5 Geology, Soils and Mineral Waste

5.1 Introduction

This chapter presents an assessment of the potential impacts of the construction and operation of the Simandou Port on geological and soil resources and land capability. The assessment considers the following types of impacts:

- loss and physical damage to soils;
- disruption of soils as a result of extraction and deposit of material during construction (borrow and spoil); and
- contamination of soils.

A range of other impacts potentially relevant to soils have been identified but are either covered by other chapters of this SEIA or not considered to warrant further assessment. Where relevant these are identified below with an explanation of why these impacts are therefore not discussed further in this chapter:

- where erosion of soils contributes to impacts on water quality this is addressed in Chapter 6: Water Environment;
- where changes to soil resources affect biodiversity this is addressed in Chapter 12: Terrestrial Biodiversity;
- loss of geological features of importance to science: no geological features of importance have been identified in the vicinity of the rail loop and main port site and this impact is not considered further; and
- the port will be designed to international standards for seismic resistance and in the event of seismic activity it is not expected that the port would itself cause any impacts to occur beyond those arising from the event itself, other than possible spillage of fuel. Measures for prevention, containment and response to fuel spills are discussed in Section 5.5.5 and Chapter 6: Water Environment. Seismic and other natural hazards are not considered further.

The remainder of this chapter is structured as follows:

- Section 5.2 describes the approach to the assessment;
- Section 5.3 presents a description of the current baseline;
- Section 5.4 presents the assessment of impacts;
- Section 5.5 describes the mitigation and assessment of residual impacts; and
- Section 5.6 presents a summary of the assessment.

5.2 Approach

5.2.1 Study Area

A large proportion of the main port site will already have been cleared and subject to ground preparation as part of the MOF project. As a result impacts to soils and geology are only considered in those areas in addition to that already covered by the MOF SEIA (1). As a result of the MOF project approximately 380 ha of soils may be disturbed and or covered / made inaccessible, this includes 135 ha of laydown area, which will be graded. The MOF SEIA was produced prior to the port pedological work undertaken as part of the Project Social and Environmental Baseline Studies (SEBS). It was based on the information available at the time and classified the soils at the site as of medium value and the magnitude of loss of soils resource was considered medium within the context of the overall MOF project. This resulted in a pre-mitigation impact on soils of moderate significance and post mitigation impact of minor significance as a result of the MOF project. The MOF and operational port layouts are presented in Chapter 2: Project Description, Figure 2.2.

The study area for the purposes of this assessment has been defined as the area within the perimeter of the port works and their immediate vicinity within which soils could be disturbed or polluted as a consequence of construction or operation. It is largely encompassed within the area to be used for construction of the port, conveyor and rail loop, and also including areas to be used for borrow pits and spoil disposal.

Impacts may extend outside the perimeter of the works as a result of erosion and run-off from the site into adjacent land and the baseline therefore extends to cover this area (taken to be up to 3 km outside the perimeter). Information on baseline conditions in this wider area also provides context for assessing the impact of loss or reduction in quality of soils within the port Project footprint.

The main borrow areas will be within the main port site boundary and at the car dumper. The precise requirements for and locations of additional borrow pits and spoil disposal areas are still being determined, however they will be selected to avoid displacement of settlements and to minimise the loss of productive land and resources. Further details on the approach to siting of borrow pits and spoil disposal areas if provided in Section 5.4 (with reference to mitigation).

The approximate areas of land required for the port include:

- 380 ha for the MOF, which will become part of the operational port in the long term;
- 419 ha additional land including the conveyor corridor, rail loop and car dumper borrow pit and the area of land on the Morebaya bank adjacent to the export wharf; and
- 85 ha of land located to the south of the conveyor which will make up the Bamboukhoun borrow pit. This is technically not part of the port SEIA and is subject to a separate Quarries Site File SEIA (1), but is highlighted for reference due to its proximity to the main port and MOF works.

5.2.2 Legal and Other Requirements

No Guinean or international legislation specific to soils management has been identified. Relevant international and corporate standards and guidelines include:

- IFC Performance Standard 3: Resource Efficiency and Pollution Prevention (January 2012);
- IFC Environmental, Health and Safety Guidelines for Railways (April 2007);
- IFC Environmental, Health and Safety Guidelines for Mining (December 2007);
- IFC Environmental, Health, and Safety Guidelines for Ports, Harbours, and Terminals (April 2007);
- IFC Environmental, Health and Safety Guidelines for Construction Materials Extraction, 2007; and

5.2.3 Prediction and Evaluation of Impacts

The approach used follows the methodology described in Chapter 1: Introduction.

The magnitude of impacts is described in terms of the area of soil resources affected and the degree of hindrance to its use caused by physical disturbance or contamination, for example its quality may be slightly degraded by compaction, or by mixing top and subsoil, it could be polluted by oil or other contaminants, or its use could be completely prevented by covering over the resource, for example underneath structures.

The value of the affected soil resources is determined in terms of their potential for beneficial use in comparison to the quality of resources available in the wider area. This is determined by reference to the type of soil and its suitability of use. The land suitability classification system adopted for the assessment is the Food and Agriculture Organisation (FAO) Framework for Land Evaluation (2). This framework provides a

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soil taxonomy and land suitability classification system that is routinely used to classify soils in tropical Africa. It considers soil physico-chemical properties, other land use qualities (eg slope) as well as biophysical conditions (eg temperature), and compares how these match conditions that are necessary for successful and sustained implementation of a specific land use. In this case the relevant use is considered to be agriculture. Land suitability is classified using a rating system that applies five discrete suitability classes (1 to 5) with Class 1 being the most suitable, and Class 5 being the least suitable. Classes 1 to 3 (also referred to as S1, S2 and S3) are generally considered suitable, and Classes 4 and 5 are not suitable (also referred to as N1 and N2) for the specific type of land use. Table 5.1 describes the Land Suitability Classes.

Table 5.1 Land Suitability Classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Code</th>
<th>Designation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S1</td>
<td>Highly suitable</td>
<td>Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level.</td>
</tr>
<tr>
<td>2</td>
<td>S2</td>
<td>Moderately suitable</td>
<td>Land having limitations which, in aggregate, are moderately severe for sustained application of a given use; the limitations will reduce productivity or benefits and increase required inputs of the extent that the overall advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected on class S1 land.</td>
</tr>
<tr>
<td>3</td>
<td>S3</td>
<td>Marginally suitable</td>
<td>Land having limitations which, in aggregate, are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs, that this expenditure will be only marginally justified.</td>
</tr>
<tr>
<td>4</td>
<td>N1</td>
<td>Marginal Land (Presently Unsuitable)</td>
<td>Marginal lands with severe limitations, which make it doubtful whether the inputs required achieving and maintaining production outweigh the benefits in the long term (presently considered unsuitable due to the uncertainty of the land to achieve sustained economic production).</td>
</tr>
<tr>
<td>5</td>
<td>N2</td>
<td>Unsuitable</td>
<td>Unsuitable land with extreme limitations that preclude its use for the proposed purpose.</td>
</tr>
</tbody>
</table>

The resulting criteria for evaluation of significance are set out in Table 5.2.

Table 5.2 Criteria for Evaluation of Significance of Impacts on Soil Resources

<table>
<thead>
<tr>
<th>Value of Affected Soil and Land Capability</th>
<th>Magnitude of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Small</td>
</tr>
<tr>
<td>Negligible</td>
<td>Not Significant</td>
</tr>
<tr>
<td>Low</td>
<td>Land Suitability Class S3</td>
</tr>
<tr>
<td>Medium</td>
<td>Land Suitability Class S2</td>
</tr>
<tr>
<td>High</td>
<td>Land Suitability Class S1</td>
</tr>
</tbody>
</table>

5.3 Baseline

5.3.1 Overview

The near surface geology, climate and topography are the main drivers of the type of soils that are found in the study area. Baseline geology and soil resource conditions were assessed using spatial data analysis of maps, remote sensing data and site visits and direct soil sampling. Land suitability has been inferred from the baseline geology, soils, topography and from the current agricultural use of the port area.
In addition to the general description of soils at the port site in particular is the delineation of potential acid sulphate soil areas. Acid sulphate soils (ASS) are described in Section 5.3.7.

The main relevant sources examined in this study include:

- Topographic map (Conakry – sheet 2C: Madine, 1: 50 000, 1956);
- Morpho-pedological map (Boulvert, 2003);
- Vegetation and land use map (Landsat Imagery Mosaic 2002 - 2003; Inventories from Environnement Illimité, 2008);
- Geological map (Carte géologique et des mineralisation de la République de Guinée, 1: 1 000 000, 1998);
- Simandou Social and Environmental Baseline Studies on soils in the port area; and
- Borehole logs and broad surface materials map developed through the early engineering studies.

5.3.2 Geology

The coastal plain is made up of Bullom Group sediments ranging in age from Tertiary to late Pleistocene. At their seaward margin these are mostly covered by Holocene to Modern sedimentary deposits, and in turn lie on a basement of metamorphic rocks including gneisses, granulites and mylonites. The basement rocks, locally referred to as the Kasila Group, form the rim to the West African Archaean Craton\(^1\). Inland of the coastal sediments they form low dissected hills. Locally, older formations in the form of granitic hills that have resisted on-going weathering and erosion because of their hardness rise from the coastal plain. These rock outcrop formations are present at the site of the port and are a valuable resource for supply of construction materials. Quarrying would only be performed once suitable studies have been undertaken to develop and implement any required mitigation for loss of habitat associated with the removal of some or all of the rock as discussed in Chapter 12: Terrestrial Biodiversity.

Figure 5.1 Localised Granite Outcrops

\(^1\) The West African craton is one of the five large masses, or cratons, of the Precambrian basement rock of Africa that make up the African Plate. The oldest sections of the craton date from the Archean.
5.3.3 Topography

The topography of the study area transitions from a slightly undulating landscape west of Maférinyah via a series of plains to the mangrove areas that border the shoreline and river bank of the Morebaya River system. The coastal formations are primarily formed by tidelands composed by fluvial and marine sediments. During the wet season there may be periodic flooding of much of the area which is an important component of the cycle of use of the bogoni rice fields.

The Morebaya River drains a watershed of approximately 450 km² in the coastal plain with a small quantity of water derived from the central Fouta Djalon mountain range. The river connects via a creek of the Soubouya River to Conakry. A large tributary of the Morebaya known locally as the ‘Sangbon’ lies to the south of the port site discharging into the Morebaya River at Touguiyiré and partially separating Ile Kaback from the ‘mainland’ to the north. It has a winding course as it penetrates over 20 km inland with several tributaries.

The steepness of slopes is an important factor in the assessment of land suitability as this influences the formation of soils and is a key determinant in soil stability and erosion potential. Within the port study area slopes are generally gentle and the terrain largely flat.

The coastal plain also includes a series of sandy ridges or cheniers. Their formation appears to be linked to geomorphological conditions, climatically induced changes in mud supply and changes in sea level since the Middle Holocene. These sandy deposits are beyond the impact of spring tides and have consequently supported the growth of both woodland and settlements. The ridges are clearly visible as a parallel series of linear elements on Ile Kaback, as in Figure 5.2 and Ile Kakossa. The access road to the port site from Senguelen is also a remnant of such a feature.

Figure 5.2 Ile Kaback showing examples of Previous Beach Ridges (possibly cheniers)
5.3.4 Soils

The coastal soil deposits found in the port area are predominantly hydromorphic, having formed in association with the main river channels and their floodplains. Saline soils can also be found in mangrove areas, with the potential for acid sulphate soils (see Section 5.3.7). The SEBS showed that soils are typically composed predominantly of clay (close to 90% silty clay) and quartz. The quartz sand fraction contains shell fragments, which become more abundant in the vicinity of river mouths. Several fossil dune ridges of predominantly fine and medium-grained sand run northwest-southeast along the coastline. Additional, sandy terraces are also scattered across the landscape. These are composed of heterogeneous sediments, namely sand, clay, duricrust debris, gravelly microconglomeratic particles and occasionally aeolian deposits. Ferrallitic soils, with low mineral and organic content, can be found further inland and one small area of lithic soil (lithosol) has been identified to the north of the port area.

Several of the port elements are situated on areas currently covered predominantly by mangroves or rice fields. The surface soils in these areas are organic or have high organic matter content (made up of leaves, and small and medium-sized roots). In these organic soils, organic matter forms an intrinsic part of the soil matrix. Seashells were also observed in soil samples taken from the mangrove areas. Rice field and mangrove surface soil samples were usually damp, grey and fine grained, with silt as the main fraction, while sandy soils were more rarely present in samples.

Figure 5.3 Illustrates Soils and Associated Land Cover in the Study Area

Surface soils in more vegetated areas, covered by reworked earth, grassland or forest, are drier and the majority have a lower organic content. Roots and / or leaves were noted in every sample collected by SEBS field studies. The main soil grain size was sand, with varying fine particle contents. One sample of brown gravely sand was collected within the footprint of the MOF road.

The most abundant metals detected in soil samples from the study area were aluminium and magnesium. Lower concentrations of a variety of other metals were also found. Comparison with Canadian Council of Ministers of the Environment (CCME) guidelines (1) revealed that nine out of 29 samples exceeded guideline concentrations, with the majority of these due to arsenic in the service wharf area. Elevated levels of arsenic were also found in the MOF access road and the conveyor areas. Chromium concentrations were above guidelines in samples from the road and service wharf and one soil sample from the road area had a molybdenum concentration above the guideline level. No concentrations were found to exceeded the

(1) Two sets of guidelines produced by the CCME, which list standards for different land uses and soil types, were used to interpret the results of the soil sample analysis. The Soil Quality Guidelines for the Protection of Environmental and Human Health (CCME Guidelines, 2011) were used for PAHs and other inorganic parameters, while concentrations of petroleum hydrocarbons were assessed using the Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil (CCME Standards, 2008).
Australian NEPC guidelines (1), which were also used to interpret the soil analysis. There was no evidence of anthropogenic or industrial sources of contamination of soils in the area, and as such these metal concentrations are likely to reflect the soil properties in this area. It is not uncommon for a combination of local geological conditions, high levels of evaporation and inundation of soils by marine waters to lead to elevated metal concentrations in some soils. For example, the presence in the soils of kaolinite, a clay mineral, and microcline, a potassium-rich silicate mineral, could be responsible for the high levels of aluminium observed. Whilst petroleum hydrocarbons (especially fraction F3: C16–C34) were detected in small concentrations (below 100 mg/kg) in almost all samples, no concentrations above CCME or Australian NEPC guideline limits were identified. Those hydrocarbons present could be potentially explained by the relatively high organic matter content in the surface soils sampled, with the more organic samples showing more elevated concentrations. None of the soil samples contained detectable concentrations of Polycyclic Aromatic Hydrocarbons (PAH). Figure 5.4 illustrates the soils found in the study area.

5.3.5 Land Use and Land Cover

Land use and land cover are used to assist in identifying land suitability in the absence of direct field data. The main land cover and land use characteristics of each region are described below and further details are provided in Chapter 20: Land Use and Livelihoods.

As described in the SEIA for Rail, Lower Guinea has variable land use and vegetation cover including:

- mangrove;
- forests on coastal silt;
- oil and coconut palms and other valuable tree species growing on sand spits and coastal and inland plateaus;
- heterogeneous plant species growing at the foot and on top of mountain ranges; and
- isolated patches of virgin forest along rivers and gallery forest.

The land cover in the study area predominantly comprises rice fields, plantations (such as oil palm or mixed plantations with kola trees and mangos), grassland and shrub grassland, mangroves lining the Morebaya River and tributaries, areas of market garden, and woodland. As illustrated in Figure 5.1 there are also two areas of granite outcrop within the study area.

(1) Results were also compared to the health investigation and screening levels described within the Australian NEPC’s Schedule B1: Guideline on Investigation Levels for Soil and Groundwater.
Figure 5.4
Sols dans la zone d'étude du port / Soils in the Port Study Area

Projection: WGS 1984 UTM Zone 29N
Date: 19/09/2012
Verifié par: LG
Projet: 0131299
Échelle: Comme barre d'échelle

Type de sol / Soil Type
- Bas plateaux - Position moyenne / Lower Plateau - Middle Position
- Contours durs intérieurs de la mangrove / Mangrove Coastal Dune Ridge
- Relief ruches résiduel / Residual Rock Relief
- Soils de mangroves / Mangrove Soil
- Soils décolés du tiers inférieur des versants, sur colluvions / Bleached Soil of Lower Part Slope, On Colluvium
- Soils ferrallitiques médials du haut des versants / Loose Ferralic Soil of Higher Slope
- Soils hydromorphes, prolongées des vallées principales / Extended Hydromorphic Soils of the Primary Valley
- Soils hydromorphes temporaires des vallées secondaires / Temporary Hydromorphic Soil of Secondary Valley
- Variante à hydromorphie de profondeur / Deep Hydromorphic Soil Type
The area in the vicinity of the proposed port is near sea level and dominated by flat terrain with a gentle rise to the north east. The terrain is intersected by mangrove lined meandering creeks that are flooded on each tide and extend up to many kilometres. Higher terrain, other than the sandy ridges, is largely covered by a mixture of wooded grassland, grassland and plantation forest.

### 5.3.6 Land Suitability and Capability Classification

The major limitations impacting land suitability and capability classification are slope grades and soil characteristics. The topography in the vicinity of the proposed port site is near sea level with generally flat alluvial terrain, predominantly occupied by coastal mangroves and bogoni rice fields. These soils are intermittently inundated with silt laden coastal flood waters, which will contribute to their physical and chemical properties. Many soils may have had a marine or fluvial origin but are less influenced by saline coastal waters the further inland they lie.

Hydromorphic soils have generally developed under conditions of poor drainage. These soils typically exhibit medium to good value for agricultural uses, and can sustain various types of crops, such as cereals, vegetables and fruits. These soils are primarily encountered near channels and are potentially subject to occasional flooding. These soils appear to be extensively cultivated with rice in dyked areas. As the alluvial soils found at the proposed port location support cultivation, they are considered to be Land Suitability Classes S1 and S2 (see Section 5.2.3). The nature of alluvial soils, comprised of unconsolidated sediments primarily marine in origin (see Chapter 7: Marine and Littoral Physical Environment) means they are not suitable for all crops and require intensive management to maintain crop yields.

Not all alluvial land is continually cultivated. Farmers may neglect to remove dykes from fields during the dry season preventing tidal waters from inundating fields and fields may degrade and become unsuitable for cultivation. When this occurs, these areas may then be abandoned by the farmers, who may clear additional areas of mangrove area to create new farmland (1). Abandoned or degraded bogoni areas would be classified as Land Suitability Class S3.

Other units identified include extremely weathered ferralitic soils. These are typically encountered in humid or very humid conditions and generally have a low agricultural output, and so an inferior land suitability and land capability class. However, oil palms and dense thickets can be found in these areas. Areas with

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ferralitic soils are generally unsuitable for crop cultivation and consequently considered of Land Suitability Class S3.

Local communities have developed a technique to increase the productivity of saline alluvial or ferralitic soils in localised market gardens. The soil bed is raised, allowing the rains to leach out salts and the soils are then enriched with mulch. This technique is also practiced in other African countries (1). The mulch (salt marsh grass) is used as covering layer to prevent desiccation and provides organic matter and nitrogen. The beds are sown with a variety of annual crops that are sold to the market. These 'managed' soils will have a medium or occasionally high resource value that is Land Suitability Class S1 and 2 as they only support some crops and require management.

Lithosols have also been identified in the area though have no significant value for agricultural use, have inferior land suitability classes and are therefore only sparsely cultivated. The soil resource is classified as Land Suitability classes N1 and N2.

5.3.7 Acid Sulphate Soils

Many coastal areas in the region have soils that contain a large amount of iron sulphide minerals. In coastal estuaries and mangroves the build-up of sulphide minerals such as iron pyrite can occur due to the highly reducing conditions that form in these waterlogged and organic rich environments with input of sulphur from the sea. These soils are referred to as acid sulphate soils.

The formation of ASS is the result of the mixing of seawater with certain coastal sediments containing iron under anoxic or water logged conditions. Sulphate in the seawater mixes with soils containing iron oxides and organic matter. Under anaerobic conditions, lithotrophic bacteria produce iron sulphides, predominantly pyrite which is then deposited in the soil. Most of the ASS was formed during the last major sea level rise during the Holocene period, when sea level was at its maximum elevation above the present high tide mark. Following the fall in sea level since the Holocene, pyrite in the soil has remained stable in the water saturated zone in soils now existing in the terrestrial environment. If the pyrite is exposed to air it oxidises and produces iron compounds and sulphuric acid. This process usually decreases the soil pH below 4.0, and consequently heavy metals may be leached into surface and ground water. Heavy metals can then subsequently become mobilised in the environment, and generate negative environmental impacts. Tropical waterlogged environments including mangroves or estuaries such as those found in the port area typically contain higher levels of pyrite than those formed in more temperate climates.

Typically, in areas above 10 m elevation, Pleistocene deposits and marine and beach deposits would present low risk of potential ASS whereas mangrove areas, rice fields and land located within the intertidal zone would present high to moderate risks.

An assessment of the ASS risk in the Project area has been undertaken as part of the geotechnical ground investigation. This has identified:

- potential acid sulphate soils associated with soft silty clay deposits to a depth of approximately 6 m in the MOF area; and
- high concentrations of potential acid sulphate soils in silty sands and sandy clays to depths of up to 22 m in the cardumper area.

On the basis of the findings of this assessment further assessment within the port area will be undertaken prior to construction.

5.4 Assessment of Impacts

5.4.1 Overview

The impacts of the Project on soil resources during construction and operation are considered under the following headings:

- loss and physical damage to soils;
- disruption of soils from borrow and spoil deposit; and
- contamination of soils, including acid sulphate issues.

The construction phase will include disturbance of soils from clearance of the construction area, earthworks associated with levelling and installing the rail loop and conveyor, excavations for the car dumper, drainage structures and main port and ancillary facilities including the power plant. It will also include the establishment of borrow pits for supply of material where this cannot be obtained from within the works and the disposal of material that is unsuitable for use in the construction (construction spoil). There will be a large borrow pit associated with the car dumper. There will also be risks associated with accidental releases (spills) from construction activities and fuel handling and storage.

During the operation of the port there will be occasional maintenance activities on the rail loop and other areas of the site, but these are unlikely to significantly affect soil resources. There will be the potential for soil contamination as a result of spillages both from minor small scale activities and low likelihood unplanned events such as a major fuel spillage from mobile tanker, or fixed infrastructure such as the fuel tank farm or over ground fuel pipelines.

5.4.2 Loss and Physical Damage to Soils

5.4.2.1 Construction Impacts

Construction of the port and associated facilities will lead to permanent loss (including loss of access) of soil resources under the port footprint (extending to 884 ha) and has the potential to cause erosion and degradation of soil quality over the larger temporary construction area as a result of clearance of topsoil, compaction, creation of temporary hardstand areas, exposure of subsoils in excavated areas, and mixing lower class with better quality soils. As noted in Section 5.2.1 much of the main port site will have previously been cleared during the construction of the MOF and this will account for 380 ha of the total area described above. New areas of soil loss (including loss of access) will be associated with the rail loop, car dumper, conveyor and work area adjacent to the export wharf. These new areas will make up 419 ha. In addition the Bamboukhoune borrow pit, subject to a separate site file under the Quarries SEIA will make up an area of 85 ha with the wider area of soil resources utilised by local communities. In some areas within the footprints, although soils will not be directly disturbed, they will effectively be lost in terms of use as an agricultural resource because access to them will be prevented.

As detailed in Chapter 20: Land Use and Livelihoods, the new area of affected land excluding that cleared for the MOF and Bamboukhoune borrow pit is presented in Table 5.3 below.

<table>
<thead>
<tr>
<th>Land Use</th>
<th>New Port Area Affected (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare Soil / Cleared Land</td>
<td>8</td>
</tr>
<tr>
<td>Fallow Land</td>
<td>6</td>
</tr>
<tr>
<td>Grassland</td>
<td>10</td>
</tr>
<tr>
<td>Mangrove</td>
<td>58</td>
</tr>
<tr>
<td>Market Garden</td>
<td>3</td>
</tr>
<tr>
<td>Oil Palm Plantation</td>
<td>81</td>
</tr>
<tr>
<td>Rice Fields</td>
<td>33</td>
</tr>
<tr>
<td>River Bank</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 5.3 Land Use Type and Area Affected by Port Development
<table>
<thead>
<tr>
<th>Land Use</th>
<th>New Port Area Affected (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt Pans</td>
<td>0.5</td>
</tr>
<tr>
<td>Shrub Grassland</td>
<td>180</td>
</tr>
<tr>
<td>Village Area (inc. village woodland)</td>
<td>17</td>
</tr>
<tr>
<td>Water</td>
<td>3</td>
</tr>
<tr>
<td>Woodland</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>419</strong></td>
</tr>
</tbody>
</table>

Topsoil will be cleared prior to construction and this is estimated to have an average depth of approximately 150 mm. The total quantity of soil removed will therefore be around 630,000 m³. In the absence of measures to protect this soil impacts could include loss of soil fertility through physical damage and loss of organic matter and nutrients, and loss of the seedbank contained with the soil.

Reshaping of the landform to accommodate the Project may lead to a degradation of soil quality over a wider area through changes to slope and erosion patterns and alterations to water drainage affecting the flood regime. The magnitude of the impact of the port through changing erosion and drainage patterns is difficult to predict. The main port site, rail loop and conveyor crosses a number of small streams and drainage lines and therefore a fairly small area could in theory be affected although this is still small in the context of the overall area being encompassed by the port. The drainage and other infrastructure will also be designed to minimise impacts on flow characteristics and maintain quasi natural flows where feasible. In the absence of additional mitigation the magnitude of the impact is considered small and the majority of soils are of low or medium value, which would result in an impact of minor significance.

The open and cultivated land and open grassland would typically be expected to be of low or medium value with only small areas of high value for example in low lying areas of bogoni and land used for market gardens and plantations. Soils in woodland areas could be of varying quality but would typically be of low suitability for agricultural use. In the absence of measures to protect these soil resources and rehabilitate temporary construction areas, sterilisation of soils and temporary reduction in soil suitability over the temporary construction area is evaluated as an impact of moderate significance taking into account the small magnitude of impact on high value land and the medium magnitude of impact on low to medium value land.

### 5.4.2.2 Operational Impacts

The area occupied by the permanent port and rail loop and ancillary facilities is virtually the same as that for the construction phase and due to the prevention of access within the Project site footprint in the long term construction phase impacts are largely considered to be permanent. These areas of soil have already been lost during construction rendering their value effectively negligible to low and therefore, although the long term continuation of this impact would be considered large magnitude, the impact would be considered to be not significant to minor significance.

Construction phase soil disturbance and erosion impacts will, without mitigation, be of moderate significance given the small loss of the high value soils and the medium loss of low and medium value soils resource.

Permanent loss of the negligible to low value soils resource results in a minor impact.

Construction and Operational phase impacts on soil resources due to changes in rates of soil erosion or flooding characteristics will be of small magnitude for low or medium value soils and will result in an impact of minor significance.
5.4.3 Contamination from Acid Sulphate Soils

5.4.3.1 Impacts During Construction

The potential for ASS to be present in the area and to be disturbed during construction presents a different potential risk to that from disturbance of other soil types. Construction work carried out in potential ASS areas, where the soils are drained, excavated during the construction of foundations or exposed to air by a lowering of the water table. This will increase the risk of sulphuric acid generation as ASS are exposed to air. These acid drainage conditions represent a hazard for communities, ecosystems and infrastructure. The risk to infrastructure is the formation of acidic water that may damage concrete and corrode steel that will be used in the construction of the port facility. In addition the generation of surface runoff with a lower pH and an increased heavy metal content, may compromise the agricultural potential of soils, as discussed in Section 5.3.7 of the baseline.

The initial geotechnical ground investigation targeting ASS has identified their presence at both the MOF and Car Dumper parts of the port site, there is the potential for additional areas of ASS and further ground investigation and testing will be undertaken. Construction activities will locally disturb the top soil, exposing the anaerobic subsoils to air and triggering acidification. This will potentially affect a substantial area both adjacent to the export wharf and near the rail loop. These areas currently support mangrove vegetation and productive bogoni rice culture and market garden. In the worst case scenario that these soils are ASS, the impact is considered to be of medium magnitude in view of the fact that the long-term productivity of the soils will be compromised over a medium area relative to the overall sized of the port development. For the productive rice fields, which have a medium resource value, the potential impact from ASS will be of moderate significance.

5.4.3.2 Impacts During Operation

ASS are not expected to produce an impact during the operational phase provided that good construction management practices have been followed as specified in the ASS Management Plan (ASSMP) - see Section 5.5.3. The impact from ASS during operations is therefore considered to be not significant. However, where ASS is present in the port area and is disturbed during construction the impacts may extend into the operational phase.

Impacts of medium magnitude from exposure of acid sulphate soils during construction will affect soils of medium value. Without mitigation, this will result in impacts of moderate significance. Impacts during operation are expected to be not significant.

5.4.4 Borrow Pits and Spoil Disposal

Construction of the port will involve major earthworks, particularly at the site of the car dumper and the associated borrow pit. The detailed design will be developed with the aim of minimising the need for import of material and for removal of surplus material. In this context a borrow pit is defined as a source of earth or similar soft fill material that can be extracted by simple excavation, without the need for blasting or significant processing. Locations where hard materials such as rock are extracted are identified as quarries and are subject to separate class SEIAs, which were approved in May 2012 (1) for quarries and December 2011 for the MOF SEIA.

In addition to the requirement to source fill material it is likely that there will be some need to dispose of surplus material created from general earthworks and excavations. The Project will seek to use as much material as possible within the construction works, for example in creation of the rail loop, embankments, noise and visual screening barriers and in general earthworks within the main port site. Some material however is likely to be generated in locations where it cannot practicably be used and some material is likely to be unsuitable for use because of its qualities. This surplus and unsuitable material (spoil) will need to

disposed of in appropriate locations within the Project boundary or if in new locations after appropriate selection, such as via a site file assessment.

The establishment of borrow pits and disposal of spoil will lead to sterilisation of land and soil resources in the affected areas during construction. One major borrow pit site has been identified near the car dumper which lies within the main port areas assessed in this chapter. The Bamboukhoun borrow pit area affects an additional 85 ha of land outside the main port footprint and is assessed by a specific site assessment under the Class SEIA for Quarries. Further requirements for borrow may be also identified affecting additional areas within the port area. It is likely that there will be significant impacts on soils and other land-based environmental resources from the development of borrow pits.

5.4.5 Contamination from Discharges and Spills

5.4.5.1 Construction Impacts

There is potential for pollution of soils to arise from any disposal of effluents or other wastes to land and from accidental spills of hydrocarbons (primarily diesel) and other hazardous substances used in construction. There are no plans to undertake discharge of untreated effluents or wastes to land other than within approved sites, which will be designed to avoid any significant environmental impacts (see Chapter 11: Resources and Non-Mineral Waste Management). As a result, no significant impacts should occur from this source. Accidental spills will occasionally occur within construction sites and enter the external environment. Typically these will be small, however, a road tanker accident could release up to 30,000 litres. A spill from the main bulk fuel storage area is unlikely, but should it occur, it would be within a bunded area thus isolating impacts. Based on the size of potential spills and their relative likelihood (probable for very small spills; unlikely for larger spills) the magnitude is predicted to be small and the resulting impact even in areas of higher value soils is of minor significance (1).

5.4.5.2 Operational Impacts

The potential for pollution of soils from spills of hazardous substances (primarily diesel) will continue during operation of the port. Design specifications for storage of diesel and other hydrocarbons and chemicals include requirements for bunding of fuel storage and loading areas to minimise the potential for spills to escape. The highest risk is likely to arise in the event of the failure of a fuel tank within the bulk fuel farm or the fuel pipeline. As is the case during construction, the likelihood of an event of this scale is very low and the affected area will be small so that the potential impacts on soil resources are considered to be of minor significance.

The significance of adverse impacts on soils as a result of accidental spills during construction and operation of the rail loop and main port site will be minor.

5.5 Mitigation Measures and Assessment of Residual Impacts

5.5.1 Overview

The measures proposed to mitigate the impacts identified in Table 5.4 and the assessment of residual impacts after mitigation is discussed below:

- loss and physical damage to soils;
- management of borrow pits and spoil; and

(1) The implications of such events for the water environment in the event of a spill happening near water are discussed in Chapter 6: Water Environment and Chapter 7: Marine and Littoral Physical Environment.
• contamination of soils.

5.5.2 Minimising Loss and Physical Damage to Soils

5.5.2.1 Minimising Loss of Soil Resources, Topsoil Protection and Erosion Control

To minimise impacts on soil resources within the construction area the Project footprint disturbance of soils will be minimised wherever feasible. Where useful soils eg those of importance for agriculture, may be disturbed, detailed measures for managing soil stripping and storage, erosion and sediment control will be developed prior to the commencement of construction. On completion of construction these controls will be updated to address topsoil and erosion and sediment management over the long term operation of the port.

A Land Use Management Plan will be developed setting out land-use zones and management objectives for all land used by the Project and how land disturbed by the Project will be rehabilitated after construction. In order to minimise impacts on soil resources within the working area the Land Use Management Plan will include measures for soil management and erosion control. The Land Use Management Plan will include the following measures to minimise impacts on soil resources:

• topsoil stripping, stockpiling and management will be planned prior to ground disturbance works commencing;
• topsoil (and subsoil where deemed necessary) will be salvaged for re-use;
• soil resources will be re-used as soon as possible after stripping by re-spreading on adjacent areas or stored in segregated stockpiles for later use in site rehabilitation;
• soil resource inventories will be maintained detailing quantities required (for rehabilitation), salvaged and storage locations, age etc;
• design and management of stockpiles to minimise loss of soil and degradation of soil quality by erosion, poor storage and compaction;
• long term soil stockpiles will be height constrained and revegetated if required to promote seed viability and reduce erosion; and
• protection of soils outside work areas by prohibiting the movement of vehicles and equipment outside designated areas.

The Land Use Management Plan will include the following measures for erosion control:

• avoiding unnecessary disturbance of stable surfaces;
• avoiding unnecessary clearance of vegetation;
• where practicable locating temporary construction areas away from land susceptible to erosion;
• avoiding works within 50 m of a river or stream unless necessary for in-stream works such as the export wharf;
• avoiding works with high erosion potential during periods of heavy rainfall whenever possible;
• diversion of surface run-off from exposed areas;
• use storm water and sediment retention ponds to reduce erosion and sediment loads in discharges;
• stabilising exposed surfaces using controls such as re-vegetation;
• armour drainage lines and off-takes using vegetation and stone pitching (rip rap);

• implementing maintenance programmes to ensure sediment control structures are fully functioning; and

• rehabilitating all disturbed land as soon as practical after completion of works.

These measures will reduce the loss of topsoil resources and the erosion of other soils resulting in an overall small magnitude of impact on a low to medium value receptors with a residual impact of minor significance during construction and not significant during operation.

5.5.3 Acid Sulphate Soils

An Acid Sulphate Soils Management Plan (ASSMP) will be produced and implemented based on the findings of the ASS study, into the occurrence of these soils in the port area, which will be carried out prior to construction. The ASSMP will contain measures to monitor soils for ASS and for safe disposal. The recommendations of the geotechnical study into ASS at the port site include liming rates and techniques designed to neutralise ASS where it is encountered and must be disturbed. To reduce the potential impact of ASS the following management principles will be applied.

• The disturbance of ASS should be avoided wherever possible.

• Where disturbance of ASS is unavoidable, preferred management strategies are:
  • minimisation of disturbance through construction techniques such as trenchless pipe laying, in situ cement piling, jet grouting and other low disturbance techniques;
  • neutralisation;
  • hydraulic separation of sulphides, either on its own or in conjunction with dredging; and
  • strategic reburial below the water table or other water body.

• Works will be performed in accordance with best practice environmental management when it has been demonstrated that the potential impacts of works involving ASS are manageable, to ensure that short and long term environmental impacts are minimised.

• The material being disturbed (including the in situ ASS) and any potentially contaminated waters associated with ASS disturbance will be included in the design of water management controls for the port. The potential requirement to treat water before discharge will be investigated once detailed site data are obtained during the site engineering investigation program.

• Receiving marine, estuarine, brackish or fresh waters are not to be used as a primary means of diluting and / or neutralising ASS or associated contaminated waters.

• Management of disturbed ASS is to occur if the ASS action criteria developed for the Project are triggered.

• The following issues should be considered when formulating ASS environmental management strategies:
  • the sensitivity and environmental values of the receiving environment. This includes the conservation, protected or other relevant status of the receiving environment;
  • whether groundwater and / or surface waters are likely to be directly or indirectly affected; and
  • the heterogeneity, geochemical and textural properties of soils on-site.

Following implementation of an ASSMP the impacts on soil suitability and water quality from acid sulphate soils are reduced to being of minor significance during construction and not significant during operation. While well established techniques are available to minimise impacts these are typically developed on a site
by site basis so the extent of control available through construction techniques compared to control of ASS in stockpiles is not yet defined. The ranking assumes that the controls are predominantly those for treatment and stockpiling of ASS.

### 5.5.4 Borrow Pit and Construction Spoil Management

The Project will adopt a range of measures to minimise the adverse impacts from sourcing of material for construction and disposal of surplus spoil through a Borrow Pit Management Plan and Spoil Management Plan. These management plans will be developed in a consistent manner under the Project HSEC Management System and will include the specific measures identified below.

- Borrow pits will be used only temporarily for short term extraction of soft materials (soil, sand, gravel etc) required solely for the purposes of the Project.

- Borrow will be extracted using mobile excavators and there will be no requirements for blasting, crushing or similar processing (sources of hard materials and materials requiring blasting or processing will be treated as quarries and will be implemented in accordance with the Class SEIA for the Simandou Quarries Programme).

- Borrow pits will avoid any specific locations of importance for biodiversity or cultural heritage.

- Borrow pits will be located at least 50 m for the nearest watercourse.

- Borrow pits will not exceed 6 m in depth or penetrate the water table whichever is the shallower.

- Borrow pits will be equipped where necessary with sediment traps to reduce discharge of sediment into surface waters.

- Sites with evidence of weed infestations will be avoided where possible. If borrow pit sites with weed infestation need to be used appropriate weed treatment, hygiene and control will be implemented prior to disturbance (1).

- Borrow pits will be located at least 300 m from the nearest existing residential property unless a shorter distance is agreed during community consultation.

- Borrow pits will be located at least 50 m from the nearest watercourse.

- Borrow pits will avoid loss of productive agricultural land (cultivated and fallow land) as far as possible.

- Borrow pits will be subject to a photographic record of their development.

- As soon as possible after completion of works, borrow pits will be rehabilitated.

- Final landforms will be free draining, not form dams or ponds, and take into account public safety, wildlife safety, pre-disturbance habitats and future beneficial use.

- Borrow pits will be developed in accordance with the provisions of the PARC Framework.

- Surplus and / or unsuitable material generated from earthworks and tunnelling will be managed in the following manner:
  - re-used for general fill, berms, access routes, noise barriers, profiling of used borrow pits, visual and noise shielding, community purposes and other useful means wherever possible;

(1) Control of invasive species is discussed in Chapter 12: Terrestrial Biodiversity.
• in the event that surplus material still exists it will be disposed of within the construction footprint if possible;

• a spoil disposal plan will be developed for all sites prior to the start of use and will cover aspects of weed management, drainage and erosion control and rehabilitation methods;

• rehabilitation will take place as soon as possible after completion of works, and take into account public safety, wildlife safety, pre-disturbance habitats and future beneficial use; and

• if additional land outside the construction footprint is required to dispose of excess spoil the above requirements also apply and development occurs in accordance to any provisions under the PARC Framework and in consultation with government and local communities.

Whilst it is not possible at this stage to predict the impacts of borrow and spoil disposal prior to or post-mitigation, careful attention to the cut and fill balance in design of the railway alignment, appropriate siting of facilities, and adoption of best practices in their design and operation, will keep the impacts as low as reasonably practicable.

5.5.5 Contamination from Spills

To minimise the risk of accidental releases all hydrocarbon and other chemical storage facilities will be designed to include:

• secure storage and labelling of hazardous substances in line with the manufacturer’s recommendations and measures to prevent contact with untrained personnel, birds, animals or fish;

• secondary containment using impervious, chemically resistant material and designed to prevent contact between incompatible materials in the event of a release;

• secondary containment for storage of hazardous materials providing up to 110% containment of the largest tank or 25% of the total volume;

• storage facilities and pipelines will have spill detection systems installed;

• secondary containment will be designed and managed to ensure that rainwater does not reduce the minimum capacity requirements. This may include installation of roofs in smaller facilities to prevent rainfall ingress

• location of all equipment, containers and distribution lines (including pipes, valves and taps), containing hazardous materials above ground and provision of appropriate containment to minimise the risk of uncontrolled or undetected releases of hazardous materials. Any below ground installations require appropriate risk assessment and Project approval; and

• containment of any transfer points so that any spills during refilling is directed to the containment structure.

There will be no intentional discharges of hazardous substances to land from the Project other than the controlled disposal of waste in specifically designed facilities. These will meet strict standards for design and operation and will be subject to grant of all required permits from the Republic of Guinea. An Emergency Prevention, Preparedness and Response Plan will be prepared prior to commencement of construction detailing how the Project will minimise the likelihood and consequences of accidental spills causing pollution of soils during construction. This will be updated for operation. It will include requirements for:

• provision and location of spill response and clean up equipment;
• spill containment and clean-up procedures;
• communication and notification protocol;
• training of staff especially drivers; and
• testing and emergency drills.

All spills that do occur will be cleaned up and sites remediated to enable their continued use. Hazardous wastes arising from spill clean-up will be treated and disposed of at suitable waste management facilities in accordance with the Project Non-Mineral Waste Management Plan (see Chapter 11: Resources and Non-Mineral Waste Management).

With these measures in place the residual impacts from spills in all phases of the Project will be **minor** or **not significant**.

### 5.6 Summary of Findings

The assessment identified a number of impacts related to soils and geology during construction and operation of the port. The findings are summarised in Table 5.4 giving an evaluation of the significance of impacts prior to mitigation, identifying key mitigation measures, and evaluating the residual impacts after mitigation. Following mitigation measures the residual impacts are summarised as follows.

- Design of the works to minimise loss of higher value soils and implementation of good construction site practices to protect soil resources from damage during construction will result in impacts from temporary and permanent loss of soil resources, including small areas of high value land such as **bogoni** and market gardens, being of **minor** significance during construction.

- Implementation of the Acid Sulphate Soils Management Plan and associated measures will reduce impact significance to **minor** in construction and **not significant** in the operational phase of the port.

- There will be **no significant** impacts in terms of loss of or damage to soils resources during operation.

- Current proposals allow for borrow within the main site footprint and an additional borrow pit at Bamboukhou covered by a specific site file assessment for these works; a Borrow Pit Management Plan and a Construction Spoil Management Plan, designed and implemented with the objectives of minimising the quantities of material requiring extraction and disposal and ensuring appropriate siting, design and operation of any necessary facilities, will ensure the impacts of sourcing and disposal of material for construction will be **as low as reasonably practicable**.

- Design of facilities for storing and handling hazardous substances to minimise the risk of accidents and development and implementation of an effective emergency plan will lead to the risk of adverse impact from spills being **minor** or **not significant** in all phases.
<table>
<thead>
<tr>
<th>Impact</th>
<th>Stage</th>
<th>Impact before Mitigation</th>
<th>Key Mitigation</th>
<th>Residual Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction in quality and or permanent loss of 419 ha of soil resources of a predominantly low or medium value within the port area.</td>
<td>Construction</td>
<td>Moderate</td>
<td>• Development and implementation of a Land Use Management Plan for the Project to include measures for protection of soils. &lt;br&gt;• Borrow pits will be used only temporarily for short term extraction of soft materials (soil, sand, gravel etc) required solely for the purposes of the Project. &lt;br&gt;• Implementation of measure to protect soils including segregation and separate storage of topsoil and subsoil, protection of stockpiles to minimise loss by erosion, re-use as soon as possible, prevention of encroachment into undisturbed area, avoiding ground at risk of erosion where possible, minimising run-off and flooding in areas at risk of erosion, scheduling works with high erosion potential in the dry season where possible, creating stable long term surfaces. &lt;br&gt;• Rehabilitation of disturbed areas as soon as possible after completion of works.</td>
<td>Minor</td>
</tr>
<tr>
<td>Impacts on soil capability and water quality from acid sulphate soils. Drainage from acid sulphate soils represent a hazard for communities, ecosystems and infrastructure (eg damage of concrete and corrosion of steel).</td>
<td>Construction</td>
<td>Moderate</td>
<td>• Design and implementation of good practice ASS Management Plan.</td>
<td>Minor</td>
</tr>
<tr>
<td>Operation</td>
<td>Not Significant</td>
<td></td>
<td></td>
<td>Not Significant</td>
</tr>
<tr>
<td>Impacts on soils and other land-based resources from extraction of material from borrow pits and disposal of surplus construction spoil.</td>
<td>Construction</td>
<td>Not known but is likely to be Significant</td>
<td>• Development of a Borrow Pit Management Plan and a Spoil Management Plan. &lt;br&gt;• Design of alignment to minimise need for sourcing and disposal of material outside the construction corridor. &lt;br&gt;• Use of as much surplus material within the works as possible. &lt;br&gt;• Appropriate siting of borrow pits and spoil disposal sites and development of site specific plans for each borrow and spoil disposal location. &lt;br&gt;• Good practice in design and operation of borrow pits and spoil disposal sites in accordance with all required permits and approvals.</td>
<td>Minor or Not Significant</td>
</tr>
<tr>
<td>Contamination of soils by spills during construction and operation.</td>
<td>Construction</td>
<td>Minor</td>
<td>• Design for safe storage of hazardous materials including bunding. &lt;br&gt;• Development and implementation of an Emergency Prevention, Preparedness and Response Plan for construction, operation and closure.</td>
<td>Minor or Not Significant</td>
</tr>
<tr>
<td>Operations</td>
<td>Minor</td>
<td></td>
<td></td>
<td>Minor or Not Significant</td>
</tr>
</tbody>
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