BOEGOEBAAI PORT FEL 1 PHASE 1

RAIL ROUTE INVESTIGATION LINKING BOEGOEBAAI PORT TO THE NORTHERN CAPE MINES

REV 0

October 2019

TM Consulting and Nelutha Consulting
Boegoebaai, South Africa

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FEL 1

October 2019

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LIST OF ABBREVIATIONS

AC	:	Alternating current
BS	:	British Standards
CAPEX	:	Capital Expenditure
CPA	:	The Richtersveld Sida !Hub Community Property Association
DC	:	Direct current
DP	:	Distributed Power
EG	:	Theoretical cant
EIA	:	Environmental Impact Assessment
EMP	:	Environmental Management Plan
EPC	:	Engineering, Procurement and Construction
FEL1	:	Front-End Loading Stage 1
HV	:	High voltage (33,000 volts to 132,000 volts)
IEC	:	International European Commission
ISO	:	International Standards Organization
K	:	Minimum Vertical Curve Radius
kg/m	:	Kilogram per meter
km	:	Kilometer
km/hr	:	Kilometer per hour
kN	:	Kilonewtons
kV	:	Kilovolts
L	:	Length
m	:	Meter
mm	:	Millimeters
m^3/km	:	Cubic meters per kilometer
MCA	:	Multi-Criteria Assessment
MPT	:	Multi-Purpose Terminal
mtpa	:	Million metric tonnes per annum
NCC	:	Network Control Centre
No	:	Number
OHTE	:	Overhead Traction Equipment
OPEX	:	Operational Expenditure
PRASA	:	Passenger Rail Agency of South Africa
R	:	Radius
R&D	:	Research and Development
SANS	:	South African National Standard
TNPA	:	Transnet National Parts Authority
TFR	:	Transnet Freight Rail
TPT	:	Transnet Port Terminals
V	:	Speed

ANNEXURES

- Book of Drawings

EXECUTIVE SUMMARY

Introduction

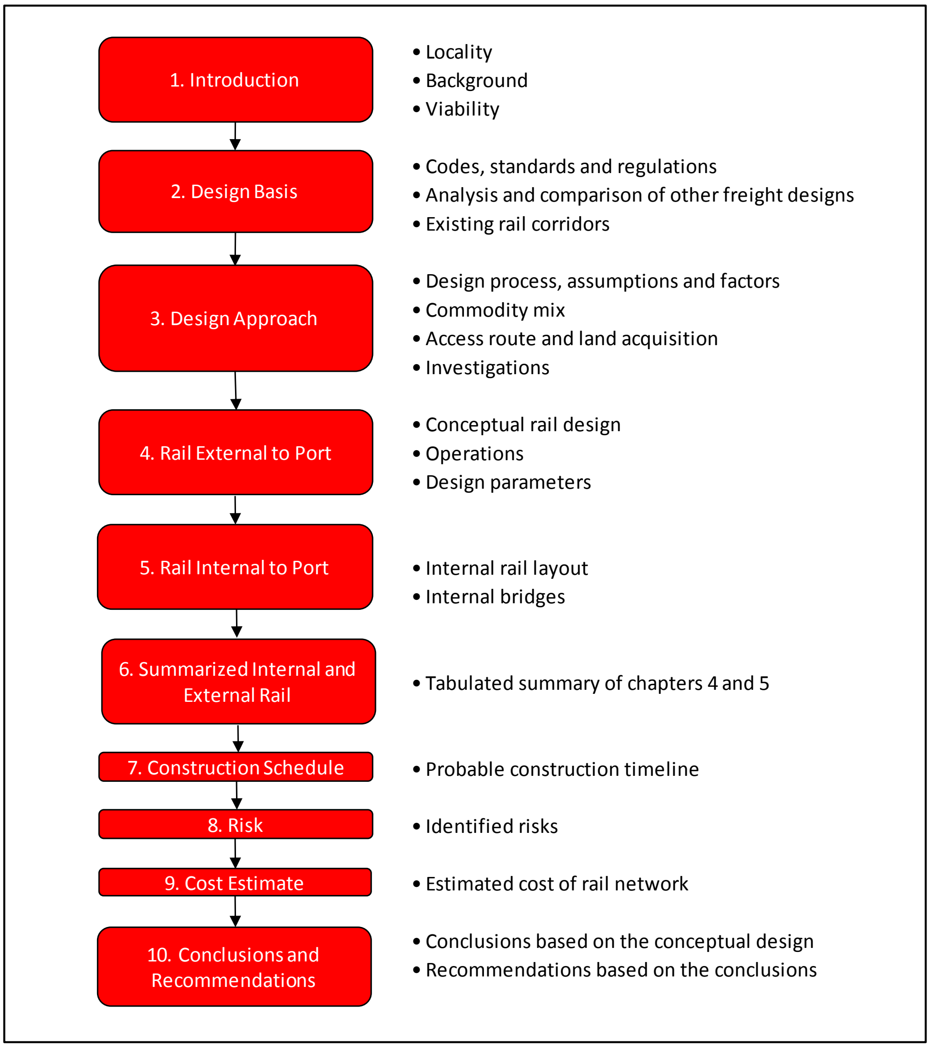
The aim of this report is to conceptualize a proposal for a railway network. This railway is intended to provide the Boegoebaai Port development with an alternative method of commodity transportation within the Northern Cape Province.

The Boegoebaai Port will be located 20km south of Alexander Bay and 60km north of Port Nolloth and developed as part of the Landside FEL2 Report. The proposed rail is aimed to connect the Boegoebaai Port to the Sishen to Saldanha Rail. The Boegoebaai Rail will be aligned alongside the R382, N7 and N14 where possible.

The port has been divided into two stages of development, Phase 1A and Phase 1B. Completion of these phases is anticipated to span over the next 10-years and 20-years, respectively. Phase 1A will include all roads (including the interchange and road-over-road bridge as well as the road-over-rail bridge on the main boulevard internal road) and platforms. Phase 1B will comprise of a railway line, platforms for the marshalling yards, and tippler infrastructure and a road over rail bridge.

Report Flow

The following diagram provides a summarized flow that the report will follow.



Design Basis

Codes, Standards and Regulations

The South African Standards used were taken from numerous SANS documents.

Furthermore, standard gauge locomotives were compared to narrow gauge locomotives. It was found that standard gauge locomotives have significant advantages over narrow gauges, including speed, stability, volumetric vehicle size and economically viability. However, a narrow Cape Gauge will likely be required to align with the gauge that the Sishen to Saldanha line uses.

TRANSNET Freight Rail Manuals were also used to aid in the design process.

Other standards used include the Road Drainage Manual, ISO and COLTO.

Notably, TRANSNET Freight Rail puts an importance on safety, by ensuring safe working practices through the management of an Integrated Safety Management System. According to TRANSNET, the quality of the environment operated in should be protected and conserved, so that the needs of present and future generations are not compromised. TRANSNET also aim to implement an Environmental Management System that complies with the SABS 14001 framework.

Analysis and Comparison of Other Freight Designs

Due to the length of the railway, the tonnage transported, the length of the trains and the operating logistics, the Boegoebaai Railway was designed according to similar standards as other South African rail networks; specifically, railways that use the same track for both passenger and freight trains.

The Boegoebaai Rail was designed to link with the Sishen to Saldanha Line and should therefore be designed to the same standards.

Existing Rail Corridors

The Sishen to Saldanha rail uses a Cape Narrow-Gauge Freight Rail; and therefore, the proposed rail should use a similar gauge should it connect to this rail network. Should the proposed railway be extended to connect to Oorkruis, a standard gauge freight rail could be considered.

Design Approach

Design Process, Assumptions and Factors

The mining activities at Groblershoop was first investigated. The existing main roads (N14, N7 and R363) were found to be the connecting routes between the proposed Boegoebaai Port and Groblershoop. The largest constraints to the design were found to be along Anenous Pass, on the R382 West of Steinkopf and on the link from Steinkopf to the N14.

Assumptions were made where information could not be acquired. Additionally, multiple factors influenced the proposed conceptual route alignment for this FEL1 phase. These factors primarily affected the rail alignment and limited the number of available routes. Factors include the topography, the existing layout of the roads and the type of minerals produced in the surrounding area.

Commodity Mix

The mining sector makes up almost 2 thirds of the total commodities traded within the Northern Cape. Approximately 25 million tons of general freight is moved from the Northern Cape. With the completion of this project, more commodities should be transported, allowing for mines to operate at a larger capacity.

Access Route and Land Acquisition

The railway is proposed to enter the port from the south-eastern direction. Furthermore, a land acquisition study will be required for the next phase of the project.

Investigations

Resources used to determine the rail alignment include Google Earth and South African Topological Maps.

Rail External to Port

Proposed Rail External to Port

The proposed railway will be approximately 500km in length. Furthermore, the Sishen to Saldanha line link exists just south of Kenhardt.

The proposed rail will be routed from the Boegoebaai Port towards Anenous Pass, intersect the N7 and then cross the N14 towards the Sishen to Saldanha railway line.

Bridges, Tunnels and Earthworks

Three bridges are required for road to rail intersections; and an additional seven river bridges will be required. Furthermore, all bridges will have a proposed width of 6m.

Two types of tunnel cross-sections were considered for this design. A single-track tunnel with an arch lining will reduce the amount of excavation required. A tunnel of rectangular form will allow for simpler construction provide more room beside the train. In total, four tunnels were proposed.

The total cut and fill required was calculated to be approximately 100 and 120 million m^3 respectively.

Operations

The Boegoebaai Railway proposed will transport predominantly Manganese from the Hotazel and Aggeneys mines. Until the freight becomes operational, the trucks will serve as the main mode of transportation to the Boegoebaai Port.

Furthermore, a detailed maintenance, emergency and operational plan will be required for the next phase of the project.

Rail Internal to Port

Internal Rail Layout

The Internal Rail will be designed to the same standards as the External Rail. However, two rails will be routed around the port to align with the material's handling operations of the port.

Internal Bridges

Two internal port bridges were required to be designed. This allowed the rail to intersect the R382 and the main boulevard.

Construction Schedule

Phase 1A, including the Marine Port Development and Landside Port Infrastructure, is expected to be operational from the year 2025. Phase 1B is envisaged to become operational after 2035, 10 years after Phase 1B has been completed.

Risk

The cost estimated is the main financial risk for this stage of the design. A quantitative risk analysis will be required to minimize the amount of financial risk involved.

Other main contributing risks include:

- Appropriate and legal acquisition of land
- Health and safety aspects concerning tunnel construction
- Eskom's ability to meet the energy demands caused by the implementation of the rail
- The surrounding ground conditions
- Environmental authorization risks
- Client procurement risks
- Property acquisition risks
- Economic risks excluding exchange rate fluctuations during the construction phase
- Business case risks (funding, revenue, tariffs, OPEX, etc)

Cost Estimate

An estimated cost for the Internal and External Rail was found to be ZAR 0.2bn and ZAR 15.5bn respectively. The total cost of the rail will therefore be approximately ZAR 16 bn, with an expected FEL1 accuracy of $\pm$50%.

TERMS OF REFERENCE

TM Consulting and Nelutha Consulting appointed PRDW and NAKO ILISO to preliminarily design a port within the Northern Cape Province. PRDW were appointed to design the port and marine engineering, and NAKO ILISO were appointed to design the landside and railway engineering. This report focuses on the landside engineering and aims to provide insight into the proposed port design.

The FEL1 Railway Report submission was to be submitted by mid October 2019.

The following documents are to be read in conjunction with this report for more information:

- Port and Marine design – FEL2 Report
- Landside Infrastructure – FEL2 Report
- Road External to the Port – FEL1 Report
- Rail Connection – FEL1 Book of Drawings

BOEGOEBAAI PORT FEL 1 PHASE 1

INTRODUCTION

RAIL ROUTE INVESTIGATION LINKING BOEGOEBAAI PORT TO THE NORTHERN CAPE MINES

1. INTRODUCTION

This chapter provides a brief introduction into the report and provides insight to some objectives and constraints of the project.

1.1 Aim

The aim of this report is to conceptualize a proposal for a railway network. This railway is intended to provide the Boegoebaai Port development with an alternative method of freight transport within the Northern Cape Province.

1.2 Location

The Boegoebaai Port will be located 20km south of Alexander Bay and 60km north of Port Nolloth. The proposed rail is aimed to connect the Boegoebaai Port to the Sishen to Saldanha Rail. The Boegoebaai Rail will be aligned alongside the R382, N7 and N14 where possible. Figure 1-1 indicates the locality of the proposed rail in relation to the Boegoebaai Port.

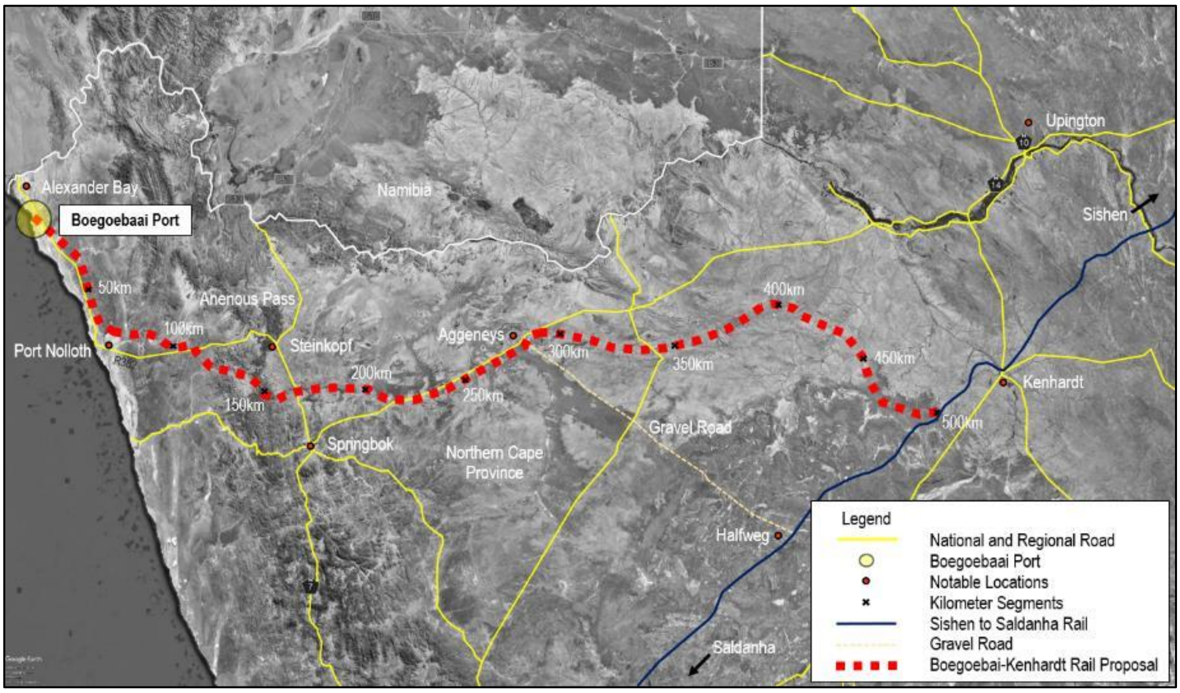


Figure 1-1: Proposed Rail connecting Boegoebaai to the Sishen to Saldanha Rail.

1.3 Background

NAKO ILISO were appointed to determine the feasibility of implementing a railway route through the Northern Cape Province. The proposed route will connect the Boegoebaai Port to the surrounding mines within the province and should be read in conjunction with the FEL2 Landside Report. The Boegoebaai Port was aimed to initially function independently of the rail via the use of freight transport by road; however, a railway system will greatly increase the total number of commodities exported out of the province.

A notable mine that will benefit from the implementation of the Boegoebaai Port includes the Aggeneys Mine (340km by road). The Aggeneys Mine primarily produces copper, manganese, lead and zinc.

The proposed railway will benefit from connecting to an existing railway system, namely the Sishen to Saldanha line, as it could then service mines along that route. Mines that would benefit from this connection include Orien Mineral's and Kumba Sishen Mine; both of which are located within the Copperton area and primarily produce zinc and copper.

Studies have shown that the Northern Cape Province will become the new mining boom province. The Northern Cape, more so than any other province within South Africa, has the potential to exponentially increase the number of exports of new-tech minerals. This includes zinc, nickel, lead, copper and cobalt. These minerals are used to manufacture smartphones, electric vehicles and renewable power systems.

The port has been divided into two stages of development, Phase 1A and Phase 1B. Completion of these phases is anticipated to span over the next 10-years and 20-years, respectively. Phase 1A, Figure 1-2, will include all roads (including the interchange and road-over-road bridge as well as the road-over-rail bridge on the main boulevard internal road) and platforms.

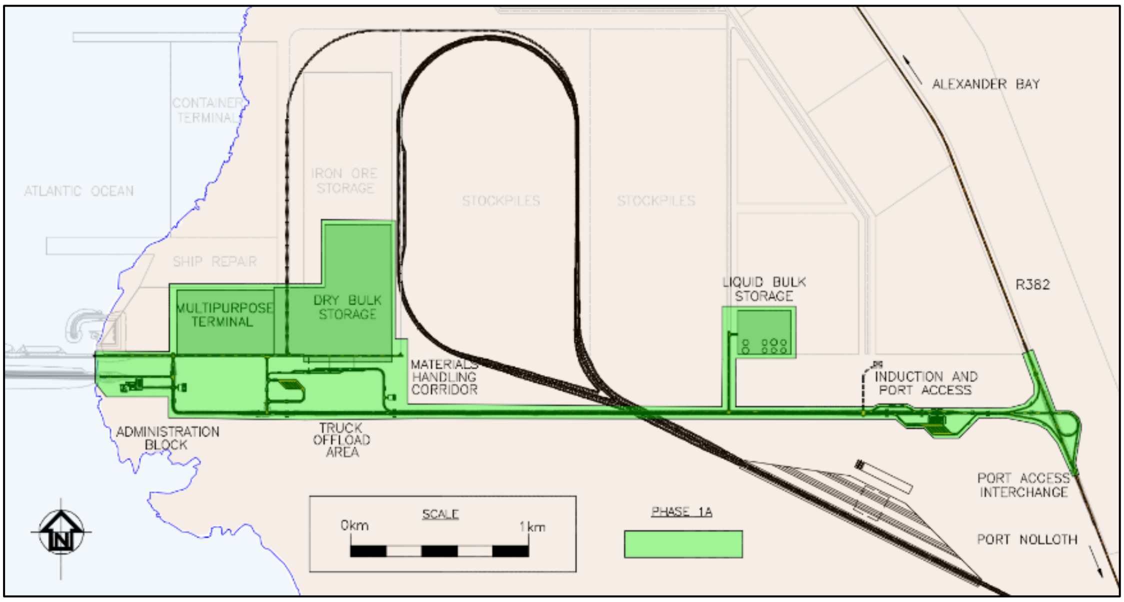


Figure 1-2: Phase 1A Internal Port Road and Terminals

Phase 1B encompasses both the External Rail that aims to connect the Boegoebaai Port to the Sishen to Saldanha rail, and the Internal Rail within the Boegoebaai Port Development, see Figure 1-3.

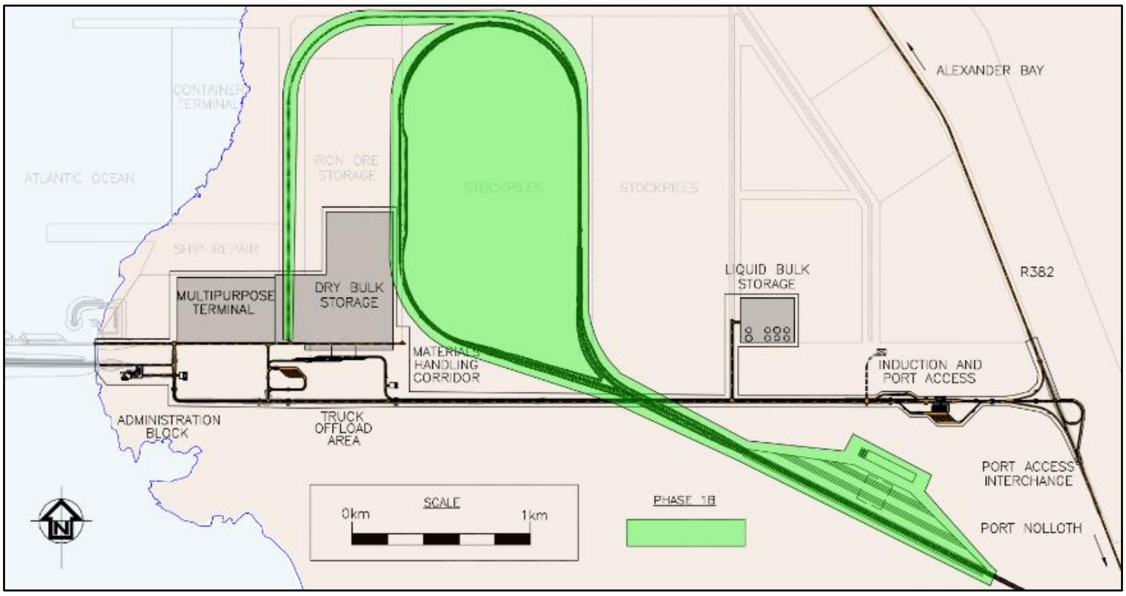


Figure 1-3: Phase 1B Internal Port Rail

1.4 Objectives

Objectives were beforehand determined to successfully design the preliminary rail network. Objectives include the determination of the scope of works, investigation of the linkage between the Northern Cape mines and possible further extensions, and the review of historical rail alignments, commodity mix and relevant reports.

Design objectives include the preliminarily design of the railway route with options and the determination of the typical cross-section, route alignments and design specifications.

Lastly, a FEL1 cost estimate and report was to be completed.

1.5 Viability

A financial and risk assessment will be required to determine the viability of the project.

1.6 Engineering analysis

The technical project has been developed up to FEL1 level with a target costing accuracy range of approximately 50%.

BOEGOEBAAI PORT FEL 1 PHASE 1

DESIGN BASIS

RAIL ROUTE INVESTIGATION LINKING BOEGOEBAAI PORT TO THE NORTHERN CAPE MINES

2. DESIGN BASIS

This chapter briefly summarizes the base information used in order to approach the design. It comprises of the codes/ standards used, the analysis and comparison of similar railways and discusses the existing rail corridors existing within South Africa.

2.1 Codes, Standards and Regulations

2.1.1 SA Standards

- SANS 10120: Code of Practice for Use with Standardized Specifications for Civil Engineering Construction and Contract Documents
- SANS 1200: Standardised Specification for Civil Engineering Construction Amendments to SANS 1200 as Required
- SANS 10100: The Structural Use of Concrete
- SANS 10102: The Selection of Pipes for Buried Pipelines
- SANS 10102 Part I: The Selection of Pipes for Buried Pipelines, Part 1 - General Provisions
- SANS 10102 Part II: The Selection of Pipes for Buried Pipelines, Part II – Rigid Pipes
- SANS 282: Bending Dimensions of Concrete Reinforcement
- SANS 10109: Floor Finishes of Concrete
- SANS 1024: Welded Wire Mesh for Concrete Reinforcement
- SANS 1491: Portland and Rapid Hardening Portland Cement
- SANS 677: Concrete Non-pressure Pipes
- SANS 1083: Aggregates for Concrete
- SANS 878: Ready Mix Concrete
- SANS 920: Steel Bars for Concrete Reinforcement
- SANS 986: Pre-cast Concrete Box Culverts
- SANS 664: Cast Iron Surface Boxes and Manhole and Inspect Cover and Frames
- SANS 667: Pre-cast Concrete Pipes
- SANS 10160: The General Procedures and Loadings to be Adopted in the Design of Buildings
- SANS 10161: The Design of Foundations for Buildings

2.1.2 Department of Transport

In August 2009, the Department of Transport completed a report called the Rail Gauge Study for South Africa. The report discussed the differences that exist between standard and narrow-gauge locomotives. It was found that standard-gauge locomotives have multiple advantages including speed, stability, volumetric vehicle size and economic viability. Standard gauge locomotives are also comparatively inexpensive based on a cost per kN tractive effort. However, new standard-gauge railway lines are often only justifiable where adequate freight traffic volumes are on offer (i.e. >10 Mtpa). Therefore, a narrow-gauge locomotive will likely be recommended as the Boegoebaai Port does not meet these requirements.

The minimum track width for South African Railways is significantly smaller than the International Standard. This reduces the total cost of the project and makes it more feasible. The following is the comparative minimum standards for rail gauges nationally and internationally:

- International Standard, 1435mm
- South African Standard, 1067mm

2.1.3 TRANSNET Standards

- TRANSNET Freight Rail Manual for Track Maintenance (2012)
- TRANSNET Freight Rail Manual for Track Welding BBB8341 Version 4 (2007)
- S410 (2006): Specification for Railway Earthworks
- S170 (2012): Flashbutt Welding Specification
- Water Office Handbook (1986): South African Transport Services
- BS8006-1:2010: Code of Practice for strengthened/reinforced soil and other fills
- Bridge Code (1983): South African Transport Services
- E.10 1996: Specification for Railway Track Work
- CEE 0041.98: 25 kV AC Electrification Overhead Track Equipment
- CEE 0060.84: Earthing and Bonding 25kV and 50kV AC Electrification
- CEE 0111.99: Specifications for 25kV AC Traction Substations
- E7/1: Specification for Works on, over, under or adjacent to Railway lines and near High Voltage Equipment
- ESI 1999: Electrical Safety Instructions 1999
- BBB 5452: TRANSNET Freight Rail's requirements for the Installation of Electrical Equipment For 3kV DC Traction Substations
- CEE.0111.99: Specification For 25kV AC Traction Substations
- CEE-T6E-1: 3kV OHTE Specification
- Signalling: As per TRANSNET Freight Rail design criteria with relevant SANS, BS and IEC standards as well as TRANSNET Freight Rail electrical safety and engineering instructions

2.1.4 Other Standards

- Road Drainage Manual 5th Edition 2006 by the South African National Roads Agency Limited
- Guidelines for Human Settlement Planning and Design by the Department of Housing 2003
- COLTO: Standard specifications for Road and Bridge Works for State Road Authorities (1998 Edition)
- ISO 9001:2000: Quality management system: Requirements

2.1.5 Legal and Safety requirements

Safety in TRANSNET Freight Rail has been regulated by the Railway Safety Regulator since 2002, which was appointed in terms of the National Railway Safety Regulator Act of 2002.

TRANSNET Freight Rail puts an importance on safety, by ensuring safe working practices through the management of an Integrated Safety Management System. According to TRANSNET, the quality of the environment operated in should be protected and conserved, so that the needs of present and future generations are not compromised. TRANSNET also aim to implement an Environmental Management System that complies with the SABS 14001 framework.

To ensure safe working practices, TRANSNET have empowered the regulator to take several actions. The regulators are responsible for conducting audits and receiving railway accident and incident reports from railway operators. The regulators are also required to complete regular inspections and analyze occurrence reports prepared by the operators. Furthermore, the regulator is required to analyze annual operators' safety plans according to the requirements of the Safety Management System regulations.

The regulator is responsible for the analysis of performance indicators and information relating to occurrences; which is submitted on a quarterly basis. They will also be required to issue notices to the operator to limit or cease activities that they deem unsafe.

The regulator will regularly review the standards, including technical standards and operating rules, and where applicable, the regulator can make applicable regulations. Lastly, the regulator is responsible for benchmarking operators' safety performance within South Africa and comparing operations internationally.

2.2 Analysis of Other Freight Designs

The Boegoebaai Rail was designed to link with the Sishen to Saldanha Line. Furthermore, due to the length of the railway, the tonnage transported, the length of the trains and the operating logistics, the Boegoebaai Railway line was designed to similar standards as other South African rail networks.

Table 2-1: South African Railway Lines used to design the Boegoebaai Rail Network

Railway Line	Track Length	Train Length	No. of Cargo	Date completed
The Mpumalanga/ Richards Bay coal line	580km	2.5km	20 800 per train	1976
The Sishen to Saldanha iron ore line	861km	2.2km	20 000 per train	1976

The design standards used for the Sishen to Saldanha railway line, as per the paper by T R Hindson, published in the Civil Engineer in South Africa, November 1979, can be seen in the table below.

Table 2-2: Design Standards used for the Sishen to Saldanha Railway Line

	Design Standard
Minimum length of grade	2.25km (train length) to ensure that no train would be on more than two at any time
Vertical curvature	Rate of change of curvature for both sags and summits were 0,016mm/m/m
Maximum grade change	One percent In exceptional cases 1.2% were allowed but only on straight sections
Approach grades to loops	Against loaded train 1:400 for 2 250m min Against empty train 1:200 for 2 250m min
Horizontal curvature	Minimum radius 1500m

Although the Boegoebaai Rail should abide to similar design standards as the Sishen to Saldanha Rail, the Sishen to Saldanha Rail was built in 1976. Therefore, another rail, the Mpumalanga / Richards Bay coal line, was investigated and used to assist in the determination of the various design parameters.

The design of these railways, together with the associated operational experience and records, can be used to make possible changes in the design standards if necessary. Notably, the N7 crossing in the Boegoebaai Rail design would specifically benefit from the relaxation of the listed standards.

In 2016, TRANSNET announced the intention to expand the Richards Bay line from the current 2 million tons of coal to 6 million tons of coal per year. The second phase of this expansion was due to be completed in 2018; however, this project is yet to be completed. This project should be reviewed closely to aid in the Boegoebaai detailed design.

A 2018 report states that stringent regulations may impede coal industry growth and that TRANSNET currently suspends operations on the Richards Bay coal mine. However, new mines are becoming approved and this will increase the number of mining commodities exported out of the Northern Cape Province.

2.3 Existing Rail Corridors

The existing South African freight railway network can be seen in Figure 2-1 below. Notably, the only ports connecting to the freight network along the West Coast is Saldanha Bay and Cape Town; both of which are in the Western Cape. This makes Boegoebaai Port, once implemented, the only freight-based dock within the Northern Cape Province.

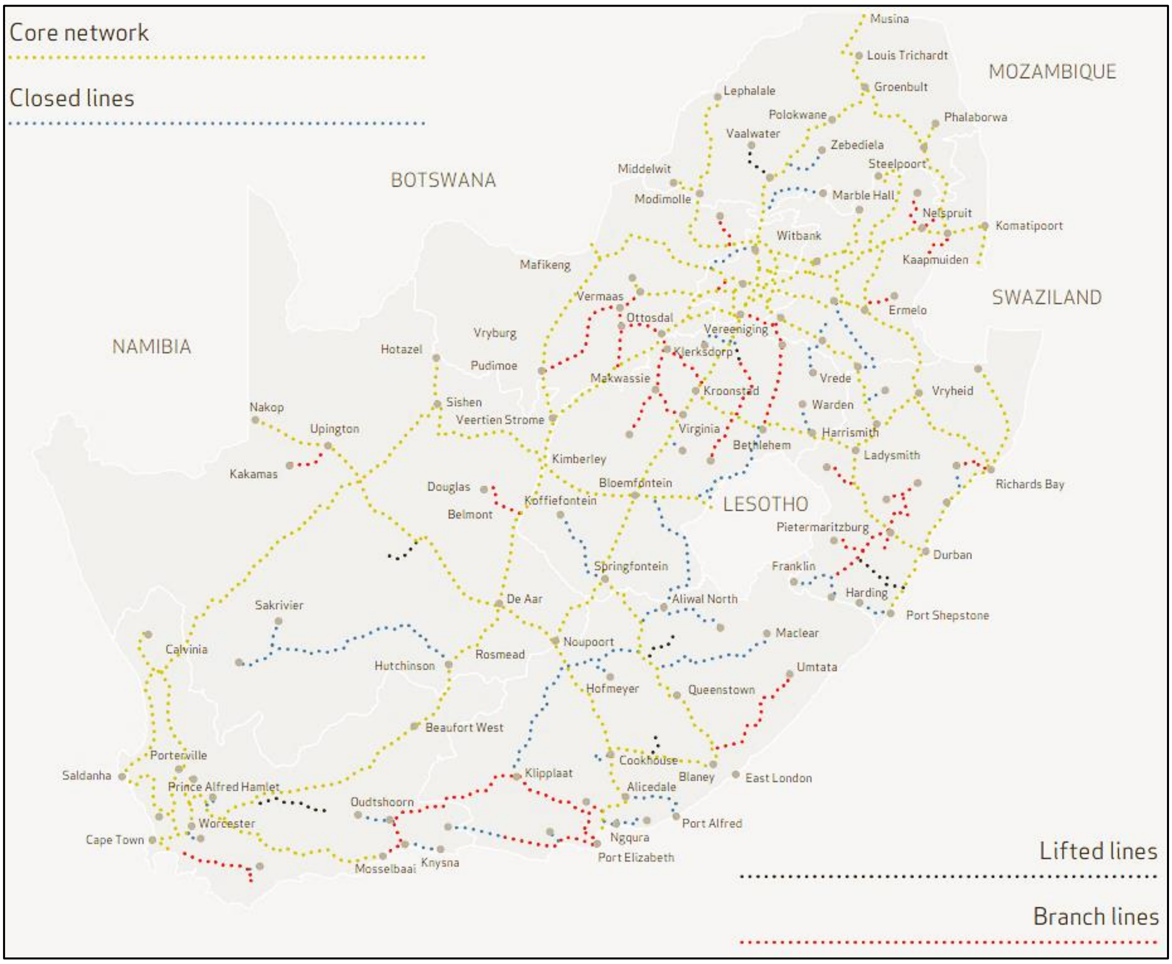


Figure 2-1: Existing Freight Networks within South Africa

Figure 2-2 indicates the different types of gauges used throughout South Africa. Notably, the Sishen to Saldanha Rail uses a Cape Narrow-Gauge Freight Rail. It is therefore proposed that the Boegoebaai Railway should use a narrow gauge should it connect to this rail network. Table 2-3 below indicates the approximate distances of the different routes from Figure 2-2.

Table 2-3: South African Railway Lines used to design the Boegoebaai Rail Network

Railway Line	Track Length
The Sishen to Saldanha iron ore line	861km
Richards Bay-Gauteng-Waterberg, freight oriented	910km
Durban-Richards Bay, freight and passenger oriented	170km
Hotazel-Gauteng, freight oriented	850
Bloemfontein-Gauteng-Polokwane, passenger oriented	750
Gauteng-Durban, very high speed	620
Kimberley-Ngqura, freight oriented	745
Noupoort-Bloemfontein, freight oriented	290

Figure 2-2: Types of Gauge Freight used within South Africa (TRANSNET 2009)

BOEGOEBAAI PORT FEL 1 PHASE 1

DESIGN APPROACH

RAIL ROUTE INVESTIGATION LINKING BOEGOEBAAI PORT TO THE NORTHERN CAPE MINES

3. DESIGN APPROACH

This chapter discusses the approach taken in order to design the rail network. It comprises of the design process, design factors, commodity mix and required land acquisition.

3.1 Design Process

First, the surrounding areas were studied in order to determine the most suitable route. Then, the existing national and regional routes (N14, N7 and R363) were found to be the ideal connecting routes between the port and Groblershoop. From here, it was found that Anenous Pass, on the R382 West of Steinkopf and on the link from Steinkopf to the N14, had the most design constraints due to the numerous changes in topology. Another constraint, introduced by Ninham Shand (1980) on the Development proposals for Namakwaland, included that mining activities around Aggeneys will need to be serviced. This meant that the railway route had to change in order to incorporate the mining activities around Aggeneys. From here, the rail route would easily connect to the Sishen to Saldanha Rail.

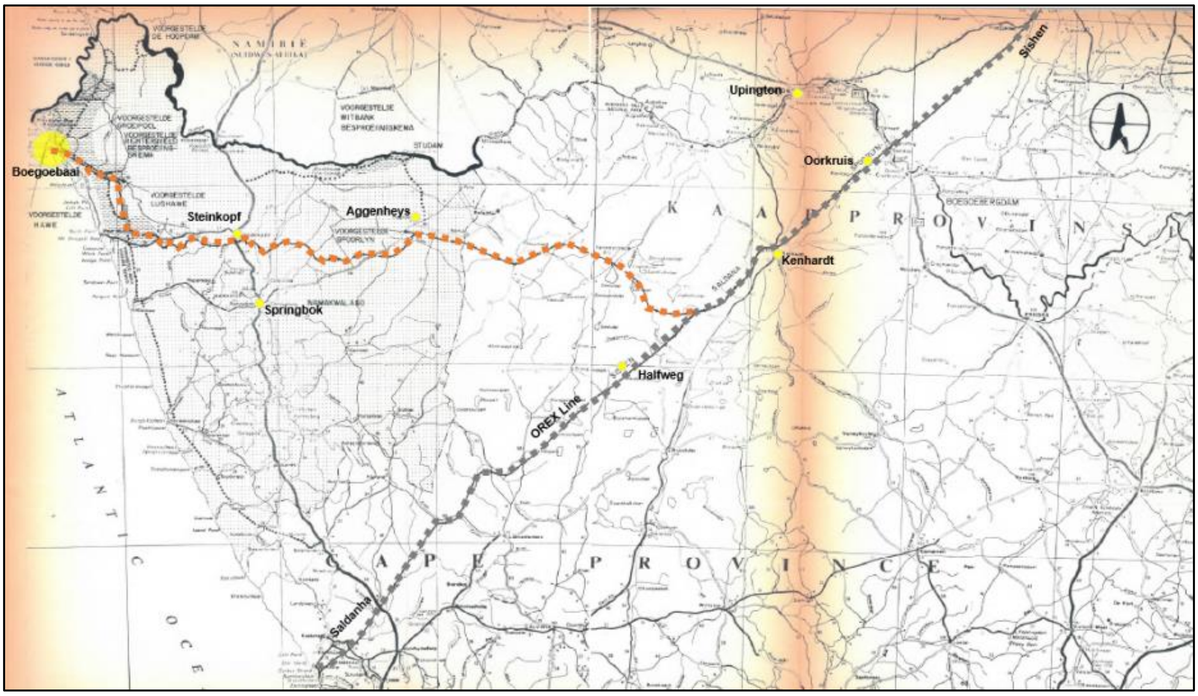


Figure 3-1: Ninham Shand route proposal (NS 1980)

3.2 Design Assumptions

Assumptions were made where information could not be acquired. It was assumed that the contours used to align the rail were the same as the existing topography on site. Furthermore, it was assumed that the contour levels would not significantly vary over time.

The rail was assumed to be operational after at least 10 years of port operations. Until rail operation, the port is assumed to function solely with the use of trucks and other heavy vehicles. These vehicles will primarily transport Manganese and other commodities from the surrounding mines to the Boegoebaai Port.

It was assumed that an EIA will be required for the next phase.

3.3 Design Factors

Multiple factors influenced the proposed design. These factors primarily affected the rail alignment and limited the number of available routes.

The existing topography guided the rail alignment. For complex areas with varying terrain, option analysis was used. Additionally, areas that required tunnels and deep excavations were avoided due to cost implications.

The existing layout and road classes of the surrounding road networks influenced the alignment of the proposed rail. The railway was aligned near roads to allow for accessible maintenance and the number of road and rail intersections were minimized. The roads primarily considered was the R382, N7 and the N14.

The locality of the different mines within the Northern Cape Province affect the route because the rails are ultimately designed to connect and serve the mines.

The type of commodities produced at the different mines also affect the rail design and route alignment. The Boegoebaai Port will primarily export manganese and the rail network will therefore aim to serve mines that primarily produce this commodity.

Lastly, the layout and location of the existing Sishen to Saldanha rail also affects the alignment of the rail. The Boegoebaai Rail will ideally link up with this rail to minimize the required length and cost.

3.4 Commodity Mix

Figures 3-1 and 3-2 express the freight demand volumes, in tons, within the Northern Cape.

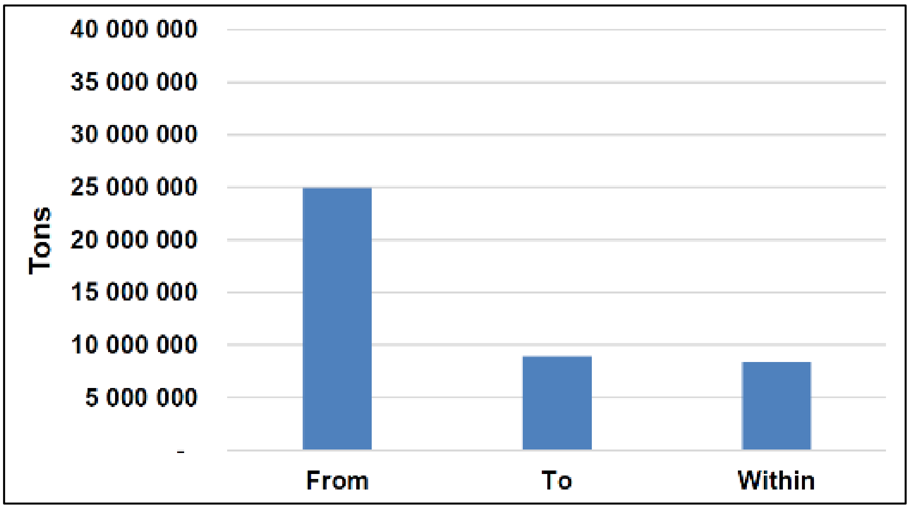


Figure 3-2: Movement of freight flows through the Northern Cape (GAIN Group, 2017)

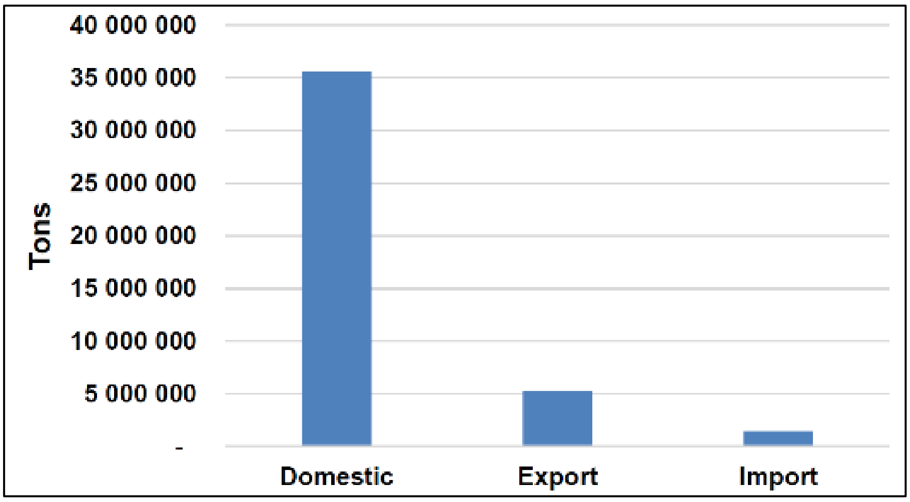


Figure 3-3: Global freight flows through the Northern Cape (GAIN Group, 2017)

Table 3-1 indicates that the mining sector makes up almost 2 thirds of the total commodities traded within the Northern Cape. Furthermore, Figure 3-1 indicates that approximately 25 million tons of general freight is moved from the Northern Cape.

Table 3-1: Commodities percentage traded within the Northern Cape

Commodity	Percentage
Agriculture	8%
Manufacturing	28%
Mining	64%

Once the project is completed, more commodities will be transported which will allow for the surrounding mines to operate at a larger capacity.

Due to the large weight and long distances required to transport the ore from the mines mentioned, heavy haul carriers are required. However, with the implementation of the Boegoebaai Port, the total cost of exporting bulk cargo will be reduced, increasing the ore export capacity.

As per Figure 3-4 below, the major mining developments within the Northern Cape Province include the following:

- Black Mountain (exports Zn, Pb, Cu and Ag)
- Danielskull (Fe)
- Kolomela (Fe)
- Lime Acres (Limestone)
- Beeshoek (Fe)
- Sishen (Fe)
- Khumani (Fe)
- Hotazel (Mn)

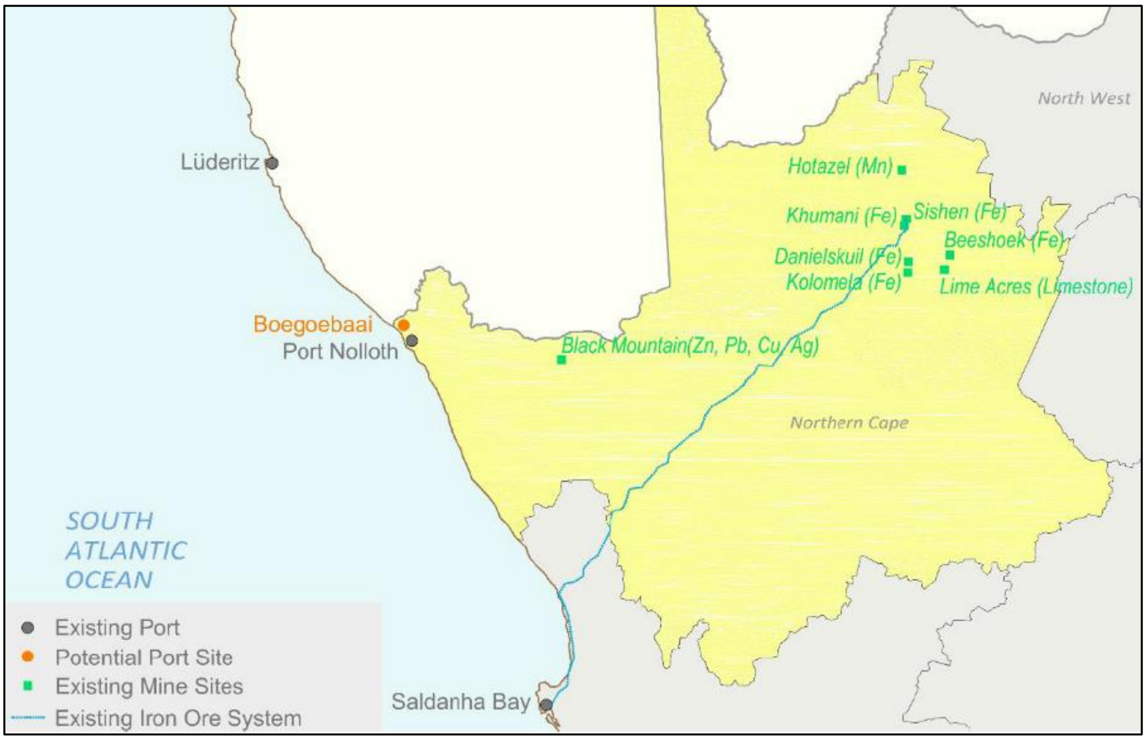


Figure 3-4: Major Mining Developments in the Northern Cape Province

Figure 3-5 below indicates the Boegoebaai Railway and Sishen to Saldanha Rail in relation to the surrounding major mining developments. The Sishen to Saldanha Bay (i.e. the OREX Line) is a heavy haul rail line that passes through the Province.

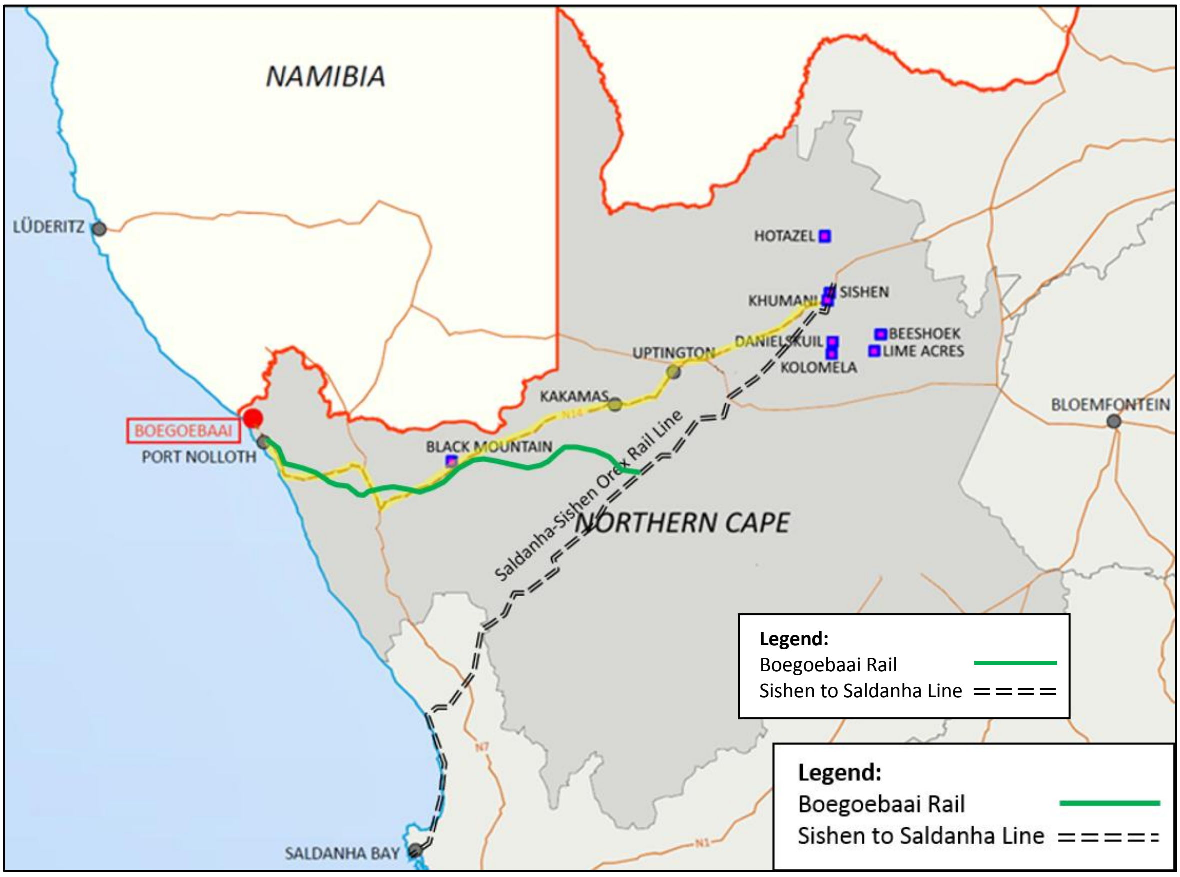


Figure 3-5: Boegoebaai railway in relation to the Northern Cape Province mines

The current rail route distance between the major mining developments and the respective ports, Boegoebaai Port and Saldanha Bay, can be seen in the Table below.

Table 3-2: Comparative Rail Line distances between the surrounding Mines

Location	Mine	Rail line distance to Boegoebaai Port (km)	Current rail line distance to Saldanha Bay (km)
Vedanta - Black Mountain - Zinc	Zn, Pb, Cu, Ag	275	455
Anglo America - Kolomela Iron Ore Mine	Fe	812	866
Assmang - Khumani Iron Ore Mine	Fe	796	850
Assmang - Beeshoek Iron Ore Mine	Fe	857	911
PPC - Lime Acres Limestone Mine	Limestone	910	964
Idwala – Danielskuil Limestone Mine	Limestone	942	996
Hotazel Manganese Mines	Mn	875	929
Anglo American - Sishen Iron Ore Mine	Fe	807	861
Afrisan - Ulco Limestone Mine	Limestone	996	1050
Oorkruis		639	692
Veddanta – Gamsberg (Aggeneys)		290	455
Postmasburg - Manganese	Mn	866	920

From Table 3-2, it can be seen that the surrounding mining developments benefit from the Boegoebaai rail line. The Boegoebaai Port will not only provide additional export capacity; but will also reduce the required rail line distance between the mines and the port by approximately 54km. Furthermore, specific developments, such as the Black Mountain (Aggeneys), will benefit significantly with a reduction in rail line distance of 180km and 165km respectively.

The Sishen to Saldanha rail was also further investigated to determine whether this rail was a feasible option. It was found that this line will eventually reach capacity and require major upgrading in order to provide additional capacity.

Other port options within the province were also investigated. Port Nolloth is another port that currently exists within the Northern Cape. However, this port cannot support large vessel cargo operations. Furthermore, most Northern Cape exports currently run through the Sishen to Saldanha Line.

Manganese is currently exported from the Northern Cape via the Port Elizabeth and Ngqura Line. Ideally, a large amount of manganese could be exported through the Boegoebaai Port instead. Figure 3-4 shows the locality of the freight rails that export iron ore and manganese from the Northern Cape Province.

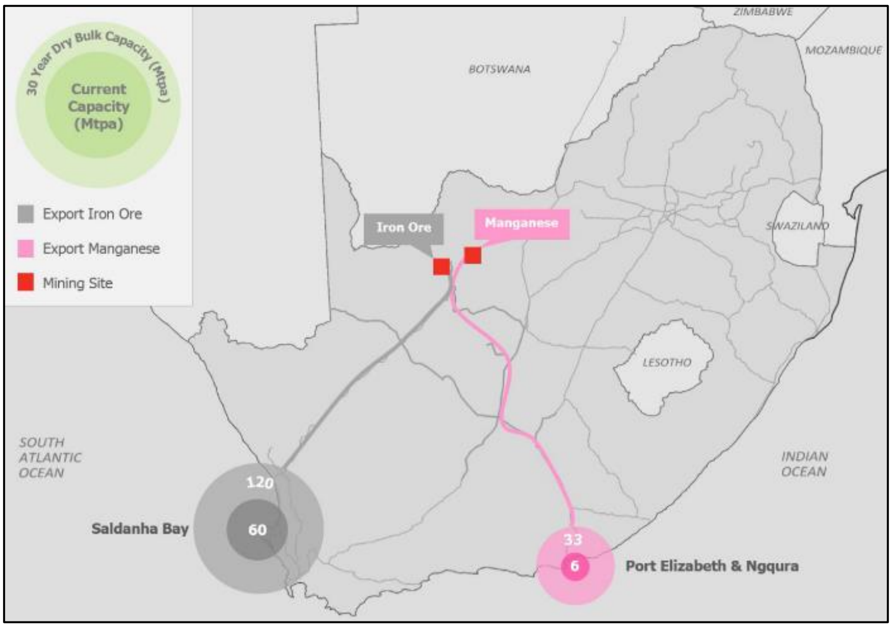


Figure 3-6: Current National Iron Ore and Manganese Rail Links (Transnet, 2015)

A low case commodity demand study was completed; where it was assumed that the manganese currently being transported to the Port of Durban and Saldanha Bay will be rerouted to the Boegoebaai Port to reduce transportation costs and create additional capacity. The low case demand study shown in Table 3-3 shows the current demand in 2019 and the demand for the proposed port commissioning date assumed for the study (i.e. 2025). Table 3-2 also indicates that the Boegoebaai Port is envisaged to be a predominantly dry bulk commodity port.

Table 3-3: Low Case Commodity Demand – Boegoebaai

Cargo Type – Commodity	Volume (Mtpa) 2019	Volume (Mtpa) 2025	Volume (Mtpa) 2050
Dry bulk – Iron Ore	1.0	1.13	1.85
Dry bulk – Manganese	4.5	4.5	4.5
Break bulk – Lead/ Zinc	0.25	0.60	0.60
Break bulk – Magnetite	0.3	0.3	0.3
Break bulk – Ilmenite	0.1	0.25	0.50
Liquid bulk – Diesel Oil	1.3	1.38	1.77
Containers – Agricultural Products	0.15	0.16	0.20
Containers – Salt	0.03	0.03	0.03
Containers – General Cargo	0.75	0.80	1.02
Total Demand	8.38	9.15	10.77

A high case commodity demand study was completed; where it was assumed that the manganese currently being transported to the Port of Durban, Saldanha Bay, Richards Bay, Cape Town and the Port of Lüderitz will be rerouted to the Boegoebaai Port. The results from the high case demand study can be seen in Table 3-4.

Table 3-4: High Case Commodity Demand – Boegoebaai

Cargo Type – Commodity	Volume (Mtpa) 2019	Volume (Mtpa) 2025	Volume (Mtpa) 2050
Dry bulk – Iron Ore	1.0	1.13	1.85
Dry bulk – Manganese	6.5	8.5	16.5
Break bulk – Lead/ Zinc	0.7	0.7	0.7
Break bulk – Magnetite	0.3	0.3	0.3
Break bulk – Ilmenite	0.1	0.25	0.50
Liquid bulk – Diesel Oil	1.3	1.38	1.77
Containers – Agricultural Products	0.15	0.27	2.88
Containers – Salt	0.03	0.03	0.03
Containers – General Cargo	0.75	0.95	2.53
Total Demand	10.83	13.51	27.10

For the high case study, the Boegoebaai Port will predominantly export dry bulk and minor bulk commodities, with only 12% of the cargo demand utilizing containers.

Through analysing the two scenarios, a base commodity demand was determined, and the following was concluded:

- No current Port Elizabeth volume will be re-routed to Boegoebaai
- No iron ore will move through Boegoebaai
- Other minerals such as zinc, lead, Ilmenite and magnetite will be routed through the lowest cost solution
- Diesel volumes are linked to general economic activity rather than other factors
- For the remaining commodities, additional capital expenditure will be required to increase the port capacity to accommodate the high case commodity demand

The base case commodity demand for Boegoebaai Port is presented in Table 3-5 below.

Table 3-5: High Case Commodity Demand – Boegoebaai

Cargo Type – Commodity	Volume (Mtpa) 2019	Volume (Mtpa) 2025	Volume (Mtpa) 2050
Dry bulk – Iron Ore	0	0	0
Dry bulk – Manganese	4.5	6.0	9.0
Break bulk – Lead/ Zinc	0.7	0.7	0.7
Break bulk – Magnetite	0.3	0.3	0.3
Break bulk – Ilmenite	0.1	0.1	0.50
Liquid bulk – Diesel Oil	1.3	1.37	1.70
Containers – Agricultural Products	0.15	0.21	0.42
Containers – Salt	0.03	0.03	0.03
Containers – General Cargo	0.75	0.90	1.28
Total Demand	7.83	9.61	13.93

For more information on the commodity mix, refer to the 'FEL2 Boegoebaai Port Phase 2 – Analysis of Commodity Mix' report.

3.5 Access Route

The Boegoebaai railway line was designed to enter the port from the R382. The rail will intersect both the R382 and the main boulevard in order to access the offloading area.

3.6 Land Acquisition

A land acquisition study will be required for the next phase of the project. This includes the investigation of all areas alongside the proposed rail alignment. It also includes the investigation of linking up the Boegoebaai Rail to the Sishen to Saldanha line.

3.7 Investigations

The preliminary corridor was determined using the investigation of different routes overlaid on topographical maps and longitudinal section drawings.

Software used during the design process included:

- Google Earth Imaginary dated 27 September 2017
- Google Earth Street View Images dated October 2010
- 1:50 000 SA Topographical Maps 4th Edition 2011
- 1:250 000 SA Topographical Maps 6th Edition 2014
- Model Maker and Road Maker software

Proposals made in this report were based on interpreted levels; and the alternative routes should be evaluated as corridors only. Furthermore, the proposed route was not inspected on site. This study will be required before the next phase is attempted.

RAIL EXTERNAL TO PORT

RAIL ROUTE INVESTIGATION LINKING BOEGOEBAAI PORT TO THE NORTHERN CAPE MINES

4. RAIL EXTERNAL TO PORT

The rail was divided into the Internal and External Rail. The Internal Rail consists of all railway components, including the platforms for the marshalling yards, tippler infrastructure and road over rail bridge structures. The External Rail involves all railway components external to the Boegoebaai Port. This chapter primarily discusses the different sections of the External Rail route.

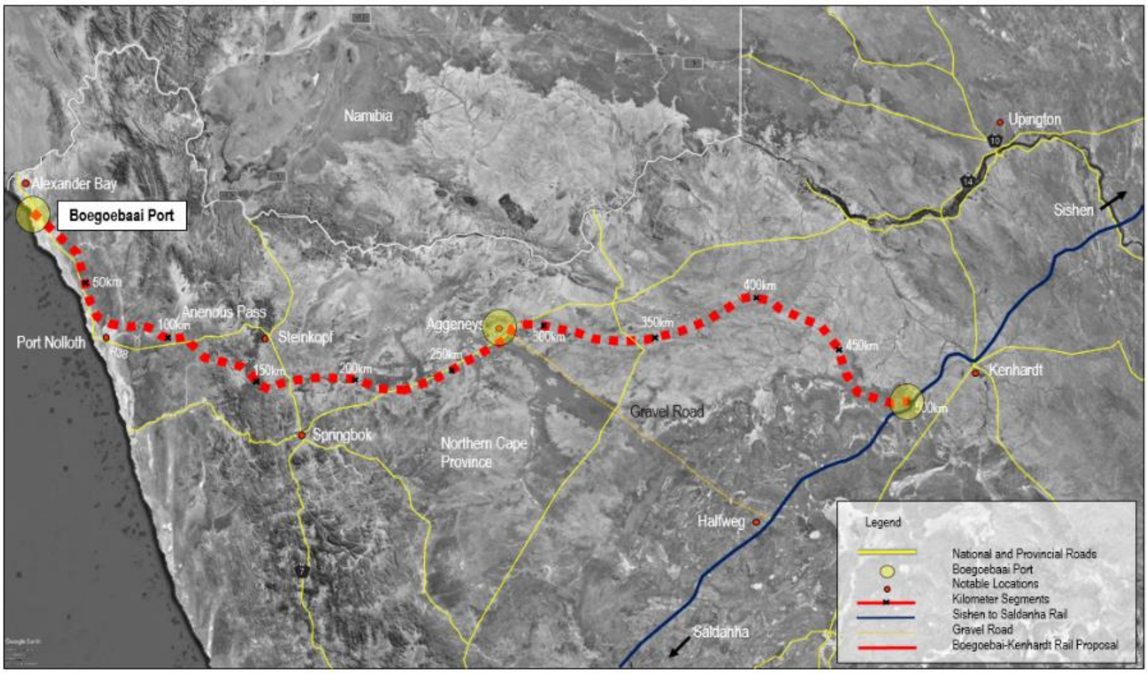


Figure 4-1: Proposed rail corridor linking Boegoebaai to Northern Cape Mines

4.1 Proposed External Rail

The proposed external railway length is approximately 500km. This includes the railway between the Boegoebaai Port and the connection to the Sishen to Saldanha Railway. This link exists just south of Kenhardt.

The detailed drawing of the horizontal layout of the External Rail can be seen in the following drawings:

- 1500103-TRANS-1004-P-00: Rail Locality Map
- 1500103-TRANS-1005-P-00: Boegoebaai Port to Hinterland Rail Layout
- 1500103-TRANS-1006-P-00: Rail Layout 100KM to 250KM

The proposed External Rail has been divided into different sections for information purposes. Figure 4-1 provides the legend for these sections that will be discussed.

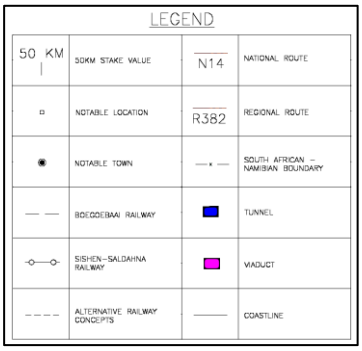


Figure 4-2: Legend for the Proposed External Rail Figures

4.1.1 Boegoebaai Port to the R382

The alignment of this section had minimal design complications and was routed along the R382. However, the rail was required to be routed around the northern road. Furthermore, several cadastral boundaries, surrounding mining facilities and other alternative routes may be required to be investigated.

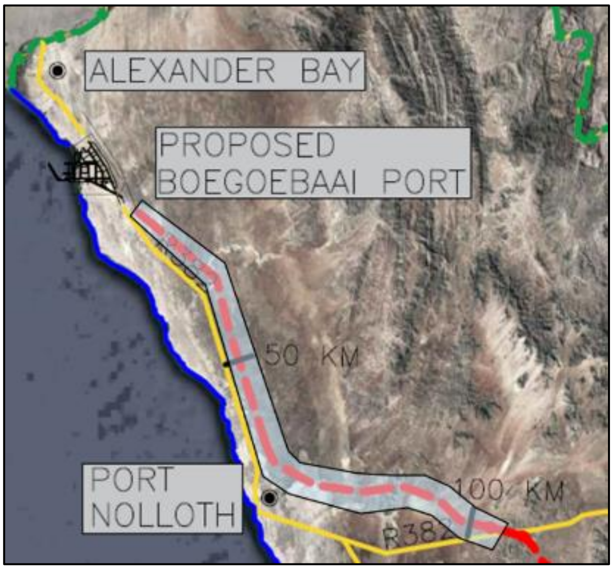


Figure 4-3: Railway between the Boegoebaai Port and the R382

4.1.2 R382 to the N7 South of Steinkopf

Anenous Pass proved to be the section that had the most design challenges. Desktop studies showed that the R382, along Anenous Pass, was constructed along an old railway track route. The curvatures along this old route vary between 100m to 200m radii. Notably, these radii are below the required freight line curvature standard of 1500m and a different route was required.

Investigations were completed to reduce the number of tunnels and viaducts required along this route; however, it was found that no other route allowed for these changes. An investigation of the route between the R355 and the northwards route along the coast was completed. It was found that the curvature along the R355 was not suitable for a railway line. Furthermore, the railway line along this route would have to go through the town of Springbok; which would end up with the same challenges that currently exist around Port Nolloth and the game reserve.

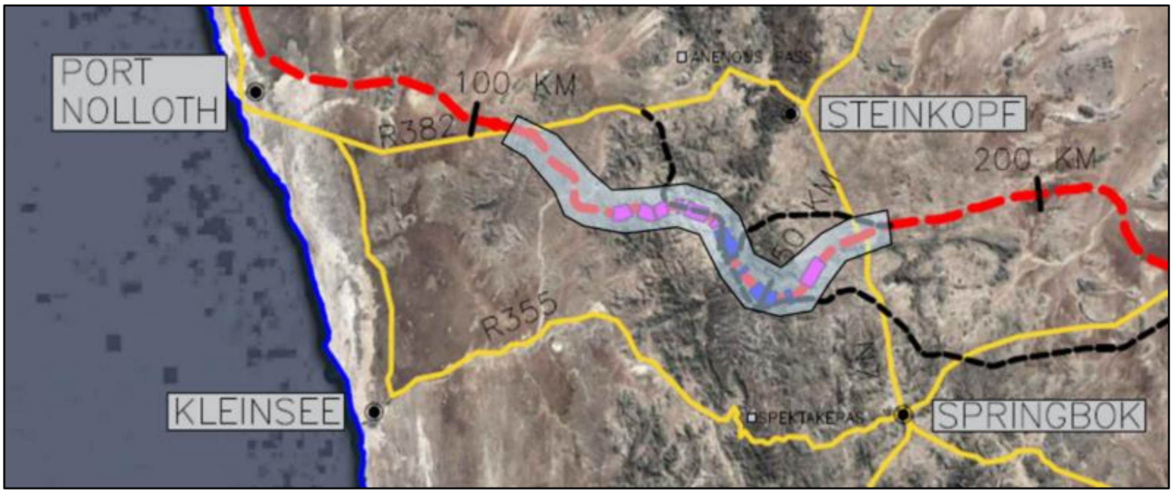


Figure 4-4: Railway between the R382 and the N7 South of Steinkopf

4.1.3 N7 South of Steinkopf to the N14

The geology of this section varies greatly due to the presence of old mining sites. This made it difficult to distinguish between the natural high points, mountains and mine dumps. As a result, six alternative route options were investigated.

An additional option, near the proposed route, is still required to be further investigated. This route would potentially cross the N14, further eastwards, in order to increase the railway length.

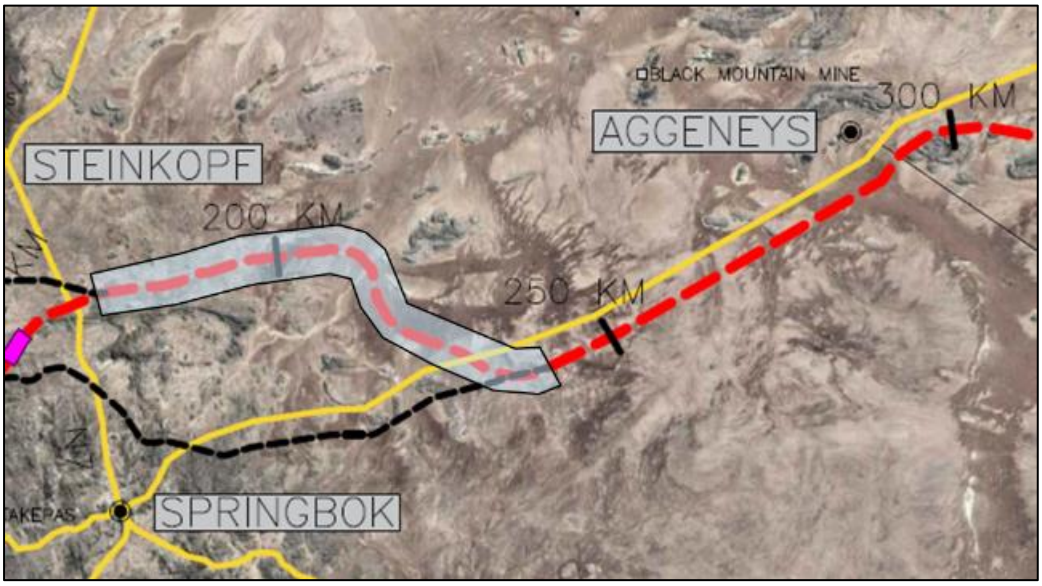


Figure 4-5: Railway between the N7 South of Steinkopf and the N14

4.1.4 N14 to Aggeneys

The proposed route is located just south of the N14; while the Ninham Shand route is located just north of the N14. This route was proposed in order to reduce the impact of the project on the surrounding mining and farming activities.

Furthermore, it was found that there is enough space to route the railway between the N14 and mines near Aggeneys. However, the available space should be further investigated as the mine dumps may have increased in size.

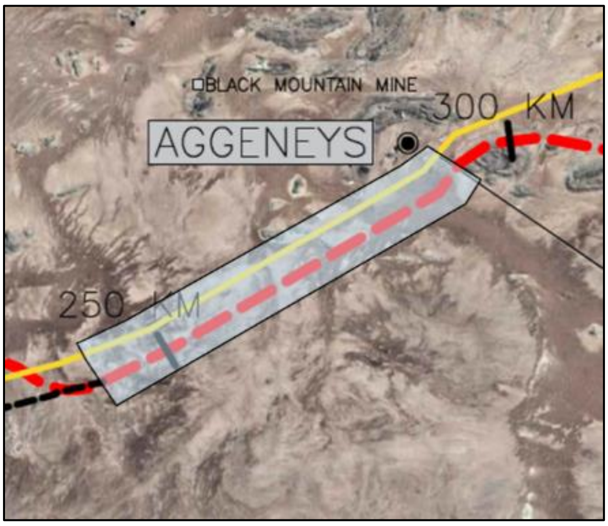


Figure 4-6: Railway between the N14 and Aggeneys

4.1.5 Aggenys to the Sishen to Saldanha link

This section of the railway provided minimal design challenges; excluding the long river bridge.

Although alternative options were investigated, the proposed route was found to be the same along this section as was proposed in the Ninham Shand report (1980).

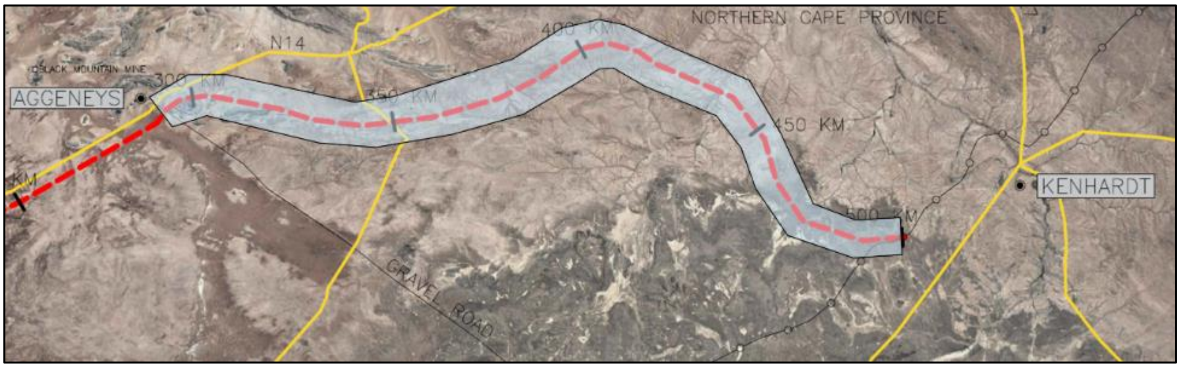


Figure 4-7: Railway between Aggeneys and the Sishen to Saldanha Rail

4.1.6 Sishen to Saldanha Link

As proposed in the Ninham Shand report, the ideal location to branch off from the existing line is just south of Kenhardt. This makes it possible for railway yards and other passing facilities to be implemented along the existing Sishen to Saldanha track.

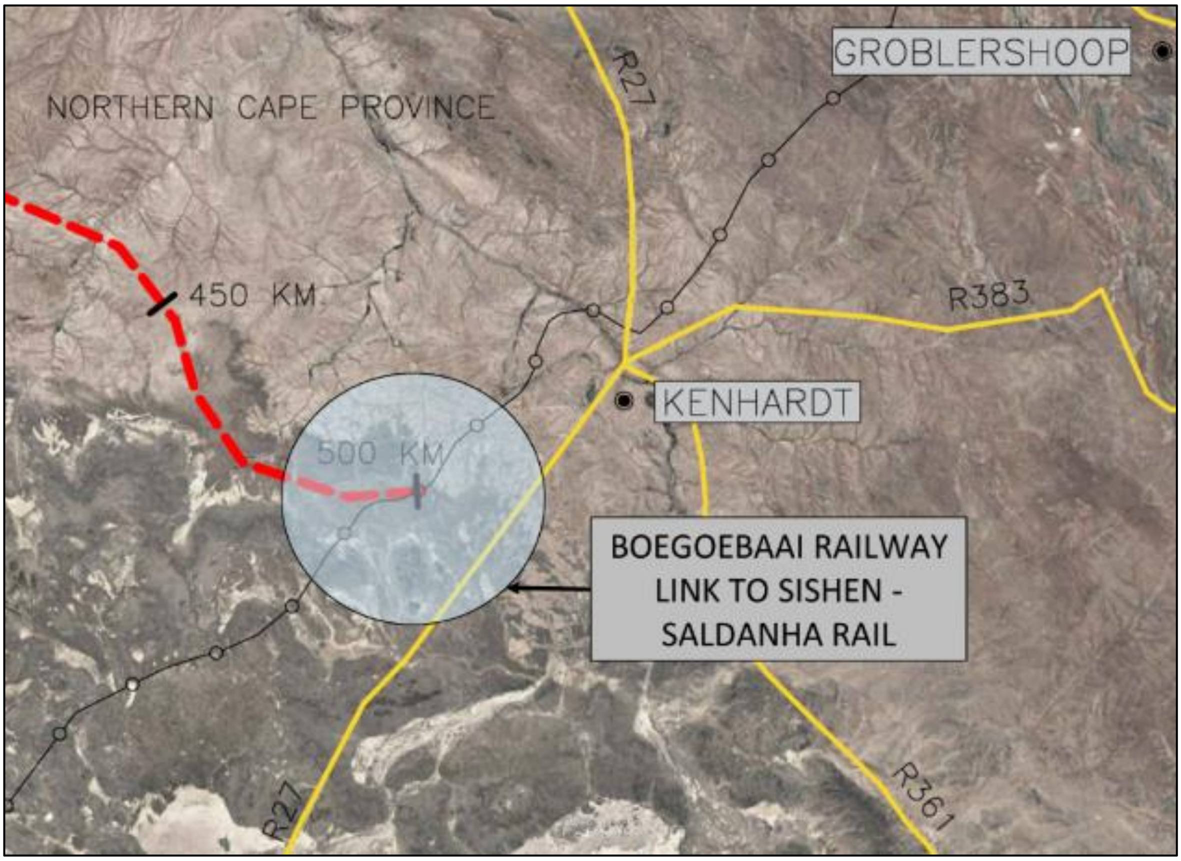


Figure 4-8: Linkage between the Sishen to Saldanha Rail and the Boegoebaai Rail

4.1.7 Subdivision of the R382 to the N7 south of Steinkopf Section

Figure 4-8 shows the locality of the different route options between the R382 and the N7 south of Steinkopf.

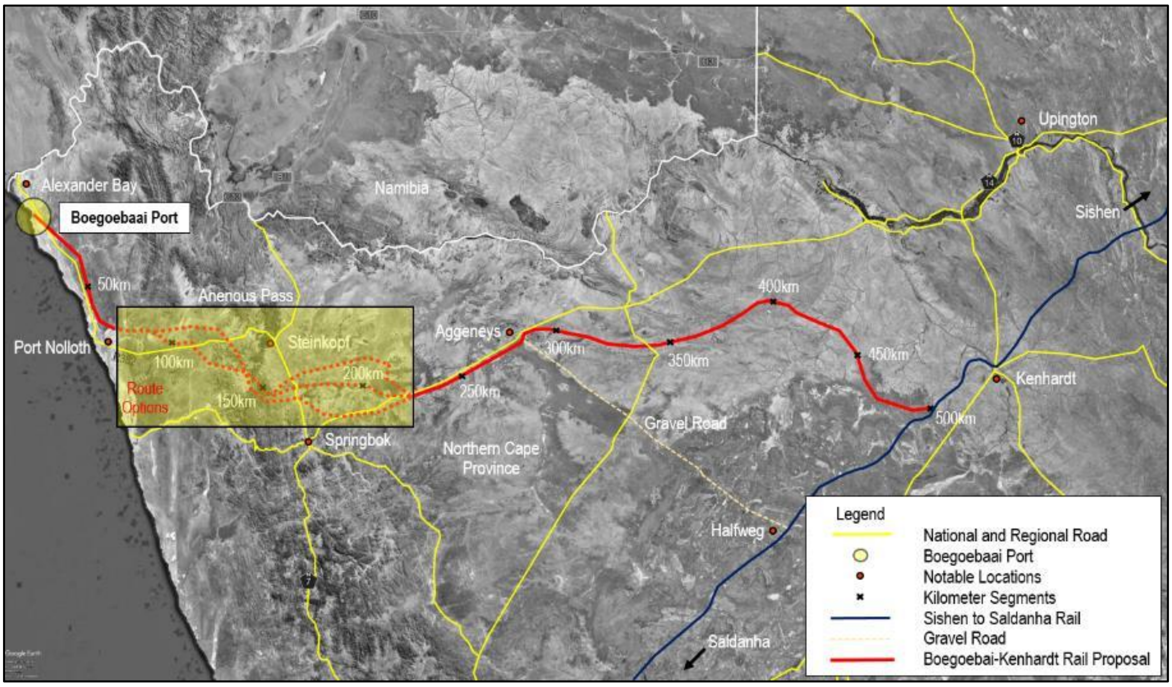


Figure 4-9: Proposed Route Options within the Rail Corridor

The R382 to the N7 south of Steinkopf section had multiple design complications and was therefore subdivided as per Figure 4-9.

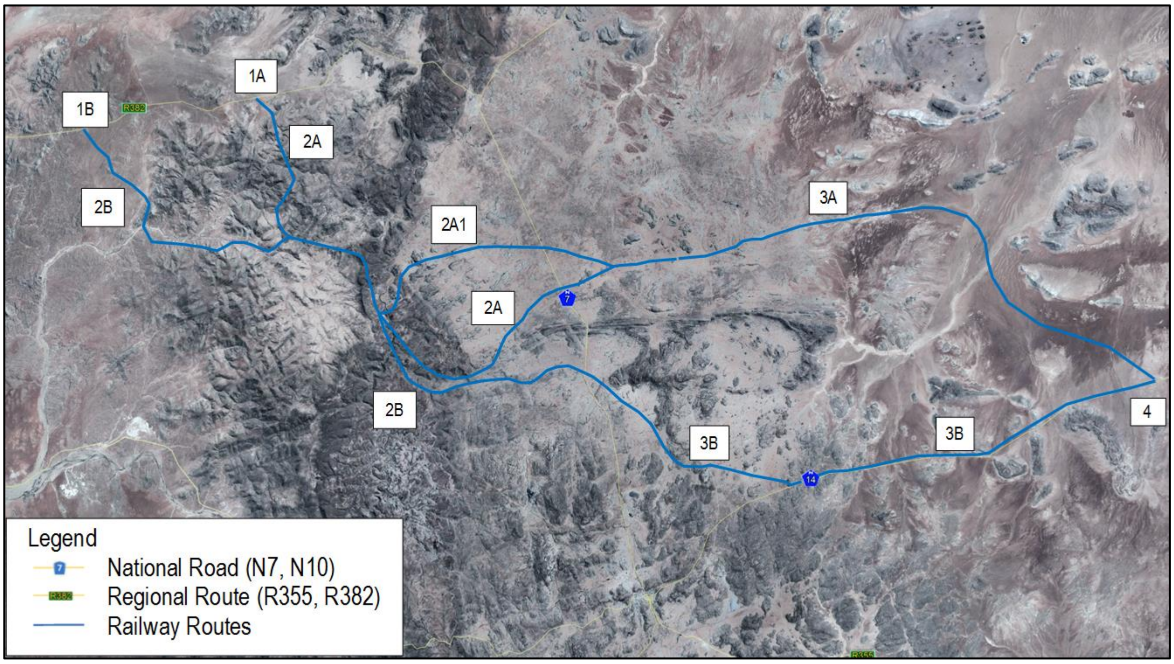


Figure 4-10: Subdivision of Sections 2 and 3

For this section, six alternative routes were designed in order to compare and determine the ideal route.

Table 4-1: Alternative Routes between Sections 2 & 3

Option No.	Route
1	Sections 1B – 2B – 3B – 4/5
2	Sections 1A – 2A – 2B – 3B – 4/5
3	Sections 1A – 2A – 3A – 4/5
4	Sections 1B – 2B – 2A – 3A – 4/5
5	Sections 1A – 2A – 2A1 – 3A – 4/5
6	Sections 1B – 2B – 2A1 – 3A – 4/5

Option 1

Option 1 made use of the southernmost route. It intersects the R382 before the mountainous terrain (1B) and is pathed alongside the N14 (3B). This provides an easier access route from the surrounding roads into the rail depots.

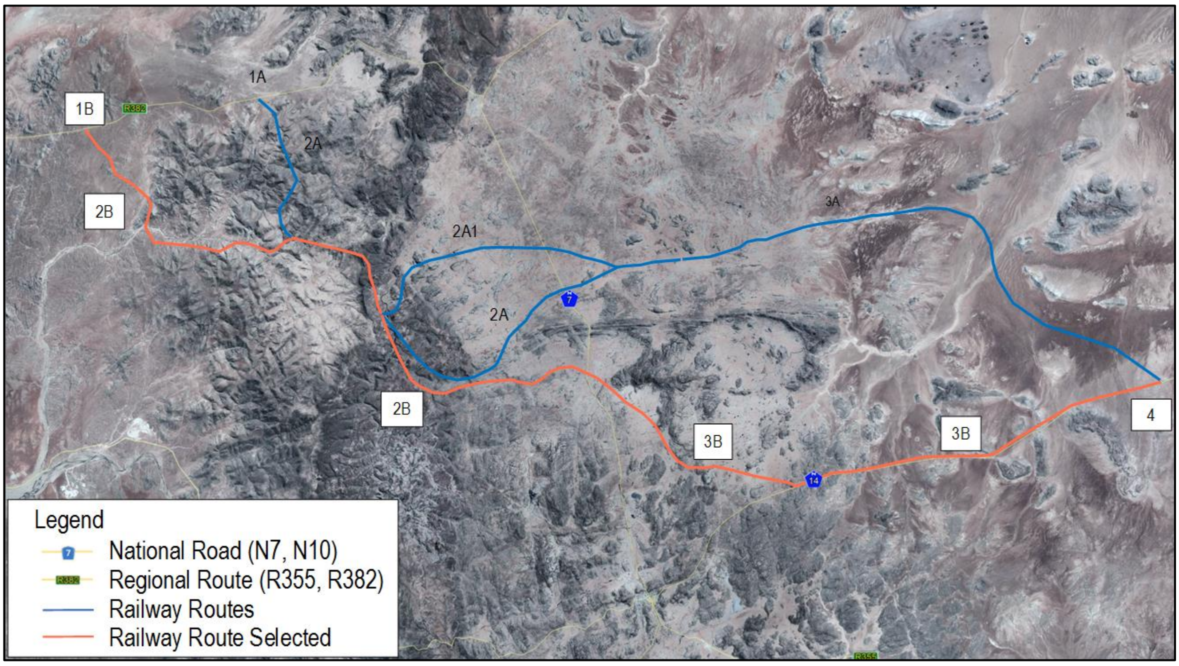


Figure 4-11: Option 1, Sections 1B-2B-3B-4

Option 2

Option 2 is routed similarly to Option 1, except it intersects the R382 along Anenous Pass. This design requires a longer tunnel than the previous option and looping the rail may prove to be difficult.

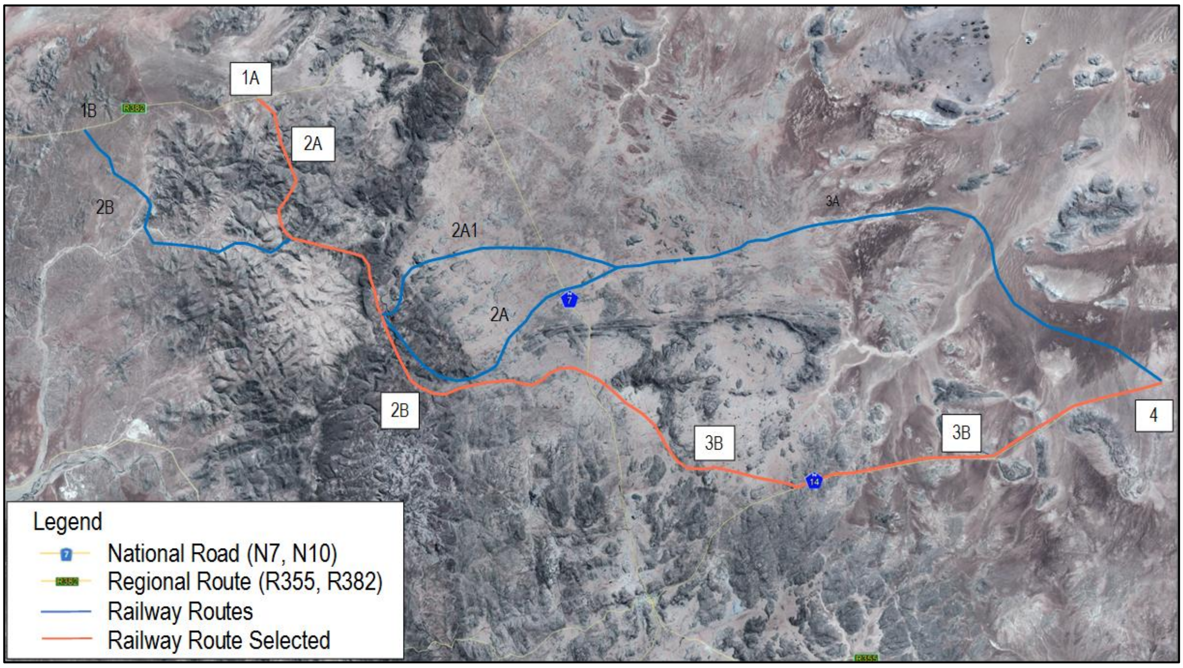


Figure 4-12: Option 2, Sections 1A-2A-2B-3B-4

Option 3

Option 3 used the same entrance (1A) as Option 2, however, the northern rail (3A) does not travel directly alongside the N14. While Route 3A is further from the N14 than Route 3B, it is still close to the N14 and can therefore be efficiently serviced. Furthermore, Route 3A is distanced away from the N14 such that freight movement will not interfere with the road network.

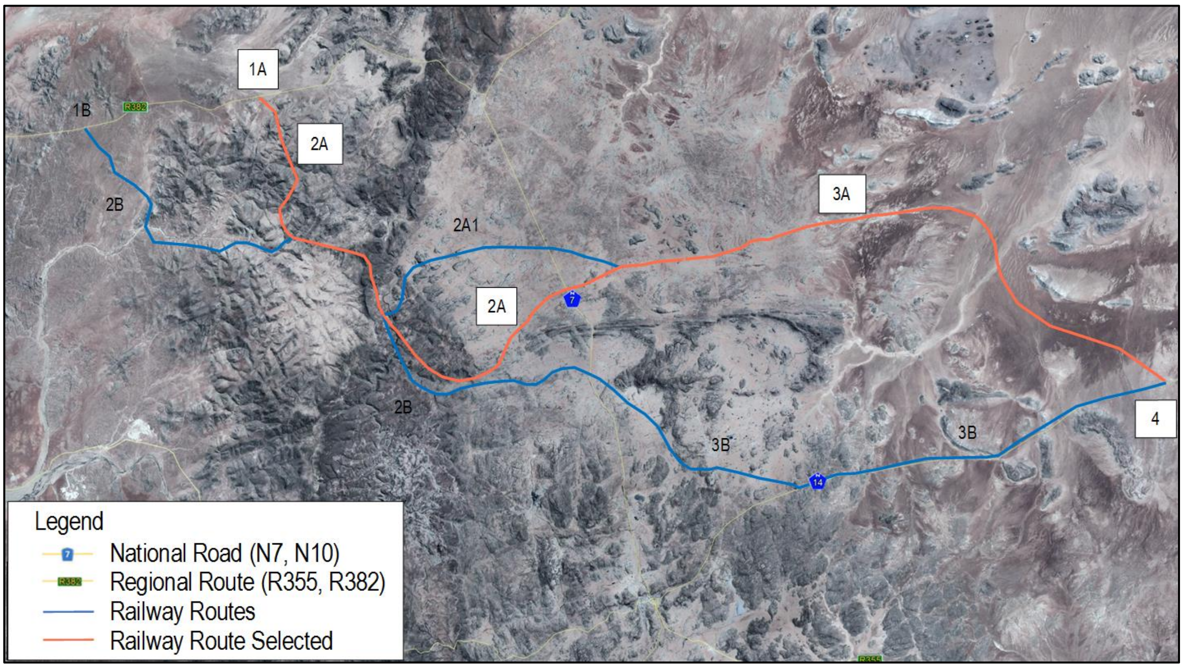


Figure 4-13: Option 3, Sections 1A-2A-3A-4

Option 4

Option 4 was taken to be the preferred design because it fits best around the toe of the mountain. However, alternate routes should still be further investigated, and a detailed comparative breakdown should be done in order to determine the most cost-effective design.

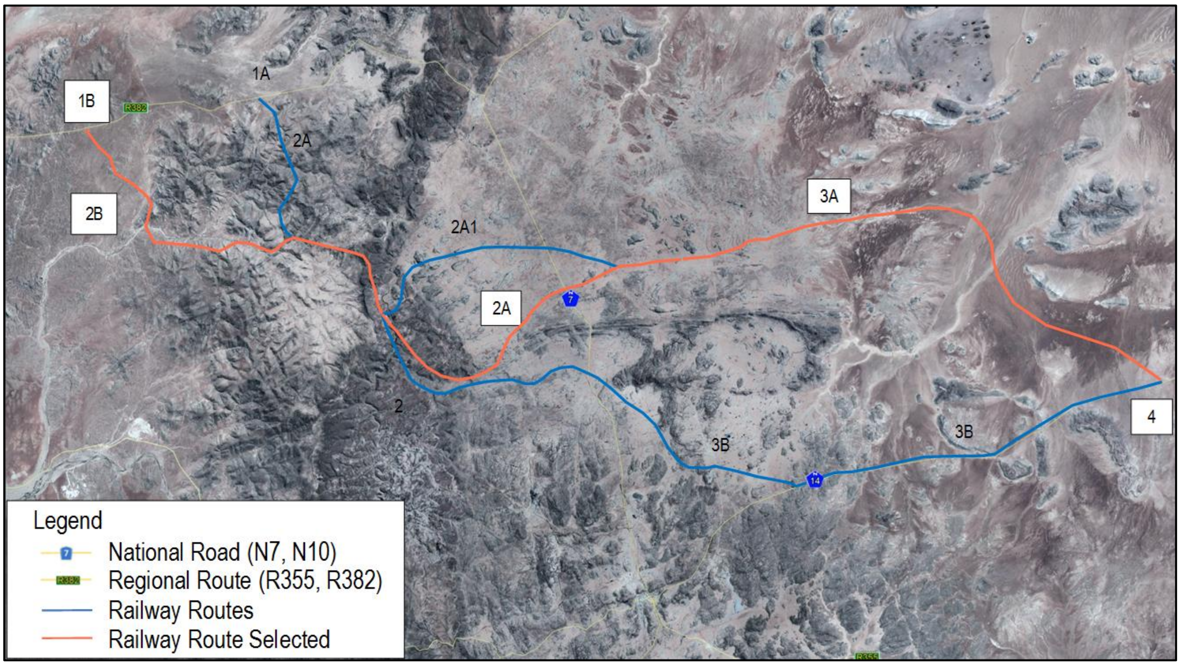


Figure 4-14: Option 4, Sections 1B-2B-2A-3A-4

Option 5

Option 5 made use of the northernmost route. It shares multiple similarities to Option 3, except it does not path through Route 2A1. This route requires a sharp turn at the toe of the mountain which makes it undesirable. It is recommended that a route with a larger turning radius is selected.

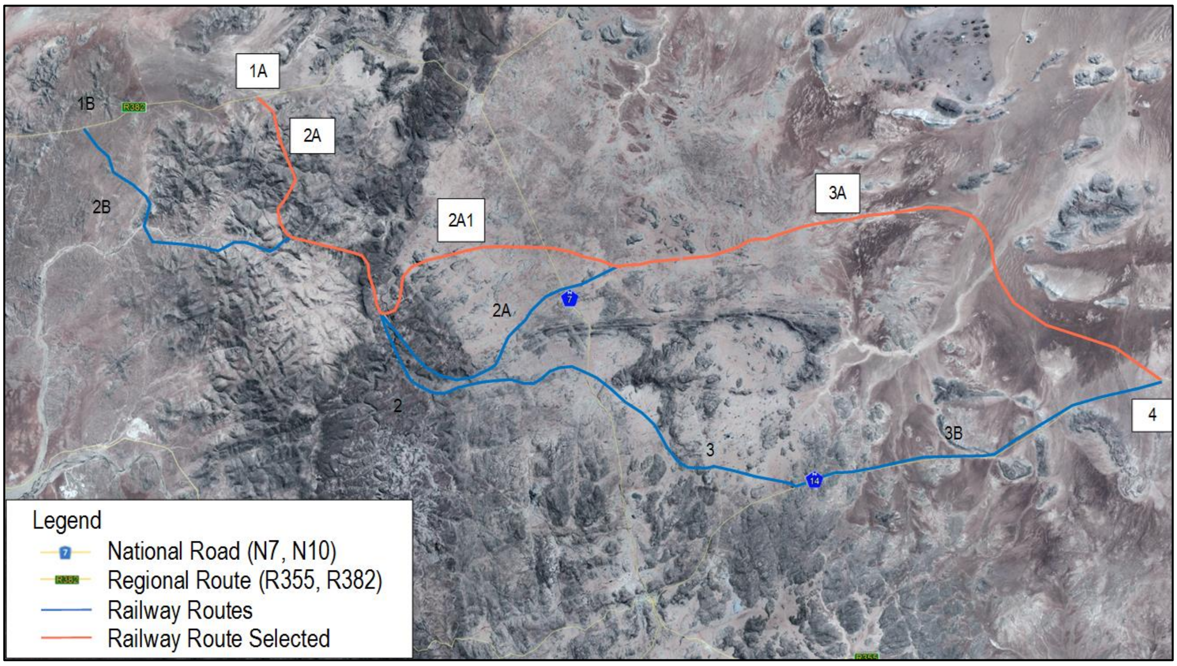


Figure 4-15: Option 5, Sections 1A-2A-2A1-3A-4

Option 6

Similarly, to Option 5, this route requires a sharp turn at the toe of the mountain. It is recommended that the section between the R382 and the N7 south of Steinkopf is further investigated and a more feasible solution is found.

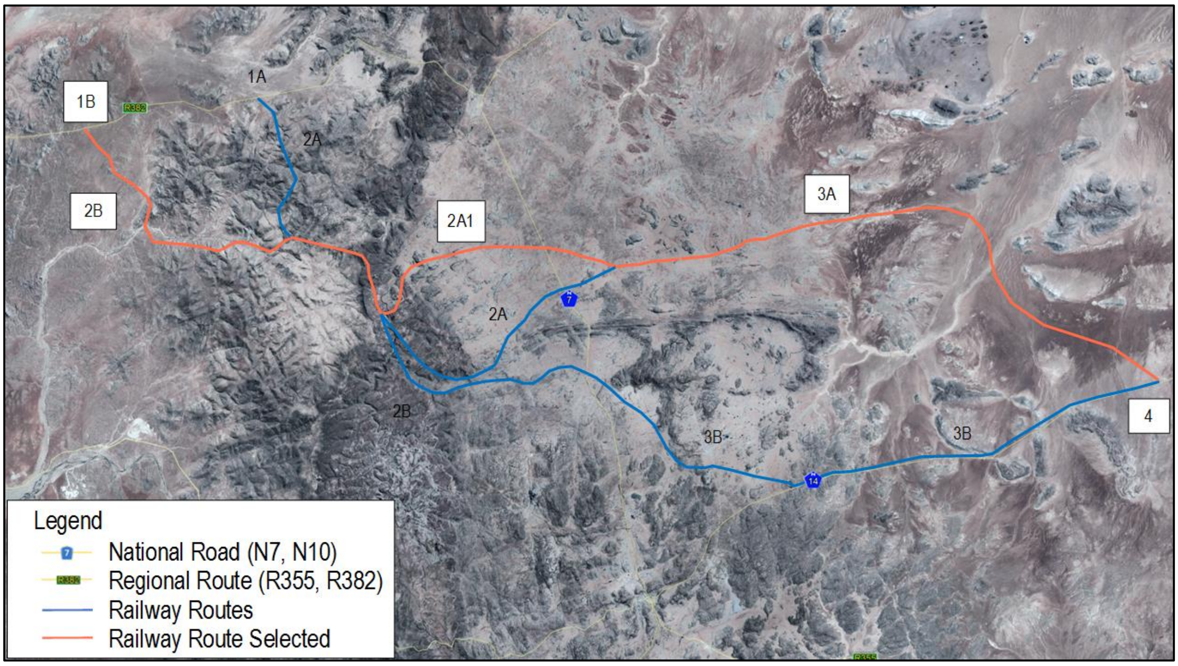


Figure 4-16: Option 6, Sections 1B-2B-2A1-3A-4

4.2 Bridges, Tunnels and Earthworks

4.2.1 External Rail Bridges

Three bridges are required for road to rail intersections; and an additional seven river bridges will be required. Furthermore, all bridges should have a proposed width of 6m. Table 4-2 below indicates the length and starting stake value of the different proposed viaducts.

Table 4-2: Viaduct Lengths and Stake Values

Viaduct	Starting Stake Value (km)	Ending Stake Value (km)	Length (km)
V1	121.0	123.6	2.6
V2	125.0	127.3	2.3
V3	127.6	129.4	1.8
V4	130.7	131.6	0.9
V5	132.2	135.5	3.3
V6	136.6	137.7	1.1
V7	156.6	160.7	4.1
Total			16.1

4.2.2 External Rail Tunnels

Two types of tunnel cross-sections were considered for this design. A single-track tunnel with an arch lining will reduce the amount of excavation required. A tunnel of rectangular form will allow for simpler construction provide more room beside the train.

The details for the proposed tunnel cross-section can be seen in drawing 1500103-TRANS-1007-P-00: Tunnel and Rail Cross-Sections.

In total, four tunnels were implemented for this design. Table 4-3 below indicates the lengths and stake values of the different tunnels.

Table 4-3: Tunnel Lengths and Stake Values

Tunnel	Starting Stake Value (km)	Ending Stake Value (km)	Length (km)
T1	138.3	143.1	4.8
T2	145.0	145.6	0.6
T3	148.0	151.7	3.7
T4	153.3	154.1	0.8
Total			9.9

4.2.3 External Rail Earthworks

The total cut and fill required was calculated to be approximately 100 and 120 million cubic meters respectively. Furthermore, no bulking will be required.

4.3 Design Specifications

4.3.1 Horizontal Curve Radius

According to the report by SMEC, 2014, on the Moloto Development Corridor Rail Design Criteria, a minimum horizontal curve radius of 700m should not be exceeded, unless topography dictates otherwise. The curve radius is required to be less than 500m on the main line. Furthermore, the radii on the crossing loops should not be less than 350m.

However, the Boegoebaai Railway line was based off the design standards of the Sishen to Saldanha Rail, and therefore used a minimum horizontal curve radius of 1500m, which is significantly greater than the 700m radii recommended by SMEC.

4.3.2 Cant

The theoretical cant formula for narrow gauges (1.067 m and effective gauge of 1.130 m) is given as:

$$EG = \frac{8.9V^2}{R}$$

Where:

EG	= theoretical cant (mm)
V	= speed (km/hr)
R	= radius (m)

The applied theoretical cant is therefore proportional to the radius of the curve. The maximum and minimum theoretical cant for narrow gauges is 90 and 10mm respectively for mainlines, whereas the minimum for yards is 0mm. The applied cant must be approximated to the nearest 5mm.

To simplify calculations, a spiral transition curve can be used. For the transition between a straight and circular curve alignment, the following formula can be used:

$$Y = \frac{X^3}{6RL}$$

Where:

Y	= Y position
X	= X position
L	= Length (m)
R	= radius (m)

4.3.3 Vertical Alignment

The detailed drawings of the vertical alignment of the External Rail can be seen in the following drawings:

- 1500103-TRANS-1008-P-00: Rail Longitudinal Sections – Section 1A
- 1500103-TRANS-1009-P-00: Rail Longitudinal Sections – Section 2B-2A
- 1500103-TRANS-1010-P-00: Rail Longitudinal Sections – Section 3A
- 1500103-TRANS-1011-P-00: Rail Longitudinal Sections – Section 4/5

The predominant gradient used for mainlines will be 1%. For running lines, the minimum vertical curve radius should be 10 000m (K=100). For staging and other yard lines, the minimum gradient will be 1:1000; and the minimum vertical curve radius should be 3000m (K=30).

For sections requiring cut, a minimum longitudinal gradient of 0.5% will be required for drainage purposes.

4.3.4 Maximum Rail Speed

The speed of the freights on the straights of all main lines and passing loops will be a maximum of 90km/hr. Furthermore, the maximum speed of the freights on the turnout of all main lines and passing loops will be 40km/hr.

4.3.5 Layer and Slope Formation

The formation from the rail surface has been designed to have a cross-sectional slope equal to 4%. This is will be maintained on the straight alignments and on curves where the theoretical cant does not exceed 40mm. The slope starts at the edge of the sleeper and falls to either side.

A slope inclination of 1:1.5 (vertical: horizontal) will satisfy the minimum factor of safety of 1.5 for fill heights less than 3m. For fill heights greater than 3m, the slopes will have to be altered accordingly.

4.3.6 Minimum Track Widths

The track was designed to accommodate a single 6-meter-wide track. The distance from the centre line to the extremity of the top of formation is therefore a minimum of 3 meters on each side.

Where double tracks are required, the distance between the two tracks must be a minimum of 4.0 m if no OHTE masts are placed between tracks, and 5.5m should masts be required. Therefore, the minimum required top width of a double track formation is 10.0m. Furthermore, a distance between tracks of 5.5m will be required for the signalling.

The rail reserve will be fenced off to suit existing boundary fences, which will provide a secure and safe corridor.

4.3.7 Structural Layers

The structural layers under the railway track are to be formed in accordance with the latest approved Transnet Freight Rail (TFR) S410 specifications for 20- and 26-ton axle load lines. Figure 4-15 shows the rail cross-section.

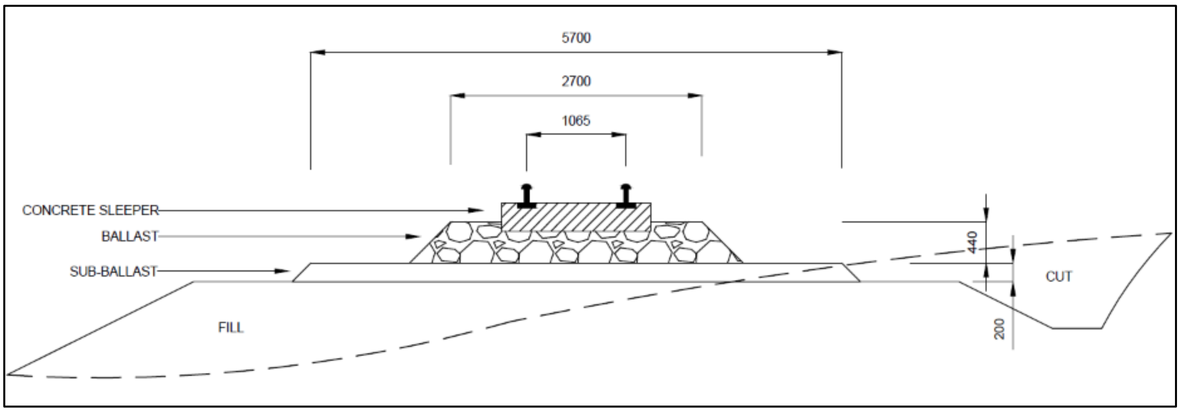


Figure 4-17: Cross-Section indicating the typical Structural Layers

4.3.8 Axle Load

The required axle load is 28 tons/ axle.

4.3.9 Sleepers

Sleepers shall be pre-stressed concrete and shall be of monolithic design. The sleepers shall be manufactured such that a gauge of 1065mm can be obtained on the straights when the flat bottom rails are placed on the sleepers.

The gauge plate insulators shall be manufactured such that the appropriate gauge widening can be obtained on the various curves. Only 1065 mm Gauge concrete sleepers at 700mm spacing will be used, according to the N1 classification. Furthermore, type “e” 2007 PANDROL elastic-type rail clips will be used.

4.3.10 Ballast

The N1 classification will be used for the main line and loop extension with a completed profile of 1500m^3/km.

4.3.11 Turnouts

60 kg/m profile rails will be used on the main line. The turnout will be fully weld-able, with no fish-plated joints, and on concrete bearers.

4.3.12 Rail Profile

Only head hardened 60kg/m rail profile will be used for all per-way works. Figure 4-16 shows the typical railway cross-section.

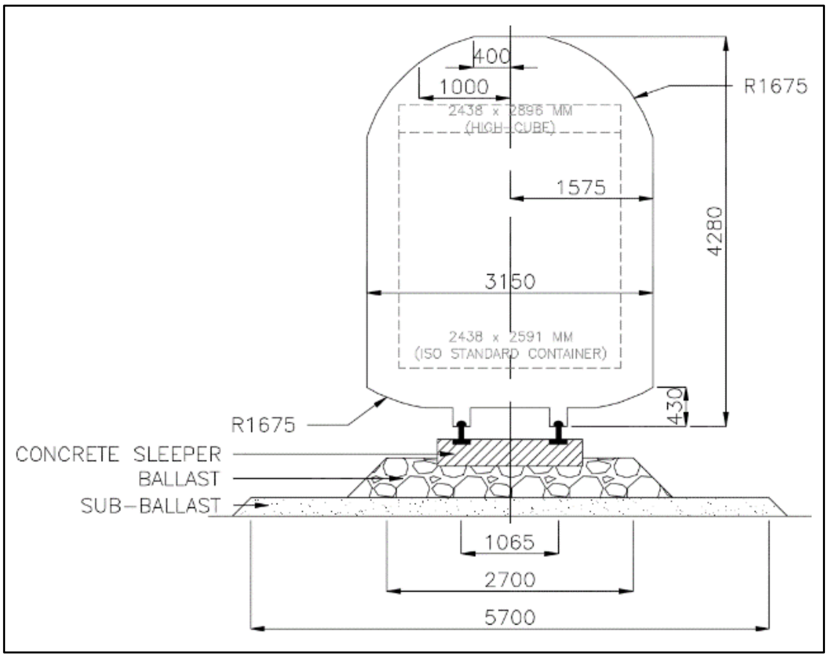


Figure 4-18: Typical Railway Cross-Section

4.4 Operations

4.4.1 Operations Plan

a) Type of service

The Boegoebaai Railway proposed will predominantly transport manganese from the Hotazel and Aggeneys mines. Until the freight becomes operational, the trucks will serve as the main mode of transportation to the Boegoebaai Port.

b) Manganese as a Commodity

The following information was taken from the "Boegoebaai Port FEL 2 Phase 2 – Analysis of Commodity Mix" report; Revision 2:

''The Kalahari Basin in the Northern Cape contains the world's largest manganese reserves, however, only 15% of global production comes from this area, leaving significant scope for development. The demand for manganese is strongly tied to the demand for steel. Manganese is used in steel as an alloying agent to achieve specific metallurgical properties which as a commodity has no viable substitute. Demand for manganese ore is driven by the strong growth in carbon and stainless steel (China), and manganese alloy production in China, India and other Asian countries. Asia accounts for 76% of the global manganese demand.

South Africa currently accounts for about 74% of the world's identified manganese resources. These mostly occur near Hotazel in the Northern Cape province. According to the United States Geological Survey (USGS), reserves were estimated at 15 billion tons in 2011. Currently, manganese is mainly exported via Port Elizabeth, Saldanha Bay and Durban.

Samancor Manganese, owned 60% by BHP Billiton and 40% by Anglo American, owns manganese mines, Wessels and Mamatwan, and associated prospecting rights in the Hotazel area in the Northern Cape. Mamatwan mine produces approximately 5 Mtpa with estimated reserves (exploited and discovered) of 433 Mt whilst Wessels mine produces approximately 2 Mtpa with estimated reserves of 190 Mt (exploited and discovered). Both mines transport their product via rail to the port of Port Elizabeth for export to markets in the east.

Assmang Manganese operates from the Black Rock area of the Kalahari, situated approximately 80 km northwest of the town of Kuruman and includes three underground mining complexes namely, Gloria which produces medium grade ore and Nchwaning 2 and Nchwaning 3 which both produce high grade ore. Current mining operations produce approximately 3.2 Mtpa. In February 2014 the Black Rock Expansion Project was commissioned to increase the output of high-grade manganese ore products and will lead to an increased output of 4.8 Mtpa. Most of the production is intended for export, but a portion is supplied for domestic use to two smelters: Cato Ridge Works in KwaZulu-Natal, and Machadodorp in Mpumalanga.

Manganese ore is transported by rail to Saldanha, Port Elizabeth and via road and rail to Durban for export. The ore is also transported to Kwazulu Natal for domestic use. Kudumane Manganese Resources is in the Northern Cape Province, near Hotazel, situated 60 km northwest of Kuruman. They currently have mining rights on two farms namely, York, which is currently operational and Telele where mining was estimated to start in 2018. York currently produces approximately 1 Mtpa and the predicted production from Telele will also be around 1 Mtpa. Both mines have an estimated life of mine of approximately 30 years. They currently transport their product via rail and road to Durban and via rail to Port Elizabeth harbours for export to markets in India, China, Russia and other countries.

Transnet is utilising the Ports of Saldanha Bay, Durban and Port Elizabeth for its manganese export operations, with deferred plans to move or consolidate these operations to the Port of Ngqura in the short term (TNPA, 2019). The main bulk export of 6 Mtpa is shipped from Port Elizabeth. Port Elizabeth has a current theoretical and installed capacity of 6 Mtpa limited by the rail line capacity, from Hotazel, which is around 8 Mtpa. The Long-Term Planning Framework (2017) indicates that in 2025, the capacity requirements will need to meet a demand of 20.7 Mtpa. In 2013/14, 65% of all manganese exports from South African ports (approximately 9 million tons) were handled by the Port of Port Elizabeth, 33% by the Port of Durban in open-top container trains, and the remainder by the Port of Saldanha Bay. The Port of Saldanha Bay commenced with the export of manganese through the multi-purpose terminal (MPT) in 2013 and will continue to do so until the manganese terminal in the Port of Ngqura is commissioned (TNPA, 2019). The Transnet Long Term Planning Framework (LTPF) 2017 considers a demand of 3 Mtpa of manganese to be handled at the MPT berth at the Port of Saldanha Bay and 1.5 mtpa for the Port of Durban.

The Port of Lüderitz in Namibia, which is a small harbour dependent on tourism, fishing and mining activities, is looking at alternative projects to expand its development potential. TradePort Namibia cc (TradePort), and Pektranam Logistics started transporting 30 000 t consignments of manganese monthly from South Africa to China via the Port of Lüderitz since 30 December 2018. However, divergent views have emerged out of the port town of Lüderitz on whether it was environmentally safe to use it as a transit for manganese ore. The Ministry of Environment and Tourism have issued TradePort with an environmental clearance certificate to undertake road and rail manganese import and export operations by utilising the Trans-Oranje Corridor, linking the Port of Lüderitz with the Northern Cape Province of South Africa. The intention is to ramp up the monthly 30 000-ton consignments to 80 000-ton (i.e. approximately 1 Mtpa) consignments (TC, 2019).

As part of Transnet's manganese expansion programme, Transnet has been able to increase the national manganese capacity from 5 million tons in 2012 to just over 13 Mtpa currently. Through its capacity creation initiatives, the new projects include minor manganese exports through the Port of Richards Bay and the Port of Cape Town. United Manganese of Kalahari (UMK) is amongst manganese players who have been instrumental in piloting new export channels that Transnet has successfully operationalised. Boegoebaai and the country could benefit from consolidating all minor flows, including all the off-route manganese such as the 3 Mtpa of manganese flows to Saldanha on the OREX rail line, the 1.5 Mtpa manganese flows by road and rail to Durban and the 1 Mtpa originating from the Northern Cape and presently destined for the Port of Lüderitz. The surface transport pricing of manganese to these ports is of such a nature as to make Boegoebaai a more competitive alternative and thus allowing for manganese to be diverted through Boegoebaai.

It is estimated that approximately 4.5 Mtpa would therefore be available for export through Boegoebaai from both the Port of Durban and Saldanha Bay in the short term (i.e. by the port commissioning date of 2025). The Transnet LTPF 2017 gap in capacity in Port Elizabeth in 2025 (as a result of lack of rail capacity) could provide a further 2 Mtpa of export manganese.''

c) Train configuration

The Sishen to Saldanha freight rail, the most comparable train, currently sits with a 3 by 114 wagon configuration. The Boegoebaai Rail will therefore make use of a train configuration of 114 wagons with a locomotive attached at each end. This will represent one unit of freight.

A possible future configuration could consist of 2 units of trains (i.e. 2 by 114 wagons) with distributed power.

d) Special operating parameters

Distributed Power (DP) will be deployed. The locomotives will be distributed throughout the train and will be remotely controlled by radio. Additionally, DP allows for longer trains and minimizes the number of required crew members.

Furthermore, the use of DP allows the train forces and dynamics to be significantly improved. Braking, as a result, is improved which ultimately allows for shorter stopping distances.

e) Hazardous goods details

Hazardous goods are those goods which pose a potential risk to health, safety, property or to the environment during transportation by rail. They are also classified according to the regulations concerning the International Carriage of Hazardous Goods by Rail (RID). Trains transporting hazardous goods are also required to be regularly inspected and approved.

Various railway group standards and documentation are required to be upheld for freights to manage and move hazardous goods. This includes relevant working manuals for rail staff and handling manuals. The network rail in charge, TRANSNET, also requires notification when a railway transports dangerous goods.

The movement of hazardous goods by rail can be undertaken in either single or mixed freight loads. The measures put in place, however, differ and therefore need to be appropriately managed.

f) Overload management system

The overloaded transportation chain within South Africa is driven solely by economic profit. A long-term solution to the overused rail network is to implement a toll collection. This toll will be based on the overall weight of the freight and limited value of the axle load. However, a toll might discourage investment from miners if not managed correctly.

g) Train Scheduling

Rolling stock maintenance can be programmed by mileage, time or condition monitoring. Of the three, condition monitoring is the most recent scheduling method. Condition monitoring is achieved by checking the operation of the equipment. This allows for equipment to only be changed once they show signs of wear beyond pre-set limits. Modern locomotives should be able to run for weeks without a maintenance inspection. There are, however, special rules for heavy freight trains that must be obeyed. It is recommended that trains are inspected every 18 days.

h) Crewing plan

Legislative rules require a minimum of two people per crew on all freight railroads. The rail operators must maintain a distinguished safety record and have experience if tasked with operating a train alone. Some employers also require train drivers to have a minimum education of grade 9.

The Sishen to Saldanha railway currently has 19 crossing loops. Loops are implemented to allow for the maintenance and temporary storage of trains. Loops also allow trains travelling in opposite directions to pass each other. As per the Ninham Shand report (1980), a minimum of 4 crossing loops will be required for the Boegoebaai Railway. It is proposed that the stations are located at Aggeneys, Steinkopf, Port Nolloth and at Boegoebaai.

Freight trains are generally operated by an engineer and a conductor. Engineers and conductors generally belong to specific crew pools and are not interchanged with members from other territories. Every crew has at least one home terminal; with some crews having at least one away from home. Home terminals imply no lodging costs are required; and away from home terminals mean that there is an implied lodging cost. Crews therefore operate as close to their home terminal as possible to limit their total cost. Furthermore, a detention payment can be claimed if the crew waits excessively at an away from home terminal.

As crews generally operate within specific areas, crews are required to be interchanged along the railway. Crews are divided into pools, with each crew pool having a set number of jobs called turns. Crews are only allowed to take on another turn if they have had the minimum 10 hours of rest.

i) Contingency and Recovery

Contingency and recovery arrangements should be made in the event of rolling stock failure. Special recovery arrangements identified as part of the risk assessment should also be identified.

j) Emergency management plans

An emergency management plan is a course of action developed to mitigate the damage of potential events. An emergency management plan will be required for the next stage of the project.

4.4.2 Signalling & Telecoms

Mobile phones and satellites will be used to assist in the transportation of materials. Radio Distributed Power (RDP) technology will also be used. A further investigation will be required to determine the feasibility, implementation and management of these systems.

4.4.3 Permanent Way

The permanent way of a railway line is the pair of rails laid on the sleepers embedded in the ballast. The intention of the permanent way is to carry the total weight of the train. It is recommended that steel rails are implemented for the Boegoebaai Rail as steel is a cost-minimizing choice for railroad companies over iron, as per the article written by A M Carlos, 2017.

4.4.4 Maintenance Plan

Train and track maintenance are extremely important and reduces the likelihood of dangerous goods spilling. Railways are complex structures comprised of mechanical and electrical systems with hundreds of moving parts. Therefore, train equipment must consistently be in a good working order for the railway system to be reliable and safe. Railway systems cannot operate for long periods of time without significant maintenance as railways eventually deteriorate and become unsafe.

Although expensive, maintenance is necessary and is cheaper than periodically replacing failed equipment. It should be noted that the most maintenance intensive part of the railway system is the rolling stock as it is the most vulnerable part of the railway system if neglected.

Specialized facilities will be required for both storage and maintenance. The layout of the maintenance facility (or depot) will consist of a storage yard, cleaning area, inspection and a locomotive shop. The depot will require good access from both road and rail. Good rail access allows for freights to get in and out of the depot without delaying other trains along the main route. Good road access allows for larger equipment, such as transformers and pre-assembled traction units, to be transported to the depot. Hard-standing areas and unloading facilities, including cranes or gantries, should also be considered when designing depots.

Empty wagons and trains will be stabled in depots when they need to be cleaned or serviced. Suitable facilities shall therefore be provided. These facilities require an adequate water and power supply from the appropriate service providers. Access to the trains and wagons must also be designed so cleaning staff can safely reach them whilst carrying the necessary equipment. The floor height of the walkways, alongside the locomotives and wagons, should therefore have a suitable height to allow for adequate maintenance.

The layout of the depot or stabling area will also be important. It is ideal that there is an exit route at the beginning and end of the stabling area; so that should a train break down, the other locomotives will always have an accessible point of exit.

Stabling areas should be built outdoors. This saves on construction costs as large sheds will not be required. However, covering the area with a weather-proof structure is preferred because it will protect the train and staff working on or around the wagons and locomotives. The additional shade will also assist in creating a more comfortable working environment.

Most modern depots require a wheel profiling facility known as a wheel lathe. These are normally designed so that the wheels can be reprofiled whilst still on the train. In order to remove the wheels, the train unit must be lifted which is an expensive process. Therefore, wheel lathes are implemented to avoid this cost. Alternatively, wheels can be removed via a wheel drop machine, however unfavourable ground conditions may make this an unsuitable solution.

Furthermore, special facilities will be required at the loops to carry out rolling stock inspections. A properly constructed shed or building will be required for this, and access to the underside of the locomotive will be necessary.

4.4.5 Electrification

A voltage of 50 kV, AC overhead catenary, was chosen instead of the usual 25 kV in order to haul heavier loads and to allow a larger distance between transformers. It is recommended that an investigation is completed to determine the number of required substations along the railway route.

4.4.6 Rolling Stock Requirements

Rolling Stock Data

Tables 4-4 and 4-5 provide the rolling stock data for both locomotives and freight wagons.

Table 4-4: Rolling Stock Data – Locomotives

Locomotives	
Class	9E
Type	Electric
Number	10
Length over Couplers	21,132mm
Length over Beams	20,120mm
Width	2,900mm
Mass	166,300kg
Gauge	1,067mm Cape Gauge
Wheel Diameter	1,220mm
Axle Load	28,000kg
Maximum Speed	90km/hr
Recommended Operating Speed	80km/hr

Table 4-5: Rolling Stock Data – Freight Wagons

Freight Wagons	
Class	210 CR
Type	Ore wagons
Gross Mass per Wagon	200 tons per wagon
Total Gross Mass of Wagons	45600 tons
Tare Mass per Wagon	121 tons per wagon
Total Tare Mass of Wagons	27600 tons

BOEGOEBAAI PORT FEL 1 PHASE 1

RAIL INTERNAL TO PORT

RAIL ROUTE INVESTIGATION LINKING BOEGOEBAAI PORT TO THE NORTHERN CAPE MINES

5. RAIL INTERNAL TO PORT

5.1 Internal Rail Layout

Figure 5-1 shows the designed Internal Rail network, and the different rail sections within the Boegoebaai Port. This network links the External Rail infrastructure to the offloading area.

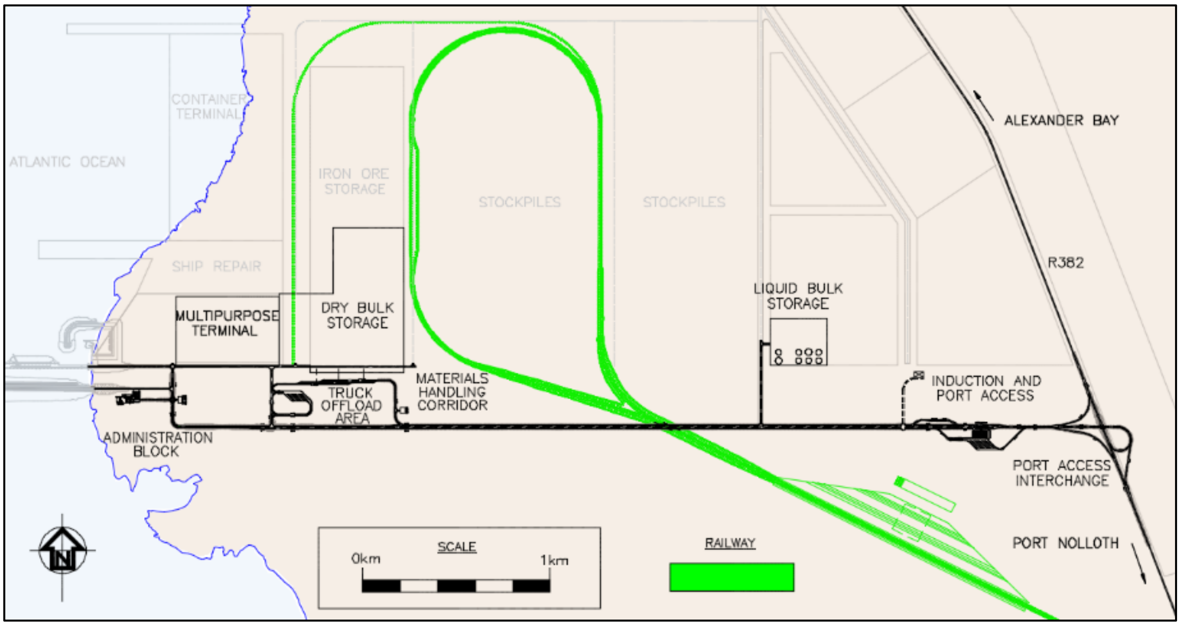


Figure 5-1: Rail Internal to Port Rail Layout

The process for the general flow of ore transported through the port is as follows:

- The ore is transported towards the port from the Rail over R382 Bridge
- The freight passes under the bridge at the Rail over Main Boulevard Bridge
- The entrance and exiting rails separate as shown
- The commodity is offloaded to the stockpiles
- The rail returns to the mines

The Internal Rail will be designed to similar standards as the External Rail. However, two rails will be routed around the port.

5.2 Internal Port Bridges

Two internal port bridges were required to be designed. This allowed the rail to intersect the R382 and the main boulevard. The following drawings can be used for more information:

- 1500103-TRANS-4002-P-00: Main Access to Port Over Rail Bridge – General Arrangement
- 1500103-TRANS-4003-P-00: Boegoebaai Main Interchange Bridge – General Arrangement
- 1500103-TRANS-4001-P-00: Road Over Rail Bridge – General Arrangement

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SUMMARIZED INTERNAL AND EXTERNAL RAIL

RAIL ROUTE INVESTIGATION LINKING BOEGOEBAAI PORT TO THE NORTHERN CAPE MINES

6. SUMMARIZED INTERNAL AND EXTERNAL RAIL

Table 6-1 provides a summary of the Internal and External Rail.

Table 6-1: Summarized Internal and External Rail

DETAIL	ASSOCIATED VALUE
4 RAIL EXTERNAL TO PORT	
4.1 Proposed External Rail	
The rail layout was divided into sections The N7 South of Steinkopf to the N14 section was subdivided further as multiple designs were required Option 4 was chosen to be the final preliminary design going forward	
4.2 Bridges, Tunnels and Earthworks	
<u>Bridges</u> No. of bridges required between rail and road intersections No. of river bridges required	 3 7
<u>Tunnels</u> No. of tunnels required Total length of tunnel required	 4 9.9km
<u>Earthworks</u> Total cut required for the External Railway Total fill required for the External Railway	 100 million cubic meters 120 million cubic meters
4.3 Design Specifications	
<u>Horizontal Alignment</u> minimum horizontal curve radius reduction in design speed required for	 700m R<700m
<u>Cant</u> max cant for narrow gauges min cant for narrow gauges max cant for yards min cant for yards	 90mm 10mm 90mm 0mm
<u>Vertical Alignment</u> predominant gradient for mainlines $K_{\text{running lines}}$ $K_{\text{staging \& yard lines}}$ min gradient required for drainage	 1% 100 30 0.5%
<u>Maximum Rail Speed</u> maximum speed of freight on a straight maximum speed of freight on a turnout	 100km/hr 40km/hr
<u>Layer and Slope Formation</u> side slope formation gradient from surface slope ratio (vertical: horizontal) for fill heights less than 3m	 4% 1:1.5
<u>Minimum Track Widths</u> Single track width distance between tracks without masts distance between tracks with masts distance between tracks for signalling	 6m 4m 5.5m 5.5m
<u>Structural Layers under railway track</u> The structural layers under the railway track are to be formed in accordance with the latest approved TRANSNET Freight Rail S410 specifications for 20- and 26-ton axle load lines	
<u>Axle Load</u> Required axle load	 28 tons/ axle
<u>Rail Profile</u> Rail profile to be used for all per-way works	 head hardened 60kg/m
<u>Sleepers</u> Sleeper to be used	 PY Concrete sleeper

DETAIL	ASSOCIATED VALUE
Ballast Ballast to abide by the N1 classification	
Turnouts Turnout profile to be used	60 kg/m
4.4 Operations	
Operations Plan The Boegoebaai Railway proposed will predominantly transport manganese from the Hotazel and Aggeneys mines. The Boegoebaai Rail will make use of a train configuration of 114 wagons with a locomotive attached at each end	
Signalling and Telecoms RDP, mobile phones and satellites will be used to assist in the transportation of materials	
Permanent Way It is recommended that steel rails are implemented for the Boegoebaai Rail	
Maintenance Plan Train and track maintenance are extremely important and reduces the likelihood of dangerous goods spilling. Although expensive, maintenance is necessary and is cheaper than periodically replacing failed equipment	
Electrification A voltage of 50 kV, AC overhead catenary, was chosen instead of the usual 25 kV in order to haul heavier loads and to allow a larger distance between transformers	
Rolling Stock Requirement Locomotive used Freight Wagon used	 9E Electric Motor 210 CR Ore Wagon
5. RAIL INTERNAL TO PORT	
Layout The Internal Rail will be designed to the same standards as the External Rail. However, two rails will be routed around the port.	
Bridges Two internal port bridges were required to be designed. This allowed the rail to intersect the R382 and the main boulevard	

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BOEGOEBAAI PORT FEL 1 PHASE 1

COST ESTIMATE

RAIL ROUTE INVESTIGATION LINKING BOEGOEBAAI PORT TO THE NORTHERN CAPE MINES

7. COST ESTIMATE

The tables below provide cost estimates for the railway. Table 7-1 provides a total cost estimate, while Tables 7-2 and 7-3 provide a breakdown of the cost estimates for the Internal and External Railway respectively.

Table 7-1: Total Railway Cost Estimate

Total Railway Cost Estimate	Cost (ZAR million)
Internal Rail	250
External Rail	15 500
Total	15 750

Table 7-2: Summarized Internal Railway Cost Estimate

Costing	Cost (ZAR million)
Trackwork	125
Earthworks and Drainage	60
OHTE	45
Sum	230

Table 7-3: Summarized External Railway Cost Estimate

Costing	Cost (ZAR million)
Trackwork	6 260
Earthworks and Drainage	2 760
OHTE	2 250
Viaduct Cost	2 580
Tunnel Cost	1 650
Sum	15 500

The above cost estimates exclude the following:

- VAT and any additional associated Taxes
- Contract Price Adjustments
- Land Acquisition
- Rolling Stock
- Operational and Maintenance Costs
- Environmental Impact Assessment
- Professional Fees
- Preliminaries and General
- Contingencies

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BOEGOEBAAI PORT FEL 1 PHASE 1

CONSTRUCTION SCHEDULE

RAIL ROUTE INVESTIGATION LINKING BOEGOEBAAI PORT TO THE NORTHERN CAPE MINES

8. CONSTRUCTION SCHEDULE

The following critical tasks will make up most of the construction during Phase 1B railway works:

- General bulk earthworks
- Viaduct construction
- Tunnel construction
- Rail construction
- Internal Rail infrastructure
- Electrification of railway

The phasing envisaged for the various work packages is planned as follows.

Table 8-1: Construction Schedule for the Boegoebaai Port Development

	2020					2025					2030					2035	
Marine Port Development	Des	Tender		Construction													
Landside Port Infrastructure	Design		Tender		Construction												
Road R382 Rehabilitation	Design		Tender		Construction												
Rail	Design			Tender		Construction											

Table 7-1 surmises that Phase 1A, the Marine Port Development and Landside Port Infrastructure, will become operational from 2025. Phase 1B is envisaged to become operational after 2035, 10 years after Phase 1A has been completed.

RISK

RAIL ROUTE INVESTIGATION LINKING BOEGOEBAAI PORT TO THE NORTHERN CAPE MINES

9. RISK

Risk management is the process of forecasting and evaluating both financial and physical risks; and identifying procedures to avoid or minimize the impact of these risks. A risk management plan report will be required to address and quantify the uncertainties that exist. This will allow for risks to be prioritised and relevant allowances to be made.

The cost estimated was the main financial risk at this stage of the design. A quantitative risk analysis will be required to minimize the amount of financial risk involved.

Other main contributing risks include:

- Appropriate acquisition of land
- Health and safety aspects concerning tunnel construction
- Excessive wear and tear on equipment
- The presence of traffic alongside the rail (on the R382, and part of the N7 and N14)
- Eskom's ability to meet the energy demands caused by the implementation of the rail
- The surrounding ground conditions
- Environmental authorization risks
- Client procurement risks
- Property acquisition risks
- Economic risks excluding exchange rate fluctuations during the construction phase
- Business Case risks (funding, revenue, tariffs, OPEX, etc)

The risk management plan should be a live document that will be reviewed and updated throughout all phases of the project. The scope of this project is limited to design and construction risks only and is not part of the coastal engineering design or landside Phase 1A design.

BOEGOEBAAI PORT FEL 1 PHASE 1

CONCLUSIONS AND RECOMMENDATIONS

RAIL ROUTE INVESTIGATION LINKING BOEGOEBAAI PORT TO THE NORTHERN CAPE MINES

10. CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

The proposed Boegoebaai Rail will provide the port development with an alternative method of freight transport within the Northern Cape Province. The rail network will be designed using similar criteria to the Sishen to Saldanha rail. The Mpumalanga/ Richards Bay coal line will also be used to compare design parameters.

With the completion of this project, more commodities should be transported, allowing for mines to operate at a larger capacity. A preliminary rail route has been designed; however, multiple financial and physical risks are present.

The Boegoebaai Railway proposed will transport predominantly manganese. But until the freight becomes operational, the trucks will serve as the main mode of transportation to the Boegoebaai Port.

10.2 Recommendations

The following recommendations were made throughout the report:

- A financial and risk assessment should be completed for the next phase of the project.
- A detailed EIA of the surrounding areas along the railway track should be completed.
- The surrounding mining facilities along the proposed railway network will need to be further investigated.

BOEGOEBAAI PORT FEL 1 PHASE 1

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RAIL ROUTE INVESTIGATION LINKING BOEGOEBAAI PORT TO THE NORTHERN CAPE MINES

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