SOIL ASSESSMENT FOR THE PROPOSED PLATREEF UNDERGROUND MINE

PLATREEF RESOURCES (PTY) LTD

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This document has been prepared by **Digby Wells Environmental**.

Report Title: **Soil Assessment for the proposed Platreef Underground Mine**

Project Number: **PLA1677**

Name	**Responsibility**	**Signature**	**Date**
Hendrik Smith	Soil survey and report		20 September 2013
Wayne Jackson	Reviewer		25 September 2013
Andrew Husted	Reviewer		25 September 2013

EXECUTIVE SUMMARY

Digby Wells Environmental (Digby Wells) was appointed by Platreef Resources (Pty) Ltd (Platreef) for specialist baselines studies to be conducted as part of the environmental authorisation process.

A soil survey was conducted in order to determine the available soil types associated with the Platreef study area. In addition to this, the current land capability and land use were also assessed and is described as a part of this report.

The project area consists largely of flat areas in the Makapan Valley, villages in the area include those of Tshamahansi, Mahwereleng, GaMadiba, Maroteng and Masodi. Macalacaskop, also known as Sefakaola is also situated within the project area.

The Platreef project site is located within the living areas of several communities. The site is well serviced by roads. Some evidence of cultivation was visible but the cultivated areas are small indicating that agriculture is practised on a subsistence level. Grazing cattle is also practised and cattle and goat numbers are uncontrolled and indications of overgrazing are evident throughout the Platreef project site.

The project site is occupied and dominated by yellow medium textured Oakleaf soils and heavy textured Valsrivier clay soils in drainage lines and valley bottom positions. The land capability of the Oakleaf soil is arable while the remainder of the site dominated by shallow sandy soils and clay soil is grazing.

The analysed soil samples pH properties are within suggested optimum pH levels. The soil Calcium (Ca), Magnesium (Mg), Potassium (K) and Carbon (C) content is good in the dominant soil types while the P status is low.

Underground mining will have a temporary influence on land capability changing the subsistence agricultural use to mining land use. Subsidence due to the underground mining might occur and is potentially very serious. Subsidence can cause changes in drainage lines, waterlogging of land and changes in land capability and land use.

It is recommended that the proposed Tailings Storage Facility (TSF) site 1 used as the TSF site of choice due to the Oakleaf soils present. Oakleaf soil consists of an orthic A horizon, overlying a neocutanic brown apedal B horizon. Oakleaf soils are considered to be good agricultural soils due to their sandy clay loam textures. These soils are cultivated easily, hold water and adsorb nutrients allowing optimal crop production. The topsoil layer should be stripped and stockpiled prior to the construction of the TSF to ensure that a source of soil is kept to cover and vegetate the TSF.

It is also recommended that the initial infrastructure site be retained due to the presence of dominating Oakleaf soil.

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Abbreviations, Acronyms and Definitions

(Used with permission from the Soil Science Society of South Africa)

TSF	**Tailings Storage Facility**
ESIA	**Environmental Social Imapact Assessment**
NEMA	**National Environmental Management Act**
MPRDA	**Minerals and Pertroleum Resources Development Act**
CARA	**Conservation of Agricultural Resources Act**
NWA	**National Water Act**
EIA	**Environmental Impact Assessment**
EMPR	**Environmental Management Plan Report**
GPS	**Global Positioning System**
Ks	**Katspruit**
P	**Phosphorus**
CEC	**Cation Exchange Capacity**
Ca	**Calcium**
K	**Potasium**
Mg	**Magnesium**
C	**Carbon**

Land

The exposed part of the earth's surface as distinguished from the submerged part.

The total natural environment of the exposed part of the earth's surface, including atmosphere and climate, soils and vegetation, animals, surface water and geological formations.

The total natural and cultural environment.

Land Capability

This is the extent to which land can meet the needs of one or more uses under defined conditions of management, including climate, on the total suitability for use without damage for crops that require regular tillage, for grazing, for woodland, and for wildlife. A more general term than land suitability and more conservation orientated. Cf. Land suitability. Land capability involves consideration of (i) the risks of land damage from erosion and other causes and (ii) the difficulties in land use owing to physical land characteristics, including climate.

Land Capability Class

A land capability Class is a grouping that contains land with similar capabilities. The classes defined in two classification systems are outlined below (The South African land capability classification, Scotney et al, 1987):

Arable land capability classes

Class i: land has few permanent limitations that restricts its use and has very high potential for intensive crop production.

Class ii: land has some permanent limitations that reduce the degree of intensity of crop production but is nevertheless of high potential.

Class iii: land has severe permanent limitations that restrict the choice of alternative uses and the intensity of crop production and is of moderate potential.

Class iv: land has very severe permanent limitations that greatly restrict the choice of alternative uses and the potential for crop production.

Non-arable land capability classes

Class v: land is unsuitable for the cultivation of annual crops, but has very slight erosion hazard under natural veld, established pastures, and forestry or special crops.

Class vi: land has permanent limitations that make it unsuited to cultivation and limit its use to natural grazing, veld re-enforcement, afforestation or wildlife.

Class vii: land has very severe permanent limitations that render it unsuitable for cultivation or intensification and restrict its use to natural grazing, afforestation or wildlife.

Class viii: land has permanent limitations that preclude its use for commercial plant production and restrict its use to wildlife, recreation, water supply or aesthetic needs.

Landscape

All the natural features, such as fields, hills, forests, and water that distinguish one part of the earth's surface from another part; usually that portion of land or territory which the eye can comprehend in a single view.

Land suitability

Land suitability is the suitability of a given type of land for a specified kind of land use.

Land type

A class of land with specified characteristics.

It has been used in South Africa as a map unit denoting land, at 1:250 000 scale, over which there is a marked uniformity of climate, terrain form and soil pattern.

Land use

Land use is the use to which land is put.

Terrain morphological units

The common terrain morphological units used in the South African landscapes are down slope from top to bottom:

Crest, Scarp, Mid slope, Foot slope, Valley bottom

1 INTRODUCTION

Digby Wells Environmental (Digby Wells) was appointed by Platreef Resources (Pty) Ltd (Platreef) for specialist baselines studies to be conducted as part of an Environmetal and Social Imapct Assessment (ESIA).

A soil survey was conducted in order to determine the available soil types associated with the Platreef study area. In addition to this, the current land capability and land use were also assessed and is described as a part of this report.

1.1 South African Legislation Pertaining to Soil

The following section outlines a summary of the most recent South African Environmental Legislation that needs to be considered with reference to the management of soil: Section 24 of the Constitution of the Republic of South Africa contains the environmental right of South Africa's citizens. Section 24(a) afforded every person with the entitlement to enjoy a right to an environment which is not harmful to their health and well-being, whilst section 24(b) impose a positive duty on the state to protect the environment through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecological sustainable development and the use of natural resources while promoting justifiable economic and social development.

- Soils and land capability are protected under the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA), the Environmental Conservation Act, 1989 (Act no. 73 of 1989), the Minerals and Pertoleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA) Minerals Act, 1991 (Act no. 50 of 1991), the Conservation of Agricultural Resources Act, 1983 (Act no. 43 of 1983) (CARA) and the National Water Act, 1998 (Act no. 36 of 1998) (NWA);
- The NEMA gives effect to the environmental right in the Constitution. Some of the principles contained in section 2 of NEMA are applicable to soil conservation and must be taken into account by organs of states and their decision-making. The sustainable development principles in NEMA require the consideration of all relevant factors, including that the disturbance of ecosystems. The NEMA also requires that pollution and degradation of the environment be avoided or where it cannot be avoided, minimized and remedied;
- The Environmental Conservation Act is applicable to soil through the prevention of pollution through the removal of litter, incorporation of waste management activities and control of activities that may have a detrimental effect on the environment such as:
  - Land use and transformation;
  - Resource removal;
  - Agricultural processes;
  - Industrial processes such as mining;
  - Transportation;
  - Waste and sewage disposal; and
  - Chemical treatment.

- The MPRDA provides a good framework for addressing rehabilitation. The MPRDA requires that a holder of a prospecting right or mining right must rehabilitate the area affected by prospecting or mining operations to its natural or predetermined state or to a land use which conforms to the generally accepted principle of sustainable development;
- The CARA, 1983 (Act 43 of 1983) provides for the conservation of the natural agricultural resources of the Republic by the maintenance of the production potential of land, by the combating and prevention of erosion and weakening or destruction of the water sources, and by the protection of the vegetation and the combating of weeds and invader plants.
  - In order to achieve the objects of this Act the Minister may prescribe control measures which shall be complied with by land users to whom they apply.
    - Such control measures may relate to;
    - Cultivation of virgin soil;
    - Utilization and protection of land which is cultivated;
    - Irrigation of land;
    - Prevention or control of waterlogging or salination of land;
    - Utilization and protection of wetlands, marshes, water sponges, water courses and water sources;
    - Regulating of the flow pattern of run-off water;
    - Utilization and protection of the vegetation;
    - The grazing capacity of veld, expressed as an area of veld per large stock unit;
    - The maximum number and the kind of animals which may be kept on veld;
    - The prevention and control of veld fires;
    - The utilization and protection of veld which has burned;
    - The control of weeds and invader plants;
    - The restoration or reclamation of eroded land or land which is otherwise disturbed or denuded;
    - The protection of water sources against pollution on account of farming practices;
    - The construction, maintenance, alteration or removal of soil conservation works or other structures on land;
    - Any other matter which the Minister may deem necessary or expedient in order that the objects of this Act may be achieved, and the generality of this provision shall not be limited; and

- In view of the close relationship between water conservation and soil conservation, provisions of the National Water Act, 36 of 1998 aimed at water conservation is of central importance to soil-conservation.

2 TERMS OF REFERENCE

Reconnaissance soil surveys of the project area were undertaken during the winters of 2012 and 2013, to establish the land capability (agricultural potential), land use and soil types present on the Platreef project site. The following tasks were fulfilled as part of an ESIA:

- Compilation of a soil survey report assessing the soil types, land capabilities and land use to determine the baseline soil status.

2.1 Deliverables

The following deliverables were completed:

- A soil report explaining the requested occurrence of soil types, soil and land capability status including land use;
- Recommendations regarding the location of the infrastructure and TSF sites; and
- Maps indicating the determined delineations in the designated Platreef project area.

3 KNOWLEDGE GAPS

There is no discernible soil survey information gaps.The Platreef study area was field surveyed by visiting the site. The proposed underground mining site was surveyed using a reconnaissance approach, including the locations of the proposed infrastructure and Tailings Facility (TSF) sites.

4 STUDY AREA

The Platreef project area starts approximately five kilometres from Makopane in the Limpopo Province, South Africa. The project area covers approximately 10 700 ha, of which much is covered by existing human settlements.

The project area consists largely of flat areas in the Makapan Valley, villages in the area include those of Tshamahansi, Mahwereleng, GaMadiba, Maroteng and Masodi. Macalacaskop, also known as Sefakaola is also situated within the project area.

The Platreef project site is located within the living areas of several communities. The site is well serviced by roads. Some evidence of cultivation was visible but the cultivated areas are small, see Figure 4-1. The crop remnants present on the higher lying cultivated fields indicated that crop production is on a subsistence level only. One larger well cultivated field was found in a lower landscape position, presented in Figure 4-2. The cultivated fields within the project site are generally unfenced providing unhindered access to cattle and goats. Cattle and goat numbers are uncontrolled and indications of overgrazing are evident throughout the Platreef project site.

Figure 4-1: Subsistence crop production on unfenced areas.

Figure 4-2: Larger fenced cultivated maize field within the Platreef project site.

5 EXPERTISE OF THE SPECIALIST

Hendrik Smith is a registered Professional Natural Scientist (Soil Science) with the South African Council for Natural Scientific Professions. He is an experienced soil surveyor and also assists with relevant sections of Rehabilitation Guidelines, Environmental Impact Assessments (EIAs) and Environmental Management Plan Reports (EMPRs). He is part of the Bio-physical Department at Digby Wells Environmental. The Department focuses on combining and actively promoting the utilisation of various disciplines within the field of environmental management which include fauna, flaura, wetlands and aquatics.

6 AIMS AND OBJECTIVES

The aim of the study was to obtain soil, land capability and land use information for the Platreef project site through a reconnaissance field soil survey. The objectives were to:

- Classify the major soil types, delineate occurrence of soil types;
- Determine current land capability;
- Obtain land use information;
- To sample and analyse dominant soils for basic fertility analysis; and
- To produce a soil report.

7 METHODOLOGY

The Platreef project area was surveyed on a reconnaissance level. The project site was traversed by vehicle and on foot. A hand soil auger was used to survey the soil properties present and to obtain soil samples. Survey positions were recorded as waypoints using a handheld Global Positioning System (GPS).

The soil forms (types of soil) found in the study area was identified using the South African soil classification system namely; Soil Classification: A Taxonomic System for South Africa (Soil Classification working group, 1991). Several digital photographs will be recorded as reference information.

The topsoil (0-30 cm) and subsoil (30-60 cm) of dominant soils were sampled. Samples were analysed at a reputable soil laboratory for soil acidity, fertility and textural indicators.

The existing land use was also recorded at each chosen soil survey point. Agricultural potential and land capability depends on soil capability which was in addition determined and recorded at soil survey positions. The dominant land capability was classified according to the method described by Schoeman *et al.* (2000).

8 RESULTS AND DISCUSSIONS

8.1 Land Type Soil Information

Existing land type data was used to obtain generalised soil information and terrain types for the Platreef project site. Land type data exists in the form of published 1:250 000 maps. These maps indicate delineated areas of similar terrain types, pedosystems (uniform terrain and soil pattern) and climate (Land Type Survey Staff, 1989).

The Platreef project site is undulating and is located within the dominant Ae, Ah and Ib land types of the 2328 Pietersburg and 2428 Nylstroom land type maps (Land Type Survey Staff, 1989). The land forms representing the various land types are contained in Figure 8-1, Figure 8-2 and Figure 8-3, while the land type map is contained in Plan 1**Error! Reference source not found.**. These land types indicate that the underlying geology consist mainly of hornfels, shale, quartzite, conglomerate, granite and biotite granite. The Ae land type covers most of the southern part of the project site while land types Ah and Ib cover the northern part of the project site.

The Ae land type is flat with slopes of 1 – 5 % while the Ah and Ib land types are undulating containing slopes of 5 – 10 % and 10 – 100 % respectively. The Ib land type is easily recognised as rocky outcrops within the Platreef project site.

Crest landscape positions are indicated as 1, scarp landscape positions as 2, mid slope positions as 3, while foot slope and valley bottom positions are indicated as the 4 and 5 landscape positions respectively.

8.1.1 Land Type Ae

Crests in the Ae land type are generally dominated by red Hutton soils but there is also in some cases shallow stony Mispah and Glenrosa soil present in the crest positions (1). The midslope (4) position is dominated by Oakleaf soil while the valley bottom positions (5) are dominated by the presence of clayey Valsrivier and Arcadia soils. The underlying geology of the Ae224 land type is very complex consisting of hornfels, shale, quartzite, conglomerate, basalt, gabbro, norite, sandstone and river alluvium. The landscape of the Ae224 land type consists of crest, 2%, foot slope, 73% and valley bottom, 25% landscape positions.

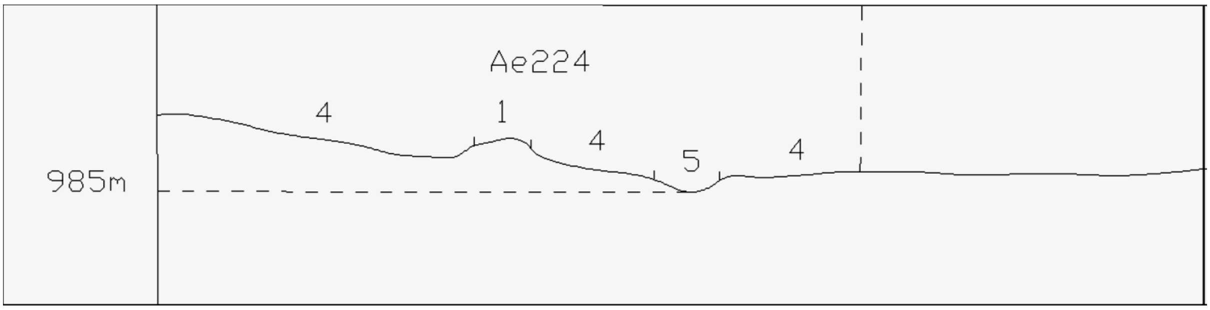


Figure 8-1: Terrain form sketch of the Ae 224 land type present in the Platreef project area.

8.1.2 Land Type Ah

Land type Ah is located in the northern part of the Platreef project site. The dominating soil types occurring in this land type are shallow Mispah and Glenrosa soil pockets within rocky outcrops in landscape positions 1 and 3 (mid slope). Sandy Clovelly and Hutton soils occupy most of the 4 landscape positions, while the 5 positions are occupied by a large variety of sandy and clayey soils. The variety was caused by the deposition of eroded soil material from higher landscape positions leading to the formation of many soil types.

Forced lateral drainage by slope steepness and the presence of underlying impermeable layers on foot slope positions caused hydromorphic soil formation such as Longlands and Fernwood form soil formation (E, medium textured subsoil over a G horizon or E only, respectively). Intermittent perched water tables allowed the formation of subsoil soft plinthite and E horizons, proving that seasonally wet conditions prevail in the landscape.

The dominant geology in this land type is represented by granite and lava. The Ah28 land type landscape consists of crest, 15%, mid slope, 40%, foot slope, 30% and valley bottom positions 15%. The crest and mid slope positions are dominated by rock and stony shallow soils, see Figure 8-4: Shallow stony soils are located in the vicinity of the hills. The foot slope and valley bottom positions are dominated by deeper red and yellow well drained soils for example Hutton, Dundee and Clovelly soils.

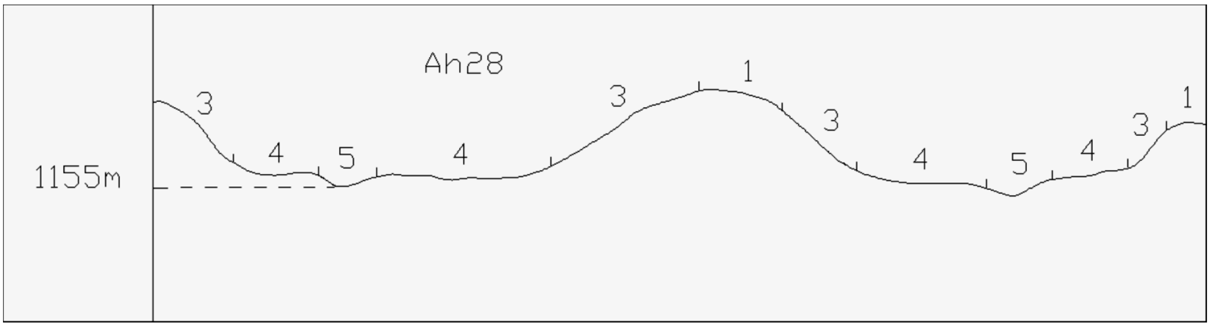


Figure 8-2: Terrain form sketch of the Ah 28 land type present in the Platreef project area.

8.1.3 Land Type Ib

The Ib land type is dominated by rocky outcrops present in the 1, 2, 3 and 4 landscape positions containing vary little usable soil in-between the rocks.

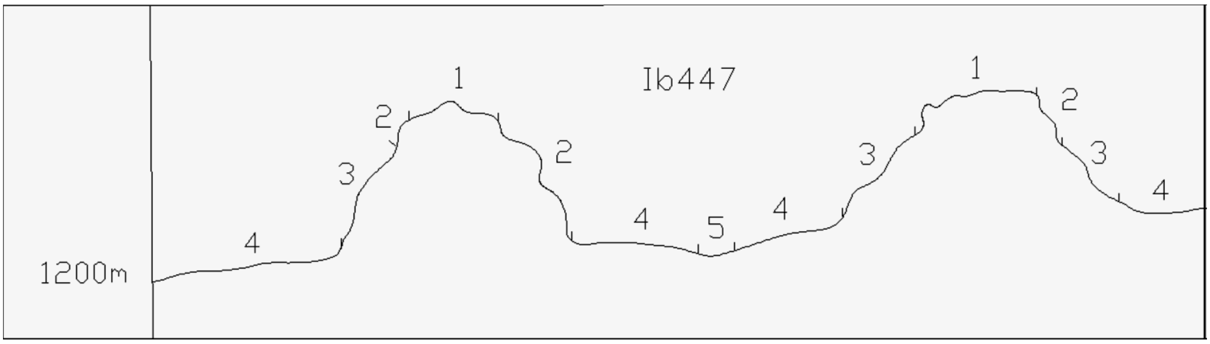
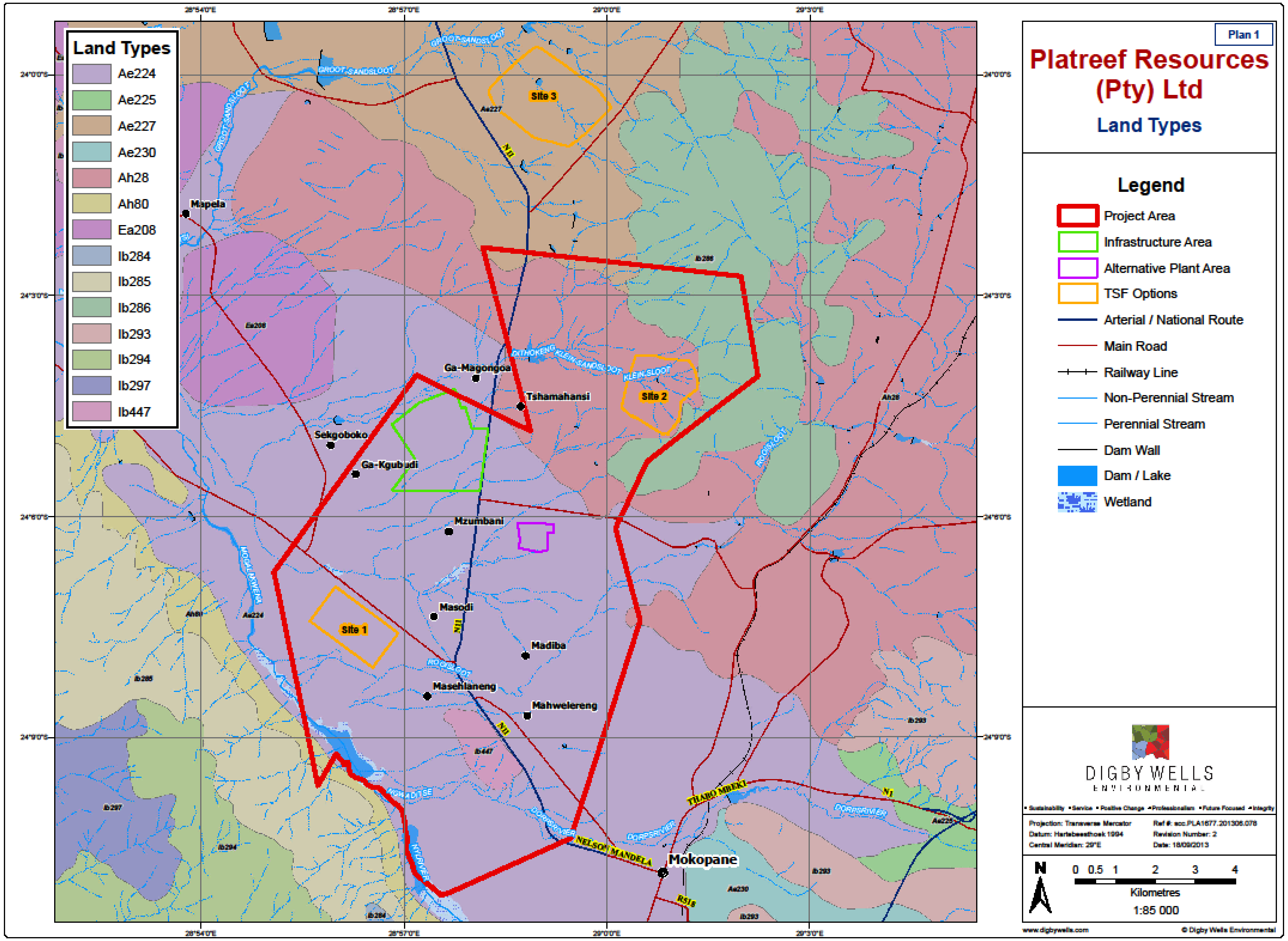


Figure 8-3: Terrain form sketch of the Ib 447 land type present in the Platreef project area

The dominant underlying geology is medium to coarse grained red biotite and granite. According to the land type data 60% of the landscape is dominated by crest and midslope positions. 90% of the crest and midslope positions are occupied by rock. 35% of the Ib447 land type is occupied by foot slope and valley bottom positions. Lower landscape positions are occupied by red well drained soils. The A horizon or topsoil is apedal (non-structured) while the B horisons may exhibit structure. Rooting depth is limited by parent rock occurring below the B soil horizon. The A horizon is likely to contain 12-20% clay due to the influence of the dominant parent material present.

Figure 8-4: Shallow stony soils are located in the vicinity of the hills.



Plan 1: The Platreef project site is located within dominating land types Ae, Ah and Ib.

8.2 Major Soil Types Occupying the Platreef Project Site.

The soil types occupying the Platreef project site are indicated in Plan 2below. The steep crest landscape positions are generally occupied by shallow rocky soil. Lower lying mid slope areas on the old flood plain, are dominated by well drained red and yellow soil such as Hutton, Oakleaf and sandy Clovelly soil types.

Hutton soils consist of an orthic A horizon overlying a red brown B horizon. The Clovelly soil consists of an orthic A horizon overlying a yellow brown B horizon while the Oakleaf soil consists of an orthic A horizon, overlying a neocutanic brown apedal B horizon. The A and B horizons have good internal drainage properties, and therefore well drained.

The lower lying areas in the foot slope and valley bottom positions are dominated by heavy clay soils such as the Valsrivier and Arcadia soil forms. The Valsrivier soil consists of an orthic A horizon overlying a structured pedocutanic B horizon. The Arcadia soil consists of a vertic A horizon.

The Katspruit (Ks) soil is a true wetland soil and is permanently wet. This soil type is found at the lowest landscape positions such as in the valley bottom landscape position. The Ks soil consists of an orthic A horizon overlying a G horizon. The G horizon is characterised high clay content and green and grey colours due to the anaerobic soil conditions caused by waterlogging.

The agricultural potential of the dominant well drained soils, for example Oakleaf and Hutton soils in the surveyed area are determined by the combination of soil depth and favourable climatic conditions. The average rainfall in the area is medium to high (650 mm per annum) and in combination with good soil, results in high arable agricultural potential as indicated in Table 8-1.

Table 8-1. Dominant cultivated soil forms found in the Platreef project area during the soil survey.

Soil Form	Average Depth (m)	General Characteristics	Agricultural Potential
Clovelly (Found near stream bed cultivated crop is maize)	1.5	Orthic topsoil A horizon overlying a deep, red, well drained, structureless, B horizon underlain by hard or weathered rock.	Low due to very sandy nature and low soil fertility conditions.
Oakleaf	0.8 – 1.5	Orthic topsoil A horizon overlying a deep, neocutanic, brown, well drained, structured B horizon.	High due to high rainfall in the region well drained status and high water holding capacity of the soil.
Hutton	0.8 – 1.5	Orthic topsoil A horizon	High due to medium to

Soil Form	Average Depth (m)	General Characteristics	Agricultural Potential
		overlying a deep, red, well drained, structureless, B horizon underlain by hard or weathered rock.	high rainfall in the region well drained status and high water holding capacity of the soil.
Valsrivier	0.75	Orthic topsoil A horison overlying a pedocutanic B horison underlain by unspecified material.	Low due to clayey nature and potential water logging conditions.

8.2.1 Infrastructure Site

Plan 3contains the soil information for the first infrastructure site. The site is dominated by deep Oakleaf soil. A small area to the south of the infrastructure site is shallow due to the presence of a rock outcrop. The location of this proposed infrastructure site is recommended from a soil point of view.

8.2.2 Alternative Plant Site

Plan 4contains the soil data for the alternative plant infrastructure site. The site is located in the valley bottom landscape position and is occupied by a variety of soils but dominated by Oakleaf and Valsrivier soils present on the western and northern part of the alternative infrastructure site. The eastern part of the site is occupied by shallow Mispah and Glenrosa soils. It is recommended to avoid this location for infrastructure due to the presence of high clay content soil located in the western part of the site for example the Valsrivier soil. Smaller areas in close vicinity of the location of the infrastructure are occupied by vertic soil such as the Arcadia soil type. Both the Valsrivier and Arcadia soil types contain high clay content. The clay minerals present within the clay fraction are dominated by crimping and swelling montmorillonite clay minerals causing large cracks when dry and dense wet soil conditions when wet. Swelling and crimping soils are notorious to break buildings due to shifting foundations when expensive mitigation procedures such as using steel in foundations, are disregarded.

8.2.3 TSF Sites

The proposed TSF sites 1, 2 and 3 are contained in Plan 5, Plan 6, and Plan 7. The properties of the soil occupying these sites are briefly discussed.

8.2.3.1 TSF Site 1

The proposed TSF site 1 is characterised by the occurrence of homogeneous deep Oakleaf soil, see Plan 5. This site is recommended as the TSF site of choice due to the Oakleaf soils present. Oakleaf soil consists of an orthic A horizon, overlying a neocutanic brown apedal B horizon. Oakleaf soils are considered to be good agricultural soils due to their sandy clay loam textures. These soils are cultivated easily, hold water and adsorb nutrients allowing optimal crop production.

The topsoil layer should be stripped and stockpiled prior to the construction of the TSF to ensure that a source of soil is kept to cover and vegetate the TSF.

8.2.3.2 TSF Site 2

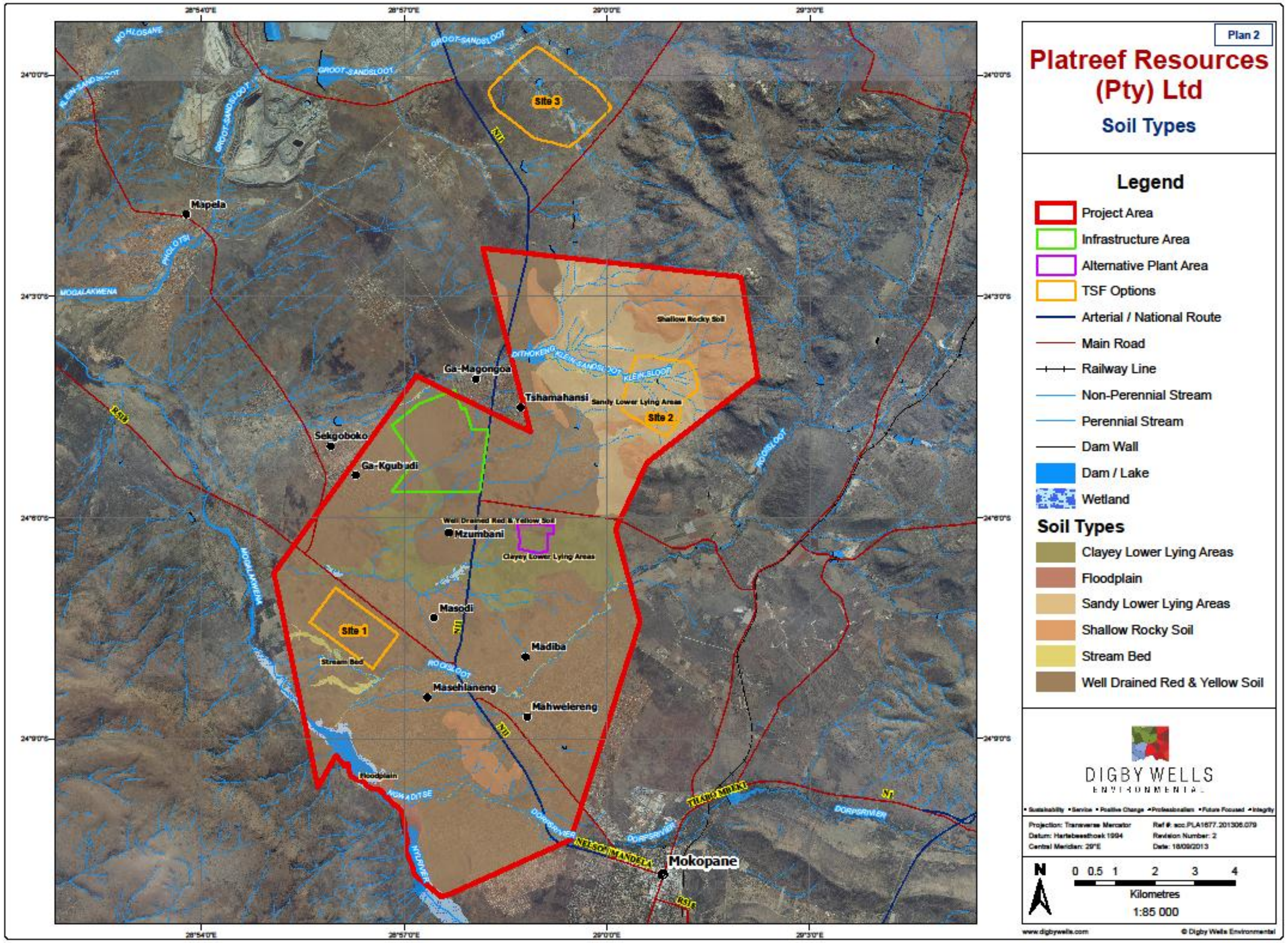
The proposed TSF site 2 is characterised and dominated by sandy shallow soils containing stones and rocks. The proposed location for TSF 2 is in a higher landscape position compared to the landscape positions of TSF 1 and TSF 3. Drainage lines can be seen in Plan 6 effectively dividing the site. Drainage lines are characterised by heavy clay Valsrivier soil.

The sandy soils occupying TSF 2 are difficult to manage due to their sandy nature. Stripping stockpiling and rehabilitation will be difficult to manage preventing erosion, due to the sandy nature of the soil and the high rainfall intensity present in the area. It is recommended that the location of TSF 2 should be avoided from a soils point of view for use as a TSF.

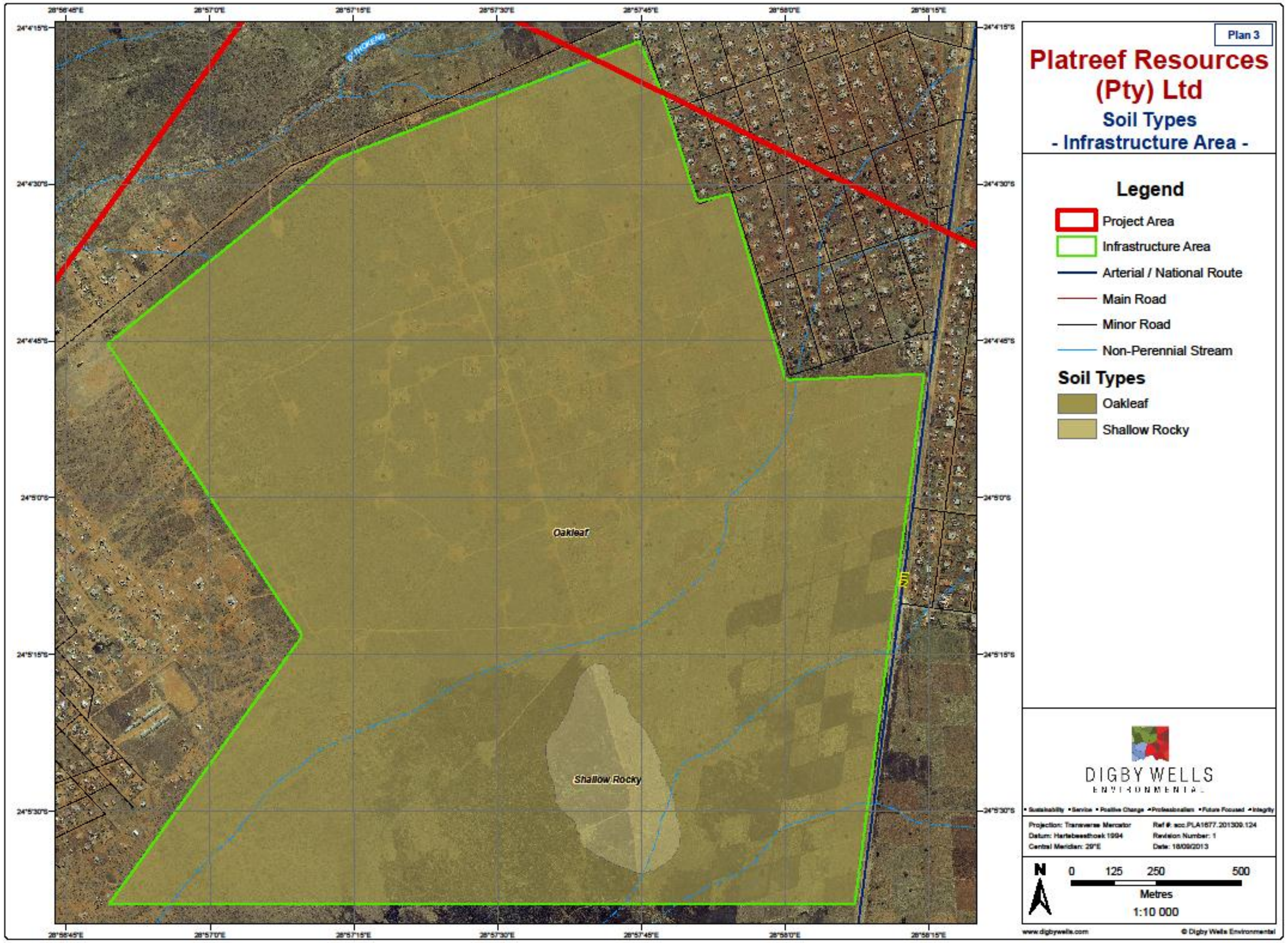
8.2.3.3 TSF Site 3

The proposed TSF site 3 is also characterised and dominated by sandy Glenrosa and Clovelly soils containing stones and rocks in places. The proposed location for TSF 3 is in a higher landscape position compared to the landscape positions of TSF 1. Drainage lines can be seen in Plan 7 effectively dividing the site down the middle. The drainage lines are eroded and large areas can be seen where the topsoil is eroded away.

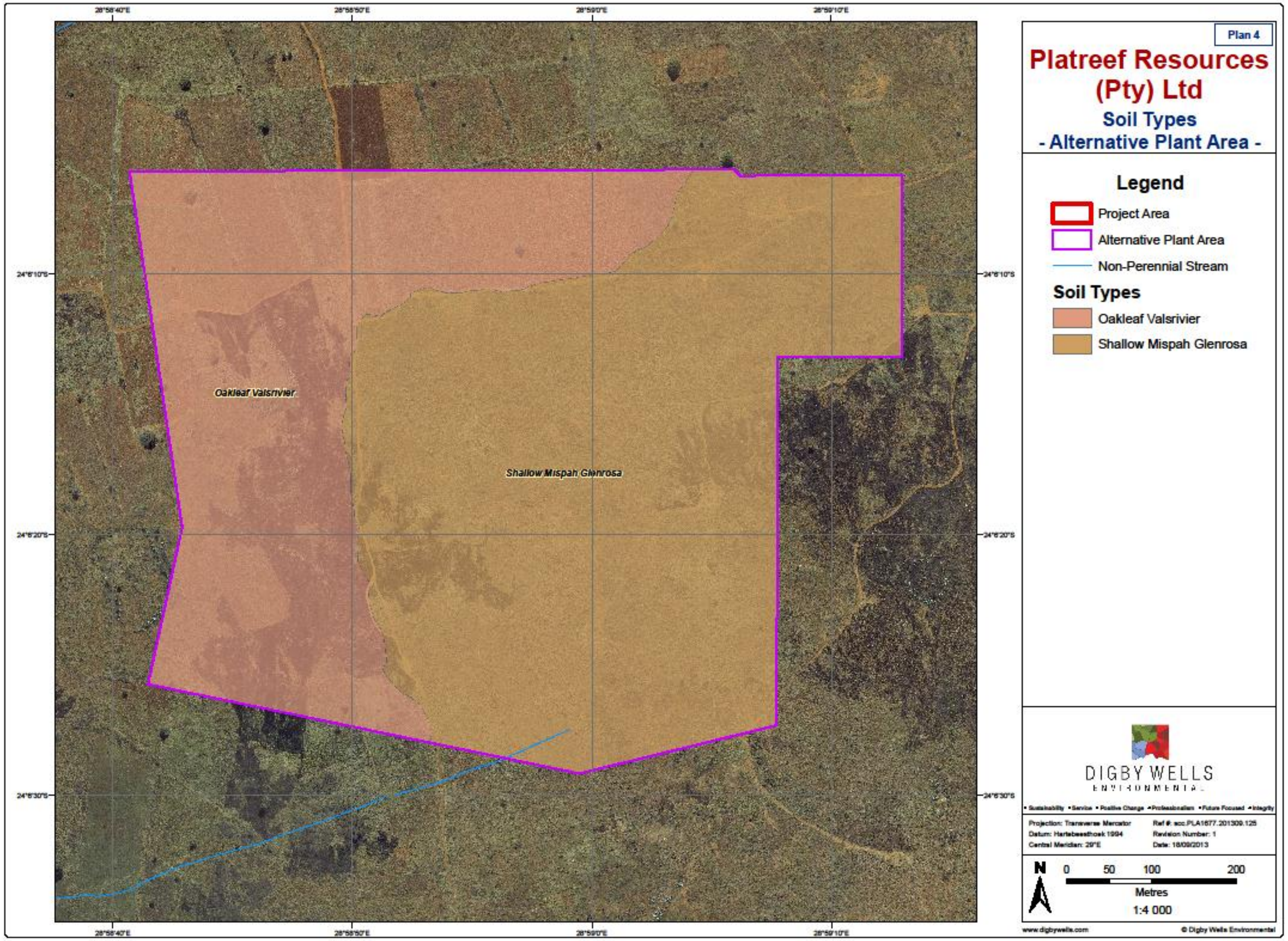
The sandy soils occupying TSF 3 will be difficult to manage due to their sandy nature. Stripping stockpiling and rehabilitation will be difficult to manage preventing erosion, due to the sandy nature of the soil and the high rainfall intensity present in the area. It is recommended that the location of TSF 3 should be avoided from a soils point of view for use as a TSF.



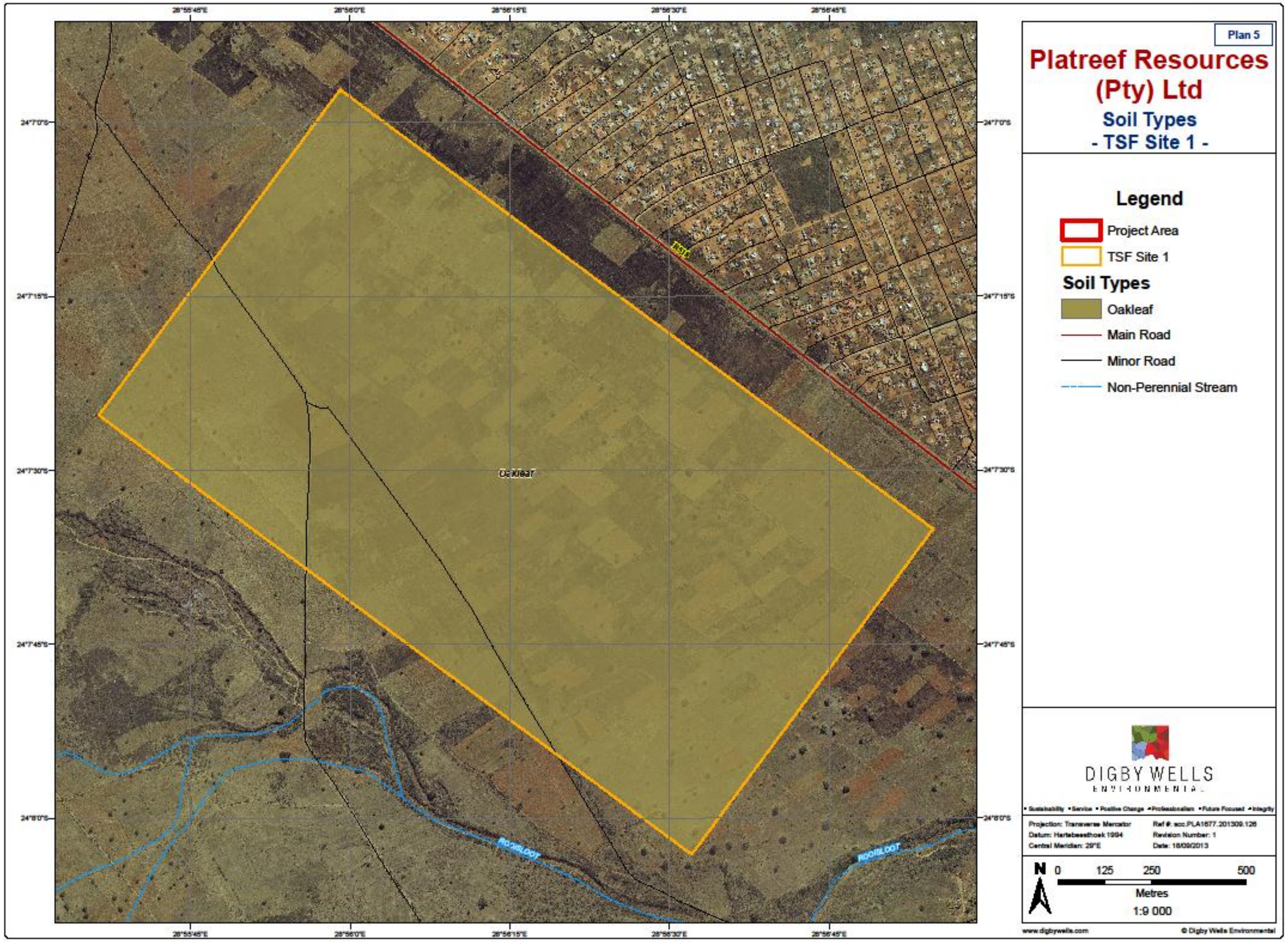
Plan 2: Delineated soil types occupying the proposed Platreef project site.



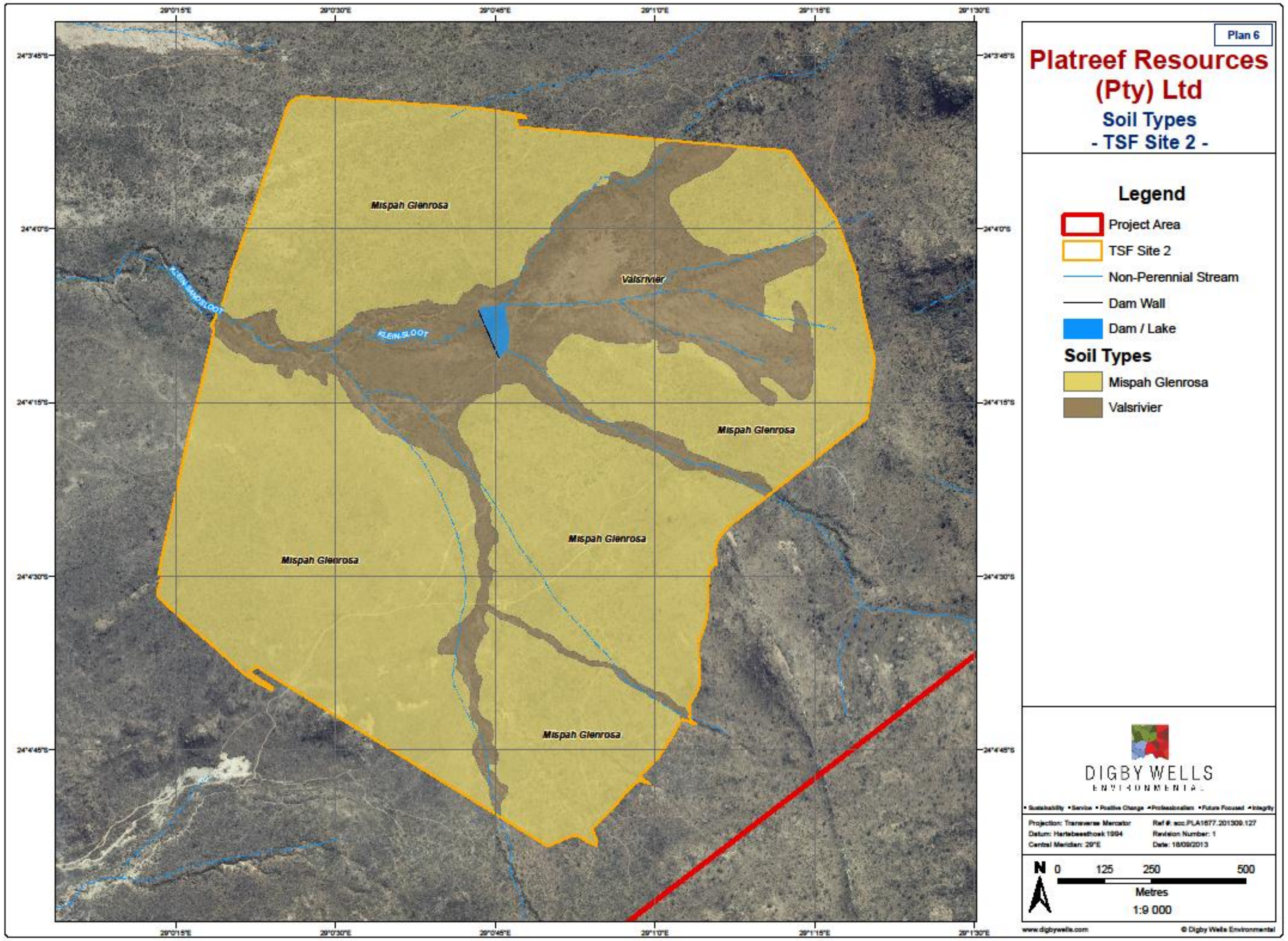
Plan 3: Soil types as occurring in the initial proposed infrastructure site.



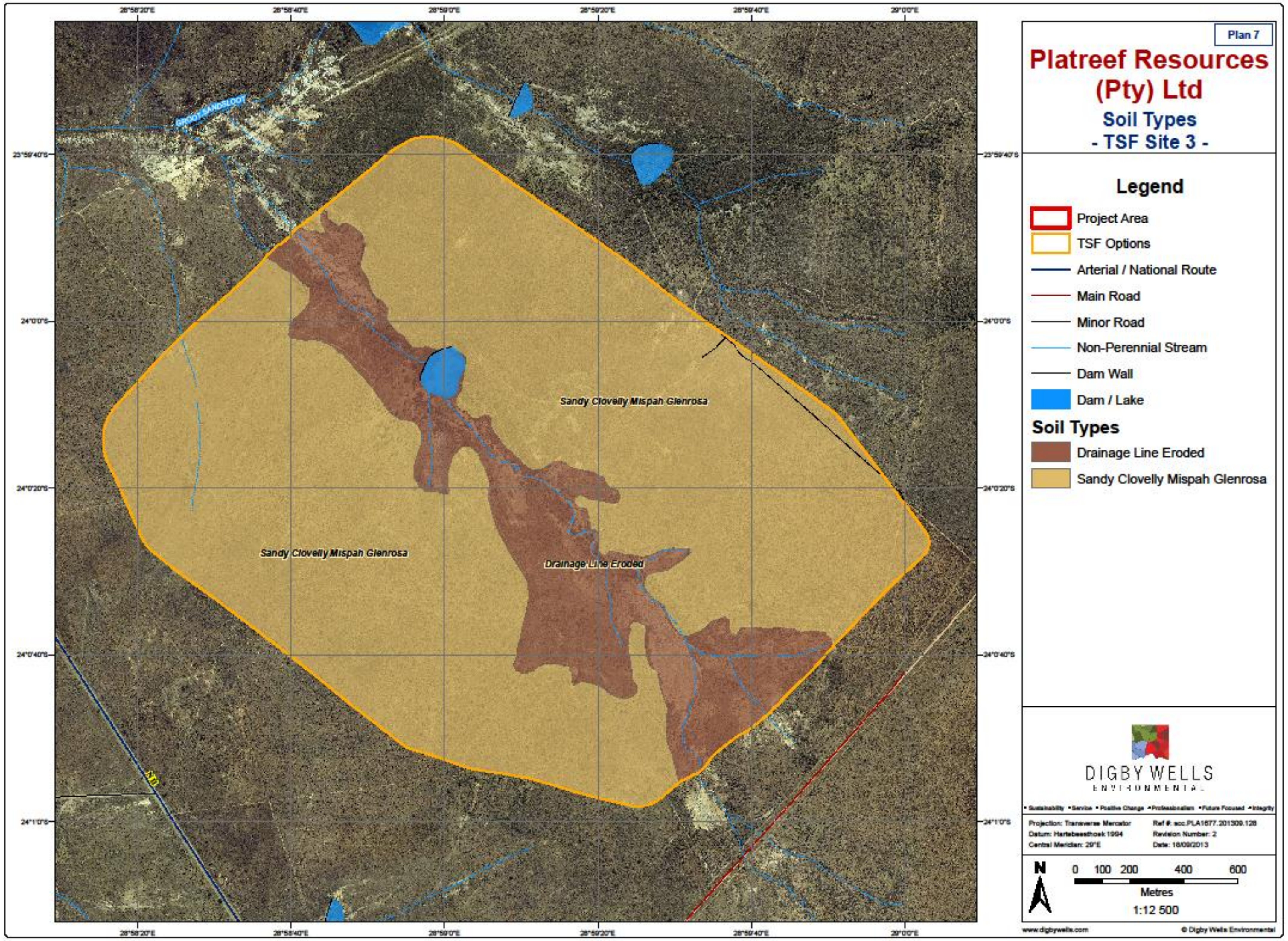
Plan 4: Soil types as occurring in the proposed alternative infrastructure site.



Plan 5: Soil types as occurring in the proposed TSF 1 site.



Plan 6 Soil types as occurring in the proposed TSF 2 site.



Plan 7 Soil types as occurring in the proposed TSF 3 site.

9 LAND CAPABILITY AND LAND USE

Land capability is determined by a combination of soil, terrain and climatic features. Land capability is defined by the most intensive long term sustainable use of land under rain-fed conditions. Simultaneously an indication is included in the definition about the permanent limitations associated with the different land use classes (Schoeman et al, 2000).

Table 9-1 contains a summary of the land capability classes and present land use of the Proposed Platreef site. The site is dominated by the Ae land type indicating that arable agriculture is potentially possible but used presently for sustainable agriculture, specifically mixed arable and grazing (cattle) but dominated by grazing.

Table 9-1: A summary of the land capability and dominating land use of land types present in the Platreef study area.

Land Type	Dominating Soil Capability Class	Dominating Land Capability Class	Dominating Land Use	Agricultural Potential
Ae224	iii	iii	Housing/Grazing	Arable
Ah28	vi	vi	Housing/Grazing	Grazing
Ib447	viii	viii	Grazing	Wildlife

Underground mining will have an influence on land capability during mining operations. Access will be restricted to mine areas effectively preventing any agricultural activities to continue. This restriction causes pressure on the resources used for agriculture because smaller areas are available for arable and grazing in close proximity of the mining land.

10 FERTILITY

Table 10-1 contains the soil analytical data of the dominant cultivated Clovelly, Oakleaf, and Hutton soil forms. Organic carbon (C) in the topsoil ranges from 0.65 – 1.07%. Generally South African cultivated soils contain a C content of around 1%. A C content of 1% is considered to be low but expected for cultivated soil under South African climatic conditions.

Phosphorus (P) status, as contained in Table 10-1 shows that the P status is very low. P is an important macro nutrient and the P content with a low of 0.96 and a high of 4.6 mg kg^{-1} is very low and indicative of poor P soil status. Natural low fertility status is deteriorated even further through loss of phosphate by fixation. Phosphate fixation is a common problem in red soils thereby depleting plant available phosphate.

The soil pH is in the order of 5.8 – 6.2. This pH range is indicative of normal soil conditions not only in the topsoil but also in the subsoil.

The soils in this area are considered to have a low cation exchange capacity (CEC). A low CEC reflects low soil clay and organic matter content, because CEC is a property of both clay and organic material. The cation exchange capacity (CEC) ranges from 5.9 to

10.8 cmol(+)kg^{-1} for the topsoils. Low CEC implies low nutrient content while the opposite is true for high CEC.

The size limits for sand, silt and clay used in the determination of soil texture classes are sand: 2.0 – 0.05 mm, silt: 0.05 – 0.002 mm and clay: < 0.002 mm. The clay content range is from 6 – 22% in the topsoil while the subsoil has a clay content ranging from 24 to 36%. This type of soil texture indicates that the soils can be cultivated easily using normal farm machinery. The texture properties of the soils analysed allow the cultivated soils to be classed as sandy clay loam soils. Sandy clay loam soils are easily cultivated using normal farming equipment.

Table 10-1: Soil laboratory results, chemical and physical analytical data.

Sample Point	Soil Form	Depth cm	Org C %	CEC Cmol (+)kg^{-1}	K mg kg^{-1}	Ca mg kg^{-1}	Mg mg kg^{-1}	Na mg kg^{-1}	P (Bray1) $mgkg^{-1}$	pH (H_2O)	Sand %	Silt %	Clay %
1	Hutton	0-30	0.65	10.78	153	403	138	17.5	1.2	6.18	76	8	16
		30-60			70	334	280	18.2	0.15	6.06	70	6	24
2	Oakleaf	0-30	1.07	10.5	253	445	173	13.5	0.96	5.9	72	6	22
		30-60			186	711	370	29.2	0.31	6.53	56	8	36
3	Clovelly	0-30	0.53	5.87	54	120	30	17.4	4.6	5.77	92	2	6

11 IMPACT ASSESSMENT

Table 11-1 contains the listed project activities for the Platreef project. The activities impacting on soil during the construction phase are Activities 1, 2 and 4. During the operation phase the activities impacting on the soil are Activities 6, 9 and 10 while the activities impacting on the soil during the decommissioning phase are Activities 12 and 13. Activity 16 impacts on the soil during the post closure phase.

Table 11-1: Expected project activities for the Platreef site are listed in chronological order.

Activity No.	Activity
Construction Phase	
1	Site Clearing: Removal of topsoil and vegetation
2	Construction of any surface infrastructure e.g. access roads, pipes, storm water diversion berms, change houses, admin blocks etc. (including transportation of materials and stockpiling)
3	Drilling, blasting and development of infrastructure and adits for mining
4	Temporary storage of hazardous products (fuel, explosives), and waste (e.g. sewage).
5	Monitoring: Environmental monitoring of construction activities' potential impacts
Operational Phase	
6	Use and maintenance of roads and infrastructure
7	Removal of overburden and ore (mining process) and backfilling when possible (including drilling/blasting of hard overburden & stockpiling it)
8	Water use and storage onsite (storm water, PC Dam, domestic waste water, and abstraction)
9	Storage, handling and treatment of hazardous products (fuel, explosives, oil) and waste (waste, sewage, PC Dam)
10	Concurrent rehabilitation by replacement of overburden, subsoil, topsoil and revegetation as mining progresses
11	Monitoring: Environmental monitoring of operational activities' potential impact
Decommissioning Phase	
12	Demolition and Removal of all infrastructure (incl. transportation off site)
13	Rehabilitation (spreading of soil, re-vegetation & profiling/contouring)
14	Storage, handling and treatment of hazardous products (fuel, explosives, and oil) and waste (waste, sewage, PC Dam).
15	Monitoring: Environmental monitoring of decommissioning activities' potential impact

Post - Closure	
16	Post-closure monitoring and rehabilitation

This section presents the findings of the assessment of potential impacts to the soil environment associated with the proposed development of the Platreef project.

The results of the impact assessment are presented as follows:

- *Significance assessment* – An assessment of the significance of anticipated positive and negative impacts to the soil environment associated with project activities is provided; and
- *Cumulative impacts* – The results of a high-level qualitative assessment of the potential cumulative impacts of the proposed project and existing and proposed developments in the reasonable future, such as mining and industrial developments in the Limpopo Province of South Africa is presented.

Recommended measures to enhance the positive impacts and to mitigate negative impacts have been included in this report.

11.1 Impact significance assessment

Activities associated with the construction, operation and decommissioning of each component of the Platreef project will result in impacts on the soil environment.

In order to assess the significance of these impacts, use was made of a semi-quantitative impact assessment methodology which is based on an assessment of the following parameters:

- *Severity* – The magnitude of change from the current baseline status of the affected environmental, socio-economic or heritage aspect;
- *Spatial scale* – The physical area which is impacted on by the potential impact;
- *Duration* – The expected time period during which a potential impact will be experienced; and
- *Probability* – The likelihood of occurrence of the impact, based on knowledge of the operating conditions and the type of activities that will be undertaken.

11.1.1 Impact of Site Clearing: Removal of topsoil & vegetation and stockpiling of overburden topsoil (applicable to Activities 1, 2 and 6).

11.1.1.1 Impact Description

Activities during early works and construction in the Platreef project area could lead to the following impacts on soils:

- Soil compaction and topsoil loss leading to reduced agricultural potential; and
- Soil erosion (sediment release to land and surface water).

Shaft and other infrastructure areas need to be stripped of soil and vegetation. The topsoil and subsoil must be stripped and stockpiled separately from the rock discard originating from the shaft area. The stockpiled topsoil and subsoil will be used in future rehabilitation and re-vegetation.

Compaction and increased erosion from increased exposure to wind and water are likely to cause changes in the soil structure and degradation of soil quality. The extent to which these occur is dependent on the properties of the soils. In the case of Platreef the extent can be significant due to the high rainfall in the area.

Water erosion may come about when water (for example runoff) comes in contact with bare soil on cleared patches, especially on sloped terrain or running down insufficiently sloped stockpiles. An occasional heavy rainstorm during the rainy season can initiate erosion on bare patches. The impact of erosion through water runoff can play a significant role because the annual rainfall is high. Most of the erosion is expected to occur along main unpaved compacted roads.

The project activities during construction will result in the change of land use from natural vegetation and agriculture (primarily mixed arable and grazing) to industrial within the Platreef project site. Land capability and productivity will be lost within the Platreef project infrastructure sites resulting from a land use change from agriculture to industrial use.

The impacts of stripping and erosion of soils will be negative and restricted to on-site. Limited impacts are expected outside of the Platreef project site, with the exception along unpaved roads within the region, where erosion can impact on adjacent areas. Impacts will occur and will be permanent in duration, but significance of the impact will decrease when disturbed areas are rehabilitated and re-vegetated during decommissioning of the Platreef project. Intensity will range from low to high as natural functions of the soil can be altered by subsidence of the soil surface above mined areas. Impact significance to soil resources and land capability pre-mitigation is expected to be low to medium depending on if subsidence will occur as well as the grade of subsidence.

Table 11-2: Impact of soil stripping activities on soil and land capability.

Parameter	**Impact Pre-Mitigation**		**Impact Post-Mitigation**	
Duration (7)	Permanent without mitigation	7	Permanent with mitigation	7
Scale (7)	Local	3	Local	3
Severity (7)	Moderate	3	Low	2
Likelihood (7)	Certain	7	Certain	7
Significance	Medium-High	97	Moderate	84

11.1.1.2 Mitigation

Construction (including site preparation)

- Plan site clearance and alteration activities for the dry season (May to October);
- Restrict extent of disturbance within the Platreef project site and minimise activity within designated areas of disturbance;
- Minimise the period of exposure of soil surfaces through dedicated planning;
- Stripping operations should only be executed when soil moisture content will minimise the risk of compaction (during dry season);
- During stockpiling, preferably use the 'end-tipping' method to keep the stockpiled soils loose;
- Ensure stockpiles are placed on a free draining location to limit waterlogging; and
- Limit stockpile height – a safe height can be regarded as the height at which material can be placed without repeated traffic over already placed material.

Operations

- Re-vegetate cleared areas and stockpiles to avoid water erosion losses;
- Preserve looseness of stockpiled soil by executing fertilisation and seeding operations by hand; and
- Soil stockpiles should be monitored for fertility via sampling and testing; and
- Monitoring of the condition of all unpaved roads is necessary due to the high rainfall and potential water runoff and erosion of the soils present in the Platreef project site. Water runoff from compacted road surfaces may cause erosion of road shoulders degrading the road surface. Weekly inspections need to be carried out of all unpaved roads especially during the rainy season.

11.1.1.3 Residual Impact

The potential for impacts to soils resources and land capability will remain present, as they typically derive from the land-take footprint from the physical presence of the underground mining development. With the implementation of the above control and mitigation measures the impact significance is likely to be reduced.

11.1.2 Assessment of the impact of temporary storage of hazardous product (fuel, explosives) and waste on soil (Applicable to Activities 4, 9 and 14).

11.1.2.1 Impact Description

Impacts to soil resources are dependent on the size of the spill and the speed with which it is addressed and cleaned up. If contaminated, the ability of soil to carry out its essential functions can be compromised, thus affecting the land capability of the soil. Contaminants transported by water would very rapidly run off due to the clay soils, but infiltrate slow in clays decreasing the risk of groundwater contamination but increasing the risk of surface water contamination.

The potential for contamination of soil resources exists during site preparation and construction as a result of spills and/or leaks of fuels, oils and lubricants from construction or operational vehicles or machinery. Fluids used for vehicles and machinery may spill during filling, or leak directly in the event that damage to the fluid system goes unnoticed. Soil contamination associated with leaks and spills from machinery are reduced during the operation phase since site activities will be reduced.

The likelihood of a spill is also associated with the volume of product that may be stored onsite. For a development of this nature, above ground storage tanks for diesel and varying amounts of hydraulic oils and used oils will be required during the construction and operational phases. Leakage of a storage tank may cause contamination should the contaminants come into contact with soil. A potentially contaminated surface water (PCSW) system should be in place to capture potentially contaminated surface water and wash from "dirty" areas (pollution control dam) during the operational phase for treatment before re-use or discharge.

Should soil be affected by an accidental spill or leak, elsewhere in the Platreef project site where vehicles and machinery will be operating or where storage tanks are located, the land capability could be compromised. The intensity of the impact on soil resource is dependent on the existing land use of area affected from the spill and may be medium. The magnitude of the impact is medium and the probability of a spill affecting soil resources is likely, therefore the impact significance should be medium.

Table 11-3: Impact assessment of accidental spills or leaks of fuel and or oil on soil (Applicable to Activities 4, 9 and 14).

Parameter	**Impact** **Pre-Mitigation**		**Impact** **Post-Mitigation**	
Duration (7)	Project Life	5	Project Life	5
Scale (7)	Limited	2	Limited	2
Severity (7)	Moderate	3	Moderate	3
Likelihood (7)	Almost certain	6	Almost certain	6
Significance	Medium-Low	60	Medium-Low	60

11.1.2.2 Mitigation

Construction

- Construction vehicles and equipment should be serviced regularly, in a designated area;
- Service areas must be paved;
- Construction vehicles should remain on designated and prepared compacted gravel roads;
- Areas that are used to store hydrocarbons must be bunded and be able to contain the spillage in the event of a spillage occurring;

- Drip trays must be used when machinery and/or vehicles are serviced; and
- Spill containment and clean up kits should be available onsite and clean-up from any spill must be in place and executed at the time of a spillage with appropriate disposal as necessary.

Operations

- Operations vehicles and equipment should be serviced regularly;
- Service and parking areas must be paved;
- Operations vehicles should remain on designated and prepared compacted gravel roads;
- Spill containment and clean up kits should be available onsite and clean-up from any spill must be in place and executed at the time of a spillage with appropriate disposal as necessary;
- Drip trays must be used when machinery and/or vehicles are serviced;
- Fuel and heavy hydrocarbon products storage on site should be secured by bunded facilities; and
- It is advisable to develop a soil monitoring plan and implement it after construction through collecting and analysis of soil samples within the Platreef Project site.

11.1.2.3 Residual Impact

Based upon the integrated mitigation measures and procedures which will be put in place to prevent, contain, clean-up and dispose of any spillage, significant effects to soil resources are unlikely to arise and impacts are expected to be of low magnitude should they occur.

11.1.3 Impact assessment of site rehabilitation on soil and land capability (Applicable to Activities 10, 12, 13 and 16).

11.1.3.1 Impact Description

The decommissioning of the Platreef project site infrastructure will entail the demolition of buildings and removal of infrastructure. During the decommissioning activities, impacts to soil resources may include compaction and contamination which may be significant only in the short term. Stripped topsoil will be replaced by stockpiled topsoil and rehabilitated. Re-vegetation of the disturbed areas will allow a return to pre-impact land capability for agricultural land use. The intensity and magnitude is likely to be medium-low.

Table 11-4: Impact of site rehabilitation on soil and land capability.

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Duration (7)	Permanent without mitigation	7	Permanent with mitigation	7
Scale (7)	Local	3	Local	3

Parameter	Impact Pre-Mitigation		Impact Post-Mitigation	
Severity (7)	Very significant	7	Low	2
Likelihood (7)	Certain	7	Certain	7
Significance	High	119	Medium High	84

11.1.3.2 Mitigation/ Enhancement

Decommissioning

The following mitigation or enhancement measures should be implemented during the decommissioning phase to increase the success of the rehabilitation of the soil resource and land capability:

- Demolition and removal of infrastructure should be restricted to the dry season (May to October);
- Shaft areas must be filled and reshaped and the soil replaced. Subsoil first then topsoil;
- Total soil thickness must at least be 1 m for the arable areas and 0.35 m (topsoil) for grazing land;
- Minimize the period of exposure of soil surfaces through dedicated planning; and
- Foundation excavations should be filled, fertilised and re-vegetated using local vegetation.

11.1.3.3 Residual Impact

Residual impact significance is likely to be enhanced by the measures outlined above. When implemented, these measures will ensure that the magnitude is a positive impact.

12 CUMULATIVE IMPACTS

One of the major impacts associated with underground mining is subsidence. This could leave a lasting impact on a large area. This could change drainage lines leading to land capability and land use changes which in turn changes farming land use significantly. This impact must be quantified through expert consultation. If however, subsidence can be contained by using support structures, then the mining operation should not leave any significant impacts on the soils, their land capability and resultant land use.

The potential site specific impacts of underground mining activities on land capability are low due to the low impacts on the soil. Fencing of the mining project site will exclude animals from grazing haphazardly. The condition of vegetation in undisturbed areas inside the mining right area may therefore improve.

The cumulative impact on regional land capability and land use is low because no commercial agricultural is practiced within the project area and the contribution therefore to regional agriculture is very low.

Land capability and land use can only be rehabilitated after the mine decommissioning phase. Mine infrastructure will be removed making the rehabilitation of soil and land capability possible. Returning to pre-mining land capability depends on the rehabilitation efforts during soil profile reconstruction of building sites and roads.

13 MONITORING PROGRAMME

Soil conservation is important during all phases of mining. Managing runoff water from building sites and roads is especially important. Runoff water causes soil erosion and therefore soil loss.

Erosion assessments should be carried out to visually check for erosion channels. This should be done in the mining area after rain events along all roads. Where fresh erosion channels are found, indicating that active erosion is occurring, remediation work will need to be programmed to improve the vegetation cover or divert rain water runoff, as indicated by the specific site conditions.

Progressive monitoring of the stripping (from building sites and roads), stockpiling and shaping of topsoil will ensure successful post-mining land and soil reclamation. Assessing post-mining soil characteristics and associated land capability and land uses is necessary but lack the opportunity to correct failures during the rehabilitation process.

Subsidence should be monitored annually using the remote sensing methodology tested and recommended by Engelbrecht *et al*, 2011.

14 RECOMMENDATIONS

The following recommendations contained in Table 14-1 are applicable to the Platreef project site.

Table 14-1. Recommendations for the Platreef project site.

Item	Time frame	Discussion
Tree and shrub removal, chipping of trees and shrubs from building sites and roads.	During construction	Chip trees and shrubs in situ to retain carbon in soil.
Topsoil stripping from TSF areas, building sites and roads.	Continuous during construction and operational phases	Strip topsoil and vegetative matter together.
Topsoil stockpiling	During construction and operational phases	Keep topsoil stockpiles well marked for use during rehabilitation because topsoil contains seeds, carbon and nutrients.
Vegetate topsoil stockpiles using site specific vegetation	Continuous during construction and operational phases	To be implemented after stockpiles are constructed to protect topsoil stockpiles. Demarcate topsoil stockpile sites clearly.
Soil chemical quality	Prior to closure	To be implemented post replacing topsoil on

Item	Time frame	Discussion
monitoring		rehabilitated construction sites and roads. Adjust any soil nutrient deficiencies, pH and organic carbon if necessary.
Vegetate rehabilitated sites.	During closure	Use adapted species to rehabilitate back to pre-mining land capability.
Monitor rehabilitated soil and vegetation quality	Annually	Ensure pre-mining land use is reached by maintaining rehabilitated soil and vegetation quality until baseline sustainability is reached.

15 CONCLUSION

Presently the Platreef project site is used for arable and grazing subsistence farming. The project site is occupied and dominated by red and yellow medium textured soils. Generally the yellow coloured soils occupy the crest landscape positions while the wet soils occupy the midslope and footslope landscape positions. The yellow soils are used for arable crop production while the wet soils are used to graze animals on.

The analysed soil samples pH properties are within suggested optimum pH levels. The soil Ca, Mg, K and C content is good in all the dominant soil types. The P status is low in all the dominant soils sampled except one indicating potential P deficiency in the arable soils. The clay content in the topsoil ranges between 16 and 40 %. Generally this type of soil texture indicates that the soils can be cultivated easily using normal farm machinery.

The dominant soil and land capability of the deep Oakleaf and Hutton soils is arable while the soil and land capability of the shallow Valsrivier soil is grazing only. Present land use is limited to subsistence crop farming and grazing.

The impacts on the soil related to the underground mining activities are low and it is possible to rehabilitate the soil back to pre-mining land capability and land use.

Subsidence of the soil surface can occur and can cause changes in drainage lines, waterlogging and a change in land capability influencing land use.

The proposed TSF site is recommended as the TSF site of choice due to the Oakleaf soils present. Oakleaf soil consists of an orthic A horizon, overlying a neocutanic brown apedal B horizon. Oakleaf soils are considered to be good agricultural soils due to their sandy clay loam textures. These soils are cultivated easily, hold water and adsorb nutrients allowing optimal crop production.

Plan 3 contains the soil information for the first infrastructure site. The site is also dominated by deep Oakleaf soil. The location of this proposed infrastructure site is recommended from a soil point of view.

16 REFERENCES

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