SPE 86683

Chad Export Project: Environmental Protection Measures

Kelly J. Moynihan;[a] Ed R. Caldwell;[a] Ulrich L. Sellier;[b] Clayton F. Kaul;[a] Neil A. Daetwyler;[c] Gary L. Hayward;[d] and Grant Batterham[e1]

This paper was prepared for presentation at The Seventh SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production held in Calgary, Alberta, Canada, 29–31 March 2004.

This paper was selected for presentation by an SPE Program Committee following review of information contained in a proposal submitted by the author(s). Contents of the paper, as presented, have not been reviewed by the Society of Petroleum Engineers and are subject to correction by the author(s). The material, as presented, does not necessarily reflect any position of the Society of Petroleum Engineers, its officers, or members. Papers presented at SPE meetings are subject to publication review by Editorial Committees of the Society of Petroleum Engineers. Electronic reproduction, distribution, or storage of any part of this paper for commercial purposes without the written consent of the Society of Petroleum Engineers is prohibited. Permission to reproduce in print is restricted to a proposal of not more than 300 words; illustrations may not be copied. The proposal must contain conspicuous acknowledgment of where and by whom the paper was presented. Write Librarian, SPE, P.O. Box 833836, Richardson, TX 75083-3836, U.S.A., fax 01-972-952-9435.

Abstract

The Chad Export Project has developed and implemented an array of measures to mitigate a wide variety of environmental impacts, issues, and challenges. Extensive integrated analyses, supported by on-the-ground surveys and public consultation, were undertaken during the Project's multi-year planning and design period so as to avoid issues/impacts to the extent practical. Selection of a route for the 1070 kilometer onshore export pipeline and locations for the Project's various permanent facilities required a complex balancing of an assortment of technical, environmental, social, and economic considerations. The width of the pipeline construction right-of-way was restricted to limit environmental and socioeconomic impacts, and an extensive program was implemented to reclaim the easement. An induced access management plan was prepared to protect the flora and fauna in three identified ecologically sensitive areas traversed by the pipeline in Cameroon. In addition, the Project established a strict anti-bushmeat policy to prevent workers from hunting, poaching, purchasing, or consuming game while working. Special programs were developed to safeguard rare/threatened/endangered (RTE) species (e.g., primates, marine turtles) known to inhabit certain Project-pertinent locales. A multi-component water monitoring program has been implemented by the Project to protect groundwater and surface water resources relied upon by local inhabitants, and several high quality waste management facilities have been put in place, including waste storage structures, engineered hazardous and non-hazardous solid waste landfills, and a hazardous waste-capable incinerator.

Background Information

A description of the Chad Export Project (the Project) highlighting its setting, components, participants, environmental regulatory regime, and management of revenues appears in a separate paper.[2] A synopsis of the integrated analyses, on-the-ground surveys and studies, and public consultation program associated with the Project's multi-year environmental documentation synthesis effort has also been included in this (separate) paper.

Environmental and Socioeconomic Issues/Impacts Management Approach

The Project adopted the following strategy with regard to the management of environmental and socioeconomic issues/impacts:

- Identify (key) issues/impacts early.
- Avoid issues/impacts where/when practical.
- Appropriately mitigate unavoidable issues/impacts.

The integration of environmental and socioeconomic considerations into the Project's design and execution plan was essential in securing buy-in and alignment at all levels in the Project team regarding the significance and importance of SHE/EMP topics.

Issues/Impacts Identification. Environmental and socioeconomic issues/impacts identification began at the outset of the planning period (1993) and continues to this day. Central to this process is the Project's comprehensive public information and consultation program.[3]

Multiple reconnaissance missions and on-the-ground studies were undertaken during the planning and construction periods in order to identify and ground-truth issues/impacts. The active participation of design, construction, and operations engineers in many of these surveys and studies was extremely beneficial since:

- Certain facility siting/design modifications and construction procedures were identified that allowed some issues/impacts to be avoided.
- Effective issues/impacts mitigation strategies were able to be more readily developed.

[1] [a]ExxonMobil Development Company, Houston, Texas; [b]Esso Exploration and Production Chad Inc., N'Djaména, Republic of Chad; [c]ENVIRON Australia Pty Ltd., East Perth, Australia; [d]NewFields International, LLC, Bedford, New Hampshire; [e]Flour Daniel, Sugar Land, Texas.

[2] See "Chad Export Project: Environmental Management and Monitoring Process and Systems"; Paper No. 86721; Seventh SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production; Calgary, Alberta, Canada; 29-31 March 2004.

[3] Ibid.

Issues/Impacts Avoidance. Examples of Project design features that allowed environmental and/or socioeconomic issues/impacts to be avoided or more effectively mitigated are as follows:

Export Pipeline

- Easement traverses previously disturbed lands, follows existing infrastructure pathways (i.e., roads, railroads) to a large extent.
- Narrow construction and operations easement widths (nominally 30 and 10-15 metres respectively).
- Burial of the pipeline to a minimum depth of 1 metre, thereby allowing for reclamation of the easement in a manner supportive of rapid revegetation or the re-commencement of agricultural activities.
- Construction at major river crossings during the dry season.

Marine Facilities

- Offshore marine terminal (Floating Storage and Offloading vessel) eliminates large land requirement for onshore facility.
- Timing the construction of the subsea portion of the export pipeline to avoid the peak marine turtle nesting period.

Communications

- Fibre optic cable placed in the pipeline trench eliminated the construction of VHF/UHF telecommunications facilities in sensitive locations (e.g., on top of hills, mountains in forested areas).

Issues/Impacts Mitigation. Noteworthy environmental issues/impacts mitigation measures that were developed and implemented by the Project are presented in the remainder of this paper. In particular, mitigation measures in the following areas are discussed:

- Habitat Protection
  - Pipeline Route Definition Process.
  - Induced Access Control.
  - Pipeline Easement Reclamation Program.
  - Offsite Environmental Enhancement Program and the Establishment of an Independent Not-for-Profit Foundation.
- Wildlife Protection
  - Incorporation of RTE Species Information and Protection Measures into Environmental Alignment Sheets and the Environmental Line List.
  - Anti-Bushmeat Policy.
  - Additional Primates Study.
  - Marine Turtle Protection and Monitoring Program.
  - Wildlife Conservation Education Programs.
- Water Monitoring
- Waste Management

Habitat Protection

Initial reconnaissance missions undertaken in 1993 revealed that the Project's habitat protection issues were primarily in Cameroon. This determination was confirmed during the studies conducted as part of the environmental assessment process. The wooded savanna habitat of southern Chad has been heavily degraded by human activities, most notably by slash and burn subsistence agriculture and livestock herding. Relatively undisturbed forested areas do not exist in this region, and wildlife is rare due to non-sustainable hunting and habitat loss.

The Project worked collaboratively with the Republic of Cameroon and the World Bank Group to develop a creative strategy aimed at fulfilling the habitat protection and enhancement expectations of World Bank Group Operational Policy 4.04 (Natural Habitats). Key aspects of this strategy are outlined below.

Pipeline Route Definition Process. Defining an acceptable route for the export pipeline represented a major challenge and opportunity for the Project with regard to habitat protection.

Four bioclimatic zones exist over the ~1000 kilometer distance between the oilfield development area in southern Chad and the Cameroonian Atlantic coast. These zones are shown in Figure 1.

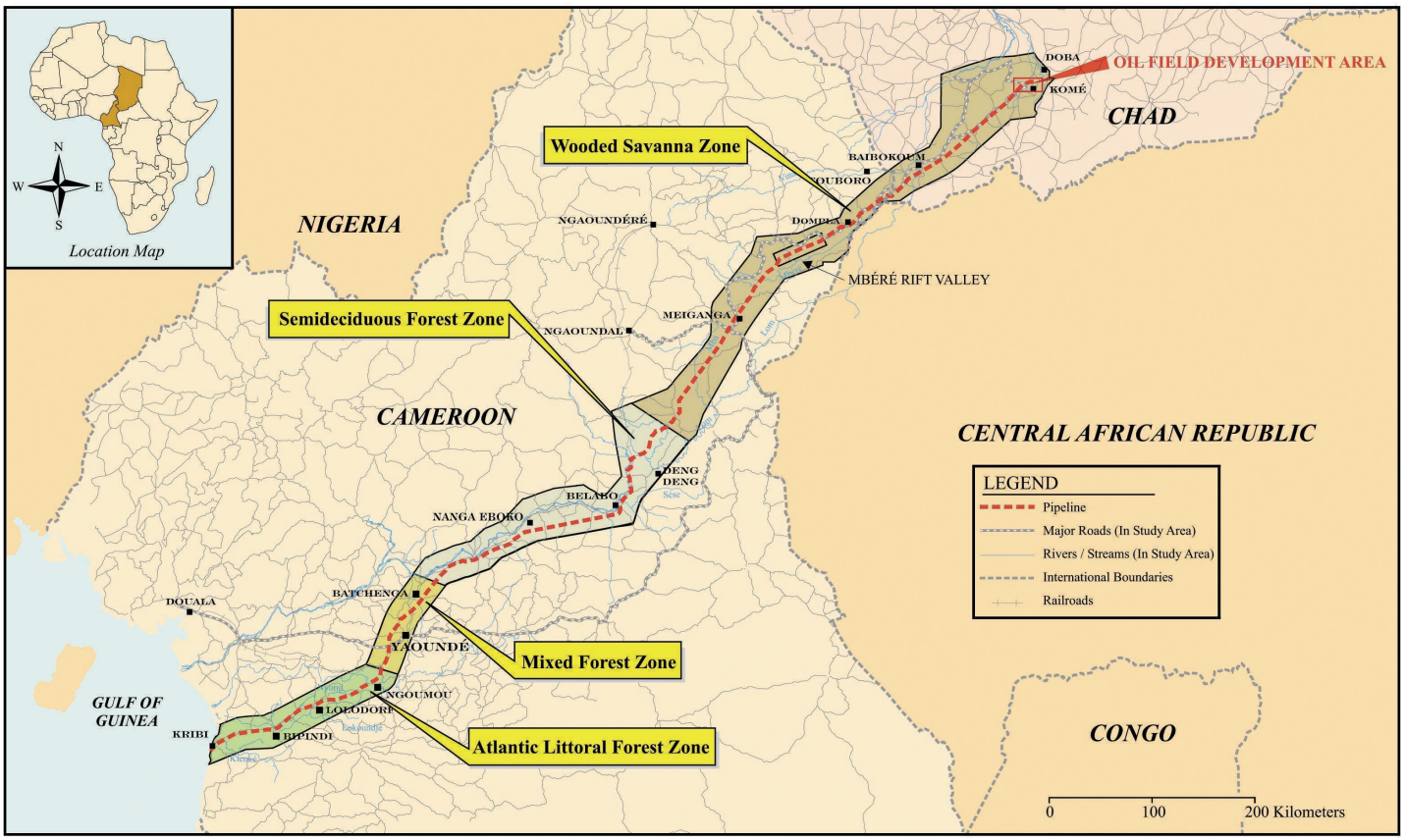

Figure 1. Bioclimatic Zones

- **Wooded Savanna Zone** - Typified by a mosaic of grassland broken by scattered trees and shrubs, small agricultural fields, overgrown fallows, pockets of relatively undisturbed wooded cover, and ribbon-like gallery forests immediately adjacent to rivers/streams. Slash and burn subsistence agriculture and livestock rearing have heavily impacted the native flora and fauna. The ecologically less-disturbed M'Béré Rift Valley lies in this zone.
- **Semideciduous Forest Zone** - North of the Lom River, disturbed savanna transitions into a mosaic of patches of semideciduous forest and savanna. Moving south, mature forest predominates. The ecologically less-disturbed Deng Deng forest area, home to primates such as chimpanzees and lowland gorillas as well as several other rare/threatened/endangered wildlife species, exists in the semideciduous zone. Logging has been on-going for decades in this zone, and the Transcamerounian Railway passes through the region.
- **Mixed Forest Zone** - In this more heavily populated zone, a transition from the semi-deciduous forest to the north and the Atlantic littoral forest to the south occurs. Vegetation is a mosaic of small subsistence agricultural fields, overgrown fallows, and fragmented forest. Timber harvesting is on-going in this region, and industrial plantation-style agriculture also occurs.
- **Atlantic Littoral Forest Zone** - Characterized by moist tropical evergreen forest vegetation, disturbed to varying extents by long-term timber harvesting, plantation-style agriculture, and subsistence agriculture. Mangrove forests exist along the Gulf of Guinea coast north of Kribi in the area of the mouths of the Nyong and Lokoundjé rivers.

Early in the planning period (i.e., in 1993), the Project adopted a policy that prevented the export pipeline from traversing:

- National parks and officially designated (gazetted) wildlife reserves and sanctuaries.
- Areas in northern Cameroon known to be inhabited by a small population of critically endangered black rhinoceros.
- Mangrove forests.
- Densely populated communities.

In addition, the Project defined several "sensitivity criteria" to aid in the identification of areas to avoid if practical. These "sensitivity criteria" included:

- Areas of high priority for protection, such as large tracts of undisturbed primary forest.
- Steep sloping terrain and areas with erosion-prone soils.
- Seismically and volcanically active areas.

A number of "opportunity criteria" were also identified so that land offering the possibility of significantly reducing environmental or socioeconomic impacts related to pipeline construction and operation could be specifically targeted. Examples of "opportunity criteria" include:

- Areas previously cleared for agricultural or timber harvesting purposes.
- Existing roadway and railway easements.
- Open, relatively flat areas.

- Obvious degraded or cleared zones of forest not requiring extensive incremental clearing for pipeline construction works.

The pipeline route definition process began by identifying three corridors, each 30 kilometers wide, running from Komé, Chad to the two potential locations for a marine terminal on the Gulf of Guinea (i.e., Kribi, Cameroon and Limbé, Cameroon). These corridors are shown in Figure 2.

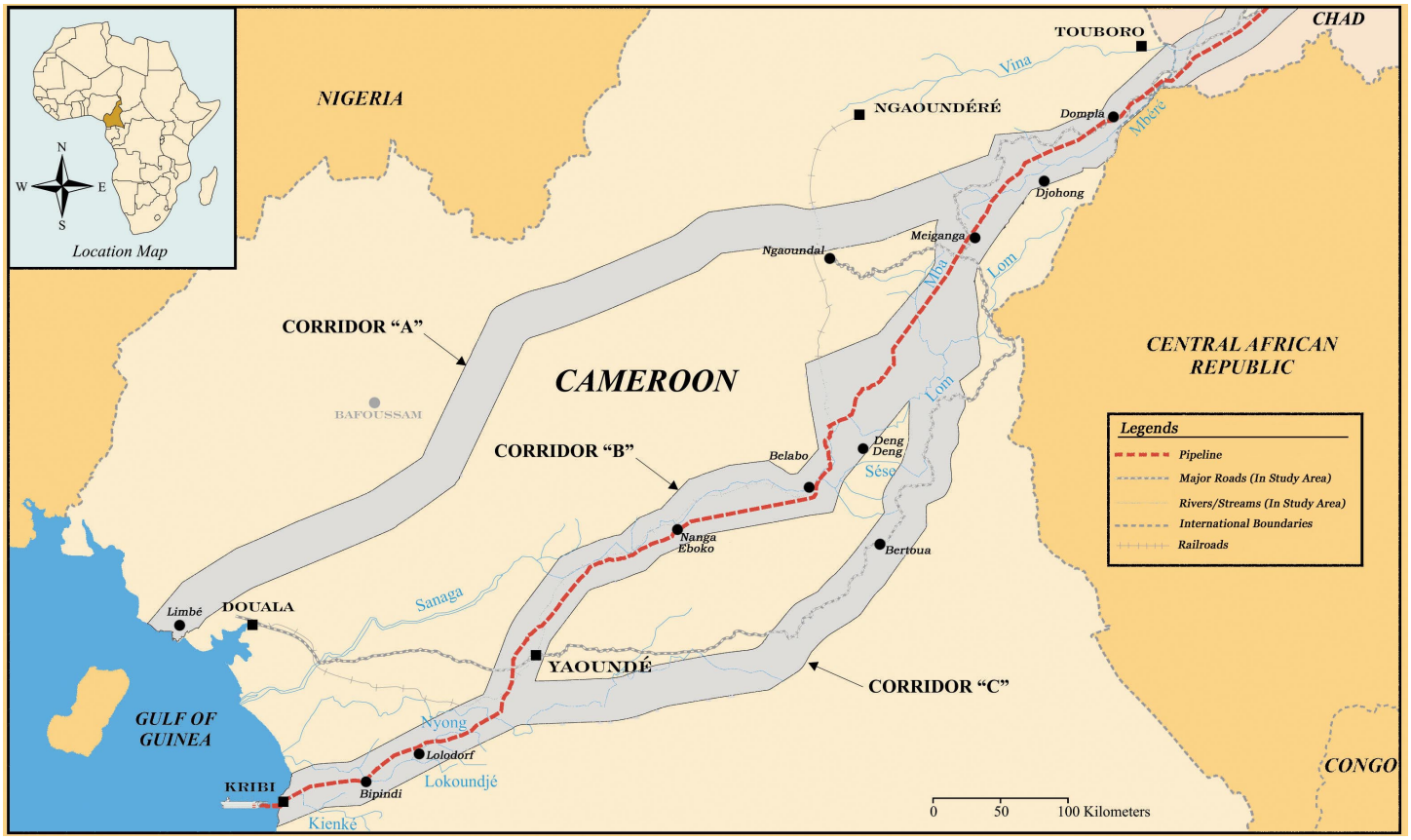

Figure 2. Potential Pipeline Corridors

Each corridor was evaluated using available information and data as well as findings from aerial surveys and on-the-ground reconnaissance. Central to this evaluation was a Geographic Information System-based terrain unit mapping analysis. This methodology facilitated the examination and comparison of a variety of information based on the "sensitivity" and "opportunity" criteria mentioned above as well as a number of other considerations. Overall, the key criterion was the proportion and locations of disturbed land that could be traversed by the pipeline.

Once one of the corridors (i.e., Corridor B) was identified as the prime candidate (influenced in part by the selection of Kribi, Cameroon as the prime location for the marine terminal), additional field studies and engineering evaluations were conducted over a multi-year period to identify the most cost-effective and environmentally/socioeconomically acceptable route for the actual pipeline easement within the corridor.

Particular attention was devoted to the routing of the pipeline in three ecologically less disturbed areas - the M'Béré Rift Valley region in northeastern Cameroon, the Deng Deng forest in east central Cameroon, and the Atlantic littoral forest between Lolodorf and Kribi in southern Cameroon. Several routing alternatives were considered in each of these areas. Additional aerial surveys and field studies were undertaken to support this work, and the route definition process also benefited from information gathered during a detailed pipeline centerline survey that took place in 1997 and 1998. The centerline survey was particularly useful in that it allowed the Project to define a pipeline right-of-way that largely avoided modern cultural sites (e.g., sacred trees, initiation sites, graves), multiple crossings of the same watercourse over a short distance, and sites/locations/resources especially valued by local inhabitants. Consultations and negotiations with villagers, the indigenous people who inhabit the Atlantic littoral forest in the south of Cameroon (the Bagyeli/Bakola[4]), local officials, NGOs, and World Bank Group technical staff were an integral aspect of the final pipeline route definition

[4] The Bagyeli/Bakola people have been referred to in the past as "Pygmies".

process. Ultimately, a route was defined that best balances the numerous engineering, constructability and operability, and environmental and social, and economic issues.

Noteworthy aspects of the final pipeline route are as follows:

- The right-of-way avoids the more ecologically sensitive part of the M'Béré Rift Valley by traversing the escarpment north of the valley.
- In the Deng Deng forest area, the less disturbed forest areas were avoided by aligning the easement adjacent to existing infrastructure (i.e., the railroad and an earthen road) through degraded forest and by traversing less sensitive wooded savanna/savanna grassland mosaics.
- The easement in the Atlantic littoral forest area intersects agriculture-impacted lands and disturbed forest identified as having a low to moderate natural habitat and conservation value over 97% of its length in this region.
- The number of stream and river crossings was reduced to the maximum extent practical.

Another tactic taken by the Project to substantially reduce habitat and other impacts was the mandating of a very narrow pipeline construction easement - nominally just 30 metres in width.[5]

The pipeline construction contractor was required to document the existing environmental conditions along the entire length of the final easement immediately before construction commenced. These surveys proved to be invaluable in developing site-specific procedures for avoiding or limiting impacts to important local natural or man-made features (e.g., exploited potable water resources). The surveys were also useful in resolving compensation disputes, refuting environmental damage allegations, and planning the pipeline easement reclamation program (see below).

Induced Access Control. The export pipeline traverses three defined ecologically sensitive areas in Cameroon where vehicular access is limited or absent and where floral and faunal resources are relatively undisturbed and abundant. These areas are:

- The plateau above the M'Béré Rift Valley between Ouantounou and Mayo Dabi (92 kilometre-long area).
- The area between the Pangar and Lom Rivers (68 kilometre-long area).
- The area between Bélabo and Nanga Eboko (113 kilometre-long area).

The map (Figure 3) provides a geographic context for these three sensitive areas.

To help preserve the habitat and wildlife in these three defined areas, the Project developed and implemented an Induced Access Management Plan.[6] The prime objective of the plan was to inhibit non-Project-related vehicular access into these areas and to hinder the movements of people along the pipeline easement where it intersects or is in close proximity to sensitive biological resources. In so doing, ecological impacts associated with the following could be significantly reduced or avoided:

- Hunting/poaching of wildlife (i.e., the "bushmeat" trade).
- Commercial timber harvesting.
- Establishment of settlements and infrastructure.

Four categories of induced access control measures were implemented by the Project where necessary in the three defined sensitive areas:

Category 1 **Awareness and Signage**: The Project's expectations and requirements regarding induced access control were communicated to all pipeline construction workers working in the three areas. Since some of these workers were from nearby communities, the importance that the Project placed on induced access control was also disseminated to the local population. Signs were posted at strategic locations in the three induced access control areas, especially at actual or potential access points. These signs provide notification that use of the pipeline easement as a vehicular route is not permissible.

Category 2 **Natural Barriers**: Examples of mitigations in this category include:

- Restoring natural topographic features (e.g., streams/rivers without bridges, re-establishing hills, banks, and other difficult-to-traverse relief).
- Establishment/re-establishment of natural barriers (e.g., construction of barriers using boulders, rock/rubble, tree stumps, and fallen timber at certain locations along the easement and where the easement intersects existing access routes [i.e., roads, railroads, trails]). Use of this strategy required a careful assessment of the operations and maintenance requirements of the export pipeline.
- Planting trees and shrubs at river and stream crossings.

Category 3 **Facilities**: Examples of mitigations in this category include:

- Limiting the number of pipeline easement access points. In the three defined sensitive areas, no new access roads were constructed - rather, existing roads/trails were utilized and upgraded to the minimum extent necessary to access the easement.
- Installing fences, locked gates, and in some cases attended checkpoints on pipeline easement access roads during and following the pipeline construction period and along the easement itself in certain areas.

[5] In areas with sloping terrain and/or natural obstacles and at locations where the pipeline crossed roads or railroad tracks, the width of the pipeline construction easement was able to be increased up to 50 metres. Similarly, at river crossings, a pipeline construction easement width of up to 60 metres was permissible.

[6] The Induced Access Management Plan was included in the Project's final (1999) suite of environmental documents - see Appendix D, Volume 1, Environmental Management Plan - Cameroon Portion.

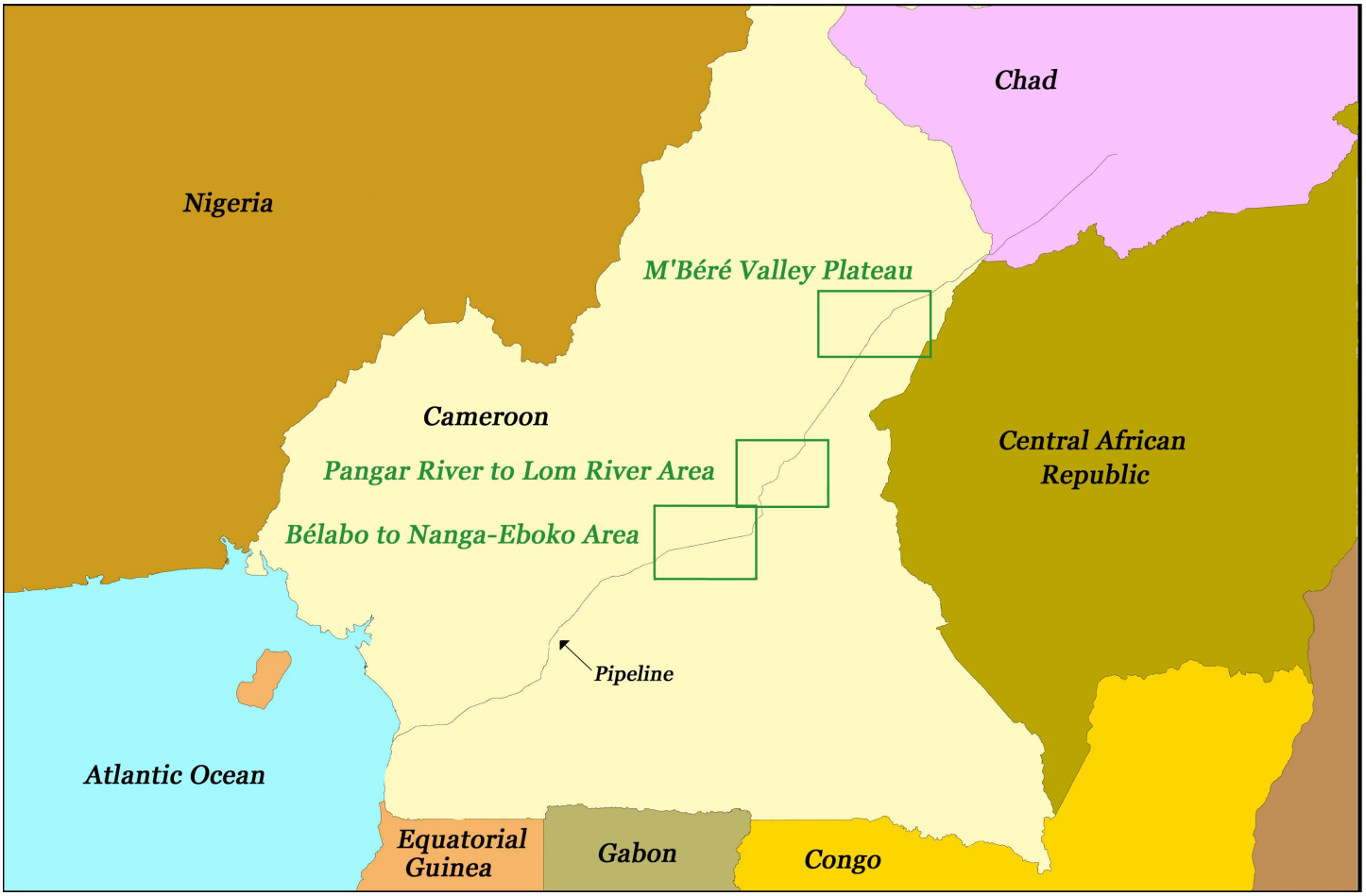

Figure 3. Location of Induced Access Control Management Areas

Category 4 **Removal of Temporary Construction Access**: All (existing) pipeline easement roads in the three defined sensitive areas were evaluated following the completion of pipeline construction, and improvements were removed as necessary to ensure that uncontrolled improved access had not been instituted.[7] In addition, temporary bridges and watercourse crossings in the three areas were removed following the completion of pipeline construction and easement reclamation activities.[8] In so doing, effective natural induced access control circumstances were able to be re-established.

Induced access control measures that were required to be implemented at specific locations within the three defined sensitive areas were stipulated on the Environmental Alignment Sheets and in the Environmental Line List for the Cameroonian portion of the pipeline route.[9] The effectiveness of the implemented induced access management devices is evaluated on an on-going basis as part of the overall pipeline integrity assurance program.[10]

Photographs depicting a number of the induced access control measures implemented by the Project appear in Figures 4A-E.

[7] It has been determined that several pre-existing roads in the induced access management areas are required for pipeline maintenance and emergency response purposes. These roads are maintained to the minimum extent possible (i.e., minimal periodic vegetation cutting), and locked gates have been strategically placed on the roads to prevent non-Project-related vehicular access to the pipeline easement.

[8] Although mandated by the Induced Access Management Plan, removal of temporary pipeline easement access infrastructure sometimes conflicted with the wishes of local communities/inhabitants. A case in point was the removal of the temporary bridge over the Lom River in central Cameroon.

[9] Environmental Alignment Sheets and the Environmental Line List for the Cameroonian portion of the pipeline route were included in the Project's final (1999) suite of environmental documents - see Volume 6, Environmental Management Plan - Cameroon Portion.

[10] Regular over flights of the pipeline easement and periodic on-the-ground inspections are key components of the overall pipeline integrity assurance program.

Figure 4A. Sign posted in an induced access management area.

Figure 4B. Guarded checkpoint on a pipeline easement access road in an induced access management area during construction in the area.

Figure 4C. A boulder pile placed at the end of a temporary bridge over a river in an induced access management area to prevent vehicular use of the bridge until it was removed.

Figure 4D. Removal of a temporary bridge over a river in an induced access management area (pre-existing railway bridge appears on the right).

Figure 4E. A locked gate placed on a pre-existing road retained for pipeline maintenance and emergency response purposes in an induced access management area.

Pipeline Easement Reclamation Program and Erosion Control. The Project undertook a major program to reclaim the pipeline easement once construction had been completed. The objectives of this program were to:

- Return land previously used for agricultural purposes to a productive state as quickly as possible.
- For all other land, create conditions that would facilitate the rapid establishment of appropriate vegetation, thereby preventing erosion.

Wherever possible, topsoil was removed from the 30 metre wide pipeline construction easement and segregated prior to commencing grading, grubbing, and trenching activities. The stockpiled topsoil was then spread on the easement once post-construction clean-up and contouring had been completed. This topsoil conservation strategy was particularly effective in helping the Project realize its pipeline easement reclamation objectives in a cost-effective manner.

A wide variety of erosion control techniques was employed during the pipeline easement reclamation effort, including the installation of earthen and vegetation barriers, diversion ditches, rip-rap, and vegetative matting. In those areas of the easement characterized by a high degree of relief (e.g., the escarpment above the M'Béré Rift Valley), erosion control interventions were extensive. Some of the erosion control techniques employed by the Project during the reclamation of the pipeline easement are shown in Figures 5A-D.

Figure 5A. Earthen berm and chipped vegetation placed on the reclaimed easement for erosion control purposes.

Figure 5B. Extensive use of vegetative matting and diversion ditches was required to control erosion in high relief areas in northern Cameroon.

Figure 5C. In certain locations, seedlings were planted in vegetative matting to enhance erosion protection.

Figure 5D. Rip-rap was used at major river and stream crossings for bank stabilization and erosion control purposes.

Most previous uses of the reclaimed pipeline easement are permitted provided that they do not threaten the integrity of the buried pipe or fibre optic communications cable or inhibit the inspection and maintenance of the pipeline.[11,12]

In many areas, local inhabitants have already begun growing crops on the reclaimed right-of-way. Furthermore, local farmers are benefiting from the additional arable land that was created by pipeline easement clearing and reclamation. In other areas, local vegetation has quickly reestablished itself on the reclaimed easement, most notably after the first post-reclamation rainy season. In some locations where local grasses and sedges have (quickly) re-colonized the reclaimed land, nomadic and sedentary herders are using the easement for livestock grazing.

Photographs illustrating the success of the Project's pipeline easement reclamation program are provided in Figures 6A-E.

Figure 6A. A view of the reclaimed pipeline easement in the Atlantic littoral forest zone in southern Cameroon after two rainy seasons.

[11] Structures (e.g., dwellings, granaries, livestock enclosures) are not permitted on the pipeline easement. Similarly, trees and deep-rooted crops are not allowed to be planted on the easement.
[12] See footnote #10.

Figure 6B. A field of manioc planted on the reclaimed pipeline easement in southern Cameroon.

Figure 6C. A view of the reclaimed pipeline easement in the semideciduous forest zone in central Cameroon after two rainy seasons.

Figure 6D. A view of the reclaimed pipeline easement in the wooded savanna zone in southern Chad after the first rainy season.

Figure 6E. Cattle grazing on the reclaimed pipeline easement near Komé, Chad after the first rains of the first rainy season.

Offsite Environmental Enhancement Program and the Establishment of an Independent Not-for-Profit Foundation. While routing the export pipeline through ecologically less sensitive land was the cornerstone of the Project's habitat protection strategy, a noteworthy habitat protection/enhancement initiative was the development of an Offsite Environmental Enhancement Program. At the heart of this program was the Republic of Cameroon's establishment of two new National Parks that possessed habitats similar to two forested areas of the country traversed by the export pipeline. The first of these parks, the 416,512 hectare Mbam and Djérem National Park in central Cameroon, was officially created by Decree No. 2000/005/PM on 6 January 2000. On the same day, the 264,064 hectare Campo-Ma'an National Park in southwestern Cameroon was officially created by Decree No. 2000/004/PM.

The Project decided to spearhead the establishment of an independent not-for-profit foundation to provide long-term focused support for ecological conservation and enhancement programs in the two new National Parks as well as for development projects for the Bagyeli/Bakola, a group of indigenous people inhabiting a portion of the Atlantic littoral forest in southern Cameroon through which the export pipeline passes.[13] The strategy of creating a foundation was adopted to:

- Ensure a high degree of transparency.
- Increase the probability of success by entrusting expert organizations/individuals to develop and implement effective ecological conservation/enhancement and indigenous peoples development programs.

The Foundation for Environment and Development in Cameroon (FEDEC) was registered as a charitable foundation in the Netherlands on 29 March 2001.[14] Republic of Cameroon Presidential Decree No. 2001/363 officially conferred Public Utility status upon FEDEC on 16 November 2002, thereby

[13] Although the pipeline easement passes through the region inhabited by the Bagyeli/Bakola, the final route was defined using a consultative approach involving the Bagyeli/Bakola aimed at avoiding encampments, gravesites, water sources, hunting grounds, and other sensitive locations.

[14] FEDEC was established in the Netherlands because of the country's flexible rules pertaining to foundation administration, membership, and management. For example, Management Board members can be nationals of any country (i.e., no residency requirements), registration requirements are neither onerous nor expensive, annual costs, fees etc. for a Dutch-registered foundation are not expensive, Management Board members are permitted to attend Board meetings electronically, and bank accounts in the name of a foundation can be opened outside the Netherlands.

allowing the Foundation to proceed with fulfilling its objectives. Shortly thereafter, COTCO[15] made a $US 3.5 million donation to FEDEC to be managed as an expendable endowment over a 28 year period. Other donors are permitted to make contributions to the foundation in support of its mandate.

A five person Management Board with the following make-up oversees FEDEC:

- Well-known and highly regarded citizen of Cameroon.
- Highly regarded and internationally recognized biological/ecological expert.
- Highly regarded and internationally recognized socioeconomic/indigenous peoples expert.
- Individual designated by the Government of Cameroon.
- Individual designated by COTCO.

FEDEC's work in the two new National Parks has commenced. The Wildlife Conservation Society has been contracted to serve as the Foundation's Implementing Organization in the Mbam and Djérem National Park. Similarly, the World Wildlife Fund has been contracted to function as FEDEC's Implementing Organization in the Campo-Ma'an National Park. The Bagyeli/Bakola people have also started to benefit from FEDEC-sponsored initiatives, facilitated by a Community Development Coordinator hired by the Foundation. Prudent management of FEDEC's fiscal resources has been ensured by contracting with UBS Zurich to serve as the organization's Fund Investment Manager.

Additional information about FEDEC can be obtained from its web site (www.fedec.org).

Wildlife Protection

The export pipeline traverses a limited number of areas that were determined to provide habitat for certain rare/threatened/endangered (RTE) species, including the following well known megafauna:

- Elephant (*Loxodonta africana*).
- Hippopotamus (*Hippopotamus amphibius*).
- Lowland gorilla (*Gorilla gorilla*).
- Chimpanzee (*Pan troglodytes*).

Portions of Cameroon's Gulf of Guinea coastline are also known to be used by several species of marine turtles for nesting.

Incorporation of RTE Species Information and Protection Measures into Environmental Alignment Sheets and the Environmental Line List. Information concerning RTE species was gathered during the various on-the-ground wildlife surveys and studies that were conducted during the preparation of the Project's environmental documentation.[16] Based on the identification of suitable habitat, (infrequent) sightings, sign (i.e., scat, prints, trails), and interviews with local inhabitants (especially hunters), the locations and estimated populations of RTE species that could potentially be impacted by Project-related activities were able to be determined.

RTE species information was incorporated into the Environmental Alignment Sheets and Environmental Line Lists. In addition, required RTE species protection measures were stipulated on the Environmental Alignment Sheets and Environmental Line Lists.

It is noteworthy that post-pipeline construction surveys in ecologically sensitive areas have identified the presence of RTE species in the immediate vicinity of the reclaimed easement, thus illustrating the effectiveness of the wildlife protection measures that were employed.

Anti-Bushmeat Policy. The Project developed the following anti-bushmeat policy to avoid exacerbating the impacts of the flourishing bushmeat trade and poaching on the fauna of Chad and Cameroon:

As a condition of employment, all Project workers are prohibited from engaging in the following activities when on Project work sites, during work hours, while on Project business, or while residing in Project field camps:

- *Hunting/poaching.*
- *Trapping.*
- *Fishing.*
- *Gathering, harvesting, or collecting medicinal or otherwise valued flora or fauna.*

Project workers are prohibited from possessing hunting or fishing devices (e.g., guns, traps, snares, fishing poles and lures) when on Project work sites, during work hours, while on Project business, or while residing in Project field camps

As a condition of employment, Project workers are prohibited from purchasing or possessing bushmeat when on Project work sites, during work hours, while on Project business, or while residing in Project field camps. Project vehicles will not, for any reason or on any occasion, be used to transport bushmeat.

Bushmeat will not be purchased for or served in Project-associated kitchens/catering facilities.

All Project workers were notified of this policy *via* an extensive education campaign and were required to formally acknowledge their understanding of the policy, including the consequences of non-compliance (i.e., disciplinary measures up to and including immediate dismissal). Visible, on-going monitoring and inspections were employed to verify compliance with the policy.

Components of the Project's anti-bushmeat program are illustrated in the Figures 7A-C.

[15] COTCO = Cameroon Oil Transportation Company, S.A., the company responsible for operating the portion of the Project's crude oil transportation system located in Cameroon.

[16] Synopses of the wildlife surveys and studies undertaken by the Project appear in the 1997 Environmental Assessments (for Chad and Cameroon) and in Volume 5 of the Supporting Documents component of the final 20 volume suite of environmental documents that was published in mid-1999.

Figure 7A. A training session regarding the Project's anti-bushmeat policy.

Figure 7B. An example of the signs posted at Project work sites informing/reminding workers about the anti-bushmeat policy.

Figure 7C. Project vehicles being inspected at a bushmeat checkpoint.

Despite the fact that the anti-bushmeat policy is contrary to the cultural norms of a large proportion of the Project workforce, compliance with the policy has been outstanding - during the construction period, only five relatively minor violations of the policy were recorded among the >35,000 individuals who worked on the Project.

Additional Primates Study. The forest in the vicinity of Bélabo, Cameroon (including the Deng Deng forest) is known to be inhabited by primates, including chimpanzees and gorillas. Field investigations conducted by Project-employed biologists during the environmental documentation synthesis period (1993-1999) confirmed this situation.

As was mentioned above, the pipeline easement was routed so that it avoids the bulk of the less disturbed/degraded portions of the Deng Deng forest - in so doing, impacts to primates and other wildlife were able to be largely avoided. Notwithstanding this strategy, the Project commissioned the Wildlife Conservation Society (WCS) to conduct an additional primate study in the immediate vicinity of the pipeline easement in the Bélabo area prior to the commencement of construction activities. The objective of this study was to confirm that the chosen route for the pipeline in this area was indeed protective of gorillas, chimpanzees, and other primates.

The WCS team encountered gorilla nests and other evidence of gorillas with increasing frequency as they moved away from the defined easement trace into the forest. These findings together with a paucity of primate observations in two study areas between Nanga Eboko and Bélabo validated the decision made during the planning phase to shift the route of the pipeline out of the central Deng Deng forest to a path that closely follows existing infrastructure (i.e., the railroad and an earthen road) through ecologically less sensitive forest and a forest/savanna mosaic.

Marine Turtle Protection and Monitoring Program. Monitoring for marine turtles and their nests was performed by a Cameroonian marine turtle expert in the immediate vicinity of the export pipeline's shoreline crossing location throughout the period that the Project's marine facilities were constructed (February-May 2003). During the 132 continuous days of monitoring, no marine turtles (including adults and hatchlings) were observed within the defined monitored shoreline area.

Special mitigation measures were also developed and implemented to safeguard marine turtles when a limited amount of blasting was required to remove some near shore rocks during the installation of the marine portion of the export pipeline. Approximately one hour prior to each blasting event, boats were used to survey the immediate vicinity of the blast site for swimming/feeding turtles. Several minutes before each detonation, a series of low power level "scare" charges were set off to frighten turtles and fish out of the area. Finally, special blasting procedures were employed to reduce the magnitude of shock waves in the water column.

As a result of these monitoring and mitigation measures, construction of the Project's marine facilities did not impact any turtles.

During the monitoring period, the Project's marine facilities construction contractor purchased nine turtles that had been captured by local fishermen. These turtles were tagged by a marine turtle expert and released as part of a global research effort related to these endangered species.[17]

Wildlife Conservation Education Programs. The Project funded two local NGOs to develop and present anti-poaching and wildlife conservation education programs in villages near to two ecologically important areas in Cameroon.

The Limbé Wildlife Centre used a theatrical approach to raise awareness regarding the importance and value of wildlife protection in communities adjacent to the Deng Deng forest and in the Bélabo area. In the Campo-Ma'an area, the Living Earth Foundation worked with local communities to establish village environmental education clubs. In addition, training workshops dealing with wildlife conservation were provided to local officials and organizations.

Water Monitoring Program

The Project avoided adversely impacting the potable water resources utilized by communities in the vicinities of Project work sites and permanent facilities by implementing a comprehensive water monitoring program that includes the following components:

1. Surveying of local surface water and groundwater usage practices prior to the commencement of Project-related surface water and/or groundwater withdrawals.
2. Monitoring of local surface water and groundwater resources within 1 kilometer of a work site while Project-related construction phase water withdrawals are occurring.
3. Monitoring of water obtained from Project-installed groundwater source wells/boreholes.
4. Regional groundwater monitoring program in the oilfield development area in southern Chad.
5. Monitoring of local groundwater and surface water resources in the vicinities of the Project's permanent facilities in Cameroon.
6. Groundwater monitoring at the Project's engineered solid waste landfill sites.
7. Monitoring of liquid effluents directly discharged to onshore surface water bodies.[18]
8. Monitoring of liquid effluents discharged from the Floating Storage and Offloading vessel.

Analyses of water samples were accomplished by using a custom-designed field test kit and/or a commercial laboratory.

In the oilfield development area, a regional groundwater monitoring network has been established. The network consists of 27 strategically located existing community wells and 34 dedicated monitoring wells installed by the Project. Both water quantity and water quality are monitored on a regular and on-going basis.[19] Water quality monitoring parameters include pH, conductivity, turbidity, major anions and cations, selected trace metals, and total petroleum hydrocarbons. To date, monitoring has shown that the Project has not had a detrimental impact on water quality and quantity in the oilfield development area. Similar (albeit smaller scale) monitoring also occurs in the immediate vicinities of Pump Station 2 (Dompta), Pump Station 3 (Bélabo), and the Pressure Reducing Station (Kribi).

Strict quality criteria have been established for the Project with regard to direct effluent discharges to surface water bodies. In particular, the oil and grease content of the discharge from the Floating Storage and Offloading vessel to the sea is required to be less than 15 mg/L as stipulated by the Lender Group. Accordingly, the vessel has been fitted with a sophisticated hydrocyclone-type discharge treatment unit. This unit is equipped with a continuously reading oil and grease content measurement device on the discharge line - non-conforming discharges are automatically routed back through the treatment unit for re-processing.

Photographs illustrating some aspects of the Project's water monitoring program are provided in Figures 8A-C.

Figure 8A. Monitoring at a surface water withdrawal location.

Figure 8B. Obtaining a surface water sample for turbidity analysis.

[17] Tag data and specimen measurements were input into an international marine turtle database.

[18] The Project has adopted systems and procedures that avoid direct discharges of liquid effluents to onshore surface water bodies.

[19] Water level monitoring of the 27 community wells and 34 dedicated groundwater monitoring wells is performed on a monthly basis. Water quality monitoring of 13 (of the 27) community wells and all 34 of the dedicated groundwater monitoring wells occurs on a quarterly basis.

Figure 8C. In-the-field analysis of a sample obtained from a Project-installed groundwater monitoring well.

Waste Management

Waste management plans (one for Chad and one for Cameroon) were included in the Project's suite of final environmental documents.[20] In addition, each of the Project's major construction contractors was contractually obligated to produce a waste management plan for Project approval. All of these plans were founded on the classic waste management hierarchy: reduce, recover, reuse, recycle, dispose.

In order to limit the generation of hazardous wastes, the Project developed a list of substances which are not permitted for use. Examples of materials on this list include electrical equipment containing PCBs, friable asbestos-type insulation, chlorinated solvents, leaded pipe dope, chromate-containing corrosion inhibitors, and instruments containing mercury.

The Project has had success recycling certain non-hazardous wastes (e.g., wood, some metal, plastic sheeting and bottles) to local communities. Recycling of used lubricating oil generated in Cameroon was accomplished by fostering the development of a joint venture between Mobil Oil Cameroun and a Douala-based company (BOCAM).[21] In the oilfield development area, approximately 60% of drilling fluids are reused/recycled.

The Project was able to avoid installing a dedicated hazardous waste-capable incinerator in Cameroon by providing technical expertise to support the establishment of a third party hazardous waste incineration facility. Over a multi-month period, Project waste management specialists worked closely with the management and technical staff of the facility to develop and implement procedures and safeguards that satisfied Project standards.

The Project put in place a number of strategically located facilities that allow for the prudent management of wastes (especially hazardous wastes) that could not be recycled or managed in an acceptable manner by local companies. Modern waste management facilities were constructed at the following locations:

- **Oilfield Development Area (Komé)** - Engineered solid waste landfill with cells for non-hazardous and hazardous solid wastes; hazardous waste-capable high temperature industrial incinerator; waste storage building.
- **Pump Station 2 (Dompta)** - Waste storage building.
- **Pump Station 3 (Bélabo)** - Engineered solid waste landfill for hazardous solid wastes; waste storage building.
- **Pressure Reducing Station (Kribi)** - Waste storage building.

Photographs showing some of these waste management facilities appear in Figures 9A-C.

Figure 9A. One of the Project's waste storage buildings.

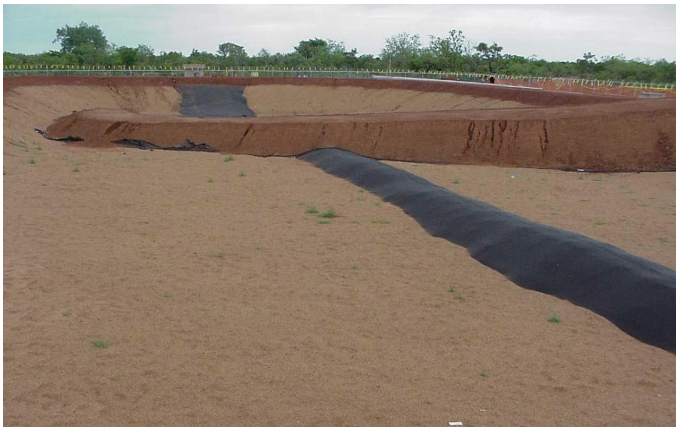

Figure 9B. The engineered non-hazardous solid waste landfill at the Komé Waste Management Facility.

[20] See Volume 5, Environmental Management Plan - Chad and Cameroon Portions.

[21] Collected used oil is processed (*via* centrifugation) at BOCAM's facility to remove water and other impurities. The treated oil is then sold to a local cement kiln for use as a diesel fuel substitute

Figure 9C. The hazardous waste-capable incinerator at the Komé Waste Management Facility.

Key environmental safeguards that were incorporated into the design of these facilities include:

- **Landfills** - Synthetic liner system; liner leakage detection system in hazardous waste cells; leachate collection and management system; perimeter groundwater monitoring wells.
- **Hazardous Waste-Capable Incinerator** - Primary (>815 ºC) and secondary (>982º C) combustion chambers; >1.5 second residence time in the secondary combustion chamber; wet scrubber-type pollution control system.
- **Waste Storage Buildings** - Curbed concrete floor; roof.

In addition to these facilities, the Project has and continues to use a variety of devices for waste management purposes, including:

- **Sewage Treatment Units** - Both packaged biological sewage treatment units and septic tank-type systems are used by the Project, with treated effluents being discharged to a sub-surface leach field or an above-ground irrigation system.
- **Domestic Garbage Incinerators** - Used to manage combustible non-recyclable non-hazardous wastes (e.g., kitchen wastes, paper, cardboard, some wood). Most domestic garbage incinerators used by the Project possess a dual chamber design (i.e., primary and secondary combustion chambers).
- **Earthen Excavations** - Used to dispose of non-hazardous non-leachable solid wastes (e.g., concrete wastes, damaged insulation, non-recyclable metal, rubber, and plastic).

Land treatment within a contained area is also used at specific monitored locations for managing hydrocarbon-contaminated soils.

Conclusion

The environmental challenges associated with the Chad Export Project, a large but conventional petroleum development project, were in large part a function of a setting featuring:

- Several bioclimatic zones over a linear distance of 1070 kilometres ranging from savanna to moist tropical evergreen forest.
- Less-disturbed areas within the bioclimatic zones that are inhabited by more abundant wildlife, including several rare/threatened/endangered species.
- Wildlife poaching and a flourishing bushmeat trade in certain forested areas.
- Widespread subsistence agriculture.
- Rudimentary (or totally absent) potable water exploitation and delivery and waste management infrastructure.

Within the context of this setting, a strategy emphasizing the early identification of issues/impacts, their avoidance where possible, and their appropriate mitigation where unavoidable was employed to develop an array of specific environmental protection measures, several of which are noteworthy for their innovative nature. These measures have been and continue to be very successful, both in the opinion of the Project's sponsors and as acknowledged by external monitoring entities.[22]

Acknowledgements

This paper is dedicated to the thousands of men and women who participated in the planning and construction of the Chad Export Project. In particular, the outstanding efforts and accomplishments of the individuals associated with the Project's EMP organization are gratefully acknowledged.

[22] Further information regarding the two external monitoring entities associated with the Project (i.e., the External Compliance Monitoring Group and the International Advisory Group) can be found in: "Chad Export Project: Environmental Management and Monitoring Process and Systems"; Paper No. 86721; Seventh SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production; Calgary, Alberta, Canada; 29-31 March 2004.