SOILS, LAND CAPABILITY, LAND USE, and HYDROPEDOLOGY

OF THE:

PORT DURNFORD MINING DEVELOPMENT

COMPRISING INTEGRATION / INTERPRETATION OF THE FOLLOWING SOIL SURVEYS:

PROPOSED STOCKPILE 8 (Current Survey), and
PORT DURNFORD PLANTATION (Previous Survey)

KING CETSHWAYO DISTRICT MUNICIPALITY
UMHLATHUZE and UMLALAZI LOCAL MUNICIPALITIES

Prepared for

WSP GROUP AFRICA (PTY) LTD
and
TRONOX KZN SANDS (PTY) LTD

By

B. B. McLeroth
Red Earth cc

……………………………………………………………………………………………………..

September 2024 (draft 1) – Updated 12 February 2025 (final)
Survey Reference: REMS67 / REHP2

View from Auger Point F1 at Stockpile 8

CONTENTS

LIST OF MAPS

B.B.McLeroth (Current Report Author):

Map scale for Maps 1-7:
1:7 500 when printed on A4 paper, and 1:5 500 when printed on A3 paper. The latter printing scale is preferred in order to read the fine mapping / legend text.

K.Snyman [Snyman, 2008] (previous report author "Port Durnford Pre-Feasibility Mining Study"; refer to REFERENCES SECTION of current Document - Note Map suffix "KS" has been added by current author):

Map scale for Maps KS1-KS6:
1: 40 000 when printed on A4 paper. Rather Print on A3 paper in order to facilitate the matching of Map shading colours with those on the Map Legends, and in order to read fine text.

LIST OF FIGURES and TABLES (in order of occurrence)

Current Report Author

Mapping scale for Figures 2a, 3a, 3b: 1:54 000 when printed on A4 paper, and 1:38 000 when printed on A3 paper.

LIST OF APPENDICES

CONFIDENTIALITY AND COPYRIGHT RECORDAL

1.0 INTRODUCTION

1.1 BACKGROUND

Bruce McLeroth of Red Earth cc was initially commissioned by WSP Group Africa to undertake a baseline Soil / Land Capability / Land Use assessment of the proposed Stockpile 8 area, an extreme western section (no previous soil survey) of the proposed Port Durnford Mining Development area. Thereafter, Bruce McLeroth was requested to make out an additional quotation (successful) for a Hydropedological assessment of the entire Port Durnford Mining Development area. The above was later extended to include an Environmental Impact Assessment for the aforementioned specialities. The fieldwork exercise for Stockpile 8 was conducted from 10-14 June 2024. Subsequent to the first Draft Scoping Report, Stockpile 8 has latterly been renamed as Sand Tailings site 8B. However, the current document retains the former naming in the text.

The original 150m grid soil survey of ‘Port Durnford Plantation’ was conducted by K.Snyman in 1994 for the Department of Water Affairs and Forestry, the plantation area being 4056ha in extent. Selected information from this survey was also requested to be incorporated into the current document, in order to produce one stand alone document for the current Project.

Land ownership was subsequently taken over by Siyaqhubeka Forests, from whom permission was granted to Exxaro (mining company) for K.Snyman to make use of his original soil survey data and associated maps, for the purposes of the ‘Port Durnford Pre-Feasibility Mining Study (Report on the Soils, Sites, Land Capability and Land Use)’, hereafter referenced as “Snyman, 2008”.
Management of the plantation is currently within the auspices of Mondi Forests.
Tronox KZN Sands currently holds a Prospecting Right for the area, later upgraded to two different Mining Rights areas. Tronox KZN Sands is currently in the process of applying for Consolidated Mining Rights for the area. Tronox KZN Sands have subsequently provided WSP Group Africa with the Snyman (2008) report document (scanned pdf), and given permission for the document (and associated maps) to be utilised/incorporated into the current document as deemed necessary by the current author. This is necessary for the purpose of compiling a single combined (as requested) Soils / Land Capability / Land Use, and Hydropedological report for the entire proposed Port Durnford Mining Development area.

The two mapped areas will hereafter in this report document be referred to / referenced as follows:

- current soil survey: “Stockpile 8” (i.e. current author, B.B.McLeroth, 2024). Extent: 117.97ha.
- previous soil survey: “Port Durnford Plantation” (i.e. “Snyman, 2008”). Extent: 4056ha.

Selected necessary information derived from the Port Durnford Plantation document, which is extracted and incorporated into the current document will thus be referenced as **“Snyman, 2008”**. The vast majority of this reference document will not be incorporated into the current document. However, certain of these non-incorporated Sections will be referred to; as such:
“Section, Figure, Table, or Appendix number - REFERENCE DOCUMENT I (Snyman, 2008).”
Refer to the REFERENCES SECTION of the current document for further details.

The Hydropedology reporting component is discussed after the former four (Soils / Land Capability / Wetlands / Land Use) reporting components, given that the former four serve to inform the latter.

The aforementioned products will serve as a scientific baseline for these components of the natural environment.

1.2 PLANNED MINING INFRASTRUCTURE, LIFE OF MINE, AND BACKFILL SEQUENCE

Figure 1a (Planned Mining Infrastructure), Figure 1b (Life of Mine), and Figure 1c (Planned Backfill Sequence); indicate the proposed Tronox KZN Sands, Port Durnford Mining Development area, the extent of which is 4787.8 hectares.

The current Port Durnford Mining Development area is a planned mining extension to the north-east of the existing Fairbreeze mine.

The mining company mines mineral rich sands; ilmenite (titanium-iron oxides), zircon and rutile being the primary valuable heavy minerals of the deposit. Hydraulic mining is conducted within deeply excavated pits to produce slurry to feed the Primary Wet Plant (PWP) at the current Fairbreeze Mine site. A second PWP is proposed at Port Durnford Mine. The heavy minerals concentrates are thereafter processed into mineral products at the Mineral Separation Plant at the Empangeni Smelter Complex (all part of the Central Processing Complex), while the ilmentite is further converted into titanium rich slag and pig iron at the smelter. The company also produces titanium-dioxide, and a broad range of related pigments and chemicals.

The current Planned / Proposed Mining Infrastructure, plus the Life of Mine mining sequence (within the various mining cells or blocks); is likely to be adapted / refined in the future.

PROPOSED MINING INFRASTRUCTURE

Primary Wet Plant (PWP).

One Plant currently exists at Fairbreeze Mine, and a further Plant is proposed to be constructed at the planned Port Durnford Mine. These facilities separate the mining targeted heavy metal concentrates from the hydraulically mined ‘ore’slurry. Tailings are pumped in solution to the RSF and Sand Tailings sites for disposal.

Residue Storage Facilities (RSF sites).

These facilities will be filled with fines tailings derived from the Primary Wet Plant, as well as a currently proposed small proportion of gypsum filter cake derived from the Empangeni Smelter Complex (also including the Mineral Separation Plant). The material deposited in the RSF sites (including the gypsum filter cake) is benign, so these facilities will not require to be sealed.

These sites will be located in the following areas:

- re-purposed Open Pit Mining areas, and sequentially refilled from the base of the previous Pit cells (RSF C: incorporating sites P1, P2, P3, and P4); or

- alternatively constructed on the surface of a non-mined area (RSF 9 – one site).

Soil fractions deposited in the RSF sites include those <45 µm in diameter.
Note: <45µm = < 0.045mm. Note: coarse silt is < 0.05mm in diameter.
Thus, these soil fractions include the vast majority of the coarse silt (0.05-0.02mm), plus all of the fine silt (0.02-0.002mm) and clay (< 0.002mm).

This material will hereafter in the current report be referred to as **"FINES" or "FINES TAILINGS".**

These soil separate size limits are based on the following reference: van de Watt H.v.H, and van Rooyen T.H. (1995) - A Glossary of Soil Science – Second Edition – Published by The Soil Science Society of South Africa.

Once the RSF sites cease to be operational, Sand Tailings (refer to next point) will be utilised to both level/re-shape and cap these facilities. This space saving procedure is likely to reduce both the number and height of Sand Tailings sites, thus reducing the impact footprint in non-mined areas.

Sand Tailings (Sand Tails).

These facilities will be the disposal sites for the vast majority of the tailings derived from the PWP plant/s.

Given, the up to approximately 30% bulking factor when comparing the previously stripped pre-mining soil volume with the post-processing tailings material, these sites will are destined to store the additional resultant volume (sand tailings).
These sites will be located in the following areas:

- majority proposed to be dumped (constructed) on the surface of a non-mined area (including Stockpile 8 now referred to as 8B, A-1, A-2 Complex, and A-3); or

- re-purposed Open Pit Mining areas, backfilled from the base of the previous Pit cells (including Sand Tailings sites 3, 4, and 5).

Soil fractions dumped or backfilled at these sites include those > 45 µm in diameter.
Note: > 45µm = > 0.045mm. Note: very fine sand is > 0.05mm in diameter.
These soil fractions include the following fractions of sand: very-coarse (2-1mm) very rare; coarse (1-0.5mm) rare; medium (0.5-0.25mm) sub-dominant; fine (0.25-0.1mm) dominant; and very-fine (0.1-0.05mm) rare. Thus, these tailings are dominantly composed of fine and medium sand. Also included in these sand tailings is a small percentage of reject heavy metal concentrates derived from the PWP.
Although these "Sand Tailings" are comprised of coarser soil separates as compared with the "Fines" separates, the previously noticed (various documents) error of referring to the Sand Tailings as "coarse sand" is not correct.

This material will hereafter in the current report be referred to as **"SAND TAILINGS"**.

Topsoil Stockpiles.

These sites are temporary storage sites for the natural soils stripped during the construction and operational phases of the Mine, this material being replaced on the surface during the rehabilitation phase. These stockpiles are limited in extent, given that a rolling over process will be implemented wherever possible, whereby topsoil stripped from one area will immediately be utilised to topsoil an area undergoing rehabilitation. The topsoil stockpiles will be in the form of either low dumps or berms. Topsoils / subsoils will not be stripped within the actual footprints of the topsoil stockpiles, this because the deposited temporarily stored topsoil / subsoil within these facilities will later be removed for rehabilitation purposes elsewhere.

Stripped Topsoil orthic A-horizon material (top 30cm) must always be stockpiled separately from suitable (for rehabilitation purposes) Subsoil B- and E-horizon materials (including red apedal B, yellow-brown apedal B, neocutanic B, and E-horizons).

Topsoils (30cm) must be stripped from ALL disturbed sites. Only within the actual open Pit boundaries will the Topsoil (30cm) alone be stripped. This is because the mining targeted 'ore' is present within the soil itself.

Subsoils (also including Topsoil) must be stripped from ALL disturbed sites outside of the mining Pit boundaries, where these facilities are constructed on the existing surface.
These sites include the following: PWP Plant; RSF 9; Sand Tails sites 8B, A1, A2, and A3 Complex; and the various Return Water Dams.

Stripping depths (total depth of suitable topsoil and subsoil) for such areas are indicated in the SECTION 10 of the current document.

LIFE OF MINE (LOM) OPERATIONS (within proposed Consolidated Mining Right boundary).

Life of Mine is currently anticipated at 43 years.

Phase 1 Operations: 2025 - 2035:

Initially, limited temporary surface Infrastructure will be constructed to support the machinery/ maintenance/human aspects of the mining operation. This is a Construction activity.

Ore will be mined by front end loader, and transported by haul trucks to a mined out Pit at Fairbreeze Mine. Hydraulic mining will then take place in the Fairbreeze Pit, the material being pumped to the Frairbreeze PWP for processing. Fines and Sand Tailings will be disposed of on the Fairbreeze property. These are Operational activities.
Figure 1b indicates the relevant block where mining will take place during this phase.

A new PWP Plant will constructed at Port Durnford Mine, during the course of the Phase 1 Mining operation. This is also a Construction activity.

Thus, there is an overlap between Construction and Operational related activities during Phase 1.

Phase 2 Operations: 2036 and 2069.

Ore will be mined by bulldozer; and deposited into either of two Dozer Trap Mining Units to remove vegetation/rocks/oversized material. Thereafter the ore will be slurried and pumped to the PWP for processing. The derived heavy metal concentrates will be trucked to the Empangeni Central Processing Complex. Fines Tailings will be pumped to the RSF sites, while Sand Tailings will be hydraulically deposited in the Sand Tails sites. These are Operational activities.
Figure 1b indicates the currently proposed mining sequence over this period.

Rehabilitation exercises will also be taking place, both during (consecutively) and after the Phase 2 Operations. Rehabilitation refers to the re-grading / re-shaping / levelling / topsoiling / re-vegetation of redundant mining related features. These are Closure related activities.

Thus, there is an overlap between Operational and Closure related activities during Phase 2.

MINING PHASES (CONSTRUCTION / OPERATIONAL / CLOSURE / POST-CLOSURE).

Generally speaking, Construction, Operational and Closure (i.e. rehabilitation) related activities will be taking place simultaneously throughout the Life of Mine.

Thus, for the purposes of the unnecessary duplication of information in the ENVIRONMENTAL IMPACT ASSESSMENT (Section 13) of the current report, Phases will be described as Construction / Operational / Closure / Post-Closure (and not as Phase 1 / Construction / Phase 2)

Construction Aspects will describe the following:

- construction of limited temporary machinery/maintenance/human related surface infrastructure in order to support the Phase 1 Mining operation; and
- construction of the new Port Durnford PWP in advance of commencement of the Phase 2 Mining operations.

Operational Aspects will describe the following:

- Mining of the first designated cells/block (Phase 1); and
- Mining (sequential) of numerous cells/blocks (Phase 2).

Closure Aspects will describe the following:

- Rehabilitation. This includes the re-grading / re-shaping / levelling / topsoiling / soil sampling/analysis / fertility amelioration / re-vegetation of redundant mining related features.

Post-Closure Aspects will describe the following:

- Monitoring, maintenance, and repair (where necessary) of the previous rehabilitation.

Figure 1a. Planned Mining Infrastructure

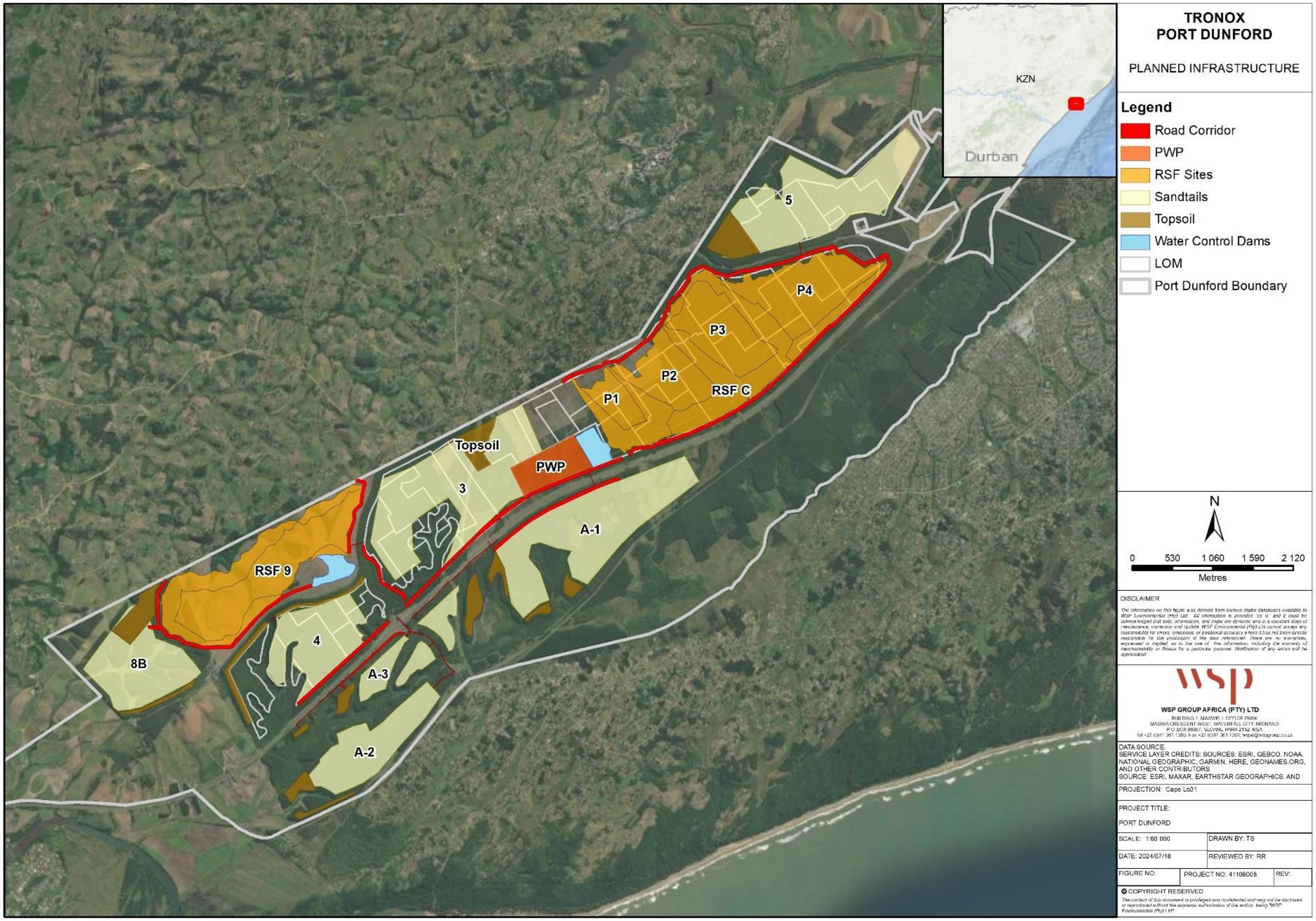


Figure 1b. Life of Mine

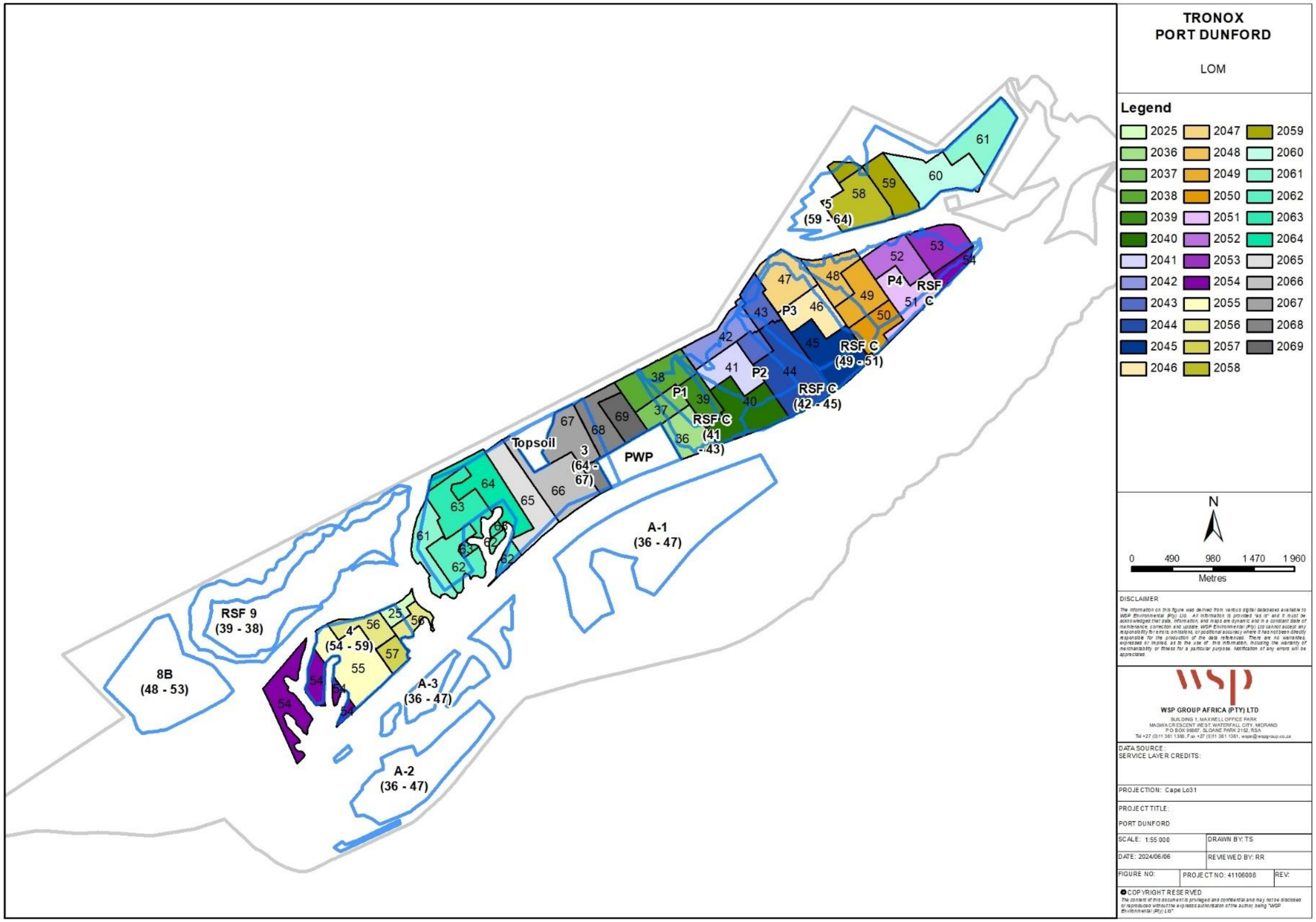
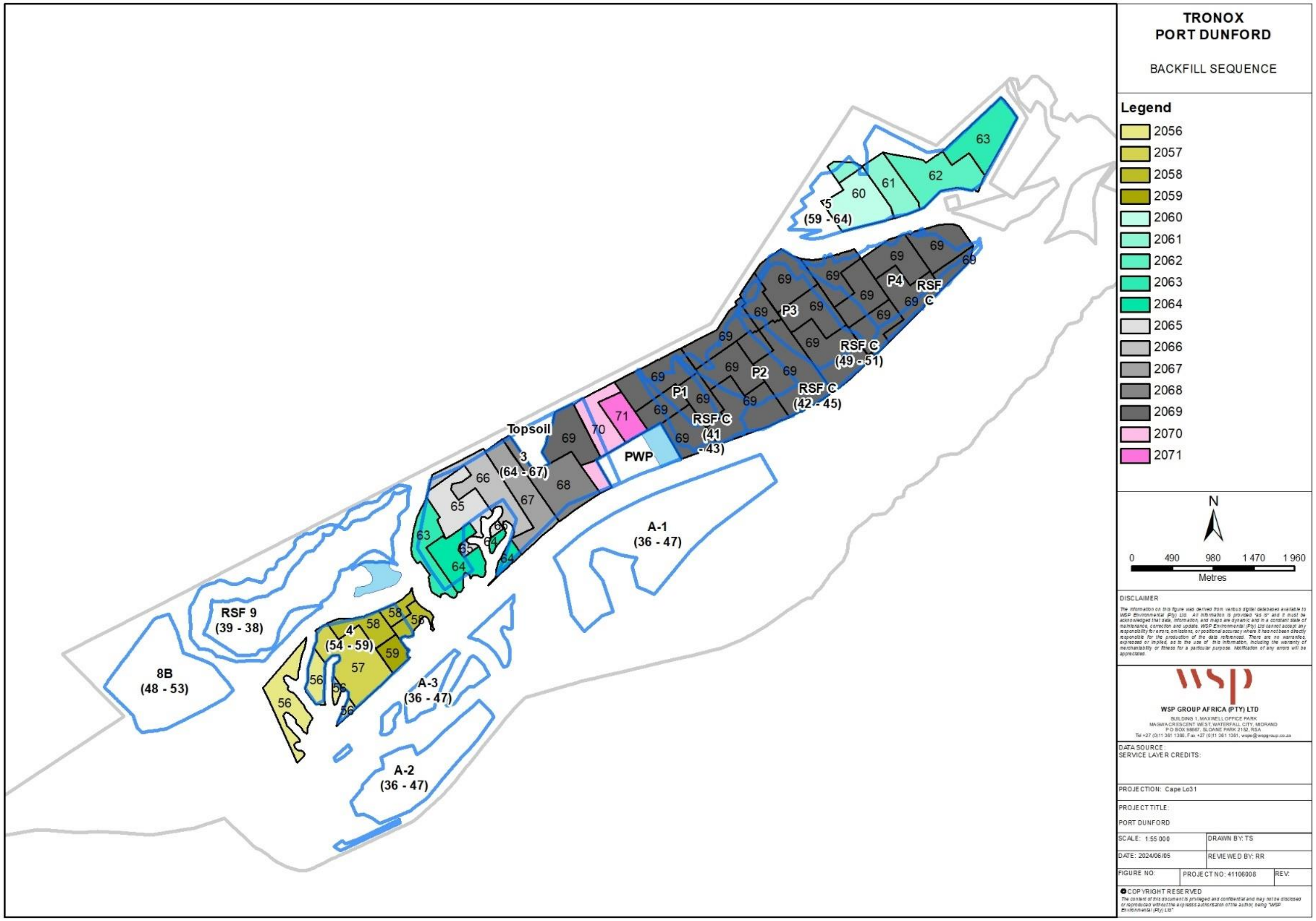


Figure 1c. Planned Backfill Sequence



1.3 LOCATION

Figure 2a (Location of Study Area [Topographical]) and Figure 2b (Location of Study Area [Open Street Map - Google]) indicate the location of the Port Durnford Mining Development study area.

The Port Durnford Mining Development area is of an approximate rectangular shape, trending from the south-west to north-east, a distance of approximately 16.2km, the maximum width varying from approximately 3.1km to 3.7km (narrowing in the extreme south-west).

Distances from the south-western and north-eastern boundaries to other features are indicated hereafter.

South-western corner to:
Mtunzini town centre - 2.6km south,
Fairbreeze Mine (Tronox KZN Sands) - 9.0km south-west,
Hillendale Mine (previously Exxaro Sands) - from 16.4 - 22.0km north-east,
Empangeni town R34 road / rail crossing - 23.7 km north-north-east, and
Richards Bay harbour (coal terminal) - 31.6km east-north-east.

Most North-eastern corner to:
Mtunzini town centre - 17.7 km south-west,
Fairbreeze Mine (Tronox KZN Sands) - 24.8km south-west,
Hillendale Mine (previously Exxaro Sands) - from 0.4 - 5.8km east,
Empangeni town R34 road / rail crossing - 9.5km north, and
Richards Bay harbour (coal terminal) - 15.7km east-north-east.

Stockpile 8 lies approximately 4.75km to the north-north-east of the town of Mtunzini, also within the overall study area.

The south-western fifth of the overall study area (including Stockpile 8) falls within the Umlalazi Local Municipality, while the majority falls within the Umhlathuze Local Municipality.

Figure 2a. Location of Study Area (Topographical)

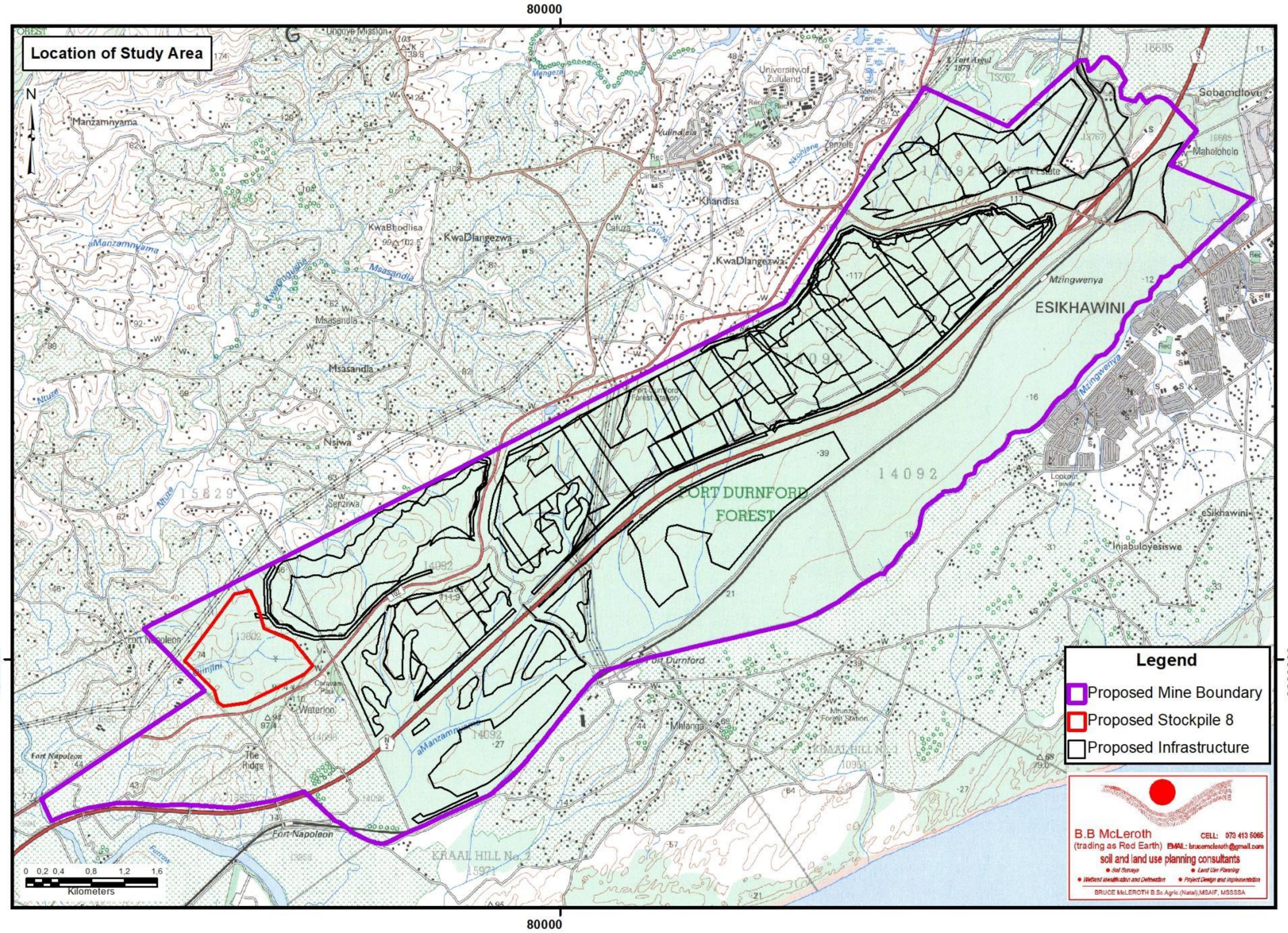
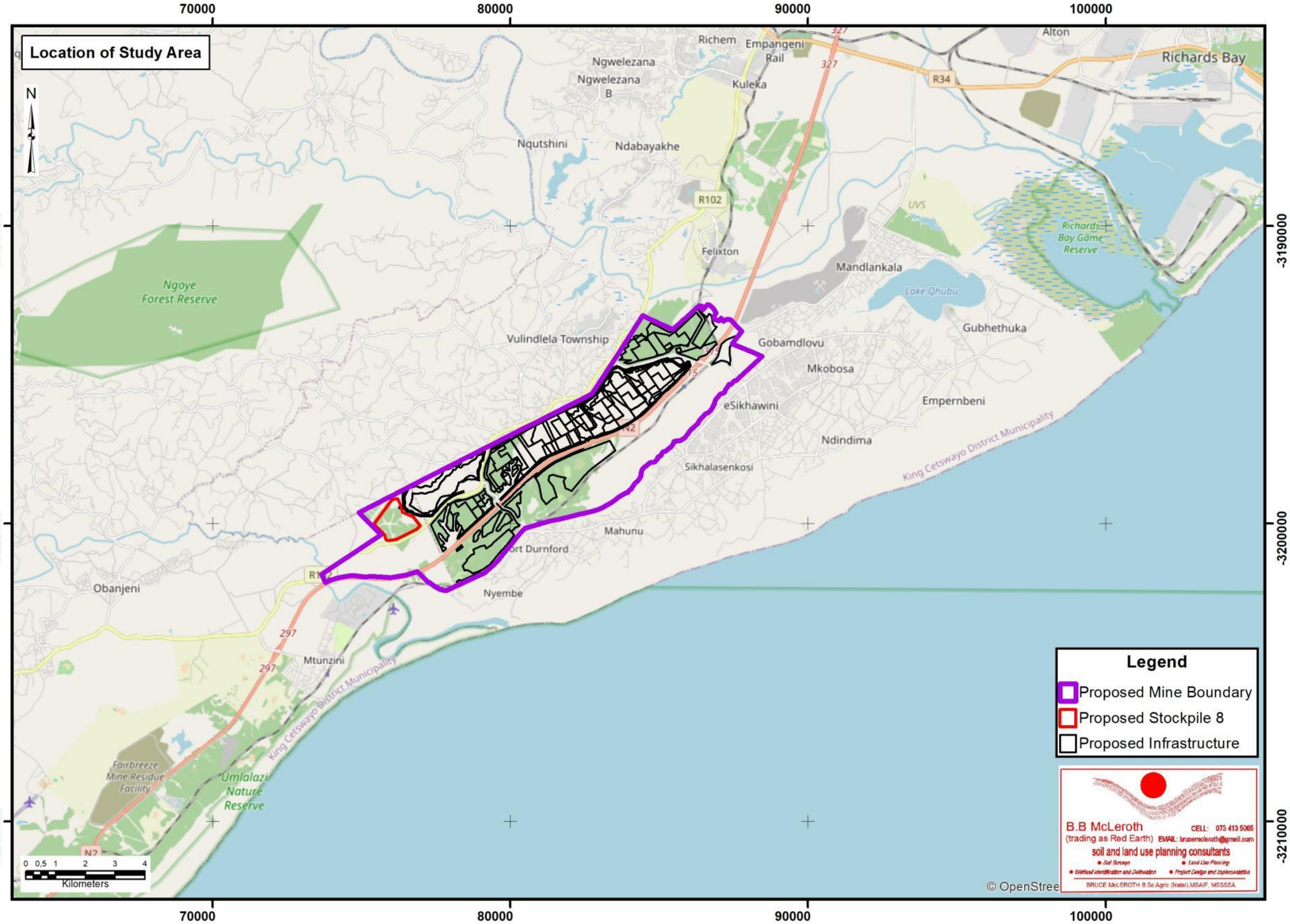


Figure 2b. Location of Study Area (Open Street Map - Google)



1.4 TOPOGRAPHY

Figure 3a (Elevation and Transects) indicates Topography for the Port Durnford Mining Development area.

The Transects (B-A, D-C, F-E, and H-G) are applicable to the HYDROPEDOLOGY Section of the current document.

A further nine other Figures displayed in Section 12 (HYDROPEDOLOGY) indicate the following: Elevation Profile Graphs and Oblique Images, aligned with maps of Elevation, Site Types, and Soils.

Slope Grade and Aspect:

Figure 3b (Slope Classes and Transects) indicates Slope Classes for the Port Durnford Mining Development area.

An ancient broad "Berea-type" (red to yellow) sand dune ridge bisects the study area, trending from the south-west to the north-east. Slopes and aspects vary to the east and west of this ridge as follows:

- to the east of the ridge: sloping land (aspect south-east, mostly 3-9 degrees), then gradually levelling out towards the coastal plain (aspect south-east, 3 degrees; then decreasing to 1 degree slope closer to the coast).
- ridge crest and scarp: (aspect north-west or south-east, mostly 1-3 degrees on the crest, and up to 9 degrees on the scarp), and
- to the west of the ridge: undulating rolling land (aspects north-west to south-east, mostly 3-9 degrees on slopes, occasionally 1-3 degrees on crests, rarely 15- >18 degrees on scarps).

Stockpile 8 lies mostly within the area to the west of the central dune ridge, with only sections of the eastern extent of the area falling on the south-western aspect slopes of the same dune ridge.

Altitude (amsl):

Port Durnford Plantation - approximate range: 102m (highest point on ridge); to 6m (eastern boundary, northern and southern corners).
Stockpile 8 - approximate range: high points: 80m-74m (hill tops); to 32m (lowest valley sections).

Figure 3a. Elevation and Transects

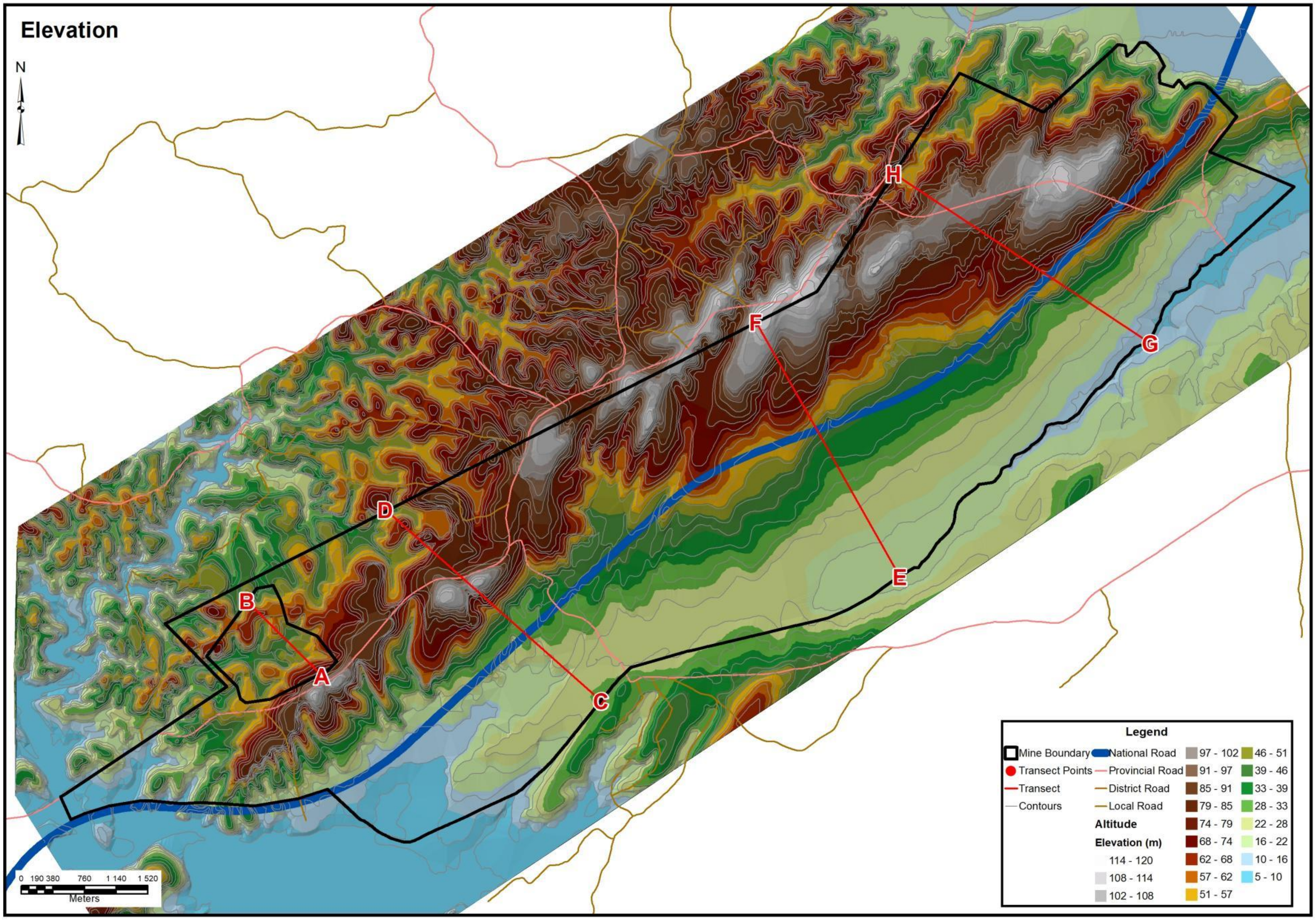
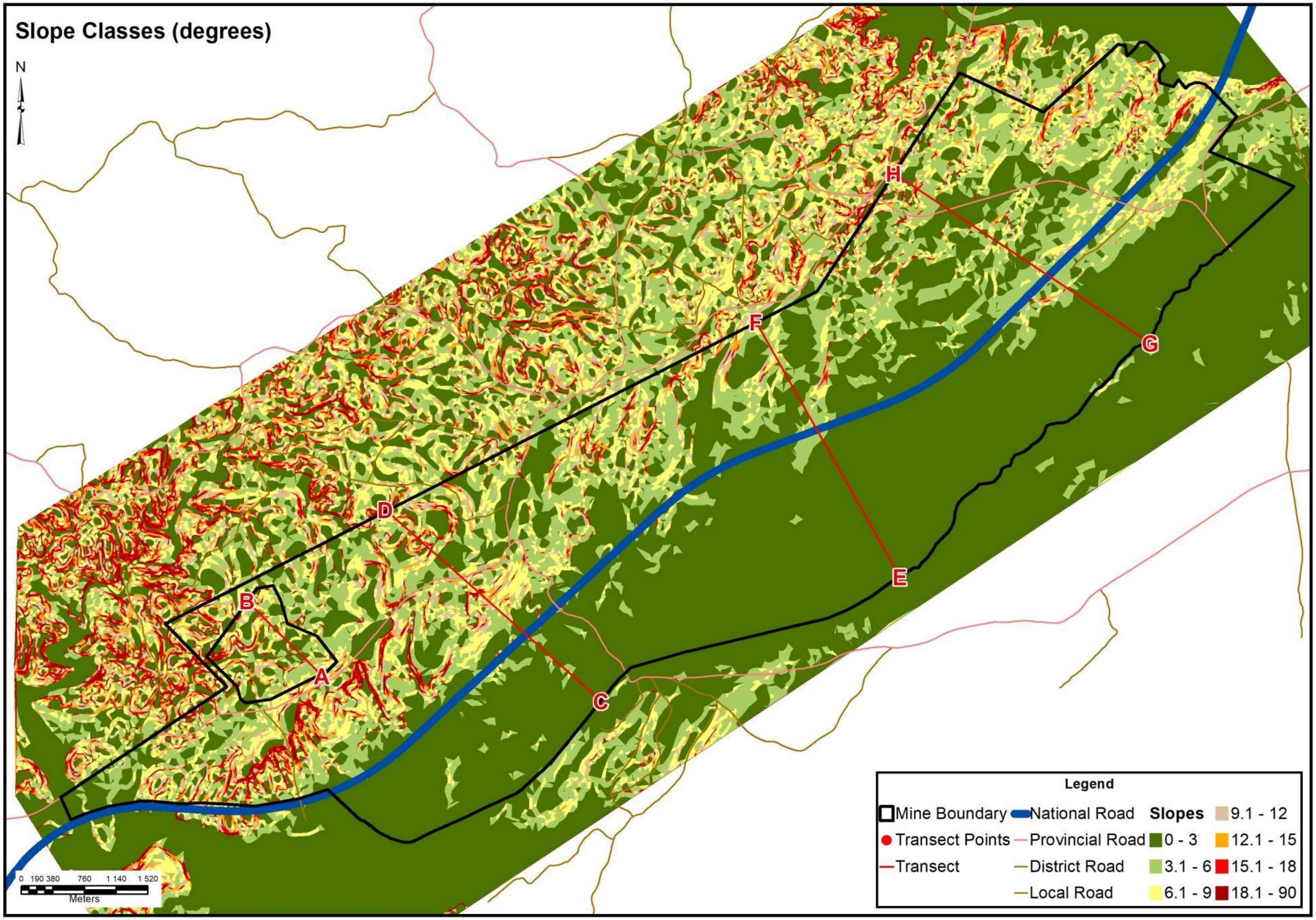


Figure 3b. Slope Classes and Transects



1.5 DRAINAGE

Figure 2a (Location of Study Area [Topographical]) also indicates drainage.

Port Durnford Mining Development area:

Major rivers do not occur within the study area. However, the Umlalazi River forms the boundary of the extreme south-western boundary, while the Mhlatuze River lies to the north of the north-eastern boundary.

The watershed to the west of the central dune ridge is drained by intermittent streams which flow into the following perennial streams (named from south-west to north-east): Ojinjine, Ntuze, Msasandla, Caluza, Nkonjane, and one unnamed stream.

The watershed to the east of the central dune ridge is drained by tributaries which flow into the following perennial streams (named from north-east to south-west): Mzingwenya, and aManzamnyama. Riparian habitats are associated with the streams, and numerous large wetlands occur in this eastern area.

Ephemeral streams occur on steeper slopes, flowing into valley-bottoms with shallow gradients where the streams are intermittent in their upper sections and perennial further downstream.

Stockpile 8:

The various wetlands and drainage lines in the Stockpile 8 area, form the headwaters of the Ojinjine Stream. The vast majority of the indigenous bush has previously been cleared from these wetlands / riparian areas, except in one lower section. Furthermore, drains have unfortunately (in the past) been constructed along the centre of many of the wetlands, with one section displaying numerous feeder drains into the surrounding footslope landscape position. Drainage of the area has resulted in a reduction of the water-table depth, and consequently also a greatly reduced incidence of hydrophytic vegetation. These areas are dominated by buffalo grass (*Stenotaphrum secundatum*), frequently grazed by small herds of cattle from local communities.

1.6 LITHOLOGY

Lithology refers to the Parent Material (i.e. geology) from which the soils are derived.

Before commencement of the specific lithologies occurring within the Stockpile 8 and Port Durnford Plantation areas, the separate mining targeted Berea Red Sands dune complex at the neighbouring (south-west) Fairbreeze Mine is described. This description is also largely applicable to the current Port Durnford dune complex.

This information was extracted from on Overview on the following website article:
KwaZulu-Natal (KZN) Sands Operation. https://miningdataonline.com
Selected text from this source is indicated within quotation marks, thus “ ”.

“The Fairbreeze” (Mine) “paleo dune complex is an elongated body extending south - south-westward from the town of Mtunzini for about 12 kilometers, reaching a maximum width of about two kilometers and a maximum elevation of 109 metres. Surface drainages has dissected the deposit into discrete ore bodies. The deposit is hosted by **fine-grained sand and silt** in a north-north-east trending complex of strandline/paleo dune couplets two kilometers inland from the modern coastline.”

These are “part of a regional near-shore coast-parallel corridor of terraces and dunes composed of reddish-coloured sands, the “Berea Red Sands”, along the south-eastern coast of Africa from Durban to Mombasa. As with most heavy mineral sand deposits, iron-titanium oxides, rutile, zircon and other heavy minerals in the HM assemblage at Fairbreeze” (Mine) “are inherited from their source rock provenance and modified by selective sorting deposition.”

“The Fairbreeze” (Mine) “deposits consist almost entirely of older (Pliocene parent) Berea-type red sands, which have been exposed to a long period of weathering resulting in the disintegration of the original components to form **silt-sized particles and clay**. Progressive enrichment in the swash zones of several beaches, which developed along the large coastal beach/dune system, resulted in the concentration of heavy minerals. Heavy minerals, derived from weathering of inland rocks and sediments, were deposited into the ocean by” rivers.

“The Fairbreeze” (Mine) “deposits” have a “length of more than 15km, striking 34 °, and reaching 630m in width. Generally the different ore bodies have **depths close to 30m**, and the elevation drops from around the 10m amsl in the south-west to around 70m amsl in the north-east.”

“Heavy minerals are disseminated in the dune systems with general preference of higher concentrations at the ridge of the dunes.”

....

Measurement of the length (by the current author) of the separate Berea Red Sands dune complex within the current Port Durnford Mining Development area is approximately 14.4km, the dune complex having been dissected (i.e. interrupted) by water erosion in the Mhlatuze River valley to the north-east and the Umlalazi River valley to the south-west.

Dune complex sand grades are mostly medium (occasionally fine) in this dune section. Maximum elevation is 102m.

A number of different lithologies occur within the combined study area (Stockpile 8, and Port Durnford Plantation). These weather to produce soils with differing physical and chemical properties.

Stockpile 8:

- Bs (Soil Map notation) - "Berea-type" - sandy phase (sand to sandy-loam texture) RED Soils - derived from recent sand. This sandy phase often overlies (blankets) the underlying clayey phase. This material appears to be Aeolian.
- Bc (Soil Map notation) - "Berea-type" - clayey phase (sandy-clay-loam to sandy-clay texture) RED Soils - derived from weathering sand.

- R1 (Soil Map notation) - Recent sands - sandy - BROWN-PINKISH Soils - probably also "Berea-type".
  Note that differential weathering of the "Berea-type" sands has occurred, probably according to their age, period of exposure, and landscape position; resulting in soil colours that are commonly reddish-brown, yellowish-brown or grey.
- T1 (Soil Map notation) - Sandstone (sedimentary) - RED or YELLOW Soils. These are probable also "Berea-type" clayey soils, and overlie sandstone (probably Natal Group) at depth.
- S1 (sub-dominant Soil Map notation) - Shale (sedimentary). Shale was rarely encountered at depth, within the above "T1" (dominant) parent material areas.

- T1,T2 (Soil Map notation) - Sandstone and Quartzite (probably Natal Group) - Shallow lithosol topsoils with a clayey texture in the topsoil (A-horizon). Abundant angular quartz stones, sandstone fragments, possible conglomerate fragments, and occasional red river rounded stone sized pebbles occur overlying (surface to top 30cm of soil profile) the weathering sandstone in these areas. The presence of the conglomerate and river rounded pebbles may indicate surface remnants of the Cenozoic Maputaland Group - Uloa Formation (inferred by current author from the following Reference: Botha, 2018).

- G2 (Soil Map notation) - Gneiss (metamorphic - parent rock is sedimentary in the area). Shallow lithosol topsoils with a clayey texture in the topsoil (A-horizon). Abundant angular quartz stones are present. This lithology occurs on the steeper slopes on the extreme western side of the area.

- C (Soil Map notation) - Colluvium (accumulated soil material in low-lying areas). Clayey hydromorphic soils.
- A (Soil Map notation) - Alluvium (deposited in a narrow band adjacent to streams in the current area).

- Other rarely encountered rock fragments encountered include: E (Dwykatillite) and D1 (Dolerite), both fragments being encountered on the surface at soil observation points D3 and D4, in the vicinity of an indicated (1 : 1 million scale Geological Map) thrust fault.

Port Durnford Plantation:

Selected text extracted from Snyman, 2008.

- Alluvium associated within and adjacent to channels gives rise to alluvial soils. These deposits occupy narrow strips parallel to channels.
- Quaternary grey brown sands occur in the east. Derived soils are typically sandy in texture with hydromorphic properties common.
- Brownish red weathered material (.... Berea Formation) occupies the central and western area. Derived soils have red hues and sandy-loam to sandy-clay-loam textures. Other Quaternary sand Aeolian material often blankets the weathering material providing sandy topsoils on top of the clay-loam textured underlying horizons.
- Gneiss of the Intuzi Formation, Matigulu Group occurs at the south-western corner of the study area. Typical derived soils are lithosols (gravelly shallow soils) with clayey textures.

1.7 PROPERTY DESCRIPTIONS

Table 1 - Property Descriptions (Surveyor General) indicates the Property Descriptions for the study area.
Note that the Area (ha) column of Table 1 represents the area of the entire Property Description, and not necessarily that section of the said property which falls within the Port Durnford Mining Development area.
Stockpile 8 is located on a section of Portion 1 (and Remainder) of Lot 132 Umlalazi 13602.

Table 1. Property Descriptions (Surveyor General)

Surveyor General. 21 Digit Code	Portion Number	Central Latitude	Central Longitude	Surveyor General Number	Deed	Farm Name	Area (ha)
N0GU00000001683200000	REM/16832	31,888842	-28,857781			BIRKETT 16832	6,61
N0GU00000001683200004	4/16832	31,885201	-28,863593	590/2008		BIRKETT 16832	2,81
N0GU00000001683200003	3/16832	31,863064	-28,883504	460/2008		BIRKETT 16832	73,31
N0GU00000001683200001	1/16832	31,877856	-28,860908	2575/1999	38371/2000	BIRKETT 16832	2,17
N0GU00000001683200002	2/16832	31,885376	-28,861562	2576/1999	38372/2000	BIRKETT 16832	30,95
N0GU00000001683200000	RE/16832	31,853276	-28,880371	1120/1996	63230/2001	BIRKETT 16832	1193,86
N0GU00000001683200000	RE/16832	31,845802	-28,894846	1120/1996	63230/2001	BIRKETT 16832	508,24
N0GU00000001683200005	5/16832	31,886436	-28,864894	591/2008		BIRKETT 16832	3,74
N0GU00000001683200000	RE/16832	31,888953	-28,862590	1120/1996		BIRKETT 16832	7,01
N0GU00000001510500001	1/15105	31,822678	-28,903263	457/2008		DURNFORD 15105	1,18
N0GU00000001510500000	RE/15105	31,824565	-28,896538	431/1975	T18649/1975	DURNFORD 15105	26,91
N0GU00000001510500000	RE/15105	31,824101	-28,908750	431/1975	T18649/1975	DURNFORD 15105	16,21
N0GU00000001683600000	16836	31,855844	-28,893202			DURNFORD RAIL 16836	51,26
N0GU00000001451900000	14519	31,831110	-28,913764	156/1935		KRAAL HILL ANNEXE 14519	1,23
N0GU00000001597100001	1/15971	31,826375	-28,915961	155/1935	1131/1937	KRAAL HILL NO.2 15971	1,11
N0GU00000001597100002	2/15971	31,814431	-28,927122	2507/1996	33012/1997	KRAAL HILL NO.2 15971	0,57
N0GU00000001388000000	RE/13880	31,771500	-28,925408			LOT 103 UMLALAZI 13880	187,10
N0GU00000001385300005	5/13853	31,784753	-28,929084	1350/2015	T29267/2021	LOT 104 UMLALAZI 13853	0,37
N0GU00000001385300000	RE/13853	31,781741	-28,927018	SV850F12		LOT 104 UMLALAZI 13853	55,10
N0GU00000001409800002	2/14098	31,790454	-28,914647	1442/1955	5101/1956	LOT 131 UMLALAZI 14098	5,94
N0GU00000001409800001	1/14098	31,792393	-28,916609			LOT 131 UMLALAZI 14098	4,43
N0GU00000001409800003	3/14098	31,793265	-28,926683	467/2008	T38502/2017	LOT 131 UMLALAZI 14098	8,52
N0GU00000001409800000	RE/14098	31,790529	-28,922449	435/1954	T67/1955	LOT 131 UMLALAZI 14098	110,60
N0GU00000001409800000	RE/14098	31,796251	-28,930281	435/1954	T67/1955	LOT 131 UMLALAZI 14098	67,03
N0GU00000001360200001	1/13602	31,781396	-28,908207	3116/1947	T4998/1954	LOT 132 UMLALAZI 13602	118,12
N0GU00000001360200000	RE/13602	31,782706	-28,915331	407/1949	103/1949	LOT 132 UMLALAZI 13602	140,40
N0GU00000001376700000	REM/13767	31,886619	-28,856165			LOT 171 UMHLATUZI 13767	29,02
N0GU00000001376700002	2/13767	31,889062	-28,852663	3708/1994	24932/1996	LOT 171 UMHLATUZI 13767	7,83
N0GU00000001376700001	1/13767	31,888342	-28,853387	5511/1950	379/1956	LOT 171 UMHLATUZI 13767	2,89
N0GU00000001376700004	4/13767	31,887565	-28,852484	2506/1996	18805/1997	LOT 171 UMHLATUZI 13767	0,28
N0GU00000001376700003	3/13767	31,888775	-28,853949	2505/1996	18805/1997	LOT 171 UMHLATUZI 13767	0,11
N0GU00000001748800000	RE/17488	31,826821	-28,931199	537/2001		MKHWANAZI 17488	4423,89
N0GU00000001683700000	16837	31,890735	-28,858068			MZINEWENYA RAIL 16837	3,41
N0GU00000001683700001	1/16837	31,891364	-28,859276	462/2008		MZINEWENYA RAIL 16837	0,54
N0GU00000001452000000	14520	31,829220	-28,914219	154/1935	28434/2003	PORT DURNFORD STATION	6,13
N0GU00000001680200001	1/16802	31,809691	-28,913979	459/2008		RICHARD 16802	29,22
N0GU00000001680200000	RE/16802	31,806599	-28,904525	1119/1996	T63230/2001	RICHARD 16802	789,28
N0GU00000001680200000	RE/16802	31,812664	-28,920473	1119/1996	T63230/2001	RICHARD 16802	376,75
N0GU00000001683300000	16833	31,883656	-28,876697			RUTH 16833	920,84
N0GU00000001683300001	1/16833	31,894549	-28,855967	461/2008		RUTH 16833	7,21
N0GU00000001358000000	13580	31,890384	-28,862782			UMHLATUZI SAR 13580	4,73

2.0 DETAILS OF SPECIALIST AND DECLARATION OF INDEPENDENCE

2.1 DETAILS OF SPECIALIST

Details:

This Report has been compiled by an experienced specialist, namely Mr Bruce Bertram McLeroth, trading as Red Earth.

Company	**Red Earth**
Affiliation	Member of the Soil Science Society of Southern Africa
Contact Person	Mr Bruce Bertram McLeroth
Physical Address	278 Bulwer Street, PIETERMARITZBURG, 3201, KwaZulu-Natal, South Africa
Cell Number	+27 73 413 5065
E-mail	brucemcleroth@gmail.com

Expertise:

Mapping and Baseline / EIA / EMP Reports on: Soil Survey, Land Capability, Present Land Use, and Wetland Identification and Delineation. Given the close inter-relationships existing between all of the aforementioned expertise, the author is therefore competent to apply such knowledge to hydropedological assessments.

Additionally Mapping of: Soil Utilisation (Stripping) Guides; Overburden / Underburden Wastes and Non-Wastes; Contaminated Land Assessment sampling and preliminary mapping; Timber Potential and Compartments; Sites for Phytoremediation; and Land Preparation Recommendations.

Qualifications:

B.Sc Agriculture (Natal); plus 38 years of soil mapping, and 35 years of consultancy experience.
Member of the Soil Science Society of Southern Africa.
Member of the South African Institute of Forestry (lapsed).

Past Experience:

INSTITUTE FOR COMMERCIAL FORESTRY RESEARCH.
March 1986 - March 1989 (3 years).
Research officer, and founder/head of the Soil Unit in the Silviculture Section.
Responsibilities included the establishment and sourcing of work for the unit, preparation/presentation of soil courses to the forestry industry, and soil/climate/site-species matching surveys for timber (mapping and reports).

RED EARTH cc: April 1989 - present (35 years).

Since 1989 Bruce McLeroth consulted firstly in the Forestry and Agricultural Industries, conducting 150m grid soil mapping and site species mapping / reports for numerous timber (particularly) and sugar companies; totalling over 117 000 hectares in area. He also conducted numerous soil / timber potential pre-purchase reconnaissance evaluation surveys.

Bruce McLeroth also commenced consulted in the Mining and Smelting industries in 1992, conducting 150m grid soil surveys and Soils/Land Capability/Land Use Baseline/EIA/EMP and Specialist Study Reports for 67 Mining and 10 Smelting Projects (to date); totalling over 130 000 hectares of 150m grid surveys, and 170 000 hectares of 200m-2800m grid ('reconnaissance') surveys.

Curriculum Vitae:

This may be made available upon request.

Document Review:

The current Report document has been peer reviewed by the following senior WSP personell:
Dr Mark Aken (WSP sub-consultant), Brent Baxter (Technical Director – Planning and Advisory), and Rob Rowles (Principal Consultant).

Furthermore, Dr Mark Aken also made significant contributions to the Impact Assessment Table (Table 14).

2.2 DECLARATION OF INDEPENDENCE

I **Bruce Bertram McLeroth** act as the independent specialist in this report;

I will perform the work relating to the report in an objective manner, even if this results in views and findings that are not favourable to the applicant;

I declare that there are no circumstances that may compromise my objectivity in performing such work;

I have expertise in conducting baseline and specialist reports, as these may be relevant to any subsequent applications, including knowledge of the (South African) Act, Regulations and any guidelines that have relevance to the current/proposed activity;

I will comply with the Act, Regulations and all other applicable legislation;

I have no, and will not engage in, conflicting interests in the undertaking of the activity;

I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to any potential application to the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;

all the particulars furnished by me in this form are true and correct; and

am aware that it is an offence in terms of [South African] Regulation 48 to provide incorrect or misleading information and that a person convicted of such an offence is liable to the penalties as contemplated in section 49B(2) of the National Environmental Management Act, 1998 (Act 107 of 1998).

B.B.McLeroth
Name of the Specialist

Red Earth
Trading as

9 September 2024 (draft 1);
15 January 2025 (final document);
11 April 2025 (final document - Executive Summary added).

3.0 METHODOLOGY AND ACTIONS PERFORMED

3.1 DESKTOP STUDY

Various figures were compiled with reference to clipped sections of the following information:

Background:

- Compile Figures of the Site Location.
    - Location of Study Area - Topographical (source: latest 1:50000 Topographical sheets 2831DC and DD, and 2832CC); and
    - Location of Study Area - Open Street Map-Google (source Google - Open Street Map).

Soil Survey:

- Compile a 1:10 000 base map for fieldwork purposes. This map was based on overlying the available contours on the colour aerial photograph.
    - Aerial Photography (source: Chief Directorate of Survey and Mapping, 2022; and
    - Contours (5m) (source:Chief Directorate of Survey and Mapping, 2022).

Hydropedology Study:

- Compile various figures from the following information sources:
    - Soils and Site Type Maps (Stockpile 8 - B.B.McLeroth, 2014 - current survey);
    - Site Types Map (Port Durnford Plantation - Snyman, 2008 - previous survey);
    - Elevation (m) amsl (source: Chief Directorate of Survey and Mapping, 2022; Mapping Program: ArcMap 10.3);
    - Slope Classes (source: 5m contours from Chief Directorate of Survey and Mapping, 2022. Mapping Program: ArcMap 10.3);
    - Oblique images (source: Google Earth. Dated 6-5-2024);
    - Elevation Profile Graphs (source: 5m contours from Chief Directorate of Survey and Mapping, 2022. Mapping Program: ArcMap 10.3).

3.2 FIELDWORK AND REPORTING

- Conduct the Fieldwork Component of the study.
  The following exercises were conducted during the fieldwork exercise:
    - Soil auguring utilising a 150mm bucket auger, till refusal (predominantly due to weathering rock, hard rock, or quartz stoneline at the current site);
    - Lay the augured soil profiles systematically out on the surface;

- describe and classify the soil profiles in a comprehensive manner, as presented in Appendix I - Soil Profile Descriptions (Stockpile 8);
- Photograph representative soil profiles, as presented in Figure 4; and
- concurrently record the land capability; and land use at each auger site.

- Conduct the Reporting Component of the study.

  - Compile the map set with reference to the data collected in-field, aerial photographic interpretation, and the contours. A list of these maps are indicated in the Table of Figures, and are available in ArcMap 10.1 shape-file format; as well as jpg and pdf formats;
  - Compile the various Figures from clipped sections of available mapping information;
  - describe and classify the soil profiles in a comprehensive manner, as presented in Appendix I - Soil Profile Descriptions (Stockpile 8); and
  - Report Document write up.

4.0 ASSUMPTIONS, UNCERTAINTIES AND KNOWLEDGE GAPS

The Soil, Land Capability (also including Wetlands) and Land Use surveys, as well as the Hydropedology assessment; were conducted in both a qualitative and quantitative manner (varies for different sub-components).
The predictive methods used throughout the studies adhere to the relevant regulating requirements and are both applicable to and adequate for the investigations conducted.

Soils:

Soil distribution and observable variables:
Given the survey intensity of one auger per 2.25ha (150m grid soil survey) a relatively high mapping purity was achieved, both within the Stockpile 8 (62 auger points) and Port Durnford Plantation (1412 auger points) areas.
Horizon and soil depths were measured in a quantitative manner.
Thus, no significant assumptions were made.

Soil physical / chemical information:
These were either verified during (observed soil variables) or after (laboratory data) the two different fieldwork exercises, as follows:

- Stockpile 8 - 5 samples were laboratory analysed from 3 different modal (i.e. typical representative) soil profiles.
  Refer to Table 3 - Soil Analytical Data (Stockpile 8).

- Port Durnford Plantation - 41 samples were laboratory analysed from 16 different modal soil profiles.
  Refer to: REFERENCE *DOCUMENT I (Snyman, 2008).* Specifically refer to: *Appendix 3 (Modal Soil Profile Descriptions and Laboratory Data) of that document.*
  This Appendix is not Incorporated into the Current Document (Refer to Separately).

Thus, the estimated (during the fieldwork exercise) soil variables were largely verified by the soil laboratory (analytical) data of the modal soil profiles.

Thus, no significant assumptions were made.

Wetland Identification and Delineation:

Due to the qualitative investigative nature of the assessments for Stockpile 8 and Port Durnford Plantation (based upon soil form/family, depth to signs of wetness in the soil profile and thus effective rooting depth, slope position, and presence of hydrophytic vegetation), no significant assumptions were made regarding the identification of wetlands in soil surveyed areas.

Furthermore, the guidelines governing the classification of wetlands are clearly defined.

Knowledge Gaps:

Stockpile 8 (current soil survey):
Seasonal and Permanent wetlands are not differentiated on Map 6 (Wetlands [Stockpile 8]) in the major valley bottom-land drainage areas, this for three reasons:
- firstly, the permanent wetlands are represented by very narrow sections at the lowest points of the gently to moderately sloping drainage areas;
- secondly, these areas have been largely subjected to previous artificial drainage (constructed drains in many areas) which has thus almost entirely eliminated hydrophytic vegetative (indicator) species, these areas mostly being dominated by a dense stand of buffalo grass; and
- thirdly, the 150m grid soil survey intensity did not provide for enough auger sampling points in these areas.

However, Temporary wetlands on midslopes and foot-slopes are clearly delineated in this area.

Port Durnford Plantation (previous soil survey - Snyman, 2008):

The soil survey was conducted in areas occupied by timber/grasslands, but was not requested indigenous bush areas. Such indigenous bush sites are occupied by a combination of wetland, riparian, and terrestrial habitats.

Map KS6 (Land Capability) indicates 100ha of wetland in the soil surveyed areas.
Map KS4 (Current Land Use within Study area) indicates wetlands (458ha) and forest indigenous riparian (290ha), many of these wetlands being located in areas of indigenous bush.

Pre-Mining Land Capability:

Stockpile 8 (current soil survey):
Due to the qualitative/quantitative investigative nature of the assessment (based upon numerous factors), no significant assumptions were made.
Furthermore, the Pre-Mining Land Capability classification system utilised is clearly defined. Refer to REFERENCES: ‘Mining Rehabilitation Guidelines (2019)’.

Port Durnford Plantation (previous soil survey - Snyman, 2008):

Knowledge gaps:

- Wetlands. Already discussed above.

- Arable areas.

  Map KS6 (Land Capability) indicates: Class II Arable land as 552ha (14%), and Class III Grazing land as 2434ha (60%).

  Given the most recent ‘Mining Rehabilitation Guidelines (2019)’ (soil survey was conducted in 2008), certain small sections of the Grazing land capability class areas may now be defined as Arable land, in areas where the slope is approximately <= 6 degrees (10.5%, 1: 9.5); these mostly in areas of Site Type A (deep red and yellow sandy soils) and particularly B (deep red sandy-clay-loam soils) soils.

Present Land Use:

Stockpile 8, and Port Durnford Plantation:
Information recorded in-field was of a qualitative nature, while surrounding Land Use is clearly indicated on the relevant 1: 50 000 topographical maps.
No assumptions were made during the mapping exercise.

Hydropedology:

The current hydropedological assessment and interpretation of flow-paths for both the Stockpile 8 and Port Durnford Plantation areas has been made based upon the detailed qualitative and quantitative data derived from the Soil and Land Capability (including wetlands) survey components, and also based upon the prevailing slopes (terrain unit, grade, and representative transects).

Given that van Tol *et al* (various sources - refer to References) are currently leading researchers in the field of hydropedology in South Africa, and have been instrumental in having the speciality become widely recognised; extensive references are made to the valuable contribution of these authors in the hydropedology section of the current document.

The current author finds it commendable that: *"The research was also readily adopted by industry and government; to such an extent that a hydropedological survey is now required as part of the Environmental Impact Assessment (EIA) and Water Use Licence Application (WULA) processes where drastic land-use change (such as open-cast mining) is foreseen"* (van Tol, 2020).

Comments by current author: It should be noted that an hydropedological assessment is not a "survey" (as indicated above), when such an assessment is conducted based upon a limited number of representative transects, as such an assessment would then be better defined as a 'reconnaissance hydropedological assessment'. Such an assessment' cannot record the variable spatial and profile detail recorded/derived from conducting a detailed soil survey of an entire site. For this reason, a detailed 150m grid (industry standard) soil survey and derived land capability map) have for many years been prerequisites for an EIA (Environmental Impact assessment) and EMP (Environmental Management Programme) specialist study report, that is required for areas where drastic land use change is foreseen. Such soil surveys presently auger down to a maximum depth of 1.5m, recording numerous physical soil properties for each horizon encountered as well as surface factors, typically followed by pit descriptions and chemical analyses of modal profiles.

"Assumptions" associated with Hydropedology (van Tol *et a*l, December 2017):

- "*soil morphology is in phase with the current soil moisture regime*" (van Tol *et a*l, December 2017). Thus signs of wetness in the soil profile, diagnostic horizon, and soil form are indicative (in the natural *in-situ* state only).
  Comment by current author: Yes.

- "*soil morphology changes slowly to alterations in soil water regimes (for example due to land use and climate change)"*(van Tol *et a*l, December 2017).

Comment by current author. From my experience, this may not always be true for moisture derived from anthropogenic sources. In such cases, morphological signatures of wetness such as organic matter build-up and mottling may develop fairly rapidly (within a couple of years).

- *"surveyed hill-slopes are representative of the entire site"* (van Tol *et a*l, December 2017). As van Tol et al (December 2017) points out, this assumption may be one of the limitations of hydropedology studies, in cases where terrain analysis was not conducted of the entire range of hill-slope types that occur within a particular study area.

  Comment by current author. This is the major limitation of 'reconnaissance hydropedological assessments'. The limitation lies in the fact that the finite (usually limited) number of "surveyed" hill-slope transects conducted, are usually (except in the case of a very small site) not representative of the hydropedology of the entire study area, and furthermore such assessments do not map/describe the variable soil patterns/depths/properties of the entire study area.

- *"hydropedological interpretations provide only qualitative descriptions of the dominant flowpaths. To quantify fluxes of water in the landscape, detailed mechanistic modelling, supplemented with measured hydraulic properties is required"* (van Tol *et al*, December 2017). Comment by current author: detailed hydropedological assessments are appropriate in order to quantify and model the aforementioned.

- *"Important to note is that hydropedological surveys cannot be used as a surrogate for mapping the agricultural potential (as required during most Environmental Impact Assessments) of an area. Conventional soil surveys (or other existing soil information) can also not always be used to infer the hydropedological response of an area, due to the differences between conventional and hydropedological surveys ...."* (van Tol *et al*, May/June 2017).

  Comments by current author. Thus comprehensive soil surveys and associated land capability mapping is already mandatory. In order for pedologists in the soil survey industry to cater for the hydropedology component, the following is recommended: soil auguring at grid points should in future be conducted to as deep as necessary (i.e. greater than 1.5m in some cases), in order to ascertain whether an horizon (non-diagnostic below 1.5m) or layer is encountered at a depth greater than 1.5m, that shows signs of hydromorphy (i.e. mottling, gleying or bleaching). If encountered and described, such a horizon/layer would then qualify the profile to be classified as an 'Interflow (soil/bedrock)' hydropedological soil type. The 'hydropedological soil type' mapping and reporting (including representative transects) could then be included as just another section of the soil survey (and associated products) report document. The aforementioned would be a good starting point for a further hydropedological assessment, where more expansive studies are conducted by a dedicated specialist (refer to previous point), if so required.

Hydropedology in the context of the current study area:
The Stockpile 8 (current survey) and Port Durnford Plantation (previous soil survey) were mapped (soils) based upon:

- a detailed 150m grid soil survey (one auger per 2.25ha), with maximum auguring depths of 1.8m and 1.5m respectively;
- knowledge that the 'Berea-type' Red sands extend to a great depth; and the
- fact that the soils derived from Quaternary sandy parent material (i.e. lithology), which occur closer to the coast; are also located upon level to shallow gradients.

Thus, no significant assumptions were made in the Hydropedology assessment.

Time of Year:

Due to the nature of the current soils / land capability / wetland / present land use / hydropedology environments, it is not expected that the season / time of the year during which the fieldwork was undertaken will have any significant influence on the outcomes of the assessments.

Should the aforementioned assessments have been conducted during the rainy season, the only variation in the data collected would be that the soil profiles would have been far more moist than they were at the time of the two different assessments. However, the aforementioned would not lead to a change the outcomes in any way.

Extent of Soil Surveys:

Apart from the Stockpile 8 soil survey (current), the Port Durnford Plantation soil survey (previous) did not extent into the south-western fifth of the current proposed Port Durnford Mining Development area

However, no other mining development is planned in this extreme south-western section.

Thus, no discussions / assumptions / recommendations have been made (or are necessary) for this area, apart from those for Stockpile 8.

Data Format of Partially Incorporated Previous Soil Survey Information:

A number of the Maps / Tables / Figures replicated from *REFERENCE DOCUMENT I (Snyman, 2008)* are rather visually unclear, given that this information was extracted from a pdf file, which was in turn produced from a scan of an existing hard copy version of the document. Despite requests to the client, the original data (word document and shapefiles) was not able to be sourced.

5.0 SOILS

5.1 SOIL POFILE DESCRIPTIONS

STOCKPILE 8:

Appendix I - Soil Profile Descriptions (Stockpile 8), indicates the following detailed information (‘Recorded soil and site variables’) for the 62 soil auger profile observation numbers described.

- ‘Recorded per diagnostic horizon’ (columns: A - L = 12):

- observation number;
- horizon name;
- horizon depth (cm);
- clay (%) [estimate];
- sand grade [estimate];
- colour name;
- Munsell colour notation;
- saprolite (if any) weathering status;
- soil structure;
- seasonal wetness hazard;
- cultural (i.e. cultivation) factors (% of horizon); and
- consistency (if not friable or soft) [also includes compaction and hard setting].

- ‘Recorded per profile’: (columns: M - X = 12):

- soil form;
- surface features (% of surface);
- organic carbon content (class);
- effective rooting depth (soil) (cm);
- ameliorated effective rooting depth (soil) (cm);
- effective rooting depth (soil & saprolite) (cm);
- depth limiting material (for rooting);
- lithology (soil) [i.e. parent material].

- remarks;
- land capability and wetland classification;
- vegetation (broad vegetation communities); and
- slope (degrees) [estimated in-field].

However, not all of the data cells were required to be filled.

Appendix II - Codes to Soil Profile Descriptions (Stockpile 8), indicates the symbols utilised in Appendix I.

PORT DURNFORD PLANTATION:

Refer to: *REFERENCE DOCUMENT 1 (Snyman, 2008).*
Specifically refer to: Appendix 1 (Soil Survey Data) of this document.

1412 auger points.

5.2 SOIL MAPS

STOCKPILE 8:

Two soil related maps were produced..

Map 1. Soil Observation Points (Stockpile 8).

This map indicates the location and reference numbers of the 62 soil observation (augurs) points. Contours and soil boundaries are also indicated in the background.

Map 2. Soil Mapping Units (Stockpile 8).

This map indicates the soil form distribution, soil depths (various, as indicated on the map legend), surface features, and parent material (i.e. lithology from which the soil is derived) for each of the identified soil mapping units (i.e. polygons).

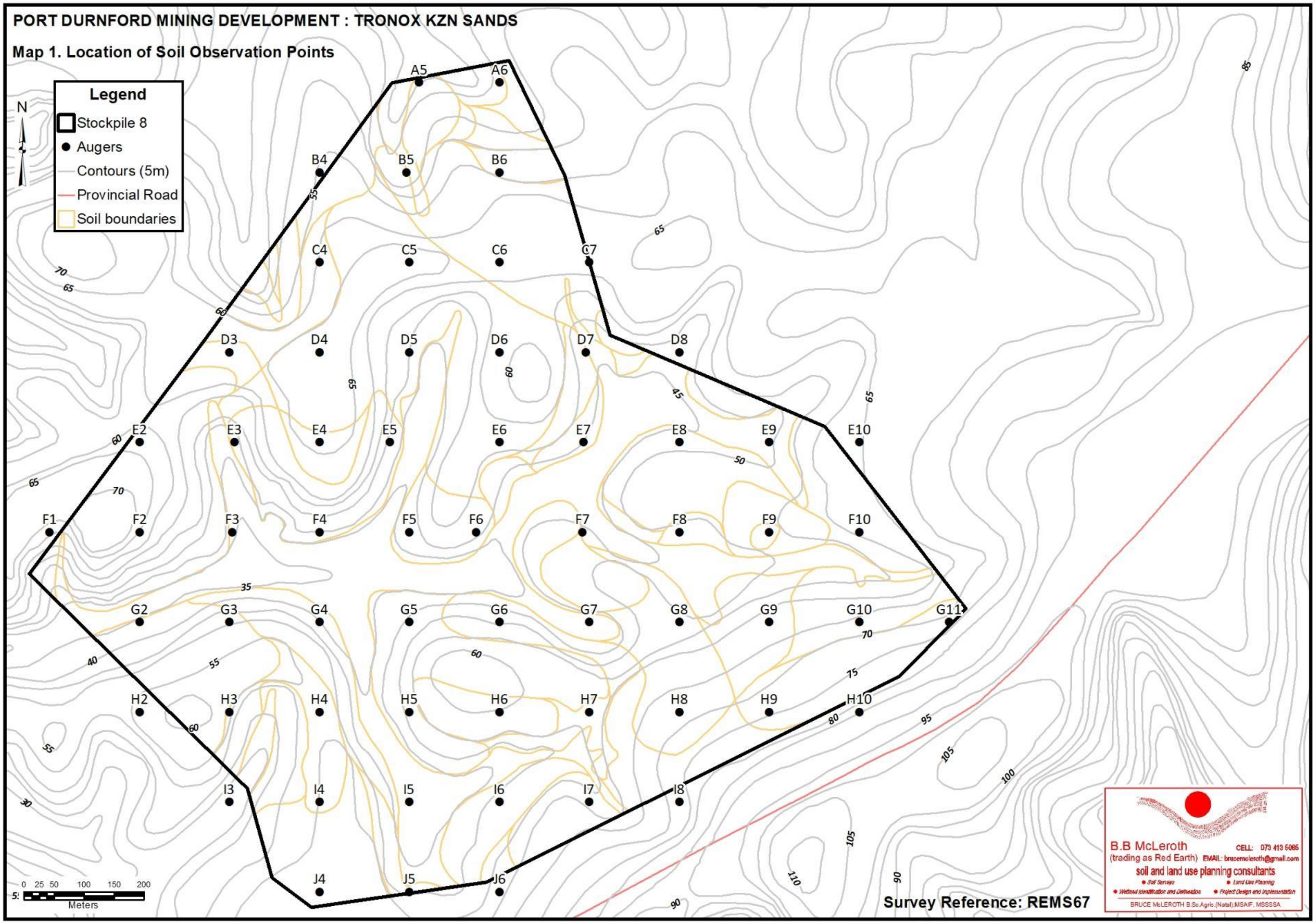
PORT DURNFORD PLANTATION:

Similarly, two soil related maps were produced.

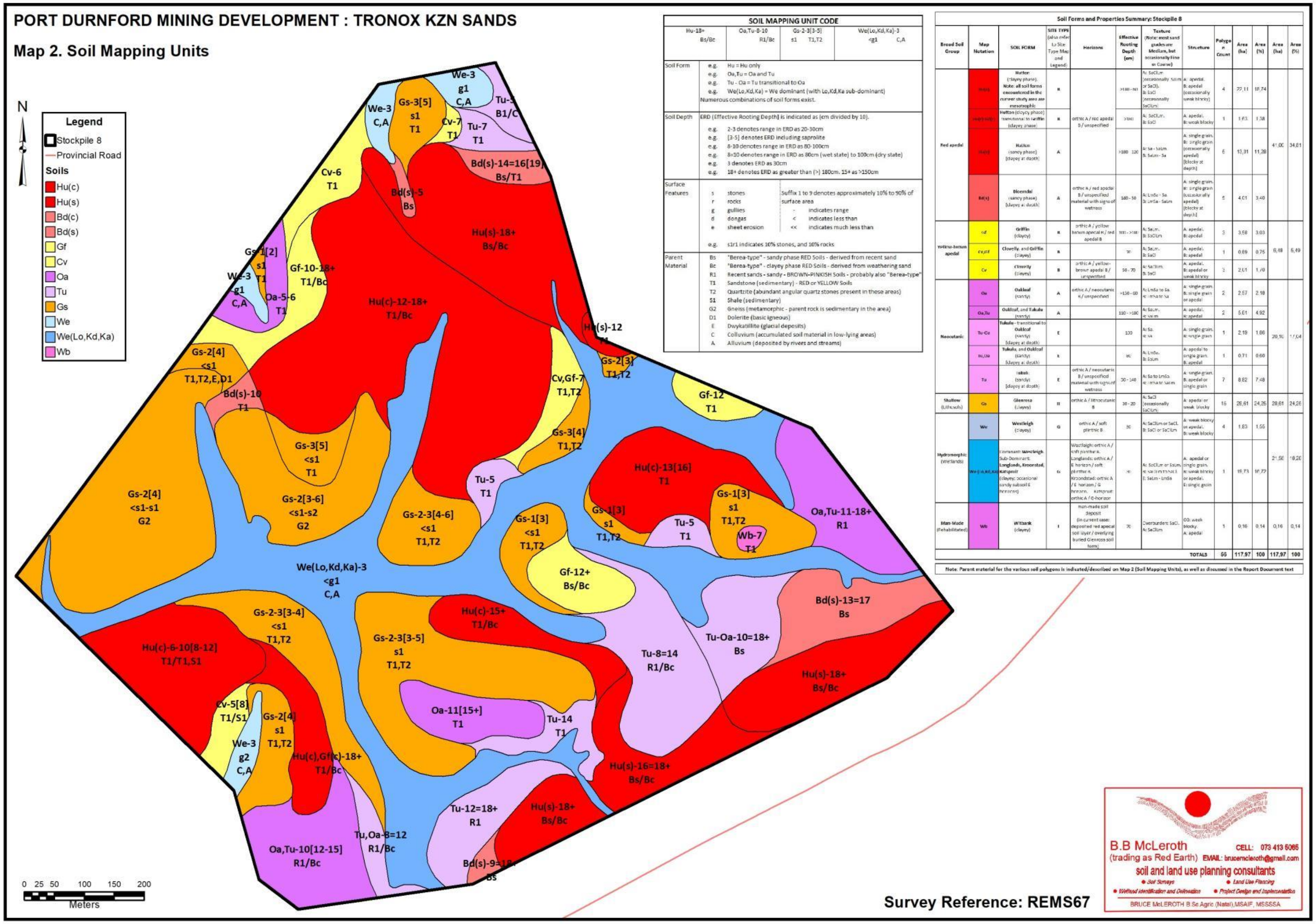
Map KS1. Location of Soil Observations and Modal Soil Profiles *(Snyman, 2008)*.
Map KS2. Soils *(Snyman, 2008)*.
Note that map suffix "KS" refers to the map author *Keith Snyman*.

Soils in both survey areas were classified as per: Soil Classification Working Group. 1991. Soil Classification, A Taxonomic System for South Africa. Department of Agricultural Development, Pretoria.

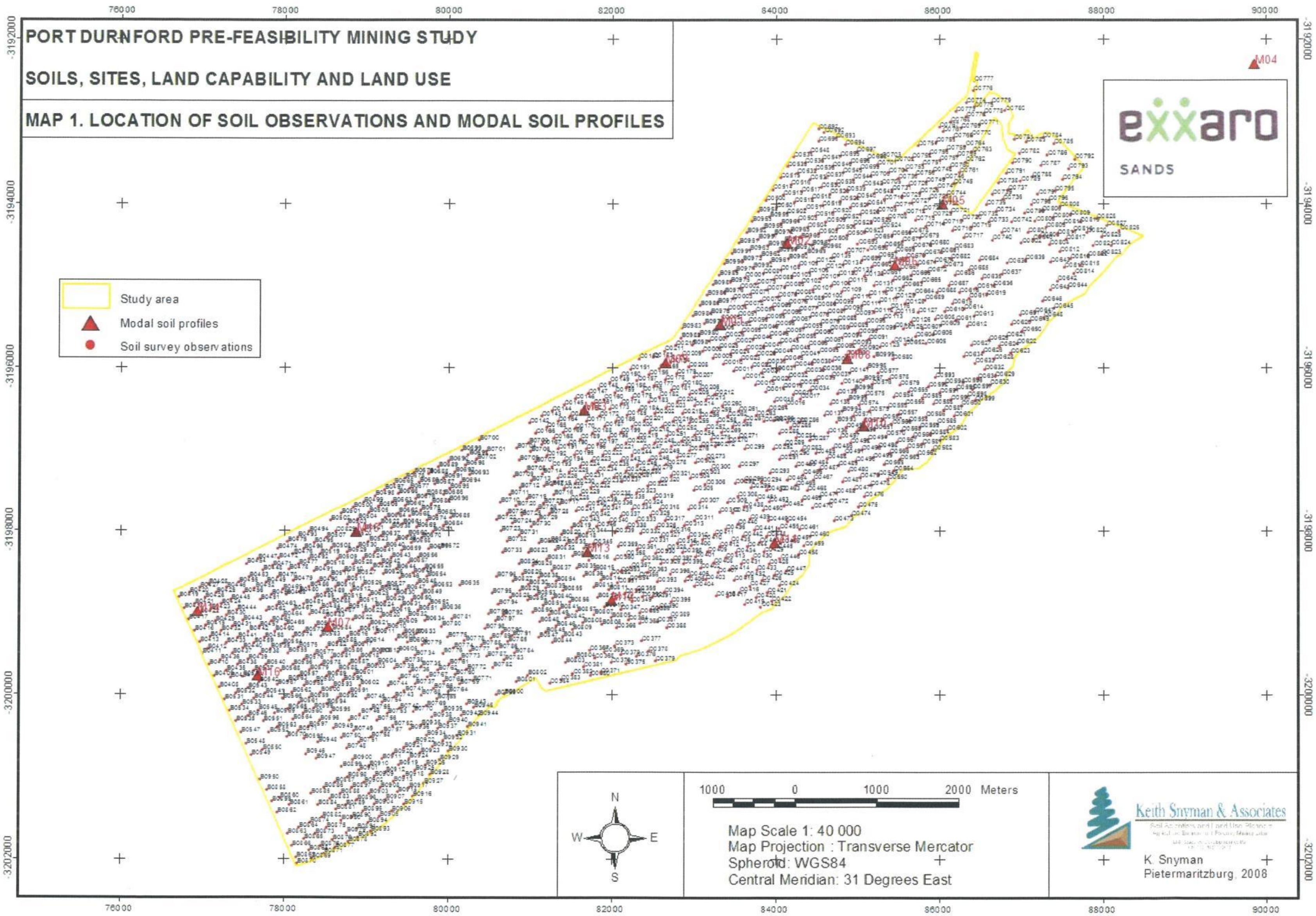
Map 1. Soil Observation Points (Stockpile 8)



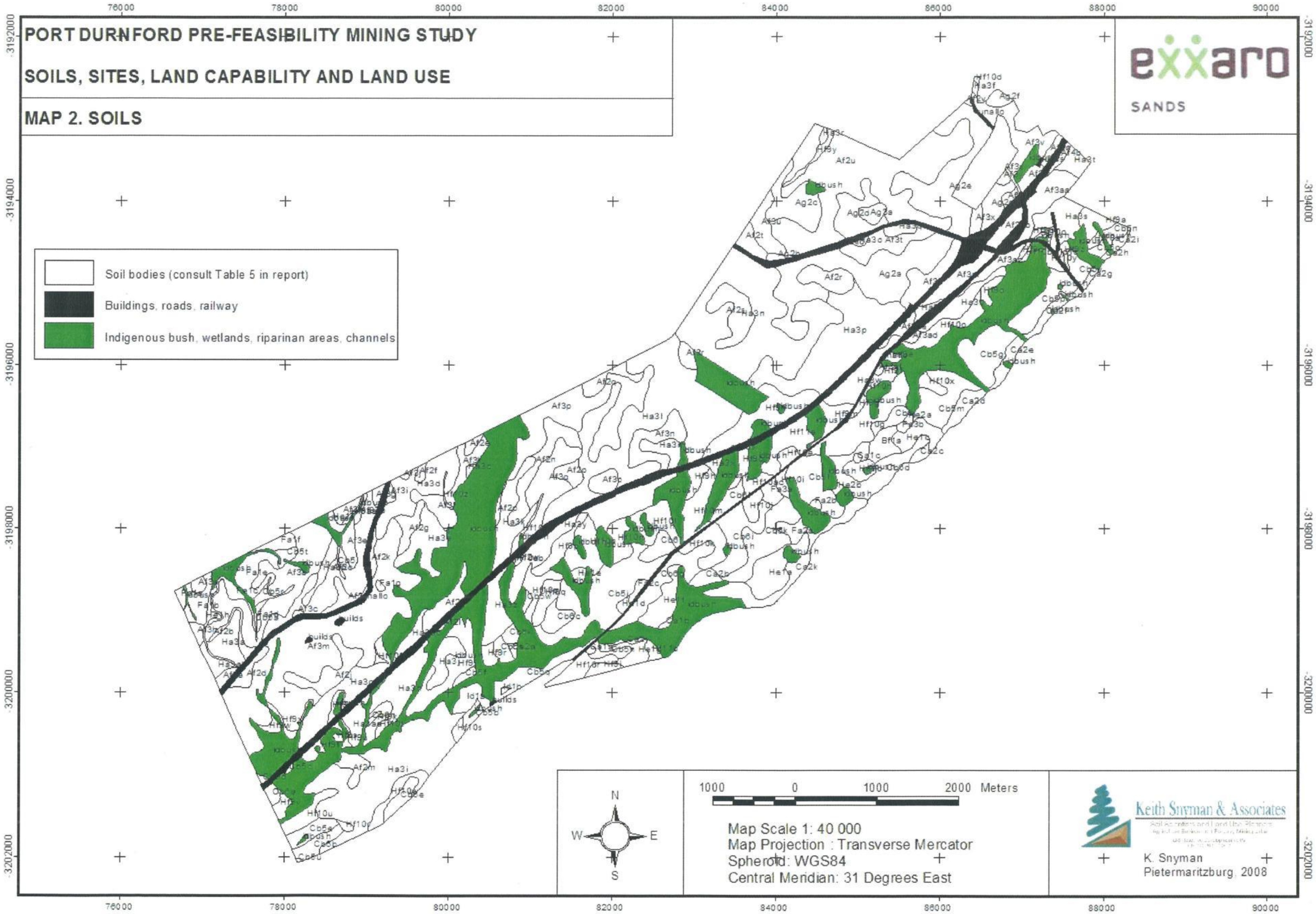
Map 2. Soil Mapping Units (Stockpile 8)



Map KS1. Location of Soil Observations and Modal Soil Profiles (Port Durnford Plantation) *[Snyman, 2008]*



Map KS2. Soils (Port Durnford Plantation) *[Snyman, 2008]*



5.3 SOIL TYPES

STOCKPILE 8:

Refer to: Map 2 (Soil Mapping Units (Stockpile 8)).

Refer to: Table 2 (Soil Forms / Properties Summary (Stockpile 8)).
This Table describes the following information for the various soil mapping units (i.e. polygons) which occur on Map 2:

Broad soil Group, Map Notation and Colour Shade (utilised on Map 2), Soil Form, Site Type (refer to current Report Document Section 6.0 - SITES), Horizons, Effective Rooting Depth, Soil Texture, Soil Structure, Polygon Count (i.e. number of mapping polygons), and Area (ha) and Area (%).

Thus it is not necessary to repeat this Soil Types information as further document text.

PORT DURNFORD PLANTATION:

Refer to: Map KS2 (Soils).

Refer to: Table KS1 (Defined Soil Bodies [Port Durnford Plantation]) (*source report: Table 5* - Snyman, 2008).
This Table indicates descriptions for the 22 different defined Soil Bodies (i.e. mapping units) which occur on Port Durnford Plantation. Homogeneous soil types and soil properties were grouped as Soil Bodies.

Refer to: REFERENCE DOCUMENT I (Snyman, 2008), specifically*: Appendix 3 (Modal Soil Profile Descriptions and Laboratory Analysis).*
This Appendix indicates detailed descriptions, laboratory analysis, and photographs of the 22 different Soil Bodies. This Appendix may be referred to separately.

Thus it is not necessary to repeat this Soil Types information as further document text.

Table 2. Soil Forms / Properties Summary (Stockpile 8)

Soil Forms and Properties Summary: Stockpile 8												
Broad Soil Group	Map Notation	SOIL FORM	SITE TYPE (also refer to Site Type Map and Legend)	Horizons	Effective Rooting Depth (cm)	Texture (Note: most sand grades are Medium, but occasionally Fine or Coarse)	Structure	Polygon Count	Area (ha)	Area (%)	Area (ha)	Area (%)
	Hu(c)	Hutton (clayey phase). Note: all soil forms encountered in the current study area are mesotrophic	B		>180 - 60	A: SaClLm (occasionally SaLm or SaCl). B: SaCl (occasionally SaClLm)	A: apedal. B: apedal (occasionally weak blocky)	4	22,11	18,74		
	Hu(c)-Gf(c)	Hutton (clayey phase) - transitional to Griffin (clayey phase)	B	orthic A / red apedal B / unspecified	>180	A: SaClLm. B: SaCl	A: apedal. B: weak blocky	1	1,63	1,38		
Red apedal	Hu(s)	Hutton (sandy phase) [clayey at depth]	A		>180 - 120	A: Sa - SaLm. B: SaLm - Sa	A: single grain. B: single grain (occasionally apedal) [blocky at depth]	5	13,31	11,28	41,06	34,81
	Bd(s)	Bloemdal (sandy phase) [clayey at depth]	A	orthic A / red apedal B / unspecified material with signs of wetness	140 - 50	A: LmSa - Sa. B: LmSa - SaLm	A: single grain. B: single grain (occasionally apedal) [blocky at depth]	5	4,01	3,40		
	Gf	Griffin (clayey)	B	orthic A / yellow-brown apedal B / red apedal B	100 - >180	A: SaLm. B: SaClLm	A: apedal. B: apedal	3	3,58	3,03		
Yellow-brown apedal	Cv,Gf	Clovelly, and Griffin (clayey)	B		70	A: SaLm. B: SaCl	A: apedal. B: apedal	1	0,89	0,75	6,48	5,49
	Cv	Clovelly (clayey)	B	orthic A / yellow-brown apedal B / unspecified	50 - 70	A: SaClLm. B: SaCl	A: apedal. B: apedal or weak blocky	3	2,01	1,70		
	Oa	Oakleaf (sandy)	A	orthic A / neocutanic B / unspecified	>150 - 60	A: LmSa to Sa. B: LmSa to Sa	A: single grain. B: single grain or apedal	2	2,57	2,18		
	Oa,Tu	Oakleaf, and Tukulu (sandy)	A		110 - >180	A: SaLm. B: SaLm	A: apedal. B: apedal	2	5,81	4,92		
Neocutanic	Tu-Oa	Tukulu - transitional to Oakleaf (sandy) [clayey at depth]	E		100	A: Sa. B: Sa	A: single grain. B: single grain	1	2,19	1,86	20,10	17,04
	Tu,Oa	Tukulu, and Oakleaf (sandy) [clayey at depth]	E		80	A: LmSa. B: SaLm	A: apedal to single grain. B: apedal	1	0,71	0,60		
	Tu	Tukulu (sandy) [clayey at depth]	E	orthic A / neocutanic B / unspecified material with signs of wetness	50 - 140	A: Sa to LmSa. B: LmSa to SaLm	A: single grain. B: apedal or single grain	7	8,82	7,48		
Shallow (Lithosols)	Gs	Glenrosa (clayey)	H	orthic A / lithocutanic B	30 - 20	A: SaCl (occasionally SaClLm)	A: apedal or weak blocky	15	28,61	24,25	28,61	24,25
	We	Westleigh (clayey)	G	orthic A / soft plinthic B	30	A: SaClLm or SaCl. B: SaCl or SaClLm	A: weak blocky or apedal. B: weak blocky	4	1,83	1,55		
Hydromorphic (Wetlands)	We (Lo,Kd,Ka)	Dominant: Westleigh. Sub-Dominant: Longlands, Kroonstad, Katspruit (clayey; occasional sandy subsoil E-horizons)	G	Westleigh: orthic A / soft plinthic B. Longlands: orthic A / E-horizon / soft plinthic B. Kroondstad: orthic A / E-horizon / G-horizon. Katspruit: orthic A / G-horizon	30	A: SaClLm or SaLm. B: SaClLm to SaCl. E: SaLm - LmSa	A: apedal or single grain. B: weak blocky or apedal. E: single grain	1	19,73	16,72	21,56	18,28
Man-Made (Rehabilitated)	Wb	Witbank (clayey)	I	man-made soil deposit (in current case: deposited red apedal soil layer / overlying buried Glenrosa soil form)	70	Overburden: SaCl. A: SaClLm	OB: weak blocky. A: apedal	1	0,16	0,14	0,16	0,14
							TOTALS	56	117,97	100	117,97	100

Note: Parent material for the various soil polygons is indicated/described on Map 2 (Soil Mapping Units), as well as discussed in the Report Document text

Table KS1. Defined Soil Bodies (Port Durnford Plantation) *(Snyman, 2008 - Table 5)*

Map Unit	Site	Soil Type	Dominant Soils	Subdominant Soils	Effective Rooting Depth (cm)	Ameliorated Rooting Depth (cm)	Depth Limiting Material	Horizon Structure	Wetness Hazard Within Horizons	Topsoil Carbon	Cultivation Factors	Surface Features	Lithology	Clay % A	Clay % E	Clay % B	TAM mm/m	Slope %	Erodibility Factor K	Usable Soil Depth (cm) and Volume (x 1million m3) for Topdress Rehab.	MAP# MAT* A-pan$	*Land Capability Classification (Chamber of Mines)*	*Afforestation Potential*
Af2 (a-w) 497.1 ha 12.3%	A	red apedal mesotrophic soils	Hu2100 mesa	Hu2200 Immesa	>150	-	-	single grain A single grain B or apedal B	-	low to medium	-	-	weathering sand	5	-	5-15	153	3-33 common 15	0.55	30 1.5	1271 21.1 1771	***Class III*** *grazing land*	*very high*
Af3 (a-af) 585.6 ha 15.0%	B	red apedal mesotrophic soils	Hu2200 Immesa	-	>150	-	-	single grain A apedal B	-	low to medium	-	-	weathering sand	5-15	-	15-40	128	6-16 common 10	0.6	30 1.8	1271 21.1 1771	***Class III*** *grazing land*	*excellent*
Af4 (a-b) 5.9 ha 0.1%	B	red apedal mesotrophic soils	Hu2200 Immesa	-	>150	-	-	single grain A apedal B	-	low	-	-	weathering sand	10	-	20-35	118	8-18 common 15	0.60	30 0.2	1271 21.1 1771	***Class III*** *grazing land*	*excellent*
Ag2 (a-g) 225.3 ha 5.6%	A	yellow apedal mesotrophic soils	Cv2200 Immesa Cv2100 Immesa	Fw1210 Immesa Ct1100 Immesa	>150	-	-	single gain A single grain B	-	low to medium	-	-	weathering sand recent sand	5	-	5-15	160	3-50 common 20	0.55	30 0.7	1271 21.1 1771	***Class III*** *grazing land*	*very high*
Ag3 (a) 5.9 ha 0.1%	A	yellow apedal mesotrophic soils	Cv2200 Immesa	Hu2200 Immesa	40-60	-	hard rock	single grain A apedal B	-	low to medium	-	-	weathering sand recent sand	5	-	15	58	5-30 common 15	0.55	30 0.2	1271 21.1 1771	***Class III*** *grazing land*	*medium*
Bf1 (a) 10.9 ha 0.3%	F	plinthic mesotrophic soils	Av2200 mesalm	Cv2200 mesalm	80-110	-	soft plinthite	apedal A apedal B1 massive B2	short periods B1 long periods B2	medium	-	-	recent sand	5-10	-	35	88	2	0.60	30 0.3	1271 21.1 1771	***Class II*** *arable land*	*high*
Ca1 (a-c) 2.9 ha 0.1%	G	undifferentiated hydromorphic soils	Ch2200 clim Kd1000 clim	-	0	-	organic topsoil watertable	massive A	all year	extremely high	-	-	weathering sands	30	-	-	0	2	0.80	- -	1271 21.1 1771	***Class I*** *wetland*	*low*
Ca2 (a-k) 73.8 ha 1.8%	G	undifferentiated hydromorphic soils	We2000 fsaclm Ka1000 fsaclm	Tu1120 fsaclm	30-60	-	soft plinthite gley	apedal A massibe B	short periods A long periods B	very high	-	-	recent sand alluvium	25-30	-	35-50	35	3	0.80	- -	1271 21.1 1771	***Class I*** *wetland*	*low*

Map Unit	Site	Soil Type	Dominant Soils	Subdominant Soils	Effective Rooting Depth (cm)	Ameliorated Rooting Depth (cm)	Depth Limiting Material	Horizon Structure	Wetness Hazard Within Horizons	Topsoil Carbon	Cultivation Factors	Surface Features	Lithology	Clay % A	Clay % E	Clay % B	TAM mm/m	Slope %	Erodibility Factor K	Usable Soil Depth (cm) and Volume (m3) for Topdress Rehab.	MAP# MAT* A-pan$	*Land Capability Classification (Chamber of Mines)*	*Afforestation Potential*
Cb5 (a-w) 272.1 ha 6.7%	E	E-horizon hydromorphic soils	Kd1000 mesaclm Lo1000 mesaclm	Tu1110 mesaclm	60-90	-	gley	apedal A single grain E massive B	short periods E long periods B	very high	-	-	recent sand	20	5	20-45	82	1-15 common 5	0.60	30 0.8	1271 21.1 1771	***Class III*** *grazing land*	*medium to high*
Cb6 (a-f) 142.3 ha 3.5%	F	E-horizon hydromorphic soils	Kd1000 mesalm Lo1000 mesalm	Vf1120 mesalm	90-120	-	soft plinthite gley	apedal A single grain E massive B	short periods E long periods B	high	-	-	recent sand	15	5	20	102	1-3 common 2	0.60	30 0.4	1271 21.1 1771	***Class II*** *arable land*	*high*
Fa1 (a-g) 46.2 ha 1.1%	H	undifferentiated lithosols	Ms1100 clm Gs1111 clm	Hu2200 clm	30-60	70	hard rock lithocutanic saprolite stoneline	wek blocky A massive B	-	high	10% gravel A 60% gravel SL	-	gneiss	35	-	40-50	41	4-28 common 20	0.55	20 0.1	1271 21.1 1771	***Class III*** *grazing land*	*low*
Fa2 (a-c) 10.3 ha 0.3%	H	undifferentiated lithosols	Cf1200 mesaclm	Ms1100 mesaclm Wa1000 mesaclm	50-70	-	hard rock saprolite	apedal A single grain E	-	high	-	-	gneiss recent sand	20	5	-	64	3	0.55	20 0.02	1271 21.1 1771	***Class III*** *grazing land*	*low to medium*
Fa3 (a-b) 7.1 ha 0.2%	H	undifferentiated lithosols	Ms1100 mesaclm	-	1-30	-	hard rock	weak blocky A	-	high	-	-	gneiss	20	-	-	25	3-7 common 5	0.55	- -	1271 21.1 1771	***Class IV*** *wilderness*	*low*
Ha3 (a-ad) 746.6 ha 18.4%	C	pale topsoil sands	Fw1210 mesa	Ct1100 mesa Cv2100 mesa	>150	-	-	single grain A single grain E	-	low	-	-	recent sand	5	5	-	159	2-12 common 8	0.55	20 1.5	1271 21.1 1771	***Class III*** *grazing land*	*very high*
He1 (a-l) 83.4 ha 2.1%	E	non-red neocutanic soils	Tu1120 mesaclm Tu1110 mesaclm	Vf1120 mesaclm	60-90	-	soft plinthite gley	weak blocky A apedal B massive C	short periods A long periods BC	very high	-	-	weathered sands	30	-	40	60	1-11 common 4	0.60	30 0.2	1271 21.1 1771	***Class III*** *grazing land*	*high*
He2 (a-b) 2.3 ha 0.1%	B	non-red neocutanic soils	Oa1120 mesaclm	-	>150	-	-	apedal A apedal B	-	very high	-	-	gneiss	25	-	40	120	3	0.55	- -	1271 21.1 1771	***Class II*** *arable land*	*high*

Map Unit	Site	Soil Type	Dominant Soils	Subdominant Soils	Effective Rooting Depth (cm)	Ameliorated Rooting Depth (cm)	Depth Limiting Material	Horizon Structure	Wetness Hazard Within Horizons	Topsoil Carbon	Cultivation Factors	Surface Features	Lithology	Clay % A	E	B	TAM mm/m	Slope %	Erodibility Factor K	Usable Soil Depth (cm) and Volume (m3) for Topdress Rehab.	MAP# MAT* A-pan$	*Land Capability Classification (Chamber of Mines)*	*Afforestation Potential*
Hf9 (a-ab) 177.8 ha 4.3%	D	dark topsoil sands	Fw2110 Immesa	Lt1100 Immesa	>150	-	-	single gain A single grain E	-	high	-	-	recent sand	8-10	5	-	158	2-15 common 5	0.35	40 0.7	1271 21.1 1771	***Class II*** *arable*	*medium*
Hf10 (a-ac) 220.5 ha 5.4%	D	dark topsoil sands	Fw2110 mesalm	Lt1100 mesalm Fw1110 mesalm	>150	-	-	single gain A single grain E	short periods E	high	-	-	recent sand	5-18	5	-	154	2	0.35	40 0.9	1271 21.1 1771	***Class II*** *arable*	*medium to low*
Hf11 (a-b) 22.8 ha 0.1%	G	dark topsoil sands	Fw2110 mesalm	-	70-100	-	watertable	apedal A single grain E	long periods A all year E	high	-	-	recent sand	15	5	-	126	2	0.60	- -	1271 21.1 1771	***Class I*** *wetland*	*low*
Id1 (a-c) 11.2 ha 0.3%	I	man-made deposits	Wb1000 mesa	-	0	-	man-made horizon	-	-	low	-	-	-	5	-	-	0	3	-	- -	1271 21.1 1771	***Class IV*** *wilderness*	*unsuitable*
642.5 ha 17%	J	conservation (wetland) (riparian) (sand forest)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- -	1271 21.1 1771	***Class IV*** *wilderness*	*unsuitable*
253.5 ha 6.3%	I	buildings roads rail	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	- -	1271 21.1 1771	***Class IV*** *wilderness*	*unsuitable*

MAP# mean annual precipitation (mm) **A-pan$** **MAT*** mean annual temperature (degrees C)

The above Table contain a large amount of information, and in order for the fine text to be readable, it must either be enlarged (and/or printed on A3 paper). Given the non-availability of an original pdf from the client, the Table was reproduced from a previously scanned hard copy document. Measures have already been taken to improve the quality of the fine text, as best as was practically possible.

5.4 SOIL ANALYTICAL DATA

STOCKPILE 8:

Refer to: Table 3 (Soil Analytical Data ([Stockpile 8]).

Five samples were laboratory analysed from three different modal (i.e. typical representative) soil profiles.

These include the following samples:

- G10A (0-10cm - orthic A) and B (50cm - B): Bloemdal form (sandy phase);
- D5 A (0-10cm - orthic A) and B (50cm - B): Hutton form (clayey); and
- F1A (0-10cm - orthic A) : Glenrosa form (clayey).

PORT DURNFORD PLANTATION:

41 samples were laboratory analysed from 16 different modal soil profiles.
For further information refer to: *REFERENCE DOCUMENT I (Snyman, 2008).*
Specifically refer to: *Appendix 3 (Modal Soil Profile Descriptions and Laboratory Data)* [also includes soil profile photographs], of that document.
This Appendix is not Incorporated into the Current Document (Refer to Separately).

The large quantity of analysed laboratory data provides a very accurate approximation of the fertility (and other information) relating to the numerous soil bodies (soil mapping units) identified, as well as for the 10 (maximum) derived (simplified) Sites Types occurring in the immediate area.

Immediately after the Rehabilitation 'topsoiling' exercise, soil nutrient deficiencies must be ameliorated (after further soil analysis at the time); as these relate to the planned post-mining vegetative cover (e.g. grassland, indigenous bush, or specified crops - varies for different areas according to the Planned Post-Mining Land Use).

Thereafter, topsoil soil analysis and corrective amelioration (fertilisation) must be conducted at least once every three years until mine closure.

Table 3. Soil Analytical Data (Stockpile 8)

FERTILISER ADVISORY SERVICE - TOPSOIL SUMMARY REPORT

SA Sugarcane Research Institute

Tel: 031 508 7474 / 75 Fax: 031 508 7593 Email: fertiliser.advisory@sugar.org.za

Report Date : 09/07/2024

CLIENT DETAILS

Bruce McLeroth
Bruce
278 Bulwer Street
Pietermaritzburg
3201

ADVISOR DETAILS

Advisor Name:
Advisor Email:

BILLING DETAILS

Order No:

FAS No. : 102060
Grower No. :
Email Address : brucemcleroth@gmail.com
Extension Area : Zululand South
Date Received : 19-JUN-24
Date Sampled :

Analysis	Lab ID / Sample ID	MS313695 G10_A	MS313696 G10_B	MS313697 D5_A	MS313698 D5_B	MS313699 F1_A
pH (in calcium chloride)		5.64	4.40	5.25	4.48	4.38
Phosphorus (P)	mg/L	11.6	1.8	3.6	1.0	4.1
Potassium (K)	mg/L	20	9	16	144	10
Calcium (Ca)	mg/L	364	49	626	674	115
Magnesium (Mg)	mg/L	93	17	175	289	83
Sodium (Na)	mg/L	11	6	21	23	10
Exch. Acidity (Al+H)	cmol/L	0.05	0.49	0.05	1.26	1.94
Total Cations	cmol/L	2.74	0.93	4.75	7.48	3.27
Acid Saturation	%	1.8	52.7	1.1	16.8	59.3
Exch. Sodium % (ESP)	%	2.0	3.0	2.0	1.0	2.0
Ca/Mg (Equivalence ratio)		2.4	1.7	2.2	1.4	0.8
Zinc (Zn)	mg/L	1.2	0.4	0.4	0.8	0.2
Copper (Cu)	mg/L	0.7	0.5	1.5	11.1	1.6
Manganese (Mn)	mg/L	8.5	4.8	14.1	33.4	7.5
Iron (Fe)	mg/L	305	498	257	473	156
Clay MIR	%					
Clay	%	7	6	17	49	40
Silt	%	5	5	5	5	8
Sand	%	88	89	78	46	52
Organic Matter MIR	%					
Organic Matter	%	0.8	0.5	2.1	1.4	4.3
Nitrogen (N) Category	Cat	1	1	2	1	4
N Volatilization	%	20.0	19.7	2.5	0.5	0.1
Volume Weight	g/mL	1.41	1.48	1.28	1.09	1.05
Reserve K	cmol/L	0.50	0.50	0.50	0.50	0.50
Sulphur (S)	mg/L	3	4	6	386	50

6.O SITES

For ease of interpretation, and particularly so for the purposes of the HYDROPEDOLOGY Assessment, the various defined soil bodies have been grouped into SITES; six for Stockpile 8, and ten for Port Durnford Plantation.
For the purposes of this report, a Site is defined as a spatial land extent that has similar soil forms, soil properties, topography (landscape position and slope grade) and climate; such that these will provide similar infiltration rates, hydropedological responses, and growth potential to a variety of crops.

The Sites classification for Stockpile 8 was based (with some necessary variations) [as indicated in Table 4] upon that utilised for Port Durnford Plantation, this in order for a consistent approach to be adopted.

STOCKPILE 8:

Refer to: Map 3. Site Types (Stockpile 8).

Refer to: Table 4. Site Types Summary (Stockpile 8).

PORT DURNFORD PLANTATION:

Refer to: Map KS3. Sites (Port Durnford Plantation).

Refer to: Table 5. Site Types, Soil Forms / Properties, and Stripping Volume (Port Durnford Plantation).

Table 5 describes the following information for the various soil mapping units (i.e. polygons) which occur on Map KS2 (Soils (Port Durnford Plantation)) (Snyman, 2008):
Site Type, Area (ha), Area (%), Soil Type, Soil Forms (and Families), Effective Rooting Depth (cm), Structure (topsoil, subsoil), Texture (topsoil, subsoil), Parent Material, Susceptibility to Erosion, Average Slope (%), Average Slope (degrees) [current author converted from %], and Stripping Volume m^3 (topsoils and subsoils combined) [current author calculated this volume].
Furthermore, the bottom text box also indicates the following:
Stripping Volume (and Depth) - Further Notes: Regarding Topsoils and Subsoils (Combined), and Topsoil (Only) [added by current author].
Table 5 information was duplicated/complied from *REFERENCE DOCUMENT I (Snyman, 2008)*, specifically with extracts from the following: *Table 6 (Sites), Section 7.2 (Sites: report document text), and Map KS3 (Sites).*

Refer to: Section 7.2- SITES; of REFERENCE DOCUMENT I (Snyman, 2008).
This Section includes Descriptions and Photographs of the 10 defined Sites A - J, grouped from the 22 defined Soil Bodies.

The defined SITES are applicable to the HYDROPEDOLOGY Section (Section 12) of the current Report Document.

Map 3. Site Types (Stockpile 8)

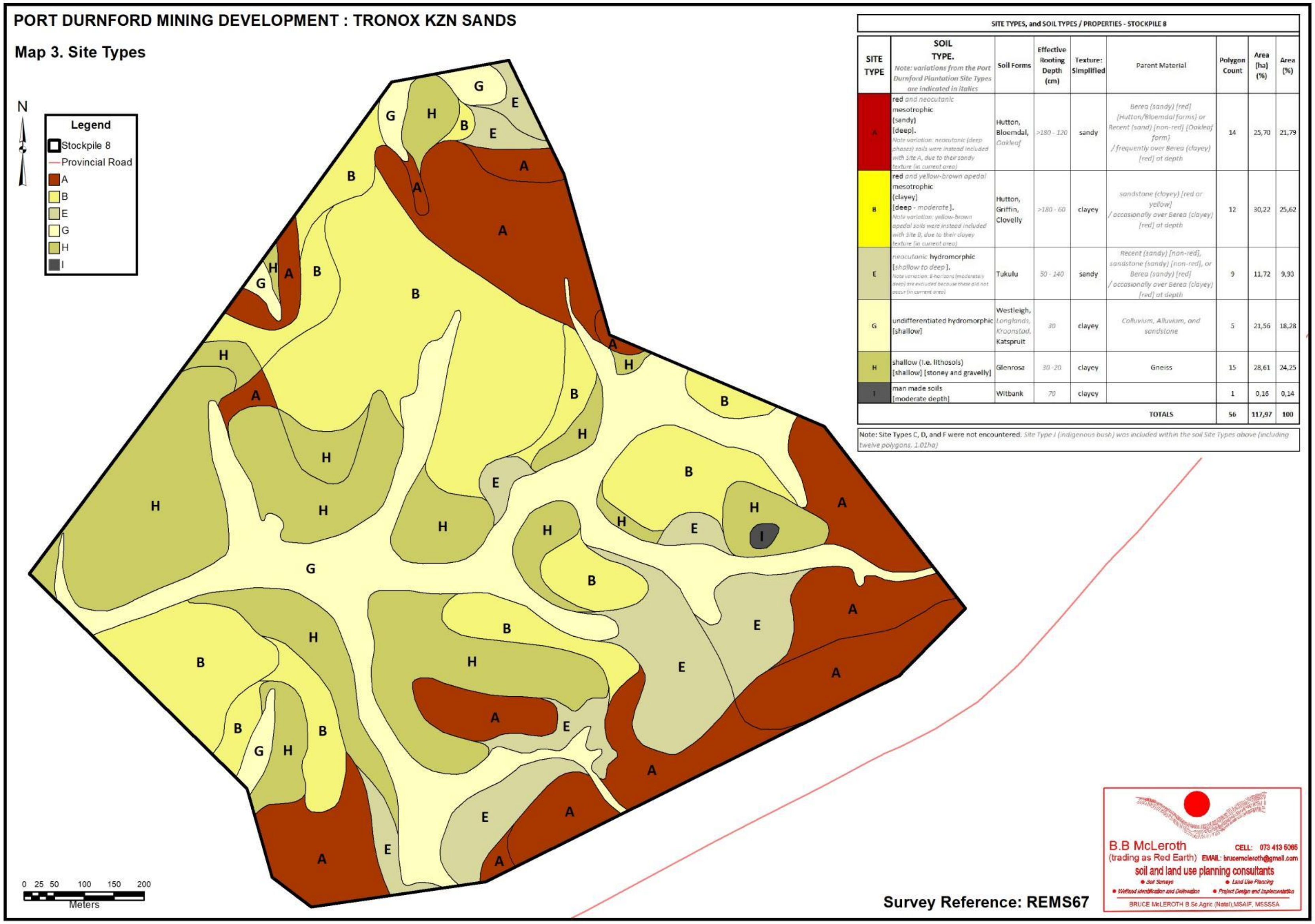


Table 4. Site Types Summary (Stockpile 8)

SITE TYPES, and SOIL TYPES / PROPERTIES - STOCKPILE 8								
SITE TYPE	SOIL TYPE. *Note: variations from the Port Durnford Plantation Site Types are indicated in italics*	Soil Forms	Effective Rooting Depth (cm)	Texture: Simplified	Parent Material	Polygon Count	Area (ha) (%)	Area (%)
A	red *and neocutanic* mesotrophic (sandy) [deep]. *Note variation: neocutanic (deep phases) soils were instead included with Site A, due to their sandy texture (in current area)*	Hutton, Bloemdal, *Oakleaf*	*>180 - 120*	sandy	*Berea (sandy) [red] {Hutton/Bloemdal forms} or Recent (sand) [non-red] {Oakleaf form} / frequently over Berea (clayey) [red] at depth*	14	25,70	21,79
B	red *and yellow-brown apedal* mesotrophic (clayey) [deep *- moderate*]. *Note variation: yellow-brown apedal soils were instead included with Site B, due to their clayey texture (in current area)*	Hutton, Griffin, Clovelly	*>180 - 60*	clayey	*sandstone (clayey) [red or yellow] / occasionally over Berea (clayey) [red] at depth*	12	30,22	25,62
E	*neocutanic* hydromorphic [*shallow to deep*]. *Note variation: E-horizons (moderately deep) are excluded because these did not occur (in current area)*	Tukulu	*50 - 140*	sandy	*Recent (sandy) [non-red], sandstone (sandy) [non-red], or Berea (sandy) [red] / occasionally over Berea (clayey) [red] at depth*	9	11,72	9,93
G	undifferentiated hydromorphic [shallow]	Westleigh, *Longlands, Kroonstad,* Katspruit	*30*	clayey	*Colluvium, Alluvium, and sandstone*	5	21,56	18,28
H	shallow (i.e. lithosols) [shallow] [stoney and gravelly]	Glenrosa	*30 -20*	clayey	Gneiss	15	28,61	24,25
I	man made soils [moderate depth]	Witbank	*70*	clayey		1	0,16	0,14
					TOTALS	56	117,97	100

Note: Site Types C, D, and F were not encountered. *Site Type J (indigenous bush) was included within the soil Site Types above (including twelve polygons, 1.01ha)*

Map KS3. Sites (Port Durnford Plantation)

Table 5. Site Types, Soil Forms / Properties, and Stripping Volumes (Port Durnford Plantation)

SOIL TYPES / PROPERTIES, SITE TYPES, and STRIPPING VOLUMES - PORT DURFORD PLANTATION

Information compiled/duplicated from: *Table 6 (Sites), Section 7.2 (Sites-report text-in italics), and Map 3 (Sites) - Snyman (2008).* Plus additonal information - B.B.McLeroth

SITE TYPE	Area (ha)	Area (%)	SOIL TYPE	Soil Forms	Effective Rooting Depth (cm)	Structure: topsoil subsoil	Texture: topsoil subsoil	*Parent Material*	Susceptability to Erosion	Average Slope (%)	Average Slope (degrees) [converted from % by B.B.McLeroth]	Stripping Volume: Topsoil and Subsoils (m^3) [calculated by B.B.McLeroth]
A	728,3	18,3	red and yellow mesotrophic (sandy) [deep]	Hu2100, Cv1200	>150	*A: single grain B: single grain becoming apedal*	A: Me Sa B: Me LmSa	*Quartenary sands*	extremely high	15	8,5	10924500
B	603,8	15,1	red mesotrophic (sandy-clay-loam) [deep]	Hu2200, Oa1120	>150	*A: apedal B: apedal, occasionally becoming weak blocky*	A: Me LmSa B: Me SaClLm	*Berea Formation*	extremely high	*10 -* 15	8,5	9057000
C	746,6	18,7	pale topsoil sands [deep]. (E-horizon "yellow'" when moist)	Fw1210	>150	*A/E: single grain*	A/E: Me Sa	*Quartenary sediments*	very high *(high)*	8	4,5	11199000
D	398,3	10,0	dark topsoil sands [water table at about 2m]	Fw2110	>150	*A/E: single grain*	A: Me LmSa E: Me-Fi Sa	*Quartenary sediments*	medium *(moderate - low)*	*2 -* 5	2,9	5974500
E	355,5	8,9	E-horizon hydromorphic [moderately deep]	Kd1000, Lo1000, Tu1120	60 - 90	*A/E: single grain G,B: massive*	A: Me SaClLm E: Sa G/B: SaClLm	*Quartenary sediments*	medium *(moderate - low)*	5	2,9	2488500
F	153,2	3,8	E-horizon hydromorphic [deep]	Kd1000, Lo1000	90 - 120	*A/E: single grain G,B: massive*	A: Me SaLm E: Sa G/B: SaClLm	*Quartenary sediments*	medium *(moderately low)*	2	1,1	1532000
G	99,5	2,5	undifferentiated hydromorphic [shallow]	We2000, Ka1000, Ch2200, Fw2110, *Lo1000, Kd1000*	30 - 60	*A: massive (to apedal) E: single grain B/G: massive*	A: Fi SaClLm B/G: clayey	*Quartenary sediments*	medium	3	1,7	298500
H	63,6	1,6	lithosols [shallow]	Ms1100, Gs1111, Cf2100	1 - 60	*A: apedal B,C: massive*	A: Me SaClLm B: clayey	*Gneiss*	medium	15	8,5	190800
I	198,4	5,0	man made sites, buildings, roads	Wb1000	0							0
J	642,5	17,0	indigenous bush, riparian, wetlands, channels		0							0
TOTALS	3990											41664800

Note: Stripping Volume (and Depth) - Further Notes [by B.B.Mcleroth]:

Topsoil & Subsoil (combined): Greater depth/volume must be stripped (than that indicted), determined by actual soil depth below sampling depth of 1,5m. So: > 41 664 800m3

Topsoil (only): 3990ha (site area) - 198 (man-made sites, buildings, roads) - 643 (indigenous bush, riparian, welands, channels) = 3149ha.
So: 3149ha x 0,3m (average A-horizon depth) x 10000 = 9 447 000m3

7.0 LAND CAPABILITY

7.1 LAND CAPABILITY - MINING

The current Port Durnford Mining Development, is a proposed (pre-mining) Project.
However, the post-mining rehabilitation recommendations will be relevant during the rehabilitation phase of the Mine.

STOCKPILE 8:

Pre-Mining Land capability classes were determined using the latest guidelines outlined in the following document:

- Land Rehabilitation Guidelines for Surface Coal Mines. May 2019. Land Rehabilitation Society of Southern Africa, Coaltech Research Association, and Minerals Council of South Africa. These are referred to in the current document as 'Mining Rehabilitation Guidelines (2019)'.

A summary of the latest ('Mining Rehabilitation Guidelines 2019') land capability classification procedure (i.e. requirements) are indicated in Table 7 (Land Capability Requirements - Mining). These are indicated for both the Pre- and Post-Mining land capability classes.

For Stockpile 8, the maximum slope chosen for an area to be accepted into the Pre-Mining Arable Capability class area was 6 degrees (10.5%).

This slope was utilised based upon Scotney (1987), wherein erosion slopes were calculated from the Soil Erodibility Nomograph (Wischmeier, *et al*, 1971). Herein, the maximum allowable slope for a ferrallitic soil to be classified as arable is 8.5 degrees (15%). In order to both cater for the non-ferrallitic soils occurring, as well as to provide a buffer against soil erosion in bare or cultivated areas, 6 degrees (10.5%) was instead utilised.

Scotney *et al.* (1987) makes use of the following critical arable slopes:

- Ferrallitic (highly weathered) soils	:	< 15.0 %	(8.5 degrees),
- Non-Ferrallitic soils without a 'clay increase B-horizon'	:	< 12.0 %	(6.8 degrees),
- Non-Ferrallitic soils with a 'clay increase B-horizon'	:	< 10.0 %	(5.7 degrees),
- Duplex soils	:	< 8.0 %	(4.5 degrees).

Unacceptable levels of soil erosion will begin to occur in bare (without grass cover) areas, where the slope exceeds that specified for the respective broad soil groups.

Refer to: Table 6. Land Capability (Pre-Mining) Summary (Stockpile 8).
Refer to: Map 5. Land Capability (Pre-Mining) (Stockpile 8).

Table 6. Land Capability (Pre-Mining) Summary (Stockpile 8)

Land Capability and Wetlands Summary: Stockpile 8								
Broad Group	Map Notation	Capability Class Detail	Capability Class Summary	Polygon Count	Area (ha)	Area (%)	Area (ha)	Area (%)
Natural *In-Situ* Soils	A	Arable	Arable	16	28,86	24,46	28,86	24,46
	G	Grazing	Grazing	4	3,15	2,67	37,08	31,43
	G slope	Grazing (slope) [Arable capability downgraded due to slope of > 6 degrees]		32	33,93	28,76		
	L	Wilderness	Wilderness	15	28,61	24,25	28,61	24,25
	Wt	Wetland (Temporary)	Wetland	4	1,70	1,44	23,26	19,72
	Ws,Wp	Wetland (Seasonal), and Wetland (Permanent) - undifferentiated		5	21,56	18,28		
Rehabilitated 'Man-Made' Soils	RA	Rehabilitated Arable	Rehabilitated Arable	1	0,16	0,14	0,16	0,14
			TOTALS	77	117,97	100,00	117,97	100,00

PORT DURNFORD PLANTATION:

The following ‘Mining Rehabilitation Guidelines’ document was applicable at the time of the previous Port Durnford Plantation survey (Snyman, 2008).

- The Chamber of Mines of South Africa / Coaltech: Guidelines for the Rehabilitation of Mined Land (November 2007). These are referred to in the current document as ‘Mining Rehabilitation Guidelines (2007)’.

Refer to: Map KS6. Land Capability (Port Durnford Plantation).

Map KS6 indicates: Class II Arable land as 552ha (14%), and Class III Grazing land as 2434ha (60%).

Given the most recent ‘Mining Rehabilitation Guidelines (2019)’ (soil survey conducted in 2008), certain small sections of the Grazing land capability class areas may now be defined as Arable land, in areas where the slope is approximately <= 6 degrees (10.5%, 1: 9.5); these mostly in areas of Site Type A (deep red and yellow sandy soils) and particularly B (deep red sandy-clay-loam soils) soils.

Table 7. Land Capability Requirements - Mining

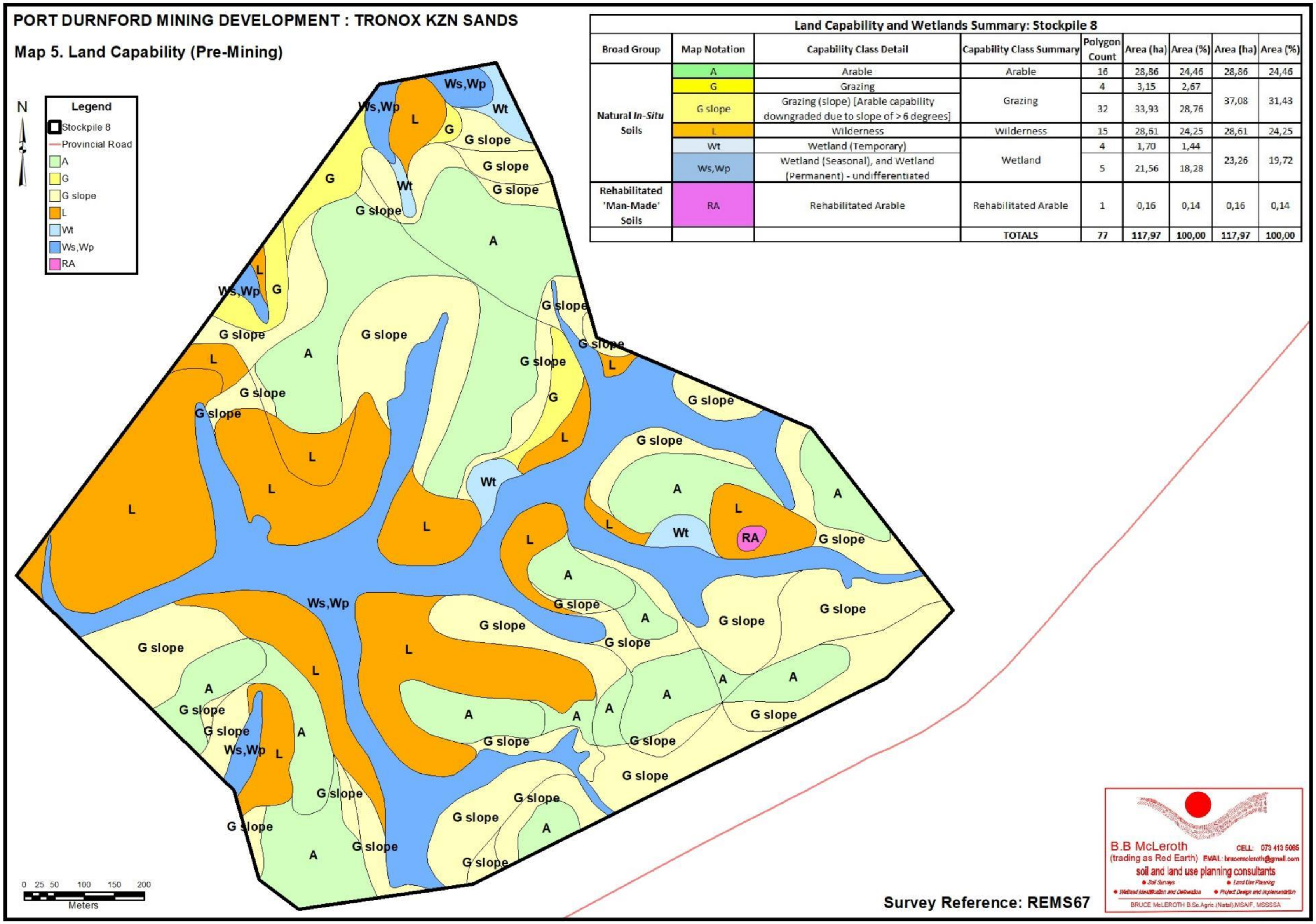
Land capability class		Classification criteria	
		Pre-mining	**Post-mining**
I	Wetland	• Usually, a water table present at shallow depth in the soil (vleis, swamps, marshes, peat-bogs, etc.). • A diagnostic[1] organic (O) horizon at the surface. • A horizon that is gleyed throughout more than 50 percent of its volume and is significantly thick, occurring within 750 mm of the surface.	• Soil depth >250 mm. • Specific wetland soil used, as stockpiled from pre-mining delineated wetland areas.
II	Arable	• Does not qualify as wetland. • Has soil that is readily permeable[2] to the roots of common cultivated plants throughout a depth of 750 mm from the surface. • Soil pH value between 4,0 and 8,4. • Electrical conductivity (EC) of the saturation extract is less than 400mS/m at 25°C, and an exchangeable sodium percentage less than 15 through the upper. • Soil depth of ≥750 mm of soil. • Permeability of at least 1,5 mm per hour in the upper 0.5 m of soil. • <10 percent by volume of rocks, or pedocrete fragments larger than 100 mm in diameter in the upper 750 mm of soil. • Slope (in percent) and erodibility factor[3] (K) such that their product is less than 2,0. • Occurs under a climate regime which permits, from soils of similar texture and adequate effective depth (750 mm), the economic attainment of yields of adapted agronomic or horticultural crops that are at least equal to the current national average for those crops. • Is either currently being irrigated successfully or has been scheduled for irrigation by the DAFF.	• Soil depth > 600 mm • Soil material must not be saline or sodic. • Slope (%) will be such that when multiplied by the soil erodibility factor K, the product will not exceed 2,0. • For typical coal fields' soils, slopes must be flatter than 1:14, and free draining.
III	Grazing land	• Does not qualify as wetland or as arable land. • Has soil or soil-like material, permeable to the roots of native plants, which is more than 250 mm thick and contains less than 50 % by volume of rocks, or pedocrete fragments larger than 100 mm diameter. • Supports or is capable of supporting a stand of native or introduced grass species or other forage plants utilisable by domesticated livestock or game animals on a commercial basis.	• Soil depth ≥ 250 mm • Slopes between 1:7 and 1:14
IV	Wilderness land	• Land that has little or no agricultural capability by virtue of being too arid, too saline, too steep or too stony to support plants of economic value. • Its uses lie in the fields of recreation and wildlife conservation. It does, however, also include watercourses, submerged land, built-up land and excavations.	• Soil depth between 150 – 250 mm.

Land capability class		Classification criteria	
		Pre-mining	Post-mining
		• Defined by exclusion, namely: land that does not qualify as wetland, arable land or grazing land.	

Footnotes:

1. Macvicar et al (1977): Diagnostic horizons and materials referred to in this discussion are as defined for the South African soil classification system.
2. Materials and diagnostic horizons which are not readily permeable and should therefore not be encountered within 0.75 m of the surface include hard rock, pedocretes (calcrete, ferricrete and silcrete) in sheet form, any soil material that is strongly cemented, dorbank, fragipans and diagnostic hard plinthic, gleycutanic and prismacutanic B horizons.
3. The erodibility factor (K) can be obtained from the nomograph published in Wischmeier, Johnson and Cross (1971).

Map 5. Land Capability (Pre-Mining) (Stockpile 8)



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	G slope	Grazing (slope) [Arable capability downgraded due to slope of > 6 degrees]		32	33,93	28,76		
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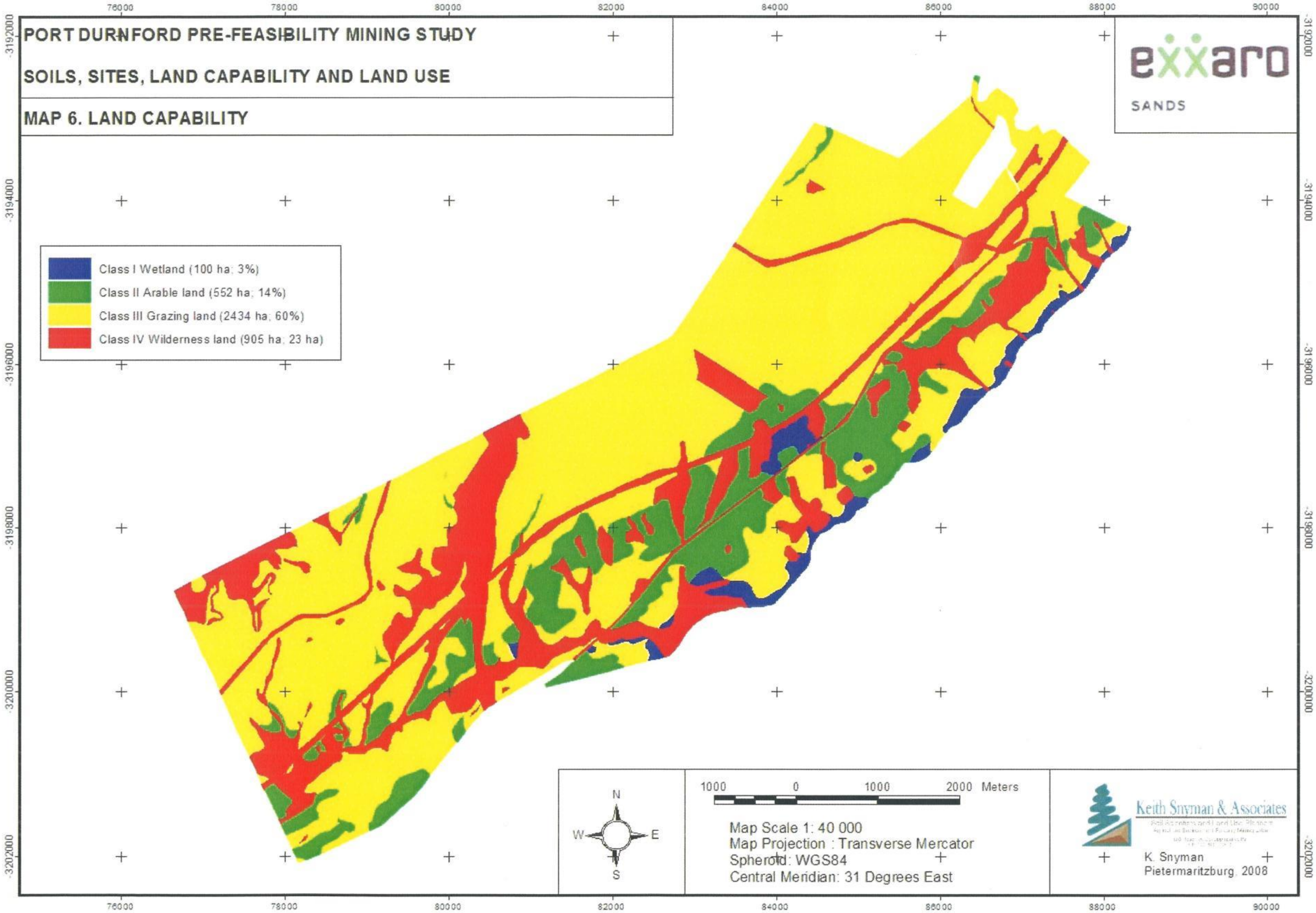
	Ws,Wp	Wetland (Seasonal), and Wetland (Permanent) - undifferentiated		5	21,56	18,28		
Rehabilitated 'Man-Made' Soils	RA	Rehabilitated Arable	Rehabilitated Arable	1	0,16	0,14	0,16	0,14
			TOTALS	77	117,97	100,00	117,97	100,00

Map KS6. Land Capability (Port Durnford Plantation) *(Snyman, 2008)*



7.2 LAND CAPABILITY - AGRICULTURE

Land capability classes may alternatively be determined using the guidelines outlined in Scotney *et al.* (March 1987, Revised January 1991) - A System of Soil and Land Capability Classification for Agriculture in South Africa.

This would be a more appropriate system of land Capability Classification, given the high agricultural productivity of the area.

Many ‘crops’ will thrive in the area due to the following factors:
frequently well drained deep to very deep soils in midslope and crest position (often well over 1.5m in depth), high rainfall, high heat units, and no frost.

“Climate. Port Durnford receives 1271mm mean annual precipitation. Mean monthly rainfall in summer peaks at 156mm and dips to 53mm in winter. Mean annual temperature is 21.1°C. Mean maximum monthly temperatures in summer are in the upper twenties whilst mean minimum monthly winter temperatures are in the lower teens. Mean annual evapotranspiration is high (A-pan 1771mm). Frost does not occur.” (Snyman, 2008).

“A variety of crops can be grown under these conditions e.g. sugar cane, banana, paw-paw, litchi, macadamia nut, timber (eucalypt and pine), cabbage and other vegetables. The climate is particularly well suited to timber (especially eucalypt) production.” (Snyman, 2008).
Eucalypts. “Average MAI (mean annual increment) across the entire plantation, based on modelled data is 31.7 m^3/ha/year over a nine-year rotation.” (Snyman, 2008).

These are exception timber yields for the South African Forestry Industry.

However, this agricultural classification procedure was not conducted, given that this is a mining related Project.

Despite this exercise not having been conducted, the following conclusions are made for the following two Soil Site Types:
Site Type A (deep red, yellow, and neocutanic sandy soils - ferrallitic soils); and Site Type B (deep red or yellow clayey soils - ferrallitic soils).

Class V (Grazing and Forestry Land), where the slope exceeds 8.5 degrees (15%) as it often does.
Class IV (Arable land, Severe limitations), slope 6.8 degrees (12%).
Class III (Arable land, Moderate limitations), slope 4.5 degrees (8%).
Class II (Arable land, High Potential, Few limitations), slope 2.2 degrees (4%).
Limited areas of Class II to IV land exist on gentle to very gentle slopes.

Shallower slopes are applicable to the non-ferrallitic soil types.

Table 8. Land Capability Requirements - Agriculture

TERRAIN AND CLIMATIC FACTORS

TERRAIN FACTORS

EROSION HAZARD AND SLOPE

Symbol	General description and upper slope gradient limits for different soils		slope %
E 1	Land with a low water and or wind erosion hazard. Generally level to gently sloping land	Group 1 Group 2 Group 3 Group 4	4 2 - -
E 2	Land with a low to moderate water and or wind erosion hazard. Generally gently sloping to moderately sloping land.	Group 1 Group 2 Group 3 Group 4	8 5 3 -
E 3	Land with a moderate water and or wind erosion hazard. Generally moderately sloping land	Group 1 Group 2 Group 3 Group 4	12 8 5 4
E 4	Land with a moderate to high water and or wind erosion hazard. Generally moderately sloping to strongly sloping land	Group 1 Group 2 Group 3 Group 4	15 12 10 8
E 5	Land with a high water and or wind erosion hazard under cultivation. Usually strongly sloping to moderately steep	Group 1 Group 2 Group 3 Group 4	25 18 12 10
E 6	Land with steep to very steep slopes which makes it very susceptable to water erosion	Group 1 Group 2 Group 3 Group 4	60 45 30 20
E 7	Land with very steep to extremely steep slopes and has a very severe erosion hazard or past erosion	Group 1 Group 2 Group 3 Group 4	> 60 > 45 > 30 -
E 8	Any slope may apply but normally includes land exceeding 100 % slope. Very erodable soils with slopes exceeding 50 % should be included	Group 1 Group 2 Group 3 Group 4	> 100 > 70 > 50 -

* Group 1 = Ferrallitic soils
Group 2 = Non-Ferrallitic soils without a "clay increase B horizon"
Group 3 = Non-Ferrallitic soils with a "clay increase B horizon"
Group 4 = Duplex soils

FLOOD HAZARD

Symbol	Rating (Possibility and duration)
F 1	None
F 2	Rare, very brief
F 3	Occasional, brief
F 4	Frequent, long
F 5	Common, very long

SOIL FACTORS

EFFECTIVE DEPTH

Symbol	Depth (mm) from the soil surface
D 1	> 1000
D 2	600-1000
D 3	400-600
D 4	250-400
D 5	< 250

TEXTURE consult Fig. 1-4 on p. 38

INTERNAL DRAINAGE

Symbol	Limitation rating and brief description
W 1	Good. All diagnostic horizons except: G-horizon, E-horizon, Gleyed material, Gleycutanic horizon, hard or soft plinthic horizons within a depth of 1000 mm
W 2	Moderately good. All diagnostic horizons except: G-horizon, E-horizon, Gleyed material, Gleycutanic horizon, hard or soft plinthic horizons within a depth of 600 mm
W 3	Moderately poor. All diagnostic horizons excluding gleycutanic, gley and gleyed material within a depth of 400 mm
W 4	Poor. All diagnostic horizons except gleyed material and gley horizons, these horizons occurring within a depth of 250 mm
W 5	Very poor. Any diagnostic horizon

MECHANICAL LIMITATIONS

Symbol	Limitation rating and brief description
M 1	Nil. No limitations occur
M 2	Slight. Bedrock/stones < 2 %
M 3	Moderate. Bedrock/stones 2-10 %. Past erosion, microrelief, slight limitation to cultivation
M 4	Moderate to severe. Bedrock/stones make intertilled crops difficult. Past erosion and slope gradients limit use of agricultural machinery
M 5	Severe. Bedrock/stones sufficient to make intertilled crops impracticable and the slope gradients cause problems in the use of agricultural machinery
M 6	Severe to very severe. Bedrock/stones sufficient to make all use of machinery impracticable (25-50 % exposure)
M 7	Very severe. Bedrock/stones sufficient to reduce grazing capacity. Past erosion severe (50-80 % exposure)
M 8	Extremely severe. More than 80 % of the surface is covered by stones/bedrock or gullied land. Total protection recommended

OTHER SOIL CHARACTERISTICS

Symbol	Limitation rating and brief description
O 1	None. No limiting factors
O 2	Slight. Crusting slight. Workability affected
O 3	Moderate. Crusting moderate, slight-moderate salinity, etc.
O 4	Moderate to severe. Severe crusting, severe salinity
O 5	Severe. Any limitation

CLIMATIC FACTORS

CLIMATE

Symbol	Limitation rating and brief description
C 1	None to slight. Local climate favourable for growing a wide range of economic crops (AMR > 1/2 MPET)
C 2	Slight. Local climate less favourable as C 1.
C 3	Moderate. Climate restricts choice of crops and yield potential (AMR > 1/3 MPET. Extremes in temperature, damage hail and wind
C 4	Moderate to severe. More unfavourable than C 3. Unreliable rainfall, extremes in temperature and severe damage due to hail or wind
C 5	Severe. Climatic factors (mainly rainfall) unfavourable for growing crops
C 6	Very severe. Climatic factors (singly or in combination) unfavourable for growing crops

AMR = Average monthly rainfall

MPET = Monthly potential evapotranspiration

ELIMINATION KEY TO SOIL AND LAND CAPABIITY CLASSES

<table>
<tr><th rowspan="2">SOIL CAPABILITY CLASS</th><th colspan="2">TERRAIN FACTORS</th><th colspan="5">SOIL FACTORS</th><th>CLIMATIC FACTORS</th><th rowspan="2">LAND CAPABILITY CLASS</th></tr>
<tr><th>Erosion hazard</th><th>Flood hazard</th><th>Effective depth</th><th>Texture</th><th>Internal drainage</th><th>Mechanical limitations</th><th>Other</th><th></th></tr>
<tr><td>1</td><td>E 1</td><td>F 1</td><td>D 1</td><td>T 1</td><td>W 1</td><td>M 1</td><td>O 1</td><td>C 1</td><td>I</td></tr>
<tr><td>2</td><td>E 2</td><td>F 2</td><td>D 2</td><td>T 2</td><td>W 2</td><td>M 2</td><td>O 2</td><td>C 2</td><td>II</td></tr>
<tr><td>3</td><td>E 3</td><td>F 3</td><td>D 3</td><td rowspan="6">T 3</td><td>W 3</td><td>M 3</td><td>O 3</td><td>C 3</td><td>III</td></tr>
<tr><td>4</td><td>E 4</td><td>F 4</td><td>D 4</td><td>W 4</td><td>M 4</td><td>O 4</td><td>C 4</td><td>IV</td></tr>
<tr><td>5</td><td>E 5</td><td rowspan="4">F 5</td><td rowspan="4">D 5</td><td rowspan="4">W 5</td><td>M 5</td><td rowspan="4">O 5</td><td>C 5</td><td>V</td></tr>
<tr><td>6</td><td>E 6</td><td>M 6</td><td rowspan="3">C 6</td><td>VI</td></tr>
<tr><td>7</td><td>E 7</td><td>M 7</td><td>VII</td></tr>
<tr><td>8</td><td>E 8</td><td>M 8</td><td>VIII</td></tr>
</table>

Factors to be considered in assessing the SOIL CAPABILITY CLASS

Factors to be considered in assessing the LAND CAPABILITY CLASS

Brief Directions for Using the Elimination Key

The Soil and Land Capability Class is arrived at by determining the symbols (**E 2** etc.) for each of the 7 or 8 factors respectively.

The capability class allocated to the area of land being classified is determined by the least favourable factor indicated by any of the 8 symbols.

LAND CAPABILITY ORDER

Order A: Arable Land - high potential land with few limitations (Classes I and II)

Order B: Arable Land - moderate to severe limitations (Classes III and IV)

Order C: Grazing and Forestry Land (Classes V, VI and VII)

Order D: Non-agricultural Land (Class VIII)

8.0 WETLANDS AND RIPARIAN AREAS

Wetlands and their associated riparian areas are generally regarded as especially sensitive landscapes under statutory protection, and as such must not be disturbed, polluted, cultivated or overgrazed without a licence. Such areas have a high significance from a preservation point of view, since they perform important hydrological functions, and are major contributors to the biodiversity of an area.

Wetlands

A wetland is defined by the South African National Water Act 36 of 1998 as follows:
Land that is transitional between terrestrial and aquatic systems where the water-table is usually at or near to the surface or the land is periodically covered with shallow water, and which under normal circumstances supports or would support vegetation typically adapted to life in saturated soil.
Given the aforementioned definition, non-wetland areas have in the current report document been referred to as 'terrestrial' areas.

The wetland classification process is presented for information purposes.

The wetland delineation procedure is based on the following document: 'A Practical Field Procedure for Identification and Delineation of Wetlands and Riparian Areas', published by the Department of Water Affairs and Forestry (DWAF) [Edition 1, September 2005].
This document was in turn largely based on the following document: 'Wetland and Riparian Habitats: A Practical Procedure for their Identification and Delineation' (2000), by The Wetland and Riparian Habitat Working Group (Forest Owners Association. S.A.).

Riparian areas

Riparian habitat (as defined by the South African National Water Act 36 of 1998) includes the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterized by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.

DWAF (Edition 1, September 2005) states that riparian areas: are associated with a watercourse; contain distinctly different plant species than adjacent areas and contain species similar to adjacent areas but exhibiting more vigorous or robust growth forms; and may have alluvial soils.

STOCKPILE 8:

Refer to: Map 6 - Wetlands (Stockpile 8), as well as Map 5 - Land Capability (Pre-Mining) (Stockpile 8).
Also Refer to: Table 9 - Wetlands Summary.

Table 9. Wetlands Summary (Stockpile 8)

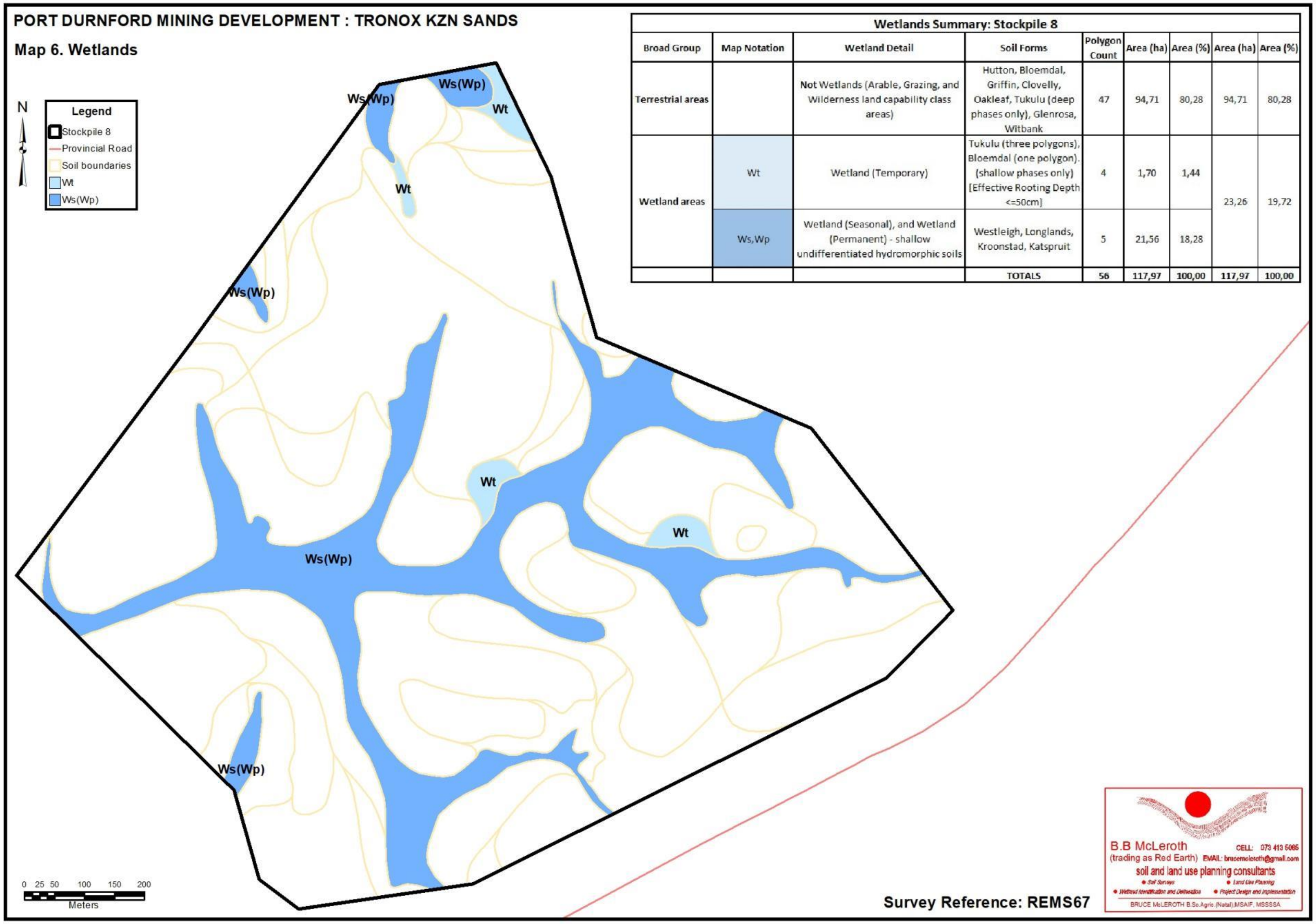
Wetlands Summary: Stockpile 8								
Broad Group	Map Notation	Wetland Detail	Soil Forms	Polygon Count	Area (ha)	Area (%)	Area (ha)	Area (%)
Terrestrial areas		Not Wetlands (Arable, Grazing, and Wilderness land capability class areas)	Hutton, Bloemdal, Griffin, Clovelly, Oakleaf, Tukulu (deep phases only), Glenrosa, Witbank	47	94,71	80,28	94,71	80,28
Wetland areas	Wt	Wetland (Temporary)	Tukulu (three polygons), Bloemdal (one polygon). (shallow phases only) [Effective Rooting Depth <=50cm]	4	1,70	1,44	23,26	19,72
	Ws,Wp	Wetland (Seasonal), and Wetland (Permanent) - shallow undifferentiated hydromorphic soils	Westleigh, Longlands, Kroonstad, Katspruit	5	21,56	18,28		
			TOTALS	56	117,97	100,00	117,97	100,00

PORT DURNFORD PLANTATION:

The soil survey was conducted in areas occupied by timber/grasslands, but was not requested indigenous bush areas. Such indigenous bush sites are occupied by a combination of wetland, riparian, and terrestrial habitats.

Map KS6 (Land Capability) indicates 100ha of wetland in the soil surveyed areas.
Map KS4 (Current Land Use within Study area) indicates wetlands (458ha) and forest indigenous riparian (290ha), many of these wetlands being located in areas of indigenous bush.

Map 6. Wetlands (Stockpile 8)



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			TOTALS	56	117,97	100,00	117,97	100,00

9.0 PRESENT LAND USE

STOCKPILE 8:

Refer to: Map 4. Present Land Use (Stockpile 8). Self explanatory.
Refer to: Table 10. Present Land Use (Stockpile 8). Self explanatory.
Also refer to: Appendix I - Soil Profile Descriptions (Stockpile 8). This provides further detailed Land Use information in column 'W'.

Furthermore, settlement areas exist to the north, sugar cane to the west, and citrus to the south of the R103 provincial tar road.

Table 10. Present Land Use (Stockpile 8)

Present Land Use Summary: Stockpile 8							
Group	Map Notation	Further Explanation	Polygon Count	Area			
				ha	%	ha	%
Vegetation	Te	Trees - *Eucalyptus* plantation	28	87,38	74,07	113,80	96,47
	G	Grasslands (dominantly in wetlands, occasionally terrestrial areas)	23	25,41	21,54		
	Bush	Indigenous Bush (dominantly in wetlands, occasionally terrestrial areas)	12	1,01	0,86		
Man-Made Features	R dirt	Road dirt - well constructed main access routes	3	1,95	1,65	4,17	3,53
	R track	Road track - surrounding the timber compartments	11	2,22	1,88		
TOTALS			77	117,97	100,00	117,97	100,00

PORT DURNFORD PLANTATION:

The Land Use previously described for the plantation and surrounds is applicable to the majority of the Port Durnford Mining Development area.

Within the Study Area:

Refer to: Map KS4. Land Use Within Port Durnford Forest.

The study are is largely bisected from the south-west to the north-east by the R102 provincial tar road (from Mtunzini to Empangeni), the N2 toll road highway, and a Spoornet railway line (from Mtunzini to Felixton).

The site is predominantly a Eucalyptus plantation. Given the frequently well drained deep to very deep soils in midslope and crest position (often well over 1.5m in depth), high rainfall, high heat units (and no frost), eucalypts experience exception timber yields, as compared with the broader South African Forestry Industry.

"Average MAI (mean annual increment) across the entire plantation, based on modelled data is 31.7 m^3/ha/year over a nine-year rotation." (Snyman, 2008).

“A variety of crops can be grown under these conditions e.g. sugar cane, banana, paw-paw, litchi, macadamia nut, timber (eucalypt and pine), cabbage and other vegetables. The climate is particularly well suited to timber (especially eucalypt) production.” (Snyman, 2008).

“The airfield is grassed and well maintained. Built-up areas consists of offices, residential staff housing, labour compound, workshops, reservoirs and a look out tower. 132 KVA Eskom lines occur” (Snyman, 2008).

Roads. “... has a well-planned and well-designed road network that services the whole study area”. This provides easy access. Many of the roads are gravelled which allows vehicle trafficability in all weather conditions (Snyman, 2008).

Outside of the Study Area:

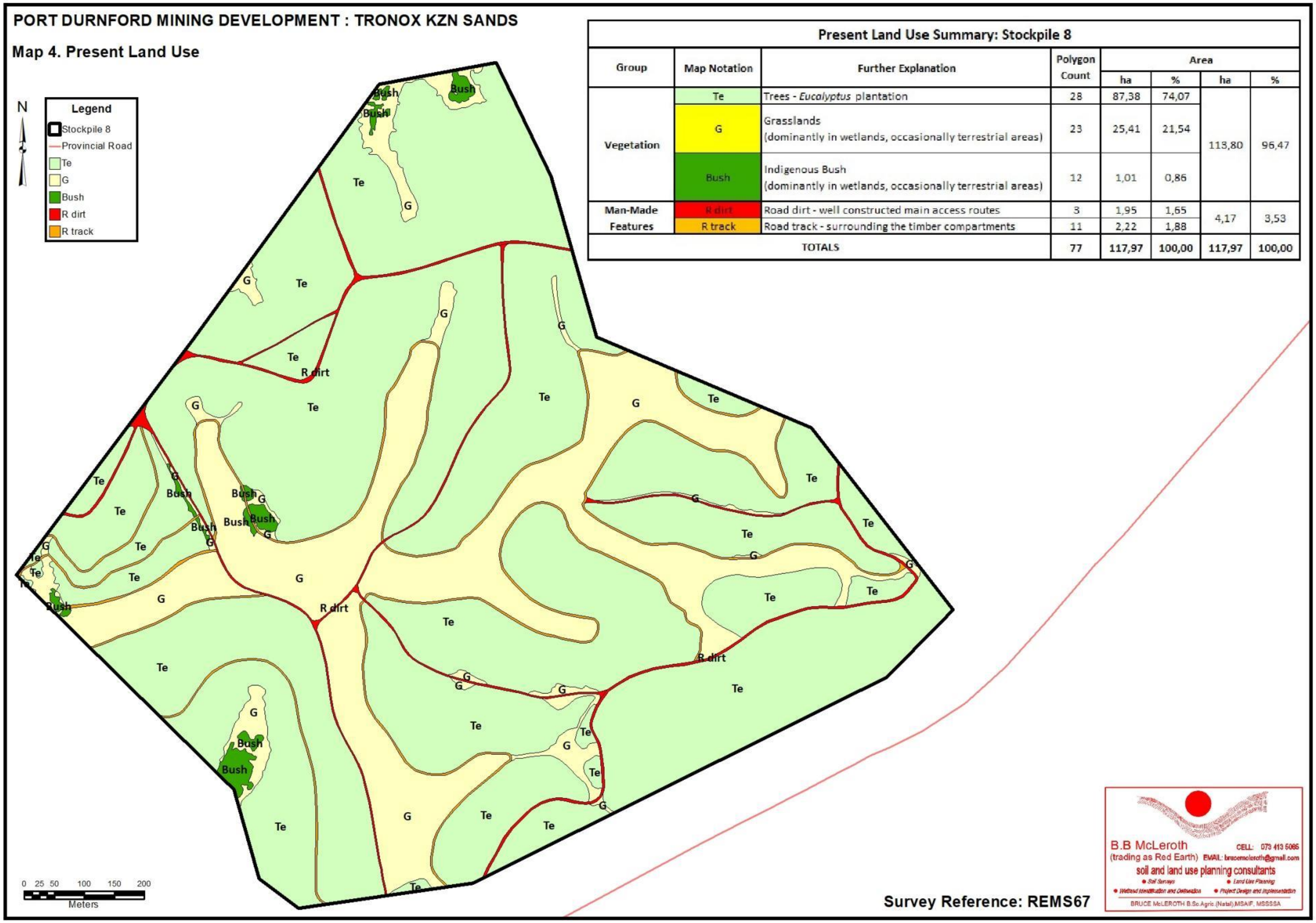
Refer to: Map KS5. Land Use Outside Port Durnford Forest.

The northern boundary of the Port Durnford Mining Development area is surrounded by numerous human settlements (named from west to east):
broad scale settlement plots (unnamed), Vulindlela Township (beyond more settlement plots), and Felixton (to the north of the Mhlatuze River).

The southern boundary is surrounded (from east to west) by:
Gobamdlovu (from the east, to the south), eSikhatwini, Sikhalasenkosi, Mahuna, Port Durnford (town), Nyembe, and Mtunzini town (to the south of the Umlalazi River).

Concerning the south-eastern fifth of the area: sugar cane lies to the west, and citrus lies to the south of the R102 tar road.

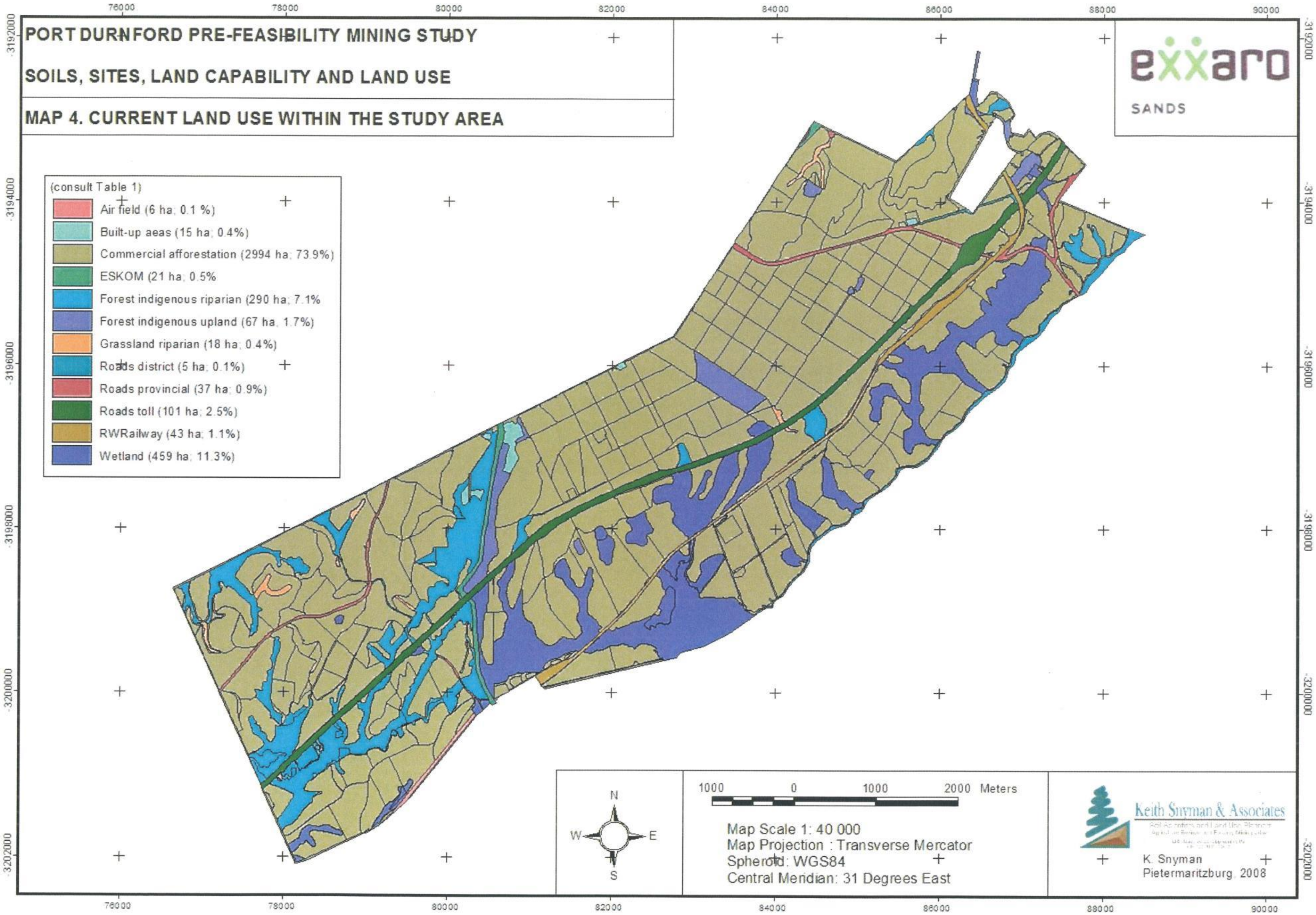
Map 4. Present Land Use (Stockpile 8)



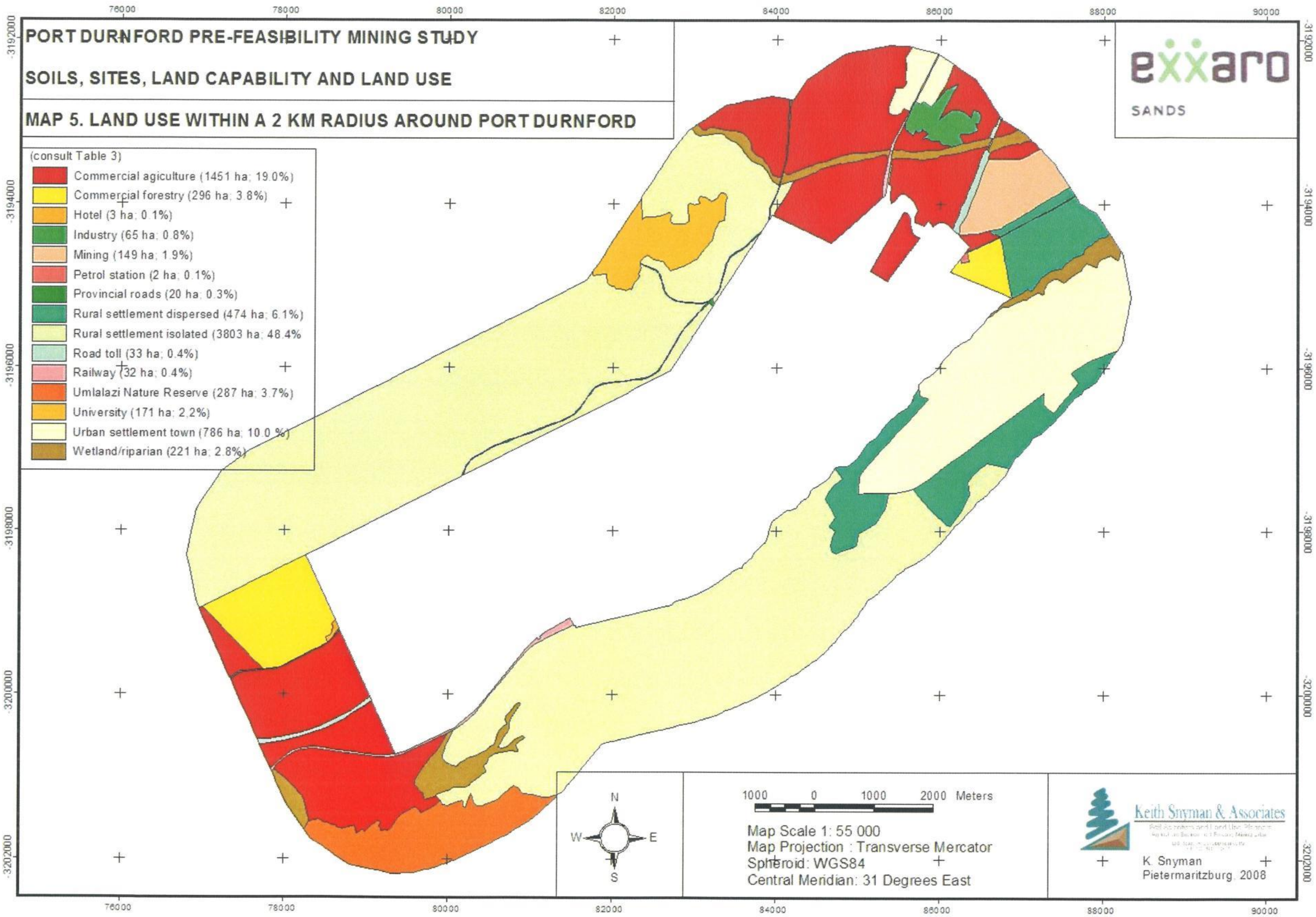
Present Land Use Summary: Stockpile 8

Group	Map Notation	Further Explanation	Polygon Count	Area (ha)	Area (%)	Area (ha)	Area (%)
Vegetation	Te	Trees - *Eucalyptus* plantation	28	87,38	74,07	113,80	96,47
	G	Grasslands (dominantly in wetlands, occasionally terrestrial areas)	23	25,41	21,54		
	Bush	Indigenous Bush (dominantly in wetlands, occasionally terrestrial areas)	12	1,01	0,86		
Man-Made Features	R dirt	Road dirt - well constructed main access routes	3	1,95	1,65	4,17	3,53
	R track	Road track - surrounding the timber compartments	11	2,22	1,88		
TOTALS			77	117,97	100,00	117,97	100,00

Map KS4. Land Use Within Port Durnford Forest



Map KS5. Land Use Outside of Port Durnford Forest



10.0 SOIL UTILISATION (STRIPPING) GUIDE

Government Regulations (R537 of 21 March 1980) require that all 'topsoil' removed be replaced on the disturbed surface during rehabilitation. All soil (suitable and unsuitable) stripped must be replaced.

Table 7 (Rehabilitation Guidelines - Mining) generally specifies various soil properties relating to soil material that may be included in an arable capability class, as follows:

- Has soil that is readily permeable (refer to Footnote 2) to the roots of common cultivated plants.
- Soil pH value between 4,0 and 8,4.
- Electrical conductivity (EC) of the saturation extract is less than 400mS/m at 25°C, and an exchangeable sodium percentage less than 15.
- Permeability of at least 1,5 mm per hour.
- <10 percent by volume of rocks, or pedocrete fragments.

Footnote 2: Materials and diagnostic horizons which are not **readily permeable** and should therefore not be encountered within 0.75 m of the surface include hard rock, pedocretes (calcrete, ferricrete and silcrete) in sheet form, any soil material that is **strongly cemented**, dorbank, fragipans and diagnostic hard plinthic, gleycutanic and prismacutanic B horizon.

In the context of the current area, the following sandy soil horizons would be considered suitable materials for rehabilitation 'topsoiling' (suitable topsoils and subsoils) purposes:
orthic A-horizon, red apedal B-horizon, yellow-brown apedal B-horizon, neocutanic B-horizon, and E-horizons (particularly those associated with the Fernwood soil form of Site Type C at Port Durnford – yellow in the moist state, but bleached in the dry state).
The clayey (sandy-clay-loam to sandy-clay textures, and weak blocky structure) phases of the red apedal and yellow-brown apedal soils are also suitable.

<u>The orthic A-horizon (topsoil) [usually top 30cm] must always be stripped / stockpiled separately from the suitable subsoils (B- and E- horizons), and must always be replaced on the immediate surface during rehabilitation.</u>

In the context of the current area, the following soil horizons would be considered unsuitable:
G-horizon, soft plinthic B-horizon, unspecified material with signs of wetness, lithocutanic B-horizon, saprolite, and hard rock.

Considering Footnote 2 above, in particular soil materials which not readily permeable or which are strongly cemented; note the following point:
Of particular concern is the following commonly occurring (in the area) unsuitable soil material, which occurs at unknown depth (below 2m), underlying the suitable subsoils of the red and yellow Site Types A and B.
Properties of this material are as follows: red to pinkish in colour, massive large blocky structure, sandy-clay texture, consistence hard to very hard in the dry state (so severe hard setting), slow permeability, and a high bulk density. Roots will certainly be unable to penetrate the soil peds, the Effective Rooting Depth thus terminating upon encountering the material.
Care must be taken not to strip / stockpile / or utilise this material within the top 2m of rehabilitated soil profiles.
Furthermore, topsoil shortages must not be made up by resorting to this material.

Any unsuitable (for rehabilitation purposes) stripped soils must be replaced below the suitable 'topsoil' types.

STOCKPILE 8:

Refer to:
Map 7. Soil Utilisation (Stripping) Guide.
Table 11. Soil Utilisation (Stripping) Guide Summary (Stockpile 8).

Stripping material types, depths, areas, and Total Existing Soil Depths/Volumes are indicated.

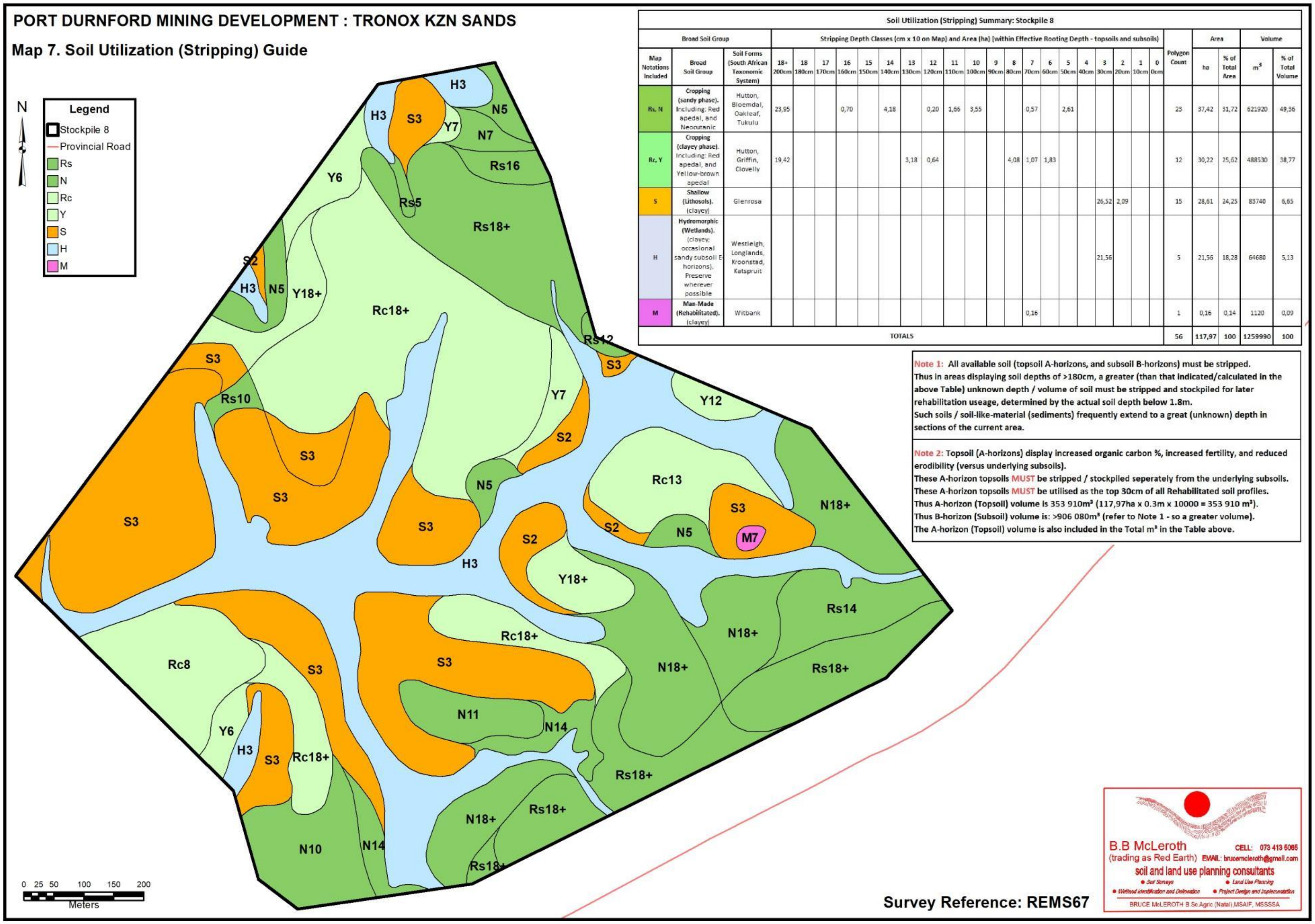
The Table 11 summary legend is extracted from Map 7. The Table is indicated separately in order that the fine detail will be readable, which is not the case on the Map (due to the printing scale).

Table 11 indicates the following volumes of suitable (for rehabilitation purposes) topsoil/subsoil to exist within the Stockpile 8 (Sand Tailings – raised above current surface, outside of Mining areas) study area:
- orthic A-horizon topsoil : 353 910m³.
- subsoils : 906 080m³.
- Total volume : >1 259 990m³.

This volume of soil must be stripped and stockpiled before the site (i.e. recently renamed Sand Tailings site 8B) is utilised as a Sand Tailings deposition area (dump). The orthic topsoil (30cm) and subsoils (balance of indicated depth/volume on Map 7 and Table 11) must be stockpiled seperately. This stockpiled material will must be utilised as top cover to rehabilitate the site, with the topsoil being the immediate surface layer, the stripped subsoils underlying the topsoils.

The sandy cropping soil phases (red apedal and neocutanic), and clayey cropping soil phases (red apedal and yellow-brown apedal) must ideally be stripped / stockpiled / utilised separately.
During the 'topsoiling' operation, the clayey phases should ideally underlay the sandy phases. However, in practise this is generally not possible (acceptable).
The shallow (lithosols) soils are far less suitable due to the stony / gravelly nature of the topsoil.
The hydromorphic (wetlands, clayey) soil areas should be preserved wherever possible, so not disturbed or stripped.

Map 7. Soil Utilisation (Stripping) Guide (Stockpile 8)



Soil Utilization (Stripping) Summary: Stockpile 8

Broad Soil Group			Stripping Depth Classes (cm x 10 on Map) and Area (ha) [within Effective Rooting Depth - topsoils and subsoils]																				Polygon Count	Area		Volume	
Map Notations Included	Broad Soil Group	Soil Forms (South African Taxonomic System)	18+ 200cm	18 180cm	17 170cm	16 160cm	15 150cm	14 140cm	13 130cm	12 120cm	11 110cm	10 100cm	9 90cm	8 80cm	7 70cm	6 60cm	5 50cm	4 40cm	3 30cm	2 20cm	1 10cm	0 0cm		ha	% of Total Area	m³	% of Total Volume
Rs, N	**Cropping (sandy phase).** Including: Red apedal, and Neocutanic	Hutton, Bloemdal, Oakleaf, Tukulu	23,95			0,70		4,18		0,20	1,66	3,55			0,57		2,61						23	37,42	31,72	621920	49,36
Rc, Y	**Cropping (clayey phase).** Including: Red apedal, and Yellow-brown apedal	Hutton, Griffin, Clovelly	19,42						3,18	0,64				4,08	1,07	1,83							12	30,22	25,62	488530	38,77
S	**Shallow (Lithosols).** (clayey)	Glenrosa																	26,52	2,09			15	28,61	24,25	83740	6,65
H	**Hydromorphic (Wetlands).** (clayey; occasional sandy subsoil E-horizons). Preserve wherever possible	Westleigh, Longlands, Kroonstad, Katspruit																	21,56				5	21,56	18,28	64680	5,13
M	**Man-Made (Rehabilitated).** (clayey)	Witbank													0,16								1	0,16	0,14	1120	0,09
TOTALS																							56	117,97	100	1259990	100

Note 1: All available soil (topsoil A-horizons, and subsoil B-horizons) must be stripped.
Thus in areas displaying soil depths of >180cm, a greater (than that indicated/calculated in the above Table) unknown depth / volume of soil must be stripped and stockpiled for later rehabilitation useage, determined by the actual soil depth below 1.8m.
Such soils / soil-like-material (sediments) frequently extend to a great (unknown) depth in sections of the current area.

Note 2: Topsoil (A-horizons) display increased organic carbon %, increased fertility, and reduced erodibility (versus underlying subsoils).
These A-horizon topsoils MUST be stripped / stockpiled seperately from the underlying subsoils.
These A-horizon topsoils MUST be utilised as the top 30cm of all Rehabilitated soil profiles.
Thus A-horizon (Topsoil) volume is 353 910m³ (117,97ha x 0.3m x 10000 = 353 910 m³).
Thus B-horizon (Subsoil) volume is: >906 080m³ (refer to Note 1 - so a greater volume).
The A-horizon (Topsoil) volume is also included in the Total m³ in the Table above.

Table 11. Soil Utilisation (Stripping) Guide Summary (Stockpile 8)

Soil Utilization (Stripping) Summary: Stockpile 8																											
Broad Soil Group			Stripping Depth Classes (cm x 10 on Map) and Area (ha) [within Effective Rooting Depth - topsoils and subsoils																			Polygon Count	Area		Volume	
Map Notations Included	Broad Soil Group	Soil Forms (South African Taxonomic System)	18+ 200cm	18 180cm	17 170cm	16 160cm	15 150cm	14 140cm	13 130cm	12 120cm	11 110cm	10 100cm	9 90cm	8 80cm	7 70cm	6 60cm	5 50cm	4 40cm	3 30cm	2 20cm	1 10cm	0 0cm		ha	% of Total Area	m^3	% of Total Volume
Rs, N	Cropping (sandy phase). Including: Red apedal, and Neocutanic	Hutton, Bloemdal, Oakleaf, Tukulu	23,95			0,70		4,18		0,20	1,66	3,55			0,57		2,61						23	37,42	31,72	621920	49,36
Rc, Y	Cropping (clayey phase). Including: Red apedal, and Yellow-brown apedal	Hutton, Griffin, Clovelly	19,42						3,18	0,64				4,08	1,07	1,83							12	30,22	25,62	488530	38,77
S	Shallow (Lithosols). (clayey)	Glenrosa																	26,52	2,09			15	28,61	24,25	83740	6,65
H	Hydromorphic (Wetlands). (clayey; occasional sandy subsoil E-horizons). Preserve wherever possible	Westleigh, Longlands, Kroonstad, Katspruit																	21,56				5	21,56	18,28	64680	5,13
M	Man-Made (Rehabilitated). (clayey)	Witbank													0,16								1	0,16	0,14	1120	0,09
TOTALS																							56	117,97	100	1259990	100

Table 11 (Continued)

Note 1: All available soil (topsoil A-horizons, and subsoil B-horizons) must be stripped. Thus in areas displaying soil depths of >180cm, a greater (than that indicated/calculated in the above Table) unknown depth / volume of soil must be stripped and stockpiled for later rehabilitation useage, determined by the actual soil depth below 1.8m. Such soils / soil-like-material (sediments) frequently extend to a great (unknown) depth in sections of the current area.
Note 2: Topsoil (A-horizons) display increased organic carbon %, increased fertility, and reduced erodibility (versus underlying subsoils). These A-horizon topsoils MUST be stripped / stockpiled seperately from the underlying subsoils. These A-horizon topsoils MUST be utilised as the top 30cm of all Rehabilitated soil profiles. Thus A-horizon (Topsoil) volume is 353 910m^3 (117,97ha x 0.3m x 10000 = 353 910 m^3). Thus B-horizon (Subsoil) volume is: >906 080m^3 (refer to Note 1 - so a greater volume). The A-horizon (Topsoil) volume is also included in the Total m^3 in the Table above.

PORT DURNFORD PLANTATION:

Refer to: Table KS1. Defined Soil Bodies (Port Durnford Plantation) *(Snyman, 2008 - Table 5)*. This duplicated (from aforementioned Report) Table is displayed in Section 5.3 (SOIL TYPES) of the current Report document.
The Table indicates descriptions for the 22 different defined Soil Bodies (i.e. mapping units) which occur on Port Durnford Plantation.
This Table also indicates soil volumes for each of the defined soil bodies (totalled by current author below):
- approximately 9.4 million m³ of orthic A-horizon topsoil is available, within the Study Area as a whole.

Further Refer to: Table 5. Site Types, Soil Forms / Properties, and Stripping Volumes (Port Durnford Plantation). *Information compiled/duplicated from Snyman, 2008 [also incorporating information from: Table 6 (Sites), Section 7.2 (Sites-report text-in italics), and Map 3 (Sites)]*.
This expanded (new) Table is displayed in Section 6.0 (SITES) of the current Report document.

Herein, further total existing available soil volumes have been calculated by the current author, as follows:

- Topsoil (only): 3990ha (site area) - 198 (man-made sites, buildings, roads) - 643 (indigenous bush, riparian, wetlands, channels) = 3149ha.
  So: 3149ha x 0.3m (average A-horizon depth) x 10000 = 9 447 000m³.

- Topsoil & Subsoil (combined): Greater depth/volume is available (than that indicted below), determined by the actual soil depth (unknown) below the sampling depth of 1.5m. Thus, in areas where the Effective Rooting Depth (ERD) is >1.5m, it would be acceptable to assume an available suitable soil depth of at least 2.0m.
  So available soil volume is: > 41 664 800m³.

Despite the soil volume calculations above, only a modest proportion of this available suitable (for rehabilitation topsoiling purposes) soil volume will be required to be stripped and replaced during rehabilitation (refer to Section 11.3 - SOIL STRIPPING AND STOCKPILING). Furthermore, much of the Life of Mine area will also not be disturbed.

Table 5 also indicates soil Effective Rooting Depth (ERD), and approximate Stripping Volume information (based on the ERD); for each of the identified Site Types (A - J).

For the various indicated ERD values, the depth utilised to calculate the stripping volume (topsoils and subsoils combined) was as follows:
Sites A-D: ERD >150cm (strip at least 150cm);
Sites E: ERD 60-90cm (strip 70cm);
Sites F: ERD 90-120cm (strip 100cm);
Sites G: ERD 30-60cm undifferentiated hydromorphic (strip 30cm);
Sites H: ERD 1-60cm lithosols (strip 30cm);
Sites I: man-made sites, buildings, roads. Not calculated; and
Sites J: indigenous bush, riparian, wetlands, channels. Not calculated.

The following comments describe the suitability of the various Soil Site Types, for rehabilitation purposes.

- Site A subsoils (sandy cropping phase - red apedal and neocutanic), Site C subsoils (sandy E-horizon – 'yellow'when moist, bleached when dry), and Site B subsoils (clayey cropping phase - red apedal & yellow-brown apedal) may be stockpiled and utilised for rehabilitation topsoiling collectively.

- The shallow (lithosols) Site H soils are far less suitable (than Site A, B, and C) soils due to the stony / gravelly nature of the topsoil, so should ideally not be stripped because large volumes of more suitable material are available. Furthermore, such areas are very limited in extent.

- The dark topsoil sands (Site D - 'sandy'), moderately deep E-horizon hydromorphic (Site E - 'clayey'), and deep E-horizon hydromorphic (Site F - 'clayey') [all are wetlands] soils MUST BE PRESERVED, so not being disturbed / mined / stripped. In order to consolidate mining related features in certain areas, some minor exceptions to this case may be acceptable.

- The undifferentiated hydromorphic (Site G - 'clayey') [wetlands] soils MUST BE PRESERVED at all costs, so not disturbed / mined / stripped. The same applies to indigenous bush, riparian, wetlands, and channels (Sites J). However, very limited sections will be impacted by mining to the west of the N2 highway, this being regarded as acceptable, provided that such soils lying to the east of the highway are not impacted in any way.

SUMMARY – STOCKPILE 8 AND PORT DURNFORD PLANTATION

This information is applicable to the Mine area as a whole, and particularly where subsoils will also be stripped and replaced.

- Suitable 'Topsoiling' (i.e. suitable topsoils and subsoils) Material.
  Port Durnford Plantation: The following Site Type soils are highly suitable for rehabilitation purposes: A, B, and C. Mine related developments must be limited to such areas only.
  Site Types D, E, and F are far less suitable, and such wetland areas should be preserved wherever possible. However, should it become necessary to disturb any such areas, the topsoils and subsoils must also be stripped for later rehabilitation purposes.
  Stockpile 8: The following Site Type soils are most suitable for rehabilitation purposes: A, B; and E (Tukulu form only). Site Types C, D, and F do not occur in this area.
  Site Types A, C, D, E, and F are almost all 'sandy' (sand to sandy-loam textures).
  Site Type B is 'clayey' (sandy-clay-loam to sandy-clay textures).

  Site Type H (shallow lithosols - stony) occurs in both study areas, and is far less suitable for rehabilitation purposes (so not ideal or recommended).

  Site Type G (shallow undifferentiated hydromorphic soils - wetland) occurs in limited sections of both study areas, and must be preserved at all costs, this soil material also being unsuitable for rehabilitation purpose in crest and midslope positions. However, such material may be utilised to rehabilitate degraded wetlands.

- 'Topsoiling' Depth.

Given that the dominant Site Types A-D generally display an Effective Rooting Depth (ERD) of > 150cm or >180cm, the actual ERD could be far greater. Furthermore, given that all suitable soil must be stripped (in other areas, but not at Port Durnford Mine), it would be logical that the rehabilitated 'topsoiling' depth may be in the order of at least 2m, should the Mine wish to do so in certain areas.

- Order of Horizons.

Site Types: A, C, D, E, and F (sandy) material:
Surface placement.
Orthic A-horizon topsoil ('sandy' phase) to a depth of 30cm. The inherently higher organic carbon percentage has the following benefits: reduces soil erosion due to maintaining aggregate stability and structural condition, increased moisture holding capacity, high nitrogen mineralisation potential, and inherent fertility.
Lower in Profile.
Suitable subsoil B- or E-horizons ('sandy' phase), to a depth of >= 2m.
Lowest in Profile.
In some cases, suitable subsoil B-horizons ('clayey' phase) may be required to be utilised. These clayey subsoil phases should then ideally be placed towards the bottom of the profile, and not be placed on the immediate surface due to their lower permeability and thus higher erosion potential.

Site Type: B ('clayey') material:
Surface Placement: Orthic A-horizon ('clayey' phase) to a depth of 30cm. However, a sandy orthic A-horizon is preferred.
Lower in Profile: Suitable subsoil B-horizons ('clayey' phase), to a depth of >= 2m.

- Avoid Stratification of Sandy versus Clayey Soils.

Profiles should avoid stratifications in the form of alternating layers of suitable 'sandy' (apedal to single grain structure, rapid to very rapid permeability) versus 'clayey' (usually weak blocky structure, rapid to moderate permeability) phases. This will not be commonly occurring if the 'sandy' versus 'clayey' soil phases are stockpiled and 'topsoiled'separately.

- Do Not Utilise Unsuitable massive large blocky structured Material (previously described)..

Despite all of the discussions in current Section 10 [SOIL UTILISATION (STRIPPING) GUIDE]; the Subsoils will now not be stripped in the Mining Pit areas (although these will be stripped at the sites of all other Mine related features), due to a Reconstituted Subsoil layer being deposited instead.
Refer to the following Report Sections for final recommendations:
Section 11.3 (SOIL STRIPPING AND STOCKPILING), in particular - Recommended Minimum Stripping Prescription for the entire Port Durnford Mine area; and
Section 11.5 (TOPSOILING, AND RECONSTITUTED 'SOIL' MIXING RATIO), in particular - Recommended Minimum Topsoiling Prescription for the entire Port Durnford Mine area.

11.0 SOILS RECOMMENDATIONS

11.1 RECOMMENDED DEVELOPMENT AREA

Open Pit mining will only be conducted to the **west of the N2 highway, while most mining related Infrastructure will also be concentrated in this area, as recommended.** This is because the ore body is concentrated within the paleo dune complex, the crests and midslopes of which mostly lie to the west of the highway at an altitude of approximately >50m amsl. The mining targeted ore is generally more highly concentrated in the crest landscape positions.

These mining targeted minerals in this area are mostly concentrated within soil Site Types A (deep red and yellow 'sandy' mesotrophic soils) [probably highest mineral concentration]; B (deep red mesotrophic 'clayey' soils) [probable reducing mineral concentration]; and C (pale topsoil sands) [probably lowest mineral concentration].

Mining related infrastructure including: Mining Open Pits; the Temporary Infrastructure area; the Primary Wet Plant; RSF sites 9 and C (latter is a re-purposed Open Pit); Sand Tailings sites 8B, 3, 4, and 5 (latter three are re-purposed Open Pits); and temporary Topsoil stockpiles; are also all concentrated in the same areas, to the north of the N2 Highway. Only Sand Tailings sites A-1, A-2, and A-3 Complex are located to the south of the highway.

The concentration of Mining and related Infrastructure to the west (may alternatively be referred to as north) of the N2 highway is also recommended for the following reasons:

- Post-mining Land capability is predominantly Grazing (mostly) and Arable (limited sections), thus sensitive landscapes will rarely be disturbed. One exception is the valley-bottom wetlands in the Stockpile 8B area, the entirety of this area being planned Sand Tailings site 8B.

- The highway was generally constructed, at the knick-point between where the dune midslopes (to the west - Grazing and rarely Arable capability class) give way to the footslopes and valley-bottoms (to the east [may alternatively be referred to as south] - Wetlands).

- Sensitive landscapes including wetlands, drainage channels, riparian areas, and indigenous bush; occupy a very limited extent of the areas to the west of the highway, such areas being mostly confined to valley-bottoms and their associated steeper.
  Furthermore, development of these relatively limited (in extent) sensitive areas would also not be feasible due to either their low-lying slope positions, or alternatively steeper slopes.

The location of Mining related Infrastructure to the east of the N2 highway (approximately <50m amsl) is generally not recommended for the reasons which follow:

- Land capability is predominantly of the Wetland (seasonal in footslopes; becoming mostly permanent in the eastern valley-bottoms) capability class, to the east of the aforementioned knick-point.

- Thus, sensitive landscapes including wetlands, drainage channels, riparian areas, and indigenous bush; occupy the majority of this area.

11.2 ISSUES – PLANNED MINING INFRASTRUCTURE

ISSUES

Undesirable Infrastructure

The current Planned Mining Infrastructure (as indicated in Figure 1a) layout in this area indicate two features of concern, including Sand Tailings Dumps A-1 and A-3 Complex.

- Sand Tailings Dump A-1:

  Over 50% of the proposed site is occupied by Site Type D (dark topsoil sands – Fernwood form – Interflow - Wetland) and E (moderately deep E-horizon hydromorphic – mostly Kroonstad and Longlands forms – Interflow - Wetlands) soils, plus sections of indigenous bush in drainage areas (also wetlands).

  The site layout must be adapted to be entirely confined to Site Type C (pale topsoil sands) soils only.

- Sand Tailings Dump A-3 Complex (comprised of 3-4 sections – number of sections varies between recent layout plans) [refer to Figure 1a]:

  The Scoping Report (current Project) Figure 7-15 (Biodiversity Sensitivity in the Project Area [WSP, 2023]) indicates (amoung other things) information derived from the KZN Biodiversity Sector Plan (2016). This figure indicates that these 3-4 sections of Sand Tailings are surrounded (within 30m) by indigenous bush with a "CBA – Irreplaceable" index. Thus, given sedimentation issues, it is recommended that these Sand Tailings Dumps (complex) are totally removed from the Planned Mining Infrastructure layout.

- Sand Tailings Dump site A-2 is acceptable from the soils perspective (based on Soils Map KS2).

  The site is boardered to the north by the uManzamnyama perennial stream, which drains into the Umlalazi River. The site is also boardered to the west and south by wetlands (and some indigenous bush). Thus, it is recommended to increase the buffer zone to greater than 32m in these (and all) areas, in order to eliminate potential sedimentation impacts into sensitive areas. Refer to Buffer Zones.

Excessive Slope and Height of Certain Features

This is addressed in Section 11.4 – SLOPE AND RE-GRADING.

Buffer Zones

Buffer Zones. Fairbreeze Mine EMPR (compiled by Adam, J. - April 2012). Refer to Table 9.1, issue number B5, page 185.

This document indicates the recommended width of buffer zones between Mining related features and sensitive habitats such as wetlands / riparian zones / streams and indigenous bush, at Fairbreeze Mine to be 60m. The current proposed width of buffer zones at the proposed Port Durnford Mine is 30m.

POTENTIAL SOLUTIONS TO IDENTIFIED ISSUES – SPACE SAVING

- Commence with the hydraulic deposition of Sand Tailings at Dump 8B first in the year 2036 (instead of years 2048 – 2053, as indicated in Figure 1a); this process being approximately consequitive with the hydraulic deposition of Fines in RSF 9. These two features are conveniently situated adjacent eachother (north of the N2 highway).

- Thus, it is recommended to not first commence with hydraulic deposition of Sand Tailings in Dumps A-1, A-2, or A-3 Complex (from years 2036-2047, as proposed in Figure 1a).

- Consequitivly conduct hydraulic backfilling (and sequential rolling over final rehabilitation) of Mined out Pits utilising co-disposal (mixture of Sand Tailings and Fines) from years 2036 or 2041 onwards. Thus, the depositional piping may require junctions and alternative brances established in order to facilitate this process.

- Rehabilitated (i.e. re-graded / topsoiled) previous Mining Pit areas (also including repurposed RSF C; and re-purposed Sand Tailings sites 3, 4, and 5):

  It is <u>strongly recommended</u> that the final profile of these sites be constructed as follows: raised above the origional surface level (up to a maximum of 15m), 'whale-backed' in shape (not level with the surrounding landscape), with side-slopes of <1:7 (ideally).
  The 15m height above ground level is derived as follows: 50m average Pit depth x 30% bulking factor = 15m.

- The large volume of additional material (arising from the bulking factor) accommodated in the 'whale-back' shaped previous mining Pits will then possibly result in a material balance indicating that there will be no need to create the further Sand Tailings Dumps A-1, A-2, and A-3 complex (all located outside of the mining Pit areas). Furthermore, the extent and height (above ground level) of RSF 9, and Sand Tailings site 8B may also potentially be reduced.

- Rehabilitated RSF 9; and Sand Tailings sites 8B, A-1, A-2, and A-3 Complex – all constructed above surface outside of mining Pit areas:

  These features should also from the outset be designed to be graded to a 'whale-backed' shape; in this case to a maximum slope of 1:5 (never as steep as 1:4 or 1:3).

  It is recommended that the outer side-slopes of these features be pre-planned to be sloped as such during the Construction phase (i.e. during the depositional process of the outer starter walls and side-slopes), and not only as late as the Decommissioning phase (i.e. not re-graded much later by bulldozer).

  Such a recommendation will facilitate the establishment of the post-mining end Land Use vegetation (e.g. *Euclayptus* trees or indigenous bush) on the outer side-slopes immediately after construction during the Operational phase. Such established vegetation will be permanent, and will significantly contribute towards the dewatering of the various facilities. Furthermore, this method will prevent the necessity of having to re-slope and re-establish vegetation for a second time during the later Decommissioning phase, thus resulting in significant cost savings due to not having to duplicate these two operations later.

Furthermore, such final landscapes would blend into that of the surrounds.

- Co-disposal of Fines and Sand Tailings. This will result in space saving in terms of the extent/height of Sand Tailings footprints, due to the fines infilling voids between the sand particles. Refer to Section 11.5 (TOPSOILING, AND RECONSTITUTED 'SOIL' MIXING RATIO) for further information.

- Seek permission (Authorities) to backfill Sand Tailings into the valley area which lies to the south of RSF9 (west of the now re-purposed Pit site, now Sand Tailings site 4), thus creating one larger combined Sand Tailings feature in this area. The backfilling of this valley (north of N2 Highway) will prevent the disturbance and potential impacts to wetlands and areas of sensitive bush in a far larger area (south of N2 Highway).

- The inclusion of RSF 9, Sand Tailings Dump site 8B, and the backfilled valley (previous point); will accomodating large volumes of material during the early stages of the depositional process.

- Should the aforementioned points be achievable, then the loss (from the proposed Mining layout indicated on Figure 1a) of the unsuitable (wetland soils or bush) sections of Sand Tailings sites A-1 (about 50%) and A-3 Complex (100%) would be more than compensated for due to space saving elsewhere.

  Plus, there would still be the option of making use of Sand Tailings sites A-1 (approximately 50%) and A-2 (approximately 100%), but only if absolutely necessary. However, these two sites are unlikely to be required if all of the aforementioned recommendations are implemented.

- All of the aforementioned recommendations would be acheivable with a high level of pre-design planning, material budgeting and management supervision.

The Mine has the option to refine the Planned Mining Infrastructure (Layout) going forward, based upon sound recommendations based on scientific research.

11.3 SOIL STRIPPING AND STOCKPILING

SOIL STRIPPING

Refer to the following information sources within the current report document; regarding potential stripping depths and volumes, or alternatively the depth / volume of existing soils.

Map 7 - Soil Utilisation (Stripping) Guide (Stockpile 8).
Table 11 - Soil Utilisation (Stripping) Guide Summary (Stockpile 8).

Map KS3 - Sites (Port Durnford Plantation) *(Snyman, 2008).* Stripping depth inferred from the soil Effective Rooting Depth column.
Table 5 - Site Types, Soil Forms / Properties, and Stripping Volumes (Port Durnford Plantation).

The presence of large *Eucalyptus* tree stumps throughout the entire mining area will make the soil stripping process challenging. It is imperative that the Mine find a solution to ensure that ALL recommended soil horizons are stripped to the correct depth.

RECOMMENDED MINIMUM STRIPPING PRESCRIPTION FOR THE ENTIRE PORT DURNFORD MINE AREA

The following is regarded as a Minimum Prescription, because wherever possible it would be adventageous to the post-mining Land Capability and a sustainable long-term end Land Use, to exceed the prescribed minimum soil stripping and topsoiling depths.

Mining Pit areas (all): These sites will later be re-purposed as either of the following:

- **RSF site C (including P1, P2, P3, and P4); or**
- **Sand Tailings sites 3, 4, and 5.**

<u>Only the topsoil (orthic A-horizon – strip depth 30cm) horizon is required to be stripped and stockpiled from these Mining Pit areas.</u>

The suitable subsoils will not be stripped in the Mining Pit areas, for two reasons:

Firstly this subsoil material is a valuable source of ore, containing a raised concentration of the mining targeted heavy minerals.

And secondly, because during the rehabilitation topsoiling exercise the Mine must create a reconstituted 'soil' mix of Fines and Sand Tailings, below the 30cm of topsoil. This procedure will save space (reduced number/height/ extent of Sand Tailings Dumps) due to the infilling of clay and silt particles between the sand particles. Refer to Section 11.5 (TOPSOILING, AND RECONSTITUTED 'SOIL' MIXING RATIO) for further information.

In order for this reconstituted 'soil' mix to be well blended (thus preventing undesirable soil layering in-field), this mixing process must take place in the depositional piping, irrespective of associated costs to the Mine.

Features in non-mining areas; including:

- **PWP Plant and Temporary Infrastructure Area (on surface);**
- **Return Water Dams (on surface);**
- **Sand Tailings sites 8B, A-1, A-2, and A-3 Complex (above surface); and**
- **RSF site 9 (above surface).**

<u>Strip Topsoils (orthic A-horizon - strip depth 30cm); plus</u>

<u>Subsoils are also required to be stripped and stockpiled from disturbed sites outside of the Mining Pit areas.</u>

The potential soil stripping depths in all areas are discussed in Section 10 (SOIL UTILIZATION (STRIPPING) GUIDE).
Soil Stripping depths for Port Durnford Plantation are indicated in Table 5. Refer to the Effective Rooting Depth column within this Table, the available soil depth being >150cm for all of the Site Type A, B, and C soils.

The recommended soil stripping depth in these areas is 150cm (minimum).

These sub-soils generally (usually) include the following Soil Site Types for most features:
Site Type A (red apedal B-, or yellow-brown apedal B-horizon);
Site Type B (red apedal B-, or neocutanic B-horizon); and
Site Type C (E-horizon).

However, at Sand Tailings Dump 8B, other subsoil types will also require to be stripped, as per Map 7 [Soil Utilisation (Stripping) Guide (Stockpile 8)]. Recommended stripping depths are indicated on the Map, and vary considerably within this area.

SOIL STOCKPILING

Proposed Topsoil stockpile locations are indicated on Figure 1a. These are very limited in extent due to the planned rolling-over Rehabilitation process (as Recommended). Topsoil stockpiles are temporary features, being removed once the stored ‘topsoil’ has been utilised to Rehabilitate (topsoil) elsewhere.

Instead of Soil Stockpiling, it is Recommended to wherever possible rather practise continually ongoing sequential rolling over rehabilitation topsoiling operations throughout the entire Phase 2 Life of Mine (from 2036 or 2041 onwards, not only commencing as late as 2056), where topsoil stripped from one mining Pit footprint is immediately utilised to topsoil another Pit area (or other redundant Mine feature) where backfilling has been completed. This process of not stockpiling soils reduces the number of soil handling operations, limits compaction, and significantly reduces operational costs. However, for logistical reasons, stockpiling is still necessary in many cases.

The implementation of this practice would have the benefits of reducing the number / height / extent of Topsoil Stockpiles (and also Sand Tailings Dumps).

The number of Topsoil Stockpiles are extremely limited on Figure 1a (Planned Mining Infrastructure); and it must therefore be interpreted that rolling-over Rehabilitation will be implemented throughout the Life of Mine. Thus, the Mine needs to ensure that Backfilling, Re-grading, Topsoiling and Re-vegetation (i.e. final Rehabilitation) takes place from either years 2036 or 2041 onwards (i.e. commencing as early as possible during the Life of Mine).

Ideally strip and stockpile soils in the dry state. This is because compaction is promoted when working soils in the moist state. However, given that mining is ongoing throught the year, this is not always possible.

Utilise tracked machinery (as opposed to wheeled veichles) for soil stripping/stockpiling operations due to the lower point loading.

Utilise dedicated traffic routes, thereby preventing unnecessary widespread compaction.

Stockpile Topsoil and Subsoils separately, in dedicated soil stockpiles. These may be in the form of either stockpiles or soil bems.

Stockpile height: normally recommended in the mining industry is a maximum height of 3m (ideal). This height recommendation is based upon deposition of the material by dump truck, and then potentially building the topsoil height to 3m utilising a shovel. During later utilisation of topsoil material for rehabilitation, the soil must be loaded onto a dump truck utilising a shovel from a machine adjacent the stockpile. In order to prevent compaction, machinery should never traverse on top of the stockpile. The Mine should investigate machinery that is able to deposit / remove soil material from a height exceeding 3m utilising a scoop, provided that such machinery does not traverse the stockpile. Increasing topsoil stockpile height will save space due to minimising the extent of the stockpile footprint.

Ensure that Soil Stockpile side-slopes are ≤1:7 (8°) [ideally], but not steeper than 1:5 (11.3°) [latter option will required a higher vegetative basal cover].

Subsoil (B- or E-horizons) Stockpiles: sample the top 10cm of soils in the stockpile / analyse (laboratory) / ameliorating soil fertility.

Revegetate Subsoil stockpiles using locally indigenous (to the site) grasses.

Topsoil (orthic A-horizon) stockpiles: should naturally revegetate without fertilisation (due to inherent fertility) or seeding (due to the inherent natural seedbank store - probably lacking in areas previously planted to *Eucalyptus* trees), but if not then intervention will also be required (as previously described for Subsoil Stockpiles).

Monitor/remove alien invasive vegetative species.

11.4 SLOPE AND RE-GRADING

This process must be conducted by re-grading (i.e re-sloping) the Sand Tailings and Fines to the desired profile. This exercise must be conducted before the topsoiling layers (Section 11.5) are applied.

The Recommended final desired end slopes are discussed in Section 11.7 (FINAL END LAND CAPABILITY AND LAND USE – BASED ON SLOPE), so will not be re-discussed here in much detail.

<u>Final side-slopes of Rehabilitated Mining features must be reduced by re-grading to ideally ≤1:7 (8 °) [but definately not more than 1:5 (11.3°)]. Terracing is optional if side slopes are so reduced by correct reshaping.</u>

Side-slopes must definately be reduced (as specified above), from the proposed (by the Mine) 1:3 (18.4° - terraced) for certain features, this slope being totally unacceptable from the soil erosion perspective. This slope is in fact the maximum recommended gradient for material dumped on level

to gently (<5 degrees) sloping terrain, before Rehabilitation (Mining Rehabilitation Guidelines – refer to References). Thus, 1:3 (18.4 degrees) slopes are not applicable to Rehabilitated areas, where an agricultural end Land Use is planned.
Furthermore, given that natural pre-mining slopes in the area vary from approximately 1 - >18 degrees (average maximum slope north of N2 Highway is 9 degrees), the Mine needs to be careful not to Dump material to 1:3 slopes in areas where the natural slope already exceeds 5 degrees, and particularly so because the Fines and Sand Tailings are hydraulically deposited. Thus, the Mine should plan for maximum slopes of 1:5, while <= 1 :7 is optimum.

Slope form/shape should wherever possible blend into that of the surrounding non-disturbed areas. Blending into the surrounding landscape does not necessarily mean that the pre-mining level must be duplicated, because replaced mined material displays a bulking factor. However, well re-shaped slightly raised areas with side-slopes of <1:5 (but <= 1:7 definately preferred) will still blend into the natural environment.
Very importantly, the creation of non-freely draining blind depressions and hollows (where surface water would accumulate) must be avoided at all costs.

Such a final landscaped shape may be either:
- ‘Whale-backed’. Applicable to all previous Mining Pits (including re-purposed Sand Tailings sites 3, 4, and 5; and RSF C). Also applicable to RSF 9; Sand Tailings Dumps A-1, A-2, and A-3 Complex; and Return Water Dams); or alternatively
- Reticular. PWP and Temporary Infrastructure areas.

Conservation Measures.
It should be noted that the Department of Agriculture stipulates that conservation measures should be implemented on slopes of over 1.1 degrees (2.0 %) on disturbed sites, where the original grass cover has been removed.
These measures involve practices such as building contour banks, re-grassing and cultivating on the contour, etc. The maximum allowable slope for annual cropping is 6.8 degrees, while the maximum slope on which a tractor can operate is approximately 11.3 degrees.

11.5 TOPSOILING, AND RECONSTITUTED ‘SOIL’ MIXING RATIO

The following are regarded as the Recommended Minimum Topsoiling Prescriptions for the entire Port Durnford Mine Area, because wherever possible it would be adventageous to the post-mining Land Capability and a sustainable long-term end Land Use (and yield potential), to exceed the prescribed minimum soil stripping and topsoiling depths.

TOPSOILING OF PREVIOUS MINING PITS (ALL)

These include the following sites:
- **re-purposed RSF site C (including P1, P2, P3, and P4); and**
- **re-purposed Sand Tailings sites 3, 4, and 5.**

Topsoiling Horizons / Depths

During the rehabilitation topsoiling exercise, place a 30cm layer of topsoil (orthic A-horizon) on the immediate surface of these areas.

The reason that the Topsoil orthic A-horizon must always be replaced on the immediate surface is because the horizon contains organic matter / carbon.
Organic matter (indicated by the amount of organic carbon) is of vital importance in soil. It improves the structural condition of both coarse- and fine-textured soils and improves the water holding capacity, especially of sandy soils. It therefore greatly reduces the erodibility of soil. Organic matter supplies greater than 99 % of total soil nitrogen (N) and 33 - 67 % of total soil phosphorus (P). Humus, the active fraction of soil organic matter has a very high CEC (between 150 and 300 cmol (+) kg^{-1}) and can adsorb up to about 6 times its own weight in water.

<u>The topsoil must overlie a 150cm (minimum) layer of Reconstituted 'soil' (below the Topsoil). The greater the thickness of this layer, the greater the plant survivability and yield potential of the rehabilitated site.</u>

Reconstituted 'Soil' – Mixing Ratio, Function, Depth

<u>Mixing Ratio</u> of Reconstituted 'soil':

The Reconstituted soil is recommended to be comprised of a mixture (well mixed) of the Mine defined Fines (almost all of the silt, plus all of the clay) and Sand Tailings (sand) grades.

<u>The current author (B.B.McLeroth – Red Earth cc) recommends the following ideal Mixing Ratio:</u>

- <u>Target Ratio: 33.3% Fines (30-27% clay) : 66.7% Sand (1:2 ratio).</u>
- <u>Less Desirable: 25% Fines (22-19% clay) : 75% Sand (1:3 ratio).</u>

- <u>Clay contents vary for each mixing ratio. This is because average silt content of natural *in-situ* soils vary from approximately 3% in the upper 2m; to up to approximately 6% in the lower horizons below 2m. Refer to 'Silt and Clay Content at Port Durnford (natural *in-situ* soils)'; further below.</u>

This material must be thoroughly mixed, without sequential stratified layering of Fines and Sand Tailings, because such a situation would severely compromise the final end Land Capability and end Land Use of the site. This is because the Fines on its own displays hard setting, increased bulk density, and a greatly reduced permeability; thereby collectively inhibiting the penetration of plant roots.

The thorough mixing objective may only be acheived thorough mixing of the Fines and Sand components within the hydraulic depositional piping system. <u>Thus, the Fines and Sand Tailings grades must be fed into the depositional piping at source, the mixing occuring along the way. Depositing sequential layers of Fines and Sand Tailings seperately is not acceptable.</u>

The Reconstituted 'soil' contains almost zero organic carbon, so must never be replaced on the immediate surface, but rather below the 30cm topsoil (orthic A-horizon) layer.

<u>Function</u> of Reconstituted 'soil':

The Mines so called 'Fines' fraction is that smaller than 0.045mm (i.e. <45µm).

This is comprised of two soil particle sizes, namely coarse (0.05-0.02mm) and fine (0.02-0.002mm) silt [both generally sub-dominant in natural soils before mining] and clay (<0.002mm).
The clay fraction is generally only slightly more dominant in natural sand to sandy-loam soil textures in the top 1.5m of natural soil profiles, but very highly dominant in natural sandy-clay-loam to clay soil textures of the same depth.
Thus, the Mines 'Fines' fraction contains almost all of the silt fractions, plus all of the clay.

These 'Fines' particle sizes display two major benefits to plant growth, as indicated hereafter.

Firstly - soil fertility.
These particles provide a proportion of exchange sites for plant nutrients, binding nutrients in place until these are required for plant growth.
[However, organic carbon in the overlying topsoil by far provides the MAJOR source of exchange sites. The higher the organic carbon/matter and clay (and silt) content of the soil, the greater the Cation Exchange Capacity (CEC) of the soil].
Sand grades on the other hand possess very few such exchange sites, with most of the applied plant nutrients being leached out of the soil profile by infiltrating rainfall.

Secondly - Available Water Capacity (AWC mm/m).
As the combined clay and silt content of a soil increases, so too does the AWC.
Thus the necessity of including these fractions in the reconstituted soil mix below the topsoil. These soil fractions hold the soil moisture necessary for the growth of plants during the establishment phase as well as to largely sustain the plant throughout the following dry season; until such time as the extending plant roots have sufficiently developed in order to access deeper moisture sources (below the fines layer).

Depth of Reconstituted 'soil':

The greater the depth of the reconstituted 'soil' layer, the greater the Total Available Moisture TAM (mm) [= AWC mm/m x Depth m) ultimately available to the plant will be. Thus, the greater the depth of the reconstituted 'soil' layer (i.e. greater than the recommended minimum depth of 150cm), the greater the initial survivability and also the plant yield which will ultimately be acheivable.

Silt and Clay Content at Port Durnford (natural *in-situ* soils)

Refer to: REFERENCE DOCUMENT I (Snyman, 2008), specifically*: Appendix 3 (Modal Soil Profile Descriptions and Laboratory Analysis).*
This Appendix indicates detailed descriptions, laboratory analysis, and photographs of the 22 different defined Soil Bodies. This Appendix may be referred to separately, and is not included in the current document.

A summary of these silt and clay contents within augured depth (150cm) are hereafter indicated by the current author for the Modal profiles of Site Type A, B, and C soils; these comprising the vast majority of the soils which will be impacted by mining operations.

Site Type A (deep red and yellow 'sandy' mesotrophic soils). Texture in B1 and B2 (where present): sand to sandy-loam. Extent: 18 % of Port Durnford Plantation.

Main soil forms: Hutton and Clovelly. Modal profiles considered: MO1, MO2, MO5, MO6, and MO15.

Silt A-horizon: 0.6 - 2.9 %. Silt B-horizons: 0.7 – 4.7 %.
Clay A-horizon: 1.5 – 5.0 %. Clay B-horizons: 0.9 – 5.9 % (outlier B2 horizon <u>39.3 %</u>).

Site Type B (deep red 'çlayey' mesotrophic soils). Texture in B1 and B2 (where present) -horizons: sandy-clay-loam. Extent: 15 % of Port Durnford Plantation.
Main soil forms: Hutton and Oakleaf. Modal profiles considered: MO3, MO7, and MO16.

Silt A-horizon: 1.2 – 3.8 %. Silt B-horizons: 2.0 – 4.3 %.
Clay A-horizon: 3.5 – 15.1 %. Clay B1-horizon: 6.8 – 12.3 % (outlier B1 horizon <u>48.7 %</u>). Clay B2-horizon: 16.1 – 19.9 %.

One further Site Type B analysed clay content outlier is presented in Table 3 (Soil Analytical Data – Stockpile 8) of the current report (B.B.McLeroth): sample reference D5 B-horizon (Hutton form): Clay B-horizon: <u>49.0 %</u>.
Appendix I (Soil Profile Descriptions – Stockpile 8) also indicates numerous estimated clay contents that on the upper end range between <u>30 - 55 %.</u>

Site Type C (pale topsoil sands). Texture: sand. Modal profiles considered: MO8 and MO9. Extent: 19 % of Port Durnford Plantation.

Silt A-horizon: 2.2 – 2.9 %. Silt E-horizons: 2.3 – 5.3 %.
Clay A-horizon: 1.6 – 3.0 %. Clay E-horizon: 0.6 – 3.4 %.

Conclusions for Silt and Clay content follow:

- Clay content. Soil Site Types A and B, although generally 'sandy' in the top 1.5m (augured depth), overlie very deep (up to 50m or more) layers of red soils (or soil-like material), these deeper layers displaying a sandy-clay-loam, sandy-clay, or clay texture, as indicated by the analytical data for outliers above. It is probable that sections of the Site Type C soils also overlie similar material at unknown depth.
  The three analysed outliers display a clay content ranging between 39.3 – 49.0 %, average 45.6 %.
  It is concluded that the clay content throughout the majority of the mining ore body Site Type A and B soils (below approximately 2m) is likely to vary from approximately <u>30 to 50 %.</u>

- Silt content. Silt contents of the analysed Site Type A, B, and C soils within the top 1.5m vary from 0.6 – 5.3 %, average 2.78 %.
  However, it appears that silt contents may increase slightly with increasing depth below 1.5m, to a potential average maximum of approximately 6 %.

  Dr Colin Smith (personal communication – 4 February 2025) is currently in the process of collecting soil samples from 1m intervals between surface and 50m in an open mining pit at Fairbreeze Mine. After analysis, this data will provide further clarity in the future.

- Clay and Silt contents of existing Reconstituted soils. Despite the moderate to high clay contents in the majority of the ore body below approximately 2m, a large proportion of these Fines (clay and silt) are deposited into the RSF sites. It must be ensured that a sufficient volume of the initial Fines grades remain for the purposes of creating the recommended Reconstituted 'soil' layer to the recommended mixing ratio (Refer to Section 11.5).

  As previously indicated in the current Section, the current author (B.B.McLeroth – Red Earth cc) recommends the following mixing ratio:
  Target Mixing Ratio: 33.3% Fines (30-27% clay) : 66.7% Sand (1:2 ratio).
  Less Desirable Mixing Ratio: 25% Fines (22-19% clay) : 75% Sand (1:3 ratio).

  Smith, C. (updated 25th August 2024) indicates in Table 1 of his report, an informative comparison of analytical data for Hillendale and Port Durnford, two of these profiles being existing Reconstituted soils from Hillendale.
  Sample MO4 (in turn extracted from Snyman, K. - March 2008): silt / clay %: first horizon 7.9 / 19.9; second horizon 4.1 / 12.4.
  Sample H1 (collected by Smith, C.): silt/clay: first horizon 8.7 / 19.3; second horizon 9.3 / 19.5; third horizon 7.0 / 23.8.
  The clay content of this data indicates that the 1:4 (Fines:Sand) mixing ratio was potentially utilised at the time.

TOSOILING OF ABOVE SURFACE FEATURES IN NON-MININIG PIT AREAS

These include the following sites:
- **PWP Plant and Temporary Infrastructure Area (on surface);**
- **Return Water Dams (on surface);**
- **Sand Tailings sites 8B, A-1, A-2, and A-3 Complex (above surface); and**
- **RSF site 9 (above surface).**

<u>During the rehabilitation topsoiling exercise, place a 30cm layer of topsoil (orthic A-horizon) on the immediate surface of these areas.</u>

<u>The Topsoil must overlie 150cm (minimum) of the originally stripped and stockpiled Subsoils (below the Topsoil).</u>
However, the Topsoiling depth may be less than 150cm in certain sections of Stockpile 8B, due to the Effective Rooting Depth of the natural soils frequently being lesser in this area (Refer to Map 7).

These suitable Subsoils must never be replaced on the immediate surface due to the fact that these horizons contain almost zero organic carbon, so display very poor soil fertility and are thus also far more erodible.

11.6 RE-VEGETATION

The recommended Final End Land Use vegetation types are indicated in following Section 11.7 (FINAL END LAND CAPABILITY & LAND USE – BASED ON SLOPE), so will not be repeared here in much detail.

Based upon final slope and topsoiling depth (thus End Land Capability), such vegetation may include some of the following:
cover crops, sugar cane, timber, “locally” indigenous grassland, or “locally” indigenous bush. Options also exist for the planting of vegetables (local communities) on most of the Arable Land Capability sites; plus demanding species such as tree crops (nuts or citrus) [local communities or farmers] on certain high potential sites.

The Forestry related report (Dr. C. Smith - updated 25 August 2024 – further updated 13 February 2024) provides detailed information regarding the potential for commercial forestry in the area post-rehabilitation.

Before re-vegetation, the surface soils must be sampled (multiple samples from each chosen site) at a depth of 0-10cm (or up to 30cm); these samples being delivered to a laboratory for fertility analysis. Thereafter, depending on the target vegetation or crop for the site, the soil fertility must be ameliorated by fertilisation. After re-vegetation, this process should be reconducted anually for crops or once every three years for grasslands (for example).

The SA Sugarcane Research Institute (Fertiliser Advisory Service - laboratory) at Mount Edgecombe is able to both analyse the soil samples, as well as to provide detailed fertiliser recommendations for different crops (or vegetetion types).

Plantings of "Locally Indigenous" (grassland and bush) species.

This frequently utilised term must be interpreted as follows:
- vegetative biological material (seeds, cuttings, runners, or bulbs) must be sourced within the LOM area or immediate surrounds only. For arguments sake, lets say within an approximately 2km radius of the Mine boundary.

This term may not be interpreted as either biological material of the target species which is sourced (nursery or other) from elsewhere, sometimes up to hundreds of kilometers away; or alternatively as species which are not encountered in the existing natural areas of the Mine and immediate surrounds (thus derived from different climatic regions).

This is because vegetative (and fauna) species are precisely genetically adapted (due to natural mutations within a species) to be able to thrive in the location where they naturally occur, this adaptive genetic process having been ongoing for thousands of years.

An inappropriate case in point would be the revegetation of the sides of the N2 highway for great distances in the region, whereby nursery grown tree species have been planted. In some cases, these indigenous (to South Africa) trees have potentially been sourced from nurseries a long distance away from their actual in-field planting position; while some of these species do not even naturally occur in the exact locations where they were planted (thus, adapted to naturally occur in a slightly to largely different climatic region). This issue creates concern for the spreading of foreign (to the immediate planting site) biological material into the surrounding natural areas. Such off-site trees may then possibly be regarded as ‘weeds’ (“a plant growing where it is not wanted” - from the natural biodiversity point of view in the privately owned areas surrounding the Highway).

The Mine may consider the establishment of a nursery to grow indigenous plants, or alternatively contract a local nursery to do so on their behalf; but only provided that the propogated biological material is sourced from the LOM area or immediate surrounds. Furthermore, the different broad classification groups of Indigenous Bush occurring in the LOM area, must only be planted into the site types to which they are precisely suited.

11.7 FINAL END LAND CAPABILITY & LAND USE – BASED ON SLOPE

FINAL END SLOPE: <= 1:7 (8°)

Applicable to the following features: top zones (more level) of rehabilitated RSF's, Mining Pits, and Sand Tailings Dumps; as well as any lower side-slopes with the same grade (if any, but recommended as ideal).

Final End Land Capability: Arable [as per erosion related principals contained within *'Mining Rehabilitation Guidelines (2019)']*.

This Land Capability assumes that the topsoiling depth/type and final side-slope recommendations are precisely followed.

Final End Land Use:
cover crops, sugar cane, commercial timber (e.g. *Eucalyptus* species), "locally" indigenous grassland (refer to Section 11.6 – RE-VEGETATION, for explanation), or "locally" indigenous bush (all options are suitable). Options also exist for the planting of vegetables (local communities) on most of these sites; plus demanding species such as tree crops (nuts or citrus) [local communities or farmers] on certain high potential sites.

FINAL END SLOPE: 1:7 (8°) - 1:5 (11.3°) [steeper than 1:7]

Possibly applicable to the side-slopes (steeper than top zones) of the following features: rehabilitated RSF's, Sand Tailings Dumps, and Mining Pits.

It should be noted that the average maximum slope in the mining areas to the west of the N2 highway is approximately 9 degrees, this being the maximum slope to which the landscape has eroded/equilibrated over many thousands of years, as determined by both soil properties and climate. However, slopes of up to approximately 11.3 degrees (1:5) are allowable from the soil erosion perspective.

Final End Land Capability: Grazing.

This Land Capability also assumes that the topsoiling depth/type and final side-slope recommendations are precisely followed.

Final End Land Use:

Initially stabilise the slope with "locally" (to the immediate surrounds) indigenous grasses.

Thereafter establish a dense stand of commercial timber (e.g. *Eucalyptus* species) along the contour, or alternatively "locally" (to the immediate surrounds) indigenous bush.
Eucalyptus trees may have already previously been planted on these slopes during the Operational Phase (e.g. to hasten the drying out of the hydraulically deposited material), such trees having the benefit of a high water demand.

During the establishment (planting) of commercial timber, the manual placement of organic litter (e.g. discarded tree waste sourced from the surrounding forestry areas) along the contour will be highly beneficial to limiting run-off; as well as ultimately building up the topsoil organic matter (and carbon) content, thereby improving soil fertility, nutrient recycling, soil moisture holding capacity, and soil structure.
The importation of compost is risky due to the potential for introducing weed species (e.g. via seeds) contained within poorly composted material, so is not recommended.

As the commercial trees (or indigenous bush) grow, a litter layer will naturally be deposited onto the soil surface. Both the leaf canopy and the litter layer will reduce soil erosion.

Thus, burning must not be allowed in any of the rehabilitated areas.

The final end Land Use must not be "locally" indigenous grasses alone. This is because the surface basal cover will be insufficient to intercept raindrop energy or stop soil erosion, while overgrazing (large numbers of cattle from local communities in the area) and the potential for wildfires would further compromise the sites.

Sugar cane has not been considered by the current author in these areas, given that the majority of the actual soil surface is bare of basal cover for periods of the year. Although the establishment of contour banks and grassed waterways is standard practice in the sugar cane industry, rehabilitated soils are more sensitive to erosion as opposed to the origional *in-situ* soils (on a similar slope). However, it is recommended that further future sugar cane trials/research be conducted; these being related to soil erosion/fertility, yield, and financial viability. The outcomes and recommendations of such research may potentially deem some of these rehabilitated sites as suitable for the cultivation of sugar cane (and/or other crops).

Although not part of our scope of work, the following Report document presents vast amounts of detailed information regarding to the growing of sugar cane in the area (including rehabilitated areas):
Steyn, C., and N. Bezuidenhout. March 2011 (Golder Associates Africa Pty. Ltd.). Monitoring and Evaluation Framework: Evaluation and Prediction of Closure Capping Functioning. Exxaro KZN Sands – Hillendale Mine.

FINAL END SLOPE >1:5 (11.3°) [Not Recommended] - 1:3 (18.4°) [Particularly Unacceptable]

Applies to moderately steep side-slopes, if these are not re-graded (re-sloped) correctly, as specified in the recommendations. In any case, slopes exceeding 1:5 must not occur post-rehabilitation.

Final End Land Capability: Wilderness.

Final End Land Use:
No sustainable end agricultural land use is feasible, due to likely excessive ongoing soil erosion, (and particularly so on 1:3 slopes).

Initially stabilise the slope with “locally” (to the immediate surrounds) indigenous grasses. However, grassland is not acceptable as the final end Land Use.

Thereafter establish a dense stand of “locally” (to the immediate surrounds) indigenous bush. This is the only potential option for such excessive slopes (moderately steep), which in any case should not occur post-rehabilitation. The leaf canopy / underlying litter layer in indigenous bush areas will buffer rain drop energy, while the underlying litter layer will also limit runoff. Given that re-established indigenous bush in such areas is unlikely to thrive or acheive the same density as that in natural areas, soil erosion will possibly continue indefinately and particularly so where 1:3 slopes are present, these steepest sites potentially remaining as a permanent scar on the landscape.

Although natural (undisturbed) “locally” indigenous bush in the immediate area in some cases grows on slopes exceeding 11.3 degrees (>1:5 slopes), it could potentially take many years (undetermined period) to re-establish the natural equilibrium (related to nutrient recycling / canopy density / litter layer) which makes vigorous growth possible.

Indigenous bush was observed growing on some of the Hillendale RSF 1:3 side-slopes, this bush having re-established naturally. Further research and monitoring is required in this regard.

Although commercial timber will certainly grow productively on rehabilitated slopes of up to 1:4 (14 degrees), this end Land Use is not recommended due to the negative impact of potential soil erosion and the resultant sedimentation of surrounding areas due to surface disturbance during the timber establishment / harvesting operations, while cattle overgrazing plus the risk of wildfire would also result in a bare surface.
Furthermore, most tractors and machinery cannot safely operate on slopes exceeding 1:5, and even if certain machinery could, the surface disturbance and compaction arising from trafficking the site would once again result in increased soil erosion and sedimentation.

Conclusion. <u>The Mine must aim for maximum side-slopes of <1:5 (<1:7 is optimal) throughout their rehabilitated areas</u>. This will ensure that productive (and financially viable) end Land Capabilities and end Land Uses are achievable post-mining.

FURTHER NOTES

Regarding the issue of the maximum allowable slopes (as indicated above) for the various Mining related features at the proposed Port Durnford Mine in the current document; these are based upon the principals expounded in the following published South African sources:

- Scotney, *et al*, 1987.
  Reference: Scotney, D.M., *et al*. March 1987.
  “A System of Soil and Land Capability Classification for Agriculture in the SATBVC States’’.

In this document, erosion slopes for typical South African soils are calculated from the Soil Erodibility Nomograph (Wischmeier, *et al*, 1971).
Reference: Wischmeier, W.H., C.B. Johnson and B.V. Cross. 1971.
"A Soil Erodibility Nomograph for Farmland and Construction Sites. J. Soil Water Conservation. 26: 189 – 193".

The nomograph exercise may in the future be conducted specifically relating to the Port Durnford soils if so required. This exercise would determine the maximum slope that may be tolerated (for different soil types/textures) before unacceptably excessive levels of soil erosion begin to occur. However, this exercise would require the collection / analysis / interpretation of further soil samples from carefully selected sites. The current author may conduct this task if so requested.

Refer to Section 7.1 (Land Capability – Mining) for further information.

The below is the major Refererence utilised during the course of the current study.

- *'Mining Rehabilitation Guidelines (2019)'.*

  Reference: Land Rehabilitation Guidelines for Surface Coal Mines. May 2019.
  Land Rehabilitation Society of Southern Africa, Coaltech Research Association, and Minerals Council of South Africa.

  Although this document was published relating to coal mines (these being the most expansive of all mining operations in the country), this is the major reference document utilised for most mining operations in South Africa. These recommendations generally apply equally to mining operations throughout South Africa (and elsewhere), because irrespective of the location/targeted mineral resource, the environmental principals which are expouneded in this document are on the whole still relevant.

The Mine potentially reserves the right to adapt their proposed rehabilitation plan (also including proposed layout/design, and planned mining related sequences), based upon future investigations and research; provided that these outcomes are both justified (beneficial to the environment – from the current, and other specialist perspectives) and proven (either accredtited data presented in the form of a Report document, or alternatively future peer-reviewed and published research).

11.8. SUPPORTING INDEPENDANT DOCUMENT RECOMMENDATIONS

In support of recommendations by B.B.McLeroth (Red Earth cc) in the current Report; relating to the following various Aspects, including:
Replacement of orthic A-horizon Topsoil on the immediate surface;
Depth of Rehabilitated Soils (either reconstituted 'soil', or replaced previously stockpiled natural soils);
Reconstituted 'Soil' Mixing Ratio;
Final Rehabilitated slopes;
Sequential Rolling-over Rehabilitation 'Topsoiling' exercises; and
Other aspects;
please note the following previous independant recommendations.

Various quoted (duplicated) text is indicated in quotation marks, thus " ".
The key points of this related text is underligned, <u>thus.</u>

<u>EMPR Fairbreeze Mine</u>: Compiled by Adam, J. (April 2012):

Refer to Table 9.1, issue number B5, page 185.
Buffer Zones: This document indicates the recommended width of buffer zones between Mining related features and sensitive habitats such as wetlands / riparian zones / streams and indigenous bush, to be <u>60m (and not 30m as currently utilised for the planned Proposed Mining Infrastructure layout, as indicated in Figure 1a).</u>

Refer to Section 10.6.3. - Topsoil Management. Page 371, first paragraph.
"Topsoil storage will only be carried out for the first ore body excavation and for soil removed from the RSF. After that removed topsoil and *Eucalyptus* harvesting residues will be moved onto backfilled areas from areas due to be mined in a sequential manner.
Topsoil stockpiles will be placed in suitable locations and away from the 1:100 year-flood-line of any watercourse. They will be protected from surface water flows by diversion berms.
Existing topsoil will be utilised as far as possible as a means for restoring soil fertility and soil structure. Emphasis will be placed on utilising the existing topsoil in combination with the forest floor and harvesting residues (bark, branches, leaves, tree tops and chipped stumps) that will be available after clear-felling of the *Eucalyptus".*

Note by current author. This statement indicates that sequential rolling-over rehabilitation will be practised.

Refer to Table 10.1 – EMP commitments for Fairbreeze Mine Operations.
Objectives to Manage Potential Impacts = Minimise Change in Topography due to Mining. Reference 1. Page 332.
"The pre-mining landscape will be surveyed to record topography. All dunes mined will be rehabilitated to the original shaping of natural topography (slope, landform and orientation) on the basis of the pre-mining survey".

Refer to Section 10.6.7.2. – Dune Shaping. Page 374.
"EXXARO will undertake dune shaping to recreate a landform that is modelled on the pre-mining land survey. Shaping of the post-mining landform will give cognisance to the pre-mining land aspect, slopes, and drainage lines. Dune shaping will be undertaken with earth moving machinery and will be undertaken immediately once the backfilled areas are trafficable".

Refer to Section 10.8.8.1. – Backfill and Shaping of Mined Areas. Page 387, last two bullets.
"Backfilling and shaping of the site will aim to create a surface landscape that mimics natural topography and matches the landform of adjoining areas.
"Natural drainage flow must be reinstated, and slopes must be suitable for traversing and not pose an erosion risk".

Note by current author. For space saving reasons elsewhere (thus limiting the extent/number/height of Sand Tailings Dumps outside of mining areas), it is recommended that the final profile of rehabilitated Pit sites be constructed as follows: raised above the origional surface level (up to a maximum of 15m), 'whale-backed' in shape (not level with the surrounding landscape), with side-slopes of <1:7 (ideally).
For further information, refer to Section 11.2 (ISSUES – PLANNED MINING INFRASTRUCTURE; Sub-Section: (POTENTIAL SOLUTIONS TO IDENTIFIED ISSUES – SPACE SAVING).

Refer to Section 10.6.7.2. - Placement of Reconstituted Soils. Page 374.

"Once the basic landform has been created EXXARO will undertake the placement of reconstituted soil. The reconstituted soil layer comprises a mixture of coarse dewatered sand and slimes material (thickener underflow). The reconstituted soil will be mixed in a bulk mixing plant at a ratio of between 70:30 and 80:20, also referred to as the co-disposal system (4.4.5.5). The sand to slimes ratio will depend on the soil properties and requirements of the post-mining land use.

The reconstituted soil will be pumped to the area of use. The reconstituted soil will be deposited within paddocks created over the rehabilitation area.

Since layering takes place during the replacement of the reconstituted soil, deep tillage behind a grader or bulldozer on the contour will be carried out to homogenize the soil and break up compacted layers when the soil is at a suitable water content. Detail management of the reconstituted soil (i.e. depth of application and specific 'sand : clay' ratio), topsoil/harvesting residue mix, incorporation of the latter within the reconstituted soil and further amelioration will be determined by the Rehabilitation Research Programme and consideration of the latest mine rehabilitation technology.

The reconstituted soil material will be deposited in layers to a minimum depth of 1.5 m".

Section 10.6.9.1. – Residue Storage Facilities. Page 377, last paragraph.

"Re-vegetation and maintenance of the drainage structure will provide long term stability of the deposit. The side walls will be "battered off" to a slope of 1:7 and contoured. However, stability analyses must be carried out by suitably qualified personnel on a long-term basis and any necessary remedial measures undertaken on a long-term maintenance basis. It must be ensured that the surface of the RSF can carry farming machinery. If not, then more sand may have to be mixed into surface of the RSF".

Note by current author. RSF side-slopes of 1:5 is allowable, but 1:7 would be optimal (as alluded to above).

Forestry: Smith, C. (5 July 2017):

Page 1. "Prior to research trials being implemented, initial experience with planting sugarcane at Hillendale resulted in the development of recommendations to remix sand, silt and clay in proportions that would result in about 25 – 30% of the reconstituted soil having < 45μ material within the top 1.5 m".

Page 5. "In general chances of successful reforestation increase with re-application of topsoil and the inclusion of small to moderate amounts of clay and silt in the soil body within a metre of the surface. The inclusion of fines in the soil body can be carried out either by storing further mineral soil prior to the extraction process or reconstituting the soil as done at large parts of Hillendale".

Page 2. "Re-application of the topsoil is fundamental to successful re-establishment/ reforestation to *Eucalyptus* since the topsoil underpins the restoration of soil fertility as well as enhancing water retention and improving aeration. For example, the average stand volume per hectare of *Eucalyptus* where 20 cm of topsoil was applied was eight times greater at four years of age compared to where it was not applied (48.4 m3 ha^{-1} compared to 6.3 m3 ha^{-1}; …). Where topsoil was applied, and trees regularly fertilized stand volume was 61.6 m3 ha-1 compared to 6.3 m3 ha^{-1} (a ten-fold difference)".

Forestry. Smith, C. (updated 25 August 2024 - further updated 13 February 2025):

Section 3.3. Hillendale Rehabilitation Trial.

"The trial was designed to address several major issues connected with the then proposed rehabilitation plan which was to spread remixed material as a capping on the backfilled sand".

The main lessons from the trial were as follows:

- There was a substantial growth response to topsoil addition. An average MAI of 20.0 m3 $ha^{-1}yr^{-1}$ for the treatments where topsoil was applied compared to 7.5 m3 $ha^{-1}yr^{-1}$ without topsoil.

- The growth response to topsoil addition is thought to be due to both nutritional and physical effects.
- There was no long-term improvement in growth where major tillage was conducted despite initial evidence that the ridging treatments were effective in alleviating waterlogging.
- The overall average for the trial was a respectable productivity of 16.9 m3 $ha^{-1}yr^{-1}$ at 8 years of age about half achieved in the adjacent Maholoholo plantation with a similar clonal hybrid (35.5 m3 $ha^{-1}yr^{-1}$).
- The best growth was achieved by topsoil retention and several fertilizer applications which is understandable given the poor initial soil fertility (21.7 m3 $ha^{-1}yr^{-1}$).
- The results were achieved under conditions where soil water was not limiting due to moderate water holding capacity in the reconstituted material.
- The surface capping of reconstituted mix acted as a strong interceptor of rainfall due to its moderate water holding capacity. This contrasts with sands where water interception will be much less due to rapid infiltration".

Section 3.4. Temporary Sampling Plots.
"Growth in two other Eucalyptus stands at Hillendale were also monitored. In the first compartment, trees were planted into 1.5 m of reconstituted material over 25m of backfilled sand without topsoil addition. With a view to minimizing erosion the first stand was planted at a high density on the contour (3333 stems per ha) but later thinned twice to one third of that. One crop of Sun hemp was planted, and the stand fertilized twice. A MAI of 23.7 m3 $ha^{-1}yr^{-1}$ at 7 years of age was recorded. The trees looked very healthy throughout. Survival was good, the stand was stable, and form was good. In terms of MAI growth was 66% of that achieved in the adjacent Maholoholo plantation at a similar age.

In the second compartment (the "sand paddock") trees were established into a compartment of 30m of backfilled sand without topsoil. The site was prepared by planting two crops of Sun hemp and fertilizing twice. Trees were stunted and showed nutritional deficiencies from the outset. Windthrow occurred close to canopy closure presumably as the root systems were poorly developed and since planting directly into sand with poor particle coherence resulting in poor stability.
A recent visit to the site also suggested that growth had stagnated presumably because of poor water availability in the deep backfilled sands. Although no measurements were taken, the visual appearance of the stand indicated a MAI more in the region of 12 - 15 m3 $ha^{-1}annum^{-1}$ which is about 35 - 40% of that achieved in the adjacent plantation and estimates for Port Durnford".

Soils: Fairbreeze Environmental Application KZ-FB-ENV-App-002DI (August 2010).
Incorporated within Application: Fairbreeze Soil Rehabilitation (Report) - G.Patterson (Agricultural Research Council – Institute for Soil, Climate and Water). 7 March 2011.
Section 1: Rehabilitation of ore bearing sand dune areas. Sub-Section 1.1: Processed involved.
"It is proposed that for rehabilitation purposes, the first stage is to deposit sand from which the heavy minerals have been removed back into the excavated area before a final mixture is placed on top, to a thickness of 1.5 metres. This final mixture is produced when the separate (sand and slimes) fractions are re-mixed, or "reconstituted", in order to produce a mixture that will be suitable for re-vegetation and re-establishment of *Eucalyptus* spp. trees, which is the current land use. It has been proposed from provisional work carried out at Hillendale mine (where similar red soils to Fairbreeze have been excavated) that a mixture with the proportions 70:30 (sand to slimes) would be the optimum mixture for rehabilitation purposes".

Soils: Reference Document 1 - Snyman, K. (March 2008):
"Section 11. Conclusions.
Point j: Rehabilitation of sites should strive to match (or improve) current soil conditions. A recommended specification for rehabilitated soil is as follows:
a. Ensure 15% clay (maximum) throughout the profile.
b. Ensure an effective rooting depth of more than 2 m.

Point k: The rehabilitation program should also ensure storage of sufficient topsoil prior to mining for application as a 30 cm thick mulch on all rehabilitated sites".

The current author B.B.McLeroth, recommends an ideal clay content of 30-27% clay = approximately 33% Fines : 67% Sand = approximately 1 : 2 Mixing Ratio.

Sugar Cane: Steyn, C., and N. Bezuidenhout (March 2011):
"Section 8. Mitigation Measures to Improve Cover Crop.
Ensure a profile with a minimum depth of 1.5m" [current author - this is one of many indicated measures].
"Section 11. Conclusions.
A number of key aspects were raised but aspect that we consider to be the most important are:
The alleviation of the textural and density stratification of the reconstructed profile.
Ensuring a larger than 27% clay + slit fraction and density above 1.3 kg/m3.
Increasing organic carbon content above 1%; and
The potential for clay migration out of the reconstructed profile into fill material".

12.0 HYDROPEDOLOGY

Given that van Tol *et al* (various - refer to references below) are currently leading researchers in the field of hydropedology in South Africa, and have been instrumental in having this speciality become widely recognised; extensive references are made to these authors in the current Hydropedology Section of our report.

The three publication references (i.e. 'Hydropedology Guidelines') that follow, apply to current Section 12 of our document.

- van Tol JJ., le Roux PAL., and Lorentz SA., 2017. The Science of Hydropedology - Linking Soil Morphology with Hydrological Processes. Article in: The Water Wheel 16(3), May/June 2017.

- van Tol JJ., le Roux PAL. 2019. Hydropedological grouping of South African soil forms. South African Journal of Plant and Soil. 36: 233–235.

- van Tol, JJ, 2020. Hydropedology in South Africa: Advances, Applications and Research Opportunities. South African Journal of Plant and Soil, 37:1, 23-33, DOI: 10.1080/02571862.2019.1640300.

Apart from the three cited publication references above, additional cited references in current Section 12 may be obtained by examining the same three publications.

Figure numbers have been changed to suit the current document format, and are preceded by 'VT'.

12.1 HYDROPEDOLOGY - CONCEPTUAL

12.1.1 BACKGROUND

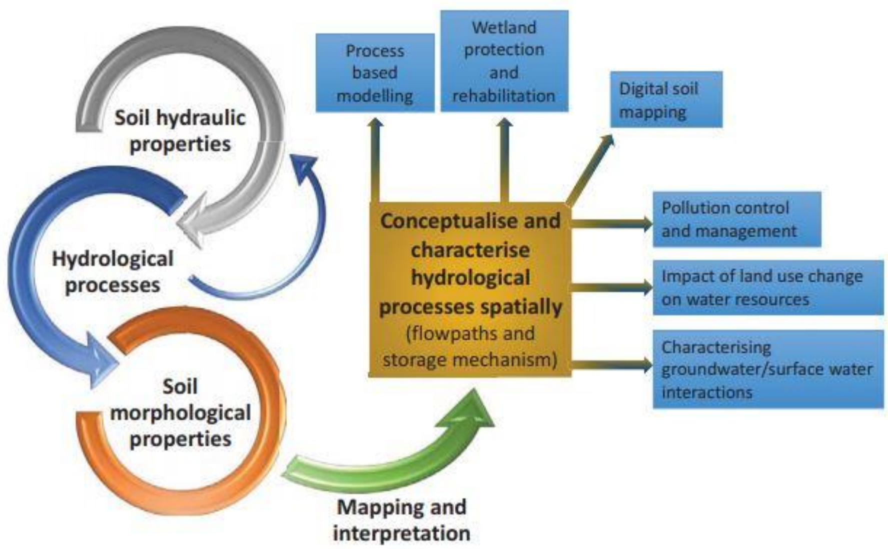
Text for the current Section 12.1.1 was extracted from the following publication:
- van Tol JJ., le Roux PAL., and Lorentz SA., 2017. The Science of Hydropedology - Linking Soil Morphology with Hydrological Processes. Article in: The Water Wheel 16(3), May/June 2017.

Hydropedology is the relatively new, interdisciplinary research field which focuses on the interactive relationship between soils and water. Soil physical properties, such as the hydraulic conductivity and porosity, have an important impact on the occurrence and rates of hydrological processes. In turn, hydrological processes play an important role on the formation of soil morphological properties such as colour, mottles, macropores and carbonate accumulations. Accurate mapping and the interpretation of these soil morphological properties can thus be used to conceptualise and characterise hydrological processes, including water flow paths, storage mechanisms and the connectivity between different flow paths. Most of these hydrological mechanisms and processes are very difficult to observe (let alone measure!) in the field because they are dynamic in nature with strong temporal and spatial variation. Nevertheless, soil morphological properties are not dynamic in nature and their spatial variation is not random – making soil properties the ideal vehicle for predicting and conceptualising hydrological processes. One of the major contributions of hydropedology is the ability to conceptualise hydrological processes spatially i.e. not only onedimensional mechanisms, but a more holistic understanding of the hydrological functioning of landscapes (catchments or hillslopes).

12.1.2 APPLICATION OF HYDROPEDOLOGY / ASSESSMENTS

Text and the Figures (one) for the current Section 12.1.2 were extracted from the following publication:
- van Tol JJ., le Roux PAL., and Lorentz SA., 2017. The Science of Hydropedology - Linking Soil Morphology with Hydrological Processes. Article in: The Water Wheel 16(3), May/June 2017.

Figure VT1: Hydropedology and some of the Applications of Hydropedological Surveys



Hydropedological information is used in process-based landscape water resource management.

This includes, for example:
• configuration and parameterisation of distributed hydrological models;
• effective wetland delineation, protection and rehabilitation;
• understanding and controlling the fate of pollution in the subsurface;
• determining the impact of land use change (e.g. open pit mining) on water resources and
• characterising groundwater/surface-water interactions, including the important mechanism of low-flow generation. In general, hydropedological information assists with effective water resource management, as required by the National Water Act through improved understanding and characterisation of hydrological processes.

Although Figure VT1 represents an oversimplification of a fraction of the complex hydrological cycle, the application of this information can make important contributions to effective management. Four scenarios are presented to support this statement.

1. Pollution
   The fate of pollution will differ depending whether it was spilled on recharge, interflow or responsive soils. A spill on recharge soils is likely to end up in the groundwater or might arrive in the stream several months after the spill via flow through the fractured rock. Pollutants spilled on interflow zones will migrate downslope through the soil. Because this downslope migration will be in contact with the soil, and hence abundance of micro-organisms, it is possible that it may be transformed into non-toxic forms (depending on the pollutant). If a pollutant is spilled on the responsive zone, it may travel quickly and unaltered to streams and other surface water bodies.

2. Conserving wetlands
   Hydropedological information can aid in identifying the sources of water in order to preserve wetlands. If the recharge zone is the major source of water to the wetland i.e. the recharge zone is the hydrological driver of the wetland, care should be taken to restrict surface sealing (paving) of the recharge zone. If the wetlands water comes from an interflow zone, care should be taken to prevent obstruction of subsurface lateral flow paths.

3. Hydrological modelling
   Hydropedological information can assist in the correct configuration of distributed hydrological models. In many landscapes different landscape elements (or Hydrological Response Units – HRU's) are not connected in a simple cascading downslope way to one another. There might be areas which are disconnected from the stream or groundwater stores. In addition, deep infiltration from recharge soils at the crest of a hillslope, may re-appear as lateral flow water further down the slope. Hydropedological information can thus be used to ensure that the model configuration properly reflects the hydrological processes. This can be critical in simulating low flows, where vegetation may have access to near-surface water and thus limit contributions to streamflow.

4. Land-use change
   Hydropedological information can support the understanding of the impact of land-use change on water resources. If, for example, the interflow zone is urbanised it may result in a build-up of water against foundations and the generation of return flow to the surface and overland flow which may cause erosion. Open pit mining close to responsive zones are likely to result in a draw-down of water levels and drying of wetlands. If such an open pit intersects lateral flow paths, it will break the connectivity of flow paths and cut the source of water to wetlands. Although the impact of land-use change cannot always be avoided, hydropedological information might aid in managing and protecting the hydrologic drivers of the ecosystem and thereby minimise negative impacts.

12.1.3 HYDROLOGICAL SOIL GROUPS OF SOUTH AFRICA

Text and Figures (one) for the current Section 12.1.3 were extracted from the following publication:

- van Tol, JJ, 2020. Hydropedology in South Africa: Advances, Applications and Research Opportunities. South African Journal of Plant and Soil, 37:1, 23-33, DOI: 10.1080/02571862.2019.1640300.

Currently seven [hydrological] soil types [groups] are recognised in South Africa (van Tol and le Roux, 2019).

Recharge soils

In these soils, vertical flow into, through and out of the profile into the underlying bedrock is the dominant flow direction. These soils will then 'recharge' groundwater aquifers or wetlands in valley bottoms. These soils do not have any morphological properties indicative of saturation (i.e. no mottles or grey colours). These soils can either be **deep** freely drained soils that can contribute significantly to evapotranspiration (Figure VT2-a, e.g. Hutton or Clovelly soil forms), or **shallow** soils on fractured rock with limited contribution to evapotranspiration (Figure VT2-b, e.g. Glenrosa or Nomanci).

Interflow soils

Subsurface lateral flow (SLF) is the dominant flow direction in interflow soils. SLF can either occur at the **A/B** horizon interface, where the vertical anisotropy in conductivity will result in a temporal build-up of water above the B horizon (Figure VT2-c). In these cases, an E horizon (albic) will normally form (van Tol *et al*. 2013a) such as in the Estcourt soil form. In the second, freely drained soils overlie relatively impermeable bedrock which promotes SLF generation on the **soil/bedrock** interface (Figure VT2-d). These soils are typically marked by hydromorphic properties associated with a water-table at the soil bedrock/interface e.g. Avalon or Tukulu soil forms. The duration and magnitude of lateral flow in interflow soils depend on the position in the hillslope (lateral addition/release), slope angle, rate of evapotranspiration as well as the anisotropy in permeability between the conducting and impeding layer.

Responsive soils

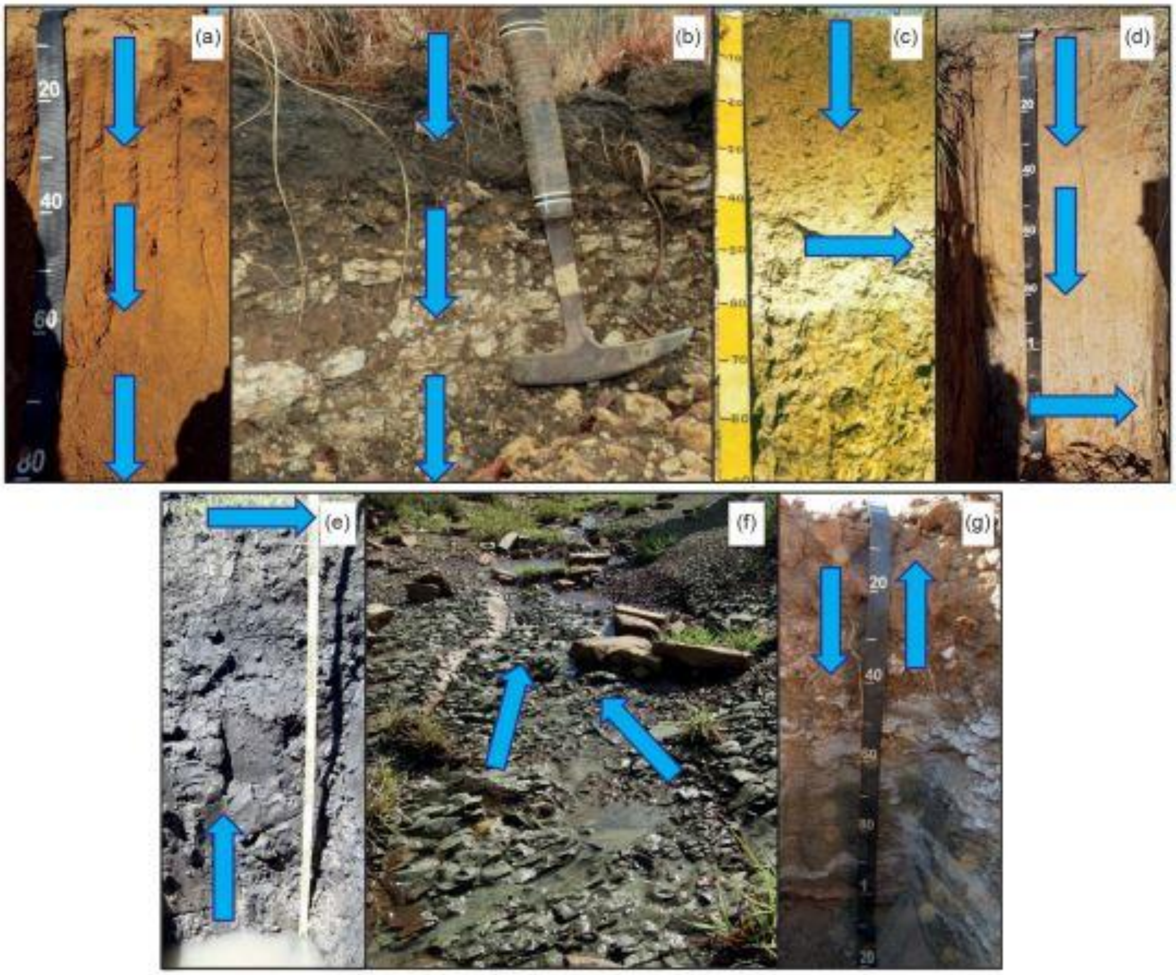
These soils 'respond' quickly to rain events and are responsible for overland flow generation during typical rain events. Soils with morphological indications of long periods of saturation (e.g. Katspruit, Champagne and other '**wet**land' soils) are close to saturation during most of the rain season (van Huyssteen *et al*. 2005). Additional precipitation on these soils will typically flow overland due to saturation excess (Figure VT2-e). **Shallow** soils that overlie relatively impermeable bedrock (e.g. Mispah), will saturate quickly due to limited storage capacity and promote overland flow (van Tol *et al*. 2010a). Soils with very low infiltration rates due to swelling (e.g. in vertic A horizons) or crusting will also generate overland flow (Figure VT2-f).

Stagnating soils

In these soils the A and/or B horizons are permeable but morphological indicators suggest that recharge and interflow are not dominant hydrological flow paths (Figure VT2-g). These soils will typically occur in areas with low rainfall and high evaporative demands. Morphological properties associated with these soils include carbonate accumulations in the subsoil, accumulation and cementation by silica, and precipitation of iron as concretions and layers. These soils are [indicative that] deep drainage of water is limited or restricted. Although infiltration occurs readily, the dominant hydrological flow path in the soil is upward, driven by evapotranspiration (van Tol and le Roux 2019).

Figure VT2: Hydrological Soil Groups of South Africa:

a) Recharge [deep]; b) Recharge [shallow]; c) Interflow [A/B]; d) Interflow [soil/ bedrock]; e) Responsive [wet]; f) Responsive [shallow] and g) Stagnating.



12.1.4 HYDROPEDOLOGICAL GROUPING OF SOUTH AFRICAN SOIL FORMS

Text and Figures (one) for the current Section 12.1.4 were extracted from the following publication:
- van Tol JJ., le Roux PAL. 2019. Hydropedological grouping of South African soil forms. South African Journal of Plant and Soil. 36: 233–235.

Soil classification is pivotal to hydropedological interpretation, and several studies have attempted to relate soil forms (as in the South African soil classification) to hydropedological behaviour. Here we present a cohesive grouping of the soil forms into four main hydropedological types, namely recharge, interflow, responsive and stagnating soils. This grouping will improve the efficiency of hydropedological assessments of soils, hillslopes and catchments for hydrological and ecological purposes.

Figure VT3: Hydropedological Grouping of South African Soil Forms

Recharge		Interflow		Responsive		Stagnating
Deep	Shallow	A/B horizon	Soil/bedrock	Shallow*	Saturated	
Kranskop	Nomanci[#]	Kroonstad	Lamotte	Nomanci[€]	Champagne	Steendal
Magwa	Mayo[#]	Longlands	Fernwood	Arcadia	Rensburg	Immerpan
Inanda	Milkwood[#]	Wasbank	Westleigh	Mayo[€]	Willowbrook	Dresden
Lusiki	Jonkersberg	Klapmuts	Avalon	Milkwood	Katspruit	Glencoe
Sweetwater	Glenrosa[#]	Villafontes	Pinedene	Glenrosa[€]		Molopo
Bonheim	Mispah[#]	Kinkelbos	Bainsvlei	Mispah[€]		Askham
Inhoek	Witbank	Cartref	Bloemdal			Kimberley
Constantia			Witfontein			Plooysburg
Tsitsikamma			Sepane			Garries
Concordia			Tukulu			Etosha
Houwhoek			Montagu			Gamoep
Griffin						Oudtshoorn
Clovelly						Addo
Hutton						Prieska
Shortlands						Trawal
Pinegrove						Augrabies
Groenkop						Brandvlei
Valsrivier						Coega
Swartland						Knersvlakte
Dundee						
Namib						

* Includes soils with very low infiltration rates

[#] Soils overlying fractured bedrock (e.g. soil families with lithocutanic B horizons that are 'not hard' and soil families where A horizons are 'not bleached')

[€] Soils overlying relatively impermeable bedrock (e.g. soil families where lithocutanic B horizons are 'hard' and soil families with bleached A horizon

12.1.5 HYDROPEDOLOGY OF HILLSLOPES

Text and Figures (one) for current Section 12.1.5 was extracted from the following publication:
van Tol, JJ, 2020. Hydropedology in South Africa: Advances, Applications and Research Opportunities. South African Journal of Plant and Soil, 37:1, 23-33, DOI: 10.1080/02571862.2019.1640300.

The hillslope or catena is generally accepted as a fundamental landscape unit to study the hydrological cycle holistically. The particular mix of different hillslopes (shapes, sizes and distribution patterns) determines the hydrological response of catchments (Sivapalan 2003). The interaction between topography, soils and climate results in soil distribution patterns which contain valuable information on the hydropedological functioning of hillslopes. These soil distribution patterns were the basis of the land type survey of South Africa (Land Type Survey Staff 1972–2004). Numerous (>100) hillslope hydropedological studies have been conducted in the past 20 years. Van Tol *et al*. (2013b) strived to classify the hydropedological response of studied hillslopes through identification of dominant flow paths (Figure VT4). This hillslope classification was based on the occurrence and coverage of different hydrological soil types (Figure VT2) on the studied hillslopes. Figure VT4 also presents an anticipated hillslope response function associated with a specific hillslope class.

1. Class 1 hillslopes are dominated by soils overlying slowly permeable bedrock which restricts vertical drainage to the bedrock. SLF causes saturation in the valley bottom and the generation of saturation excess overland flow.

2. Class 2 hillslopes are marked by shallow soils with limited storage capacity. These slopes will typically promote overland flow across most of the slope during significant rainfall. Hillslopes with soils prone to surface sealing, which generate infiltration excess overland flow will also form part of this hillslope class.

3. In semi-arid areas, groundwater and surface water are often not connected. Class 3 hillslopes present an example where recharge to the groundwater or fractured rock aquifer is dominant, but the groundwater is not connected to the stream.

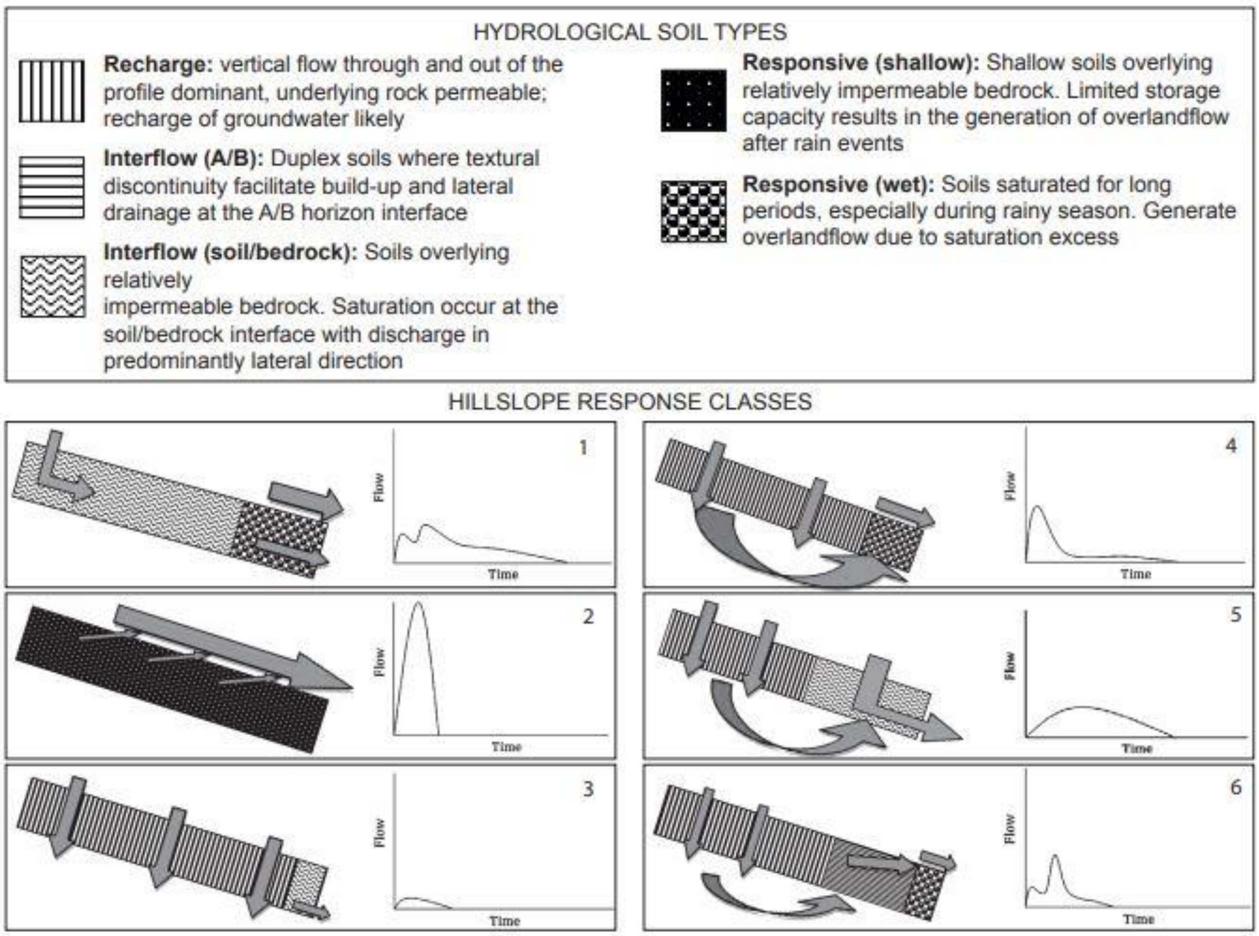
4. In Class 4 hillslopes, recharge is dominant on the upper slopes, but feeds wetlands and streams downslope via a fractured rock flow path. The wetlands in the valley bottom of these hillslopes are typically associated with very long periods of saturation due to the constant supply of water from the recharge zone.

5. Class 5 hillslopes are also marked by a prominent recharge zone. Return flow occurs however higher in the landscape (midslope positions). Lateral flow at the soil bedrock interface is consequently generated from the return flow to the solum.

6. Rapid near surface lateral flow is the dominant streamflow generation process as indicated by bleached eluvial horizons at the A/B horizon interface in Class 6 hillslopes.

In many cases the hillslope classification was supported with soil hydraulic, hydrometric and geochemistry measurements (e.g. van Tol *et al*. 2010b, Kuenene *et al*. 2013, Freese 2013). Although this hillslope hydrological response classification system only presents qualitative descriptions of flows, it can be used as a basis for quantification of EWRs, configure distributed catchment scale models, and assist with assessing the impact of land-use change, especially in ungauged areas (van Tol and Lorentz 2018).

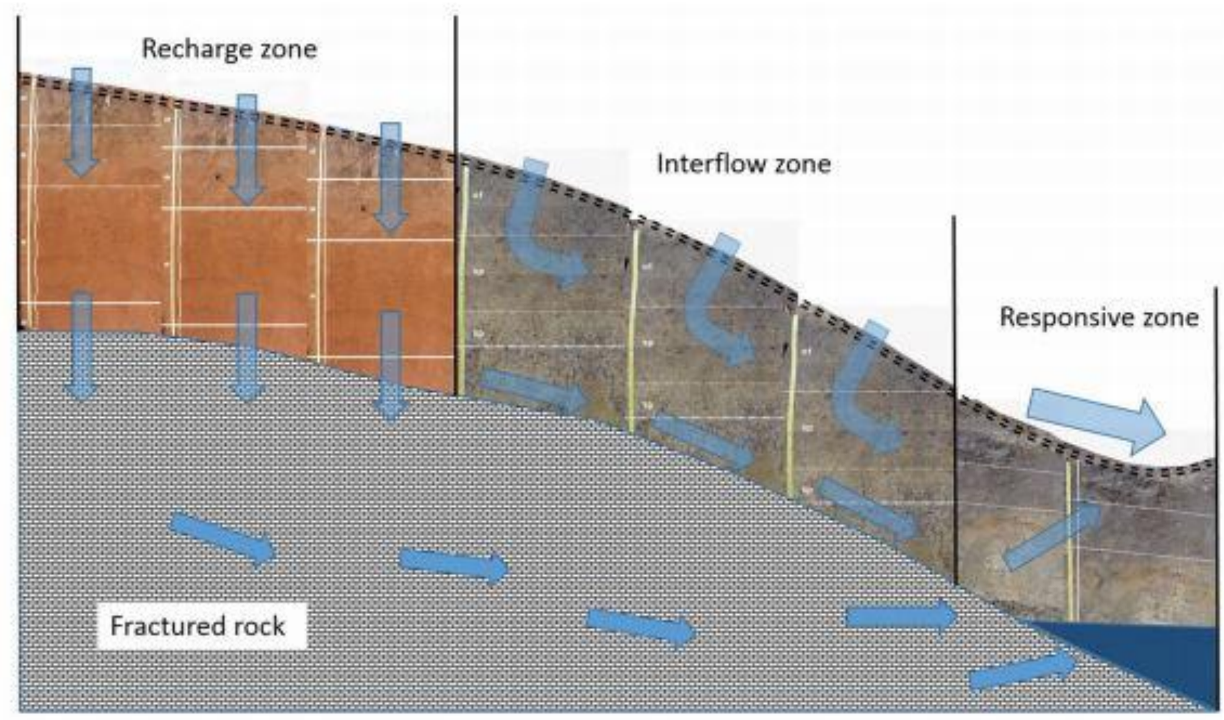
Figure VT4: Hydropedological Soil Groups and Hillslope Classes
(adapted from van Tol *et al*. 2013b).



12.1.6 CONCEPTUAL HILLSLOPE RESPONSE

Figure VT5 indicates a conceptual hydropedological response for a typical (not necessarily in the current combined study area) hillslope soil catena. This typical landscape includes a crest, midslope, footslope, and valley-bottom landscape position, the latter often also including a water-course.

Figure VT5. Conceptual Hillslope Hydropedological Behaviour (van Tol *et al*, 2017)



12.2 HYDROPEDOLOGY - ACTUAL SURVEY RESULTS

All of the preceding document Sections, Maps, Table and Figures are relevant to the Hydropedology assessment. Hence the clients request to combine the Stockpile 8 (current - B.B.McLeroth) and pertinent information from the Port Durnford Plantation (previous - Snyman, 2008) soil surveys into one stand alone document.

12.2.1 SOIL CHARACTERISTICS

Soil Characteristics are usually described in a stand alone Hydropedology report. However, in the case of the current document where the Hydropedology is a latter Section of the Soils (and other) report, there is no need to repeat the soils information.

The Soils and Sites have been mapped and described in detail.

Refer to Section 5 (SOILS):

- Text.
- Map 2. Soil Mapping Units (Stockpile 8).
- Table 2. Soil Forms / Properties Summary (Stockpile 8).
- Map KS2. Soils (Port Durnford Plantation) *(Snyman, 2008).*
- Table KS1. Defined Soil Bodies (Port Durnford Plantation) *(Snyman, 2008).*

Refer to Section 6 (SITES):

- Text.
- Map 3. Site Types (Stockpile 8).
- Table 4. Site Types Summary (Stockpile 8).
- Map KS3. Sites (Port Durnford Plantation) *(Snyman, 2008).*
- Table 5. Site Types, Soil Forms / Properties, and Stripping Volume (Port Durnford Plantation) *(compiled from: Snyman, 2008).*
- *REFERENCE DOCUMENT I (Snyman, 2008). Section 7.2 (Sites: report document text).*

Soil properties relating to the various Soil Forms / Soil Types / Site Types are nevertheless still indicated in Table form in the following Section 12.2.2.

12.2.2 REGROUPING OF OCCURING SOILS AND SITES, INTO HYDROPEDOLOGICAL SOIL GROUPS

Refer to: Table 12a. Regrouping of Soil Forms (and Site Types) into Hydropedological Soil Groups (Stockpile 8).
Refer to: Table 12b. Regrouping of Site Types (and Soil Types / Soil Forms) into Hydropedological Soil Groups (Stockpile 8).
Refer to: Table 12c. Regrouping of Site Types / Soil Types / Soil Forms into Hydropedological Soil Groups (Port Durnford Plantation).

These Tables indicate Soil Types / Soil Forms / Soil Properties, and Site Types (plus other information).

Thereafter these Tables regroup the various Soil and Site Mapping Units into Hydropedological Soil Groups.

These Hydropedological Tables are self explanatory, so no additional report document text is necessary.

Given that shapefiles for the Port Durnford Plantation soil survey (Snyman, 2008) are not available (from the Mine or my Client), Maps of the derived Hydropedological Soil Groups were not able to be produced. Hydropedological maps are not a pre-requisite for Hydropedology reports. However, such Maps may in the future be produced (at the clients request), provided that the relevant shapefiles become available.

Furthermore, such potential Hydropedological Maps would also need to consider the prevailing slope occurring, whereby soils occurring on slopes of less than and greater than 6 degrees, would need to be regrouped separately for the Site Type B (red sandy-clay-loam to sandy-clay textures) soils on Port Durnford Plantation.

This is because on slopes of approximately >6 degrees, the otherwise entirely Recharge (deep) [Hydropedological Group] Site Type B soils, will also exhibit an Interflow component within this Mapping Unit. Given that Snyman (2008) indicates the average slope within this Site Type B mapping unit to be 8.5 degrees (15%), consequently a sub-dominant Interflow component is likely to exist throughout the steeper sections of this Site Type.

Table 12a. Regrouping of Soil Forms (and Site Types) into Hydropedological Soil Groups (Stockpile 8)

Broad Soil Group	Soils Map Notation	SOIL FORM	SITE TYPE (also refer to Site Type Map and Legend)	Horizons	Effective Rooting Depth (cm)	Texture (Note: most sand grades are Medium, but occasionally Fine or Coarse)	Structure	HYDROPEDOLOCICAL SOIL GROUP	Polygon Count	Area (ha)	Area (%)	Area (ha)	Area (%)
Red apedal	Hu(c)	Hutton (clayey phase). Note: all soil forms encountered in the current study area are mesotrophic	B	orthic A / red apedal B / unspecified	>180 - 60	A: SaClLm (occasionally SaLm or SaCl). B: SaCl (occasionally SaClLm)	A: apedal. B: apedal (occasionally weak blocky)	Recharge (deep). Interflow component present on slopes approximately > 6 °	4	22,11	18,74	41,06	34,81
	Hu(c)-Gf(c)	Hutton (clayey phase) - transitional to Griffin (clayey phase)	B		>180	A: SaClLm. B: SaCl	A: apedal. B: weak blocky		1	1,63	1,38		
	Hu(s)	Hutton (sandy phase) [clayey at depth]	A		>180 - 120	A: Sa - SaLm. B: SaLm - Sa	A: single grain. B: single grain (occasionally apedal) [blocky at depth]		5	13,31	11,28		
	Bd(s)	Bloemdal (sandy phase) [clayey at depth]	A	orthic A / red apedal B / unspecified material with signs of wetness	140 - 50	A: LmSa - Sa. B: LmSa - SaLm	A: single grain. B: single grain (occasionally apedal) [blocky at depth]	Interflow (soil/bedrock)	5	4,01	3,40		
Yellow-brown apedal	Gf	Griffin (clayey)	B	orthic A / yellow-brown apedal B / red apedal B	100 - >180	A: SaLm. B: SaClLm	A: apedal. B: apedal	Recharge (deep). Interflow component present on slopes approximately > 6 °	3	3,58	3,03	6,48	5,49
	Cv,Gf	Clovelly, and Griffin (clayey)	B		70	A: SaLm. B: SaCl	A: apedal. B: apedal		1	0,89	0,75		
	Cv	Clovelly (clayey)	B	orthic A / yellow-brown apedal B / unspecified	50 - 70	A: SaClLm. B: SaCl	A: apedal. B: apedal or weak blocky		3	2,01	1,70		
Neocutanic	Oa	Oakleaf (sandy)	A	orthic A / neocutanic B / unspecified	>150 - 60	A: LmSa to Sa. B: LmSa to Sa	A: single grain. B: single grain or apedal	Recharge (deep). Interflow component present on slopes approximately > 6 °	2	2,57	2,18	20,10	17,04
	Oa,Tu	Oakleaf, and Tukulu (sandy)	A		110 - >180	A: SaLm. B: SaLm	A: apedal. B: apedal		2	5,81	4,92		
	Tu-Oa	Tukulu - transitional to Oakleaf (sandy) [clayey at depth]	E		100	A: Sa. B: Sa	A: single grain. B: single grain	Interflow (soil/bedrock)	1	2,19	1,86		
	Tu,Oa	Tukulu, and Oakleaf (sandy) [clayey at depth]	E		80	A: LmSa. B: SaLm	A: apedal to single grain. B: apedal		1	0,71	0,60		
	Tu	Tukulu (sandy) [clayey at depth]	E	orthic A / neocutanic B / unspecified material with signs of wetness	50 - 140	A: Sa to LmSa. B: LmSa to SaLm	A: single grain. B: apedal or single grain		7	8,82	7,48		
Shallow (Lithosols)	Gs	Glenrosa (clayey)	H	orthic A / lithocutanic B	30 - 20	A: SaCl (occasionally SaClLm)	A: apedal or weak blocky	Recharge (shallow)	15	28,61	24,25	28,61	24,25
Hydromorphic (Wetlands)	We	Westleigh (clayey)	G	orthic A / soft plinthic B	30	A: SaClLm or SaCl. B: SaCl or SaClLm	A: weak blocky or apedal. B: weak blocky	Responsive (saturated), and Interflow (soil/bedrock) components. High clay content (clayey) corresponds with reduced permeability	4	1,83	1,55	21,56	18,28
	We (Lo,Kd,Ka)	UNDIFFERENTIATED. Dominant: Westleigh. Sub-Dominant: Longlands, Kroonstad, Katspruit (clayey; occasional sandy subsoil E-horizons)	G	Westleigh: orthic A / soft plinthic B. Longlands: orthic A / E-horizon / soft plinthic B. Kroondstad: orthic A / E-horizon / G-horizon. Katspruit: orthic A / G-horizon	30	A: SaClLm or SaLm. B: SaClLm to SaCl. E: SaLm - LmSa	A: apedal or single grain. B: weak blocky or apedal. E: single grain	Responsive (saturated), and Interflow (soil/bedrock) components: Westleigh (We) soil form (since clayey). Interflow (A/B): Longlands (Lo) and Kroonstad (Kd) soil forms. Responsive	1	19,73	16,72		
Man-Made (Rehabilitated)	Wb	Witbank (clayey)	I	man-made soil deposit (in current case: deposited red apedal soil layer / overlying buried Glenrosa soil form)	70	Overburden: SaCl. A: SaClLm	OB: weak blocky. A: apedal	Recharge (shallow)	1	0,16	0,14	0,16	0,14
								TOTALS	56	117,97	100	117,97	100

Note: Parent material for the various soil polygons is indicated/described on Map 2 (Soil Mapping Units), as well as discussed in the Report Document text

Table 12b. Regrouping of Site Types (and Soil Types / Soil Forms) into Hydropedological Soil Groups (Stockpile 8)

SITE TYPE	SOIL TYPE *Note: variations from the Port Durnford Plantation Site Types are indicated in italics*	SOIL FORM	Effective Rooting Depth (cm)	Texture: Simplified	Parent Material	HYDROPEDOLOGICAL SOIL GROUP	Polygon Count	Area (ha) (%)	Area (%)
A	red *and neocutanic* mesotrophic (sandy) [deep]. *Note variation: neocutanic (deep phases) soils were instead included with Site A, due to their sandy texture (in current area)*	Hutton, Bloemdal, *Oakleaf*	*>180 - 120*	sandy	*Berea (sandy) [red] {Hutton/Bloemdal forms} or Recent (sand) [non-red] {Oakleaf form} / frequently over Berea (clayey) [red] at depth*	Recharge (deep): slopes approximately <6 °. Interflow component present in cases (most) where the sandy B1 subsoil overlies a clayey B2 subsoil at depth, and slopes approximately > 6 °: Hutton and Oakleaf forms. Interflow (soil/bedrock): Bloemdal form.	14	25,70	21,79
B	red *and yellow-brown apedal* mesotrophic (clayey) [deep *- moderate*]. *Note variation: yellow-brown apedal soils were instead included with Site B, due to their clayey texture (in current area)*	Hutton, Griffin, Clovelly	*>180 - 60*	clayey	*sandstone (clayey) [red or yellow] / occasionally over Berea (clayey) [red] at depth*	Recharge (deep): slopes approximately <6 °. Interflow component present on slopes approximately >6 °, due to clayey textures in the B1 subsoil. These reduce moisture permeability (compared with the orthic A-horizon). Consequently a lateral downslope waterflow component also exists (also applicable to Site Type A - B2 subsoils).	12	30,22	25,62
E	*neocutanic* hydromorphic [*shallow to deep*]. *Note variation: E-horizons (moderately deep) are excluded because these did not occur (in current area)*	Tukulu	*50 - 140*	sandy	*Recent (sandy) [non-red], sandstone (sandy) [non-red], or Berea (sandy) [red] / occasionally over Berea (clayey) [red] at depth*	Interflow (soil/bedrock)	9	11,72	9,93
G	undifferentiated hydromorphic [shallow]	Westleigh, *Longlands, Kroonstad,* Katspruit	*30*	clayey	*Colluvium, Alluvium, and sandstone*	Responsive (saturated), and Interflow (soil/bedrock) components: Westleigh (We) soil form (clayey). Interflow (A/B): Longlands (Lo) and Kroonstad (Kd) soil forms. Responsive (saturated): Katspruit (Ka) form.	5	21,56	18,28
H	shallow (i.e. lithosols) [shallow] [stoney and gravelly]	Glenrosa	*30 -20*	clayey	Gneiss	Recharge (shallow)	15	28,61	24,25
I	man made soils [moderate depth]	Witbank	*70*	clayey		Recharge (shallow)	1	0,16	0,14
					TOTALS	TOTALS	56	117,97	100

Note: Site Types C, D, and F were not encountered. *Site Type J (indigenous bush) was included within the soil Site Types above (including twelve polygons, 1.01ha)*

Table 12c. Regrouping of Site Types / Soil Types / Soil Forms into Hydropedological Soil Groups (Port Durnford Plantation)

Information compiled/duplicated from: *Table 6 (Sites), Section 7.2 (Sites-report text-in italics), and Map 3 (Sites) - Snyman (2008).*
Hydropedological Soil Groups added by B.B.McLeroth

SITE TYPE	Area (ha)	Area (%)	SOIL TYPE	SOIL FORM	Effective Rooting Depth (cm)	Structure: topsoil subsoil	Texture: topsoil subsoil	*Parent Material*	Susceptability to Erosion	HYDROPEDOLOGICAL SOIL GROUP	Average Slope (%)	Average Slope (degrees) [converted from % by B.B.McLeroth]
A	728,3	18,3	red and yellow mesotrophic (sandy) [deep]	Hu2100, Cv1200	>150	*A: single grain* *B: single grain becoming apedal*	A: Me Sa B: Me LmSa	*Quartenary sands*	extremely high	Recharge (deep): slopes approximately <6 °. Interflow component present in cases (frequent) where the sandy B1 subsoil overlies a clayey B2 subsoil at depth, and slopes approximately >6 °.	15	8,5
B	603,8	15,1	red mesotrophic (sandy-clay-loam) [deep]	Hu2200, Oa1120	>150	*A: apedal* *B: apedal, occasionally becoming weak blocky*	A: Me LmSa B: Me SaClLm	*Berea Formation*	extremely high	Recharge (deep): slopes approximately <6 °. Interflow component present on slopes approximately >6 °, due to clayey textures in the B1 subsoil. These reduce moisture permeability (compared with the orthic A-horizon). Consequently a lateral downslope waterflow component also exists (also applicable to Site Type A - B2 clayey subsoils).	*10 -* 15	8,5
C	746,6	18,7	pale topsoil sands [deep]. (E-horizon "yellow"' when moist)	Fw1210	>150	*A/E: single grain*	A/E: Me Sa	*Quartenary sediments*	very high *(high)*	Interflow (soil/bedrock, or A/B). Recharge (deep) component also present.	8	4,5
D	398,3	10,0	dark topsoil sands [water table at about 2m]	Fw2110	>150	*A/E: single grain*	A: Me LmSa E: Me-Fi Sa	*Quartenary sediments*	medium *(moderate - low)*	Interflow (soil/bedrock, or A/B)	*2 -* 5	2,9
E	355,5	8,9	E-horizon hydromorphic [moderately deep]	Kd1000, Lo1000, Tu1120	60 - 90	*A/E: single grain* *G,B: massive*	A: Me SaClLm E: Sa G/B: SaClLm	*Quartenary sediments*	medium *(moderate - low)*	Interflow (A/B)	5	2,9
F	153,2	3,8	E-horizon hydromorphic [deep]	Kd1000, Lo1000	90 - 120	*A/E: single grain* *G,B: massive*	A: Me SaLm E: Sa G/B: SaClLm	*Quartenary sediments*	medium *(moderately low)*	Interflow (A/B)	2	1,1
G	99,5	2,5	undifferentiated hydromorphic [shallow]	We2000, Ka1000, Ch2200, Fw2110, *Lo1000, Kd1000*	30 - 60	*A: massive (to apedal)* *E: single grain* *B/G: massive*	A: Fi SaClLm B/G: clayey	*Quartenary sediments*	medium	Responsive (saturated): Katspruit form (Ka), Champagne (Ch), Westleigh (We 2000 - luvic). Interflow (A/B, or soil/bedrock): Fernwood (Fw 2110 - dark orthic A). Interflow (A/B): Longlands (Lo), Kroonstad (Kd).	3	1,7
H	63,6	1,6	lithosols [shallow]	Ms1100, Gs1111, Cf2100	1 - 60	*A: apedal* *B,C: massive*	A: Me SaClLm B: clayey	*Gneiss*	medium	Recharge (shallow): Glenrosa (Gs) form. Recharge (shallow): Mispah (Ms) form - "rock" encountered is most likely a quartz stoneline. Interflow (A/B): Cartref (Cf) form.	15	8,5
I	198,4	5,0	man made sites, buildings, roads	Wb1000	0					Unknown		
J	642,5	17,0	indigenous bush, riparian, wetlands, channels		0					PREDOMINANTLY: - INDIGENOUS BUSH: Recharge (deep). - RIPARIAN: Interflow A/B. - WETLANDS, CHANNELS: ditto Site G information. [Soil Survey not conducted in these areas].		
TOTAL	3990											

12.2.3. SOIL PROFILE PHOTOGRAPHS

Figure 4. Selected Soil Profile Photographs (Stockpile 8) - also indicating Soil Form and Hydropedological Soil Group

Auger D5. Hutton form. Recharge (deep)

Auger B4. Clovelly form. Recharge (deep)

Auger H6. Oakleaf form. Recharge (deep)
Also **Interflow (soil/bedrock)** component - note bleached topsoil

Auger A5. Glenrosa form. Recharge (shallow)
Also **Interflow (soil/bedrock)** component - bleached topsoil (sandstone parent material)

Auger F1. Glenrosa form. Recharge (shallow)
(gneiss parent material)

Auger G10. Bloemdal form. Interflow (soil/bedrock)

Horizons: A(20cm)/B(130cm)/'E'(170cm)/U(>180cm)

Auger G8. Tukulu form. Interflow

Horizons: A(30cm)/B(90cm)/'E'(140cm)/U-C(>180cm)

Auger A6. Tukulu form. Interflow (soil/bedrock)

Horizons: A(50cm)/B(100cm)/'E' (130cm)/G(>180cm)

Auger D8. Westleigh. Reactive (saturated).
Also ***Interflow (soil/bedrock)*** *component.*

Horizons: A(30cm)/B(110cm)/'E' (120cm)/G(>150cm)

Auger G7. Kroonstad form. Interflow (A/B).
Also ***Responsive (Saturated)*** *component, due to shallow depth (60cm) to G-horizon (gley).*

Horizons: A(15cm)/E(60cm)/G(>90cm)

12.2.4 REPRESENTATIVE TRANSECTS

Topography of the entire Port Durnford Mining Development area is described in Section 1.4 (TOPOGRAPHY).

Refer to the following relevant Sub-Section document text and Figures:

- Section 1.4 - TOPOGRAPHY. Sub-Section: Slope Grade and Aspect.
- Figure 3a. Elevation and Transects.

- Section 1.4 - TOPOGRAPHY. Sub-Section: Altitude.
- Figure 3b. Slope Classes and Transects.

- Section 1.5 - DRAINAGE.
- Figure 2b. Location of Study Area (Topographical) - also indicates drainage.

In the current HYDROPEDOLOGY Section, four representative transects were chosen to represent the diverse Topography and Soils (also including Site Types) of the entire site. These include one for Stockpile 8 (Transect B-A), and three for Port Durnford Plantation (Transects D-C, F-E, and H-G). These Transects are also indicated on Figures 3a and 3b.

Given the heterogeneous landscapes (determined by landscape position, slope grade, altitude, and aspect) and varying lithologies (i.e. parent materials from which the soils have weathered) which occur within the rolling study area, four Transects were deemed to be necessary.

Two Figures have also been produced for each of the four Transects, these displaying visually aligned comparisons of the following:

- Site Types (soil related Map), versus Elevation Profile Graphs; and
- Elevation Classes (Altitude), versus Oblique Images (Google).

For Stockpile 8, an additional Figure has also been produced, as follows:

- Soil Forms (Map), versus Elevation Profile Graph.

A list of these Transect Figures follow:

Figure B-A 1a. Site Types vs. Elevation Profile Graph (Stockpile 8).
Figure B-A 1b. Soil Forms vs. Elevation Profile Graph (Stockpile 8).
Figure B-A 2. Elevation vs. Oblique Image (Stockpile 8).

Figure D-C 1. Site Types vs. Elevation Profile Graph (Port Durnford Plantation).
Figure D-C 2. Elevation vs. Oblique Image (Port Durnford Plantation).

Figure F-E 1. Site Types vs. Elevation Profile Graph (Port Durnford Plantation).
Figure F-E 2. Elevation vs. Oblique Image (Port Durnford Plantation).

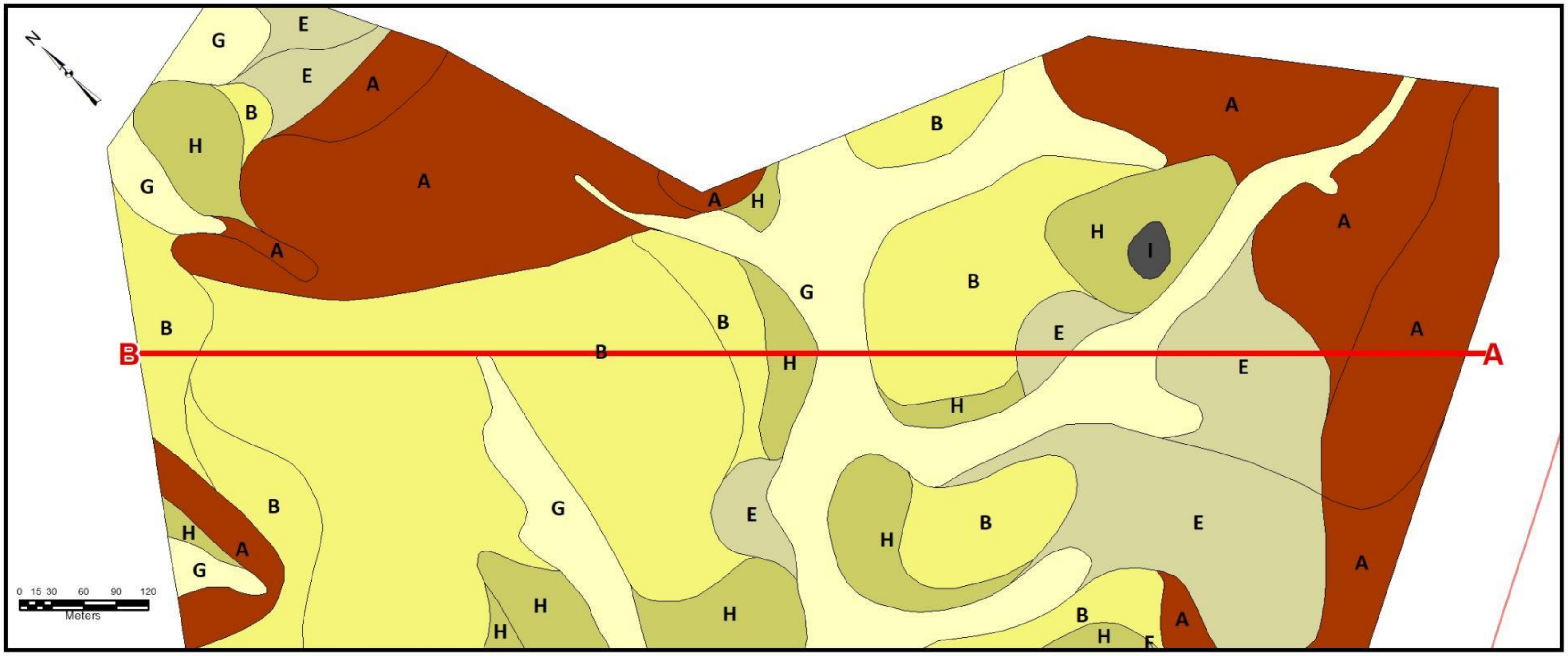
Figure H-G 1. Site Types vs. Elevation Profile Graph (Port Durnford Plantation).
Figure H-G 2. Elevation vs. Oblique Image (Port Durnford Plantation).

These Transect Figures are self explanatory, indicating at how the different Site Types (and Soil Forms) vary across the diverse rolling landscapes, as determined predominantly (in the Figures) by landscape position and slope grade.
However; soil texture, soil structure, and lithology (parent material from which the soils have developed) is also relevant.

For the purposes of this report, a Site Type is defined as a spatial land extent that has similar soil forms, soil properties, topography (landscape position and slope grade) and climate; such that these will provide similar infiltration rates, hydropedological responses, and growth potential for a variety of crops. Refer to Section 6 (SITES).

Thereafter in the current Report, the Hydropedology / Hydrology of the study area is described. Refer to: Section 12.2.5 - HYDROPEDOLOGICAL / HYDROLOGICAL RESPONSE OF STUDY AREA.

Figure B-A 1a. Site Types vs. Elevation Profile Graph (Stockpile 8)



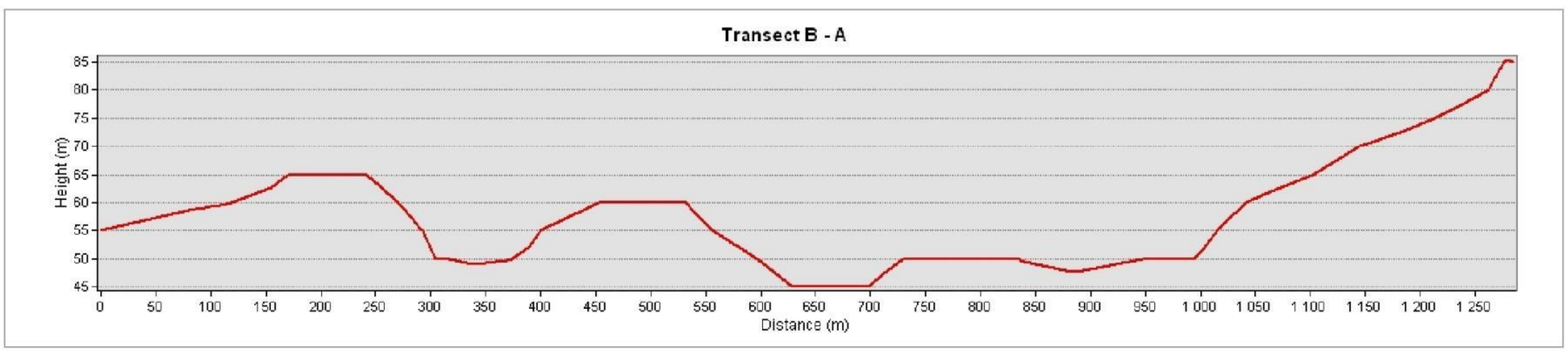
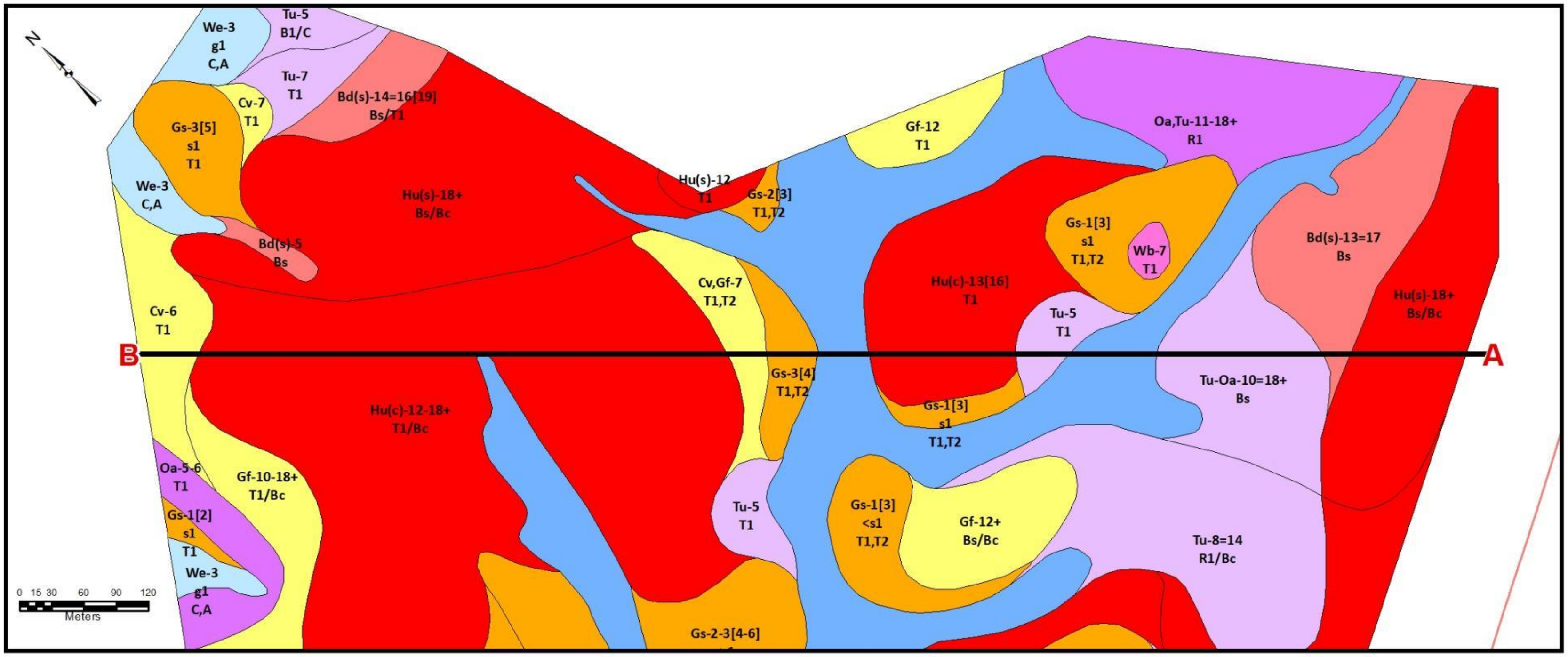


Figure B-A 1b. Soil Forms vs. Elevation Profile Graph (Stockpile 8)



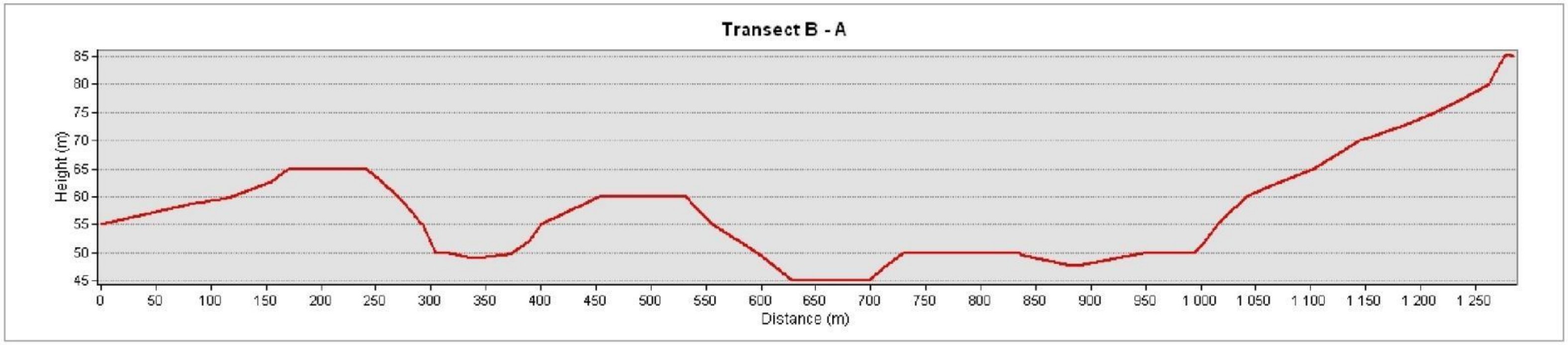
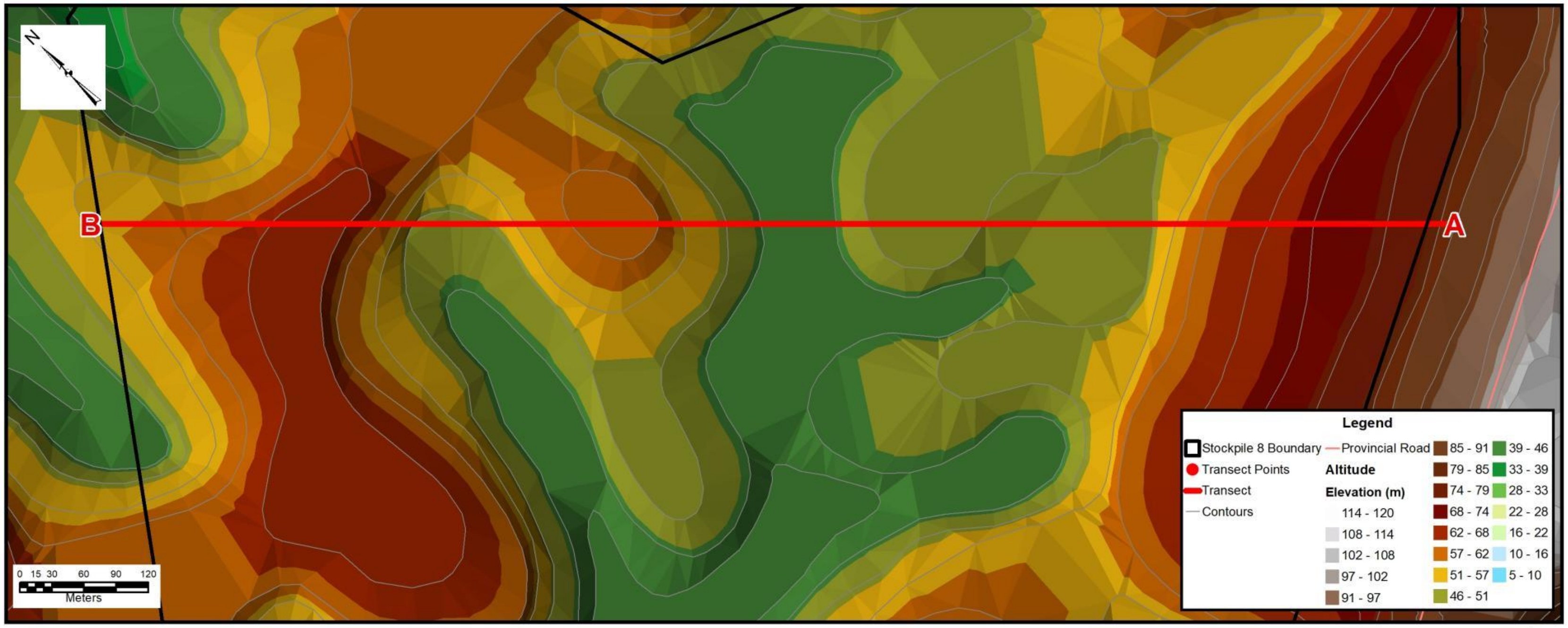


Figure B-A 2. Elevation vs. Oblique Image (Stockpile 8)



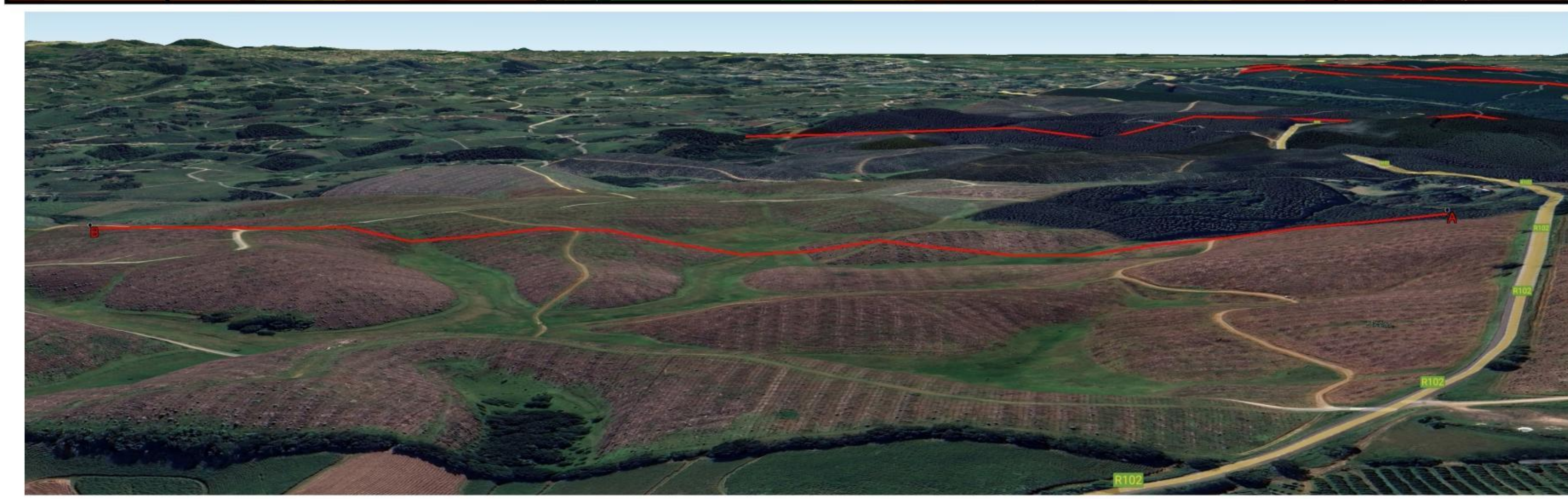
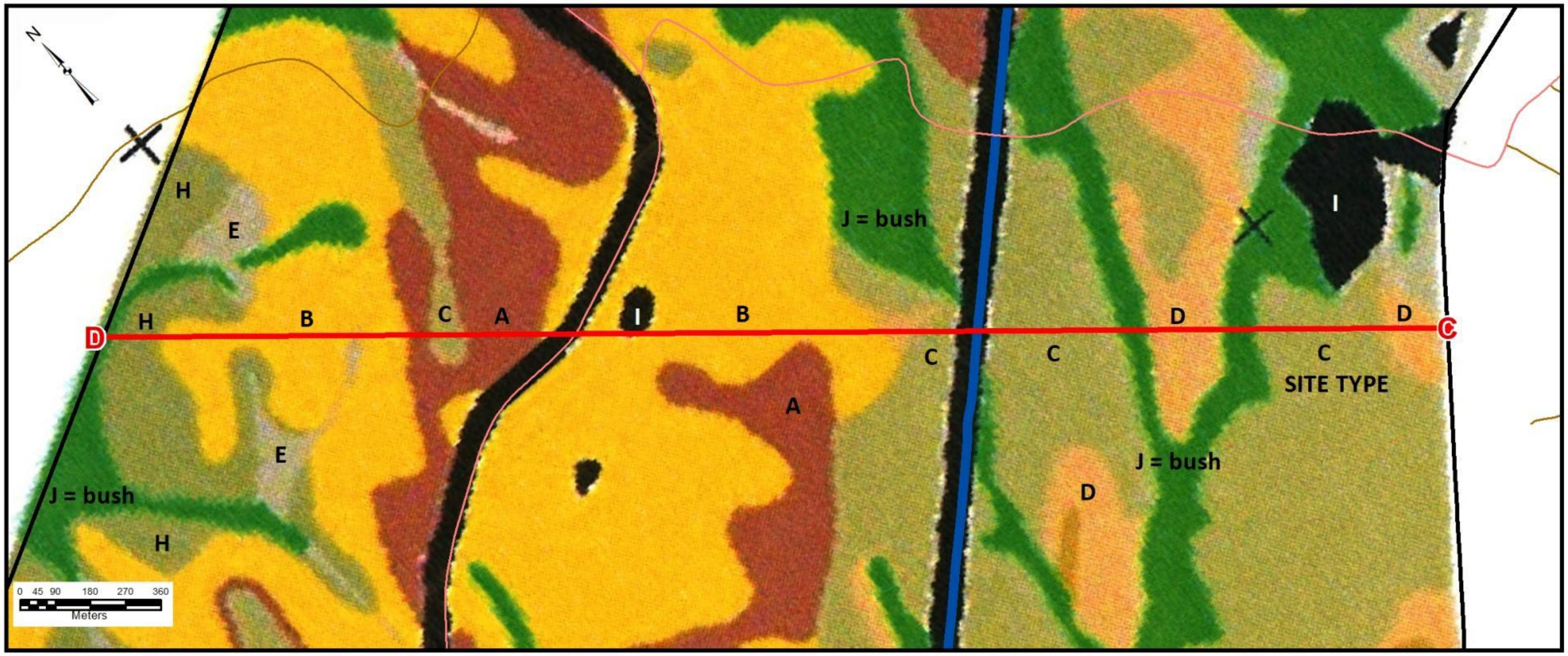


Figure D-C 1. Site Types vs. Elevation Profile Graph (Port Durnford Plantation)



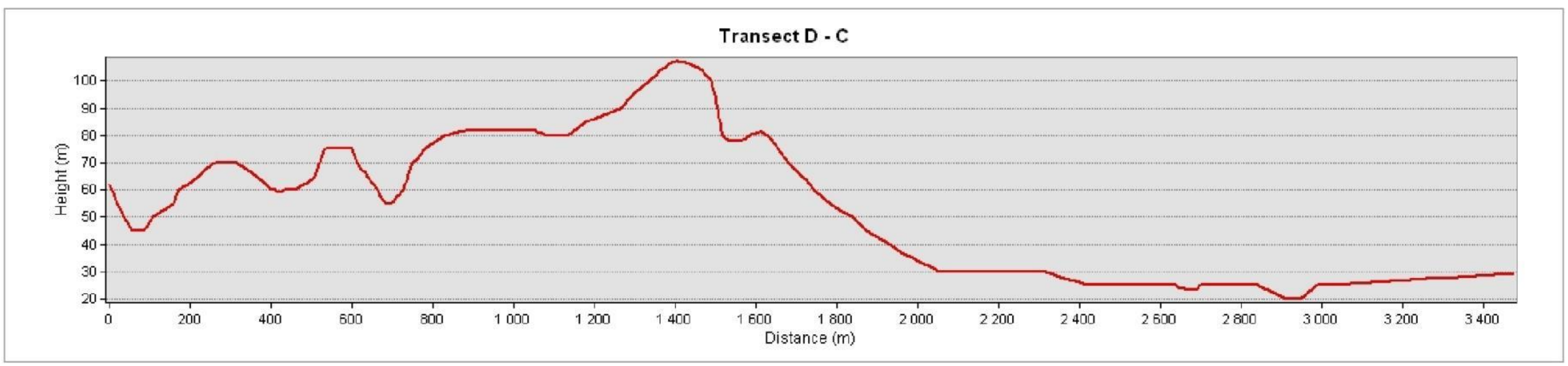


Figure D-C 2. Elevation vs. Oblique Image (Port Durnford Plantation)

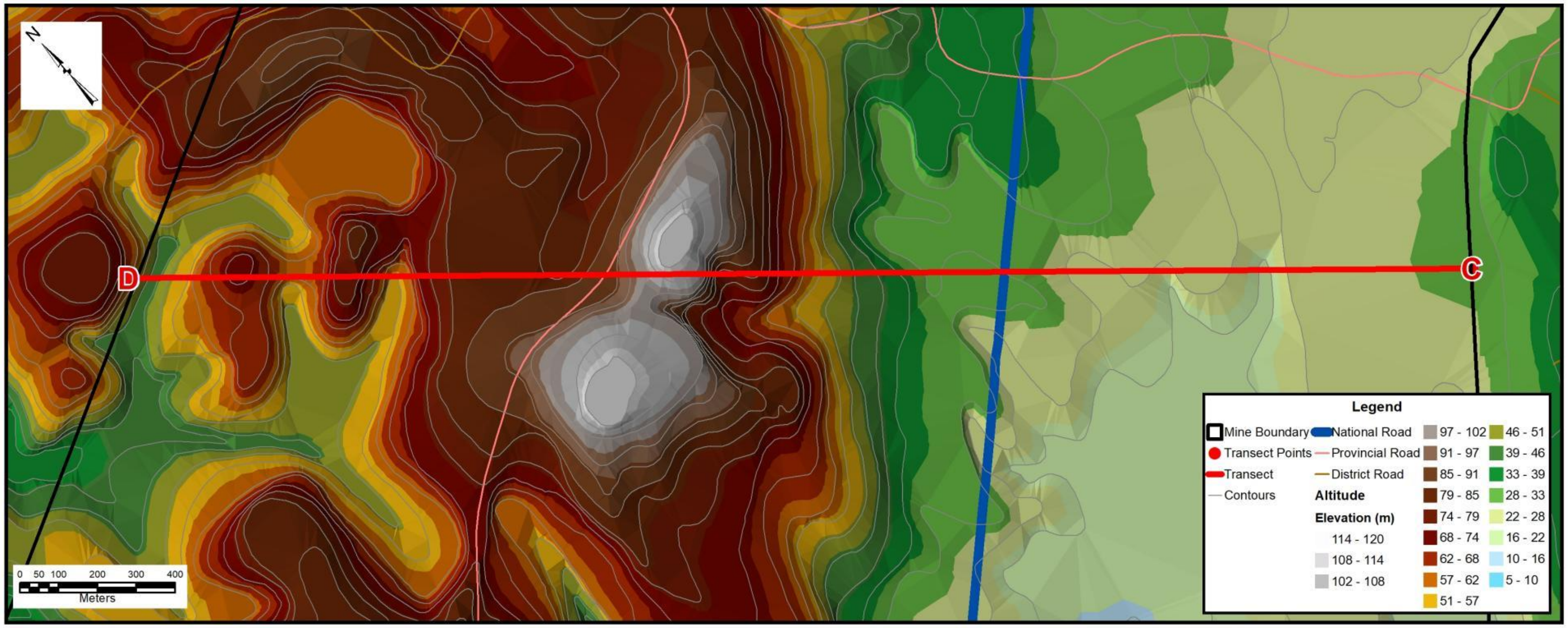
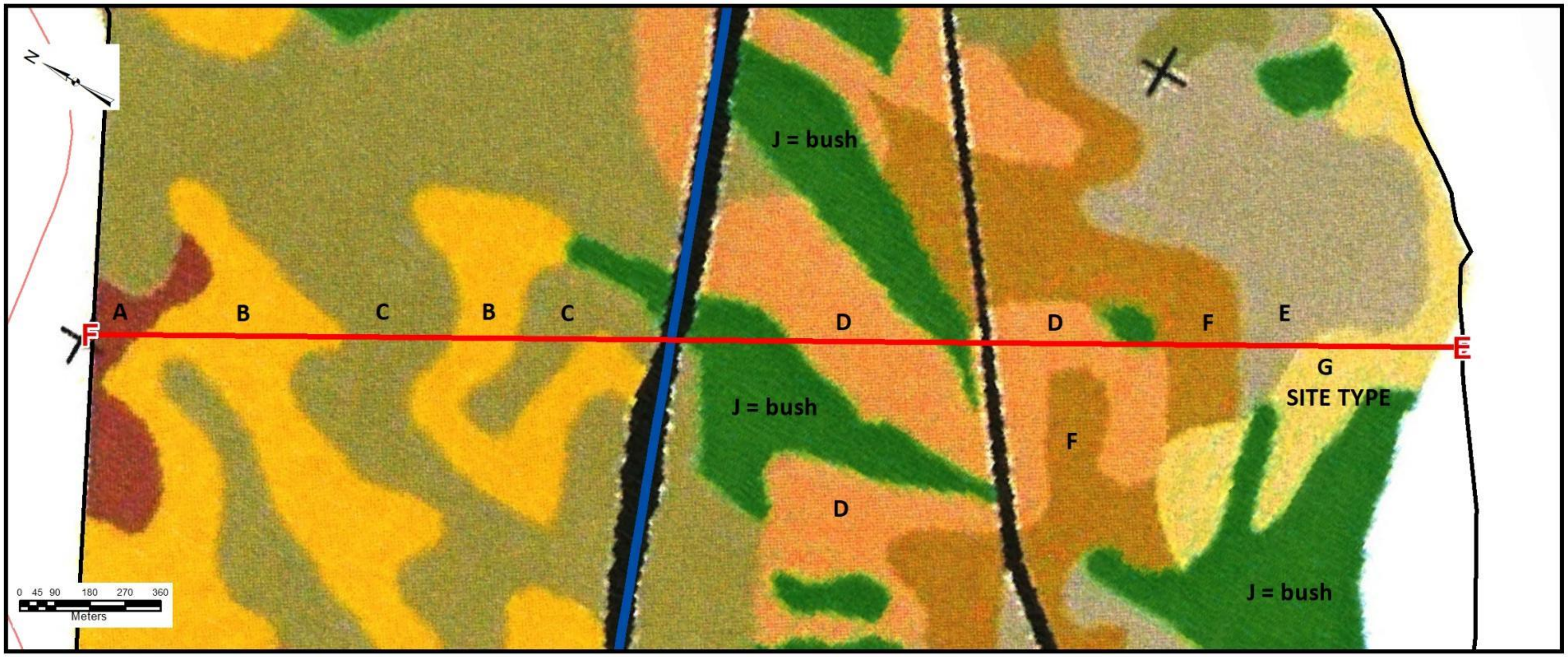


Figure F-E 1. Site Types vs. Elevation Profile Graph (Port Durnford Plantation)



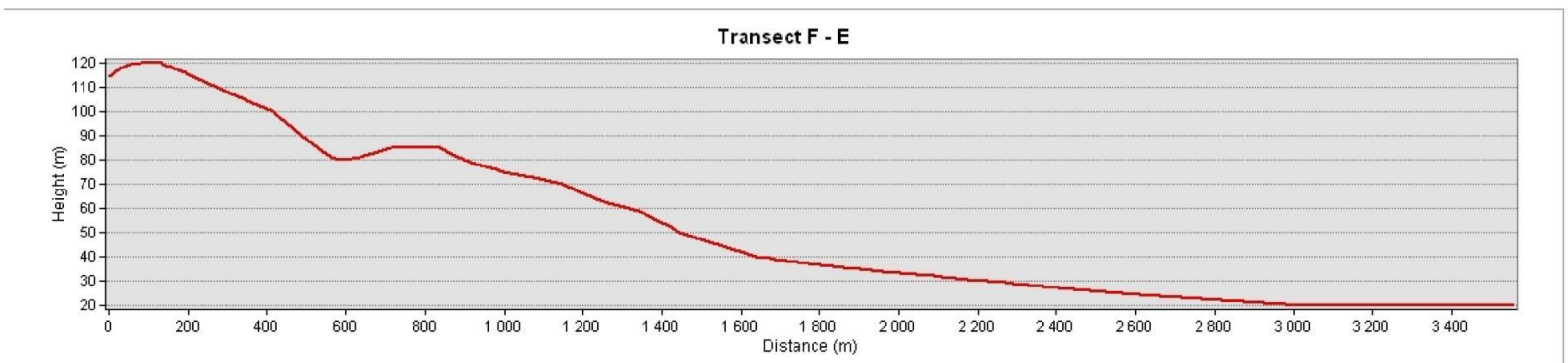
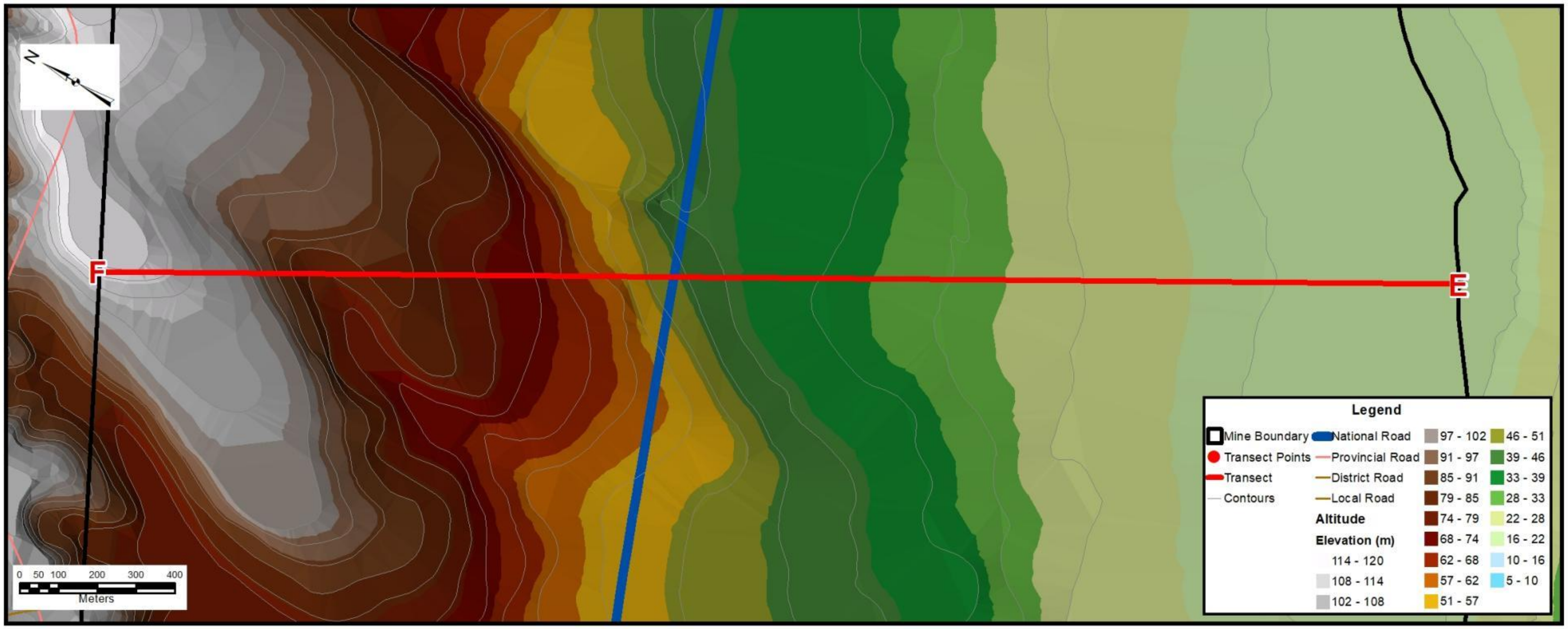


Figure F-E 2. Elevation vs. Oblique Image (Port Durnford Plantation)



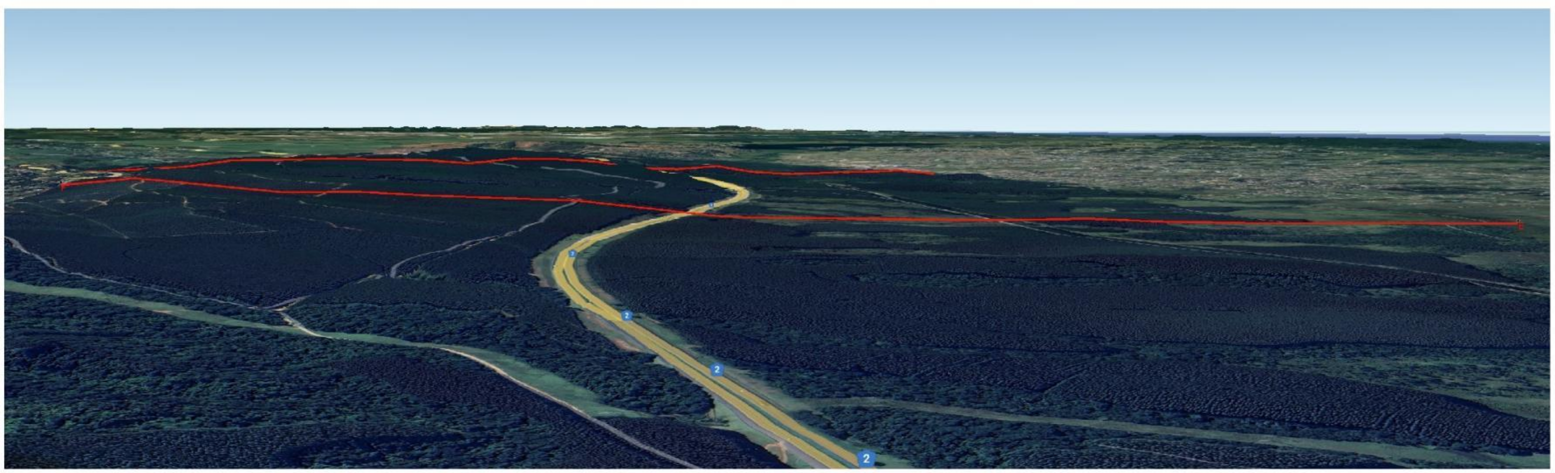
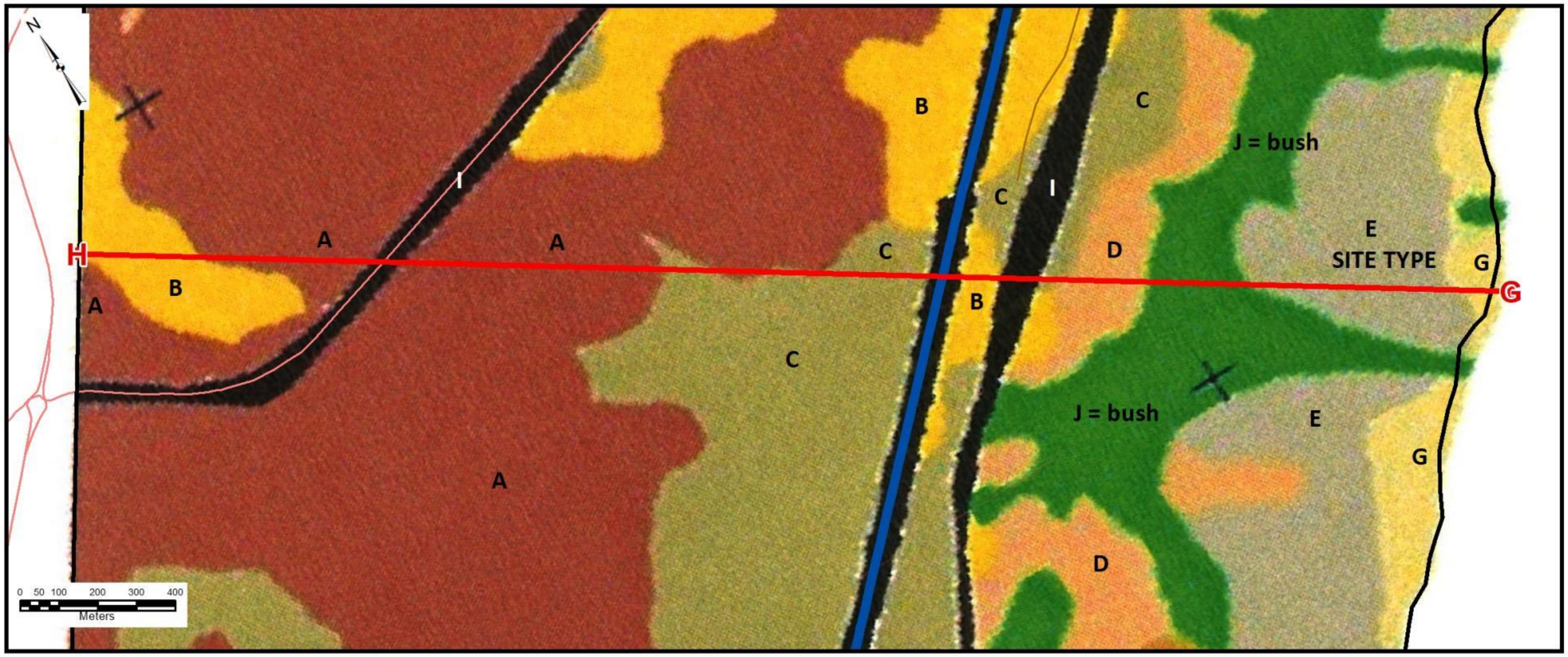


Figure H-G 1. Site Types vs. Elevation Profile Graph (Port Durnford Plantation)



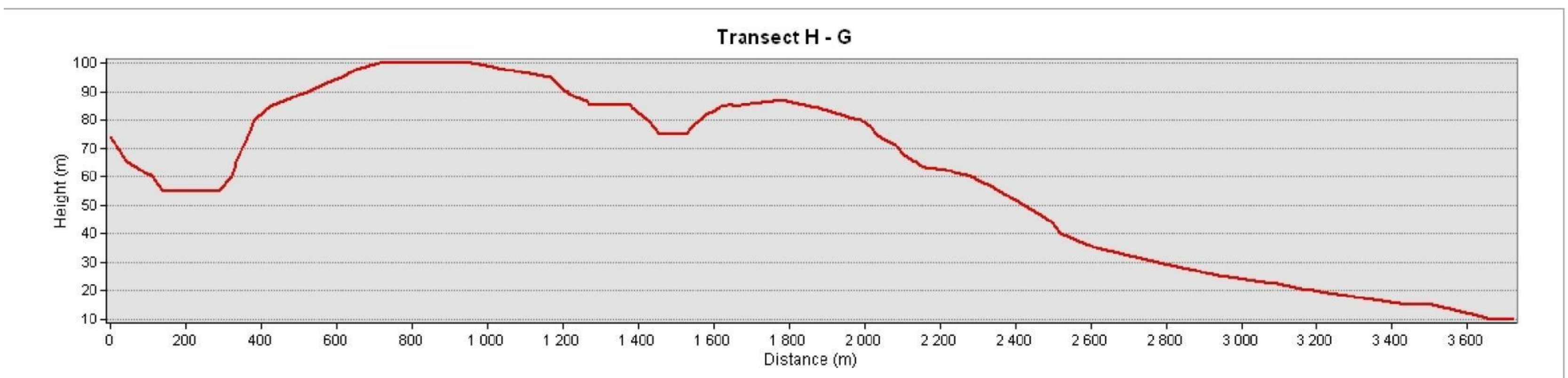
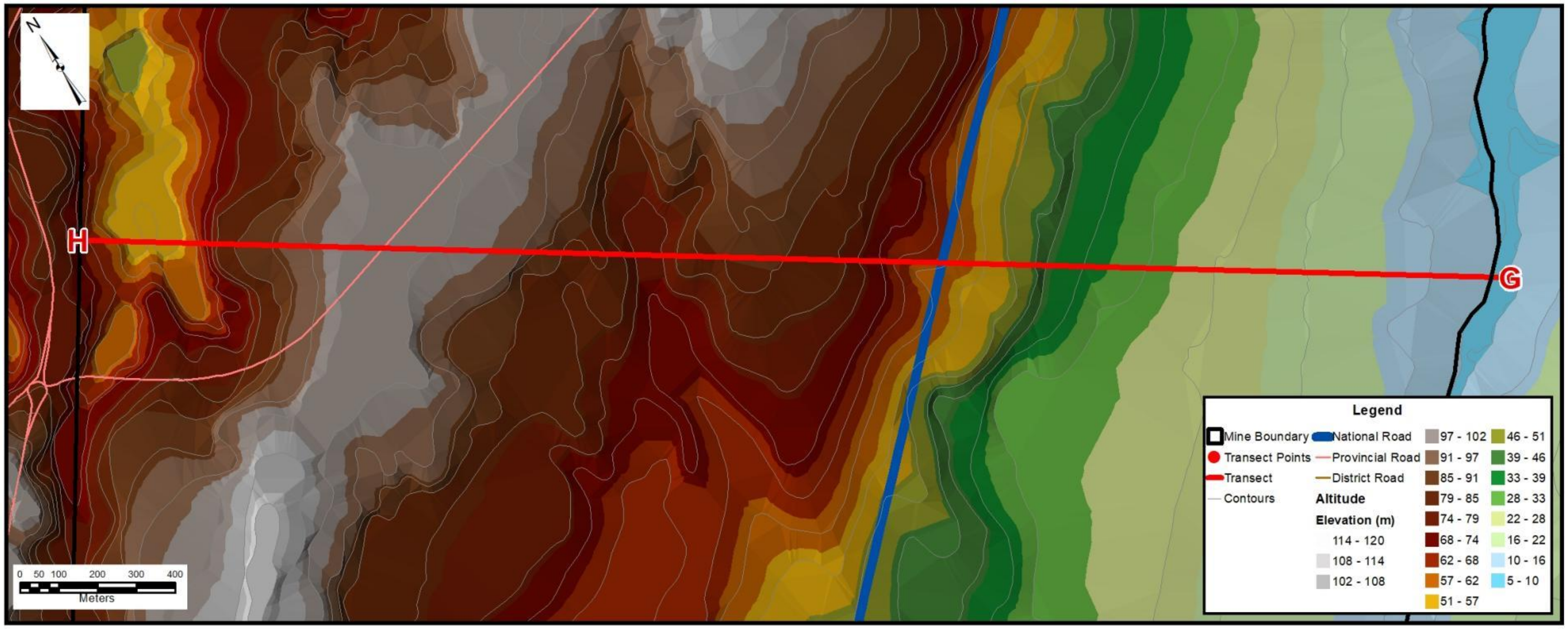
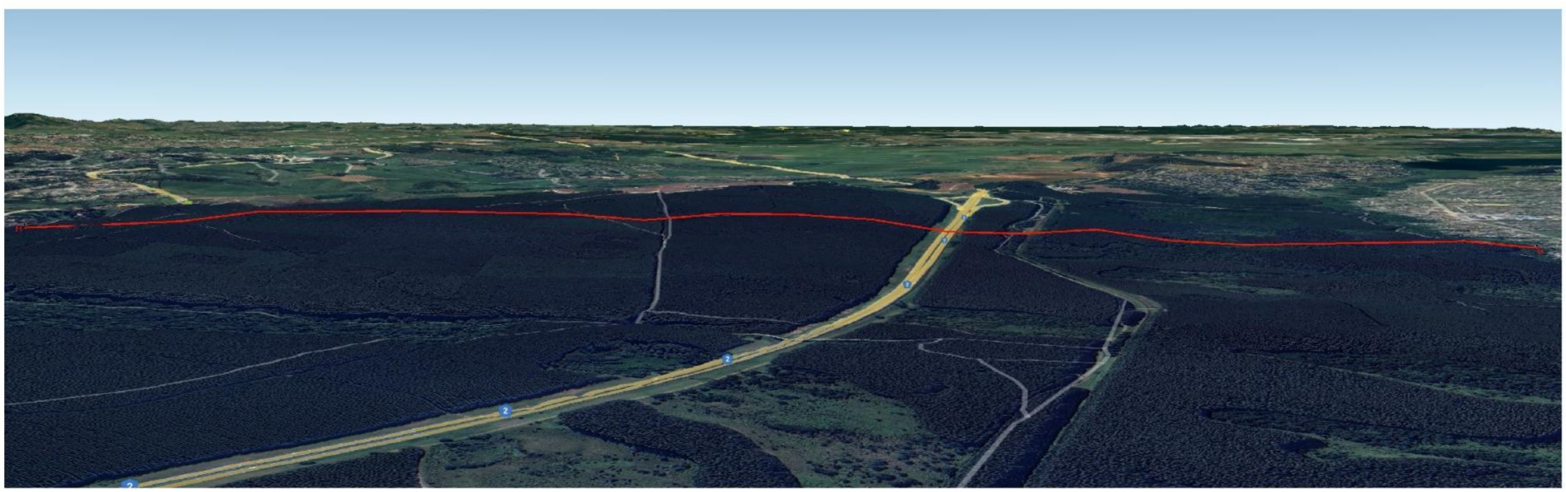


Figure H-G 2. Elevation vs. Oblique Image (Port Durnford Plantation)





12.2.5 HYDROPEDOLOGICAL / HYDROLOGICAL RESPONSE OF STUDY AREA

12.2.5.1 BACKGROUND

Interactions between landscape position, slope grade, parent material type / hardness / incidence of underlying rock fractures, moisture additions / subtractions (related to climate, slope, aspect, and evapotranspiration), and time; all interact together; leading to differential soil formation processes and thus ultimately soils (i.e. soil form, order of horizons / colour / texture / permeability / depth / physical & chemical properties).

These diverse interactions combine, ultimately also determining soil Hydropedology and Hydrology.

Three representative Transects (D-C, F-E, and H-G) were chosen within the Port Durnford Plantation, and one (B-A) within Stockpile 8; thereby indicating at the area as a whole.

The Port Durnford Mining Development area will be discussed based upon these four representative Transects, as presented in Section 12.2.4 (REPRESENTATIVE TRANSECTS). Furthermore also bearing in mind Figure VT5 (Conceptual Hillslope Hydropedological Behaviour).

Relevant Figures relating to the four Transects include the following:

Figure B-A 1a. Site Types vs. Elevation Profile Graph (Stockpile 8).
Figure B-A 1b. Soil Forms vs. Elevation Profile Graph (Stockpile 8).
Figure B-A 2. Elevation vs. Oblique Image (Stockpile 8).

Figure D-C 1. Site Types vs. Elevation Profile Graph (Port Durnford Plantation).
Figure D-C 2. Elevation vs. Oblique Image (Port Durnford Plantation).

Figure F-E 1. Site Types vs. Elevation Profile Graph (Port Durnford Plantation).
Figure F-E 2. Elevation vs. Oblique Image (Port Durnford Plantation).

Figure H-G 1. Site Types vs. Elevation Profile Graph (Port Durnford Plantation).
Figure H-G 2. Elevation vs. Oblique Image (Port Durnford Plantation).

Figure 3a. Elevation and Transects.
Figure 3b. Slope Classes and Transects.

Two modal (typical) Soil Catena s were derived after collectively considering all of the above Figures.

A soil catena is defined as follows:
"A sequence of soils of similar age, derived from similar parent material, and occurring under similar macro-climatic conditions, but having different characteristics due to variation in relief and drainage" (Soil Classification Working Group, 1991).

This statement is applicable to the two different Soil Catena s described in the following Sections.

The Hydropedological / Hydrological Response of the combined study area will be achieved by describing the two selected modal Hillslope Soil Catena s, utilising the following processes:

- firstly based upon the Landscape Position occurring; and
- secondly based upon the Soil Forms / Soil Properties occurring (also bearing in mind the point indicated above).

In the course of the various discussions; ‘Sandy’ includes textures of sand, loamy-sand, and sandy-loam; while ‘Clayey’ includes textures of sandy-clay-loam to sandy-clay.

12.2.5.2 TYPICAL HILLSLOPE SOIL CATENAS - PARENT MATERIAL

12.2.5.2.1 SOIL CATENA 1. WEATHERED FROM ROCK - BEDROCK ENCOUNTERED

Bedrock was encountered within the soil augur depth of 1.8m, usually at shallow to intermediate depth.

Such soils have mostly weathered from the underlying parent material (i.e. lithology = rock type), and are all located immediately to the north-west (i.e. further from the current coastline) of the "Berea-type" paleo dune complex.

However, many instances exist within this Catena type in the Stockpile 8 area, where intermediate (depth) "Berea-type" deposits blanket the underlying weathering rock (in the case of sandstone parent material only). Such areas lie on the periphery of the "Berea-type" deposits, the mining of such areas being deemed as unprofitable.

The soils occurring in Catena 1 areas are derived from the following parent material types,
(also indicating resultant soil textures and colours):

- **Sandstone (**and very rarely **Shale) (probably Natal Group)**, 'clayey'.
  Usually 'sandy' topsoils over 'clayey' subsoils.
  Sandy-clay-loam subsoil textures - yellowish colours in B1-horizon, often becoming reddish at depth in B2-horizon.

- furthermore, **"Berea-type" deposits ('sandy' to 'clayey' phases) often blankets (overlies) areas where weathering Sandstone (alone)** is encountered at depth.
  Loamy-sand to sandy-clay-loam textures - reddish, yellowish or brownish colours.

- **Quartzite and Sandstone intermixed (probably Natal Group)**, 'clayey'.
  Sandy-clay-loam textures - greyish to brownish colours.
  Soils are lithosols (shallow, and stony - quartz, sandstone, conglomerate, river rounded pebbles).

- **Gneiss (Intuzi Formation)**, 'clayey'.
  Sandy-clay (occasionally sandy-clay-loam) textures - dark-brown to brown colours).
  Soils are lithosols (shallow, and stony - quartz).

- intermixed **Colluvium and Alluvium**, 'clayey'.
  Both occur in low-lying wetland areas, initially derived from the local parent materials.
  Sandy-clay-loam (or clay-loam) to sandy-loam textures in A-horizons, sandy-loam to loamy-sand in E-horizons, and sandy-clay-loam to sandy-clay in B/G-horizons - mottled dark, greyish or pale colours).

12.2.5.2.2 SOIL CATENA 2. WEATHERED FROM VERY DEEP QUATERNARY DEPOSITS - BEDROCK NOT ENCOUNTERED)

Bedrock was not encountered within the soil augur depth of 1.8m, due to the great depth of the associated quaternary parent material (i.e. lithology) deposits.

Section 1.6 (LITHOLOGY) of the current document indicates the following regarding the depth of the 'ore body' (i.e. "Berea-type" paleo dune complex) associated with the Fairbreeze Mine (to the south-west):
"Generally the different ore bodies have depths close to 30m." Reference: KwaZulu-Natal (KZN) Sands Operation - https://miningdataonline.com.

This statement probably applies equally to the current Port Durnford paleo dune complex.

The soils occurring in Catena 2 areas are derived from the following Quaternary parent material types (also indicating resultant soil textures and colours):

- **"Berea-type", 'sandy' phase**.
  Sand to sandy-loam textures - reddish to yellowish colours.

- **"Berea-type", 'clayey' phas**e.
  Sandy-clay-loam (occasionally sandy-clay) textures - reddish (dominant) to brownish colours.
  Both above are part of the "Berea-type" paleo dune complex.

- **Recent sands** at Stockpile 8 [probably also "Berea-type"], 'sandy'.
  Sand to loamy-sand, occasionally sandy-loam textures - brownish to pinkish colours.

- **Quaternary Grey Brown sands**, 'sandy'.
  This parent material occurs in the low-lying areas to the east of Port Durnford Forest.

  Sand to loamy-sand textures in A-horizons, sand in E-horizons - colours are light brown to dark in the topsoil A-horizons, and light-yellowish-brown or white in the subsoil E-horizons - both for very deep soils.
  Sandy-clay-loam to sandy-loam in A-horizons, sand in E-horizons, sandy-clay-loam in G/B-horizons - colours are dark in the topsoil orthic A-horizons, greyish in the E-horizons, and mottled greyish in the G/B-horizons - both for intermediate to deep soils.

- **Alluvium** (deposited by streams, low-lying narrow strips within and adjacent to drainage channels - riparian areas and wetlands); and
- **Colluvium** (unconsolidated deposits of soil accumulated at the base of slopes in footslopes and bottom-lands as a result of gravitational action; often adjacent to alluvium - wetlands and riparian areas).
  Alluvium and Colluvium are associated with each other in low-lying slope positions.
  Recent Alluvium and Colluvium display 'sandy' textures throughout, while Weathered Alluvium and Colluvium generally display 'clayey' textures throughout.
  Colours are dark to greyish in the topsoil orthic A-horizons, greyish to pale in the subsoil E-horizons when present, and mottled greyish in the subsoil B/G-horizons.

12.2.5.3 TYPICAL HILLSLOPE SOIL CATENAS - LANDSCAPE POSITION, SOIL FORMS AND HYDROLOGICAL / HYDROLOGICAL RESPONSE

12.2.5.3.1 GENERAL

The Hydropedological Response of the various Soil Forms and Site Types occurring, have already been described in Section 12.2.2 (REGROUPING OF OCCURRING SOILS AND SITES INTO HYDROPEDOLOGIAL SOIL GROUPS).

Refer to the following relevant Tables from Section 12.2.2:
Table 12a. Regrouping of Soil Forms (and Site Types) into Hydropedological Soil Groups (Stockpile 8).
Table 12b. Regrouping of Site Types (and Soil Types / Soil Forms) into Hydropedological Soil Groups (Stockpile 8).
Table 12c. Regrouping of Site Types / Soil Types / Soil Forms into Hydropedological Soil Groups (Port Durnford Plantation).

That which remains to be done in the current Section, is to determine and describe the Hydropedological / Hydrological Response of the soils along each typical Hillslope Catena.

Soil Forms:

Soil forms are indicated in sequential order from crest, to midslope (upper, middle and lower), to footslope (upper, middle and lower), to valley-bottom, and finally to water-course (when present). Soil horizons, *textures*, and underlying material is also indicated.
Soil structure is indicated in cases where it is weak blocky or massive (not necessarily indicated for apedal or single grain structure).

A greater number of Soil Forms are present in the two derived catena s than on any one individual hillslope in the four selected Transects. This is in order to cater for the Transects as a whole, which all display a number of crests and valleys (i.e. rolling landscapes) along their length.

Permeability:

Permeability (i.e. moisture infiltration rate) of the various soil textures and horizons needs to be born in mind for the different slope positions, this having an impact on the Hydrology and Hydropedology of the two different Soil Catena s.

To this end, the Permeability has been estimated as follows:

- **Rapid: > 3600 mm/hr.** Sand (*S*a) soil texture [single grain soil structure].
  Midslope (lower), and long-gentle Footslopes (upper to middle) adjacent coastal flats: subsoil horizon (E-horizon ‘yellow’ when moist, ‘light topsoil’ Fernwood soil form).
  Site Type C.

- **Rapid: >3600 mm/hr.** Loamy-sand (*LmSa*) to sandy-loam (*SaLm*) soil textures [single grain to apedal soil structure].

Crest to Midslope (upper to middle) subsoil horizons (red apedal B- and yellow-brown apedal B-horizons) [all areas], and
Midslope (lower) subsoil horizons (neocutanic B-horizon) [Stockpile 8 only].
Both are Site Type A.

Footslope (upper to middle, long and very gently sloping, upslope of coastal flats) orthic topsoil ('dark' topsoil Fernwood soil form). Permeability of subsoil E-horizon is very rapid. Water-table present at about 2m due to proximity to low-lying coastal flats. Site Type D.

- **Moderate-Rapid: 360-3600 mm/hr.** Sandy-clay-loam (*SaClLm*) soil texture [apedal soil structure].
  Midslope (upper to middle, occasionally lower) subsoil horizons (red apedal B-horizon in both survey areas; and neocutanic B-horizon at Port Durnford Forest only). Site Type B.
  This texture also frequently occurs at depth as a B2 horizon in the previous Site Type A permeability category.

- **Moderate: >36 mm/hr.** Sandy-clay (*SaCl*) soil texture [weak blocky soil structure].
  Crest to Midslope (upper) subsoil B1 or B2 horizons (red apedal, & yellow-brown apedal) at Stockpile 8; and
  Midslope (upper to lowest) subsoil B2 horizon frequently occurs (red apedal) at Port Durnford Plantation.
  Frequently at depth in Site Type B areas, rarely at depth in Site Type A areas.

  Footslope to valley-bottom subsoil horizon (soft-plinthic B-horizon, where soil structure is weak blocky or apedal only).
  Present at depth in some areas of Site Types E, F, G and J.
  The overlying orthic A- and E-horizons of these Site Types are more permeable.

- **Slow-Moderate: 3.6-36.0 mm/hr.** Sandy-clay (*SaCl*) to clay (*Cl*) soil texture.
  Footslope to valley-bottom subsoil horizon (soft-plinthic B-horizon, when soil structure is almost massive).
  Present at depth in some areas of Site Types E, F, G and J.
  The overlying orthic A- and E-horizons of these Site Types are more permeable.

- **Slow: 0.36-3.6 mm/hr.** Clay (*Cl*) soil texture [massive structure only].
  Only present in footslope to valley-bottom positions (for the subsoil G-horizon only).
  Present at depth in some areas of Site Types E, F, G and J.

12.2.5.3.2 SOIL CATENA 1. WEATHERED FROM ROCK - BEDROCK ENCOUNTERED

Soil Catena 1 soils are **rare** in the Port Durnford Mining Development study area as a whole, and also mostly lie outside of the mine-able “ore body”. This Catena occurs only sporadically in the vicinity of the northern corner of the most western boundary of **Port Durnford Plantation (1.6%)**, as well as sporadically (**approximately 50%**) within (mostly) the western two-thirds of the **Stockpile 8** area, these two sections being located in the same vicinity.

However, many instances exist within this Catena type in the Stockpile 8 area, where intermediate (depth) “Berea-type” deposits blanket the underlying weathering rock (in the case of sandstone parent material only). Such areas lie on the periphery of the “Berea-type” deposits, the mining of such areas being deemed as unprofitable.

CREST, to MIDSLOPE (UPPER):

Soil Forms:

Hutton (‘clayey’ phase).
Horizons: orthic A *(SaLm - SaClLm)* / over red apedal B1 *(SaCl)* / red apedal B2 (*SaCl* -weak blocky structure) / highly - moderately weathered Sandstone Saprolite *(SaCl*).

Griffin (‘clayey’).
Horizons: orthic A *(SaClLm)* / over yellow-brown apedal *(SaCl)* / red apedal B (*SaCl - Cl* - weak blocky structure) / highly - moderately weathered Sandstone Saprolite *(SaCl)*, Rock, or quartz Stoneline.
Parent material: weathering sandstone occurs at depth for both soil forms. However, ‘Berea-type’ (‘clayey phase’) derived soils frequently blanket (overlies) the underlying sandstone.

Hydropedological Response:

- Recharge (deep): Majority of Response: slopes < 6 degrees (approximately).

- Interflow subordinate component may exist in certain areas: slopes > 6 degrees (approximately), above sandy-clay to clay textured B2-horizons (where present), and particularly those displaying at least weak-blocky structure.
  For further information, Refer to current Soil Catena 1:
  ‘Point 1’ for CREST, TO MIDSLOPE (UPPER) below; and
  ‘Point 2’ for MIDSLOPE (LOWER) to FOOTSLOPE (UPPER) - relevant photographs.

  ***‘Point 1’*. A proportion (far less than the downward water flow associated with Recharge deep) of lateral moisture flow occurs during heavy or prolonged rainfall events, on slopes of approximately > 6 degrees within the soil solum itself, in cases where there is a decreasing permeability between the overlying conductive horizon versus an underlying less permeable horizon. This commonly occurs in the area, where ‘sandy’ soil horizons overly (blanket) ‘clayey’ (sandy-clay to clay textured) B2 soil horizons (where present), and particularly those displaying at least weak-blocky structure.**

Hydrological Response:

Rainfall will recharge the perched water-table deeply in the weathered zone (sandstone -saprolite and soft rock), until such a depth is reached that the sandstone rock becomes non-weathered and hard. On crest and upper midslope positions at Stockpile 8 the soils are deep (mostly 100 - >180cm), the non-weathered sandstone usually occurring far deeper than a manual soil auger (1.8m utilised) is able to penetrate. This high degree of sandstone weathering is due to both climatic (high rainfalls and temperatures) and slope (<6 degrees) factors, whereby infiltrating water has mostly not run off (either on surface or laterally within the soil solum), thereby contributed to the weathering of the underlying rock over time. A fair proportion of the infiltrating water will ultimately find its way down to the deeper groundwater (saturated zone) via rock fractures.

A proportion of the infiltrating water will gradually move downslope on top of the impermeable sandstone rock layer (when encountered at depth), to ultimately reappear within the soil solum in lower slope Interflow (soil/bedrock) / Interflow (A/B) / Responsive (saturated) Hydropedological Soil Group positions (to be discussed later).

MIDSLOPE (MIDDLE):

Soil Form:

Clovelly (‘clayey’).
Horizons: orthic A (*SaClLm - SaLm*) / over yellow-brown apedal B (*SaCl - SaClLm*) / moderately weathered Sandstone Saprolite, Rock or quartz Stoneline.
Parent material: sandstone or sandstone/quartzite (intermixed) occurs at depth. However, ‘Berea-type’ (‘clayey phase’) derived soils occasionally blanket (overlies) the underlying parent material.

Hydropedological Response:

- Recharge (deep): Majority of Response: slopes < 6 degrees (approximately).

- Interflow subordinate component may exist in certain areas: slopes > 6 degrees (approximately), above sandy-clay to clay textured B2-horizons (where present), and particularly those displaying at least weak-blocky structure.
  For further information, Refer to current Soil Catena 1:
  ‘Point 1’ for CREST, TO MIDSLOPE (UPPER); and
  ‘Point 2’ for MIDSLOPE (LOWER) to FOOTSLOPE (UPPER) - relevant photographs.

Hydrological Response:

Rainfall will recharge the perched water-table in the weathered zone (sandstone - saprolite and soft rock), until such a depth is reached that the sandstone rock becomes non-weathered and hard. On steeper midslopes the soil depth is intermediate (50 - 100cm), due to increased slope, the weathered sandstone being encountered within soil augur depth, while the thickness of the weathered rock zone is also significantly less. A lesser proportion (than on the crest and upper midslope) of water will find its way down to the deeper groundwater via rock fractures.

Thus, a larger proportion of infiltrating water will not infiltrate to greater depths, but will move more rapidly (slope/gravity related) downslope on top of the impermeable sandstone rock layer (when this is encountered), to ultimately reappear within the soil solum in lower slope Interflow (soil/bedrock) / Interflow (A/B) / Responsive (saturated) Hydropedological Soil Group positions (to be discussed later).

MIDSLOPE (LOWER):
Mostly Midslope (Lower), but also occasionally also occurs in Crest and Midslope (Middle) positions.

Soil Form:

Glenrosa ('clayey).
Horizons: orthic A (*SaCl - SaClLm*) / lithocutanic B (*SaCl - SaClLm*) (moderately weathered, stony - quartz, no signs of wetness).
Parent material: Gneiss (majority), Sandstone/Quartzite (intermixed), and Sandstone (alone).

Hydropedological Response:

- Recharge (shallow).

Hydrological Response:

Rainfall will recharge the perched water-table in the weathered zone (lithocutanic B-horizon and underlying saprolite - both essentially weathering rock), until such a depth is reached that the various parent materials become non-weathered and hard (i.e. rock).

On these mostly moderately sloping midslopes the soil depth is shallow (mostly 20 - 30cm) due to the increased slope, the weathered material being encountered thereafter. Overland flow (surface run-off) is a consideration, this evidenced by the stones that occur on the immediate soil surface, the associated soil matrix having been washed away. A far lesser proportion (than on the crest and upper midslope) of infiltrating water will find its way down to the deeper groundwater via rock fractures.

Thus, the largest proportion of infiltrating water will not infiltrate to greater depths, but will move more rapidly (slope/gravity related) downslope on top of the relatively impermeable underlying rock layers, to ultimately reappear within the soil solum in lower slope Interflow (soil/bedrock) / Interflow (A/B) / Responsive (saturated) Hydropedological Soil Group positions (to be discussed later).

MIDSLOPE (LOWER) to FOOTSLOPE (UPPER):

Landscape shape is usually becoming concave in these areas.

Soil Form:

Tukulu ('sandy').
Horizons: orthic A (*Sa - LmSa*) / over neocutanic B (*Sa - SaLm* - greyish, pale, or brown colours) / unspecified material with signs of wetness *(SaCl - Cl*) / mottled weathered Sandstone Saprolite.

Tukulu form also associated with Oakleaf ('sandy') form.
Horizons: orthic A (*Sa - LmSa*) / over neocutanic B (*Sa - SaLm*).

Bloemdal ('sandy').
Horizons: orthic A (*LmSa - Sa*) / over red apedal B (*LmSa - SaLm*) / unspecified material with signs of wetness *(SaClLm - Cl*) / mottled weathering sandstone saprolite (*SaCl*).

For both soil forms, a non-diagnostic E-horizon (*Sa*) occasionally lies between the B- and U-horizons, indicative of sub-surface lateral water flow.

Parent material: sandstone ('sandy').

Hydropedological Response:

- Interflow (soil/bedrock).

- Interflow subordinate component definitely exists in certain areas: slopes > 6 degrees (approximately), above sandy-clay to clay textured B2-horizons (where present), and particularly those displaying at least weak-blocky structure.
  For further information, Refer to current Soil Catena 1:
  ***** ***'Point 1'*** for CREST, TO MIDSLOPE (UPPER); and
  ***** ***'Point 2'*** for MIDSLOPE (LOWER) to FOOTSLOPE (UPPER) - relevant photographs.

Hydrological Response:

This moisture is derived from rainwater in the upslope Hydropedological Recharge (deep) and Recharge (shallow) Soil Groups, whereby infiltrated ground-water has reappeared in the soil solum in this lower-slope position. Also, some of this water will have migrated downslope on top of the relatively impermeable solid sandstone/quartzite/gneiss rock which occurs at greater (unknown) depth below the weathering rock (saprolite) material.

Furthermore, a far lesser proportion of water will also be derived from the subordinate Interflow component that exists upslope on slopes > 6 degrees (approximately), above sandy-clay to clay textured B2-horizons (where present), and particularly those displaying at least weak-blocky structure.

*** 'Point 2'. Refer to: Figure 4, in Section 12.2.3 (SOIL PROFILE PHOTOGRAPHS).**
Herein, the photographs of Auger G10 (Bloemdal soil form - slope approximately 12 degrees) and Augur A6 (Tukulu soil form - slope approximately 6 degrees) visually indicate how a 30 - 40cm thick sand textured non-diagnostic 'E'-horizon (caused by lateral moisture flow) has developed at depth (from 130cm and 90cm respectively), overlying a less permeable (than the overlying horizons - texture and structure related) subsoil horizon.

For the current Interflow (soil/bedrock) Hydropedological Soil Group, the vast majority of reappearing (from upslope ground-water) and infiltrating rainwater will not infiltrate to greater depths than the soil solum itself; but will flow off laterally (slope/gravity/texture related) downslope within the non-diagnostic 'E-horizon' (when present), and the mottled 'unspecified material with signs of wetness' horizons (both hydromorphic horizons). The underlying 'clayey' saprolite is also mottled, indicating hydromorphy within this zone as well. A relatively impermeable sandstone rock layer will underlay the weathering material at greater unknown depth.

This water will drain into the Interflow (soil/bedrock) / Interflow (A/B) / Responsive (saturated) Hydropedological Soil Groups that occur immediately downslope in the valley-bottom wetlands.

VALLEY-BOTTOM:

Slope position is Footslope (lower) for some of the the Longlands and Westleigh soil forms, in this undifferentiated hydromorphic soil mapping unit.
These are all wetland (seasonal and permanent) areas. Parent material is quaternary colluvium (highly weathered) and more recent alluvium (less weathered).

Soil Forms, Horizons, and Wetlands:

Longlands. Orthic A / E-horizon / soft plinthic B. Seasonal wetlands.
Kroonstad. Orthic A / E-horizon / G-horizon. Permanent wetlands.
Westleigh. Orthic A / soft plinthic B. Seasonal wetlands (*SaClLm texture*, and apedal to weak blocky structure; or Permanent-Seasonal wetlands *(SaCl - Cl texture*, and structure bordering on massive).
Katspruit. Orthic A / G-horizon. Permanent wetlands.
'Stream Channels'. Permanent wetlands.

The majority of these soils display 'clayey' (*SaClLm*) orthic A-horizon topsoils, 'sandy' (*SaLm - LmSa*) E-horizons (where present), 'clayey' (*SaClLm - SaCl*) soft plinthic B-horizons, and 'clayey' (*C*l) G-horizons.

Hydropedological Response:

- Interflow (A/B): Longlands or Kroonstad soil forms. The Kroonstad form in the current area displays a Responsive (saturated) component due to the shallow depth (<60cm) to the relatively impermeable underlying G-horizon (gley).
- Interflow (soil/bedrock): Westleigh soil form (*SaClLm subsoil texture,* apedal or weak blocky structure);

- Responsive (saturated): Westleigh soil form (*SaCl - Cl subsoil textures*, examples with structure bordering on massive);
- Responsive (saturated): Katspruit soil form (*usually Cl subsoil texture*, massive structure); and

- Responsive (saturated): 'Stream Channels'.

Hydrological Response:

The water in this area is derived from the following sources:
- from upslope Hydropedological Recharge (deep) and Recharge (shallow) Soil Groups [in crest, and midslope upper-middle-lower positions], whereby infiltrated ground-water in the weathered

or fractured rock zone has reappeared either in the soil solum itself, or in the valley-bottom stream channels; and
- from the immediately upslope Interflow (soil/bedrock) Soil Group [in midslope lower to footslope upper positions], whereby the subsurface lateral water flow migrated downslope within the soil solum itself (overlying the bedrock); as well as
- from rainfall falling into the valley-bottom.

Hydromorphic soil properties occur in these valley-bottom position, including the following:
- dark (in moist state, but grey in the dry state) topsoils, reflecting a raised organic carbon content as a result of seasonal to semi-permanent anaerobic conditions;
- soil mottling throughout, reflecting a fluctuating water-table;
- bleached grey to pale colours; and
- soils remain very moist during the dry season, becoming wet to waterlogged during the rainy season.

Interflow (A/B): Sub-surface lateral water flow occurs in the E-horizon of the Longlands and Kroonstad forms, this flowing into the stream channels.

Interflow (soil/bedrock): Sub-surface lateral flow will occur far more gradually overlying the underlying bedrock, through the soft plinthic B-horizon of the Westleigh form.

Responsive (saturated): Overland flow will be generated by those soils overlying a relatively impermeable clay-textured G-horizon (as well as for clay-textured soft plinthic B-horizons), where these horizons lie close to the soil surface This depth is typically at 20-30cm for the Katspruit and Westleigh (clay textured) forms, and 40-60cm (in current area) for the Kroonstad form.
These soils are close to saturation during most of the rainy season, thus additional precipitation quickly leads to saturation excess, the soil response being overland flow.

Given that the stream channels in Soil Catena 1 areas are intermittent upper sections (only), they are generally not in contact with the ground water-table.

12.2.5.3.3 SOIL CATENA 2. WEATHERED FROM VERY DEEP QUATERNARY DEPOSITS - BEDROCK NOT ENCOUNTERED

Soil Catena 2 soils are highly dominant (98.4 %) in the Port Durnford Plantation area, and also occupy approximately 50 % of the Stockpile 8 area; thus indicating at the vast majority of the Port Durnford Mining Development study area as a whole.

CREST and MIDSLOPE (UPPER to MIDDLE):
Crest in Transects D-C & F-E; and Crest to Midslope (Upper to Middle) in Transects H-G & B-A.

The crests are not very broad, and are mostly comprised of the dune ridges and associated side slopes.

Site Type: A. Deep red and yellow sandy mesotrophic.

Parent material: "Berea-type" 'sandy' phase - paleo dune complex.
Note: "Berea-type" 'clayey' phase occasionally underlies the 'sandy' phase within soil augur depth, the 'sandy' phase blanketing the 'clayey' phase.
Effective Rooting Depth: >150cm.

Soil Forms / Families:

Hutton 2100 ('sandy' phase).
Horizons: orthic A *(Sa)* / over red apedal B *(LmSa)* / occasionally over red apedal B2 *(SaClLm)* [to great depth].

Clovelly 1200 ('sandy' phase).
Horizons: orthic A *(Sa)* / yellow-brown apedal *(LmSa)* [to great depth].

Hydropedological Response:

- Recharge (deep).

- Interflow subordinate component may exist in certain areas: slopes > 6 degrees (approximately), above sandy-clay to clay textured B2-horizons (where present), and particularly those displaying at least weak-blocky structure.
  For further information, Refer to previous Soil Catena 1:
  'Point 1' for CREST, TO MIDSLOPE (UPPER); and
  'Point 2' for MIDSLOPE (LOWER) to FOOTSLOPE (UPPER) - relevant photographs.

Hydrological Response:

The 'ore body' (i.e. "Berea-type" paleo dune complex) associated with the Fairbreeze Mine (to the south-west) has a depth of close to 30m (https://miningdataonline.com.). This probably applies equally to the current Port Durnford paleo dune complex.

Rainwater will infiltrate deeply (to unknown depth) through the highly weathered zone of the dune complex, until such depth that the perched water-table overlying the massive strong blocky 'soil' structure layer is reached (refer to ***'Note 3'*** below).

'Note 3'.

At an unknown far greater depth within the dune, the 'soil' structure of the deposits become massive large blocky, and continue as such to even greater depth. This layer commonly displays sandy-clay to sandy-clay-loam textures (kaolinite clay mineral is dominant), severe hard-setting (when dry), reddish to pinkish colours, and probable slow permeability. Thus this layer may be regarded as an aquitard (soils and rocks having porosity, but limited permeability), resulting in reduced recharge to the deeper underling regional groundwater. A perched water-table will develop above this layer, this water mostly flowing laterally downslope above the impeding layer. This water is likely to ultimately reappear within the soil solum in lower slope Interflow (A/B) and Responsive (saturated) Hydropedological Soil Group positions (to be discussed later).

As per Section 11.3 (SOIL STRIPPING AND TOPSOILING), such massive strong blocky material must not be utilised for rehabilitation 'topsoiling' purposes.

MIDSLOPE (UPPER to MIDDLE, and occasionally LOWER):
Midslope (Upper to Middle) in Transects D-C and F-E; and Midslope (Middle to Lower) in Transect H-G. Does not occur in Transect B-A.
Hutton form dominant in Upper to Middle positions, and Oakleaf form dominant in Middle to Lower positions.

Site Type: B. Deep red clayey mesotrophic.

Parent material: "Berea-type" 'clayey' phase - paleo dune complex.
Effective Rooting Depth: >150cm.

Soil Forms / Families:

Hutton 2200 ('clayey' phase).
Horizons: orthic A *(LmSa)* / over red apedal B1 *(SaClLm)* / frequently over red apedal B2 *(SaClLm - Cl)* [to great depth].

Oakleaf ('clayey' phase).
Horizons: orthic A *(LmSa)* / neocutanic B *(SaClLm*, non-red) [to great depth].

Hydropedological Response:

- Recharge (deep).

- Interflow subordinate component may exist in certain areas: slopes > 6 degrees (approximately), above sandy-clay to clay textured B2-horizons (where present), and particularly those displaying at least weak-blocky structure.
  For further information, Refer to previous Soil Catena 1:
  'Point 1' for CREST, TO MIDSLOPE (UPPER); and
  'Point 2' for MIDSLOPE (LOWER) to FOOTSLOPE (UPPER) - relevant photographs.

Hydrological Response:

Rainwater will infiltrate deeply (to unknown depth) through the highly weathered zone of the dune complex, until such depth that the perched water-table overlying the massive strong blocky 'soil' structure layer is reached (refer to **** 'Note 3'*** for the CREST landscape position). Thereafter the perched water-table will flow off laterally downslope on top of the impeding layer. This water is likely to ultimately reappear within the soil solum in lower slope Interflow (A/B) and Responsive (saturated) Hydropedological Soil Group positions (to be discussed later).

MIDSLOPE (MIDDLE to LOWER), or FOOTSLOPE STREAM TERRACE (UPPER to LOWER - long and very-gentle gradient):
Midslope (Middle to Lower) in Transects D-C and F-E; and Footslope Stream Terrace (Upper to Lower - long and very gentle) in Transect H-G.

Site Type: C. Pale topsoil sands.

Parent material: Quaternary sediments reported. These are likely "Berea-type" within the relevant sections of Transects D-C and F-E, these sections occurring on midslopes of the paleo dune complex.
Effective Rooting Depth: >150cm.

Soil Form / Family:

Fernwood 1210 ('sandy').
Horizons: orthic A (light coloured) *(Sa)* / over E-horizon (yellow when moist) *(Sa).*

Hydropedological Response:

- Interflow (soil/bedrock, or A/B). For all Transects.
  It is unknown whether the relatively impermeable limiting layer somewhere below 1.5m depth is massive strong blocky structure [most likely - refer to **** 'Point 3'***] (then Interflow); bedrock [possible] (then Interflow soil/bedrock); or gley [very unlikely] (then Interflow A/B).

- a sub-dominant Recharge (deep) component may also be present (for Transects D-C and F-E only).

Hydrological Response:

Rainfall will infiltrate rapidly, to a greater depth than 1.5m (soil augur depth). At this unknown greater depth, a perched water-table will be encountered, overlying relatively impermeable bedrock or subsoil horizon. Water in the perched water-table will have flowed downslope on top of the massive strong blocky 'soil' layer that is encountered at great depth in the extensive Recharge (deep) Soil Group units that occur upslope on the paleo dune complex.

FOOTSLOPE (UPPER to LOWER - long and very-gentle gradient):
Transects D-C (Lower Stream Terrace), F-E (Upper to Lower), and H-G (Upper to Middle).

Site Type: D. Dark topsoil sands.

Parent material: Quaternary sediments.
Effective Rooting Depth: >150cm (less before the planting of *Eucalyptus* trees).

Soil Form / Family:

Fernwood 2110 ('sandy'). A perched water-table was reported at approximately 2m (Snyman, 2008). Horizons: orthic A (dark coloured) *(LmSa)* / over E-horizon (grey when moist, white when dry) *(Sa) / over Unknown (non-diagnostic soil horizon).*

Hydropedological Response:

- Interflow (soil/bedrock, or A/B).
  It is unknown whether the relatively impermeable limiting layer somewhere below 1.5m (soil augur length) depth is bedrock or ferricrete (hard plinthic B) (then Interflow soil/bedrock), or alternatively gley (then Interflow A/B).

Hydrological Response:

Rainfall will infiltrate rapidly, to a greater depth than 1.5m (soil augur depth). A perched water-table was reported at about 2m (Snyman, 2008), overlying the unknown relatively impermeable limiting layer.

Water in the perched water-table will mostly have flowed downslope on top of the massive strong blocky 'soil' layer (refer to *** 'Note 3'**) that is encountered at great depth in the extensive Recharge (deep) Soil Group units that occur upslope on the paleo dune complex, as well as within the soil solum from the Interflow unit which lies immediately upslope.

Apart from the Site Type C soils immediately upslope, where the sub-surface lateral water flow occurs at a greater (unknown) depth below 1.5m; the current Site Type D soils are the first case within the Soil Catena, of where the perched sub-surface lateral water flow has reappeared in the soil solum within augured depth.

Furthermore, the current Soil Catena matches that associated with a **Class 4 hillslope**, as described in Section 12.1.5 (HYDROPEDOLOGY OF HILLSLOPES). The information in that Section was extracted from a publication (van Tol, JJ, 2020). In this publication, such a hillslope class is described as follows:
"In Class 4 hillslopes, recharge is dominant on the upper slopes, but feeds wetlands and streams downslope via a fractured rock flow path. The wetlands in the valley bottom of these hillslopes are typically associated with very long periods of saturation due to the constant supply of water from the recharge zone." (which are located upslope in the crest and midslope positions).
Thus for the current Site Type D soils, a proportion (probably the minority) of the water encountered (at approximately 2m) is likely to be return flow to the soil solum, derived from the groundwater (saturated zone).
This corresponds with the prevailing landscape position (footslope upper to lower), very-gentle to gentle slopes (3-6 degrees), and altitude (approximately mostly 45 - 20m. rarely 45 - 50m amsl).

The dark topsoils (organic carbon build up), white E-horizons, perched water-table and slope position are all indicators that these areas were in the natural state (before the planting of timber) saturated with laterally flowing water almost to the soil surface during the rainy season, and deeper in the soil profile during the dry season. These areas are footslope seeps, thus temporary or seasonal wetlands in the original undisturbed natural state.

However, the ‘artificial drainage’ (by man) of these areas via the high transpiration demand of the planted *Eucalyptus* trees (and possible excavated drains) has transformed the site into highly productive agricultural land. These areas are extremely fertile due to the organic carbon rich topsoils, and also provide an endless supply of water at depth. In their currently drained state, these soils are utilised as timber / arable land, such drainage being widespread in the broader region.

The sub-surface lateral water flow within these soils drains downslope into further hydromorphic Site Types in very-gently sloping to level areas, and in Transect D-C into the aManzamnyama perennial stream. In the local Zulu language, this stream name interprets as “black water”, so the water must obviously be mixed with organic matter, a further indicator of the hydromorphic nature of the soils (in their natural state) in the current Site Type D areas.

Indigenous bush patches/strips still bisect many areas of the current Site Type D soils, these bush sections occurring in the most low-lying areas. The soils in these bush areas are probably (not soil surveyed) of the Champagne form (organic A-horizon), this being a Reactive (saturated) Hydropedological Soil Group (to be discussed later).

FOOTSLOPE (LOWEST - long and very-gentle gradient):
Only encountered in Transect F-E. However, also commonly occurs in other areas of Port Durnford Plantation, for which Transects were not made.

Site Type: F. Deep E-horizon hydromorphic

Parent material: Quaternary sediments.
Effective Rooting Depth: 90 - 120cm.

Soil Forms / Families:

Kroonstad 1000 (‘sandy’).
Horizons: orthic A *(SaLm)* /over E-horizon (grey when moist) *(Sa) /* G-horizon (*SaClLm - Cl*).

Longlands 1000 (‘sandy’).
Horizons: orthic A *(SaLm)* / E-horizon (grey when moist) *(Sa) /* over soft plinthic B (*SaClLm*).

Hydropedological Response:

- Interflow (A/B).

Hydrological Response:

Sub-surface lateral flow derived from upslope next appears in the lower E-horizon (and deeper horizons) of either the lower-lying (approximately 35-20m amsl) current Site Type F soils, or alternatively in the very similar shallower Site Type E soils (approximately 35-12m amsl) (to be discussed later); this Soil Catena Hydrological response order varying between F and E, from area to area. Site Type F is discussed first given the greater depth of the E-horizon (90-120cm), overlying the 'relatively' impermeable hydromorphic G-horizon or soft plinthic B-horizon.

Apart from the water derived from the upslope perched water-table, an increased proportion (possibly the minority) of the moisture encountered is likely to be return flow to the soil solum, derived from the groundwater (saturated zone), as described for Class 4 hillslopes.
This corresponds with the prevailing landscape position (footslope lowest), very-gentle slopes (<3 degrees), and altitude (approximately 35 - 20m amsl).
Once again these soils are currently dryer than they would have been in the natural state, due to the high evaporative demand of the planted *Eucalyptus* trees.

G-horizons are saturated almost year round (grey colours and lack of soil mottling indicate at permanent anaerobic conditions); while soft plinthic B-horizons are seasonally saturated, displaying a fluctuating water-table (soil mottling indicates at saturation and anaerobic conditions during the rainy season, and partly aerobic conditions during the dry season). The overlying E-horizon indicates at sub-surface lateral water flow, the depth of this water below the soil surface varying depending on the season.

The appearance of the G- and soft plinthic B-horizons (and E-horizon) within the augured soil solum, indicates low-lying wetland (seasonal) areas.

The sub-surface lateral water flow within this Site Type will continue to drain downslope (gradually due to the minimal slope) into further hydromorphic Site Types, also in very-gently sloping areas.

FOOTSLOPE (LOWER to LOWEST - long and very-gentle gradient):
Only encountered in Transects F-E and H-G. Occasionally also occurs in the vicinity of Transect D-C.

Site Type: E. Moderately-Deep E-horizon hydromorphic
Parent material: Quaternary sediments.
Effective Rooting Depth: 60 - 90cm.

Soil Forms / Families:

Kroonstad 1000 ('clayey').
Horizons: orthic A *(SaClLm)* /over E-horizon (grey when moist) *(Sa) /* G-horizon (*SaClLm* - *Cl*).

Longlands 1000 ('clayey').
Horizons: orthic A *(SaClLm)* / E-horizon (grey when moist) *(Sa) /* over soft plinthic B (*SaClLm*).

Tukulu 1120 ('sandy'). Sub-dominant soil form, on isolated slightly raised sections.

Horizons: orthic A (*probably SaLm* - not bleached) / neocutanic B (*probably SaLm* - non-red) / unspecified material with signs of wetness (*SaClLm*).

Hydropedological Response:

- Interflow (A/B). Kroonstad and Longlands forms.

- Interflow (soil/bedrock) - as per published classification. Tukulu form.

Hydrological Response:

Sub-surface lateral flow derived from upslope generally next appears in the lower E-horizon (and deeper horizons) of these marginally lower-lying current Site Type E soils. However, as previously mentioned, the Hydrological response order varies between F and E, from area to area within Port Durnford Plantation.

Apart from the water derived from the upslope perched water-table, a further increased proportion (probably the majority) of the moisture encountered is likely to be return flow to the soil solum, derived from the groundwater (saturated zone), as described for Class 4 hillslopes.
This corresponds with the prevailing landscape position (footslope lower-lowest), very-gentle slopes (<3 degrees), and altitude (approximately 35 - 12m amsl).
Once again these soils are currently dryer than they would have been in the natural state, due to the high evaporative demand of the planted *Eucalyptus* trees.

The depth to the base of the E-Horizon is 60-90cm for the current Site Type E soils, versus 90-120cm for the previously discussed Site Type F soils. The reduced depth to the underlying G- and soft plinthic B-horizons for the current Site Type E, indicate at increasing hydromorphy.

The current Site Type is a wetland (seasonal) for the Kroonstad and Longlands soil forms; and a wetland (temporary) for the sub-dominant (isolated slightly raised sections) Tukulu soil form.

The sub-surface lateral water flow within this Site Type will continue to drain downslope (gradually due to the minimal slope) into the most low-lying hydromorphic Site Types.

VALLEY-BOTTOM (almost level gradient):

Site Type: G. Shallow undifferentiated hydromorphic

Parent material: Quaternary sediments.
Effective Rooting Depth: 30 - 60cm.

The associated Site Type G soils are predominantly encountered in Transects F-E and H-G, as a relatively narrow band along the upper 62% of the eastern boundary of Port Durnford Plantation only. The Mzingwenya perennial stream approximately forms the Plantation boundary, trending to the north-east.
Although Transect D-C also traverses two connected ‘valley-bottoms’ (stream terraces) towards its eastern extent (eastern 30%), the soils encountered in this area are of Site Types C and D (already

discussed). The western of these two connected valley-bottoms is drained to the south-west by the aManzamnyama perennial stream, while the eastern valley-bottom is drained to the north-east by the Mzingwenya perennial stream. Mzingwenya Zulu to English translation: "Home of the Crocodile". 'Mzi' is in this case most likely a shortening of the word 'umuzi', meaning home or dwelling.
Altitude gradually increases to the east of these eastern valley-bottoms, outside of the Plantation boundary.

Soil Forms / Families:

Dominant:

Westleigh 2000 ('clayey').
Horizons: orthic A (*SaClLm texture*) / over soft plinthic B (*SaCl*).

Katspruit 1000 ('clayey').
Horizons: orthic A (*SaClLm*) / G-horizon (*SaCl* - *Cl*).

Champagne 2200.
Horizons: organic A (humified organic material dominant) / unknown (probably G-horizon, *SaCl*).

Fernwood 2110 ('sandy').
Horizons: orthic A (dark coloured) (*SaLm*) / E-horizon (grey when moist) (*Sa*).

Sub-dominant:

Kroonstad 1000 ('clayey').
Horizons: orthic A *(SaClLm)* / over E-horizon (grey when moist) *(SaLm - Sa) /* G-horizon (*Cl* - *SaCl*).

Longlands 1000 ('clayey').
Horizons: orthic A *(SaClLm)* / E-horizon (grey when moist) *(LmSa - Sa) /* over soft plinthic B (*SaClLm* - *SaCl*).

Hydropedological Response:

Responsive (saturated): Katspruit and Champagne. Probably also Responsive (saturated) for the Westleigh form (due to luvic nature, plus *SaCl texture*), but still displaying the Interflow component.

Interflow (A/B, or soil/bedrock): Fernwood.

Interflow (A/B): Longlands and Kroonstad. Note: Reactive (saturated) component present where the E-horizon depth is shallow.

Hydrological Response:

Sub-surface lateral flow derived from upslope finally appears in the subsoils of these most low-lying current Site Type G soils. However, surface flow will also be encountered after heavy rainfall events, hence the dominant Hydropedological reaction of the Site Type being Responsive (saturated).

Such soils are normally close to saturation almost all year round. However, the soils occurring in the current area are slightly dryer than would normally be expected for a valley-bottom slope position, this being due to the high evaporative demand of the vast established *Eucalyptus* plantation in the upslope positions to the west.

Apart from the water derived from the upslope perched water-table, a further increased proportion (certainly the majority) of the water encountered is likely to be return flow to the soil solum, derived from the regional groundwater (saturated zone), as described for Class 4 hillslopes.
This corresponds with the prevailing landscape position (valley-bottom), almost level slopes (1 degree), and altitude (approximately 20 - 5m amsl).

Once soil field capacity has been achieved, excess water flows off both surface (mostly after rainfall events during summer) and sub-surface (year round) into the aManzamnyama and Mzingwenya perennial streams. Stream flow volume will be far greater during the rainy season, but will continue throughout the dry season as a result of an ongoing return from the regional groundwater (saturated zone).

INDIGENOUS BUSH, RIPARIAN, WETLANDS, CHANNELS:

Port Durnford Plantation:

This previous soil survey was excluded in the majority of the areas occupied by Indigenous Bush. This survey was also excluded from some of the wetlands which were too wet to traverse at the time, some of which are also occupied by indigenous bush.

The broad range of Soil Forms and Soil Site Types that will be encountered in these areas, may be generally inferred from all of the previous discussions. The Hydropedological Soil Group (Reaction) may also be inferred.

Indigenous Bush areas appear to occupy a number of different categories in the Port Durnford Plantation area, as follows:
- Drainage areas: Forest Indigenous Riparian.
  Hydropedological Response: Interflow (A/B or soil/bedrock).
- Drainage areas: Forest Indigenous Wetland (wetlands and stream channels).
  Hydropedological Response: Interflow (A/B or soil/bedrock), or Responsive (saturated).
- Steeper terrestrial slopes: Forest Indigenous Upland.
  Hydropedological Response: Recharge (deep or shallow).

Note. Site Type H (shallow lithosols) has already been discussed, in Soil Catena 1.

12.3 HYDROPEDOLOGY – RECOMMENDED DEVELOPMENT AREA

Motivation for the proposed Mining related developments to the west of the N2 highway, versus the non-development of the areas to the east of the highway (also bearing in mind 'Exception 1' below), are discussed. In this regard, also refer to Section 11.1 (SOILS – RECOMMENDED DEVELOPMENT AREA).

Areas to the west of the highway are predominantly of the Recharge (deep) [plus very limited Recharge (shallow)] Hydropedological Soil Group.
These 'terrestrial' soils occur in crest to midslope landscape positions and as such may be developed. Furthermore limited (in extent) areas of Interflow and Reactive (saturated) Hydropedological Soil Groups occur in the deeply incised footslope and valley-bottom landscape positions, and such areas must wherever possible be excluded.

Areas to the east of the highway are predominantly of the Interflow (A/B and soil/bedrock) Hydropedological Soil group, as well as mostly Responsive (saturated) in the valley-bottom to the east. These wetland soils occur in very gently sloping footslope, to almost level valley-bottom landscape positions and as such must not be developed.

Development (excavation) of such Interflow areas would interrupt sub-surface water flow to further (more wet) wetlands downslope, thereby impacting wetland health. The foundations of man-made structures in such areas would also be compromised due to sub-surface lateral water flow, while man-made excavations would fill with water.
Development of waterlogged valley-bottom wetlands in these areas is obviously also not allowable.

Wetlands are highly sensitive landscapes under statutory protection, and may not be disturbed without a licence. Furthermore, such areas are repositories of bio-diversity (hydrophytic vegetative species, indigenous bush, and further flora and fauna).

'Exception 1': Certain areas of Site Type C soils exist in the south-western third of the study area to the east of the N2 highway. It is acceptable for Sand Tailings sites to be established on the Site Type C soils (Hydropedological Recharge deep) in these areas; provided only that these sites do not encroach on Soil Site Types D-F (Interflow, and Responsive saturated) or areas of indigenous bush.

13.0 ENVIRONMENTAL IMPACT ASSESSMENT

The current Environmental Impact Assessment and Proposed Mitigation Measures relate to the Soils, Land Capability, Land Use, and Hydropedology components of the Environment.

The purpose / methodology of this Impact Assessment (Table 14) is as follows:

- firstly to indentify and compile an Impact Description (each allocated with an individual Impact number, and described in detail), relating to the various:

  Aspects - Soils, Land Capability, Land Use, and Hydropedology;

  Mine Related Features - Temporary Infrastructure Area, Primary Wet Plant = PWP, Mining Pits (all later re-purposed), Residue Storage Facilities = RSF, Sand Tailings Dumps, and Return Water Dams;

  Project Stages and Phases – Site Establishment, Operational (Phases 1 and 2), Decommissioning & Closure, and Post-Closure.

  A Cumulative 'Stage' is also included at the end of the Assessment, indicating how the current Proposed Project is in combination influenced by all of the Heavy Mineral Sands Mines (previous, current, and proposed) in the immediate surrounding areas.

  These Projects include the following:

  Proposed Port Durnford Mine (current document);

  Current Tronox Fairbreeze Mine (will conclude its life of mine in 2037 – Port Durnford Phase 2 and Fairbreeze rehabilitation and closure will take place simultaneously);

  Tronox Hillendale Mine (Currently in closure phase);

  Richards Bay Minerals – Zulti South project; and

  Adjacent mining leases for heavy mineral sands – to the south-west, south and west of the proposed Port Durnford Mine area.

- Secondly to allocate semi-quantitative (because this is based on the Specialists professional judgement, experience, and understanding of the Impacts and Mitigation Measures at hand) rating scores (for each Impact) for the following five criteria:
  Magnitude, Extent, Reversibility, Duration, and Probability.
  Utilising a formula (including these five criteria), the Significance of the specified Impact is then determined.
  This derived Risk Matrix process applies to 'Pre-Mitigation' (before any Mitigation Measures are implemented).

- Thirdly, detailed Mitigation Measures are proposed for each identified Impact number.

- Fourthly, re-allocate rating scores for the five criteria (as indicated in the Second point), once again arising with an Impact Significance.
  This derived Risk Matrix process applies to ‘Post-Mitigation’ (after implementation of all of the proposed Mitigation Measures).

  The objective of the proposed Mitigation Measures (third point); is for the Significance of the Residual Impacts Post-Mitigation to have dropped to an acceptable level, from the Environmental perspective (in this case).

Refer to the following document Tables in the current Section:

- Table 13. Impact Assessment Methodology.
- Table 14. Impact Assessment Table - Soils, Land Capability, Land Use, and Hydropedology. This Table has been produced in Excell format.

The following previously incorporated Figures are relevant to the Table 14 discussions:

- Figure 1a (Planned Mining Infrastructure).
- Figure 1b (Life of Mine).
- Figure 1c (Planned Backfill Sequence).

The following previously incorporated document Sections are particularly relevant to the Table 14 discussions (some of which was extracted from Table 14):

- Section 1.2 (PLANNED MINING INFRASTRUCTURE and LIFE OF MINE);

- Section 11 (SOILS RECOMMENDATIONS);
- Section 11.1 (RECOMMENDED DEVELOPMENT AREA);
- Section 11.2 (ISSUES – PLANNED MINING INFRASTRUCTURE);
- Section 11.3 (SOIL STRIPPING AND STOCKPILING);
- Section 11.4 (SLOPE AND RE-GRADING);
- Section 11.5 (TOPSOILING, AND RECONSTITUTED ‘SOIL’ MIXING RATIO);
- Section 11.6 (RE-VEGETATION); and
- Section 11.7 (FINAL END LAND CAPABILITY & LAND USE – BASED ON SLOPE).

Table 14 describes the various Impacts and Mitigation Measures in great detail.
Thus, in order to prevent duplication, this information will not be repeated in text form in the current Section.

However, do refer to Section 11 (11.1 – 11.7), where a large amount of additional information relevant to the current Section is also provided.

Table 13. Impact Assessment Methodology
As per the following three pages.

Nature or Type of Impact:

Nature or Type of Impact	Definition
Beneficial / Positive	An impact that is considered to represent an improvement on the baseline or introduces a positive change.
Adverse / Negative	An impact that is considered to represent an adverse change from the baseline or introduces a new undesirable factor.
Direct	Impacts that arise directly from activities that form an integral part of the Project (e.g. new infrastructure).
Indirect	Impacts that arise indirectly from activities not explicitly forming part of the Project (e.g. noise changes due to changes in road or rail traffic resulting from the operation of Project).
Secondary	Secondary or induced impacts caused by a change in the Project environment (e.g. employment opportunities created by the supply chain requirements).
Cumulative	Impacts are those impacts arising from the combination of multiple impacts from existing projects, the Project and/or future projects.

Physical Extent Rating of Impact:

Score	Description
1	the impact will be limited to the site;
2	the impact will be limited to the local area (local study area);
3	the impact will be limited to the region;
4	the impact will be national; or
5	the impact will be international;

Duration (Lifetime) Rating of Impact:

Score	Description
1	of a very short duration (0 to 1 years)
2	of a short duration (2 to 5 years)

3	medium term (5–15 years)
4	long term (> 15 years)
5	permanent (this is considered permanent if the impact will be experienced post mine closure)

Reversibility Rating of Impact:

Score	Description
1	The impact is immediately reversible.
3	The impact is reversible within 2 years after the cause or stress is removed; or
5	The activity will lead to an impact that is in all practical terms permanent.

Magnitude Rating of Impact:

Score	Description
0	small and will have no effect on the environment.
1	minor and will not result in an impact on processes (to be defined by individual specialist fields).
2	low and will cause a slight impact on processes.
3	moderate and will result in processes continuing but in a modified way.
4	high (processes are altered to the extent that they temporarily cease).
5	very high and results in complete destruction of patterns and permanent cessation of processes.

Probability (actually occurring) Rating of Impact:

Score	Description
1	very improbable (probably will not happen).
2	improbable (some possibility, but low likelihood).
3	probable (distinct possibility).
4	highly probable (most likely).
5	definite (impact will occur regardless of any prevention measures).

SIGNIFICANCE Rating of Impact:

The significance, which is determined through a synthesis of the characteristics described above (refer formula below) and can be assessed as low, medium or high.

This is related to the following:

- The status, which is described as either positive, negative or neutral;
- The degree to which the impact can be reversed;
- The degree to which the impact may cause irreplaceable loss of resources; and
- The degree to which the impact can be mitigated.

The significance is determined by combining the above criteria in the following formula:

Significance = (Extent + Duration + Reversibility + Magnitude) x Probability

[S= (E+D+R+M) ×P]

The Significance weightings for each potential impact are as follows:

Overall Score	Significance Rating (Negative)	Significance Rating (Positive)	Description
< 30 points	Low	Low	where this impact would not have a direct influence on the decision to develop in the area.
31 - 60 points	Medium	Medium	where the impact could influence the decision to develop in the area unless it is effectively mitigated.
> 60 points	High	High	where the impact must have an influence on the decision process to develop in the area.

Table 14. Impact Assessment Table – Soils, Land Capability, Land Use, and Hydropedology

SITE ESTABLISHMENT (Phase 1 Temporary Infrastructure construction, and pre-construction of Phase 2 PWP during Phase 1): Years 2025-2035

Impact number	Aspect	Feature	Phase	Project Stage	Impact Description	Character	Pre-Mitigation							Mitigation Measures	Post-Mitigation						
							(M+	E+	R+	D)x	P=	S	S Rating		(M+	E+	R+	D)x	P=	S	S Rating
Impact 1:	Soil	Temporary Infrastructure Area & PWP. Phase 2 Infrastructure (PWP) will also be constructed during the course of Phase 1	Phase 1	Site Establishment	Loss of soil depth/volume - due to understripping. Destruction of originally existing soil profiles.	Negative	3	1	3	5	4	**48**	**N3**	- Strip 30cm Topsoil (orthic A-horizon); and minimum 150cm Subsoil. These soils include the following Soil Site Types: Site Type A (red apedal B-, or yellow-brown apedal B-horizon); Site Type B (red apedal B-, or neocutanic B-horizon); and Site Type C (E-horizon). - Stockpile Topsoil and Subsoils separately, in dedicated soil stockpiles. [Note for all Impacts relating to Understripping in this Table: the presence of large *Eucalyptus* tree stumps throughout the entire mining area will make the soil stripping process challenging, resulting in a Pre-Mitigation Probability rating of 4 (highly probable). It is imperative that the Mine find a solution to ensure that ALL recommended soil horizons are stripped to the correct depth. Post-Mitigation Probability ratings of 3 (probable) have been applied for Understripping in the current Table].	2	1	3	4	3	**30**	**N2**
						Significance	**N3 - Moderate**								**N2 - Low**						
Impact 2:	Land Capability and Land Use	Temporary Infrastructure Area & PWP	Phase 1	Site Establishment	Destruction of the existing Land Capability (class - as defined for Pre-Mining) potential. These include Grazing, and rarely Arable classes. Destruction of the existing Land Use potential. This is comprised of very high potential *Eucalyptus* plantations (also suitable for highly demanding agricultural crops).	Negative	4	1	5	5	5	**75**	**N4**	- No mitigation is possible until the sites are no longer active, and have been rehabilitated (re-graded / topsoiled / soil fertility tested / fertilised / re-vegetated. Cross-reference to Rehabilitated Impacts (Decommissioning / Closure Phase): Impact 3. PWP.	4	1	5	5	5	**75**	**N4**
						Significance	**N4 - High**								**N4 - High**						
Impact 3:	Soil	Soil Stockpile (soil stripped from Temporary Infrastructure Area & PWP)	Phase 1	Site Establishment	Reduction of soil quality - due to compaction.	Negative	3	1	3	4	3	**33**	**N3**	- Ideally strip and stockpile soils in the dry state. This is because compaction is promoted when working soils in the moist state. - Utilise tracked machinery for soil stripping/stockpiling operations due to lower point loading. - Utilise dedicated traffic routes, thereby preventing unnecessary widespread compaction. - Stockpile height: normally recommended in the mining industry is a maximum height of 3m (ideal). Stockpiles may be raised slightly above 3m, provided only that suitable machinery is sourced that has a greater boom length, and also provided that the machine never traverses the stockpile. Previous comment is applicable to all soil stockpiles. This height recommendation is based upon deposition of the material by dump truck, and then potentially building the topsoil height to 3m utilising a shovel. During later utilisation of topsoil material for rehabilitation, the soil must be loaded onto a dump truck utilising a shovel from a machine adjacent the stockpile. In order to prevent compaction, machinery should never traverse on top of the stockpile.	2	1	3	2	2	**16**	**N2**
						Significance	**N3 - Moderate**								**N2 - Low**						
Impact 4:	Soil	Soil Stockpile (soil stripped from Temporary Infrastructure Area & PWP)	Phase 1	Site Establishment	Loss of soil volume / quality - due to erosion, also resulting in sedimentation of the surrounding area.	Negative	3	2	3	4	3	**36**	**N3**	- Ensure that Soil Stockpile side-slopes are ≤1:7 (8°) [ideally], but not steeper than 1:5 (11.3°) [latter option will required a higher vegetative basal cover]. - Subsoil (B- or E-horizons) Stockpiles: sample the top 10cm of soils in the stockpile / analyse (laboratory) / ameliorating soil fertility. - Revegetate Subsoil stockpiles using locally indigenous (to the site) grasses. - Topsoil (orthic A-horizon) stockpiles: should naturally revegetate without fertilisation (due to inherent fertility) or seeding (due to natural seedbank store - probably lacking in areas previously planted to *Eucalyptus* trees), but if not then intervention will also be required (as previously described for Subsoil Stockpiles). - Monitor/remove alien invasive vegetative species.	1	1	3	2	2	**14**	**N1**
						Significance	**N3 - Moderate**								**N1 - Very Low**						
Impact 5:	Soil	Soil Stockpile (soil stripped from Temporary Infrastructure Area & PWP)	Phase 1	Site Establishment	Loss of soil quality - due to reduction in soil fertility.	Negative	3	1	3	4	4	**44**	**N3**	- Ameliorate stockpile soil fertility, as necessary, and as indicated by soil analysis.	2	1	3	1	2	**14**	**N1**
						Significance	**N3 - Moderate**								**N1 - Very Low**						
Impact 6:	Soil	Temporary Infrastructure Area & PWP	Phase 1	Site Establishment	Loss of soil quality - due to soil contamination by hydrocarbons and other chemicals, resulting in secondary impacts on surface and sub-surface water. Lower level of impact compared with Operational Phase 2.	Negative	3	2	3	5	3	**39**	**N3**	Temporary Infrastructure Area and PWP should be designed to include the following precautions: - separate storage of fuels and chemicals under roofing and on concrete pads that incorporate appropriately sized sumps and bund walls. - construction of concrete pads for workshops. - provision of drip trays and spill kits and in all of the above areas. - construction of lined dirty water incept drains in downslope positions of the PWP (not necessary for Temporary Infrastructure site), these flowing through oil/sediment traps before draining into a lined return water dam. - construction of unlined clean stormwater diversion drains upslope of the PWP (not necessary for temporary Infrastructure site), these being built close to the contour in order to encourage infiltration. The drain/s should discharge onto the soil surface in a midslope position. A concrete energy dissipating structure should be constructed at this discharge point, functioning to both reduce the velocity of the water flow, as well as to spread the discharge over a broader area (thus promoting infiltration into the surrounding sandy soils).	2	2	3	4	2	**22**	**N2**
						Significance	**N3 - Moderate**								**N2 - Low**						
Impact 7:	Hydropedology & Hydrology	Temporary Infrastructure Area & PWP	Phase 1	Site Establishment	Reduced recharge (deep) in infrastructure footprint areas due to roofing, impermeable concrete pads, and tarred / paved surfaces.	Negative	2	2	3	4	3	**33**	**N3**	- Reduced recharge in the infrastructure footprint areas is somewhat offset by the following: higher recharge within the unlined clean stormwater interception drains constructed close to the contour in upslope positions of these areas, plus the associated concrete energy dissipating structure at the discharge point of each of the drains in a midslope position.	1	1	3	4	2	**18**	**N2**
						Significance	**N3 - Moderate**								**N2 - Low**						

OPERATIONAL PHASE 1: Years 2025 - 2035

Impact number	Aspect	Feature	Phase	Project Stage	Impact Description	Character	Pre-Mitigation								Post-Mitigation						
							(M+	E+	R+	D)x	P=	S	S Rating		(M+	E+	R+	D)x	P=	S	S Rating
Impact 1:	Soil	Temporary Infrastructure Area	Phase 1	Operational	Loss of soil quality - due to soil contamination by hydrocarbons and other chemicals, resulting in secondary impacts on surface and sub-surface water.	Negative	2	2	3	5	2	**24**	**N2**	Temporary Infrastructure Area. Develop standard procedures for the operation and maintenance of all of the following: - separate storage of fuels and chemicals under roofing and on concrete pads that incorporate appropriately sized sumps and bund walls. - concrete pads for workshops. - drip trays and spill kits and in all of the above areas, as well as good housekeeping. - lined dirty water incept drains in downslope positions of the PWP, and oil/sediment traps and the lined return water dam. - unlined clean stormwater diversion drains constructed close to the contour upslope of the PWP, also including the concrete energy dissipating structure at the discharge points to encourage the safe infiltration of water in midslope positions.	1	1	3	4	1	**9**	**N1**
						Significance	**N2 - Low**								**N1 - Very Low**						
Impact 2:	Soil. (Note: Land Capability and Land Use Impact - Refer to Operational Phase 2 Impact 3, which is the same)	Mining Pit (first)	Phase 1	Operational	Loss of soil depth/volume - due to understripping. Destruction of originally existing soil profiles.	Negative	3	1	5	5	4	**56**	**N3**	- Strip 30cm Topsoil (orthic A-horizon). - Stockpile Topsoil in dedicated soil stockpile.	2	1	3	3	3	**27**	**N2**
						Significance	**N3 - Moderate**								**N2 - Low**						
Impact 3:	Soil	Soil Stockpile (soil stripped from first Mining Pit)	Phase 1	Operational	Reduction of soil quality - due to compaction.	Negative	3	1	3	3	3	**30**	**N2**	- Ideally strip and stockpile soils in the dry state. This is because compaction is promoted when working soils in the moist state. - Utilise tracked machinery for soil stripping/stockpiling operations due to lower point loading. - Utilise dedicated traffic routes, thereby preventing unnecessary widespread compaction. - Stockpile height: normally recommended in the mining industry is a maximum height of 3m (ideal). This height recommendation is based upon deposition of the material by dump truck, and then building the topsoil height to 3m utilising a shovel. During later utilisation of topsoil material for rehabilitation, the soil must be loaded onto a dump truck utilising a shovel from a machine adjacent the stockpile. In order to prevent compaction, machinery should never traverse on top of the stockpile.	2	1	3	2	2	**16**	**N2**
						Significance	**N2 - Low**								**N2 - Low**						
Impact 4:	Soil	Soil Stockpile (soil stripped from first Mining Pit)	Phase 1	Operational	Loss of soil volume/quality - due to erosion, also resulting in sedimentation of the surrounding area.	Negative	3	2	3	3	3	**33**	**N3**	- Ensure that Soil Stockpile side-slopes are ≤1:7 (8°) [ideally], but not steeper than 1:5 (11.3°) [latter option will required a higher vegetative basal cover]. - Stockpile height: normally recommended in the mining industry is a maximum height of 3m (ideal), where sufficient footprint area is available (but not the case in the current area). Stockpiles may be raised slightly above 3m, provided only that suitable machinery is sourced that has a greater boom length, and also provided that the machine never traverses the stockpile. Previous comment is applicable to all soil stockpiles. - Topsoil (orthic A-horizon) stockpiles: should naturally revegetate without fertilisation (due to inherent fertility) or seeding (due to natural seedbank store - probably lacking in areas previously planted to *Eucalyptus* trees), but if not then intervention will be required as follows: - Sample the top 10cm of soils in the stockpile / analyse (laboratory) / ameliorating soil fertility; and - Revegetate stockpiles using locally indigenous (to the site) grasses. - Monitor/remove alien invasive vegetative species.	2	1	3	2	2	**16**	**N2**
						Significance	**N3 - Moderate**								**N2 - Low**						
Impact 5:	Soil	Soil Stockpile (soil stripped from first Mining Pit)	Phase 1	Operational	Loss of soil quality - due to reduction in soil fertility.	Negative	3	1	3	3	4	**40**	**N3**	- Ameliorate stockpile soil fertility, as necessary, and as indicated by soil analysis.	2	1	3	1	2	**14**	**N1**
						Significance	**N3 - Moderate**								**N1 - Very Low**						
Impact 6:	Soil	Mining Pit - Phase 1 (also applicable to all Phase 2 Mining Pits)	Phase 1	Operational	Erosion of soil into the first Mining Pit, plus highwall slumping - due to runoff erosion from upslope surrounding areas.	Negative	3	2	3	4	4	**48**	**N3**	- Construct runoff diversion berm in all upslope positions at least 10m from the pit highwall, utilising a soil berm created by grading the existing surface soils. Comment is also applicable to all Phase 2 Mining Pits.	2	1	3	1	2	**14**	**N1**
						Significance	**N3 - Moderate**								**N1 - Very Low**						
Impact 7:	Hydropedology & Hydrology	Mining Pit (first)	Phase 1	Operational	Greatly reduced recharge (deep) in the Mining Pit footprint due to the removal of the recharge soils (targeted mineral 'ore') and pumping infiltrated water out of the Pit; thus interrupting the hydropedological moisture flow pathway.	Negative	4	1	5	3	4	**52**	**N3**	- No mitigation is possible until the Pit has been rehabilitated (backfilled / re-graded / topsoiled), and a moisture flow pathway (partly altered) has been re-established.	4	1	5	3	4	**52**	**N3**
						Significance	**N3 - Moderate**								**N3 - Moderate**						

OPERATIONAL PHASE 2: 2036 - 2069 (Mining)

Impact number	Aspect	Feature	Phase	Project Stage	Impact Description	Character	Pre-Mitigation								Post-Mitigation						
							(M+	E+	R+	D)x	P=	S	S Rating		(M+	E+	R+	D)x	P=	S	S Rating
Impact 1:	Soil	Mining Pits (extensive / numerous, before being later repurposed)	Phase 2	Operational	Loss of soil depth/volume - due to understripping (before commencement of mining). Destruction of originally existing soil profiles.	Negative	4	2	5	5	4	**64**	**N4**	- Strip 30cm Topsoil (orthic A-horizon). - Stockpile this Topsoil in dedicated soil stockpiles, only when absolutely necessary. <u>Instead of Soil Stockpiling, it is Recommended to wherever possible rather practise continually ongoing sequential rolling over rehabilitation topsoiling operations (as described for Operational Impact No. 12). Current comment is applicable to all Soil Stockpiles and Mining Pits in this entire Table.</u>	3	2	3	4	3	**36**	**N3**
						Significance	**N4 - High**								**N3 - Moderate**						
Impact 2:	Soil	RSF & Sand Tailings footprints constructed Above Surface. Including: RSF 9; and Sand Tails A-1, A-2, A-3 complex, and 8B	Phase 2	Operational	Loss of soil depth/volume - due to understripping (before commencement of deposition). Destruction of originally existing soil profiles.	Negative	4	2	5	5	4	**64**	**N4**	- Strip 30cm Topsoil (orthic A-horizon); and minimum 150cm Subsoil. Stripping depths at Sand Tailings site 8B vary and are frequently less than 150cm (refer to Map 7). The dominant soils in these areas include the following Soil Site Types: Site Type A (red apedal B-, or yellow-brown apedal B-horizon); Site Type B (red apedal B-, or neocutanic B-horizon); and Site Type C (E-horizon). However, further Soil Site Types also occur at Sand Tailings site 8B. - Stockpile Topsoil and Subsoils separately, in dedicated soil stockpiles. - Do not utilise stripped soil for the construction of berms in downslope positions of RSF and Sand Tailings sites, because this valuable resource could then become buried/lost due to sedimentation. Rather construct such berms from Sand Tailings or Reconstituted 'soil' (mix of fines and sand).	3	2	3	4	3	**36**	**N3**
						Significance	**N4 - High**								**N3 - Moderate**						
Impact 3:	Land Capability and Land Use	Mining Pits (all Phase 2 Pits, also including the Phase 1 Pit); and Above Surface constructed RSF & Sand Tailings footprints	Phase 2	Operational	Destruction of the existing Land Capability (class - as defined for Pre-Mining) potential. Midslope to crest landscape positions are mostly of the Grazing, and occasionally Arable classes. Although the soils in these positions are generally very deep / high potential, Land Capability is mostly determined by the prevailing slope in the current area. Footslope positions are generally of the Wetland (seasonal) class. Destruction of the existing Land Use potential. This includes very high potential *Eucalyptus* plantations (also suitable for highly demanding agricultural crops); as well as Grasslands, and occasional patches of Indigenous Bush (latter mostly in riparian/wetland/or steep areas).	Negative	4	2	5	5	5	**80**	**N4**	- No mitigation is possible until the sites are no longer active, and have been rehabilitated (re-graded / topsoiled / soil fertility tested / fertilised / re-vegetated). - Avoid the mining related disturbance of Wetland / Riparian areas at all costs. Cross-reference to Rehabilitated Impacts (Operational Phase 2): Impact 12. Mining Pits (filled with Sand Tailings only), Impact 14. RSF 9, and Impact 15. Sand Tailings Dumps 8B, A-1, A-2, and A-3 Complex. Cross-reference to Rehabilitated Impacts (Decommissioning / Closure Phase): Impact 1. RSF C.	4	2	5	5	5	**80**	**N4**
						Significance	**N4 - High**								**N4 - High**						
Impact 4:	Soil	Soil Stockpiles - soil stripped from footprints of: Mining Pits (All); and Above Surface constructed features (RSF 9; & Sand Tailings A-1, A-2, A-3 complex, and 8B)	Phase 2	Operational	Reduction of soil quality - due to compaction	Negative	3	1	3	4	3	**33**	**N3**	- Ideally strip and stockpile soils in the dry state. This is because compaction is promoted when working soils in the moist state. - Utilise tracked machinery for soil stripping/stockpiling operations due to lower point loading. - Utilise dedicated traffic routes, thereby preventing unnecessary widespread compaction. - Stockpile height: normally recommended in the mining industry is a maximum height of 3m (ideal). This height recommendation is based upon deposition of the material by dump truck, and then building the topsoil height to 3m utilising a shovel. During later utilisation of topsoil material for rehabilitation, the soil must be loaded onto a dump truck utilising a shovel from a machine adjacent the stockpile. In order to prevent compaction, machinery should never traverse on top of the stockpile.	2	1	3	2	2	**16**	**N2**
						Significance	**N3 - Moderate**								**N2 - Low**						

						Significance	**N3 - Moderate**								**N2 - Low**						
Impact 5:	Soil	Soil Stockpiles - soil stripped from footprints of: Mining Pits (All); and Above Surface constructed features (RSF 9; & Sand Tailings A-1, A-2, A-3 complex, and 8B)	Phase 2	Operational	Loss of soil volume/quality - due to erosion, also resulting in sedimentation of the surrounding area. [Note: Hydropedology / Hydrology will not be impacted by the Topsoil Stockpiles due to the following: limited extent and limited height. Thus, this Aspect will not be discussed as a Impact in the current Table].	Negative	3	2	3	4	3	**36**	**N3**	'- Ensure that Soil Stockpile side-slopes are ≤1:7 (8°) [ideally], but not steeper than 1:5 (11.3°) [latter option will required a higher vegetative basal cover]. - Stockpile height: normally recommended in the mining industry is a maximum height of 3m (ideal), where sufficient footprint area is available (but not the case in the current area). Stockpiles may be raised slightly above 3m, provided only that suitable machinery is sourced that has a greater boom length, and also provided that the machine never traverses the stockpile. Previous comment is applicable to all soil stockpiles. - Subsoil (B- or E-horizons) Stockpiles [stripped from footprints of RSF 9, and all Sand Tailings sites]: sample the top 10cm of soils in the stockpile / analyse (laboratory) / ameliorating soil fertility. - Revegetate Subsoil stockpiles using locally indigenous (to the site) grasses. - Topsoil (orthic A-horizon) stockpiles [stripped from all sites]: should naturally revegetate without fertilisation (due to inherent fertility) or seeding (due to natural seedbank store - probably lacking in areas previously planted to *Eucalyptus* trees), but if not then intervention will also be required (as previously described for Subsoil Stockpiles). - Monitor/remove alien invasive vegetative species. - Instead of stockpiling soil from mining Pit footprints, it is wherever possible Recommended to rather practise continually ongoing sequential rolling over rehabilitation topsoiling operations throughout the entire Phase 2 Life of Mine, where topsoil stripped from one Pit footprint is immediately utilised to topsoil another Pit area where backfilling has been completed (as described for Operational Impact No. 12). Current comment is applicable to all Pit Soil Stockpiles in the current Table.	2	2	3	2	2	**18**	**N2**
						Significance	**N3 - Moderate**								**N2 - Low**						
Impact 6:	Soil	Soil Stockpiles - soil stripped from footprints of: Mining Pits (All); and Above Surface constructed features (RSF 9; & Sand Tailings A-1, A-2, A-3 complex, and 8B)	Phase 2	Operational	Loss of soil quality - due to reduction in soil fertility.	Negative	3	1	3	4	4	**44**	**N3**	- Ameliorate stockpile soil fertility, as necessary, and as indicated by soil analysis.	2	1	3	1	2	**14**	**N1**
						Significance	**N3 - Moderate**								**N1 - Very Low**						
Impact 7:	Hydropedology & Hydrology	Mining Pits (extensive / numerous, before being later repurposed)	Phase 2	Operational	Significantly reduced Recharge in the extensive Mining Pit footprints due to the complete removal of the recharge soils (targeted mineral 'ore') and pumping infiltrated water out of the Pit; thus temporarily destroying the hydropedological / hydrological moisture flow pathway; with resultant lowering of the groundwater saturated zone (watertable).	Negative	4	3	5	4	5	**80**	**N4**	- No mitigation is possible during the course of mining operations. Mitigation will only be possible once the Pits have been rehabilitated (backfilled / re-graded / topsoiled), and a moisture flow pathway (partly altered) has been re-established. Cross-reference to Rehabilitated Impacts (Operational Phase 2): Impact 13. Mining Pits (filled with Sand Tailings only). Cross-reference to Rehabilitated Impacts (Decommissioning / Closure Phase): Impact 2. RSF C.	4	3	5	4	5	**80**	**N4**
						Significance	**N4 - High**								**N4 - High**						
Impact 8:	Hydropedology & Hydrology	Backfilling of mined-out Pits. Including: All Pits (backfilled with Sand Tailings only); and repurposed RSF C (backfilled with Fines, inside internal Sand Tailings walls)	Phase 2	Operational [Note: Backfilling of RSF C continues into the Decommissioning Phase]	Large temporary (over a long period) increases in recharge and interflow water volumes during the hydraulic backfilling process. Further detail: Large <u>temporary</u> (during depositional / backfilling phase) increase in Recharge to groundwater (vertically downward) and Interflow (laterally downslope) as a result of saturated hydraulically pumped Fines and Sand Tailings being backfilled into the mined out Pits. As the Pit backfilling progresses and the saturated material gets closer to the surface, the Interflow component will <u>temporarily</u> increase along its previous flow pathway (where present), until hydraulic pumping stops and the saturated zone drops below the level of the surrounding (outside of the Pit) natural Interflow boundary (where present).	Negative	3	3	5	4	5	**75**	**N4**	- No mitigation is possible during the course of the backfilling (Fines into RSF C, and Sand Tailings into all other Pits) operation. Note: although further backfilling of RSF C will take place during the Decommissioning phase (with Sand Tailings, during that Phase only), in order to avoid duplication of information, the current backfilling Impact is not repeated in the Decommissioning Phase. Cross-reference to Rehabilitated Impacts (Operational Phase 2): Impact 13. Mining Pits (filled with Sand Tailings only). Cross-reference to Rehabilitated Impacts (Decommissioning / Closure Phase): Impact 2. RSF C.	3	3	5	4	5	**75**	**N4**
						Significance	**N4 - High**								**N4 - High**						

Impact 9:	Hydropedology & Hydrology	Deposition Above Surface, Outside of mining footprints. Including: RSF 9 (Fines deposited within a Sand Tailings starter wall); and Sand Tailings dumps A-1, A-2, A-3 complex, and 8B (Sand Tailings only)	Phase 2	Operational	Impact refers to the Large temporary (over a long period) increase in Recharge to groundwater (vertically downward) and Interflow (laterally downslope) water volumes during the hydraulic depositional Phase. This is as a result of saturated hydraulically pumped Fines and Sand Tailings being deposited above the original ground level. Toe seepage is likely to compromise toe stability, leading to slumping and erosion, also resulting in increased downslope sedimentation.	Negative	3	3	5	3	5	**70**	**N4**	- Direct surface water (supernatant) on the top of the RSF to penstocks and spillways for capture in the Return Water Dam and later reuse in the PWP. - Seepage water collected in underdrains below the RSF will also be collected in the Return Water Dam for reuse. - Toe Paddocks and Berms at the base of the RSF side slopes, and Berms surrounding the Sand Tailings dumps will contain runoff water and sedimentation. - If at all possible during the Operational (depositional) phase, implement the following rehabilitation (early) measures to the lower side-slopes only: reduce slope to ideally ≤1:7 (8 ° - terraced) [but not more 1:5 (11.3°)], Topsoil with 150cm (minimum) of Reconstituted 'soil' (fines and sand mix) overlaid by 30cm of orthic Topsoil, regrass, and plant water demanding vegetation such as Eucalyptus trees or indigenous bush. These measures will hasten the drying out and stabilisation of the facilities, and reduce the unnaturally high volume of water being directed to recharge and interflow. - Ongoing monitoring and maintenance is required. - No further mitigation is possible until these facilities are decommissioned, thereafter dry out substantially, and are fully rehabilitated. Cross-reference to Rehabilitated Impacts (Operational Phase 2): Impact 16 (RSF 9), and Impact 17 (Sand Tailings Dumps).	3	3	5	3	5	**70**	**N4**
						Significance	**N4 - High**								**N4 - High**						
Impact 10:	Hydropedology & Hydrology	PWP (and Temporary Infrastructure Area, if still existing)	Phase 2	Operational	Reduced recharge (deep) in infrastructure footprint areas (PWP; and Temporary Infrastructure area if still existing) due to roofing, impermeable concrete pads, and tar/paved surfaces.	Negative	3	2	3	4	4	**48**	**N3**	'- Reduced recharge in the infrastructure footprint areas is somewhat offset by the following: higher recharge within the unlined clean stormwater interception drains constructed close to the contour in upslope positions of these areas, plus the associated concrete energy dissipating structure at the discharge point of each of the drains in a midslope position. Cross-reference to Rehabilitated Impacts (Decommissioning / Closure Phase): Impact 4.	2	2	3	4	2	**22**	**N2**
						Significance	**N3 - Moderate**								**N2 - Low**						
Impact 11:	Soil	PWP (and Temporary Infrastructure Area, if still existing)	Phase 2	Operational	Loss of soil quality - due to soil contamination by hydrocarbons and other chemicals, resulting in secondary impacts on surface and sub-surface water. Higher level of impact compared with Site Establishment phase.	Negative	3	2	3	5	4	**52**	**N3**	Adhere to the standard procedures for the operation and maintenance of all of the following: - separate storage of fuels and chemicals under roofing and on concrete pads that incorporate appropriately sized sumps and bund walls. - concrete pads for workshops. - drip trays and spill kits and in all of the above areas, as well as good housekeeping. - lined dirty water incept drains in downslope positions of the PWP, and oil/sediment traps and the lined return water dam. - unlined clean stormwater interception drains constructed close to the contour in upslope positions of these areas, plus the associated concrete energy dissipating structure at the discharge point of each of the drains in a midslope position.	2	2	3	4	2	**22**	**N2**
						Significance	**N3 - Moderate**								**N2 - Low**						

Impact 12:	Soil, Land Capability, and Land Use	Rehabilitation of Mining Pits that were backfilled with Sand Tailings only (re-purposed Sand Tailings sites 3, 4, and 5). Includes: All Pits (except repurposed RSF C)	Phase 2	Operational	Unacceptable soil erosion due to proposed 1:3 (18.4°, terraced) side slopes, and Topsoiling depth due to capping with only 30cm of Topsoil (orthic A-horizon). Also poor soil properties (fertility & compaction). Consequently reduced Land Capability / Land Use potential, as compared with the pre-mining potential. Note: Mining Pits are all situated very close to the LOM boundary (thus also influencing Extent of Impact).	Negative	3	3	5	5	5	**80**	**N4**	- Current Significance assumes that soil erosion is reduced by re-grading side slopes to ideally ≤1:7 (8 °) at previous Pit sites. Terracing is optional if side slopes are so reduced by correct reshaping. Slopes must definitely be reduced as specified, from the proposed 1:3 (18.4° - terraced). - Final rehabilitated Pit profiles should be whale-backed in shape, with the apex height being raised to approximately 15m above the original ground level. This height may be increased provided that side-slopes are maintained at ≤1:7. - The existing Berm surrounding the Pits must be maintained during rehabilitation, this in order to trap sediment. - Improve land capability and land use potential by capping with150cm (minimum) Reconstituted 'soil' layer (mixing ratio: 33% Fines : 77% Sand); and - Place a 30cm layer of previously stockpiled Topsoil (orthic A-horizon) over this reconstituted layer. - Analyse soil fertility and ameliorate as required. - Initially Revegetate with locally indigenous (to the site) grasses to stabilise the surface soils, until such time as an alternative sustainable land use is implemented (e.g. *Eucalyptus*). - Monitor/remove alien invasive vegetative species. - Monitoring, maintenance, and repair work must be ongoing. **- SEQUENTIAL BACKFILLING & REHABILITATION:** Wherever possible, practise continually ongoing sequential rolling over backfilling and rehabilitation topsoiling operations throughout the entire Phase 2 Life of Mine (from 2036 onwards, not only commencing as late as 2056), where topsoil stripped from one mining Pit footprint is immediately utilised to topsoil another Pit area where backfilling has been completed. The implementation of this practice would have the following benefits: - reduce the number / height / extent of Topsoil Stockpiles, and particularly importantly Sand Tailings Dumps. If Sand Tailings site 8B was utilised first; then this may probably exclude the necessity of Sand Tailings dumps A-3 Complex, A-1 & A-2 (or sections of these) in the planned Mine design.	3	2	3	5	3	**39**	**N3**
						Significance	**N4 - High**								**N3 - Moderate**						
Impact 13:	Hydropedology & Hydrology	Rehabilitation of already backfilled Mining Pits. Includes: all Pits that were backfilled with Sand Tailings only	Phase 2	Operational	Reduced volume of infiltrated water reporting to the base of the previous Pits post-rehabilitation (versus that pre-disturbance) due to the following: increased surface area (raised above surface) versus that of the footprint, thus higher evapotranspiration losses from vegetation / wind. The Recharge (derived from rainfall) moisture flow pathway will dominate within the actual depth of the backfilled Pits, this due to the rapid permeability (in the dry state) of the sand grade material utilised to backfill these sites. Upon encountering the base of the Pit, the infiltrating water will thereafter reconnecting with the underlying existing moisture flow pathways. Note: Mining Pits are all situated very close to the LOM boundary (thus also influencing Extent of Impact).	Negative	3	3	5	5	4	**64**	**N4**	- Implement all Rehabilitation Mitigation Measures, as specified for Impact 12 above. This will ensure that hydropedological / hydrological moisture flow pathways underlying the site will be largely re-established post-rehabilitation. It is likely that only a slightly reduced volume of water will report to the downslope wetlands and streams.	3	3	3	5	3	**42**	**N3**
						Significance	**N4 - High**								**N3 - Moderate**						
Impact 14:	Soil, Land Capability, and Land Use	Rehabilitation of Above Surface deposit. Includes: RSF 9 (Fines were deposited, inside a Sand Tailings starter wall)	Phase 2	Operational	Unacceptable soil erosion / depth due to proposed 1:3 (18.4°, terraced) side slopes [also constructed on an undulating landscape], and Topsoiling with only 30cm of orthic A-horizon Topsoil (directly over the capping of sand proposed by the Mine for levelling and trafficability purposes). Also poor soil properties (fertility & compaction). Consequently significantly reduced Land Capability / Land Use potential, as compared with the pre-mining potential. Note: RSF 9 is situated very close to the LOM boundary (thus also influencing Extent of Impact).	Negative	3	3	5	5	5	**80**	**N4**	- Current Significance assumes that soil erosion is reduced by re-grading side slopes to ideally ≤1:7 (8 °) [but not more than 1:5 (11.3°)]. Terracing is optional if side slopes are so reduced by correct reshaping. Slopes must definitely be reduced as specified, from the proposed 1:3 (18.4° - terraced). - Final rehabilitated profiles should ideally be whale-backed in shape. - Avoid the presence of any surface water bodies, - Improve land capability and land use potential by capping with 150cm (minimum) of the originally stripped and stockpiled Subsoils [potential soil shortages may be compensated for by partly utilising Reconstituted 'soil']; and - Place a 30cm layer of previously stockpiled Topsoil (orthic A-horizon) over this Subsoil layer. - Topsoiling operation conducted utilising tracked (rather than wheeled) machinery and also utilise dedicated traffic routes, this in order to limit soil compaction. - Analyse soil fertility and ameliorate as required. - Revegetate with locally indigenous (to the site) grasses to stabilise the surface soils, until such time as an alternative sustainable land use is implemented. Monitor/remove alien invasive vegetative species. - Toe Paddocks and a Berm surrounding the feature must be established during construction, this in order to trap water / sediment. - Monitoring, maintenance, and repair work must be ongoing.	3	2	5	5	3	**45**	**N3**
						Significance	**N4 - High**								**N3 - Moderate**						

Impact 15:	Soil, Land Capability, and Land Use	Rehabilitation of Above Surface deposited Sand Tailings Dumps. Includes: A-1, A-2, A-3 complex, and 8B	Phase 2	Operational	The excessive height and slope will result in excessive soil erosion, thus also resulting in significant sedimentation of the surrounding area. Also poor soil properties (fertility & compaction), and droughty soil conditions. Consequently poor post-rehabilitation Land Capability (wilderness), and very limited future Land Use potential. Unacceptable proposed design due to: steep slopes (1:3 = 18.4° - terraced); excessive height above ground level (majority approximately 25-100m; recently potentially amended to maximum height of 50m); and limited Topsoil cover depth (30cm - orthic A-horizon). Note: Sand Tails Dumps 8B and A-2 are situated very close to the LOM boundary (thus also influencing Extent of Impact).	Negative	4	3	5	5	5	**85**	N5	- Current Significance assumes that the Sand Tailings dumps excessive heights (and number) remain as they are, but this will be recalculated in the future when the proposed dump heights are reduced. It is Recommended to significantly reduce both the height and number of planned dumps. - Current Significance also assumes that soil erosion is reduced by re-grading side slopes to ideally ≤1:7 (8 °) [but not more than 1:5 (11.3°)]. Terracing is optional if side slopes are so reduced by correct reshaping. Slopes must definitely be reduced as specified, from the proposed 1:3 (18.4° - terraced). - Final rehabilitated profiles should ideally be whale-backed in shape. - Improve the post-rehabilitation land capability (to grazing) and future land use potential, by Topsoiling (final capping) with 150cm (minimum) of the originally stripped / stockpiled Subsoils; and - Place a 30cm layer of previously stockpiled Topsoil (orthic A-horizon) over this Subsoil layer. - Topsoiling operation conducted utilising tracked (rather than wheeled) machinery and also utilise dedicated traffic routes, this in order to limit soil compaction. - Analyse soil fertility and ameliorate as required. - Initially Revegetate with locally indigenous (to the site) grasses to stabilise the surface soils, until such time as an alternative sustainable land use is determined / implemented. Monitor/remove alien invasive vegetative species. - Toe Paddocks (and outer Berm) surrounding these features must be established during construction, this in order to trap water / sediment. - Monitoring, maintenance, and repair work must be ongoing throughout LOM.	4	2	5	5	4	**64**	N4
						Significance	**N5 - Very High**									**N4 - High**						
Impact 16:	Hydropedology & Hydrology	Rehabilitation of Above Surface deposited Fines. RSF 9	Phase 2	Operational	After Rehabilitation, the Recharge and Interflow (derived from rainfall) components will be reduced below the faculty compared with the pre-mining condition. This will be due to the following factors: - lower infiltration rate (slow to slow-moderate) within the deposited fines of the RSF; - runoff on the steep side-slopes; - evapotranspiration losses from established vegetation over the larger constructed surface area (as compared with that of the footprint) of the facility; and - evaporative losses due to wind flow exposure (due to being raised above surface). The phreatic line and thus hydraulic head will drop/reduce over time as the facility dries out. A reduced proportion of rainfall recharge will move downward through the facility, gradually entering the underlying soils, after which this moisture will reconnect with the original/existing hydropedological / hydrological flow pathways beneath the facility. Note: RSF 9 is situated very close to the LOM boundary (thus influencing Extent of Impact).	Negative	3	3	5	5	4	**64**	N4	- No mitigation is possible to provide the same pre-mining volume of moisture that will enter the underlying hydropedological / hydrological flow pathways. - Thus, a reduced volume of water is likely to report to the downslope wetlands. However, the previously recommended reduction of the side-slopes to ideally ≤1:7 (8 °) [but not more than 1:5 (11.3°)], will be beneficial to reducing rainfall runoff, thus encouraging infiltration.	3	3	5	5	4	**64**	N4
						Significance	**N4 - High**									**N4 - High**						
Impact 17:	Hydropedology & Hydrology	Rehabilitation of Above Surface deposited Sand Tailings dumps: A-1, A-2, A-3 complex, and 8B	Phase 2	Operational	Recharge and Interflow (derived from rainfall) will be significantly reduced below the sand dumps compared with the pre-mining condition. This is due to the following factors: - excessive extent / slope / height / volume leading to moisture being retained within the dumps and not all reporting as seepage at the base. -greatly increased evaporation from: high wind exposure (due to excessive dump heights); a larger surface area (as compared with that of the footprint); and bare surfaces caused by vegetation die-back on the internal droughty sandy material or on areas of surface erosion. -evapotranspiration losses from vegetated areas.	Negative	4	3	5	5	5	**85**	N5	No mitigation is possible to provide anything close to the pre-mining volume of moisture that will enter the underlying hydropedological / hydrological flow pathways. This is due to the excessive extent / height / volume / exposure of the sand dumps. Thus, a permanently reduced volume of water will report to the wetlands downslope, this situation only improving if the dump heights are significantly reduced. However, the previously recommended reduction of the side-slopes to ideally ≤1:7 (8 °) [but not more than 1:5 (11.3°)], is beneficial to reducing rainfall runoff, thus encouraging infiltration. Current Post-Mitigation Significance assumes that Dump slopes were already reduced (as specified) during Construction Phase. Note: Sand Tails Dump 8B and A-2 are situated very close to the LOM boundary, while all are bordered and/or disected by drainage channels [and A-2 and A-3 by perennial streams] (thus also influencing Extent of Impact).	3	3	5	5	5	**80**	N4
						Significance	**N5 - Very High**									**N4 - High**						

DECOMISSIONING AND CLOSURE: 2069 - 2071 (Nevertheless, Decommissioning related Rehabilitation operations will have already been taking place throughout the Life of Mine)

							Pre-Mitigation								Post-Mitigation						
Impact number	**Aspect**	**Feature**	**Phase**	**Project Stage**	**Impact Description**	**Character**	**(M+**	**E+**	**R+**	**D)x**	**P=**	**S**	**S Rating**		**(M+**	**E+**	**R+**	**D)x**	**P=**	**S**	**S Rating**
Impact 1:	Soil, Land Capability, and Land Use	Rehabilitation of backfilled RSF C mining cells (repurposed Mining Pit) [Note: other Mining Pits were already rehabilitated during the Operational Phase 2 - refer to Impact No. 12]	Phase 2	Decommissioning & Closure	Unacceptable soil erosion / depth due to proposed 1:3 (18.4°, terraced) side slopes and capping with 30cm of Topsoil (orthic A-horizon) only [directly overlying the sand capping proposed by the Mine for levelling and trafficability purposes]. Also poor soil properties (fertility, compaction). Consequently reduced Land Capability / Land Use potential, as compared with the pre-mining potential. Note: RSF C is situated very close to the LOM boundary (thus also influencing Extent of Impact).	Negative	3	3	5	5	5	**80**	**N4**	- Current Significance assumes that soil erosion is reduced by re-grading side slopes to ideally ≤1:7 (8 °) [but not more than 1:5 (11.3°)]. Terracing is optional if side slopes are so reduced by correct reshaping. Slopes must definitely be reduced as specified, from the proposed 1:3 (18.4° - terraced). - Final rehabilitated Pit profiles (repurposed RSF C) should be whale-backed in shape, with the apex height being raised to approximately 15m above the original ground level. This height may be increased provided that side-slopes are maintained at ≤1:7. - A Berm (and Toe Paddocks when the feature height exceeds ground level) surrounding the RSF must be established during rehabilitation, to trap sediment. - Improve land capability and land use potential by Topsoiling (capping) with a 150cm (minimum) Reconstituted 'soil' layer (mixing ratio: 33% Fines : 77% Sand); and - Place a 30cm layer of previously stockpiled Topsoil (orthic A-horizon) over this reconstituted layer. - Topsoiling operation conducted utilising tracked (rather than wheeled) machinery and also utilise dedicated traffic routes, this in order to limit soil compaction. - Wherever possible, practise rolling over rehabilitation topsoiling throughout the entire Life of Mine, where topsoil stripped in one area is immediately utilised to topsoil another area where deposition / backfilling has been completed.- Analyse soil fertility and ameliorate as required. - Initially Revegetate with locally indigenous (to the site) grasses to stabilise the surface soils, until such time as an alternative sustainable land use is implemented (e.g. *Euclayptus*). - Monitor/remove alien invasive vegetative species. - Monitoring, maintenance, and repair work must be ongoing. - SEQUENTIAL BACKFILLING & REHABILITATION: It is imperative that these operations continue throughout the Phase 2 Life of Mine (as described for Operational Phase 2 Impact 12).	3	2	3	5	3	**39**	**N3**
						Significance	**N4 - High**								**N3 - Moderate**						
Impact 2:	Hydropedology & Hydrology	Rehabilitation of backfilled RSF C mining cells (repurposed Mining Pit) [Note: other Mining Pits were already rehabilitated during the Operational phase]	Phase 2	Decommissioning & Closure	Reduced vol. of infiltrated water reporting to the base of the Pit (vs. that pre-disturbance) due to: increased surface area (raised above surface) vs. that of the footprint, thus higher evapotranspiration losses from vegetation / wind. The Recharge and Interflow (derived from rainfall) flow pathways will vary within the RSF, based upon the grade of material utilised for backfilling as follows: - Fines grades sections. Interflow will dominate close to the surface on top of the fines grades (probable slow-mod infiltration rate in the dry state), a greater proportion of this moisture moving laterally downslope to the previous Pit edge, until encountering the surrounding Recharge (deep) soils whereafter this moisture will move vertically downwards. However, a Recharge (slow) component will also exist within the Fines grades; - Sand grades (internal starter walls, now buried) sections. Moisture will move rapidly downward as Recharge, thereafter reconnecting with the underlying existing moisture flow pathways.	Negative	3	3	5	5	4	**64**	**N4**	Implement all Rehabilitation Mitigation Measures, as specified for Impact 1 above. This will ensure that hydropedological / hydrological moisture flow pathways (although largely altered) underlying the site will be re-established post-rehabilitation . However, no mitigation is possible to ensure the volumes of sub-surface water moving as Recharge versus Interflow will be replicated. It is likely that only a slightly reduced volume (post-mitigation vs. pre-mitigation) of water will report to the downslope wetlands and streams from RSF C. This because infiltrating water will still migrate to the most low-lying slope positions due to gravitational action.	3	3	3	5	3	**42**	**N3**
						Significance	**N4 - High**								**N3 - Moderate**						

Impact 3:	Soil, Land Capability, and Land Use	Rehabilitation of PWP	Phase 2	Decommissioning & Closure	Unacceptable soil erosion / depth, and poor soil properties (fertility / compaction). Only slightly reduced Land Capability / Land Use potential, as compared with the pre-disturbance condition. Such an occurrence would be due to failure (*albeit* partial) to conduct the following site rehabilitation procedures correctly, including: - non-removal of all rubble, scrap, impermeable surfaces (tar and paving), wastes, and potentially contaminated soils from site, for proper disposal. - non-achievale of correct PWP footprint reshaping, in order to be free draining and to tie into the surrounding topography, with final slopes of <u>≤1:7 (8°)</u>, also including the closing in of established clean and dirty water drains., and - failure to replace all of the previously stripped Topsoils (30cm) and Subsoils (additional 150cm) over the reshaped area.	Negative	**3**	**2**	**5**	**5**	**3**	**45**	**N3**	- Demolish all infrastructure and associated foundations, concrete pads, tarred surfaces / paving; and remove rubble, scrap, waste material, and any potentially contaminated surface soils from site. - Close in the clean and dirty water drains, utilising the soil berms immediately upslope (this being the material excavated during their construction). - Reshape the associated Return Water Dam, remove contaminated sediments / soil, re-grade (re-shape) to slope <u>≤1:7 (8°)</u>, topsoil with soils removed during construction (Subsoils overlaid by Topsoil), ameliorate fertility, and re-vegetate. - Re-grade (re-slope) the PWP footprint area to be free draining and to approximate the topography of the surrounding area (considering shape, and <u>slope ≤1:7 (8°)</u>, before topsoiling). - Replace 150cm (minimum) of the originally stripped and stockpiled Subsoils over the reshaped area. - Then replace a 30cm layer of previously stockpiled Topsoil over this Subsoil layer. - Topsoil operation conducted utilising tracked (rather than wheeled) machinery and also utilise dedicated traffic routes, this in order to limit soil compaction. - Analyse soil fertility and ameliorate as required. - Initially Revegetate <u>only with locally indigenous (to the site) grasses</u> to stabilise the surface soils, until such time as the selected sustainable land use is implemented (e.g. *Eucalyptus*). - Monitor/remove alien invasive vegetative species.	2	1	3	2	2	**16**	**N2**
						Significance	**N3 - Moderate**								**N2 - Low**						
Impact 4:	Hydropedology and Hydrology	Rehabilitation of PWP	Phase 2	Decommissioning & Closure	Non-achieval of close to the pre-disturbance Hydropedological / Hydrological moisture flow pathways / water volume beneath the rehabilitated PWP site, due to failure to rehabilitate correctly.	Negative	3	2	3	5	3	**39**	**N3**	- Implement all Mitigation Measures, as specified for Impact 3 above. This will ensure that the pre-disturbance hydropedological / hydrological moisture flow pathways underlying the site will be largely re-established post-rehabilitation.	1	2	3	2	3	**24**	**N2**
						Significance	**N3 - Moderate**								**N2 - Low**						

POST CLOSURE

Impact number	Aspects	Feature	Phase	Project Stage	Impact Description	Character	Pre-Mitigation							Mitigation Measures	Post-Mitigation						
							(M+	E+	R+	D)x	P=	S	Rating		(M+	E+	R+	D)x	P=	S	Rating
Impact 1:	Soils, Land Capability, Land Use, and Hydropedology	Whole Mine site	Post Closure	Post closure	Failure to achieve pre-defined closure objectives, and Tronox's Key Aims as follows: - safe and healthy post-mining environment, - economically viable and sustainable post-mining land use, - limited residual environmental Impacts, and - optimal post-mining social opportunities. Note: Mining Pits (Sand Tailings), RSF C and 9, and Sand Tails Dumps 8B and A-2 are all situated very close to the LOM boundary (thus also influencing Extent of Impact).	Negative	3	3	5	5	3	**48**	N3	Implement post closure monitoring and maintenance programmes that should be continued until such time as all rehabilitated areas / facilities are demonstrated to be stable, non-erosive, non-polluting and sustainable in the long term (after Closure). Adaptive management practices may need to be implemented to ensure that all predefined Closure objectives have been achieved.	3	2	3	3	3	**33**	N3
						Significance	**N3 - Moderate**								**N3 - Moderate**						
NOTE 1: Site Establishment (Construction) / Operational / Decommissioning (Closure) / Post-Closure Phases														IMPLEMENT ALL MITIGATION MEASURES as specified for all Stages of the Project, as previously indicated in the Table above (too numerous to duplicate here). In particular, failure to fully implement the recommended Mitigation Measures (for ALL post-mining Rehabilitated features) relating to the following: - <u>reduction of all final slopes</u> (conducted during re-grading / re-sloping operations during rehabilitation) to ideally ≤1:7 (8 °) [but not more than 1:5 (11.3°)]. Slopes must definitely be reduced as specified, from the proposed 1:3 (18.4° - terraced); and - <u>Topsoiling Depths / Soil Types</u> as specified (conducted during topsoiling operations); will disqualify the current Post-Mitigation Significance Rating, thereby rendering the current derived Rating as totally incorrect.							
NOTE 2: Final End Land Capability and Land Use (Post-Rehabilitation) [mostly related to Final End Slope, and Topsoiling Depth]. **Applies equally to the Mitigation Measures for all of the following Impacts:** **- Operational Phase 2 - Impacts 12, 14, & 15;** **- Decommissioning / Closure Phase - Impacts 1 - 3:** **- Post-Closure - Impact 1; and** **- Cumulative - Impacts 1 - 4.** **Further information is provided in Section 11.7 (Final End Land Capability & Land Use - Based on Slope) of the Report Document.**														**FINAL END SLOPE: <= 1:7 (8°)**. Applicable to the following features: top zones (more level) of rehabilitated RSF's, Mining Pits, and Sand Tailings Dumps; as well as lower side-slopes with the same grade (if any, but recommended as ideal). **Final End Land Capability** (as per latest Mining Rehabilitation guidelines): Arable. This Land Capability assumes that the topsoiling depth/type and final side-slope recommendations are precisely followed. **Final End Land Use**: cover crops, sugar cane, commercial timber (e.g. *Eucalyptus*), "locally" indigenous grassland (refer to Report Document Section 11.6 for explanation), or "locally" indigenous bush (all options are suitable). Options also exist for the planting of vegetables (local communities) on most of these sites; plus demanding species such as tree crops (nuts or citrus) [local communities or farmers] on certain high potential sites. **FINAL END SLOPE: 1:7 (8°) - 1:5 (11.3°) [steeper than 1:7]**. Possibly applicable to the side-slopes (steeper than top zones) of the following features: rehabilitated RSF's, Mining Pits, and Sand Tailings Dumps. **Final End Land Capability**: Grazing. This Land Capability also assumes that the topsoiling depth/type and final side-slope recommendations are precisely followed. **Final End Land Use**: Initially stabilise the slope with "locally" (to the immediate surrounds) indigenous grasses. Thereafter establish a dense stand of commercial timber (e.g. *Eucalyptus*) along the contour, or alternatively "locally" (to the immediate surrounds) indigenous bush. *Eucalyptus* trees may have already previously been planted on these slopes during the Operational Phase (e.g. to hasten the drying out of the hydraulically deposited material). Grassland is not recommended due to soil erosion risks related to slope, low basal cover, cattle overgrazing, and the risk of wildfire. **FINAL END SLOPE >1:5 (11.3°) [Not Recommended] - 1:3 (18.4°) [Particularly Unacceptable]**. Applies to moderately steep side-slopes , if these are not re-graded (re-sloped) correctly, as specified in the recommendations. **Final End Land Capability**: Wilderness. **Final End Land Use**: No sustainable end agricultural land use is feasible, except for "locally" Indigenous bush (not "locally" indigenous grassland).							

CUMULATIVE

Impact number	Aspect	Feature	Phase	Project Stage	Impact Description	Character	Pre-Mitigation								Post-Mitigation						
							(M+	E+	R+	D)x	P=	S	S		(M+	E+	R+	D)x	P=	S	
Impact 1:	Soils	All Mineral Sand Mines (previous, existing, and proposed) in the immediate Region.		Cumulative	Loss of post-rehabilitation Soil Quality due to the following factors: - loss of soil depth / volume due to **understripping / stockpiling / replacement** of Topsoils (orthic A-horizon) and Subsoils (most suitable: red apedal, yellow-brown apedal, neocutanic, and E-horizon soils where the E is yellow in the dry state; as well as less suitable types where encountered in other areas); - increased Soil Erosion due to post-mining slopes exceeding 1:7 (8 °) or 1:5 (11.3°) in certain areas (Residue Storage Facilities, and Sand Tailings Dumps), potentially resulting in sedimentation of drainage lines / wetlands / associated indigenous bush areas; - reduced Soil Fertility mostly due to the non-replacement of Topsoil (orthic A-horizon) on the immediate surface during rehabilitation; - increased soil compaction, and; - potential soil pollution.	negative	4	3	5	5	5	**85**	N5	IMPLEMENT ALL MITIGATION MEASURES as specified for all Stages of the Project, as previously indicated in the Table above (too numerous to duplicate here). In particular, failure to fully implement the recommended Mitigation Measures (for ALL post-mining Rehabilitated features) relating to the following: <u>- reduction of all final slopes</u> (conducted during re-grading / re-sloping operations during rehabilitation) to ideally ≤1:7 (8 °) [but not more than 1:5 (11.3°)]. Slopes must definitely be reduced as specified, from the proposed 1:3 (18.4° - terraced) [but not necessarily applicable to sand dunes on the immediate coast line]; and - <u>Topsoiling Depths / Soil Types as specified</u> (conducted during topsoiling operations); will disqualify the current Post-Mitigation Significance Rating, thereby rendering the current derived Rating as totally incorrect.	3	3	3	5	3	**42**	**N3**
						Significance	N5 - Very High								N3 - Moderate						
Impact 2:	Land Capability	All Mineral Sand Mines (previous, existing, and proposed) in the immediate Region.		Cumulative	Reduced post-rehabilitation Land Capability class / potential, due to the following factors: - reduced soil depth (major contributor); - excessive slopes exceeding 1:7 (8°) or 1:5 (11.3°) (major contributor at Residue Storage Facility and Sand Tailings Dump sites); - reduced soil fertility; - increased soil compaction, and; - potential soil pollution.	negative	4	3	5	5	5	**85**	N5	IMPLEMENT ALL MITIGATION MEASURES as specified for all Stages of the Project, as previously indicated in the Table above (too numerous to duplicate here). In particular, failure to fully implement the recommended Mitigation Measures (for ALL post-mining Rehabilitated features) relating to the following: <u>- reduction of all final slopes</u> (conducted during re-grading / re-sloping operations during rehabilitation) to ideally ≤1:7 (8 °) [but not more than 1:5 (11.3°)]. Slopes must definitely be reduced as specified, from the proposed 1:3 (18.4° - terraced) [but not necessarily applicable to sand dunes on the immediate coast line]; and - <u>Topsoiling Depths / Soil Types as specified</u> (conducted during topsoiling operations); will disqualify the current Post-Mitigation Significance Rating, thereby rendering the current derived Rating as totally incorrect.	3	3	3	5	4	**56**	**N3**
						Significance	N5 - Very High								N3 - Moderate						

Impact 3:	Land Use	All Mineral Sand Mines (previous, existing, and proposed) in the immediate Region.		Cumulative	- Reduced post-rehabilitation Land Use (agricultural) Potential due the Impacts to the Soils and Land Capability (as described for Impacts 1 and 2). - Incompatibility between pre-mining (on generally high potential soils / landscapes) and post-mining (on lowered potential soils / landscapes) land uses, resulting in the non-suitability of many rehabilitated sites for the cultivation of demanding crops such as citrus trees (and other). Nevertheless, timber and sugar can may still be planted on most rehabilitated sites, *albeit* with a lower yield potential. - Loss of Indigenous Bush in certain areas. - Increased potential for the intrusion of alien invasive species in disturbed areas. - Permanently changed landscapes in areas occupied by Residue Storage Facilities and Sand Tailings Dumps.	negative	4	3	5	5	5	**85**	N5	IMPLEMENT ALL MITIGATION MEASURES as specified for all Stages of the Project, as previously indicated in the Table above (too numerous to duplicate here). In particular, failure to fully implement the recommended Mitigation Measures (for ALL post-mining Rehabilitated features) relating to the following: <u>- reduction of all final slopes</u> (conducted during re-grading / re-sloping operations during rehabilitation) to ideally ≤1:7 (8 °) [but not more than 1:5 (11.3°)]. Slopes must definitely be reduced as specified, from the proposed 1:3 (18.4° - terraced) [but not necessarily applicable to sand dunes on the immediate coast line]; and - <u>Topsoiling Depths / Soil Types as specified</u> (conducted during topsoiling operations); will disqualify the current Post-Mitigation Significance Rating, thereby rendering the current derived Rating as totally incorrect.	3	3	3	5	4	**56**	N3
						Significance	N5 - Very High								N3 - Moderate						
Impact 4:	Hydropedology	All Mineral Sand Mines (previous, existing, and proposed) in the immediate Region.		Cumulative	- Altered post-rehabilitation Hydropedological Soil Types, due to their previous destruction during the course of mining related operations. - Differential (pre- versus post-rehabilitation) volumes of water flowing into the downslope wetlands / streams, via either the groundwater (derived from recharge) or interflow pathways. - Reduced volume of water-make to the downslope wetlands / streams. This is due to increased evapotranspiration losses from the raised (above surface) rehabilitated mining features (increased surface area and wind exposure). - Resultant changes to ground (groundwater table and interflow) and surface water (streams within Project area) regimes in terms of volume (reduced) and quality (sedimentation and potential soil pollution). - Potential degradation (reduced water volume / quality) of downstream Functional Zones (with associated potential Impacts to the fauna and flora).	negative	4	3	5	5	4	**68**	N4	IMPLEMENT ALL MITIGATION MEASURES as specified for all Stages of the Project, as previously indicated in the Table above (too numerous to duplicate here). In particular, failure to fully implement the recommended Mitigation Measures (for ALL post-mining Rehabilitated features) relating to the following: <u>- reduction of all final slopes</u> (conducted during re-grading / re-sloping operations during rehabilitation) to ideally ≤1:7 (8 °) [but not more than 1:5 (11.3°)]. Slopes must definitely be reduced as specified, from the proposed 1:3 (18.4° - terraced) [but not necessarily applicable to sand dunes on the immediate coast line]; and - <u>Topsoiling Depths / Soil Types as specified</u> (conducted during topsoiling operations); will disqualify the current Post-Mitigation Significance Rating, thereby rendering the current derived Rating as totally incorrect.	3	3	3	5	4	**56**	N3
						Significance	N4 - High								N3 - Moderate						

ASSUMPTIONS REGARDING METHODOLOGY UTILISED FOR CALCULATING RATING SCORES IN CURRENT IMPACT SIGNIFICANCE TABLE:

"PRE-MITIGATION" vs. "POST-MITIGATION": Magnitude, Extent, Reversibility, Duration, and Probability.
The various Rating Scores have strictly followed the consequences of the "Pre-Mitigation" versus "Post-Mitigation" periods. These Rating Scores reflect the Mitigation Measures which have either not ("Pre-Mitigation"), or already have ("Post-Mitigation") taken place. Thus the "Pre-Mitigation" Impact Significance Rating has therefore been assessed <u>without</u> the proposed design controls in place. If not so conducted, then this procedure would present an unreasonable expectation of the various Aspect Impact Significances ('Pre-Mitigation"), to the Mine / Interested and Affected Parties / Authorities.

EXTENT.
Rating Scores: 1 (Site Feature footprint only); 2 (inside Activity Area = inside Life of Mine boundary); and 3 (outside Activity Area = outside LOM boundary). **Based upon DEAT, 1988 (as is the current WSP procedure).**

Extents of Impacts: Given that: Mining Pits (all, also including the later re-purposed RSF C) / RSF 9 / Sand Tailings sites 8B and A-2; are all situated very close to the LOM boundary; the Extent of numerous Impacts have been rated as 3 (usually pre-mitigation, and occasionally also post-mitigation).

Compiled by: B.B.McLeroth (Red Earth cc); in collaboration with Dr. Mark Aken. January 2025. Updated 12 February 2015.
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FIGURES:

Various figures were compiled with reference to clipped sections of the following available mapping information, the sourced information thereafter being further processed:

Site Location:

Location of Study Area - Topographical (source: latest 1:50000 Topographical sheets 2831DC and DD, and 2832CC); and

Location of Study Area - Open Street Map (source Google - Open Street Map).

Soil Survey:

Base Map: Aerial Photography (source: Chief Directorate of Survey and Mapping, 2022; and

Contours (5m) (source:Chief Directorate of Survey and Mapping, 2022).

Hydropedology Study:

Soils and Site Type Maps (Stockpile 8 - B.B.McLeroth, 2024 - current survey);

Site Types Map (Port Durnford Plantation - Snyman, 2008 - previous survey);

Elevation (m) amsl (source: Chief Directorate of Survey and Mapping, 2022; Mapping Program utilised: ArcMap 10.3);

Slope Classes (source: 5m contours from Chief Directorate of Survey and Mapping, 2022. Mapping Program utilised: ArcMap 10.3);

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Soils: Snyman, K. March 2008. Port Durnford Pre-Feasibility Mining Study Report on the Soils, Sites, Land Capability and Land Use. Produced for Exxaro KZN Sands. By Keith Snyman & Associates. 202 Pages.

APPENDIX I. SOIL PROFILE DESCRIPTIONS (STOCKPILE 8)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
OBSERVATION NUMBER	HORIZON	DEPTH (cm)	CLAY (%) [Estimate]	SAND GRADE (Estimate]	COLOUR	MUNSELL COLOUR	SAPROLITE WEATHERING	STRUCTURE	WETNESS HAZARD	CULTURAL FACTORS	CONSISTENCY	SOIL FORM	SURFACE FEATURES	CARBON CONTENT	EFFECTIVE ROOTING DEPTH (cm) ERD (SOIL)	AMELIORATED ERD (SOIL)	ERD (SOIL + SAPROLITE)	DEPTH LIMITING MATERIAL (DLM)	LITHOLOGY SOIL	REMARKS	LAND CAPABILITY; and WETLANDS	VEGETATION	Approximate Slope (degrees) [Estimated]
A5	A	30	30	m	G	10YR 5/1		wb				Gs	s1	h	30		50	lc	T1		L	Eucalyptus plantation	8
	BL	61	30	m	ARY	7.5YR 6/6	m	wb			f												
A6	A	50	20	m	DG	10YR 4/1		a	w1			We - Tu		vh	50			sp/e/gc,so	R1/C		Ws	Eucalyptus	6
	B	100	30	m	MPB	10YR 6/3		a	w1														
	E	130	6	m	MIG	10YR 7/2		sg	w2														
	G,C	181	50	m	MAGB	10YR 5/2		m	w2		f												
B4	A	40	25	m	B	10YR 5/3		a				Cv		h	60			r	T1		G	Eucalyptus	4
	B	60	40	m	YB	10YR5/4		a															
	R	60																					
B5	A	20	12	m	RB	5YR 4/3		sg - a				Hu		m	181				Bs/Bc		G slope	Eucalyptus	12
	B	100	16	m	RB	2.5YR 4/6		sg - a															
	B	181	50	m	DRB	2.5YR 3/4		wb			f												
B6	A	30	12	m	B	7.5YR 5/4		sg				'Bd'		m	140	160	190	e/so	Bs/T1	C: Soil like Sprolite (highly weathered)	G slope	Eucalyptus	5
	B	140	14	m	RB	5YR 5/4		sg															
	'E'	160	6	m	PB	10YR 6/3		sg	w1														
	C	181	50	m	MAR	2.5YR 4/4	h	wb	w1		f												
C4	A	45	30	m	B	7.5YR 4/2		a				Hu - Gf		vh	181				T1/Bc	Almost humic	G slope	Eucalyptus	8
	B	80	40	m	RB	5YR 4/4		a															
	B	181	50	m	DRB	2.5YR 3/4		wb			f												
C5	A	45	25	m	B	7.5YR 4/2		a				Hu		mh	181				T1/Bc		A	Eucalyptus	4
	B	110	35	m	RB	2.5YR 3/4		a															
	B	181	55	m	DRB	2.5YR 3/4		wb			f												
C6	A	30	14	m	B	7.5YR 4/2		a - sg				Hu		m	181				Bs/Bc		A	Eucalyptus	6
	B	110	16	m	RB	5YR 4/4		a															
	B	181	50	m	DRB	2.5YR 3/4		wb			f												
C7	A	30	12	m	B	7.5YR 5/4		sg				Hu		m	181				Bs/Bc		A	Eucalyptus	2-4
	B	150	16	m	RB	5YR 4/4		a - sg															
	B	181	30	m	DRB	2.5YR 3/4		a															

OBSERVATION NUMBER	HORIZON	DEPTH (cm)	CLAY (%) [Estimate]	SAND GRADE (Estimate)	COLOUR	MUNSELL COLOUR	SAPROLITE WEATHERING	STRUCTURE	WETNESS HAZARD	CULTURAL FACTORS	CONSISTENCY	SOIL FORM	SURFACE FEATURES	CARBON CONTENT	EFFECTIVE ROOTING DEPTH (cm) ERD (SOIL)	AMELIORATED ERD (SOIL)	ERD (SOIL + SAPROLITE)	DEPTH LIMITING MATERIAL (DLM)	LITHOLOGY SOIL	REMARKS	LAND CAPABILITY; and WETLANDS	VEGETATION	Approximate Slope (degrees) [Estimated]
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
D3	A	30	25	m	GB	10YR 5/2		wb		s2g2		Gs	<s1	h	20		40	lc	T1,T2,E, D1	Quartz stones on surface. Rare dolerite fragments on surface (vicinity of thrust fault)	L	Eucalyptus	4
	BL	61	40	m	ARB	5YR 4/4	m	wb		g3	f												
D4	A	40	25	f	DB	7.5YR 3/2		a				Hu		m	150		180	so	T1,D1		A	Eucalyptus	4
	B	80	45	f	RB	5YR 3/2		a															
	B	150	50	f	R	2.5YR 4/6		wb			f												
	C	181	40	f	R	2.5YR 4/6	h	wb			f												
D5	A	30	17	m	B	10YR 4/3		a				Hu - Gf		h	100			r	T1/Bc	SOIL SAMPLE: A-horizon (0-5cm) and B-horizon (50cm). Clay A: 17%, clay B: 49%	G Slope	Eucalyptus	12
	B	60	49	m	RB	5YR 4/4		a															
	B	100	55	m	R	2.5YR 4/6		wb			f												
	R	100																					
D6	A	30	16	m	RB	5YR 5/3		a				Hu		m	160			r	T1/Bc		A	Eucalyptus	6
	B	90	25	m	RB	2,5YR 4/4		a															
	B	160	55	f	R	2.5YR 4/6		wb			f												
	R	160																					
D7	A	50	16	m	B	10YR 4/3		a				Cv - Gf		h	70			sl	T1,T2	Probably red below quartz StoneLine	G	Eucalyptus	12
	B	70	25	m	B	7.5YR 4/4		a															
	SL	71																					
D8	B	30	14	m	MDGB	10YR 4/2		sg	w2			We	g1	vh	30			sp/gc	C,A/ C	Moist 30cm, Wet 100cm	Ws	Grass, Buffalo grass	2/4
	R	120	35	m	MDG	10YR 4/1		a	w2														
	G	151	50	m	G	10YR 5/1		m	w3														
E2	A	20	35	m	B	10YR 4/3		a		g2		Gs	<s1	h	20		35	gl/lc	G2	Gneiss parent material areas (Glenrosa soil form) - always display angular quartz stones (surface and profile)	L	Eucalyptus	6
	GL	30	35	m	AB	10YR 5/3		a		s2g3													
	BL	61	35	m	AR	2.5YR 4/6	m	wb		g2													
E3	A	30	40	m	DB	7.5YR 4/3		wb		s2g3		Gs	s2	h	15		35	lc	G2		L	Eucalyptus	20
	BL	51	50	m	ARY	7.5YR 6/6	m	wb		g4													
E4	A	30	25	m	DGB	10YR 4/2		a		s3		Gs	<s1	vh	25		50	lc	T1		L	Eucalyptus	6
	BL	61	35	m	ARB	5YR 4/4	m	wb		g2													
E5	A	40	40	m	B	7.5YR 4/3		a		s g2		Gs	<s1	h	30		60	lc	G2		L	Eucalyptus	12
	BL	81	50	m	AYR	5YR 4/6	m	wb		g1	f												
E6	A	35	25	m	B	7.5YR 4/3		a				Hu		mh	181				T1/Bc		A	Eucalyptus	6
	B	70	40	m	RB	5YR 4/4		a															
	B	181	50	m	R	2.5YR 4/6		wb			f												

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
OBSERVATION NUMBER	HORIZON	DEPTH (cm)	CLAY (%) [Estimate]	SAND GRADE [Estimate]	COLOUR	MUNSELL COLOUR	SAPROLITE WEATHERING	STRUCTURE	WETNESS HAZARD	CULTURAL FACTORS	CONSISTENCY	SOIL FORM	SURFACE FEATURES	CARBON CONTENT	EFFECTIVE ROOTING DEPTH (cm) ERD (SOIL)	AMELIORATED ERD (SOIL)	ERD (SOIL + SAPROLITE)	DEPTH LIMITING MATERIAL (DLM)	LITHOLOGY SOIL	REMARKS	LAND CAPABILITY; and WETLANDS	VEGETATION	Approximate Slope (degrees) [Estimated]
E7	A	20	25	m	B	10YR 4/3		a		s1		Gs		h	20		40	sl/so	T1,T2	Sandstone, Quartzite parent material areas (Glenrosa form) - always display angular quartz fragments, sandstone, and occasional river rounded sandstone (red) stones	L	Eucalyptus	16
	SL	40	25	m	B	10YR 4/3		a		s4													
	C	51	40	m	ARB	5YR 4/4	m	wb															
E8	A	50	16	m	B	7.5YR 4/2		a				Hu		mh	130		160	so	T1		G slope	Eucalyptus	12
	B	130	50	m	RB	5YR 4/4		wb			f												
	C	151	40	m	ARB	5YR 4/4	h	wb															
E9	A	30	10	m	MDGB	10YR 4/2		sg	w1			We		vh	30		160	sp	C,T1		Ws	Buffalo Grass	4/8
	B	61	35	m	MDG	10YR 4/1		a	w2														
E10	A	30	30	f	B	10YR 5/3		sg				'Tu'		mh	110	170		e=uw /sp	R1		A	Eucalyptus	6
	B	110	8	f	AIYB	10YR 6/4		sg															
	'E'	170	6	m	VPB	10YR 7/3		sg	w1														
	U	181	25	m	MVPB	10YR 7/3		a	w2														

F1	A	30	40	c	DB	10YR 3/3		wc		s1g2		Gs	S1	vh	20		40	lc	G2	SOIL SAMPLE: A-horizon (0-5cm): clay 40%	L	Eucalyptus	20
	BL	81	30	c	ARY	7.5YR 6/6	m			g3													
F2	A	20	40	c	RB	5YR 4/4		wb		s1g3		Gs	S1	h	20		40	lc	G2		L	Eucalyptus	18
	BL	51	30	c	ARY	7.5YR 6/6	m			g4													
F3	A	30	40	f	MDB	7.5YR 3/2		a	w1			We		vh	30			sp	C		Ws	Buffalo Grass	6
	B	61	50	f	MB	7.5YR 5/3		wb	w2		f												
F4	A	30	40	m	DB	7.5YR 3/2		a		s2g2		Gs	S2	h	20		40	lc,gl	G2		L	Eucalyptus	18
	BL	61	40	m	IB	7.5YR 6/4	m	a		s3g3													
F5	A	30	30	m	DGB	10YR 4/2		a		g1		Gs - Hu	<s1	vh	30		60	lc	T1,T2	Some river rounded sandstone pebbles	L	Eucalyptus	8
	BL	50	50	m	AYR	5YR 4/6	m	wb		g1													
	C	101	35	m	AYR	5YR 5/6	w			g1													
F6	A	20	25	f	GB	10YR 5/2		a		s1g2		Gs	<<s1	h	20		40	lc/r	T1,T2		L	Eucalyptus	16
	BL	60	35	f	AR	2.5YR 5/6	h	wb															
	R	60																					
F7	A	30	20	m	MVDG	10YR 3/1		a	w1			We - Tu		vh	30	50		sp/so	T1		Ws	Eucalyptus	8
	B	100	40	m	MB	7.5YR 4/3		wb	w2		f												
	C	121	50	m	MRB	5YR 4/4	m	wb	w2		f												
F8	A	20	12	m	GB	10YR 5/2		sg				Tu		m	50			uw/r	T1		Wt	Eucalyptus	5
	B	50	16	m	APB	10YR 6/3		a	w1														
	U	80	50	m	MB	7.5YR 5/4		wb	w2														
	R	80																					
F9	MA	40	50	f	AMRY	5YR 6/6		m			f	Wb/over buried Gs	<<s1	lm	70		70	lc	T1	Rare building rubble on surface, disturbed	RA	Eucalyptus	4
	A	70	8	m	IBG	10YR 6/2		sg															
	BL	151	55	f	AMRY	5YR 6/6	m	m	w1		f												
F10	A	20	8	m	SB	7.5YR 5/4		sg				Oa		m	181				R1		G slope	Eucalyptus	18
	B	120	8	m	AIB	7.5YR 6/4		sg															
	B	181	6	m	NG	7.5YR 7/2		sg	w1														

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
OBSERVATION NUMBER	HORIZON	DEPTH (cm)	CLAY (%) [Estimate]	SAND GRADE (Estimate)	COLOUR	MUNSELL COLOUR	SAPROLITE WEATHERING	STRUCTURE	WETNESS HAZARD	CULTURAL FACTORS	CONSISTENCY	SOIL FORM	SURFACE FEATURES	CARBON CONTENT	EFFECTIVE ROOTING DEPTH (cm) ERD (SOIL)	AMELIORATED ERD (SOIL)	ERD (SOIL + SAPROLITE)	DEPTH LIMITING MATERIAL (DLM)	LITHOLOGY SOIL	REMARKS	LAND CAPABILITY; and WETLANDS	VEGETATION	Approximate Slope (degrees) [Estimated]
G2	A	40	30	f	KR	2.5YR 3/2		a				Hu		m	100		130	so	T1		G slope	Buffalo grass	14
	B	100	50	f	DRB	2.5YR 3/4		wb			f												
	C	151	40	f	ARB	2.5YR 4/4	m	wb			vf												
G3	A	30	30	m	RB	5YR 4/3		a		g4		Hu		m	40		70	gl/so	T1		G slope	Eucalyptus	16
	B	50	40	m	DRB	2.5YR 3/4		a															
	C	81	30	m	R	2.5YR 4/6	m	wb			f												
G4	A	20	30	m	B	10YR 5/3		a				Gs	<<s1	h	20		35	sl,lc/so	T1,T2		L	Eucalyptus	14
	SL	40	35	m	B	10YR 5/3	w	a		s4 g1													
	C	101	50	m	R	2.5YR 4/6	h	wb			f												
G5	A	20	35	m	SB	7.5YR 5/6		a		s2 g2		Gs	s1	mh	15		35	lc,sl	T1,T2		L	Eucalyptus	14
	BL	51			DRB	2.5YR 3/4	m	wb			f												
G6	A	30	30	m	RB	5YR 4/4		a				Hu		mh	151				T1/Bc		A	Eucalyptus	14
	B	60	40	m	DRB	5YR 3/3		a															
	B	151	50	m	DRB	2.5YR 3/4		wb			f												
G7	A	15	30	m	MDGB	10YR 4/2		a	w2			Kd		vh	10			e/gc	C,A	Valley - bottom	Wp	'Buffalo' grass, Sedge	2
	E	60	16	m	MGB	10YR 5/2		sg	w2														
	G	91	55	m	DG	10YR 4/1		m	w3		vf												
G8	A	20	6	m	N	7.5YR7/3		sg				'Tu'		m	90	140		e=uw/so	R1/Bc	Note: Interflow (i.e. lateral flow) of moisture in loamy-sand 'E'-horizon, above clay-textured U-horizon	A	Eucalyptus	6
	B	90	10	m	B	7.5YR 5/4		a-sg															
	'E'	140	4	m	NG	7.5YR 7/2		sg	w2														
	U-C	181	55	f	MYR	5YR 4/6		m	w1		vf												
G9	A	20	6	m	B	7.5YR 5/4		sg				'Tu' - Oa		mh	100	181		e=uw	Bs		G slope	Eucalyptus	10
	B	100	8	m	ARB	5YR 5/4		sg															
	'E'	181	4	m	AN	7.5YR 7/3		sg	w1														
G10	A	20	7	m	RB	5YR 5/4		a -sg				'Bd'		m	130	170		e=uw/uw	Bs	SOIL SAMPLE: A-horizon (0-5cm) and B-horizon (50cm). Clay A: 7%, B: 6%	G slope	Eucalyptus	12
	B	130	6	m	RB	2.5YR 4/4		a-sg															
	'E'	170	6	m	N	5YR 7/3		sg	w1														
	U	181	20	m	MNG	5YR 7/2		a	w2														
G11	A	20	8	m	DRB	2.5YR 3/3		sg				Hu		m	181				Bs		G slope	Eucalyptus	20
	B	181	10	m	DRB	2.5YR 3/4		sg															
H2	A	20	25	m	B	7.5YR 5/3		a		s1 g2		Hu		m	60		90	so	T1/S1		A	Eucalyptus	6
	B	70	40	m	DRB	2.5YR 3/4		wb			f												
	C	121	30	m	R	2.5YR 4/6	m	wb			f												
H3	A	30	25	m	B	7.5YR 4/2		a				Cv - Hu		mh	55		80	gl/so	T1/S1		G slope	Eucalyptus	18
	B	55	40	m	B	7.5YR 4/3		wb		g6													
	GL	65	40	c	B	7.5YR 4/3		wb		s1 g2													
	C	121		m	R	2.5YR 4/6	m	wb			f												
H4	A	40	30	m	B	7.5YR 4/3		a				Hu - Gf		mh	151				T1/Bc		A	Eucalyptus	5
	B	80	40	m	RB	5YR 4/3		wb															
	B	151	50	m	R	2.5YR 4/6		wb			f												
H5	A	40	30	m	DRB	5YR 3/3		a				Gs	<s1	mh	40		55	lc	T1,T2	C is Soil like Saprolite. Stones: river rounded pebbles (red sandstone), and sandstone & quartzite	L	Eucalyptus	14
	BL	71	40	m	ADRB	2.5YR 3/4	h	wb		s2 g3													

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
OBSERVATION NUMBER	HORIZON	DEPTH (cm)	CLAY (%) [Estimate]	SAND GRADE (Estimate)	COLOUR	MUNSELL COLOUR	SAPROLITE WEATHERING	STRUCTURE	WETNESS HAZARD	CULTURAL FACTORS	CONSISTENCY	SOIL FORM	SURFACE FEATURES	CARBON CONTENT	EFFECTIVE ROOTING DEPTH (cm) ERD (SOIL)	AMELIORATED ERD (SOIL)	ERD (SOIL + SAPROLITE)	DEPTH LIMITING MATERIAL (DLM)	LITHOLOGY SOIL	REMARKS	LAND CAPABILITY; and WETLANDS	VEGETATION	Approximate Slope (degrees) [Estimated]
H6	A	30	18	m	AB	7.5YR 4/2		a				Oa		m	110		151	'so'	T1		A	Eucalyptus	5
	B	110	18	m	AB	7.5YR 4/2		a															
	C	151	50	m	ADRB	2.5YR 3/4	h	wb			f												
H7	A	30	14	m	VDGB	10YR 3/2		a-sg				'Tu'		h	140			uw-vp	T1		A	Eucalyptus	4/8
	B	140	18	m	AB	10YR 5/3		a															
	U	151	50	m	GB	10YR 5/2		wb	w2		f												
H8	A	20	8	f	N	7.5YR 7/3		sg				'Tu'		m	80	140		ud=so	R1/Bc	'E' displays interflow	A	Eucalyptus	10
	B	80	10	f	B	7.5YR 4/3		sg															
	'E'	140	4	f	NG	7.5YR 7/2		sg	w1														
	U-C	181	55	m	ADR	2.5YR 3/6		m	w1		f												
H9	A	30	6	f	RB	5YR 5/4		sg				Hu		m	181				Bs		G slope	Eucalyptus	8
	B	181	8	f	RB	5YR 5/4		sg															
H10	A	20	8	m	RB	5YR 4/4		sg				Hu		m	110	181			B/Bc		G slope	Eucalyptus	10
	B	110	12	m	DRB	2.5YR 3/4		sg															
	B	181	50	f	DRB	2.5YR 3/4		wb			f												
I3	A	30	40	f	MVDG	10YR 3/1		mb	w2		f	We	g2	vh	20			sp	C,A	Valley-bottom. Very narrow drainage channels	Ws	Indigenous bush	2/4
	B	61	40	f	MDG	10YR 4/1		wb	w2														
I4	A	30	10	f	B	10YR 5/3		sg				'Tu' - Gf		mh	100	151		vp	R1/Bc	Rain-water perching on U (some mottling)	A	Eucalyptus	4
	B	100	12	f	IB	7.5YR 6/4		a-sg															
	U	151	45	m	MDR	2.5YR 3/6		wb-mb	w1		f												
I5	A	30	14	f	DGB	10YR 4/2		sg	w1			We		vh	30			sp/e/uw/gc	C,A	Wet 90cm	Ws	Sedge, Grass	2
	B	60	25	f	MG	10YR 5/1		wb	w2														
	'E'	90	6	f	W	10YR 8/1		sg	w2														
	U	130	8	f	G	10YR 5/1		a-sg	w2														
	G	151	45	m	G	10YR 5/1		m	w3		f												
I6	A	20	12	f	IB	7.5YR 6/4		sgt				'Tu'		mh	120	181		e=uw	R1		G slope	Eucalyptus	16
	B	120	18	f	AIB	7.5YR 6/4		a															
	'E'	151	10	f	N	7.5YR 7/3		sg	w1														
I7	A	20	8	f	RB	5YR 5/4		sg				Hu		m	181				Bs/Bc		G slope	Eucalyptus	12
	B	80	18	f	RB	2.5YR 4/4		a															
	B	181	40	m	DRB	2.5YR2. 5/4		wb			f												
I8	A	20	10	f	IRB	5YR 6/4		sg				Hu		m	160	181		ud	Bs/Bc		G slope	Eucalyptus	10
	B	160	12	f	DRB	5YR 3/4		sg															
	U	181	50	m	DR	2.5YR 3/6		wb			f												
J4	A	40	14	f	GB	10YR 5/2		a-sg				Oa - Tu		mh	90		120	so=vp	R1/Bc	C: Soil like Saprolite	A	Eucalyptus	2
	B	90	14	f	IB	7.5YR 6/3		a															
	C	151	40	m	AMRB	2.5YR 4/4	m	wb	w1		f												
J5	A	40	12	f	AIB	7.5YR 6/3		a-sg				Tu		h	80	120	120	uw/so	R1/Bc/T1	C: Soil like Saprolite	G slope	Eucalyptus	8
	B	80	20	f	AB	7.5YR 4/3		a															
	U	120	40	m	MB	7.5YR 5/4		wb	w2		f												
	C	151	45	m	MRB	2.5YR 4/4	h	m	w1		f												
J6	A	10	10	f	IB	7.5YR 6/4		a-sg				'Bd'		m	90	181		e=uw	Bs		G slope	Eucalyptus	8
	B	90	18	f	RB	5YR 5/4		sg-a															
	'E'	181	6	f	N	7.5YR 7/3		sg	w1														

APPENDIX II. CODES TO SOIL PROFILE DESCRIPTIONS

HORIZON	
OB	Overburden
O	O-horizon
A	A-horizon
E	E-horizon
B	B-horizon
G	G-horizon
BL	*B-horizon (Lithocutanic)*
C	C-horizon
U	Unconsolitated /
	Unspecified material
R	hard rock
SL	stoneline (includes
	stone and rock lines)
GL	*gravel line (lithic gravel)*
GLc	*gravel line (concretions)*
MA	man-made soil horizon

SAND GRADE	
f	fine
m	medium
c	coarse

SOIL COLOUR	
R	red
Y	yellow
B	brown

SAPROLITE WEATHERING	
w	*weakly (add ERD 10cm)*
m	*moderatey (add ERD 30cm)*
h	*highly [soil like] (add ERD 60cm).*

STRUCTURE (TYPE & GRADE)	
sg	single grain (non-coherent)
a	apedal (coherent)
wb	weak blocky (indistinct peds, some unaggregated material)
mb	moderate blocky (distinct peds, little unaggregated material)
sb	strong blocky (very discrets peds, no unaggregated material)
wc	weak crumb (as for mb)
mc	moderate crumb (as for mb)
sc	strong crumb (as for sb)
m	massive (dense)

WETNESS HAZARD	
w1	short periods (mottles on good background colour)
w2	long periods (mottles on poor background colour)
w3	almost year round (gleyed colours throughout, dark colours,
	channel oxidation)

CULTURAL PRACTISES (FACTORS AFFECTING)	
g	gravel
s	*stones*
r	rocks
b	boulders

SOIL FORM	
As per standard abbreviations.	
Hu	*Hu only*
Hu-Gf	*Hu - transitional to Gf*
Hu(Gf)	*Hu (occasional Gf)*

SURFACE FEATURES	
s	*stones*
r	rocks
b	boulders
o	outcrops
e	sheet erosion
g	gullies
d	dongas
c	*surface capping (previously 's')*
t	*precipitated salt efflorescences*
suffix 1 - 9 denotes 10% - 90% of	
surface area coverage	

ORGANIC CARBON CONTENT	
l	low (<0.3%)
lm	low to medium (0.3-0.6%)
m	medium (0.6-1%)
mh	medium to high (1-1.4%)
h	high (1.4-<1.8%)
vh	very high (1.8-3%)
eh	extremely high (>3%)

DEPTH LIMITING MATERIAL	
so	weathering rock/saprolite
lc	lithocutanic horizon
r	hard rock
gl	gravel or concretion layer
sl	stoneline
sp	soft plinthite
hp	hard plinthite
e	E-horizon
gc	gleyed material
ne	limiting neocutanic material
vp	non-red structured horizon
vr	red structured horizon
uw	unconsolidated / unspecified
	material with signs of wetness
ud	unconsolidated / unspecified
	material without signs of wetness
c	compaction
h	hardsetting horizon
ve	limiting vertic horizon
pr	prismacutanic horizon
ma	limiting man-made horizon
oo	organic topsoil
wt	watertable

PARENT MATERIAL (LITHOLOGY)	
S	general fine sedimentary rock
S1	shale
S2	mudstone
T	general quartzitic rock
T1	sandstone
T2	quartzite
T3	chert
D	general mafic rock
D1	dolerite
D2	basalt
D3	gabbro
D4	undifferentiated basic rock
D5	undifferentiated ultrabasic rock
G	general acidic rock
G1	granite
G2	acid gneiss
G3	undifferentiated acid igneous rock
L	general calcareous rock
L1	limestone
L2	dolomite
R	general sands
R1	recent sand
* R2	weathering sand (e.g. Berea sands)

N	*pink*	h	hardsetting horizon	ROOTING DEPTHS (cm)		LAND CAPABILITY (Pre-Mining) and		E	tillite
K	*dusky*	suffix 1 - 9 denotes 10% - 90% of soil volume		ERD	(Soil): Effective Rooting Depth.	WETLANDS		F	ferricrete
S	strong	*CONSISTENCE (Moist or Dry states) [instead of compaction depths]*		depth of soil above a restricting layer		A	Arable	A	alluvium
D	dark	*sf*	*slightly firm*	AERD	(Soil): Ameliorated ERD.	G	Grazing	C	colluvium
I	light	*f*	*firm (moist state)*	ERD after the depth limitation is		G slope. Grazing. Deeper soils downgraded			
P	pale	*vf*	*very firm (moist state)*	ameliorated by mechanical means such			due to slopes of >6 degrees	* Note	Current area (Stockpile 8): R2 symbol
G	grey	*sh*	*slightly hard*	as ripping		L	Wilderness		was instead notated as follows:
L	light	*h*	*hard (dry state)*	*ERD*	*(Soil + Saprolite): Add ERD according*	Wt	Wetland (Temporary)	Bs	Berea (sandy phase)
M	mottled	*vh*	*very hard (dry state)*	*to the saprolite weathering status.*		Ws	Wetland (Seasonal)	Bc	Berea (clayey phase)
V	*very*	*Not indicated for: Moist - loose, friable; Dry - loose, soft; or Wet state*		*All depths reduced for % coarse fragments.*		Wp	Wetland (Permanent)		

Note: Symbols and text in italics represent variations from the original FSD (Forestry Soil Datatbase) standards

REFERENCE DOCUMENT I (Snyman, 2008).

Snyman, K. March 2008. Port Durnford Pre-Feasibility Mining Study Report on the Soils, Sites, Land Capability and Land Use. Produced for Exxaro KZN Sands. By Keith Snyman & Associates. 202 Pages.

This Reference Document is only partially Incorporated into the Current Document.
Refer to and consider the entire Reference Document I separately.

List of duplicated (into current document) information:
Map 1. Location of Soil Observations and Modal Soil Profiles (Port Durnford Plantation).
Map 2. Soils (Port Durnford Plantation).
Map 3. Sites (Port Durnford Plantation).
Map 4. Current Land Use within Study Area (Port Durnford Plantation).
Map 5. Land Use within a 2km radius around Port Durnford (Plantation).
Map 6. Land Capability (Port Durnford Plantation).

New Table KS1 [source report: Table 5]. Site Map Legend (Port Durnford Plantation).

List of information considered for creation of new (in current document) Table:
New Table 5. Site Types, Soil Forms / Properties, and Stripping Volume (Port Durnford Plantation). *Incorporates extracts from Section 7.2. Sites; Table 6. Sites; and Map 3. Sites.*

List of discussed (but not duplicated) information [refer to Reference Document I separately]:
Appendix 3. Modal Soil Profile Descriptions and Laboratory Analysis.
Section 7.2. Sites. This Section includes Descriptions and Photographs of the 10 defined Sites A - J, grouped from the 22 defined Soil Bodies.

END...

Respectively Submitted. B.B.McLeroth (Red Earth cc).

APPENDIX III - EXECUTIVE SUMMARY

This Executive Summary was produced by the current author (B.B.McLeroth of Red Earth cc).

SOILS – PRE-MINING (NATURAL)

A typical soil catena is described, for soils derived from very deep quatenary deposits (bedrock not encountered). Such soils are highly dominant (98.4 %) in the Port Durnford Plantation area, and also occupy approximately 50 % of the Stockpile 8 area; thus indicating at the vast majority of the Port Durnford Mining Development study area as a whole.

Soil Site Types A, B, and C mostly occur to the west of the N2 Highway, the remainer mostly occurring to the east.

CREST and MIDSLOPE (UPPER to MIDDLE):
Soil Site Type: A. Deep red and yellow sandy mesotrophic.
Parent material: “Berea-type” ‘sandy’ phase - paleo dune complex.
Note: “Berea-type” ‘clayey’ phase occasionally underlies the ‘sandy’ phase within soil augur depth, the ‘sandy’ phase blanketing the ‘clayey’ phase.
Effective Rooting Depth: >150cm.
Soil Forms / Families:
Hutton 2100 (‘sandy’ phase).
Horizons: orthic A *(Sa)* / over red apedal B *(LmSa)* / occasionally over red apedal B2 *(SaClLm)* [to great depth].
Clovelly 1200 (‘sandy’ phase).
Horizons: orthic A *(Sa)* / yellow-brown apedal *(LmSa)* [to great depth].

MIDSLOPE (UPPER to MIDDLE, and occasionally LOWER):
Site Type: B. Deep red clayey mesotrophic.
Parent material: “Berea-type” ‘clayey’ phase - paleo dune complex.
Effective Rooting Depth: >150cm.
Soil Forms / Families:
Hutton 2200 (‘clayey’ phase).
Horizons: orthic A *(LmSa)* / over red apedal B1 *(SaClLm)* / frequently over red apedal B2 *(SaClLm - Cl)* [to great depth].
Oakleaf (‘clayey’ phase).
Horizons: orthic A *(LmSa)* / neocutanic B *(SaClLm,* non-red) [to great depth].
Hutton form dominant in Upper to Middle positions, and Oakleaf form dominant in Middle to Lower positions.

MIDSLOPE (MIDDLE to LOWER), or FOOTSLOPE STREAM TERRACE (UPPER to LOWER - long and very-gentle gradient):
Site Type: C. Pale topsoil sands.
Parent material: Quaternary sediments reported. These are likely “Berea-type” within the relevant sections of Transects D-C and F-E, these sections occurring on midslopes of the paleo dune complex.
Effective Rooting Depth: >150cm.
Soil Form / Family:
Fernwood 1210 (‘sandy’).
Horizons: orthic A (light coloured) *(Sa)* / over E-horizon (yellow when moist) *(Sa).*

FOOTSLOPE (UPPER to LOWER - long and very-gentle gradient):
Site Type: D. Dark topsoil sands.
Parent material: Quaternary sediments.
Effective Rooting Depth: >150cm (less before the planting of *Eucalyptus* trees).
Soil Form / Family:
Fernwood 2110 ('sandy'). A perched water-table was reported at approximately 2m (Snyman, 2008).
Horizons: orthic A (dark coloured) *(LmSa)* / over E-horizon (grey when moist, white when dry) *(Sa) / over Unknown (non-diagnostic soil horizon).*

FOOTSLOPE (LOWEST - long and very-gentle gradient):
Site Type: F. Deep E-horizon hydromorphic
Parent material: Quaternary sediments.
Effective Rooting Depth: 90 - 120cm.
Soil Forms / Families:
Kroonstad 1000 ('sandy').
Horizons: orthic A *(SaLm)* /over E-horizon (grey when moist) *(Sa) /* G-horizon (*SaClLm* - *Cl*).
Longlands 1000 ('sandy').
Horizons: orthic A *(SaLm)* / E-horizon (grey when moist) *(Sa) /* over soft plinthic B (*SaClLm*).

FOOTSLOPE (LOWER to LOWEST - long and very-gentle gradient):
Site Type: E. Moderately-Deep E-horizon hydromorphic
Parent material: Quaternary sediments.
Effective Rooting Depth: 60 - 90cm.
Soil Forms / Families:
Kroonstad 1000 ('clayey').
Horizons: orthic A *(SaClLm)* /over E-horizon (grey when moist) *(Sa) /* G-horizon (*SaClLm* - *Cl*).
Longlands 1000 ('clayey').
Horizons: orthic A *(SaClLm)* / E-horizon (grey when moist) *(Sa) /* over soft plinthic B (*SaClLm*).
Tukulu 1120 ('sandy'). Sub-dominant soil form, on isolated slightly raised sections.
Horizons: orthic A (*probably SaLm* - not bleached) / neocutanic B (*probably SaLm* - non-red) / unspecified material with signs of wetness (*SaClLm*).

VALLEY-BOTTOM (almost level gradient):
Site Type: G. Shallow undifferentiated hydromorphic
Parent material: Quaternary sediments.
Effective Rooting Depth: 30 - 60cm.

Soil Forms / Families:

Dominant:
Westleigh 2000 ('clayey').
Horizons: orthic A (*SaClLm texture*) / over soft plinthic B (*SaCl*).
Katspruit 1000 ('clayey').
Horizons: orthic A (*SaClLm*) / G-horizon (*SaCl* - *Cl*).
Champagne 2200.
Horizons: organic A (humified organic material dominant) / unknown (probably G-horizon, *SaCl*).
Fernwood 2110 ('sandy').
Horizons: orthic A (dark coloured) (*SaLm*) / E-horizon (grey when moist) (*Sa*).

Sub-dominant:
Kroonstad 1000 (‘clayey’).
Horizons: orthic A *(SaClLm)* / over E-horizon (grey when moist) *(SaLm - Sa) /* G-horizon (*Cl - SaCl*).
Longlands 1000 (‘clayey’).
Horizons: orthic A *(SaClLm)* / E-horizon (grey when moist) *(LmSa - Sa) /* over soft plinthic B (*SaClLm - SaCl*).

INDIGENOUS BUSH, RIPARIAN, WETLANDS, CHANNELS:
Indigenous Bush occupies a number of different categories in the Port Durnford Plantation area, as follows:
- Drainage areas: Forest Indigenous Riparian.
- Drainage areas: Forest Indigenous Wetland (wetlands and stream channels).
- Steeper terrestrial slopes: Forest Indigenous Upland.
  Hydropedological Response: Recharge (deep or shallow).

SOILS - POST-MINING (REHABILITATED)

The following are regarded as the Recommended Minimum Topsoiling Prescriptions for the entire Port Durnford Mine Area, because wherever possible it would be adventageous to the post-mining Land Capability and a sustainable long-term end Land Use (and yield potential), to exceed the prescribed minimum soil stripping and topsoiling depths.

TOPSOILING OF PREVIOUS MINING PITS (ALL)

These include the following sites:
- **re-purposed RSF site C (including P1, P2, P3, and P4); and**
- **re-purposed Sand Tailings sites 3, 4, and 5.**

Topsoiling Horizons / Depths:

<u>During the rehabilitation topsoiling exercise, place a 30cm layer of topsoil (orthic A-horizon) on the immediate surface of these areas.</u>
The reason that the Topsoil orthic A-horizon must always be replaced on the immediate surface is because the horizon contains organic matter / carbon.

<u>The topsoil must overlie a 150cm (minimum) layer of Reconstituted ‘soil’ (below the Topsoil). The greater the thickness of this layer, the greater the plant survivability and yield potential of the rehabilitated site.</u>

<u>Mixing Ratio</u> of Reconstituted ‘soil’:

The Reconstituted soil is recommended to be comprised of a mixture (well mixed) of the Mine defined Fines (almost all of the silt, plus all of the clay) and Sand Tailings (sand) grades.

<u>The current author (B.B.McLeroth – Red Earth cc) recommends the following ideal Mixing Ratio:</u>
- <u>Target Ratio: 33.3% Fines (30-27% clay) : 66.7% Sand (1:2 ratio).</u>
- <u>Less Desirable: 25% Fines (22-19% clay) : 75% Sand (1:3 ratio).</u>

This material must be thoroughly mixed, without sequential stratified layering of Fines and Sand Tailings. Thus mixing should ideally take place within the depositional piping.

TOSOILING OF ABOVE SURFACE FEATURES IN NON-MININIG PIT AREAS

These include the following sites:
- **PWP Plant and Temporary Infrastructure Area (on surface);**
- **Return Water Dams (on surface);**
- **Sand Tailings sites 8B, A-1, A-2, and A-3 Complex (above surface); and**
- **RSF site 9 (above surface).**

<u>During the rehabilitation topsoiling exercise, place a 30cm layer of topsoil (orthic A-horizon) on the immediate surface of these areas.</u>

<u>The Topsoil must overlie 150cm (minimum) of the originally stripped and stockpiled Subsoils (below the Topsoil).</u>
However, the Topsoiling depth may be less than 150cm in certain sections of Stockpile 8B, due to the Effective Rooting Depth of the natural soils frequently being lesser in this area (Refer to Map 7).

LAND CAPABILITY - PRE-MINING (NATURAL)

Pre-Mining Land capability classes were determined using the latest (at the time of the relevant soil survey) guidelines outlined in the following documents:

Stockpile 8B (Soil Mapping conducted in 2024, by B.B.McLeroth) - 'Mining Rehabilitation Guidelines (2019)' [refer to References], and
Port Durnford Plantation (Soil Mapping conducted in 2008, by K.Snyman) - 'Mining Rehabilitation Guidelines (2007)'.

Findings:

Land capability is dominantly Grazing to the west of the N2 highway. Despite the deep prevailing soils occurring on the dune, slopes of over 6 degrees (10.5%, 1: 9.5) disqualify the vast majority from the Arable capability class. Given the latest 'Mining Rehabilitation Guidelines (2019)', certain small sections of the indicated Grazing land capability class areas may now be defined as Arable land, in areas where the slope is approximately <= 6 degrees; these mostly being located in areas of Site Type A (deep red and yellow sandy soils) and particularly B (deep red sandy-clay-loam soils) soils.

Land capability to the east of the N2 highway is predominantly Wetland (seasonal), with Wetland (permanent) occurring in the most low-lying areas.

Land Capability – chosen Agricultural definition (Scotney *et al.* [March 1987, Revised January 1991]):

This would be a more appropriate system of land Capability Classification, given the high agricultural productivity of the area. However, this agricultural classification procedure was not conducted, given that this is a mining related Project.

Nevertheless, the following conclusions are made for the Site Type A (deep red, yellow, and neocutanic sandy soils); and Site Type B (deep red or yellow clayey soils - ferrallitic soils) Soil Site Types:
Class V (Grazing and Forestry Land), where the slope exceeds 8.5 degrees (15%) as it often does.
Class IV (Arable land, Severe limitations), slope 6.8 degrees (12%).
Class III (Arable land, Moderate limitations), slope 4.5 degrees (8%).
Class II (Arable land, High Potential, Few limitations), slope 2.2 degrees (4%).
Limited areas of Class II to IV land exist on gentle to very gentle slopes.

LAND USE - PRE-MINING (CURRENT)

The study are is largely bisected from the south-west to the north-east by the R102 provincial tar road (from Mtunzini to Empangeni), the N2 toll road highway, and a Spoornet railway line (from Mtunzini to Felixton).

Given the frequently well drained deep to very deep soils in midslope and crest position (often well over 1.5m in depth), high rainfall, high heat units (and no frost), eucalypts experience exception timber yields, as compared with the broader South African Forestry Industry.

Thus the site is predominantly a *Eucalyptus* plantation, although pine species will also thrive. Within the south-eastern fifth of the area (outside of the plantation), farmers cultivate sugar cane to the west and south of the R102 tar road, while a small block of citrus lies to the south of the same road. Normal forestry / farming / human related infrastructure is also present in certain areas. The site is serviced by a well distributed road (either tracks or gravelled) network, while a grassed airfield is also present on the plantation. Sections of Eskom power lines also exist.

Given the very favourable soil and climatic conditions, high yields will also be obtained from a broad variety of other crops, for example: citrus, macadamia nuts, avocado, litchi, paw-paw, banana, and numerous vegetable types; many of which are already cultivated in the surrounding areas outside of the study area.

Various categories of indigenous bush and grassland occur adjacent to drainage lines / streams (intermittant and perennial), valley-bottom wetlands, and riparian areas. Furthermore, indigenous bush also occurs in certain steeper sections of the study area.

Numerous human settlement areas surround (outside) the majority of the study area.

LAND CAPABILITY & LAND USE (BASED ON SLOPE) - POST-MINING (REHABILITATED)

Final End Slope: <= 1:7 (8°)

Applicable to the following features: top zones (more level) of rehabilitated RSF's, Mining Pits, and Sand Tailings Dumps; as well as any lower side-slopes with the same grade (if any, but recommended as ideal).

Final End Land Capability: Arable [as per erosion related principals contained within *'Mining Rehabilitation Guidelines (2019)'].*

This Land Capability assumes that the topsoiling depth/type and final side-slope recommendations are precisely followed.

Final End Land Use:

cover crops, sugar cane, commercial timber (e.g. *Eucalyptus* species), “locally” indigenous grassland (refer to Section 11.6 – RE-VEGETATION, for explanation), or “locally” indigenous bush (all options are suitable). Options also exist for the planting of vegetables (local communities) on most of these sites; plus demanding species such as tree crops (nuts or citrus) [local communities or farmers] on certain high potential sites.

Final End Slope: 1:7 (8°) - 1:5 (11.3°) [steeper than 1:7]

Possibly applicable to the side-slopes (steeper than top zones) of the following features: rehabilitated RSF's, Sand Tailings Dumps, and Mining Pits.

Final End Land Capability: Grazing.

This Land Capability also assumes that the topsoiling depth/type and final side-slope recommendations are precisely followed.

Final End Land Use:

Initially stabilise the slope with “locally” (to the immediate surrounds) indigenous grasses.

Thereafter establish a dense stand of commercial timber (e.g. *Eucalyptus* species) along the contour, or alternatively “locally” (to the immediate surrounds) indigenous bush.
Eucalyptus trees may have already previously been planted on these slopes during the Operational Phase (e.g. to hasten the drying out of the hydraulically deposited material), such trees having the benefit of a high water demand.

During the establishment (planting) of commercial timber, the manual placement of organic litter (e.g. discarded tree waste sourced from the surrounding forestry areas) along the contour will be highly beneficial to limiting run-off; as well as ultimately building up the topsoil organic matter (and carbon) content, thereby improving soil fertility, nutrient recycling, soil moisture holding capacity, and soil structure. Both the leaf canopy and the litter layer will reduce soil erosion. Thus, burning must not be allowed in any of the rehabilitated areas.

The final end Land Use must not be “locally” indigenous grasses alone. This is because the surface basal cover will be insufficient to intercept raindrop energy or stop soil erosion, while overgrazing (large numbers of cattle from local communities in the area) and the potential for wildfires would further compromise the sites.

Sugar cane has not been considered by the current author in these areas, given that the majority of the soil surface is bare of basal cover for periods of the year, while rehabilitated soils are also more sensitive to erosion. The planting of sugar cane in rehabilitated areas may be further considered, based upon the findings in the referenced document by Steyn, C., and N. Bezuidenhout (March 2011).

Final End Slope >1:5 (11.3°) [Not Recommended] - 1:3 (18.4°) [Particularly Unacceptable]. Terracing will be required.

Applies to moderately steep side-slopes, if these are not re-graded (re-sloped) correctly, as specified in the recommendations. In any case, slopes exceeding 1:5 must not occur post-rehabilitation.

Final End Land Capability: Wilderness.

Final End Land Use:

No sustainable end agricultural land use is feasible, due to likely excessive ongoing soil erosion, (and particularly so on 1:3 slopes).

Initially stabilise the slope with "locally" (to the immediate surrounds) indigenous grasses. However, grassland is not acceptable as the final end Land Use.

Thereafter establish a dense stand of "locally" (to the immediate surrounds) indigenous bush.

HYDROPEDOLOGY

Pre-Mining (Natural):

Soil Site Types:
A & B - Recharge (deep);
H - Recharge (shallow);
C, D, E, & F - Interflow; and
G - Interflow (most soil forms), and Responsive (Westleigh and Champagne forms).

Post -Mining (Rehabilitated):

The existing hydropedology and hydrology will be altered by the mining related operations.

LAND FORM (SHAPE & GRADE) – POST-MINING (REHABILITATED)

Assumption: The following recommendations are integral to the entirety of the Executive Summary text above.

This process must be conducted by re-grading (i.e re-sloping) the Sand Tailings and Fines to the desired profile. This exercise must be conducted before the topsoiling layers are applied.

Slope form/shape should wherever possible blend into that of the surrounding non-disturbed areas. Blending into the surrounding landscape does not necessarily mean that the pre-mining level must be duplicated, because replaced mined material displays a bulking factor of approximately 30%. However, well re-shaped slightly raised areas with side-slopes of <1:5 (but <= 1:7 definately preferred) will still blend into the natural environment.
Very importantly, the creation of non-freely draining blind depressions and hollows (where surface water would accumulate) must be avoided at all costs.

Recommendations follow for the Final Rehabilitated Landscape (Land-Form) / Grade (all Rehabilitated features):

'Whale-backed' in shape:

Applicable to all previous Mining Pits (including re-purposed Sand Tailings sites 3, 4, and 5; and RSF C). Also applicable to RSF 9; Sand Tailings Dumps A-1, A-2, and A-3 Complex; and Return Water Dams.

It is <u>strongly recommended</u> that the final profile of these sites be constructed as follows:
raised above the origional surface level and 'whale-backed' in shape. It is not possible for these rehabilitated sites to be level with that of the surrounding landscape due to the post-replacement bulking factor.

Specifically:

ALL previous Mining Pits (including re-purposed Sand Tailings sites 3, 4, and 5; and RSF C):
<u>Raised above the origional surface level</u>; up to a maximum of 15m (although 20m may also be acceptable, if so required).

Heights of less than 15m would also be acceptable for these features, provided only that the <u>extent and height</u> of mining related features located <u>outside of previous mining Pit sites</u> (Sand Tailings Dumps, and RSF 9) are <u>limited as far as possible</u>; as follows:
Sand Tailings Dump A-3 Complex must be eliminated entirely;
Sand Tailings Dump A-1 must be reduced in extent, so as not to intrude into areas of Site Type D soils, or areas of indigenous bush / wetlands; while
Sand Tailings Dumps A-2 and 8B are still acceptable for utilisation (in entirety - less the appropriate buffer zones).
Refer to:
Section 11.2 (ISSUES - PLANNED MINING INFRASTRUCTURE); and
Sub-Sections ISSUES and POTENTIAL SOLUTIONS TO IDENTIFIED ISSUES - SPACE SAVING; for further details.

The 15m height above ground level is derived as follows: 50m average Pit depth x 30% bulking factor = 15m.
<u>Final side-slopes <= 1:7 (8 °) (clearly acheivable given that the Mine origionally planned for these features to be level with that of the surrounding landscape).</u>

RSF 9; Sand Tailings Dumps A-1 & A-2; and Return Water Dams:
Raised above the origional surface level; ideally < 15m for RSF 9 and the Return Water Dams, and < 50m for the Sand Tailings Dumps.
<u>Final side-slopes ideally ≤1:7 (8 °) [but definately not more than 1:5 (11.3°)].</u>

Reticular in shape:

Applicable to PWP and Temporary Infrastructure area.
Slope and altitude must as closly as possible match that of the pre-mining condition, although peripheral adjustments may be nececessary in order for these sites to grade into that of the surrounding raised (above origional surface level) previous Pit sites.

ENVIRONMENTAL IMPACT ASSESSMENT - MITIGATION MEASURES

Such recommendations / information is provided in the following Reporting Sections:

Section 11. SOILS RECOMMENDATIONS:

Section 11.1. RECOMMENDED DEVELOPMENT AREA;
Section 11.2. ISSUES – PLANNED MINING INFRASTRUCTURE;
Section 11.3. SOIL STRIPPING & STOCKPILING;
Section 11.4. SLOPE & RE-GRADING;
Section 11.5. TOPSOILING, AND RECONSTITUTED 'SOIL' MIXING RATIO;
Section 11.6. RE-VEGETATION;
Section 11.7. FINAL END LAND CAPABILITY & LAND USE – BASED ON SLOPE; and
Section 11.8. SUPPORTING INDEPENDANT DOCUMENT RECOMMENDATIONS.

Section 13. ENVIRONMENTAL IMPACT ASSESSMENT: Specifically refer to:
Table 14. Impact Assessment Table – Soils, Land Capability, Land Use, & Hydropedology.

ENVIRONMENTAL AUTHORISATION

This Project can be Authorised provided that the Recommendations in this Report are adhered to.

This Project cannot be Authorised if the Recommendations in this Report are not adhered to.