ISCOR - YSKOR

SISHEN - SALDANHA PROJECT

PROPOSED RAILWAY ROUTE

FINAL REPORT ON THE RECONNAISSANCE ENGINEERING GEOLOGICAL SURVEY

VOLUME 1. (FINAL)

October 1972

Undertaken for :

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IMPORTANT NOTE

The results of the Engineering Geological appreciation and Soil Engineering Mapping, as summarised in this report, should be studied taking into consideration both the reconnaissance nature of the survey and the stringent deadline arrangements which necessitated rapid and curtailed field work.

The conclusions from the survey should be viewed as our best judgement of the conditions prevailing from the evidence and information available at the time of presenting this report.

TABLES AND MAPS ACCOMPANYING THE REPORT

Volume 1 (Final) Final reconnaissance report accompanied by test result tables and twenty-three Facet Index tables describing the properties of the various materials delineated on the maps of Volume II. A geological maps showing the different Engineering - Geological Sections discussed in the report.

Volume II: Forty-three soil engineering maps, compiled at the same scale as the mosaics.

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ABSTRACT

Those aspects of the geology, physiography, geomorphology, engineering characteristics and construction materials that pertain to the planning and construction of the proposed Sishen - Saldanha Bay railway line are discussed relative to the results of the Engineering Geological Study undertaken by R.F.Loxton, Hunting and Associates on behalf of ISCOR.

This report should be read in conjunction with the Facet Index tables and the Soil Engineering maps accompanying the report.

Photogeological mapping and land pattern mapping extending ± 3,4 kilometres either side of the centre line and detailed land pattern/facet mapping extending over a width of 500 metres to both sides of the centre line, has been carried out. Field investigation was undertaken by helicopter, this somwhat rapid survey being necessitated by the stringent deadline arrangements for the submission of the results of each section progressively on completion. Samples collected during the field trip were tested in the Laboratories of Steyn and de Waal. The investigation placed special emphasis on the engineering characteristics of the geology, geomorphology, stability of slopes, foundations and construction materials in the vicinity of the proposed route.

The results of the survey give a sound reconnaissance appreciation of the engineering geological conditions along the route, and in certain problem areas a more detailed follow-up examination has been recommended.

Separate reports on the Hydrogeological and Ballast investigations have been submitted previously.

SUMMARY OF CONCLUSIONS

1. The railway route from Sishen to Saldanha Bay traverses generally flat, featureless terrain, in places broken by exposed rock outcrop in the form of ridges and hills.

2. The variation of rainfall over the length of the rail route is from 100 to 400 millimetres.

3. Vegetation is very sparse and the dominant weathering process is one of disintegration, except along the coastal section where chemical decomposition occurs.

4. A few perennial rivers drain the area to the west, but the majority of the streams and rivers are ephemeral.

5. Over much of the route the solid geology is covered by a relatively thick layer of sand of variable depth.

6. The geological formations present along the route include, from oldest to youngest rocks : the Basement Complex, Kheis System, Transvaal System, Waterberg System, Koras Formation, Nama System, Klipheuvel Formation, Cape System, Karoo System, Post-Karoo System intrusive dolerites and Tertiary, Quaternary and Recent deposits.

7. Superficial deposits along the route include calcrete, silcrete, dorbank, gypsum, alluvial gravels to clays, sand, beach deposits and mobile dunes.

8. Hillslopes are generally stable throughout the whole route under existing climatic conditions, with the exception of mobile dune areas.

9. Rail bed foundation conditions are generally good to moderate throughout the area of route. In aeolian sand areas compaction difficulties may be encountered due to their poor grading. Alluvial and marine clay and gypsum areas may also cause problems but these zones are limited in extent.

10. In general foundation conditions at the proposed bridge sites are highly variable and further investigation is necessary to establish a suitable founding depth or depth to bedrock. Areas demanding further examination are detailed in the report.

11. Adequate supplies of construction materials, including : crushed aggregate, sub-ballast, binder, fill and concrete sand occur along the route, with the exception of a shortage of crushed aggregate stone, concrete sand and possibly sub-ballast in the Aeolian section, and concrete sand in the Dwyka, Nama and Coastal sections.

12. The reconnaissance land pattern/facet mapping has delineated areas of similar soil profile and defined the different material properties. The results of this mapping confirm the feasibility of rail line construction along the route, as well as defining and locating the various problem areas.

13. No detailed routine sampling and testing was undertaken of the materials along the route due to the reconnaissance nature of the survey. However, approximately 80 samples were taken during the helicopter field trip, the analysis of which was used in determining the engineering properties and potential use of these materials in construction. The test results have been classified according to their respective land patterns, facets and horizons and also relative to the Unified Soil Classification. These results are tabulated at the back of the report.

1. INTRODUCTION

During May, 1969, R.F. Loxton, Hunting and Associates were commissioned by Messrs. Scott and De Waal to carry out a feasibility study along the route of the then proposed Saldanha – Sishen Railway Line. Annotated maps and tables with descriptions of units on the maps were submitted to Scott and De Waal in June, 1969.

In August, 1971, discussions with ISCOR and the Consulting Engineer's Consortium, Steyn and De Waal, resulted in R.F. Loxton, Hunting and Associates being commissioned by ISCOR, on 8th. September, 1971, to undertake Ballast and Soil Engineering Mapping along the proposed Saldanha – Sishen Railway line.

The final Ballast Report was submitted in February, 1972. The detailed land pattern/facet mapping and borrow pit overlays, together with the Facet Index tables, were submitted both to ISCOR and the Consultants progressively as the various priority sections were completed. The maps and tables were provisional, although the final mapping does not differ to any great extent.

The final report, together with tables and maps, is submitted in composite form, summarising all aspects of the engineering geological work undertaken during the project.

Detailed land pattern / facet mapping was carried out to a minimum distance of 500 metres either side of the centre line, while geological and land pattern mapping, together with borrow pit investigation, was extended to the limit of air photo coverage, i.e. approximately 6,8 Km.

Due to the stringent deadline arrangements on mapping and borrow pit location, field examination was undertaken by helicopter to enable detailed geological and soil engineering investigations to be carried out by a senior engineering geologist and hydrogeologist. The investigations included the collection of near surface soil and rock samples by pitting and augering at pre-selected points along the route. The testing of the samples was carried out by Messrs Steyn and De Waal.

The proposed route has been divided into seven engineering geological sections, each of which is dealt with separately in the report.

Hydrology and geology has been interpreted in detail in the hydrogeological reports.

Close liaison has at all times been maintained with both the Civil Engineering Consultants and ISCOR.

2. OUTLINE OF THE GEOLOGY

The proposed route of the Sishen to Saldanha Bay railway line is underlain by a variety of geological formations which are tabulated below:-

Tertiary, Quaternary and Recent Deposits
Post Karoo System intrusive dolerites
Karoo System
Cape System
Klipheuvel Formation
Nama (Malmesbury) System
Koras Formation
Waterberg System
Transvaal System
Kheis System
Basement Complex

The Basement Complex occurs in the area between the Orange River and the Karoo System (Dwyka Series) as well as in the Krom River Canyon area to the north-northeast of Van Rhynsdorp. The rocks are mainly granitoid and gneissic, and show complex tectonic and metamorphic relationships.

The Kheis System overlies and is infolded with the rocks of the Basement Complex in the Kenhardt-Orange River section and in a north-northwesterly trending strip along the eastern side of the Orange River. The system comprises metavolcanic and metasedimentary rocks (the former predominant), and shows a marked change of tectonic style and metamorphic grade from east to west in the Orange River - Kenhardt Section. Near the Orange River valley the metamorphic grade is low, and fine structures (schistosity and cleavage) are well preserved, whereas to the west and southwest, the metamorphic grade becomes higher and granitisation (partial melting) phenomena are associated with coarser crystallisation and coarser structures (foliation etc). The metavolcanic rocks include basic, intermediate and acid lavas and their associated pyroclastic rocks, which are difficult to recognise at high grades of metamorphism.

The Transvaal System (Precambrian) is represented in the Sishen area, and forms part of the Northern Cape, Transvaal System basin. A variety of sedimentary and volcanic rock types occur in this section, and these are correlated with the Pretoria Series of the main Transvaal System basin. Quartzites, shales, limestones, conglomerates, chert, jasper, banded ironstone, andesitic lavas and tuffs, are all developed within this sequence and the volcanic rocks (Ongeluk lavas) underlie an extensive area southwestwards from Sishen. The Pretoria Series rocks are folded with axial traces parallel or sub-parallel to the "Langeberg Trend" (see below).

The Waterberg System (Precambrian), including the Matsap beds, consists of a well-developed, arenaceous sequence (quartzites, grits, conglomeratic grits etc.) which builds the prominent Langeberg range. The beds are folded with axial traces parallel or sub-parallel to a N-S, NNW trend (the so-called "Langeberg Trend"). These rocks extend well to the west of the Langeberg Range, but are there depicted as Kheis System on the 1 : 1 000 000 geological map of South Africa.

The Koras Formation is probably associated with the Waterberg System and consists of conglomerate, feldspathic sandstone, andesitic, basaltic and felsitic lavas. This Formation is developed in a small area northeast of Kleinbegin.

The Nama System (including the Malmesbury System) crops out in the Knersvlakte region and to the south. It consists of carbonate rocks (limestone, marbles, etc.) shales (schists and phyllites), feldspathic quartzites, grits and local developments of conglomerate, all weakly metamorphosed, variably sheared and folded. The System is probably of Late-Precambrian age and is intruded by the Cape Granite which underlies the southern part of the coastal section of the line of route.

The Klipheuvel Formation (post-Cape Granite) occurs in a very minor area in the southern parts of the study area and consists of sandstones and shales (the age relationships are, however, not clear since it may represent the base of the Cape System or may be younger).

The Cape System (Palaeozic) is represented by the Table Mountain Sandstone Series along the southern parts of the proposed route. This consists of sandstone, conglomerates and minor shale bands. These rocks occur on the fringes of the Cape Fold Belt, although in the study area, the strata are relatively flat-lying.

The Karoo System crops out over a large area in the central parts of the proposed route, and consists of the basal Dwyka Series tillite and shales. The shales are extensively intruded by dolerite sheets and sills and contact metamorphism has resulted in the production of baked shales and lydianite on a widespread scale.

Large sections of the line of route are underlain by younger formations (Tertiary to Recent in age) which mantle the older formations previously described. These younger formations include unconsolidated gravels, sands and beach deposits, together with calcretes, dorbank, gypsum and related deposits. The gravels and sands include alluvial deposits, beach deposits and mobile sands (wind blown accumulations).

A more detailed study of the geology is recorded under the Engineering Geological Sections which, together with the photogeological overlays to the mosaics will give a more comprehensive outline of the geological conditions existing along the line of route.

The geomorphology, individual rock types, their engineering properties and uses as construction materials etc., is likewise discussed in detail under "Engineering Geological Sections Along the Route".

3. PHYSIOGRAPHY

Climate and Weathering

The climate from Sishen to the Coast is semi-arid, to arid, with the rainfall distribution generally varying as follows:-

North of Kleinbegin 200 - 400 mm (summer rainfall)
Kleinbegin to Sout River 100 - 200 mm (summer rainfall)
Sout River to Coast - average ± 100 mm (winter rainfall)

Weinert's N-value for this region varies from 10 to ± 35, hence the dominant weathering process operating throughout the area is one of disintegration (physical break down of rock). Thus the weathering products derived from the disintegration of basic igneous rocks e.g., dolerite, andesite etc., should be relatively non-active and will cause no major foundation problems. In general, weathering depths are shallow especially in the sandstone, quartzite, granite, tillite, limestone and lydianite rock types, while deeper weathering tends to be found in the shales, mudstones, phyllites, dolerites, gneisses, schists and amphibolites.

Rainfall along the coastal section occurs mainly in winter and varies from 200 mm in the north to 400 mm at Saldanha Bay. Weinerts N-value in the coastal section varies from 4 - 10, hence minor to moderate chemical decomposition will occur within this zone and materials derived from basic igneous rocks, e.g. the olivine basalt near Lamberts' Bay, are likely to have high P.I.'s.

Recent and present day weathering and erosional effects on the sedimentary rocks of the Table Mountain Series, the Cape Granite and rocks of the Nama (Malmesbury) System are considered to be subordinate relative to the weathering effects undergone by these rocks during past periods of marine erosion.

Hydrology and Erosion

Due to the very low rainfall throughout the region, free surface water remains in dams, river beds, pans etc., for only limited periods after rains. Drainage and erosion channels generally show only minor incision in the wide open valleys, being chiefly wash areas (during periods of flood) where the river course is poorly defined and subject to periodic changes in direction.

Perennial rivers along the route include: Orange River, Olifants River, Verlorevlei and Groot Berg River.

Ephemeral rivers with well defined courses, include: Gamagara River, Hartbees River, Rietfontein River, Zooafsleegte River, Bysteekleegte River, Krom River, Doring River, Sout River, Hol River, Varsche River, Gemsbok River, Kleinfontein River, Sandlaagte River, Jakkals River and Langvlei River.

Due to the low rainfall in the area, ground water is generally located at depth. The water table tends to be highly variable and is dependant on local conditions such as topography and geology. However, this aspect of the terrain is covered fully in the "Water Feasibility Study" report.

Sources of water for construction purposes are at present being investigated, but a general recommendation for the location of such sources of water would appear to be the sandy beds of the larger streams and river courses, in addition to boreholes and dams located on the various farms.

Vegetation

Natural

With semi-arid to arid climatic conditions occurring throughout the area, natural vegetation tends to be sparse. The dominant vegetation types are: Kalahari Thornveld and Shrub Bushveld between Sishen and the Orange

River; Orange River Broken Veld between the Orange River and Kenhardt; Arid Karoo and Desert False Grassveld from Kenhardt to the Krom River; Western Mountain Karoo along the Krom River; Succulent Karoo from the Krom River to the coast and West Coast Sandveld along the coast to Saldanha.

The above vegetation types comprise mainly, grass, scrub, bush and succulents with scattered (thorn) trees, the latter are chiefly associated with drainage ways.

Artificial

Due to the lack of water throughout the area, intense cultivation is confined to the flood plains of perennial rivers and certain areas along the coastal belt. In addition small areas of maize, wheat, lucerne etc., are cultivated by irrigation using borehole water. Trees, acting as windbreaks are found around farm houses.

4. SOIL ENGINEERING MAPPING

Detailed land pattern/facet mapping has been carried out along a strip of width approximately 500 metres either side of the centre line of the proposed railway. Land pattern and photo-geological mapping was extended beyond this strip to a width of 3,4 km, either side of the centre line (i.e. to limit of mosaic coverage). The soil engineering maps included with this report combine both land pattern/facet boundaries and dominant lithological types. Mapping was carried out on uncontrolled mosaics of approximately 1 : 25 000 scale and hence the degree of accuracy attained is limited.

The region has been divided into twenty-seven land patterns, selected on the basis of predominant rock type(s) and their topographic influence within each geomorphological unit. Each land pattern has been sub-divided into separate soil and rock units called "facets", having approximately similar engineering-geological properties.

The different land patterns, together with their names and number of facets, are listed below:

L.P.	Name	No. of facets in each Land Pattern
A	Aeolian Sand	5
B	Matsap/Quartzite	5
C	Kheis / Schist	6
D	Alluvial / Sand - Silt	4
E	Basement / Calcrete	4
F	Koras - Kheis / Quartzite	4
G	Dwyka / Shale	7
H	Karoo / Dolerite	4
I	-	-
J	Karoo / Dolerite - Sand	6
K	Dwyka / Baked Shale - Dolerite	6

L.P.	Name	No. of Facets in each Land Pattern
L	Dwyka/Shale - Dolerite	Not defined
M	Dwyka/Tillite - Colluvial	6
N	Quaternary/Coastal Sand	12
O	-	-
P	Nama/Aeolian Sand	7
Q	Nama/Colluvium - Phyllite	10
R	Table Mountain/Sandstone	Not defined
S	Nama/Siltstone - Mudstone	Not defined
T	Basement/Granite - Gneiss	9
U	Basement/Gneiss	8
V	Kheis/Gneiss - Schist	8
W	Kheis/Granulite - Amphibolite	5
X	Dwyka/Tillite	6
Y	Pretoria/Quartzite - Ironstone	5
Z	Daspoort/Andesite	5
AA	Recent/Calcrete - Sand	4
BB	Pretoria/Iron Formation	8
CC	Dwyka/Tillite	Not defined

Facet Index tables, giving a detailed explanation of form, soil origin, materials, hydrological conditions, unified classification of materials, foundation conditions, use of materials, land cover and any other pertinent engineering properties occurring within each facet of a land pattern, are included with this report.

The Facet Index tables, when used in conjunction with the soil engineering maps, give detailed information about the different material layers in the form of generalised soil profiles, and may be used as an additional legend.

No detailed soil profiles have been included with this report, as sites visited during the field trip were invariably off the centre line. The generalised soil profiles supplied in the Facet Index tables are thought to be more representative and of greater use in predicting material types along the route.

Field Work

Due to the necessity to adhere to very stringent deadline arrangements, field checking was undertaken by helicopter and, although adequate, more detailed checking of the mapping would normally have been carried out. Field investigations included the visiting and sampling of numerous surface outcrops, as well as the collection of near-surface soil and rock samples by pitting and augering. Sampling points were pre-selected during the preliminary airphoto - interpretation study and rechecked in the field to ensure they were representative of the area and materials present.

5. ENGINEERING GEOLOGICAL CONDITIONS ALONG ROUTE

The area covered by the proposed route has been divided into seven engineering-geological sections, chiefly on a basis of geology, but also taking into account the dominant rock and soil types, occurring in each particular area.

The seven engineering-geological sections occurring along the route are as follows:-

	Section	Rock and Soil Type
A.	Coastal Section	(Sand/Cape Granite, Table Mountain Sandstone and Nama phyllite, quartzite and limestone).
B.	Nama Section	(Sand/Nama phyllite, quartzite and limestone, also exposed mudstone and sandstone bands).
C.	Krom River Section	(Basement granites, gneisses, pegmatities etc).
D.	Dwyka Section	(Shale, lydianite, dolerite and tillite).
E.	Basement Section	(Basement, Kheis and Koras, granite, gneiss, amphibolite, quartzite, schist etc.).
F.	Aeolian Section	(Sand/Calcrete/Matsap quartzite (exposed)).
G.	Sishen Section	(Ongeluk and Pretoria shale, iron formation, lava, quartzite also sand and calcrete).

Fault and shear zones occur along the length of the route, but in general will be of little consequence with regard to foundations and materials, except in the vicinity of the proposed tunnel at Elandsbaai.

A COASTAL SECTION

A.1. GEOMORPHOLOGY

The Atlantic coastal plain is generally flat, featureless and of low relief (< 60 m in elevation), being part of the Quaternary and Recent erosion cycles.

The only hills in this area are the Zoutpansklipheuvel, north of Lambert's Bay (>100 metres), the Elandsberg (191 metres), the Langeberg (>120 metres), the Rondeberg, south of Elandsbaai (230 metres) and the Patrysberg, southwest of the Groot Berg Rivier (264 metres).

Drainage is westwards to the sea and approximately at right angles to the coast, with the major river mouths characterised by lagoonal areas. The railway route is crossed by a few minor, unnamed drainages, having moderately well defined courses, which are marked on the Soil Engineering Maps.

The more well-defined and larger rivers include the :

Sandlaagte, Jakkals, Langvlei, Verlorevlei and Grootberg Rivers.

All these rivers show typical coastal lagoonal features at or near their mouths with evidence of coastal drowning. This drowning is thought to be of the order of 30 - 60 metres. It is uncertain whether it has been caused by continental sinking or a rise of sea level.

Lagoonal infilling of sand and alluvium has occurred to varying depths and detailed investigations are required to determine depths to solid rock or safe foundation depth.

A.2. GEOLOGY

Three main geological systems are represented along the coastal section. Due to the relatively thick sand and marine depositional cover, geological boundaries can only be indicated approximately.

From Strandfontein in the north, to south of Elandsbaai in the south, isolated outcrops of the Table Mountain Series (Cape System) project through the Tertiary, Quaternary and Recent sand and soil cover, occasionally giving rise to hills and ridges. Minor exposures of the Klipheuvel Formation are present along the southern margin of the Verlorevlei, southeast of Elandsbaai. The Nama (Malmesbury) System is exposed west of Velddrif. Rocks of the Nama System probably underlie much of the sandy soil-covered area north of the Grootberg River, while Table Mountain Sandstone crops out to the south of Elandsbaai. South of the Grootberg River, the solid geology consists of the intrusive Cape Granite of post-Nama (Malmesbury) System age.

The geological formations present are as follows :-

Tertiary, Quaternary and Recent Deposits
Cretaceous System
Cape System
Klipheuvel Formation
Cape Granite
Nama (Malmesbury) System

Nama (Malmesbury) System

Only very minor exposures of this system occur along the coastline, west of the Grootberg River mouth near Velddrif, but rocks of this system probably underlie much of the country northwards towards Elandsbaai. The beds are normally folded with steep dips and consist of slaty arenaceous rocks, fine-grained argillaceous quartzites with phyllites and limestone developed locally. North of Strandfontein these beds are also exposed along the beach front and in the coastal cliffs.

Cape Granite

The Saldanha - Langebaan intrusive granite mass, which underlies the area between Saldanha and the Grootberg River, consists of an earlier intrusive phase of a coarse to medium-grained, foliated, biotite or biotite-muscovite granite, in which inclusions are common and parts of the body have been contaminated by absorption of xenolithic sedimentary material, and a later intrusive phase consisting of a medium to fine-grained granite which is transitional into granite-porphyry and quartz porphyry. Some of the quartz porphyry displays flow structure.

Inclusions of the earlier, coarse-grained granite are found in the later intrusive phase. Absorption of xenolithic material has resulted in a final stage in certain areas represented by the production of an even-grained, micro-granitic rock sometimes showing indistinct banding. Minor transgressive felsite dykes have been recorded.

Klipheuvel Formation

This Formation, which post-dates the intrusion of the Cape granites and which is pre-Cape System in age, crops out over a very narrow belt some 5 kilometres in length on the southern side of the Verlorevlei (just east of Elandsbaai village). Exposures also occur further to the southeast, but well away from the proposed route of the railway. The rocks consist of well-bedded sandstones and reddish sandy shales.

Cape System

The Cape System (Palaeozoic) comprises three series, but only the lowermost Table Mountain Series is represented in this area. It underlies the whole of the northern half of the coastal belt, unconformably overlying the Nama (Malmesbury) System and in places the Klipheuvel Formation. Only scattered exposures are found in the generally sand-covered coastal plain, but there are fairly continuous, narrow belts of rock exposure along the coast line south of Lambert's Bay and again north of Lambert's Bay to Strandfontein. A detailed study of the lithology and mode of deposition of the Table Mountain Group has been carried out by Rust (1967).

In this area the Table Mountain Series comprises sandstone and conglomerate with minor shale bands. Dips are generally low in the area south of Groothoekbaai (5^{o} to 15^{o}) but slightly steeper to the north (15^{o} to 45^{o}). The dip is generally directed to the northeast, but is easterly in the Strandfontein area. Occasionally dips are directed southeast and northwest as for example in the Kreefbaai and Langeberg- Rondeberg area, south of Verlorevlei.

Cretaceous System

Pyroclastic rocks and olivine basalt which are possibly of Cretaceous age crop out along about 1,25 kilometres of the Jakkals River, east and west of a point some 4 miles east of Lambert's Bay. A detailed description of a volcanic vent about 340 metres in diameter cutting the Table Mountain Series sandstone, 3 kilometres east-northeast of Lambert's Bay, has been given by Walker (1951). The rocks consist predominantly of pyroclasts and olivine basalt which have in general been deeply weathered.

Tertiary, Quaternary and Recent Deposits.

Superficial deposits mantle the greater portion of the area and consist of the following :

Alluvium
White to reddish sands (predominant)
Silty sands to sandy silt of the hillocky veld
Reddish-brown fine sandy soil
Calcareous and gypsiferous sands
Gravels on river terraces
Fossiliferous marine deposits on beach terraces
Ferricrete
Silcrete and surface sandstone
Dolomitic limestone
Consolidated to semi-consolidated phosphatic sand
Dune sand (mainly in a narrow belt along the coast)
Beach deposits

There is considerable variation in the thickness of these deposits in the coastal area, and maximum thickness cannot be ascertained without much more detailed investigation. However, in general the deposits thicken from north to south, and developments up to 30 metres thick occur in some of the major valleys. These deposits mantle a wave-cut rock platform which is elevated in the north, but slopes seawards in the south. Thus a thin cover (up to 3 metres thick) is commonly developed in the north and this thickens southwards where the rock platform dips increasingly seawards. Another feature of interest here is the development of marine deposits in the south and these include sheets of phosphatic calcrete in the Saldanha Bay area.

The phosphatic calcretes tend to mantle Cape granite and are developed from sea level up to elevations of 150 metres. Northeastwards along the coastal area, the marine deposits give way to terrestrial deposits which fringe the present coastline in the northern parts of the area.

Fossiliferous marine deposits on raised beach terraces are present particularly north of Groothoekbaai where they occur at a general level of 18 metres northwards to Bruinpunt. South and north of Strandfontein they are at a general level of 27 metres.

Semi-consolidated fossil sand dunes and old beach lines fringe the coastal area (these being distinct from fossil back-beach deposits) and erosion of these appears to have produced patches of mobile wind-blown sand along the coastal area.

The dashed geological boundary (shown on Mosaics 36 and 37) denotes a possible boundary between the Table Mountain Series overlain by moderately thin sand cover and the Table Mountain Series overlain by large thicknesses of sand and marine sediments.

A.3. ENGINEERING CHARACTERISTICS

N.B. For detailed descriptions of material occurring within individual facets, see Facet index tables.

A.3.1. Slope Stability

Hillslopes throughout this region are stable under existing climatic conditions. The only unstable areas are mobile dunes, however, all dune areas as well as sand plains are subject to instant mobility should the natural relief or vegetation be disturbed.

A.3.2. Foundations

A.3.2.1. Rail Bed

Foundation conditions on the sand plains and dune areas are only moderate, due to the poor grading and moderately low insitu density of the sands; compaction difficulties may be experienced. The raised fossil strand lines and calcified beach deposits, as well as the solid rock, should provide good foundations.

Old coastal lagoons and alluvial depressions should be carefully investigated, as foundation conditions in these areas will be poor. The constituent materials are probably compressive, and dependent on their location and the level of the water table, may produce minor "quick-sand" conditions. High percentages of gypsum are often associated with these areas.

A.3.2.2. Bridges

All bridges require detailed investigation to determine depth to solid rock, as this will vary from site to site. At certain of the bridge sites rocks may only be encountered at depth due to the previous drowning of this section of coast. A general assessment of foundation conditions for bridges along the coastal section, concludes that, solid rock should be encountered relatively close to the surface upstream of the coastal lagoons, hence these lagoonal areas should be avoided.

A.4. CONSTRUCTION MATERIALS

Areas proposed as sources of the various types of borrow materials have been located along the route and are delineated on the Soil Engineering Maps accompanying the report.

The different construction materials are discussed below :

A.4.1. Crushed Aggregate

Cape Granite in the Saldanha Bay area and Table Mountain sandstone exposed along the length of the coastal section provide the main sources of ballast, concrete aggregate, pitching and slope stability stone.

A.4.1.1. The Cape Granites are variable in grain size and hence hardness, however, the fine-grained varieties should be suitable for ballast and concrete aggregate.

A.4.1.2. The Table Mountain sandstone is variable in consistency and hardness, varying from hard quartzite, through friable silty sandstone, to pebble conglomerate. These materials require detailed investigation to prove quarry sites.

A.4.2. Sub-Ballast

A.4.2.1. Old calcified beach deposits intermixed with sand and shells may be suitable as sub-ballast. However, being recent deposits, a high percentage of soluble salts are likely to be present (some are deleterious, e.g. gypsum).

A.4.2.2. Beach shingle deposits found in certain low lying areas near the shore line and overlain by a relatively thin layer of aeolian sand may be suitable as sub-ballast but may also contain varying quantities of deleterious salts.

A.4.2.3. Banded marine mudstones and siltstones may also provide suitable sub-ballast material, but may require mixing with the shingle deposits to improve their grading.

A.4.2.4. Weathered, friable varieties of decomposed granite and weathered Table Mountain sandstone (e.g. pebble conglomerates and coastal grits), should be suitable sub-ballast material, although minor blasting may be required for excavation.

A.4.2.5. Dorbank deposits located on the outwash slopes below large Table Mountain sandstone outcrops are of variable consistency and quantity, but are generally suitable as sub-ballast material.

A.4.3. Binder

The finer grained calcrete deposits should provide good binder material. These calcretes however contain a high percentage of soluble salts, including gypsum, which may be deleterious.

A.4.4. Fill

Sands should be suitable, but may require the addition of a (semi-plastic) binder to assist in compaction.

A.4.5. Concrete Sand

No naturally occurring concrete sands were located along this section. Crusher dust from the nearest ballast crushing site is recommended. Mixing and washing of alluvial and aeolian sands with beach sands or crusher fines should be investigated, as these admixtures may produce a suitably graded material for use in concrete.

A.5. SUMMARY AND CONCLUSIONS OF COASTAL SECTION

(i) The Atlantic coastal plain is generally flat, featureless and of low relief. The rainfall is 200 - 400 mm, the vegetation being of the West Coast Sandveld type.

(ii) Drainage is westwards to the sea, with the major river mouths characterised by lagoonal areas with infillings of sand and alluvium to varying depths.

(iii) Weinert's N-value varies from 4 - 10, hence a certain amount of chemical decomposition will occur and basic igneous rocks should be investigated for high P.I.'s

(iv) A relatively thick sand cover of unknown depth often obliterates much of the geology in this section.

(v) Outcrops of Table Mountain Sandstone, Klipheuvel Formation, Nama System and Cape Granite are found along the coast. In addition Cretaceous olivine basalt is found along the Jakkals River, and numerous superficial Tertiary, Quatemary and Recent deposits mantle the greater portion of this section.

(vi) Hillslopes are stable under existing climatic conditions, and only the mobile dune areas show evidence of instability.

(vii) Foundation conditions on the sand plains are moderate, but along both existing and old coastal lagoonal areas and alluvial depressions they are poor and careful investigation is required. A general assessment of foundation conditions for bridges along the coastal section concludes that these lagoonal areas should be avoided.

(viii) Alignment of this section of the route should be as far inland as possible to take advantage of better foundation conditions.

(ix) Adequate material for use as ballast, concrete aggregate, pitching and slope stability stone, as well as sub-ballast should be readily available.

(x) Fine-grained calcrete deposits should make good binder material. These contain soluble salts which may be deleterious.

(xi) No naturally occurring concrete sands were located along this section of the proposed route.

(xii) The surface sand deposits should be suitable as fill, but may require a binder.

B. NAMA SECTION

B.1 GEOMORPHOLOGY

This section is typified by the featureless colluvial peneplain of the Knersvlakte, north of Van Rhynsdorp, extending to the valley of the Olifants River. This peneplain, developed to the west of the Bokkeveld Escarpment, is characterised by surface colluvial sediments related to the Nama escarpment, Table Mountain, Dwyka and Ecca Series rocks to the east, as well as the Basement granite-gneiss to the west, rather than residual materials from the underlying Nama Formation.

The peneplain appears to belong to the Post-African (Late Cainozoic) cycle of erosion, although Quaternary and Recent cycles have modified the existing plain.

The main drainage is the perennial Olifants River, which flows generally westerly and then southwestwards across the southern part of the area, its flow being regulated by dams at Clanwilliam and Bulshoek to the east. The main tributary drainage to the Olifants River is from the north across the Knersvlakte.

The larger rivers including the Krom, Doring, Sout, Hol, Varsche, Gemsbok, Rooiberg and Kleinfontein have deposited large quantities of alluvial material on the peneplain. The alluvial terraces so formed are consequently usually associated with the flood plains of the different rivers.

B.2 GEOLOGY

This section of the actual railway line route is underlain entirely by rocks of the Nama (Malmesbury) System.

The Malmesbury Formation was formerly considered to be on older separate formation from the Nama System, but it is now generally grouped with it and they are here both described together.

The geological formations present in the general area are as follows:-

Tertiary, Quaternary and Recent Deposits
Intrusive Rocks
Cape System
Nama (Malmesbury) System

Nama (Malmesbury) System

The rocks of the system formerly assigned to a separate Malmesbury Formation, comprise basal limestone and marble, overlain by a thick mass of phyllite and quartzitic phyllite with interbedded and slightly metamorphosed feldspathic quartzite, grit, siltstone, erratic conglomerate and local bands of biotite schist. The quartzite may be schistose, feldspathic, gritty or massive. The upper portion of the succession comprises coarse-grained quartzites with layered grit, feldspathic quartzite, conglomerate and phyllite. Along the Olifants River, in the neighbourhood of Vredendaal, Rogers (1904) also records black shales and slates interbedded with the limestones and thick bands of schistose quartzite, and refers to the presence of limonite beds. This succession is typically developed in the southern and southwestern part of the region. In the central and northeastern parts, Von Backstrom (1960) has differentiated a Kuibis Series overlain by a Schwarzkalk Series in turn overlying Malmesbury Formation rocks. The Kuibis Series consists of quartzite with lenticular shale bands and conglomerate locally at the base. The Schwarzkalk Series is divided into three stages. The lower stage consists of siltstone, mudstone and shale with interbedded bands of sandstone, grit and conglomerate.

The middle stage consists of shale, mudstone and siltstone with interbedded bands of sandstone and greywacke with locally a thin sandstone at the top. The upper stage, (the Schwarzrand Stage) which comprises a glacial horizon and other sedimentary rocks, is not developed in the area along the railway route.

The rocks of the Nama (Malmesbury) System have been folded to varying degrees of intensity with fold axes trending WNW-ESE and pitching NW. Several large parallel faults strike NW-SE across the Knersvlakte area, certain of which are crossed by the railway route. The sedimentary rocks assigned to the Kuibis and Schwarzkalk Series dip consistently southwest and are also folded, with the incompetent Schwarzkalk beds more intensely folded than the more competent Kuibis quartzite. Faults cutting these rocks are usually characterised by northeasterly downthrows and numerous northwesterly trending quartz veins occur throughout the rocks of this system.

Cape System

The Table Mountain Series, which is present to the east of the route, is represented chiefly by feldspathic sandstones in this section with thin lenses of conglomerate. In the northeastern section along the Bokkeveld escarpment the Table Mountain Series provides a capping to the Nama siltstones and mudstones. This Series has been cut by two intersecting faults, which have tilted the sequence in this area.

Intrusive Rocks

Dolerite dykes of probable post-Karoo age are present mainly in the southwestern section (north of the Olifants River) and these usually trend west-northwestwards.

Tertiary, Quaternary and Recent Deposits

Superficial silcretes and conglomerates occur in many places. Surface limestone (calcrete) is of widespread occurrence. River terrace gravel is well developed on terraces of two ages along the Sout River and its tributaries, on terraces of five different ages along the Olifants River, and on terraces of six different ages along the Hol River (near its confluence with the Olifants River). Large quantities of alluvium occur along all major river valleys and light reddish-coloured aeolian sand is widespread. Gypsum is frequently encountered in the area north of the Olifants River in clayey or sandy drainage depressions, also associated with the calcrete deposits, or underlying the silty soils of the Knersvlakte.

B.3 ENGINEERING CHARACTERISTICS

N.B. For detailed descriptions of the materials occurring within individual facets, see the Facet Index tables.

B.3.1. Slope Stability

Hillslopes throughout the region appear to be stable under existing climatic conditions.

Unstable conditions may be encountered in the mobile dune areas, located in the vicinity of the Hol and Olifants Rivers. Water has eroded numerous dongas, gullies and rills in localised areas adjacent to the Sout River which are subject to scour after rains. South of the Doring River where the proposed line runs adjacent to the Bokkeveld escarpment, continual erosion and colluvial deposition is taking place.

The remainder of the route over the old colluvial peneplain appears to be stable.

B.3.2. Foundations

B.3.2.1. Rail Bed; South of the Varsche River to the Olifants River and beyond to the edge of the Nama Section, aeolian sands are present, producing moderate foundation conditions which may give compaction difficulties due to the poor grading of the sand.

North of the Varsche River, where the old Quaternary peneplain is still in evidence, the fine silts, sands and gravels may be compressive, and may also give compaction difficulties. Where recent erosion has exposed the underlying Nama beds, good foundation conditions will be experienced, except in those areas of active erosion where the phyllites have been deeply weathered (c.f. those areas of active erosion as described under Slope Stability above). Generally the phyllites southwards from the 610 km mark (west of Kleinfontein River) to the end of the Nama section appear to be more deeply weathered than those to the north, with the possible exception of the alluvial wash area north of the Doring River.

The alluvial wash and flood plain north of the Doring River may produce foundation difficulties due to the presence of compressive materials.

The route northwards from the Doring River floodplain, to the Nama/Basement Complex boundary is across terrain weathered to an unknown depth, with a complete lack of rock exposure. Foundation conditions in general appear to be moderate, but surface materials could be compressive.

All the colluvial materials throughout the Nama section, appear to contain a high percentage of crystalline gypsum and will warrant further investigation. Tests to determine the affects of this material,when underlying and/or included in the rail bed, both during and after construction, will have to be carried out.

B.3.2.2. Bridges; Drilling investigations will be required to determine depths to solid bed rock in the alluvial materials of the incised Olifants River, especially on the eastern bank of the river.

Solid rock (limestone) is exposed in the bed of the Varsche River, while the banks comprise alluvial terrace materials. These features should provide good abutment foundations and no foundation problems are envisaged.

Limestone is exposed on the southern bank of the Hol River, while alluvial material, apparently greater than 2 metres in depth occurs on the northern bank near the bridge site. Drilling investigations may also be necessary at this site.

Along the Sout River the phyllites are generally deeply weathered, and solid rock for founding will be at variable depths below the river bed and banks.

At the Doring River site weathered phyllites crop out on the southern bank. On the northern bank of the river alluvial silts overlie deeply weathered phyllites to unknown depths, and drilling will be required to determine accurate depths to solid rock.

B.4. CONSTRUCTION MATERIALS

Areas proposed as sources of the various types of borrow materials have been located along the route and are delineated on the Soil Engineering Maps accompanying this report.

The different construction materials are discussed below :-

B.4.1. Crushed Aggregate

Surface outcrops of solid, jointed limestone, quartzite and ferruginous quartzite, have been proposed as crushed aggregate sources, of these, the limestone deposits appear to be the most suitable. The phyllites have variable consistencies due to their laminated character and deep weathering.

Limestone and quartzite of high quality would be suitable for ballast and concrete aggregate, while lower quality quartzite, ferruginous quartzite and phyllite could provide pitching and slope stability stone.

B.4.2. Sub-Ballast

Possible sources of sub-ballast material are provided by the following:

B.4.2.1. thicker dorbank deposits in the vicinity of the Olifants River;
B.4.2.2. alluvial river gravel deposits from the Olifants, Hol and Doring Rivers;

B.4.2.3. calcrete in the vicinity of the Doring River and further north in the Stinkfontein area;

B.4.2.4. weathered mudstones and siltstones of the Upper Nama System at the base of the Bokkeveld escarpment;

B.4.2.5. dorbank and calcrete deposits in the vicinity of the Krom River;

B.4.2.6. lesser weathered phyllites which can be ripped may also be used as sub-ballast when mixed with a suitable binding material. The laminar and foliated nature of the phyllites, may cause compaction problems.

B.4.3. Binder

The fine alluvial calcrete deposits, as well as the more powdery calcrete, lying below the sandy materials of the colluvial peneplain, could be used as suitable binder material. The fine sandy silts with scattered quartz gravels may also be suitable for intermixing with sub-ballast materials.

B.4.4. Fill

B.4.4.1. Materials suitable for use as fill include the surface sands located south of the Varsche River and sand from the bed of the Olifants River.

B.4.4.2. The loose colluvial materials north of the Varsche River and the alluvial wash materials north of the Doring River, have a high gypsum content. Depending on the results of investigations into the effects of gypsum, they may also be suitable for use as fill.

B.4.5. Concrete Sand

B.4.5.1. Alluvial sands from the Varsche, Hol, Sout, Gemsbok, Kleinfontein and Doring Rivers will have a high gypsum content, in addition to other deleterious salts. However, suitably graded deposits could be washed and used as fine aggregate for concrete. Sand from the bed and floodplain of the Olifants River should be checked for use as concrete sand.

B.4.5.2. Crusher fines from the nearest ballast quarry would be suitable for use as concrete sand. The above mentioned sources could also be blended with the crusher fines to produce a suitable material.

B.5. SUMMARY AND CONCLUSIONS OF NAMA SECTION

(i) The Nama section is typified by the featureless colluvial peneplain of the Knersvlakte, with a winter rainfall of $\pm$ 100 mm and succulent Karoo vegetation..

(ii) Weinert's N-value for this section varies from 10 to approximately 35; hence the dominant weathering process is one of disintegration.

(iii) The main drainage is the perennial Olifants River. Other large rivers include the Krom, Doring , Sout, Hol, Varsche, Rooiberg, Kleinfontein and Gemsbok. These rivers have deposited large quantities of alluvial material on the peneplain.

(iv) The Nama section of the route is for the most part underlain by Nama phyllites, limestones and quartzites. Other rocks present are Nama mudstones and siltstones, Table Mountain Series sandstones, post-Karoo dolerite intrusions, and superficial calcretes, dorbank, gypsum and conglomerates.

(v) The thickness of the overlying sand and calcrete is very variable, being $\pm$ 2 metres on the sand plains, mobile sands and hillwash slopes; up to 5 metres in the dune areas; and 1 to $>$3 metres in the alluvial depressions.

(vi) Hillslopes throughout this section appear to be stable under existing climatic conditions. Unstable conditions may however be encountered in the mobile dune areas in the vicinity of the Hol and Olifants Rivers.

(vii) Rail bed foundation conditions are generally moderate. Compaction difficulties may be encountered due to the poor grading of the sands. All colluvial materials contain a high percentage of gypsum, and warrant further investigation.

(viii) Detailed investigation will be required to determine depth to bedrock at the proposed bridge sites over the Olifants, Hol, Sout and Doring Rivers. No foundation problems are envisaged at the Varsche River bridge site.

(ix) Adequate supplies of Crushed Aggregate, Sub-Ballast, Binder and Fill should be available. Concrete sands may be in short supply depending on the feasibility of washing the gypsiferous sands of the Varsche, Hol, Sout, Kleinfontein and Doring Rivers. Tests should also be carried out on the Olifants River sand, with and without blending with crusher fines.

C. KROM RIVER SECTION

C.1. GEOMORPHOLOGY

This section covers the area to the north and northeast of the Nama Section, where the proposed railway route follows the general course of the Krom River to the edge of the Dwyka plateau.

In certain areas the Krom River has cut a relatively deep canyon into the surrounding Namaqualand gneiss complex and Dwyka Series rocks. The general level of the surrounding country is of the order of about 666 metres, with peaks rising to about 742 metres. The Krom River canyon appears to belong to the Post African (Late Cainozoic) erosion cycle, while the surrounding hills bear remnants of the African (Early Cainozoic) erosion cycle.

In the south of this section the country flattens out at an elevation of about 408 metres and the Basement rocks disappear beneath the overlying colluvial material of the Knersvlakte peneplain.

The main drainage is formed by the northerly, westerly and then south-westerly flowing Krom River. Tributary drainages to this river are directed southwest, south and southeast towards it, with more minor drainages trending northeast and east.

The Krom River drains Dwyka Series (Karoo System) rocks in its upper reaches, but crosses on to gneissic rocks in the southwestern part of this section. While not flowing strongly throughout the year, the upper reaches of the Krom River are perennial, becoming ephemeral only above the confluence with the Swart Dorings River.

The Basement gneisses are exposed as rugged hills, ridges and dissected plateaux while the interspaced depressions and valleys are filled with colluvial and alluvial materials deposited by the Krom River and its numerous tributaries.

C.2. GEOLOGY

The geological formations present in this area are as follows:-

Tertiary and Quaternary Deposits
Intrusive Rocks
Dwyka Series, Karoo System
Namaqualand Gneiss Complex (Basement Complex)

Namaqualand Gneiss Complex - (Basement Complex)

This complex consists mainly of granitic gneisses which contain numerous strongly metamorphosed remnants of metasedimentary rocks (Martin, 1965). The bulk of the rocks consist of granitic, often garnet-bearing, biotite gneisses ranging in texture from poorly foliated homogeneous types to well-foliated rocks. Metasedimentary rocks include metaquartzite and biotite-rich rocks with abundant sillimanite, garnet and occasionally cordierite or corundum. Amphibolites and calc-silicate rocks are also present. Pegmatite veins are numerous. Some of the more homogeneous gneisses which show occasional transgressive contacts have been termed granites (Benedict and others, 1964). Middlemost (1963), however, has concluded that, although local transgressive contacts do occur, the gneissic granites are the results of migmatisation and anatexis of Kheis rocks. The tectonic and metamorphic history of the rocks is typically complex.

Karoo System

The Karoo System is represented predominantly in the northeast of the region by the Dwyka Series, but scattered hill cappings and valley remnants occur through-out this section. This Series, overlies an irregular basement and consists of tillite and boulder beds, overlain by shales. These form a continuation of the Dwyka plateau to the northeast (described under the Dwyka Section of the report).

Tertiary, Quaternary and Recent Deposits

Calcrete occurs throughout this section, chiefly associated with the colluvial and alluvial deposits.

Clayey colluvial soils (with calcrete) overlie the Dwyka Series shales and the gneiss in the northeast of this section. Sand and unconsolidated drift overlie large areas of the gneissic rocks. There are relatively extensive, but narrow developments of alluvium along the Krom River and its larger tributaries.

Intrusive Rocks

Post-Karoo System dolerite sheets and dykes intrude the sedimentary rocks of the Dwyka Series in the northeastern section of the region only and they are absent to the west of the Krom River.

C.3. ENGINEERING CHARACTERISTICS

N.B. For detailed descriptions of materials occurring within individual facets, see Facet Index tables.

C.3.1. Slope Stability

Hillslopes within this section are stable,with the higher slopes being cut into solid granite-gneiss or Dwyka tillite.

C.3.2. Foundations

C.3.2.1. Rail Bed; Foundation conditions are generally good throughout this section, except perhaps on certain of the colluvial slopes and the floodplain of the Krom River. The aeolian sand areas will only provide moderate foundation conditions.

C.3.2.2. Bridges; Solid granite gneiss is exposed on the west bank of the Krom River bridge site, while the bed of the river and the eastern floodplain comprise alluvial sandy materials in excess of 4 metres in depth. The river bed and floodplain will thus require further investigations to determine depth to solid rock.

C.4. CONSTRUCTION MATERIALS

Areas proposed as sources of the various types of borrow materials have been located along the route, and are delineated on the Soil Engineering Maps accompanying the report.

The different construction materials are discussed below :-

C.4.1. Crushed Aggregate

C.4.1.1. Hill cappings of solid Dwyka tillite may be suitable for crushing as ballast and concrete stone, depending on previous experience with regard to the use of this material under similar climatic conditions.

C.4.1.2. The granite-gneiss in this section is of highly variable composition. Detailed investigation will be necessary to establish which of the various granite-gneiss types are suitable for specific usage.

C.4.1.3. Most crushed aggregate sources delineated on the maps of this section show minimal depth of weathering, and therefore overburden stripping will not be a problem.

C.4.2. Sub-Ballast

C.4.2.1. Calcrete and dorbank deposits, associated with the alluvial and colluvial materials, should provide suitable sub-ballast material.

C.4.2.2. Gravelly sands from the bed and banks of the Krom River, together with outwash materials, where gullies meet the colluvial pediment should also be suitable; but may require the addition of a semi-plastic binder.

C.4.2.3. The deeply weathered granite-gneiss zones, located below colluvial deposits, should also be suitable for use in the sub-ballast layer.

C.4.3. Binder

The finer more powdery alluvial and colluvial calcrete deposits should make good binder material.

C.4.4. Fill

Virtually all the loose sandy materials found in this section will be suitable for use as fill.

C.4.5. Concrete Sand

This section of the route contains a large supply of sand, the chief sources being the bed and recent floodplain of the Krom River, together with the alluvial wash deposits of the larger tributaries and the colluvial fans of the smaller steeper graded streams.

C.5. SUMMARY AND CONCLUSIONS OF KROM RIVER SECTION

(i) In the Krom River section the line generally follows the course of the Krom River which has in places eroded a deep canyon. The general elevation of the surrounding country is of the order of 666 metres above sea level.

(ii) The rainfall varies from 100 to 200 mm and vegetation is of the Western Mountain Karoo type. Weinert's N-value varies from 10 to 35, hence the dominant weathering process is one of disintegration.

(iii) The main drainage comprises the Krom River, with its numerous smaller tributaries.

(iv) The proposed route in this section passes over rocks of the Namaqualand Gneiss Complex, Karoo System and post-Karoo intrusives. In addition sand and unconsolidated drift overlie the Namaqualand Gneissic rocks.

(v) In the Namaqualand gneiss areas, the depths to bedrock vary from ± 2 metres on hillwash slopes, >3 metres in alluvial depressions and <0,5 metres on low convex hills.

(vi) Hillslopes are stable under existing climatic conditions.

(vii) Rail bed foundations are generally good, except perhaps in the beds of the Krom River and its larger tributaries, where saturation and scour are are likely to occur.

(viii) The river bed and eastern bank floodplain at the Krom River bridge site will require investigation to determine depth to bedrock.

(ix) Sufficient quantities of Crushed Aggregate, Sub-ballast, Binder, Fill and Concrete sand appear to be available along this section of the proposed route.

D. DWYKA SECTION

D.1. GEOMORPHOLOGY

This section of the proposed route covers an area extending from the edge of the Dwyka Plateau in the southwest (± 500 km mark on original centre line) to the farm Olyven Kolk in the northeast (± 310 km mark on original centre line).

The area forms part of the Dwyka plateau standing at a general elevation of just over 900 metres. Pans are numerous, and where a number of large pans occurs, as in the Commissioner's Salt Pan area, the elevation falls to about 850 metres above sea level. In the northeast of the section, where tillite crops out, the surface is undulating and of the 'bult' type. South of this area in the shales, the surface is remarkably flat and nearly all prominent features are due to outcrops of intrusive dolerite.

The resultant featureless, flat terrain is part of the planed African (Early Cainozoic) land surface or erosion cycle.

The Kleine Rooiberg River which is the main tributary of the Krom River drains the southwestern area of this section. In general drainages are centripetal towards pans and no other major effluent rivers or drainage systems are present. Where drainages cross shale beds the valleys become very flat and during flood periods these rivers spread out over a wide area with no definite channel, resulting in extensive alluvial wash areas. Commissioner's Salt Pan is the largest pan in the area, with a bare pan surface floor extending for over 11 kilometres along its longest axis, and with a width of some 5 kilometres.

D.2 GEOLOGY

The whole of this section is underlain by rocks of the Dwyka Series (Karoo System), which have been intruded by Post-Karoo dolerite sheets and dykes. The Dwyka Series consists of tillite and boulder beds, overlain by shales deposited on an uneven basement of granitic gneiss and related rocks of Precambrian age. Owing to the lack of relief in this area good sections showing the contacts between the tillite and the underlying rocks are rarely exposed.

The tillite country, which occurs predominantly in the northeast of the Dwyka Section and as a thin layer, together with scattered outcrops in the southwest is covered by thickly strewn boulders of varying size, resulting from weathering of the boulder beds. The area underlain by the tillite is also characterised by the presence of much surface limestone (calcrete). Through decrease in the size and number of inclusions in the tillite there is a transition upwards into shale and the boundary can be quite sharp.

The shales, which are found throughout this section to the south of the tillite, are bluish in colour when fresh, but weather to a greenish-pink and pinkish colour. Certain thin bands are very hard and almost quartzitic in composition. Thin layers of lenticular massive limestones are abundant in the middle and upper layers of the Upper Shales. Ferruginous layers of clay-ironstone appear above the middle of the group. Gypsiferous layers also occur within the Dwyka Shales in this area.

Numerous intruded dolerite sheets and dykes have metamorphosed large areas of the shale by baking, with intense baking effects evident in a number of areas. (In general the dolerites are black, hard, strongly jointed, medium to fine-grained rocks). Calcretes are associated with the more decomposed dolerite areas i.e., drainage depressions and stream beds.

Tertiary, Quaternary and Recent deposits are not particularly well developed in the region. With the exception of the silt-covered drainage areas, soils and sands are poorly developed. In areas underlain by tillite, pebble and boulder pavements are prominently developed.

D.3 ENGINEERING CHARACTERISTICS

N.B. For detailed descriptions of materials occurring within individual facets, see Facet Index tables.

D.3.1. Slope Stability

Gradients throughout the area are generally slight, with the possible exception of those in the vicinity of Rooiberg. The slopes are considered stable throughout. The only possible area of instability is the zone of mobile dunes in the vicinity of Commissioner's Salt Pan.

D.3.2. Foundations

D.3.2.1. Rail Bed; Good rail bed foundations are provided by the tillites, shales and dolerites, as well as most of their associated colluvial deposits.

Moderate foundation conditions will be encountered in the small alluvial valleys encountered along this section, while moderate to poor foundations will be produced in the large alluvial wash and pan areas, especially where clays have been deposited.

Foundation conditions throughout those areas underlain by dolerite are generally good, except in the case of large drainage depressions and pans where active clays may have been deposited or formed in situ, and where the gypsum content may be high.

D.3.2.2. Bridges; The calcified colluvial gravel deposits and alluvial sands in the Krom River bed are thought to overlie the Dwyka tillite. These gravels and sands would appear to be shallow and further investigation is necessary to substantiate this.

D.4 CONSTRUCTION MATERIALS

Areas proposed as sources of the various types of borrow materials have been located along the route, and are delineated on the Soil Engineering maps accompanying this report.

The different construction materials are discussed below:

D.4.1. Crushed Aggregate

D.4.1.1. Unweathered varieties of Dwyka tillite. These should be suitable for crushed aggregate, but their use will be dictated by previous experience with regard to this material under similar climatic conditions.

D.4.1.2. Solid, fresh dolerite. Only medium to fine-grained varieties of dolerite were noted within this section and hence these should be suitable for ballast and concrete aggregate stone.

D.4.1.3. Lydianite or baked Dwyka shale. The consistency and hardness of these baked shales is dependent upon the size, proximity, heat of intrusion and attitude of the intruding dolerites. Hence baked shales will vary from highly suitable material for crushed aggregate to poor quality slope stability stone.

D.4.2. Sub-Ballast

D.4.2.1. The most suitable sources of sub-ballast are the granular or sugary decomposed dolerites. The weathered dolerite found in depressions and on their peripheral areas is generally good quality sub-ballast material, however, in these areas the weathering depth is variable. If in-sufficient material is available on the sideslopes, it is suggested that the materials be sought towards the alluvial depressions. It should be noted, however, that P.I.'s will tend to increase towards the centres of these depressed areas.

D.4.2.2. Another suitable source of sub-ballast material is the colluvial calcrete (especially the more nodular varieties). This material is often intermixed with gravels and erratics in the tillite areas, and sands and gravels in the shale areas. Good quality calcretes are often developed on the dolerite intrusions, and along fault zones.

D.4.2.3. The more deeply weathered and rippable shale zones, especially those which have been strongly or partially baked by the dolerite, should be suitable for use in the sub-ballast layer, but may require the addition of a binder to improve their grading.

D.4.3. Binder

The fine-grained more powdery calcretes, as well as certain of the finer hillwash deposits, located along the length of this section should make suitable binder materials. The aeolian sands in the vicinity of Commissioner's Salt Pan, and certain fine alluvial sands located on the larger dolerite sills should be suitable for use as stabilising agents.

D.4.4. Fill

All silty and sandy materials along the length of the route will be suitable for fill material, irrespective of whether they are derived from shales,baked shales or dolerites. The clayey alluvial deposits located chiefly in depressions and pans in the shale and tillite areas are possible exceptions.

D.4.5. Concrete Sand

Coarse alluvial sand and gravel deposits found in the beds of the larger streams and rivers and in the alluvial fans where the rivers enter pan areas are often suitably graded for use as concrete sand. Frequently however, the constituent rock fragments are not sufficiently hard, and these materials may exhibit shrinking aggregate properties. Detailed testing will be required to determine whether these materials are suitable as concrete sands.

Alluvial sands derived from the larger dolerite sills may be suitable for use as concrete sand in small structures, e,g, culverts etc.

D.5 SUMMARY AND CONCLUSIONS OF DWYKA SECTION

(i) This section of the proposed route forms part of the Dwyka Plateau at a general elevation of 900 metres above sea level.

(ii) Rainfall varies from 100 to 200 mm and the vegetation is Arid Karoo and Desert False Grassveld. Weinert's N-value varies from 10 to approximately 35, hence the dominant weathering process is one of disintegration.

(iii) Drainages are centripetal towards the numerous pans. No major effluent rivers or drainage systems are present.

(iv) The whole of this section is underlain by rocks of the Dwyka Series (Karoo System) which have been intruded by post-Karoo dolerite sheets and dykes.

(v) The superficial cover to the Dwyka rocks is usually thin, being of the order of <2 metres in the alluvial areas, and <1 metre on the plains.

(vi) Slopes are considered stable throughout this section and only the mobile sand dunes in the vicinity of Commissioner's Salt Pan are unstable.

(vii) Rail bed foundtions are moderate to good throughout the area, however, drainage depressions and pans may provide poor foundations and should be avoided.

(viii) The thickness of overlying gravels and sands at the proposed Krom River bridge site warrants further investigation.

(ix) Sufficient quantities of Crushed Aggregate, Sub-ballast, Binder and Fill should be available. Concrete sand sources throughout the Dwyka Section are scarce and may exhibit shrinking aggregate properties? Hence they appear to be suitable only for small structures.

E. BASEMENT SECTION

E.1 GEOMORPHOLOGY

This section encompasses and area extending from the farm Olyvenkolk in the southwest, to the farm Bokpoort in the northeast, just north of the Orange River. The area has a flat or gently undulating surface with an average elevation of 900 metres and is thus probably part of the Post African (Early Cainozoic) cycle of erosion. This undulating surface is broken south and southwest of Kenhardt at Driekop and Rooiberg where a series of folded ridges occur, composed of granulites which have enveloped cores of granitic gneiss. Again, in the northeast of the section, west of the Orange River, the topography is broken by prominent northerly trending quartzite ridges with elevations of 1 076 to 1 219 metres. In the central portion, the country falls to an elevation of 606 to 909 metres in the Hartbees River valley.

Drainage in this section is effected by tributaries to the Orange River with its extensive alluvial flood plain, which is the only perennial river and which lies to the north and northeast in the region under discussion. The main tributary is the northerly draining Hartbees River which trends northwest to the north of Kenhardt, and joins the Orange River below the Augrabies Falls. A Recent cycle of erosion extends up this river valley and is operating in the Kenhardt area. Hence thick soil cover is lacking having been stripped off by incision of this Recent cycle. Drainage along the Orange River is Post-African in age and this also probably applies to the watershed area in the vicinity of 220 K (on original centre line). The Hartbees River has subsidiary drainages from quartzite hillocks to the east, northeast and southeast of Kenhardt, the main tributaries here being the Rugseer and and Mottels Rivers. The main drainages to the Hartbees River from the west are the Rietfontein and Tuins Rivers with headwaters of the latter, and the upper reaches of the Hartbees, draining the interior Dwyka plateau. In spite of its large drainage area, the Hartbees River has a small bed which is remarkably free of gravels and pebbles.

E.2 GEOLOGY

With the exception of the tract bordering the Orange River, the solid geology is generally only poorly exposed beneath a thin cover of surface limestone deposits and sandy soil. The soil in the valleys is naturally thicker, but alluvial ground is only conspicuous in the larger valley of the Hartbees River.

The geological formations present are as follows:-

Tertiary, Quaternary and Recent Deposits
Intrusive Rocks
Koras Formation
Kheis System
Pre-Kheis Basement Complex

Pre-Kheis Basement Complex

Gneissic rock types of this group account for the greater portion of the rocks present in the Kenhardt area. They vary in composition from truly granitic to tonalitic and granodioritic types, and from fine-grained to coarse-grained and porphyritic varieties. They occur either as homogeneous bodies of considerable areal extent or as strongly banded amphibolitic gneisses. In addition, granulitic rocks, thin strips of hornblende schist, altered silicic porphyries and diorites have been recorded (Rogers and Du Toit, 1909).

Pegmatites have also been recorded and along the Hartbees River valley, granulites and schists are seamed with pegmatite and graphic granite (Rogers and Du Toit, 1909).

Due to a lack of critical exposure it is difficult to decide to what degree many of these bodies of gneissic material are intrusive, but it appears that while many of these bodies are locally discordant most are concordant on a regional scale. It is thus difficult to decide what proportion of the gneissic rocks represent the original basement on which the Kheis System was deposited and what proportion of them represent metamorphosed Kheis System rocks. In general, however, it would appear that the more strongly banded amphibolitic gneiss varieties and the narrow bands of obviously metasedimentary and metavolcanic material represent reconstituted Kheis System rocks; whereas the more homogeneous and generally larger areal bodies of gneiss probably represent the original basement. Closer inspection of the basement areas usually reveals more complex deformation than in the Kheis System rocks and the presence of pre-Kheis System basic dykes.

Kheis System

The Kheis System is typically developed in the Kleinbegin area and to the northeast of Kleinbegin.

The previous sub-division of the Kheis System (Marydale, Wilgenhoutdrift and Kaaien Series) has been amended (see Water Feasibility Report), and in the present area it mainly consists of metavolcanic rocks of basic to acid composition, which are infolded with the Basement Complex. The intensity of metamorphism and deformation in the region is considerably greater than in the Aeolian Section to the northeast.

The metavolcanic rocks include amphibolites (meta-andesites and related pyroclastic rocks), meta-rhyolites and associated pyroclastic rocks (quartz-sericite schists, etc) and meta-dacitic rocks (quartz-porphyries, etc). Areas underlain by these rocks include the area around Kenhardt, the area southwest of Kleinbegin, and the area west and southwest of Kenhardt (especially on mosaic No. 15). The latter area encompasses a complexly folded suite of metavolcanic rocks of acid and intermediate composition, with the development of a major synclinal structure which incorporates refolded isoclinal folds and prominent drag folds.

Koras Formation

N.B. Rocks of this formation are described as Koras-Kheis in the Land Pattern/Facet mapping.

The Koras Formation is only represented by a small wedge shaped block overlying the Kheis System, present some 2,5 kilometres west of the railway line at the 185 kilometre mark (original centre line) on the farm Blaauwbospan, and it is bounded in the east by a north-south trending fault.

The formation consists of quartzite, conglomerate, feldspathic sandstone, andesitic, basaltic, amygdaloidal and felsitic lavas. Quartz porphyries occur among the felsitic lavas. The succession is complicated by the presence of intrusive bodies of diabase and quartz porphyry. These, and an upper group of sedimentary rocks (conglomerates, feldspathic sandstone and quartzites) occur further to the northwest.

Intrusive Rocks

The intrusive rocks (mainly recorded away from the actual proposed railway line) include post-Kheis charnokitic adamellite, serpentinite and feldspathic pyroxenite. The adamellites occurs as bodies emplaced in the hinge zones of folds, bodies of irregular shape and as thin dykes. Serpentinite and feldspathic pyroxenite occur as small irregular bodies. Peridotite of uncertain age has been recorded as a dyke rock on Driekop parallel to the granulite belt present there. Post-Karoo dolerite intrusions, as dykes only, are rare in the tract of granitic and Kheis rocks (Rogers and Du Toit, 1909) and are not present in the thin fringing development of the Karoo System in the southwest.

Tertiary, Quaternary and Recent Deposits

Superficial Tertiary, Quaternary and Recent deposits occur throughout the area although they are not of great thickness. Surface limestone or calcrete is a common deposit over most of the area except in the neighbourhood of the Hartbees River and over higher outcrop areas. This calcareous material occurs as innumerable small patches between the Hartbees River and the hills to the northeast, but it only becomes thick in some of the valleys.

Gravels are not frequent, though thin gravels may cover the ground along the Orange River, in places being found up to about 50 metres above the river. Stretches of alluvium occur along the Orange River and are most prominently developed on the west bank of the river.

E.3. ENGINEERING CHARACTERISTICS

N.B. For detailed descriptions of material occurring within individual facets, see the Facet Index tables.

E.3.1. Slope Stability

Slope gradients throughout this section are generally slight, with the exception of the elevated folded and faulted areas around Kenhardt and Kleinbegin, where gradients are moderately steep. Hillslopes throughout this section are stable under existing climatic conditions. The small localised areas of mobile and semi-mobile sand dunes scattered along the route are not stable and slopes in these areas will be subject to wind erosion.

E.3.2. Foundations

E.3.2.1. Rail Bed

Good rail bed foundation conditions are provided by the weathered and unweathered granite gneiss, schist, amphibolite, granulite and quartzite rocks, as well as the overlying colluvial deposits.

Moderate foundation conditions prevail in the beds and floodplains of the larger rivers due to the development of sandy clays in these areas. The aeolian sand areas will also provide moderate foundation conditions, although their extent is relatively small in this section.

E.3.2.2. Bridges

The Hartbees River valley and floodplain will require detailed investigation to establish the depth of sedimentation in the vicinity of the proposed bridge site. The banks on either side of the river floodplain show weathered granite gneiss with thin amphibolite zones. Founding conditions are not expected to be problematic, although sediments in the bed are likely to extend to greater than 15 metres in depth.

The alluvial floodplain on either side of the Orange River comprises sands, sandy silts and silts, varying from 0,3 to greater than 5 metres in depth. Solid rock is exposed in the existing bed of the river, and therefore no foundation problems are anticipated in construction of the proposed bridge

E.4. CONSTRUCTION MATERIALS

Areas proposed as sources of the various types of borrow material have been located along the route and are delineated on the Soil Engineering Maps accompanying the report.

The different construction materials are discussed below :

E.4.1. Crushed Aggregate

E.4.1.1. Suitable sources of crushed aggregate include the younger intrusive granites; the harder varieties of the gneissic and granulitic rocks; and the hard quartzites of the Kheis and Koras Systems. Additional material could be obtained from the sporadically developed pegmatite areas.

E.4.1.2. Material from the magnetite quartzite and dolerite outcrops would also be suitable, however, only boulder occurrences were located along this section.

E.4.2. Sub-Ballast

Suitable sub-ballast materials include :-

E.4.2.1. Friable weathered gneiss, with or without the intermixing of the overlying residual or colluvial materials.

E.4.2.2. Powdery to hard, nodular calcrete deposits including those on the river divide between km 210 and 233 (as marked on the original proposed route).

E.4.2.3. Concentrations of quartz gravels and pebbles intermixed with silty sands, occurring as alluvial wash areas in the beds of the larger streams and rivers.

E.4.2.4. Colluvial calcrete deposits located largely adjacent to the major streams and rivers and often intermixed with colluvial sandy material.

E.4.2.5. The colluvial outwash fan and talus deposits associated with the raised Koras rocks in the vicinity of Kleinbegin.

E.4.3. Binder

The alluvial more powdery calcrete deposits located adjacent to the larger rivers, as well as the colluvial sandy calcretes, should all be suitable for binder material. For stabilising agents or non-plastic binders, the fine sandy silts to silty sands located on the floodplain of the Orange River as well as the scattered aeolian sand dunes should be suitable.

E.4.4. Fill

Almost all the loose sandy materials throughout this section should be suitable for fill material, with the possible exception of the more clayey deposits in the alluvial depressions.

E.4.5. Concrete Sand

E.4.5.1. Coarse-grained sands located in the beds of the larger rivers should provide adequate concrete sand, with the main and most suitable source being located southwest of Kenhardt at the confluence of the Hartbees River with one of its larger tributaries.

E.4.5.2. Colluvial sands occurring on the steeper slopes of the Koras Hills as well as in outwash fans may also be suitable as concrete sand.

E.5. SUMMARY AND CONCLUSIONS OF BASEMENT SECTION

(i) The Basement section comprises a flat or gently undulating surface, with an average elevation of 900 metres above sea level, broken by ridges in the north-east and southwest.

(ii) Rainfall varies from 100 - 200 mm south of Kleinbegin and 200 - 300 mm north of Kleinbegin. Weinert's N-value varies from 10 to approximately 35, hence the dominant weathering process is one of disintegration.

(iii) The vegetation type is Broken Veld between the Orange River and Kenhardt, and Arid Karoo and Desert False Grassveld over the rest of this section.

(iv) Drainage in this section is effected by tributaries to the Orange River, namely the Hartbees, Rugseer, Mottels, Rietfontein and Tuins Rivers.

(v) This section is underlain by rocks of the Basement Complex, Kheis System and Koras Formation. The solid geology is generally overlain by a thin cover of calcrete and sandy soil.

(vi) The depth of cover overlying the Basement gneiss as well as the Kheis rocks is variable, but is generally of the order of 0,5 - 2 metres.

(vii) Hillslopes throughout this section are stable under existing climatic conditions and only the scattered mobile sand dunes show any evidence of instability.

(viii) Moderate to good rail bed foundations prevail throughout this section.

(ix) Detailed investigations to determine depth to solid bedrock are required at the Hartbees River bridge site, while no foundation problems should be encountered at the Orange River site.

(x) Adequate supplies of Crushed Aggregate, Sub-ballast, Binder, Fill and Concrete sand should be available in this section.

AEOLIAN SECTION

F.1 GEOMORPHOLOGY

This section encompasses an area extending from just east of the Orange River, in a northeasterly direction to the contact between the Matsap and Transvaal System rocks (± 40 km mark).

In the southwest of this section the general Kalahari plain slopes from an elevation of about 1 045 metres in the O'Poort farm area to 833 metres in the Orange River Valley. In the O'Poort and Titiespoort farm areas, northeast of the Orange River, the proposed route crosses the southern portion of the Skurweberge (or Skeurberg) range of hills. Here quartzite ridges rise to heights of 1 303 and 1 395 metres.

From O'Poort farm, northeast to Mount Leonard farm the flat sand-covered Kalahari Plain falls from 1 170 metres in the northeast to about 1 060 metres in the southwest. West-northwest trending sand dunes are present throughout this part of the section, with locally developed calcretes.

In the extreme northeast of this section roughly parallel quartzite ridges striking N-S crop out. This direction corresponds to the trend of the prominent Langeberg in the west.

The land surface represented in this section is the aggradational equivalent of the African (early Cainozoic) cycle of erosion.

No drainages exist in the southwest and central parts of this section, but in the northeast, a number of impeded drainages occur which are normally restricted in length and terminate in alluvial fans on the sand-covered plain. The highly absorbent sand flats and tuffaceous limestone plains preclude run-off of surface water.

F.2 GEOLOGY

The only geological formations present along this section of the proposed route are Matsap Series (Waterberg System) and Tertiary, Quaternary and Recent Deposits.

It should be noted that much of the area mapped as Kheis System on the 1 : 1 000 000 geological map appears to be Matsap (Waterberg System) and has been mapped as such. It is interesting to note that Rogers (1908) originally mapped these rocks as Matsap Beds, a correlation which was subsequently altered by the Geological Survey without further mapping.

Matsap Series (Waterberg System)

Rocks of this system build the Skurweberge range of hills crossed by the railway line route on the farms O'Poort, Titiespoort and Rooi Lyf in the southwest of this region. The range of hills is built by gritty purplish quartzites with sericite commonly developed (Rogers, 1908). The beds generally dip at low angles (20°) to the west. Rogers (1908) records that a rough cleavage has been produced which obscures the bedding planes and which is more important in determining the action of weathering than the bedding planes. On air photographs it can be seen that the beds have been tightly folded along general N-S axes. Shears have developed along this direction or along directions slightly east of north.

In the central alluvial basin area, there are very few exposures of solid geology. However, in the northeast of this section rocks of the Matsap Series build the conspicuous Langeberg Range, and are characterised by fairly intense folding. The direction of the dip is to the west with a strike direction slightly west of north. The Matsap Series (Waterberg System) here is composed of a great thickness of well-bedded, siliceous rocks consisting for the greater part of medium-grained, purple coloured feldspathic quartzites containing scattered quartz and jasper pebbles. Pebble washes commonly demarcate bedding planes but these rarely develop into conglomerate bands. Grits which grade into coarser conglomeratic grits are commonly developed within this sequence.

The beds are folded into tight anticlines and synclines, usually assymetrical and frequently further deformed by kink bands and drag folding. Many of the folds appear to be overturned to the east. The beds are strongly sheared with shear planes dipping at about 45° to the west and often obscuring the bedding. Quartz veining is common in these rocks.

Tertiary, Quaternary and Recent Deposits

In the southwest and northeast of this section the Matsap quartzites are buried under surface limestone, gravels and sand of Tertiary and Quaternary age. Gravels in the nature of terrace deposits are restricted mainly to the vicinity of present day drainage channels. All the large kloofs draining the Langeberg are filled with rock, rubble and sand. Unconsolidated scree deposits of a local nature occur along the western side of the Langeberg. Large areas are covered by fine yellowish to reddish sand which has been blown into dunes striking WNW-ESE in the areas west of the Langeberg.

The central basin area of this section is almost entirely mantled by a superficial cover of generally thin, but locally variable windblown sands.

This cover is well-developed towards the centre of the basin, where over large areas the sands have been thrown into prominent WNW trending longitudinal dune features. In the southwestern section of the basin, patchy developments of thin surface limestone (calcrete) deposits are exposed, although surface limestone probably underlies most of the region beneath thesand cover. On the margins of the basin, the surface limestones are overlain by hillwash materials consisting of sands and, in areas of drainage, boulder beds. The deeper-lying sediments are reported to be mainly sands and gravels (Truter and others, 1938).

The region forms part of the Griqualand West zone of Permo-Carboniferous glaciation (du Toit, 1954). A considerable deepening of ancient valley floors of drainages tributary to the Molopo River, to the north of Sishen, has been caused by this glaciation. Where this has occurred coarse detritus has partially infilled the glacial valleys. It is not improbable that a similar situation may prevail in parts of this flat basin area. It should be noted, however, that in this region there are no clear surface expressions of drainages.

F.3 ENGINEERING CHARACTERISTICS

N.B. For detailed description of materials occurring within individual facets, see Facet Index tables.

F.3.1. Slope Stability

This section comprises a very flat aeolian plain through which prominent inselbergs of Matsap quartzite protrude, the slopes of the quartzite being completely stable. However the sand dunes banked up against these ridges will not be stable.

The other areas of instability within this section are the dunes, many of which are semi-stable while the longitudinal dunes in the vicinity of Titiespoort appear to be mobile.

F.3.2. Foundations

F.3.2.1. Rail Bed

Most of the founding materials along this section are windblown sands with poor grading, and areas of semi-mobile dunes. Hence foundations along the majority of this section of the route are only moderate.

Pans, surface seepage zones and depressions which would otherwise produce poor foundation conditions, due to occasional saturation in time of rain, have been avoided by the proposed route of the railway.

F.3.2.2. Bridges

No major bridge sites are located along this section of the proposed route.

F.4 CONSTRUCTION MATERIALS

Areas proposed as sources of the various types of borrow material have been located along the route, and are delineated on the Soil Engineering Maps accompanying the report.

The different material types are discussed below :

F.4.1. Crushed Aggregate

F.4.1.1. The only source of crushed aggregate in this section is the Matsap quartzite. The majority of this material is found to be generally unsuitable for use as ballast and concrete aggregate, but should be ideal for pitching and slope stability stone.

F.4.1.2. One area where the Matsap quartzites may be suitable for ballast and/or concrete aggregate, is in the vicinity of the 50 km mark (original centre line). This location has been delineated on the ballast overlays supplied with a separate report.

F.4.2. Sub-Ballast

F.4.2.1. The predominantly powdery and occasionally nodular calcrete deposits occurring in alluvial depressions and seepage zones, appear to be the main source of possible sub-ballast material.

F.4.2.2. The most suitable single source of sub-ballast material is located in the basal sheared conglomerates of the Matsap Series in the vicinity of the 35 km mark (on the original proposed centre line). This friable, pelitic material should be easily ripped, but may require the addition of a binder to improve its grading.

F.4.2.3. Due to the prevailing climate only minor weathering and disintegration has occurred, hence the availability of suitable sub-ballast materials, derived from the Matsap quartzites, is limited to colluvial fans, outwash deposits and talus slopes. Quantities of sub-ballast materials from these sources are likely to be small.

F.4.2.4. Calcrete and weathered Matsap quartzite in the vicinity of the pan adjacent to kilometre 120, (on original centre line) should also be suitable for sub-ballast material, however, the quantity may be small and a high gypsum content may also be present.

F.4.3. Binder

Many of the finer more powdery calcrete deposits which are unsuitable for sub-ballast, together with the pan deposits, could be used as binder material.

F.4.4. Fill

Sands throughout the area should be suitable for use as fill, although minor amounts of binder could be added to facilitate compaction.

F.4.5. Concrete Sand

No suitable concrete sands are available along this section of the proposed route.

F.5 SUMMARY AND CONCLUSIONS OF AEOLIAN SECTION

(i) This area forms part of the vast, sand covered Kalahari Plain, broken in places by Matsap quartzite outcrop, particularly in the southwest and northeast.

(ii) Rainfall varies from 200 - 400 mm, and Weinert's N-value varies from 10 to approximately 35, hence the dominant weathering process is one of disintegration.

(iii) The vegetation comprises Kalahari Thornveld and Shrub Bushveld.

(iv) No drainages exist in the southwest and central areas, while in the northeast numerous impeded drainages, terminating in alluvial fans on the sand plain, are present.

(v) Cover on the Matsap quartzites varies from >2 metres on the sand slopes to $<0,3$ metres on the ridges. Depth to bed rock on the sandy plains is unknown, however, calcretes generally are found 1 - 2 metres below the sand cover.

(vi) The only areas of instability are the dunes, which vary from semi-stable to semi-mobile.

(vii) Rail bed foundations are moderate along this section of the proposed route, due to the poor grading and compaction of the wind blown sands.

(viii) No major bridge sites occur along this section.

(ix) There is a shortage of Ballast, Concrete Aggregate stone and Concrete sand in this section. Adequate supplies of Binder and Fill are available. More detailed investigation and testing will be required to determine the extent and quality of the suggested sources of sub-ballast material.

G. SISHEN SECTION

G.1. GEOMORPHOLOGY

This section extends from the boundary between the Matsap Formation and Transvaal System rocks ($\pm$ 40 Km mark on the original route), in a northeasterly and northerly direction to Sishen.

The area forms part of the Kalahari physiographic region (Wellington, 1955) marginal to the Kaap Plateau to the east and is part of the aggradational equivalent of the African (Early Cainozoic) cycle of erosion.

The country has moderate relief and is characterised by vast level tracts of sand and calcrete which are broken by north-south, or slightly west of north, striking ridges of banded ironstone and quartzite (in the south), andesite (central area) and haematite or quartzite (northern area).

The landscape is of inselberg type with a general elevation in the order of 1 120 metres above sea level.

The only river of significance in the area is the ephemeral Gamagara River, which drains northwards towards the Kuruman River. Elsewhere, numerous impeded drainages occur which are of restricted lengths and terminate in alluvial fans on the sand covered plains. The highly absorbent sand flats and tuffaceous limestone plains preclude run-off of surface waters.

G.2. GEOLOGY

P.R. de Villiers (1967) has suggested a new stratigraphic correlation and interpretation of the Postmasberg - Sishen area, which is followed in this discussion, with reference being made where necessary to the former classification of J. de Villiers (1960).

The geological formations present in this area are as follows :-

Tertiary and Quaternary Deposits		
Intrusive Rocks		
		Smelterskop and Magaliesberg Stages (including upper Gamagara Formation rocks of old classification).
Transvaal System	Pretoria Series	Daspoort Stage (Upper, middle and lower Griquatown Stages of old classification).
		Timeball Hill Stage (including lower Gamagara Formation rocks of old classification).

A fairly extensive cover of sand and Kalahari Beds is present over much of the region, but good exposures of theolder rocks do occur.

Transvaal System

The lowest, Dolomite Series, of the Transvaal System is present well to the east of Sishen and the lowermost beds of the Transvaal System cropping out in this region are quartzite, shale, conglomerate and sedimentary breccia of the Timeball Hill Stage (delineated as Pretoria/ Iron Formation in the Land Pattern/Facet Mapping) developed about 1,5 kms to the east and southeast of Sishen. The quartzite, shale and conglomerate of this stage were formerly included in the Gamagara Formation of the old classification (J. de Villiers, 1960). Sishen itself is underlain by the Ongeluk andesitic lava with interbedded tuff, chert and jasper, formerly termed Middle Griquatown or Ongeluk Stage in the 1960 classification. The lower Tillite Zone of the Daspoort Stage does not crop out along the railway route.

The Ongeluk lava is present for some 20 kilometres southwest and west of Sishen, from which point on, quartzite, shale, jasper, chert, banded ironstone and limestone (formerly classified as being Upper Griquatown Stage, but here included in the Daspoort Stage) are present. These rocks are overlain in the southwest of this section by quartzite, shale and limestone (upper Gamagara Formation of old classification), shale and lava (now equated with the Machadadorp volcanics and formerly assigned to the Upper Griquatown Stage) and andesitic lava (correlated with the Dullstroom volcanics), purple quartzite, breccia, tuff and basal conglomerate (formerly correlated with the Lower Matsap or Hartley Hill Stage of the Matsap Formation, Waterberg System). These are now grouped in the Magaliesberg and Smelterskop (Hartley Hill) stages.

In the area occupied by the remarkably uniform Ongeluk lavas no tectonic features can be discerned. The sedimentary rocks of the Daspoort and higher stages of the Transvaal System, have been fairly intensely folded with the main structural features parallel to the Langeberg trend.

Intrusive Rocks

Numerous diabasic dyke-like rocks occur throughout this section particularly to the southwest of Sishen and they are apparently related to the Ongeluk lavas. True dolerites are absent or rare.

Tertiary, Quaternary and Recent Deposits

Over large areas in this section, the older rocks are buried under Tertiary, Quaternary and Recent Deposits, varying from a few metres to over 66 metres in thickness. These deposits consist mainly of calcretes, gravels and sand. The calcretes which are typically developed in areas of low relief are frequently tuffaceous and are siliceous to a greater or lesser extent.

Gravels in the nature of terrace deposits are restricted mainly to the vicinity of present day drainage channels, but are also scattered over other areas.

G.3 ENGINEERING CHARACTERISTICS

N.B. For detailed descriptions of materials occurring within individual facets, see Facet Index tables.

G.3.1. Slope Stability

Hillslopes throughout this section are of variable gradient, but should be stable under existing climatic conditions.

G.3.2. Foundations

G.3.2.1. Rail Bed

G.3.2.1.1. Foundation conditions in the Pretoria quartzite and banded ironstone areas are good.

G.3.2.1.2. Moderate foundation conditions will be encountered in the aeolian sand areas, with good foundations on the nodular calcretes.

G.3.2.1.3. The section of the route overlying the Daspoort andesites has in general good foundation conditions, with the exception of the alluvial wash and vlei areas where clayey materials are likely to be found.

G.3.2.1.4. Within the area covered by the Pretoria Iron Formation, foundation conditions are variable, but in general should be good except in the Gamagara alluvial area.

G.3.2.2. Bridges

Solid foundations should be located relatively close to the surface at the Gamagara bridge site. However, the thickness of the sandy to clayey material in the bed and on the floodplain of the river will be highly variable.

G.4. CONSTRUCTION MATERIALS

Areas proposed as sources of the various types of borrow material have been located along the route, and are delineated on the Soil Engineering Maps accompanying this report.

The different construction materials are discussed below :-

G.4.1. Crushed Aggregate

G.4.1.1. Pretoria Series quartzites, located in the vicinity of the 34 km mark (original centre-line) and the Gamagara River, should be suitable as crushed aggregate. The quartzites in the vicinity of the Gamagara River may in addition be suitable for ballast and concrete **aggregate** stone.

G.4.1.2. Fresh unweathered Daspoort andesite in the vicinity of km 16 (original centre-line) should be suitable for ballast and concrete aggregate stone.

G.4.1.3. The waste dumps in the vicinity of km -4 (original centre-line) may provide suitable crushed aggregate material (requiring little or no processing) for use as slope stability or pitching stone.

G.4.2. Sub-Ballast

G.4.2.1. Nodular calcretes overlying the Pretoria Series rocks and the Daspoort andesites, together with the harder calcretes overlain by sand in the vicinity of Sishen mine, should be suitable as sub-ballast material.

G.4.2.2. Other possibly suitable materials include residual weathered andesite together with the overlying colluvial deposits, and weathered Pretoria shales and banded ironstones.

G.4.2.3. Possibly the main and most suitable sources of sub-ballast material will be the dumps of waste material in the vicinity of the various workings in the Sishen area. However, these materials may require the addition of a semi-plastic binder.

G.4.3. Binder

G.4.3.1. The finer-grained colluvial calcrete deposits (powdery) occurring throughout this section should make suitable binder.

G.4.3.2. The fine-grained poorly graded aeolian sands should be suitable for use as non-plastic stabilising agents, which may be required to reduce the P.I.'s of the more clayey decomposed andesites, shales or calcretes being used as sub-ballast material.

G.4.4. Fill

G.4.4.1. The majority of the fine-grained loose sandy materials throughout this section of the route should be suitable for use in the fill layers.

G.4.4.2. Use of the more clayey deposits associated with the alluvial and alluvial wash areas overlying the Daspoort andesite and dolerite intrusions, as well as the Gamagara alluvial flood plain materials, should be avoided wherever possible.

G.4.5. Concrete Sand

Only one possible area of concrete sand was delineated in this section of the route. This material consists of colluvial outwash from the Pretoria quartzites, located in the vicinity of the 34 km mark (old centre-line).

TEST RESULTS

Identification					Material	Sieve Analysis											Constants			Compaction				
Land Pattern	Sample No.	Facet	Horizon	Unified Class.	Material Description	75,0 mm.	53,0 mm.	37,5 mm.	26,5 mm.	19,0 mm.	13,2 mm.	4,75 mm.	2,00 mm.	0,425 mm.	0,075 mm.	Silt/ Clay	L. L.	P. I.	L. S.	Max. Density	O. M. C.	95% CBR	90% CBR	Swell (max).
A	37	3	2	SM	White silty sand + calcrete					100	98	94	90	79	21		Non Plastic							
A	35	3	3	SM	Light brown silty sand + calcrete				100	99	90	65	58	54	14		Non Plastic							
B	36	5	3	GM	Gravelly decomposed phyllite + Fe pebbles.				100	95	80	49	39	30	20		20	5	2,5					
C	30	5	1	SM	Red-brown silty sand								100	85	24		Non Plastic							
C	32	5	1	SM	Red-brown silty sand							100	96	59	19		Non Plastic							
D	20	3	1	SP	Brown gravelly sand								100	62	7		Non plastic							
D	31	3	1	ML	Fine brown clayey silt									100	64		Non plastic							
D	212	3	1	SM	Light-brown-white silty sand								100	93	11		Non plastic							
F	29	4	1+2	SC	Red brown clayey sand + white friable calcrete					100	93	84	72	64	31		22	8	4,0					
G	26	3	1	SM	Brown silty sand + shale fragments.						100	98	95	72	35		16	5	2,5					
G	187	3	1	SP	Gravelly sand wash+ shale fragments.					100	98	83	65	30	10		Non plastic							
G	193	3	1	SM	Brown silty sand + shale fragments.					100	99	93	86	65	16		Non plastic							
G	189	3	2	ML	White clayey silt + shale fragments.								100	69	51		15	3	1,5					
G	190	3	3	GP	Light grey-brown disintegrated shale + gypsum					100	85	45	25	11	9		24	8	4,0					
G	24	4	1	SC	Brown sandy clay + gravel.					100	99	95	86	66	23		23	11	5,5					
G	7	4	1	CL	Brown sandy clay							100	99	87	59		27	13	6,5					
G	186	4	1	SM	Grey coarse silty sand					100	96	90	78	31	14		Non plastic							
G	25	6	1	SM	Light brown silty sand + gravels and pebbles.				100	97	83	65	56	39	16		17	4	2,0					
G	12	7	1	CL	Brown, firm, fissured, sandy clay.					100	95	94	92	88	70		28	12	6,0					

TEST RESULTS

Land Pattern	Sample No.	Facet	Horizon	Unified Class.	Material Description	75,0 mm.	53,0 mm.	37,5 mm.	26,5 mm.	19,0 mm.	13,2 mm.	4,75 mm.	2,00 mm.	0,425 mm.	0,075 mm.	Silt/Clay	L.L.	P.I.	L.S.	Max. Density	O.M.C.	95% CBR	90% CBR	Swell (max).
Identification					Material	Sieve Analysis											Constants			Compaction				
G	13	7	2	CL	Grey gypsum + shale fragments						100	94	80	61	54		37	18	9,3					
H	8	2	1	SC	Brown clayey sand + nodular calcrete				100	99	86	62	54	36	17		25	8	4,0					
H	9	4	1	SM	Brown silty sand					100	99	96	94	73	21		Slightly Plastic							
J	180	3	1	SM	Brown silty sand							100	99	69	11		Non Plastic							
J	181	4	1	ML	Brown moist clayey silt									100	80		18	6	3,0					
J	11	4	1	SM	Brown silty sand (Dolerite)						100	99	94	50	12		Non Plastic							
J	5	4	1	SM	Light brown silty sand						100	98	94	70	34		19	5	2,5					
M	184	5	1	SM	Light brown silty sand + gravels, pebbles and boulders							100	83	62	31		18	4	2,0					
N	138	1	1	SM	Brown silty sand + calcrete pebbles and boulders						100	98	93	82	11		Non Plastic							
N	139	1	1	SM	Brown, coarse, firm, intact, silty sand							100	90	61	28		14	1	0,5					
N	141	1	2	CL	Grey-brown firm, fissured, sandy clay							100	91	74	59		45	22	11,3					
N	140	1	3	SP	Friable decomposed granite						100	68	31	9	4		20	8	4,0					
N	145	4	1	SM	Fine brown silty sand + scattered shells & calcrete					100	93	79	74	71	25		Slightly Plastic		0,3					
N	242	5	2	SM	Brown dense silty sand								100	94	17		Non Plastic							
N	207	6	1	SM	Fine brown silty sand									100	24		Non Plastic							
N	240	6	1	SM	Brown silty sand								100	75	19		Non Plastic							
N	206	6	2	SM	Light grey-brown silty sand									100	30		23	6	3,0					
N	239	6	2	CL	White sandy calcrete (gypsum)									100	66		31	12	6,3					
N	205	7	1	SP	Mobile white sand									100	2		Non Plastic							
N	210	8	1	SM	Beach sand								100	93	13		Non Plastic							
N	143	9	1	SP	Dark brown gravelly sand + shells								100	85	10		Non Plastic							
N	144	9	1	SC	Light green-brown sandy clay + calcrete								100	99	40		24	8	4,0					
N	142	9	2	SP	Fine brown sand + scattered shells								100	78	9		Non Plastic							

TEST RESULTS

Identification					Material	Sieve Analysis											Constants			Compaction				
Land Pattern	Sample No.	Facet	Horizon	Unified Class.	Material Description	75,0 mm.	53,0 mm.	37,5 mm.	26,5 mm.	19,0 mm.	13,2 mm.	4,75 mm.	2,00 mm.	0,425 mm.	0,075 mm.	Silt/Clay	L.L.	P.I.	L.S.	Max. Density	O.M.C.	95% CBR	90% CBR	Swell (max).
N	234	9	2	SM	Grey-brown silty sand								100	84	31		Slightly Plastic		0,3					
N	235	9	2	SP	Light brown gravelly sand								100	78	6		Non Plastic							
N	211	9	2	SC	Yellow brown clayey sand + calcrete								100	96	38		32	13	6,5					
N	241	10	2	SP	Grey gravelly sand								100	87	5		Non Plastic							
N	237	11	1	SM	Brown silty sand								100	72	22		Non Plastic							
N	236	11	2	SM	Hard Dorbank				100	93	88	80	75	55	20		Slightly Plastic		0,3					
N	204	12	3	SM	Brown silty sand + shingles and gravels									100	46		17	4	2,0					
N	209	12	3	SM	Brown silty sand								100	94	15		Non Plastic							
N	208	12	5	SC	Laminated disintegrated clayey sand and sandstone				100	97	94	92	90	87	45		33	15	7,5					
N	243	-	-	SM	Grey decomposed lava							100	98	84	31		16	4	2,0					
N	244	-	-	SC	Grey-brown sandy clay						100	81	57	26	19		53	25	12,5					
P	214	2	1	SM	Fine brown silty sand							100	98	83	30		14	2	1,0					
P	215	2	1	SP	Red-brown sand								100	97	6		Non Plastic							
P	213	4	2	SM	Red-brown silty sand			100	95	92	86	72	68	61	31		13	3	1,5					
Q	195	1	1	SM	Light brown fine silty sand								100	82	49		13	2	1,0					
Q	194	2	1	ML	Light brown silty-clayey sand								100	93	54		14	2	1,3					
Q	18	2	1	SM	Light red brown silty sand						100	99	98	71	25		Non Plastic							
Q	200	3	1	SP	Red brown silty sand + gravel					100	93	72	51	25	9		14	2	1,3					
Q	17	4	1	GM	Brown silty gravel + hard nodular calcrete				100	82	78	47	44	41	25		12	1	0,5					
Q	19	4	1	ML	Brown clayey silt + quartz gravel					100	99	98	98	93	56		16	5	2,5					
Q	196	4	1	ML	Light brown clayey silt + scattered gravel							100	98	95	82		15	4	2,0					
Q	199	4	2	SC	Brown sandy clay + gypsum crystals							100	99	45	41		37	18	9,0					
Q	174	4	2	ML	Light brown-white clayey silt + gypsum crystals									100	80		14	2	1,0					

TEST RESULTS

Identification					Material	Sieve Analysis											Constants			Compaction				
Land Pattern	Sample No.	Facet	Horizon	Unified Class.	Material Description	75,0 mm.	53,0 mm.	37,5 mm.	26,5 mm.	19,0 mm.	13,2 mm.	4,75 mm.	2,00 mm.	0,425 mm.	0,075 mm.	Silt/Clay	L. L.	P. I.	L. S.	Max. Density	O. M. C.	95% CBR	90% CBR	Swell (max).
Q	175	4	2	SC	Brown sandy clay + calcrete						100	97	92	72	43		46	20	10,0					
Q	14	4	5	ML	Disintegrated phyllite							100	99	90	72		14	2	1,3					
Q	197	7	1	ML	Light brown clayey silt								100	97	50		19	5	2,5					
Q	15	10	1	SM	Fine brown silty sand								100	99	26		Non Plastic							
T	16	2	1	SC	Brown sandy clay + scattered pebbles, gravel and boulders						100	97	90	73	50		18	7	3,5					
T	33	2	1	SM	Red brown silty sand						100	99	94	64	20		Slightly Plastic		0,3					
T	183	2	1	SM	Brown silty sand + scattered quartz gravel						100	99	94	59	20		Slightly Plastic		0,3					
T	179	2	2	SM	Brown silty sand + gravel and boulders					100	96	86	74	38	14		Slightly Plastic		0,3					
T	178	4	1	SM	Brown silty sand + gravelly sand layers								100	92	26		Non Plastic							
T	185	4	1	ML	Light brown gypsiferous sandy silt						100	94	91	89	78		Slightly Plastic		0,3					
T	177	5	1	SP	Dark brown-grey moist, coarse sand					100	98	95	85	35	4		Non Plastic							
T	182	5	1	SM	Light brown silty sand + gravels and pebbles					100	99	93	81	31	12		Non Plastic							
T	176	8	1	SM	Brown silty sand + calcareous gravels and pebbles				100	99	95	81	71	63	27		Slightly Plastic		0,3					
V	34	4	1	SP	Loose brown sand						100	98	83	21	1		Non Plastic							
X	22	2	3	SC	Nodular and powdery calcrete + pebbles and clay					100	94	73	62	37	17		21	8	4,0					
X	23	5	1	SC	Brown sandy clay					100	98	96	93	66	30		18	7	3,8					

LAND PATTERN A (PRELIMINARY)

MATERIAL AEOLIAN SAND

EXTENT 27K - 31K 35K - 159K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1	Dune Sands.	>2.0m - Aeolian fine red brown loose sand on >1.0m - white nodular calcrete. Above ground water action.	SM/ SM - GM	Sand - moderate. Calcrete - good.	BIN. & FILL.	Sparce grass and scrub.	Dunes will mobilize if natural form or vegetation is disturbed, hence cut, fill and embankment slopes must be protected immediately.
2	Sheet Sands.	0.5m - 1.5m - Aeolian fine red brown sand on >1.0m - white nodular calcrete. Above ground water action.	SM/ SM - GM	Sand - moderate. Calcrete - good.	BIN. & FILL.	Grass, scrub and scattered bush.	Sand is aeolian and hence has poor grading. All embankment slopes to be protected.
3	Drainage Depressions and Alluvial Wash Areas.	0 - 1.5m - Colluvial fine brown silty sand (with powdery calcrete) on 1.0 - >3.0m - white nodular calcrete - upper layer more consolidated, becoming friable with depth on > 2.0m - Solid rock. Periodic saturation or flooding.	SM/ SM - GM/ rock.	Sand - moderate. Calcrete & rock - good.	SB	Grass, scrub and succulents.	Mixing of sand and calcrete should provide good quality fill in these areas. Culverts often required.
4	Low Benches and Domes.	< 0.2m - Colluvial fine brown silty sand and powdery calcrete on > 1.0m - light grey-brown weathered rock (quartzite). Generally above ground water action.	SM/ GP/rock.	Sand - moderate. Weathered rock - good.	SB	Sparce grass and scrub.	Occurrence extremely scarce.
5	Pan Floors.	0.3 - >1.0m - Alluvial light brown sandy clay with salt (gypsum?) and powdery calcrete. > 1.0m - white, powdery and nodular calcrete. > 2.0m - light brown weathered rock (quartzite). Subject to periodic saturation or flooding.	CH - CL/ SM GP/rock.	Clay - poor. Calcrete - moderate to poor. Weathered rock - good.	Plastic BIN?	Nil	Occurrence extremely scarce. Intermixing of sand and clay should give good fill material.

LAND PATTERN B (PRELIMINARY)

MATERIAL MATSAP QUARTZITE **EXTENT** 26K - 155K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1	Quartzite Hills and Ridges. V1 V2	< 0.3m - Residual brown - red brown silty sand with boulders on ± 0.3m - residual brown friable weathered quartzite on > 2.0m - light brown mod. hard quartzite and sheared quartzite. > 2.0m - unweathered quartzite exposed on surface. Above ground water action	SM/ GP/ rock. rock.	All materials - good.	Crushed Aggregate.	Sparce bush and grass.	Rock moderately soft and friable for excavation purposes.
2	Colluvial Slopes and Fans.	1.0 - 3.0m - Colluvial red brown silty sand with quartzite pebbles and boulders intermixed on > 2.0m - residual solid grey brown quartzite. Subject to periodic saturation.	SM - GM/ rock.	Sand - moderate. Quartzite - good.	FILL & SB?	Grass, scrub and scattered bush.	Deposits often limited in depth and extent.
3	Sand Slopes. V1 V2	1.0 - > 2.0m - Aeolian red brown sand on 1.0 - 2.0m - colluvial red brown silty sand with quartzite pebbles and boulders on > 2.0m - residual solid jointed grey-brown quartzite. > 1.0m - aeolian red brown sand on > 2.0m - unweathered quartzite. Generally above ground water action.	SM/ SM - GM/ rock. SM/ rock.	Sand and silty sands } Moderate but susceptible to wind erosion Quartzite and weathered quartzite } - Good	FILL FILL	Sparce grass and scrub.	Variable thicknesses of aeolian sand cover.
4	Fault and Fracture Zones.	> 0.3m - White to light brown quartzite boulders and pebbles with fine sand on > 2.0m - white sheared and possibly recrystallised quartzite. Generally above ground water action.	GP/ rock.	Colluvium and Quartzite } - Good	Crushed aggregate.	Sparce bush and grass.	Outcrops very scarce and limited in extent.

LAND PATTERN C (PRELIMINARY)

MATERIAL KHEIS/SCHIST

EXTENT 159K - 185K, 188K - 210K, 256K - 258K.

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Low Rounded Hills & Ridges.	< 0,3 m - Residual scattered pebbles and boulders with brown silty sand on >2,0 m - light brown to grey weathered meta volcanics, schist and quartzite with thin quartz veins (and calcrete). Above ground water action.	GM/ rock	All materials - good.	Crushed Aggregate	Scrub & grass.	Weathered rock often exposed on surface.
2.	Hillwash Slopes						
	V.1	0,3 m - 2,0 m - Brown to red brown colluvial silty sand with scattered quartz gravels and quartzite boulders on >2,0 m - weathered meta volcanics, quartzite or schist grading to solid.	SM/ rock	All materials - good.	Fill SB?	Scrub, grass & scattered bush.	Variable depth of hillwash material and insitu weathering, but generally shallow.
	V.2	0,3 m - 1,0 m - Red brown colluvial silty sand with gravels & pebble float on 0,3 m - 0,8 m - white nodular calcrete with red brown sand on >1,0 m - weathered meta volcanics, quartzite or schist. Minor ground water action after rain.	SM/ SC/ rock	All materials - good.	SB SB SB?		
3.	Sand Dunes.	>1,0 m - Brown to red brown fine loose aeolian sand to silty sand on >2,0 m - solid quartzite, schist, meta volcanics or calcrete. Above ground water action.	SM/ rock	Sand - moderate Rock - good.	Bin -	Reeds & grass.	Dunes semi-stable, any interference will cause erosion problems. Cut faces will require protection.
4.	Rugged Quartzite Ridges & Hills.	> 3,0 m - Solid hard quartzite exposed on surface. Above ground water action.	Rock	Rock - good	Crushed Aggregate	Scattered grass & scrub.	Outcrops scarce.
5.	Alluvial Wash Areas.						
	V.1	0,3 m - >1,0 m - Red brown silty sand on 0,3 m - 1,0 m - red brown sandy silt to sandy clay on >1,0 m - weathered meta volcanics, quartzite or schist.	SM/ SC/ rock	Sands - moderate Rock - good	Fill - Bin? Fill SB ?	Bush & scrub.	Sediment depth varies with size of river or drainageway. Intermixing of layers may provide SB material?
	V.2	0,3 m - >1,0 m - Red brown loose alluvial silty sand (with calcrete) on 0,3 m - >1,0 m - white powdery to nodular sandy calcrete on >1,0 m - weathered meta volcanics, quartzite or schist. Periodic saturation or flooding.	SM/ SM - SC/ rock	Sand & calcrete } - moderate Rock - good	Bin? Bin - SB? SB?		
6.	Dolerite Dykes	0,1 - 0,6m - Dark brown loose residual dolerite boulders & pebbles with red brown silty sand on >1,0 m - weathered fractured dolerite. Generally above ground water action.	Boulders-GP/ rock	All materials - good.	Fill -	Sparse bush & scrub.	Dykes generally very thin.

LAND PATTERN D (PRELIMINARY)

MATERIAL ALLUVIAL SAND - SILT

EXTENT 165K - 166K, 651K - 656K, 671K-672K.

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	River Beds						
	V.1	0,3 - >2,0 m - Water	-	Variable.	-	Nil	Test for use as "mix-water", also "attack-water" on concrete. Materials variable and sometimes associated with deleterious salt (gypsum) deposition.
	V.2	0,8 - >2,0 m - Brown loose sand to silty sand with gravels and scattered pebble lenses, (salt and gypsum encrustations). Continual or periodic flooding.	S.P. -SM/ GM.	Sands - poor to bad.	Fill Conc. S? SB? Bin?	Sparse reeds & scrub.	
2.	Solid Rock Outcrops	>2,0 m - Solid, hard quartzite, schist, limestone, phyllite etc., exposed in river beds. Subject to periodic/continual flooding or above river and ground water action.	Rock.	Rock - good	-	Nil	Rock is strongly jointed but usually fresh.
3.	Flood Plains.						
	V.1	1,0m - >3,0 m - Fine brown sandy silt with scattered pebbles - boulder float on surface (gypsiferous) on >2,0 m - solid rock (quartzite, schist, limestone).	ML/ rock	Sand & alluvial gravels - moderate. Rock - good.	Bin. Fill	Bush, reeds, grass & trees.	Material variable in consistency. Bridge embankments require protection against scour.
	V.2	1,0m - >3,0m - Light brown loose sand to silty sand on >1,0m - solid rock or alluvial gravel, pebble and boulder beds. Subject to periodic flooding and saturation.	S.P.-SM/ rock -GP		Bin? Conc. S? SB?		
4.	Raised Terraces.	1,0m - >5,0m - Fine brown silty sand with nodular calcrete fragments on 0,3m - >1,0m - weathered rock with calcrete in joints. >2,0m - solid quartzite and schist. Variable ground water action (occasional saturation).	SM/ GP/ rock	Sand - moderate. Solid & weathered rock } - good	Bin Fill	Cultivation, bush & trees.	Material generally too fine for concrete sand. Bridge embankments require protection.

LAND PATTERN E (PRELIMINARY)

MATERIAL BASEMENT/CALCRETE

EXTENT 210 - 222 K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Convex Calcrete Cappings.	<0,3 m - Brown to red brown transported silty sand with scattered calcrete fragments on 0,5 - >1,0 m - white hard nodular calcrete on >1,0 m - weathered gneiss, schist, quartzite or amphibolite, grading to solid. Above ground water action.	SM/ SM - GM GP - rock	All materials - good.	Bin SB SB?	Grass & scrub.	Calcretes should be hard and nodular to layered in this facet.
2.	Hillwash Slopes	0,3 - 1,0 m - Red brown loose transported silty sand on 0,5 - >1,0 m - light brown to white powdery to nodular calcrete on >1,0 m - weathered gneiss, schist, quartzite or amphibolite, grading to solid. Minor ground water action after rain.	SM/ SM - GM GP - rock	All materials - good.	Bin - Fill SB SB?	Bush, grass & scrub.	Highly variable calcrete development in this facet.
3.	Aeolian Sands	0,1 - >2,0 m - Red brown very loose aeolian sand Above ground water action.	SP	Sand - moderate.	Bin? Fill	Sparse scrub.	Dunes semi-stable, hence all cut and fill slopes will require protection against wind erosion.
4.	Alluvial Wash Areas	0,5 - 1,0 m - Red brown alluvial silty sand on 0,0 - 1,0 m - white powdery to nodular calcrete on >1,0 m - weathered rock grading to solid. Periodic saturation and flooding.	SM/ SM - GM/ GP - rock	Sand and calcrete - moderate. weathered rock - good.	Fill - Bin? SB?	Scrub, bush and grass.	Alluvial deposits generally shallow in depth.

LAND PATTERN F (PRELIMINARY)

MATERIAL KORAS / QUARTZITE

EXTENT 185K - 188K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Rock Outcrops						
	V1	>3,0 m - Brown solid (massive) jointed quartzite exposed on surface.	Rock	Good	Crushed Aggregate	Sparse scrub.	Blasting required for excavation.
	V2	<0,3 m - Brown loose residual sand, pebbles and boulders on >3,0 m - brown banded (or laminated) solid quartzite and schist. Above ground water action.	GP rock	Good	Crushed Aggregate		
2.	Talus Slopes	0,3 - 0,7 m - Brown loose colluvial silty sand with intermixed gravels, pebbles and boulders on	GP	Talus - moderate	Fill	Scrub & grass.	Materials have highly variable gradings. Steep cross-slopes encountered in this facet.
		>2,0 m - brown solid jointed quartzite or schist. Above ground water action.	rock	Rock - good	-		
3.	Hillwash Slopes & Fans.	0,3 ->1,0 m- Light brown to brown colluvial silty sand with scattered gravels on	SM/	All materials - good.	SB? - Bin?	Scrub, grass & scattered bush.	Fan deposits more likely to supply large quantities of sub-ballast material. Fans should also be checked as source of Conc S?.
		0,5 - 1,0 m - white powdery to nodular calcrete on >1,0 m - brown weathered quartzite or schist grading to solid. Moderate ground water action after rain.	SM - GM/ rock		SB?		
4.	Alluvial Wash Areas	0,5 - >1,5 m - Brown to red brown loose alluvial silty sand with scattered gravels on	SM - SW/	All materials - moderate to poor.	Conc S?	Scrub, grass, reeds & bush.	Calcretes may have variable P.I.s Conc S deposits are more likely to be found in river beds than on flood plains.
		0,6 - >2,0 m- white powdery to nodular calcrete. Subject to periodic saturation and flooding.	SM - GM		Bin? - SB?		

LAND PATTERN G (PRELIMINARY)

MATERIAL DWYKA / SHALE

EXTENT 324K - 346K, 356K - 380K, 386K - 414K, 453K - 466K, 480K - 492K,

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Rugged Baked Shale Hills.	<0,1 m - Residual weathered baked shale fragments and silty sand on >2,0 m - solid resistant hard baked shale (occasional limestone & sandstone bands). Above ground water action.	GP/ rock	All materials - good.	Crushed aggregate (Slope Stab).	Scrub.	Generally requires blasting for excavation.
2.	Low Rounded Hills & Ridges.	<0,3 m - Residual weathered shale fragments and brown silty sand (calcrete) on >2,0 m - green-grey jointed shale, baked shale or shaly tillite (occasional limestone or sandstone bands interbedded). Generally above ground water action.	GP-GM/ rock	All materials - good.	Fill SB?	Scrub.	Material will probably require the addition of binder for use in SB layer. Generally requires ripping for excavation.
3.	Hillwash Slopes						
	V.1	0,3 - 1,0 m - Brown colluvial silty sand with shale fragments and surface gravel float on 0,2 - 0,5 m - green-brown weathered shale and baked shale on >2,0 m - green-grey jointed shale, baked shale, or shaly tillite with occasional sandstone or limestone bands.	SM/ GP/ rock	All materials - good.	Fill - Bin? SB? SB?	Scrub with scattered bush and grass.	Material highly variable in consistency, depth and P.I. May be suitable for S.B. when intermixed with underlying weathered shale.
	V.2	0,3 - 1,0 m - Colluvial brown silty sand with shale fragments on 0,3 - 1,0 m - light brown powdery to nodular calcrete and/or gypsum (with fragments) on >0,3 m - brown to light grey weathered shale, grading to solid (with sandstone bands).	SC-SM/ SM-ML/ GP - rock	Sand, gypsum and calcrete } - moderate to poor. weathered rock - good.	Fill Bin? - SB? SB?		
	V.3	0,3 - 0,9 m - Aeolian brown sand to silty sand (dunes) on 0,3 - 1,0 m - light brown to white nodular to powdery calcrete on 0,3 - 0,8 m - brown weathered shale (with calcrete in joints) on >1,0 m - solid jointed shale, baked shale or shaly tillite. Minor ground water action after rain.	SP-SM/ SM-SC/ GP/ rock	Sand - moderate Weathered & solid rock & calcrete } - good.	Fill - Bin? Bin - SB? SB? SB?		
4.	Alluvial Wash Areas.						
	V.1	0,5 - >1,0 m - Alluvial light brown silty to clayey sand with loose gravel surface float on 0,3 - 0,8 m - brown to yellow brown friable (clayey) weathered shale on >2,0 m - green-brown jointed shale	SM-SC/ GP-GC/ rock	Clayey sand - moderate to poor. Weathered & solid shale } - good.	Fill? SB? SB?	Scattered bush, scrub and minor grass.	Rail-bed should be in fill when crossing this facet, with sufficient culverts to ensure free water movement. Minor foundation problems may occur in this facet.
	V.2	0,3 - >1,0 m - Alluvial light brown silty to sandy clay on 0,3 - 0,8 m - brown to yellow brown friable (clayey) weathered shale on >2,0 m - green-brown jointed shale. Subject to periodic saturation and flooding.	CL-ML/ GP-GC/ rock	Clay - poor Weathered & solid shale } - good	Nil SB? SB?		
5.	Dolerite Ridges & Hills.						
	V.1	>2,0 m - Residual dark brown to grey boulder or solid jointed dolerite, exposed on surface.	Rock	Good.	Crushed aggregate	Sparse scrub & scattered bush.	Blasting usually required for excavation.
	V.2	0,5 - 1,0 m - Residual loose rounded dolerite boulders with brown-red brown silty sand and fragments on 0,1 - 1,0 m - brown friable weathered dolerite on >2,0 m - dark grey solid jointed dolerite. Generally above ground water action.	GM-boulders/ GP/ rock	All materials - good.	Fill Fill Crushed aggregate		
6.	Dolerite Hillwash Slopes.						
	V.1	0,2 - 1,0 m - Colluvial light brown silty sand with scattered (dol) gravels on >1,0 m - brown weathered boulder or solid dolerite.	SM/ rock	All materials - good.	Fill - SB? -	Scrub with scattered bush and grass.	Material usually suitable as SB, but may require the addition of a binder to improve grading and C.B.R.
	V.2	0,2 - 0,8 m - Colluvial brown loose silty sand on 0,5 - >1,0 m - brown decomposed granular dolerite (with calcrete) on >1,0 m - brown weathered boulder dolerite. Minor ground water action after rain.	SM/ SP-SM/ rock	All materials - good.	Bin? SB. -		
7.	Pan Floors						
	V.1	0,1 - 0,5 m - Alluvial brown to light brown sandy clay with shale fragments on 0,7 - >1,0m - grey-brown clayey gypsum with shale fragments.	CL-SC/ CL	All materials - poor.	Nil Nil	Scattered scrub.	Pans often have highly gypsiferous layers below the surface. Rail-beds should be in fill when crossing pans, with sufficient culverts to ensure free water movement. Foundation problems may be encountered.
	V.2	0,5 - >1,5m - Alluvial light brown loose sand to silty sand with scattered pebbles on >1,0 m - brown weathered /decomposed dolerite or shale. Subject to periodic saturation and flooding.	SP-SM/ SM-SC	Sand - moderate Weathered rock } - good.	Fill Fill		

LAND PATTERN H (PRELIMINARY)

MATERIAL KAROO / DOLERITE

EXTENT 435K - 442K,

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Boulder Dolerite Outcrops.						
	V.1	0,5 - 1,0m - Black to dark grey residual rounded loose dolerite boulders on	Boulders/	All materials - good.	Fill	Scrub.	Blasting generally required for excavation.
		0,5 - >1,5m - dark grey-brown weathered pebble or boulder dolerite on	GP/		Fill		
		>2,0 m - grey solid jointed dolerite (medium to fine grained).	rock		Crushed aggregate.		
	V.2	0,5 - 1,0 m - Brown to black residual loose dolerite boulders intermixed with aeolian sand on	Boulders-SP/	All materials - good.	Fill		
		0,5 - >1,5m - dark grey-brown weathered pebble or boulder dolerite on	GP/		Fill		
		>2,0 m - grey solid jointed dolerite (medium to fine grained).	rock		Crushed aggregate.		
		Above ground water action.					
2.	Hillwash Slopes.	0,2 - 0,5 m - Brown loose colluvial silty sand with scattered calcrete nodules and rock fragments on	SM/	All materials - good.	Bin	Scrub & succulents.	Variable weathering depth in this facet.
		0,5 - 1,0 m - light brown to white nodular sandy calcrete on	SC-SM/		Bin-SB?		
		>0,6 m - greybrown weathered pebble or boulder dolerite with calcrete in joints - grading to solid.	GM-GP/ rock		Fill		
		Moderate ground water action after rain.					
3.	Aeolian Sands and Dunes.						
	V.1	0,5 - >1,5 m - Light brown to red brown loose aeolian sand to silty sand on	SM-SP/	Sand - moderate	Fill	Sparse scrub & bush.	Care must be taken when disturbing the surface topography or natural vegetation in this facet, as wind erosion is active - cut and fill slopes require immediate protection.
		>2,0 m - brown to black residual weathered boulder dolerite.	rock	Dolerite - good.	Fill		
	V.2	0,5 - >1,5 m - Light brown to red brown loose aeolian sand on	SP/	Sand - moderate	Fill		
		0,5 - 1,0 m - light brown nodular to powdery sandy calcrete with rock fragments on	SC-SM/	Calcrete & dolerite } - good	Bin -SB?		
		>1,0 m - brown weathered boulder dolerite, with calcrete in joints.	rock		Fill		
		Generally above ground water action.					
4.	Alluvial Wash Areas & Pans.						
	V.1	0,2 - 0,8 m - Brown fine transported silty sand with scattered rock fragments on	SW -SM/	Sands, silts & clays } - poor.	Bin?	Scrub with scattered bush & succulents.	Minor foundation problems may be associated with this facet, but will occur chiefly in the pan areas.
		0,5 - >1,0 m - light brown, soft sandy silt to sandy clay with powdery salt, gypsum or calcrete intermixed on	SC - CL/	Weathered rock } - good	Nil		
		>2,0 m - grey brown weathered dolerite.	rock		-		
	V.2	0,3 - 1,0 m - Brown to red brown silty sand with scattered calcrete nodules on	SM/	Sand & calcrete - poor	Bin?		
		0,5 - 1,0 m - light brown to white sandy calcrete on	SM-SC	Dolerite - good	Bin - SB?		
		>2,0 m - grey-brown weathered boulder dolerite.	rock				
		Subject to periodic saturation and flooding.					

LAND PATTERN J (PRELIMINARY)

MATERIAL KAROO / DOLERITE - SAND

EXTENT 346K - 356K, 380K- 386K, 419K - 435K, 446K - 453K, 492K - 504K,

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Rugged Boulder/ Solid Outcrops.						
	V.1	>2,0 m- Residual solid dolerite exposed on surface.	Rock	Good	Crushed aggregate Fill	Nil or sparse scrub & grass.	Solid dolerite sheets seldom found on surface. Requires blasting for excavation.
	V.2	0,1 - 0,5 m- Residual loose rounded dolerite boulders and pebbles, with brown silty sand on	Boulders-SM/				
		0,2 - 0,5 m- brown friable weathered pebble dolerite on	GP/	All materials - good	Fill		
		>2,0 m - hard jointed boulder or solid dolerite.	rock		Crushed aggregate		
	V.3	0,3 - 1, 0 m- Residual loose rounded dolerite boulders with brown to red brown silty sand on	Boulders-SM/	All materials - good	Fill		
		0,5 - 1,0 m- brown weathered boulder dolerite grading to solid.	rock		Fill		
		Generally above ground water action.					
2.	Thin Dykes	0,2 - 0,5 m- Residual loose dolerite boulders with brown to red brown silty sand on	GM/	All materials - good	Fill	Scrub & bush	Very limited occurrence of this facet. Possible source of underground water?
		0,5 - 1,0 m- brown weathered "fractured" dolerite grading to solid.	rock				
		Generally above ground water action.					
3.	Concave Dolerite Slopes.						
	V.1	0,5 - >1,0m- Transported brown silty sand (dol) with scattered pebbles, and occasional boulders on	SM/	All materials - good	Bin	Scrub & scattered grass.	Decomposed granular dolerite may require the addition of a binder, to improve the grading and C.B.R.
		0,5 - 1,0m- residual brown decomposed granular dolerite with boulder dolerite zones on	SP-SM/		SB		
		>2,0 m- solid jointed or boulder dolerite.	rock		-		
	V.2	0,5 - 0,8m- Colluvial light brown to brown silty sand with scattered pebbles on	SM/	All materials - good	Bin		
		0,3 - 0,9 m- white to light brown nodular to powdery calcrete on	SM-SC/		Bin-SB?		
		0,5 - 1,0 m- brown friable decomposed granular or weathered boulder dolerite on (calcrete in joints) or occasionally weathered baked shale.	SM-boulders		-		
		Minor ground water action after rain.					
4.	Drainage Depressions & Pans.						
	V.1	0,5 - >1,0m -Brown alluvial loose silty sand to sandy silt (with salt or gypsum) on	ML-SM/	Sand & silt. } - moderate to poor	Bin?	Scrub, bush & reeds.	Sands variable in grading and material type. In general will only be suitable as Conc. S. for small structures. Minor foundation problems may occur in pans.
		>1,0 m- brown weathered granular dolerite with boulder zones, grading to solid.	SM or boulders	Dolerite - good	SB?		
	V.2	0,7 - >2,0 m- Brown alluvial sand with scattered pebbles and boulders on	SW-SM/	Sand - moderate	Conc. S?		
		>1,0 m- solid rock.	rock	Rock - good.	-		
		Subject to periodic saturation and flooding.					
5.	Calcrete Mounds	0,0 - 0,3m- Colluvial brown silty sand with shale and calcrete fragments on	SM/	Sand & calcrete } - moderate	Bin	Scrub & succulents	Calcrete may have moderately high P.I. P.I. often increases with working during construction.
		0,5 - 1,0m- light brown sandy nodular to powdery calcrete on	SC-SM/	Dolerite - good	Bin - SB?		
		>0,5 m- brown decomposed or boulder dolerite with calcrete in joints	SM-boulders		Fill		
		Moderate ground water action after rain.					
6.	Baked Shale Hills & Ridges.	0,1 - 0,5 m- Residual brown silty sand with numerous weathered baked shale fragments on	GP/	All materials - good	Crushed aggregate	Scrub.	May possibly be ripped to provide S.B. and slope stability stone, but usually requires blasting for excavation.
		>2,0 m- grey-green solid jointed baked shale.	rock				
		Generally above ground water action.					

LAND PATTERN K (PRELIMINARY)

MATERIAL DWYKA/BAKED SHALE – DOLERITE **EXTENT** 414K – 419K, 442K – 446K, 466K – 480K,

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Baked Shale Hills and Ridges.	<0,3 m – Residual weathered baked shale fragments, with silty sand on	SP-GP/	All materials – good	Crushed Aggregate	Scrub	Material generally hard and suitable for slope stability stone. Often requires blasting for excavation.
		>2,0 m – solid hard baked shale (with limestone bands).	rock				
		Above ground water action.					
2.	Hillwash Slopes						
	V.1	0,3 – 1,0 m – Brown to light brown, loose colluvial silty sand with numerous weathered shale fragments on	SM/	All materials – good	Bin?	Scrub and succulents	Material variable in consistency and P.I. Where dolerite is unavailable or unsuitable for S.B. weathered baked shales should be investigated.
		0,3 – 0,6 m – brown friable weathered baked shale on	SM – GP/		SB?		
		>2,0 m – grey to brown hard solid baked shale, sometimes interbedded with bands and lenses of limestone	rock		Crushed Aggregate		
	V.2	0,2 – 1,0 m – Brown to light brown colluvial silty sand with shale fragments on	SM/	All materials – good	Bin?		
		0,2 – 1,0 m – white to light brown powdery to nodular calcrete with shale fragments on	SM – GM/		SB?		
		>1,0 m – light brown to brown friable weathered baked shale or decomposed dolerite.	SM – GP		SB		
		Minor ground water action after rain.					
3.	Concave Dolerite Slopes.						
	V.1	0,3 – 1,0 m – Brown to loose colluvial silty sand with shale fragments and scattered dolerite boulders on	SM/	All materials – good	Bin	Scrub and succulents	Main source of proposed SB. materials limiting factor will be depth of decomposed granular zone. If weathering depths are shallow, site B.P. in or near alluvial depressions (facet 5).
		0,6 – >1,5 m – brown friable residual decomposed granular dolerite.	SP – SM.		SB		
	V.2	0,1 – 0,8 m – Brown loose colluvial silty sand with shale and calcrete fragments on	SM/	All materials – good	Bin		
		0,3 – >1,0 m – light brown to white powdery to nodular calcrete with fragments on	SM – SC/		Bin? – SB?		
		>1,0 m – brown friable decomposed granular dolerite (with calcrete in joints).	SP – SM/		SB.		
		Minor to moderate ground water action after rain.					
4.	Boulder Dolerite Outcrops						
	V.1	0,3 – 1,0 m – Residual loose rounded dolerite boulders, with red brown silty sand on	Boulders/	All materials – good	Fill	Scrub and scattered bush.	Blasting required for excavation. Generally limited to small, in surface extent.
		0,7 – >1,5 m – brown weathered boulder dolerite, grading to solid.	rock		–		
	V.2	0,1 – 0,5 m – Residual loose rounded dolerite boulders, with brown silty sand on	Boulders/	All materials – good	Fill		
		0,2 – 0,6 m – brown to grey friable weathered pebble dolerite on	GP/		SB?		
		>1,5 m – hard jointed boulder or solid dolerite.	rock		Crushed Aggregate.		
		Generally above ground water action.					
5.	Alluvial Depressions						
	V.1	0,6 – >1,0 m – Light brown transported loose silty sand to sandy silt (with salt and/or gypsum) on	SM – ML/	Sand and silt – poor	Fill?	Sparse scrub and grass.	Minor foundation problems may occur in this facet. Railbed should be in fill over this facet with sufficient culverts to ensure free water movement in the depression area.
		>1,0 m – brown decomposed granular dolerite with boulder zones, grading to weathered boulder dolerite.	SM – SP/ rock	Dolerite – good	SB?		
	V.2	0,3 – 1,0 m – Light brown transported silty sand to sandy clay with fragments (with salt and/or gypsum) on	SM – CL/	Sand and clay – poor	Fill?		
		0,2 – 0,8 m – brown friable weathered baked shale (with calcrete in joints) on	SM – GP/	Weathered & solid shale } – good	SB?		
		>1,0 m – grey-brown hard jointed baked shale.	rock		Crushed Aggregate.		
		Subject to periodic saturation and flooding.					
6.	Aeolian Sands and Dunes.	0,5 – >1,5 m – Brown loose aeolian sand to silty sand with loose surface gravel float on	SM – SP/	Sand – moderate	Fill	Sparse scrub or nil	Care must be taken when disturbing the surface topography or natural vegetation in this facet, as wind erosion is active – cut and fill slopes require protection.
		>1,0 m – brown weathered boulder dolerite.	rock	Dolerite – good	Fill		
		Above ground water action.					

LAND PATTERN N (PRELIMINARY)

MATERIAL QUATERNARY/COASTAL SAND **EXTENT** 685 K - 854K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Rounded Granite Hills V.1	0,3 - 0,8 m - Brown aeolian loose silty sand with scattered calcrete pebbles & boulders on 0,3 - >1,0 M - marine white hard nodular calcrete (phosphatic) on >1,0 m - solid or slightly weathered granite.	SM/ GP/ rock.	Sand - moderate Calcrete & Rock } - good	Fill SB	Grass, scrub, heather & succulents	Requires further investigation to determine accurate soil profile. Probably requires blasting for excavation?
	V.2	0,2 - >1,0 m - brown residual coarse silty sand with scattered boulders on 0,5 - 0,9 m - grey-brown friable weathered & decomposed granite on >2,0 m - solid grey to pink jointed granite. Generally above ground water action.	SM/ SP - GP/ rock.	All materials - good	Fill S.B.? Crushed aggregate		
2.	Solid Granite Domes	3,0 - >10,0 m - Pink to grey, coarse to medium grained granite, exposed on surface. Above ground water action.	Rock .	Good	Crushed aggregate	Nil	Not encountered along centre line.
3.	Solid Table Mountain Sand-stone Outcrops.	>2,0 m - Light brown residual friable to hard, weathe red (occasionally ferruginised) sandstone, quartzite or pebble conglomerate with loose boulders exposed on surface, and sometimes interbedded with friable siltstone layers. Above ground water action.	Rock	Good	Crushed aggregate	Nil or scattered bush	Material extremely variable in consistency & hardness.
4.	Calcrete Ridges & Exposures. V. 1	0,5 - 1,0 m - Marine solid white nodular calcrete with boulders exposed on surface.	GP	Good	S.B.?	Grass, scrub, heather, cultivation & succulents.	Material variable in consistency with varying gypsum & phosphate contents.
	V.2	0,1 - 0,7m - Light brown loose aeolian sand to silty sand on 0,5 - >1,0m - solid white marine nodular calcrete, sometimes intermixed with shells. Generally above ground water action.	SM - SP/ SM-GP/	Sand - moderate Calcrete - good	Fill S.B.?		
5.	Sand Plains	0,5 - >1,0m - Light brown to red brown loose aeolian silty sand to to sand on 0,3 - >1,0m - white powdery to nodular calcrete (and gypsum) on >1,0 m - solid or slightly weathered rock, or marine shingle deposits. Generally above ground water action.	SM - SP/ CL-GP/ GM-rock	Sand - moderate Calcrete, Rocks & Shingles. } - good.	Fill Fill SB? SB?	Cultivation, scrub and bush.	Variable sand thicknesses overlie the calcrete. Special care should be taken when disturbing the natural vegetation in this facet (wind erosion).
6.	Coastal Dunes	1,0 - >3,0 m - White to grey brown loose aeolian sand (with shell fragments) on 0,5 - >2,0 m - white friable, powdery & layered marine sandy calcrete and/or gypsum. Above ground water action.	SM-SP	Sand - moderate Calcrete - moderate to good	Fill Bin?	Bush & succulents	Dune areas are highly susceptable to wind erosion, hence immediate protective measures required where natural vegetation is disturbed.
7.	Mobile Sands	0,7 - >2,0m - Red brown to white very loose aeolian sand (unstable) Above ground water action.	SP	Sand - poor	Nil	Nil	Sand of single grain size, hence poor compaction & easily eroded by wind.
8.	Beach Area	0,5 - >1,0m - Light brown very loose marine sand with shells & scattered pebbles. Regularly saturated and/or flooded.	SM - SP	Sand - poor	Nil	Nil	Sand has poor grading & is subject to scour by the sea.
9.	Alluvial & Old Coastal Lagoon Depressions V.1	0,5 - >1,0m - Fine brown alluvial sand with shell fragments on 0,6 - >1,0m - dark grey-brown sand with shell fragments on >1,0m - marine shingle deposits or weathered rock.	SP/ SM-SP GM-rock.	Sand, Calcrete & Gypsum } - poor	Fill SB?	Reeds, grass, scrub & cultivation	Lagoonal areas & large depressions, require detailed investigation to determine depth to solid rock & bearing capacity of saturated sands. Possible foundation problem area.
	V.2	0,6 - >1,5m - Light green-brown, clayey sand to sandy silt with salt encrustation on 0,5 - >1,0m - white layered or powdery calcrete and/or gypsum Moderate ground water action with periodic saturation.	SC-ML/ SM-CL		Fill Bin.		
10.	River Floodplains & Swamps V.1	Water in river bed.	-		-		
	V.2	Mud and sand tidal flats Permanently saturated & regularly flooded.	CL-SP	Bad	Nil	Nil or succulents	Detailed foundation investigations required.
11.	Hillwash Slopes V.1	0,5 - >2,5m - Brown loose hillwash of silty sand on 0,5 - >3,0m - moderately hard brown dorbank on >1,0m - light brown weathered sandstone, quartzite or pebble conglomerate.	SM/ GM-SM/ GM-rock.	Sand - moderate Dorbank & Rock } - good	Fill SB SB	Scrub, cultivation & succulents.	Materials variable in consistency and quantity. Overburden depths to possible S.B. material will also be variable.
	V.2	0,3 - >1,0m - Light brown loose hillwash of sand on >1,0m - light brown weathered sandstone, quartzite or pebble conglomerate.	SM/ GM- rock.	Sand - moderate Rock - good	SB		
	V.3	0,1 - >1,0m - Light brown loose aeolian sand on 0,6 - >5,0m - yellow brown to grey brown residual clayey sand with scattered pebbles on >2,0m - dark grey brown decomposed basalt. Minor ground water action after rain.	SM/ SC/ SM-GM	Sand & Clayey sand } - moderate Dec. Rock - good.	Fill Nil SB		

LAND PATTERN N (PRELIMINARY)

MATERIAL QUATERNARY/COASTAL SAND **EXTENT** 685K - 854K

Page 2.

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
12.	Coastal Cliffs.						
	V.1	>2,0m - Solid rock exposed on surface.	Rock	Good	Crushed aggregate	Sparse scrub & succulents	Materials generally unconsolidated, which together with moderately steep slopes, provides poor foundation conditions and unstable cut faces.
	V.2	0,5 - >1,0m - Loose brown aeolian sand to silty sand on 0,0 - >1,0m - brown silty sand with calcrete (& gypsum) on 1,0 - >6,0m - intermixed beach shingles with brown sand & occasional hardpan layers on	SP-SM/ SM/ SM-GM/	All materials - moderate to poor	Fill Fill SB ?		
		>1,0m - yellow-purple-brown banded friable mudstones & siltstones.	SC-GP		SB?		
		Generally above ground water action.					

LAND PATTERN P (PRELIMINARY)

MATERIAL NAMA/AEOLIAN SAND **EXTENT** 644K – 685K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Rock Outcrops						
	V.1	>2,0 m Grey to light brown solid limestone, exposed on surface.	Rock	Good.	Crushed aggregate.	Sparse scrub.	Only limited outcrops of this face occur along the route. Blasting often required for excavation.
	V.2	<0,2 m Grey-brown residual weathered phyllite & quartzite fragments on >2,0 m grey-brown fractured hard quartzite.	SP-GP/ rock	Good.	Crushed aggregate.		
	V.3	0,0 – 0,3 m Brown-grey residual disintegrated phyllite fragments intermixed with brown silty sand (quartz gravels) on >2,0 m grey-green weathered fractured & laminated phyllite with thin quartzite bands & quartz inclusions. Above ground water action.	SP-GP/ rock	All materials – good.	Fill & SB?		
2.	Sand Plains						
	V.1	0,5 – >1,0 m Brown to red brown loose aeolian sand to silty sand on 0,3 – >1,0 m white powdery to nodular calcrete (with gypsum) on >1,0 m weathered rock or marine/alluvial gravel deposits.	SM-SP/ CL-GM/ rock -GM	Sand – moderate Calcrete, gravel & weathered rock. } – good.	Fill SB? SB	Scrub and cultivation.	Variable sand thicknesses overlie the calcrete. Special care shoul be taken when disturbing the natur vegetation in this facet (wind erosion).
	V.2	0,1 – 0,6 Brown to red brown aeolian silty sand with calcrete or dorbank fragments on 0,5 – >1,0 m white to light brown powdery to nodular calcrete or dorbank on 0,5 – >1,0 m alluvial gravels or weathered rock. Generally above ground water action.	SM/ SM-GM/ GM-rock	Sand – moderate. Calcrete, dorbank gravels & rock } – good.	Fill SB? SB.		
3.	Mobile Sands	0,5 – >2,0 m Light brown to red brown very loose aeolian sand (unstable). Above ground water action.	SP	Sand – poor	Nil	Nil	Mobile sands are chiefly localised "blow-outs". Sand of single grainsize, hence poor compaction & easily eroded by wind.
4.	Dune Areas	1,0 – >3,0 m Light brown to red brown loose aeolian sand on 0,5 – >1,0 m light brown to white calcrete or dorbank on 0,5 – >1,0 m alluvial gravels or weathered rock. Above ground water action.	SP-SM/ SM-GM/ GM-rock	Sand – moderate – poor Calcrete, dorbank gravels & rock. } – good.	Fill SB? SB.	Scrub	Dunes are highly susceptable to wir erosion, hence require immediate protective measures when natural vegetation is disturbed.
5.	Raised Gravel Terraces.	0,5 – >2,0 m Alluvial rounded river gravels, pebbles and scattered boulders intermixed with brown silty sand on >1,0 m grey-brown weathered phyllite, quartzite or limestone. Above ground water action.	GM-GP/ rock	All materials – good	SB SB?	Scrub & scattered bush.	Gravels are variable in consistency and thickness.
6.	Alluvial Depressions.	0,0 – 0,5 m Transported light brown to brown silty sand on 0,5 – >2,0 m yellow brown sandy calcrete (with gypsum). Strong ground water action after rain.	SM/ ML-SC	All materials – poor	Fill	Nil	Very minor development in this land pattern.
7.	Hillwash Slopes						
	V.1	0,0 – 0,5 m Brown colluvial loose silty sand with scattered pebbles on 0,5 – >3,0m brown to light brown hard dorbank with thin calcrete layers on >1,0 m light green-brown sandy gypsum beds.	SM/ SM-GM/ SM-ML	Sand, dorbank calcrete & gypsum. } – poor	Fill SB Nil	Scrub & scattered bush.	Highly variable slopes and material consistencies in this facet.
	V.2	0,5 – >1,0 m Brown colluvial loose silty sand with scattered gravels, pebbles and calcrete fragments on 0,0 – >1,0 m light brown friable calcrete with scattered gravels, pebbles and boulders on >1,0 m weathered rock. Minor ground water action after rain.	SM/ SM-GM/ rock	Sands – moderate – good Calcrete & rock. } – good	Bin SB? SB?		

LAND PATTERN Q (PRELIMINARY)

MATERIAL NAMA/COLLUVIUM - PHYLLITE

EXTENT 562 K - 644 K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Rounded Hills, Ridges & Slopes.						
	V.1	<0,3 m - Light brown, loose silty sand with disintegrated phyllite fragments & quartz gravels on >2,0 m - brown friable weathered mudstone, phyllite & siltstone grading to solid (green-grey phyllite has quartz inclusions & discontinuous conglomerate layers).	SM - SP/ rock	Good	Fill S.B.?	Sparse scrub.	Material generally rippable.
	V.2	<0,2 m - Light brown loose silty sand with quartz gravels, disintegrated phyllite & quartzite fragments, pebbles & boulders on >2,0 m - brown to green-grey solid quartzite.	SP - GP/ rock	Good	Crushed Aggregate		Material requires blasting.
	V.3	<0,2 m - Light brown, loose silty sand with fragments & boulders on >2,0 m - light brown to grey solid hard limestone.	GP / rock	Good	Crushed Aggregate		Material requires blasting.
	V.4	>2,0 m - Dark brown to black haematite & goethite rich quartzite zones exposed on surface. Generally above ground water action.	Rock	Good	S.B.?		Material possibly rippable.
2.	Sand Plains						
	V.1	0,3 ->1,0 m - Brown to red brown silty sand to sandy silt with scattered surface gravels on >1,0 m - brown to light brown powdery to nodular calcrete or hard dorbank, often intermixed with sand, gravels and pebbles on >2 0 m - weathered rock.	SM-ML/ SM-GM/ rock	Sand - moderate Gypsum - poor. Calcrete, Dorbank & Rock } - good.	Fill S.B.? S.B.	Scrub & succulents	Gypsum deposits generally very fine grained (ML) and loosely compacted. Materials in this facet should be checked for consolidation and/or collapsing properties.
	V.2	0,5 - >1,5 m - Grey-brown silty sand with calcified gravels and pebbles exposed on surface.	SM-SP	Moderate	S.B.?		
	V.3	0,3 - 0,7 m - Light brown loose sandy silt to silty sand on 1,0 - >3,0 m - brown sandy to silty gypsum beds on >0,3 m - white powdery to nodular calcrete. Generally above ground water action.	SM-ML SC / SP - GP	Sand - moderate Gypsum - poor Calcrete - good	Fill - S.B.		
3.	Pedogenic Exposures						
	V. 1	0,0 - 0,3 m - Brown silty sand with scattered gravels on 0,5 - >1,0 m - brown hard dorbank with scattered gravels & pebbles.	SM/ SP	Sand - moderate Dorbank - good	Bin S.B.	Scrub, reeds & succulents.	Pedogenic materials very variable in consistency, with harder varieties being suitable for S.B. Gypsum may have been precipitated with the calcrete and dorbank?
	V.2	0,0 - 0,3 m - Brown silty sand with scattered gravels on 0,5 - >1,0 m - light brown to white powdery to hard nodular calcrete (with scattered gravels & pebbles). Minor ground water action after rain.	SM/ SP-GP	Sand - moderate Calcrete - good	Bin S.B.		
4.	Hillwash Areas						
	V.1	0,5 - 1,0 m - Brown to red brown silty sand with scattered weathered rock fragments & gravels on 0,3 ->1,0 m - powdery to nodular sandy calcrete or dorbank with gravels and pebbles on >0,5 - green-brown weathered phyllite, quartzite or limestone.	SM/ SC-GP/ rock	Sand - moderate Calcrete, Dorbank & rock } - good	Fill & S.B.?	Scrub, reeds & succulents.	In general the highly gypsiferous deposits should be excluded from the control layers of the railbed, due to fine grading and possible deleterious effects.
	V.2	0,3 - 1,0 m - Light brown loose sandy silt with scattered fragments on >2,0 m - grey-green (weathered) phyllite, quartzite or limestone.	ML/ rock	Sand - moderate Rock - good	Fill & S.B.?		
	V.3	0,2 - 0,9 m - Red brown to light brown silty sand with quartz gravels on 0,5 - >1,0 m - light brown silty to sandy gypsum beds with calcrete bands on >1,0 m - green-grey weathered phyllite, quartzite or limestone. Minor ground water action after rain.	ML-SM/ ML/ GM-GP	Sand - moderate Gypsum - poor Rock - good	Fill Nil S.B.?		
5.	Raised Gravel Terraces	0,5 - 1,0 m - Brown loose intermixed rounded river sand, gravels & pebbles with scattered boulders on >1,0 m - grey-green weathered phyllite, quartzite or limestone. Above ground water action.	GP-GM/ SP-GP	All materials - good	Fill & S.B. Crushed Aggregate?	Sparse scrub & succulents	Gravels have variable thickness & consistency, but generally cover a large area.
6.	Alluvial Wash Areas						
	V.1	0,3 - 1,0 m - Red brown to light brown loose silty sand on 0,5 - >2,0 m - brown to grey-brown sandy to silty gypsum beds (with calcrete bands) on >1,0 m - green-grey, friable disintegrated shale, phyllite, siltstone & quartzite layers, grading to solid.	SM/ SM-ML/ SM-GM	Sand - moderate Gypsum - poor Rock - good	Fill - S.B.?	Scrub, succulents & reeds	Gypsum deposits associated to varying degrees with materials in this facet.
	V.2	0,3 - 1,0 m - Brown to red brown loose silty sand (with weathered rock fragments) on 0,5 - >1,0 m - light brown to white calcrete with gravels & pebbles on >1,0 m - weathered rock. Strong ground water action after rain.	SM/ SM-GM/ rock	Sand - moderate Calcrete & Weathered Rock } - good	Bin? S.B.		

LAND PATTERN Q (PRELIMINARY)

MATERIAL NAMA/COLLUVIUM - PHYLLITE

EXTENT 562 K - 644 K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
7.	Flood Plains V.1	0,3 - 0,6 m - Brown loose silty sand on 1,0 - >2,5 m - brown-grey silty to sandy gypsum beds on >2,0 m - friable disintegrated or weathered rock .	SM/ ML-SM/ GP-ML.	Sand & Gypsum } - poor. Weathered Rock - moderate to good	Bin - S.B.?	Bush, scrub & reeds	Materials variable but generally fine grained.
	V.2	0,5 - >2,0 m - Light brown loose interbedded layers of silty sand & sandy silt. Subject to periodic saturation & flooding.	SM-ML	Moderate	Bin		
8.	River Beds V.1	0,6 - >1,5 m - Grey-brown very loose gravelly sand with scattered pebbles - salt & gypsum encrustations on surface.	SM-GM	Bad	Conc. S? S.B.? Fill	Sparse scrub & reeds	Often strong evidence of deleterious salt deposition, hence water not suitable as "mix water" for concrete, & will "attack" normal concrete.
	V.2	>2,0 m - Solid rock exposed in river bed. Often saturated and subject to periodic flooding.	Rock	Good	-		
9.	Aeolian Sands	0,5 - >1,0 m - Red brown fine aeolian sand on 0,3 - >1,0 m - brown silty to clayey sand with (gypsum) calcrete & scattered gravels on >1,0 m - grey to green weathered phyllite, limestone or quartzite. Above ground water action.	SP-SM/ SC-GM/ rock	Sand Gypsum & Calcrete } - moderate Weathered rock - good	Bin? Fill S.B.? S.B.?	Scrub	Sands are semi-stable, but will become mobile if surface vegetation or topography is disturbed.
10.	Strongly Dissected Slopes	0,0 - 0,8 m - Brown silty sand with scattered gravels on 0,0 - >1,0 m - brown silty to sand gypsum beds (with calcrete) on >1,0 m - brown to grey weathered phyllite, quartzite or limestone. Generally above ground water action.	SM/ SM-ML/ GM	All Materials - poor	Fill - S.B.?	Nil	Materials strongly susceptible to erosion & scour. Fills in this facet should be constructed of good material and have their sides protected. Cuts should have low batters & be protected.

LAND PATTERN T (PRELIMINARY)

MATERIAL BASEMENT / GRANITE - GNEISS

EXTENT 515K - 561K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Solid Rock Outcrops. V.1	<0,3 m - Brown residual boulders, pebbles and silty sand on >3,0 m - pink to grey solid granite-gneiss (slightly weathered).	GM-Boulders Rock	All materials - good.	Crushed aggregate	Sparse scrub.	Material is variable in consistency and hardness. Requires blasting for excavation.
	V.2	<0,5 m - Brown residual boulders pebbles and silty sand on >3,0 m - white to light brown quartz - schist and granulite interbanded with granite - gneiss and pegmatite. Above ground water action.	GM-Boulders Rock	All materials - good.	Fill		
2.	Hillwash Slopes and Fans. V.1	0,6 ->2,0 m- Brown to light brown loose, colluvial silty to gravelly sand with pebbles on 0,0 - 0,8 m- light brown powdery to nodular calcrete on >1,0 m- weathered granite - gneiss grading to solid (or shale).	SM-GM/ SM-GP/ rock	All materials - good	Conc.S - SB? Bin - SB? -	Scrub & grass.	Material variable, but suitable for excavation by mechanical methods. Colluvial fans should supply material suitable for Conc. S.
	V.2	0,0 - 0,7 m- Brown, loose colluvial silty to gravelly sand and quartz pebbles on >1,0 m - pink to grey brown friable weathered granite-gneiss or friable biotite-gneiss with hornblende schist bands. Minor ground water action after rain.	SM-GM/ GP-rock	All materials - good	Fill SB?		Ripping and blasting may be required for excavation.
3.	Colluvial Plains	0,3 - >1,0 m- Brown to red brown colluvial loose silty sand to sandy silt with scattered surface gravels on >1,0 m - brown to light brown, powdery to nodular calcrete or hard dorbank (with sand, gravels and pebbles) on >2,0 m - weathered granite-gneiss grading to solid. Generally above ground water action.	SM-ML/ SM-GM/ rock	Sand and silt } - moderate. Calcrete, dorbank & weathered rock } - good.	Bin? SB? -	Scrub, grass & succulents.	Gypsum may be associated with this facet. Materials should be checked for consolidation and/or collapsing properties.
4.	River Flood Plains V.1	0,3 - 1,0 m- Brown loose alluvial sand with scattered gravels on 0,5 - 1,0 m- light brown to white, powdery to nodular calcrete on 0,8 - >2,0m- alluvial gravels and sand on >2,0m - solid granite-gneiss (or shale).	SM/ SM-GP/ SM-GM/ rock	Sand, calcrete & gravels } - moderate Rock - good	Conc. S SB? - Bin SB -	Scrub, grass & succulents.	Sand will be variable in grading, but may be suitable for use in concrete.
	V.2	0,8 - >1,5m- Brown to red brown loose aeolian sand on 1,0 - >2,0m- interbedded alluvial brown silty sand and gravelly sand layers (with calcrete). Subject to periodic saturation and occasional flooding.	SP/ SM	Sand - moderate Alluvial materials } - good.	Fill -Bin? SB-Conc. S?		
5.	River Beds V.1	0,6 - >2,0m- Brown loose alluvial sand with scattered gravels and pebbles on >1,0 m- solid or weathered rock.	SP-SM/ rock	Sand - moderate to poor. Rock - good.	Conc. S - Fill -	Reeds & scrub.	Evidence of precipitation of deleterious salts often occurs in this facet. Sands will have variable gradings, but should be suitable for use in concrete.
	V.2	0,5 ->1,0m- Brown loose alluvial sand with scattered gravels on 0,5 - 1,0m- light brown powdery, to nodular calcrete. Subject to periodic saturation and flooding.	SP-SM/ SM	Sand and calcrete } - moderate to poor.	Conc. S Bin - SB?		
6.	Tillite Cappings	0,0 - 0,2 m - Residual loose erratics and weathered tillite on >2,0 m- grey-green solid tillite. Above ground water action.	GP/ rock	All materials - good.	Crushed aggregate	Sparse scrub.	Located on hilltops and not encountered within the detailed mapping area.
7.	Dwyka Colluvial Slopes. V.1	0,5 - 1, 0 m- Brown colluvial silty sand with numerous weathered shale fragments and scattered erratics on >2,0 m - solid or weathered granite-gneiss.	SM-GM/ rock	Colluvial sand } - moderate Rock - good	Fill -	Scrub & grass.	Only small occasional scattered outcrops occur along this section of the route.
	V.2	0,1 - 0,6m - Brown colluvial silty sand with numerous weathered shale fragments and scattered erratics on >1,0 m- green to grey-brown friable residual weathered shale or tillite. Minor ground water action after rain.	SM-GM/ GP-rock	All materials - good	SB? - Fill -		Material will probably require the addition of a binder, if used in the sub-ballast layer.
8.	Pedogenic Exposures	0,0 - 0,3 m - Brown colluvial silty sand with scattered gravels on 0,5 ->1,0m- brown hard dorbank or powdery to nodular calcrete, with scattered gravels and pebbles. Minor ground water action after rain.	SM/ SM-GP/	Sand - moderate Dorbank & calcrete } - good	Bin? SB?	Scrub & succulents	Only small scattered outcrops occur along this section of the route.
9.	Aeolian Sands	0,5 ->1,0m- Brown to red brown loose aeolian sand on >1,0m - pedogenic or alluvial deposits. Above ground water action.	SP/ SM-GP	Sand - moderate Other materials - good	Fill SB?	Nil or sparse scrub.	All cut and fill slopes will require protection against wind erosion in this facet.

LAND PATTERN U (PRELIMINARY)

MATERIAL BASEMENT / GNEISS

EXTENT 222K - 256K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Dome & Boulder Outcrops.						
	V.1	< 0,3 m – Grey to brown loose residual gneiss boulders with brown silty sand on	SM-Boulders/	All materials – good.	Fill	Bush, scrub & grass.	Very few outcrops occur in mappin zone.
		>1,0 m – pink to grey weathered friable hornblende schist, amphibolite or gneiss, grading to solid.	SM-GP		SB?		Blasting required for excavation.
	V.2	>2,0 m – Pink to grey solid granite-gneiss exposed on surface.	Rock	Good	Crushed aggregate	Sparse scrub.	
		Above ground water action.					
2.	Low Convex Hills.	< 0,3 m – Brown loose residual silty sand with scattered pebbles and boulders on	SM/	All materials – good.	Fill	Scrub & grass.	Materials can often be ripped with mechanical excavation.
		>1,0 m – pink to grey friable weathered gneiss, amphibolite or hornblende schist, grading to solid.	SM-GP		SB?		
		Above ground water action.					
3.	Hillwash Slopes						
	V.1	0,5 – 1,0 m – Brown loose colluvial silty sand with scattered gravels on	SM/	All materials – good	Bin?	Scrub & grass.	Variable weathering depths and calcrete precipitation.
		>1,0 m – pink to grey weathered friable gneiss, hornblende schist or amphibolite, grading to solid.	SM-GP		SB?		Generally mechanical excavation.
	V.2	0,3 – 0,7 m – Brown loose colluvial silty sand with scattered gravels and erratics on	SM/	All materials – good	Bin?		
		0,5 – 1, 0 m – white powdery to nodular calcrete (with sand) on	SM-GM/		Bin – SB?		
		>1,0 m – pink to grey friable weathered gneiss, amphibolite or hornblende schist, grading to solid.	SM-GP		SB?		
		Minor ground water action after rain.					
4.	Aeolian Sand Dunes.	>1,0 m – Red brown loose aeolian sand.	SP	Sand – moderate	Fill	Sparse scrub.	All cut and fill slopes require protection in this facet.
		Above ground water action.					
5.	Alluvial Wash Areas.						
	V.1	0,5 – >1,0 m – Red brown loose alluvial silty sand with scattered gravels on	SM/	Sand & calcrete } – moderate.	Conc S?	Scrub, bush & grass.	Bridge and culvert abutments should be protected against scour in this facet.
		0,5 – 1,0 m – light brown powdery to nodular calcrete with scattered gravels on	SM-GM/	Rock – good.	SB? – Bin		
		>1,0 m – weathered rock.	rock		–		
	V.2	0,5 – >1,0 m – Red brown loose alluvial silty sand on	SM/	All materials – moderate to poor.	Conc S?		
		>0,5 m – red brown alluvial sandy clay.	SC-CL		Nil		
		Periodic saturation or flooding.					
6.	Calcrete Deposits.	< 0,3 m – Light brown loose colluvial silty sand with scattered calcrete fragments on	SM/	All materials – good.	Bin?	Scrub & succulents.	Material consistency highly variable.
		0,6 – >1,0 m – white to light brown, powdery to nodular calcrete with scattered gravels.	SM - GM		Bin – SB?		
		Moderate ground water action after rain.					
7.	Dolerite Dykes	0,2 – 0,6 m – Brown residual loose dolerite boulders with pebbles and silty sand on	GP-Boulders/	All materials – good	Fill	Sparse bush & scrub.	Dykes usually very thin.
		>1,0 m – brown to grey weathered, fractured dolerite.	rock		–		
		Generally above ground water action.					
8.	Pegmatite Veins	>1,0 m – White residual fractured and broken pegmatite (quartz & feldspar) fragments, pebbles & boulders, grading to solid jointed material with depth.	GP-Boulders/ rock	All materials – good.	SB? Crushed aggregate	Sparse scrub.	Outcrops generally limited in extent.
		Generally above ground water action.					

LAND PATTERN V (PRELIMINARY)

MATERIAL K[illegible]/GNEISS - SCHIST

EXTENT 258 K - 286 K, 290 K - 298 K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Domes and Boulder Outcrops	>3,0 m Solid granite-gneiss, pink to grey in colour, exposed on surface. Above ground water action.	Rock	Good	Crushed aggregate	Sparse scrub	Requires blasting for excavation.
2.	Low Convex Hills	0,2 - 0,6 m Brown to light brown residual silty sand with scattered gravels, calcrete and pebbles on >1,0 m grey to pink, friable weathered banded gneiss, schist, amphibolite or metavolcanics, grading to solid with depth. Generally above ground water action.	SM/ GM-GP/ rock	All materials - good	S.B. S.B?-Fill	Scrub	Variable material types and rock hardnesses, often rippable.
3.	Aeolian Sands	>1,0 m Red brown loose aeolian sand. Above ground water action.	SP	Sand - moderate	Fill	Sparse scrub and grass	Dunes only partially stable, hence all cut and fill slopes require immediate protection.
4.	Alluvial Wash Areas V1	0,3 - 1,0 m Brown loose alluvial silty sand with scattered calcrete nodules on 0,3 - >1,0 m white sandy, powdery to nodular calcrete on >1,0 m weathered rock.	SM/ SM-SC/ GM	Sand and calcrete - moderate Rock - good	Fill-Bin SB? SB?	Scrub and bush	Culvert abutments should be protected against scour.
	V2	0,3 - >1,0 m Brown loose alluvial silty to clayey sand with scattered gravels on >1,0 m weathered or solid rock. Subject to periodic saturation and flooding.	SM-SC/ GM-rock	Sand - moderate Rock - good	Fill -		
5.	Pegmatite Veins	>1,0 m White loose residual pegmatite gravels, pebbles and boulders (quartz and feldspar) exposed on surface and grading to solid with depth. Generally above ground water action.	GP	Good	Conc A?	Sparse scrub	Veins and "blow-outs" usually small and thin.
6.	Flood Plains	>3,0 m Interbedded fine brown alluvial silty sand and light brown alluvial sandy silt. Subject to periodic saturation and flooding.	SM/ ML	All materials - moderate to poor	Conc S? - Fill	Scrub, reeds and bush	Bridge abutments should be protected against scour.
7.	River Beds	>2,0 m Brown loose (coarse) alluvial silty sand to sand. Subject to continual or periodic saturation, also flooding.	SM-SW	Sand - poor	Conc S	Nil	Evidence of deleterious salt precipitation often visible in bed.
8.	Basic Rock Outcrops	0,5 - >1,0 m Black to dark brown, friable weathered hornblende schist or amphibolite bands grading to solid with depth. Generally above ground water action.	SM-SP/ rock	All materials - good	Fill	Scrub	Zones generally limited in extent.

LAND PATTERN W (PRELIMINARY)

MATERIAL KHEIS/GRANULITE - AMPHIBOLITE

EXTENT 286 K - 290 K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Folded Steep Ridges	< 0,2 m Brown colluvial silty sand with gravels, pebbles and boulders on > 2,0 m grey, solid jointed gneiss or granulite. Above ground water action.	GP/ rock	All materials - good	Fill Crushed aggregate	Scrub, bush and scattered trees (Kokerboom)	Blasting required for excavation.
2.	Low Rounded Hills	0,2 - 0,6 m Brown residual silty sand with scattered gravels and pebbles on >1,0 m light brown to grey weathered schists, gneiss, metavolcanics and quartzites. Generally above ground water action.	SM/ GM-GP	All materials - good	Bin?-Fill SB?	Scrub	Sand and weathered rock can usually be ripped. Blasting will be required for solid rock.
3.	Amphibolite Outcrops	> 2,0 m Grey to black friable residual sand with pebbles and boulders intermixed, grading to solid jointed amphibolite with depth. Generally above ground water action.	GM/ rock	All materials - good	Fill	Scrub	Weathered rock can be ripped while solid requires minor blasting.
4.	Alluvial Wash Areas						
	V1	0,5 - >1,0 m Brown to red-brown alluvial silty sand on >1,0 m weathered metavolcanics, schist or quartzite.	SW-SM/ GM	Sand - moderate Weathered rock - good	Bin? Conc S? -	Scrub, bush and trees	Most likely sources of concrete sand are located in the larger stream and river beds.
	V2	0,3 - >1,0 m Brown loose alluvial silty sand with scattered calcrete nodules on 0,3 - 1,0 m white powdery to nodular sandy calcrete on >1,0 m weathered metavolcanics, schist or quartzite. Subject to periodic saturation or flooding.	SW-SM/ SM-SC/ GM	Sand and calcrete - moderate Weathered rock - good	Conc S? SB? SB?		
5.	Talus Slopes	0,5 - 1,0 m Grey-brown loose colluvial intermixed sand, gravels, pebbles and boulders (talus) on >2,0 m solid jointed gneiss, quartzite, schist, metavolcanics. Generally above ground water action.	GP/ rock	Talus -moderate to poor Rock - good	Fill Crushed aggregate	Scrub, bush and scattered trees	Talus can generally be excavated mechanically, rock requires blasting.

LAND PATTERN X (PRELIMINARY)

MATERIAL DWYKA/TILLITE

EXTENT 300K - 324 K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.		UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Tillite Outcrops	< 0,3 m >2,0 m	Residual brown silty sand with scattered erratics, gravels, pebbles and boulders on solid grey-brown jointed tillite. Above ground water action.	GM/ rock	All materials - good	Fill Crushed aggregate	Sparse scrub	Material requires blasting for excavation.
2.	Low Convex Hills V1	0,3 - 0,5 m >1,0 m	Residual brown silty sand with nodular calcrete fragments on grey-brown solid jointed tillite.	SM/ rock	All materials - good	Fill Crushed aggregate	Scrub and grass	Upper material layers could be ripped - solid tillite will require blasting.
	V2	0,1 - 0,5 m 0,3 - 0,8 m >1,0 m	Colluvial brown silty sand with scattered erratics and pebbles on white powdery to nodular calcrete on grey-brown solid jointed tillite. Generally above ground water action.	SM/ SM-SC/ rock	All materials - good	SB? SB? Crushed aggregate		
3.	Surface Calcretes	0,5 - >1,0m >0,6 m	White powdery to nodular calcrete with scattered gravels and pebbles exposed on surface on weathered friable dolerite or tillite. Moderate ground water action after rain.	SM-SC/ GP	All materials - good	SB? SB?	Sparse scrub	Deposits generally shallow in depth - mechanical excavation required.
4.	Hillwash Slopes V1	0,3 - 0,8 m >1,0 m	Brown silty to clayey sand with erratics, gravels, pebbles and boulders intermixed on grey-brown weathered tillite or shaly tillite.	SC-SM/ GP-GM	All materials - good	Fill-SB? SB?	Scrub and grass	Depths of weathered tillite will generally be small - P.I.'s will be variable.
	V2	0,5 - 1,0 m 0,3 - 1,0 m >1,0 m	Brown silty sand with intermixed gravels and pebbles on white powdery to nodular calcrete on grey-brown weathered tillite or shaly tillite. Moderate ground water action after rain.	SM/ SM-SC/ GP-GM	All materials - good	SB? SB? SB?		
5.	Alluvial Wash Areas V1	0,5 - 1,0 m 0,5 - 1,0 m >1,0 m	Brown loose alluvial silty sand with intermixed gravels on brown firm alluvial clayey sand to sandy clay on weathered tillite.	SM/ SC-CL/ rock	Sands and clays - moderate to poor Tillite - good	Bin? Nil -	Scrub and scattered bush	Materials variable in consistency and P.I.
	V2	0,5 - 1,0 m 0,3 - 0,9 m >1,0 m	Brown loose alluvial clayeysand with scattered gravels and pebbles on white powdery to nodular calcrete with scattered gravels on weathered tillite or shaly tillite. Subject to periodic saturation and flooding	SC/ SC-SM/ GM-GP	Sands and calcrete - moderate Tillite - good	Fill SB? SB?		
6.	Dolerite Intrusions V1	>1,0 m	Dark brown to black residual dolerite boulders, pebbles and silty sand grading to weathered fractured dolerite with depth (dykes).	GP/ rock	All materials - good	Fill	Scrub and grass	Dykes are generally scarce and thin in width, while sills only appear to occur at the contacts of tillite/gneiss and tillite/shaly tillite.
	V2	0,3 - 0,8 m >1,0 m	Brown colluvial silty sand with scattered gravels and pebbles on brown decomposed or weathered dolerite with boulders (sills). Variable water table conditions.	SM/ SM-GM	All materials - good	SB? SB?		

LAND PATTERN Y (PRELIMINARY)

MATERIAL PRETORIA / QUARTZITE - IRONSTONE **EXTENT** 31K - 35K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Rock Outcrops	<0,3 m - Brown residual silty sand with scattered gravels, pebbles and boulders (talus) on >1,0 m - solid jointed and banded quartzite, ironstone, shale or limestone. Above ground water action.	GP/ rock	All materials - good	Fill Crushed aggregate	Bush & grass	Requires blasting for excavation.
2.	Sand Slopes	0,6 - >1,0 m - Brown to red brown loose transported sand on >1,0 m - weathered or solid rock Generally above ground water action.	SM-SP/ rock	Sand - moderate to good Rock - good.	Fill -	Scrub, grass & scattered bush.	Sand thicknesses highly variable - mechanical excavation.
3.	Alluvial Wash Areas.	0,3 - 1,0 m - Brown colluvial silty sand on 0,7 - >2,0 m - white powdery to nodular calcrete on >1,0 m - weathered or solid rock. Subject to periodic saturation or flooding	SM/ SM-GM/ rock	Sand - moderate Calcrete & rock } - good.	Bin? SB? -	Grass, scrub & bush.	Calcrete has variable PI.
4.	Calcrete Deposits	<0,3 m - Brown colluvial silty sand with scattered calcrete fragments on >1,0 m - white powdery to nodular calcrete. Generally above ground water action.	SM-SP/ SM-GM/	All materials - good.	Bin? SB.	Grass, scrub & succulents.	Deposits have variable thicknesses - mechanical excavation usually required.
5.	Dolerite Dykes	0,0 - 0,5 m - Brown transported silty sand with scattered dolerite pebbles and boulders on >1,0 m - brown weathered and fractured dolerite grading to solid. Raised water table in vicinity of dyke.	SM/ rock	All materials - good.	Fill -	Bush & scrub.	Dykes generally thin and sinuous - may require blasting for excavation.

LAND PATTERN Z (PRELIMINARY)

MATERIAL DASPOORT / ANDESITE

EXTENT 6K - 27K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Rounded Hills	0,2 - 0,8m - Brown residual gravels and pebbles intermixed with brown silty sand on	GM-GP/	All materials - good.	SB?	Grass & bush	Requires blasting for excavation.
		>1,0m - brown weathered boulder andesite.	rock		Crushed aggregate ?		
		Generally above ground water action.					
2.	Surface Outcrops	>2,0m - Brown residual boulder or solid jointed andesite exposed on surface.	Rock	All materials - good.	Crushed aggregate	Sparse bush & grass.	Requires blasting for excavation.
		Above ground water action.					
3.	Hillwash Slopes						
	V.1	0,5 - 1,0m - Brown colluvial silty to clayey sand with scattered gravels and pebbles on	SM-SC/	All materials - moderate to good.	Fill- SB?	Grass & scrub.	Non-plastic binder may be required to reduce P.I. of upper layers.
		0,5 - 0,9m - brown (residual) sandy clay with intermixed gravels and pebbles on	CL-GC/		Fill-SB?		
		>1,0m - brown weathered boulder andesite.	rock		-		
	V.2	0,5 - 0,8m - Brown colluvial silty to clayey sand with scattered gravels on	SM-SC/	All materials - moderate to good.	Bin?		
		0,3 - 0,9m - light brown powdery to nodular calcrete with scattered gravels on	SC-SM/		SB?		
		>1,0m - brown weathered boulder andesite with calcrete in joints.	rock		-		
		Moderate ground water action after rain.					
4.	Alluvial Wash Areas.	0,3 - 1,0m - Brown alluvial silty to clayey sand with scattered gravels on	SM-SC/	All materials - moderate to good.	Fill	Grass with scattered bush and scrub.	Variable to high P.I. materials will be located in this facet.
		0,3 - 1,0m - brown alluvial sandy clay on	CL/ SM-SC		Nil		
		> 0,5m - light brown powdery to nodular clayey calcrete.			Fill?		
		Subject to periodic saturation or flooding.					

LAND PATTERN AA (PRELIMINARY)

MATERIAL RECENT / CALCRETE - SAND

EXTENT Start -- 9K, 2K - 6K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Low Hills & Ridges	>2,0 m - White hard nodular calcrete exposed on or near surface, becoming more powdery with depth. Above ground water action.	GM - SM	Good.	SB	Scrub & succulents	May require minor blasting for excavation.
2.	Flat Plains	0,2 - 0,9m - Brown to red brown aeolian sand with scattered calcrete nodules on >1,0 m - light brown to white nodular to powdery calcrete. Minor ground water action after rain.	SM -SP/ GM - SM	Sand - moderate Calcrete - good	Fill SB	Bush & scrub	Variable sand cover on calcrete - calcrete has variable P.I.
3.	Sand Dunes	>1,0 m - Brown to red brown aeolian sand on >1,0 m - white nodular to powdery calcrete. Above ground water action.	SM-SP/ GM-SM	Sand - moderate Calcrete - good.	Fill -	Bush & scrub.	Dunes are semi-mobile hence all cut and fill slopes require protection.
4.	Drainage Depressions	0,3 - >1,0 m - Light brown to white, sandy, powdery calcrete, grading to nodular calcrete with depth. Perched water tables after rain.	SC/ SM - GM	All materials - good.	Bin? SB?	Sparse scrub.	Calcretes have variable P.I.'s.

LAND PATTERN BB (PRELIMINARY)

MATERIAL PRETORIA / IRON FORMATION

EXTENT -9K -2K

FACET	FORM	SOIL ORIGIN, MATERIALS & HYDROLOGY.	UNIFIED CLASS.	FOUNDATIONS	USE	LAND COVER	REMARKS
1.	Iron Formation Hills.	0,0 - 1,0m - Brown loose residual boulders and pebbles with silty to clayey sand on >2,0m - red brown to grey solid jointed and fractured iron formation (haematite). Generally above ground water action.	GM/ rock	All materials - good.	Fill - SB? -	Bush, scrub, & grass.	Blasting required for excavation.
2.	Quartzite Outcrops.	<0,5m - Brown to light brown loose residual boulders and pebbles with sand on >2,0m - light brown to purple solid jointed quartzite. Above ground water action.	GP-GM/ rock	All materials - good.	Fill Crushed aggregate.	Bush, scrub & grass.	Blasting required for excavation.
3.	Shale Outcrops	0,0 - 0,6m - Brown to red brown residual silty to clayey sand with numerous shale fragments on >0,5m - black to red brown bedded shales with manganese. Variable ground water action.	SM-SC/ GP	All materials - good.	Fill SB?	Scrub & grass.	Shale bands often thinly bedded, with the quartzite layers.
4.	Dumps and Made-Ground.	> 2,0m - Dumps of loose iron ore, waste material etc. Above ground water action.	-	Poor.	Fill - SB?	Nil	Materials variable, dependent on dump-waste, dumps may be suitable for sub-ballast.
5.	Sand Plains	0,2 - 0,9m - Brown to red brown loose aeolian sand with scattered calcrete nodules on 0,6 ->1,0m- light brown nodular to powdery calcrete on >1,0m - weathered rock. Minor ground water action after rain.	SP-SM/ SM-GM/ rock	Sand - moderate Calcrete & weathered rock } - good.	Bin? SB? -	Scrub, grass & scattered bush.	Calcrete deposits, variable in thickness and consistency.
6.	Colluvial Slopes V.1	0,3 - 1,0m - Brown colluvial silty to clayey sand with intermixed boulders, pebbles and gravels on >1,0m - weathered, shale, quartzite, conglomerate, breccia or iron formation, grading to solid.	GM-GP/ rock	All materials - good.	Fill - SB? -	Bush, grass & scrub.	Highly variable materials in this facet.
	V.2	0,3 - 1,0m - Brown colluvial silty to clayey sand with scattered pebbles and boulders on 0,3 - 1,0m - light brown nodular to powdery, sandy calcrete on >1,0m - weathered, shale, quartzite, conglomerate, breccia or iron formation, grading to solid. Moderate ground water action after rain.	SM-SC/ SM/ rock	All materials - good	Fill SB? -		
7.	Alluvial Wash Areas.	0,5 - >1,0m- Brown to light brown silty to clayey sand with scattered gravels on 0,3 - 1,0m - light brown nodular to powdery calcrete on >1,0m - weathered rock. Subject to periodic saturation or flooding.	SM-SC/ SM-SC/ rock	Sand & calcrete - moderate Rock - good.	Fill? - -	Bush, scrub & grass.	Materials may have variable to high P.I.s in this facet.
8.	River Flood Plains.	0,5 - >1,0m - Brown to light grey silty sand to sandy clay with powdery calcrete on > 2,0m - white powdery to nodular calcrete with scattered gravels. Subject to periodic saturation or flooding.	SM-CL/ SC-GM	Sands & clays - poor. Calcrete - moderate	Nil-Fill? SB?	Trees, bush & grass.	Calcrete may have moderately high P.I.s.