REPORT

Central Térmica de Temane Project - Soil Baseline & Impact Assessment Report

Moz Power Invest, S.A. and Sasol New Energy Holdings (Pty) Ltd

Submitted to:

Ministry of Land, Environment and Rural Development (MITADER)

Submitted by:

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Executive Summary

Golder Associates (Golder), was appointed by Sasol New Energy Holdings (Pty) Ltd (SNE) to conduct the Environmental and Social Impact Assessment (ESIA) for the proposed construction and operation of a gas to power facility, known as the Central Térmica de Temane (CTT) project. The proposed CTT project will draw gas from either the Sasol Exploration and Production International (SEPI) gas well field via the phase 1 development of the PSA License area, covering gas deposits in the Temane and Pande well fields in the Inhassoro District and the existing Central Processing Facility (CPF) or from an alternative gas source. Consequently, the Central Térmica de Temane (CTT) site is located in close proximity to the CPF. The preferred location for the CTT plant is approximately 500 m south of the CPF. The CPF, and the proposed site of the CTT project, is located in the Temane/Mangugumete area, Inhassoro District, Inhambane Province, Mozambique; and approximately 40 km northwest of the town of Vilanculos. The Govuro River lies 8 km west of the proposed CTT site. The estimated footprint of the CTT is 20 ha. As part of the ESIA a baseline soil study and an impact assessment were conducted. The study was undertaken to:

- Understand the baseline soil conditions;
- Evaluate the potential impacts of the proposed CTT project on the soil and land use; and
- Describe and evaluate any other limiting characteristics of the soil.

Based on the findings of the baseline study and impact assessment, the following is concluded:

- Soil types occurring in the CTT plant area, the gas pipeline area, most of the transmission line area and the southern part of the water pipeline area have considerable resilience with respect to water and wind erosion as well as chemical pollution but are somewhat susceptible to compaction and surface crusting. The agricultural potential is moderate and the land capability Class III.
- Soil type transitions occur roughly between the EN1 road and the Govuro lowlands along the water pipeline route. These soils are widely used for cultivation, although they have soil fertility limitations in places. They are susceptible to water erosion, compaction and surface crusting to a degree. The agricultural potential is moderate and the land capability Class III.
- The Govuro lowlands are encountered in the water pipeline corridor and the potential access road *via* the pipe bridge. Where not under water they are occupied by deep, wet, grey sands or loamy sands with organic-rich top-soils. These wetland soil areas are not regularly used for arable agriculture. The land capability is Class V.
- Between the Govuro lowlands soils are very widely used for cultivation, particularly around Inhassoro town, and are the main arable soils of the area. These soils are susceptible to wind and water erosion, as well as compaction. The agricultural potential is moderate and the land capability Class III.
- A narrow strip of white coastal sand line the beach at Inhassoro town where it will be encountered in potential beach landing sites. It has no arable potential and the land capability is Class VII (low grazing capacity) or VIII (wilderness land).
- The main soil analytical dataset for 10 of the 20 sites sampled (consisting of 19 samples) from the Jones Environmental and Forensic Laboratories show, what may in most cases be considered as baseline values, for a limited range of inorganic elements. Toluene, ethylbenzene and styrene were found to be above the reporting limits in the surface soils analysed in the vicinity of the CTT plant site and water pipeline.

The key impacts on the soil and land arising from the project activities were found to be:

- Changes in land use;

- Soil quality degradation;
- Contamination of soils;
- Soil erosion;
- Soil compaction; and
- Loss of soil agricultural potential.

Of these impacts, the disturbance of soil (including soil compaction); loss/ change of land use; and loss of potentially arable land was rating as moderate significance (prior to implementation of the recommended mitigation measures). The impact of change in land use, soil compaction and loss of agricultural potential remain of a moderate significance (irrespective of implemented of mitigation measures), due to the nature of the project activities, and the inherent soil properties which will be altered (impacted) by the project activities.

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ACRONYMS

Acronym	Description
AMITSA	Regional Agricultural Input Market Information and Transparency System
Brl	below reporting limit
CPF	Central Processing Facility
CTT	Central Térmica de Temane
DAF	Dilution Attenuation Factor
DTA	*Departamento de Terra e Agua*
DWA	Department of Water Affairs (South Africa)
EMP	Environmental management plan
FAO	Food and Agricultural Organisation of the United Nations
GoM	Government of Mozambique
IFC	International Finance Corporation
INIA	National Agronomic Research Institute
IPCC	Intergovernmental Panel on Climate Change
ISRIC	World Soils Information
IUSS	International Union of Soil Sciences
KLINOS	Climate and Development Programme (partnerships between universities and university colleges in Flanders and the South)
MGtP	Mozambique Gas to Power Project
RCP	Representative Concentration Pathway (used in climate change scenarios)
SSG	Soil Screening Guidance
SSL	Soil Screening Level
THQ	Target Health Quotient
UNDP	United Nations Development Programme
US EPA	United States Environmental Protection Agency
WRB	World Reference Base for Soil Resources

1.0 PROJECT OVERVIEW

The Mozambican economy is one of the fastest growing economies on the African continent with electricity demand increasing by approximately 6-8% annually. In order to address the growing electricity demand faced by Mozambique and to improve power quality, grid stability and flexibility in the system, Moz Power Invest, S.A. (MPI), a company to be incorporated under the laws of Mozambique and Sasol New Energy Holdings (Pty) Ltd (SNE) in a joint development agreement is proposing the construction and operation of a gas to power facility, known as the Central Térmica de Temane (CTT) project. MPI's shareholding will be comprised of EDM and Temane Energy Consortium (Pty) Ltd (TEC). The joint development partners of MPI and SNE will hereafter be referred to as the Proponent. The Proponent propose to develop the CTT, a 450MW natural gas fired power plant.

The proposed CTT project will draw gas from either the Sasol Exploration and Production International (SEPI) gas well field via the phase 1 development of the PSA License area, covering gas deposits in the Temane and Pande well fields in the Inhassoro District and the existing Central Processing Facility (CPF) or from an alternative gas source. Consequently, the CTT site is in close proximity to the CPF. The preferred location for the CTT is approximately 500 m south of the CPF. The CPF, and the proposed site of the CTT project, is located in the Temane/Mangugumete area, Inhassoro District, Inhambane Province, Mozambique; and approximately 40 km northwest of the town of Vilanculos. The Govuro River lies 8 km east of the proposed CTT site. The estimated footprint of the CTT power plant is approximately 20 ha (see Figure 1).

Associated infrastructure and facilities for the CTT project will include:

1) Electricity transmission line (400 kV) and servitude; from the proposed power plant to the proposed Vilanculos substation over a total length of 25 km running generally south to a future Vilanculos substation. [Note: the development of the substation falls outside the battery limits of the project scope as it is part of independent infrastructure authorised separately (although separately authorised, the transmission line will be covered by the Project ESMP, and the Vilanculos substation is covered under the Temane Transmission Project (TTP) Environmental and Social Management Plans). Environmental authorisation for this substation was obtained under the STE/CESUL project. (MICOA Ref: 75/MICOA/12 of 22nd May)];
2) Piped water from one or more borehole(s) located either on site at the power plant or from a borehole located on the eastern bank of the Govuro River (this option will require a water pipeline approximately 11km in length);
3) Access road; over a total length of 3 km, which will follow the proposed water pipeline to the northeast of the CTT to connect to the existing Temane CPF access road;
4) Gas pipeline and servitude; over a total length of 2 km, which will start from the CPF high pressure compressor and run south on the western side of the CPF to connect to the power plant or from an alternative gas source;
5) Additional nominal widening of the servitude for vehicle turning points at points to be identified along these linear servitudes;
6) A construction camp and contractor laydown areas will be established adjacent to the CTT power plant footprint; and
7) Transhipment and barging of equipment to a temporary beach landing site and associated logistics camp and laydown area for the purposes of safe handling and delivery of large oversized and heavy equipment and infrastructure to build the CTT. The transhipment consists of a vessel anchoring for only approximately 1-2 days with periods of up to 3-4 months between shipments over a maximum 15 month period early in the construction phase, in order to offload heavy materials to a barge for beach landing. There are 3 beach

landing site options, namely SETA, Maritima and Briza Mar (Figure 7). The SETA site is considered to be the preferred beach landing site it therefore shall be selected unless it is found to be not feasible for any reason;

8) Temporary bridges and access roads or upgrading and reinforcement of existing bridges and roads across sections of the Govuro River where existing bridges are not able to bear the weight of the equipment loads that need to be transported from the beach landing site to the CTT site. Some new sections of road may need to be developed where existing roads are inaccessible or inadequate to allow for the safe transport of equipment to the CTT site. The northern transport route via R241 and EN1 is considered as the preferred transport route (Figure 8)) on terrestrial impacts; however, until the final anchor point is selected, and the barge route confirmed, the marine factors may still have an impact on which is deemed the overall preferable route.

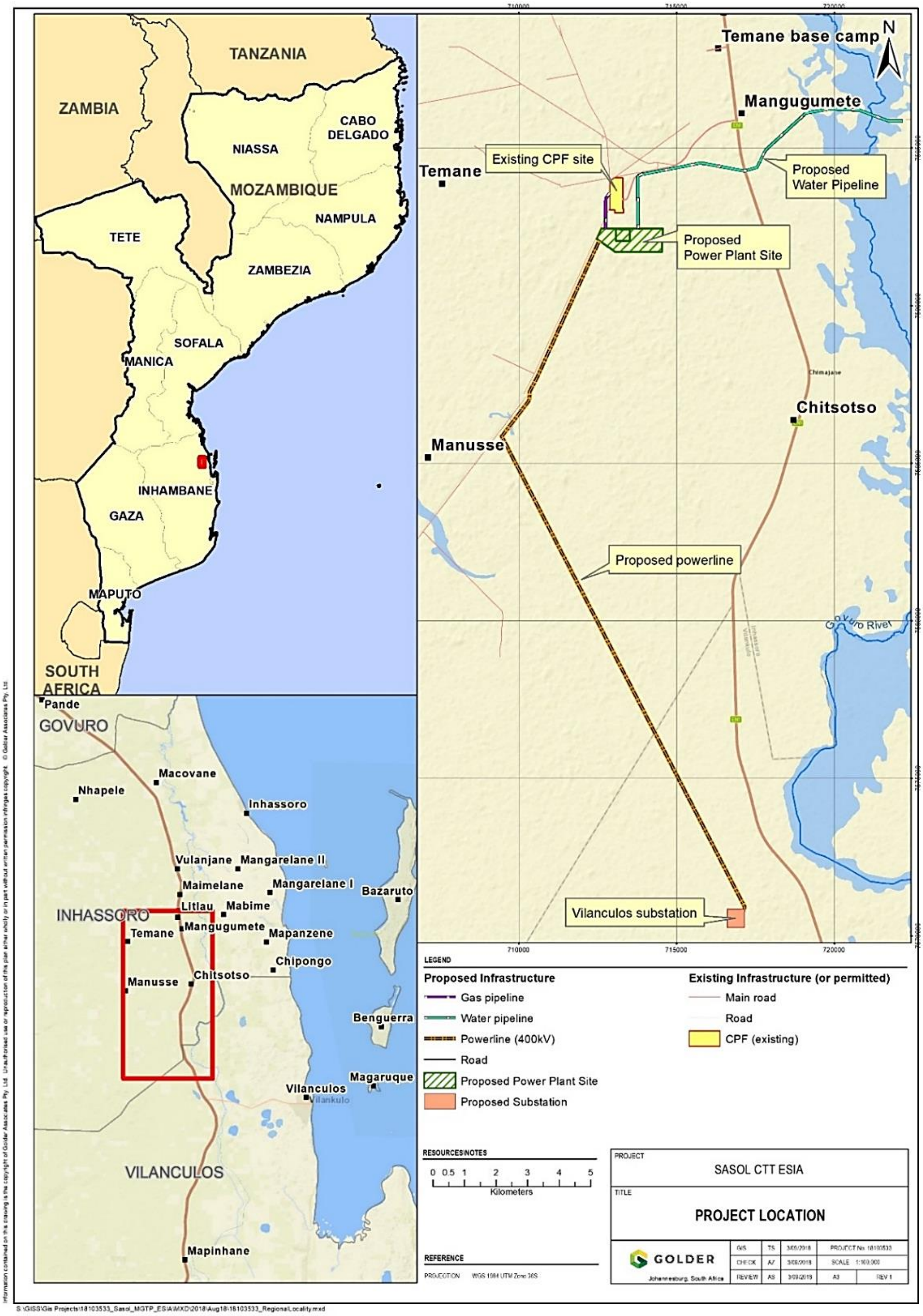

Figure 1: Project Location

2.0 DESCRIPTION OF THE KEY PROJECT COMPONENTS

The CTT project will produce electricity from natural gas in a power plant located 500m south of the CPF. The project will consist of the construction and operation of the following main components:

- Gas to Power Plant with generation capacity of 450MW;
- Gas pipeline (±2 km) that will feed the Power Plant with natural gas from the CPF or from an alternative gas source;
- 400kV Electrical transmission line (± 25 km) with a servitude that will include a fire break (vegetation control) and a maintenance road to the Vilanculos substation. The transmission line will have a partial protection zone (PPZ) of 100m width. The transmission line servitude will fall inside the PPZ;
- Water supply pipeline to a borehole located either on site or at borehole located east of the Govuro River;
- Surfaced access road to the CTT site and gravel maintenance roads within the transmission line and pipeline servitudes;
- Temporary beach landing structures at Inhassoro for the purposes of delivery of equipment and infrastructure to build the power plant. This will include transhipment and barging activities to bring equipment to the beach landing site;
- Construction camp and contractor laydown areas adjacent to the CTT power plant site; and
- Temporary bridge structures across Govuro River and tributaries, as well possible new roads and/or road upgrades to allow equipment to be safely transported to site during construction.

Figure 2: Examples of gas to power plant sites (source: www.industcards.com and www.wartsila.com)

The final selection of technology that will form part of the power generation component of the CTT project has not been determined at this stage. The two power generation technology options that are currently being evaluated are:

- Steam turbines for Combined Cycle Gas Turbine (CCGT); and
- Open Cycle Gas Engines (OCGE).

Please refer to Chapter 4 of the main ESIA document for further details on the technology option.

At this early stage in the project a provisional layout of infrastructure footprints, including the proposed linear alignments is indicated in Figure 1. A conceptual layout of the CTT plant site is shown below in Figure 3.

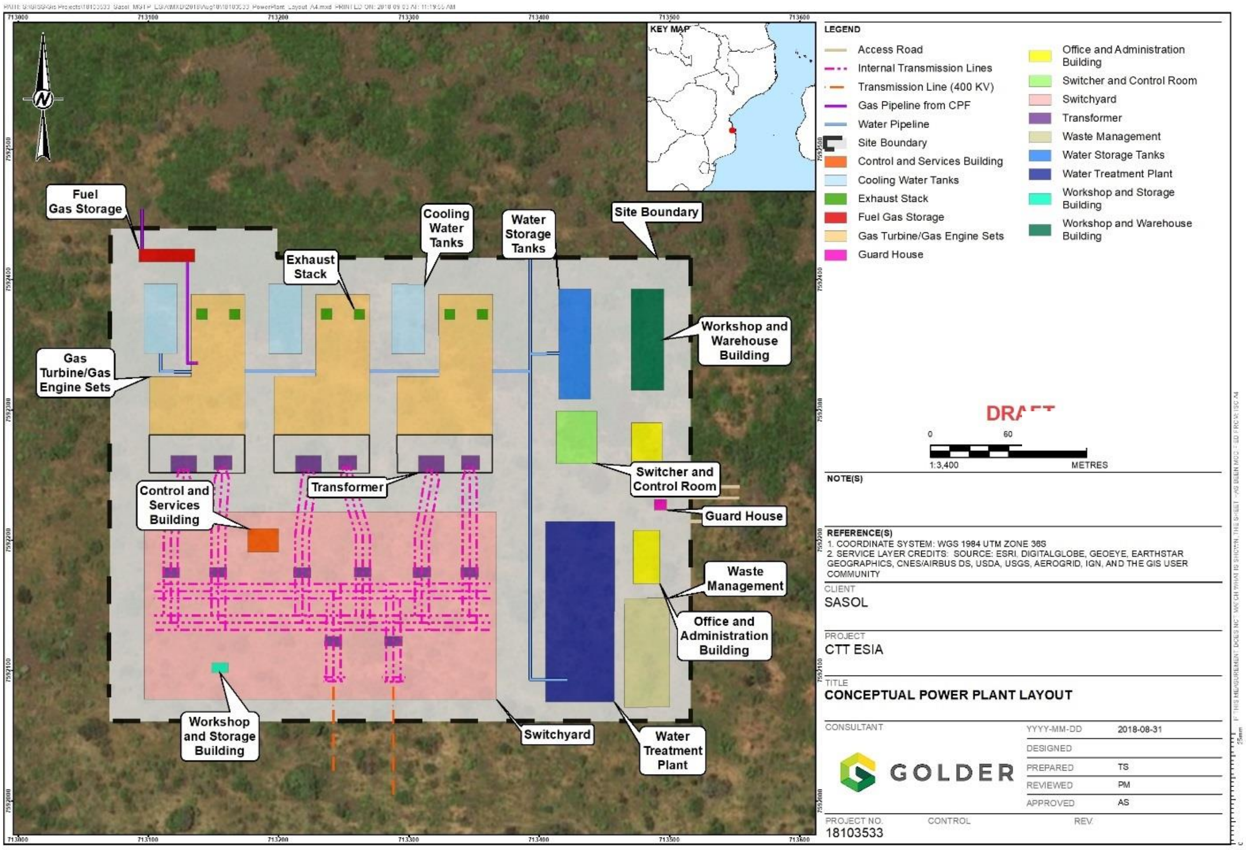

Figure 3: Conceptual layout of CTT plant site

2.1 Ancillary Infrastructure

The CTT project will also include the following infrastructure:

- Maintenance facilities, admin building and other buildings;
- Telecommunications and security;
- Waste (solid and effluent) treatment and/or handling and disposal by third party;
- Site preparation, civil works and infrastructure development for the complete plant;
- Construction camp (including housing/accommodation for construction workers); and
- Beach landing laydown area and logistics camp.

The heavy equipment and pre-fabricated components of the power plant will be brought in by ship and transferred by barge and landed on the beach near Inhassoro. The equipment and components will be brought to site by special heavy vehicles capable of handling abnormally heavy and large dimension loads. Figure 4, Figure 5 and Figure 6 show examples of the activities involved with a temporary beach landing site, offloading and transporting of large heavy equipment by road to site.

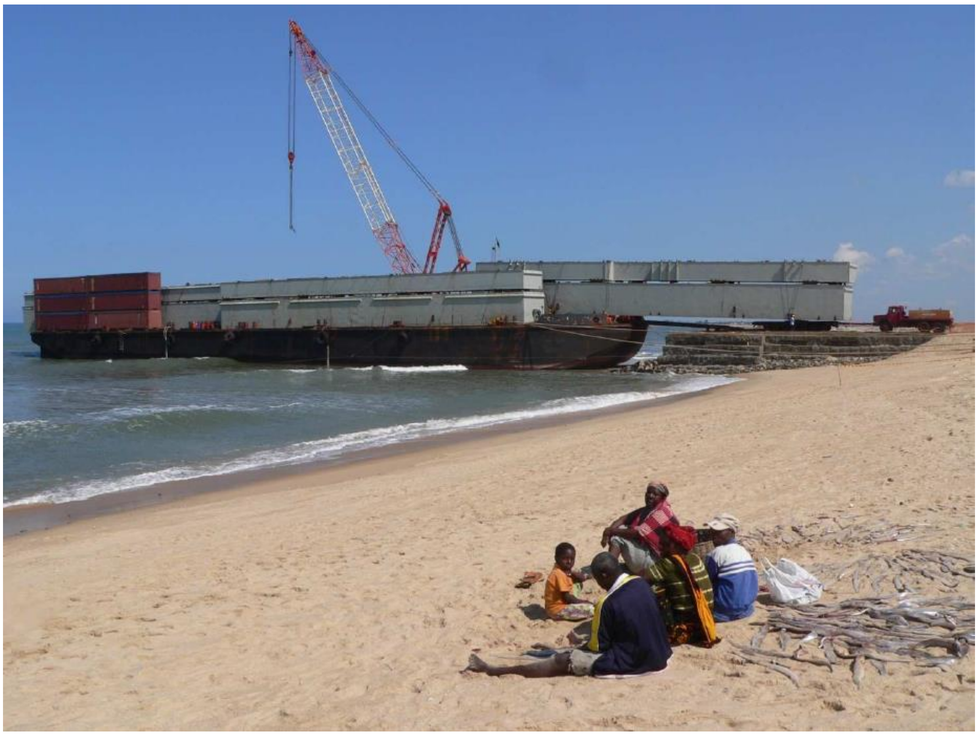

Figure 4: Typical beach landing site with barge offloading heavy equipment (source: Comarco)

Figure 5: Example of large equipment being offloaded from a barge. Note the levels of the ramp, the barge and the jetty (source: SUBTECH)

Figure 6: Heavy haulage truck with 16-axle hydraulic trailer transporting a 360 ton generator (source: ALE)

2.2 Water and electricity consumption

The type, origin and quantity of water and energy consumption are still to be determined based on the selected technology to construct and operate the CTT plant. At this stage it is known that water will be sourced from existing boreholes located on site or east of the Govuro River for either of the technology options below:

- Gas Engine: ± 12 m^3/day; or
- Gas Turbine (Dry-Cooling): ± 120 – 240 m^3/day.

2.3 Temporary Beach Landing Site and Transportation Route Alternative

As part of the CTT construction phase it was considered that large heavy equipment and materials would need to be brought in by a ship which would remain anchored at sea off the coast of Inhassoro. Equipment and materials would be transferred to a barge capable of moving on the high tide into very shallow water adjacent to the beach to discharge its cargo onto a temporary off-loading jetty (typically containers filled with sand) near the town of Inhassoro. As the tide changes, the barge rests on the beach and off-loading of the equipment commences.

Currently, the SETA beach landing site is the preferred beach landing site together with the road route option to be used in transporting equipment and materials along the R241 then the EN1 then via the existing CPF access road to the CTT site near the CPF. Figure 7 and Figure 8 indicate the beach landing site and route transportation option. The alternative beach landing sites of Maritima and Briza Mar are still being evaluated as potential options, as well as the southern transport route, which would also require road upgrades and a temporary bridge construction across the Govuro at the position of the existing pipe bridge. As part of the transportation route, the Grovuro River bridge may need to be upgraded / strengthened to accommodate the abnormal vehicle loads. Alternatively, a temporary bypass bridge will be constructed adjacent to the existing bridge.

Figure 7: The three beach landing site options and route options at Inhassoro

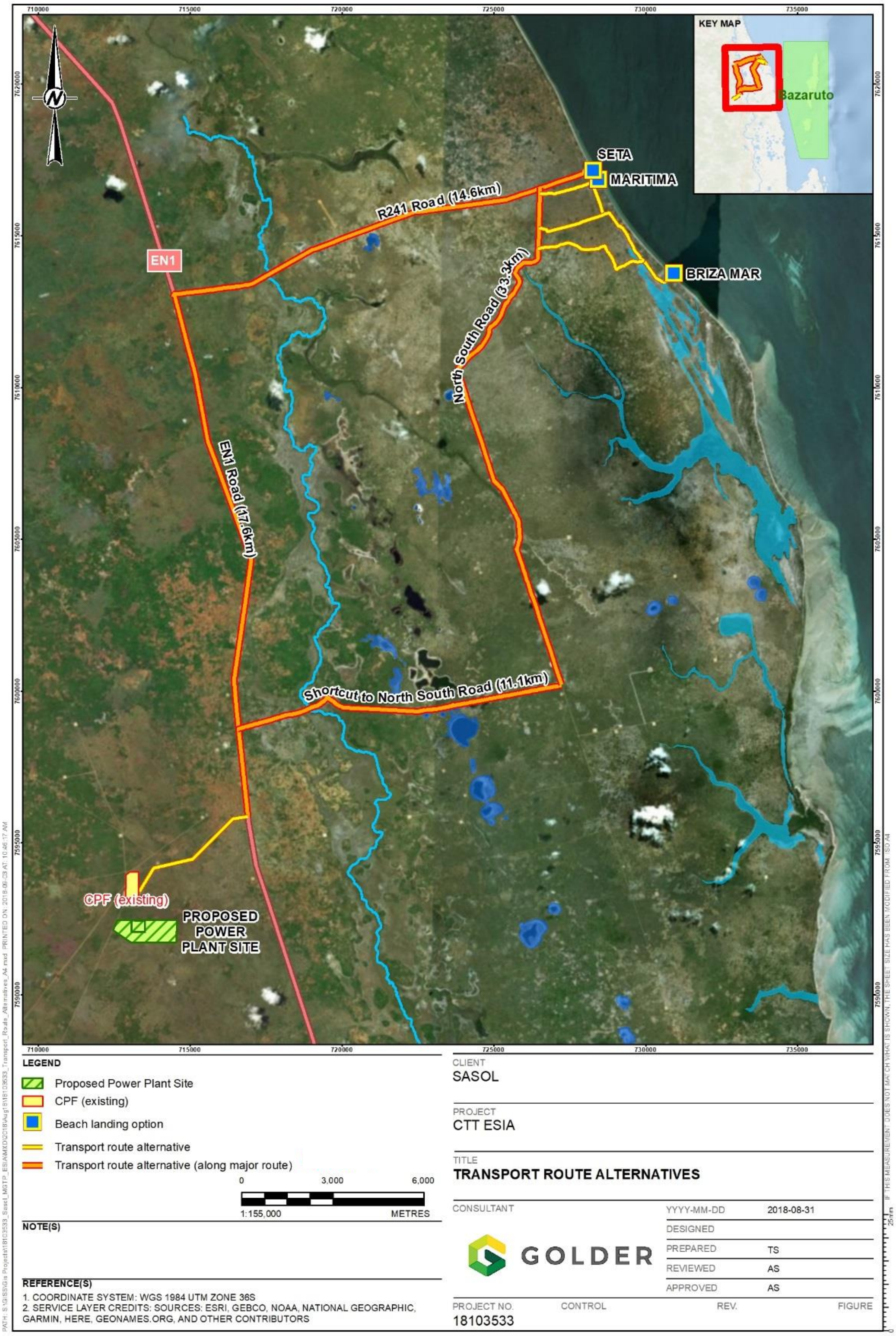

Figure 8: The two main transportation route alternatives from the beach landing sites to the CTT site

3.0 SCOPE OF THE SPECIALIST STUDY

The baseline soil and land use survey of the project site was conducted in 2015. As part of the ESIA the baseline soil study and an impact assessment were undertaken to:

- Understand the baseline soil conditions;
- Evaluate the potential impacts of the proposed CTT project on the soil and land use; and
- Describe and evaluate any other limiting characteristics of the soil.

The approach to this specialist study involved the following:

- A desk-top phase which was aimed at collecting and interpreting relevant soil, geomorphological, land-use, climate and other applicable information to enable relating site-specific findings from the fieldwork phase to the provincial and wider context;
- A fieldwork phase, which consisted of:
  - Soil surveys of, and wetlands delineation in, the following proposed sites or corridors.
    - CTT plant site (29 ha cleared area);
    - Transmission line corridor (25 km);
    - Gas pipeline corridor (2 km);
    - Water pipeline corridor (13 km); and
    - Beach landing alternatives and transport route (30 km).
  - Soil classification was to be in terms of the South African Taxonomic System and World Reference Base (WRB);
  - Land-use was to be noted;
- Data and information analysis (survey data, analytical data, literature information) and interpretation including land capability analysis.
- The significance of impacts on soil, land use and land capability was assessed using a commonly-applied ranking system (detailed in Section 9.0) to indicate those impacts which require mitigation and is based on the criteria as listed below:
  - Potential impact in terms of the nature of the impact;
  - Extent and duration of the impact;
  - Probability of the impact occurring;
  - Degree to which the impact may cause irreplaceable loss of the resources; and
  - Degree to which the impact can be mitigated.
  - Actions to mitigate significant impacts will be recommended.

4.0 LEGAL FRAMEWORK

The Proponent's existing commitments in respect to the management of issues that are pertinent to the soil resource include the following:

- An existing Operational EMP that manages impacts mainly around the Plant site;
- An existing Construction EMP that manages impacts mainly for new construction contracts located at the plant site;
- An existing Construction EMP that manages impacts associated with the civil works for flowline corridors and well pads; and

- An existing Drilling EMP which manages impacts associated with the drilling of wells.

The legal framework pertaining to soils, soil management and soil contamination in Mozambique includes the following:

- Environmental Law (Law 20/97 of 1 October);
- Petroleum Law (Law 3/2001 of 21 February);
- Regulations on Petroleum Operations (Decree 24/2004 of 20 August);
- Regulation for the Prevention of Pollution and Marine Coastal Environmental Protection (Decree 45/2006 of 30 November);
- Regulation for Waste Management (Decree 13/2006 of 15 June) and the IFC EHS Guidelines for Waste Facilities (December 2007);
- Law of Territorial Ordinance and respective Regulations (Law 19/2007 of 18 July and Decree 23/2008 of July);
- Regulations on the Resettlement Process resulting from Economic Activities (Decree 31/2012 of 8 August);
- WHO Air Quality Guidelines Global Update;
- Regulations on the Emission of Effluent and Environmental Quality Standards (Decree 18/2004 of 2 June) and Decree 67/2010 of 31 December; and
- International Finance Corporation's Performance Standards.

These are discussed in more detail below. It is notable that soil management guidelines have not been established under Mozambican Law or by IFC Performance Standards. However, in accordance with other regulations, international good practice is recommended regarding the appropriate soil management to avoid soil contamination and/or degradation.

Environmental Law (Law 20/97 of 1 October)

Article 9 relates to the prohibition of the production and deposition on any toxic and polluting substances on soils, sub-soils, water or atmosphere as well as the conduct of activities that will tend to accelerate erosion and desertification, deforestation or any other form of environmental degradation beyond the limits established by law.

Petroleum Law (Law 3/2001 of 21 February)

This law has the following relevant articles:

- Article 20:
  - The holder of a right to conduct petroleum operations…causes damage to crops, soils, building and improvements or requires the relocation of the legal users or occupants of the land within the respective contract area, has the obligation to compensate the holders of title to the assets and the persons relocated.
- Article 23:
  - Ensure that there is no ecological damage or destruction caused by petroleum operations, but where unavoidable, ensure that measures for protection of the environment are in accordance with internationally acceptable standards;
  - Control the flow and prevent the escape or loss of petroleum discovered or produced within the contract area;
  - Avoid destruction to land, the water table, trees, crops, buildings or other infrastructure and goods;
  - Clean up the sites after closure of petroleum operations and comply with the environmental restoration requirements; and

- Guarantee the disposal of polluted water and waste oil in accordance with approved methods, as well as the safe plugging of all boreholes and wells before these are abandoned.

Regulations on Petroleum Operations (Decree 24/2004 of 20 August)

These regulations require the following:

- Monitor and reduce the effect of all operational and accidental discharge, handling of waste and emissions into the sea, lakes, rivers and soil; and
- Take corrective measures and repair damage to the environment when petroleum operations endanger the physical safety of people or property or cause pollution or other environmental damage harmful to people, animals or vegetation;

Regulation for the Prevention of Pollution and Marine Coastal Environmental Protection (Decree 45/2006 of 30 November)

This regulation prohibits the discard or discharge of any wastewater of a toxic or harmful nature as well as any other substances or waste that may in any way pollute water, meadow or banks in violation of the relevant legal provisions.

Regulation for Waste Management (Decree 13/2006 of 15 June)

This regulation establishes the rules relative to the production, discharge into the soil and sub-soil, into water or the atmosphere, of any toxic and polluting substances as well as the conduct of activities that accelerate the degradation of the environment – so as to prevent or minimise their negative impacts on health and the environment. Waste management guidelines are also outlined in the IFC EHS Guidelines for Waste Facilities (December 2007).

Law of Territorial Ordinance and respective Regulations (Law 19/2007 of 18 July and Decree 23/2008 of 1 July).

This Law establishes sustainability principles to add value to physical space and equality in access to land and natural resources. It establishes preventative systems to minimise significant or irreversible impacts on the environment. The Law places responsibility on public or private entities for any intervention which may cause damage to, or affect the quality of the environment, by ensuring that any adverse effects to quality of life are reversed or compensated.

Regulations on the Resettlement Process resulting from Economic Activities (Decree 31/2012 of 8 August)

This regulation establishes the basic rules and principles on the resettlement process by providing the opportunity to improve the quality of life of affected households. The most relevant principles relate to environmental accountability (i.e. the investors obligations to restore or compensate for environmental damages) and social responsibility (i.e. the investors obligations to create social infrastructure to promote learning, health, and other projects of community interest).

Air Emission Regulations and Guidelines

Air emissions guidelines are outlined in the WHO Air Quality Guidelines Global Update and the Regulations on the Emission of Effluent and Environmental Quality Standards (Decree 18/2004 dated of 2 June) and Decree 67/2010 of 31 December.

International Finance Corporation's Performance Standards

The most pertinent Performance Standard (PS) is PS3: Resource Efficiency and Pollution Prevention. This PS requires the investor to avoid or minimise adverse human impacts on human health and the environment by avoiding or minimising pollution from project activities.

Study methodology

For the purpose of contributing to the baseline assessment, this report aims to understand the role and ability of the soil - as a sub-system of the local environment - in providing natural goods and services. The assessment is separated into four sub sections:

- Desktop information;
- Field data;
- Analytical data; and
- Interpretive soil information.

The methodology employed in establishing a soil resources baseline assessment is described below.

The desktop study was largely facilitated by accessing key natural resource studies and materials that were conducted or produced during various regimes of the past and were archived on the Internet, mainly by ISRIC, but also by other international organisations. Contact was made with a local soil scientist, Dr Jacinto Mafalacusser. It was found, however, that recent natural resource data applicable to the province and wider project area are limited or inaccessible.

The field work phase was conducted aided by Google Earth colour printouts, showing about 300 potential/provisional soil observation points from GPS and Google Earth. The area was traversed by motor vehicle. At each soil observation point the soil was exposed by hand augering to a depth of 120 cm unless prevented by the presence of hardpan carbonate. The actual (final) soil observation points were georeferenced and the soils described in an internationally acceptable standard manner. They were classified in accordance with the South African Taxonomic Soil Classification System (Soil Classification Working Group, 1991) - due to the accurate way it differentiates southern African soil types - and subsequently correlated into WRB Reference Groups (IUSS Working Group WRB, 2006). The land use was noted.

The soil observation points (305 in total) were spaced approximately 100 m apart at the intended CTT plant area and 300 m apart along the linear corridors and beach landing site alternatives. Maps indicating the locations of the observation points can be found in Appendix A. At twenty representative sites, the topsoil and subsoil were sampled. The samples were couriered to the Jones Environmental and Forensic Laboratories in the UK for analysis. A subset was submitted to local Nvirotek laboratories for additional fertility-related analyses.

As a result of the considerable co-variation that commonly exists between soil properties that can readily be measured and complex properties that are difficult or expensive to measure, it is common practice to make qualitative statements about derived soil properties including the wetland delineation, land use and land capability.

5.0 DESKTOP INFORMATION

This section outlines available desktop information and presents a summary of field and laboratory data.

5.1 Soils

Accessible published information on the soils of the area appears to be limited to three national-scale maps, as summarised in Table 1. The terrain to the west of the Govuro River is largely covered by what is termed broad soil type A for simplicity's sake (following Schoeman and Verster, 2014) as indicated on Figure 9. These are red, well-drained medium textured soils - on early maps classified as Red Fersiallitic and on later maps as Luvisols or Lixi / Luvisols. The latter classification implies a distinct clay increase from top-soil to upper sub-soil. The alluvial soils along the Govuro River and associated lowlands (termed broad soil type B) were classified as Fluvisols with Gleysols in places. The terrain between the Govuro River and the ocean (termed broad soil type C) had been described by earlier maps in a way reflective of the diverse nature of the coastal belt (e.g. Fluvial and Lacustrine alluvial soils, Fluvisols and Gleysols). The part of the coastal belt immediately south of Inhassoro town appears to be less diverse, however, and the subsequent classification of Arenosols describes the dominant sandy soils well.

Table 1: Overview of published soil map information

<table>
<tr><th rowspan="2">Data source</th><th>Broad soil type A</th><th colspan="2">Broad soil type B</th><th>Broad soil type C</th></tr>
<tr><th>Soils west of Govuro River</th><th colspan="2">Floodplains of Govuro River</th><th>Soils east of Govuro River</th></tr>
<tr><td>SOIL MAP OF MOZAMBIQUE (Godinho Goveia et al., 1972); scale 1:4 million; archived by Panagos et al. (2011)</td><td>Red fersialitic soils on unconsolidated sediments; red soils of urrongas</td><td colspan="2">Regosols, regolíthic soils or sandy brownish hydromorphic soils on unconsolidated sediments</td><td>Fluvial and lacustrine alluvial soils</td></tr>
<tr><td>SOIL RESOURCES INVENTORY (GoM-INIA-FAO Project Moz- 75/001 by Voortman & Spiers (1982); archived by Panagos et al. (2011); scale 1:2 million</td><td>Orthic Luvisols with minor Luvic Arenosols; medium or fine textured</td><td colspan="2">Eutric Fluvisols with minor Luvic Arenosols; medium or fine textured</td><td>Association of Eutric Fluvisols, Eutric Gleysols and minor Humic Gleysols; medium or fine textured</td></tr>
<tr><td>NATIONAL SOIL MAP:
FAO CLASSIFICATION
(INIA-DTA, 2002); archived by Panagos et al. (2011);
scale 1:5 million</td><td>Lixi / Luvisol</td><td>Gleysol</td><td>Fluvisol</td><td>Arenosol</td></tr>
</table>

Largely based on the 2002 map above, Mafalacusser (2013) prepared a set of maps showing derived soil attributes. Those relevant to the study area are shown in Table 2.

Table 2: Derived soil or land characteristics as assessed at national scales

<table>
<tr><th>Soil/land attribute</th><th>Broad soil type A</th><th>Broad soil type B</th><th>Broad soil type C</th></tr>
<tr><td>Effective depth (1)</td><td>Moderately deep (50-100 cm)</td><td>Very deep (>150 cm)</td><td>Very deep (>150 cm)</td></tr>
<tr><td>Drainage class (1)</td><td>Well-drained</td><td>Poorly drained</td><td>Excessively drained</td></tr>
<tr><td>Top-soil organic matter content (1)</td><td>Low (0.6-1.5%)</td><td colspan="2">Moderate (1.6-3.0)</td></tr>
<tr><td>Available water holding capacity (1)</td><td>Very high (180-240 mm/m)</td><td colspan="2">Very Low (50-70 mm/m)</td></tr>
<tr><td>Electrical conductivity (mS/m) (1)</td><td>Very low</td><td colspan="2">Very low</td></tr>
<tr><td>Susceptibility to water erosion (2)</td><td>Low</td><td colspan="2">Very low</td></tr>
<tr><td colspan="4">Source:
(1) Mafalacusser (2013)
(2) Van Wambeke & Marques (undated).</td></tr>
</table>

Figure 9: Broad soil types in project area

5.2 Climate context

Due to the limited number of years (23 yrs) that the on-site weather station had been operative, it does not yet serve as a source of long-term data. As a result, use was made of available published data. Of note are wind data (Figure 10) from the on-site weather station, rainfall data from the weather station at Vilanculos, modelled rainfall data by a number of international organisations and modelled information from a comprehensive atlas of the climate of tropical Africa (Le Roux, 1983).

The area appears to have a high long-term average annual rainfall of about 800 mm (Westerink,1996) at the coast (Table 3) that decreases rapidly with increased distance from the coast. The area is frost free and warm sub-tropical. Drought and the impacts of tropical cyclones are major risk factors. The area south of the Save River experiences drought during seven out of ten years. The coastal areas lie in the path of highly destructive hurricanes and cyclones. The heavy rainfall associated with these events may contribute a significant proportion of the normal wet season's rainfall over a period of a few days (KLIMOS, 2012; The World Bank Group, 2011). There are uncertainties about the interpretive and practical value of the rainfall figures. Averages in rainfall are known to mask abnormally dry and wet periods. At least one information source (World Weather Online, 2015) indicates a lower rainfall (483 mm per annum). The presence of baobab trees right up to the coast begs explanation as they are normally found in areas with about 400-500 mm rainfall.

Various sources (such as Adaptation Learning Mechanism, 2009, The World Bank Group, 2011 and KLIMOS, 2012) stress the vulnerability of the coastal zone, stating that it is likely to experience significant impacts as a result of climate change during the course of this century due to the rising of mean sea levels, altered wave patterns, and changed frequencies and intensities of storms. It is suggested that the inherent dynamic nature of coastlines (combined with exposure to destructive maritime hazards, rising sea levels, inefficient land usage, and the strain on natural resources) will render the Mozambican coastline highly vulnerable to the impacts of climate change, particularly coastal erosion.

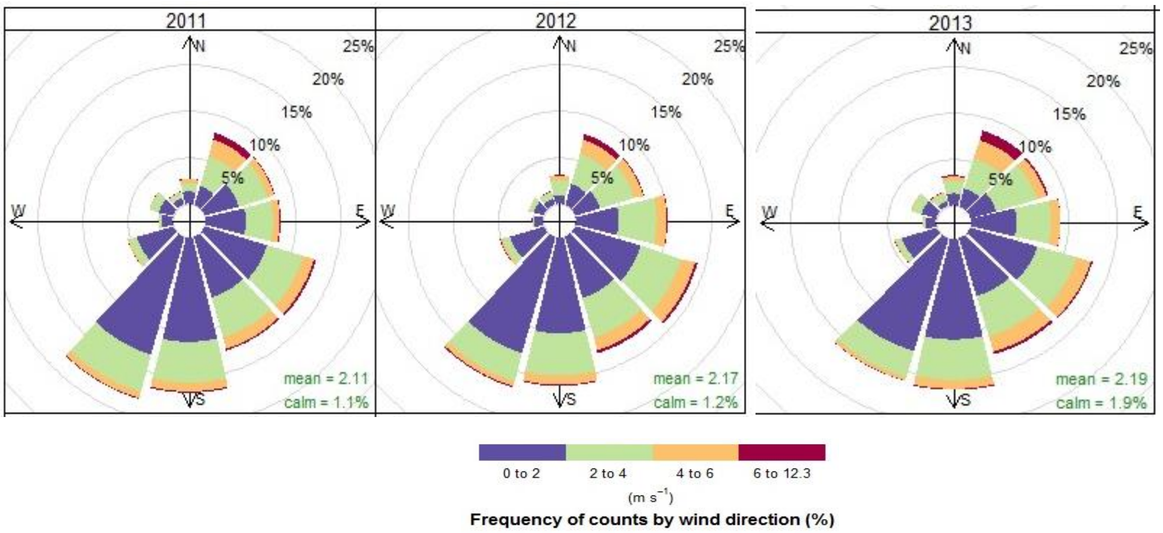

Figure 10: Wind rose diagrams for Temane

(Source: Sasol Project site wind monitoring data prepared by Airshed, 2014)

Table 3: Long-term climate information

Climate parameter		Period												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average rainfall (mm)	[1] [3] [4] [5]	150-200 75 166 180	125-150 132 167 177	100-125 39 84 91	30-50 36 40 41	30-50 30 35 34	10-30 9 24 24	10-30 15 15 16	5-20 6 22 26	10-20 6 13 19	15-25 36 34 28	50-75 21 63 75	125-150 78 155 152	660-925 750-1250 [2] 483 817 864
Rain days [1]		10-11	10-11	10-11	5-10	3-6	3-6	3-6	2-5	1-3	0-4	3-6	5-10	55-88
Relative humidity (%) [1]		70-80	70-80	70-80	70-75	60-75	60-75	70-75	70-75	65-75	60-70	60-70	70-80	66-76
Temp average (°C) [1]		25-27	26-28	25-27	23-25	22-23	20-21	19-20	20-21	22-23	23-25	24-26	25-27	23-24
Temp maximum (°C) [1]		32-34	31-32	31-32	30-32	28-30	26-27	27-28	26-28	28-29	29-31	29-31	30-33	29-31
Temp minimum (°C) [1]		19-21	19-23	17-21	17-20	14-17	12-14	12-14	13-16	16-19	16-20	17-22	17-23	16-19
Growing period (d) [4]		150-180												
Temp. regime during growing period (°C) [4]		Moderately warm (20-25)												
Number of growing periods per year [4]		Occurrence of two growing periods per year in 45% of the years, one growing season per year in 30% of the years and three growing periods per year in 15% of the years)												

Source:
[1] Le Roux (1983)
[2] World Trade Press (2007)
[3] SamsamWater Climate Tool (Inhassoro; period of archiving of modelled data not stated)
[4] World Weather Online (Modelled data for Inhassoro and Vilanculos 2000-2012)
[5] Westerink (1996); Meteo Database Station No. 213 at Vilanculos; data period 23 years
[6] FAO-UNDP-GoM (1982)

5.3 Crop suitability

Available information on crop suitability (AMITSA, 2009a and 2009b) is presented in Table 4, as it may shed light on the agricultural potential of the area. Surprisingly, almost no differences between the coastal sands and the inland red loams were shown on the set of small-scale electronic maps that were consulted. This apparent insensitivity may be an artefact of the small scale, crude data and imprecise yield norms, or may reflect the decrease in rainfall to the west being balanced out by higher soil quality. Whatever the case, the picture that emerges is one of moderate suitability for a range of field crops. Considering the generally low susceptibility to water erosion (Van Wambeke & Marques, undated), and moderate or higher susceptibility of the coastal sands to wind erosion, this translates to a moderate arable potential (see land capability, Section 8.4).

The World Bank Group (2011) foresees a country-wide decline in maize yields of between seven and 16% between the 1990s and 2080s due to climate change. Considering the devastating effects drought can have on rainfed permanent crops (and the near absence of such crops), it is suggested that the area should be regarded as unsuitable for rainfed tropical or sub-tropical fruit and nut crops, bamboo and timber other than cashew.

Table 4: Available crop suitability information

Crop	Input level	Approximate yield (t/ha)	Suitability rating
Maize	Low	0.7-1.1	Moderately suitable
	High	2.8-4.3	
Sorghum	Low	0.5-0.8	Moderately suitable
	High	2.0-3.1	
Pearl millet	Low	0.6-0.8	Suitable
	High	2.3-3.1	
Soybean	Low	0.3-0.5	Moderately suitable
	High	1.4-2.0	
Groundnut	Low	0.3-0.5	Moderately suitable
	High	1.3-2.0	
Cassava	Low	<0.7-1.4	marginally suitable
	High	<2.7-5.4	
Cotton (lint)	Low	<0.06-0.11	Marginally suitable
	High	0.2-0.4	Not suitable or marginally suitable

Source: AMITSA (2009 a and b)

6.0 FIELD DATA

This section presents the field data from the soil assessment.

6.1 Sampling

Top-soils and subsoils were sampled at twenty representative sites, particulars of which are shown in Table 5. The locations of the soil sampling points are indicated on Figure 11.

From these ten sites were selected for analysis (shown in bold in the table). In order to strengthen and expand the soil environmental health baseline established for the area by Schoeman and Verster (2014) the samples from the selected ten sites were subjected to exhaustive chemical analysis at the Jones Environmental and Forensic laboratories in the UK, the certificates of analysis are shown in Table 5

To aid assessment of the soils' potential for agricultural use, a subset of 6 sites were submitted to agriculturally related analysis which is also shown in Appendix B.

6.2 Soil types

Broad soil group A

A number of sub-types of the broad soil types (Table 5) were encountered during the fieldwork phase. Within the red loam soil area, the following were encountered:

- Modal, or commonly occurring, deep red apedal sandy clay loams or clay loams, referred to below as soil type 1.
- Similar soils in which large limestone remnants protrude into the soil profile, resulting in shallow and very deep profiles occurring in close proximity to each other. These are referred to as soil type 2.
- Weakly or moderately structured, darker coloured, red-brown sandy clay loams or clay loams of drainage depressions. Some members show a marked clay increase from the top-soil to the subsoil while others show signs of having been reworked by fluvial processes. These variants are referred to as soil type 3. These soils appear to be preferred for cultivation within the red soil area.
- Relatively sandy variants that appear to be transitional to the more sandy areas towards the coast. These red or yellow-brown, apedal sandy loams or loamy sands, referred to below as soil type 4, contain about 10 to 18% clay in the subsoils. They are widely used for cultivation (Figure 9).

Broad soil group B

The soils of broad soil type B (occupying flood plains associated with the Govuro River and other drainage depressions) encountered in the study area all exhibit dark grey silt loam top-soils underlain by grey, mottled, loamy sand or sandy loam E horizons. They range from temporary to permanent wetlands (see below). The main morphological expression of increased wetness is an increased darkening of the top-soils by organic matter. No sub-types were identified. They are referred to as soil type 5.

Broad soil group C

In the sandy areas to the east of the Govuro River, two sub-types were identified:

- Soils with thin, grey, sandy top-soils overlying yellow-grey or pale yellow, sandy, subsoils in which the colour increases slightly with depth. The subsoil clay percentage is less than 10.They are terrestrial soils (upland topography) and do not constitute wetlands. They are intensively cultivated. They are referred to as soil type 6.
- White coastal sands, occurring in close proximity to the coast, referred to as soil type 7.

Alignment of these locally occurring soil types with the broad soil types as defined in Table 1 are shown in Table 6.

Table 5: Sampling sites

Sample ID	Sampling depth (cm)	Area	Soil type	South African soil form	WRB soil Reference Group	Field clay (%)	Colour	Structure	Coordinates
45A	0-20	Trans-mission line	1	Hutton	Haplic Luvisol (Rhodic)	25	Red-brown	Massive	-21.84676 35.04223
45B	90-110					29	Red	Apedal	
67A	0-20	Trans-mission line	3	Oakleaf	Haplic Luvisol (Rhodic)	25	Red-brown	Weak blocky	-21.89926 35.07224
67B	100-120					29	Red-brown	Weak blocky	
79A	0-20	Trans-mission line	1	Hutton	Haplic Luvisol (Rhodic)	21	Red-brown	Massive	-21.92819 35.08870
79B	80-100					27	Red	Apedal	
85A	0-20	Trans-mission line	3	Valsrivier	Cutanic Luvisol (Rhodic)	20	Red-brown	Massive	-21.94246 35.09685
85B	80-100					35	Red-brown	Moderate blocky	
104A	0-20	Water pipeline	2	Plooysburg	Haplic Luvisol (Rhodic)	25	Red-brown	Massive	-21.75354 35.06742
104B	60-80					30	Red	Apedal	
109A	0-20	CTT plant site	2	Plooysburg	Haplic Luvisol (Rhodic)	25	Red-brown	Massive	-21.76004 35.06641
109B	60-80					29	Red	Apedal	
115A	0-20	CTT plant site	1	Hutton	Haplic Luvisol (Rhodic)	26	Red-brown	Massive	-21.75991 35.06049
115B	90-110					31	Red	Apedal	
145A	0-20	CTT plant site	1	Hutton	Haplic Luvisol (Rhodic)	20	Red-brown	Massive	-21.76292 35.06444
145B	90-110					23	Red	Apedal	

Sample ID	Sampling depth (cm)	Area	Soil type	South African soil form	WRB soil Reference Group	Field clay (%)	Colour	Structure	Coordinates
153A	0-20	Water pipeline	4	Clovelly	Hypoluvic Arenosol	10	Yellow-brown	Massive	-21.72878 35.11324
153B	110-120					12	Yellow-brown	Apedal	
157A	0-20	Water pipeline	5	Dundee	Gleyic Fluvisol (Arenic)	14	Dark grey-brown	Massive	-21.72404 35.12096
157C	100-120					11	Yellow-grey	Massive	
159A	0-20	Water pipeline	4	Clovelly	Haplic Arenosol	11	Grey-brown	Massive	-21.72335 35.12925
159B	100-120					12	Yellow-brown	Apedal	
165A	0-20	Beach landing alternatives	6	Hutton	Haplic Arenosol	8	Grey-brown	Massive	-25.54267 35.20563
165B	100-120					8	Pale red	Apedal	
185A	0-20	Beach landing alternatives	5	Unclassifiable	Haplic Gleysol (epi-Arenic)	26	Dark grey-black	Weak blocky	-25.55819 35.18679
185E	60-80					2	Grey	Single grain	
187A	0-20	Temporary road	6	Fernwood	Haplic Arenosol	5	Grey-brown	Massive	-21.56009 35.18677
187E	90-110					4	Pale yellow-grey	Single grain	
205A	0-15	Temporary road	6	Fernwood	Haplic Arenosol	6	Grey-brown	Massive	-21.59604 35.16266
205E	90-110					6	Pale yellow-grey	Massive	
211A	0-15	Temporary road	6	Vilafontes	Endogleyic Arenosol	5	Dark grey-brown	Massive	-21.61115 35.16823
211B	90-110					7	Pale yellow	Massive	
225A	0-15	Temporary road	6	Clovelly	Haplic	6	Grey-brown	Massive	-21.64608

Sample ID	Sampling depth (cm)	Area	Soil type	South African soil form	WRB soil Reference Group	Field clay (%)	Colour	Structure	Coordinates
225B	100-120				Arenosol	6	Pale yellow	Apedal	35.18175
246A	0-15	Temporary road	6	Clovelly	Haplic Arenosol	4	Grey	Single grain	-21.68827 35.19096
246B	100-120					6	Pale yellow	Apedal	
270A	0-20	Temporary road	5	Fernwood	Haplic Gleysol (Arenic)	22	Dark grey	Massive	-21.69340 35.12253
270E	80-100					12	Grey	Massive	
276A	0-20	Temporary road	5	Tukulu	Gleyic Fluvisol (Arenic)	10	Dark grey-brown	Massive	-21.69881 3510354
276B	100-120					12	Pale yellow-brown	Massive	

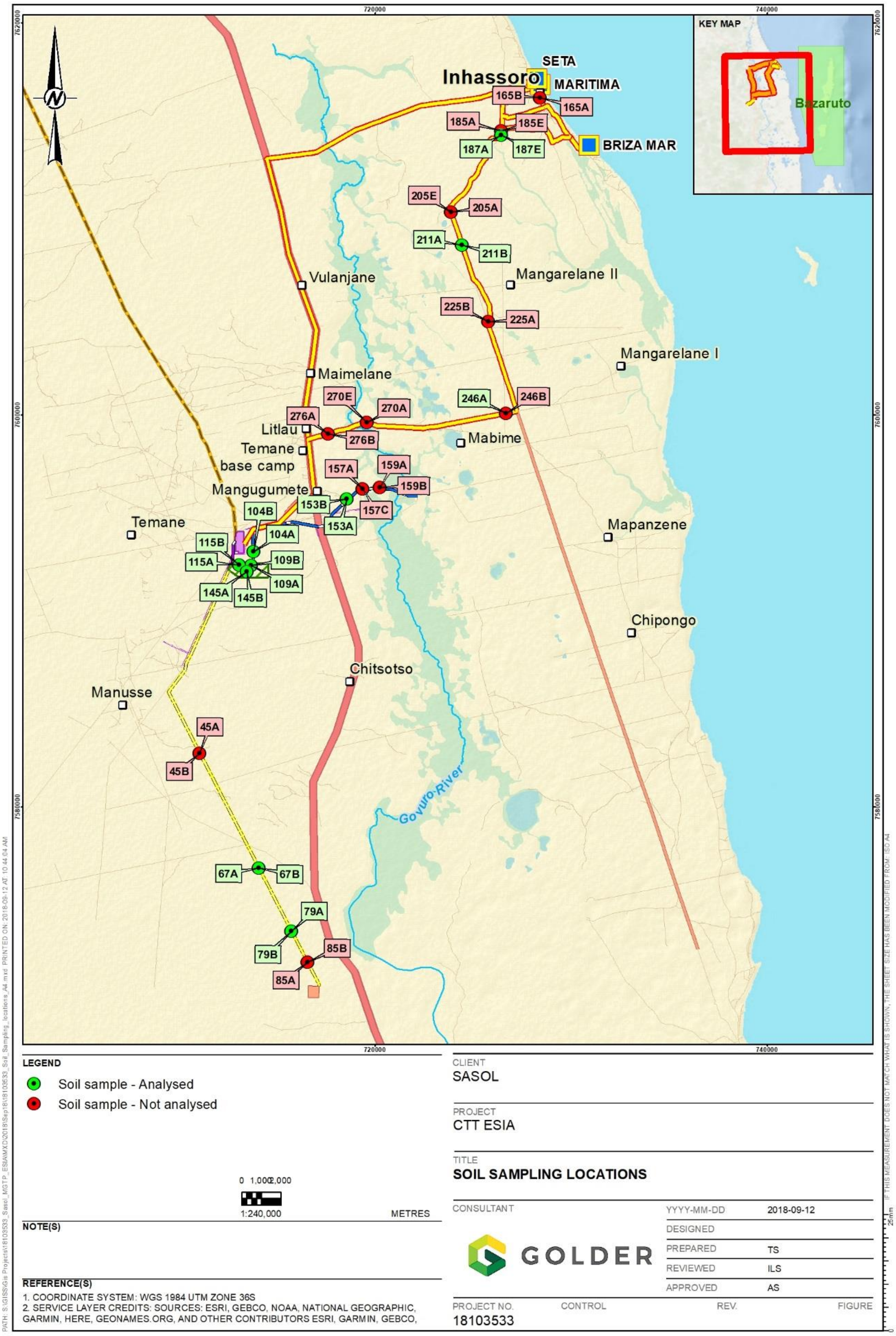

Figure 11: Soil sampling locations

6.3 Soil types in relation to investigated areas

The preferred CTT plant site straddles soil type 1 and 2 (Figure 12). There appears to have been no cultivation in this area. The gas pipeline corridor is situated in a soil type 1 area. Likewise, there was no cultivation. The north-south segment of the transmission line corridor (no cultivation) is situated in a soil type 1 and 2 area and the south-east oriented segment is underlain by type 1 and 3 soils (Figure 13). The soil type 3 area contains a number of cultivated fields. The southern portion of the water pipeline corridor is situated in a soil type 1 and 2 area (Figure 14). From about one km west of the EN1 road up to the Govuro wetlands the corridor traverses soil type 4 with small areas of soil type 5. The Wetlands are occupied by soil type 5 or are covered with water. The pipe bridge option of the temporary road traverses soil type 4 from the EN1 road to the Govuro wetlands and about 2 km beyond these. In this segment east of the EN1 there are few cultivated fields. The wetlands and associated floodplains appear to be largely occupied by soil type 5 (not cultivated), or are covered with water. Eastwards and northwards up to the Inhassoro town area the corridor traverses soil type 6 (Figure 15). This area contains substantial cultivation. Between the gravel road and the town is an intensively cultivated area in which the potential routes all traverse soil type 4, with a belt of soil type 6 west of the wetland that runs parallel to the coast south of the town. The wetland is occupied by soil type 5. A wedge of soil type 7 (broader in the south and thinning out in the north) lies between the wetland and the beach. The broad soil types are related to the infield types in Table 1.

6.4 General description of the soils

The soil types are further defined and described in terms of their topographic position, parent materials and classification in Table 7 Sample sites are listed in the table.

6.5 Soil physical and hydrological properties

Soil physical and hydrological properties that commonly affect land-use, and which are to be considered if land-use change is intended, include the following:

- Soil textural properties (sand, silt and clay content), as these are known to be co-variants with a number of other more complex properties;
- Soil water-holding capacity (a co-determinant of agricultural potential) is largely dependent on the effective soil depth, soil texture and organic matter;
- Susceptibilities to wind and water erosion (to be considered if changes in land cover and changes in slope may result from a developmental initiative);
- Soil internal drainage and the presence and duration of water tables (to be considered in infrastructure placement);
- Susceptibility to compaction (to be considered in issues of overland movement); and
- Susceptibility to surface crusting (potentially affecting runoff and erosion in the absence of plant cover).

These properties and susceptibilities are assessed in Table 8. With respect to water-holding capacity, it will be noted that the key determinant is effective soil depth. Assessing the effective soil depth of the very deep, easily rootable soils is, however, an imprecise exercise due to the general absence of soil limitations such as acidity or indurated layers. This shifts the emphasis to the rooting characteristics of crops and other plants. Unless otherwise indicated an arbitrary soil depth of 120 cm was selected.

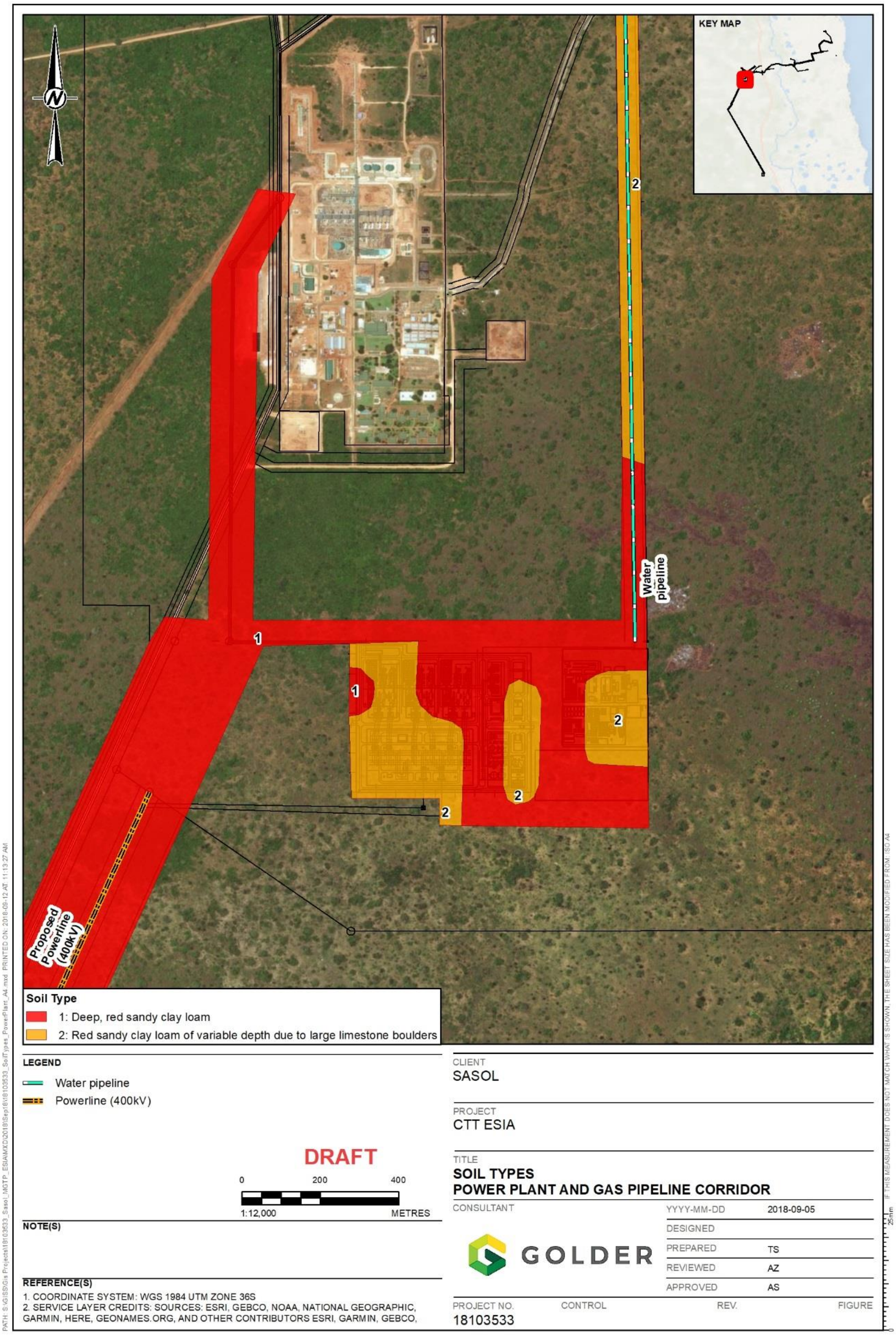

Figure 12: Soil types identified in CTT plant site and gas pipeline corridor

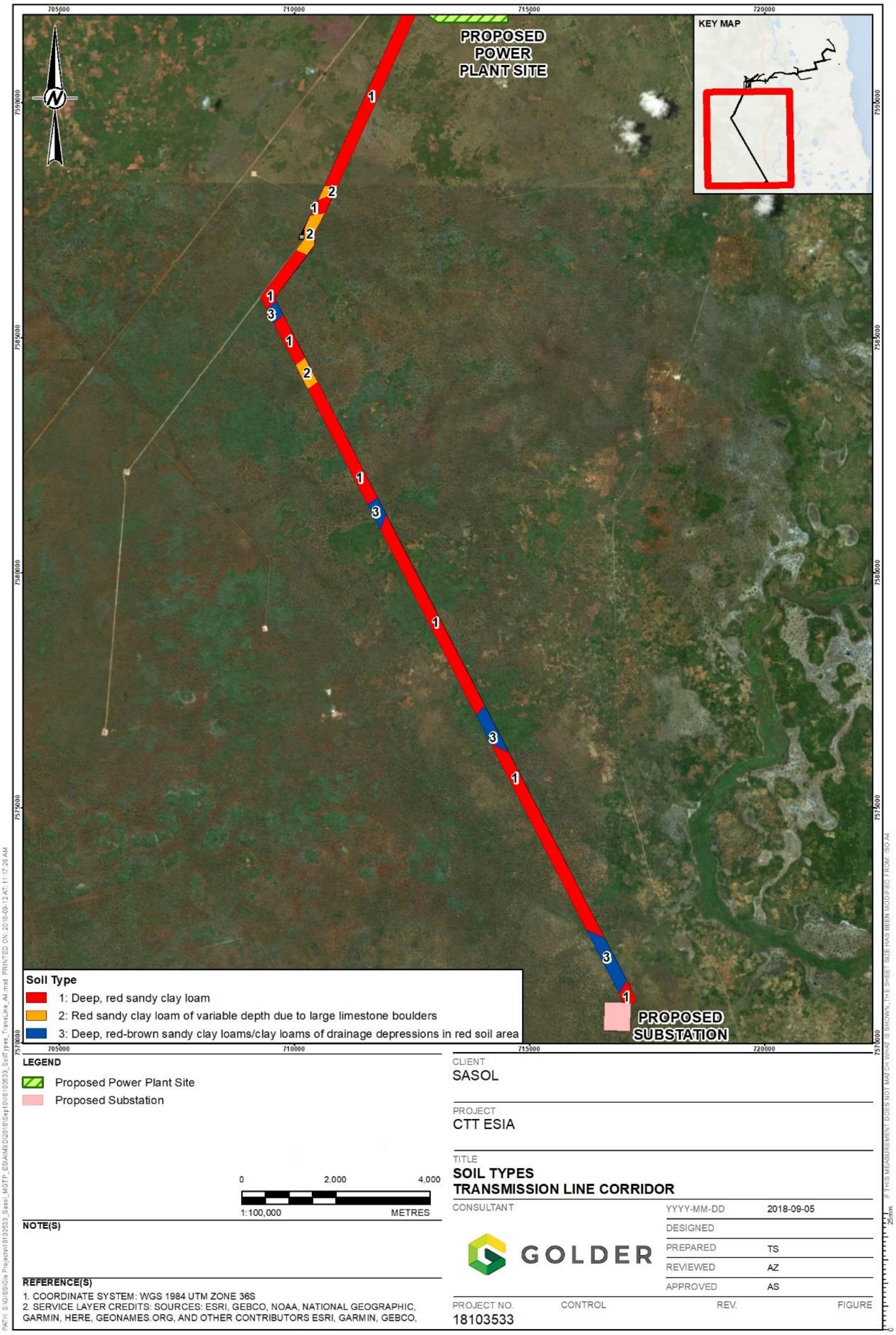

Figure 13: Soil types identified in transmission line corridor

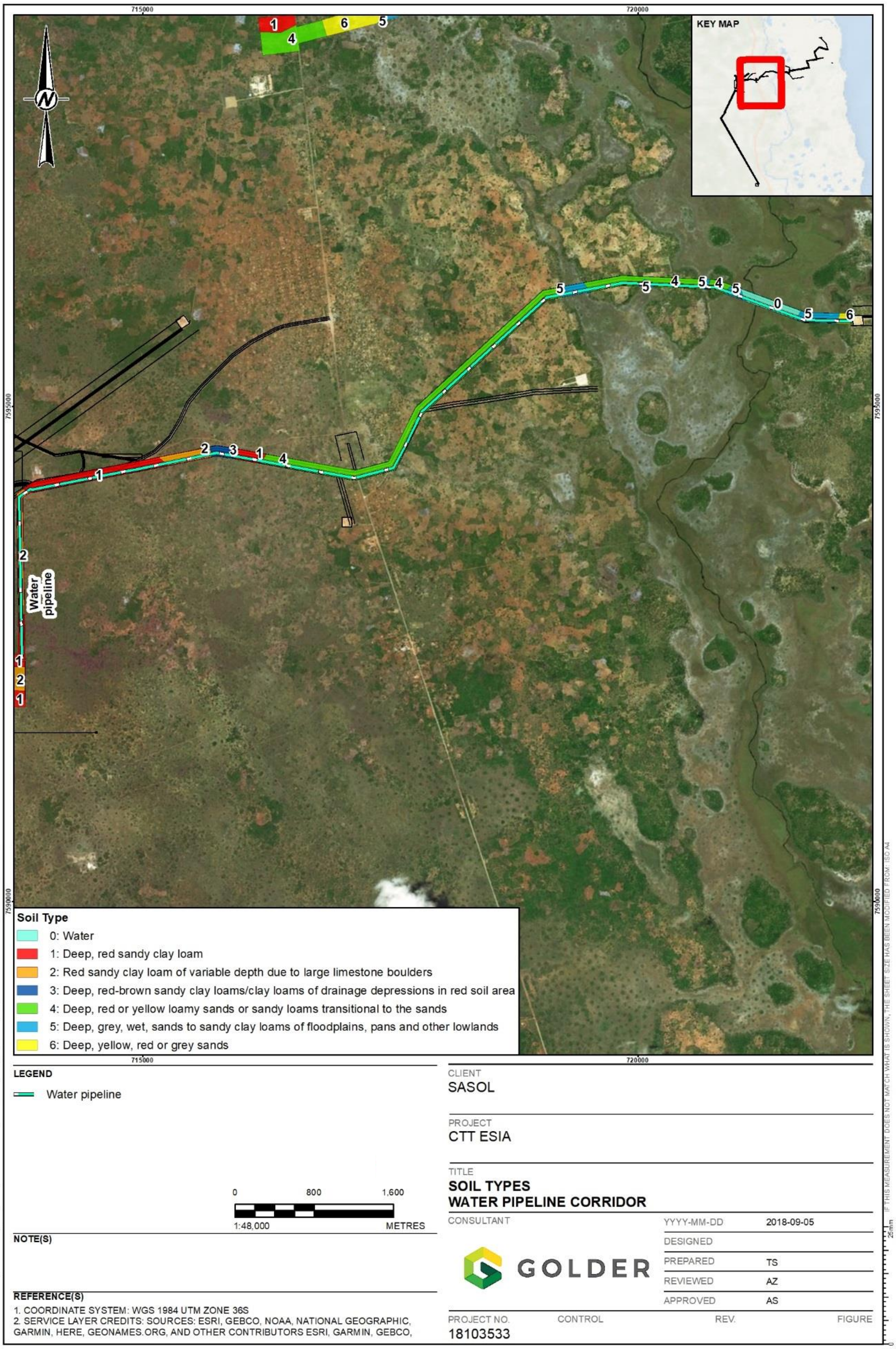

Figure 14: Soil types identified in water pipeline corridor

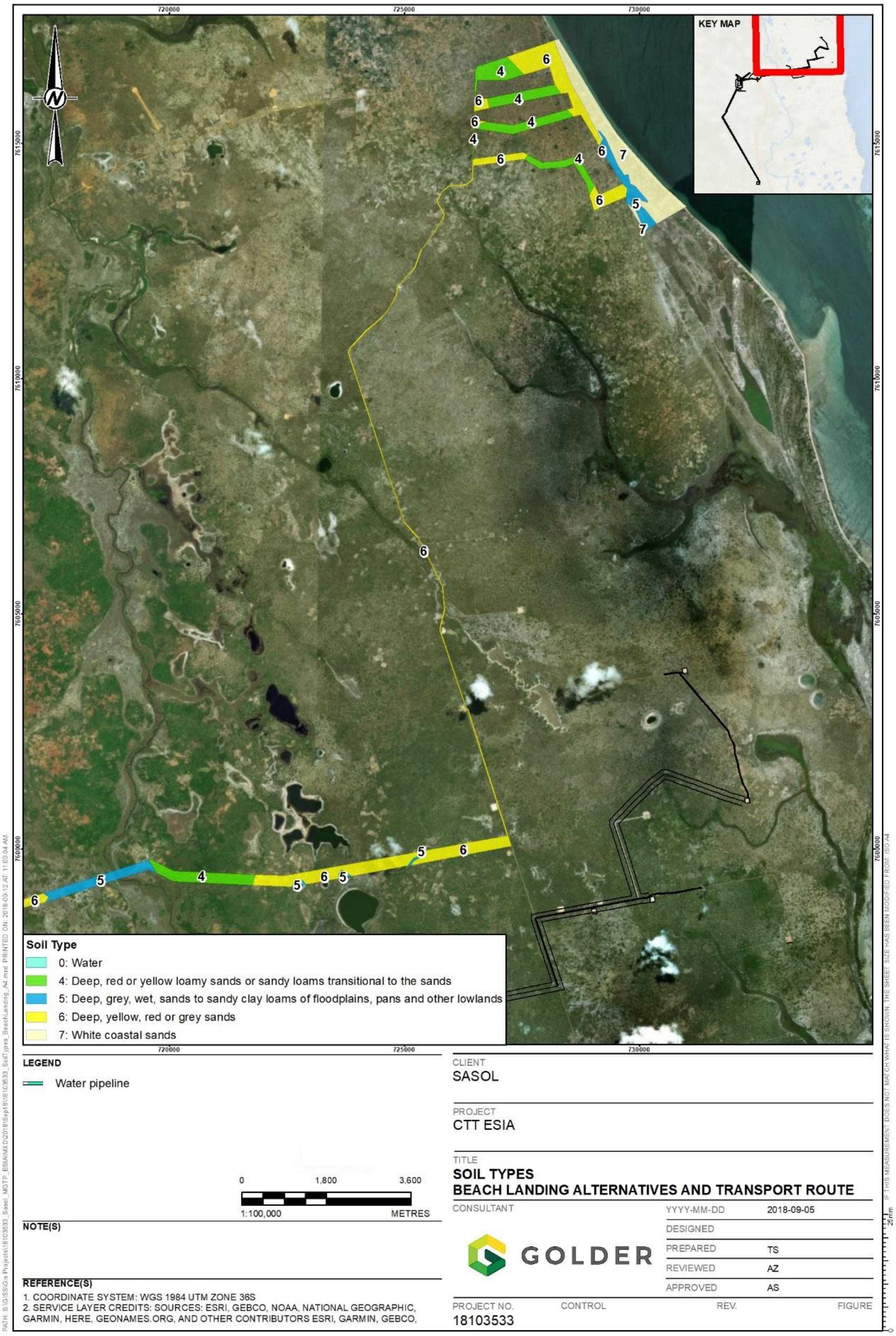

Figure 15: Soil types identified at beach landing alternative and transport route

Table 6: Soil types of the study area in relation to the broad soil types of national-scale maps

Broad soil type Data source	A Upland and lowland soils west of Govuro River				B Floodplains associated with Govuro River and depressions in sandy areas		C Upland soils east of Govuro River	
Soil Map of Mozambique (1972)	Red fersialitic soils on unconsolidated sediments; red soils of *urrongas*				Regosols, regolíthic soils or sandy brownish hydromorphic soils on unconsolidated sediments		Fluvial and lacustrine alluvial soils	
Soil Resources Inventory (1982)	Orthic Luvisols with minor Luvic Arenosols; medium or fine textured				Eutric Fluvisols with minor Luvic Arenosols; medium or fine textured		Association of Eutric Fluvisols, Eutric Gleysols and minor Humic Gleysols; medium or fine textured	
National Soil Map: FAO Classification (2002)	Lixi / Luvisol				Gleysol	Fluvisol	Arenosol	
Fieldwork phase	1 Red loam	2 Red loam on hardpan carbonate	3 Red-brown loam/clay loam of drainage depressions within red loam areas	4 Red or yellow-brown transitional loamy sands (≥10% clay in subsoil)	5 Dark grey silt loam on mottled grey sand or loamy sand or sandy loam		6 Grey or pale yellow sand or loamy sand (<10% clay in subsoil)	7 White coastal sand

Table 7: General description of the soils

Soil Type	Topography	Parent material	Generalised soil description	Classification		Repre-sentative samples
				WRB	SA Taxonomic System	
1	Level to very slightly undulating uplifted coastal plain at ±30 m above mean sea level	Holocene or late Pleistocene aeolian or colluvial material over Neogene marine limestone	Dark reddish brown sandy clay loam A horizons, 20-30 cm thick; massive or weak blocky structure; friable; gradual transition to reddish brown or red sandy clay loam B horizons, 60 to more than 120 cm deep; apedal or weak blocky structure; friable	Haplic Luvisol (Rhodic)	Hutton sandy clay loam[1]	45A, 45B 79A, 79B 115A, 115B
2	As for 1	As for 1	As for 1, but with large limestone erosion/dissolution remnants present within the soil profile and extending to the surface in places; deep and shallow profiles occur alongside each other	As for 1	Plooysburg sandy clay loam	104A, 104B 109A, 109B
3	Drainage depressions within red loam areas; in places weakly developed and/or poorly defined	Holocene/Late Pleistocene aeolian and colluvial material; redistributed and/or locally enriched by clay accumulation	Dark reddish brown sandy loam or sandy clay loam A horizons, 20-30 cm thick; massive or weak blocky structure; gradual or clear transition to reddish brown, weak or moderate blocky, well or moderately well drained sandy clay loam, sandy clay or clay loam B horizons of unknown depth	Cutanic Luvisol (Rhodic)	Oakleaf sandy clay loam; Valsrivier sandy clay loam	67A, 67B 85A, 85B 145A, 145B
4	As for 1; gradational to sandy areas	Holocene aeolian material	Pale yellow-brown or pale red-brown loamy sand A horizons, 15-20 cm thick, over yellow-brown or red loamy sand or sandy loam subsoils of unknown depth; ≥10% clay in subsoil	Haplic Luvisols (Arenic)	Clovelly loamy sand; Hutton loamy sand; Oakleaf sandy loam	153A, 153B 159A,159B 276A, 276B
5	Floodplains associated with	Riverine or lacustrine alluvium	Dark greyish brown, fine or medium, organic rich, sandy loam or sandy clay loam A horizons, 30-50 cm	Gleyic Fluvisol	Fernwood sandy loam;	157A, 157C 185A, 185E

Soil Type	Topography	Parent material	Generalised soil description	Classification		Repre-sentative samples
				WRB	SA Taxonomic System	
	Govuro River; depressions in sandy areas		thick; massive or weak blocky structure; gradual or sharp transition to grey or grey brown, mottled, poorly drained, loamy sand or sandy loam of unknown thickness; massive or weak blocky structure.	Haplic Gleysol	Inhoek sandy clay loam; Dundee sandy loam	270A, 270E
6	Gently sloping to undulating uplifted coastal plain close to mean sea level	Holocene sands	Grey sand A horizons, 15-20 cm thick, over yellowish-grey, pale yellow or pale red sand or loamy sand subsoils of unknown thickness	Hypoluvic Arenosols	Fernwood sand; Clovelly sand Vilafontes sand Hutton sand	165A,165B 187A,187E 205A, 205E 211A, 211B 225A, 225B 246A, 246B
7	As for 6, but in close proximity to the sea	Holocene sands	Thin (2-10 cm) dark grey-brown or grey-brown fine or medium sand A horizons over white, fine or medium sand of unknown thickness	Hyper-albic Arenosol	Fernwood sand	

[1] Dominant top-soil texture class

Table 8: Selected soil physical and hydrological properties

Soil Type		Clay %		Silt %		Water-holding capacity [1]					Water infiltration rates	Soil internal drainage class[2]	Water table (position, condition and duration)[3]
		Top-soil	Sub-soil	Top-soil	Sub-soil	Drained upper limit	Wilt-ing point	Plant avail-able	Arbitrary profile depth limit (mm)	Profile available water (mm)			
						(mm/mm)							
1	Red loam	20-28	24-32	5-8	6-10	0.23	0.14	0.101	1200	121	Moderate	Well-drained	None
2	Red loam on hardpan carbonate	20-28	24-32	5-8	6-10	0.23	0.14	0.101	800	81	Moderate	Well-drained	None
3	Red-brown Loam/clay loam of drainage depressions	16-25	28-35	4-7	7-11	0.24	0.15	0.107	1200	128	Moderate	Moderately well to well-drained	None
4	Red or yellow-brown loamy sand/sandy loam (subsoil clay ≥10%)	12-15	10-18	3-5	4-6	0.18	0.08	0.104	1200	125	Rapid	Well-drained	None
5	Dark grey/grey silt loam/loamy sand/sand of drainage depressions (of sandy areas)	12-25	5-15	4-7	4-7	0.18	0.08	0.106	800	85	Variable	Poorly drained	E Horizon and lower A horizon, temporary/ seasonal, substantial

Soil Type		Clay %		Silt %		Water-holding capacity[1]					Water infiltration rates	Soil internal drainage class[2]	Water table (position, condition and duration)[3]
		Top-soil	Sub-soil	Top-soil	Sub-soil	Drained upper limit	Wilting point	Plant available	Arbitrary profile depth limit (mm)	Profile available water (mm)			
						(mm/mm)							
													periods after rain events
6	Grey or pale yellow sand or loamy sand (<10% clay in subsoil)	4-6	5-8	1-2	1-3	0.14	0.04	0.093	1200	112	Rapid	Somewhat poorly to well-drained	Unknown; improbable
7	White coastal sand	2-5	1-3	0-1	0	0.11	0.02	0.092	1200	110	Rapid	Well-drained	None

[1] Use was made of algorithms by Hutson, Schulze and Cass (1985)

[2] Qualitatively assessed on basis of soil colour, mottling, redox depletion and position in the landscape

[3] Assessed on basis of soil properties and climate

7.0 ANALYTICAL DATA

7.1 Soil Fertility Properties

Selected baseline soil fertility properties, based on the analytical data APPENDIX B, are summarised in Table 9. The following are of note:

- The soils are of high base status, with little or no natural acidity, but with slight alkalinity and/or sodicity in places towards the coast;
- They are low in magnesium and, in places, in potassium. At relatively high calcium levels, this causes imbalances and deficiencies;
- The phosphorus status is very low, in both the top-soils and subsoils;
- The overall natural fertility can be described as low to moderate.

7.2 Soil chemical properties

The soils were analysed for total metal and organic concentrations. Due to the lack of available soil screening values for Mozambique, the US EPA Soil Screening Guidance (SSG) (US EPA, 1996) was used.

7.2.1 Soil – Industrial SSL

The SSG provides a framework for developing risk-based, soil screening levels (SSLs) for the protection of human health. Soil screening levels are not clean up levels but aim to identify and define areas, contaminants and conditions that do not require further attention. Where a contaminant concentration is equal to or exceeds the SSLs, further study or investigation but not necessarily clean-up is warranted. It does not replace the Remedial Investigation or risk assessment but can assist in aiming such an assessment on aspects of concern. By screening out areas of the site, potential constituents of concern or exposure pathways for further investigation, the scope of a remedial investigation or risk assessment can be limited.

The framework provides for three approaches to establish SSLs to be used for comparison to soil contaminant concentrations:

- Apply generic SSLs developed by the EPA;
- Develop SSLs using site-specific methodology; or
- Develop SSLs using a more detailed site-specific approach.

The first approach is the simplest and assumes a generic exposure scenario which is intended to be broadly protective under a wide range of site conditions. The SSLs are derived using conservative assumptions about site conditions and are likely to be more stringent than SSLs developed using more site-specific approaches. With the information available this approach was selected to assess the status of contamination for the soil.

In general, sites where the anticipated future use is either commercial or industrial can be screened using the industrial/commercial SSLs. If industrial/commercial SSLs are used in screening evaluations, the elimination of an area for further consideration is dependent on an analysis of institutional control options. Generally the non-residential SSLs are less stringent than the corresponding residential values.

7.2.2 Soil – Migration to ground water

The SSG provides SSLs for the ingestion of leachate contaminated ground water. This approach aims to protect off-site receptors, including residents, who may ingest contaminated ground water that migrate from the site as well as potentially potable ground water aquifers that may exist beneath the investigated property. Therefore, this approach is protective of the ground water resource and human health. This approach may necessitate that sites meet stringent SSLs if the migration to ground water pathway applies, regardless of future land use. The migration to ground water pathway is applicable to all potentially potable aquifers.

The migration to ground water SSLs is back-calculated from an acceptable target soil leachate concentration using a dilution attenuation factor (DAF). Soil screening levels are calculated using a DAF 20 (considered a conservative DAF) to account for reductions in contaminant concentration due to natural processes occurring in the subsurface.

A target hazard quotient (THQ) of 1.0 is used in this assessment as mostly natural conditions are expected as screening was done for one contaminant. Generally, if screening multiple chemicals it is preferred to use the THQ = 0.1 tables.

7.2.3 Results

7.2.3.1 Inorganic Analysis

Table 10 and Table 11 summarises the laboratory data with respect to trace metal compounds presented in Appendix B. From the results it was observed that As concentrations were found to exceed the industrial and risk based SSL values in the majority of the soils and exceeds the Risk Based SSL in two soils along the water pipeline. Iron concentrations exceed the Risk based SSL for the samples collected at the plant site, transmission line and water pipeline. Manganese exceeds the Risk based SSL in some samples collected at the plant site and one at the water pipeline. The concentrations are higher in the red soils and low in the coastal sands. The As, Fe and Mn concentrations are well within the typical background ranges provided by Kabata-Pendias and Mukherjee (2007), respectively <0.1 – 67 mg/kg, 300 - 300000 mg/kg (0.03 – 300%), 10 – 9000 mg/kg.

Table 9: Selected soil fertility properties

Soil Types		pH (Water) [2]	Extractable acidity [2]	Extractable Bases [3]				Base Status [3]	Sodicity [3]	Cation Imbalances [3]	Phosphorus Status [3]	Overall Natural Fertility [3]
				Ca	Mg	K	Na					
1 2 3	Red loam Red loam on hardpan carbonate Red-brown loam/clay loam of drainage depressions	Slightly acid -very slightly alkaline	None - low	Mod - High	Low	Mod	Low	High	None -low	Mg low in relation to Ca and K	Very low	Low - moderate
4	Red or yellow-brown loamy sand/sandy loam (subsoil clay ≥10%)	Neutral - moderately alkaline	None - low	Mod - High	Low	Low - mod	Low	High	Low	Mg and K low in relation to Ca	Very low	Low - moderate
5	Dark grey/grey silt loam/loamy sand/sand of drainage depressions (of sandy areas)	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd
6	Grey or pale yellow sand or loamy sand (<10% clay in subsoil)	Slightly acid - moderately alkaline	Non - low	High - mod high	Low	Low	Low - mod	High	Low -mod	In places, Mg low in relation to Ca and K	Very low	Low - moderate
7	White coastal sand	nd	nd	nd	nd	nd	nd	nd	nd	Nd	nd	nd

[1] Data from main data set (Table A-1) [2] data from both main and ancillary (Table A-2) sample sets [3] Limited data; from ancillary data set only

Table 10: Comparison of metal concentrations with US EPA industrial and Risk based SSLs for samples collected at CTT site and transmission line

Constituent	Unit	Industrial Soil	Risk based SSL	CTT Plant site						Transmission Line			
Sample number	-	-	-	109A	109B	115A	115B	145A	145B	67A	67B	79A	79B
Depth	cm	-	-	0-20	90-110	0-20	90-110	0-20	90-110	0-20	100-120	0-20	80-100
EC	uS/cm	-	-	brl	brl	brl	brl	brl	brl	Brl	brl	brl	brl
pH	pH units	-	-	7.3	6.9	7.4	6.9	7.5	6.4	7.3	6.6	6.9	6.5
Aluminium	mg/kg	1100000	600000	20600	27420	23200	27310	15520	26760	11220	19000	5221	10650
Arsenic	mg/kg	3	0.03	24.6	28.3	12.9	17.6	15.4	18.4	13.8	16.7	4.9	7.1
Cadmium	mg/kg	980	ng	0.1	brl	brl	brl	brl	brl	Brl	brl	brl	brl
Copper	mg/kg	47000	560	12	11	11	15	10	10	9	9	4	5
Iron	mg/kg	820000	7000	27430	33260	25340	34840	22910	28950	21580	28080	9908	15530
Lead	mg/kg	800	ng	17	18	15	23	11	14	13	14	7	7
Manganese	mg/kg	26000	560	630	353	748	439	336	249	464	375	317	198
Mercury	mg/kg	40	0.66	brl	brl	brl	brl	brl	brl	Brl	brl	brl	brl
Nickel	mg/kg	22000	520	28	32	26	32	22	31	18	22	8.5	12

Constituent	Unit	Industrial Soil	Risk based SSL	CTT Plant site						Transmission Line			
Vanadium	mg/kg	5800	1720	108	141	94	129	77	103	67	93	24	40
Zinc	mg/kg	350000	7400	14	12	11	15	10	10	11	11	6	7

Purple: Values exceed the industrial soil screening criteria

Orange: Values exceed the Risk based SSL criteria

brl: Below reporting limit

Table 11: Comparison of metal concentrations with US EPA industrial and Risk based SSLs for samples collected at water pipeline and temporary road

Constituent	Units	Industrial Soil	Risk Based SSL	Water Pipeline				Temporary Road				
Sample number	-	-	-	104A	104B	153A	153B	187A	187E	211A	211B	246A
Depth	cm	-	-	0-20	60-80	0-20	110-120	0-20	100-120	0-20	60-80	0-15
EC	uS/cm	-	-	brl	brl	brl	brl	brl	Brl	brl	brl	brl
pH	pH units	-	-	7.41	7.9	8.2	7.4	8.6	8.5	5.8	7.1	6.4
Aluminium	mg/kg	1100000	600000	26320	28590	3385	3812	2538	3607	1409	3256	1776
Arsenic	mg/kg	3	0.03	20.8	22.6	1.7	2.2	brl	Brl	brl	brl	brl
Cadmium	mg/kg	980	ng	brl	brl	brl	brl	brl	Brl	brl	brl	brl
Copper	mg/kg	47000	560	14	13	4	3	brl	Brl	1	brl	1

Constituent	Units	Industrial Soil	Risk Based SSL	Water Pipeline				Temporary Road				
Iron	mg/kg	820000	7000	29490	32990	7098	7825	935	1303	699	1425	983
Lead	mg/kg	800	ng	17	20	6	5	brl	Brl	brl	brl	brl
Manganese	mg/kg	26000	560	711	455	258	114	137	24	66	15	133
Mercury	mg/kg	40	0.66	brl	brl	brl	brl	brl	Brl	brl	brl	brl
Nickel	mg/kg	22000	520	32.3	34.3	6.7	7	1.1	1	brl	1	brl
Vanadium	mg/kg	5800	1720	116	134	21	23	3	5	2	5	4
Zinc	mg/kg	350000	7400	14	14	brl	brl	brl	Brl	brl	brl	brl

Purple: Values exceed the industrial soil screening criteria

Orange: Values exceed the Risk based SSL criteria

brl: Below reporting limit

7.2.3.2 Organic Analysis

A limited number of soil samples in the vicinity of the CTT site were assessed for organic contaminants. The selection was based on elevated concentrations found in this area according to Schoeman and Verster (2014). Only constituents that were above the reporting limit are shown in Table 12.

The results indicate the following:

- The following organic constituents are present at levels of two units or more above the detection limit of 2-3 µg/kg:
  - Toluene was found above the reporting limit in one of the surface samples taken at the CTT site.
  - Ethylbenzene and styrene were found to exceed the reporting limit in 2 samples analysed in the CTT vicinity and one in the water pipeline area.

Although values are below the screening values, the occurrence at surface could indicate impacts resulting from the operations. The potential for increased levels of toluene over time and in closer proximity to the plant site may exist and should be monitored in future. Currently, the samples collected are below screening values and do not indicate to a significant current risk.

Table 12: Comparison of some organic constituents with US EPA industrial and Risk based SSLs for samples collected at CTT site and water pipeline

CONSTITUENT	UNIT	Industrial Soil	Risk based SSL	CTT PLANT SITE			WATER PIPELINE
Sample number	-	-	-	109A	115A	145A	104A
Depth	cm	-	-	0-20	0-20	0-20	0-20
Toluene	ug/kg	47000	15.2	0.003	brl	brl	Brl
Ethylbenzene	ug/kg	25	0.034	0.008	brl	0.005	0.004
Styrene	ug/kg	35000	26	0.010	brl	0.014	0.012

8.0 INTERPRETIVE SOIL INFORMATION

8.1 Derived soil properties

As a result of the considerable co-variation that commonly exists between soil properties that can readily be measured and complex properties that are difficult or expensive to measure, it is common practice to make qualitative statements about derived soil properties. Selected statements of this kind are offered in Table 13.

Table 13: Interpretive soil properties

Soil Type		Susceptibility to erosion [3]		Susceptibility to compaction [1]	Susceptibility to surface crusting [2]	Absorption capacity for pollutants [2]	Dust Potential [2]	Agricultural potential (rainfed) [3]
		Water	Wind					
1	Red loam	Low	Low	Moderate	Moderate	High	Moderate	Moderate
2	Red loam on hardpan carbonate	Low	Low	Moderate	Moderate	High	Moderate	Low
3	Red-brown Loam/clay loam of drainage depressions	Low	Low	Moderate	Moderate	High	Moderate	Moderate
4	Red or yellow-brown loamy sand/sandy loam (subsoil clay ≥10%)	Mode-rate	Mode-rate	High	Moderate	Moderate	Moderate	Moderate
5	Dark grey/grey silt loam/loamy sand/sand of drainage depressions (sandy areas)	High	Mode-rate	High	High	Moderate	Moderate	Low
6	Grey or pale yellow sand or loamy sand (subsoil clay <10%)	High	High	High	Low	Low	Moderate to high	Moderate
7	White coastal sand	High	High	High	Low	Low	Moderate to high	Low

[1] Intrinsic soil susceptibilities without considering soil cover and slope factors. Largely based on soil textural, organic matter and drainage properties.
[2] Based on soil textural properties, derived clay mineralogy and organic matter.
[3] Taking climatic limitations into account

8.2 Wetland soils

In most methodologies of the assessment of wetland soils use the following key factors (not necessarily in this sequence):

- Soil classification taxa and soil morphological properties (e.g. grey matrix colours within 50 cm of the soil surface and mottling);
- Position in the landscape (primarily floodplains or other bottomland types but also upper foot slopes and hanging wetlands on sloping land);
- Periodic presence of water; and
- Vegetation.

With respect to soil morphological properties in the study area, it is to be noted that some of the soils of the sandy coastal areas (e.g. some members of soil type 6) are redox depleted to the stage where red or yellow soil colorants (mostly iron oxides or hydroxides) may be in very low supply, particularly in the upper parts of the profile. This may be the main cause of the presence of grey matrix colours that are not necessarily indicative of active wetness, and few or faint mottles. In these cases the absence of mottles clearly are not indicative of permanent wetlands. Lowlands in the area, particularly bottomlands, however, are sufficiently well expressed to be useful as an indication of wetlands, provided that the soil morphology is concurring. The distinction between permanent, seasonal and temporary wetland zones (DWA, 2005) is rather difficult in the study area with its extremes of droughts and flooding. Channelled riverine areas and adjacent (inner) floodplains and pans appear mostly to be permanent wetlands. Outlying, disconnected floodplains and small tributary streams and depressions (e.g. the depression south-east of Inhassoro town) are probably best considered as temporary wetlands with islands of terrestrial soils. Drainage depressions encountered in the red soil area (soil type 3) contain terrestrial soils.

8.3 Land-use

Land-use information was observed and recorded during fieldwork in view that it may be helpful in understanding and assessing the soils, their land-use options and land capability. The main land-use types encountered are listed in Table 14 and shown in Figure 16 to Figure 19. Individual cultivated fields are shown on the map where the scale permits. In the Inhassoro area this was not possible due to numerous very small fields, and the broad land use type was mapped as UA (urban with agriculture) and PuA (peri-urban with agriculture) as defined in Table 15. Rainfed arable agriculture is practiced in the area as a form of low-input shifting agriculture with hand hoeing only. Shifting agriculture is necessitated by an almost total absence of the use of chemical fertilizers and animal manure. In this farming system selected fields are left fallow and the natural trees, bush and grasses are allowed to grow back. After quite a number of years, the vegetation of such fallowed fields are cut down and burned in a slash-and-burn manner, with the ashes providing nutrition for the following few years' crops. In order to further improve the soil fertility, intercropping is employed with legumes (groundnut as main crop), maize (commonly a limited number of scattered plants, limited probably to prevent overshadowing – which is known to hamper nitrogen fixation by the legume) and cassava (also a limited number of scattered plants). Wind erosion on sandy soils is curbed by the small size of most fields, trees left in the fields and the surrounding bush acting as natural windbreak. This cropping system appears to be sustainable.

Apart from wild cashew trees, very few subtropical fruit or nut trees were observed. As the temperature regimes are ideal for many such crops, this may be pointing to inadequate rainfall, or more likely, periodic occurrences of severe drought.

Livestock numbers (cattle, goats) appear to be very limited. Very seldom was rangeland observed in which the grasses are grazed to below knee height. The only other rangeland use appears to be charcoal making. Tall, reedy wetland vegetation is extensively harvested and used/sold as building and roofing material.

Table 14: Land-use

Land-use map symbol	Land-use type	Description
C	Cultivated fields	Fields or clusters of fields that are predominantly under current cultivation
O	Old lands	Savannah or grassed areas where differences in bush height, bush density, diversity of bush or boundary patterns, (observable in the field and on Google Earth) appear to indicate shifting cultivation in periods past

Land-use map symbol	Land-use type	Description
N	Savannah areas with few or no old lands	Little or no indications in bush height, bush density, diversity or boundary patterns can be observed (in the field and on Google Earth) that serve to indicate previous cultivation
W	Wetland (seasonal or permanent)	Areas where the soils appear to be generally too wet for normal arable agriculture
Wt	Wetland (temporary)	Wetland areas where soil wetness, at least in some seasons, appears not to preclude normal arable agriculture
UA	Urban areas, commonly with some urban agriculture	Areas with formal streets and houses, commonly with small to larger cultivated fields in which the similar crops are grown as in rural areas
PuA	Peri-urban areas with smallholdings that are commonly intensively cultivated	Smallholder areas in or around the urban fringe with many homesteads, few or no formal streets or roads, and many small to larger cultivated fields
P	Sand pits	Areas with few to many, non-contiguous, small to large sand pits
S	Storage areas	Areas that are cleared of vegetation and used for the temporary storing of bulky materials

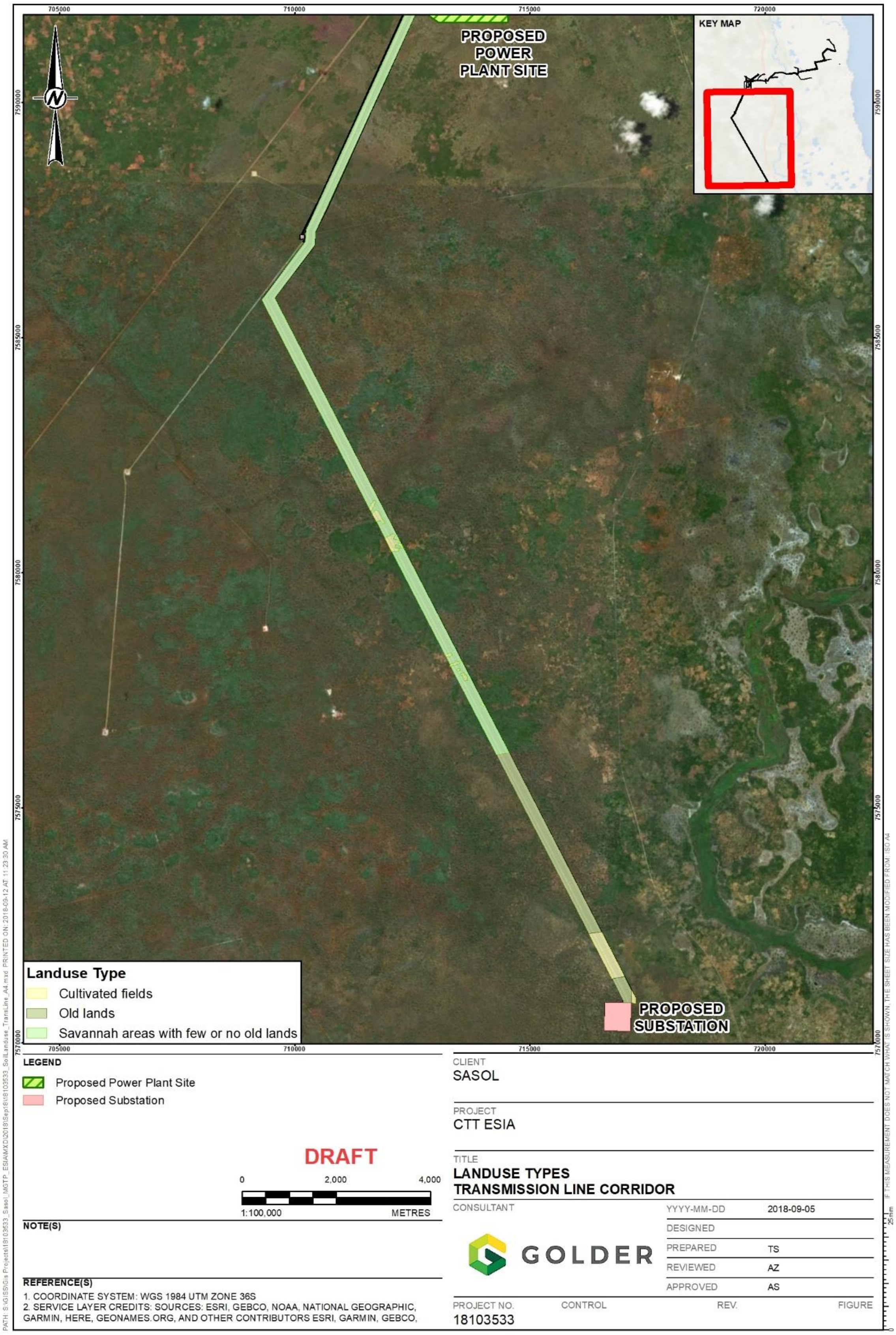

Figure 16: Land use types for transmission line corridor

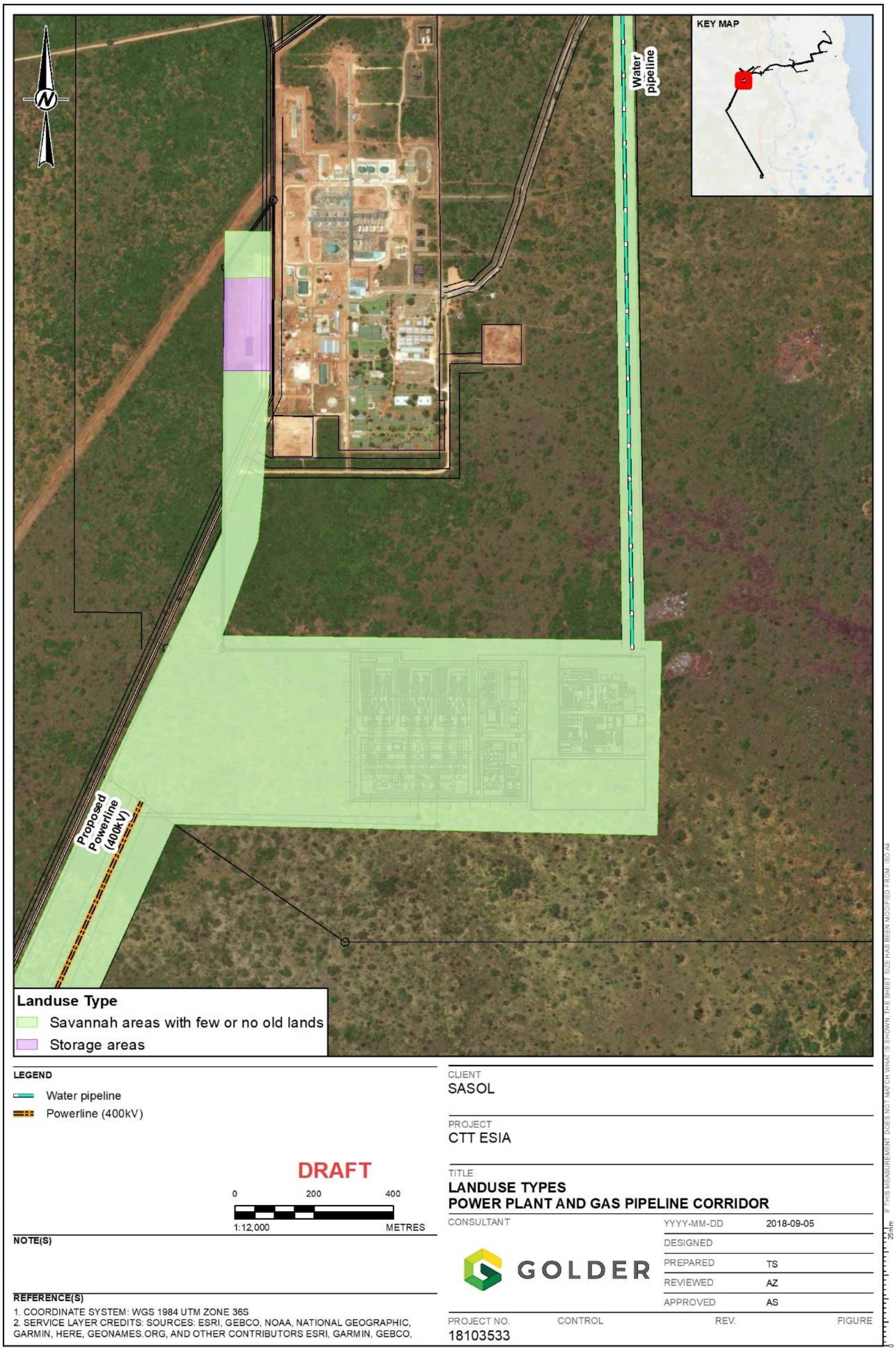

Figure 17: Land use types for CTT site and gas pipeline corridor

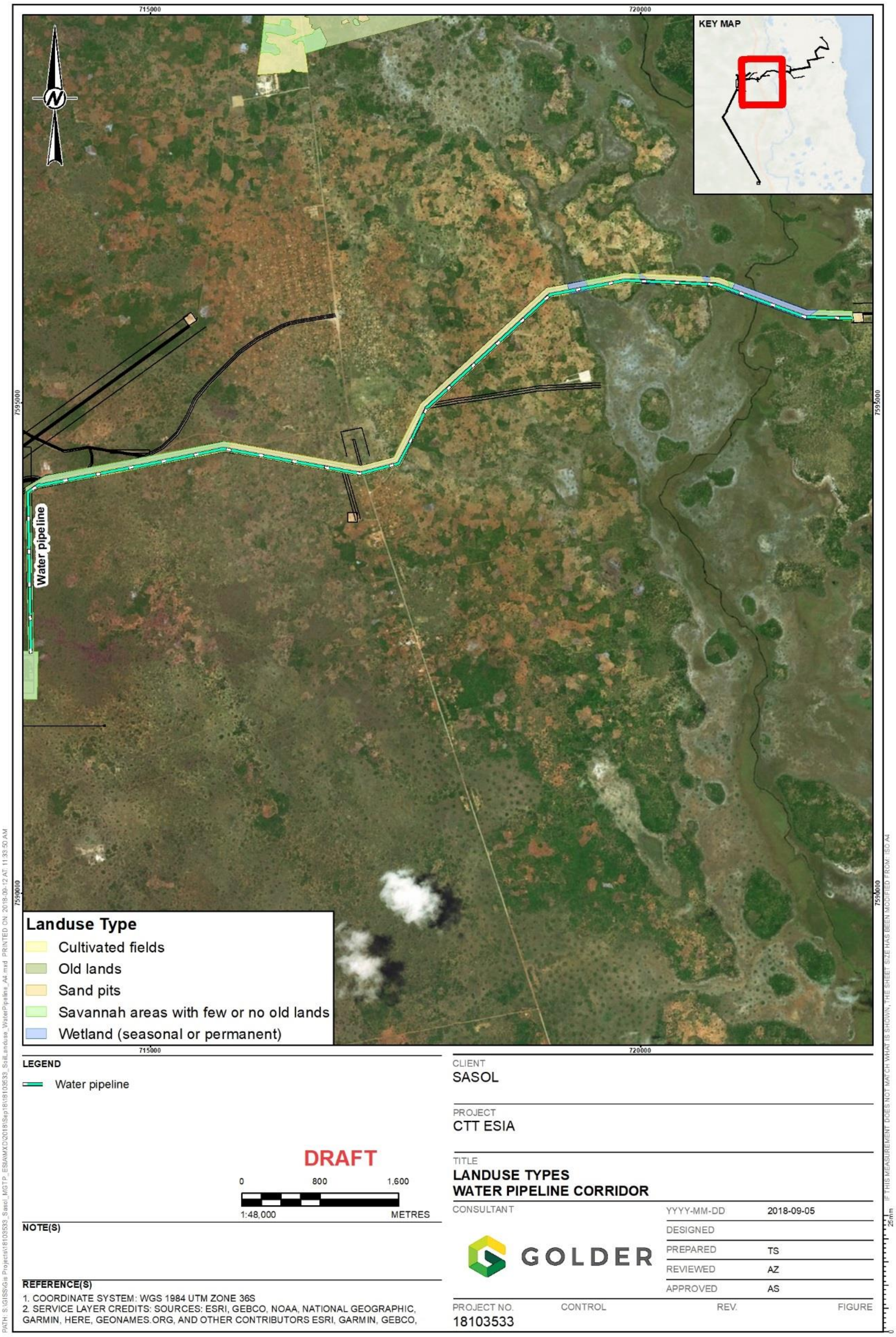

Figure 18: Land use types for water pipeline corridor

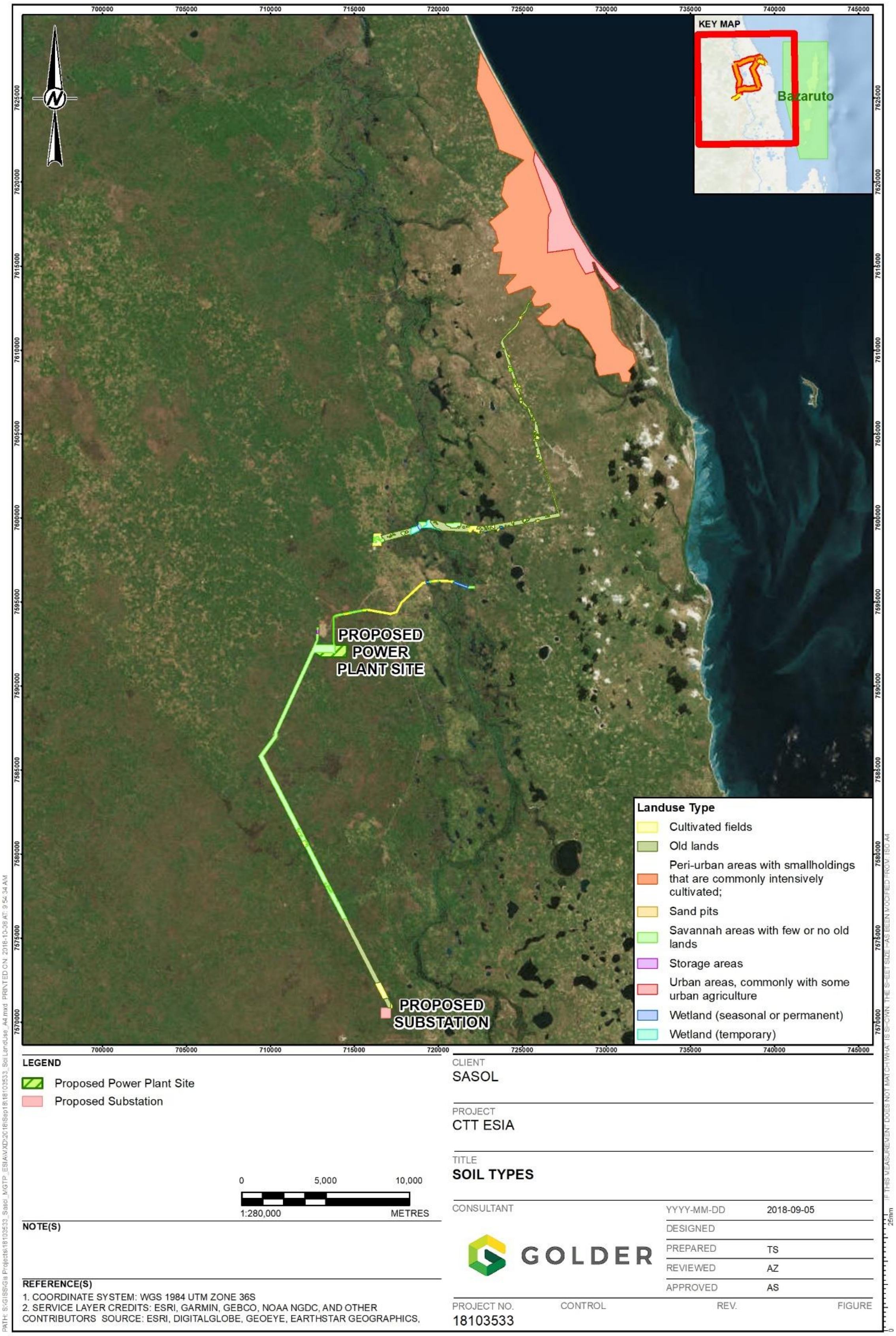

Figure 19: Land use types for beach landing alternatives and transport route

8.4 Land capability

Land capability (Table 15) was assessed in accordance with the classic eight-class system of Klingebiel and Montgomery (1961) as adapted to southern African conditions by Scotney *et al.* (1991). Land capability refers to the "basket" of land use types that are possible and may be expected to result in acceptable profitability and environmental sustainability. It is determined by the cumulative effects of climate, soils and terrain features.

In this assessment it became evident that inadequate or irregular rainfall is a key limitation in the study area, particularly the areas away from the coast. Following Schoeman and Verster (2014) inadequate or irregular rainfall was rated as a moderate climatic limitation, putting a general ceiling of Class III on the whole area. As a result, without irrigation, none of the soil types in Table 15 may receive a higher rating than Class III (translating to moderate rainfed arable potential). Other, cumulative limitations applying to individual soil types include mechanical restrictions, susceptibility to wind erosion, hydric soil conditions, susceptibility to flooding and low nutrient reserves.

Table 15: Land capability

Soil Type		Land capability		
		Class	Description	Key limitations
1	Red loam	III	Moderate capability to sustain rainfed arable land-use	Moderate to moderately low rainfall; occurrence of drought
2	Red loam on hardpan carbonate	IV	Marginal capability to sustain mechanised rainfed arable land-use	As for soil type 1 but with mechanical restrictions
3	Red-brown loam/clay loam of drainage depressions	III	As for Class III	As for soil type 1; in addition susceptibility to flooding
4	Red or yellow-brown loamy sand/sandy loam (subsoil clay ≥10%)	III	As for Class III	Moderate rainfall; occurrence of drought
5	Dark grey/grey silt loam/loamy sand/sand of drainage depressions (sandy areas)	V	Low or no capability for rainfed arable land-use due to soil wetness and/or flooding	Little or no arable potential due to seasonal/periodic hydric soil conditions; susceptibility to flooding
6	Grey or pale yellow sand or loamy sand (subsoil clay <10%)	III	As for III	Moderate rainfall, but higher towards the coast; occurrence of drought; susceptibility to wind erosion; low nutrient reserves
7	White coastal sand	VII-VIII	Wilderness land (Class VIII) or land with low grazing capacity (Class VII)	General instability and fragility

9.0 IMPACT ASSESSMENT

9.1 Assessment methodology and rating criteria

Potential impacts are assessed according to the direction, intensity (or severity), duration, extent and probability of occurrence of the impact. These criteria are discussed in more detail below:

Direction of an impact may be positive, neutral or negative with respect to the particular impact. A positive impact is one which is considered to represent an improvement on the baseline or introduces a positive change. A negative impact is an impact that is considered to represent an adverse change from the baseline or introduces a new undesirable factor.

Intensity / Severity is a measure of the degree of change in a measurement or analysis (e.g. the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as none, negligible, low, moderate or high. The categorisation of the impact intensity may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgment). The specialist study must attempt to quantify the intensity and outline the rationale used. Appropriate, widely-recognised standards are used as a measure of the level of impact.

Duration refers to the length of time over which an environmental impact may occur: i.e. transient (less than 1 year), short-term (1 to 5 years), medium term (6 to 15 years), long-term (greater than 15 years with impact ceasing after closure of the project) or permanent.

Scale/Geographic extent refers to the area that could be affected by the impact and is classified as site, local, regional, national, or international. The reference is not only to physical extent but may include extent in a more abstract sense, such as an impact with regional policy implications which occurs at local level.

Probability of occurrence is a description of the probability of the impact actually occurring as improbable (less than 5% chance), low probability (5% to 40% chance), medium probability (40 % to 60 % chance), highly probable (most likely, 60% to 90% chance) or definite (impact will definitely occur).

Impact significance will be rated using the scoring system shown in Table 16 below. The significance of impacts is assessed for the two main phases of the project i) construction ii) operations. While a somewhat subjective term, it is generally accepted that significance is a function of the magnitude of the impact and the likelihood (probability) of the impact occurring. Impact magnitude is a function of the extent, duration and severity of the impact, as shown in Table 16.

Table 16: Scoring system for evaluating impacts

Severity	Duration	Extent	Probability
10 (Very high/don't know)	5 (Permanent)	5 (International)	5 (Definite/don't know)
8 (High)	4 (Long-term – longer than 15 years and impact ceases after closure of activity)	4 (National)	4 (Highly probable)
6 (Moderate)	3 (Medium-term- 6 to 15 years)	3 (Regional)	3 (Medium probability)
4 (Low)	2 (Short-term - 1 to 5 years)	2 (Local)	2 (Low probability)
2 (Minor)	1 (Transient – less than 1 year)	1 (Site)	1 (Improbable)

Severity	Duration	Extent	Probability
1 (None)			0 (None)

After ranking these criteria for each impact, a significance rating was calculated using the following formula:

SP (significance points) = (severity + duration + extent) x probability.

The maximum value is 100 significance points (SP). The potential environmental impacts were then rated as of High (SP >75), Moderate (SP 46 – 75), Low (SP ≤15 - 45) or Negligible (SP < 15) significance, both with and without mitigation measures in accordance with Table 17.

Table 17: Impact significance rating

Value	Significance	Comment
SP >75	Indicates **high** environmental significance	Where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. Impacts of high significance would typically influence the decision to proceed with the project.
SP 46 - 75	Indicates **moderate** environmental significance	Where an effect will be experienced, but the impact magnitude is sufficiently small and well within accepted standards, and/or the receptor is of low sensitivity/value. Such an impact is unlikely to have an influence on the decision. Impacts may justify significant modification of the project design or alternative mitigation.
SP 15 - 45	Indicates **low** environmental significance	Where an effect will be experienced, but the impact magnitude is small and is within accepted standards, and/or the receptor is of low sensitivity/value or the probability of impact is extremely low. Such an impact is unlikely to have an influence on the decision although impact should still be reduced as low as possible, particularly when approaching moderate significance.
SP < 15	Indicates **negligible** environmental significance	Where a resource or receptor will not be affected in any material way by a particular activity or the predicted effect is deemed to be imperceptible or is indistinguishable from natural background levels. No mitigation is required.
+	**Positive impact**	Where positive consequences / effects are likely.

In addition to the above rating criteria, the terminology used in this assessment to describe impacts arising from the current project are outlined in Table 18 below. In order to fully examine the potential changes that the project might produce, the project area can be divided into Areas of Direct Influence (ADI) and Areas of Indirect Influence (AII).

- Direct impacts are defined as changes that are caused by activities related to the project and they occur at the same time and place where the activities are carried out i.e. within the ADI.
- Indirect impacts are those changes that are caused by project-related activities, but are felt later in time and outside the ADI. The secondary indirect impacts are those which are as a result of activities outside of the ADI.

Table 18: Types of impact

Term for Impact Nature	Definition
Direct impact	Impacts that result from a direct interaction between a planned project activity and the receiving environment/receptors (i.e. between an effluent discharge and receiving water quality).
Indirect impact	Impacts that result from other activities that are encouraged to happen as a consequence of the project (i.e., pollution of water placing a demand on additional water resources).
Cumulative impact	Impacts that act together with other impacts (including those from concurrent or planned activities) to affect the same resources and/or receptors as the project.

9.2 Identified impacts

Key potential impacts on soils, land capability and land use that have been identified for the project are:

- Changes in land use;
- Soil quality degradation;
- Contamination of soils;
- Soil erosion;
- Soil compaction; and
- Loss of soil agricultural potential.

9.3 Construction phase impacts

The significance rating of the predicted environmental impacts resulting from the construction phase of the project provided in Table 19.

9.3.1 Change of land use

One potential negative impact of the project activities is the change in land use. The land uses observed during the field survey as detailed in Section 8.3 indicate limited industrial use. With the onset of the project construction activities, the cultivated fields, savannah areas, urban areas (with portions of cultivated lands) and the peri-urban areas land use will permanently change for industrial use. It is understood that the entire project footprint will be impacted during the construction phase of the project. Therefore, the significance of the impact on land use is considered to be moderate.

Mitigation

The potential negative impacts relating to land disturbance and change of land use can be mitigated as follows:

- Minimise the project footprint and therefore disturbance to a minimal area as possible;
- Identify and investigate sustainable land use options within the project footprint and adjacent communities; and
- Promote sustainable land use and agricultural practices in the project area and adjacent areas.

9.3.2 Soil quality degradation

Land disturbance is expected to occur due to initial clearing and ground levelling and excavation activities. The consequences of those activities during construction phase are:

- loss of the original spatial distribution of soil types and natural soil horizon sequences;
- loss of some original soil fertility;
- loss of original topography and drainage pattern;
- loss of original soil depth and soil volume; and
- loss of the natural functioning of the soil (habitat for fauna and flora).

In essence, land disturbance during the construction phase, has a direct negative impact on the overall soil quality. Disturbed degraded soils, have lost their capacity to function within natural or managed ecosystem boundaries. The following activities will impact negatively on soil quality: Soil clearing and ground levelling, stripping topsoil and sub-soils, removal of organic horizon by heavy machines during the development of project infrastructure. The significance of the impact is moderate and with the appropriated mitigation measures, the significance of the impact can be low.

Mitigation

- Minimise the project footprint;
- Minimize surface footprints to the smallest extent possible and restrict heavy machinery and heavy truck access to sensitive soil areas (utilize machinery with the least amount potential to damage soils in sensitive soils areas i.e. smaller graders in sensitive areas);
- Implementing soil conservation measures (e.g. segregation, proper placement and stockpiling of clean soils and overburden material for existing site remediation and maintaining soils fertility on topsoils stored for future rehabilitation);
- Ensuring that the overall thickness of the soils utilised for rehabilitation is consistent with surrounding undisturbed areas and future land use;
- Designing slopes to an appropriate gradient for rehabilitation; and
- Basing the soil fertilizing programs on the soil chemical, biological and physical status after topsoil replacement.

9.3.3 Soil contamination

During the construction phase an increased presence and use of machinery and earthmoving vehicles is expected on site. Potential leakages of oil and diesel from the machinery could cause contamination of soils and shallow groundwater. The significance of the impact is moderate. To reduce the probability of the leakages of oil and diesel from the machinery and earthmoving vehicles, it is recommended that dedicated laydown areas for equipment are established. With the appropriated mitigation measures, the significance of the impact can be low.

Mitigation

- Ensure proper handling and storage of hazardous chemicals and materials (e.g. fuel, gasoil, cement, concrete, reagents, etc.) as per their corresponding Materials Safety Data Sheets (MSDS);
- Maintenance of vehicles and equipment should be carried out in designated appropriate facilities fitted with spills containment, floors and sumps to capture any fugitive oils and greases.;

- Ban the use of fire as a site clearance activity and establish fire breaks to minimise potential soil contamination and protect site areas;
- Implementing regular site inspections for materials handling and storage as well as pipeline monitoring; and
- Development of detailed procedures for spills containment and soils clean up.

9.3.4 Soil erosion

The sandy loam soils found within the study area are predominantly erodible in nature and once vegetation has been removed are susceptible to excessive soil loss. Soil instability is increased when soils are wet, which will intensify the process of erosion if mitigation measures are not implemented. Soil erosion is expected to have a negative effect with a moderate significance rating.

Mitigation

- Contractors (in particular heavy machinery contractors) need to be restricted to designated areas as defined by the Environmental Department;
- The procedures on land clearance and soils handling needs to be followed;
- Implement, monitor and control soil erosion minimisation procedures within project footprint;
- Implement measures to protect soil stockpiles from erosion. Minimise stockpile height to <1.5m (if soil is stockpiled on construction site); and
- Investigate the use of binding agents for roads as an alternative to water dust suppression.

9.3.5 Soil compaction

This occurs when the soil particles and porous network within, are rearranged because of pressure applied on the surface. Pressure will be applied by the movement of heavy vehicles and machinery during the construction phase. The soil is expected to be more prone to compaction if the stripping process takes place when the soil is in a moist state. The impact of the construction phase will therefore have a moderate significance due to duration and high probability of this impact occurring.

Mitigation

- Remove and place soils in dry state when possible;
- Loosen soil through ripping and disking prior to revegetation;
- Limit unnecessary trafficking and movement over areas targeted for soil removal.

9.3.6 Loss of soil agricultural potential.

The loss of agricultural potential refers to the reduction of the soils suitability and thus potential to produce crops. The project footprint will be unusable for agricultural production for the life of the project. Activities likely to impact the soil quality, suitability and thus its agricultural potential occurring during each phase of the project are discussed per project phase. It must be noted that even if surface rehabilitation is possible, the pre-construction soil agricultural potential and soil suitability will be reduced due to the soil disturbances (and subsequent changing in the soil health and quality), handling and replacement processes.

In the project area, there will be a definite and permanent loss of the soils with high agricultural potential. Since the soil's inherent potential will be altered due to the project activities and the land will not be rehabilitated back to agricultural land, the significance of the impact remains high. This impact remains significant irrespective of whether the soil is currently cultivated, since this aspect/characteristic of the soil will be changed during the project life.

Table 19: Construction phase - impact analysis

Indicator of potential impact	Pre-mitigation					Post-mitigation				
	Magnitude	Duration	Geographic Extent	Probability	Significance	Magnitude	Duration	Geographic Extent	Probability	Significance
Change of land use	8	5	1	5	**Moderate 70**	8	5	1	5	**Moderate 70**
Soil quality degradation	8	5	2	5	**Moderate 75**	6	2	1	3	**Low 27**
Soil contamination	4	5	1	3	**Low 30**	4	2	1	2	**Low 14**
Soil erosion	8	5	1	4	**Moderate 56**	4	4	1	3	**Low 27**
Soil compaction	8	5	1	5	**Moderate 70**	8	3	1	5	**Moderate 60**
Loss of soil agricultural potential	8	5	1	5	**Moderate 70**	8	5	1	5	**Moderate 70**

9.4 Operational phase impacts

Soil contamination, erosion and compaction are the key impacts to be considered during the operational phase of the project. The impact analysis is provided in Table 20.

9.4.1 Soil contamination

During the operational phase an increased presence and use of vehicles and machinery is expected on site. As in the case of the construction phase, the potential for leakages of oil and diesel from the machinery is more likely and could cause contamination of soils and the shallow groundwater. The significance of the impact is low. To reduce the probability of the leakages of oil and diesel from the machinery and earthmoving vehicles, it is recommended that dedicated laydown areas for equipment are established. With the appropriated mitigation measures, the significance of the impact can be lower.

Mitigation

- Ensure proper handling and storage of hazardous chemicals and materials (e.g. fuel, gasoil, cement, concrete, reagents, etc.) as per their corresponding Materials Safety Data Sheets (MSDS);
- Maintenance of vehicles and equipment should be carried out in designated appropriate facilities fitted with spills containment, floors and sumps to capture any fugitive oils and greases;
- Ban the use of fire as a site clearance activity and establish fire breaks to minimise potential soil contamination and protect site areas;
- Implementing regular site inspections for materials handling and storage as well as pipeline monitoring.

- Development of detailed procedures for spills containment and soils clean up.

9.4.2 Soil erosion

During the operational phase, soil erosion is expected to most likely occur along the untarred roads within the project area as well as in areas where vegetation has been removed without the construction of any surface cover (concrete, or road surface, or gravel). This significance of the impact is moderate. With the appropriated mitigation measures, the significance of the impact can be low.

Mitigation

- Contractors (in particular heavy machinery contractors) need to be restricted to designated areas as defined by the Environmental Department;
- The procedures on land clearance and soils handling needs to be followed;
- Implement, monitor and control soil erosion minimisation procedures within project footprint;
- Implement measures to protect soil stockpiles from erosion. Minimise stockpile height to <1.5m (if soil is stockpiled on construction site); and
- Investigate the use of binding agents for roads as an alternative to water dust suppression.

9.4.3 Soil compaction

Similar to the activities related to the impact of soil contamination, the compaction of soils may still occur with the prevalence of heavy machinery and vehicles. The increased traffic on unprepared soil surfaces (areas not designated for machinery and vehicles) will apply pressure to the soils, resulting in compaction, and potentially further erosion. This impact will therefore have a moderate significance. With the appropriated mitigation measures, the significance of the impact can be low.

Mitigation

- Remove and place soils in dry state when possible;
- Loosen soil through ripping and disking prior to revegetation;
- Limit unnecessary trafficking and movement over areas targeted for soil removal.

Table 20: Impact analysis for operational phase

Indicator of potential impact	Pre-mitigation					Post-mitigation				
	Magnitude	Duration	Geographic Extent	Probability	Significance	Magnitude	Duration	Geographic Extent	Probability	Significance
Soil contamination	4	5	1	3	**Low 30**	4	2	1	2	**Low 14**
Soil erosion	4	5	1	5	**Moderate 50**	4	3	1	2	**Low 16**
Soil compaction	4	5	1	5	**Moderate 50**	4	3	1	3	**Low 24**

9.5 Decommissioning phase impacts

The following activities may impact negatively on the soil quality whilst the activities are being carried out:

- Spreading of sub-soil and topsoil, profiling and contouring of the area to the area to preserve natural drainage lines; and
- Re-vegetation of disturbed area and rehabilitation of areas disturbed by hauling activities, removal of pipeline during decommissioning.

The main potential impacts on the soil and land resulting from the activities underway during the decommissioning of the site is the potential change in land use (to be confirmed), degradation of soil quality, soil contamination, soil compaction, insufficient soil volumes available for surface rehabilitation actions and erosion. Land disturbances, as expected during the decommissioning, generally affect the soil stability and erodibility. The impact analysis is provided in Table 21.

Mitigation

The mitigation measures for the same impacts detailed during the construction phase apply during the decommissioning phase of this project (see section 9.3).

Table 21: Impact analysis for decommissioning phase

Indicator of potential impact	Pre-mitigation					Post-mitigation				
	Magnitude	Duration	Geographic Extent	Probability	Significance	Magnitude	Duration	Geographic Extent	Probability	Significance
Soil quality degradation	8	5	2	5	**Moderate 75**	6	2	1	3	**Low 27**
Soil contamination	4	5	1	3	**Low 30**	4	2	1	2	**Low 14**
Soil erosion	8	5	1	4	**Moderate 56**	4	4	1	3	**Low 27**
Soil compaction	8	5	1	5	**Moderate 70**	8	3	1	5	**Moderate 60**
Insufficient soil for surface rehabilitation	10	5	1	5	**High 80**	6	2	1	3	**Low 27**

10.0 ENVIRONMENTAL ACTION PLAN

The recommended mitigation measures for each identified impact are discussed per impact in Sections 9.3, 9.4 and 9.5.

11.0 MONITORING PROGRAMME

The impact of the project activities on soil quality/productivity, land use and land capability can be monitored by the following methods described in Table 22.

Table 22: Soil, Land use and Land Capability Monitoring Program

Aspect	Monitoring Requirements	Locations	Parameters	Frequency
Soil Quality	Visual verification; and sampling of soils for analysis.	Along the perimeter of the newly developed project infrastructure.	pH and salinity values; Content of major plant nutrients; Organic matter content; Metals and hydrocarbons	Bi-annually
Soil Stockpiles	Visual verification; Sampling of stockpiled soil	All stockpiled soils. Minimum of one sample per 50m^2 of stockpile taken at regular intervals from both the surface 1m and the core of the stockpile.	Volume of soil stockpiled. Height of stockpile Type of soil stockpiled. pH and salinity values; Content of major plant nutrients; Organic matter content; Heavy metals and hydrocarbons.	Annually
Soil erosion	Visual assessment Surface water monitoring.	All infrastructure. Streams and rivers near the soils with high erodibility (see Table 8).	Evidence of erosion.	Monthly, and weekly during
Land use	Land use	Project Area	Satellite imagery to be utilized to evaluate Land use.	2 Years

12.0 CONCLUSIONS

The baseline soil and land use study on the footprint of the CTT power plants and its associated infrastructure, was used to assess the potential impacts arising from the intended project activities. The key impacts on the soil and land arising from the project activities were found to be:

- Changes in land use;
- Soil quality degradation;
- Contamination of soils;
- Soil erosion;
- Soil compaction; and
- Loss of soil agricultural potential.

Of these impacts, the disturbance of soil (including soil compaction); loss/ change of land use; and loss of potentially arable land was rating as moderate significance (prior to implementation of the recommended mitigation measures). The impact of change in land use, soil compaction and loss of agricultural potential remain of a moderate significance (irrespective of implemented of mitigation measures), due to the nature of the project activities, and the inherent soil properties which will be altered (impacted) by the project activities.

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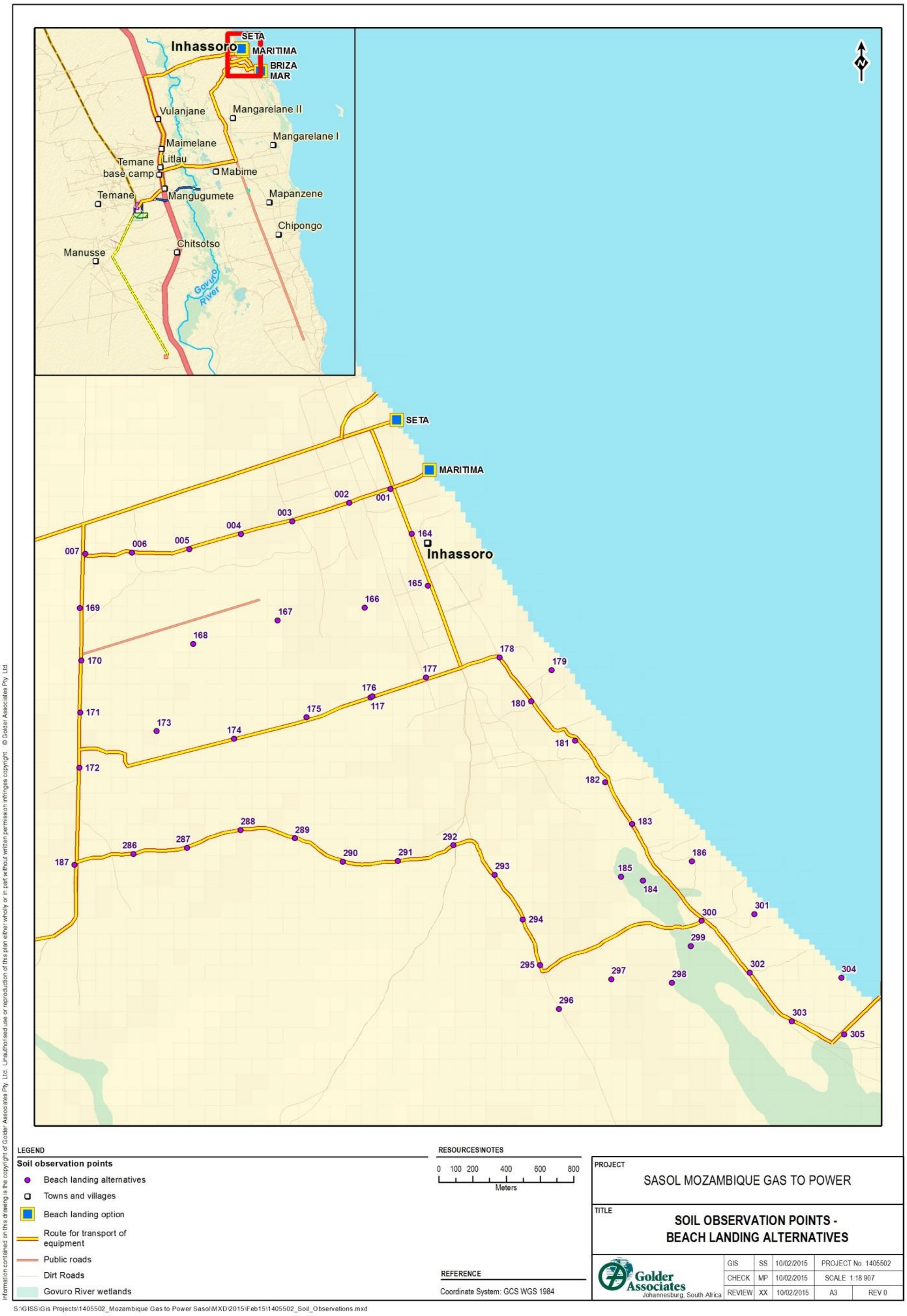
APPENDIX A

Soil Observation Points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LEGEND
Soil observation points
Beach landing alternatives
Towns and villages
Beach landing option
Route for transport of equipment
Public roads
Dirt Roads
Govuro River wetlands
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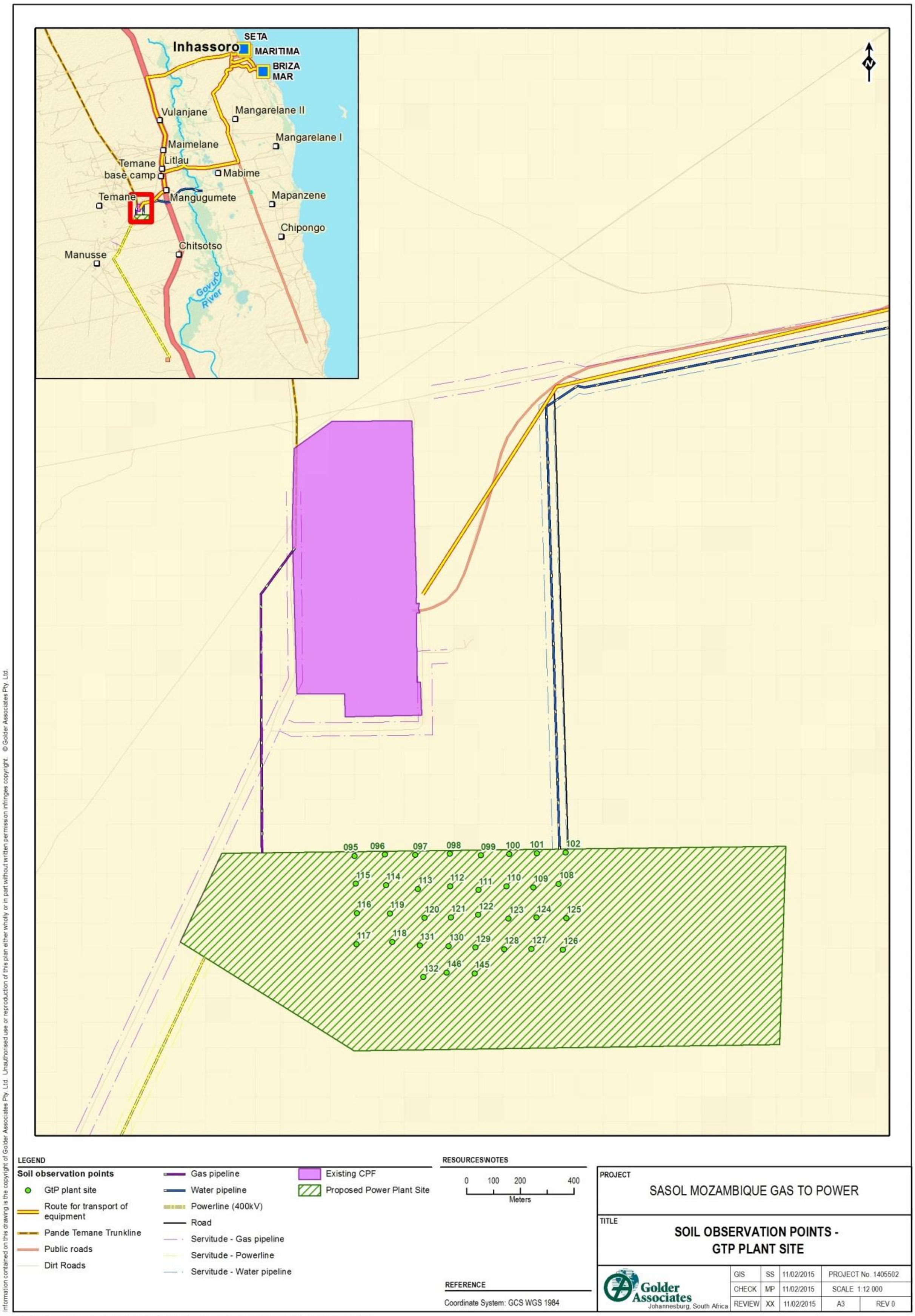

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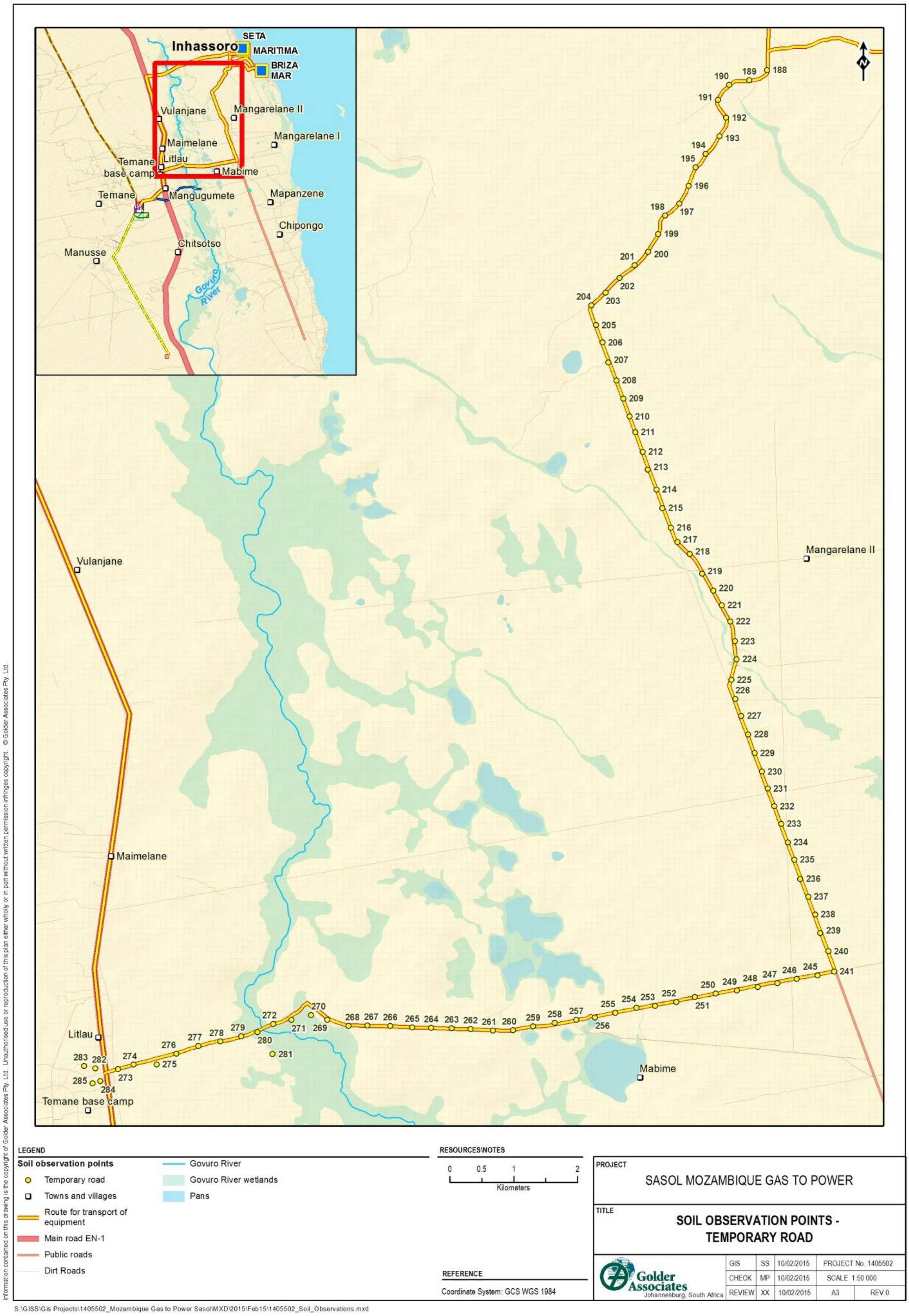
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Chipongo
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LEGEND
Soil observation points
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Towns and villages
Route for transport of equipment
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Public roads
Dirt Roads
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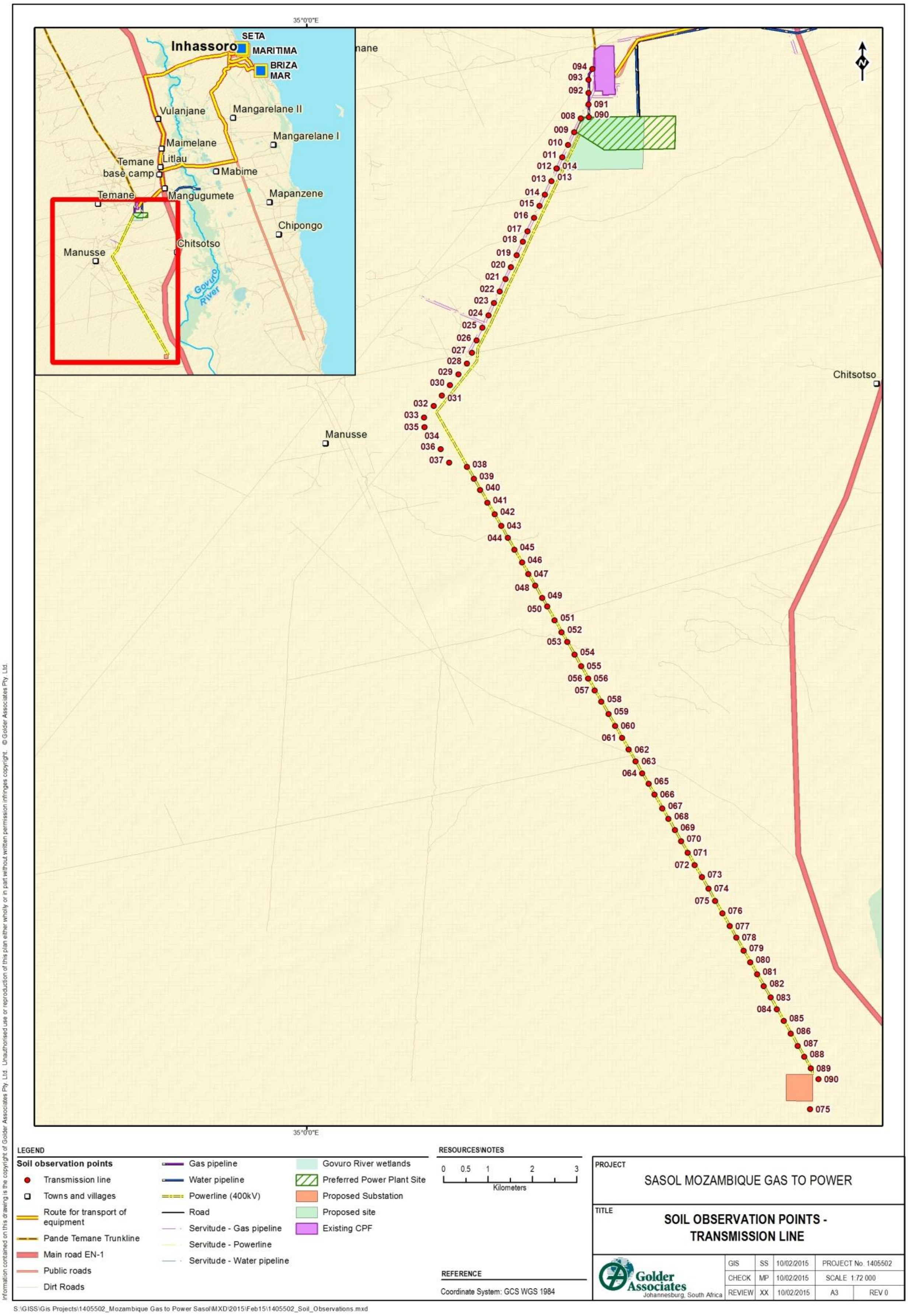

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Mapanzene
Chipongo
Manusse
Chitsotso
Govuro River
LEGEND
Soil observation points
Transmission line
Towns and villages
Route for transport of equipment
Pande Temane Trunkline
Main road EN-1
Public roads
Dirt Roads
Gas pipeline
Water pipeline
Powerline (400kV)
Road
Servitude - Gas pipeline
Servitude - Powerline
Servitude - Water pipeline
Govuro River wetlands
Preferred Power Plant Site
Proposed Substation
Proposed site
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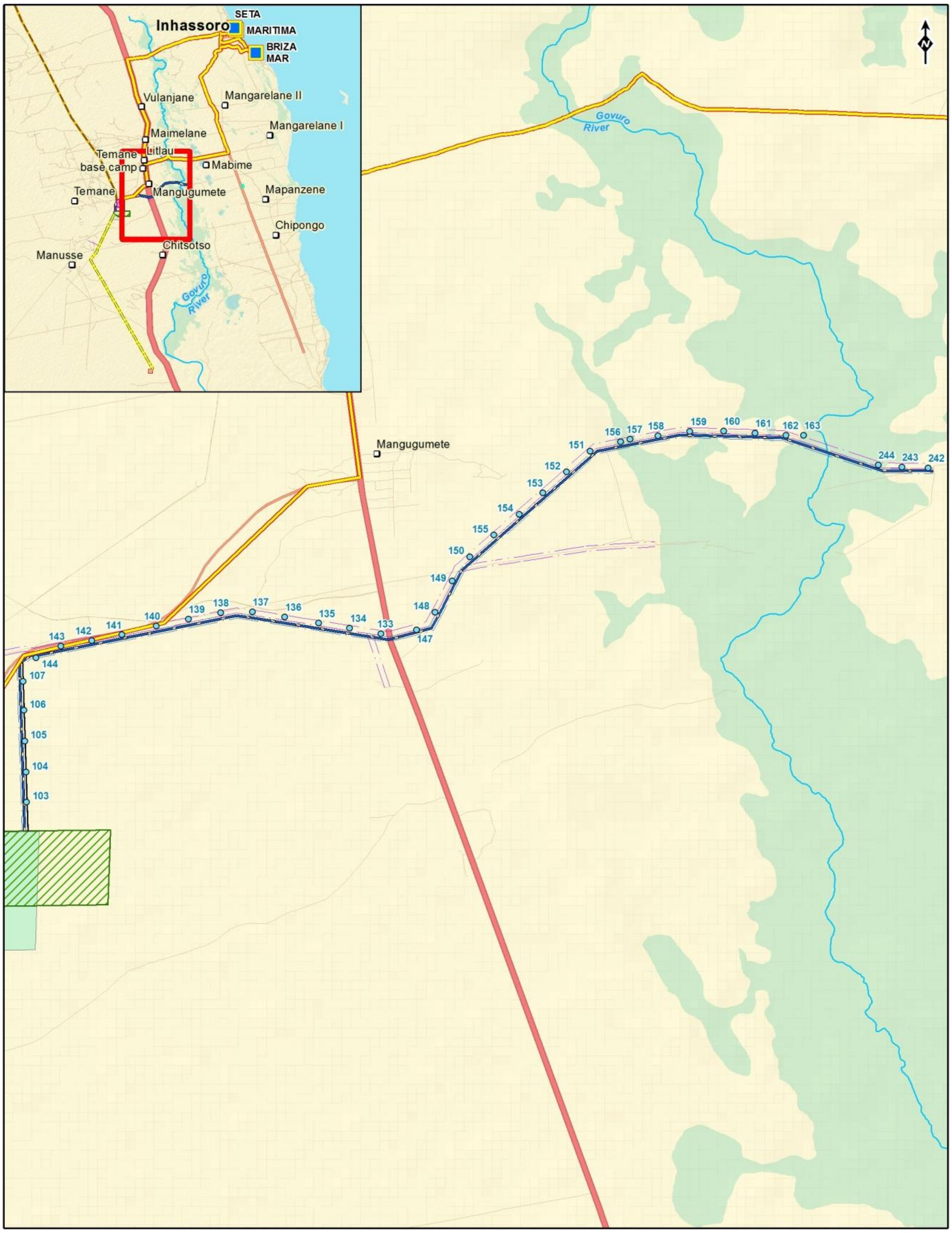

LEGEND

Towns and villages	Water pipeline	Preferred Power Plant Site
Water pipeline	Road	Proposed site
Route for transport of equipment	Servitude - Gas pipeline	
Main road EN-1	Servitude - Water pipeline	
Public roads	Govuro River	
Dirt Roads	Govuro River wetlands	
	Pans	

RESOURCES\NOTES

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Kilometers

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Coordinate System: GCS WGS 1984

PROJECT

SASOL MOZAMBIQUE GAS TO POWER

TITLE

SOIL OBSERVATION POINTS - WATER PIPELINE

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APPENDIX B

Certificate of Analysis

APPENDIX C

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