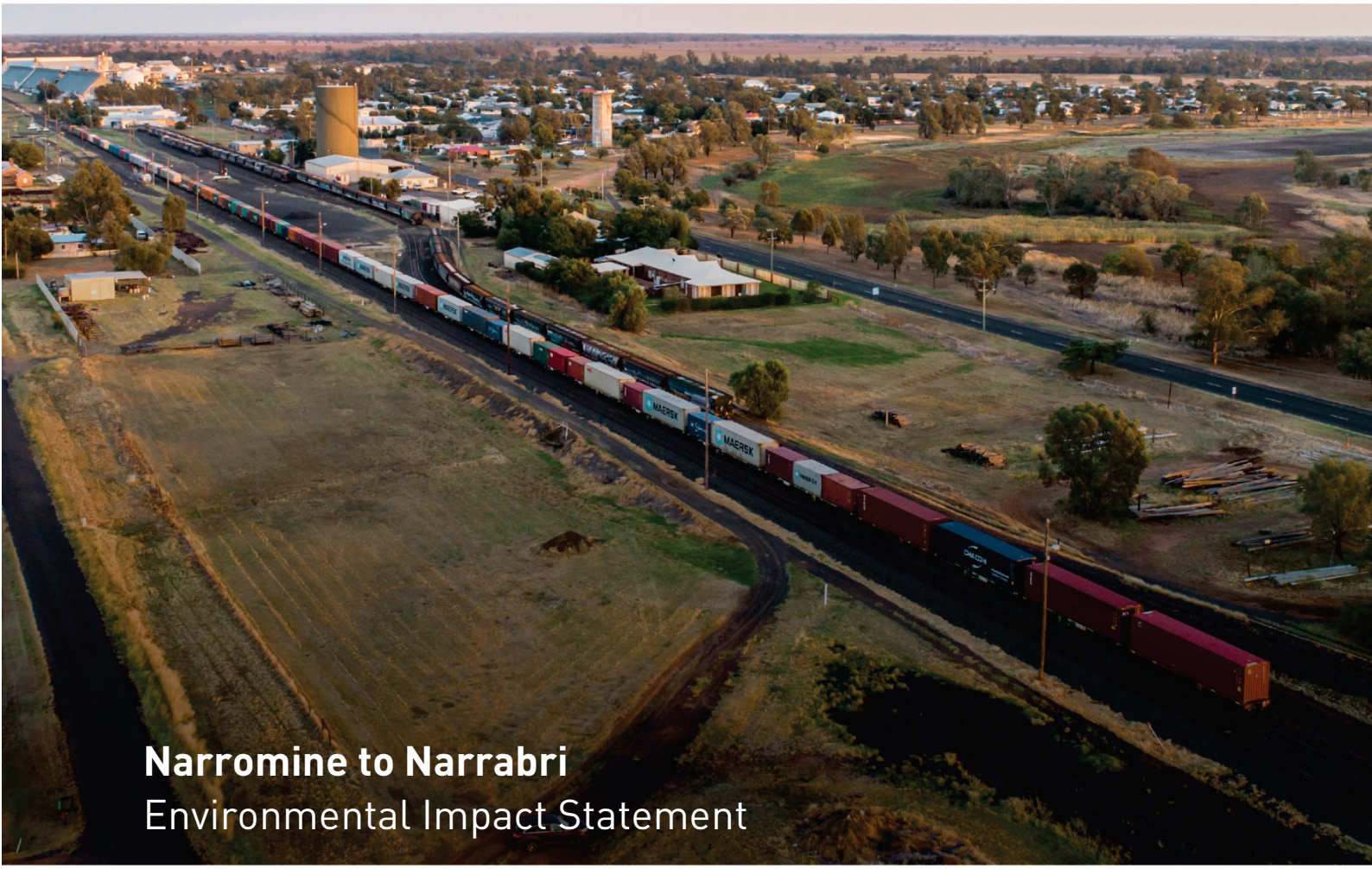
PART B
Impact assessment
proposal infrastructure

INLAND RAIL

CHAPTER B4
Soils and contamination



Narromine to Narrabri
Environmental Impact Statement

ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

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B4. Soils and contamination

This chapter provides the soils and contamination assessment undertaken for the Narromine to Narrabri project (the proposal). It describes the existing soil environment, including potential contamination, assesses the potential impacts during construction and operation, and provides recommended mitigation and management measures.

B4.1 Approach

The approach to the assessment is provided in this section, including the legislation, guidelines and/or policies driving the approach and the methodology used to undertake the assessment.

B4.1.1 Legislative and policy context to the assessment

Relevant legislation, policies and guidelines

The assessment was undertaken in accordance with the SEARs and with reference to the requirements of relevant legislation, policies and/or assessment guidelines, including:

- The EP&A Act, *Contaminated Land Management Act 1997* (NSW) (CLM Act) and *State Environmental Planning Policy No 55—Remediation of Land* (SEPP 55)
- *National Environment Protection (Assessment of Site Contamination) Measure 1999* (as amended) (the NEPM) (NEPC, 2013)
- *Contaminated Sites: Guidelines for Consultants Reporting on Contaminated Sites* (NSW EPA, 2020)
- *Contaminated Sites: Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997* (NSW EPA, 2015)
- *Guide to the investigation and sampling of sites with potentially contaminated soil. Part 1: Non-volatile and semi-volatile compounds (AS 4482.1-2005)* (Standards Australia, 2006)
- *Managing Land Contamination Planning Guidelines SEPP 55—Remediation of Land* (Department of Urban Affairs and Planning and EPA, 1998)
- Urban and regional salinity—guidance given in the local government salinity initiative booklets (**environment.nsw.gov.au/salinity/solutions/urban**), which includes *Site Investigations for Urban Salinity* (DLWC, 2002b)
- *Acid Sulfate Soils Assessment Guidelines* (Acid Sulfate Soils Management Advisory Committee (ASSMAC), 1998)
- *Landslide risk management guidelines* (Australian Geomechanics Society, 2007)
- *Managing Urban Stormwater: Soils and construction* - Volume 1 (Landcom, 2004), *Volume 2C Unsealed roads* (DECC, 2008a) and *Volume 2D, Main Road Construction* (DECC, 2008b) (collectively referred to as the Blue Book)
- *Guidelines for the Management of Acid Sulfate Materials: Acid Sulfate Soils, Acid Sulfate Rock and Monosulfidic Black Ooze* (RTA, 2005).

Secretary's Environmental Assessment Requirements

The SEARs relevant to soils and contamination, together with a reference to where they are addressed in the EIS, are provided in Appendix A.

B4.1.2 Methodology

Study area

The study area for the soils and contamination assessment is the proposal site, as described in chapter A2. Desktop searches for the contamination assessment also extended a further 500 metres (m) around the proposal site.

Key tasks

The assessment involved:

- Reviewing the following databases to identify areas of known and potential contamination:
  - NSW EPA's register of contaminated sites and list of notified sites, under sections 58 and 60 of the CLM Act
  - NSW EPA's environment protection licence records under section 308 of the POEO Act
  - WaterNSW's database for registered groundwater bores
  - NSW Department of Primary Industries' cattle dip site locator
  - Australian Government Department of Agriculture, Water and the Environment's National Waste Reporting Mapping Tool
  - Department of Defence's Unexploded Ordinance (UXO) Mapping Application
  - ARTC's contaminated site register.
- Reviewing publicly available data and web-based information searches, and background information relevant to the study area, survey data and topography, including:
  - Historical aerial photographs from the NSW Government Land and Property Information website
  - Australian Soil Resource Information System (maintained by the Commonwealth Scientific and Industrial Research Organisation (CSIRO))
  - 1:250,000 scale NSW geological maps (specifically sheet SI/55-3 Narromine, sheet SH/55-15 Nyngan, sheet SH/55-16 Gilgandra and sheet SH/55-12 Narrabri)
  - Hydrogeological Landscapes for the Central West Catchment Management Authority Western Study Area
  - NSW Soil and Land Information System
  - NSW Resources and Geosciences naturally occurring asbestos database
  - NSW Government's acid sulfate soils risk mapping.
- Site visits to ground truth the findings of the desktop assessment
- Identifying the potential to disturb acid sulfate soils and areas of salinity
- Reviewing the results of the preliminary soil and contamination assessment undertaken as part of geotechnical investigations (see below)
- Providing recommendations for additional investigations, where required
- Identifying mitigation measures.

Soil and contamination investigations

The geotechnical investigations undertaken to inform the design included a preliminary soil and contamination assessment, which involved:

- Obtaining soil samples from 24 boreholes/test pit locations within the proposal site, including one borehole/test pit location at each borrow pit site
- Analysis of soil samples for contaminants of potential concern, including heavy metals (arsenic, cadmium, chromium, copper, lead, nickel zinc and mercury), benzene, toluene, ethyl-benzene and xylene (BTEX), total recoverable hydrocarbons (TRH), polycyclic aromatic hydrocarbons (PAH), pesticides and asbestos
- Comparing the analytical results to health and environmental screening criteria.

The selection of sampling locations was initially informed by the results of the desktop assessment and review of existing databases. Site visits were then undertaken to ground truth potential sources of contamination identified through the desktop assessment and identify any additional potentially contaminating activities or locations. This included identifying any stockpiled material within the proposal site and sampling of this material, if noted. One sample was collected during the site visit from an illegal waste dumping location (site CS-21—see Figure B4.1).

The potential contaminants of concern for analysis were chosen based on the identification of potential contamination sites or sources as part of the desktop assessment and site visits. Due to the size of the proposal site, sampling locations were selected to target locations of potential contamination as identified during the desktop assessment and site visits, rather than meet the minimum sampling requirements within the *Contaminated Sites: Sampling Design Guidelines* (EPA, 1995). This was considered appropriate given the initial purpose was to identify areas of gross contamination within the proposal site and use this to determine if further assessment or remediation is necessary.

Further information regarding the potential contamination sites or sources that were targeted is provided in section B4.2.3.

Assessment criteria

The assessment criteria (investigation levels) for the assessment were taken from the following guideline levels provided by the NEPM (refer to schedule B1):

- Health investigation levels—to assess human health risk via all relevant pathways of exposure. The level adopted for the assessment was D—commercial/industrial use, based on operational use of the majority of the proposal site as a railway and road corridor.
- Health screening levels—for hydrocarbon vapour intrusion under different land use scenarios. The level adopted for the assessment was D—commercial/industrial use.
- Ecological investigation levels—for a range of metals and organic substances to assess risk to terrestrial ecosystems. The levels adopted for this assessment were commercial/industrial use.
- Ecological screening levels—for selected hydrocarbon compounds and total recoverable hydrocarbons to assess risk to terrestrial ecosystems. The levels adopted for this assessment were commercial/industrial use for course-grained soils.

The NEPM also provides health-based screening levels for different forms of asbestos contamination in soil. Significant assessment is required to apply this criteria; as a result, for the purposes of this preliminary assessment, it was determined that if asbestos was identified in soil samples or surface soils, the need for further investigation would be considered.

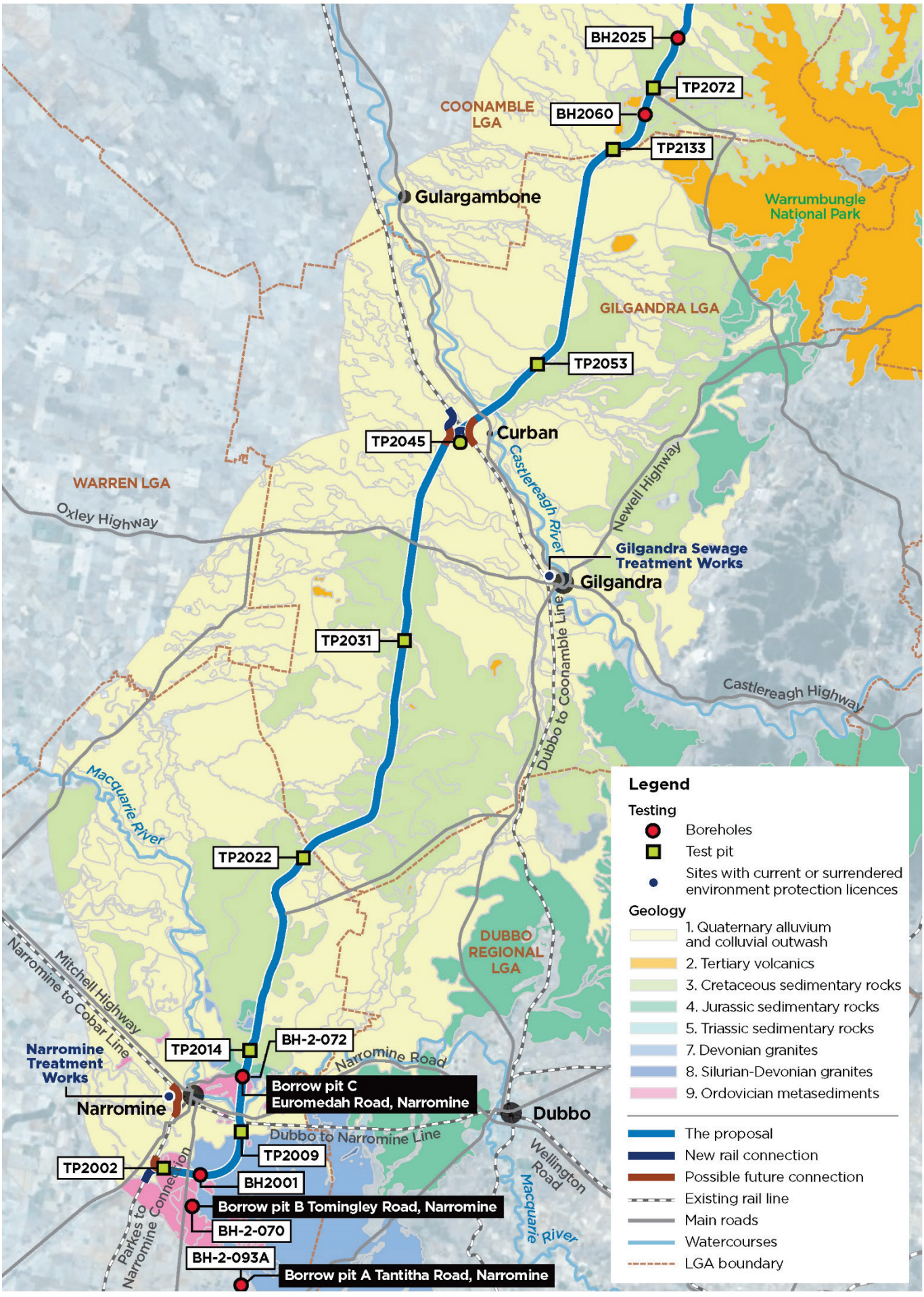

Figure B4.1 **Regional geology and contamination sampling locations (map 1)**

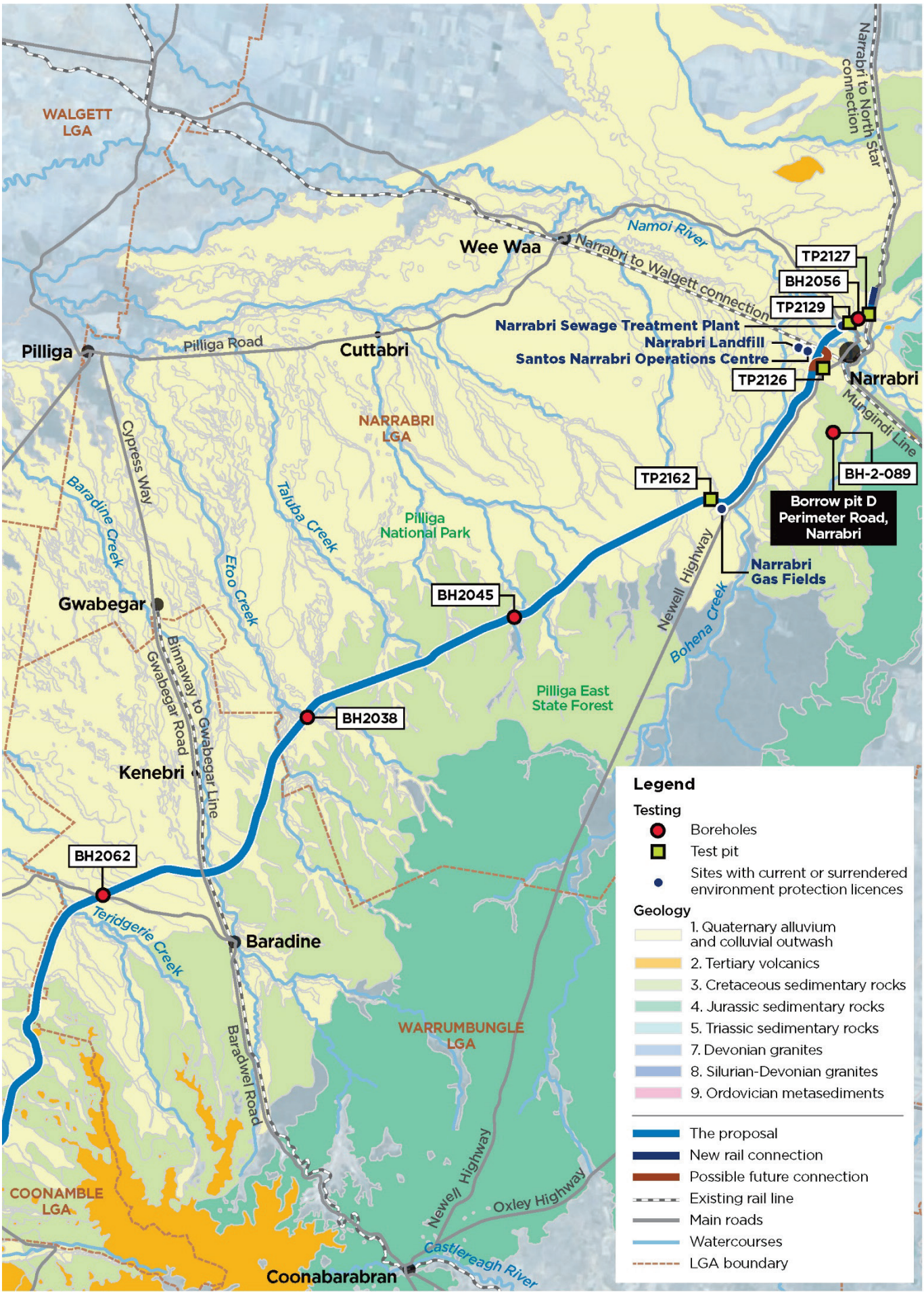

Figure B4.1 **Regional geology and contamination sampling locations (map 2)**

B4.1.3 Risks identified

The environmental risk assessment for the proposal (see Appendix E) included consideration of potential soils and contamination risks. Soils and contamination risks with an assessed level of medium or above, identified by the environmental risk assessment, included:

- Erosion as a result of the disturbance of soils during construction, particularly in soil landscapes characterised by dispersive soils
- Potential to disturb contaminated soils during construction
- Contamination of soils/groundwater due to spills and leaks during construction
- Exposure of acid sulfate soils or saline soils and subsequent erosion
- Potential to disturb hazardous materials during the demolition of buildings and structures
- Erosion of soils during operation and maintenance works.

The soils and contamination assessment considered the potential risks identified by the environmental risk assessment, in addition to potential risks and impacts identified by the scoping report (see section A9.1), the SEARs and relevant guidelines and policies (as appropriate).

B4.1.4 How potential impacts have been avoided/minimised

In general, potential soils and contamination impacts have been avoided by:

- Managing contamination in accordance with relevant legislative and policy requirements, as described in section B4.1.1
- Designing, constructing and operating the proposal to minimise impacts from soil issues, including minimising the extent of construction in black soils
- Providing a high-quality haul road within the proposal site
- Minimising the area of disturbance.

B4.2 Existing environment

B4.2.1 Topography and geology

The topography of the proposal site is dictated by its location relative to the Great Dividing Range to the east and the lower-lying and typically flat Great Australian Basin to the west. The proposal site predominately runs along the foot slopes of the Great Dividing Range; as such, the relief is varied, with some areas consisting of flat to gently undulating terrain and other areas, such as the flanks of the Warrumbungles range to the east of the proposal site and the hills in the Pilliga East State Forest to the north-east, consist of more pronounced moderate slopes.

Elevations within the study area generally range from 240 metres Australian Height Datum (mAHD) to 270 mAHD, with the exception of directly west of the Warrumbungles, where Mount Tenandra has an elevation of 300 mAHD.

No evidence of pronounced slope instability (such as landslides) was observed based on a review of aerial imagery and site investigations undertaken during the geotechnical assessment to inform the design. This is likely to be a result of the typically low angle of slopes as well as the deep-water table and low rainfall observed in the study area (see Section B2.2).

The regional geology underlying the proposal site is dictated by its location within the Surat Basin, a sub-basin of the Jurassic-Cretaceous Great Australian Basin. The Surat Basin straddles the boundary between NSW and Queensland. It comprises a predominantly flat sequence of mainly sedimentary rocks in an Early Jurassic–Early Cretaceous continental basin.

Weathering is pronounced within the sedimentary strata across the study area, which are often deeply weathered to significant depth. Cretaceous and Jurassic sedimentary rocks within the proposal site are often described in the literature as 'labile' (which essentially means unstable) reflecting their susceptibility to breakdown and degrade exposure.

The Warrumbungles and Mount Kaputar (north of Narrabri) were formed by basaltic shield volcanoes. Some of these basalts can be observed close to the proposal site, in the vicinity of the Warrumbungles, forming the more elevated and pronounced hillsides in the area.

Extensive Quaternary sediments have been deposited in the recent geological past, resulting in vast low-relief slopes and plains comprising thick layers of alluvial and colluvial sediments.

Regional geology within the study area is shown in Table B4.1.

Naturally occurring asbestos

Naturally occurring asbestos refers to a group of fibrous minerals associated with altered ultramafic rock. 'Ultramafic' describes igneous rocks that were originally formed deep in the earth; however, by the time they are exposed at the earth's surface by erosion, the rocks have been successively metamorphosed into serpentinite rock containing minerals such as lizardite, chrysotile, and antigorite. These rocks are known to outcrop in parts of NSW and may include chrysotile asbestos or tremolite/actinolite asbestos, or sometimes no asbestos at all.

A search of the NSW Resources and Geosciences naturally occurring asbestos database indicated that the nearest geological units with asbestos potential were located over 10 kilometres (kms) to the south-east of the proposal site. No naturally occurring asbestos was mapped within the proposal site. The potential for naturally occurring asbestos to be encountered has not been considered further.

B4.2.2 Soils

Soil types

Published soil landscape mapping is not available for the majority of the proposal site. Where available, it notes that soil erosion, salinity and soil structure decline are major soil issues in the area (DLWC, 2002c). Soil mapping data from the Office of Environment and Heritage indicates that soil types along the proposal site can be best described as follows:

- Narromine to the Oxley Highway—dominated by red brown earths, red earths and solodic soils
- Oxley Highway to Baradine—dominated by cracking clays (vertosols), red and red brown earths (non-cracking clays) and non-calcic brown soils (duplex soils)
- Baradine to Narrabri—dominated by solodic soils (duplex soils) and earthy sands (non-cracking clays)
- Narrabri—dominated by solodic soils (duplex soils) south of Narrabri and cracking clays (vertosols) close to Narrabri.

The characteristics of these soil types are described in Table B4.1.

The geotechnical investigations undertaken to inform the design noted that the majority of soil and rock materials sampled within the proposal site indicate dispersive characteristics, so would be susceptible to erosion and dispersion.

TABLE B4.1 SOIL TYPES

Soil group	Sub-group	Characteristics
Cracking clays (vertosols)	Black earths Grey brown clays Grey red brown clays	Characterised by deep, high-plasticity clays that crack significantly when dry and swell when wet. Gilgais are commonly present. Commonly formed on weathered basalt rocks, or from alluvial clays sourced from the weathered basalt. Clay that is often 'sodic' (i.e. high concentrations of sodium) and prone to dispersive erosion. Sodic/dispersive soils break down in water, forming a cloudy colloidal suspension. The suspension contains clay particles that are much finer than silt, hence conventional silt fences would not combat turbid runoff during rainfall.
Duplex soils (also known as texture contrast soils)	Solodic soils Podzolic soils Non-calcic brown soils	Characterised by texture contrast soils that comprise an upper pale (bleached) silt/sand horizon abruptly overlying a clay-rich horizon. Commonly formed on weathered sedimentary rocks and the older Quaternary alluvium/colluvium. Clay-rich horizon that is typically 'sodic' and prone to dispersive erosion.
Non-cracking clays	Red earths Red brown earths Brown earths Earthy sands	Characterised by massive sandy textured, porous, earthy soil materials with generally gradual boundaries. Commonly formed on better drained weathered sedimentary rocks and better drained and/or younger Quaternary alluvium. Earthy sands are characterised by uniform profiles of coherent, clayey sands that are dominantly red in colour but in some cases yellow. These soils are usually deep and are characterised by uniform sand texture and a massive, single-grained structure.
Alluvial soils	Recent alluvium	Mostly associated with watercourses. Comprise alluvial sands, silts and clays with little or no soil profile development. Exhibit significant variations in engineering character from soft/loose to stiff/dense.

Acid sulfate soils and rock

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. This increase in acidity can result in the mobilisation of aluminium, iron and manganese from the soils. Acid sulfate soils are widespread around coastal regions and are also locally associated with saline sulfate-rich groundwater in some agricultural areas, or with freshwater wetlands.

The CSIRO Australian Soil Resource Information System indicates that there is either a low probability or no known occurrence of acid sulfate soils within most of the proposal site, except around the Macquarie, Castlereagh and Namoi rivers, which are mapped as having a high probability of acid sulfate soils.

Acid sulfate rock, which is defined as rock that contains sulfide or sulfate minerals (commonly pyrite), also has the potential to oxidise when exposed to produce sufuric acid. Acid sulfate rock is present where the sulfide bearing rock that has previously been protected from weathering, or is below the water table, becomes exposed, such as in deep earthwork cuttings.

Sedimentary pyrite is a common constituent of organic-rich, typically fine-grained marine and anoxic terrestrial sediments. Sedimentary rocks formed in deep marine environments, coal measures and some igneous rock types are typical examples of where acid sulfate rock material may be encountered; however, low concentrations of sulfide or sulfate mineral can also be present in sandstone.

To date, no occurrences of acid sulfate rock have been documented along the proposal site. The bedrock along the proposal is typically deeply weathered, with groundwater at depth, and therefore any acid sulfate that may once have been present is most likely to have already oxidised. Additionally, no deep earthwork cuttings are proposed as part of the proposal, with the exception of the borrow pits. On this basis, the potential for encountering acid sulfate rock during the construction of this proposal is considered to be low and has not been considered further.

Another potential source of acid is monosulfidic black ooze, which are gels associated with soils that contain high concentrations of heavy metals. Monosulfidic black ooze forms when there is a combination of acid sulfate runoff, carbon (from plants) and a low-flow environment, which is why it is commonly found in drains in coastal areas. It has been identified in the Macquarie Marshes wetlands as well as in drains in inland areas affected by salinity and has the potential to occur in waterways in acid sulfate and saline areas (RTA, 2005). Due to the location and construction methodology, these sources present a low risk to the proposal.

Saline soils

Soils can become saline when water tables rise and bring salt to the surface. This can occur as a result of weathering of rocks containing salt, use of saline irrigation water, or proximity to marine environments. 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.

Areas prone to salinity are usually at low positions in the landscape, such as in valley floors and along floodplains.

Salinity has the potential to damage foundations of infrastructure, make soils unsuitable for reuse as fill, and may affect landscaping. Saline soil and water have the potential to damage concrete and metal structures, including bridge piers and foundations. Sodic soils are innately unstable, exhibiting poor physical and chemical properties that can impede water availability and infiltration, ultimately impacting plant growth.

The review of hydrogeological landscape mapping identified the following areas in the proposal site as having either high salinity or sodicity hazard:

- Armatree to Baradine (extent of the mapped area)—moderate to high salinity hazard
- Near Narromine, Curban and Pine Grove/Teridgerie—high sodicity hazard
- Near Tonderburine—very high sodicity hazard.

All other areas of the proposal site were classified as having low to moderate salinity or sodicity hazard.

This is consistent with the results of the geotechnical investigations, which noted that colluvial soils, residual soils and extremely weathered materials across the proposal site are generally sodic to highly sodic.

B4.2.3 Potential for contamination

Searches of the databases listed in section B4.1.2 identified the following:

- No sites listed on NSW EPA's contaminated land record or NSW EPA's record of notices are located within 500 m of the proposal site
- No sites listed on ARTC's contaminated sites register are located in proximity to the proposal site
- A search of the NSW Department of Primary Industries cattle dip site locator did not identify any cattle dip structures within the proposal site, and none were identified during the site visits
- A search of the Department of Defence's UXO Mapping Application identified no unexploded ordinance within 1 km of the proposal site
- A review of NSW EPA's environment protection licence records identified five sites located within 500 m of the proposal site that either currently have, or have previously held, environment protection licences. These sites are listed in Table B4.2 and shown in Figure B4.1.

The Narrabri Landfill is also listed on the Department of Agriculture, Water and the Environment's National Waste Reporting Mapping Tool (Narrabri Refuse Depot). In addition, a review of Crown land licences relevant to land near the proposal site noted that the land denoted by lot 21, 44, 48, 128 and 155 of DP 757093 was historically used for landfilling. This site is located on the northern side of Yarrie Lake Road, directly opposite the existing Narrabri Landfill.

TABLE B4.2 SITES WITH CURRENT OR SURRENDERED ENVIRONMENT PROTECTION LICENCES

Site name and address	Licence holder and Licence No.	Activity	Status	Location in relation to proposal site
Narrabri Sewage Treatment Works Newell Highway, Narrabri, NSW	Narrabri Shire Council Licence no. 200	Sewage treatment processing by small plants	Current	Located directly adjacent and within the proposal site
Narrabri Landfill Yarrie Lake Road, Narrabri, NSW (Dump Road)	Narrabri Shire Council Licence no. 312193	Waste disposal by application to land Waste storage—waste tyres	Current	About 450 m west
Narrabri Gas Fields X Line Road, Narrabri, NSW	Santos NSW Licence no. 20350	Petroleum exploration, assessment and production	Current	Located within and around the proposal site
Santos Narrabri Operations Centre 300 Yarrie Lake Road, Narrabri, NSW	Santos NSW Licence no. 20378	Non-thermal treatment of hazardous and other waste Waste storage—hazardous, restricted solid, liquid, clinical and related waste and asbestos waste	Current	About 50 m west Located directly adjacent to the Narrabri West multi-function compound
Gilgandra Sewage Treatment Works Chelmsford Avenue, Gilgandra, NSW	Gilgandra Shire Council Licence no. 4640	Sewage treatment processing by small plants	Current	About 800 m north-east of the Gilgandra temporary accommodation facility
Narromine Treatment Works Dandaloo Road, Narromine, NSW	Narromine Shire Council Licence no. 11762	Sewage treatment processing by small plants	Surrendered (April 2006)	About 200 m west

Based on the desktop assessment and site visit, a number of existing land uses or sites within or near the proposal site have been identified as having a risk of contamination. These land uses/sites are listed in Table B4.3. Of these, only the locations of existing railways and rail infrastructure and the Santos Narrabri Operations Centre were identified as having a high risk of contamination.

TABLE B4.3 LAND USES OR SITES WITH CONTAMINATION RISK

Land use	Potential location relevant to proposal site	Potential contamination sources	Potential contaminants present
Dams	Throughout the proposal site	Contaminated sediments and water in dams due to use of agricultural chemicals and livestock grazing within the dam catchments. Contamination is likely to be isolated and it is unlikely that soils surrounding dams would be affected.	Heavy metals, hydrocarbons (TRH, BTEX), herbicides, pesticides and micro-biological organisms
Degraded road surfaces	Throughout the proposal site	Bitumen, asphalt or tar-based materials in degraded road surfaces that could impact adjacent surface soils and runoff. Contamination associated with degraded road surfaces is likely to be relatively isolated to surface soils and flow paths immediately underlying and surrounding existing roads.	Hydrocarbons (TRH, BTEX, PAH)
Existing railways and rail infrastructure	Northern and southern ends of proposal site and at existing rail connections	Contaminated surface soils and drainage paths adjacent to interchanges, intersections with existing roads and other stoppage points, due to leaks, brake pad use, etc. Contamination associated with existing railways and rail infrastructure is likely to be relatively isolated to the fill materials, ballast and surface soils immediately adjacent to existing infrastructure; however, the likelihood of encountering contamination at these locations is considered to be high.	Heavy metals, hydrocarbons (TRH, BTEX, PAH), herbicides, pesticides and asbestos
Buildings and/or chemical storages including dwellings, storage, sheds and commercial buildings	Throughout the proposal site	Contaminated surface soils impacted by hazardous materials used in construction, chemicals stored within buildings or pesticides used for pest control. Contamination associated with buildings and chemical storage is likely to be relatively isolated to surface soils surrounding the structures.	Heavy metals, hydrocarbons (TRH, BTEX, PAH), pesticides and asbestos
Wastes and waste infrastructure, including waste stored on private properties or illegally dumped waste (generally building material) as well as existing or historic landfill sites	Throughout the proposal site Narrabri Landfill and historical landfill on Yarrie Lake Road Narrabri (about 450 m west)	Contaminated soils and groundwater and potential landfill gas/vapours due to the presence of, or leaching from, organic waste, or the presence of hazardous materials. There is potential for groundwater underlying the proposal site to be leachate impacted from adjacent landfills. There is also the potential for landfill gas to migrate towards the proposal site (depending on geological conditions); however, given the distance to the Narrabri landfill and historical landfill the likelihood of encountering contamination in the form of landfill gas is considered low. Contamination associated with illegal dumping or waste on private properties is likely to be relatively isolated to the surface soils immediately surrounding the wastes; however, given the findings of the site visit, the potential to encounter illegal waste dumps is considered high.	Heavy metals, hydrocarbons (TRH, BTEX, PAH), volatile and semi-volatile organic compounds (VOC and SVOC) pesticides, polychlorinated biphenyls (PCBs), asbestos, nutrients, micro-biological organisms and methane

Land use	Potential location relevant to proposal site	Potential contamination sources	Potential contaminants present
Commercial and industrial premises/facilities including large-scale grain and food storage, sales yards, speedways, mechanics and smash repairers	Located around major townships at northern and southern end of the proposal site (Narromine and Narrabri)	Contaminated surface soils due to leaks and spills associated with the storage and management of chemicals. Contamination from historical and current commercial and industrial activities, if present, is likely to be isolated to surface soils and soils immediately surrounding each site/premises.	Heavy metals, hydrocarbons (TRH, BTEX, PAH), VOC and SVOC, pesticides and PCBs
Old houses/dwellings and sheds	Throughout the proposal site	Asbestos and lead-based paints that could impact surface soils due to the inappropriate demolition and/or degradation of building materials. Contamination associated with hazardous building materials is likely to be relatively isolated to the surface soils immediately surrounding former and current structures.	Heavy metals (Pb) and asbestos
Airports, RAAF bases and fire stations/rural fire service facilities	Narromine Airport (about 320 m north-west of the Narromine west connection) Gilgandra Aerodrome (about 430 m north-west of the Gilgandra temporary accommodation facility) and the Euromedah Rural Fire Brigade (within the proposal site)	Contaminated soils and groundwater due to the historical use of firefighting foams and liquids for training exercises and fire suppression. There is potential for groundwater underlying the proposal site to be contaminated; however, as the Euromedah Rural Fire Brigade was constructed after 2008, it is unlikely that the site has had significant long-term storage or use of firefighting foams.	Per-and poly-fluoroalkyl substances (PFAS)
Water treatment and sewage treatment plants/works.	Narrabri Sewage Treatment Works (immediately adjacent to the proposal site) The Narrabri Gas Project—Santos Leewood Facilities water treatment plant (immediately adjacent to the proposal site) Gilgandra Sewage Treatment Works (about 310 m north-east of the proposal site) Narromine Treatment Works (about 200 m west of the proposal site)	Contaminated soils and groundwater due to the improper storage of waste and chemicals and irrigation of treated effluent. Contamination associated with the application of effluent to surface and sub-surface soils in the proposal site is likely to be relatively isolated to areas immediately adjacent to the facilities and not widespread.	Heavy metals, hydrocarbons (TRH), PFAS, nutrients and micro-biological organisms
Petroleum or chemical storage facilities and distribution	Trangie Road, Narromine (BP fuel station and Inland Petroleum fuel station on Trangie Road, Narromine (about 640 m north-east of the Narromine West Connection) Santos Narrabri Operations Centre (directly adjacent)	Contaminated soils and groundwater due to the improper storage and handling of chemicals and petroleum products. Contamination from petroleum or chemical storage, if present, is likely to be isolated to soils and groundwater immediately surrounding each site/premises; however, given the proximity of the Santos Narrabri Operations Centre, the potential to encounter contamination associated with this site is considered high.	Heavy metals, hydrocarbons (TRH, BTEX, PAH) and VOCs

Land use	Potential location relevant to proposal site	Potential contamination sources	Potential contaminants present
Agricultural activities	Throughout the proposal site	Contaminated soils and groundwater due to the use of agricultural chemicals, chemical storage (e.g. pesticides, fuels), disposal of farm wastes, livestock burial areas and livestock grazing; however, contamination is likely to be diffuse in nature (e.g. low-level pesticide use over large areas) or sporadic and localised.	Contaminants of concern could include heavy metals, hydrocarbons (TRH, BTEX), herbicides, pesticides and micro-biological organisms

Samples collected as part of the preliminary soil and contamination assessment found no visual or olfactory evidence of contamination in any of the test pits or boreholes.

All samples except one had laboratory results either below the limit of reliability or below the nominated human health and ecological criteria.

The sample collected from the illegal waste dump location (sample CS-21) recorded the presence of chrysotile, amosite and crocidolite asbestos. This sample consisted of fibre cement sheet; and was collected during the site inspection from an illegal waste dump consisting of building materials located in Pilliga East State Forest on Pilliga Forest Way, directly adjacent to the proposal site.

Based on the findings of the desktop review, site inspection and preliminary contamination assessment, no evidence of gross or widespread contamination was identified within soils in the proposal site.

B4.3 Impact assessment—construction

Excavation and ground disturbance activities would expose and disturb soils. If not adequately managed, this could result in:

- Erosion of exposed soil and stockpiled materials
- Dust generation
- An increase in sediment loads entering the stormwater system and/or local runoff, and therefore nearby receiving waterways
- Increase in salinity levels in soil
- Acid sulfate soil conditions
- Mobilisation of contaminated sediments, with resultant potential for environmental and human health impacts.

Potential impacts as they relate to soils and contamination are considered below. Potential water-quality impacts, including impacts caused by increased sediment loads, are considered in chapter B5. Air quality (dust) impacts are considered in chapter B10.

B4.3.1 Soils

Soil erosion

Construction would temporarily expose the natural ground surface and sub-surface through the removal of vegetation, overlying structures (such as existing roads) and excavation. The exposure of soil to runoff and wind can increase soil erosion potential, particularly where construction activities are undertaken in soil landscapes characterised by dispersive soils, given their susceptibility to erosion. As noted in section B4.2.2, dispersive soils are present in the majority of the proposal site. The potential for erosion impacts would be minimised by implementing standard best-practice soil erosion management measures during construction (see section B4.5).

Acid sulfate soils

The exposure of acid sulfate soils to oxygen during disturbance can lead to the generation of sulfuric acid. The subsequent acidic leachate can then lead to mobilisation of heavy metals such as aluminium and iron into water bodies. Drainage from acid sulfate soils may affect water quality and can impact aquatic organisms.

Acid sulfate soils may be encountered during piling for bridge piers near the Macquarie, Castlereagh and Namoi rivers. Further investigations would be undertaken within these areas during detailed design. The investigations would also consider the potential for the presence of monosulfidic black ooze.

Soils excavated or exposed from potential acid sulphate areas would be subject to the provisions of an acid sulfate soil management plan. Once acid sulfate soils have been treated, depending on the results of testing, they could either be reused onsite, or disposed of at an appropriate facility.

Salinity

Excavation would be undertaken in areas with high salinity or sodicity hazard as noted in section B4.2.2. In addition, construction may disturb soils in areas with unidentified salinity potential.

High salinity soil can reduce or preclude vegetation growth and produce aggressive soil conditions, which may be detrimental to concrete and steel. Impacts may also occur as a result of the erosion and offsite transport of saline sediments, resulting in impacts on the receiving environment.

The potential for impacts due to the presence of saline soils is considered to be low. Any potential impacts would be temporary and managed by implementing standard best-practice erosion and sediment control measures. Soils associated with areas of high salinity potential would be considered during detailed design. Management measures would be developed and implemented, as appropriate, to minimise impacts associated with salinity.

B4.3.2 Contamination

As described in section B4.2.3, potentially contaminating land uses are present along and in the vicinity of the proposal site. Exposure or disturbance of contaminants may have the following potential for impacts:

- Direct contact and/or inhalation by site workers, users and visitors
- Impacts on surrounding environmental receivers (including surrounding ecosystems and flora and fauna, where present)
- Mobilisation and migration of surface and subsurface contaminants via leaching, runoff and/or subsurface flow, impacting nearby soils, surface water and groundwater.

The findings of the desktop assessment and preliminary soil and contamination assessment indicates that generally where there is the potential for contamination to be present, it would likely be localised or diffuse.

As noted in section B4.2.3, no evidence of contamination was reported in representative soil samples collected from areas of potential contamination as per those identified in Table B4.3; therefore, there is considered to be a low potential for gross contamination within the proposal site. Prior to the disturbance of areas identified to have high potential for contamination (described in section B4.2.3), however, further investigation and testing would be undertaken to determine the likely risk and appropriate management protocols. This may include the requirement for remediation in certain areas.

Unexpected soil contamination could also be encountered, the evidence of which could include:

- Unexpected staining or odours
- Potential asbestos-containing materials
- Unexpected underground storage tanks, buried drums or machinery, etc.

The potential for impacts due to the potential disturbance of contamination would be minimised by implementing the mitigation measures in section B4.5.

Construction has the potential to result in the contamination of soil and groundwater due to spills and leaks of fuel, oils and other hazardous materials. In addition, there is the potential to introduce contamination to the proposal site through the acceptance of imported fill that has not been properly verified. These potential impacts would be minimal with the implementation of standard mitigation measures, provided in section B4.5.

Hazardous materials

The removal of buildings and structures, such as sheds, on land that is required for the proposal may result in disturbance of hazardous materials. Mishandling of hazardous material waste has the potential to contaminate soils. Mitigation measures are provided in section B4.5 to minimise the potential impacts of hazardous materials.

Site assessment and remediation

The preliminary soil and contamination assessment confirmed that the soils are considered suitable to remain within the proposal site for the uses proposed (rail and road corridor); however, it should be noted that sampling was not undertaken in accordance with the *Contaminated Sites Sampling Design Guidelines* (EPA, 1995) given the size of the proposal site. Therefore, the findings of the assessment can only be used to determine the presence of gross contamination within the proposal site.

Further assessment would be undertaken at locations identified as having a high potential for contamination (at the connections with existing rail lines and adjacent to the location of the Santos Narrabri Operations Centre) to confirm the extent of contamination and identify appropriate management and remediation requirements. Requirements for remediation would be driven by the site-specific exposure scenarios and environmental risk.

Where contamination cannot be managed appropriately in accordance with standard construction processes, a remediation action plan would be developed, and an EPA accredited site auditor may be engaged to audit the works, in accordance with the *Guidelines for the NSW Site Auditor Scheme (3rd edition)* (EPA, 2017b). Triggers for a remediation action plan and the involvement of an auditor include the following:

- The contamination is highly complex, e.g. significant groundwater contamination or contamination associated with vapour
- Specialised remediation techniques are required to remediate the contamination
- The contamination requires ongoing active management during and beyond construction.

B4.4 Impact assessment—operation

B4.4.1 Soil

Soil erosion and sediment transport

There is potential for recently disturbed soils to be susceptible to erosion, particularly during initial periods of landscaping and re-establishment of vegetation. This may occur in areas where planting is proposed, including adjacent to disturbed areas, along embankments and in the reinstatement of temporary ancillary facilities where topsoil is settling and vegetation is establishing. Temporary soil stabilisation may be required immediately following construction, to prevent potential erosion, topsoil loss or soil migration. This is particularly likely to be required following severe storms. A rehabilitation strategy would be prepared to guide the approach to rehabilitation of disturbed areas and would include requirements for ongoing monitoring following the establishment of these areas, as described in section B4.5.

Operation is not likely to result in any significant impacts on soils, topography or geology. The risk of soil erosion during operation would be minimal, as all areas impacted during construction would be sealed or rehabilitated and landscaped to prevent soil erosion. Maintenance activities involving ground disturbance would be undertaken in accordance with ARTC's standard operating procedures.

During operation, erosion of dispersive soils from activities not associated with the proposal could result in silting of drainage infrastructure, including culverts. To manage this potential operational impact, dispersive soils would be treated where exposed in cut batters, culvert crossings and drainage lines. Additional impacts from unsuitable soils would be minimised by taking soil types into consideration during design and construction.

Acid sulfate soils

Operation would not impact on acid sulfate soils. Maintenance activities would be unlikely to involve ground disturbance activities of sufficient depth to encounter acid sulfate soils.

Salinity

Operation is not expected to impact the salinity levels of the proposal site. Maintenance activities would be unlikely to involve ground disturbance activities of sufficient magnitude to increase water infiltration resulting in erosion and offsite transport of saline sediments, particularly with the implementation of standard best-practice erosion and sediment control measures.

Salinity and potential effects on the durability of infrastructure would be considered further during detailed design.

B4.4.2 Contamination

Operation has the potential to contaminate soil and groundwater from leaks and spills of fuel, oils and other hazardous materials during maintenance activities; however, the risk of this potential impact is considered to be low, given the likely scale and duration of maintenance activities.

This potential impact would be minimised by implementing ARTC's existing procedures to handle dangerous goods and hazardous materials, and to manage spills.

B4.5 Mitigation and management

B4.5.1 Approach

Approach to mitigation and management

Approach to managing the key potential impacts identified

The key approach to managing soils during construction would involve preparing a soil and water management plan as part of the CEMP in accordance with mitigation measure WR6 (see section B2.5). The plan would define the processes, responsibilities and erosion and sediment control measures that would be implemented during construction (in accordance with the Blue Book).

To confirm the risk of contamination and associated management requirements, intrusive soil investigations would be undertaken within the proposal site at those locations identified as having a high potential for contamination due to existing land uses. These are the connections with existing rail lines and adjacent to the Santos Narrabri Operations Centre.

The potential for contamination impacts would also be managed by preparing and implementing a contamination and hazardous materials plan as part of the CEMP. This plan would detail how potential and actual contaminated soils and materials would be managed to minimise the potential for onsite and offsite impacts.

Further information on the CEMP is provided in chapter D5. The requirements for the plans that form part of the CEMP are described in Appendix I.

Site-specific analysis would be undertaken during detailed design to inform how issues associated with constructing infrastructure in dispersive and saline or sodic soils would be managed, including appropriate treatment measures (as required). Design documents would specify construction procedures to identify and address 'unsuitable' subgrade soils.

As described in section A8.7, a rehabilitation strategy would be prepared to guide rehabilitation planning, implementation, monitoring and maintenance of disturbed areas. The strategy would include measures to immediately stabilise and provide for the long-term rehabilitation of areas disturbed by construction. This would assist in minimising the potential for soil and erosion impacts.

Approach to managing other impacts

An unexpected finds protocol would be developed as part of the contamination and hazardous materials plan to ensure that any unexpected contamination encountered during construction does not expose workers, site users, and/or the environment to contamination in excess of regulatory guideline levels. The unexpected finds protocol would outline the activities to be undertaken in the event that previously undetected contamination is identified, which would include making the site safe, carrying out an assessment of the finds, and managing the finds based on the results of the assessment.

Hazardous material surveys would be undertaken for structures to be removed.

Other impacts would be managed by implementing the measures provided in section B4.5.2.

Expected effectiveness

Erosion and sediment control measures would be implemented in accordance with the requirements of the Blue Book. The measures contained in the Blue Book are based on field experience and have been previously demonstrated to be effective. In general, implementing measures in accordance with the Blue Book would reduce the potential for the impact to be realised (by using controls such as hay bales, covers on stockpiles, etc.) or enable the impact to be avoided completely (e.g. by not undertaking works during wet weather). As a result, the proposed mitigation measures are expected to be effective.

In relation to potential impacts associated with contamination, implementing the proposal measures (including the unexpected finds protocol and spill procedures) would reduce the potential for impacts.

Interaction between measures

A waste management plan would also be developed as part of the CEMP (see chapter D2). The waste management plan would include an asbestos-management component to ensure waste materials that contain asbestos are appropriately managed.

Measures to control impacts associated with soil and contamination may overlap with measures proposed for the control of potential air quality, water quality and waste-management impacts. All measures for the proposal would be consolidated and described in the CEMP. The plan would identify measures that are common between different aspects. Common impacts and common mitigation measures would be consolidated to ensure consistency and implementation.

B4.5.2 List of mitigation measures

Measures that will be implemented to address potential soils and contamination impacts are listed in Table B4.4.

TABLE B4.4 SOILS AND CONTAMINATION MITIGATION MEASURES

Stage	REF	Impact/issue	Mitigation measure
Detailed design/ pre-construction	SC1	*Structural integrity*	Foundation and batter design would include engineering measures to minimise operational risks from shrink swell, dispersive and/or low-strength soils.
	SC2		Soil salinity would be considered in the design of subsurface structures.
	SC3	*Acid sulfate soils*	Prior to ground disturbance in high probability acid sulfate areas, testing would be carried out to determine the presence of acid sulfate soils. If acid sulfate soils are encountered, they would be managed in accordance with the *Acid Sulfate Soil Manual* (Acid Sulfate Soil Management Advisory Committee, 1998), and the *Waste Classification Guidelines—Part 4: Acid Sulfate Soils* (NSW EPA, 2014a).
	SC4	*Contamination*	Hazardous materials surveys would be undertaken during detailed design for all proposed demolition activities.
	SC5		An appropriately licensed asbestos removal contractor would be engaged to remove all asbestos identified at the illegal waste dump at which sample CS-21 was collected (easting 737305, northing 6617403) prior to works commencing. Asbestos would be removed in accordance with the requirements of applicable work health and safety legislation and codes of practice.
	SC6		Site investigations would be undertaken by a suitably qualified and experienced consultant, as defined in Schedule B9 of the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPC, 2013) to assess exposure risks to site workers and other receptors as a result of disturbances to the following areas considered to be at a higher risk of being contaminated: ▸ Narromine West connection ▸ Parkes to Narromine connection ▸ Dubbo to Coonamble Line connection ▸ Narrabri to Walgett Line connection ▸ Narrabri to North Star connection ▸ Where the proposal site borders the Santos Narrabri Operations Centre (directly west of the Narrabri West multi-function compound). The results of the site investigations would be assessed against the criteria contained within the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPC, 2013) to determine the need for any remediation.

Stage	REF	Impact/issue	Mitigation measure
Construction	SC7	*General soil and erosion management*	The soil and water management plan (mitigation measure WR6) would include erosion and sediment controls appropriate for dispersive soils.
	SC8	*Contamination*	A contamination and hazardous materials plan would be prepared and implemented as part of the CEMP. It would include measures, processes and responsibilities to minimise the potential for contamination impacts on the local community, workers and environment, and procedures for incident management and managing unexpected contamination finds (an unexpected finds protocol).
	SC9	*Rehabilitation*	Disturbed areas would be rehabilitated following construction in accordance with the rehabilitation strategy (mitigation measure BD11).
Operation	SC10	*Soil erosion and sedimentation*	During any maintenance work where soils are exposed, sediment and erosion control devices would be installed in accordance with *Managing Urban Stormwater: Soils and Construction, Volume 1* (Landcom, 2004).
	SC11	*Contamination*	ARTC's existing spill response procedures would be reviewed to determine applicability and suitability during operation. The adopted procedure would include measures to minimise the potential for impacts on the local community and the environment as a result of any leaks and spills.

B4.5.3 Managing residual impacts

Residual impacts are impacts of the proposal that may remain after implementation of:

- Design and construction planning measures to avoid and minimise impacts (see sections A7.2 and A8.1)
- Specific measures to mitigate and manage identified potential impacts (see sections B4.5.1 and B4.5.2).

The key potential soils and contamination issues and impacts originally identified by the environmental risk assessment (see section A9.1) are listed in Table B4.5. The (pre-mitigation) risks associated with these impacts, which were identified by the environmental risk assessment, are provided. Further information on the approach to the environmental risk assessment, including descriptions of criteria and risk ratings, is provided in section A9.1.

The potential issues and impacts identified by the environmental risk assessment were considered as part of the soils and contamination impact assessment, summarised in sections B4.3 and B4.4. The mitigation and management measures (listed in Table B4.4) that would be applied to manage these impacts are also identified. The significance of potential residual impacts (after application of these mitigation measures) is rated using the same approach as the original environmental risk assessment. The approach to managing significant residual impacts (considered to be those rated medium or above) is also described.

TABLE B4.5 RESIDUAL IMPACT ASSESSMENT—SOILS AND CONTAMINATION

Assessment of Pre-mitigated risk (see section A9.1 and Appendix E)					Mitigation measures (see Table B4.4)	Residual impact assessment			
Phase	**Potential impacts**	**Likelihood**	**Consequence**	**Risk rating**		**Likelihood**	**Consequence**	**Risk rating**	**How residual impacts will be managed[1]**
Construction	Erosion as a result of the disturbance of soils during construction, particularly in soil landscapes characterised by dispersive soils, given their susceptibility to erosion	Likely	Moderate	High	SC7 and SC9	Possible	Not significant	Low	n/a
	Contamination of soils/ groundwater due to spills and leaks during construction	Possible	Moderate	Medium	SC8	Unlikely	Minor	Low	n/a
	Exposure of acid sulfate soils or saline soils and subsequent erosion	Possible	Moderate	Medium	SC3 and SC7	Possible	Not significant	Low	n/a
	Potential to disturb hazardous materials during the removal of buildings and structures	Possible	Moderate	Medium	SC4	Rare	Moderate	Low	n/a
	Potential to disturb contaminated soils during construction and mobilise contamination	Possible	Moderate	Medium	SC6 and SC8	Rare	Moderate	Low	n/a
Operation	Erosion during operation and during maintenance works	Possible	Moderate	Medium	SC10	Rare	Moderate	Low	n/a

Note: 1. For residual impacts with a risk rating of medium or above.