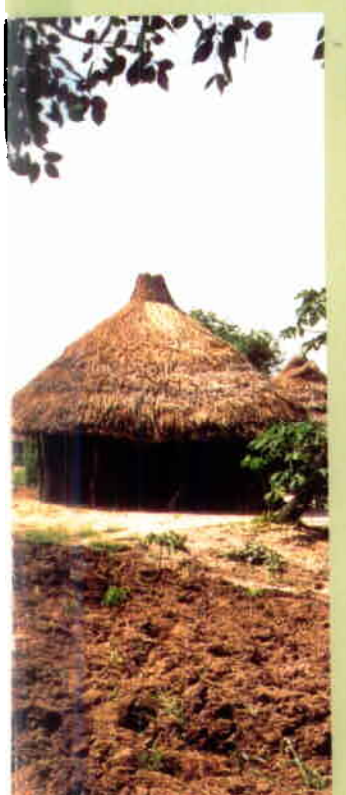


Environmental Impact Assessment

CORRIDOR SANDS RAIL LINK

Chibuto to Barragem, Gaza Province, Mozambique




VOLUME 2

Specialist Reports


ENVIRONMENTAL IMPACT ASSESSMENT

CORRIDOR SANDS LIMITADA'S RAIL LINK BETWEEN CHIBUTO AND BARRAGEM

VOLUME 2:

SPECIALIST REPORTS

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CHAPTER 1

GENERAL INTRODUCTION

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EXECUTIVE SUMMARY

Introduction
Coastal & Environmental Services (CES) were commissioned by Corridor Sands Limitada (CSL) to carry out an environmental impact assessment (EIA) of the proposed construction and operation of a rail link between Barragem and Chibuto, Mozambique. This EIA forms part of a series of studies covering all components of the Corridor Sands project.

The rail spur will probably be designed, constructed, operated and owned by a new company established for that purpose. This company will initially be wholly owned by CSL.

Project description
The railway line will be used to transport the products (titanium slag, ductile iron, rutile and zircon) of the Corridor Sands mineral processing plant to a dedicated bulk cargo facility at Matola Harbour for export. In addition, fuel oil, anthracite, mine-consumables and spares will be railed into Chibuto from Maputo.

Route alternatives
Three possible alternative routes for crossing the Limpopo River were investigated jointly by McClintock & Skinner (2000) Incorporated, specialist railway engineers, and Coastal & Environmental Services. They were the Leonde, Chokwe and Barragem routes:

- *The Leonde Route:* This is the shortest route, with the new rail spur linking into the Limpopo line at Leonde after crossing the Limpopo via a major bridge.
- *The Chokwe Route:* This is a longer route and the spur would link into the Limpopo line at Chokwe after crossing the Limpopo via a major bridge.
- *The Barragem Route:* This is the longest route and the spur would link into the Limpopo line at Barragem before the Limpopo line crosses the river. No bridge is required and this route would involve fewer engineering problems than the other two.

The Barragem Route was chosen and the preliminary design for it produced by McClintock & Skinner was "Approved in Principle" by Caminhos de Ferro de Moçambique (CFM) on 20 June 2000. This route and approved design was used in the Full Feasibility Study for the Corridor Sands Project completed in August 2000.

Refinement of the Barragem Route
Access difficulties caused by the floods of February 2000 made it difficult to assess the impact of the proposed route on the local communities. In November 2000, CES carried out a detailed field investigation and concluded that it impacted on an unacceptable number of households. Consequently Arcus Gibb, specialist rail engineers, were appointed to refine the alignment, in conjunction with CES, in order to minimise the number of affected households. This EIA therefore assesses the final route as refined by Arcus Gibb.

Description of the Barragem – Chibuto route
Horizontal Alignment: The proposed rail link is 86.5km long, and will extend from Chibuto across the Changane and Limpopo floodplains to join the existing CFM-S mainline north of Barragem, approximately 228km from Maputo.

The route starts at the Corridor Sands Plant site and descends down the eastern slope of the dune plateau for 10km and then turns west across the floodplain, following the alignment of the existing Chibuto-Barragem road. After approximately 16km the route climbs out of the floodplain onto a low ridge, bypassing the small town of Chaimite, and then some 5km later descends back into the floodplain. The route continues through the floodplain until the town of Santa Isadoro, where it begins a slow ascent out of the floodplain onto a low elongated levee ridge[1] lying parallel to the current channel of the Limpopo. The route then runs along the levee all the way to the junction with the CFM-S mainline near Barragem.

Vertical Alignment: The gradients along the route, with the exception of the descent down the dune, are very flat. Flooding is a serious risk as a 27km portion of the rail line, from the foot of the dune across the Changane floodplain to Santa Isidoro, lies below the Limpopo 25-year flood line. Furthermore, the lowest portion of the rail route, the 800m portion in the area of the Changane River crossing, will flood frequently, as it lies just below the 10-year flood line of 10.3 mamsl. The rest of the route lies above the Limpopo 50-year flood line.

To minimise flood damage, the formation (i.e. the bulk fill material and layer-work) and storm water drainage have been designed to ensure that damage is limited to contamination and loss of ballast. The bridges and culverts have been positioned to match the existing drainage system in order not to change the natural watercourses and channels. This is particularly the case where the railway runs adjacent to the existing road.

Basic Design Criteria

The alignment has been selected to comply with the following requirements:

- Horizontal and vertical geometry compatible with normal freight train operation;
- The minimisation of impacts on existing households;
- The avoidance of stormwater floodplains where possible; and
- The use of minimum ground surface area.

The design and specifications of the Chibuto-Barragem rail link as well as the Chibuto and Matola marshalling yards will correspond to CFM mainline standards.

The cargoes

The project will produce four products, namely titanium slag, ductile iron, rutile and zircon, for export through Matola. The titanium slag, a non-toxic powder, will be exported in bulk in purpose built rail tankers. The rutile and zircon will be either railed in 2-tonne bulk bags or in bulk rail tankers. The ductile iron will be exported in bulk in the form of 5 to 10kg lumps of iron. During stage 1 a total of three trains (two with titanium slag and one with mixed cargoes) must leave the mine daily, 313 days per annum, increasing to six trains per day at full production. In addition anthracite, diesel fuel oil and mine consumables will be transported to the mine from Maputo.

Environmental Impact Ratings

The primary purpose of this report, the baseline specialist studies, is to generate sufficient factual information to assess the significance and severity of environmental impacts. Impacts were assessed using a standard rating system developed by CES and used in other EIAs, including the EIA of the mining project.

Six standard rating scales were defined and used to assess and quantify the identified impacts, namely the relationship of the issue to temporal scales; the relationship of the issue to spatial scales; and the severity of the issue. These first three criteria are combined to describe the forth criterion, the significance. An additional two parameters are used to describe the issues, the risk or likelihood of the issue occurring; and the degree of confidence placed in the assessment of the issue.

[1] A levee is defined as "a natural embankment built up by overbank deposition from a river."

SUMÁRIO EXECUTIVO

Introdução

A Corridor Sands Limitada (CSL) encarregou a Coastal & Environmental Services (CES) de empreender um estudo do impacto ambiental (EIA) da construção e implementação proposta de uma ligação ferroviária entre a Barragem e o Chibuto em Moçambique. Este EIA forma parte de uma série de estudos que cobrem todos os elementos do projecto Corridor Sands.

A linha ferroviária será provavelmente desenhada, construída, operada por e irá pertencer a uma empresa nova estabelecida para esse propósito. Esta empresa será inicialmente propriedade integral da CSL.

Descrição do projecto

A linha ferroviária será utilizada para transportar produtos (escória de titânio, ferro dúctil, rutilo e zircão) da fábrica de processamento de minerais do Corridor Sands para instalações dedicadas de cargas a granel no Porto Matola para exportação. Adicionalmente, óleo combustível, antracite, e consumíveis e peças sobresselentes da mina serão transportadas por via ferroviária de Maputo para o Chibuto.

Alternativas de vias para passagem

Investigaram-se três alternativas possíveis de vias para a passagem do Rio Limpopo, elas tendo sido realizadas juntamente pela McClintock & Skinner (2000) Incorporated, engenheiros de caminhos-de-ferro, e a Coastal & Environmental Services. As vias foram a Leonde, a Chokwe e a Barragem:

- *A Via Leonde:* Esta é a rota mais curta, com a linha ferroviária nova ligando à linha Limpopo em Leonde após ter atravessado o Limpopo por meio de uma ponte principal.
- *A Via Chokwe:* Esta é uma rota mais longe e a linha ligar-se-ia à do Limpopo em Chokwe depois de ter atravessado o Limpopo por meio de uma ponte principal.
- *A Via Barragem:* Esta é a rota mais longa e a linha ligar-se-ia à do Limpopo na Barragem antes da linha Limpopo atravessar o rio. Neste caso uma ponte não seria necessária e esta rota envolveria menos problemas de engenharia que as outras duas.

Escolheu-se a Via Barragem e o seu desenho preliminar, produzido pela McClintock & Skinner, foi "Aprovado em Princípio" pelos Caminhos de Ferro de Moçambique (CFM) no dia 20 de Junho de 2000. Esta rota e o desenho aprovado foram utilizados no Estudo Integral de Viabilidade para o Projecto Corridor Sands concluído em Agosto de 2000.

Aperfeiçoamento da Via Barragem

As dificuldades em acesso provocadas pelas cheias de Fevereiro de 2000 dificultaram a avaliação do impacto da rota proposta sobre as comunidades locais. Em Novembro de 2000 a CES realizou uma investigação de campo detalhada e concluiu que a rota iria afectar de modo adverso um número inaceitável de casas. Consequentemente a Arcus Gibb, engenheiros especialistas de caminhos-de-ferro, em combinação com a CES, foram designados para aperfeiçoar o alinhamento, a fim de minimizar o número de casas afectadas. O presente EIA portanto avalia a via final conforme aperfeiçoada pela Arcus Gibb.

Descrição da via Barragem – Chibuto

Alinhamento horizontal: A ligação ferroviária proposta tem 86,5 km de comprimento, e estender-se-á do Chibuto através das planícies de inundações do Changane e do Limpopo para ligar à linha principal actual de CFM-S a Norte da Barragem, aproximadamente 228km de Maputo.

A via começa no local da Fábrica do Corridor Sands e desce 10km por abaixo da encosta ocidental do planalto dunar, dirigindo-se então para o oeste através da planície de inundações, seguindo o alinhamento da estrada actual de Chibuto-Barragem. Após cerca de 16km a rota sobe fora da planície de inundações para uma saliência baixa, contornando a aldeia de Chaimite, e então uns 5km mais adiante volta a descer para a planície de inundações. A rota continua através da planície de inundações até à cidade de Santa Isadoro, onde começa a subir lentamente fora da planície de inundações e para cima duma crista do dique[2] situada paralela ao canal actual do Limpopo. A rota então segue ao longo do dique continuamente até à junção com a linha principal do CFM-S perto da Barragem.

Alinhamento Vertical: Os declives ao longo da rota, com a excepção da descida pela duna, são muito chatos. Cheias é um risco sério devido à porção de 27km da linha ferroviária, desde o pé da duna através a planície de inundações do Changane até a Santa Isidoro, ficar abaixo do nível de cheias de 25 anos do Limpopo. Adicionalmente, a porção mais baixa da via ferroviária, uma porção de 800m na área da passagem do rio Changane, inundará frequentemente devido a estar precisamente abaixo do nível de cheias de 10 anos de 10,3 manm. O resto da rota encontra-se acima do nível de cheias do Limpopo de 50 anos.

Para minimizar danos provocados por cheias, a formação (ou seja os materiais de enchimento a granel e as obras de camadas) e os esgotos pluviais foram desenhados para garantir que danos sejam limitados a contaminação e a perda de balastro. As pontes e as passagens subterrâneas foram colocadas para condizer com o sistema de escoamento actual para que não mude os canais e cursos de água naturais. Este é especialmente o caso onde o caminho-de-ferro corre adjacente à estrada actual.

Critérios Básicos do Desenho

O alinhamento foi seleccionado para cumprir com os seguinte requisitos:

- A geometria horizontal e vertical compatíveis com as operações normais de combóio de mercadorias;
- A minimização de impactos sobre as casas actuais;
- Evitar quanto o possível planícies de inundações de águas pluviais; e
- Utilização mínima de área de superfície de terreno.

O desenho e especificações da ligação ferroviária de Chibuto-Barragem assim como as instalações de triagem do Chibuto e da Matola corresponderão aos padrões da linha principal dos CFM.

As cargas

O projecto irá produzir quatro produtos, nomeadamente escória de titânio, ferro dúctil, rutilo e zircão, para exportação através da Matola. A escória de titânio, um pó não-tóxico, será exportado a granel em vagões cisterna construídos para esse fim. O rutilo e o zircão serão enviados ou por via ferroviária a granel em sacos de 2 toneladas ou por vagões cisterna. O ferro dúctil será exportado na forma de granel em pedaços de ferro de 5 a 10kg . Durante a primeira fase deverão sair diariamente da mina um total três comboios (dois com escória de titânio e um com cargas misturadas), durante 313 dias por ano, esta quantidade sendo aumentada até seis comboios por dia quando em plena produção. Adicionalmente a antracite, óleos combustíveis de diesel e consumíveis da mina serão transportados de Maputo para a mina.

[2] Neste contexto um dique é definido como "um declive natural construído por deposições sobre a margem dum rio por ele próprio."

Classificação dos Impactos Ambientais

O objectivo primário do relatório presente, os estudos de referência especializados, é gerar informações concretas suficientes para avaliar a significância e gravidade dos impactos ambientais. Os impactos foram avaliados utilizando um sistema padrão de classificação desenvolvido pela CES e usado em outros EIA, incluindo o EIA do projecto mineiro.

Definiram-se e utilizaram-se seis escalas padrão de classificação para avaliar e quantificar os impactos identificados, nomeadamente a relação entre a questão e as escalas temporais; a relação entre a questão e as escalas espaciais; e a gravidade da questão. Estes três primeiros critérios são reunidos para descrever o quarto critério, que é a significância. Dois parâmetros adicionais são usados para se descreverem as questões, o risco da probabilidade da ocorrência da questão e o grau de confiança que se coloca na avaliação da questão.

1. GENERAL INTRODUCTION

1.1 BACKGROUND

Coastal & Environmental Services (CES) were commissioned by Corridor Sands Limitada (CSL) to carry out an environmental impact assessment (EIA) of the proposed construction and operation of a rail link between Barragem and Chibuto, Mozambique (Figure 1.1). This EIA forms part of a series of studies covering all components of the Corridor Sands project, namely:

- The mine, mineral processing plant and smelter operation in Chibuto;
- The 86.5km rail link from Chibuto to Barragem;
- The bulk cargo facility at Matola Harbour; and
- The 400kV power line from Matola to Chibuto.

The Scoping and Terms of Reference (Volume 1) for the Corridor Sands rail link were approved by the Ministry for the Co-ordination of the Environment (MICOA) on 20 December 2000. This report forms Volume 2 of the EIA and contains the specialist studies.

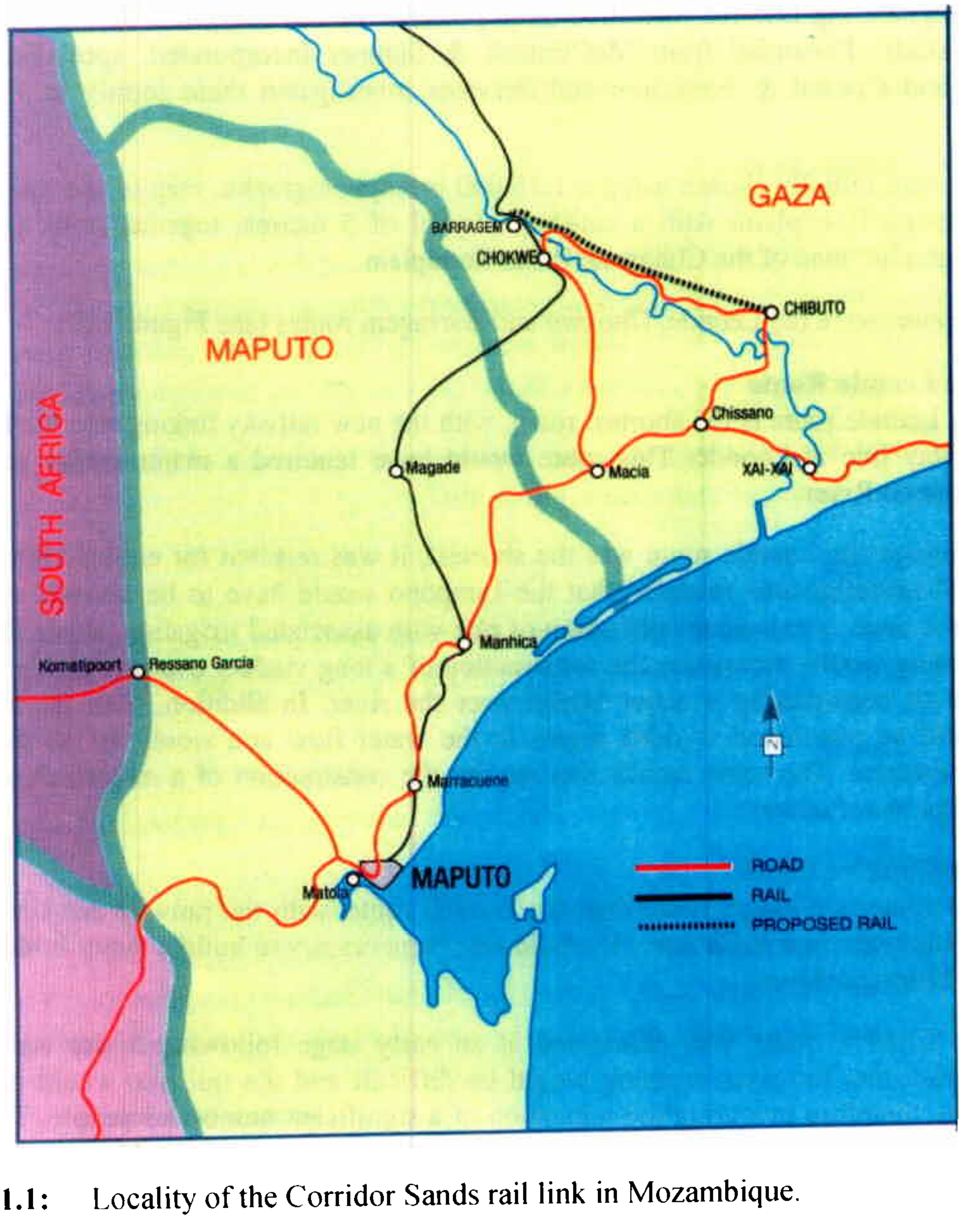


Figure 1.1: Locality of the Corridor Sands rail link in Mozambique.

1.2 RAIL LINK OWNERSHIP

The rail spur will probably be designed, constructed, operated and owned by a new company established for that purpose. This company will initially be wholly owned by CSL.

1.3 PROJECT DESCRIPTION

1.3.1 OVERVIEW

The construction of an 86.5km long rail line linking the Corridor Sands mineral processing plant located near Chibuto to the Limpopo main railway line near Barragem, together with the supporting infrastructure is an important component of the Corridor Sands project. The railway line will be used to transport the products (titanium slag, ductile iron, rutile and zircon) generated from the Corridor Sands project to a dedicated bulk cargo facility at Matola Harbour for export. In addition, fuel oil, anthracite, mine-consumables and spares will be railed into Chibuto from Maputo.

1.3.2 ROUTE ALTERNATIVES

Bateman Engineering Limited identified three possible alternative routes during the Phase 1 feasibility study. Personnel from McClintock & Skinner Incorporated, specialist railway engineers, and Coastal & Environmental Services investigated these jointly in November 1999.

The routes were initially chosen using a 1:25 000 orthophotographic map of the relevant part of the Limpopo floodplain, with a contour interval of 5 metres, together with a 1:20 000 orthophotographic map of the Changane River floodplain.

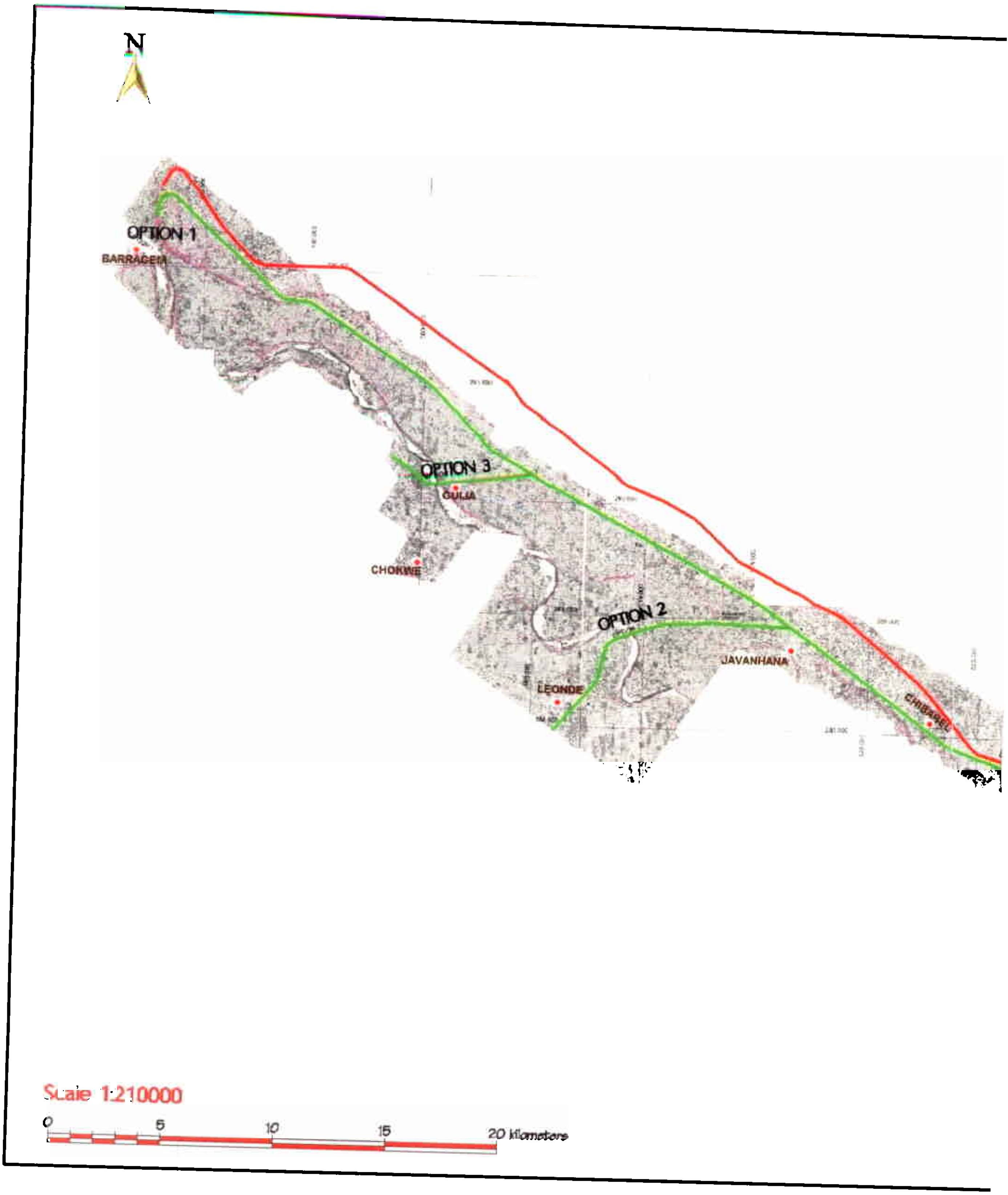
The three routes were the Leonde, Chokwe and Barragem routes (see Figure 1.3):

- **The Leonde Route**
  The Leonde route is the shortest route, with the new railway linking into the Limpopo railway line at Leonde. This route would have required a major bridge across the Limpopo River.

  Although the Leonde route was the shortest, it was rejected for engineering reasons. Field investigations revealed that the Limpopo would have to be crossed in an area where there is extensive cultivation of rice with associated irrigation canals. The river crossing would necessitate the construction of a long viaduct over the paddy fields as well as constructing a major bridge over the river. In addition, both the structures would be positioned at right angles to the water flow and would act as barriers to floodwaters. The route would also require the construction of a major rail-over-road bridge near Leonde.

- **The Chokwe Route**
  This route is a longer route than the Leonde route, with the railway line linking into the Limpopo line at Chokwe. It would also be necessary to build a major bridge across the Limpopo River.

  The Chokwe route was eliminated at an early stage following a site visit, which showed that the river crossing would be difficult and the rail line would bisect the town, therefore involving the relocation of a significant number of people. This route was rejected for environmental reasons as both the structures would be positioned at right angles to the water flow and would act as barriers to the floodwaters.


N
OPTION 1
BARRAGEM
OPTION 3
GUIJA
CHOKWE
OPTION 2
JAVANHANA
LEONDE
CHIBAREL
Scale 1:210000
0
5
10
15
20 kilometers

Title: Alternative Railway Routes Considered During the Design Phase	Figure No. 1.3

Legend

- Old Proposed Railway Routes with options
- New Proposed Railway
- Town

CEODATEC cc

- **The Barragem Route**
  This is the longest route and the railway line would link into the Limpopo line near Barragem before it crosses the Limpopo River. Thus, no bridge is required. The Barragem Route was favoured by the ports and harbour authority, Caminhos de Ferro de Moçambique (CFM) because it obviates the need for a new bridge over the Limpopo River. The disadvantage with this route is its length, which is approximately 41km longer than the Leonde route. However, the route was chosen as the preferred route, even though it is the longest route, as it would encounter less engineering problems than the other two routes.

The choice of the Barragem route and the preliminary design for it produced by McClintock & Skinner was "Approved in Principle" by CFM on 20 June 2000. By giving approval, CFM agrees to accept the proposed traffic onto its system and confirms that:

1. The point of connection of the proposed rail link into the Limpopo main line is acceptable from operating and technical considerations; and
2. The proposed design standards and specifications are acceptable.

This route and approved design was used in the Full Feasibility Study for the Corridor Sands Project completed in August 2000.

1.3.3 REFINEMENT OF THE BARRAGEM ROUTE

The McClintock & Skinner design for the Barragem route was based on an aerial survey of the route flown in 1999. However, the floods of February 2000 limited the amount of ground verification because of access difficulties and this made it difficult to assess the impact of the route on the communities along the route.

To rectify this, CES carried out a detailed field investigation during November 2000 along the proposed route and concluded that it was environmentally unacceptable as it impacted on an estimated 925 households. The study suggested that several slight realignments of the route in certain well-populated areas would significantly reduce this impact.

This information was communicated to Corridor Sands Limitada (CSL) who then instructed that, in keeping with the philosophy of minimising negative project impacts, alternative alignments should be identified.

As a result, Arcus Gibb were appointed to review the proposed rail route and to identify and design the necessary changes to achieve the objective of minimising the impact of the rail route on the local population. In addition, it was decided to re-survey the rail route corridor using airborne laser technology, as this would give the design team a much higher degree of accuracy in their survey data. Arcus Gibb were also instructed to work in conjunction with CES, in order to ensure that the ecological and socio-economic implications of the refined route were fully integrated into their design process.

Arcus Gibb and CES achieved this integration with a combined site visit in March 2001. The objective was to examine minor route alternatives, and then working together to analyse the airborne laser data to ensure that Arcus Gibb's final route design took cognisance of any environmental issues.

The final site visit took place from 23 to 27 July 2001 when a combined team of Arcus Gibb design engineers and CES environmental consultants travelled along the entire route to achieve final ground truth verification. This Environmental Impact Assessment therefore assesses the final route, described in detail in Section 1.3.4.

Thus, the environmental input into route design can be summarised as follows:

- *Initial scoping survey* – Undertaken in November 1999, before the completion of the initial rail route by McClintock & Skinner Incorporated (consultant railway engineers).
- *Detailed field survey* – A 10-day survey undertaken in November 2000 to examine the implications of the rail route designed by McClintock & Skinner.
- *Route modification survey* – A 3-day survey undertaken in March 2001, with Arcus Gibb, to examine possible modifications to the route before the aerial survey was flown by Airborne Laser Surveys.
- *Final verification survey* – A 5-day survey undertaken in July 2001 with the Arcus Gibb rail design team, to "ground truth" and verify the final route.

1.3.4 DESCRIPTION OF THE CHIBUTO-BARRAGEM ROUTE

Background to the engineering of this route

A significant amount of preliminary engineering work, involving choosing the optimal route and then designing and costing the necessary rail infrastructure and rolling stock, was undertaken during 1999 and 2000 by McClintock & Skinner Incorporated. Since then Arcus Gibb have refined the design and slightly re-aligned the route to minimise the number of households that need to be relocated (see Chapters 5 and 6).

Horizontal alignment

The proposed rail link is 86.5 km long, and will extend from the marshalling yard on top of the dune plateau near Chibuto, across the Changane and Limpopo floodplains to join the existing CFM-S mainline north of Barragem, approximately 228km from Maputo. The layout of the railway line is presented in Figure 1.3.

The railway line starts at the marshalling yard (i.e. Chainage 86.5[3]) on top of the dune, at an elevation of 120 metres above mean sea level (mamsl). The route winds down the eastern slope of the dune plateau overlooking the Changane floodplain and to the northwest of Chibuto town until it reaches the Changane floodplain, which is approximately 100m lower than the marshalling yard. This part of the route is the steepest, losing 100m in elevation over a distance of 10km. The rest of the route is fairly flat.

The railway line for the most part tries to follow the Chibuto to Barragem road. The route crosses onto the Changane floodplain at Chainage 76 where it turns west across the floodplain, following the alignment of the existing Chibuto-Barragem road. After approximately 16km (average elevation 10 mamsl) the route climbs out of the floodplain onto a low ridge (average elevation 20 mamsl), bypassing the small town of Chaimite, and then some 5km later descends back into the floodplain. The route continues through the floodplain (average elevation 16 mamsl) until Chainage 49, near the town of Santa Isadoro, where it begins a slow ascent out of the floodplain onto a low elongated levee ridge[4] lying parallel to the current channel of the Limpopo.

The route then runs along the levee all the way to the junction with the CFM-S mainline near Barragem. For the next 34km, from Santa Isidoro to Chainage 15, the route varies in elevation from 26 mamsl to about 30 mamsl. Thereafter the route steadily climbs to a maximum elevation of 44 mamsl at Chainage 6 and then drops down slightly before joining the Limpopo line at Chainage 0. The proposed joining point on the CFM-S mainline is approximately 228km from Maputo.

[3] Railway line chainages originally started in Chibuto and ended near Barragem. However, for engineering purposes this has been changed so that the starting point is where the rail link joins the existing CFM-S mainline (i.e. Chainage 0) and the end is Chibuto (i.e. Chainage 86.5km). Railway line chainages are given in kilometres.
[4] A levee is defined as "a natural embankment built up by overbank deposition from a river."

The railway line crosses a secondary road at Chainage[5] 3 and the Barragem to Chibuto main road twice at Chainages 13.6 and 17.4.

The signalling and communications from the CFM-S connection at Barragem to the interface at Chibuto mine will be installed and operated as an integral part of the CFM-S system. All rail and road intersections will have level crossings. The railway servitude will not be fenced.

Vertical Alignment

The railway will be built on fill material, with bridges, culverts and a 250-metre viaduct[6]. As the railway line winds its way down the dune to the Changane River floodplain, the line includes a series of cuts and fills at an up-gradient of 1 in 80.

Flooding is a serious risk, and as such is discussed in more detail in Section 2.4.1 (Chapter 2). The 27km portion of the rail line, from the foot of the dune (Chainage 76) across the Changane floodplain to Santa Isidoro (Chainage 49), lies below the Limpopo 25-year flood line. Furthermore, the lowest portion of the rail route, the 800m portion running from Chainage 75.2 to 74.4 in the area of the Changane river crossing, will flood frequently, even if the Limpopo does not burst it banks. With an elevation of 10 mamsl this section of the route lies just below the 10-year flood line of 10.3 mamsl. The rest of the rail line is not affected as it lies above the Limpopo 50-year flood line.

To minimise flood damage, the formation (i.e. the bulk fill material and layer-work) and stormwater drainage have been designed to ensure that damage is limited to contamination and loss of ballast. However, the height of the rail link embankment is constrained by the CFM requirement that the maximum height of the fill material beneath the ballast is restricted to 4 metres.

The stormwater drainage system, i.e. bridges and culverts, has been positioned to match the existing drainage system in order not to change the natural watercourses and channels. This is particularly the case where the railway runs adjacent to the existing road.

Three major bridges will be constructed in the section of railway line that crosses the Changane River floodplain, and will be in line with the existing road bridges. A fourth bridge together with about 125 metres of viaduct on either side of it will have to be constructed at approximately Chainage 46.1 to allow the line to cross a major watercourse located to the north of the town of Chibabel.

Basic Design Criteria

The rail system has been designed in two stages:

- Stage 1: Capacity to rail all cargoes produced at a production rate of 500 000 tonnes titanium slag per annum.
- Stage 2: Capacity to rail all cargoes produced at a production rate of 1 000 000 tonnes titanium slag per annum.

[5] Chainage of the railway line is given in kilometres and starts (0km) where the rail link connects into the existing Limpopo railway line.

[6] A viaduct is a long bridge-like structure for carrying a road or railway line over a valley or dip in the ground.

Within the limitations of the mapping, the alignment has been selected to comply with the following requirements:

- Horizontal and vertical geometry compatible with normal freight train operation;
- The minimisation of impacts on existing households;
- The avoidance of stormwater floodplains where possible; and
- The use of minimum ground surface area.

The design and specifications of the Chibuto-Barragem rail link as well as the Chibuto and Matola marshalling yards will correspond to CFM mainline standards. These standards are, however, higher than those on the existing Limpopo line, which will therefore have to be upgraded to meet them.

The key criterion is that all the tracks will have to be built and/or rehabilitated to a standard 20 tonnes maximum axle loading. This will allow an increase of 1.5 tonnes per axle from the current standard for the Limpopo line of 18.5 tonnes axle loading. The railway wagons that will be used will have a nominal mass of 74 tonnes and will not exceed a gross mass of 80 tonnes.

The track structure will consist of 45kg/m 900 Mpa ultimate tensile strength rail on concrete sleepers with Pandrol fastening sets. The rails and sleepers will be embedded into crushed stone ballast to provide support for the superimposed loads. The minimum ballast depth below the sleepers is 225mm, with the track supported by the earth sub-ballast and formation. The ballast volume will be 1.250m^3 per kilometre, with a top width of 2.6 metres. The existing ground would be grubbed and cleared to a depth of about 200mm, compacted and pavement layers of the formation placed directly on the compacted ground.

Bulk fill material

The four layers of fill material required are:

1. Layer 1 – Upper sub-ballast layer;
2. Layer 2 – Lower sub-ballast layer;
3. Layer 3 – Upper sub-grade layer; and
4. Layer 4 – Bottom layer or lower sub-grade layer.

Geotechnical investigations have concluded that there is no suitable material for layers 1 and 2 along the route, and these upper two layers will have to be stabilised with lime or cement. However, there is bulk fill material available for layers 3 and 4. Layer 4 occurs throughout the last 54km of the route, and the only section where material will have to be hauled greater than 3km is between Chainage 68.8 and 76.5, with a maximum haul distance of 4km. Layer 3 is widely spread in two sections along the route (between Chainage 38.5 and 46.1, and Chainage 76.5 and 85.9) and it is anticipated that between these two sections haulage distances will not be more than 3km. Outside these two sections, between Chainage 28.5 and 38.5, the haul distance is anticipated to be approximately 5km, and between Chainage 46.1 and 76.5, the maximum haul distance is anticipated to be approximately 15km.

Table 1.3a summarises the quantities of material and lengths of various structures.

Table 1.3a: Quantities of material and lengths of various structures.

Description	Quantities
Bridges	4
Viaduct	0.25km
Major culverts	140m
Minor culverts	246m
Fill materials	1 630 000 m³
Selected layers for formation	890 000 m³
Cut material	330 000 m³

1.3.5 THE CARGOES

The Corridor Sands mineral processing plant and smelter will produce four products, namely titanium slag, ductile iron, rutile and zircon, and all will be railed to a purpose built bulk cargo facility at Matola Harbour for export. The forecast volumes of bulk cargoes to be railed are shown in Table 1.3b.

Table 1.3b: Forecast Bulk Cargo Volumes (tonnes per year).

Phase	Year	Slag	Ductile Iron	Zircon	Rutile
1	2005	375 000	183 750	34 664	10 500
2	2007	500 000	245 000	46 500	14 000
3	2009	625 000	306 250	57 491	17 500
5	2011	750 000	367 500	69 327	21 000
6	2013	875 000	428 750	80 318	24 500
7	2015	1 000 000	490 000	93 000	28 000

Titanium slag

The titanium slag, a non-toxic powder, will be transported in bulk in purpose built rail tankers from Chibuto to Matola Harbour. The slag must be kept dry and free from contamination, and consequently all slag transport, storage and loading facilities will be enclosed and equipped with dust extraction systems.

Rutile, zircon and ductile iron

The rutile and zircon will be transported either in 1-tonne bulk bags or in bulk in rail tankers, depending on the individual customer requirements. The ductile iron will be exported in the form of 5 to 10kg lumps of iron and will be loaded using grabs or magnets.

Anthracite, diesel and mine consumables

In addition anthracite, diesel fuel oil and mine consumables will be transported to the mine from Maputo. The initial volume of anthracite will be 75 000 tonnes per annum and this will increase to 200 000 tonnes per annum at full production. Initially, 12 million litres of diesel fuel oil per year will be transported to the mine and this will increase to 36 million litres at full production. This includes the fuel requirement for the shunting locomotives.

Mainline locomotives will not be used for shunting. A few anthracite and diesel fuel wagons would be coupled to the train sets to haul these consumables from Matola Harbour to Chibuto.

Number of trains
During stage one (i.e. capacity to rail all cargoes produced at a production rate of 500 000 tonnes titanium slag per annum) a total of three trains per day, two with titanium slag and one with mixed cargoes, will leave the site at Chibuto, 313 operating days per annum. Train activity will increase to six trains per day at full production during stage 2 (i.e. capacity to rail all cargoes produced at a production rate of 1 000 000 tonnes titanium slag per annum).

Trains carrying titanium slag will consist of 23 tankers loaded with slag. These wagons can be turned around in 48 hours. Mixed cargo trains consisting of 20 wagons will be loaded with rutile, zircon and ductile iron. These wagons can also be turned around in 48 hours.

1.4 PURPOSE OF THE SPECIALIST BASELINE REPORTS

The primary purpose of the baseline specialist studies is to gain an understanding of baseline conditions and generate sufficient factual information to assess the significance and severity of environmental impacts. In order to achieve this, the specialist reports contain facts and information describing the affected environment, and include primary data collected specifically for the study, as well as secondary data from published and unpublished sources. Data relevant for identifying and assessing environmental impacts that might occur on a specific component of the environment under study were collected, and each specialist explained and interpreted the various components of the natural and human environments of the rail route.

The baseline studies phase was divided into six distinct studies, and covered all the important and relevant components of the physical, biological and social environments. The specialist reports are:

1. Surface Water (Chapter 2);
2. Vegetation (Chapter 3);
3. Fauna (Chapter 4);
4. Social Impact Assessment (Chapter 5);
5. Resettlement and Compensation Plan (Chapter 6); and
6. Archaeology (Chapter 7).

Impacts were assessed using a standard rating system developed by CES and used in other EIAs, including the EIA of the mining project (see Section 1.6). This was done to ensure that various impacts could be assessed in a similar fashion, in order to compare the significance of impacts on different affected systems. Furthermore, recommendations on how to mitigate adverse effects and optimise beneficial ones were included in these studies, thus allowing experts in the respective fields to make value judgements based on the information collected during their studies. Relevant information presented in the specialist reports is summarised and presented in Volume 3, the Environmental Impact Report.

1.5 SPECIALIST TEAM FOR THE SPECIALIST STUDIES

A list of these specialists, their qualifications and their expertise is provided in Table 1.5 below.

Table 1.5: List of specialists, their qualifications and their expertise.

NAME & QUALIFICATION	AFFILIATION	REPORT/ CHAPTER NO.	EXPERTISE
Avis, A.M. Dr PhD	Coastal & Environmental Services (CES) P.O. Box 934 Grahamstown, 6140 Email: sec@cesnet.co.za	EIA project manager. Reviewer of all chapters.	Director of Coastal and Environmental Services. Coastal ecologist and environmental scientist with research and consulting experience in EIAs, rehabilitation studies, project management, coastal zone management and vegetation surveys. Associate lecturer at Rhodes University in Environmental Sciences.
Blood, J.R. Mr BSc (Hons)	Coastal & Environmental Services P.O. Box 934 Grahamstown, 6140 Email: j.blood@cesnet.co.za	Project co-ordination and liaison. Introduction (ch 1) Vegetation (ch 3)	Full time environmental consultant for CES. Completed numerous scoping reports, EIAs and vegetation surveys.
Branch, W.R. Dr PhD	P.E. Museum Box 13147 Humewood Port Elizabeth, 6013 Email: pemwrb@zoo.upe.ac.za	Fauna (ch 4)	Curator of Herpetology at the Port Elizabeth Museum. Involved in diverse herpetological studies. Chairman of the IUCN African Reptile and Amphibian Group. Completed 13 Environmental Impact Assessment reports, over 100 scientific publications and 4 books. Permanent associate of CES.
Hoare, D. Mr MSc	David Hoare Consulting PostNet Suite # 270 Private Bag X844 Silverton 0127	Vegetation (ch 3)	Specialist in vegetation description, mapping and dynamics. Experience in biological surveys for the mining, forestry and utility industries in South Africa; national vegetation mapping programmes for government and research organisations; natural resource management using remote sensing and aerial photography; authored or co-authored 38 scientific papers and technical reports.
Huggins, G. Mr M.Soc.Sc (Social Anthropology)	IWR Environmental P.O. Box 789 Howick, 3390 Email: huggins@iafrica.com	Social Impact Assessment (ch 5) Resettlement & Compensation Plan (RCP) (ch 6)	Director of IWR Environmental. Specialises in social impact assessment, resettlement and development planning, socio-economic analysis and applied research. Has twelve years of experience in these fields. Involved in a number of resettlement studies prepared to World Bank standards.
Kaplan, J. Mr MA (Archaeology)	Agency for Cultural Resource Management PO Box 159, Riebeek West, 7306, Western Cape Email: acrm@wcaccess.co.za	Archaeology (ch 7)	Director of the Agency for Cultural Resource Management. Specialists in archaeological impact assessments and heritage resource management.

NAME & QUALIFICATION	AFFILIATION	REPORT/ CHAPTER NO.	EXPERTISE
Lubke, R.A. Prof. PhD (University Western Ontario)	Department of Botany Rhodes University Grahamstown, 6140	Vegetation (ch 3)	Associate Professor and Head of Department of Botany, Rhodes University, and Director of Coastal & Environmental Services. Has been involved in numerous EIAs and has extensive experience in ecological and vegetation studies.
Shepherd, P. Mr BSc (Hons) (Hydrology)	SRK Consulting P.O. Box 55291 Northlands, 2116	Hydrology (ch 2)	Principal Scientist at SRK Consulting with 9 years experience in the field of hydrology. Has undertaken extensive work in the supply and management of water in new and existing mines and specialises in hydrology relevant to dams, rivers, stormwater, flood control, environmental water aspects and water resource management.
Sitoi, J. Mr B.Tech	P.O. Box 1899 Umhlanga Rocks, 4320	Social Impact Assessment (ch 5) Resettlement and Compensation Plan (RCP) (ch 6)	Expertise in development planning and facilitation, and community consultation.

1.6 ASSESSMENT OF ENVIRONMENTAL IMPACTS

Although specialists were given free reign on how they conducted their research and obtained information, they were required to provide the reports in a specific layout and structure, so that a uniform specialist report volume could be produced. Consequently, the specialists were given detailed information on how these reports should be laid out, and considerable time has been spent ensuring that reports are of the highest standard possible. Furthermore, to ensure the integration of the various disciplines, the study team undertook their site investigations at the same time. This helped specialists to inform each other of key aspects that required consideration during the course of their investigation.

To ensure a direct comparison between various specialist studies, six standard rating scales were defined and used to assess and quantify the identified impacts. This is necessary since impacts have a number of parameters that need to be assessed. The rating system used for assessing issues is based on three criteria, namely:

1) The relationship of the issue to temporal scales (Box 1.6a);
2) The relationship of the issue to spatial scales (Box 1.6b); and
3) The severity of the issue (Box 1.6c).

These three criteria are combined to describe the overall importance rating, namely the significance (Box 1.6d). In addition, the following parameters are used to describe the issues:

4) The risk or likelihood of the issue occurring (Box 1.6e); and
5) The degree of confidence placed in the assessment of the issue (Box 1.6f).

1.6.1 TEMPORAL SCALE

The temporal scale defines the significance of the impact at various time scales, as an indication of the duration of the impact.

Box 1.6a: Temporal scale used in assessing issues.

- Short term - less than 5 years. Many construction phase impacts will be of a short duration.
- Medium term - between 5 and 20 years.
- Long term - between 20 and 40 years (a generation) and from a human perspective essentially permanent.
- Permanent - over 40 years and resulting in a permanent and lasting change that will always be there.

1.6.2 SPATIAL SCALE

The *spatial scale* defines physical extent of the impact.

Box 1.6b: Spatial scale used in assessing issues.

- *Individual* - this scales applies to person/s along the affected route.
- *Household* - this scales applies to households along the affected route.
- *Localised* - at localised scale and a few hectares in extent. The specific area to which it refers is defined in the chapter in which it appears.
- *Rail route* - the area of primary impact, equivalent to the study area.
- *District* - the administrative districts of Chibuto, Guija, Barragem and Chokwe.
- *Regional* - Gaza Province.
- *National* - Mozambique.
- *International*

1.6.3 SEVERITY/BENEFICIAL RATING SCALE

The ***severity scale*** was used by the various specialists in order to scientifically evaluate how severe negative impacts would be, or how beneficial positive impacts would be on a particular affected system (for ecological impacts) or a particular affected party. It is a methodology that attempts to remove any value judgements from the assessment, although it relies on the professional judgement of the specialist.

Box 1.6c: Severity/beneficial scale use in the EIA.

Very severe An irreversible and permanent change to the affected system(s) or party (ies) which cannot be mitigated. For example, the permanent change to topography resulting from a quarry.	***Very beneficial*** A permanent and very substantial benefit to the affected system(s) or party(ies), with no real alternative to achieving this benefit. For example, the creation of a large number of long term jobs.
Severe Long term impacts on the affected system(s) or party(ies) that could be mitigated. However, this mitigation would be difficult, expensive or time consuming or some combination of these. For example, the clearing of forest vegetation.	***Beneficial*** A long term impact and substantial benefit to the affected system(s) or party(ies). Alternative ways of achieving this benefit would be difficult, expensive or time consuming, or some combination of these. For example, an increase in the local economy.

Moderately severe Medium to long term impacts on the affected system(s) or party (ies), that could be mitigated. For example, constructing a narrow road through vegetation with a low conservation value.	***Moderately beneficial*** A medium to long term impact of real benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are equally difficult, expensive and time consuming (or some combination of these), as achieving them in this way. For example a slight improvement in the (local) roads.
Slight Medium or short term impacts on the affected system(s) or party(ies). Mitigation is very easy, cheap, less time consuming or not necessary. For example, a temporary fluctuation in the water table due to water abstraction.	***Slightly beneficial*** A short to medium term impact and negligible benefit to the affected system(s) or party(ies). Other ways of optimising the beneficial effects are easier, cheaper and quicker, or some combination of these. For example, a slight increase in the amount of goods available for purchasing.
No effect The system(s) or party(ies) is not affected by the proposed development	***Don't know/Can't know*** In certain cases it may not be possible to determine the severity of an impact.

1.6.4 SIGNIFICANCE SCALE

The ENVIRONMENTAL SIGNIFICANCE scale is an attempt to evaluate the importance of a particular impact. This evaluation needs to be undertaken in the relevant context, as an impact can either be ecological or social, or both. The evaluation of the significance of an impact relies heavily on the values of the person making the judgement. For this reason, impacts of especially a social nature need to reflect the values of the affected society. A six-point significance scale has been applied (see Box 1.6d).

In many cases scientists have to produce an assessment in the absence of all the relevant and necessary data. American legislation (CEQ regulations at 40 CFR 1502.22) has considered these limitations, and makes the following recommendations:

"When an agency is evaluating reasonably foreseeable significant adverse effects on the human environment in an Environmental Impact Statement (EIS) and there is incomplete or unavailable information, the agency shall always make clear that such information is lacking if the incomplete information is essential to a reasoned choice among alternatives. If the overall costs of obtaining it are not exorbitant, the agency shall include the information in the EIS".

There are two acceptable procedures to follow to compensate for a shortage of data:

1. **It is more important to identify likely environmental impacts than to precisely evaluate the more obvious impacts**

All assessors (the different specialists) try to evaluate all the significant impacts, recognising that precise evaluation is not possible. It is better to have a *possible* or *unsure* level of certainty on important issues than to be *definite* about unimportant issues.

2. **It is important to be conservative when reporting likely environmental impacts**

Because of the fact that assessing impacts with a lack of data is more dependable on your own scientific judgement, the rating on the certainty scale cannot be too high. If the evidence for a potential type of impact is not definitive in either direction, the conservative conclusion is that the impact **cannot be ruled out with confidence**, not that the impact is not proven. It is for these reasons that a *degree of certainty* scale has been provided, as well as the categories DON'T KNOW and CAN'T KNOW.

Box 1.6d: The significance rating scale

VERY HIGH

These impacts would be considered by society as constituting a major and usually permanent change to the (natural and/or social) environment, and usually result in **severe** or **very severe** effects, or **beneficial** or **very beneficial** effects.

Example: The loss of a species would be viewed by informed society as being of VERY HIGH significance.

Example: The establishment of a large amount of infrastructure in a rural area, which previously had very few services, would be regarded by the affected parties as resulting in benefits with a VERY HIGH significance.

HIGH

These impacts will usually result in long term effects on the social and/or natural environment. Impacts rated as HIGH will need to be considered by society as constituting an important and usually long term change to the (natural and/or social) environment. Society would probably view these impacts in a serious light.

Example: The loss of a diverse vegetation type, which is fairly common elsewhere, would have a significance rating of HIGH over the long term, as the area could be rehabilitated.

Example: The change to soil conditions will impact the natural system, and the impact on affected parties (in this case people growing crops on the soil) would be HIGH.

MODERATE

These impacts will usually result in medium- to long-term effects on the social and/or natural environment. Impacts rated as MODERATE will need to be considered by society as constituting a fairly important and usually medium term change to the (natural and/or social) environment. These impacts are real but not substantial.

Example: The loss of a sparse, open vegetation type of low diversity may be regarded as MODERATELY significant.

Example: The provision of a clinic in a rural area would result in a benefit of MODERATE significance.

LOW

These impacts will usually result in medium to short term effects on the social and/or natural environment. Impacts rated as LOW will need to be considered by the public and/or the specialist as constituting a fairly unimportant and usually short term change to the (natural and/or social) environment. These impacts are not substantial and are likely to have little real effect.

Example: The temporary change in the water table of a wetland habitat, as these systems are adapted to fluctuating water levels.

Example: The increased earning potential of people employed as a result of a development would only result in benefits of LOW significance to people who live some distance away.

NO SIGNIFICANCE

There are no primary or secondary effects at all that are important to scientists or the public.

Example: A change to the geology of a particular formation may be regarded as severe from a geological perspective, but is of NO significance in the overall context.

DON'T KNOW

In certain cases it may not be possible to determine the significance of an impact. For example, the primary or secondary impacts on the social or natural environment given available information.

Example: The effect of a particular development on people's psychological perspective of the environment.

1.6.5 RISK OR LIKELIHOOD

The risk or likelihood of all impacts taking place as a result of project actions differs. There is no doubt that some impacts would occur if the rail link goes ahead, but certain other (usually secondary) impacts are not as likely, and may or may not result from the rail link. Although these impacts may be severe, the likelihood of them occurring may affect their overall significance and will be taken into account.

Box 1.6e: The risk or likelihood scale.

Very unlikely to occur – the chance of these impacts occurring is extremely slim, e.g. an earthquake destroying rail bridge over the Changane River.
Unlikely to occur – the risk of these impacts occurring is slight. For example an impact such as an increase in alcoholism and associated family violence as a result of increased wealth is unlikely to occur.
May occur – the risk of these impacts is more likely, although it is not definite, for example the chance that a road accident may occur during the construction phase.
Will definitely occur – there is no chance that this impact will not occur, for example the clearing of vegetation in the proposed rail route.

1.6.6 DEGREE OF CONFIDENCE OR CERTAINTY

It is also necessary to state the degree of certainty or confidence with which one has predicted the significance of an impact. For this reason, a 'degree of certainty' scale has been provided to enable the reader to ascertain how certain we are of our assessment of significance:

Box 1.6f: The degree of certainty or confidence used in this EIA.

Definite:	More than 90% sure of a particular fact. To use this one will need to have substantial supportive data.
Probable:	Over 70% sure of a particular fact, or of the likelihood of that impact occurring.
Possible:	Only over 40% sure of a particular fact or of the likelihood of an impact occurring.
Unsure:	Less than 40% sure of a particular fact or the likelihood of an impact occurring.