CHAPTER 7 - SOILS

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7. Soils

This chapter describes the existing soils environment, considers potential impacts on soils from construction, operation and decommissioning of the project, and provides measures to mitigate and manage identified impacts.

The assessment identifies soil erosion as a potential risk during construction, particularly once earthworks (including trenching) commence following vegetation removal. This risk is associated with temporary stockpiles and the presence of dispersive subsoils. However, once the trench has been backfilled, topsoil reinstated and vegetation re-established, the erosion risk would be similar to existing conditions. With the implementation of proposed mitigation measures, based on best practice industry guidelines, potential impacts on soils and erosion are expected to be effectively managed.

The potential to encounter localised and/or unexpected contamination during construction would be managed by implementing an unexpected finds protocol as part of the CEMP.

Further information on the existing soil environment is provided in Technical Reports 4 (Water) and 7 (Land use and agriculture). Further information on land and soil capability with respect to agricultural land is provided in Technical Report 7.

7.1 Approach

7.1.1 Overview

The main potential impacts on soils from construction activities would result from the removal of vegetation, and the excavation and stockpiling of soils during construction. Exposure and loosening of soils can result in off-site movement through wind and rain action, potentially resulting in erosion and sedimentation. Construction can also expose soils to air resulting in chemical changes, or disturb historically contaminated land, which can result in a risk of pollution. It is important that such risks are identified and planned for so they can be minimised and effectively managed through design and construction planning.

The primary technical reference used for the soils assessment was *The land and soil capability assessment scheme* (NSW Office of Environment and Heritage (OEH), 2012) (the LSC Scheme), which was developed to provide guidance on the physical capability of the land to support agricultural land uses. The LSC Scheme uses the biophysical features of the land and soil to derive ratings based on a range of soil hazards. These hazards are used to determine the capability of land and soils.

The soils assessment and proposed approach to management has been undertaken in accordance with the SEARs (see Appendix A (SEARS compliance table)) and with reference to other relevant policies and guidelines, including the APGA Code of Environmental Practice, which references best practice erosion and sediment control as set out in the International Erosion Control Association (Australasia) (IECA) document *Best Practice Erosion and Sediment Control* (IECA, 2008). Appendix P of *Best Practice Erosion and Sediment Control* provides specific guidelines on the application of best practice erosion and sediment control to the construction of land-based pipelines, and pipeline crossings of watercourses.

An overview of the methodology for the assessment is provided below. Further information on the soils assessment methodology is provided in section 3.3.3 of Technical Report 7 (Land use and agriculture). Other considerations regarding potential effects on water quality are provided in Technical Report 4 (Water).

7.1.2 Methodology

Study area

The study area for the assessment is the project site, as described in section 2.2.2. Desktop searches for potential soil contamination extended one kilometre around the project site.

Key tasks

The assessment involved:

- reviewing publicly available data and databases, including historical aerial photographs, and mapping of topography, geology, soil landscapes and acid sulfate soil risks
- considering the potential for construction erosion and sedimentation impacts, informed by field data from a soil investigation conducted to inform the agricultural impact assessment included in Technical Report 7 (Land use and agriculture)
- identifying sites and areas of potential contamination, including review of relevant statutory databases and a site visit to ground truth the findings
- identifying the potential to disturb acid sulfate and saline soils
- assessing potential construction, operation and decommissioning impacts that may result from disturbing soils
- identifying mitigation and management measures.

7.2 Existing environment

7.2.1 Topography and geology

Elevation across the study area ranges from about 239 to 372 metres Australian Height Datum (AHD), with higher elevations within the Pilliga East and Bibblewindi State forests, and lower elevations in the north-west around the Leewood facility and at the eastern end of the study area. The terrain is predominantly flat (less than one per cent) or slightly undulating (one per cent to five per cent) with areas of steeper terrain (up to 14 per cent) within the Pilliga East State Forest.

The study area is located within the Permian-Triassic Gunnedah Basin and the overlying Jurassic-Cretaceous Surat Basin (Herr et al, 2018). Extensive Quaternary sediments and debris (alluvium, colluvium and talus) have been deposited in the recent geological past, resulting in low-relief slopes and plains comprising thick layers of alluvial and colluvial sediments across the majority of the study area.

Information from groundwater bore logs within and near the study area indicate the surface geology is likely to be sand and/or silt, underlain by clay and bedrock (sandstones, shales and siltstones) between two and 50 metres below ground level.

Further detail regarding the geology of the study area is provided in section 4.4.1 of Technical Report 4 (Water).

7.2.2 Soil types and characteristics

Soil types

Soil types mapped within the study area (DPIE, 2021a) are shown on Figure 7.1 and Figure 7.2. The dominant soil types, classified in accordance with the Australian Soil Classification system, are sodosols and vertosols, with some tenosols, chromosols and kandosols.

Sodosols are the dominant soil group in the study area. They typically feature surface textures ranging from sandy loam, loam, and light sandy clay loam to sandy clay loam overlying medium or medium-heavy clay subsoils. Sodosols generally have low nutrient status and are prone to erosion and dryland salinity, particularly when vegetation is removed or where the clay subsoils are exposed. Sodosols also contain moderate levels of exchangeable sodium (i.e., they are sodic), which causes clay particles to disperse easily when wet. This dispersion can lead to the formation of hard-setting, low-permeability layers or result in downslope erosion. Field data indicates that these soils generally consist of non-sodic topsoil overlying sodic subsoils.

Vertosols are the second most common soil type, occurring in areas adjacent to Yellow Spring Creek and Beehive Road within the Pilliga East State Forest, west of Curracabah Road, at Tulla Mullen Creek, and at the Baan Baa construction compound. These soils are typically found in lower lying to flat alluvial areas and on gentle slopes. Vertosols have a uniform vertical texture, with medium to heavy clay surface soils and subsoils, and are characterised by high fertility and water-holding capacity. Due to their high clay content and generally low landscape position, they present a lower erosion hazard compared to Sodosols; however, sheet erosion may occur if vegetation cover is removed.

Tenosols occur in small patches within the Pilliga East State Forest, featuring sandy textures overlying clayey sand or weathered and hard rock. Due to their sand-dominant nature, tenosols are susceptible to erosion by wind and water when vegetation cover is removed.

Chromosols occur in a small area east of Tulla Mullen Creek. These soils exhibit a marked increase in clay content with depth, transitioning from a sandy to loamy surface layer to a more clay rich subsoil. Due to the sandy to loamy nature of the surface soil, Chromosols can be susceptible to erosion by both water and wind.

Kandosols occur adjacent to Bohena Creek. These soils have a high sand content in surface layers, with increasing clay content at depth and a relatively weak structure. The combination of high sand content and weak structure can make kandosols susceptible to erosion when vegetation cover is removed.

Soil erodibility

Soil erodibility represents the soil's response to rainfall and runoff processes. A combination of factors contribute to soil erodibility, including slope, soil organic carbon levels, surface soil texture, groundcover type and density and dispersion potential.

Physical and chemical testing (as described in section 3.3.3 of Technical Report 7 (Land use and agriculture)) confirmed the mapped soil types described above are present within the study area. Sodosols, as the dominant soil type, were identified to have a lower dispersion potential (a lower erosion potential) in shallower soils, less than 0.5 metres deep. The majority of deeper sodosols greater than 0.5 metres deep have higher dispersion potential and higher erosion potential from water.

Figure 7.3 and Figure 7.4 present desktop mapping of soil erodibility across the study area represented by the modelled annual hillslope bare soil erosion data calculated by the NSW Government. The figures indicate areas of higher erosion risk are generally located within the steeper terrain of the Pilliga East State Forest and west of Towri Road, and east of Tulla Mullen Creek.

Acid sulfate soils

Acid sulfate soils and potential acid sulfate soils are naturally occurring soils containing iron sulfides. If the soils are drained, excavated or exposed to air, the sulfides react with oxygen to form sulfuric acid. Acid sulfate soils in NSW are commonly located in low-lying coastal areas, particularly below 10 metres AHD, including areas near estuaries and floodplains, but can also occur inland above 10 metres AHD under certain circumstances.

The CSIRO Atlas of Australian Acid Sulfate Soils indicates a low or extremely low probability of acid sulfate soils occurring within the study area.

Saline soils

Soils can become saline when water tables rise and the water evaporates, leaving concentrated salts behind on the surface or in the rootzone. Areas prone to salinity are usually at low positions in the landscape, such as at the base of a slope, in valley floors and along floodplains. Soil salinity can be from a combination of salts such as sodium, chloride, potassium, calcium, magnesium and is not limited to sodium (soil sodicity). A saline soil can become sodic (high concentrations of sodium) from the leaching of salt through the soil profile, which can leave sodium behind bound to clay particles.

Results from the soil investigation within agricultural land indicate that salinity is generally very low in topsoils (less than 50 centimetres deep), rising to moderate in subsoils up to one metre deep. At depths greater than one metre, salinity levels increase to slightly high as a result of an increase in soil chloride levels. Despite these observations, salt stores in this landscape are not considered to be high overall, with no direct observation of salt crystals at sampling locations during the soil investigation.

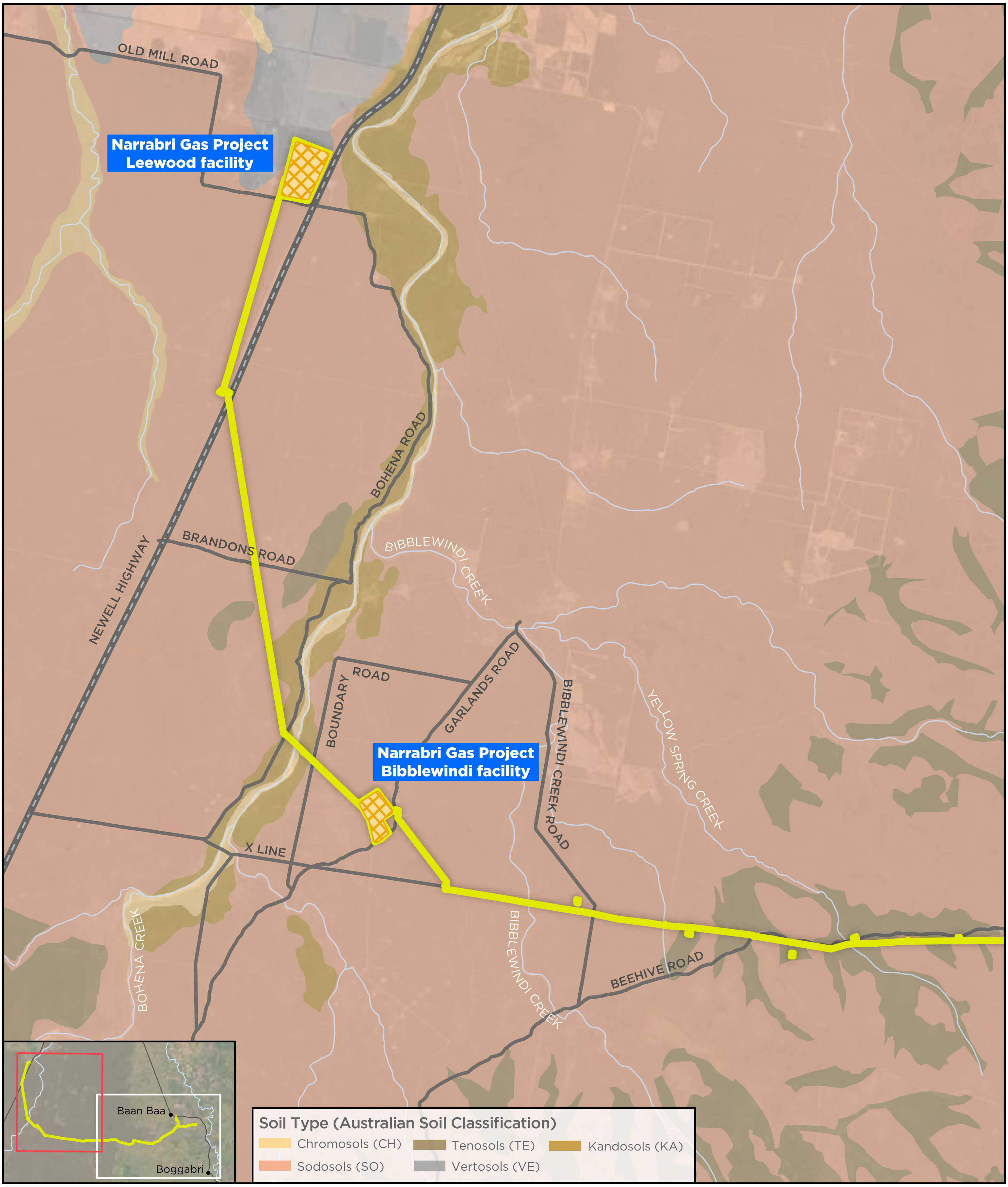


Figure 7.1 Soil types – map 1

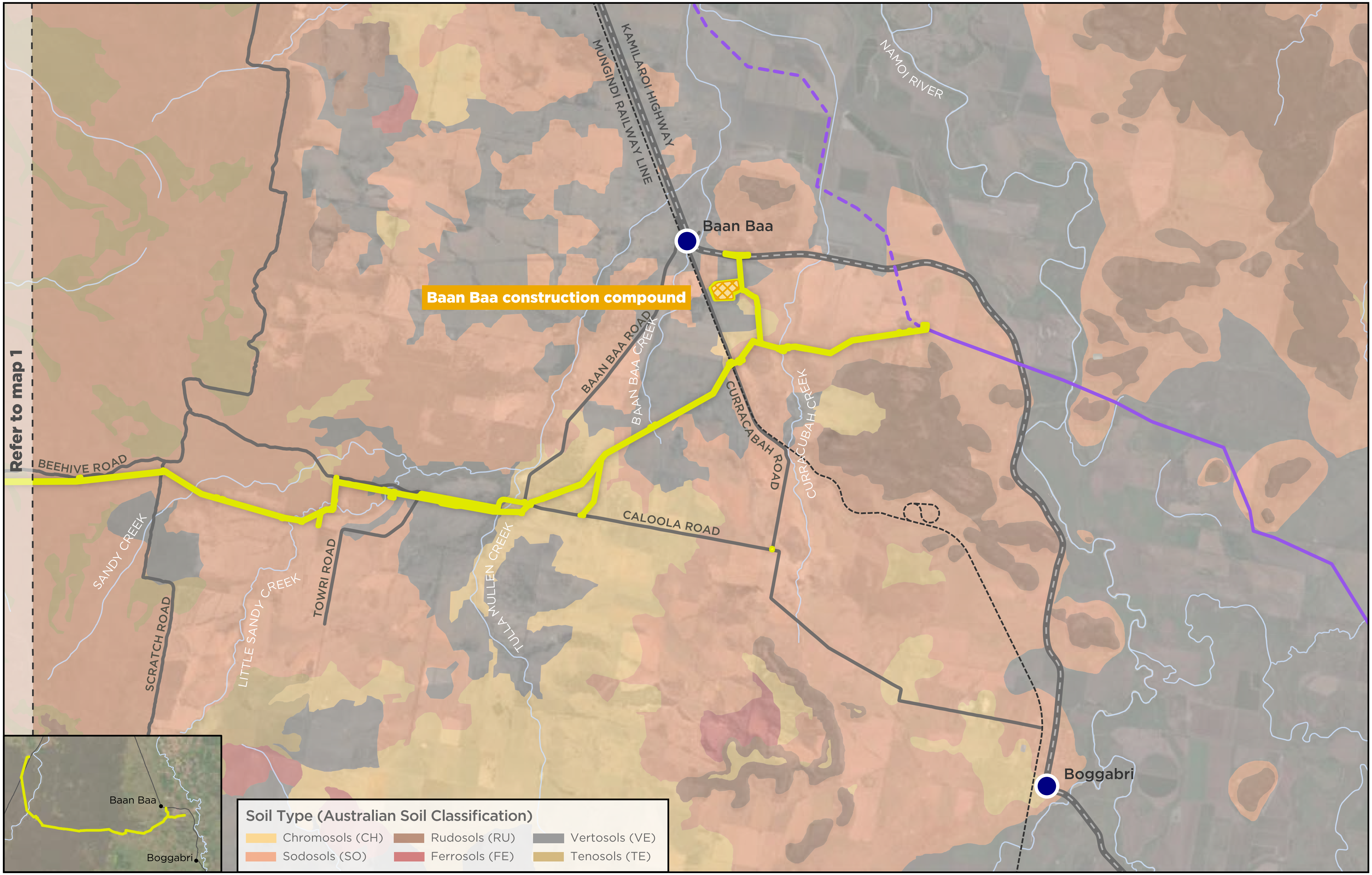
Legend

Project infrastructure: Project site Construction facility

Highway Watercourse

Santos | HUNTER GAS PIPELINE

Data source: Roads, Rail, watercourses - DCS2024; State Forest - Forestry 2024; Hunter gas pipeline - Santos 2023; World Imagery: Earthstar Geographics.



Santos | HUNTER GAS PIPELINE

Data source: Roads, Rail, watercourses - DCS2024; State Forest - Forestry 2024; Hunter gas pipeline - Santos 2023; World Imagery: Earthstar Geographics.

Legend

Project infrastructure: Project site, Construction facility

Stage 2 Hunter Gas Pipeline – Indicative pipeline route, Stage 3 Hunter Gas Pipeline – Indicative pipeline route

Town, Highway, Railway line, Watercourse

Figure 7.2 Soil types – map 2

0 1 2 3 4

Kilometres

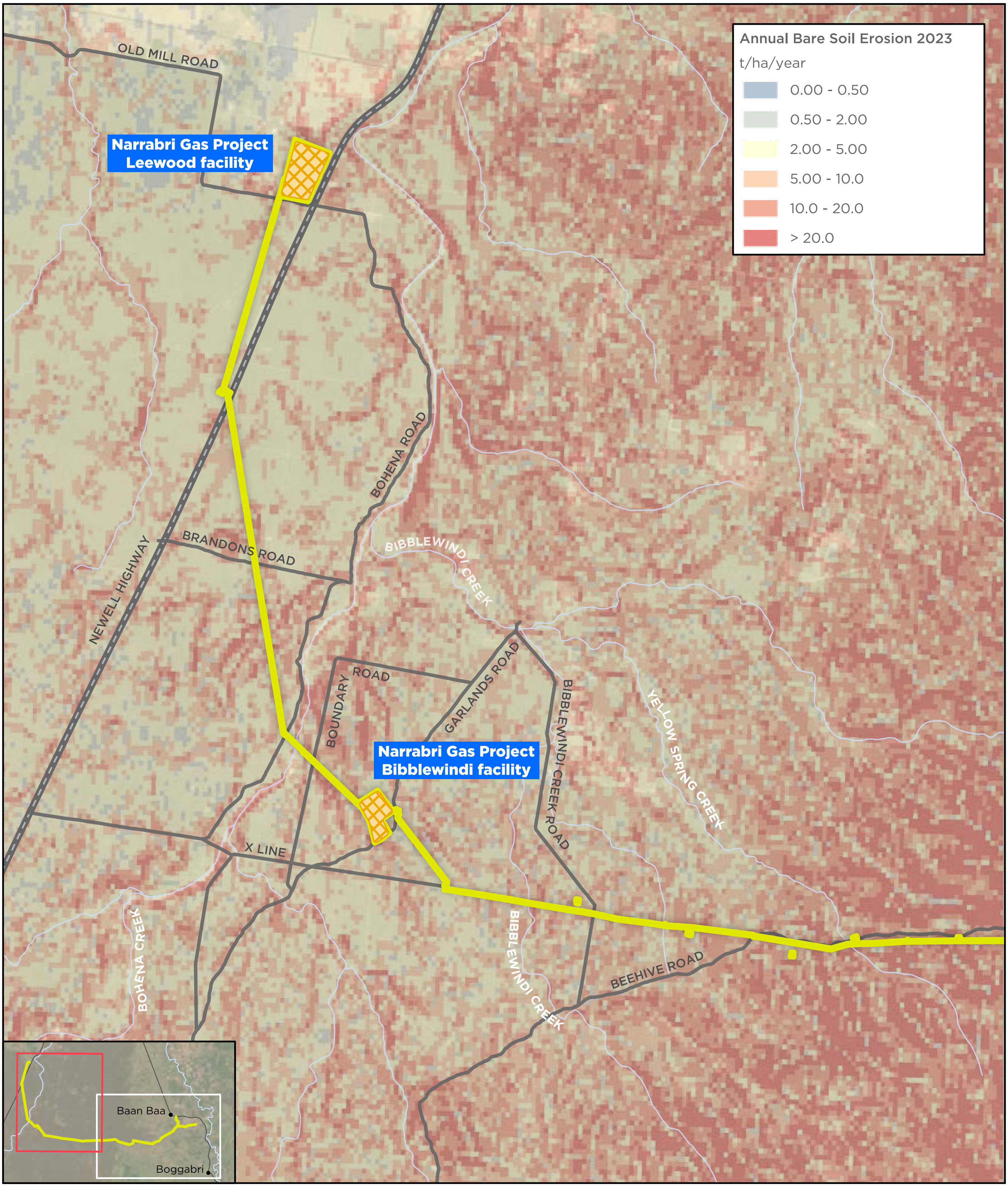


Figure 7.3 Soil erodibility – map 1

Legend

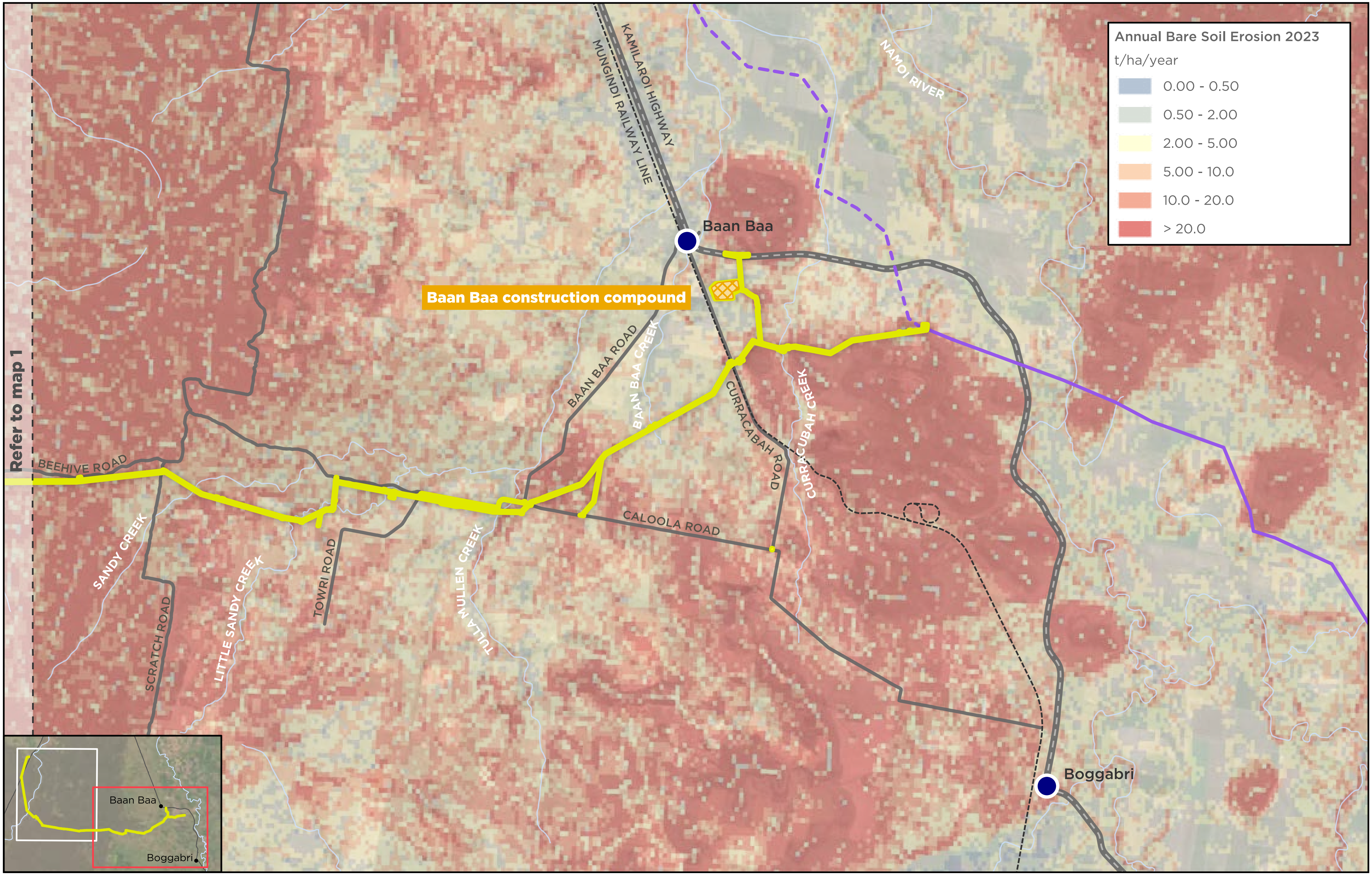
Project infrastructure: Project site | Construction facility

Highway | Roads | Watercourse

Santos | HUNTER GAS PIPELINE

Data source: Roads, Rail, watercourses - DCS2024; State Forest – Forestry 2024; Hunter gas pipeline – Santos 2023; Soil/NSW_Annual_Hillslope_Erosion_Modelling; World Imagery: Earthstar Geographics.

0 1 2 3 4
Kilometres



Santos | HUNTER GAS PIPELINE

Figure 7.4 Soil erodibility – map 2

Legend

Project infrastructure: Project site; Construction facility

Stage 2 Hunter Gas Pipeline – Indicative pipeline route; Stage 3 Hunter Gas Pipeline – Indicative pipeline route

Town; Highway; Roads; Railway line; Watercourse

0 1 2 3 4
Kilometres

Data source: Roads, Rail, watercourses – DCS2024; State Forest - Forestry 2024; Hunter gas pipeline – Santos 2023; Soil/NSW_Annual_Hillslope_Erosion_Modelling; World Imagery: Earthstar Geographics.

7.2.3 Historical contamination

Searches of NSW EPA regulatory databases did not identify any sites within the study area that are listed on the contaminated land record or where a record of contamination notice has been made. Additionally, no sites that are part of the NSW EPA per-and polyfluoroalkyl substances (PFAS) investigation program are located within the study area. The likelihood of encountering widespread and substantial contamination of either soils or groundwater within the study area is therefore considered to be low.

Historical land uses in the study area could have introduced diffuse (such as broadacre application of pesticides or herbicides on agricultural land) or localised (such as accidental fuel spills or leaks of hazardous or dangerous goods) contamination into the soil.

The former Bibblewindi water treatment facility was the site of pollution incidents in 2010 and 2011 (prior to Santos acquiring the facility), which resulted in elevated salts in an area of soil. The affected area, which has since been rehabilitated, is located about 500 metres from the disturbance footprint and would not be disturbed during construction, operation or decommissioning of the project.

7.3 Construction impacts

7.3.1 Soil erosion

Excavation during construction would disturb the soil profile and temporarily expose both surface and subsurface soils to rain and wind, which can lead to soil erosion, particularly in areas of steeper slopes such as within the Pilliga East State Forest. As noted in section 7.2.2, sodosols with higher dispersion rates are dominant within the study area, with dispersive characteristics typically increasing at depths beyond about 0.5 metres, where higher sodicity occurs. If rainfall contacts these dispersive subsoils, or if any exposed soil types on steep slopes are left unprotected, the risk of erosion can increase. Additionally, the operation of heavy construction machinery may lead to soil compaction, which can reduce infiltration, increase surface runoff, and further contribute to soil erosion. The potential for erosion within the project site would be present until the land is rehabilitated.

As described in section 3.4.5, as soon as practicable after pipe laying and backfilling, the construction right of way and temporary workspaces would be cleared of all construction equipment, materials and waste would be removed, and the land rehabilitated.

The approach to erosion and sediment control would be defined by the construction soil and water management plan (see section 7.6). Site and activity-specific erosion and sediment controls would be developed in accordance with the APGA Code of Environmental Practice, which references best practice erosion and sediment control from *Best Practice Erosion and Sediment Control* (IECA, 2008). In particular, Appendix P of the *Best Practice Erosion and Sediment Control* provides specific guidelines on the application of best practice erosion and sediment control to the construction of land-based pipelines, and pipeline crossings of watercourses.

Site and activity-specific erosion and sediment controls would be developed in accordance with these documents as design progresses, informed by investigations undertaken (as relevant) as part of the design process. The risk of rainfall impacting dispersive subsoils would be managed using common ameliorants such as gypsum or polymers where dispersive soils occur. Application of gypsum to sodic subsoils also mitigates potential impacts to subsequent agricultural productivity within the crop or grass rootzone.

7.3.2 Acid sulfate soils

As noted in section 7.2.2, the potential to encounter acid sulfate soils is considered to be low or extremely low across the study area. Any acid sulfate soils identified will be managed in accordance with the *Acid Sulfate Soils Assessment Guidelines* (Acid Sulfate Soils Management Advisory Committee (ASSMAC), 1998), and the *Waste Classification Guidelines — Part 4: Acid Sulfate Soils* (NSW EPA, 2014b) (see section 7.6).

7.3.3 Soil salinity

As noted in section 7.2.2, excavations up to one metre may encounter moderately saline soil conditions, with higher salinity soils generally at greater depths. Saline soils can inhibit vegetation growth and create conditions that accelerate corrosion of buried infrastructure.

Landscape salt stores are generally low in the State forests and moderate in agricultural areas. Reinstating excavated soils in their original position, avoiding undue mixing with topsoil, would preserve the natural soil structure and reduce potential impacts of saline subsoils deeper in the landscape. Topsoil would be re-spread on top of subsoils as soon as practicable, limiting impacts on vegetation re-establishment.

As detailed in chapter 3 (Project description), the pipeline would be designed, constructed, operated and maintained in accordance with AS 2885 and would be able to withstand saline soil conditions. The construction soil and water management plan, implemented under the CEMP, would detail measures for managing saline soils and the handling of topsoil, subsoil, and stockpiles.

7.3.4 Contamination including accidental spills and leaks

Unexpected existing soil contamination may be encountered during construction, evidence of which could include:

- staining or odours
- buried materials, potentially containing asbestos
- buried drums or machinery.

The potential for impacts due to disturbance of any unexpected contamination, including diffuse or localised sources, would be minimised by implementing the mitigation measures in section 7.6. This includes developing and implementing an unexpected contaminated finds procedure as part of the construction soil and water management plan.

Construction would involve storage and handling of materials and wastes that require management to prevent contamination of soils and water. Implementation of standard measures to manage the potential for accidental spills and leaks of fuel, oils and other hazardous materials would ensure there is minimal potential for contamination of soil and groundwater. The potential for impacts associated with handling hazardous materials during construction is considered in section 16.3. Waste management during construction is considered in section 17.2.

Water used for dust suppression would be sourced from the preferred water sources in accordance with relevant water access licences, which may include groundwater, surface water and/or treated water from the Leewood reverse osmosis treatment facility. If improperly applied, the application of water for dust suppression has the potential to cause erosion, waterlogging and salt accumulation, particularly on compacted surfaces where drainage is impeded. These potential impacts would be minimised by regulating the quantity of water applied. As outlined in section 5.1.2 of Technical Report 4 (Water), the water quality from these sources of construction water is appropriate for irrigation use and would have a negligible impact on soils.

7.4 Operation impacts

As described in section 3.4.5, disturbed areas not required for surface infrastructure would be rehabilitated following construction in accordance with the rehabilitation strategy. This would ensure there is minimal potential for erosion and soil stabilisation issues post-construction.

Operation is not likely to result in impacts on soils. Routine maintenance activities would include inspections for erosion and subsidence which would be remediated as required. There would also be limited handling and use of dangerous goods, which would be managed in accordance with Santos' standard operating procedures.

7.5 Decommissioning impacts

At project closure, the pipeline would be decommissioned as described in section 3.8. Activities with the potential for impacts on soils (if inadequately managed) include:

- minor earthworks associated with the removal of surface infrastructure, which may disturb topsoil and subsoil
- excavation of bell holes (where required by the abandonment plan) to enable sections of the pipeline to be filled and capped
- disturbance of stabilised surfaces, potentially increasing the risk of sediment transport during rainfall events.

Only limited areas would be subject to surface disturbance as a result of decommissioning, including the location of surface facilities and sections where cutting, capping and filling of the pipeline would be required. Potential soil-related impacts associated with decommissioning at these locations include:

- short-term erosion risk due to exposure of soil during infrastructure removal
- soil compaction from the operation of machinery
- loss of topsoil or mixing of soil horizons
- localised contamination risks, such as fuel or lubricant spills during machinery operation.

These potential impacts are similar to, although more limited than, the potential construction impacts on soils. Leaving the pipeline in place avoids widespread land disturbance and the potential for soil and erosion impacts.

All decommissioning activities are expected to be of short duration at any given location (typically up to about a week) and are not expected to result in significant long-term soil degradation. Activities will be managed in accordance with relevant guidelines and regulatory requirements in effect at the time of decommissioning to ensure protection of soils and minimisation of the potential for erosion.

Measures to manage soil and erosion impacts during decommissioning would be detailed in the soil and water management plan included in the decommissioning environmental management plan, which will be adapted from the CEMP. Further information about the decommissioning environmental management plan is provided in section 20.4.

Provided the specified controls (as defined in the decommissioning environmental management plan) are implemented, potential impacts on soils would be minimal.

7.6 Mitigation and management

7.6.1 Approach to mitigation and management

The main potential for impacts on soils would be during construction if erosion and sedimentation is not managed effectively, particularly in areas of steeper slopes and/or where dispersive subsoils are stockpiled and may be exposed to rainfall.

The CEMP will include a construction soil and water management plan, providing detailed measures to manage and minimise impacts to soils (including erosion). The construction soil and water management plan will require the preparation of site and activity-specific erosion and sediment control plan/s, prepared in accordance with the APGA Code of Environmental Practice and *Best Practice Erosion and Sediment Control* (IECA, 2008) (in particular Appendix P: Land-based pipeline construction).

The management measures specified in the plan will be informed by further soils and geotechnical investigations undertaken (as relevant) as part of subsequent design processes.

Further information on environmental management is provided in chapter 20 (Approach to environmental management and mitigation).

7.6.2 List of mitigation measures

Measures that will be implemented to address potential impacts on soils are listed in Table 7.1.

Table 7.1 Soil mitigation measures

Impact/issue	Ref	Management measures	Timing
Potential impacts of soil disturbance and erosion	SC1	A construction soil and water management plan will be prepared and implemented as part of the CEMP. The plan will identify reasonably foreseeable risks relating to soil erosion, soil and water quality impacts, including from any contamination, and describe how these risks will be addressed during construction. The plan will be prepared with reference to relevant guidelines, in particular the *Code of Environmental Practice – Onshore Pipelines* (APGA, 2022), *Best Practice Erosion and Sediment Control* (IECA, 2008) and *Guidelines for controlled activities on waterfront land* (DPE, 2022c). The plan will detail management measures to be implemented, including in relation to: • areas of higher erosion hazard, saline or sodic soils, including the requirement to prepare site and activity-specific erosion and sediment control plans as per mitigation measure SC2 • managing topsoil and subsoil stockpiles • managing any unidentified contamination in accordance with an unexpected contaminated finds procedure • managing any accidental spills or leaks of fuels and chemicals • managing the application of dust suppression water, including the quality and quantity of water used, and the rate of application • arrangements for managing wet weather, including monitoring potential high-risk events (such as storms) and specific controls to be applied to dispersive soils and follow-up measures • the process for progressively rehabilitating disturbed areas in accordance with the rehabilitation strategy (mitigation measure LU8).	Pre-construction, construction
Erosion and sediment control plans	SC2	Site and activity-specific erosion and sediment controls plan/s will be prepared by a suitably qualified erosion and sediment control specialist and include erosion and sediment controls appropriate for site-specific soil types, locations and activities, including the use of soil ameliorants (e.g. gypsum) or polymers as required. The erosion and sediment control plans will be prepared with reference to the *Code of Environmental Practice – Onshore Pipelines* (APGA, 2022) and *Best Practice Erosion and Sediment Control* (IECA, 2008).	Construction
Acid sulfate soils	SC3	Any potential or actual acid sulfate soils will be managed in accordance with the *Acid Sulfate Soils Assessment Guidelines* (ASSMAC, 1998) and the *Waste Classification Guidelines – Part 4: Acid Sulfate Soils* (NSW EPA, 2014b).	Construction
Contamination	SC4	Storage and handling of dangerous and hazardous goods (e.g., fuel, oil and other chemicals) will be undertaken in accordance with Australian Standard *AS 1940:2017 The storage and handling of flammable and combustible liquids*.	Construction, operation
Managing potential impacts during decommissioning	SC5	A soil and water management plan will be included in the decommissioning environmental management plan and implemented during decommissioning to minimise potential impacts on soils and water quality. The plan will include measures for erosion control, management of any contaminated areas, and restoration of disturbed areas.	Decommissioning