area the swamp area has also been used as a large communal "waduk", a water reservoir from which water is extracted for irrigation of the paddy rice. This source of irrigation water is essential for the rice cultivation in the area, because the salinity of the Saramacca River water is sometimes too high to take in water from the river. The wetland rice farmers withdraw ~75% of their irrigation water from the swamp (pers. comm. resort leader LVV, 2009).

At certain stages of the wetland rice cultivation the rice fields needs to be dry and excess irrigation water is discharged from the fields into the Saramacca River through small culverts below the Lareco Road.

Through this system, a small part of the southern swamp water is being released to the Saramacca River in the south, more or less the way it used to do under natural pre-plantation conditions. From the hydrological study (Amatali, 2009) it has been assessed that only 2% of the total discharged swamp water of the southern Buru Swamp is taken up by the farmers for irrigation purposes. The remaining swamp water will have to drain to the north because to the east the flow is blocked by the Tambaredjo oil polder, while to the west the drainage path is partially blocked by the Moniz rice polder.

West of the TA-58 field two canals have been dug up to the southern edge of the mangrove zone, the Poeran-canal and the Soekha-canal (that have created Poeran-dam and Soekha-dam). These canals stretch far beyond the "red line".
In the same area Staatsolie has constructed the Ritsweg on top of the local low ridges. To some extent these structures block the S-N water movement, but this blockage was already present in the form of the ridge. The lack of hydrological connection at the Ritsweg is demonstrated by EC readings on July 11, 2009, which showed that salinity of the water to the north of the ridge was twice as high as that south of the ridge. But water can flow around the ridge at the western end of the Ritsweg and no actual difference in water level north and south of the ridge has been observed. At the end of the Ritsweg a natural opening in the ridge is present allowing the water to pass. The ridge continues further east as an interrupted low ridge as shown in Figure 11. Three more ridges are present in the study area showing the same interrupted and low character as the one at Ritsweg. Ridges therefore do not significantly obstruct the swamp water flow.

The hydrology of the study area, as based on above description and taking into account the water budget analysis (Amatali, 2009), is shown on the hydrological map of the area (**Figure 11**).

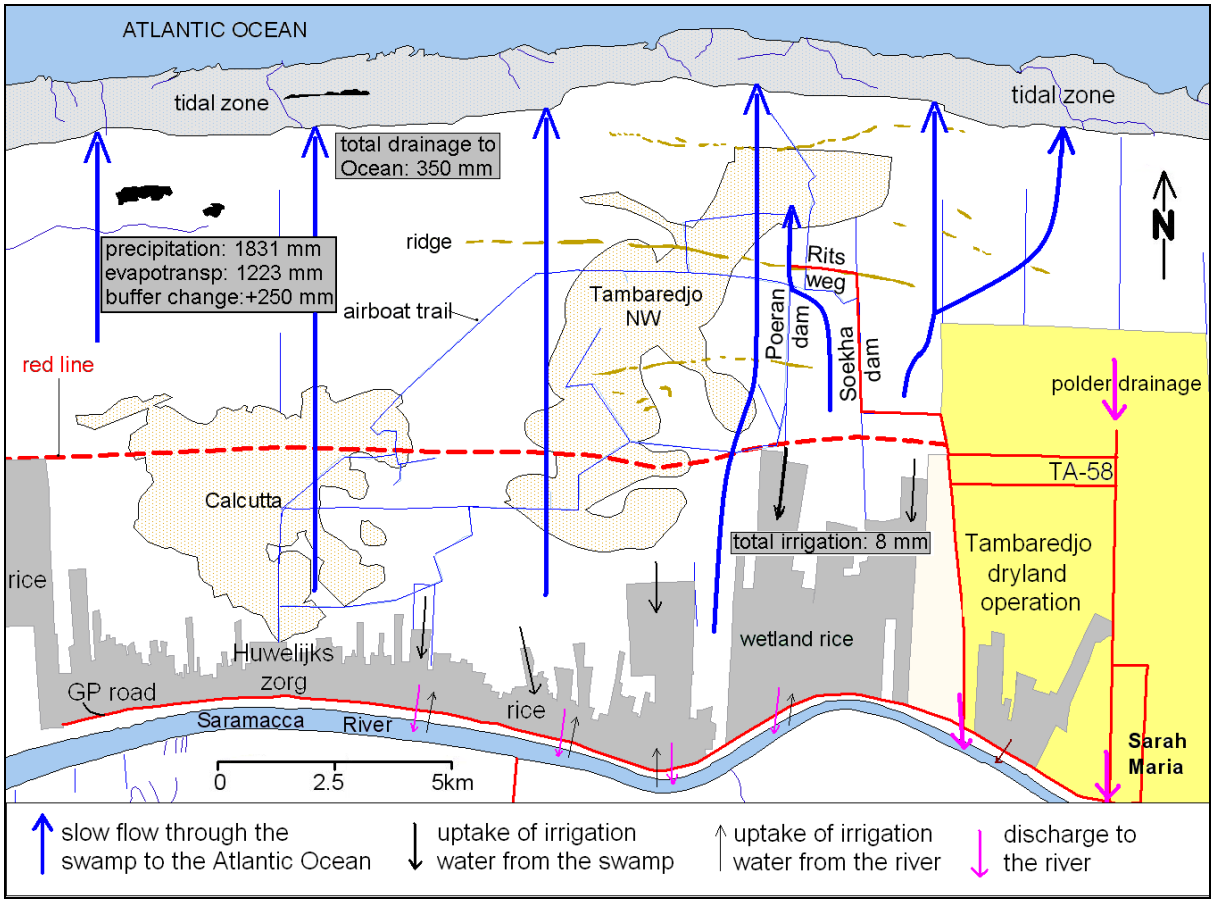

Figure 11: Schematic presentation of the hydrology of the study area and surroundings using the water budget for the study period

During the current study, the water depth of the swamp in the Long Dry Season mostly ranged between 40 and 75 cm at the Calcutta oil field (location 02). Higher water depths up to 82 cm have occurred here for a short period after heavy rainfall, but these were not recorded during reading of the staff gauges. For most of the freshwater and brackish water (Typha) swamp of the Tambaredjo NW area the water depth has ranged between 50 and 90 cm, but locally shallower (35-75 cm) and deeper (80-120 cm) water conditions are found. In the mangrove zone, the swamp water depth was 10-20 cm at the end of the Long Dry Season, but is rose to 55-60 cm in the rainy season. The shallower water depths in this zone are attributed to a slightly higher elevation of the clay surface.
Teunissen et al. (2000) indicate that the water depth in the Wayambo swamp, east of the study area with comparable hydrological conditions, varies between 40 and 90 cm, with a median depth of 70 cm above the mineral surface. Also in this area, shallower water depths have been found in and near the mangrove zone. Conditions are thus comparable.

Because the total amount of rainfall for the study period does not significantly differ from the long-year average, the hydrological conditions for the study area can be considered as normal, despite a different rainfall pattern. In wetter years the maximum water levels will not significantly differ from the maximum levels during the current study (82 cm at Huwelijkszorg), with a possible exceedance of 5-10 cm.
But in coming years, it is possible that the swamp completely dries out, as this has occurred in the El Nino year of 1993. Such scenario has a low probability but still it could occur during the project's lifespan.

During the period February-mid July the water level mostly fluctuated around 70 cm (± 2 cm; relative to location 02). Lower levels, down to 64 cm, occurred in late February and late May, coinciding with dry spells. Higher water levels were observed in March and April, when levels above 75 cm where occasionally reached. Significant discharge to the Ocean only takes place when the swamp level comes above ~71 cm (relative to a selected datum at location 02). The volume of discharge increases with rising swamp water level. For the study area discharge took place for only 81 of 165 days in the rainy periods, with estimated flow velocity mostly below 0.5 mm/sec. Maximum flow velocity has been estimated at 1.5 mm/sec. Maximum water displacement is 45 and 125 meter per day respectively.
However, in open trails the flow velocity can be higher, because there is no peat and far less vegetation present. A velocity of 2-3 cm/sec has been observed and a similar velocity is thought to be possible during conditions of high rainfall at high swamp levels. Maximum water displacement in the trails could be as high as 2-2.5 km per day under such conditions.

Despite the presence of a network of dams and trails, there are no clear indications that the oil production activities in the Calcutta oil field significantly affect the hydrology of the Buru Swamp. Swamp levels in the oil field show the same fluctuations as those outside the oil field. However, the trails promote a more rapid discharge of swamp water at a swamp level of ~ 71 cm (with reference to the staff gauge at location 02). The impact of this for the Calcutta oil field is thought to be hardly relevant, because the field is situated in the south of the Buru Swamp (far from the outlet to the ocean) and the trails network is not connected to an outlet creek.

There is no tidal influence in the northern project area, which is still some 2.5 km from the coast. Tidal influence is thought to occur in the zone with young mangrove forest, a belt of about 1200 meter wide along the Ocean. Apparently, the parwa forest of the northern project area is blocked from the sea, meaning that no ocean water ever reaches the area. This can also be concluded from the salinity study that never shows a significant sudden increase. However, water from the project area does drain to the ocean during periods of high rainfall and high swamp water levels (see Figure 11).

The study area will be subjected to the projected accelerated sea level rise because of climate change. The impact of this phenomenon has not been considered for the current study because the impacts are not yet clear and no impact is expected to become of relevance within the project period.

3.8 WATER QUALITY

3.8.1 Introduction

The water quality of the swamps in the Coastal Plain varies from saline to brackish water near the coast to freshwater in the south. Main factors affecting the quality of swamp water are the characteristics and the volume of incoming water (rain, floodwater, discharge water from higher elevations), the chemical characteristics of the prevailing soils and peat in the area, the vegetation type, the depth and duration of inundation, and the effects of diffusion, dilution and/or concentration.

A narrow zone along the coast has slightly alkaline to slightly acid water, with a high to moderate salinity. To the south of it, a zone with neutral to slightly acid water and a moderate

to low salt content is found. The swamps in the southern part of the Coastal Plain have slightly to very acid water and no salts.

Swamps generally have low oxygen content, with values changing over the day. Values are lowest in the early morning and increase during daytime. Oxygen is continuously consumed by decomposing organic materials, but during the daytime, a considerable production of oxygen occurs by photosynthesis of algae. The temperature, water movement and precipitation furthermore affect the oxygen content.

Nutrients are medium in the northern swamps, near the coast, to low or very low in the swamps on older deposits in the south of the Coastal Plain.
The water quality of canals and creeks in the Coastal Plain may vary considerably. In the absence of human impact, their water quality reflects that of their source and/or that of the area(s) through which they flow.

3.8.2 Water quality of the project area

The water of the project area is mostly clear and slightly brownish. Turbidity has only been observed at locations where heavy transport has taken place by means of swamp carriers. No signs of other water pollution have been observed.

The water of the mangrove zone can be classified as mesohalinous (1,000-10,000 mg Cl/l) and the other three zones as oligohalinous (100-1,000 mg Cl/l). The Typha swamp usually has values above 300 mg Cl/l, while part of the freshwater swamp has values below 100 mg Cl/l during the rainy season. Only the water of the freshwater swamp is suitable to be used as irrigation water for wetland rice.

The pH values indicate near neutral conditions for the (slightly) brackish environments and slightly more acid conditions for the freshwater swamps, with lowest values for the high swamp wood. In time lowest values have been measured during the Long Dry Season, with values increasing as soon as rain started falling, but no changes have occurred in the swamp wood environment.

The levels of Dissolved Oxygen are low to very low in swamps and medium in canals. Values vary considerably, depending upon sampling location, time of day and weather conditions.

Levels of phosphorus (as PO_4), nitrate and ammonium are normal for the swamps of the Young Coastal Plain.

The current data are in good agreement with the findings of earlier studies (Teunissen et al., 2000; Noordam & Teunissen, 2006) in respectively the Wayambo swamp and the Tambaredjo NW swamp.
Generally speaking the findings are in agreement with those reported by Mohadin (1980), Mol (1993a) and IBT (1999).

The frequent presence of insect-eating Bladderwort (Blaasjeskruid, *Utricularia foliosa)* in almost all of the airboat trails may indicate a non-polluted (oligotrophic = poor in nutrients) aquatic environment (Teunissen, personal communication, 2009).

3.8.3 The Calcutta oil field

Water quality at the Calcutta oil field is slightly different from that of the Tambaredjo NW project area.
The water is often turbid, with the highest turbidity in the main canal. Only very occasionally some minor oil pollution in the form of an oil film has been observed.
The salinity levels of the water of the Calcutta oil field appear to be slightly elevated when compared to the neighboring freshwater swamp. This increase is most pronounced at the inset of the rainy season and is lowering during the rainy season. After ~ 4 months the levels in the oil field is comparable to those in the undisturbed freshwater swamp. Even though the salinity is increased the water is still very suitable for irrigation of rice (150 mg Cl/l) in the irrigation season, where 300 mg Cl/l is the threshold value.

There are no indications that other water quality parameters differ significantly from the undisturbed freshwater swamp, but there appears to be less Bladderwort (Blaasjeskruid, *Utricularia foliosa).* This lower presence is thought to be the result of increased turbidity, where clay and peat particles may clog the submerged insect-catching bladders.

3.9 VEGETATION

3.9.1 Vegetation records

Vegetation studies in the coastal zone of Suriname have been carried out by Lindeman (1953); Sterringa (1971); Teunissen (1972, 1978; 1980); Pons (1972) and Julen (1974).
To support the ecosystem mapping of Northern Suriname (Teunissen, 1978, 1980), in 1975 28 vegetation plots were recorded along "fish holes" near the present Tambaredjo/Tambaredjo oil field and Calcutta oil field. Of the 28 records, 21 records are located in still existing natural vegetations, the others are now located in impounded areas (polders) and deforested areas.
Additional vegetations records have been made during the study for the EIA of the Tambaredjo oil field area (Teunissen, 1998) and the PEIA's of the Calcutta oil field (Noordam & Teunissen, 2005) and the Tambaredjo NW prospective area (Noordam & Teunissen, 2006).
For the current study vegetation plots have been recorded at 19 water monitoring locations. All 49 records from the Buru Swamp are presented in the Vegetation Table (see Appendix B).

3.9.2 Vegetation types and mapping

The vegetation of the Tambaredjo NW area and surroundings was first mapped at the scale 1: 200 000 "Reconnaissance map of the Ecosystems of the Coastal Region and Savanna Belt of Suriname (Teunissen, 1978; 1980). That map is based on aerial photos scale 1: 30 000 taken between 1971 and 1974 by KLM-Aerocarto on behalf of the Central Bureau for Aerial Survey (CBL). Ground truthing and vegetation sampling took place in 1975 (see above).

However, recent satellite imagery (Landsat, 2002) shows that since the early 1970s, quite some vegetation changes have been taken place in the area, mainly caused by:

- grass and peat fires (traces of recent fires are visible on the 2002 imagery)
- usual vegetation succession
- impoundment and deforestation (oil and rice polders) and possibly also by
- changes in the hydrology of the swamp

Because of these changes, it was decided to use Landsat imagery to produce a new vegetation map (see Figure 12).

From interpretation of the satellite imagery, ground truthing and vegetation records, vegetation types could be distinguished and mapped. Table 6 presents an overview of the vegetation types that could be distinguished in the Tambaredjo NW area and surroundings.

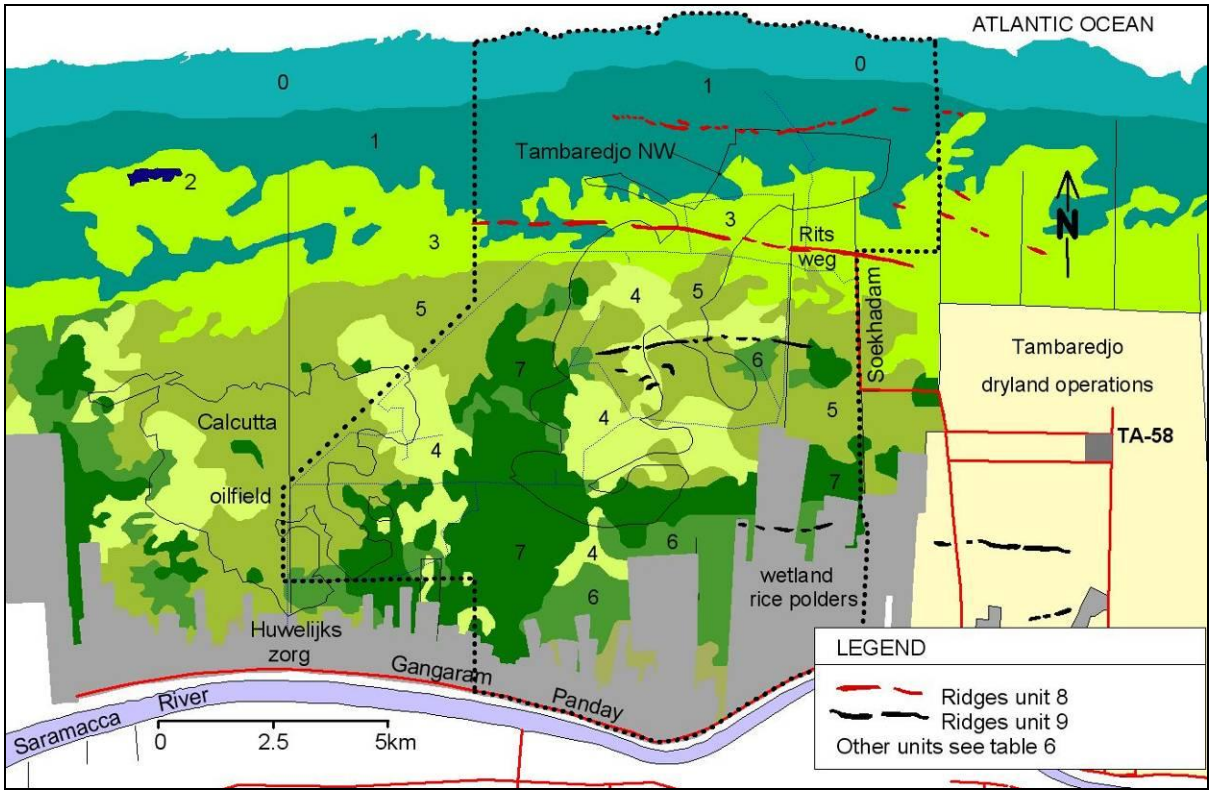

Figure 12: Vegetation of the Tambaredjo NW area and surroundings (based on Landsat 2002, updated by ground truthing)

Table 6: Overview of the vegetation types of the Tambaredjo NW area.

Mapping unit	Vegetation type	# of vegetation plots (see Appendix B)
0	**Mudflats and young coastal mangrove forest** dominated by Black Mangrove (ST: Parwa; SC: *Avicennia germinans*) with White Mangrove (ST: Akira; SC: *Laguncularia racemosa*) treelets along tidal creeks	2
1	**Closed to open mature coastal mangrove forest** dominated by Black Mangrove (ST: Parwa; SC: *Avicennia germinans*)	6
2	**Salt water lagoon** (ST/SD: Pan)	No lagoons in study area
3	**Herbaceous brackish water swamp** dominated by Cat Tails (ST: Payagrasi of Langagrasi or Kunsuwiwiri; SC: *Typha domingensis*) with or without scattered Black Mangrove trees (ST: Parwa; SC: *Avicennia germinans*)	8
4	**Herbaceous freshwater swamp** with scattered shrubs and bushes. Freshwater swamp richer in species than brackish water swamp. Several species may dominate (see vegetation table).	22
5	**Swamp scrub and bushes** characterized by Swamp Plumb (SD: Zwamppruim; SC: *Chrysobalanus icaco*) and Swamp Soursop (SD: Zwampzuurzak; SC: *Annona glabra*) alternating with spots of (still) open (herbaceous) swamp	0
6	**Low swampwood** characterized by Swamp Plumb (SD: Zwamppruim; SC: *Chrysobalanus icaco*) and Swamp Soursop (SD: Zwampzuurzak; SC: *Annona glabra*)	6
7	**High swampwood** dominated by Swamp Cork Wood (ST: Watrabebe; SC *Pterocarpus officinalis*) and White Cedar (ST: Swampu-panta; SC: *Tabebuia insignis*)	2
8	**Coastal ridge wood**: mixed xerophytic coastal ridge wood in brackish areas	0
9	**Ridge forest:** mixed xero-mesophytic dryland and marsh forest in fresh water swamps	0
not shown[(a)]	Floating vegetation of abandoned well locations and trails. Several species may dominate (see vegetation table).	3
Total number of vegetation records		49

ST=Sranan Tongo Name; SC= Scientific Name; SD=Surinamese-Dutch Name

(a) Floating vegetation is found in (recent) open water across all mapping units

All above vegetation types (except # 2) are found within the boundaries of the study area (the Tambaredjo NW area, its downstream and upstream areas). The project area is located in an area that is dominated by mangrove forest, brackish and freshwater herbaceous swamps and freshwater swamp scrub and low and high swamp wood (units 1 and 3-7).

A more generalized ecosystems map has been used for other baseline studies presented in this report. At this generalized map the units 4, 5 and 6 have been combined to form the unit

"**Herbaceous freshwater swamp with or without shrubs and bushes and areas with low swampwood",** on maps abbreviated to "**Mixed herbaceous to low swampwood"**.

Pictures of the ecosystems of the project area are presented below (Figure 13 till Figure 17).

Figure 13: Closed mature coastal mangrove forest

Figure 14: Herbaceous brackish water swamp

Figure 15: Herbaceous freshwater swamp with low swampwood

Figure 16: High swampwood

Figure 17: Trail in the Calcutta oil field with herbaceous freshwater swamp

Figure 13: Shallow airboat trail in mature Black Mangrove (Parwa, *Avicennia germinans*) forest at staff gauge 16.
Figure 14: Herbaceous brackish water swamp with Tall grass (Langagrasi, *Typha angustifolia*), with scattered Parwa trees in the background.
Figure 15: Herbaceous freshwater swamp with low swampwood close to staff gauge 11.
Figure 16: Shallow airboat trail in high swampwood at staff gauge 12.
Figure 17: Wide channel (sampling station staff gauge 1) in herbaceous freshwater swamp in the Calcutta oil production field.

3.9.3 Vegetation succession

Along the coast, young Black Mangrove (*Avicennia germinans*) forest (mapping unit 0) develops as soon as mudflats are silted up above mean sea level. In time, this may develop into a mature Black Mangrove forest. Young or mature Black Mangrove forest may become uprooted by erosion processes after which it disappears. However, at regular intervals mature Black Mangrove forest stays intact resulting in an average net coastal accretion and development of a closed to open Black Mangrove belt (mapping unit 1).

Parts of the Black Mangrove belt may die due to worsening of drainage conditions caused by soil subsidence and/or blocking of tidal creeks by fresh mudflats. Then salt water lagoons are formed. Deep lagoons never dry out. However, lagoons may silt up with sediments brought in by the sea during high tide. As soon as lagoons are completely silted up, and drainage conditions improve, Black Mangrove forest may re-establish (mapping unit 1). No lagoons are found in the study area.
Lagoons can also be man-made as is the case with a number of abandoned drilling sites. It has been observed that such lagoons are quickly covered by vegetation again.

South of the Black Mangrove belt, an herbaceous brackish water swamp (with or without scattered Black Mangrove trees) may develop on slightly firmer soils on which a peat layer develops (mapping unit 3). In the Saramacca area, these swamps are dominated by Cat tails (*Typha domingensis*, formerly known as *Typha angustifolia)*. Grass and peat fires, which may occur during dry seasons, may prevent the development of any woody vegetation within this vegetation type. This ecosystem is gradually becoming fresh, as shown by the surface water resources study.

Further inland, grass swamps become fresh and richer in species (mapping unit 4).

In the absence of fire herbaceous fresh water grass swamps (mapping unit 4) may gradually develop in *Chrysobalanus-Annona* swamp scrub and bushes (mapping unit 5) followed by low *Chrysobalanus-Annona* swamp wood (mapping unit 6) and high swamp wood, dominated by *Pterocarpus officinalis*) and *Tabebuia insignis.* This high swamp wood may eventually develop into species-rich high swamp forest, in Suriname known as *Virola-Symphonia-Euterpe* forest. Although some *Virola surinamensis* (Babun) trees, *Symphonia globulifera* (Mataki) trees and *Euterpe oleracea* (Pina) palms are already present in the high swamp wood of unit 7, the species-rich high Babun-Mataki-Pina swamp forest has not yet been developed in the study area. Unit 7 is therefore still considered a succession stage towards high swamp forest.

Comparing the 2002 map (Figure 12) with the map based on aerial photos of the early 70s (Teunissen, 1978) it is clear that many areas of herbaceous freshwater swamp developed into swamp scrub and bushes while open swamp wood developed into closed low swamp wood and even high swamp wood.

Observations made in the Calcutta oil field indicate that, apart from the cleared parts, the vegetation is not significantly affected by the wetland operations. Some localized yellowing of Pina palms has been seen, which may be caused by a slight increase of the swamp water level, but no die-off of plants has been observed. No indications are found of water quality changes: no eutrophication, increased salinity or oil pollution.

Trails and well locations that have been constructed as part of the 2006 exploration program in Tambaredjo NW show various stages of vegetation development:

1) Trails and well locations that are not longer used are completely closed with floating vegetation composed of grasses, and broad-leafed herbs, sometimes even carrying floating shrubs. Often one species dominates, also depending upon the local conditions. Many of these trails and well locations are no longer accessible for airboats.
2) Smaller trails that are still being used have clear dark water with aquatic plants and localized small patches of floating vegetation Floating grass-like plants and floating broad-leaved herbs enter the trails from its vegetated sides.
3) Wider trails that are still being used have become considerably narrower, because they are only used for airboat and carrier transport. Along both sides of the open channel conditions are similar to those described under 1), while the open channel is similar to the situation described under 2).

3.9.4 Grass and peat fires

Since early times, during every dry season, many "grass" swamps are burned intentionally, a common practice to keep such areas accessible for men and to keep them attractive for certain game species such as deer. Burning is also done to create less favorable conditions for mosquitoes. In the Saramacca area, burning may also have had the intention to remove or reduce woody vegetation in order to lower the costs of future land reclamation.
Seen from the air, the Buru Swamp is full of traces of tractors and airboats used by modern hunters and poachers who may set grass on fire to keep swamps accessible for their vehicles. Finally, swamps are also set on fire just for fun.

Grass swamp fires may also start unintentionally when in swamp areas the grassy vegetation along road sides and on plantation dams are burned as a way of weed control or when slashed secondary plantation vegetation is burned for (re)cultivation purposes. Also campfires may lead to grass fires.

If rains fail to fall during the Short Rainy Season, the Long Dry Season, normally ending in mid November, is extended up to late April and thus lasts for 8 months, up to the next Long Rainy Season that normally starts in May. For Suriname, such extremely dry periods were reported from 1745/46, 1767/68, 1797/98, 1845/46, 1898/99, 1911/12, 1925/26, 1939/40, and 1963/64 (Bubberman, 1973).

When swamps dry up, also their peaty topsoil may desiccate completely and grass fires may become peat fires. Although peat fires may be self-generating by lightening or bacterial heating, there are strong indications that most fires, if not all, are human-induced (Bubberman, 1973).

Once peat layers are burning, it is virtually impossible to extinguish the fire. Only the next rains of the Long Rainy Season (LRS) may stop them. Where peat has been burned, the LRS rains may create open water areas for the following years. On such open waters, floating vegetation may develop which quickly form a new peat layer with a speed of up to 1 cm a

year (Van Donselaar et al., 1965-1975). After the building up of a new peat layer, woody swamp vegetation may develop again.

Based on the thickness of the peat layer in the area it is concluded that peat fires have been absent for a considerable period of time. But grass fires in the Typha zone (unit 3) are thought to be rather common as can be deduced from the 2002 satellite image, from which it is clear that grass fires have recently swept over the Buru Swamp area and prevented vegetation succession.
To the northeast of the Tambaredjo oil polder a grass fire was observed in early December 2008.
From above observations it appears that in particular Typha is susceptible to fire, probably due to the considerable mass of flammable material present in older Typha swamps.

3.9.5 Unique vegetation

WWF's Conservation Science Program distinguishes worldwide 200 unique Ecoregions with ecosystems with the highest conservation values. Two of these ecoregions are of relevance for the present study area:

1) **Guianan Mangroves**, in Suriname represented by:

- Black-mangrove (*Avicennia*) forests: young and mature Black-mangrove forest is found in a 3.5 km wide zone along the coast, covering ~ 3,500 ha within the study area and ~ 350 ha (of mature) Black Mangrove forest within the project area.

This type of mangrove forest is exclusively found in the Guiana's, nowhere else in the world. The conservation status of these mangroves has been estimated as relatively stable or intact (Olson & Dinerstein, 2002)

2) **Suriname Swamp Forest**, represented by:

- High Swamp Forest

High Swamp Forest itself is not present in the study area, but the High Swampwood in the freshwater swamps (ecosystem type 7) forms a succession stage towards High Swamp Forest. In the study area High Swampwood covers ~2,000 ha of which ~ 400 ha is found within the project area.
Because "Suriname swamp forest", is restricted to Suriname and not found elsewhere in the world, it has a high international conservation value. High Swamp Forest is very vulnerable to peat fires and to changing surface water levels. On a national level High Swamp Forest should be considered as a vulnerable forest type. Damage to the High Swamp Wood in the project area will delay the development of High Swamp Forest here.

3.10 FLORA

3.10.1 Methods

A flora is a list of plant species that is present in a certain area, in this case the study area. The flora from the Buru Swamp became known by vegetation studies since 1974 (see 3.9).

3.10.2 Results

The Vegetation Table (see Appendix B) shows the list of species found in the Buru Swamp area between the Moniz rice farm in the west and fish hole "Fräser" in the east. The list includes 74 plant species, found in the wetlands. Certainly this list is not complete; other species will be found as fieldwork continues.

The majority of plant species found in the brackish area along tropical coasts has a cosmopolitan, a pan-tropical, an Afro-American, or a Caribbean distribution, probably because most propagules are distributed by the sea, by tidal currents and by migratory birds. However, farther inland, in the freshwater swamps, the majority of plant species has a distribution, which is more confined to the South American continent or even restricted to the Guyana Region (Lindeman, 1953). This is also true for the study area.
There are a few species that are normally not encountered in herbaceous freshwater swamps along the coast. Most uncommon is the Sabana mangro (*Clusia nemorosa*), which is a species found in savanna forests and in peat swamps. Also "Pijlkruid" (*Sagittaria lancifolia*) and Watra-okro (*Hibiscus sororius*) are rather uncommon species in these types of swamps.

3.10.3 Conclusions

The flora list of 74 species (Appendix B) was compared with the flora lists of more intensive studied coastal areas, such as Galibi (Van den Berg, 1972), Wia-Wia, Krofayapasi and Matapica (Lindeman, 1953; Sterringa, 1971; Pons, 1972 and Julen, 1974) and of observations in the Weg naar Zee area and the Wayombo area (E2 Environmental Alliance Inc, 2000; Teunissen & Noordam, 2001), the area north of the Tambaredjo oil field (IBT, 1999), Coppename-monding (Teunissen ed., 1972), the Coronie-coast (Lutchman, 1978; Teunissen, 2004), Burnside-Nickerie (Teunissen, 1973). It can be concluded that the Tambaredjo NW area and surroundings are relatively poor in species (also due to the absence of pronounced beaches and ridges) and that unique, rare, endangered or biogeographically important plant species have not been found and are not expected in the area.

3.10.4 Goods and services from vegetation and flora

The flow of clean fresh water from the Buru Swamp adds to the brackish environment in which mangrove forests along the coast (and in and outside the Coppename-monding Nature Reserve) and along the Saramacca River flourish.

At a national level, the mangrove vegetation along the coast and lower river courses contribute to the many goods and services the estuarine zone has to offer (Werkgroep

Estuariene Kuststrook, 1976). Conversion of mangrove forest means loss of free coastal protection and reducing the high primary production of mangrove forest. Loss of mangrove forest reduces the secondary production of fauna, including ocean fish and shrimp (Teunissen, 2004).

3.11 FAUNA

3.11.1 Introduction

In the past fauna studies in the North Saramacca area have mainly focused on the waterfowl of coastal mudflats, the mangrove zone and the lagoons (De Jong, Spaans & Held, 1986). Fish and shrimp studies focused on main catches of commercial marine and coastal species (Malone-Jessurun, 1995; Heidanus, 1996).
A first inventory of the fauna of the Tambaredjo oil field area was carried out on behalf of the EIA of that area (IBT, 1999; Haskoning & IWACO & IBT, 1999) followed by a baseline study for the Wayombo seismic survey EIS (E2 Environmental Alliance Inc, 2000), the Calcutta oil field (Noordam & Teunissen, 2005) and the Tambaredjo NW prospective area (Noordam & Teunissen, 2006). From these studies it became clear that more detailed information was required about aquatic ecology and the avifauna (birds) in case of production development. Therefore extensive fieldwork has been conducted for these two groups. For the other fauna elements no additional field studies have been carried out, but additional information has been gathered during fieldwork of other disciplines and through interviews.

3.11.2 Aquatic ecology

3.11.2.1 Introduction

Impoundment and drainage of areas for oil exploration and production and associated construction of roads have brought major changes in the landscape and hydrology of the existing TA58 and Tambaredjo oil production fields, i.e. a change from natural swamp land to an oil production polder (Van Maren, 1999). The baseline study of environmental conditions in the old TA58 and Tambaredjo oil production fields (Environmental Research Center, 1999) stressed the importance of hydrological connectivity (i.e. unimpaired water flow) for the functioning of the swamp ecosystems in the Tambaredjo Area. In the more recent development of the Calcutta oil production field, Staatsolie has attempted to minimize changes in the landscape, vegetation and hydrology by avoiding the construction of polders (canals, dikes etc) and opt for the so-called ‘wet operations’ system of oil production (Noordam & Teunissen, 2005). Staatsolie N.V. intends to develop the Tambaredjo NW concession along lines laid out in the Calcutta ‘wet operations’ model.

In the present study baseline data were collected on the aquatic ecosystems of the fresh- and brackish-water swamps in Staatsolie’s Tambaredjo NW oil concession. Additional data were collected from (1) control areas outside the Tambaredjo NW concession and (2) the Calcutta oil production field in order to assess potential impacts of Staatsolie’s projected oil-production activities in the Tambaredjo NW concession. Data were collected on (1) fish community structure and diversity, (2) (fish) habitat, (3) phytoplankton and zooplankton composition and (4) aquatic macro-invertebrates. The complete results of two surveys in (1) the Long Dry Season (sampling round 1-3 December 2008) and (2) the Long Rainy Season (sampling round 20-22 May 2009) are added as a separate report to this study (Mol, 2009). Here only the issues as relevant for the baseline description are presented.

3.11.2.2 Baseline description of the affected environment

Basic water quality and site characteristics

Weather conditions during the first survey were characteristic of a normal (Long) Dry Season, but during the second survey of 20-22 May weather conditions were rather unusual for the time of the year (Long Rainy Season) as May 2009 was a very dry month in the Coastal Plain of Suriname (see Chapter 3.1.3).

Basic water quality data and site characteristics of the sampling stations are shown in Table 1, Appendix C. Salinity/conductivity was highest in the mangrove forest, close to the Atlantic Ocean (1,000-6,700 µS/cm); conductivity was higher at the end of the dry season (December 2008) than at the start of the rainy season (May 2009). However at most stations in the swamp (wood) to the south of the mangrove forest, conductivity was in the range 300-1,000 µS/cm and again highest at the end of the dry season.
The pH varied between 5 and 7 and showed no clear seasonal pattern.
Secchi transparency was low in the mangrove forest at the end of the dry season and in the disturbed Calcutta Oil Production Field (3-5 cm), but relatively high in the undisturbed swamp (wood) (10-31 cm). During the second (May) survey, Secchi transparency had improved considerably (12-18 cm) in the shallow canal in the mangrove forest.
The dissolved oxygen concentration was never very high, ranging mostly between 0.5 and 2.0 mg/L (but slightly higher at station 1 [2.55-3.30 mg/L], a large 'canal' with presumably a lot of wind-induced turbulence).
In the undisturbed swamp (wood) the water color was dark brown, but in the mangrove forest and Calcutta Oil Production Field the water had a grey color from suspended fine sediments.

Phytoplankton and zooplankton

The phytoplankton community structure of the sampling stations at the end of the dry season (December) is shown in Table 2, Appendix C. In the Calcutta Oil Production Field the phytoplankton was present in low abundance (10-20 individuals/L), with few species (3-6), and low species diversity (1.10-1.79) when compared to phytoplankton at undisturbed stations in mangrove and freshwater swamp(wood) with 80-240 individuals/L, 15-24 species/station, and species diversity of 2.29-3.08. Species evenness was 0.77-0.97 at the undisturbed stations. Zooplankton organisms present in the phytoplankton samples are shown in Table 3, appendix C.

Aquatic macro-invertebrates

In total 1640 aquatic macro-invertebrates (wet mass 413.8 g) were collected at the sampling stations (Table 4, Appendix C). The macro-invertebrate fauna was dominated in numbers by the freshwater shrimp *Palaemonetes carteri* (52.3%) and a hemipteran water strider (38.4%) and in mass by *Pomaceae* snails (43.6%), the shrimp *P. carteri* (31.2%) and three specimens of the freshwater crab *Trichodactylus spinifer* (18.8%).

Fishes

The fish community structure of the sampling stations is shown in Tables 5 and 6 (Appendix C). In total, we collected 1235 fishes (68,261 g wet mass) in 23 species in the Tambaredjo and Calcutta concessions of Staatsolie (Table 6, Appendix C).

The total number of collected fishes and their total mass for the different ecosystems is shown in Figure 18.
Total collected mass is highest in the mangrove forest, followed by the Typha swamp and lowest in the freshwater herbaceous swamp. The total weight for high swampwood and the Calcutta oil field are in between. Most fishes were caught in the freshwater herbaceous swamp and the lowest number in the Calcutta oil field.

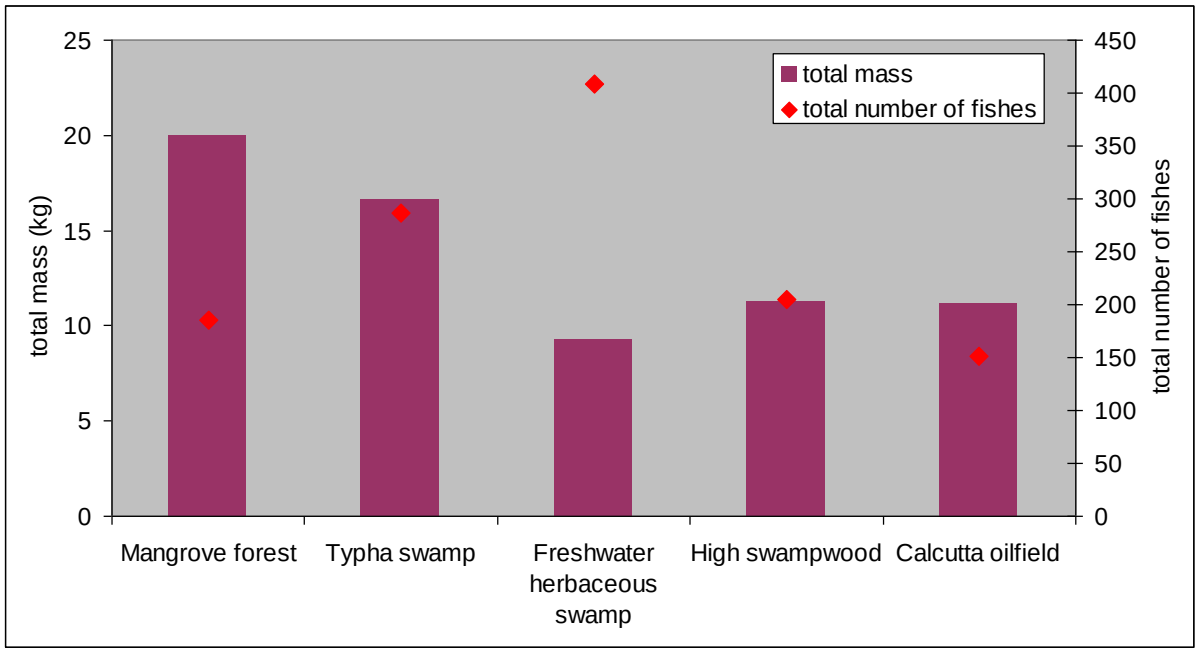

Figure 18: Combined number and mass of fishes collected at the sampling stations during the two sampling campaigns

The number of fish species for the 5 ecosystems is presented in Figure 19. Highest number of species is found in mangrove forest, Typha and the freshwater herbaceous swamp. The number of species for the Calcutta oil field is low compared to the other freshwater ecosystems.

Overall, redi-tere sriba *P. maxillaris* (41.5%), bladvis *Polycentrus schomburgkii* (19.3%), patakka *Hoplias malabaricus* (9.0%), guppy *Micropoecilia picta* (5.6%), noja *Trachelyopterus galeatus* (4.6%) and dwarf cichlid *Nannacara anomala* (4.2%) dominated in numbers, while patakka *Hoplias malabaricus* (35.3%), trapun *Megalops atlanticus* (33.8%; Figure 20), soké kwikwi *Hoplosternum littorale* (11.5%), noja *Trachelyopterus galeatus* (9.5%), walapa *Hoplerythrinus unitaeniatus* (3.5%) and krobia *Cichlasoma bimaculatum* (2.9%) dominated in mass (Table 5, Appendix C).

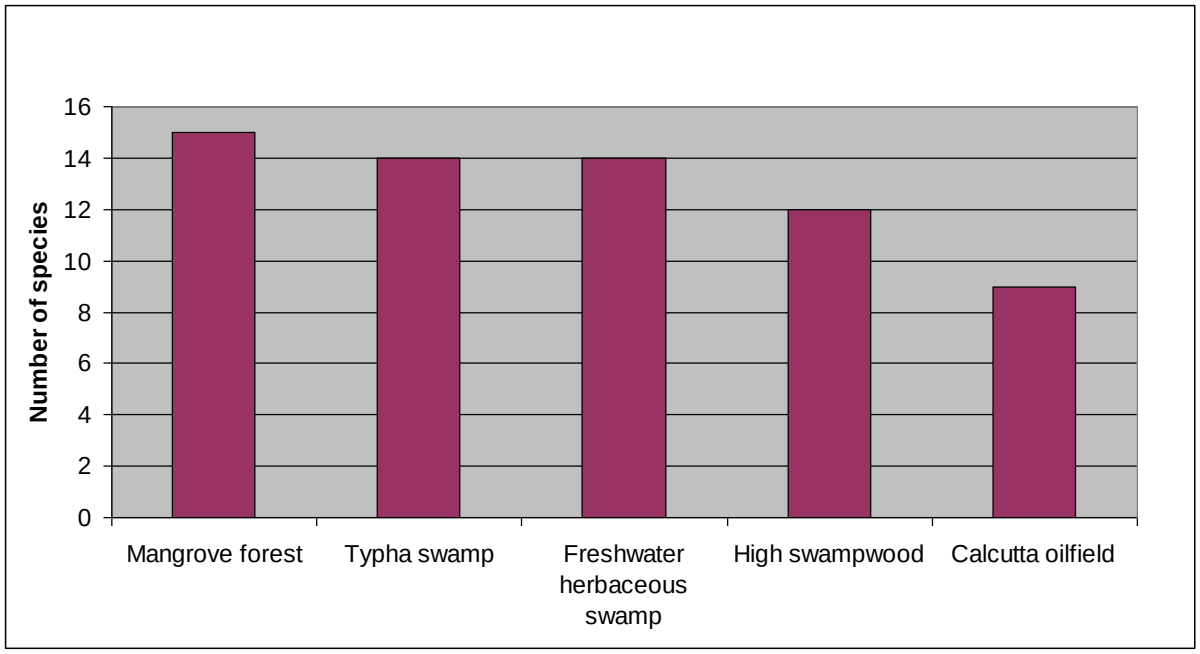

Figure 19: Combined number of fish species collected in the different ecosystems during the two sampling campaigns

Figure 20: A 5 kg juvenile tarpon (Megalops atlanticus) collected by trammel net in the Calcutta oil production field (staff gauge 1). Spawning of tarpon takes place in the Atlantic Ocean after adults migrate from freshwater swamps and rivers to the ocean.

Neither unique, rare, endangered, vulnerable or biogeographically important fish species, nor exotic or invasive fish species were recorded in the Staatsolie concessions and the mangrove forest to the north of the concessions. For example the introduced tilapia *Oreochromis mossambicus* that could be expected in the area (Mol & Van der Lugt 1995) was not recorded from the Staatsolie concessions in Saramacca, both in the present study and in 1998 (Mol & Ouboter 1999). At the undisturbed sites, fishes were often large (e.g. Figure 21; soké or he-

ede kwikwi *Hoplosternum littorale*) with brilliant colors (e.g. *Pristella maxillaris*) and no parasites.

Figure 21: A large specimen of the soké or he-ede kwikwi *Hoplosternum littorale* (24 cm Total Length; wet mass 244 g) collected by trammel net in an airboat trail at gauge 11 (freshwater herbaceous swamp vegetation).

During the December 2008 survey dead fishes (*Hoplosternum littorale*, *Cichlasoma bimaculatum*, *Hoplias malabaricus*) were observed in the mangrove forest (gauges 16 and 17;); the dying of these fishes may have been related to deteriorating environmental conditions in the recently opened airboat trail (oxygen depletion, release of hydrogen sulfide).

Figure 22: Localized fish kill after opening a new airboat trail in mangrove forest (staff gauge 17; December 2008 survey). This fish kill apparently did affect the fish populations to a great extent in December 2008 and fish populations had completely recovered in May 2009 (no dead fishes observed in May).

In Suriname, swamp fishes like patakka *H. malabaricus* (J. Mol personal observations) and the three kwikwi species soké *H. littorale*, platkop *Callichthys callichthys* and katrina *Megalechis thoracata* (Mol 1993, 1996) are known to concentrate their reproductive effort in the Long Rainy Season of May-July, although considerable plasticity in the timing of reproduction is known in the three kwikwi species (Mol 1996). On the other hand, small fish species (e.g. guppies) and cichlids may reproduce throughout the year. The large-to-medium-sized swamp fishes showed no ripe gonads (eggs) during the rainy season survey of May 2009 and the conspicuous floating bubble nests of *H. littorale* (Mol 1993b) were also not observed during this survey (although our airboat captain R. Setoe observed a single *H. littorale* nest approximately one week before our survey started). Most spawning of the swamp fishes may have occurred in the exceptionally wet 'short dry season' of March-April (see Chapter 3.1.3) as Mr. R. Setoe observed at least 10 *H. littorale* nests in April (i.e. one month before our May survey) (R. Setoe personal communication). With respect to kwikwi it is known that they are ready to span (i.e. ripe gonads present) at the end of the long dry season (December) with actual spawning depending on local rainfall and swamp water level in the period January-July (Mol 1996; Mol *et al.* 2000).

Observations of aquatic amphibians, reptilians and mammals

Amphibian tadpoles were observed at most stations, but they were not collected because identification is difficult (sometimes they have to be grown into the adult frog before identification is possible). The fully aquatic Surinamese toad *Pipa pipa* and the giant tadpole of the paradox frog (*Pseudis paradoxa*) were not observed during the present study although they are expected to occur in the area (and the latter was collected in the area during a previous study in 1998; Mol & Ouboter 1999). The spectacled caiman (*Caiman crocodilus*) was observed at staff gauges 5 and gauge 11 and a juvenile *C. crocodilus* (65 cm total length) was caught in the trammel net at gauge 5. Capybaras (*Hydrochaeris hydrochaeris*) were observed at gauge 12 and near gauge 16 (Figure 23).

Figure 23: A capybara (*Hydrochaeris hydrochaeris*) fleeing from an approaching airboat in a shallow airboat trail near staff gauge 12.

3.11.2.3 Discussion

The aquatic ecosystems that were studied during the present survey can be roughly categorized as (1) brackish-water mangrove forest, (2) herbaceous swamp and low and high swampwood and (3) disturbed freshwater swamp (Calcutta Oil Production Field).
(Fish) community structure can be summarized by indices like number of species (*S*), species diversity (*H*, based on both number of species and number/mass of individuals in each species), and evenness (*J*, a measure of (un)equal representation or dominance against a hypothetical community in which all species are equally common (and evenness = 1)).
Table 7 shows that species diversity and evenness of fish communities of mangrove forest, *Typha* swamp and high swamp forest were slightly higher in the present study than in the 1998 study by Mol & Ouboter (1999). On the other hand, both species diversity and evenness of the fish community of Calcutta oil production field were slightly lower than species diversity and evenness of the fish community of the TA58 oil production polder in 1998 (see discussion of (disturbed) ecosystems below).

The mangrove forest

The aquatic fauna of the mangrove ecosystem may eventually yield many more fish and macro-invertebrate species than recorded during the present study. For example, a study by the present author in 1998 (Mol & Ouboter 1999) in adjacent mangrove forest (Tambaredjo Area) yielded several species not recorded during the present survey: the fishes snook *Centropomus undecimalis*, kumakuma *Sciades couma*, molly *Poecilia vivipara*, kutai *Anableps* sp. and the American sole (Sur. boki) *Achirus lineatus* (Table 7), the crabs *Callinectes bocourti* and *Uca* sp. and a penaeid shrimp *Penaeus* sp. (Mol & Ouboter 1999). A possible explanation for this difference in catches between 1998 and the present study is that the 1998-sampling location was more in connection with the Atlantic Ocean (natural creek) than the sites in the present study (a man-made airboat trail that was not in direct connection with the Atlantic Ocean). On the other hand *Eleotris pisonis* and, surprisingly, platkop kwikwi *Callichthys callichthys* were collected in mangrove forest during the present study, but not in 1998 (Table 7). Also remarkable was the large number of soké kwikwi *Hoplosternum littorale* that was collected in mangrove forest during the present study (this species is usually considered as characteristic of freshwater swamps, although this freshwater fish species certainly seems to like water with relatively high conductivity (Mol 1994)). The fish species collected in the mangrove forest during the present study were essentially characteristic of the fish fauna of freshwater swamps). Apparently, the airboat trail into the mangrove forest was invaded by swamp fishes moving in northerly direction from the freshwater swamp and, lacking a direct connection with the Atlantic Ocean, not so much by marine/brackish-water fishes and shrimps/crabs from the north.

Table 7: Comparison between fish communities in Staatsolie's Tambaredjo oil concessions in the district Saramacca in 1998 (Mol & Ouboter 1999) and 2008-2009 (present study) based on numerical proportions (%). Herbaceous swamp habitat was not sampled in 1998. Oil production fields are TA58 (1998) and Calcutta (2008-09), respectively.

	Mangrove forest		*Typha* swamp		High swampwood		Oil production field	
Order, **family**, *species*	2008-09	1998	2008-09	1998	2008-09	1998	2008-09	1998
Characiformes								
Characidae								
Astyanax bimaculatus		1		1		<1		3
Ctenobrycon spilurus		1	1	33		47		20
Hemigrammus boesemani			<1					
Hemigrammus unilineatus			2	2	6	7		5
Hyphessobrycon simulata						2		1
Pristella maxillaris	26	9	33	26	21	19	64	3
Crenuchidae								
Crenuchus spilurus							2	
Curimatidae								
Curimata cyprinoides			1				3	1
Erythrinidae								
Erythrinus erythrinus								<1
Hoplerythrinus unitaeniatus	5	<1		<1	1	1		1
Hoplias malabaricus	10	<1	8	<1	20	1	9	<1
Lebiasinidae								
Copella arnoldi	1				15	4		
Siluriformes								
Ariidae								
Sciades couma		1						
Auchenipteridae								
Trachelyopterus galeatus	2		5		2		13	
Callichthyidae								
Callichthys callichthys	1							
Hoplosternum littorale	15	<1	1	12	2		1	<1
Megalechis thoracata [1]						<1		
Heptapteridae								
Rhamdia quelen [2]								
Loricariidae								
Hypostomus sp.								<1
Loricariichthys maculatus			1					<1
Perciformes								
Centropomidae								
Centropomus undecimalis		<1						
Cichlidae								
Nannacara anomala	2		5		5	<1		
Cichlasoma bimaculatum	8				6	2		1
Crenicichla saxatilis			<1					1
Krobia guianensis	1			1		2		4

	Mangrove forest		*Typha* swamp		High swampwood		Oil production field	
Order, **family**, *species*	2008-09	1998	2008-09	1998	2008-09	1998	2008-09	1998
Eleotridae								
Eleotris pisonis	1							
Polycentridae								
Polycentrus schomburgkii	20	2	29	4	11	2	4	19
Miscellaneous groups								
Achiridae								
Achirus lineatus		<1						
Anablepidae								
Anableps sp.		1						
Megalopidae								
Megalops atlanticus	4	74	2	1			1	<1
Poeciliidae								
Micropoecilia picta	4		11		7		5	
Poecilia reticulata		6		20		11		37
Poecilia vivipara		4						
Rivulidae								
Rivulus sp	1			1	2			4
Synbranchidae								
Synbranchus marmoratus								<1
Number of specimens collected	185	676	286	345	205	277	151	575
Number of species (*S*)	15	14	14	12	12	14	9	20
Species diversity (*H*)	2.1	1.0	1.9	1.7	2.2	1.7	1.3	1.9
Evenness (*J*)	0.8	0.4	0.7	0.7	0.9	0.6	0.6	0.6

[1] see Reis *et al.* (2005) for remarks on the nomenclature of the katarina kwikwi *Megalechis thoracata*

[2] the catfish *Rhamdia quelen* was only collected in low swamp wood habitat (not shown in the table) during the present (2008-09) study

The freshwater swamp (Typha swamp, mixed herbaceous swamp, low and high swampwood)

The freshwater swamp ecosystem is characterized by low dissolved oxygen concentration (Table 1; Appendix C) and slightly acidic water with high humic acid content (dark-brown color of the water due to dissolved tannin and lignin molecules; e.g. Environmental Research Center 1999; for a good description of a Neotropical swamp is referred to Carter & Beadle 1930). The swamp fishes are adapted to the low oxygen concentrations in the water (Carter & Beadle 1931) and often show air-breathing habits (Graham 1997) or other morphological adaptations such as swollen lips used in aquatic surface respiration (Winemiller 1989; Mol & Ouboter 1999) or floating bubble nests (Mol 1993b). Overall fish species richness was moderate to low in the freshwater swamp in the Staatsolie Concession (both in 1998 and in the present study; Table 7) when compared with other Neotropical swamps such as Kaw Swamp in French Guiana (Keith *et al.*, 2001, JM personal observation), Rupununi in Guyana (Lowe-McConnell 1964) or the Venezuelan Llanos (Mago 1970). However, Kaw Swamp is directly bordering the hilly interior of the Guiana Shield (with its species-rich clear-water streams) and both the Rupununi and Llanos are associated with large species-rich river

systems (Rio Branco /Amazon/ Essequibo and Orinoco, respectively). The fish fauna of the freshwater swamp in the Staatsolie Concession in the Young Coastal Plain also seems less diverse than the fish fauna of Surinamese swamps in the Old Coastal Plain (e.g. Mol *et al.*, 2007); however, the latter may include some fish species from black-water streams in the Savanna Belt, which are missing in the Young Coastal Plain. Although fish diversity is moderate, the freshwater swamps in the Young Coastal Plain are prime habitat of the popular soké or hé-ede kwikwi *Hoplosternum littorale* (Mol 1994), a species that is protected by law in Suriname (Rondeel 1965). These swamps also comprise a beautiful and threatened landscape in a densely populated area of Suriname (i.e. the Young Coastal Plain) and as such deserve special conservation effort. Commercial and sport fisheries (e.g. 'visgaten' such as Durga's 'Beni kwikwi soela' at Gangaram Panday Road) in the swamps of the Young Coastal Plain mainly target the three kwikwi species (soké or hé-ede *Hoplosternum littorale*, platkop *Callichthys callichthys*, and katrina *Megalechis thoracata*), patakka (*Hoplias malabaricus*), walapa (*Hoplerythrinus unitaeniatus*) and krobia (*Cichlasoma bimaculatum* and *Krobia guianensis*).

Disturbed freshwater swamp

The importance of hydrological 'connectance' (i.e. unimpaired water flow) in the swamps for the aquatic life was stressed in an earlier study of Staatsolie's Tambaredjo Concession (TA58/Sarah Maria) immediately to the east of the present study area (Environmental Research Center 1999). The existing Tambaredjo oil polder is characterized by south-north running dams and canals that obstruct the natural water flow in the swamp (i.e. polders that may be considered a hydrological disturbance). In the Calcutta Oil Production Field, Staatsolie has avoided the construction of polders as much as possible by the so-called 'wet operations' technique (Noordam & Teunissen, 2005), but the Calcutta production field still has numerous shallow 'canals' cleared of vegetation for transport of equipment, supplies and personnel (exploration, installation and maintenance of oil pumps). Although some of these 'canals' in the Calcutta Oil Production Field are of unduly large width (Figure 17) they are all very shallow (<1m water depth), and the overall hydrology and swamp landscape (vegetation) are much better conserved in the Calcutta Oil Production Field than in the Tambaredjo oil polder. It is thus disappointing that phytoplankton and fish abundance and diversity were to some extent negatively affected by the activities in the Calcutta Oil Production Field (as compared with undisturbed swamps) (Tables 2, 3 and 5, appendix C). Although fish diversity of the Calcutta Oil Production Field was higher in the second survey (May) than in the first survey (December) (compare appendices 3a and 3b; Mol 2009), overall fish abundance and diversity of the Calcutta Oil Production Field was low compared to diversity and abundance in the Tambaredjo oil polder (Table 7).

The low abundance and diversity of phytoplankton and fishes in the Calcutta production field during the December survey may have been caused by disturbance associated with busy traffic in the 'canals' (gauge 1; JM personal observations) or recent removal of vegetation (site 6). Fish communities at both sites 1 and 6 showed signs of recovery in May 2009 (phytoplankton was not sampled in May 2009).

With respect to the relatively high fish diversity in the Tambaredjo oil polder (as compared to the Calcutta production field), it should be noted first that, in 1998, fish diversity and abundance was also higher in the TA58 production field than in the undisturbed *Typha* swamp and high swampwood (Table 7). Apparently, some fish species that were collected from the canals in the TA58 oil production field are absent (or present in low numbers or

difficult to catch) in the natural swamp and high swampwood habitat (for example swamp eel *Synbranchus marmoratus*, ston-walapa *Erythrinus erythrinus*, warawara *Hypostomus* sp. and datrafisi *Crenicichla saxatilis*). These species either occur in the natural swamp(wood) but are difficult to catch and/or are present in low numbers in their natural habitat (swamp eel, ston-walapa and datrafisi) or they are river fish that enter the canals of the Tambaredjo oil polder from the Saramacca River (warawara). On the other hand, fish diversity (and abundance) in the Calcutta production field was somewhat low compared to fish diversity in the natural freshwater swamp and high swampwood habitat (Table 7) although this may have been caused to some extent by the extremely low fish diversity in the Calcutta production field during the December survey (with fish diversity showing signs of recovery during the May survey).

3.11.3 Birds

3.11.3.1 Introduction

The coastal swamp areas are poorly accessible. The knowledge on (among others) its avifauna is mostly based on observations made from roads, dams, canals, rivers and creeks that cross such areas. In addition, aerial surveys are applied to monitor certain bird species. Generally speaking limited ground information on the avifauna of the center of swamps is available.
The presence of a network of airboat trails in the Tambaredjo NW-Calcutta area gives access to central swamp areas and provides the opportunity to conduct terrestrial monitoring in such areas. However, the trails are concentrated in the open swamps and only a few trails cross through swamp wood or swamp forest.

The study has focused on the study area, but additional monitoring was conducted in the southern part of the Coppename-monding NR because noise and other impacts could affect avifauna here, in particular the breeding colonies of ibises and egrets.

3.11.3.2 Methodology

The primary objective of the bird survey was to assess the species richness of the Tambaredjo NW avifauna, and to compare different habitats at different times of the year.
The bird survey was intended to be balanced among as many habitats as possible, because it is expected that different habitats will have different bird species.
Four general habitats have been distinguished during a previous study of the area (Noordam & Teunissen, 2006):

1. Closed to open mature coastal mangrove forest
2. Herbaceous swamp dominated by Cat Tails
3. Mixed herbaceous swamp to low swampwood
4. High swampwood

The habitats are described in Ch. 3.9.
Four sites were selected for bird monitoring, one in each habitat (Figure 24 and Table 8).

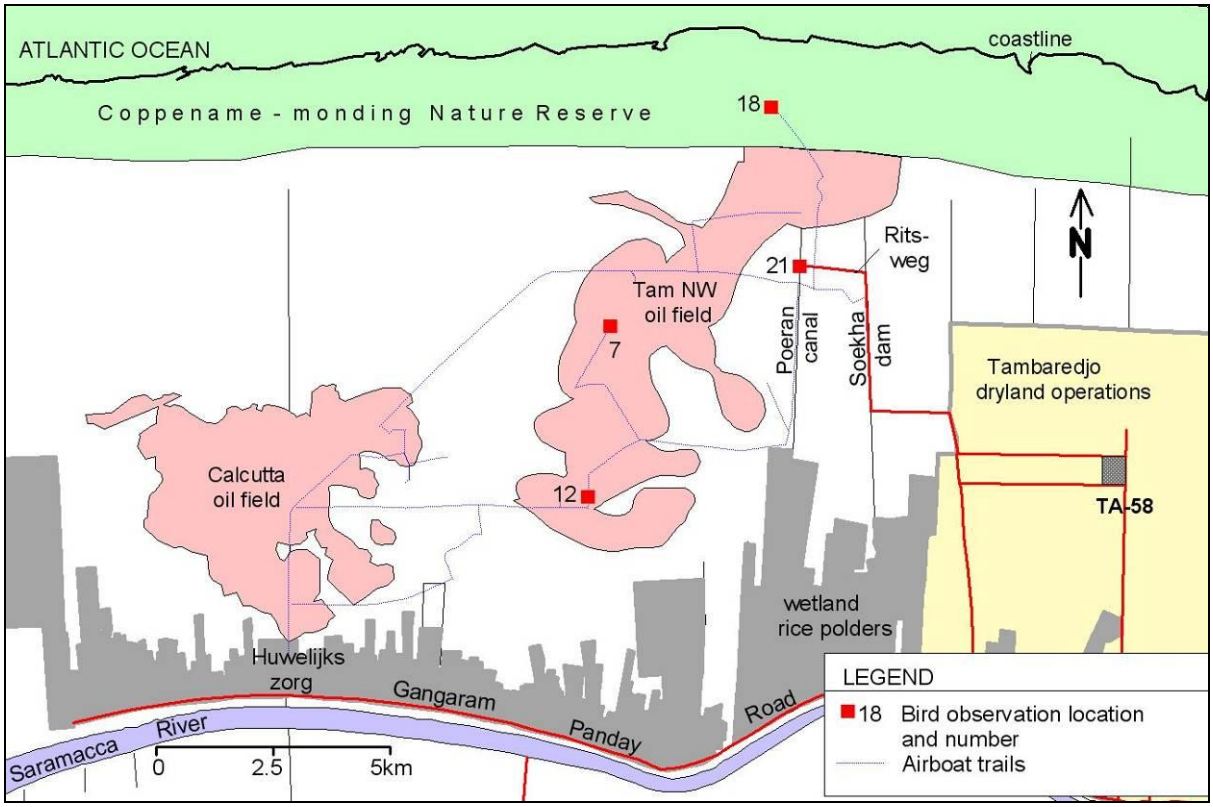

Figure 24: Location of the bird monitoring sites

Table 8: The monitoring sites in the four habitats of the Tambaredjo NW area

Site #	Habitat	Coordinates
18	Closed to open mature mangrove forest	5° 59' 02" N, 55° 34' 55.0" W
21	Herbaceous brackish water swamp	5° 57' 6.4"N, 55° 37' 30.4" W
07	Mixed herbaceous swamp to low swampwood	5° 56' 24.0" N, 55° 36' 42.3" W
12	High swampwood	5° 54' 17.3" N, 55° 36' 58.1" W

Apart from the ground survey, aerial surveys have been made during the Long Dry and the Long Rainy Seasons. The purpose of these flights was to observe the number and the location of areas with bird concentrations (more specific bird nesting sites) and the bird species present here. Observations have been made along the Wanica and Saramacca coast and above the study area using a Cessna 206 flying at 200 feet with an air speed of 80 knots. The flight paths are presented in Figure 25.

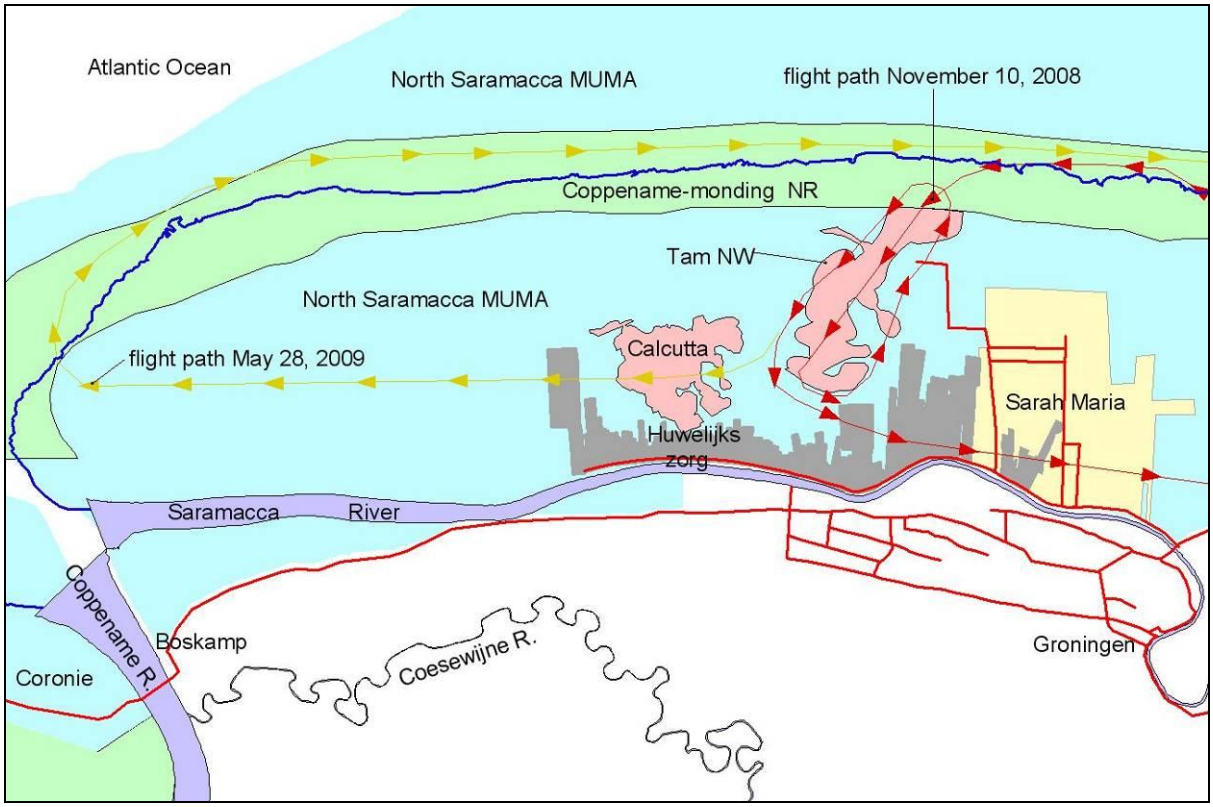

Figure 25: Flight lines of the two aerial bird surveys

The presence and level of activity of a number bird species is dependant upon the season and therefore seasonal monitoring was applied in order to find as many species as possible (Table 9).

Table 9: Observation dates

Season	Date	Type
Long Dry Season	November 10, 2008	Air
	November 11, 2008	Ground
Short Rainy Season	December 10, 2008	Ground
Short Dry Season	March 31, 2009	Ground
Long Rainy Season	May 28, 2009	Air
	May 29, 2009	Ground

In addition to the on-site observations, all species recorded during traveling between the sites have been recorded. Birds will fly away because of noise of the airboat and can then be identified. These species have been scored for the habitat of observation. All monitoring sites are along airboat trails, which are the only means of access to the area.

At the selected sites, a stationary observer (Otte Ottema, assisted by Foek Chin Joe and Serano Ramcharan) recorded all birds seen or heard during a fixed time period. The counts commenced at first light (between 06h30-06h45) at the first observation site and lasted at least 30 minutes. Due to the considerable traveling distances between sites, the final observation period usually ended at around 10-11h PM.
In every season a different survey order between habitats was applied in order to record as many as possible species. Bird vocal activity is highest around sunrise and it decreases significantly with increasing daylight.

Monitoring was predominantly qualitative, but quantitative information has been obtained by comparing species occurrences between observation sites and between seasons. Absolute quantitative monitoring is not possible, because only a very limited part of the area is accessible and many species are skulking.

Species lists have been made for all habitats and for all seasons. Species were considered to be restricted to a particular habitat if they were only recorded in a certain habitat during the same or other seasons. Data from different seasons was examined for changes in abundance of particular species.

In the total species list (Appendix D), a species is marked common (C), uncommon (U) or rare (R) for the study area. Here C means that the species is observed during every survey in at least one habitat. R means that a species has been observed only 3 times or less. U means that a species is observed more than 3 times, but not during every survey.

The total list of species from Tambaredjo NW was compared to the accumulated species lists for the coastal plain from Ribot (2009). Based on this comparison, species have also been marked C, U or R with respect to their occurrence in the Suriname freshwater swamps behind the mangroves (Ottema et. al, in press). The meaning of C, U and R is similar to the one above, but is described in more general terms by Ribot (Table 10).

Table 10: Explanation of the distribution codes (Ribot, 2009).

Common	if you know the bird and you are in his habitat of choice, chances are big that you see it that day
Uncommon	there is a good chance of noticing the bird, but certainly not every day
Rare	not often seen in this area, so not much chance to notice it

This latter information was used to determine the uniqueness of the Tambaredjo NW avifauna relative to the remaining coastal plain.

3.11.3.3 Results

A total of 119 species have been recorded during the study (Appendix D).
The Short Dry Season yielded the highest number of species and the Long Dry Season the lowest number (Figure 26).

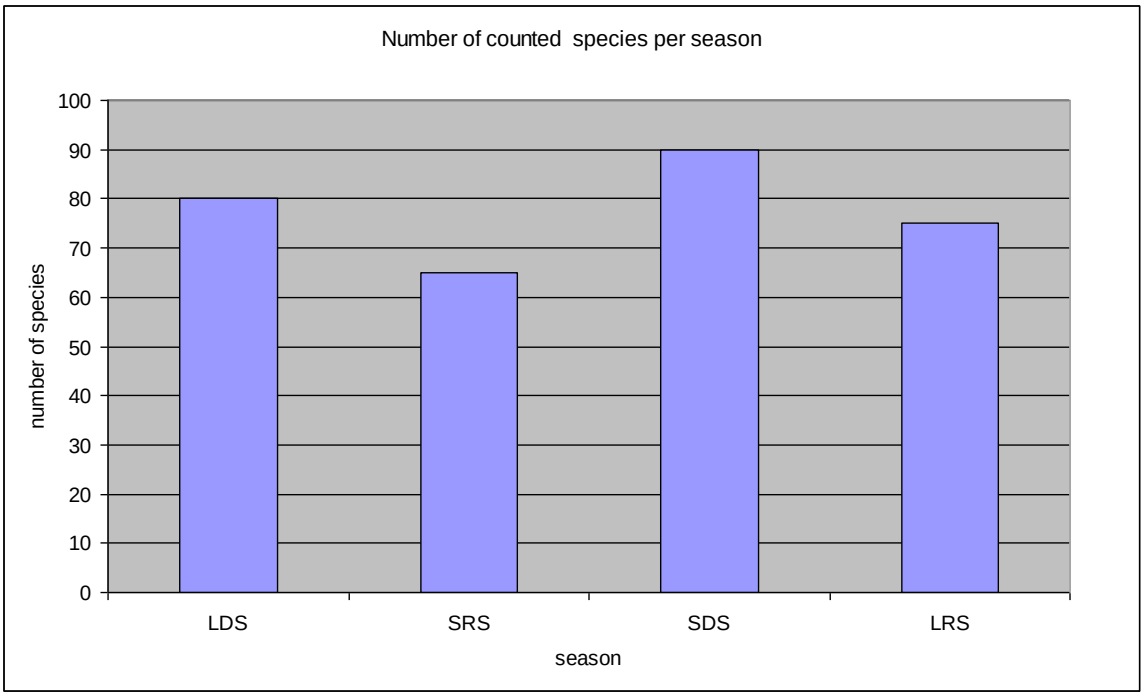

Figure 26: Number of counted bird species per season

With respect to the habitats, the highest number of species was counted for the herbaceous swamp dominated by Cat Tails (Typha swamp) and the lowest for the mixed herbaceous swamp to low swampwood.

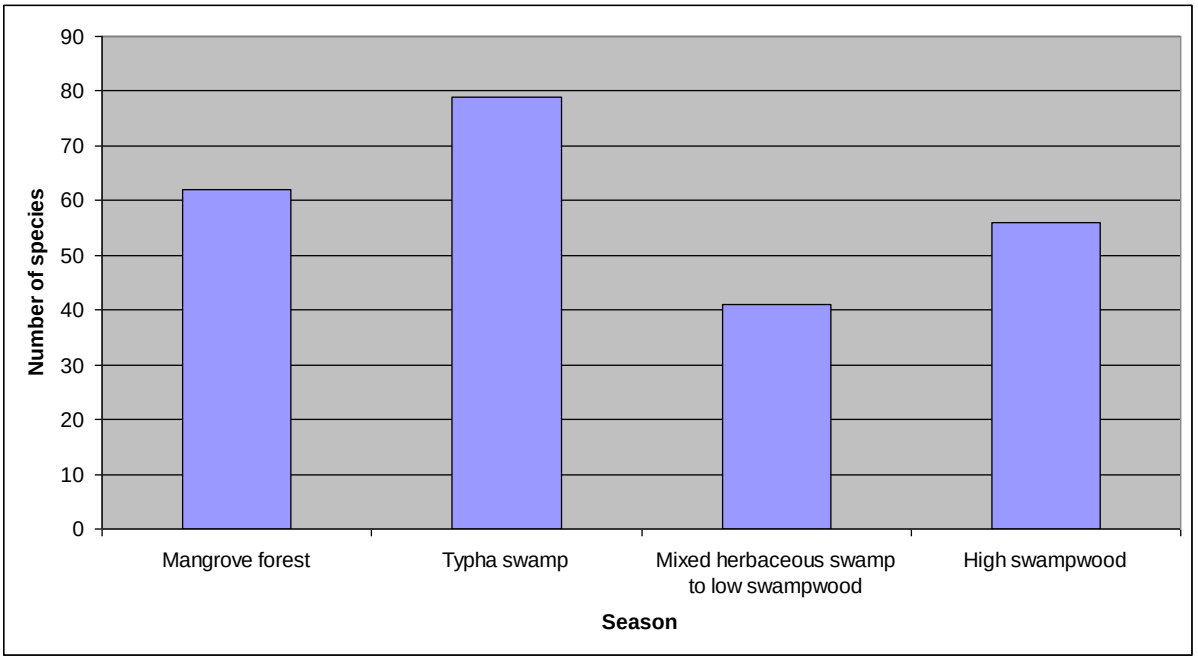

Figure 27: Number of counted bird species per ecosystem

Of the total number of species counted in Tambaredjo NW, 79 are found to be common, 17 are uncommon and 23 are rare within the study area. The occurrence of the counted species related to their occurrence in the coastal plain is respectively 98, 16 and 5 (Figure 28).
Of the five rare species for the Coastal plain, four are also rare for the study area. Only *Botaurus pinnatus, which normally is only very occasionally spotted (rare) along accessible*

edges of swamps, is classified as uncommon for the study area. The reason for this is that it is a skulking species that relatively often been seen in the study area because the noise of the airboat made it fly up. Also elsewhere in the Coastal Plain it may be more common than assumed.

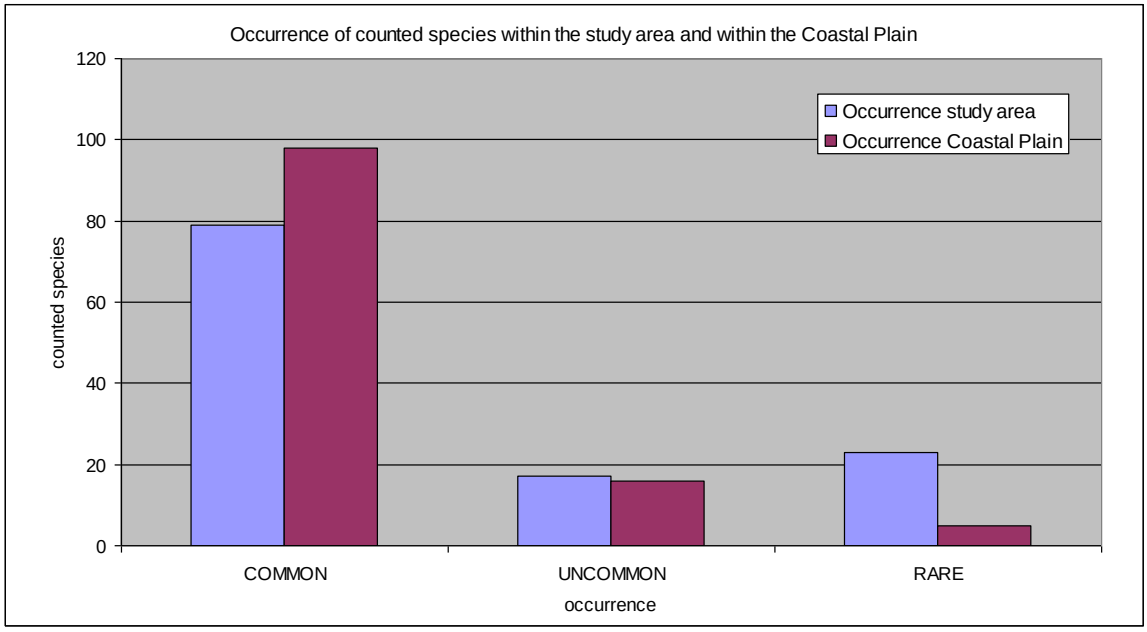

Figure 28: Occurrence of counted species within the study area and within the Coastal Plain

The first aerial survey (November 2008) did not result in any location with bird concentrations. The May 28 survey resulted in the counting of six egret and one scarlet ibis colony in between the Coppename and the Suriname River. The location, species and number of couples is presented in Figure 29. The coordinates are presented in Table 2 (Appendix D). All colonies are found in the young mangrove zone near the coastline and only one colony is found in the neighborhood of the oil field.

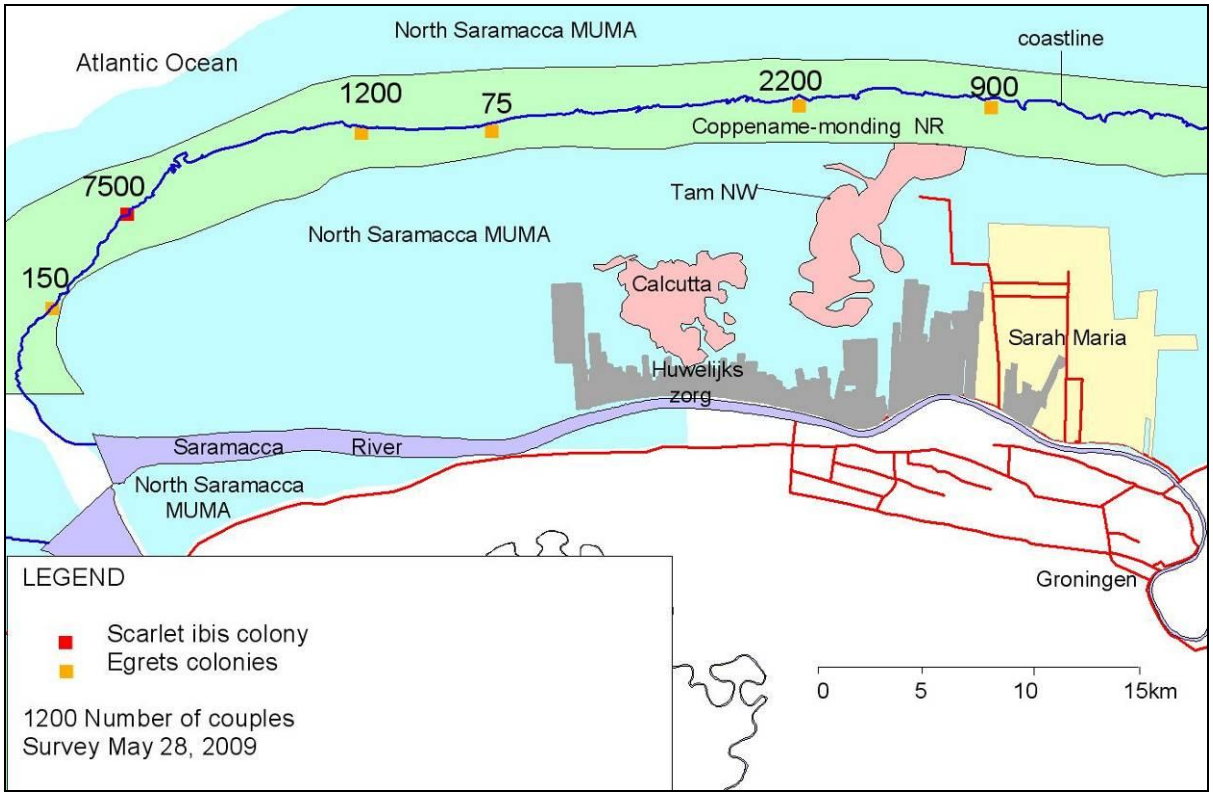

Figure 29: Location of bird colonies along the Wanica-Saramacca coast

3.11.3.4 Discussion & Conclusions

Context

In the bio-geographical coastal region between mouths of the Amazon River and the Orinoco River, the coast of Suriname contains the most important feeding and nesting sites for residential coastal birds and the most important feeding grounds for migratory birds from the north. According to De Jong, Spaans & Held (1984), the Surinamese coastal area, including the Saramacca-Wanica area is of special importance as feeding and nesting ground for more than 118 species of coastal birds, of which more than 70 species are defined as waterfowl according to the criteria of the RAMSAR Convention.
For 21 waterfowl species, parts of the Surinamese coastal area are of international importance (De Jong, Spaans & Held 1984). The criterion for international importance is: 10,000 or more individuals, and/or at least 1% of the bio-geographic population per area (as defined by Scott and Carbonell 1988).

The study area

The study area can be characterized as a freshwater swamp, including a narrow zone of mature mangrove forest that is currently becoming fresh (see Ch. 3.8). The four habitats of the study area are common in the Young Coastal Plain of Suriname at least in the wetlands at 10-20 km from the coastline.
No essential differences have been found in the avifauna of the study area compared with the avifauna of the rest of the freshwater zone.

Compared to rainforest the total number of species in the study area is low. Any place in lowland rainforest will have more than 400 species. Also the near-coastal zone with young

mangrove, mudflats and lagoons normally has a larger number of species than the 119 recorded in the study area.
However, compared to other freshwater swamps the species density can be considered to be normal.

Only five species have been found, which are rare in the freshwater swamps. The rest is either uncommon or common, with the vast majority (over 80%) being common.

A number of recorded species have been classified as rare for the study area, while their occurrence for the Coastal Plain of Suriname is classified as uncommon, or even common, indicating a relatively low occurrence of these species in the study area compared to the remainder of the Coastal Plain. But it should be noted that the Coastal Plain comprises many rural and urban areas, where certain species will prevail that are less common in the natural area of the Coastal Plain. For instance there are more than 400 species recorded for Paramaribo and surroundings.

With respect to the study area it is safe to assume that the bird species found in the current surveys occur in similar (near-) coastal habitats throughout Suriname.

Apart from the breeding colonies and some migrants no seasonal patterns have been found, as could be expected.

The presence of bird colonies is in line with long-time records that indicate that breeding of the Egrets and Scarlet ibises starts in April and finishes in the beginning of September.

In each habitat we found the species, which based on our knowledge could be expected there. For almost all species the habitats where they have been found are the only habitats where they occur. Many birds are territorial and the adults that have settled will stay all of their life in their territory.
Exceptions are formed by the Orange-winged Parrots (*Amazona amazonica*) that are feeding more inland but that use communal roosts in the coastal area (Spaans & Baal, 1990). The Wattled Jacana (*Jacana jacana*) has been observed in all habitats, but within these habitats it is mostly confined to open water areas. Also the Snail Kite (*Rostrhamus sociabilis)* is bound to open water from where he catches his snails.

Within the project area nine bird species have been recorded for which the Suriname coast is of international importance (Table 11).

Table 11: Bird species recorded in the study area for which the Suriname coast is of international importance (Scott & Carbonell, 1988).

Shorebirds	
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Semi-palmated Sandpiper	*Calidris pusilla*
Ciconiiform birds (Herons, Ibises, Storks and Spoonbills)	
Scarlet Ibis	*Eudocimus ruber*
Little Blue Heron	*Egretta caerulea*
Tricoloured Heron	*Egretta tricolor*
Snowy Egret	*Egretta thula*
Raptors	
Rufous Crab-Hawk	*Buteogallus aequinoctialis*
Snail Kite	*Rostrhamus sociabilis*

The migratory shorebirds breed in the Canadian tundra's. During the northern spring, they remigrate to their breeding grounds and return with their young to Suriname by the end of the northern summer. In Suriname, they mainly feed on the mudflats along the coast during low tide, be it during the day or during the night (Haverschmidt & Mees, 1994). But they can also be seen in near-dry lagoons. They rest in the (young) mangrove forest.
At disturbance, they easily fly away and quickly return when the environment is quiet again (Spaans 2006, Personal communication).

Less numerous, but present around the year, and much more conspicuous, are the ciconiiform birds. During the day, these birds feed on mudflats and in the mangrove belt. In the young Black Mangrove forests along the Saramacca coast almost every year breeding colonies of scarlet ibises and heron species are present. The breeding seasons start between March and April and end between August and September (Spaans, 2006: personal communication).

Of the two raptors, the Rufous Crab-Hawk lives exclusively in the mangrove zone, while the Snail Kite also lives in the brackish and freshwater swamps south of the mangrove zone.

There are no vulnerable or endangered bird species in the study area (IUCN red data list 2009)

Noteworthy observations

On March 31, 2009 a Merlin *Falco columbarius* flew across in the area of the Ritsweg. This was the first observation of this species in Suriname. The Merlin is a northern migrant that does not depend on the habitats of the study area.
Other rare species, which have been found are *Ixobrychus involucris* Stripe-backed Bittern, which is probably also a migrant, since it is only found in Suriname from December through July, *Amazona ochrocephala* Yellow-crowned Parrot and *Pardirallus maculatus* Spotted Rail. The latter is a very skulking bird, which probably is not so rare, but difficult to find.
The endemic Arrowhead Piculet *Picumnus minutissimus* has been found common in the High swampwood. However this species is very common on many places in the coastal area and also in Paramaribo.

The airboat trails in the Tambaredjo NW area have created open water areas that favor the Wattled Jacana (*Jacana jacana*) and the Snail Kite (*Rostrhamus sociabilis)*. These two species are now very frequent in the area.
Other species that are favored by the presence of Staatsolie infrastructure are the swallows that use the electricity lines as resting and sleeping place.

3.11.4 Mammals and herpetofauna

3.11.4.1 Methods

The table with remaining fauna elements (see Appendix E) shows data on mammals, reptiles, and amphibians.

Mammal data are mainly based on Husson (1978). Next to this, the list of mammals has been extended by "new" species found during the Tambaredjo oil field baseline study (IBT, 1999). Data on the species of reptiles and amphibians are mainly derived from the Tambaredjo baseline study (IBT, 1999).

During field trips for the current study Capybaras were spotted at several occasions and also Howler monkeys could frequently be heard. Observations made during the aquatic ecology baseline study have been reported in the respective chapter (3.11.2).

During the field trips no "new" mammals, reptiles and amphibians were observed. Also interviews did not add "new" species to the existing lists.

3.11.4.2 Baseline description

Mammals

In Suriname, the mammalian fauna of the coastal zone was never systematically inventoried. However, from literature (Husson, 1978) a list of over 50 species of mammals can be extracted for the coastal zone, including: 7 species of marsupials (opossums), 13 species of bats, 4 species of monkeys: the Capuchin Monkey (*Cebus apella*), the Squirrel Monkey (*Saimira sciureus*), the Howler Monkey (*Alouatta seniculus*) and the Guianan Saki (*Pithecia pithecia*); 3 species of Edentates, among which the Giant Ant-eater (*Myrmecophaga tridactyla*); 8 species of carnivores, among which the Jaguar (*Panthera onca*), the Puma (*Puma concolor*), the Ocelot (*Leopardus pardalis*), the Guiana Otter (*Lutra enudris*), and the (very common) Crab-eating Raccoon (*Procyon cancrivorus*); 4 species of Ungulates, among which the White-tailed Deer (*Odocoileus virginianus*); and 12 species of rodents, among which the largest rodent in the world: the Capybara (*Hydrochaeris hydrochaeris*). Only part of these mammals is actually present in the swamps of the study area (Appendix E).

Herpetofauna

Sand and shell beaches of importance as nesting beaches for sea turtles are not found in the study area.

The herpetofauna of the freshwater swamps and agricultural areas of the North Saramacca are not yet studied. Out of a list of reptiles three species should be mentioned: the Iguana

(*Iguana-iguana*), the Spectacled Caiman (*Caiman crocodilus*) and the Anaconda (*Eunectes murinus*). These reptiles are still common in Suriname, but are diminishing in the populated areas.

Two interesting amphibians, common in the North Saramacca area, are the up to 7 cm Paradoxal Frog (*Pseudis paradoxa*) with its up to 22 cm long tadpole, locally known as "tododyaki", and the large and flat Pipa Toad (*Pipa pipa*) of which the development from egg to tadpole takes place in cavities in the swollen skin at the back of the female.

3.11.4.3 Conclusions

Mammals

None of the listed mammals is confined to the coastal area and none of them is listed as vulnerable or endangered on the IUCN Red List.

Herpetofauna

According to Dr. P. Ouboter, herpetologist and contributor to the Tambaredjo baseline study (IBT, 1999), the number of reptiles and amphibians in the nearby Tambaredjo Swamp is limited while no unique, rare, endangered, vulnerable or biogeographically important species were found in that area.
As both the Tambaredjo oil field and Tambaredjo NW areas are parts of the same Buru Swamp, both showing the same set of ecosystems, it is not expected that unique, rare, endangered, vulnerable or biogeographically important species of reptiles and amphibians will be present in the Tambaredjo NW area.

3.11.4.4 Goods and services from fauna

The ecosystems of the coastal zone of Suriname, with their abundant bird and fish life, contribute to the increase of local and international nature tourism and outdoor recreation and also attract international and local researchers and students.

3.12 SOCIO-ECONOMIC ENVIRONMENT

3.12.1 Introduction

This socioeconomic impact assessment focuses on people, living conditions, and economic activities along the Gangaram Panday road, better known as the Lareco road, in the district of Saramacca. The Gangaram Panday road is situated between the Saramacca River and the Tambaredjo and Calcutta oil fields. Our main interest is in the part of this road situated immediately south of the new Tambaredjo NW oil field. This is the main road section in which impacts from the new oil field, if any, will be experienced. The road section to the east and west of the study area will be affected by any impact from respectively the Tambaredjo and Calcutta oil fields. Because it is not always possible to distinguish between the impacts from different oil fields, the consultants will, where appropriate, also discuss anticipated impacts on other parts of the road and other areas of the Saramacca district.

3.12.2 Methodology

Socioeconomic and demographic data were collected from existing reports, interviews, and field observations. In terms of written sources, the most important documents were the Preliminary Environmental Impact Assessments (PEIA) conducted by Noordam and Teunissen for the Oil Exploration Areas of Tambaredjo NW (2006) and for the Calcutta oil field development (2005). Other relevant data were provided by Staatsolie Maatschappij Suriname and included, among others, operational guidelines (e.g. on Health, Safety, Environment, and Quality), accident reports, and maps of the area.

In addition to studying existing documentation, the consultant conducted interviews with local stakeholders. These included local government representatives named ‘Bestuursopzichters’ (Governmental supervisor) and Resort Council (RR) members; farmers with fields extending into the swamp area; and the representative of a local contractor firm. Interviews were also conducted with Public Relations and Environmental representatives at Staatsolie. The interviews were held in Dutch and/or Sranantongo, depending on what language the respondent felt most comfortable with.

In producing this report, we assume that the interviewees answered truthfully and that their opinions are representative for the larger study population. We reduced bias by cross-checking the information from one person with that provided by others. We also assume that Staatsolie has provided all relevant information and that their reports provide accurate data on, for example, the numbers of spills and accidents.

3.12.3 Socioeconomic baseline

3.12.3.1 History and archeology

Suriname’s Young Coastal Plain used to be intensely used by pre-Columbian indigenous peoples from ca 300 AD on (Versteeg, 2003). The earliest archeological sites along the Saramacca River, several km south of the proposed drilling area, are traced to the Kwatta

culture. These artisans in shells and stone probably populated the area between the 9th and the 12th century after Christ. We do not know whether people ever lived in the proposed drilling area but this is unlikely given that large ridges and mounds, which were favored as living places by early coastal indigenous populations, are not present.

Upon colonization, plantations were established on the fertile coastal plains. The development of the plantation economy depended on forced labor of thousands of African slaves. After the abolition of slavery (1863) former slaves were still obliged to perform plantation labor during a 10-year period of 'state supervision'. Once they were free to go, many became small-farmers and, along the Saramacca River, developed a flourishing cacao production. In the beginning of the 20th century, agricultural diseases and other factors reduced the incomes of these Creole small-farmers and many left for the capital city.

In order to meet the plantation labor demand after the abolition of slavery, indentured laborers were recruited in China, (British) India, and the Indonesian (then Dutch Indies) island of Java. The people now living on the Northern banks of the Saramacca River are mostly the descendents of East Indian contract laborers. Many of their grandparents came from plantations in this region, such as Dankbaarheid and Huwelijkszorg. After their contracts finished, they bought plots where they started farming rice, fruits, and vegetables on a small scale. Their children and grandchildren, who are now running the farms, have extended these plots further into the swamp area.

No places of special historical interest are situated within the study area.

3.12.3.2 Population and demographic trends

The only people living between the Saramacca River and the Tambaredjo NW operation area are those who built their homes along the Gangaram Panday road, before known as the Lareco road. According to the local Government Supervisors (Bestuursopzichters), about 90 households (~750 people) live along this road. We counted 53 inhabited houses along the stretch of the road south of the proposed Tambaredjo NW field. Based on this figure, we estimate a population of between 200 and 250 people in the target area. These people are primarily of Hindustani descent, though one or two Creole families also have their home here.

Before independence (1975) the area was more densely populated. Many people left in the 1970s and '80's to try their luck in the Netherlands or in the capital city of Paramaribo.

The arrival of Staatsolie has not brought many new people to the area, but may have prevented some from leaving due to the new labor opportunities. Nevertheless, the out-migration of young people continues and makes it difficult for farmers to find farm laborers. Some area inhabitants believe that better facilities in the area would entice more of these youngsters to stay in or return to the area.

3.12.3.3 Employment and commercial activities

Most inhabitants living along the Gangaram Panday road are small farmers (5-10 ha), in addition to about eight larger farmers (50-200 ha). Indeed, in the target area 36 out of the 53 houses belong to farmers that possess land. The fields of three of the larger farmers are situated directly south of the projected Tambaredjo NW field. All agricultural land is situated

in the southern half of the Buru Swamp. The main crop is rice (*Oryza sativa*). According to the Ministry of Agriculture, Animal husbandry, and Fisheries (LVV), rice was produced on about 800 ha along the Gangaram Panday road and on ca 450 ha within the target area. In addition to rice, people plant plantains, citrus, coconut, cassava, pulses and various vegetables (pepper, egg plant) for sale. The rice is sold to both wholesalers and smaller consumers. Fruits and vegetables are either being sold to middlemen driving by, or taken by the farmers themselves to the market in Paramaribo.

Several inhabitants of the study area who do not own farms are working in farming-related economic activities, such as temporary field hands and renters of agricultural equipment. A couple of individuals have wage labor jobs in Groningen and another few are working for the government, primarily for the Ministries of Regional Development (Regionale Ontwikkeling; e.g. Bestuursopzichter (Government supervisor), Resort Council member) and Public Works (Openbare Werken; e.g. maintain the road, dig water trenches, clean road sides, etc).

Staatsolie employs about 150 people from the Saramacca district. According to the local Bestuursopzichters, only three people living along the Gangaram Panday road are employed in lower level functions with Staatsolie. In addition to these employees, Staatsolie's contractors' database (2008 data) suggest that about 370 inhabitants of Saramacca are working as contractors; cleaning and maintaining pipes, roadsides, and other operational infrastructure. Contracting provides a regular income as long as Staatsolie is active in the area, but no job security or social benefits.

Commercial hunting and fishing do not occur in the swamp area. Relatively near the proposed drilling area, bank net fisheries exploit the mudflats along the Saramacca coast. In addition, a few people living along the Gangaram Panday road are fishermen on the Saramacca River or in the Coppename Estuary. One property owner (Abelakh) used to operate a fishing hole where people from the urban areas would pay to fish, but this fishing spot is no longer open for business. The large farmer Tewari also has a fishing hole but he does not take payment from recreational fishers.

3.12.3.4 Land use and tenure rights

Most farmers in the area hold land under a combination of tenure regimes. The piece of land closest to the road, where the house is built, is typically property. The property is usually extended further into the swamp to include domain (state-owned) land, for which the farmer may have obtained a long-term lease permit (beschikking) to cultivate. In addition, (some) farmers have extended their terrain to cultivate domain land to which they do not have any formal title. They may -or may not- at some point in time have submitted a lease request to the office of domains, but given the lengthy procedure, just started working without awaiting the formal permit. They do not see this as a problem because, as one of the farmers put it, 'We are not bothering anyone'.

Extending one's field typically requires the construction of dykes around the area, and next pumping the water out ('inpolderen'). Because the fields of most farmers immediately border those of neighbors, extension of their land means going further north into the swamp. The dams built by Staatsolie in the swamp are in some places hindering such extensions.

Hunting and fishing are not allowed in the areas where Staatsolie operates. Occasionally people -both locals and people from Paramaribo- penetrate the northern Multiple Use

Management Area (MUMA) and the Coppename-monding Nature Reserve for (illegal) hunting, poaching, bird collecting, fishing and crab collecting. In the past year Lands Bos Beheer (Suriname Forest Service - LBB) has begun to more strictly control the MUMA and arrested and fined violators, while guns and game have been confiscated. As a result, clandestine activities have reportedly reduced.

There are no current national or regional government plans for the area or for the Gangaram Panday road. But with Staatsolie still exploring in the Duivelsbroek and the Wayambo Swamps, there is a possibility that more area here will be turned into oil fields. But at this moment there are no known recoverable crude oil reserves outside the already developed fields and the Tambaredjo NW field.

3.12.3.5 Use of surface water resources

Paddy rice farmers need plenty of fresh water. The traditional method for cultivating the crop is flooding the fields –which are surrounded by low dams- while or after setting the young seedlings. This method reduces the growth of weeds and deters vermin. It does require sound planning and servicing of the water supply. Through a system of dams, canals, and culverts, rice farmers divert water onto their fields; usually about two to three times per season. The culverts have a valve that can be opened or closed (‘klepkokers’). Through this system, farmers take in a water level of about 10-15 cm. Both small and large farmers in the study area prefer swamp water over river water. River water is less suitable for use in paddy cultivation when it gets brackish in the dry season. Farmers can only take in water from the swamp, however, when the water level is high enough. The Ministry of LVV has estimated that farmers extract about 75% of their irrigation water from the swamp.

Two canals in the study area, the so-called Poeran and the Soekha-canals, provide swamp water to respectively the Poeran and Soekha farms. These south-north canals are connected to the northern edge of the named large rice farms in the south. The Poeran canal was dug by the farmer Poeran, to provide irrigation water for rice production at his farm. The canal is also used to catch fish in the dry season. The Soekha canal was dug by Staatsolie to provide access for the drill rig during past exploration activities.

Both canals have been dug up to the Black Mangrove zone in the north, thus running across the “red line”. However, the ministerial resolutions establishing the North Saramacca MUMA and regulating its land allocation, prohibits the withdrawal of water from the swamp north of this “red line”. Therefore at the “red line”, these canals should be dammed by the land users, respectively Poeran and Staatsolie, in order to prevent water withdrawal from the northern swamp.

In the past it has been reported that the presence of Staatsolie affected some farmers’ water management. Near Calcutta flooding of rice fields has occurred, while south of Tambaredjo I, the swamp water supply was affected by the construction of a canal. Staatsolie has addressed all complaints associated with these events and all problems have been settled. For the last couple of years no complaints about such matters have been received by Staatsolie.

In the dry season, farmer families fish for own consumption in the canals along their own fields. They rarely enter further into the swamp area where the oil drilling would take place. South of Tambaredjo I the flow of swamp water towards the fields has been disrupted and, as a result, the fish population has largely disappeared in this area.

3.12.3.6 Infrastructure and development

Elderly people recall that before construction of the Gangaram Panday road (1960s) the area between the Saramacca River and the Buru swamp was much more isolated. To get to Paramaribo one had to walk on the dams, cross the river to the Tijgerkreek in a rowing boat, and next take the bus to town. Construction of the Gangaram Panday road and its maintenance by Staatsolie has facilitated access to the nearest urban centers. Nevertheless, the target area remains marginalized, with most basic public and social services lacking.

The main facility lacking in the area is access to a reliable source of drinking water. There is no connection to the drinking water net from the Suriname Waterworks Company (Surinaamse Waterleiding Maatschappij-SWM). For drinking water the families along the road mostly rely on rain water they collect from the roofs into large bins or storage containers. In the dry season when there is not sufficient rain water, people buy containers with drinking water from DWV-NH, but delivery is not very reliable. The water from the nearby Saramacca River is not suitable for drinking and even washing clothes, oneself, or the dishes in this water is not advisable.

There is a clinic in La Prevoyance but medical personnel -a nurse and a doctor from Groningen- is only present twice a month. All other times, one needs to travel to Paramaribo or Groningen for medical help, which may take between half an hour to an hour depending on the state of the road and one's location. In cases of emergency the Staatsolie clinic is providing assistance.

Electricity is provided through two power lines; one public EBS (Energie Bedrijven Suriname) power line for the area inhabitants and a separate source for Staatsolie. Apart from near the Staatsolie offices, there are no street lights.
Most of the road is within reach of a mobile phone connection but there are no land lines. Mail is being delivered only once a month.

3.12.3.7 Health and safety issues with Staatsolie

Despite its extensive Health, Safety, Environment, and Quality (HSEQ) regulations, incidents occur as a result of Staatsolie activities. A significant share of these incidents involves vehicles. Only considering the Saramacca operations, 2007 statistics show 55 transportation accidents, involving either vehicles or air boats. In that year, 15 incidents (transportation and other) resulted in injuries. Most of these injuries were benign and only two resulted in lost time. In total for 2007, 11 days were lost due to transportation-related incidents. No injury or damage to third parties did occur.

In addition, the activities of Staatsolie may cause oil spills. In 2007, 46 spills and releases were reported for the Saramacca Operations, of which 27 concerned spills of less than one barrel and none exceeded 50 barrels. In addition, 20 corrosion related spills were reported for that year. Table 12 lists the oil spills that occurred between January and November 2008 at the Saramacca Operation, of which some will have occurred within the study area.

Table 12: Oil spills at the Saramacca operations, January-November 2008.

Location	<1 barrel	1-10 barrel	10-50 barrel	>50 barrel	Corrosion related
Sarah Maria	12	6	-	-	11
TA-58 plant	-	-	1	-	-
TA 58/45	8	9	1	1	14
Calcutta	3	5	1	-	1

3.12.3.8 Existing interactions with Staatsolie

During its more than 25 years presence in Saramacca district, Staatsolie has established good relations with the local population. Staatsolie maintains these relations as part of its social responsibility program, which emphasizes paying special attention to the people living near the working area. In practice, this 'attention' translates to (1) providing employment, (2) executing projects, and (3) giving donations.

In terms of projects, the most important thing that Staatsolie does for the people living between the Saramacca River and the Buru swamp is continuous maintenance (filling, scraping) of the largest part of the Gangaram Panday road (up to km 25). In addition, the company has supported the district government by replacing the culverts (duikers) beneath this road to divert excess water.

Other projects have focused on the district of Saramacca at large. The largest community project has been the renovation of Jacques Eliazer sports complex in Groningen, to celebrate the 25th anniversary of Staatsolie (USD 160,000; 2006). Other considerable investments have been the acquisition of two vehicles and related accessories for the police force of Saramacca district (USD 26,191; 2006). Staatsolie also renovated and leveled the drinking water provision at Tijgerkreek; both for its own operations and for people in that neighborhood.

Furthermore, Staatsolie regularly donates to schools, neighborhood groups, and organizations, such as sports clubs. The largest one of these donations was made to support the organization of the annual Children Books Festival at Saramacca in 2006 (€10,000). Other events that, since 2005, have been supported for smaller (<USD 750) amounts include kite competitions, sports tournaments, educative events (e.g. youth debate, lecture), cultural celebrations and specific festivities. In addition, various schools received donations to help maintain school bus transportation (Mathooraschool, USD 140), to renovate and paint the school (O.S. Von Freyburg, USD 1797), to renovate a media-centre (O.S. Jarikaba, USD 540), and to purchase a computer and printer (O.S. Mahoproject, USD 1079). Three district schools (H.J. de Vriesschool, O.S. Von Freyburg, and V.O.J. Von Freyburg) received shell-sand (schelpzand) (USD 431).

The Staatsolie communication officer notes that the inhabitants from the Gangaram Panday road rarely use formal channels to ask for donations. Usually requests are made on a person-to-person basis. In such cases, an individual approaches a Staatsolie staff member for help with, for example, dredging a channel or repairing a dyke when the Staatsolie machines are nearby.

Transportation accidents, oil spills, and other incidents are dealt with by Staatsolie's Health, Safety, Environment, and Quality (HSEQ) Committee. This Committee is responsible for designing and providing leadership for the company's HSEQ plan. In addition, its tasks

include monitoring of programs and measures that enhance occupational health and safety, environmental protection, and quality; and fostering of awareness and participation in the aforementioned programs and measures. The HSEQ division investigates incidents, reports on them, and is responsible for initiation of corrective measures. Safety regulations are issued to all employees by way of a pocket size booklet that summarizes all major rules to be followed by employees and contractors. In addition, the General Field Instruction Manuals are main documents to communicate safety rules and regulations, and convey minimum requirements for the performance of various activities in the field.

Staatsolie generally reacts swiftly in the case of complaints resulting from the above-mentioned incidents. One of the larger oil spills in the Saramacca River in February 2008, for example, resulted in damage to plants and other property (e.g. fishing nets) of people living along the river. In addition, people complained that they could no longer fish. In this case, financial compensation was paid to the plaintiffs.

Such larger incidents are resolved at the higher level, such as the manager of operations or the executive director. They typically require further research by the HSEQ committee. Small complaints (e.g. an employee drove over someone's plant with the pick-up) are usually being resolved immediately in the field by the field manager. People in the area generally find that Staatsolie is easy to approach and settles disputes in a satisfactory manner. Staatsolie recently developed a formal complaints procedure, which is awaiting implementation. In order to facilitate communication with area inhabitants and (local) government officials, it would be useful to appoint a community relations officer for the area.

4 PROJECT DESCRIPTION

The project will comprise all activities necessary for crude production, but also supporting and sustaining activities like inspection, maintenance and monitoring.
Three phases of the project can be distinguished: a construction, an operation and a decommissioning (closure) phase. Below the activities that are associated with these three phases of oil field development will be presented after a brief discussion on the planning.
Except for some minor increase in fishing and/or hunting, it is not expected that other project-induced developments will occur during the project lifetime. However, induced development could occur after decommissioning. This development could be negative when the project area is left behind in an accessible state. But it could also be positive when the available infrastructure is utilized for a sustainable form of land use, like nature recreation. All these aspects are taken into consideration during the impact analysis.

4.1 PLANNING

The development of the Tambaredjo NW oil field is a complex and elaborate task that requires the involvement of many departments within Staatsolie. Planning and execution of activities is conducted by a number of departments under the general coordination of a project leader.

The general outline of the oil field is based on oil occurrences that showed during exploration drilling. The nature of the oil occurrences in the Tambaredjo field is such that the location of "sweet spots" (concentrated oil occurrences) cannot be determined by exploration drilling only. Additional drilling in a more detailed grid is needed to delineate the sweet spots; this is part of the development activities. A detailed field development layout is therefore not yet available at the start of the project. However, the field will be developed according to general principles and procedures that will be discussed below.

The overall layout of the field is shown in Figure 30. The location of the Transfer station is at the corner of the Soekhadamweg and the Noorddamweg. The station and the header dam that connects the station with the phase 1 development area are presented in Figure 30. A detailed layout has yet only been made for this 1st phase. The outline of the phase 2 area has been determined (Figure 30), but a detailed layout has yet to be made after appraisal drilling in the area. For the second project phase, another main pipeline will be placed along the existing Soekhadam in order to transfer the crude from the northern section of the Tambaredjo NW oil field.

During production development, every year a certain sub-area will be developed (Table 13). Every year the number of producing wells will increase until year 5 when the production development will be finalized. During the first 5 years, construction (production development) will go hand in hand with production (production operation).
Following year 5 no more drilling will be done in the field and from then on the oil field will only be a crude production field (only production operation) and activities will be limited to monitoring, maintenance and servicing. Once the oil is depleted, the field will be decommissioned. The decommissioning date cannot be exactly set, because the exact volume of the reservoir is not yet known. Current projections point to an end date in 2031.

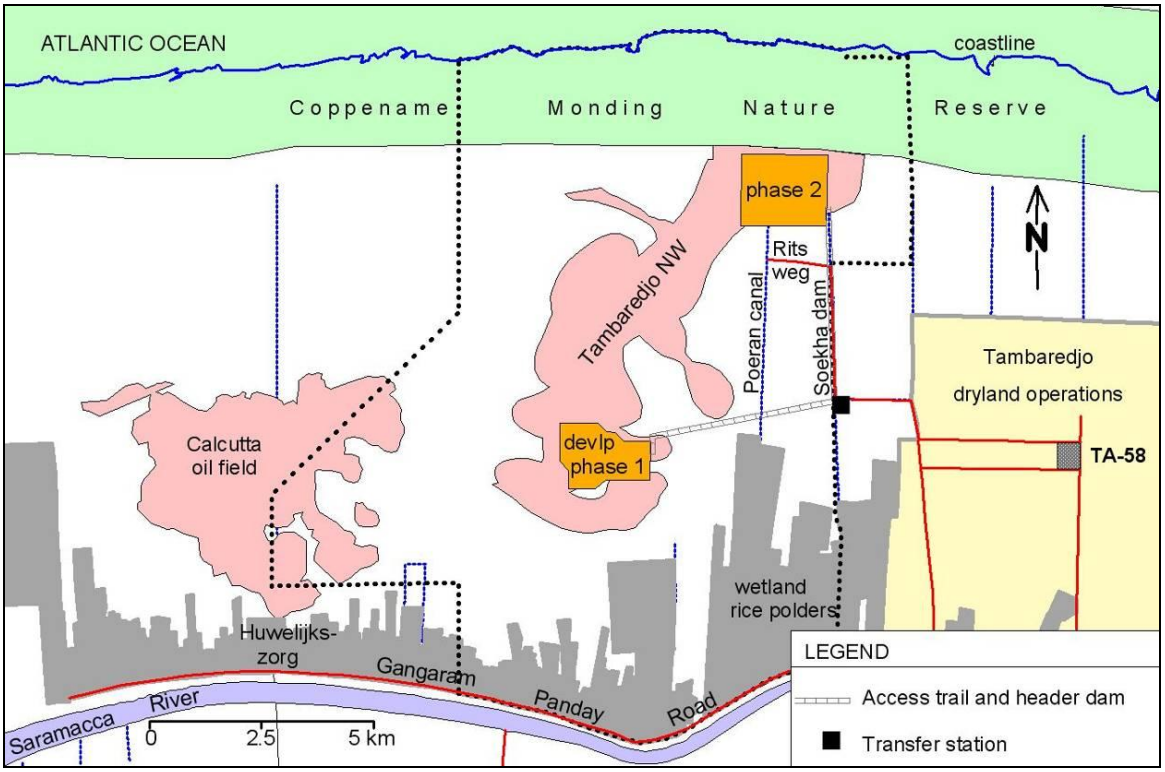

Figure 30: Project overview of the Tambaredjo NW oil field (phase 1 and 2)

Figure 31 presents the detailed field lay-out as this has been planned for the first development phase. A similar lay-out will be used for all development sections during following years up to year 5 when drilling activities will be completed. Drilling will start in end June 2010.

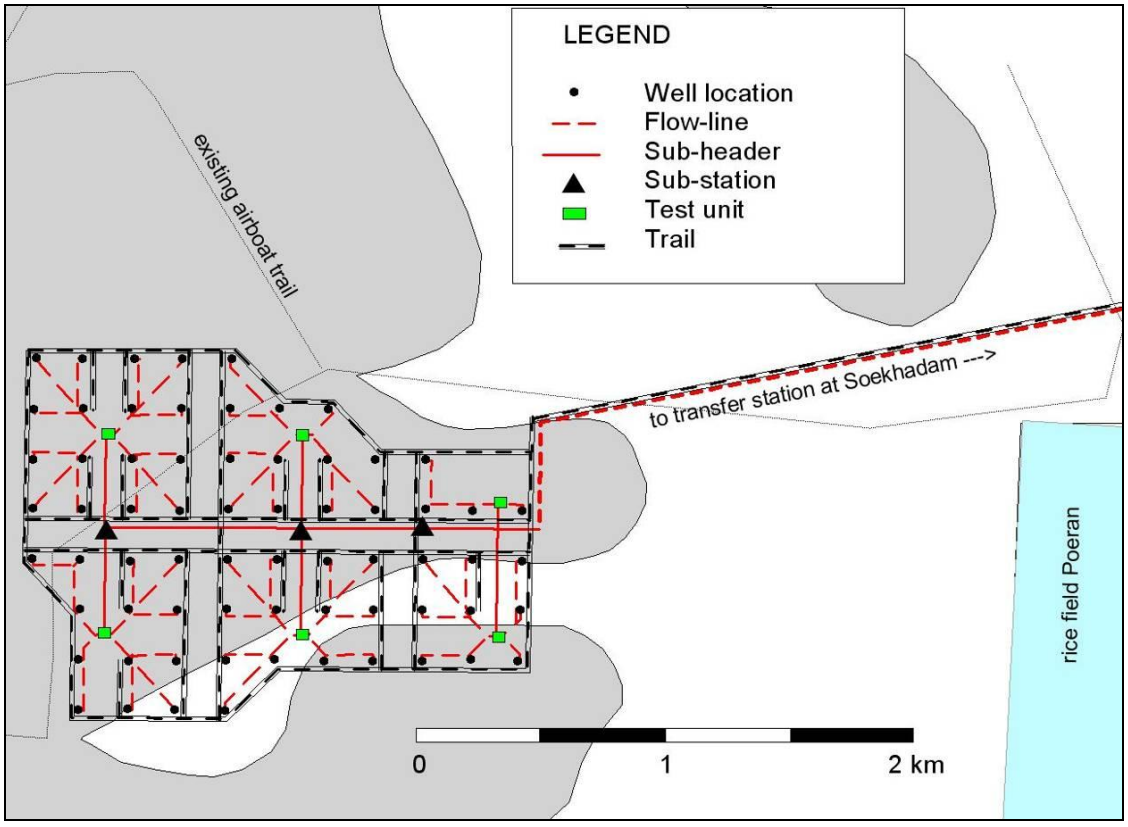

Figure 31: Lay-out for production development in year 1

Table 13: Drilling program

Year	No. drilling locations	Producers
1	67	50
2	107	80
3	87	65
4	53	40
5	32	40
TOTAL	**346**	**275**

4.2 CONSTRUCTION PHASE

During this phase the oil field will be prepared for crude production activities. The following activities will be undertaken:

1) Construction of the Transfer Station.
   This has been described in the first PEIA report (Noordam & Teunissen, 2009). The following option has been selected:

   - The station will be constructed at the corner of the Soekhadam and the Noorddamweg (modified alternative 1)
   - Multi-phase inline booster pumps will be installed

2) Construction of access and equipment trails
   For general access first airboat trails are constructed. Airboat trails typically have a width of 3-4 m and they are created by the removal of vegetation and peat (locally known as "pegasse").
   A 4.8 km long equipment trail with a width of 6 m will be constructed from the Soekhadam to the south of the new field (Figure 31). This trail forms the main infrastructure of the field and further development starts from here.
   For the construction of the trails the vegetation will be cleared by a swamp excavator, followed by the removal of the peat layer. The removed material will be piled on one side of the trail. It will be done in such a way that the peat and vegetation debris form a dam with a number of openings to allow free flow of water.

3) Construction of the header dam
   This dam, next to the equipment trail, will carry the HS (12.7 KV) line that supplies power to the field, and the main (14" diam.) pipeline that connects the field with the Transfer Station along the Soekhadam/Noorddamweg. The header dam is 4 m wide and it has a design elevation at 50 cm above the highest swamp water level. The trail next to the dam will be used to transport the crew from the Soekhadam to and from the working locations in the swamp and to deliver fuel for the excavators. Construction of the dam proper is done by excavation of clay at one side of the dam. Before excavation starts the vegetation in the location line is flattened and trees are removed. The clay of the excavation is placed on the flattened surface on top of remaining vegetation debris and the peat layer. Along the excavation side of the dam a narrow flat surface is created. This will be used to place the poles of the electric

grid. At regular distances cuts are made into the header dam in order to allow swamp water to flow through.

4) Construction of test facility platforms, sub-header and flow-line dams
Sub-header and flow-line dams carry the electricity grid that supplies electricity for the well pumps, and the pipelines (respectively 10" and 3-4" diameter) through which the crude oil is transported to the TNW Transfer Station. The construction of these dams is similar to the one described for the header dam. The dimensions of the sub-header dam are similar to those of the header dam, but the flow-line dams are 3 m wide. For power lines, wooden poles are installed on the clay dams or directly in the ground if the clay dam is absent. In both options, long poles will be required to increase the stability of the pole due to the soft underground.
Each well is individually connected on a production and testing manifold. These manifolds are on test facility platforms. The platforms consist of manifolds, location for a temporary test tanks and provisions for multi phase flow meter hook up. The terrain for test facility platforms needs to be raised to a design level of 1/2 meter above the highest swamp water level. This will be done with clay that will be excavated from the surrounding swamp around the area. The final test facility platforms area will measure 10 x 10 meter.

5) Construction of the substations within the oil field.
Substations are to convert the High Voltage into low voltage system, to furnish the wells with power. For year 1 three substations will be constructed. These substations comprise: Transformer (150 KVA), Disconnect switches, Load center, Area lighting and Grounding. The terrain for a substation needs to be raised to a design level of 1 meter above the highest swamp water level. This will be done with clay that will be excavated from the surrounding swamp around the area. The final substation area will measure 6 x 10 meter.

6) Preparation for drilling
The location of the drilling sites and related infrastructure works are marked by airboats, after access trails to these sites have been made.
To provide access for the drilling rig and other heavy equipment, the airboat trails need to be widened through additional clearing from vegetation and peat. The width of the rig trail depends upon the type of rig. In case the swamp rig (Rig VII) is used, the trail should be some 12 m wide.
In case of the Hover barge (Althev Rig), a wider trail (at least 30 m wide) is required.
Airboats and swamp carriers will use the trail for transportation of personnel and consumables.
For both type of rigs the drill site will be cleared of all vegetation and peat over an area of 150 ft x 150 ft (50 x 50m). Clearing will be done by a swamp excavator.

4.3 OPERATION PHASE

1) Drilling rigs
The production wells will be drilled with two swamp rigs that are suitable for operations in the coastal swamps. For the period 2010-2015, a maximum of 346 production wells will be drilled with 200 m spacing for the vertically drilled wells.

Transportation of labor will be by airboat using airboat traces. Furthermore, transportation of materials will be done by carrier.
Two types of rigs are considered for drilling:

- A drilling Rig unit mounted on pontoons. The pontoons are equipped with caterpillars and the rig is moved with a carrier from one location to another. In addition, the set-up consists of a pontoon on which the drill pipes are stored, a pontoon with the mud treatment system, a pontoon with the office and the generators and a pontoon with the logging unit. The latter takes measurements in the hole after drilling.
- A drilling rig mounted on a Hover barge (lifts itself on an air cushion). This barge is sufficiently large (170 x 90ft, 52 x 30 m) to store all equipment. This rig is moved, floating on its air cushion, from one location to another by the swamp excavator.

Both rigs move at a speed of approximately 15 km/hr.

2) Drilling

The well is created by drilling a hole, 9" inches diameter, into the earth with a drilling rig, which rotates a drill string with a bit attached.
In an initial stage of the drilling process, a surface steel pipe casing is pushed down to a depth of about 77 feet. After the surface casing has been put into place, drilling is resumed to the final depth, which is about 1500 feet in the Tambaredjo NW oil field. When the oil sands are found, initial well tests are conducted to establish the production capacity of the well (see wireline logging).
If the well is considered to have commercial value, a steel casing will be cemented down the entire length of the well. For extraction of the oil, a second, smaller set of pipes ('tubing') is run down through the well and attached to a flow and production control device on the surface. During the preparation of the hole and the placement of the screen a "completion fluid", in the form of salt water, is present in the hole to remove cuttings residues and to control the pressure (see completion).
In case the well is considered a 'dry hole', meaning not capable of producing commercial amounts of petroleum, the well is plugged with cement and abandoned.
Cementing is done by the cementing unit that is placed on a pontoon. Cement is transported in bulk to the rig site.

3) Drilling fluid

Drilling fluid (also known as "mud") is pumped down the inside of the drill pipe and exits at the drill bit. For the Saramacca Operations water-based drilling mud is used, mainly composed of water, Drispac and clay (Bentonite). Particular functions of the drilling mud include cooling the bit, lifting cuttings to the surface, preventing destabilization of the walls of the well hole and overcoming the pressure of fluids inside the sediment so that these fluids do not enter the well hole.
During drilling "cuttings" are generated, for the Saramacca Operations consisting of clay, sand and shell fragments. These "cuttings" will be brought to surface through the mud circulation system. The cuttings are separated from the mud in the mud treatment system and at regular depth intervals sampled.
The drilling mud will be re-used as much as possible and only minimal amounts will be dumped. For the current wetland operations in the Calcutta oil field, the excess cuttings

and the remaining drilling mud are dumped at the drill site, since no significant impacts were predicted because of this practice.

Per well hole, the following quantities of chemicals are being used on average for drilling:

Bentonite	3,100 kg
Drispac	110 kg
Sodium bicarbonate	85 kg

4) Wireline Logging

After completion of the drilling operations, the hole is logged with a variety of logging tools that are lowered into the open well hole. Measurements include electrical properties (resistivity and conductivity at various frequencies), sonic properties, and active and passive nuclear measurements. The equipment is placed on a caterpillar-mounted pontoon, where also the logging is recorded. No emissions occur during the logging process.

5) Well completion

After drilling and casing the well, it must be 'completed'. Completion is the process in which the well is enabled to produce oil or gas.
In a cased-hole completion, small holes called perforations are made in the portion of the casing, which passed through the production zone, to provide a path for the oil to flow from the surrounding rock into the production tubing.
Completion fluid is used to avoid swelling of clays, which may cause the drill string to be stuck in the hole. For the current wetland operations in the Calcutta oil field brine consisting of chemicals and cuttings is dumped at the drill site, since no significant impacts were predicted because of this practice.

For the preparation of the completion fluid on average the following quantities are used per well hole:

NaCl	3,200 kg
KCl	2,000 kg

6) Production

The production hole is first closed with a preliminary 2-3/8” OR 2-7/8” tubing, after which a small electrical pump is placed to pump up the crude.
The produced crude will be transported through a system of flow lines, sub-headers and headers to the Transfer Station at Soekha Dam. From there the oil fluid will be routed to the TA-58 crude treatment Plant through a high-pressure pipeline.

7) Well testing

Production data of each producing well is needed for efficient production optimization purposes and for reservoir/geological modeling. Therefore all production needs to be tested. Awaiting the multiphase flow meters[7], fifty small (60 bbls) test tank units will be

[7] A multiphase flow meter is a device used in the oil and gas industry to measure the individual phase flow rates of petroleum, water and gas mixtures produced during oil production processes.

used as test facility for the first 3-6 months. These test units will be established at a number of locations within the field. For the first year five test units are projected. During the testing period oil is collected in the test tank from which samples are collected for laboratory analysis. The testing crew visits the test units by airboat.

8) Field and well inspection and maintenance of production facilities

Inspections are conducted according to the field and well inspection procedures (Staatsolie, 2006c). These inspections are conducted at least 2 times a day with the objective to identify unsafe and potentially risky situations, and defects and failures of production facilities (including oil spills and leaks). Any unsafe and dangerous situation and all defects and failures are reported immediately and prompt action is taken.

During field inspection also corrosion measurements are performed using corrosion coupons[8]. Based on the results pipe replacements can be made timely, thus avoiding spills due to corrosion.

Maintenance of the wells is done according to schedule by a maintenance crew with an airboat. It includes lubrication and replacement of broken or worn-out parts.

In certain wells a work-over may be necessary, especially in older wells Such remedial work is performed using a work-over unit on a pontoon, also known as pulling unit. It comprises pulling and replacement of tubing and screens. Work-over jobs on average have to be performed 10 times per year in a new field. After the first year this number will increase, due to the increasing number of wells.

During maintenance and work-over a boom is placed in the water around the well in order to contain any leaked oil. The leaked oil is removed according to the "oil spill clean-up guidelines".

4.4 DECOMMISSIONING PHASE

The current reserves of the Tambaredjo NW oil field are estimated to last until 2031, but wells will start to be closed earlier when they reach their economical limits.

At that point, they will be dismantled and abandoned. In this process, tubing is removed from the well and sections of well bore are filled with cement to isolate the flow path between oil and water zones from each other, as well as the surface. Completely filling the well bore with cement is costly and unnecessary. The casing of the well will be sealed 1.5 meters below ground level to allow agriculture or other activities after terminating the crude production activities.

When the economic limit of the field is reached the remaining wells and the supporting facilities will be dismantled.

[8] Corrosion coupon testing is an in-line monitoring technique; coupons are placed directly in the process stream and extracted for measurement. This monitoring technique provides a direct measurement of metal loss that allows calculating the general corrosion rate.

Two scenarios are possible:

1) The area is going to be abandoned and it is returned to nature, with or without intervention
2) There is a follow-up land use, meaning that part of the infrastructure can be maintained to be used by the next entrepreneur.

The latter is unlikely given that fact that no land allocation is permitted in the area north of the "red line" (see Ch. 2.1). Most of the oil field falls within this zone. However, there may be a possibility for touristic, recreational or educational uses.

In case of abandonment, all facilities will have to be removed and dams and roads will need to be breached in order to allow free flow of water.
Buildings, offices, steel and iron hardware and the electrical grid will be removed or demolished and all waste will be removed.

In case of future use, parts of the infrastructure (including buildings, when appropriate), could be maintained, but this cannot be decided at this point.

A Groundwater and Soil Quality Assessment will be conducted for all processing areas. Remediation can include on-site land-farming, but when necessary contaminated soil will be removed from site for treatment or for safe disposal elsewhere.

4.5 EQUIPMENT DEPLOYMENT & PERSONNEL

Several Staatsolie departments are active in the oil field of which Production Development (PD), Production Operation (PO) and Drilling are the most important.
During all phases, equipment will be deployed.
The equipment to be used for construction and operation activities are presented in Table 14.

Table 14: Equipment to be deployed for Tambaredjo NW production development

	#	Deployment	Activity
Construction (mostly Production Development)			
Airboat	2	Daily – workdays	Personnel transport Field monitoring
Gator tail	1	Daily – workdays	Personnel transport Field monitoring
Carrier	1	Daily – workdays	Transport supplies and materials
Excavator	3	Daily - workdays	Clearing and earth moving
Pontoon	2	once a week	Transport supplies and materials
Operation (mostly Drilling and Production Operations)			
Airboats	2	Daily – 24/7	Personnel transport
Gator tail	3	Daily – workdays	Personnel transport
Carrier	3	Daily – 24/7	Transport supplies and materials
Pontoon	3	± 2 x week	Transport supplies and materials
Excavator Jabez #1	2	± 2 x week	Clearing and earth moving
Rig VII	1	Continuous - 24/7	Drilling
Jabez Hover rig	1	Continuous - 24/7	Drilling

The number of personnel involved in daily activities in the field will be about 50, but a total of 100 different individuals will be involved by activities in the field, including those who occasionally visit the field.

4.6 NON-PLANNED PROJECT-RELATED EVENTS

The activities that are included in the design and operation of the project were described in the previous paragraphs. Apart from that, activities there are some unforeseen events that could occur in relation to the project. These events can be considered as risks that should be managed through appropriate emergency response procedures in the Staatsolie Emergency Response Plan or other regulations. Notwithstanding that, there could be an impact that should be assessed.

Events that could have an impact on the environmental and social conditions in the study area are:

1) Spills and leakages

Spills and leakages are possible at several project locations and during several project activities:

- Oil spills and leakages from equipment during construction, operation and decommissioning
- Oil spills or leakages from storage or transfer tanks during operation
- Oil spills and leakages at well sites and from pipelines during operation
- Spills of drilling chemicals during transportation and use at the rig

For all oil-related spills, the clean-up procedures are laid down in a guidelines report (Staatsolie, no year). All spills including chemical spills are investigated and monitored. The

reports are kept in an Incident management database. All chemicals used are evaluated on HSE aspects and approved before purchased.

In the Calcutta oil field, only 5 (minor) oil spills have been reported since the start of the activities here in 2005. The Calcutta oil field is similar to the Tambaredjo NW oil field to come, so that lessons learned in the first can be applied in the latter.

2) Vegetation and peat fires

Since early times, during dry seasons, people burn herbaceous ("grass") swamps:

On purpose:

- a common practice to keep such areas accessible (open water) for men and to keep them attractive for certain game species such as deer and for fishing
- just for fun

Unintentionally:

- when fires are set to control weed growth on road shoulders it has spread to neighboring vegetation
- when the a fire set to clear farmland spreads to neighboring vegetation
- when campfires get out of control

The extent and intensity of the fires depend upon the season and the type of vegetation. Generally speaking the fire will be worse, when the swamp is dryer and the swamp water level lower.
During normal dry seasons the swamps still contain some water and the impact of fires is limited to the vegetation. On November 18, 2008 a relatively small vegetation fire was observed to the northeast of the study area, probably in a Tall grass (Typha) swamp north of the Ensberg farm. Also in other years vegetation fires have been observed in the northern part of the Buru Swamp, so it appears to be a relatively normal event that also could occur near or within the Tambaredjo NW oil field. Extensive burning “scars” are visible on recent Landsat images (ca. 2001).
Tall grass swamps contain relatively large amounts of dry, combustible material and therefore take fire easily. Other herbaceous swamps are less susceptible, while forests only will burn under very dry conditions when their peat layer has desiccated.
The latter conditions will arise when rains fail to fall during the Short Rainy Season so that the Long Dry Season - normally ending in mid November - is extended up to late April and thus lasts for 8 months, up to the next Long Rainy Season that starts in May. Fortunately such conditions have occurred only 4 times during the last 100 years, the last one being in 1963/64 (Bubberman, 1973). But if such event occurs the results could be catastrophic.

3) Boat collisions

Airboats are the main means of transportation. Due to their high speed and poor maneuverability they pose a risk to other water users and to animals. Those users could be other airboats or the smaller gator-tail boats. Wildlife at risk is birds and water animals like the Capybara (Kapuwa). The risk becomes higher when operating in areas with shrubs and trees that block the view at corners.
The Calcutta Waterway Regulations (Staatsolie, 2006a) regulate water transportation within the Buru Swamp.

5 (POTENTIAL) IMPACTS AND PROPOSED MITIGATION MEASURES

5.1 INTRODUCTION

In this chapter, the actual and potential impacts of the proposed activity and their mitigation measures will be discussed per component. A comparison for the alternatives is presented in chapter 6, analysis of alternatives.

The applied methodology is explained in Ch. 5.2.
Mitigation measures are presented for all significant (major or moderate) impacts. In addition to this, recommendations are given for minor impacts. No analysis has been made of impacts for which mitigation measures are already in place as part of the routine Staatsolie procedures. In below discussion of the impacts only the analysis for major, moderate and minor impacts have been included in tables. For negligible impacts, the breakdown has been left out.

The project area, being the area where the projected activities of the Tambaredjo NW area will take place, is shown in Figure 2. It covers an area of approximately 23 sq km.

The boundary of the impacted area will differ from the project area depending upon the environmental component being considered. For land, soil, vegetation and flora, the potential impacts will be restricted to the directly affected part of the project area. For other components such as noise, water and fauna, the impacts may extend well beyond the boundaries of the project area. The study area measures about 150 sq km.

5.2 METHODOLOGY

The significance of all potential impacts that would result from the proposed project is determined in order to assist managers.
Key potential impacts have been listed in the scoping report. Further studies are required to address these impacts, to determine whether they are likely to occur and to assess how they will manifest themselves.
For key potential impacts identified by the scoping study, it will be necessary to determine the significance of each impact, based upon qualitative or quantitative assessment of the following attributes:

- magnitude
- geographical scale
- duration
- probability of occurrence

The resulting impact will be indicated by their significance class, which classes are defined as:

Negative	< Impact significance >	**Positive**
Class 1	**Major (significant) effect:** effect expected to be permanent or continuous and nonreversible on a national scale and/or have international significance.	Class +1
Class 2	**Moderate (significant) effect:** long-term or continuous effect, but it is reversible and/or it has regional significance.	Class +2
Class 3	**Minor (not significant) effect:** effect confined to the local area and/or of short duration, and it is reversible.	Class +3
Class 4	**Negligible (not significant) effect:** effect not detectable.	Class +4
Class 5	**Unknown effect:** insufficient data available to assess the significance of the effect.	Class +5

In addition, impacts have been classified as

- positive: indicating whether the impact will have a positive (beneficial) effect; or
- negative: indicating whether the impact will have a negative (adverse) effect on the environment, including affected people

The degree of detail will enable the determination of required mitigation and possible enhancement measures, respectively to prevent or reduce significant negative impacts and to promote any positive impacts already in the planning phase. The implementation of mitigation measures will reduce negative environmental impacts to an acceptable level.
After implementation of mitigation/enhancement measures the significance of the impacts will again be determined.

The impact assessment methodology is described below.

The **significance** of an impact is defined as a combination of the **severity** of the impact occurring and the **probability** that the impact will occur. The significance of each identified impact will be rated according to the methodology set out below:

First the **intensity/magnitude/size, scale** and **duration** of the impact are determined according to below tables (1 & 2).

Table 15a: Defining the intensity/magnitude/size of the negative impacts

Rating	Description of Rating for		
	Natural environment	Socio-cultural	Health/safety
High	Irreversible damage to highly valued species, habitats or ecosystems	Irreparable damage to highly valued items of cultural significance, or social functions or processes are severely altered	Event resulting in loss of life, serious injuries or chronic illness; hospitalization required
Medium	Reversible damage to species, habitats or ecosystems	Repairable damage to items of cultural significance, or impairment of social functions and processes	Event resulting in moderate injuries or illness; may require hospitalization
Low	Limited damage to biological or physical environment	Low-level damage to cultural items, or social functions and processes are negligibly altered (nuisance)	Event resulting in annoyance, minor injuries or illness, not requiring hospitalization
Negligi-ble	No relevant damage to biological or physical environment	No damage is done to cultural items and social functions and processes are not altered	Event is not experienced by receptors or only occasional minor annoyance

Table 16b: Defining the intensity/magnitude/size of the positive impacts

Rating	Description of Rating for		
	Natural environment	Socio-cultural	Health/safety
High	Direct benefits to species, habitats and resources with significant opportunities for sustainability	Benefits to local community and beyond	Health and safety will be significantly improved
Medium	Moderate benefits to species, habitats and resources with some opportunities for sustainability	Benefits to many households or individuals	Health and safety will be improved
Low	Minor benefits to species, habitats and resources with possible opportunities for sustainability	Benefits to few households or individuals	Health and safety will be slightly improved

Table 17: Defining duration and scale of the impact

Rating	Definition of Rating
Duration– *the time frame for which the impact will be experienced*	
Short-term (ST)	Up to 1 year
Medium-term (MT)	1 to 10 years
Long-term (LT)	More than 10 years
Scale– *the area in which the impact will be experienced*	
Small (SS)	Localized spot
Medium (MS)	Part of study area
Large (LS)	Study area or beyond

Then the **Severity Rating** of the impact is determined by combining the **magnitude** of the impact with **duration** and **scale** of the impact as set out below (Table 3).

Table 18: Determination of the Severity Rating of the impact

Magnitude	High	Medium	Low	Negligible
Duration and/or Scale				
LT-LS, LT-MS or MT-LS	High	High	Medium	Negligible
LT-SS, MT-MS, MT-SS, ST-MS or ST-LS	High	Medium	Low	Negligible
ST-SS	Medium	Low	Negligible	Negligible

The next step is to define the **probability** of an impact to occur, as defined below (Table 4).

Table 19: Defining the probability of the impact

Probability– *the likelihood of the impact occurring*	
High	Sure to happen, or happens often
Medium	Could happen, and has happened in Suriname
Low	Possible, but only in extreme circumstances

Finally, the overall **significance** of the impact is determined as explained below (Table 5).

Table 20: Determination of the overall Significance of the impact

Severity	High	Medium	Low	Negligible
Probability				
High	Major	Moderate	Minor	Negligible
Medium	Major	Moderate	Minor	Negligible
Low	Major	Minor	Negligible	Negligible

5.3 AIR QUALITY

5.3.1 Key considerations

It is expected that the ambient air of the Tambaredjo NW is currently almost devoid of any pollution from manmade sources.
Air emissions can broadly be classified into gaseous and particulate emissions. Most of the particulate emissions are due to "fugitive" sources. In the project area, no significant atmospheric dust is expected to arise, because it is a "wetland" operation and virtually all activities take place in a swamp area.
Gaseous emissions would mainly originate from vehicle exhausts and power generation units on drilling rigs. Most vehicles and equipment utilize diesel as fuel, except for the airboats and the gator tails that utilize gasoline. All these sources are mobile and they will be active is consecutive sections of the oil field. The drilling rig will move once every 1-2 weeks to another location.
Above emissions normally occur during working hours, with the exception of those related to drilling that take place continuously, i.e. 24 hours per day, 7 days per week.
The overall level of activities will be low (see Ch. 4).

Apart from that there will be emissions resulting from venting of associated gas from storage tanks. This issue has already been dealt with in the study for the Transfer station (Noordam & Teunissen, 2009).
Finally, fugitive emissions could emerge in association with leaking pipes and tubing, valves, connections, flanges, packings, open-ended lines, pump seals, compressor seals and pressure relief valves.

5.3.2 Sources of impacts

Table 21 provides a summary of the identified air emission sources for the proposed production development.

Table 21: Source activity and identification

Activity	Identification of Sources
Transportation; exhaust emissions	Carrier, Swamp pulling unit (diesel), swamp rig
Transportation; exhaust emissions	Airboat, Gator tail (gasoline)
Construction; exhaust emissions	Excavator (diesel)
Drilling; exhaust emissions	Diesel generator
Moving Jabez rig; exhaust emissions	Three diesel engines
Crude storage, venting	Tanks
Oil transport through pipes, storage	Equipment leaks

The principal emissions from vehicles are: Nitrogen oxides (NOx), Carbon monoxide (CO), Sulphur dioxide (SO_2), Diesel particulates and Volatile Organic Compounds (VOC).
Venting and fugitive emissions comprise Volatile Organic Compounds (VOC), Methane (CH_4), Hydrogen sulfide (H_2S).

The project activities take place in an extensive swamp with closest receptors at 4 km distance living along the Gangaram Panday road. Development activities in the zone closest to these receptors will only take during one year and from that year closest development

activities will be at least 6 km away from the receptors. During production the activities will be limited to well monitoring and inspection and maintenance, which activities have a relatively low frequency.

The study area has a general northeast to southeast wind direction, with the first dominating in the February-April and the latter during the July-September period. The other months show directions mostly ranging between northeast and southeast. Northern winds are only very occasionally recorded. A potential impact of air emissions could only occur during north-northwestern to northeastern winds, which occur during 34% of the time (Figure 32). With east-northeastern to south-southwestern winds (64% of the time) all emissions will end up in an area without receptors (Figure 32). Calm winds (<0.5 m/s) occur during 40% of the time, mostly during the night and early morning.

Along the southwest boundary, the Tambaredjo NW oil field is shielded by the high swampwood that will further reduce a potential impact of air emissions.

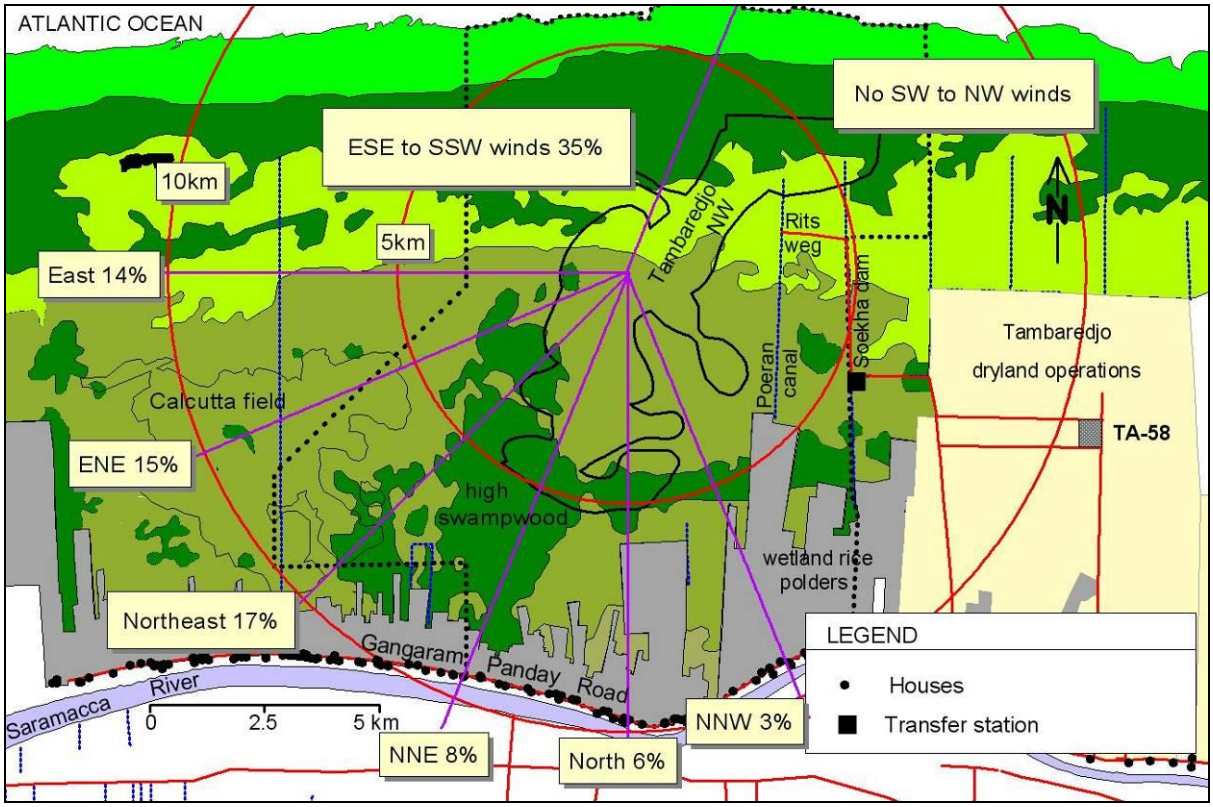

Figure 32: Distribution of wind directions in % of the total period with wind (based on data from Zanderij, 1961-1970).

5.3.3 Impact assessment

Impact AQ1: Impaired human health or nuisance caused by poor air quality

The assessment of the impacts of air emissions from activities in the Tambaredjo NW area has been made qualitatively taking into account below considerations.

1. Existing ambient conditions indicate very low levels of pollution

2. There will be relatively few emission sources, with relatively low emissions
3. Emission is spread over a very large area (area source)
4. Most emission is from mobile sources
5. Receptors are present at a distance of at least 4 km (up to 15 km)
6. Receptors will only be potentially exposed during one-third of the year. However, with hourly variations in wind directions of 25-35 degrees, a single location is (potentially) exposed during only part of this period, so there is only incidental exposure.
7. In between the emissions sources and the receptors is a high swamp wood that provides a buffer
8. No air quality background levels are available
9. No local wind data are available and use has to be made of data from Zanderij airport
10. A cumulative effect with emissions from the Calcutta field is not likely to occur, given the fact that production development at Calcutta will have been completed at the moment that relevant development at Tambaredjo NW will start
11. Traffic intensity along the Gangaram Panday Road is not known in detail and also information on farm equipment is lacking, but the impact of these two sources on local air quality will considerably surpass that of the activities for the production development in the Tambaredjo oil field.

Construction

During construction, clay dams and facility yards are established and trails and drilling locations are prepared. This will be done by excavators. The personnel will be transported to and from the project area by car from Sarah Maria to Soekha dam. From Soekha dam, the personnel will be further transported by airboat.
Materials and supplies will be transported by swamp carrier.
Given the limited number of daily trips and the limited number of excavators, exhaust fumes are in general not expected to be present in sufficient concentrations to affect the distant receptors during the construction phase (**negligible** impact).

Operation

During operation, the wells will be drilled. The personnel will be transported to and from the project area by car from Sarah Maria to Soekha dam. From Soekha dam, the personnel will be further transported by airboat.
Materials and supplies will be transported by swamp carrier.
Once every week the drilling rig will be moved to its next position. The caterpillar-mounted swamp rig and associated drilling train will travel on its own power, while the Hover rig will be pulled by excavators while being lifted. The whole move for the Hover rig takes about 1 hour for a distance of 200 m.
Other activities will involve well inspection, monitoring and maintenance for which airboats, Gator tails and carriers will be used. Although the activity level during operation is higher than during the construction phase the impact of emissions is still considered negligible, due to scattered and usually non-continuous character of the activities and the large distance to receptors.
For the same reason also potential fugitive emissions from the piping network is considered to have a **negligible** impact. Nevertheless, prevention and mitigation will be presented in the Environmental Management Plan (EMP).

Closure
The activity level during the closure phase will be comparable to those during the construction phase. Activities will predominantly involve excavators, carriers and airboats. Given the limited number of daily trips and the limited number of excavators, exhaust fumes are in general not expected to be present in sufficient concentrations to affect the distant receptors during the closure phase (**negligible** impact).

5.4 NOISE

5.4.1 Key considerations

Existing noise levels in the Tambaredjo NW area are typical of remote areas, where the natural sounds dominate the noise climate. The daytime noise level averages a low 40 dB(A), while noise levels in the swamp actually increase at night, to 49 dB(A).
At daytime occasionally a brief increase of noise is found when an airboat or swamp carrier passes through the area. Depending upon the distance between the source and the receptor the noise level could be slightly elevated (when the airboat is not within a few hundreds of meters) to very loud, when passing nearby. But higher noise levels occurred more frequently during past exploration activities in the Tambaredjo NW area.
Therefore, the wild life in the area is thought to be adapted to elevated noise levels to a certain extent. And certain species may already have moved out of the area toward quieter zones. But this could not be confirmed by the current baseline study.

Aside from personnel, the only other human receptors in the vicinity are found along the Gangaram Panday Road to the south of the project. These receptors may theoretically be affected by elevated ambient noise levels due to the Tambaredjo NW operations. But no baseline noise monitoring has been conducted along this road because the nearest receptor is still 4 km away from the nearest project activity. At this distance none of the project noises will exceed a level of 55 dB(A) (LA_{eq}) that is the allowable daytime ambient noise limit for residential areas (IFC, 2007c). For the noisiest equipment, the airboat, a maximum distance of 700 m has been found for the 55 dB(A) contour (downwind). Normally the airboat only operates during daytime.
The drilling rig produces continuous noise during drilling operation, which is a 24/7 operation. During daytime, the excavators and other construction equipment produce continuous noise in the 08.00-15.00h period during weekdays and occasionally also during the weekends. All other noises are associated with transportation and these are intermittent in time and place.
Noise levels in a certain section of the field will be highest during the development phase. Once developed the only sources of noise will be generated by transport means for inspection and maintenance. There will be no fixed sources of noise generation in the Tambaredjo oil field and ancillary structures.

5.4.2 Sources of impact

Direct impacts on noise levels in the concession are likely to result from a number of project activities, summarized in Table 22:

Table 22: Sources of direct impacts on Tambaredjo NW noise levels

Excavation of trails
Construction of header dams
Noise during the construction of stations, tanks, pipelines and electricity grid
Movement of the drilling rig
Transport noise (airboats, gator tails, swamp carriers)
Drilling

5.4.3 Impact assessment

Impact N1: Noise impacts on fauna

Noise affects wildlife differently from humans and the effects of noise on wildlife vary from serious to nonexistent in different species and situations.
Kaseloo & Tyson (2004) prepared a synthesis of ongoing work on the effects of noise on wildlife populations to date, mostly focusing on the effects of road noise. This describes the effects of wildlife on continuous elevated sound levels.
Larkin et al., (1996) present a literature overview of the effects of military noise on wildlife. This comprises the effects of intermittent noise to wildlife, including sudden very high noise levels (blasts).
The studies sketch a more or less similar picture about the effect of noise to wildlife.

When exposed to man-made noise animals may suffer both physiological and behavioral effects. With regard to the former, an animal's response may range from mild annoyance to panic and escape behavior. These responses are manifestations of stress, which may harm an animal's health, growth and reproductive fitness. For example, energy losses due to escape and panic responses could result in impaired growth and health. For some animals, increased noise levels also interfere with communication. Bats, for example, a species group totally reliant on echo location, are unable to find food if noise levels are too high.
In terms of behavior, animals may avoid places with high levels of noise. In the case of birds, it was found that fewer birds visit a spot when the noise level at a given spot increases. Also for other animals, like for instance the mountain goat and white-tailed deer, evidence indicates avoidance of noisy areas. This might decrease chances of surviving and reproducing when retreat occurs from favorable habitat near noise sources and when time spent feeding is being reduced. Increased noise levels could also result in [bird] nest abandonment and decreased reproductive success if such activity occurs during the breeding season. Decreased reproductive success have been documented in some studies and documented to be lacking in other studies on other species.
On the other hand decreased responsiveness after repeated noises is frequently observed, which is usually attributed to habituation.
Risk of hearing damage in wildlife is reported, but this is probably greater from exposure to nearby very loud noise than from long-lasting exposure to continuous noise.

From the evidence presented by above mentioned authors it is reasonable to say that noise interferes with animals' feeding, hunting and breeding behavior and performance.
However, the effects of noise on animals vary markedly among, as well as within species, owing to a variety of factors. It is therefore hard to draw any general conclusions about the effects of increased noise on animals.

There are currently no international standards or guidelines regarding noise emissions and ambient noise levels for the protection of wildlife.
However, some indicative guidelines for birds have been recommended by Dooling and Popper (2007) (Table 23). In the absence of standards or guidelines for wildlife in general these indicative guidelines have been used as if they apply for wildlife in general. It is not expected that this will lead to underestimation of the impact of noise on animals.

Table 23: Recommended interim guidelines for potential effects from different noise sources

Noise Source Type	Hearing Damage	Temporary threshold shift (TTS)[(a)]	Potential Behavioral/ Physiological Effects
Single impulse (e.g. blast)	140 dB(A)	None	Any audible component of noise has the potential of causing behavioral and/or physiological effects
Multiple impulse (e.g. pile driver)	125 dB(A)	None	
None-strike continuous (e.g. construction noise	None	93 dB(A)	
Road noise	None	93 dB(A)	

[(a)] Temporary loss of hearing because of exposure to sound over time.

The production development activities at Tambaredjo NW will have an impact on the fauna in the proximity to the working faces and transportation routes, but it is hardly possible to quantify or rate these impacts. Based on the recommended guidelines of Table 23 and the equipment noise levels it can be stated that no hearing damage to birds will occur, because all noise levels of the current activity are below 125 dB(A). In addition, TTS will only occur when an airboat at maximum speed comes within 70 m of a receptor. This effect is temporary. When the airboat is stationary, the noise level is only 75 dB (A).
As indicated in Table 23 there is a potential of behavioral and/or physiological effects at all noise levels above the baseline levels, but the actual impact on specific animals is not known.
The general impact of noise on animals in the project area is thought to be **minor**, being localized and short-lived (Table 24). Either on the long run, animals will adapt to the (usually intermittent) elevated noise levels, or they will move to quieter zones of the Buru Swamp. No permanent damage is expected. Once into production the noise level will substantially decrease, because the activities will then be reduced to monitoring and maintenance. Mitigation measures are presented below, but these will not further reduce the impact class.

Table 24: Significance of the noise impacts on fauna

	Intensity	***Duration***	***Scale***	***Severity***	***Probability***	***Significance***	***Status***
Without mitigation	Low	Short-term	Small	Low	High	**MINOR**	neg
With mitigation	The impact cannot be further reduced						

<u>Impact N2: Noise impacts on breeding colonies</u>

The only surely sensitive areas with respect to noise disturbance are the Ibis and Egrets colonies in the young parwa along the coast and the Cocoi Heron colonies in the mature parwa further away from the coast south of the young parwa. The breeding season of these birds is from the end of April until September. These colonies are very sensitive for noise, especially at the end of the breeding season when the young are almost fledging. Because of fear for the noise, they may fledge too soon with fatal consequences. When in the beginning

of the breeding season the birds want to settle, noise of airboats can chase them away. It should be noted that in the next breeding season colonies might have a different location.
In relation to oil and gas development in short-grass prairies the Bureau of Land Management (US department of the Interior) recommends that the noise levels at nesting sites during the bird nesting season are reduced to 49 dB(A) or less. This implies that sufficient distance should be kept between noisy activities and breeding sites.
The potential impact of noise on these colonies is considered as to be of **major** significance, being of high intensity, medium-term and medium-scale (Table 25). The high intensity is also related to the international importance and reputation of the area, being (close to) a Nature Reserve that is part of the Western Hemisphere Shorebird Reserve Network. However, the probability of disturbance is considered low, because most colonies are found in the northern parwa forest, at a considerable distance from the project activities, and also it is likely that birds will not locate their colony in an area close to human presence like the Tambaredjo NW oil field.
With the implementation of appropriate mitigation measures, this impact can be reduced to **negligible**.

Table 25: Significance of the noise impacts on breeding colonies

	Intensity	***Duration***	***Scale***	***Severity***	***Probability***	***Significance***	***Status***
Without mitigation	High	Medium-term	Medium	High	Low	**MAJOR**	neg
With mitigation	Medium	Short-term	Small	Low	Low	**NEGLIGIBLE**	neg

Mitigation measures that should be implemented include:

General:

- Select the quietest and most effective equipment available, also for the drilling rig.
- When possible: use the Gator-tail boats instead of airboats.
- When using airboats: operate at a moderate speed (2500 RPM) to reduce noise levels, provided that conditions allow such.

Breeding colonies:

- Plan activities in the northern section of the oil field in the October – March period, when the likelihood of breeding colonies is lowest.
- In case work in the northern part of the oil field is planned for the May-September breeding season an aerial survey should be conducted in early May[9], to determine the locations of eventual breeding colonies in and near (within 1 km of the boundary) the project area. This survey should be conducted every year once this section is developed.
- In case breeding colonies are present within 1 km from the oil field boundary no development activities in this zone should be conducted during the breeding period and monitoring and maintenance activities should be conducted with Gator-tails at a low noise-level.
- Furthermore the number of transportation trips in the area in a radius of 1 to 2 km from breeding colonies should be limited to the minimum during the breeding season.

[9] By then most breeding colonies will have settled; a survey in April is too early.

5.4.4 Further study

Further detailing of noise-speed relations should be made for the airboat and the Gator-tail in order to enable the formulation of the optimum speed with respect to minimum noise impact at a still feasible working speed.
The sound level of the caterpillar-mounted rig during drilling and moving could not be measured yet. This should be done prior to commencement of the Tambaredjo NW drilling program for this rig so that this information can be included in noise management guidelines.
With respect to that also all noise specifications for eventual new (quiet) equipment should be measured.

5.5 VISUAL RESOURCES, TOPOGRAPHY AND LANDSCAPE

Impact VIS1: Loss of visual quality

The study area is characterized by a low relief and has no prominent landscape features. The project will not involve essential alterations of landscape and topography.
During construction and operation the oil field and its infrastructure will be visible from the air, among others during bird counts and inspections by the dedicated management authorities.
The impact is considered to be **moderate** because it has a long-term effect (Table 26). It cannot be further reduced by mitigation measures.

Table 26: Significance of loss of visual quality due to project

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Low	Long-term	Medium	Medium	High	**MODERATE**	neg
With mitigation	No mitigation measures possible						

Impact VIS2: Improvement of visual quality

After closure, the vegetation will establish itself again with a positive impact of **moderate** significance for the area (Table 27). This impact cannot be further enhanced by measures.

Table 27: Significance of re-establishment of vegetation on the visual quality of the area

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Low	Long-term	Small	Medium	Medium	**MODERATE**	pos
With mitigation	No further enhancement possible						

5.6 SURFACE WATER RESOURCES

5.6.1 Key considerations

The key findings of the water resources baseline study (Amatali, 2009) are the following:

1) The project area comprises swamps with different depths. The deepest part is found in the central part with mixed herbaceous and Typha swamps. Here the swamps have a depth of 80-90 cm in the Long Dry Season (LDS) and of 110-120 cm in the Long Rainy Season (LRS). For the remaining mixed herbaceous and Typha swamps, the depth is 45-65 cm (LDS) to 75-95 cm (LRS). The parwa forest has much shallower depth with ~14 cm in the LDS and 47 cm in the LRS.
2) The swamps (except for the parwa forest) have relatively thick peat layers (40-80 cm) that have formed over at least the last 45 years.
3) At rainless days and at low swamp levels, the daily drop of the water level amount ~ 5 mm. This drop is thought to be caused (almost) completely by evapotranspiration.
4) A considerable water flow, with a velocity of at least 2-3 cm/sec is possible in the trails when sufficient difference in head is present. Such difference could originate from local rainfall, during which some areas receive far more rain than others do. Differences in water level are relatively quickly compensated for by water flow through trails.
5) Water flow in swamps is much slower than that in trails due to the presence of peat and vegetation parts that pose a high hydraulic resistance. Using simulation the water flow velocity through the Buru Swamp is assessed at ~ 0.5 – 1.5 mm/sec, with the latter only occurring after heavy rainfall at high swamp water levels.
6) Discharge from swamps occurs only at sufficiently high swamp levels. For the Buru Swamp, this level is at ~ 71 cm (with reference to the staff gauge at location 02). Discharge took place during about half of the time during rainy periods (81 out of 165 days).
7) From the diver readings, it can be concluded that rainfall in the study area is not evenly distributed. Local showers do occur frequently causing a local swamp water level rise.
8) During the study period, the local rice farmers have withdrawn estimated 2 million cub meter water from the Buru Swamp, which is 1% of the total incoming water (rainfall) during the study period, and 5% of the water that was discharged from the swamp.
9) An estimated 350 mm of swamp water is discharged into the tidal zone in the north of the study area.
10) The parwa forest in the northern project area is of the blocked type, i.e. the ocean water is not longer reaching the forest, but fresh water from the southern swamp is still drained into the tidal zone to the north of it.
11) The relatively low salinity of the water in the parwa forest zone indicates that it is in the process of becoming fresh. Also the salinity in the Typha zone is relatively low (oligohalinous).
12) The water of the mixed herbaceous swamp and the swampwood has less than 300 mg chloride/l throughout the year and is therefore suitable for irrigation of wetland rice.

13) The water in the Calcutta oil field shows temporarily increased salinity levels, probably due to the disposal of completion fluid into the swamp, but the water is still suitable for irrigation purposes.
14) The water of the Buru Swamp is clear and slightly brownish. Secchi in undisturbed swamps is relatively high and Total Suspended Solids (TSS) and Turbidity are low. The water of the Calcutta oil field is often turbid, especially in the main canal. Therefore TSS is much higher and Secchi much lower than in non-disturbed sections of the Buru Swamp. Occasionally also in trails outside the oil field turbid water arises in particular after the passage of a swamp carrier. Airboats in general do lead to minor increased turbidity in such trails.
15) The water in the Buru Swamp is oligotrophic, which can be concluded from the low nutrient levels and from the frequent presence of Bladderwort (Blaasjeskruid, *Utricularia foliosa)* in almost all of the airboat trails. The water quality in general is typical for swamps in the Young Coastal Plain.
16) During the study period, no relevant signs of oil pollution have been observed in the Buru Swamp, including the Calcutta oil field.

In the baseline study it has become clear that the hydrology of the swamp area plays a critical role in the proper functioning of the coastal ecosystems.
Swamps are also important for the local rice cultivation as they supply irrigation water.
Hydrological disturbance in the study area can have adverse ecological effects in the near-coastal zone.

5.6.2 Sources of impacts

Impacts on the surface water resources are likely to result from a number of project activities

Table 28: Sources of impacts to surface water sources

Construction of dams
Creation of a network of open water (trails)
Oil spills and leakages
Release of drilling fluid and cuttings

5.6.3 Impact assessment

Impact WR1: Changes in the hydrology of the Buru Swamp due to blockage of water

Activities that could lead to a disturbance of hydrology are the following:

Construction phase:

The oil field development will include the construction of a network of clay dams and trails. Many of the dams will have an east-west direction. During the construction of trails, the excavated peat is accumulated on one side of the trail. Construction of these dams and trails could lead to blockage of water flow to the north, thus diminishing the flow of fresh water to the northern swamps, which may result in:

- higher swamps levels south of such blockage,
- reduced freshwater flow to the northern zone
- die off of vegetation (see impacts on vegetation)
- flooding of rice polders as a result of overtopping or breaching of the low polder dams

The hydrological changes, could potentially lead to an ecological or social impact of **major** significance as will be further elaborated in the respective sections (Table 29).

Operation phase:
Poor maintenance of dams could potentially have the same adverse impact of **major** significance as described for construction (Table 29).

Closure phase:
In case dams are not adequately removed, significant long-lasting negative impacts may occur, as described above for the construction and operation phase, either directly or some time after abandonment of the area (Table 29).

Table 29: Significance of blockage of the swamp water flow during construction, operation and after closure

	Intensity	***Duration***	***Scale***	***Severity***	***Probability***	***Significance***	***Status***
Without mitigation	Medium	Long-term	Medium	High	Low	**MAJOR**	neg
With mitigation	Negligible	Long-term	Small	Negligible	Low	**NEGLIGIBLE**	neg

Preventive and mitigation measures for water management should aim at a minimum impact on the current hydrological conditions.

Preventive and mitigation measures regarding hydrology include:

Construction phase:
- Provide dams with sufficient and adequately openings (cuts) in between. The current practice at the Calcutta oil field appears to be adequate and can be maintained, unless monitoring proves differently. The current practice is the creation of a 1 meter wide opening every 500-1000 m and a number of larger openings (up to 70 meters) at places where other trails are connecting.

Operation phase:
- Conduct monitoring to the functioning of the system, as openings may easily be clogged by vegetation or caving in. Conduct more frequent monitoring directly after heavy rainfall, when the chance of increased water levels is highest. Preferably, the monitoring should be automated.
- In case water flow blockage is occurring: check whether the dam openings are properly functioning and clear when necessary. In case water blockage is not caused by clogging: double the number of openings in the dams.

Closure phase:
- level or breach the dams, unless management is taken over by another party (e.g. tourism development)

With proper implementation of mitigation measures, the project's impact on hydrology is regarded as to be **negligible**.

Impact WR2: Changes in the hydrology of the Buru Swamp due to increased discharge

The hydrology study has pointed out that water flow through trails is much faster than through the swamp, because of considerable differences in hydrological resistance. At this moment this hardly has an impact, because the current Calcutta field is situated in the south of the Buru Swamp where there is no direct connection with an outlet (e.g. creek in the coastal zone). The creation of a network of open water along the northern edge of the Buru Swamp, as planned for the Tambaredjo NW project, could however create a situation where swamp water from the Tambaredjo oil field is discharged much faster than it normally does. This network is continuing into the mangrove forest where hydrological resistance is less than in herbaceous swamp or in swampwood (there is less peat and the trees in the mangrove zone are far apart), which further promotes a relatively rapid discharge. In particular south-north trails will promote a more rapid discharge. Increased swamp flow could affect the swamp water level in the Buru Swamp that will become lower than normal under the given conditions. An impact of increased water inflow in the mangrove zone is not thought to have an impact because a sea-bound water flow is a normal process and the extra quantities will relatively fast find their way to the ocean, without much impact on the swamp water levels in this zone.
However, a water level drop in the Buru swamp could result in a decrease of its irrigation capacity and thus affect the rice farmers along the Gangaram Panday Road. The potential impact is considered to be of **moderate** significance, but it can be reduced to negligible with the implementation of below prevention and mitigation measures (Table 30)

Table 30: Significance of increased water flow towards the northern swamp due to the network of trails

	Intensity	***Duration***	***Scale***	***Severity***	***Probability***	***Significance***	***Status***
Without mitigation	Medium	Short-term	Medium	Medium	Medium	**MODERATE**	neg
With mitigation	Low	Short-term	Small	Negligible	Low	**NEGLIGIBLE**	neg

Preventive and mitigation measures regarding increased water flow include:

- Limit the number of south-north trails in the mangrove forest zone to the minimum
- Limit the width and depth of trails in the mangrove forest zone to the minimum
- Plan east-west trails in the northern section of the field preferably in zones with herbaceous vegetation (Typha) which provides a buffer for rapid water flow
- In case trails are constructed in the mangrove forest where open outflow is possible, these should be provided with low clay dams along the sides and a closing dam at the northern end. These dams will prevent that water from the trail network to the south is flowing directly into the mangrove. No dams should be made where herbaceous vegetation (Typha) is present.
- These measures are only applicable for the zone with a mixture of closed and open parwa forest interspersed with Typha swamp.

Impact WR3: Increased salinity of the swamp water as result of clay excavation for the construction of dams

During the construction phase, clay excavation for the construction of dams and yards will bring saline clay to the surface. The salts will leach from the clay into the surface water resulting in a local and temporary increase of salinity of the water. Salt release will be highest in the rainy season, but gradually the excess salts will be diluted. The impact to water quality is considered minor, and it cannot be further reduced by mitigation measures (Table 31).

Table 31: Significance of salt release from excavated clay

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Medium	Short-term	Small	Low	High	**MINOR**	neg
With mitigation	No mitigation possible						

WR4: Water pollution with spilled and leaked oil and/or grease during construction

Maintenance of equipment will normally be done on dryland, but on-site emergency maintenance will potentially have an impact through the release of some oil and grease into the surrounding water. The impact, if any, is regarded to be **negligible**, being very localized and very incidental. Apart from the already existing clean-up procedures, no additional mitigation measures are required.
Fuel for the excavators and other earth moving equipment will have to be transported to the working location in the swamp. Transport will take place by airboat with the fuel stored in a tank. Fuel will be temporarily stored in a tank along the Soekhadam. Spills or leaks may occur during storage, transport or handling of fuel. Also could oil from the machinery leak into the swamp. Depending upon the quantity and the location of the event, the impact could be **minor** (Table 32). Any pollution will as soon as possible be contained and cleaned up according to the oil spill clean-up guidelines. It is expected that the water quality of the swamps and canals, in case of fuel, oil or grease pollution, will rapidly recover by its self-cleaning capacity.

Table 32: Significance of oil, grease or fuel leakage or spills during construction

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Medium	Short-term	Small	Low	Medium	**MINOR**	neg
With mitigation	Low	Short-term	Small	Negligible	Low	**NEGLIGIBLE**	neg

Preventive and mitigation measures regarding oil, grease or fuel spills and leaks include:

- use leak proof containers and storage tanks
- provide adequate containment for containers or tanks
- have the oil spill contingency plan in place for the area under consideration
- follow the Staatsolie procedures for maintenance and clean-up

After implementation of the above mitigation measures, the impacts are regarded as to be of **negligible** significance.

Impact WR5: Water pollution with spilled and leaked oil and/or grease during operation

Similar impacts as described for the construction phase are possible in the operation phase during transportation and maintenance.
Oil spills are possible from pipelines, well pumps and storage tanks. Oil will affect the aquatic environment and floating plants. Even though the intensity of such event will be high, the potential impact is considered as to be **minor**, because such spills are short-term and small-scale (Table 33). Inspections will be twice daily, so that no large amounts of oil can be spilled. During the 4-year operation period of the Calcutta oil field 5 spills have occurred. It has been reported by Staatsolie that such spills here never reach far from their source and that the (heavy) oil sinks to the bottom and remains there till it is cleaned up. With the implementation of appropriate mitigation measures, the impact can be reduced to **negligible**.

Table 33: Significance of oil spills from pipelines and tanks during operation

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	High	Short-term	Small	Medium	Low	**MINOR**	neg
With mitigation	Low	Short-term	Small	Low	Low	**NEGLIGIBLE**	neg

Preventive and mitigation measures regarding oil spills from pipelines and tanks include:

- provide adequate containment for tanks
- conduct frequent inspections and replace pipes and valves in time (according to experience acquired in other oil fields)
- have the oil spill contingency plan in place for the area under consideration
- follow the Staatsolie guidelines for inspection, maintenance and clean-up

Impact WR6: Water pollution due to the release of drilling fluid and cuttings

The on-site release of drilling cuttings and liquid drilling waste, as well as eventually spilt drilling chemicals, will change the water quality in the swamp surrounding oil wells. Water based drilling mud will be used during the Tambaredjo NW drilling operations.
From an earlier survey (Noordam & Teunissen, 2003) and a special study (Noordam, 2005) it has been determined that even in freshwater wetlands the impacts are low and that the main impact is temporary with a localized increase of salinity. This is confirmed by the results of the current study, which concludes that at the operational Calcutta oil field only a minor and temporary increase in salinity occurs. In addition to that, no visual signs of salt effects to the vegetation have been observed in the Calcutta oil field. The potential impact of the on-site dumping of drilling waste is considered to be **negligible**, being of low intensity, small scale and short-lived. In the northern part of the project area the impact will even be less because the swamp water already has a higher salinity (Typha swamp and mangrove forest).

5.7 VEGETATION

5.7.1 Key considerations

The vegetation of the Tambaredjo NW area is characterized by a zonation of (blocked) closed to open Black-mangrove (parwa) forest, brackish open swamps, and freshwater swamps. The freshwater swamp shows a succession from mixed herbaceous swamp, swamps shrub, low swampwood and high swampwood. The final succession stage, high swamp forest, has not yet developed in the area.

The area coverage of the four ecosystems in the project area is:

Black Mangrove forest	16%
Herbaceous brackish water (Typha) swamps	24%
Mixed herbaceous swamp, swamp shrub and low swampwood	51%
High swampwood	9%

The above ecosystems are very common in the ~ 400 km long zone along the coast of Suriname.

Black-mangrove forest is exclusively found in the Guiana's, nowhere else in the world. It therefore has a high conservation value (WWF Conservation Science Program). The conservation status of these mangroves has been estimated as relatively stable or intact (Olson & Dinerstein, 2002).
High swampwood forms a succession stage towards high swamp forest. Because high swamp forest is restricted to Suriname and not found elsewhere in the world, it has a high international conservation value. On a national level, high swamp forest should be considered as a vulnerable forest type, because it is susceptible to peat fires and to elevated swamp water levels. Damage to the high swampwood in the project area will delay the development of high swamp forest here.

According to the IUCN Red List, one tree species of the present study area belongs to the international category "Endangered": Babun-udu (*Virola surinamensis*). This tree is one of the characteristic tree species of the "Babun-Mataki-Pina" or high swamp forest and a few Babun trees are present few in the high swampwood (Appendix B). Babun-udu is a very common tree in Suriname and the present "Endangered" status needs to be reviewed. See correspondence with IUCN Red List Programme Officer (APPENDIX H).
No other Red List plant species are found in the study area.

Although very limited in total surface area and occurring as very small and isolated spots, ridge woods and ridge forests are yet important. They form "islands" with higher biodiversity within generally monotonous swamps with a relatively low biodiversity. Within the Buru Swamp, certain plant and animal species do only occur in ridge wood and ridge forest. Moreover, it is an important habitat that provides food and lairing, roosting and breeding place for some animal species that live in the Buru Swamp. Ridge ecosystems form an essential component in the life cycle of some swamp animal species.

5.7.2 Sources of impacts

- Removal of vegetation for trails, dams, drilling locations, dams and facility areas. Figure 33 presents the proportional clearing for the four main ecosystems, using different rig types.
- Changes in swamp hydrology due to construction of dams and trails
- Swamp water pollution with hydrocarbons
- Revegetation during mine closure.
- Increased incidence of fire

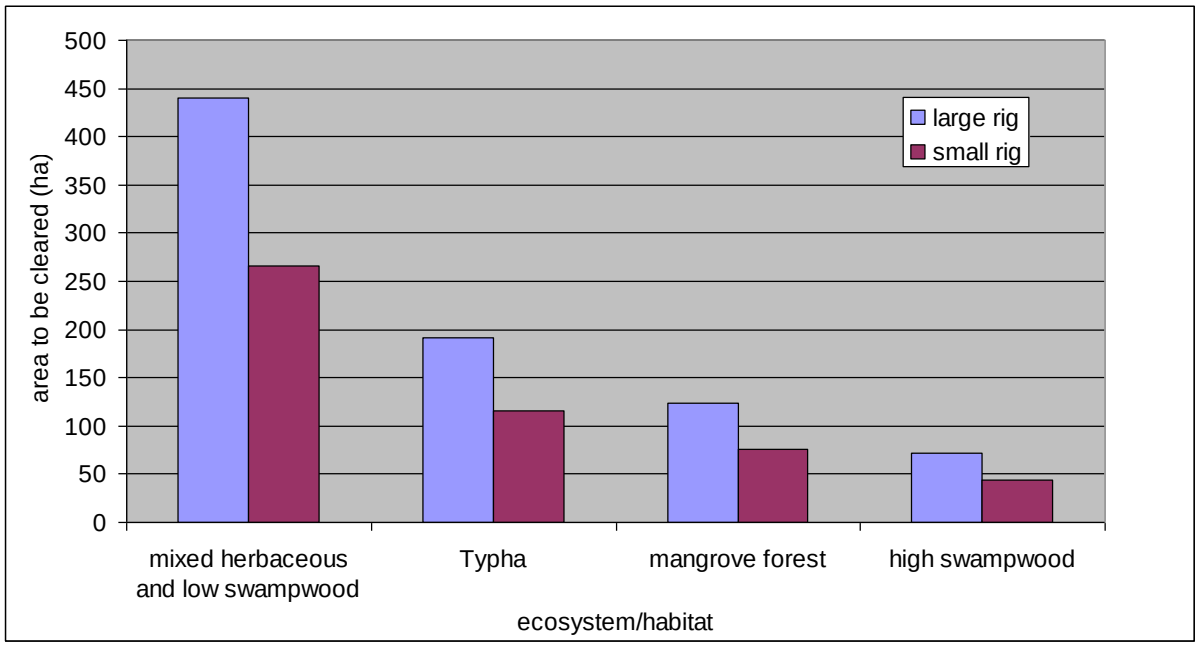

Figure 33: Estimated areas to be cleared in the four ecosystems using a small and a large rig

5.7.3 Impact assessment

Impact VEG1: Loss of Black Mangrove (Avicennia-Parwa) forest

About 75-125 ha (depending upon the type rig) of this ecosystem of high conservation value will be cleared for the project. However, the mangrove forest in the project area is of the blocked type, i.e. it is no longer connected to the sea, and its water is gradually becoming fresher. The Black Mangrove forest in the project area is closed in the north and open in the south. Blocked mangroves are in the process of disappearing and in their place brackish vegetation will gradually develop. Blocked mangroves also do not provide all of the multiple functions and goods of seaside mangroves.
Based on their general conservation status the impact should be major, but given above consideration on the blocked character of the mangrove forest the potential impact during construction is considered to be of **major** significance, but it can be reduced to moderate significance with appropriate mitigation (Table 34).

Table 34: Significance of loss of Black Mangrove forest

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Medium	Long-term	Medium	High	High	**MAJOR**	neg
With mitigation	Medium	Long-term	Small	Moderate	High	**MODERATE**	neg

Mitigation measures include:

- Limit the footprint of disturbance to the minimum through optimized planning and the use of the smaller caterpillar rig instead of the Hover rig. The required clearing for these rigs is respectively 29% versus 47% of the development areas.

Impact VEG2: Loss of herbaceous swamp vegetation

The herbaceous swamp vegetation, including low swampwood is the dominant vegetation type in the project area. It is a very common type in the Coastal Plain of Suriname. It forms the first stages of the succession to high swamp forest and it has a high potential for recovery to its pre-clearing stage.

The potential impact during construction is considered to be of **moderate** significance, and this cannot be further reduced (Table 35).

Table 35: Significance of loss of herbaceous swamp vegetation

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Low	Long-term	Medium	Medium	High	**MODERATE**	neg
With mitigation	No mitigation possible						

Impact VEG3: Loss of high swampwood

High swampwood forms a succession stage towards high swamp forest, which has high international conservation value. Damage to the high swampwood in the project area will delay the development of high swamp forest here.

Based on the latter the potential impact during construction is considered to be of **major** significance, but it can be reduced to moderate significance with appropriate mitigation (Table 36).

Table 36: Significance of loss of high swampwood

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Medium	Long-term	Medium	High	High	**MAJOR**	neg
With mitigation	Medium	Long-term	Small	Medium	High	**MODERATE**	neg

Mitigation measures include:

- Limit the footprint of disturbance to the minimum through optimized planning and the use of the smaller caterpillar rig instead of the Hover rig. The required clearing for these rigs is respectively 29% versus 47% of the production development areas.

With above mitigation measures in place, still it cannot be avoided that some high swampwood is cleared. Clearing is considered acceptable taking into account the following:

a) There are approximately 28,000 ha of high swamp forest in Suriname. The area to be cleared for the project is ~ 0.15% of this area.
b) The local high swampwood is a succession stage towards high swamp forest and at the moment it has only a few elements of high swamp forest.
c) The high swamp forest is already protected in three Nature Reserves: Peruvia, Copi and Boven Coesewijne, and in the proposed Nanni Nature Reserve.

For these reasons the impact to the Buru Swamp high swamp forest is considered to be acceptable with proper follow-up of the mitigatory measures.

Impact VEG4: Vegetation changes due to changes in hydrology

In the baseline study it has become clear that the hydrology of the swamp area plays a critical role in the proper functioning of the coastal ecosystems (see also impacts on hydrology).

Construction of header and flow-line dams in the swamp could lead to blockage of water flow. And even if appropriate measures are taken in the form of cuts, problems could still arise due to poor maintenance of these structures during the operation phase. And finally blockage of the swamp flow could follow from improper closure measures. Blockage could lead to higher swamps levels south of such blockage potentially resulting in large-scale die-off of (especially trees, treelets, palms and shrubs.
The potential impact of blocked water on the vegetation is potentially of **major** significance when large areas of mangrove forest or high swampwood are affected, but with appropriate prevention measures the impact will be negligible (Table 37).

Table 37: Significance of potential impacts of blocked water flow vegetation

	Intensity	***Duration***	***Scale***	***Severity***	***Probability***	***Significance***	***Status***
Without mitigation	Medium	Long-term	Large	High	Low	**MAJOR**	neg
With mitigation	Negligible	Long-term	Small	Negligible	Low	**NEGLIGIBLE**	neg

Preventive and mitigation measures regarding hydrology and vegetation include:

- See measures proposed for hydrology.

Impact VEG5: Damage to vegetation due to water pollution

Water pollution is possible during all project phases (see also impacts on water quality).

- **No** impact on the vegetation and flora is expected from changes in water salinity in the area, because the area is predominantly fresh to slightly brackish and it also communicates with other freshwater swamps surrounding affected spots.

- Impacts on the local vegetation and flora as a result of (minor) fuel and grease spills will be **negligible** because such spills will only affect small areas, they are short-lived and they are reversible. Larger spills could affect larger areas, but still the impact to vegetation will be of **minor** significance, because only the plants along the trails will be affected (Table 38). With proper prevention and mitigation measures, the impact can be reduced to negligible.

Table 38: Significance of potential impacts of oil spills on vegetation

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Low	Short-term	Medium	Low	Medium	**MINOR**	neg
With mitigation	Low	Short-term	Small	Negligible	Low	**NEGLIGIBLE**	neg

Preventive and mitigation measures regarding water pollution and vegetation include:

- See water quality; oil pollution

Impact VEG6: Return of vegetation during and after closure

If not being used for another type of development, the vegetation in the area will establish again once equipment and structures are removed. The abandoned dams and facility areas are slightly above the swamp level and therefore dryland or marsh vegetation will develop. The forest that will establish itself on the long run on this higher land will provide a habitat that is new for the local swamp, attracting animal species that are not found elsewhere in the wider area. The herbaceous swamps will very rapidly return and cover the abandoned trails and drilling locations. The regeneration of swampwood will take much longer.
The overall development of vegetation upon closure is considered as a positive impact of **major** significance (Table 39).

Table 39: Significance of the establishment of vegetation upon closure

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Medium	Long-term	Medium	High	High	**MAJOR**	pos
With mitigation	No enhancement measures are foreseen						

No enhancement measures are yet to be foreseen because this development that will only take place over 20 years from now.

Impact VEG7: Loss of ridge wood and ridge forest, also as a habitat

The clearing of ridge wood and ridge forest results in the local loss of a number of plant and animal species that are rather unique for the Buru Swamp, because they are only found as small and isolated spots in an extensive swamp area. But more importantly, it means the loss of a habitat that is essential for a number of animal species. Depending upon the degree of disturbance of forest and land, the loss will be either permanent or very long-term, especially in the case of ridge forest. The clearing of ridges for trails is unlikely though, because there is no water for transport at such locations. But also clearing of trails close to these ridges will affect the habit.
Clearing of ridge vegetation for other purposes, like header dams or facility yards, could potentially result in an impact of **major** significance. With the implementation of below prevention and mitigation measures, the impact will be negligible (Table 40).

Table 40: Significance of potential impacts of loss of ridge wood and ridge forest

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	High	Long-term	Medium	High	High	**MAJOR**	neg
With mitigation	Negligible	Long-term	Small	Negligible	High	**NEGLIGIBLE**	neg

Preventive and mitigation measures regarding loss of ridge ecosystems include:

- do not project large trails and infrastructure on top of, or near ridges (indicated on Figure 12); keep a distance of 50 meters at least
- in case of south-north dams: project such trails, as much as possible, in open spots in between ridges
- if passage of a ridge cannot be avoided: keep the clearing width limited to the bare minimum

Impact VEG8: Vegetation fires

Grass and peat fires are a relatively common phenomenon in the Buru Swamp. As can be seen on satellite images and aerial photographs in and near the Tambaredjo NW area grass and peat fires frequently occur. These fires are partly caused by burning on purpose (to attract game species and to keep the area accessible for hunters) or by inattention. Fires occur especially in the more open mangrove forest with a sub-growth of giant ferns and in herbaceous brackish swamps with Typha. Such fires may destroy the drilling rig, oil field infrastructure and facilities, and vehicles, not only in the Tambaredjo NW area itself but also in the downwind-situated Calcutta oil field near Huwelijkszorg in the southwest. Swamp fires that would start elsewhere in the Buru Swamp may reach the Tambaredjo NW operations.
To the east and northeast, the station area is protected by respectively the Soekha dam and Poeran canal, and by the Ritsweg.
Fire “impacts” are more correctly considered as a risk, since the activity is not implicit in the design and operation of the project and would be managed through appropriate emergency response procedures in the Staatsolie Emergency Response Plan. As such, the risk is not rated using the formal impact rating methodology. In the unlikely event that the catastrophic events

described above do occur, the impacts will be of **major** significance, but could be reduced to negligible through proper prevention measures.
Key preventive measures include:

- develop a fire contingency plan
- develop and implement strict fire control procedures and measures; measures could include that the vegetation of the Poeran and Soekha dams is kept low and that in the dry season all debris are removed, thus creating a fire break
- implement a fire risk awareness program for Staatsolie personnel and contractors working in the Tambaredjo NW area
- discuss the risks of vegetation and peat fires to Staatsolie personnel, materials and equipment in stakeholders meetings and organize special meetings during extremely dry periods to point out the fire risk again
- conduct fire patrols in extremely dry periods

5.8 AQUATIC ECOLOGY

5.8.1 Key considerations

Neither unique, rare, endangered, vulnerable or biogeographically important fish species, nor exotic or invasive fish species were recorded in the Staatsolie concessions and the mangrove forest to the north of the concessions.

The mangrove ecosystem and adjacent shallow coastal mudflats are important 'nursery areas' for early stages of marine fishes and macro invertebrates (e.g. penaeid shrimps) (Nagelkerken *et al.* 2008, Artigas *et al.* 2003, Primavera 1998, Lhomme 1994, Longhurst & Pauly 1987) and thus are important for sustainable marine fisheries. Currently it is still not possible to make a clear distinction between the contribution of the mangrove forest and the shallow mud flats to the nursery function of the coastal ecosystem. Early life stages of penaeid shrimps enter the mangrove forest with the flood tide via natural creeks and withdraw from the mangroves with the ebb tide (Dumas 2006). Thus residence times of the young shrimps in the mangrove can be short (3-4 hours per tidal cycle) (Dumas 2006), but in brackish-water lagoons (e.g. Bigi Pan Lagoon, district Nickerie) they may stay for a much longer time (months) in the mangrove forest. The best indication for the nursery function of the mangrove forest in Suriname is the important fishery for juvenile brown shrimp *Penaeus* (*Farfantepenaeus*) *subtilis* in the Bigi Pan lagoon (JM, personal observations; Mario IJspol, Visserijdienst LVV, pers. communication); the brown shrimp is the most important target species in the commercial shrimp fisheries off Suriname and it also features prominently in Surinamese fisheries export (Charlier 1996). Presently, seabob shrimps (*Xiphopenaeus kroyeri*) dominate the shrimp catches (2,000,000 kg *X. kroyeri* vs. 700,000 kg of *P. subtilis* in 2008; Mario IJspol, pers. communication) and export, but the seabob shrimp has the same life cycle as *P. subtilis* and is also highly depended of the mangrove / shallow adjacent shelf nursery (Lhomme 1994, Dumas 2006). The mangrove forest has also an important function in the protection of the coast from wave-induced erosion. Thus, it is important that the mangrove forests and especially its tidal creeks and brackish-water lagoons are either not removed and/or disturbed or disturbance is restricted as much as possible. Removal of the mangrove ecosystem will have an impact on both protection of the coast against erosion and the nursery function for marine fisheries resources. Disturbance of the mangrove forest, and

especially its tidal creeks and brackish-water lagoons will have an impact on the nursery function of marine fisheries resources.
Under the current conditions, there is no connection between the mangrove forest in the northern project area and the Atlantic Ocean, The mangrove forest is of the blocked type, i.e. there is no longer tidal influence. However, during the rainy seasons there is flow of freshwater from the southern swamp through the mangrove forest towards the near-coastal zone. An impact to this flow could affect the zone north of the project area.

The Tambaredjo NW oil production development following 'wet operations' procedures will result in areas with shallow, open water (e.g. canals, well sites with oil pumps) that are presently occupied by dense herbaceous swamp and swampwood vegetation. The creation of open water in a densely vegetated swamp habitat can result in local fish kills (as was observed in December at sites 16 and 17 in the new mangrove trail; Figure 22). These localized fish kills probably result from oxygen depletion or the release of toxic gasses (e.g. H_2S) after stirring the peaty bottom substrate. The kill represented a temporary situation of poor water quality; the fish populations in the mangrove trail had completely recovered in May 2009. The real impact of the creation of open water is probably mainly related to the extent of the clearance of vegetation. Large open spaces can result in sustained, wind-induced turbidity (see below), disturbance of peat layers on the bottom and lack of shelter for the aquatic fauna, resulting in changes in water quality and community structure of phytoplankton and aquatic fauna. However, the creation of limited open space (e.g. airboat trails) may be beneficial to some aquatic vertebrates (fishes, capybara, otter). Conditions of adverse water quality (increased turbidity, oxygen depletion and release of H_2S gas) are probably short-lived and fishes may profit from the newly created open water habitat (although fishes use aquatic vegetation for shelter against predators they apparently do not thrive in dense aquatic or swamp vegetation; JM pers. observations in aquaria and in dense swamp vegetation in Suriname).

Turbidity will increase in the newly created canals, especially when in a canal traffic is important and/or when a (shallow) canal has a large width resulting in wind-induced turbulence. For example, in December Secchi transparency was low (i.e. turbidity high) in the newly created airboat trails in mangrove forest (staff gauges 16 and 17), the newly opened swamp site at Gauge 6, and the wide canal at Gauge 1 (Appendix C, Table 2). This high turbidity was caused by suspended sediments, not by blooms of algae. The high turbidity at the newly opened sites (gauges 16, 17 and 6) was only temporary as Secchi values were much higher during the second survey in May (apparently sediments had settled). However, turbidity did not decrease in the large, wide canal at gauge 1, presumably due to wind action and considerable boat/rig traffic in the canal. Turbidity can affect phytoplankton composition because it results in (1) low (sun) light availability for photosynthesis and (2) increased nutrient availability (stirring up of the bottom substrate). Standing water with high temperature, low light and high nutrients may favor blooms of blue-green algae (Cyanobacteria) that can be toxic to fishes, wildlife and even human beings (if they drink the water) (Chorus & Bartram 1999). Blue-green algae were collected in the Tambaredjo Area (Appendix C, Table 2) and fish kills probably related to blue-green toxins have been observed elsewhere in Suriname (JM pers. observations). However, blue-green algae and other phytoplankton were either not observed or not abundant in the large canal with permanent high turbidity (Appendix C, Table 2; gauge 1) and this may be related to high turbulence in the water induced by wind and traffic.

Overall, from an environmental point of view, the Calcutta 'wet operations' method with good hydrological connectance, preservation of the general swamp landscape and vegetation and a slightly lowered fish diversity (with signs of recovery) is largely preferred over the Tambaredjo polder system with elevated fish diversity, but poor hydrological connectance and grossly disturbed landscape/vegetation. Post-operation restoration of the shallow 'canals' (trails) of the Calcutta oil production field by spontaneous growth/extension of natural swamp vegetation will probably be very fast and natural restoration of the swamp fauna will follow.

Increased salinity is expected to occur locally at boreholes because drilling waste generated during well completion contains a high level of chlorides. In the wetland operations this saline wastewater ends up in the swamp where it is almost completely diluted to acceptable levels (300 mg/L Cl) within a radius of 50 m around the drilling location. No adverse environmental impact from this operation, e.g. dehydration of vegetation, has been detected and/or reported during field inspections.

5.8.2 Sources of impacts

Direct impacts on aquatic ecology are likely to be the result of a number of project activities as summarized below.

Sources of direct impacts on the Tambaredjo NW aquatic ecosystems:

(1) Removal/disturbance of mangrove forest
(2) Creation of open water by removal of vegetation and peat at the locations of trails and drilling sites
(3) Increased turbidity due to trail construction and traffic of swamp carriers and rigs
(4) (Slightly) elevated salinity levels as a result of dam construction and/or on-site dumping of drilling fluids
(5) Water pollution as a result of chronic release of hydrocarbons and oil spills

Sources of indirect impacts on the Tambaredjo NW aquatic ecosystems:

(6) Improved access into the concession, resulting in increased fishing

5.8.3 Impact assessment

Impact F1: Loss of 'nursery function' due to clearing and/or disturbance of the mangrove (parwa) forest.

The significance of the impacts of removal and/or disturbance of the mangrove ecosystem is difficult to assess, particularly with respect to the nursery function (given that the associated tidal mud flats may also have this function), but is probably related to the extent of removal/disturbance of the mangroves.
During phase 2, a total of ~75 (when the small rig is used) to ~125 (Hover rig) ha of mangrove forest will be cleared. This is 1.5-2.0% of the mature mangrove forest in the area between Sarah Maria and the end of Gangaram Panday Road (along 30 km of coastline). Clearing will take place at a distance of 2.5-3.5 km from the coastline. The mature mangrove forest within the oil field is no longer experiencing the influence of the ocean and its water is

slightly brackish to almost fresh. Forest clearing itself will not impact the 'nursery function' as discussed above. The mangrove forest within the oil field is not connected to the ocean and it is also not expected to become so during production development. Therefore the 'nursery function' is not likely to be affected as a result of project activities and the impact on the mangrove ecosystem functions along the coast is considered as to be **negligible** (Table 41).

Table 41: Significance of loss of nursery function due to clearing/disturbance of mangrove forest

	Intensity	***Duration***	***Scale***	***Severity***	***Probability***	***Significance***	***Status***
Without mitigation	Low	Medium-term	Small	Low	Low	**NEGLIGIBLE**	neg
With mitigation	No mitigation measures necessary						

Impact F2: Changes in aquatic diversity and abundance due to the increase in open water habitat.

Although local fish kills of short duration can result from the creation of open water habitat this impact is probably mainly related to the extent of clearance of vegetation. In small, open spaces such as airboat trails, the clearance of vegetation may have a positive impact on the fish fauna. However, in large open spaces, fish and phytoplankton communities are probably negatively affected as indicated by the samples from the Calcutta oil field (gauges 1 and 6). In large canals, water traffic can also negatively affect aquatic fauna. Sufficient undisturbed swamp(wood) 'refugia' ('control' areas) for fishes and other swamp life are maintained at close distance of the cleared areas and post-operation restoration of the shallow 'canals' and other open areas by spontaneous growth/extension of natural swamp vegetation will probably be fast and natural restoration of the swamp fauna will follow (**minor** impact; Table 42).

Table 42: Significance of changes in aquatic diversity and abundance due to the increase in open water habitat and increased turbidity.

	Intensity	***Duration***	***Scale***	***Severity***	***Probability***	***Significance***	***Status***
Without mitigation	Low	Medium-term	Small	Low	High	**MINOR**	neg
With mitigation	No mitigation measures possible						

Impact F3: Changes in aquatic communities due to increased turbidity.

In shallow aquatic habitats, increased turbidity from in-situ suspended sediments (from either wind-induced turbulence, traffic or clearance of vegetation) is often associated with increased nutrient concentrations from stirring of the bottom substrate. Conditions of calm, standing water, high water temperature, low light (high turbidity) and high nutrient levels (eutrophication) are favorable to the occurrence of blooms of toxic blue-green algae. These so-called Harmful Algae Blooms (HABs) can cause the death of fishes, wildlife, cattle, dogs and even human beings when they drink the water. The potential impact of the occurrence of HAB is considered to be of **minor** significance, but it can be further reduced to negligible by the implementation of proposed measures (Table 43).

Table 43: Significance of the occurrence of Harmful Algae Blooms (HABs) due to increased turbidity

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	High	Short-term	Small	Medium	Low	**MINOR**	neg
With mitigation	Low	Short-term	Small	Low	Low	**NEGLIGIBLE**	

Preventive and mitigation measures regarding Harmful Algae Blooms include:

- avoid the construction of undue wide trails/canals, such as the main access canal of the Calcutta oil field; limit the width of canals to the minimum to reduce turbulence-induced turbidity

Impact F4: Toxicological impacts to aquatic ecosystems due to chronic hydrocarbon release and acute oil spills.

In areas of oil exploitation and with oil transport pipelines, there is a potential for oil spills. Toxicological impacts from hydrocarbons can be acute from substantial spills or chronic via low-level releases and spills from operating machinery and storage facilities. The sensitivities of local aquatic biota to hydrocarbons are not known. The basic premise used in this assessment is that the local biotas are no more or less sensitive than other international biota. Therefore, ecological effects threshold values derived from international toxicity databases and guidelines can be used for assessment purposes. Measurements of oil and grease showed no increased levels within the Calcutta oil field, when compared to the natural swamp. In addition, reports on the five oil spills that occurred to date in the Calcutta oil field indicate that oil never moved farther than 50 meter from the source of the spill. The first reason for that is early detection of the oil spills. Apart from that, there is an absence of significant swamp water flow. In addition, there is the fact that the oil is sinking to the bottom instead of floating at the surface. Moreover, Staatsolie has special guidelines for the clean-up of oil spills, which provides specific methods for specific habitats, among which are swamps and lagoons (Staatsolie, no date).
Impact assessment of chronic releases and acute spills of hydrocarbons is made assuming above mentioned mitigation measures are in place. Depending upon the type of spill the significance of the impact of water pollution with hydrocarbons on the aquatic ecology is considered to be **negligible** (leakage; Table 44) to **minor** (spill; Table 45).

Table 44: Significance of toxicological impacts to aquatic ecosystems due to chronic release of hydrocarbons.

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Low	Short-term	Small	Negligible	High	**NEGLIGIBLE**	neg
With mitigation	No mitigation measures necessary						

Table 45: Significance of toxicological impacts to aquatic ecosystems due to acute oil spills.

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Medium	Short-term	Small	Low	High	**MINOR**	neg
With mitigation	No mitigation measures necessary above the measures presented in the oil spill clean-up guidelines						

Impact F5: Decline of fish population because of increased fishing in the Staatsolie concessions.

The oil exploration/exploitation activities by Staatsolie potentially give access to areas that are otherwise difficult to access. Although Staatsolie controls the main entrances to its concessions, their still exist opportunities for illegal hunting and fishing. Hunting and fishing in the Staatsolie concessions is prohibited for Staatsolie personnel and this should also apply for other people living near the concession area. When allowed or tolerated these activities could result in an impact of **minor** significance. With the implementation of proposed measures, it should be possible to keep the impact of illegal fishing in the area at a **negligible** level (Table 46).

Table 46: Significance of the decline of fish population as a result of increased fishing in the Staatsolie concession.

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Low	Long-term	Medium	Low	Medium	**MINOR**	neg
With mitigation	Low	Long-term	Small	Low	Low	**NEGLIGIBLE**	neg

Preventive and mitigation measures regarding increased fishing include:

- provide strict control at the entrances
- conduct regular at random patrolling in the concession by air boat
- upon closure either:
  - destroy all access roads, dams, canals and trails, or
  - hand over all infrastructure and facilities to a responsible party that will develop a sustainable type of land use for the area, like the establishment of an education center, a (eco) touristic or recreational facility; the handover should be made in consultation with relevant authorities, like the Nature Conservation Division

5.9 BIRDS

5.9.1 Key considerations

The avifauna of the Tambaredjo NW oil field is characterized by moderate species richness and a prevalence of common species.

The habitats are present in an environment in which some degree of disturbance already is occurring. Therefore, the avifauna of the Tambaredjo NW area is already accustomed to human disturbance, in particular noise disturbance.

Compared to the Tambaredjo NW oil field, much higher species densities can be expected in the area along the coastline, where mud banks and lagoons provide ample food to a wide range of species, which often occur in large numbers. For nine bird species, these areas are considered to be of international importance.

5.9.2 Sources of impact

Direct impacts on the avifauna of the study area are likely to result from a number of project activities, summarized below:

Sources of direct impacts on the Tambaredjo NW avifauna:

- Removal of vegetation, including forest for access trails, drilling sites and development of ancillary infrastructure in the oil field.
- Generation of noise during construction (vegetation clearing, transport), operation (transport, drilling, rig traveling) and decommissioning (transport, excavation activities, demolition noise).
- Increased water turbidity due to trail construction and traveling of swamp carriers and rigs.
- Water pollution with oil

Indirect impacts on the avifauna of the Tambaredjo NW area are likely to result from the activities summarized below:

Sources of indirect impacts on the Tambaredjo NW avifauna:

- Improved access into the study area

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5.9.3 Impact assessment

Impact B1: Loss and alteration of habitats (food, shelter, nesting) for birds because of vegetation clearing

Vegetation cover will be removed to create a network of trails that connect the drilling sites. Vegetation removal in the affected areas will be done over approximately 29 (small rig) – 47 (large rig) % of the oil field area or 5.0 (small) to 8.3 (large) km^2. The majority of the vegetation to be removed is found in zone with herbaceous freshwater swamps and low swampwood (51%), followed by the herbaceous brackish water (Typha) swamp (24%). The oil field further comprises smaller portions of parwa mangrove forest (16%) and high swampwood (9%).
Clearing will cause direct loss of habitat for all bird species in affected areas, and displacement of individual birds.

No large-scale clearing will occur and considerable areas of vegetation will remain in-between the cleared trails, many of which areas will remain interconnected.

A pattern of remaining vegetation alternating with open water will be developed during construction and operation, with the open water covering 25-35% of the area and the original vegetation the remainder. Most individual birds will be able to move to the neighboring vegetated areas. It should be noted that vegetation removal will be executed over a period of 5 years, so only a small area will be cleared every year.
After drilling has been completed in a certain area, the area is only used for production. Aquatic and semi-aquatic vegetation will gradually emerge within the trails and along the edges of the trails so that these will become smaller with a decrease of the open water surface. One to two year after drilling the trails width will have diminished to a width sufficient to allow a swamp carrier to pass as is needed for maintenance and servicing. Only the main access trails will keep their original width.
Vegetation removal will have a low intensity impact on bird species in the affected area. This potential *direct* impact during the construction phase is at a local scale, medium-term and therefore of **minor** significance (Table 47). It cannot be further reduced by mitigation measures.

Table 47: Significance of the impact of vegetation clearing on birds

	Intensity	***Duration***	***Scale***	***Severity***	***Probability***	***Significance***	***Status***
Without mitigation	Low	Medium-term	Small	Low	High	**MINOR**	neg
With mitigation	No further reduction possible						

Nevertheless, it is recommended to minimize the footprint of the project by deploying the smaller Rig VII instead of the larger Hover rig, in particular in the high swampwood and the parwa forest.

Impact B2: Disturbance of birds by noise

For this issue reference is made to the impact assessment for noise.

Impact B3: Water pollution impacts to birds

Water pollution in the form of increased turbidity occurs because of traveling of excavators, swamp carriers and rigs through trails. Such pollution will be most prevalent during the construction and operation phases and far less during the decommissioning phase. This increased turbidity does not have an impact on birds, because they have time to retreat from the area, while the turbid water has no impact at all.
Even though some birds may be killed because of an oil spill, the impact is still considered as to be **negligible**, having a low probability and being short-lived and small-scale.

Impact B4: Increased hunting and trapping of birds

No hunting and capturing is allowed within areas where Staatsolie operates. Moreover, there are relatively few game species and only one songbird species within the Tambaredjo NW oil field. The latter is the Oranka a favored songbird species, which is declining rapidly because of capturing. No impact of increased hunting or trapping will occur during construction and operation, except for trapping of the Oranka. Other impacts may arise upon decommissioning when the area would still be accessible, presenting an opportunity for poachers to go hunting till inside the Coppename Monding Nature Reserve. The potential impact of such is considered as to be of **major** significance (Table 48). With the implementation of appropriate mitigation measures no impact will occur.

Table 48: Significance of increased hunting and trapping

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	High	Medium-term	Small	High	Low	**MAJOR**	neg
With mitigation	No impact						

Mitigation measures that could be implemented include:

- See Aquatic ecology, impact F5.

5.10 MAMMALS AND HERPETOFAUNA

5.10.1 Key considerations

The Buru Swamp supports a rather high diversity of animal species, but diversity is considerably less than in rainforest areas of the Guyana Shield.
The species recorded in the Buru Swamp are widely distributed throughout the coastal lowlands of the Guyana's (and beyond) and none are endemic to the region.
With respect to habitat preference often a clear distinction can be made between wildlife of the salt and brackish swamps at the one side, and the freshwater swamps at the other. Only few of the species present are found within both habitats. And few are restricted to particular areas of the Buru Swamp, with the exception of aquatic species and some species that only live in woods and forests (e.g. sloths and monkeys).
A number of mammals recorded for the Buru Swamp are listed on the IUCN Red List:

- The Jaguar and the Puma (Near threatened) are still common in the Coastal Plain, but in the study area, they have only been observed at Sarah Maria, where more dryland is present.
- The Giant anteater (Near threatened) is rare in the Coastal Plain; it is more commonly found in savannah areas and is likely to be an uncommon visitor to the area (recorded for Sarah Maria).

All other animal species are classified as Lower risk or Least concern.

The project area, as well as the areas to the east, west and south of it, is already experiencing human influence for a considerable time and it is likely that certain species avoid the activity areas, while other may have adapted to human presence.

5.10.2 Sources of impacts

Direct impacts on mammals and herpetofauna are likely from a number of project activities, summarized below:

- Removal of vegetation for trails, dams, drilling locations, and yards of ancillary infrastructure.
- Generation of noise during construction, operation and closure.
- Water traffic.
- Decreased water quality (increased turbidity and chemical pollution)

Indirect impacts on mammals and herpetofauna in the Tambaredjo NW area are likely to result from the activities summarized below:

- Improved access into the concession, resulting in increasing hunting pressure.

5.10.3 Impact assessment

FG1: Decrease in animal abundance

Like aquatic life and birds, also mammal and herpetofauna abundance is likely to be affected by most human activity in the Tambaredjo NW area, during construction and operation of the project. Removal of vegetation will result in decreased habitat availability and quality, and a decrease in available food sources, but only part of the vegetation will be cleared and considerable portions (~65%) of the vegetation will remain intact and most animals will be able to move to these 'refugia'.
Some animals (including birds) are vulnerable to water traffic and kills, in particular by airboats, are inevitable.
Any decrease in water quality will affect both food sources for many mammals and habitat quality for aquatic amphibians, reptilians and mammals.
Since only a portion of the project area will be developed at any given time, the extent of the directly affected area is limited throughout the duration of the impact.
Conditions will improve during and after closure.
The potential direct impact during the construction and operation phases is at a local scale and of **moderate** significance, but can be reduced to minor significance with appropriate mitigation (Table 49).

Table 49: Significance of the decrease of animal abundance.

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Medium	Long-term	Medium	Medium	High	**MODERATE**	neg
With mitigation	Low	Long-term	Small	Low	High	**MINOR**	neg

Preventive and mitigation measures regarding decreased animal abundance include:

- Minimize the footprint of disturbance of the project.
- Develop the forested areas in such a way that fragmentation is minimal and inter-connection of residual parts optimum. An ecologist should be consulted during planning.
- Impose the Calcutta Waterway Regulations also for the Tambaredjo NW oil field.
- Restrict access to non-working areas within the project area to authorized personnel only.
- Continue to impose a ban on wildlife harvesting at the Tambaredjo NW oil field for all Staatsolie personnel, contractors and authorized visitors.
- Undertake a continuous environmental awareness and education program for Staatsolie employees focusing on the importance of minimizing harm to the environment.

5.11 NATURE CONSERVATION CONSTRAINTS

A considerable part of the project area is projected in the buffer zone of the Coppename-monding Nature Reserve (CMNR). This nature reserve is of high national, regional and international importance.

- Between 1955 and 1966, the area had the status of a local “Bird Sanctuary”.
- In 1966 the same area became a national “Nature Reserve” (Coppename-monding Nature Reserve);
- In 1989, it received the regional status of "Western Hemispheric Reserve" within the Western Hemisphere Shorebird Reserve Network (WHSRN). As such, the area is twinned with two protected areas in the Bay of Fundy in Canada;
- In 1985 it was declared a RAMSAR Convention Wetland of International Importance;
- In 2002, the area has been embedded in the North Saramacca Multiple-Use Management Area (MUMA) that may be considered as a buffer zone.

The swamps in the CMNR are virtually undisturbed and pristine and any decline in water quality will affect the environmental integrity of the CMNR. But with a northbound swamp water flow, the possibility exists that decline in water quality in the nature reserve (by changes in salinity or oil pollution) could affect the reserve. Apart from that, also increased noise levels in the project area could disturb wildlife in the reserve.
The north of the project area borders on the CMNR and an impact on the swamp water quality or by increased noise levels is possible. A potential impact of **major** significance could occur in case of disturbance or damage in the CMNR, caused by Staatsolie activities in the Tambaredjo NW oil field (Table 50). This impact can be reduced to negligible by the

implementation of measures proposed for hydrology, water quality and noise. Given the international importance of the CMNR, it is clear that no impact to the reserve will be acceptable.

Table 50: Significance of loss of environmental integrity of the Coppename-monding NR

	Intensity	***Duration***	***Scale***	***Severity***	***Probability***	***Significance***	***Status***
Without mitigation	High	Long-term	Medium	High	Low	**MAJOR**	neg
With mitigation	Low	Short-term	Small	Negligible	Low	**NEGLIGIBLE**	neg

In order to ensure the proper implementation of proposed measures it is recommended that the line at 2 km to the south of the CMNR is clearly marked in the field. In between this line and the southern border of the CMNR special measures are in place with regard to noise (see Ch. 5.3.3), thus creating a kind of noise buffer zone.
With respect to hydrology and water quality monitoring special attention is given to this zone (see Ch. 8.3.12 and Table 58).

5.12 SOCIO-ECONOMIC ISSUES

5.12.1Archeology

Given the small likelihood that indigenous people ever lived in the proposed operation area, we do not expect that new archeological sites will be found there. Nevertheless, in the case that archeological artifacts are encountered, appropriate legal and ethical guidelines need to be followed. Suriname's 2002 law on monuments (Monumentenwet; law # 72, 2002 of the Republic of Suriname) prescribes the procedures to be followed upon the encounter of (land with) historic buildings and structures -or the remainders thereof- that are at least 50 years old and have a particular value due to their beauty, artistic quality, scientific meaning, national history, etc, or have been constructed in memory of a specific happening or person.

Suriname's legal framework does not regulate the actions to be taken after finding incidental archaeological artifacts. Nevertheless, general courtesy and unwritten rules of conduct prescribe that the nature of such artifacts, their finder, and the (GPS) coordinates are reported to the Director of the Suriname Museum at the Fort Zeelandia Office of the Museum. These facts will be recorded in the national archaeological register.

5.12.2 Population and demography

The only inhabited areas north of the Lower Saramacca River are located along (parts of) the Gangaram Panday Road (Noordam & Teunissen, 2004). The population here lives far from the Tambaredjo NW oil field and it is unlikely that their living conditions will be affected by the activities. Because hardly anything will change for local area inhabitants, we do not expect that the project will affect social life, community cohesion or cultural identity.

Given that there will be no or hardly any new jobs or other economic opportunities created because of the construction and operation of the new oil field, we do not expect an influx of people into the area. Hence, it is unlikely that new houses will be constructed, that there will be more pressure on existing living spaces, or that the prices of existing houses will increase because of the Tambaredjo NW project. Neither do we expect the project to lead to out-migration. Resettlement is not an issue.

5.12.3 Employment

It is not expected that many new jobs will be created by the operation of the new oil field. Where possible, existing wage laborers at the Calcutta field - that will be in operation until 2020 - will be transferred to this neighboring oil field. Hence, the presence of a new operation will secure employment, especially specialized jobs, for a longer time. In addition, the contactors will continue to perform the same maintenance jobs as long as Staatsolie is active. It is possible that the construction of new trails will increase the demand for contracting jobs. Local area inhabitants voiced the opinion that many more local people have the education and skills to be hired as wage laborers with Staatsolie.

Providing more jobs to local people will result in a positive impact of **moderate** significance that cannot be further enhanced by additional measures (Table 51).

Table 51: Significance of employment of local people

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Medium	Long-term	Small	Medium	Medium	**MODERATE**	pos
With mitigation	No further enhancement possible						

5.12.4 Land and water use

Among the main issues of concern to area inhabitants is whether and how the project will affect existing and future land uses, particularly their access to fresh swamp water for irrigation and the quality of it. To the rice farmers along the Gangaram Panday road, year-round access to fresh water is the key to a successful harvest.

In the construction of a new oil field, Staatsolie may compete with farmers for fresh water and affect its quality in various ways:

(1) Swamp water is used in the operational process for, among others for testing of pressure in the pipes and for rinsing of the pipes to remove mud and grass.
(2) The construction of dams and/or canals may change the availability and flows of fresh water for farming. As described above, such infrastructural works may lead to either flooding or water shortage at paddy fields.
(3) When there is a leakage of the pipes, oil may leak or spill into the swamp or the soil, and thus end up in the irrigation water of farmers.
(4) Turbid water may arise that is taken in by the farmers.

The risk of such occurring is highest for the Poeran and Soekha Canals, which have an open connection with the Tambaredjo NW area.
The potential impact of such occurring is considered as to be of **moderate** significance, being potentially small-scale, short-lived and of medium intensity, while the probability is medium (Table 52). The impact can be reduced to negligible with the implementation of appropriate mitigation measures.

Table 52: Significance of reduced crop yields at farms along the Gangaram Panday road

	Intensity	*Duration*	*Scale*	*Severity*	*Probability*	*Significance*	*Status*
Without mitigation	Medium	Short-term	Small	Low	Medium	**MODERATE**	neg
With mitigation	Negligible	Long-term	Small	Negligible	Low	**NEGLIGIBLE**	neg

For mitigation measures see the Sections on Hydrology and Water quality, and:

- Locate trails in such a way that no water pollution, including increased turbidity, of canals is possible. In practice this means that there should be no open connection

between the project trails and canals. A vegetated strip of 50 meter[10] between the Poeran Canal and nearby trails is considered sufficient to block potential pollution with suspended solids (turbidity) and oil.

Apart for competition over fresh water, the proposed Tambaredjo NW operation is not likely to affect existing land uses or create conflict. Conflicts over land with traditional and/or tribal peoples are non-existent given that none of the present-day groups inhabiting Suriname's coastal plains considers the Buru swamp part of their traditional homelands.

Also, there are no places of cultural significance, such as worship houses or schools that will be affected. The project is not visible from the road and people's homes, and hence will not affect the scenic value of the area.

Within the Tambaredjo NW project area the impact on land during construction will be limited to the use of small portions of land for the station yards and road and dam corridors. The total surface area of land where soil excavation will take place is estimated at 125 ha (5% of the total oil field). Excavation will result in ~67 ha dams and ~58 ha of canals.
Prior to excavation activities only vegetation clearing will take place, but the peat will usually remain in place.
The overall impacts during the construction and operation phase will be **negligible** given the small portion of land used.

After closure of the area there could be a positive impact of the higher land of dams and facility yards within the swamp, by using the highland for tourism development (access to the area and terrain for buildings, nature tracking along dams). This positive impact is considered as to be of **minor** significance, because the area does not have a very special character that would attract many viewers (Table 53).

Table 53: Significance of tourism facility development after abandonment of the project area

	Intensity	***Duration***	***Scale***	***Severity***	***Probability***	***Significance***	***Status***
Without mitigation	Low	Long-term	Small	Medium	Low	**MINOR**	pos
With mitigation	No enhancement measures foreseen yet						

No enhancement measures are foreseen, as this would be a development that will only take place after 25-30 years from now. Yet Staatsolie could provide incentives for above closure options at the time this will become current.

5.12.5 Infrastructure and development

No new infrastructure in the form of roads or storage facilities will be constructed. Oil that will be extracted will be piped to the existing facilities at the TA58 plant. Here the water will be removed and oil remains skimmed, before it is released in the drainage system of the

[10] During the current study it has been observed that suspended solids penetrate 25 m at most in the vegetation along trails with turbid water.

Tambaredjo oil polder. This water is diverted to the river through culverts. From the TA58 plant, the oil goes by pipe to the Josie facilities. Because there will be no shipping of oil on the Saramacca river, an oil spill in the river is not possible.

Staatsolie will continue maintenance of the Gangaram Panday road up to km 25, at least until 2020 when Calcutta is projected to close down.

5.12.6 Human health and safety

The project will not use storage, production or handling techniques that may be harmful to human health. In fact, hardly any new facilities will be constructed (see above).

Excess noise is not expected, given that the drilling operation is far removed from the living area. Noise of airboats is unlikely to cause a nuisance, given the fact that the closest airboat trail is 4 km from the road. For the same reason no impact of the project activities on the ambient air quality along the Gangaram Panday Road is possible.

5.12.7 Recommendations for a positive contribution to area development

1) We did not observe a clear policy about the maintenance of relations with area inhabitants. In developing a social responsibility program that includes people living along the Gangaram Panday road, it would be useful to inform these people about the procedures to file requests for donations or in-kind support. One possible model is that community groups may submit proposals according to a standard format[11]. In this context, it would be most transparent if Staatsolie would donate a fixed amount or percentage of profits every year. At present, it is not clear to local people what they can expect and what they can do to steer these expectations.

2) Also lacking is a formal policy about the maintenance of relations with (local) government officials. We noted that staff members of the various government sections with interests in the area, such as the Ministry of LVV and the Ministry of Regional Development, know little of activities in the swamp. Taking the Bestuursopzichters (Governmental supervisors- BO), who serve as a liaison between the area inhabitants and the national government, on a swamp tour could help them discuss concerns about the operations with local people. Also field staff of the Ministry of LVV may be able to take more informed policy decisions about local agricultural development if they have seen the field operations first hand.

3) In line with the above points 2 and 3, it would be useful to have a community relations officer at the Sarah Maria plant; someone familiar with the people living in the area, their living conditions, and their customs. At this moment it is not fully clear to area locals and officials whom they can approach if problems or questions arise.

[11] A similar model is followed by Iam Gold (formerly Cambior) with respect to its gold mine in the district of Brokopondo. In their case, a communications committee is formed in each one of the affected communities. The committees may submit proposals that are developed through discussion in the community.

5.13 SOLID WASTE AND SEWAGE

Solid waste will be generated during all phases of the project, but the composition will vary for each phase.

Waste generated during Construction comprises:

- Waste oils, scrap metal, batteries, welding waste

Waste generated during Operation (Drilling) comprises:

- Waste oils, filters, scrap metal, packaging materials, pallets, cuttings, used drilling mud, excess drilling fluid, cleaning clothes, oily rags, used ear plugs, gloves.

Oil spills could result in:

- Oil-polluted soil and vegetation.

Hazardous waste generated by the project will be limited to batteries and paint residues.

All solid waste will be managed according to the existing waste handling and treatment/disposal procedure (General Field Instruction (GFI) no. 611). Therefore, impact of solid waste is regarded as to have a **negligible** significance.

This GFI indicates as its objective "to reduce the creation of waste to a minimum and to process the waste that nevertheless originates in a safe and environmentally friendly manner". The instructions point out that the person that generates the waste is responsible for its removal. As a first step, it is indicated that waste must be separated in one of three groups:

a) waste intended for reuse or recycling
b) waste for burial
c) waste for disposal at the dumpsite.

All waste is collected by a contractor and disposed of at the companies' dumpsite. Collection and disposal of routine waste is the responsibility of the PS&PS (Plant Security and Personnel Services) department, while the waste generator is responsible for non-routine waste collection and removal. The latter should be done in consultation with the PS&PS department.
The Procurement Division handles waste that is identified as recyclable or reusable.
The instructions do not present specific measures. Currently, as part of the construction of a landfill and a landfarm, a new waste management plan is drafted. The new landfill has a special hazardous waste compartment.

Oil spill clean up will be conducted under the responsibility of the SORT team according to the Oil Spill Contingency plan and relevant General Field Instructions. The oil-polluted soil and vegetation will be brought to the land farm for treatment.

Sewage should be carefully managed in order to prevent the occurrence of Harmful Algae Blooms (see potential impact F3). Mobile toilets are present at every working location in the oil field, so also the impact of this waste will be **negligible** when properly managed.

5.14 CUMULATIVE IMPACTS

Cumulative impacts are defined as "The combination of multiple impacts from existing projects, the proposed project, and/or anticipated future projects that may result in significant adverse and/or beneficial impacts that would not be expected in case of a stand-alone project" (IFC, 2006).
No analysis of the potential cumulative impacts is made, because there are no significant impacts from existing projects (only wetland rice), and because future projects are not anticipated during the project lifetime.

5.15 CONCLUSION

The results of the above impact analysis have been summarized in below tables in which also the residual impact after implementation of mitigation measures is presented. Table 54 shows the potential major impacts, all of which are negative.

Table 54: Summary of the potential major impacts

COMPONENT	DESCRIPTION	RESIDUAL IMPACT
POTENTIAL MAJOR NEGATIVE IMPACTS		
Noise	Noise impacts on breeding colonies	negligible
Vegetation	Loss of Black Mangrove (Avicennia) forest	moderate
	Loss of High Swampwood	moderate
	Vegetation changes due to changes in hydrology	negligible
	Loss of ridge wood and ridge forest, also as a habitat	negligible
	Damage to ecosystems and to the Tambaredjo NW development project, due to fires	negligible
Nature conservation	Disturbance or damage to the Coppename monding Nature Reserve	negligible

Part of the major impacts can be effectively managed by mitigation and prevention measures so that only negligible impacts will remain. However, the impacts due to the clearing of Black Mangrove (Parwa) and High swampwood can only be reduced to moderate by minimizing the footprint of project activity.

Table 55 presents the potential moderate impacts, part of which are negative and part is positive.

Table 55: Summary of the potential moderate impacts

COMPONENT	DESCRIPTION	RESIDUAL IMPACT
POTENTIAL MODERATE NEGATIVE IMPACTS		
Visual	Loss of visual quality due to project	moderate
Surface water resources	Changes in the hydrology of the Buru Swamp due to blockage of water	negligible
	Changes in the hydrology of the Buru Swamp due to increased discharge	negligible
Vegetation	Loss of herbaceous swamp vegetation	moderate
Birds	Increased hunting and trapping of birds	none
Mammals and herpetofauna	Significance of the decrease of animal abundance.	minor
Land use	Loss of rice yield due to impact on the irrigation water supply and/or quality	negligible
POTENTIAL MODERATE POSITIVE IMPACTS		
Visual	Improvement of visual quality after closure	moderate
Vegetation	Return of vegetation during and after closure	moderate
Socio-economics	Increased employment opportunities	moderate

The potential impacts to swamp hydrology and water quality (land use) can be effectively managed, as is the case with the potential impact of increased hunting and trapping of birds and the decrease of animal abundance. Wildlife kills during clearing and as a result of collisions is unavoidable and it is sure that a certain disturbance of wildlife will occur.
No mitigation is possible for the loss of herbaceous swamp vegetation and the loss of visual quality that is created by the network of trails made in the Buru Swamp.
These impacts will only be reversed upon closure, when regeneration of vegetation will effectively start. All open areas will very quickly be covered by herbaceous growth, but full recovery of the high swampwood will take decades. The mangrove forest will not return, because at the forest at the project location is already in the process of succession towards a brackish swamp vegetation is already in progress (see Ch. 3.9.3). The re-growth at the current locations with mangrove forest will be of a brackish herbaceous type. The return of the vegetation in open trails and drilling locations will have a moderate positive impact that at the same times improves the visual quality (also moderate positive impact)
Another positive impact is the result of the expected positive impact on local employment, due to the increase of the activities that will require additional labor force for field maintenance activities.

In Table 56 the potential minor impacts are summarized.

Table 56: Summary of the potential minor impacts

COMPONENT	DESCRIPTION	RESIDUAL IMPACT
POTENTIAL MINOR NEGATIVE IMPACTS		
Noise	General noise impacts on fauna	minor
Surface water resources	Increased salinity of the swamp water as result of clay excavation for the construction of dams	minor
	Water pollution with spilled and leaked oil and/or grease during construction	negligible
	Water pollution with spilled and leaked oil and/or grease during operation	negligible
Vegetation	Damage to vegetation due to water pollution - large oil spills	negligible
Aquatic ecology	Changes in aquatic diversity and abundance due to the increase in open water habitat.	minor
	Changes in aquatic communities due to increased turbidity	negligible
	Toxicological impacts to aquatic ecosystems due to acute oil spills.	minor
	Decline of fish population as a result of increased fishing in the Staatsolie concessions.	negligible
Birds	Loss and alteration of habitats (food, shelter, nesting) for birds as a result of vegetation clearing	minor
POTENTIAL MINOR POSITIVE IMPACTS		
Land use	Tourism facility development after abandonment of the project area	minor, positive

Most impacts to aquatic life and birds are minor, because the local habitats are only partly cleared, while wetland functions remain intact. About 750 ha of vegetation will be cleared but on the other hand, a new habitat, open water, will be created that poses opportunities wildlife.

Finally, there are a number of negligible impacts, while also – for completeness sake – a number of no impact issues have been included in Table 57.

Table 57: Summary of negligible and zero impacts

COMPONENT	DESCRIPTION	RESIDUAL IMPACT
NEGLIGIBLE IMPACTS		
Air	Impaired human health or nuisance caused by poor air quality	negligible
Surface water resources	Water pollution due to the release of drilling fluid and cuttings	negligible
Vegetation	Damage to vegetation due to water pollution - oil leakage and small spills	negligible
Aquatic ecology	Loss of 'nursery function' due to clearing and/or disturbance of the mangrove forest.	negligible
	Toxicological impacts to aquatic ecosystems due to chronic hydrocarbon release	negligible
Birds	Water pollution impacts to birds - oil spill	negligible
Land use	Loss of potential agricultural land	negligible
NO IMPACTS		
Noise	Noise impacts on residents along the Gangaram Panday Road	
Vegetation	Damage to vegetation due to water pollution - increased salinity	
Socio-economics	Damage or disturbance of archaeological or cultural sites or objects	
	Changes in social life, community cohesion, cultural identity and population dynamics	

6 ANALYSES OF ALTERNATIVES

At this stage, the project design has only one alternative with two options for the drilling rig. These are the Hover rig and the caterpillar-mounted swamp rig. Main differences between these options are that the Hover rig requires a much wider trail than the swamp rig. Also the noise level during moving is thought to be higher for the Hover rig, but this could not be confirmed by sound level measurements.

From the above impact assessment it can be concluded that the potential impact of the Hover rig is higher than that of the swamp rig in a number of situations:

1. Drilling in mangrove forest due to the much larger footprint in this ecosystem with a high international conservation value
2. Drilling in mangrove forest because of the anticipated higher sound level during moving
3. Drilling in high swampwood, again due to much larger footprint in this ecosystem that is the nearest succession stage towards the high swamp forest, which is an ecosystem with an international high conservation value.

Based upon this analyses it is recommended that the Hover rig is only deployed for drilling in the herbaceous swamp (mixed herbaceous swamp, low swampwood and Typha swamp). The caterpillar-mounted swamp rig should carry out the drilling in the mangrove forest and the high swampwood.

7 PUBLIC PARTICIPATION

As part of their Environmental Assessment process NIMOS has formulated a program for the involvement of stakeholders (see below box) during the review process (NIMOS, 2005).

Public Participation as part of the Review process (NIMOS)

NIMOS understands and recognizes the importance of public participation throughout the EA process. Moreover, NIMOS will adopt procedures to ensure full public participation at the early stage in the EA process, and particularly at the scoping and reviewing phase.

In order to ensure timely and meaningful public participation NIMOS will use different communication and public participation mechanisms, as follows:

(a) A summary of the EA study, in non-technical language, will be required; this summary report will be accessible at various easy-to-access locations, in the region where the project is proposed to be developed;

(b) During the review process, information regarding the major positive and negative effects of the project, and the proposed mitigation measures will be disclosed in the media, via radio, newspapers and television by the proponent; full (complete) EA available at NIMOS;

(c) NIMOS will receive public comments and concerns regarding the project and forward them to be addressed by the EA team;

(d) Optional: Prior to formal Public Hearings, smaller community-based meetings will be held at which local residents and other interested parties will be given the opportunity to discuss their concerns in the presence of NIMOS and representatives of the applicant (including the study team). Also in attendance will be spokespersons for government agencies and research establishments who also make representations to the EA if needed;

(e) The Public Hearing will be publicized in the media with a minimum of 15 business days in advance;

(f) To ensure that the affected people are able to participate in the hearing, the Public Hearing will take place in the most accessible location in the region where the project is going to be implemented;

(g) The Applicant will record and include minutes of the Public Hearing in the project files;

NIMOS will develop, with the assistance of international consultants, detailed regulations regarding the administrative procedures of the EA process, including public participation mechanisms and procedures.

As the first step in the screening phase, in April 2008 an announcement was placed in the local newspapers, inviting stakeholders to submit their concerns and to add any other issues that should be addressed by the EIA (Appendix F-1). For information on the project is referred to the preliminary Terms of Reference that can be consulted at Staatsolie and at NIMOS.
No responses were received on this announcement and in May 2008, the Terms of Reference for the project were finalized.

The study started on October 22, 2008. To a large extent, stakeholders had already been identified during previous studies in the area (Noordam & Teunissen, 1998, 2003, 2005, 2006, 2009).

Identified stakeholders are presented in below table.

Members of the District and Resort Councils
Ministry of Physical Planning, Land and Forest Management (RGB)
National Nature Conservation Board (NBC), also Scientific Authority for RAMSAR Convention
Head of Suriname Forest Service (LBB), responsible for management of protected areas, including nature reserves & MUMA's
Head of Nature Conservation Division (NB) responsible for daily management and control of protected areas
Director of STINASU, responsible for research, education, ecotourism in protected areas
Ministry of Labor, Technological development and Environment (ATM)
National Institute for Environment and Development (NIMOS)
Ministry of Regional Development (RO)
Districts-Commissioner
District Secretary
Ressort Supervisors (BO)
Districts Chief of Police
Ministry of Agriculture, Fisheries and Animal Husbandry
Regional office ministry of Agriculture
Ministry of Public Works
Regional office ministry of Public Works
Other parties
Farmers along the Gangaram Panday road between km 11-21
Chief fire brigade Saramacca
WWF
Conservation International
University of Suriname as interested (research) party

In the course of the study, relevant stakeholders were interviewed. An overview of interviewed persons and their concerns is presented in Appendix F-2.
Upon completion of the draft report a Stakeholders meeting was organized on December 15, 2010. Appendix F-3 presents details and results of this meeting.

At that occasion, the Draft EIA report has been made available to interested parties and a period of 30 days was given to submit comments and to request additional information.
On April 16, 2010 comments on the Draft EIA from the Nature Conservation Division were received, which were the only comments submitted.

Many key issues of the project had already been identified during previous studies in the area and the interviews and hearings confirmed the issues that had already been listed.

The identified key issues include the following:

- Noise
  - Potential disturbance of wildlife, in particular birds in colonies, because of increased noise levels generated by equipment.
- Surface water quality
  - Potential pollution of water resources because of oil production activities in the Buru Swamp with possible consequences for the Coppename-monding Nature Reserve, particularly in the event of an oil spill.
  - Potential pollution of water resources because of oil production activities in the Buru Swamp (increase in suspended solids and increase in salinity). This has possible consequences for the irrigation water quality.
- Hydrology
  - Potential changes in the swamp hydrology with possible consequences for ecosystems, among which those of the Coppename-monding Nature Reserve, and for irrigation water supply.
- Ecosystems:
  - Potential loss of ecosystems of high conservation value, in particular mangrove forest.
- Fauna:
  - Improved access could lead to increased poaching in the Coppename-monding Nature Reserve.
- Socio-economic issues
  - Employment opportunities for local residents.
  - Potential impact of production development activities on existing socio-economic activities, in particular agriculture.
- Nature Conservation

  Effective enforcement of the Game Law and the Nature Conservation Act by the authorities within the Coppename-monding Nature Reserve will not be possible due to shortage of staff of the Nature Conservation Division. In order to fulfill its international obligations, the Nature Conservation Division should be able to send regular reports about activities that take place close to the Coppename-monding Nature Reserve, a Wetland of International Importance and a Hemispheric Reserve.

These and other issues are addressed in the assessment of impacts in Chapter 5.

All issues and concerns have been taken into consideration, as far as applicable to the study.
On short notice Staatsolie will invite the staff of the Nature Conservation Division in order to discuss the comments made on Fauna and Nature Conservation and to find a solution to the identified problems.

Especially during interviews and at the stakeholders meeting many general issues related with Staatsolie activities in general, were brought forward as can be concluded from Appendix F-3. Relatively few comments were made on the proper EIA study.

In order to deal with complaints from the public, Staatsolie has already established a special Complaints unit. Given the large number of general complaints and other issues, in this study it has been proposed to appoint a community relations officer, which person should not only wait for problems to arise, but who will take a pro-active approach.

8 GENERAL CONCLUSION

The Tambaredjo NW production development project will result in a number of unavoidable adverse environmental impacts, which is common for such projects. But the project is developed in an area in which oil exploration and production activities are already taking place and based on lessons-learned, improved operational measures have gradually been implemented. In addition, regulations and procedures have been developed and implemented for the specific conditions of the Buru Swamp in which the project is located.
Observations in production areas during the current study have indicated that part of the implemented mitigation measures is effective, while others need to be improved.

The EIA describes the available information on project design and operation. Baseline data of previous studies have been used, but in addition to that baseline data have been collected in the field. Due to operational shortcomings not all planned data could be collected (e.g. equipment noise and meteorological data). These gaps in information do not essentially affect the outcomes of the analyses. The general data of the Meteorological Service have been used in the analyses of air quality impacts, which is acceptable because emissions are low and the area uninhabited. For noise, it has been indicated that additional measurements should be made.

Matching of the project activities with the baseline conditions has enabled the identification and analyses of environmental (biophysical as well as socio-economic) impacts of the proposed production project.
The EIA report presents an impartial and complete evaluation of the possible impacts of the project. Mitigation measures are presented to manage these impacts.

Based on the study it is predicted that very few of the impacts of the project are of concern.
One of the main concerns is associated with the fact that the project will be developed directly south of the Coppename-monding Nature Reserve, a wetland of international importance. There will be no activities within the boundaries of the nature reserve, but certain impacts could have an effect here, if not managed properly. A buffer zone, with measures to manage noise impacts is proposed, while more detailed monitoring of water flow and water quality should guarantee that water pollution, if any, does not reach the reserve.

Staatsolie has committed itself that it will ensure that the project will be conducted to high standards, achieved through implementation of the recommended mitigation measures and by ongoing monitoring of performance.

A Non-Technical Summary (in Dutch) of this report was distributed to stakeholders that were invited for the stakeholders meeting where the findings of the EIA have been discussed with key stakeholders and members of the public. When relevant for the subject, the comments have been included in the EIA.
Upon request the Draft EIA Report was made available for public comments and stakeholders were invited to review the report. Comments were only received from the Nature Conservation Division.

9 ENVIRONMENTAL MANAGEMENT PLAN

Environmental risks and impacts can be managed through an effective Environmental Management Plan (EMP). An effective EMP must be implemented as part of normal operations by incorporating the key components into daily activities, such as including environmental issues in the decision-making process and maintaining complete records.
Environmental responsibility must be incorporated into the EMP to assure implementation of environmentally responsible operating practices. Below a framework of this EMP is presented for consideration by Staatsolie.

Environmental management should include the following:

- Communicate environmental, health and safety[12] policies and commitment to those involved.
- Provide financial and personnel resources.
- Assign environmental accountability to all relevant parties and personnel for:
    - Operating procedures,
    - Training of affected personnel,
    - Monitoring and auditing systems, and
    - Emergency response planning.

The key to the success of the EMP is that it must be practical and relatively easy to implement. All personnel must understand their roles and responsibilities. An environmental specialist must be assigned to conduct on-site inspection throughout the project and to provide guidance on the appropriate application of the mitigation measures. This specialist may also be responsible for briefing the other project personnel on the EMP and on the environmental sensitivities of the area. He/she must have the full support of management. For Staatsolie this specialist should be from the EHS department.

9.1 PRIMARY ENVIRONMENTAL SENSITIVITIES

The Tambaredjo NW oil field is found within the Buru Swamp, a wetland that is part of the North Saramacca MUMA. Directly north of the oil field is the Coppename-monding Nature Reserve, a wetland of international importance. In addition to the many goods and services provided by its mangrove ecosystem, the Nature Reserve is particularly known as a bird sanctuary. A large part of the Tambaredjo NW oil field is within the buffer zone of the Nature Reserve. The smaller southern part is in an area from which irrigation water is withdrawn.

Wetlands serve vital functions such as providing wildlife habitat, marine fauna productivity, coastal protection and flood control, water filtering and purification, carbon sequestration, irrigation water supply and recreational usage. They provide breeding and nesting grounds for many types of animals.
Special care must be taken to maintain the natural equilibrium of the wetland ecosystems and the surrounding transition areas. Construction of trails and dams may affect the water flow, which can cause changes to the water levels and water quality over large areas far beyond the

[12] This EMP only deals with environmental issues

immediate site of the disturbance with consequent alteration of vegetation and fish and wildlife habitats.
Damage to fish and wildlife are possible through water pollution, while disturbance of wildlife, in particular birds, is possible through excessive sound levels.
In large expanses of wetlands, small areas of raised dry land can constitute very important habitats. The ridge ecosystems are limited in distribution in the Tambaredjo NW area, but they serve as important habitats and are an important element of the wetland complex.

In summary, the primary environmental sensitivities of the Tambaredjo NW area are:
- Natural surface water drainage and water quality,
- Vegetation and other components of fish and wildlife habitats,
- Fish and wildlife and their susceptibility to disturbance and/or water pollution, and
- Water use compatibility with other existing and potential uses.

Human receptors are found at a distance of at least 4 km from the project activities and no direct environmental impact to this group has been identified.

9.2 PROJECT ACTIVITIES WITH SIGNIFICANT IMPACT POTENTIAL

Care of the environment requires knowledge of the potential affects of the proposed activities and operations. Following is an overview of the main project features that have the potential to cause negative impacts.

9.2.1 Access

Opening up an area, whether through the development of dams, trails or canals, creates access for others who may cause damage to the environment in various ways. Therefore, it is important to find some mechanism to control such access over the long term.

9.2.2 Construction of trails, dams and drilling locations

The principal concerns related to clearing and excavation for oil field development relate to loss of ecosystems with high conservation value, loss and alteration of habitats, and direct disturbance of fish and wildlife. Apart from these general issues, the potential extended reach of the project's effects is of significance. For example, fires and hydrological changes can all have consequences over an extensive area and those effects may persist for a long time.

9.2.3 Drilling Operations

The principal concerns from drilling operations relate to their potential for direct disturbance and for contamination. Possible impacts arise from the use of equipment, transportation, application of a considerable volume and variety of materials, resulting in noise impacts and potential pollution from drilling liquid and cuttings. Vegetation fires remain a risk during this phase.

9.2.4 Oil field production

Concerns during production are associated with the rather dense network of production wells, and pipelines that transport the crude through the wetland to the Transfer Station. Leakages could potentially affect the surface water over large areas, although the current study indicates a very low probability of such resulting from a spill. The water flow is too slow and the oil tends to sink to the bottom instead of floating.
Another, more likely concern relates with the transport of personnel and supplies for monitoring, inspection and maintenance, which could disturb wildlife through noise impacts.
Poor maintenance of cuts in dams during production could result in hydrological changes with potential consequences over extensive areas of wetlands, also beyond the oil field boundaries. Vegetation fires remain a risk during this phase.

9.2.5 Decommissioning/Closure

The adverse impacts associated with increased access have the potential to become prominent during this phase. Also could poor execution of required closure measures still lead to hydrological changes that have the potential to affect considerable areas.
But normally this phase will lead to an improvement of the environmental conditions in the Tambaredjo NW oil field by allowing the spontaneous re-growth of the vegetation and restoration of habitats.

9.3 ENVIRONMENTAL IMPACT AVOIDANCE AND MITIGATION

Following is a description of the measures that will be taken in various phases of the exploration program to avoid impacts to the extent reasonably possible and to limit the severity of those that do occur. The measures have been derived from many years of industry experience in similar conditions. Three primary references for relevant impact mitigation are: Oil and Gas Exploration and Production in Mangrove Areas (IUCN and E&P Forum, 1993), Oil Industry Operating Guideline for Tropical Rainforests (E&P Forum, 1991) and IFC/World Bank guidelines (IFC 2007a, c and d).

9.3.1 Planning

Environmental considerations have been included in the project's decision-making process.
As part of the planning of the Collection & Transfer Station, it has already been decided that booster pumps will be used in order to reduce the project's emission of Greenhouse Gases to a minimum.

The project will avoid or reduce damage to sensitive locations and, to the extent possible, disturbing activities during sensitive times/seasons for flora and fauna, and for nearest residents and others who use the area.

The project will avoid hydrological changes of the wetland by careful planning of dams and trails, and by the implementation of proper construction measures to prevent any blockage or any accelerated drainage of swamp water.

Environmental issues must be part of both pre-survey and daily planning. Staatsolie will ensure that relevant environmental issues are addressed during the planning stage. All personnel will be informed about what can, and cannot, be done. An Emergency Response Coordinator with prior spill response training will be designated as the individual responsible for all facets of the emergency response plan.

Additionally, the following will be addressed prior to start-up:

- Reconcile environmental and safety conflicts,
- Explain the EMP to pertinent government agencies,
- Discuss environmental issues and responses and reporting procedures with crew supervisors and managers, senior crew personnel and subcontractors,
- Describe the emergency response plans, including functional responsibilities, to all personnel.

Planning will address the following and other questions where relevant:

- Seasonal considerations:
    - Bird breeding; sensitive time periods, especially near the mangrove belt, are March/ April to August/September.
    - Irrigation of paddy rice; depends on the rainfall pattern, but usually irrigation water will only be withdrawn at high swamp water levels.
- Sensitive and unique areas:
    - Mangrove forest and high swampwood
    - Ridges
    - Significant wildlife breeding, nesting, spawning or migration areas.
    - Swamp areas with irrigation water withdrawal
- What reporting is required for contractors (and subcontractors)?
    - Do all parties understand their reporting responsibilities?
    - How is this information to be documented during operations?
- Who will handle communications with:
    - Government representatives
    - Area landowners and land users.

9.3.2 Construction of access trails and header dams

Already existing access, including canals, will be used as much as possible.
When clearing, the objective is to provide sufficient and safe access for personnel and equipment while minimizing environmental effects. The extent of clearing will be limited by removing the minimum amount of vegetation and soil necessary for the equipment being used (depth and width).

In sensitive areas that have a high conservation value, equipment that has minimum operational space requirements will be employed.
Sensitive locations with respect to this are:

- the mangrove forest in the north of the project area
- the high swampwood
- ridge ecosystems

For the first two ecosystems, the physical disturbance will be kept to the minimum by using the smaller caterpillar mounted rig instead of the hover rig.

Clearing of ridge ecosystems will be avoided, or if not possible clearing will be kept to the bare minimum by the following measures:

- No large (east-west) trails and other infrastructure will be established close to ridges (indicated on Figure 12); keep a distance of 50 meters at least.
- In case of south-north dams and trails: dams and trails will be projected, as much as possible, in open spots in between ridges,
- If south-north passage of a ridge cannot be avoided: the clearing width through the ridge vegetation will be kept to the bare minimum.

Ensure that the access trails and dams will not impede natural water flow patterns or create new flow patterns. Potential hydrological changes in the wetland will be counteracted by the following measures:

In order to prevent blockage of water flow:

- The creation of unnatural dams and dikes by piling of excavated material along trails will be avoided. Excavated material from the trail (mainly peat) should be placed on one or both sides of the canal with a break every 100 meters in order to preserve, as much as possible, the existing drainage patterns.
- The current practice at the Calcutta oil field, with respect to number of openings (cuts) will be maintained, unless monitoring proves differently. The current practice is the creation of a 1 meter wide opening at every 500-1000 m of dam, and a number of larger openings (up to 70 meters) at places where other trails are connecting.
- In case monitoring indicates that the swamp flow is obstructed the openings will be checked for their performance and when clogged they will be cleaned.
- In case monitoring indicates that the number of openings is inadequate, additional openings will be provided.
- Upon closure of the project the dams will be breached or leveled, unless management is taken over by another party (e.g. tourism development)

In order to avoid accelerated drainage within the zone with a mixture of closed and open parwa (mangrove) forest[13] interspersed with Typha swamp:

- East-west trails in the northern section of the field will preferably be planned in zones with herbaceous vegetation (Typha) which provides a buffer for rapid water flow due to the high hydraulic resistance of the vegetation and the peat
- The number of south-north trails in the mangrove forest zone will be limited.
- The width and depth of trails in the mangrove forest zone will be limited to the minimum
- In case trails are constructed in the mangrove forest where open outflow is possible, these trails will be provided with low clay dams along the sides and a closing dam at the northern end. These dams will prevent that water from the trail network to the south is flowing directly into the mangrove forest. Dams will only be made in sections

[13] The closed parwa forest has an open sub-growth and little peat, so the hydraulic resistance is low; connecting open trails with this zone will lead to rapid drainage of the southern swamp, a process that is now strongly reduced by the presence of a zone with dense herbaceous vegetation and peat to the south of the mangrove zone

with closed mangrove forest and no dams will be made where herbaceous vegetation (Typha) is present.

Ensure that the potential of turbidity is reduced to the minimum by:

- The width of trails/canals will be limited to the minimum to reduce turbulence-induced turbidity

Sensitive swamp areas with respect to irrigation water supply are the southern swamps, south of the "red line", but in particular the area of the Poeran and Soekha Canals. Trails will be located in such a way that no water pollution, including increased turbidity, of these canals is possible. In practice, this means that there should be no open connection between the project trails and the canals. A vegetated strip of 50 meter[14] between the Poeran Canal and nearby trails is considered sufficient to block potential pollution with suspended solids (turbidity) and oil.
The above considerations will all be included in the project lay-out.

9.3.3 Transportation of crew and supplies during all project phases

Technical guidelines for water traffic are laid down in the Calcutta Waterway Traffic regulation (Staatsolie, 2006a). These regulations will also apply for Tambaredjo NW.

In general, the following guidelines will apply to travel in wetlands operations:

- Minimize number of transport vehicles and crews.
- Minimize travel, and prohibit joyriding, hunting, fishing and capturing.
- Only travel along dedicated trails and do not create new routes parallel to existing trails.
- Leave tracked or wheeled vehicles in the field overnight, using water transportation to and from the landing.
- Do not perform maintenance of transportation equipment in the field.

Caution and common sense can help minimize environmental effects of water travel. When traveling in water, care will be exercised to reduce the risk to aquatic life. Speeds will be adjusted to allow sufficient reaction time to avoid collisions with wildlife. Fuel transfer and handling will be done in such a way that prevents spills. Other measures to be followed include:

- Operations in or near significant bird nesting areas (the mangrove zone) will be planned to minimize disturbances. In the October – March period the likelihood of presence of breeding colonies is lowest.
- Noise disturbance near noise sensitive areas will be reduced by the deployment of Gator-tails at a low noise-level for monitoring, inspection and maintenance activities.
- Fuel tanks will have caps and will not be filled over water.
- Maintenance will ensure that fuels, lubricants or other foreign materials do not enter the water.
- Engine tuning will ensure that pollutants in engine exhausts are minimized.

[14] During the current study it has been observed that suspended solids penetrate 25 m at most in the vegetation along trails with turbid water.

- Absorbent materials will be kept on board in case of small fuel spills.
- Docking areas will be planned such that safe and environmentally sound supply, maintenance and refueling activities can take place.

Airboats
Airboats leave only a temporary footprint on the vegetation and soil, but operate at a noise level that may temporarily displace animals and that may have fatal consequences for breeding colonies. Airboats will be utilized only where their noise affects on animals will not result in unacceptable disturbance (in practice not within 1 km distance from sensitive zones) and they will be operated at a moderate speed to reduce noise levels within 1-2 km of sensitive zones).

Small Boats
The smaller Gator-tail boats are quieter than airboats but are limited to open waterways. They will be used for inspection, maintenance and monitoring in areas near noise-sensitive zones (up to 125 m from colony at moderate speed).

9.3.4 Drilling Operations

There are some environmental concerns that are specific to drilling operations, relating principally to the potential for a blowout and potential of noise impacts during drilling and traveling of the rig. As explained in the EIA, there are no significant concerns regarding the handling, storage and disposal of materials used during drilling. Drilling liquid and cuttings will be disposed of in the swamp without causing a significant impact and other waste will be handled through the waste management plan.
Following are some impact mitigation measures that will be applied to any drilling operations.

- Though vegetation will be cleared from the immediate site of the drilling operation (approximately 50 x 50 m), there will be no attempt to dike and drain the site.
- The drilling rig will be equipped with a blowout prevention system.
- The produced water is collected in an area that is surrounded by a boom in order to contain any oil. Oil pollution will be cleaned following the existing Staatsolie guidelines.
- Containment equipment e.g. booms, and other response equipment and materials will be carried on the drilling rig for deployment in case of a large spill.

9.3.5 Crude production

Main concerns during production are oil leakages and spills, and fugitive emissions from wells and pipelines. All crude oil will be pumped by in-line booster pumps to the treatment facility at TA-58 and no storage tanks are included in the design.

Oil spills
Spill prevention and control measures specific to onshore oil production include:

- Installation of corrosion control and prevention systems in all pipelines, process equipment, and tanks will be ensured.

- Around all wells, circular booms will be placed to prevent spread of potentially leaked oil in the swamp surrounding the well.
- Secondary containment around vessels and tanks to contain accidental releases will be installed;
- Shutdown valves to allow early shutdown or isolation in the event of a spill will be installed.
- Leak detection systems will be installed. On pipelines, measures such as telemetry systems, Supervisory Control and Data Acquisition (SCADA9), pressure sensors, shut-in valves, and pump-off systems will be considered.
- Corrosion maintenance and monitoring programs will be developed to ensure the integrity of all field equipment. For pipelines, maintenance programs should include regular pigging to clean the pipeline.
- Adequate personnel training in oil spill prevention, containment, and response will be ensured.
- It will be ensured that pill response and containment equipment is deployed or available for a response.

Fugitive emissions
Fugitive emissions from wells and pipelines will be controlled by:

- Appropriate valves, flanges, fittings, seals, and packings will be selected to reduce gas leaks and fugitive emissions.
- Leak detection and repair programs will be implemented.

9.3.6 Transport vehicles and equipment

The most important concern related to transport vehicles and equipment are the often high sound levels that may cause disturbance of wildlife. Some noise reduction measures have been presented above and one more is given below:

- The quietest and most effective equipment available will be selected.

Emissions are hardly a problem in the context of the project, but nevertheless some measures are presented below. Emissions from transport vehicles and equipment will be controlled by the following approach:

- Drivers / operators will be instructed on the benefits of practices that reduce both the risk of accidents and fuel consumption, including measured acceleration and driving within safe speed limits.
- Older transport vehicles and equipment will in time be replaced with newer, and if possible more fuel efficient, alternatives.
- The use of high-fuel consumption transport vehicles or equipment will be reduced, where feasible.
- Emissions control devices, such as catalytic converters, will be installed and maintained, where feasible
- A regular vehicle and equipment maintenance and repair program will be in place.

9.3.7 Fuels Storage and Handling

Field operations will require that some equipment be refueled and maintained in the field. Small fuel and oil spills that might occur may result in contaminated soil, surface and groundwater.

Fuel and Oils

- Leak proof tanks and containers will be used.
- Fuel storage facilities will be installed to contain spills and protect soil and water from contamination.
- Stationary fuel storage facilities will have a secondary containment system, such as a berm, capable of holding the capacity of the largest container plus an appropriate volume to accommodate rainfall (total 150% of tank volume).
- Stationary fuel storage areas will be free of other combustible material to isolate potential fires.
- Fuels will be stored in a manner that minimizes the potential for spills.
- Fuel tanks will be inspected routinely for leaks and a report made by the person responsible for the vehicle or tank.
- Emergency repair equipment for the refueling hose and connections should be kept at the tank site.
- All fuel tanks or drums will be marked with their contents and the name of the company that owns or operates them.

Refueling

- Fuel transfer operations will be done so that there is no spillage.
- Drip pans or absorbent material or drip basins will be placed under unsealed connections during refueling.
- The fuel handler will never leave the refueling operation while it is in progress. He/she will be trained to respond to and contain a fuel spillage.
- While performing maintenance on equipment, there will be sufficient drip trays in position to catch any spills or leaks. A large impermeable plastic sheet placed under the whole vehicle could act as a secondary catchment system.
- While refueling boats, if automatic shut-off nozzles are not available, fuel will be transferred to a portable tank/drum on dry land and then the tank will be transferred to the boat. Where this is not practical, be prepared to deploy a containment boom quickly.
- Appropriate spill response equipment will be available with all fuel transfer and storage facilities and equipment.

9.3.8 Fish and Wildlife

A number of measures will be taken to prevent or limit direct or indirect effects on fish and wildlife in the Tambaredjo NW area.

Measures to address direct effects to fish and wildlife are the following:

- To prevent hunting, fishing and capturing by third parties in the concession area:

    - All access will be located and constructed in such a way that use by unauthorized persons can be controlled. The access routes will be made inaccessible when they are no longer needed for the project by creating pullbacks (barriers to travel) at all the potential entry points, unless there is an overriding reason to do otherwise.
    - Conduct regular at random patrolling in the concession by air boat
- Interactions with wildlife will be avoided.
- The existing ban on hunting, fishing and capturing at the Tambaredjo NW oil field for all Staatsolie personnel, contractors and authorized visitors will remain to be imposed. Random checks will be made at the entrances.
- Pets will not be allowed on the project.
- Any areas of high sensitivity will be noted as exclusion zones and project activities will avoid these areas. This will be applicable for the Coppename-monding Nature Reserve and the areas near breeding colonies (see measures for transportation). The boundary will be clearly marked by signs (in cooperation with Nature Conservation Division – LBB).
- Construction and drilling activities in the northern section of the oil field (until 1 km south of the northern boundary) will be performed in the October – March period, when the likelihood of breeding colonies is lowest.
- In case still construction and/or drilling work needs to be performed in the northern part of the oil field in the May-September breeding season an aerial survey should be conducted in early May, to determine the locations of eventual breeding colonies in and near (within 1 km of the boundary) the project area. This survey should be conducted every year once this section is developed and regular inspection, maintenance and monitoring activities will be conducted.
- In case breeding colonies are present within 1 km from the oil field boundary no development activities in this zone should be conducted during the breeding period and monitoring and maintenance activities should be conducted with Gator-tails at a low noise-level.

Measures that address the indirect effects are the following:

- The footprint of disturbance of the project will be minimized.
- The forested areas will be developed in such a way that fragmentation is minimal and inter-connection of residual parts optimum.
- A continuous environmental awareness and education program for Staatsolie employees will be undertaken, focusing on the importance of minimizing harm to the environment.
- Upon closure either:
    - All access roads, dams, canals and trails will be destroyed, or
    - All infrastructure and facilities will be handed over to a responsible party that will develop a sustainable type of land use for the area, like the establishment of an education center, a (eco) touristic or recreational facility. The handover should be made in consultation with relevant authorities, like the Nature Conservation Division.

Finally it is suggested that the aquatic life is monitored during the project lifetime. This does not necessarily be in the form of a consultancy, but it could be done as a research project of the University of Suriname, whereby Staatsolie is the facilitator.

9.3.9 Waste Management

In addition to and based upon the existing general instructions for solid waste handling and disposal (Staatsolie, 2002a) the following measures will be effectuated:

- A project waste management plan will be prepared from the field perspective to provide general guidance for the handling of each waste stream.
- Wastes from field facilities, including domestic wastes, will be collected in a manner that will ensure an adequate level of environmental protection, and stored and disposed of at the Staatsolie landfill at Sarah Maria.
- No solid or liquid wastes will be left in the wetland area.
- Used oils and lubricants will be stored in labeled containers for future disposal or recycling.
- The work sites and the camp/landing area will be kept free of debris, which will be collected periodically.
- All hazardous materials will be stored separately and disposed of according to local requirements.
- Oil contaminated soil will be treated at the Staatsolie landfarm at Sarah Maria.
- Sewage (e.g. from the office complex at the Transfer Station) will be treated before being released into the swamp (e.g. through a small engineered wetland for water treatment projected in the local Typha swamp.

9.3.10 Prevention and Contingency Plans

Oil spills
The probability of spills can be reduced, but even with careful design and construction of facilities oil spill contingency plans will be required.
Staatsolie already has developed an Oil Spill Contingency Plan and Oil Spill Clean-Up guidelines, and the capability to implement the plan are in place. The Oil Spill Clean-Up guidelines address potential oil and fuel spills in the various habitats where Staatsolie is active.
The Oil Spill Contingency Plan will be adapted for the Tambaredjo NW production development operation based on the estimates of the size and location of potential spills. All spills will be documented and reported. Following a spill, a root cause investigation is carried out and corrective actions are undertaken to prevent reoccurrence.

Fire hazard
The risk of vegetation fires is low, but they cannot be completely ruled out. As first step to lower the risk fire prevention plans will be developed that comprise the following issues:

- Strict fire control procedures and measures will be developed and implemented.
- A concrete control measures will be that the vegetation of the Poeran and Soekha dams will be kept low and that in the dry season all debris are removed, thus creating a fire break.
- A fire risk awareness program for Staatsolie personnel and contractors working in the Tambaredjo NW area will be implemented.
- The risks of vegetation and peat fires to Staatsolie personnel, materials and equipment will be discussed in stakeholders meetings.

- Special meetings will be organized during extremely dry periods to stress the fire risk once more
- In extremely dry periods fire patrols will be conducted.
- Spark-arresting mufflers will be used in dry areas.
- All transport vehicles and equipment will carry a suitable fire extinguisher.
- Smoking will not be allowed in the Tambaredjo NW oil field

Nevertheless a fire contingency plan will be required. This plan will allow Staatsolie and the contractors to respond promptly in the case of a vegetation fire. A quick and organized response will minimize any loss of property and reduce the potential for serious injury to people.

The plan will outline:

- Lines of communication and individuals who must be contacted in case of a fire.
- Series of actions to undertake in the event of vegetation fire in the area.
- Equipment needed to control a fire.
- Emergency response personnel and their responsibilities.

9.3.11 Training

Environmental operating procedures and policies must be understood for effective implementation. Emphasis should be placed on the importance of each individual's environmental performance. Training will be conducted by the Environmental Department on appropriate environmental issues according to job responsibility.
Operations training will include information on:

- Regulations which apply
- Wildlife and aquatic life that might be encountered
- Current land and water use
- Clearing, access and transportation
- Waste minimization, handling and disposal methods
- Fire and spill prevention and control
- Handling and storage of hazardous materials, fuels and oils
- Reclamation measures.

9.3.12 Inspection and Monitoring

In order to effectively protect the environment and mitigate environmental impacts, proper implementation of environmental plans is essential. This will be achieved through the inclusion of a dedicated environmental officer on the project. The officer will be familiar with the environmental planning that was done for the project and aware of any significant environmental impacts that are to be avoided. He/she will review how things are being done, ensure that the plans are followed and, when required, that plans are altered in environmentally responsible manners. Clear documentation will be included as part of the environmental officer’s reporting process.
A key focus of the monitoring program will be the impacts from the various production development activities on the environment at representative sites and at any sites where

problems have arisen or are suspected. This will provide information on the accuracy of the impact predictions that were made and on the effectiveness of the Environmental Management Plan. It will also provide important input information for any future development activities in similar areas. The monitoring will be site specific, with some variation in methodology and variables possible from location to location.
The primary variables to be addressed in the monitoring program will be surface water hydrology and quality, birds and vegetation. Data will be acquired at selected sites throughout the project's lifetime. Subsequent sampling and analysis will be conducted to collect comparative data. Some data have already been collected during the baseline studies completed for this report. The monitoring framework program is presented in Table 58.

Table 58: Monitoring framework program

Aspect	Parameters	Frequency	Monitoring locations
Noise	Check on proper maintenance of transport vehicles and equipment	Monthly	
	Sound measurements equipment and drilling (repeat baseline measurements)	Once	On location
	Check on use of airboat and speed level	Daily	Noise buffer zone, once northern oil field developed
Hydro-logy	Swamp level by staff gauges that have been adjusted to the same level – no essential differences should be present N and S of dams (automated recording should be considered)	Weekly in the rainy season; daily after heavy rainfall (>20 mm)	North and south of all E-W running dams
	Swamp water level reference monitoring with divers	Continuous	To be decided after field lay-out is known in detail.
	Swamp water flow velocity (to be conducted by WLA - Hydraulic Research Department)	Every long rainy season	All trails in the northern section of the oil field (2km from boundary), once developed
Water quality	EC or chlorides[15], TSS	Monthly	1. Poeran Canal, south of the oil field 2. At three locations along the boundary of the Coppename-monding NR[16]. 3. Mangrove forest north of the oil field (e.g. sampling point 17 in existing trail) 4. Soekha dam landing 5. Wells drilled in this months – edge of drilling location and 10 meter into surrounding swamp
	Check for oil spills and oil films	Daily	Oil field
Vegeta-tion	Width and location of trails in forested parts – according to design	Directly upon completion of trails	Mangrove forest, high swampwood and ridge vegetation
Bird colonies	Location in early May (aerial survey) – with proper planning this could possibly be included in the routine program of the Nature Conservation Division of LBB	Once every year	Mangrove zone of the oil field and to the north of the oil field up to the ocean
Waste	Check if landing sites and station yards are clean Check proper storage of waste Check proper disposal of waste Log on waste	Daily weekly weekly daily	All working locations

[15] For the water of the Buru Swamp the following relation has been found: EC [µS] = 2.95 x Cl [mg/l]. The standards for chloride are 600 mg/l (average), 1200 mg/L (maximum). Expressed into EC this becomes 1765 and 3540 µS respectively. For the Typha swamp and the Parwa zone higher figures are allowed (see Ch. 2.4.3.4).

[16] Only after the northern oil field section has been developed. Before that time monitoring can take place at 3 of the most northern locations that is accessible (e.g. near test tanks and north of the Ritsweg).

10 DECOMMISSIONING PLAN

Decommissioning should return the land to such a state that it would be able to provide its previous goods and functions without maintenance by implementing the following activities:

- removal of all equipment, materials and parts of it
- removal of all waste
- clean-up of any soil and water pollution
- leveling and/or breaching of all constructed dams, unless such structures could get a new function under responsible management
- do NOT fill in the created open water surfaces, which will provide additional feeding grounds for certain birds
- blocking of all access routes over land and water in order to prevent illegal access of the Nature Reserve after abandonment

As already suggested in the text above there could be a potential use of the abandoned terrain. The area has a special character and there are only few places where such coastal wetland environment is accessible. The presence of good quality access road from the public road makes it a suitable location for the establishment of a special purpose tourism resort, with or without lodges. The area and the nearby mangrove zone are very attractive for bird watchers and other nature lovers. This option can be further elaborated at the time that abandonment is approaching. There are no other use options for most of the terrain, because it is located north of the “red line”, where no land allocation is allowed. The land south of the line is not likely to become developed and other use than swamp would also be conflicting with the water reservoir function that is already has.

After abandonment, the relevant authorities (see Ch. 2) have to inspect the area for approval of decommissioning activities. This inspection needs to be repeated 2-3 times in the following months in order to check whether the system reacts as foreseen. In case of non-compliance or in case unexpected impacts are encountered in a later stage, corrective measures have to be implemented by Staatsolie.

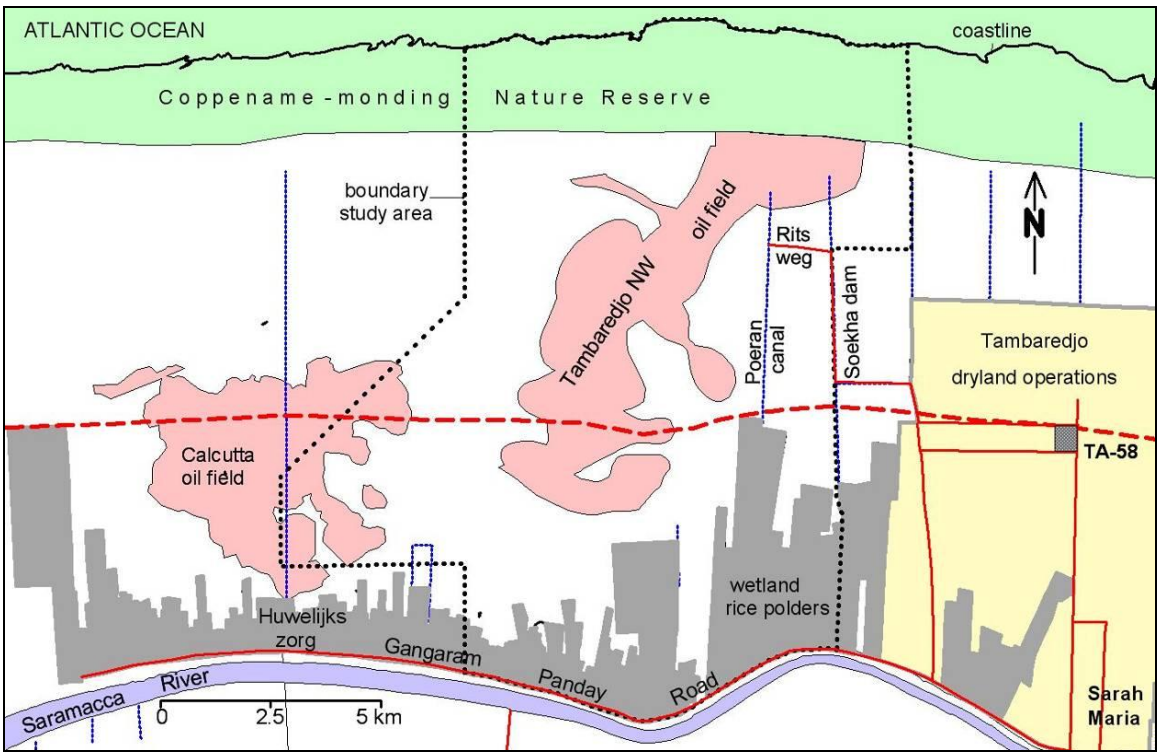
Apart from the general inspection to the integrity of the protected area, also increased inspections of game and fish warden should be conducted in the first months after abandonment.

Staatsolie is advised to support the above inspections by providing transportation and access to their operational area.

In addition to above inspections, it is recommended that surveys (and maybe studies) be conducted to monitor the behavior of birds after abandonment. Such surveys could provide valuable information that can be used in comparable areas in Suriname and abroad. Support of such studies will promote Staatsolie as a responsible oil company.

ENVIRONMENTAL IMPACT ASSESSMENT OF PRODUCTION DEVELOPMENT OF THE TAMBAREDJO NORTH-WEST OIL FIELD IN SURINAME

APPENDICES



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Final report
April 1, 2010

APPENDIX A: DATA FROM THE WATER RESOURCES STUDY

Table 1: Gauge readings November 18, 2008 - July 23, 2009; raw data

gauge no	18-Nov	26-Nov	3-Dec	8-Dec	22-Dec	16-Jan	12-Feb	26-Feb	16-Mar	9-Apr	22-Apr	12-May	19-May	28-May	27-Jun	11-Jul	23-Jul	Correction factor
1	35.0	32.5	30.0	29.0	39.0	53.0	64.0	60.0	64.0	66.0	64.5	63.5	60.0	57.0	62.0	62.0	66.0	10
2	45.0	42.0		39.0	46.0	62.0	68.0	68.0	71.5	75.5		72.0	68.5		71.0	72.5	73.5	0
3				39.0	47.0		70.0	68.0	68.0									0
4			42.0	40.0	47.0	63.0	73.0	69.0	74.0	75.5	74.0	74.0	72.0	67.0	72.5	72.0	73.5	-1
5			59.0	56.0	64.0	80.0	90.0	85.0	90.0	91.5	90.0	90.0		83.0	89.0	89.0	89.0	-17
6	45.0	41.0	38.0	37.5	47.0	62.0		68.0	72.0	74.0						71.0		2
7				39.0	41.5	59.0		64.0	69.5	71.5					67.5	67.0		0
9				39.0	49.5	61.5	72.0	67.5	73.0	74.0					70.0			0
10			39.0	39.0	49.0	62.5	72.0	68.0	74.0	75.0	75.5	72.5	69.0	66.0	71.0	71.0	73.5	0
11			42.5	42.5	47.5	62.0	72.0	68.0	73.0	75.5	73.5			66.0	71.0	71.0	72.0	-4
12			39.0	39.0	49.5	61.5	68.0	66.0	73.0	75.0	74.0	72.0			70.5	71.5	72.0	0
13			42.0	42.0	48.5	62.0	73.0	68.0	74.0	77.0	74.0	75.0		67.5	72.0	71.5	72.0	-3
14				39.0	43.5	61.5		67.5	74.0	76.0		73.0	70.0		71.5	72.0	72.0	0
15				42.0	49.0	66.0	76.0	71.0	77.0	79.0	75.0	77.5	73.5		75.0	75.5		-3
16			101.0	101.0		123.0	131.0	127.0	131.0	133.5	131.0	132.0		125.0	132.0	130.0	129.0	-62
17			88.0	88.0		113.0	118.0	115.0	119.5	120.5	120.0	120.0	117.0	114.0	120.5	119.0	117.5	-49
19				39.0	46.0	62.0	72.0	67.0	73.0	75.0	72.0	73.5	69.0		70.0	71.0	71.0	0
20				39.0	47.0	62.5	73.0	68.0	72.5	75.0	73.0	73.0			72.0	72.0	69.0	0

Table 2: Gauge readings November 18, 2008 - July 23, 2009; corrected data (all leveled for December 8, 2008, using correction factor table 1)

gauge no	18-Nov	26-Nov	3-Dec	8-Dec	22-Dec	16-Jan	12-Feb	26-Feb	16-Mar	9-Apr	22-Apr	12-May	19-May	28-May	27-Jun	11-Jul	23-Jul
1	45.0	42.5	40.0	39.0	49.0	63.0	74.0	70.0	74.0	76.0	74.5	73.5	70.0	67.0	72.0	72.0	76.0
2	45.0	42.0		39.0	46.0	62.0	68.0	68.0	71.5	75.5		72.0	68.5		71.0	72.5	73.5
3				39.0	47.0		70.0	68.0	68.0								
4			41.0	39.0	46.0	62.0	72.0	68.0	73.0	74.5	73.0	73.0	71.0	66.0	71.5	71.0	72.5
5			42.0	39.0	47.0	63.0	73.0	68.0	73.0	74.5	73.0	73.0		66.0	72.0	72.0	72.0
6	46.5	42.5	39.5	39.0		48.5		63.5		69.5	73.5	75.5				72.5	
7				39.0	41.5	59.0		64.0	69.5	71.5					67.5	67.0	
9				39.0	49.5	61.5	72.0	67.5	73.0	74.0					70.0		
10			39.0	39.0	49.0	62.5	72.0	68.0	74.0	75.0	75.5	72.5	69.0	66.0	71.0	71.0	73.5
11			39.0	39.0	44.0	58.5	68.5	64.5	69.5	72.0	70.0			62.5	67.5	67.5	68.5
12			39.0	39.0	49.5	61.5	68.0	66.0	73.0	75.0	74.0	72.0			70.5	71.5	72.0
13			39.0	39.0	45.5	59.0	70.0	65.0	71.0	74.0	71.0	72.0		64.5	69.0	68.5	69.0
14				39.0	43.5	61.5		67.5	74.0	76.0		73.0	70.0		71.5	72.0	72.0
15				39.0	46.0	63.0	73.0	68.0	74.0	76.0	72.0	74.5	70.5		72.0	72.5	
16			39.0	39.0		61.0	69.0	65.0	69.0	71.5	69.0	70.0		63.0	70.0	68.0	67.0
17			39.0	39.0		64.0	69.0	66.0	70.5	71.5	71.0	71.0	68.0	65.0	71.5	70.0	68.5
19				39.0	46.0	62.0	72.0	67.0	73.0	75.0	72.0	73.5	69.0		70.0	71.0	71.0
20				39.0	47.0	62.5	73.0	68.0	72.5	75.0	73.0	73.0			72.0	72.0	69.0

Table 3: Electrical Conductivity (EC) measurements November 26, 2008 - July 11, 2009

Gauge #	Location	26-Nov	8-Dec	22-Dec	16-Jan	13-Feb	16-Mar	9-Apr	12-May	28-May	27-Jun	11-Jul
1	canal		1,026	726	948	574	561	553		541	453	487
1	swamp	523		334	321							
2	canal		816	700	604		497	490	380		402	395
2	swamp	669		720	503							
3	canal		660	646	660		662	670				
3	swamp	310	304	449	203							
4	canal	963	1,001	1,609	1,507	815	881	1,011		786	740	788
4	swamp	2,439		787	622							
5	canal	1,730	1,740	1,314	1,478	797	864	1,040		838	767	799
5	swamp	3,195		2,286	1,301							
6	canal		1,229	1,052	855		413	278				495
6	swamp	1,496	1,666	1,621	823							
7	canal		617	777	778		475	411			423	428
7	swamp		457	502	553							
9	canal		900	692	547		403	358			397	
9	swamp		2,102	791	555							
10	canal		950	753	663	442	439	292	256	339	362	358
10	swamp		557	286	707							
11	canal	736	804	851	761	326	356	358		435	432	416
11	swamp			1,260	793							

Gauge #	Location	26-Nov	8-Dec	22-Dec	16-Jan	13-Feb	16-Mar	9-Apr	12-May	28-May	27-Jun	11-Jul
12	canal	752	836	672	569		404	381			386	403
12	swamp		737	474	590							
13	canal	784	863	806	638	359	342	324		437	386	352
13	swamp			863	637							
14	canal		1,046	868	991		410	349	308		470	481
14	swamp			1,002	1,042							
15	canal		1,437	1,382	1,477		944	871			910	820
15	swamp		1,122	1,186	1,271							
16	canal		4,432		1,622	1,165	1,250	979		1,130	1,140	1,150
16	swamp				1,624							
17	canal		6,353		2,663	1,942	1,897	1,434	1,320	1,620	1,930	1,580
17	swamp				2,284							
19	canal		1,260	1,241	1,362		720	526			770	783
19	swamp		1,338	1,008	1,079							
20	canal		2,072	2,217	1,490		903	750			848	859
20	swamp		1,806	1,397	1,413							
TAMNW-21	Abandoned drill location		7,284					2,060			2,390	
Kaaiman pan	Abandoned drill location							794				
Ritsweg, swamp N of ridge												1,480
Ritsweg, swamp S of ridge												790

Table 4: Calculated chloride content of the swamp water during the study period November 26, 2008 - July 11, 2009

Gauge #	location	26-Nov	8-Dec	22-Dec	16-Jan	13-Feb	16-Mar	9-Apr	12-May	28-May	27-Jun	11-Jul
1	canal		308	208	282	157	153	150		146	117	128
1	swamp	140		77	73							
2	canal		238	199	167		132	129	93		100	98
2	swamp	189		206	134							
3	canal		186	181	186		187	189				
3	swamp	69	67	116	34							
4	canal	287	300	503	469	238	260	303		228	213	229
4	swamp	779		228	173							
5	canal	543	546	404	459	232	254	313		245	222	232
5	swamp	1,032		729	400							
6	canal		376	317	251		104	58				131
6	swamp	465	522	507	240							
7	canal		172	225	225		124	103			107	109
7	swamp		118	133	150							
9	canal		266	197	148		100	85			98	
9	swamp		667	230	151							
10	canal		283	217	187	113	112	63	51	79	87	85
10	swamp		152	61	202							
11	canal	211	234	250	220	74	85	85		111	110	105
11	swamp			386	230							
12	canal	217	245	190	156		101	93			95	100
12	swamp		212	124	163							

Gauge #	location	26-Nov	8-Dec	22-Dec	16-Jan	13-Feb	16-Mar	9-Apr	12-May	28-May	27-Jun	11-Jul
13	canal	227	254	235	179	86	80	74		112	95	83
13	swamp			254	178							
14	canal		315	256	296		103	82	69		123	126
14	swamp			300	313							
15	canal		445	427	459		281	257			269	239
15	swamp		340	361	390							
16	canal		1,445		507	355	383	292		343	346	350
16	swamp				508							
17	canal		2,086		854	614	599	444	406	506	610	493
17	swamp				728							
19	canal		386	380	420		206	141			223	227
19	swamp		412	302	326							
20	canal		657	706	463		267	216			249	252
20	swamp		568	432	437							
Ritsweg: N of ridge												460
Ritsweg: S of ridge												229
Light orange highlighted is water that is not suitable for irrigation purposes (>300 mg chloride/liter)												

Table 5: pH - November 26, 2008 - July 11, 2009

Gauge #	location	26-Nov	22-Dec	16-Jan	26-Feb	16-Mar	22-Apr	12-May	28-May	27-Jun
1	canal		6.9	7.2	6.4	6.5	6.7		6.7	6.4
1	swamp	4.7								
2	canal		5.9	6.2	6.1	6.3		5.9		6.0
2	swamp	5.0								
3	canal		5.2	5.8	5.6	5.8				
3	swamp									
4	canal	6.3	6.0	6.2	6.1	6.2	6.5		6.7	6.1
4	swamp	5.2								
5	canal	6.5	6.4	6.1	6.2	6.3	6.5		6.3	6.3
5	swamp	5.1								
6	canal		7.0	7.0	7.1	6.4				
6	swamp	5.0								
7	canal		5.3	5.7	5.7	5.8				5.7
7	swamp									
9	canal		5.8	5.8	6.0	6.1				6.0
9	swamp		5.8							
10	canal		5.9	5.8	5.8	5.8	5.9	5.7	4.8	5.9
10	swamp		5.4							
11	canal - mid	5.7	6.0	5.9	6.0	6.0	6.0		4.9	6.0
11	canal-side		5.8							

Gauge #	location	26-Nov	22-Dec	16-Jan	26-Feb	16-Mar	22-Apr	12-May	28-May	27-Jun
11	swamp									
12	canal	5.9	5.8	5.9	5.7	5.9	6.0			6.2
12	swamp		5.7							
13	canal - mid	5.8	5.6	5.9	5.8	5.8	6.0		5.9	5.9
13	canal-side		5.4							
13	swamp									
14	canal		6.4	5.7	5.6	5.6		5.7		5.6
14	swamp									
15	canal		6.5	6.4	6.4	6.5				6.5
15	swamp									
16	canal			6.3	6.2	6.2	6.3		5.5	5.8
16	swamp									
17	canal			6.3	6.2	6.1	6.2	6.2	6.3	6.3
17	swamp									
19	canal		6.3	6.4	6.2	6.2	6.5			6.3
19	swamp									
20	canal		6.6	6.2	6.4	6.4	6.4			6.4

Table 6: Dissolved Oxygen (DO; mg/l) - November 26, 2008 - July 11, 2009

Gauge #	26-Nov	22-Dec	16-Jan	26-Feb	16-Mar	27-Jun
1		2.6	6.9	6.1	4.7	3.3
2		2.1	1.2	3.7	4.5	1.3
3	1.3	1.6	1.1	1.2	3.9	
4	2.6	2.0	1.5	1.5	1.9	0.7
5	3.8	2.4	2.4	3.4	3.4	1.8
6	1.4	2.4	5.8	5.6	3.1	
7		2.6	5.9	4.3	4.5	1.1
9		1.4	2.4	2.4	1.9	0.9
10		1.3	2.7	3.2	1.8	0.7
11	2.5	2.5	2.9	3.3	2.6	0.7
12	4.0	1.2	3.0	4.1	1.8	1.8
13	3.4	1.5	5.3	4.9	2.4	0.6
14		3.5	6.7	3.6	3.1	0.9
15		2.1	2.0	2.5	1.4	1.0
16			1.8	2.7	1.8	0.9
17			2.1	4.6	1.9	1.7
19		1.9	2.0	1.4	1.8	0.4
20		2.8	5.0	4.5	3.2	2.2

Yellow highlighted data have been excluded from the study

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Additional information on vegetation and species

Scientific name	Local name / fancy name	Growth form	Salt tole-rance
CLOSED TO OPEN MANGROVE	**GESLOTEN TOT OPEN MANGROVE**		
Avicennia germinans	Parwa	T	h-f
Laguncularia racemosa	Akira	T	
Sesuvium portulacatrum	Strandpostelein	H	
Batis maritima	Krapegrasi	H	
Paspalum vaginatum	Zeegras	G	p-o
Acrostichum aureum	Tabakatiki	F	h-f
Rhabdadenia biflora	Merkitetei	V	p-o
Eleocharis mutata	Drikanti	G	
Funastrum clausum	Merkitetei	V	
Nymphaea ampla	Sekanti pankukuwiwiri	A	
Acnida cuspidata	Zwampklaroen	H	p-o
BRACKISH SWAMPS	**BRAKWATER ZWAMPEN**		
Typha angustifolia	Payagrasi or Langagrasi	G	m-f
Hydrocotyle umbellata	Waternavel	H	o-f
Mikania micrantha	Brokobaka	V	m-f
Cyperus articulatus	Fini-adrungu	G	p-f
FRESHWATER SWAMPS	**ZOETWATER ZWAMPEN**		
Montrichardia arborescens	Mokomoko	H	o-f
Leersia hexandra	Alesigrasi	G	m-f
Blechnum indicum	Zwampvaren	F	o-f
Heliconia psittacorum	Popokaitongo	H	o-f
Cissus erosa	Redi bun-ati-mama	V	
Fuirena umbellata	Fefikanti	G	f
Hymenachne amplexicaulis	Bambugrasi	G	
Phaseolus campestris	Geelbloemige zwampboon	V	o-f
Cordia macrostachya	Blaka-uma struikje	S	?-f
Hibiscus bifurcatus	Watra-okro gevorkte bijkelk	S	o-f
Cyperus ferax	Gele cyperus	G	m-f
Hibiscus sororius	Watra-okro	S	f
Ipomoea tiliacea	Patatatete	V	o-f
Ludwigia nervosa	Ludwigia groot	H	f
Ludwigia leptocarpa	Ludwigia klein	H	m-f
Philodendron jenmanii	Taya-tete	V	
Aeschynomene sensitiva	Aeschynomene	H	
Polygonum acuminatum	Waterzuring	H	?-f
Ludwigia hyssopifolia	Ludwigia liaan	V	
Cissus sicyoides	Weti bun-ati-mama	V	
Acrostichum daneifolium	Tabakatiki	F	?-f
Cyperus giganteus	Prasorograsi	G	
Solanum stramonifolium	Bolomaka	S	
Paulinia pinnata	Boter, melk en kaas / Fefifinga	V	
Ipomoea subrevoluta	Patatatete	V	
Ipomoea spec.	Patatatete	V	o-f
Ludwigia affinis	Ludwigia klein	H	
Lisianthus alatus	Geribde sabana tabaka	H	
Sphenoclea zeylanica	Zeylanica	H	?-f

Sesbannia exasperata	Grote sesbannia	H	
Thalia geniculata	Zwampwarimbo	H	
Eleocharis interstincta	Prapra-gras	G	f
Dryopteris serrata	Zwampvaren	F	f
Sagittaria lancifolia	Pijlkruid	H	f
Vigna luteola	Gele zwampboon	V	
Brachyaria mutica	Paragras	G	o-f
Rhynchospora corymbosa	Twatwagras	G	f
SWAMP WOOD			
Chrysobalanus-Annona wood	**Pruimen-zuurzak bos**		
Chrysobalanus icaco	Zwamppruim	T	o-f
Annona glabra	Zwampzuurzak	T	m-f
Clusia nemorosa	Sabana mangro	T	f
Ilex guianensis	Nyamsi-udu	T	
Pterocarpus-Tabebuia wood	**Bebe-panta bos**		
Pterocarpus officinalis	Watrabebe	T	o-f
Tabebuia insignis	Zwamppanta	T	o-f
Ficus 1-3 spp	Ficus soorten	T	?-f
Virola surinamensis	Babun	T	f
Cecropia obtusa	Bospapaja	T	
Euterpe oleracea	Pina palm	P	f
Centropogon cornutus	Diaklaroen	H	f
FLOATING MEADOWS			
Scirpus cubensis	Cubagras	G	?-f
Luziola spruceana	Padigras	G	o-f
Ipomoea reptans	Dagublat	H	o-f
Habenaria repens	Zwamporchidee	H	?-f
Aquatics			
Azolla caroliniana	Kroosvaren	A	o-f
Salvinia auriculata	Vlotvaren	A	o-f
Pistia stratioides	Nijlsla	A	o-f
Nymphoides humboldtianum	Kleine pankuku	A	o-f
Utricularia foliosa	Blaasjeskruid	A	o-f
Wolfiella lingulata	Doksiwiwiri	A	o-f
Nymphaea rudgeana	Pankukuwiwiri	A	o-f

LEGEND

Column 3

Growth forms

T = Tree
P = Palm
S = Shrub
G = Grasslike plants
H= not-grasslike herb
F = Fern
V = Vine
A = Aquatic plant

Column 4

Salt tolerance (Lindeman, 1953)

h =hyperhalien
p =polyhalien
m =mesohalien
o =oligiohalien
f = fresh

Column 5 and higher

D = Dominant
X = Present
(x) = Present near recorded plot

APPENDIX C: DATA FROM THE AQUATIC ECOLOGY STUDY

Table 1: Basic water quality and site characteristics of the sampling stations in Staatsolie's Tambaredjo and Calcutta concessions in the Long Dry Season (1-3 December 2008) and Long Rainy Season (20-22 May 2009).

Station	Gauge17/SO1		Gauge16/SO2		Gauge4/SO3		Gauge5/SO4		Gauge13/SO5		Gauge11/SO6		Gauge12/SO7		Gauge10/SO8		Gauge1/SO9		Gauge6/SO10	
GPS coordinates	N5°58'50.3" W55°34'43.3"		N5°58'26.7" W55°34'25.9"		N5°57'1.6" W55°35'41.1"		N5°57'36.2" W55°35'45.6"		N5°54'57.4" W55°35'15.4"		N5°55'44.2" W55°36'47.9"		N5°54'24.6" W55°36'58.0"		N5°54'17.7" W55°07'38.7"		N5°50'27.8" W55°40'27.8"		N5°54'53.2" W55°38'37.2"	
Ecosystem	Closed mangrove (parwa) forest				Herbaceous *Typha* swamp				Mixed herbac. to low swampwood				High swampwood				Calcutta oilfield			
Canal/channel width (m)	7		5		10		20		4		10		8		9		approximately 100 m		-	
Water depth (cm)	50-118 (gauge)		50-129 (gauge)		70 (gauge)		100-86 (gauge)		70 (gauge)		70-150		70-68 (gauge)		70-150		50		50	
Canopy cover (%)	50		65		0		0		0		0		70		50		0		0	
Aquatic macrophytes	Mangroves , *Salvinia*, *Hydrocotyle*, ferns		Mangroves, *Hydrocotyle*, *Salvinia*, *Nymphaea*		*Typha*, *Salvinia*, *Utricularia*, *Ipomoea*		*Typha*, *Salvinia*, *Utricularia*, *Ipomoea*		*Hydrocotyle*, *Montrichardia*, *Pistia*, *Azolla*, *Utricularia*, Cyperaceae		*Hydrocotyle*, *Pistia*, *Salvinia*, grasses		*Montrichardia*, *Pistia*, *Salvinia*, *Utricularia*, Cyperaceae		*Euterpe oleracea* palm, *Hydrocotyle*, *Pistia*, grasses		*Typha*, grasses, *Ipomoea*, *Ludwigia*, *Hydrocotyle*, *Azolla*, *Pistia*		Grasses. *Azolla*, *Ludwigia*, *Utricularia*	
Banks	Flat		Flat		Flat		Flat		Flat		Flat		Flat/moderate		Flat/moderate		Moderate		Flat	
Water color	Grey to dark-brown		Grey to dark-brown		Grey-brown		Dark-brown		Dark-brown		Dark-brown		Dark-brown		Dark-brown		Grey-brown		Grey-Brown	
Miscellaneous observations	Dead fishes observed in December 2008		Capybara and pink eggs of *Pomacae* snails spotted				*Caiman crocodillus* spotted and caught net				*Caiman crocodillus* spotted and filamentous green algae observed		Guppies observed mid-channel, but not collected; Capybara observed on 22 October 2008		Pink eggs of *Pomacae* snails observed					
Survey	Dec	May	Dec	May	Dec	May	Dec	May	Dec	May	Dec	May	Dec	May	Dec	May	Dec	May	Dec	May
Current velocity	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Water temperature (ºC)	26.5	27.6	26.5	27.5	28.0	28.3	28.6	28.3	28.8	28.8	27.7	26.5	27.9	26.5	27.6	26.3	30.9	30.7	28.2	29.3
pH[1]	6.3	6.30	6.3	5.84	3.5-6.3	6.11	5.2-6.5	6.30	5.4-5.8	5.91	5.4-6.0	6.02	5.8-5.9	6.19	5.8-5.9	5.90	6.9	6.41	5.1-7.0	-
Conductivity (µS/cm)	6600	1750	3660	1000	915	880	1665	810	750	383	760	540	744	397	870	320	910	534	1100	360
Salinity (ptt)	3.6	0.8	1.8	0.5	0.4	0.4	0.8	0.4	0.4	0.2	0.4	0.3	0.4	0.2	-	0.2	0.4	0.3	0.5	0.2
Turbidity (NTU)	-		-		-		-		-		-		-		-		-		-	
Secchi transparency (cm)	4	12	5	18	22	2	18	10	30	11	14	20	31	15	18	-	3	5	3	10
Dissolved oxygen (mg/L)[1]	2.07	1.74	1.83	0.87	1.32-2.58	0.67	2.44-3.75	1.83	1.47-3.40	0.63	2.48-2.50	0.73	1.23-3.45	1.83	1.30	0.66	2.55	3.30	1.35-2.41	0.00

n.d. = not detected; [1] = measurements of pH and DO by A. Amatali of Hydraulic Research Division (WLA) in periods 26 November – 22 December (dry season) and 27 June 2009 (wet season).

Table 2: Phytoplankton community structure of mangrove swamps – closed Parwa (16 and 17), Typha swamps (4 and 5), freshwater herbaceous swamp and low swampwood (11 and 13), high swampwood (10 and 12) and the Calcutta oil production field (1 and 6), long dry season, 1-3 December 2008.

Calculations of species diversity (*H*) and evenness (*J*) are based on the number of individuals/L (*N*): *a* = 1-5 individuals/L, *ee* = 6-20 individual/L, *ra* = 21-50 individuals/L, *va* = 51-100 individuals/L and *m* = >100 individuals/L.

Phylum, *species*	*SOD1 / Gauge17*	*SOD2 / Gauge16*	*SOD3 / Gauge4*	*SOD4 / Gauge5*	*SOD5 / Gauge13*	*SOD6 / Gauge11*	*SOD7 / Gauge12*	*SOD8 / Gauge10*	*SOD9 / Gauge1*	*SOD10 / Gauge6*
Chrysophyta										
Achnanthes spec.1		*a*								
Actinella brasiliensis			*a*	*a*			*a*			
Cyclotella stelligera			*a*							
Cymbella turgida							*a*			
Dinobryon spec.						*a*				
Eunotia flexuosa									*a*	
Eunotia lunaris							*a*			
Eunotia monodon										*a*
Eunotia pectinalis	*a*									
Eunotia spec.1		*a*								
Eunotia spec.2				*a*						
Eunotia spec.4								*a*		
Eunotia spec.5								*a*		
Gomphonema augur			*a*							
Gomphonema gracile		*a*					*ee*	*a*		
Gyrosigma balticum		*a*								
Gyrosigma strigile			*a*	*a*						
Gyrosigma wansbeckii	*a*									
Hantzschia spec.							*a*			
Navicula oblonga								*a*		
Navicula spec.1					*a*					
Navicula spec.2								*a*		
Navicula spec.3									*a*	
Nitzschia acicularis			*ee*							
Nitzschia closterium	*a*	*a*	*ee*	*a*						
Nitzschia filiformis	*ee*		*ee*				*ee*	*ee*		
Nitzschia lacustris			*ee*							
Nitzschia obtusa	*a*	*ee*	*ra*	*a*						
Nitzschia obtusa var. *scalpelliformis*		*a*								
Nitzschia philippinarum			*ee*					*a*		
Nitzschia sigmoidea								*a*		*a*
Nitzschia spec.1	*a*									
Pinnularia gibba		*a*		*ee*				*a*		
Pinnularia nobilis										*a*
Pinnularia macilenta			*a*							
Pinnularia spec.								*a*		
Pinnularia streptoraphe										*a*
Pleurosigma angulatum	*a*	*a*		*a*						
Pleurosigma elongatum			*ra*							
Pleurosigma spec.1		*a*								
Pleurosigma spec.2								*a*		
Surirella spec.1			*a*							
Synedra ulna var. *oxyrhynchus*									*a*	
Synura spec.						*a*				
Euglenophyta										
Colacium gojdiscae				*a*		*ra*	*ra*			
Euglena acus	*ra*	*a*		*ra*	*ee*	*ee*	*ee*			
Euglena acus var. *pallida*							*ee*			
Euglena charkowiensis							*ee*			
Euglena clavata					*a*					
Euglena ehrenbergii	*a*	*a*	*a*							
Euglena gasterosteus	*a*						*ee*			
Euglena oblonga							*ra*			
Euglena oxyuris	*ee*			*a*	*ee*					
Euglena pusilla var. *longa*				*a*						
Euglena rostrifera	*ee*									
Euglena spathirhyncha	*ee*			*a*		*ee*	*ee*			
Euglena spec.1	*a*									
Euglena spirogyra	*a*					*a*				

Phylum, *species*	*SOD1 / Gauge17*	*SOD2 / Gauge16*	*SOD3 / Gauge4*	*SOD4 / Gauge5*	*SOD5 / Gauge13*	*SOD6 / Gauge11*	*SOD7 / Gauge12*	*SOD8 / Gauge10*	*SOD9 / Gauge1*	*SOD10 / Gauge6*
Euglena spirogyra var. *marchica*			*a*							
Euglena spirogyra var. *suprema*		*a*								
Lepocinclis mespiliformis						*ee*				
Lepocinclis ovum var. *dimidio-minor*					*ee*					
Lepocinclis ovum var. *discifera*				*a*						
Lepocinclis salina	*a*					*ee*				
Lepocinclis spec.1		*a*								
Phacus acuminatus							*a*	*a*		
Phacus gigas		*a*								
Phacus longicauda var. *insecta*		*a*								
Phacus longicauda var. *rotunda*	*a*									
Phacus orbicularis		*a*			*a*					
Phacus platalea	*ee*									
Phacus spec.1		*a*								
Phacus tortus			*a*							
Strombomonas ensifera					*a*					
Strombomonas gibberosa						*a*				
Strombomonas spec.1	*a*									
Strombomonas subcurvata										*a*
Trachelomonas abrupta		*a*						*a*		
Trachelomonas acanthophora					*va*	*ra*				
Trachelomonas allorgei			*a*			*a*				
Trachelomonas armata			*a*	*ra*	*a*	*a*	*a*	*a*		
Trachelomonas bernandinensis	*a*									
Trachelomonas globularis			*a*		*a*					
Trachelomonas hispida var. coronata								*a*		
Trachelomonas megalacantha					*a*					
Trachelomonas oblonga								*a*		
Trachelomonas spec.1			*a*							
Trachelomonas spec.2				*a*						
Trachelomonas volvocina	*ee*	*a*	*a*	*ee*	*a*	*ee*	*ra*	*a*		*a*
Chlorophyta										
Ankistrodesmus fractus				*a*						
Closterium gracile var. elongatum					*ee*		*ee*	*a*		
Closterium keutzingii			*ra*		*ee*			*a*		
Closterium macilentum							*ee*			
Closterium moniliferum		*a*								
Closterium setaceum					*ee*					
Closterium spec.1				*a*						
Closterium spec.2						*a*				
Cosmarium spec.1					*a*					
Cosmarium spec.2								*a*		
Eudorina elegans					*a*			*a*		
Mougeotia spec.1				*a*						
Mougeotia spec.2					*a*					
Mougeotia spec.3								*a*		
Pandorina morum				*a*	*a*	*a*		*a*		
Spirogyra spec.1					*a*					
Spirogyra spec.2								*a*		
Staurastrum spec.1					*a*					
Cyanophyta										
Anabeana spec.				*a*						
Lyngbya spec.				*a*						
Oscillatoria spec.1	*a*									
Oscillatoria spec.2		*a*								
Spirulina gigantea		*a*								
Total number of individuals per L (N)	*158*	*79*	*212*	*150*	*195*	*159*	*240*	*82*	*9*	*18*
Number of species (S)	*22*	*23*	*22*	*22*	*21*	*15*	*18*	*24*	*3*	*6*
Species diversity (H)	*2.696*	*3.030*	*2.592*	*2.511*	*2.350*	*2.289*	*2.592*	*3.076*	*1.099*	*1.792*
Evenness (J)	*0.872*	*0.966*	*0.839*	*0.812*	*0.772*	*0.845*	*0.897*	*0.968*	*1.000*	*1.000*

Table 3: Zooplankton in phytoplankton samples of mangrove swamps – closed Parwa (16 and 17), Typha swamps (4 and 5), mixed herbaceous to low swampwood (11 and 13), high swampwood (10 and 12) and the Calcutta oil production field (1 and 6) , long dry season, 1-3 December 2008.

a = 1-5 individuals/L, *ee* = 6-20 individual/L, *ra* = 21-50 individuals/L, *va* = 51-100 individuals/L and *m* = >100 individuals/L.

Taxon	SOD1 / gauge17	SOD2 / gauge16	SOD3 / gauge4	SOD4 / gauge5	SOD5 gauge13	SOD6 gauge11	SOD7 / gauge12	SOD8 / gauge10	SOD9 / gauge1	SOD10 / gauge6
Rotifera										
Brachionus spec.	*a*									
Colurella spec.				*a*						
Filinia terminalis						*a*				
Lecane bulla				*a*				*a*		
Lecane proiecta	*a*									
Lecane spec.					*a*					
Lepadella spec.				*a*						
Macrochaetus collinsi										
Mytilina ventralis								*a*		
Platyias patulus			*a*							
Polyathra spec.				*a*		*a*				
Rotifera						*a*				
Rotifera (eitjes)				*a*						
Testudinella patina patina								*a*		
Trichocerca spec.				*a*						
Copepoda										
Copepoda	*a*									
Cyclopoida			*a*							
Harpaticoidea	*a*									
Nauplius larve		*a*		*a*		*a*		*a*		
Cladocera										
Ceriodaphnia cornuta								*a*		
Cladocera					*a*	*a*	*a*			
Diaphanosoma spec.	*a*									
Rhizopoda										
Arcella vulgaris		*ra*	*ra*	*a*	*a*	*a*		*a*		
Centropyxis aculeata		*ee*	*a*					*a*		
Difflugia spec.1		*a*	*a*					*a*		
Difflugia spec.2			*a*					*a*		
Nebela spec							*a*			
Wailesella eboracensis							*a*			
Gastrotricha										
Neogossea spec.					a	a				
Ciliata										
Vorticella spec.							a			

Table 4: Aquatic macro-invertebrates in mangrove swamps – closed Parwa (gauges 16 and 17), Typha swamps (gauges 4 and 5), mixed herbaceous to low swampwood (gauges 11 and 13), high swampwood (gauges 10 and 12) and the Calcutta oil production field (ga uges 1 and 6) in Staatsolie's Tambaredjo and Calcutta concessions, Saramacca District, Suriname, based on numbers (N) and wet mass (M; in g); pooled samples of dry season (1-3 December 2008) and long rainy season (20-22 May 2009).

Taxon	SO1/gauge17		SO2/gauge16		SO3/gauge4		SO4/gauge5		SO5/gaug13		SO6/gage11		SO7/gauge12		SO8/gauge10		SO9/gauge1		SO10/gauge6		SO1-SO10 Total N		SO1-SO10 Total M(g)	
	N	M	N	M	N	M	N	M	N	M	N	M	N	M	N	M	N	M	N	M		%	(g)	%
Decapoda																								
Euryrhynchus sp.			2	0.5					7	0.7	3	0.3	1	0.1							13	0.79	1.6	0.39
Palaemonetes carteri	57	5	30	3.5	97	16	98	22	106	12	34	2.5	164	18	79	7	59	13	134	30	858	52.32	129	31.17
Trichodactylus spinifer													2	46	1	32					3	0.18	78	18.85
Gastropoda																								
Pomacae sp	2	24	11	54	5	10	10	5	7	2.5	4	24	7	24	4	24	3	12	1	1	54	3.29	180.5	43.62
Insecta																								
Coleoptera spp	1	0.1	1	0.1	1	0.2	2	0.4	1	0.1	1	0.1									7	0.43	1	0.24
Dytiscidae sp (larvae)							1	1							1	0.3					2	0.12	1.3	0.31
Belostoma sp			1	0.1	3	1	2	1	3	3	1	1			5	3					15	0.91	9.1	2.20
Ranatra sp					1	0.3			2	0.2			3	0.3	8	2	1	0.2			15	0.91	3	0.72
Hemiptera sp.					9	0.9	1	0.1	4	0.4	3	0.3	1	0.1	6	0.6	4	0.2	602	1.2	630	38.41	3.8	0.92
Odonata, Libellulidae	1	0.2	8	1	1	0.2	4	0.8	13	1.6	2	0.3	3	0.3	5	0.6	1	0.1	1	0.1	39	2.38	5.2	1.26
Odonata, Aeshnidae			2	1											1	0.2	1	0.1			4	0.24	1.3	0.31
total N/M(g)	61	29.3	55	60.2	117	28.6	118	30.3	143	20.5	48	28.5	181	88.8	110	69.7	69	25.6	738	32.3	1640	100.00	413.8	100.00

Table 5: Fish community structure of mangrove swamps – closed Parwa (gauges 16 and 17), Typha swamps (gauges 4 and 5), mixed herbaceous to low swampwood (gauges 11 and 13), high swampwood (gauges 10 and 12) and the Calcutta oil production field (gauge s 1 and 6) in Staatsolie's Tambaredjo and Calcutta concessions based on numbers (N) and wet mass (M; in g); pooled samples of dry season (1-3/12/2008) and long rainy season (20-22/05/2009).

Species	SO1/gauge17		SO2/gauge16		SO3/gauge4		SO4/gauge5		SO5/gauge13		SO6/gauge11		SO7/gauge12		SO8/gauge10		SO9/gauge1		SO10/gauge6		SO1-SO10 total N		SO1-SO10 total M	
	N	M	N	M	N	M	N	M	N	M	N	M	N	M	N	M	N	M	N	M		%	(g)	%
Ctenobrycon spilurus							2	2													2	0.16	2	0.00
Hemigrammus boesemani							1	1			1	0.5									2	0.16	1.5	0.00
Hemigrammus unilineatus					3	0.5	4	1.5	1	0.4	1	0.5	12	6							21	1.70	8.9	0.01
Pristella maxillaris	33	4	15	2.5	12	2	81	5.5	175	14	57	4	39	4	5	0.5	2	0.3	94	14	513	41.54	50.8	0.07
Crenuchus spilurus																	3	1.5			3	0.24	1.5	0.00
Curimata cyprinoides					2	266	1	150									1	78	4	736	8	0.65	1230	1.80
Hoplerythrinus unitaeniatus	4	906	6	1030									2	460							12	0.97	2396	3.51
Hoplias malabaricus	2	240	16	3900	7	1386	15	3580	6	1250	12	2800	26	5000	14	3300	3	650	10	2000	111	8.99	24106	35.32
Copella arnoldi			1	1							3	1	22	1.5	9	1					35	2.83	4.5	0.01
Trachelyopterus galeatus			4	400	6	670	9	932	13	1298	1	100	5	500			14	2100	5	500	57	4.62	6500	9.52
Callichthys callichthys	1	58																			1	0.08	58	0.08
Hoplosternum littorale	5	1046	23	2970	4	900			3	700	5	1350	4	600	1	150	1	128			46	3.72	7844	11.49
Rhamdia quelen									2	508											2	0.16	508	0.74
Loricariichthys maculatus							4	226													4	0.32	226	0.33
Nannacara anomala	1	0.2	3	1.1	14	4	1	0.3	15	4	8	2.5	5	2.5	5	0.5					52	4.21	15.1	0.02
Cichlasoma bimaculatum	5	176	10	637					1	1			8	730	5	450					29	2.35	1994	2.92
Crenicichla saxatilis					1	32															1	0.08	32	0.05
Krobia guianensis			1	90																	1	0.08	90	0.13
Eleotris pisonis	2	1																			2	0.16	1	0.00
Polycentrus schomburgkii	14	4	23	5	44	21	38	6	55	22	35	12	11	3.5	12	3	2	1	4	1	238	19.27	78.5	0.12
Megalops atlanticus	3	4400	5	4100	3	4400	2	4000			3	1200					1	5000			17	1.38	23100	33.84
Micropoecilia picta	1	1	6	1	24	2.5	8	1	5	0.6	3	1			15	2	4	0.5	3	0.5	69	5.59	10.1	0.02
Rivulus sp	1	1							3	1					5	1					9	0.73	3	0.00
Total N/M(g)	72	6837	113	13138	120	7684	166	8905	279	3799	129	5472	134	7308	71	3908	31	7959	120	32525	1235	100.0	68261	100.0
Number of species (*S*)	11		12		11		12		11		11		10		9		9		6					
Species diversity (*H*)	1.776	1.104	2.155	1.554	1.892	1.257	1.588	1.139	1.241	1.378	1.610	1.121	1.977	1.071	2.018	0.533	1.761	0.964	0.850	0.950				
Evenness (*J*)	0.741	0.460	0.867	0.625	0.789	0.524	0.639	0.458	0.518	0.575	0.671	0.467	0.859	0.465	0.918	0.243	0.801	0.439	0.474	0.530				

Table 6: Summary of fish communities of mangrove swamps – closed Parwa, Typha swamps, mixed herbaceous to low swampwood, high swampwood and the Calcutta oil production field in Staatsolie's Tambaredjo and Calcutta concessions based on numbers (N) and wet mass (M; in g); pooled samples of the long dry season (1-3 December 2008) and long rainy season (20-22 May 2009).

Order, family, ***species***	Closed mangrove forest (n=4)				*Typha* grass swamp (n=4)				Mixed herbaceous to low swampwood (n=4)				High swampwood (n=4)				Calcutta oil field (n=4)			
	N	N(%)	M	M(%)	N	N(%)	M	M(%)	N	N(%)	M	M(%)	N	N(%)	M	M(%)	N	N(%)	M	M(%)
Characiformes																				
Characidae																				
Ctenobrycon spilurus					2	0.70	2	0.01												
Hemigrammus boesemani					1	0.35	1	0.01	1	0.25	0.5	0.01								
Hemigrammus unilineatus					7	2.45	2	0.01	2	0.49	0.9	0.01	12	5.85	6	0.05				
Pristella maxillaris	48	25.95	6.5	0.03	93	32.52	7.5	0.05	232	56.86	18	0.19	44	21.46	4.5	0.04	96	63.58	14.3	0.13
Crenuchidae																				
Crenuchus spilurus																	3	1.99	1.5	0.01
Curimatidae																				
Curimata cyprinoides					3	1.05	416	2.51									5	3.31	814	7.26
Erythrinidae																				
Hoplerythrinus unitaeniatus	10	5.41	1936	9.69									2	0.98	460	4.10				
Hoplias malabaricus	18	9.73	4140	20.73	22	7.69	4966	29.93	18	4.41	4050	43.69	40	19.51	8300	74.00	13	8.61	2650	23.64
Lebiasinidae																				
Copella arnoldi	1	0.54	1	0.01					3	0.74	1	0.01	31	15.12	2.5	0.02				
Siluriformes																				
Auchenipteridae																				
Trachelyopterus galeatus	4	2.16	400	2.00	15	5.24	1602	9.66	14	3.43	1398	15.08	5	2.44	500	4.46	19	12.58	2600	23.19
Callichthyidae																				
Callichthys callichthys	1	0.54	58	0.29																
Hoplosternum littorale	28	15.14	4016	20.11	4	1.40	900	5.43	8	1.96	2050	22.11	5	2.44	750	6.69	1	0.66	128	1.14
Heptapteridae																				
Rhamdia quelen									2	0.49	508	5.48								
Loricariidae																				
Loricariichthys maculatus					4	1.40	226	1.36												
Perciformes																				
Cichlidae																				
Nannacara anomala	4	2.16	1.3	0.01	15	5.24	4.3	0.03	23	5.64	6.5	0.07	10	4.88	3	0.03				
Cichlasoma bimaculatum	15	8.11	813	4.07					1	0.25	1	0.01	13	6.34	1180	10.52				

Order, family, ***species***	Closed mangrove forest (n=4)				*Typha* grass swamp (n=4)				Mixed herbaceous to low swampwood (n=4)				High swampwood (n=4)				Calcutta oil field (n=4)			
	N	N(%)	M	M(%)	N	N(%)	M	M(%)	N	N(%)	M	M(%)	N	N(%)	M	M(%)	N	N(%)	M	M(%)
Crenicichla saxatilis					1	0.35	32	0.19												
Krobia guianensis	1	0.54	90	0.45																
Eleotridae																				
Eleotris pisonis	2	1.08	1	0.01																
Polycentridae																				
Polycentrus schomburgkii	37	20.00	9	0.05	82	28.67	27	0.16	90	22.06	34	0.37	23	11.22	6.5	0.06	6	3.97	2	0.02
Miscellaneous groups																				
Megalopidae																				
Megalops atlanticus	8	4.32	8500	42.55	5	1.75	8400	50.64	3	0.74	1200	12.94					1	0.66	5000	44.60
Poeciliidae																				
Micropoecilia picta	7	3.78	2	0.01	32	11.19	3.5	0.02	8	1.96	1.6	0.02	15	7.32	2	0.02	7	4.64	1	0.01
Rivulidae																				
Rivulus sp	1	0.54	1	0.01					3	0.74	1	0.01	5	2.44	1	0.01				
Total N/M(g)	185	100.00	19974.8	100.00	286	100.00	16589.3	100.00	408	100.00	9270.5	100.00	205	100.00	11215.5	100.00	151	100.00	11210.8	100.00
Number of species (*S*)	15				14				14				12				9			
Species diversity (*H*)	2.133		1.498		1.878		1.273		1.414		1.448		2.177		0.928		1.288		1.294	
Evenness (*J*)	0.788		0.553		0.712		0.482		0.536		0.549		0.876		0.373		0.586		0.589	

APPENDIX D: OVERVIEW OF TAMBAREDJO NW BIRDS

Table 7: Status of occurrence found during surveys and status of occurrence in the freshwater swamp zone (Ottema et al).

LEGEND: **Type of observation: X=seen, O=heard** **Frequency: C=common, U=uncommon, R=rare**			**type of observation**	**frequency**	
Taxonomy /scientific names	**English names**	**Local names (Surinamese and Dutch)**		**this survey**	**fresh water swamps**
ARDEIDAE					
Ardea cocoi	White-necked Heron	Kumawari	X	R	C
Ardea alba	Great Egret	Galin	X	R	C
Egretta thula	Snowy Egret	Witi Sabaku	X	U	C
Egretta caerulea	Little Blue Heron	Blaw Sabaku	X	U	C
Egretta tricolor	Tricoloured Heron	Drikloru Sabaku	X	U	C
Butorides striatus	Striated Heron	Tjon tjon	X	C	C
Bubulcus ibis	Cattle Egret	Kaw Sabaku	X	R	C
Nycticorax nycticorax	Black-crowned Night-Heron	Blaka-ede Dikkop	X	R	U
Ixobrychus involucris	Stripe-backed Bittern	Gestreept Wouwaapje	X	R	R
Ixobrychus exilis	Least Bittern	Kleinst Wouwaapje	X	C	U
Botaurus pinnatus	Pinnated Bittern	Zuidamerikaanse Roerdomp	X	U	R
CICONIIDAE					
Mycteria americana	American Wood-Stork	Nengre Kopu	X	U	C
THRESKIORNITHIDAE					
Mesembrinibis cayennensis	Green Ibis	Grun Korokoroko	X	C	C
Eudocimus ruber	Scarlet Ibis	Redi Korokoroko	X	U	C
ANATIDAE					
Cairina moschata	Muscovy Duck	Bosdoks	X	R	U
CATHARTIDAE					
Coragyps atratus	Black Vulture	Blaka-ede Tingi-fowru	X	C	C
Cathartes aura	Turkey Vulture	Redi-ede Tingi-fowru	X	C	C
Cathartes burrovianus	Lesser Yellow-headed Vulture	Pikin Geri-ede Tingi-fowru	X	C	C
Cathartes melambrotus	Greater Yellow-headed Vulture	Bigi Geri-ede Tingi-fowru	X	U	C
ACCIPITRIDAE					
Chondrohierax uncinatus	Hook-billed Kite	Haaksnavel Wouw	X	R	U
Rostrhamus sociabilis	Snail Kite	Pakro Aka	X	C	C
Rostrhamus hamatus	Slender-billed Kite	Busi Pakro Aka	X	C	C
Buteo magnirostris	Roadside Hawk	Weg Buizerd	X	C	C
Busarellus nigricollis	Black-collared Hawk	Moeras Buizerd	X	C	C
Buteogallus aequinoctialis	Rufous Crab-Hawk	Krabu Aka	X	C	C
Circus buffoni	Long-winged Harrier	Zuidamerikaanse Kiekendief	X	U	C

LEGEND: **Type of observation: X=seen, O=heard** **Frequency: C=common, U=uncommon, R=rare**			**type of observation**	**frequency**	
Taxonomy /scientific names	**English names**	**Local names (Surinamese and Dutch)**		**this survey**	**fresh water swamps**
FALCONIDAE					
Milvago chimachima	Yellow-headed Caracara	Tingi-fowru Aka	X	C	C
Caracara cheriway	Crested Caracara	Gekuifde Tingi-fowru Aka	X	R	C
Falco columbarius	Merlin	Smelleken	X	R	R
CRACIDAE					
Ortalis motmot	Little Chachalaca	Wakago	O	R	C
ARAMIDAE					
Aramus guarauna	Limpkin	Kraw kraw	X	C	C
RALLIDAE					
Pardirallus maculatus	Spotted Rail	Gevlekte Ral	X	R	R
Porzana albicollis	Ash-throated Crake	Grijskeel Ral	X	C	C
Laterallus exilis	Gray-breasted Crake	Grijsborst Ral	O	C	U
Porphyrula martinica	Purple Gallinule	Blaw Kepanki	X	C	C
JACANIDAE					
Jacana jacana	Wattled Jacana	Brown Kepanki	X	C	C
CHARADRIIDAE					
Charadrius semipalmatus	Semipalmated Plover	Amerikaanse Bontbekplevier	X	R	C
SCOLOPACIDAE					
Tringa solitaria	Solitary Sandpiper	Amerikaanse Bosruiter	X	R	C
Tringa flavipes	Lesser Yellowlegs	Pikin Toriman	X	R	C
Tringa melanoleuca	Greater Yellowlegs	Bigi Toriman	X	R	C
Calidris pusilla	Semipalmated Sandpiper	Grijze strandloper	X	R	C
COLUMBIDAE					
Columba cayennensis	Pale-vented Pigeon	Mangro Doifi	O	C	C
Columbina talpacoti	Ruddy Ground-Dove	Ston Doifi	X	C	C
Leptotila verreauxi	White-tipped Dove	Sabana Paska Doifi	X	U	U
PSITTACIDAE					
Aratinga pertinax	Brown-throated Parakeet	Karu prakiki	X	C	C
Forpus passerinus	Green-rumped Parrotlet	Okro prakiki	X	C	C
Amazona ochrocephala	Yellow-crowned Parrot	Geelkop amazone	X	R	R
Amazona amazonica	Orange-winged Parrot	Kule kule	X	C	C
CUCULIDAE					
Piaya minuta	Little Cuckoo	Kleine koekoek	X	C	C
Crotophaga major	Greater Ani	Busi Kawfutuboy	X	C	C
Crotophaga ani	Smooth-billed Ani	Kawfutuboy	X	C	C
Tapera naevia	Striped Cuckoo	Drey Ten	X	C	C

LEGEND: **Type of observation: X=seen, O=heard** **Frequency: C=common, U=uncommon, R=rare**			**type of observation**	**frequency**	
				this survey	**fresh water swamps**
Taxonomy /scientific names	**English names**	**Local names (Surinamese and Dutch)**			
APODIDAE					
Chaetura brachyuran	Short-tailed Swift	Kortstaart Gierzwaluw	X	C	C
TROCHILIDAE					
Polytmus guainumbi	White-tailed Goldenthroat	Witstaart Goukeelkolibrie	X	C	U
Amazilia fimbriata	Glittering-throated Emerald	Grunneki Korke	X	U	C
ALCEDINIDAE					
Megaceryle torquata	Ringed Kingfisher	Kwata kwata	X	C	C
Chloroceryle aenea	Pygmy Kingfisher	Zuidamerikaande dwergijsvogel	X	C	C
BUCCONIDAE					
Bucco tamatia	Spotted Puffbird	Gevlekte Dikbek	O	U	U
RAMPHASTIDAE					
Ramphastos toco	Toco Toucan	Reuzentoekan	X	R	U
PICIDAE					
Picumnus minutissimus	Arrowhead Piculet	Surinaamse Dwergspecht	O	C	C
Chrysoptilus punctigula	Spot-breasted Woodpecker	Gevlekte Groene Specht	X	C	U
Celeus flavus	Cream-coloured Woodpecker	Roomkleurige Specht	X	C	U
Veniliornis sanguineus	Blood-colored Woodpecker	Redi baka Temreman	O	C	C
Campephilus melanoleucos	Crimson-crested Woodpecker	Crimsongekuifde Specht	X	C	U
DENDROCOLAPTIDAE					
Xiphorhynchus picus	Straight-billed Woodcreeper	Letimofo Subiman	O	C	C
Xiphorhynchus guttatus	Buff-throated Woodcreeper	Grote Gestreepte Houtkruiper	O	C	C
FURNARIIDAE					
Synallaxis albescens	Pale-breasted Spinetail	Bleekborst Fityo	O	C	C
Synallaxis gujanensis	Plain-crowned Spinetail	Bruine Fityo	O	C	C
Certhiaxis cinnamomea	Yellow-throated Spinetail	Gerineki Fityo	O	C	C
THAMNOPHILIDAE					
Taraba major	Great Antshrike	Grote Mierklauwier	O	R	C
Sakesphorus canadensis	Black-crested Antshrike	Blaka borsu Peprefowru	X	C	C
Thamnophilus doliatus	Barred Antshrike	Koko	O	C	C
Cercomacra nigrescens	Blackish Antbird	Blaka Mirafowru	O	R	C
Myrmoborus leucophrys	White-browed Antbird	Witte wenkbrouw	O	R	U

LEGEND: **Type of observation: X=seen, O=heard** **Frequency: C=common, U=uncommon, R=rare**			**type of observation**	**frequency**	
Taxonomy /scientific names	**English names**	**Local names (Surinamese and Dutch)**		**this survey**	**fresh water swamps**
		Miervogel			
Sclateria naevia	Silvered Antbird	Zilver Miervogel	O	C	C
Myrmeciza atrothorax	Black-throated Antbird	Blaka borsu Mirafowru	O	C	C
TYRANNIDAE					
Fluvicola pica	Pied Water-Tyrant	Katoenvogeltje	X	C	C
Arundinicola leucocephala	White-headed Marsh-Tyrant	Witi-ede Gotromotjo	X	C	C
Tyrannus melancholicus	Tropical Kingbird	Kronto Grikibi	X	C	C
Legatus leucophaius	Piratic Flycatcher	Piraten Tyran	X	C	C
Megarynchus pitangua	Boat-billed Flycatcher	Bigimofo Grikibi	X	U	C
Myiozetetes cayanensis	Rusty-margined Flycatcher	Marechaussee Grikibi	X	C	C
Pitangus sulphuratus	Great Kiskadee	Grikibi	X	C	C
Philohydor lictor	Lesser Kiskadee	Pikin Grikibi	X	U	C
Attila cinnamomeus	Cinnamon Attila	Kufleur	O	U	C
Myiarchus ferox	Short-crested Flycatcher	Kortkuif Tyran	O	C	C
Cnemotriccus fuscatus	Fuscous Flycatcher	Moeras Tyran	O	R	U
Tolmomyias flaviventris	Yellow-breasted Flatbill	Geelbuik Platsnavel	O	C	C
Todirostrum cinereum	Commmon Tody-Flycatcher	Bakba Titri	X	C	C
Todirostrum maculatum	Spotted Tody-Flycatcher	Peni Titri	O	C	C
Inezia caudata	Pale-tipped Inezia	Bleektip Inezia	O	C	C
Elaenia flavogaster	Yellow-bellied Elaenia	Witkuif Tityari	O	C	C
Phaeomyias murina	Mouse-coloured Tyrannulet	Popioli	O	C	C
Camptostoma obsoletum	Southern Beardless-Tyrannulet	Zuidelijke Baardloze Dwergtyran	X	C	C
Pachyramphus polychopterus	White-winged Becard	Witvleugel Bekarde	O	C	C
HIRUNDINIDAE					
Tachycineta albiventer	White-winged Swallow	Liba Zwaluw	X	C	C
Progne chalybea	Gray-breasted Martin	Greysiborsu Zwaluw	X	C	C
Hirundo rustica	Barn Swallow	Boerenzwaluw	X	C	C
TROGLODYTIDAE					
Donacobius atricapillus	Black-capped Donacobius	Kap Donacobius	X	C	C
Thryothorus leucotis	Buff-breasted Wren	Busi Gadotjo	O	C	C
Troglodytes aedon	House Wren	Gadofowru	O	C	C
SYLVIIDAE					
Polioptila plumbea	Tropical Gnatcatcher	Tropische Vliegenpikker	O	C	C
EMBERIZIDAE					
Sporophila americana	Wing-barred Seedeater	Djak	X	C	C

LEGEND: Type of observation: X=seen, O=heard Frequency: C=common, U=uncommon, R=rare			type of observation	frequency	
Taxonomy /scientific names	**English names**	**Local names (Surinamese and Dutch)**		**this survey**	**fresh water swamps**
Sporophila minuta	Ruddy-breasted Seedeater	Oranka	X	U	U
Volatinia jacarina	Blue-black Grassquit	Srio	O	C	C
CARDINALINAE					
Saltator coerulescens	Grayish Saltator	Grijze Saltator	O	C	C
THRAUPIDAE					
Conirostrum bicolor	Bicolored Conebill	Tweekleurige Spitssnavel	X	U	C
Tangara mexicana	Turquoise Tanager	Turquoise Tangare	X	C	C
Euphonia finschi	Finsch's Euphonia	Blawdas Kanari	X	R	U
Thraupis episcopus	Blue-gray Tanager	Blawforki	X	C	C
Ramphocelus carbo	Silver-beaked Tanager	Redi Kin	X	C	C
Tachyphonus rufus	White-lined Tanager	Blaka Kin	X	C	C
PARULIDAE					
Dendroica aestiva	Yellow Warbler	Koprofowru	X	U	C
Geothlypis aequinoctialis	Masked Yellowthroat	Blakafesi Titri	X	C	C
VIREONIDAE					
Hylophilus pectoralis	Ashy-headed Greenlet	Grijskop Groentje	O	C	C
ICTERIDAE					
Molothrus bonariensis	Shiny Cowbird	Putter	X	C	C
Psarocolius decumanus	Crested Oropendola	Pon pon	X	C	C
Agelaius icterocephalus	Yellow-hooded Blackbird	Geri-ede	X	C	C
Icterus nigrogularis	Yellow Oriole	Banafowru	X	C	C

Table 8: Results of aerial counts of bird colonies (May 28, 2009)

Species	Coordinates	# of couples
Egrets	N 05˚58'05.4", W 055˚20'06.1"	90
Egrets	N 06˚00'02.1", W 055˚32'39.6"	900
Egrets	N 05˚59'48.1", W 055˚37'50.1"	2200
Egrets	N 05˚59'16.8", W 055˚45'24.2"	75
Egrets	N 05˚59'00.0", W 055˚48'36.7"	1200
Scarlet Ibis	N 05˚57'16.7", W 055˚55'11.0"	7500
Egrets	N 05˚54'17.6", W 055˚56'32.9"	150

APPENDIX E: MAMMALS, REPTILES & AMPHIBIANS OF THE TAMBAREDJO NW AREA AND SURROUNDINGS

TAXONOMY SCIENTIFIC NAMES	ENGLISH NAMES	LOCAL NAMES (SURINAMESE AND DUTCH)	STATUS
MAMALIA	**MAMMALS**	**ZOOGDIEREN**	
ORDER (=O)			
PRIMATES	**PRIMATES**	**PRIMATEN**	
Family Cebidae	**Monkeys**	**Apen**	
Alouatta seniculus	Red Howler Monkey	Babun, Brulaap	common
Cebus apella	Brown Capuchin	Kekskesi, Bruine Capucijneraap	common
Saimira sciureus	Squirrel Monkey	Monkimonki, Doodskopaapje	common
O. EDENTATA		**TANDARMEN**	
Family Mymecophagidae	**Anteaters**	**Miereneters**	
Myrmecophaga tridactyla	Giant Anteater	Tamanwa, Grote miereneter	rare
O. CARNIVORA	**CARNIVORES**	**ROOFDIEREN**	
Family Procionidae			
Procyon cancrivorus	Crab-eating Raccoon	Krab'dagu, Wasbeer	very common
Family Mustelidae	**Mustelids**		
Lutra ennudris	Guiana Otter	Watradagu, Zwampotter	common
Family Felidae	**Cats**	**Katachtigen**	
Puma concolor	Puma	Reditigri, Poema	common
Panthera onca	Surinamese Jaguar	Penitigri, Jaguar	common
O. ARTIODACTYLA	**EVEN-TOED UNGULATES**	**EVENHOEVIGEN**	
Family Cervidae	**Deer**	**Herten**	
Odocoileus vriginianus	White-tailed Deer	Wojodia, Strandhert	rather common
O. RODENTIA	**RODENTS**	**KNAAGDIEREN**	
Family Hydrochaeridae	**Capybaras**	**Capibara's**	
Hydrochaeris hydrochaeris	Capybara	Kapuwa, Capybara	common
Family Dasyproctidae	**Agoutis**	**Goudhazen**	
Dasyprocta leporina	Orange-rumped Agouti	Konkoni, Agoeti	common

TAXONOMY SCIENTIFIC NAMES	ENGLISH NAMES	LOCAL NAMES (SURINAMESE AND DUTCH)	STATUS
HERPETOFAUNA	**REPTILES AND AMPHIBIANS**	**REPTIELEN EN AMPHIBIEEN**	
O. TESTUDINAES	**TURTLES**	**SCHILDPADDEN**	
Rhinoclemmys punctularia	Galap	Arakaka, moerasschildpad	common
O. CROCODYLIA	**CROCODILIA**	**KOKODILLEN**	
Caiman crocodilus	Spectacled caiman	Kaiman, Brilkaaiman	common
O. SQUAMATA	**LIZARDS AND SNAKES**	**HAGEDISSEN EN SLANGEN**	
Iguana iguana	Iguana	Legu, Legwana, Leguaan	common
Anolis auratus	Grass Anolis	Gras anolis	common
Cnemidophorus lemniscatus	Whiptail Lizard	Strandhagedis	common
Tupinambis nigropunctatus	Tegu Lizard	Sapakara, Grote Teju	common
Eunectes mutinus	Anaconda	Aboma, Anaconca	common
Helicops angulata	Red-bellied Water Snake	Watrasneki	common
Bothrops atrox	Fer de Lance	Owrukuku, Labaria, Rasper, Lanspuntslang	common
O. ANURA	**FROGS AND TOADS**	**KIKKERS EN PADDEN**	
Bufo marinus	Giant Toad	Bigitodo, Reuzenpad	common
Hyla rubra	Tree Frog	Papitodo	common
Pipa pipa	Pipa Toad	Pipatodo, Swamputodo, Surinaamse pad	common
Pseudis paradoxus	Paradoxal Frog	Tododyaki	rather common

APPENDIX F: STAKEHOLDER CONSULTATION

F-1: Public announcement

STAATSOLIE

Staatsolie Maatschappij Suriname N.V.
State Oil Company Suriname

Staatsolie Maatschappij Suriname N.V. is een geïntegreerde oliemaatschappij die zich bezig houdt met exploratie, productie, transport, raffinage en verkoop van crude en petroleumproducten. Ook bevordert Staatsolie actief de ontwikkeling van het Surinaamse aardoliepotentieel. Op zeven bedrijfslocaties verspreid over Saramacca, Paramaribo en Wanica zetten ruim 655 gemotiveerde medewerkers zich dagelijks in voor de verdere ontwikkeling van de nationale petroleumindustrie.

Vertrouwen in Eigen Kunnen

BEKENDMAKING

PARTICIPATIE MILIEUEFFECTENRAPPORTAGE OLIEPRODUCTIE-ACTIVITEITEN IN TAMBAREDJO-NOORDWEST-OLIEVELD

Staatsolie Maatschappij Suriname N.V. (Staatsolie) is van plan olieproductie-activiteiten uit te voeren in het nieuwe Tambaredjo-Noordwest-olieveld in het district Saramacca. Voordat hiertoe wordt overgegaan, dient er volgens de richtlijnen van het Nationaal Instituut voor Milieu en Ontwikkeling in Suriname (NIMOS) eerst een milieu-effecten rapportage (mer) uitgevoerd te worden.

Belanghebbenden worden uitgenodigd om tijdens de voorbereidende fase van deze studie hun commentaar en/of suggesties over de '*Terms of Reference*' voor de milieu-effecten rapportage schriftelijk kenbaar te maken. Deze bevindingen zullen worden meegenomen in de rapportage. De '*Terms of Reference*' ligt voor het publiek ter inzage bij het hoofdkantoor van Staatsolie en bij het NIMOS.

Schriftelijke reacties kunnen tot en met **3 mei 2008** worden gericht aan:
Mevr. Karin Lie-A-Kwie
Environmental Engineer
HSEQ Divisie
- Dr. Ir. H.S. Adhinstraat 21, Paramaribo, of
- Gangaram Pandayweg km 5½, district Saramacca
of per e-mail: klieakwie@staatsolie.com

PUBLIC ANNOUNCEMENT

PARTICIPATION ENVIRONMENTAL IMPACT ASSESSMENT OIL PRODUCTION ACTIVITIES IN TAMBAREDJO NORTH-WEST OIL FIELD

State Oil Company Suriname (Staatsolie) is required by the National Institute for Environment and Development in Suriname (NIMOS) to undertake an Environmental Impact Assessment (EIA) for its planned oil production expansion activities in the new Tambaredjo North-West Oilfield in the Saramacca District.

At this scoping stage stakeholders are invited to submit in writing any issue and/or concerns they wish to be considered in the Terms of Reference for the EIA. This Terms of Reference is available at the Staatsolie Main Office and NIMOS.

Submissions may be made untill May 3, 2008 to:
Mrs. Karin Lie-A-Kwie
Environmental Engineer
HSEQ Division
- Dr. Ir. H.S. Adhinstraat 21, Paramaribo or
- Gangaram Pandayweg km 5½, district Saramacca
or by e-mail: klieakwie@staatsolie.com

F-2: Interviewed persons

Name	Organization/Function	Method	Date	Topic
Jaroenaeme	*Bestuursopzichter* - Governmental supervisor	meeting	16-Jan-09	Data collection socio-economy and impacts on local population and landuse
Gayadhar,	*Bestuursopzichter* - Governmental supervisor	meeting	16-Jan-09	Data collection socio-economy and impacts on local population and landuse
Soekelal	*Bestuursopzichter* - Governmental supervisor	meeting	16-Jan-09	Data collection socio-economy and impacts on local population and landuse
Mr. Debipersad	Resort council members	meeting	16-Jan-09	Data collection socio-economy and impacts on local population and landuse
Raghoenath	Local contractors firm	interview	16-Jan-09	Employment of local and outside people by Staatsolie
Bissesar, Kailash S.	Public Relations Staatsolie	interview/e-mail	28-Jan-09	Staatsolie community relations strategy and activities related to its social corporate responsibility program
H. Poeran	large rice farmer	interview	30-Jan-09	Data collection socio-economy and impacts on local population and landuse
Debi Tewari	large rice farmer (wife)	interview	30-Jan-09	Data collection socio-economy and impacts on local population and landuse
Jaroenaeme	*Bestuursopzichter* - Governmental supervisor	telephone	Jan-Feb 2009	Data collection socio-economy and impacts on local population and landuse
Drakensteyn, B.	Nature Conservation Division of LBB (head)	meeting	2-Feb-09	Coppename-monding Nature Reserve and North Saramacca MUMA
Pluvier, D.	WWF - regional representative	meeting	17-Mar-09	Impacts on ecosystems and environmental management
Ramdhani (rayon leader) Badjasing Ismael Gummels Debipersad	Ministry of Agriculture - rayon Gangaram Pandayweg	meeting	29-Jun-09	Data collection and impacts on agriculture, land and water use and infrastructure

F-3: Stakeholders Meeting Tam NW Production Development Project

List of invited stakeholders

Districtsbestuur & Autoriteiten

1	Districtscommissaris Saramacca Mevr. M. Ghisaidoobe Districtskantoor Groningen Saramacca	2	Districtssecretaris *1.1.1.1 Dhr. S. Lemmert* Districtscommissariaat Groningen
3	Ressortleider Huwelijkszorg De Bestuursopzichter BO-kantoor Gangaram Pandayweg Huwelijkszorg Saramacca	4	Korpspolitie Suriname-Gewest Saramacca De GPK Dhr. K. Emanuels Groningen Saramacca
5	Korps Brandweer Suriname-Gewest Saramacca Dhr. O. Sluer Commandant Groningen Saramacca	6	Ministerie van LVV Dhr. R. Martodimedjo Ressortleider Saramacca Tibitiweg Groningen Saramacca
7	Ministerie van Openbare Werken Dhr. R. Ronomedjo Sectiehoofd Saramacca Landingstraat Groningen Saramacca	8	Stg. Regionale Gezondheidsdienst Dhr. J. Mahabier Arts P/a RGD-poli Groningen Groningen Saramacca
9	Stg. Regionale Gezondheidsdienst Dhr. S. Mohan Arts P/a RGD-poli Groningen Groningen Saramacca	10	Stg. Regionale Gezondheidsdienst Dhr. P. Ramautar Arts P/a RGD-poli Tijgerkreek Groningen Saramacca
11	Stg. Regionale Gezondheidsdienst Mw. G. Ramautar-Birdja Arts P/a RGD-poli Tijgerkreek Groningen Saramacca		

Volksvertegenwoordigers Saramacca

12	Dhr. M. Jogi DNA-lid Geraniumstraat 1 Groningen Saramacca	13	Dhr. S. Malhoe DNA-lid Calcutta perc. 407 Groningen Saramacca
14	Dhr. J. Sital DNA-lid Chandi Shawweg 214 Saramacca	15	Districtsraad Saramacca D.t.k.v. Dhr. A. Kasi Ondervoorzitter P/a Milieubeheer Saramacca Kantorencomplex Calcutta Saramacca

Andere autoriteiten

17	NIMOS Mw. M. Harris Directeur Onafhankelijkheidsplein 2 Paramaribo	18	NIMOS Dhr. C. Nelom B.Sc. Director EME Onafhankelijkheidsplein 2 Paramaribo
19	Ministerie van Ruimtelijke Ordening, Grond- en Bosbeheer Mw. Ing. M. Djosetro, MPA Wnd. OD Bosbeheer/Hoofd LBB Cornelis Jongbawstraat 10-12 Paramaribo	20	Ministerie van Ruimtelijke Ordening, Grond- en Bosbeheer Dhr. B. Drakenstein Wnd. Hoofd Natuurbeheer Cornelis Jongbawstraat 10-12 Paramaribo

Internationale organisaties

21	World Wild Life Fund Dhr. D. Plouvier Director H. Arronstraat 63 boven Paramaribo	22	Conservation International Suriname Mw. A. Tjon Sie Fat Directeur Kromme Elleboogstraat 20 Paramaribo

Perceel eigenaren en bewoners

Alle bewoners langs de Gangaram Pandayweg tussen km 17-20

MAATSCHAPPIJ SURINAME N.V.
STATE OIL COMPANY SURINAME N.V.
P.O.BOX 4069 FLORA, DR. IR. H.S. ADHINSTRAAT 21, PARAMARIBO-SURINAME TEL.: 499649 FAX: 491105

Onderwerp: *Uitnodiging*
Subject

Kenmerk :
Our reference

Bijlage: *Agenda*
Enclosure *Samenvatting Milieu Effecten Rapportage*

Aan:
De buurtbewoners
Gangaram Pandayweg km. 10-14

Paramaribo, 4 december 2009

Geachte buurtbewoner,

De Directie van Staatsolie Maatschappij Suriname N.V. heeft het genoegen u uit te nodigen voor een stakeholdersbijeenkomst waarop de voorgenomen activiteiten in het kader van de productieontwikkeling van het Tambaredjo-Noordwest olieveld zullen worden belicht. Tijdens de presentatie zullen de technische aspecten van het project en de resultaten van de uitgevoerde Milieu Effecten Rapportage met u worden gedeeld.

Datum : woensdag 15 december 2009

Tijd : 1.00 uur – 3.00 uur 's middags

Plaats : Sarah Maria, Conference Training Facility, Conference Room 4

Gangaram Pandayweg km 5½

District Saramacca

Aangehecht doen wij u toekomen de agenda van de bijeenkomst en de samenvatting van het conceptrapport "Milieu en Sociale Effecten Rapportage Betreffende Ontwikkeling Tambaredjo-Noordwest". Uw commentaar en suggesties betreffende het bovengenoemd document kunt u van tevoren opsturen naar Staatsolie ter attentie van mw. K. Lie A Kwie (480501 tst. 62428 of klieakwie@staatsolie.com) of tijdens de presentatie bespreken.

Uw aanwezigheid wordt zeer op prijs gesteld.

Hoogachtend,

_____

M.C.H. Waaldijk

Algemeen Directeur

STAATSOLIE
MAATSCHAPPIJ SURINAME N.V.
STATE OIL COMPANY SURINAME N.V.

P.O.BOX 4069 FLORA, DR. IR. H.S. ADHINSTRAAT 21, PARAMARIBO-SURINAME TEL.: 499649 FAX: 491105

Agenda stakeholders meeting
Tambaredjo-Noordwest Production Development Project

Datum : dinsdag 15 december 2009

Tijd : 13.00-15.00 uur

Plaats : Sarah Maria, Conference Training Facility, Conference Room 4

Adres : Gangaram Pandayweg km 5½
District Saramacca

13.00 u.	Welkom en introductie
13.05-13.15	Overzicht van productieactiviteiten van Staatsolie G. Sairras – Directeur Production & Development
13.15 – 13.40 u.	Overzicht van geplande activiteiten in het kader van Tambaredjo-NW Production Development Project Mw. L. Mwakipesile-Arnon – Project Team Leader
13.40 – 14.10 u.	Resultaten en aanbevelingen Milieu Effecten Rapportage Mw. K. Lie-A-Kwie, Act. Environmental Administrator
14.10 – 14.30 u.	Gelegenheid tot het stellen van vragen
14.30 u.	Afsluiting
14.30 – 15.00 u.	Informeel samenzijn

Stakeholder meeting EIA Tambaredjo NW: Questions/remarks and response

Location: Sarah Maria, Conference Training Facility (Conference room 3)
Date: Tuesday December 15, 2009
Time: 13-15 h

Name	Question	Answer
Mr. Humbert Eersel –local resident	Is exploration going on elsewhere?	Mr. Sairras: yes (Weg naar Zee, Commewijne and Coesewijne). But it takes over 2 years to actually develop a field after oil has been indicated.
	Indicates that the area south of the Gangaram Panday road is frequently flooded by the Saramacca River. Could Staatsolie assist in improvement of protection works?	Staatsolie is not the authority for this, but this should be brought to the attention of the DC/BO.
	Will there be more employment from the Tambaredjo NW development?	Mr. Sairras: very little, because workers will be transferred from other locations; estimate 15 persons
Mr. Geurts – local resident	Points to the increase in traffic on the Gangaram Panday road leading to a bumpy road. Maintenance by Staatsolie is insufficient.	Mr. Sairras indicates that Staatsolie does it part regarding maintenance and that Staatsolie also has a budget for repairs/rehabilitation, but others damage the road and do nothing.
	Complaints about the fact that (noisy) transportation of pipes occasionally takes place in the evening and also on Sunday	Mr. Sairras is not aware of this, but will investigate and take action when appropriate
	Complaints about the dust in dry periods. A lower speed could help, but the speed limit of 40 km is not kept (also not by Staatsolie cars).	Mr. Sairras agrees that the speed is sometimes too high. He promises to take action
Mr. Debitewari – rice farmer	Ask for clarification on the fate of produced water; is afraid that this will end up in the swamp and thus affect the irrigation water quality from this source	Mrs. Lie A Kwie: the produced water does not end up in the swamp, because it is only removed at TA-58, from where it is directed to the Saramacca River.
Mr. Birdjasingh – local resident	Asks for the distance between the Tambaredjo NW field and the river.	D. Noordam: 4 km at nearest point
	Will there be an increase in employment due to the project?	See above
Mr. Debitewari –rice farmer	What is the risk of salt intrusion from the sea for the rice farmers?	D. Noordam: In the southern section of the swamp there is only fresh water; the nearest saline water zone is north of the project area and the project area is not connected with this zone. The risk of salinization from this sea is therefore absent

ANNEX G: REFERENCES TAMBAREDJO NORTH-WEST

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APPENDIX H: CORRESPONDENCE WITH IUCN

In 2006 the botanist Pieter Teunissen presented feedback to the IUCN Redlist about critically endangered, endangered and vulnerable trees in Suriname. The correspondence included:

- **Virola surinamensis**
- **Vouacapoua americana**.
- **Couratari guianensis**
- **Cedrela odorata**

Of these trees *Virola surinamensis* is found in the study area. According to the Redlist this species is classified as Endangered.

The comment by Teunissen was as follows:

- **Virola surinamensis** is not "Endangered" at all; it is one of the most common trees in Lowland Suriname, present in almost all forest types, even in secondary forest.

As of April 2010, this comment has been included in the Redlist (http://www.iucnredlist.org/apps/redlist/details/33959/0) as follows:

Population [top]

Population:	Although the species is listed as globally threatened it is one of the most common trees in lowland Suriname being found in almost all forest types, including secondary forest (P. Teunissen pers. comm. 2006).