CHAPTER 09

INLAND RAIL

Land Resources

CALVERT TO KAGARU ENVIRONMENTAL IMPACT STATEMENT

ARTC

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9.1 Scope of chapter

The purpose of this chapter is to provide an assessment of the Calvert to Kagaru Project's (the Project) impact on land resources. This assessment includes an evaluation of the existing environment to identify and assess the risks arising from the disturbance and excavation of land and the disposal of soil or unsuitable spoil material. The assessment includes contaminated land, important agricultural areas (IAA) and soil properties. The existing environment for the Project was investigated through a desktop assessment of existing available information. Field assessments of soil for salinity, acid sulfate soils (ASS), sodic, dispersive and cracking clay soils were undertaken to provide input to the assessment.

A quantitative compliance risk assessment was undertaken for soil properties, including agricultural and problematic soils. A qualitative risk assessment of contaminated land and any risks that this may present from a construction or operational perspective was also undertaken.

9.2 Terms of Reference

The Terms of Reference (ToR) describe the matters the proponent must address in the Environmental Impact Statement (EIS) for the Project and are detailed in Table 9.1.

TABLE 9.1: TERMS OF REFERENCE COMPLIANCE TABLE—LAND RESOURCES

Terms of Reference requirements		Where addressed
Topography, geology and soils		
10.4	Describe and illustrate the topography of the preferred alignment and surrounding area, and highlight any significant features shown on the maps. Include and name all waterways, including watercourses, rivers and creeks. Maps should include a scale and have contours at suitable increments relevant to the scale, location, potential impacts and type of project, shown with respect to Australian Height Datum (AHD) and drafted to GDA94.	Section 9.5.1.1 and Figure 9.3
10.6	Where relevant, describe and map in plan and cross-sections the geology and landforms, including catchments, of the project area. Show geological structures, such as aquifers, faults and economic resources (such as coal, mineral and petroleum resources, agricultural products and KRAs) that could have an influence on, or be influenced by, the project's activities.	Section 9.5.1.2, Figure 9.4 and Figure 9.5
10.7	Where relevant, describe, map and illustrate soil types and profiles of the project area at a scale relevant to the proposed project. Identify soils that would require particular management due to wetness, erosivity, depth, acidity, salinity, contamination or other relevant features.	Section 9.5.4 and Figure 9.6–Figure 9.13
11.46	Undertake a salinity risk assessment in accordance with Part B of the Salinity Management Handbook, Investigating Salinity. In particular, consider how the project will change the hydrology of the project area and provide results of the risk assessment.	Sections 9.5.4.5, 9.6.5 and Figure 9.8–Figure 9.13
11.48	Describe appropriate management and mitigation strategies and provide contingency plans for: a) Management of acid sulfate soils and acid producing rock and associated leachate from excavations and disturbed areas.	Sections 9.5.4.3 and 9.7
11.51	Where a salinity risk is identified, detail strategies to manage salinity ensuring the development must be managed so that it does not contribute to the degradation of soil, water and ecological resources or damage infrastructure via expression of salinity. See Part C of the Salinity management handbook second edition, Department of Environment and Resource Management 2011.	Sections 9.5.4.5 and 9.7.2

Terms of Reference requirements		Where addressed
11.80	Describe the potential impact of the construction and operation of the project on existing land uses and land uses permitted under the relevant planning scheme along the preferred alignment and adjacent areas including impacts on Council assets and KRAs. Discussion in relation to KRAs (particularly KRA No. 82 Purga) should describe the: a) Geological properties that may influence ground stability (including seismic activity), and how this might compromise rail infrastructure and operation over short and long-term time horizons	Section 9.5.1.2, Figure 9.4 and Figure 9.5
11.90	The assessment of impacts on topography, geology and soils will be in accordance with the DEHP Information guideline for an environmental impact statement – Land and the CSIRO guidelines – Guidelines for surveying soil and land resources and Australian soil and land survey field handbook.	Sections 9.4, 9.5.4 and 9.6
11.91	Discuss the project's impacts on Important Agricultural Areas as per the SPP – state interest guideline – Agriculture with reference to Agricultural Land Use and Property Categories under the Queensland Agricultural Land Audit methodology.	Sections 9.5.5 and 9.6.2 Chapter 8: Land Use and Tenure, Sections 8.5.2.1 and 8.6.2.1
11.92	Identify and investigate areas of salinity, acid sulfate soils, sodic, dispersive and cracking clay soils and potential and actual areas of acid sulfate soils. Where potential areas are identified, further investigations (including field surveys) should be undertaken in accordance with accepted industry guidelines and the requirements of the relevant SPP – state interest guideline – Water quality are followed.	Sections 9.5.4 and 9.7
11.93	Provide details, including maps, of the location of project works/infrastructure with respect to soil conservation works (contour banks, waterway discharge points, etc.)	Section 9.5.6.1
11.94	Identify activities or operations likely to impact soil conservation property plans approved under the *Soil Conservation Act 1986*.	Section 9.5.6.1
11.95	Measures to avoid or mitigate potential impacts of the project on soil values must be described.	Section 9.7
Land contamination		
11.161	Detail any known or potential sources of contaminated land within or adjoining the project area, including the location of any potential contamination identified by landholders. Provide results of searches of the Environmental Management Register (EMR) and/or the Contaminated Land Register (CLR) under the *Environmental Protection Act 1994* for the preferred rail alignment and disturbance areas.	Section 9.5.7 and Appendix H: EMR Searches and Lab Certificates
11.162	Provide a description of the nature and extent of contamination at identified site(s).	Sections 9.5.7 and 9.5.8
11.163	Describe the proposed management of any contaminated land either previously identified or encountered during construction activities and the potential for contamination from construction, commissioning, operation and decommissioning.	Sections 9.7 and 9.7.2.1 Appendix V: Spoil Management Strategy, Section 2.2.2
11.164	Describe strategies and methods to be used to prevent, manage or remediate any land contamination resulting from the project, including but not limited to the management of any acid generation or management of chemicals and fuels to prevent spills or leaks.	Sections 9.7 and 9.7.2.1 Appendix V: Spoil Management Strategy, Section 2.2.2
11.165	Describe how the presence of any known potential unexploded ordnance will be identified on maps of an appropriate size and scale and assessed within or adjoining the project area. Describe how any known or potential unexploded ordnance will be managed.	Sections 9.5.7 and 9.7

9.3 Legislation, policy, standards, and guidelines

The land resources assessment presented in this chapter was undertaken in accordance with the legislation, policies, standards and guidelines presented in Table 9.2, which are intended to protect and manage land resources. Further information on legislation, policies, standards and guidelines relevant to the Project are in Chapter 3: Project Approvals.

TABLE 9.2: REGULATORY CONTEXT

Legislation, policy or guideline	Relevance to the Project
Commonwealth	
National Environment Protection (Assessment of Site Contamination) Measure 1999 (Cth) (ASC NEPM)	The *Assessment of Site Contamination National Environment Protection Measure* (ASC NEPM) is the national guidance document for the assessment of site contamination in Australia, which aims to establish a nationally consistent approach to assess site contamination to ensure sound environmental management practices are adopted. The desired outcome of ASC NEPM is to protect human health and the environment. Contaminated land in Queensland (QLD) is expected to be assessed in accordance with the processes and guidance detailed in the ASC NEPM. A Tier 1 desktop assessment of the land resources study area was undertaken for the Project.
Guidelines for Surveying Soil and Land Resources (McKenzie et al., 2008)	The *Guidelines for Surveying Soil and Land Resources* aims to promote the development and implementation of consistent methods for conducting soil and land resource surveys in Australia. The guideline provides information on how to best undertake field surveys to identify, describe, map and evaluate various soils or land resources. The Project considered the guidelines during the assessment of soil within the land resources study area.
Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain, 2009)	The *Australian Soil and Land Survey Field Handbook* provides specific methods and terminology for soil and land surveys. It is widely used throughout Australia to provide one reference set of definitions for the characterisation of landforms, vegetation, land surface, soil and substrate. The Project considered information provided in the handbook during the assessment of soil within the land resources study area.
State	
Environmental Protection Act 1994 (Qld) (EP Act)	The EP Act aims to protect Queensland's environment by legislating activities relevant to land resources including: - Soil testing activities - Contaminated land/soil management processes (including removal and treatment or disposal of contaminated soil) as well as grounds for including land on environmental registers. The Project traverses, or is in proximity to, environmentally relevant activities (ERAs) and Environmental Management Register (EMR) listed properties prescribed under the EP Act.
Environmental Protection Regulation 2019 (Qld)	The Environmental Protection Regulation 2019 regulates activities relevant to land resources including: - A prescribed process for soil testing - Regulatory requirement for activities involving ASS and acid producing rock - Prescribed management of contaminants and contaminated land.
Soil Conservation Act 1986 (Qld)	The *Soil Conservation Act 1986* governs the conservation of soil resources and the implementation of soil conservation measures by landholders for the mitigation of soil erosion. Under the Act, the Project will need to meet the requirements of the legislation with respect to soil conservation. The Project does not contain approved soil conservation plans (property or project) within the land resources study area.
Soil Conservation Guidelines for Queensland (Department of Science Information Technology and Innovation (DSITI, 2015)	The *Soil Conservation Guidelines for Queensland* provide information on soil degradation and practical tools for its prevention from water-based erosion. They also provide tools and techniques to remediate degraded areas. The Project does not contain approved soil conservation plans (property or project) within the land resources study area.

Legislation, policy or guideline	Relevance to the Project
State Planning Policy, State Interest Guideline, Agriculture (SPP) (Department of Infrastructure, Local Government and Planning (DILGP), 2016b)	The SPP was established by the QLD Government to define specific matters of State interest in land use planning and development. Agriculture is identified as a State interest within the SPP. Specifically, the resources on which agriculture depends are protected to support the long-term viability and growth of the agricultural sectors. Audit information has been used to support the identification and mapping of IAAs, and Agricultural Land Class A and B, which intersect the land resources study area.
Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines (Dear et al., 2014)	The management guidelines for ASS provide risk-based management measures, with a variety of 'preferred' or 'high-risk' strategies that can be used to manage documented ASS. If ASS is disturbed directly or indirectly during Project activities, an ASS Management Plan is required to be prepared. The technical manual was considered during the assessment of soil within the land resources study area.
Salinity Management Handbook, 2nd edition (Department of Environment and Resource Management (DERM), 2011)	The *Salinity Management Handbook* provides a guide to salinity processes, investigating salinity risks within landscapes, and developing integrated management strategies should saline soils be encountered. The technical manual was considered during the assessment of soil within the land resources study area.
Guidelines for Soil Survey along Linear Features (Soil Science Australia, 2015)	*Guidelines for Soil Survey along Linear Features* addresses soil survey techniques required for linear features, which are generally considered 10 m to 100 m wide, and include rail. The guideline identifies varying scales of soil mapping are required for different stages of a project. The guidelines recommend soil information for an environmental impact statement (EIS) to require a scale of 1:250,000, while for the construction stage of a project, a scale of 1:5,000 is considered more appropriate. The Project considered the scale of mapping required under the guideline for the assessment of soil within the land resources study area, at the current project stage (i.e. EIS).
Environmental Impact Statement Information Guideline—Land (DEHP, 2016d)	The QLD *Environmental Impact Statement Information Guideline—Land* describes information required to support applications for statutory approvals concerning land related matters. The guideline describes the information required for an EIS for land-related aspects such as topography, geology and geomorphology and description of soil, which are relevant to this Project.
Environmental Impact Statement Information Guideline—Contaminated Land (DEHP, 2016d)	The QLD EIS guideline for contaminated land describes the information required to support the EIS, including: ▶ Existing contamination, potential impacts and management measures to be implemented during the Project ▶ The extent to which Project activities would cause soil contamination, and how that would be managed ▶ The risks to human health and the environment posed by existing and potential soil contamination. The guideline also prescribes the information required should ASS be encountered during the Project.

9.4 Methodology

9.4.1 Assessment methodology

An assessment of land resources was undertaken to identify and assess the risks arising from the disturbance and excavation of land and the disposal of soil and spoil. The assessment was conducted in accordance with statutory requirements and guidelines identified for QLD as shown in Table 9.2, which included the *Guidelines for Soil Survey along Linear Features* (Soil Science Australia, 2015). The guideline recommends a 1:250,000 scale of soil mapping for characterisation of soil for an EIS.

Aspects of land resources that were assessed as part of the assessment included:

- Topography
- Geology
- ASS/acid rock
- Naturally occurring asbestos
- Saline, dispersive and reactive soils
- Erosion risk
- Contaminated land
- Agricultural land
- Unexploded ordnance (UXO).

The land resources assessment included a Tier 1 Preliminary Site Investigation (contaminated land assessment) (National Environment Protection Measure (NEPM), 2013). A Tier 1 Preliminary Site Investigation was undertaken to identify the potential for contamination within the EIS investigation corridor. This type of assessment is used to assess the potential for the land to pose a risk to ecological and human health receptors due to potentially contaminating activities. The assessment of contaminated land was conducted by a Suitably Qualified Person in accordance with the relevant Department of Environment and Science (DES) requirements.

Other information sources used for the assessment of existing conditions for land resources included:

- Detailed solid geology—QLD (Department of Natural Resources, Mines and Energy (DNRME), 2018a)
- Detailed surface geology—QLD (DNRME, 2018b)
- Atlas of Australian Soils (Northcote et al., 1960–68)
- Queensland Agricultural Land Audit (DAFF, 2013)
- Contour mapping (DNRME, 2017)
- Australian Soil Resource Information System (Commonwealth Scientific and Industrial Research Organisation (CSIRO), 2014)
- Department of Defence UXO mapping (2017)
- DNRME Soil Conservation Plans (under the *Soil Conservation Act 1986*) (DNRME, 2018c)
- Department of Environment and Science (DES) Contaminated Land Register (CLR) and EMR.

A geotechnical field assessment was undertaken as input to the design and assessment and included the drilling of boreholes for soil investigations, with three samples collected between depths of 0 m to 1.10 m below ground level at varying intervals, dependent on subsurface conditions (refer Figure 9.1). The three soil samples were analysed by a National Association of Testing Authorities (NATA) accredited laboratory, with further details of results provided in Section 9.5.4.1 and Table 9.4.

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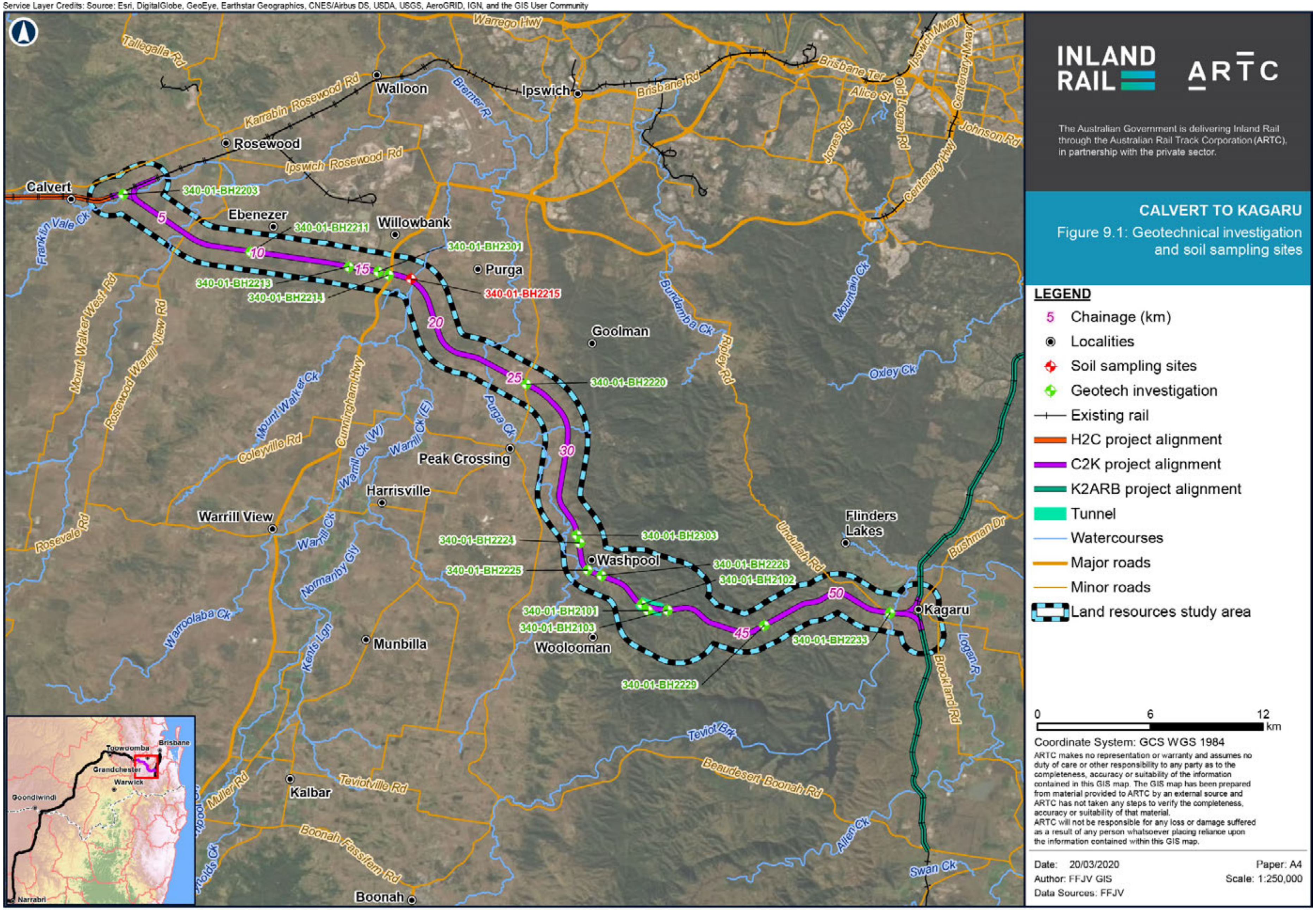

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Geotechnical investigations drilled 16 boreholes and analysed for a suite of analytes, including the following, which are relevant to this chapter:

- Moisture content (four tests performed)
- Particle size distribution (grading) (eight tests performed)
- Atterberg Limits and Linear Shrinkage (seven tests performed)
- Shrink/swell properties (one test performed)
- Emerson Class Number (six tests performed)
- Aggressivity Testing Suites (four tests performed).

In addition to the geotechnical assessment, soil samples were analysed for the following analytes:

- Sodium adsorption ratio
- Cation exchange capacity
- Exchangeable sodium percentage.

Laboratory results are included in Appendix H: EMR Searches and Lab Certificates.

The geotechnical field assessment, soil sampling and laboratory analysis has been used to inform the assessment of existing conditions for problematic soils (saline, dispersive and reactive) and erosion risks, and to supplement the desktop study undertaken using available information. The scope for sampling and analysis included only soil properties and not potential contaminants.

The desktop study and geotechnical field assessments have informed the assessment of potential impacts and development of appropriate mitigation measures, where required.

9.4.2 Land resources study area

The land resources study area is illustrated in Figure 9.2. This study area adopts the EIS investigation corridor, being an approximate 2 km wide study area, 1 km either side of the proposed rail alignment. The land resources study area includes the disturbance footprint, which encompasses all areas where works are proposed, including both permanent and temporary works, and land within a 1 km buffer either side of the proposed rail alignment.

The disturbance footprint includes:

- Permanent disturbance footprint: the rail corridor, which includes the rail tracks and associated infrastructure as well as other permanent works associated with the Project (e.g. where changes to the road network are required)
- Temporary disturbance footprint: the permanent disturbance footprint and any temporary storage and laydown areas to be used on a temporary basis during the construction phase.

The land resources study area also includes additional areas (in close proximity to or adjoining lots) outside the EIS investigation corridor where intensive industrial activities or other potentially contaminating activities are identified that may pose a risk to the Project, or where ground disturbance may occur as a result of the Project. Commercially operated quarries are excluded from this assessment as they operate under their own environmental approvals/permits.

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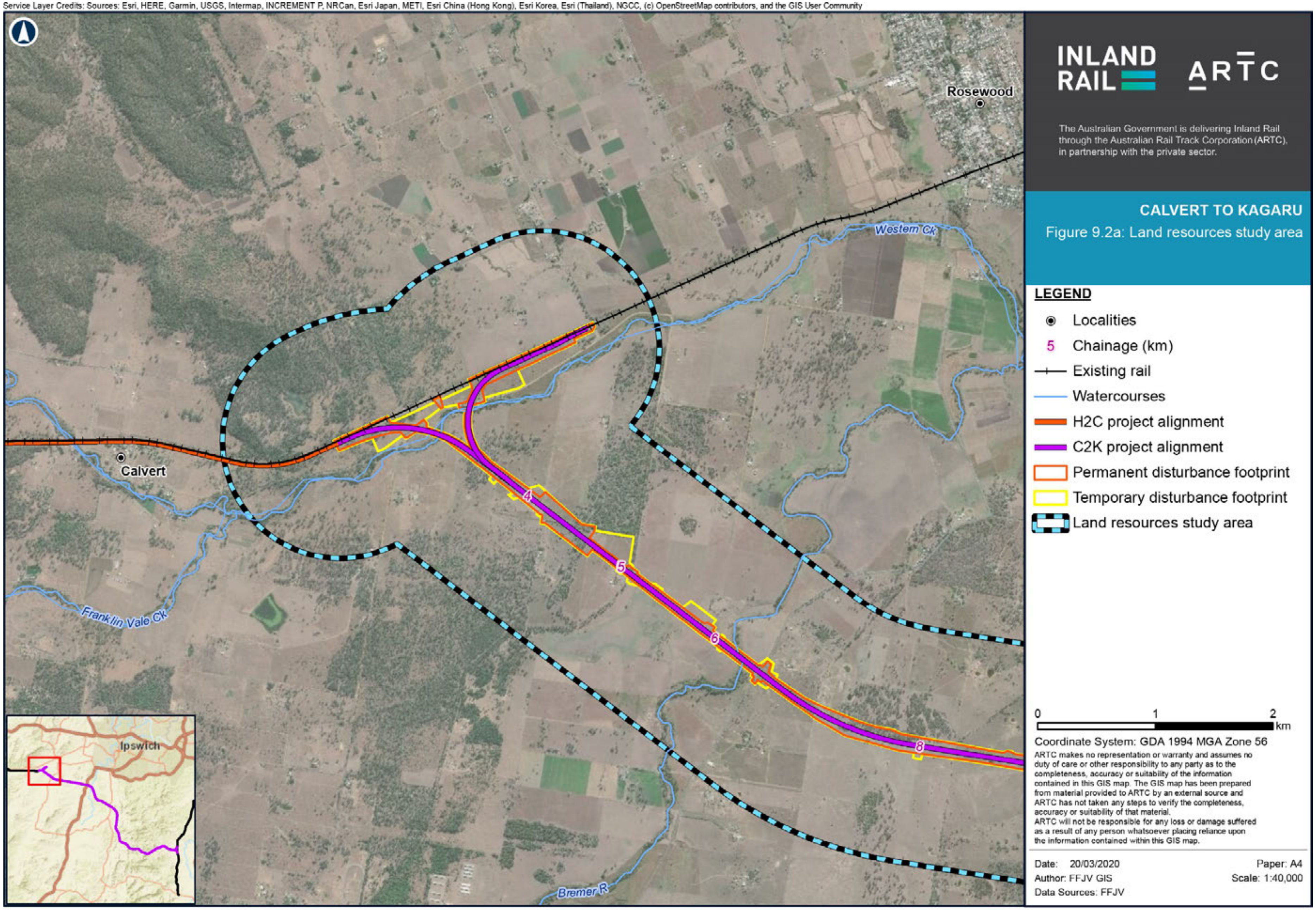

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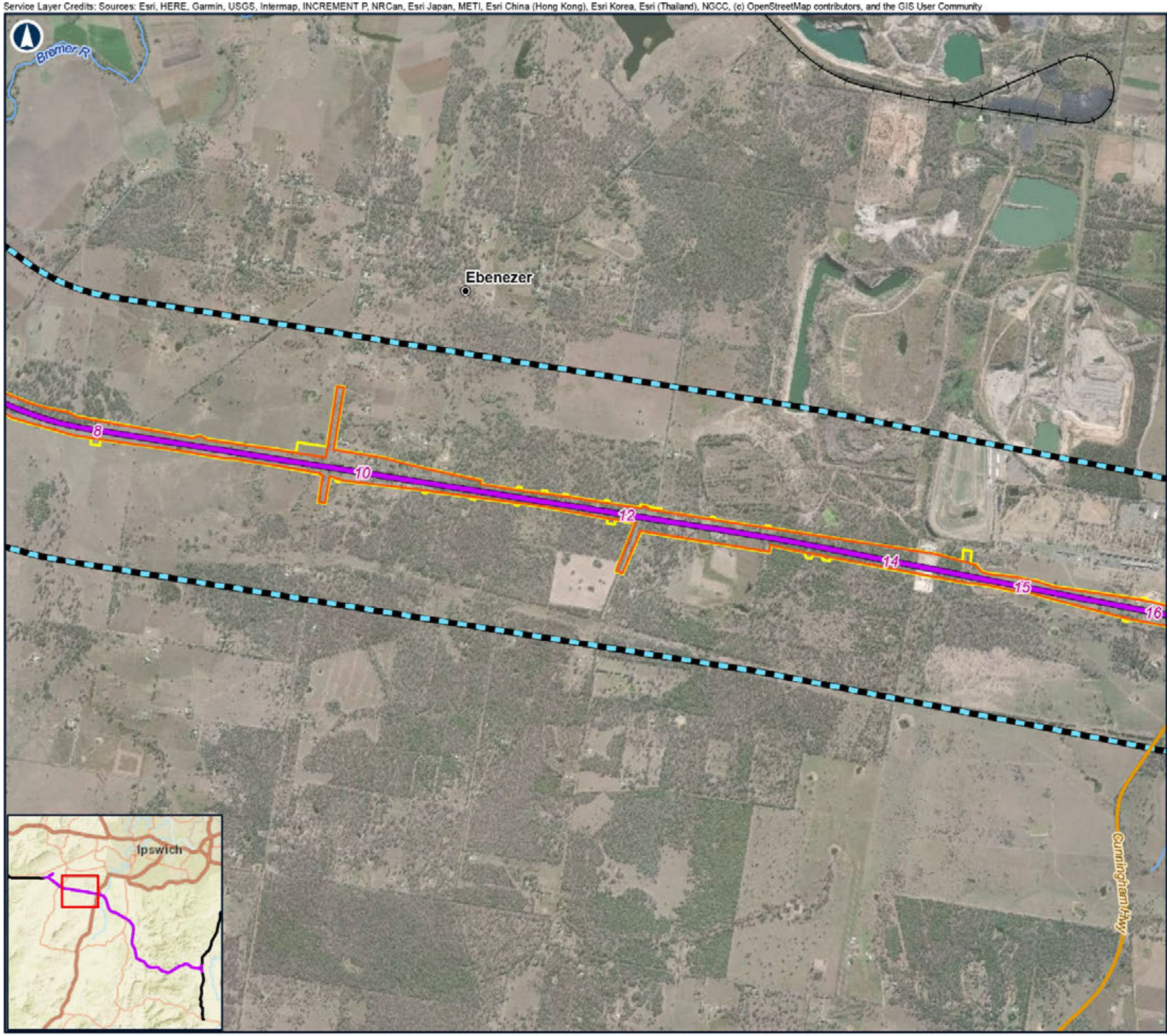

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CALVERT TO KAGARU

Figure 9.2b: Land resources study area

LEGEND

- Localities
- 5 Chainage (km)
- Existing rail
- Watercourses
- Major roads
- C2K project alignment
- Permanent disturbance footprint
- Temporary disturbance footprint
- Land resources study area

0 1 2 km

Coordinate System: GDA 1994 MGA Zone 56

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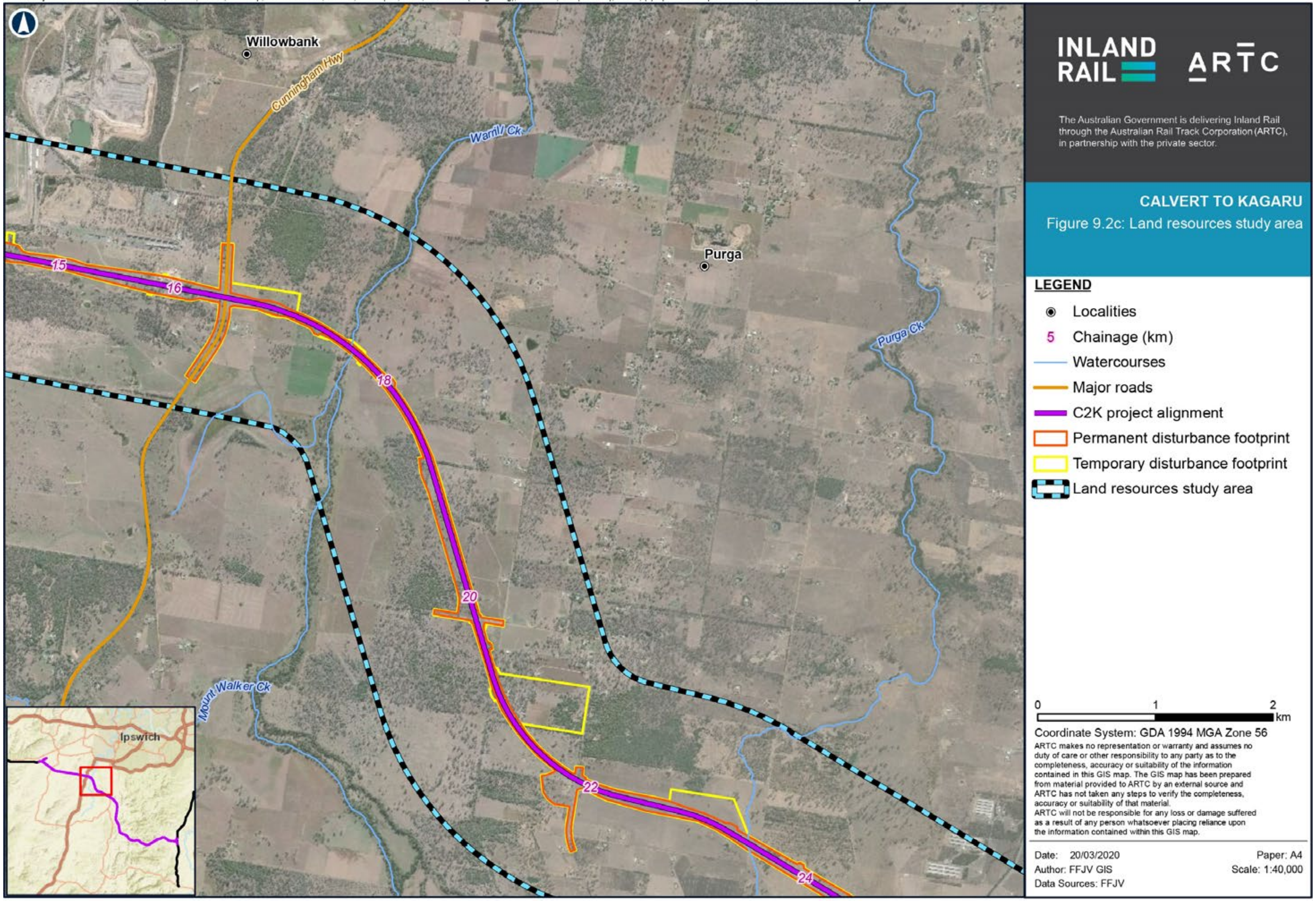

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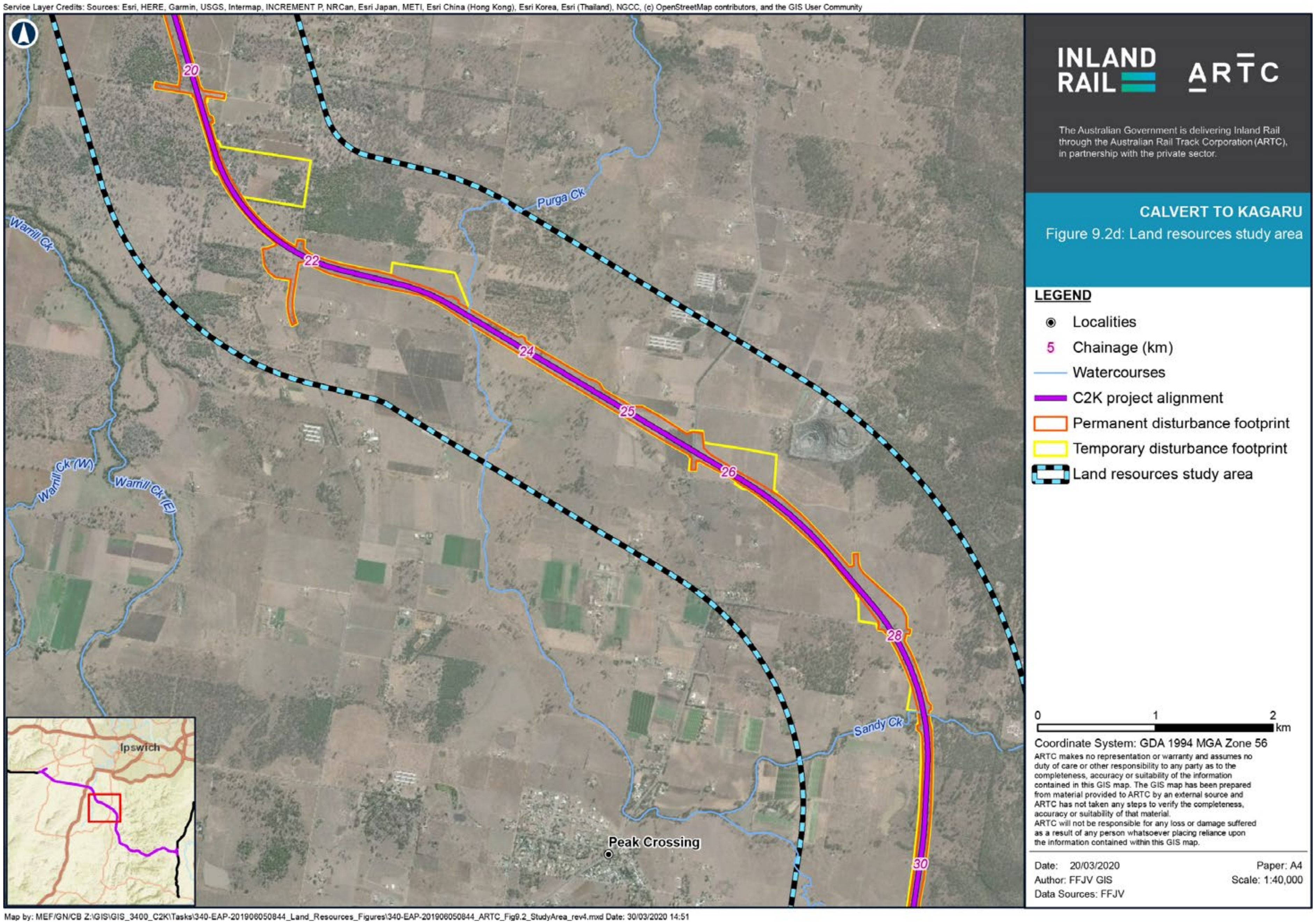
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CALVERT TO KAGARU
Figure 9.2d: Land resources study area
LEGEND
Localities
Chainage (km)
Watercourses
C2K project alignment
Permanent disturbance footprint
Temporary disturbance footprint
Land resources study area
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1
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km
Coordinate System: GDA 1994 MGA Zone 56
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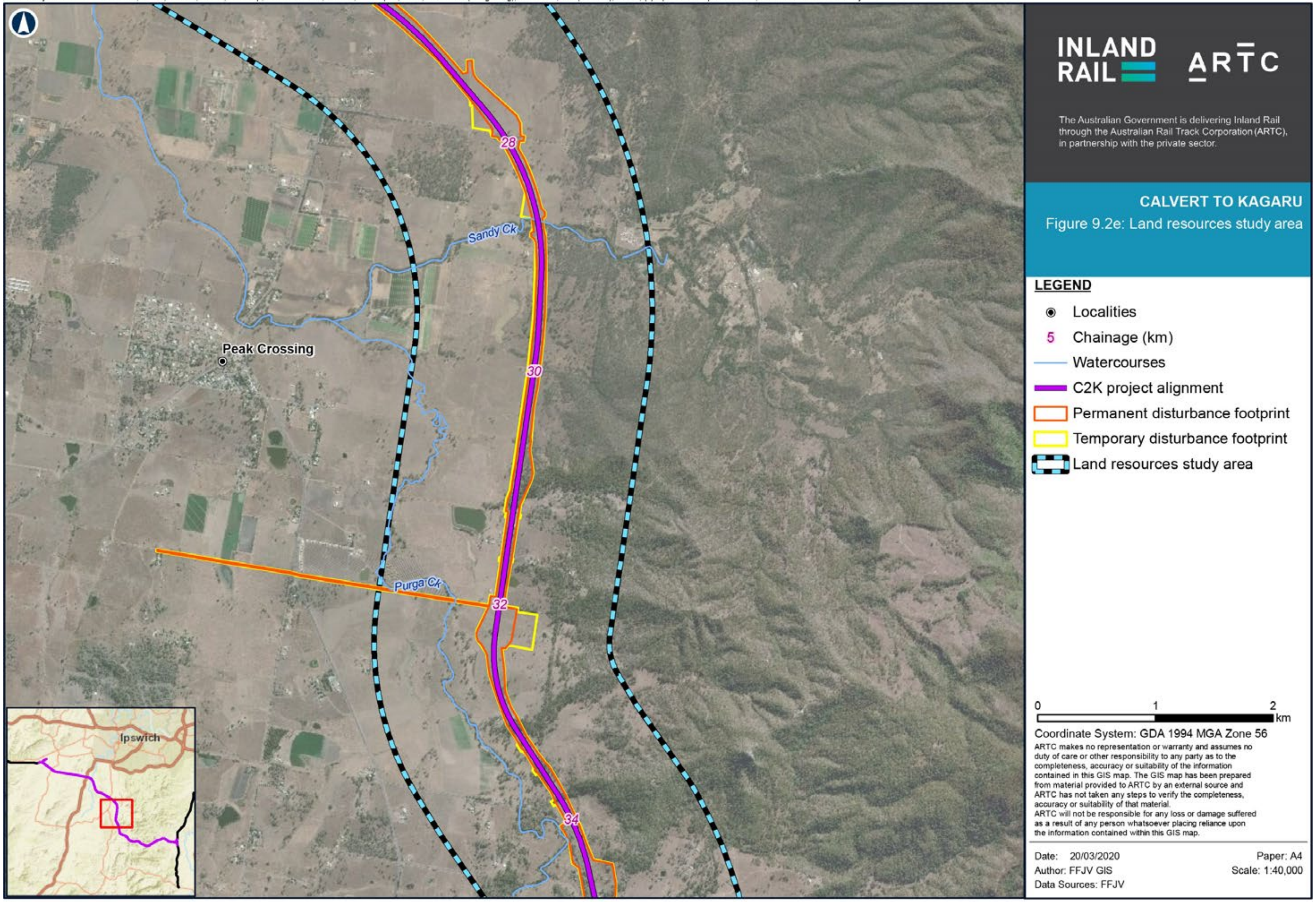

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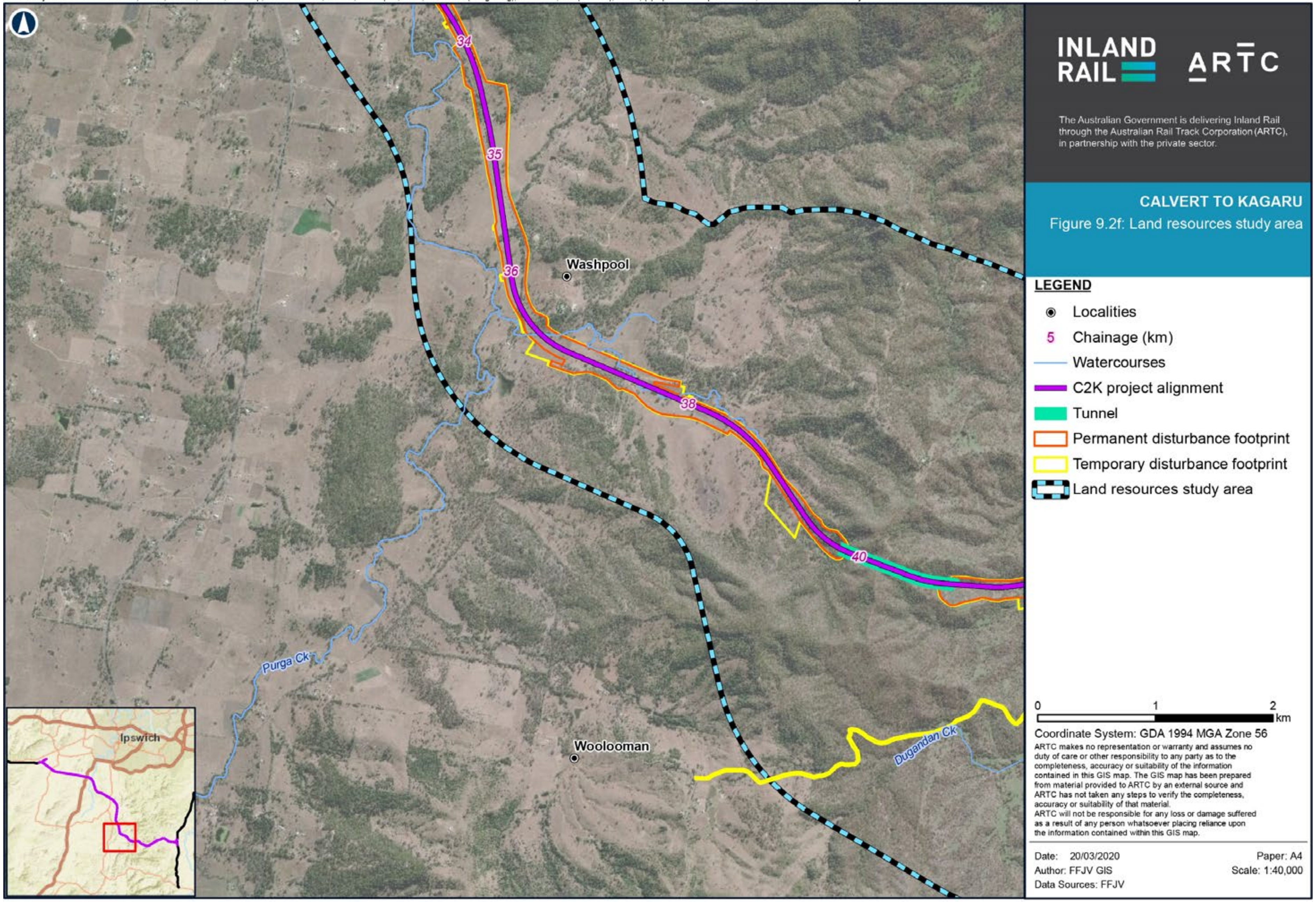

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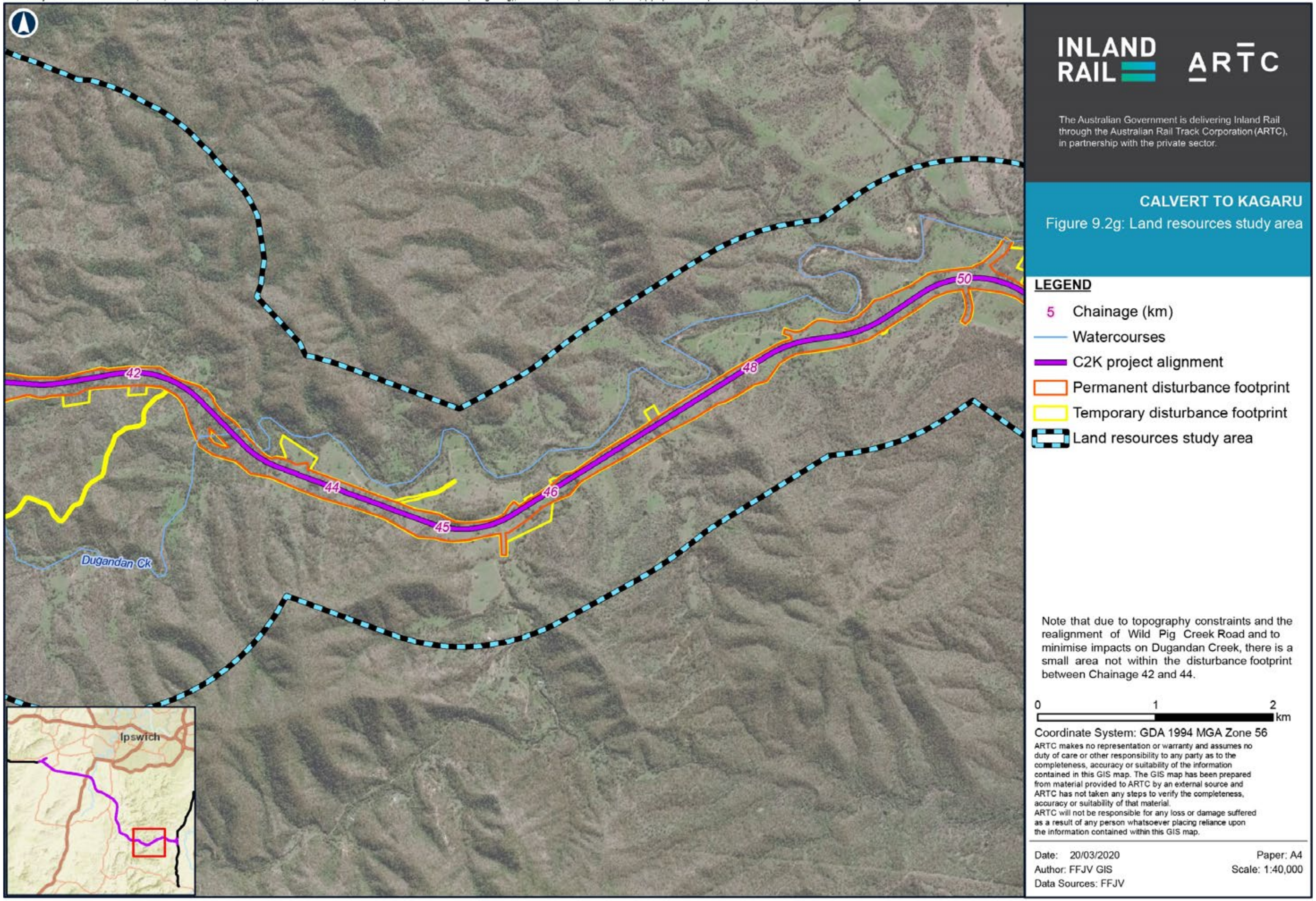

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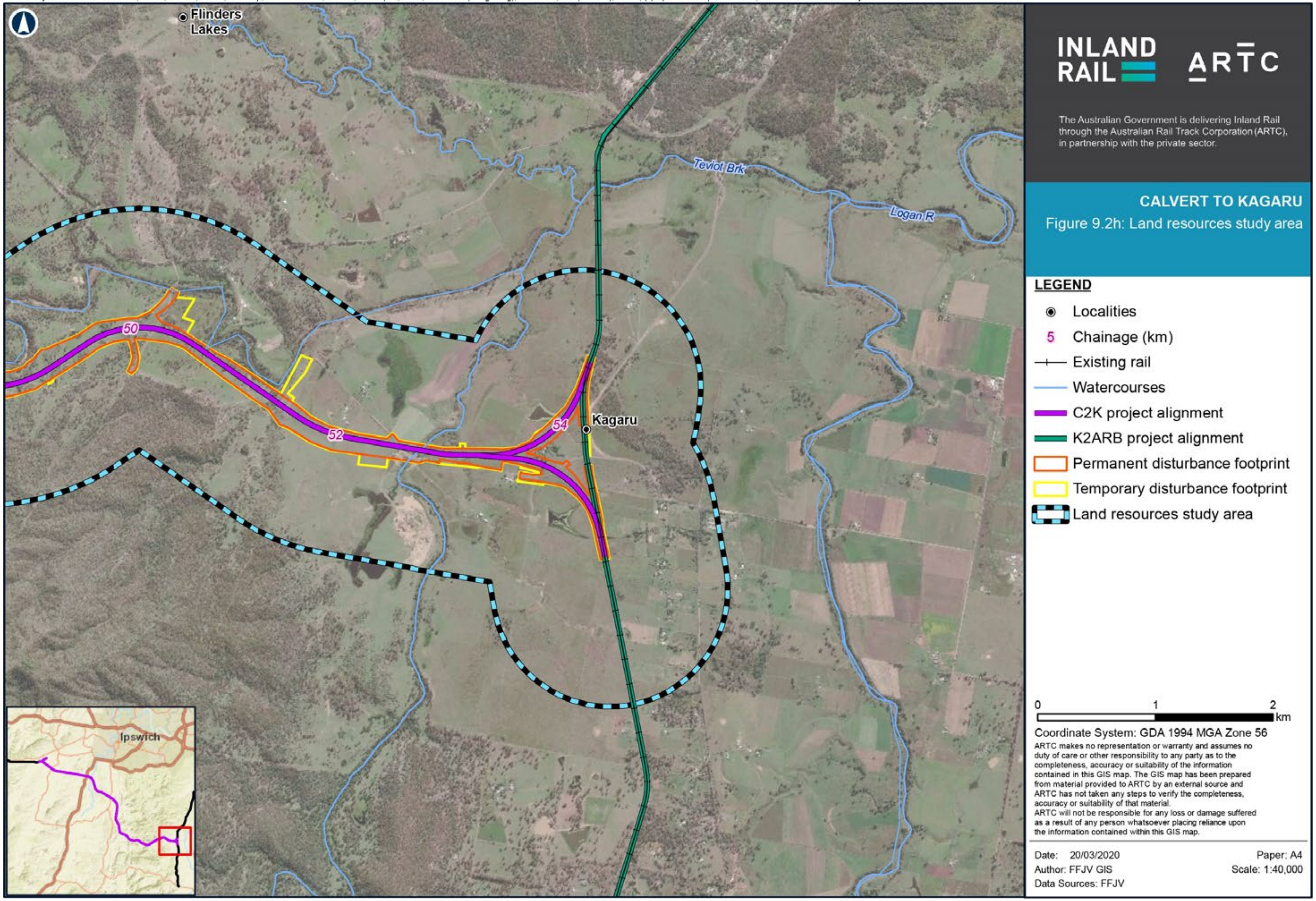

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9.4.3 Impact assessment methodology

Impact assessment was undertaken using both quantitative compliance assessment and qualitative risk assessment methodologies, assessing potential risks within the land resources study area throughout the life of the Project, construction, operation and decommissioning phases.

A quantitative compliance assessment was undertaken for:

- Soil properties, including:
  - Erosion and sedimentation
  - Problematic soils (i.e. saline, dispersive and reactive soils).

A qualitative risk assessment was undertaken for:

- Contaminated land, including:
  - Existing contaminated land
  - Construction risks (e.g. hydrocarbon spills)
  - Operational risks (e.g. hydrocarbon spills, use of pesticides/herbicides)
- Geology, topography and geomorphology
- Agricultural, which also included soil conservation plans
- ASS/acid rock
- Naturally occurring asbestos
- UXO.

Chapter 4: Assessment Methodology describes the qualitative and quantitative assessment methodology in further detail. Following an assessment of potential risks for the Project, appropriate mitigation measures were developed.

9.5 Description of existing land resources

9.5.1 Geological and topographical setting

9.5.1.1 Topographical setting

Topography in the land resources study area ranges between 30 metres Australian Height Datum (m AHD) at several drainage lines/surface water features, and 200+ m AHD in the Teviot Range (refer Figure 9.3), with most slopes having a grade of less than 30 per cent.

The land resources study area broadly consists of three distinct topographical areas: the western lowlands, the central ranges (Teviot Range), and the Beaudesert Basin.

The landscape reflects the underlying geology with a central anticline, forming rugged sandstone hills, and flanking synclines containing coal, sedimentary and igneous rocks that form gently undulating lowlands. The lowlands are traversed by numerous ephemeral and perennial watercourses that have given rise to several wide floodplains. The geology of the land resources study area and surrounding areas are illustrated in Figure 9.4 and discussed in Section 9.5.1.2.

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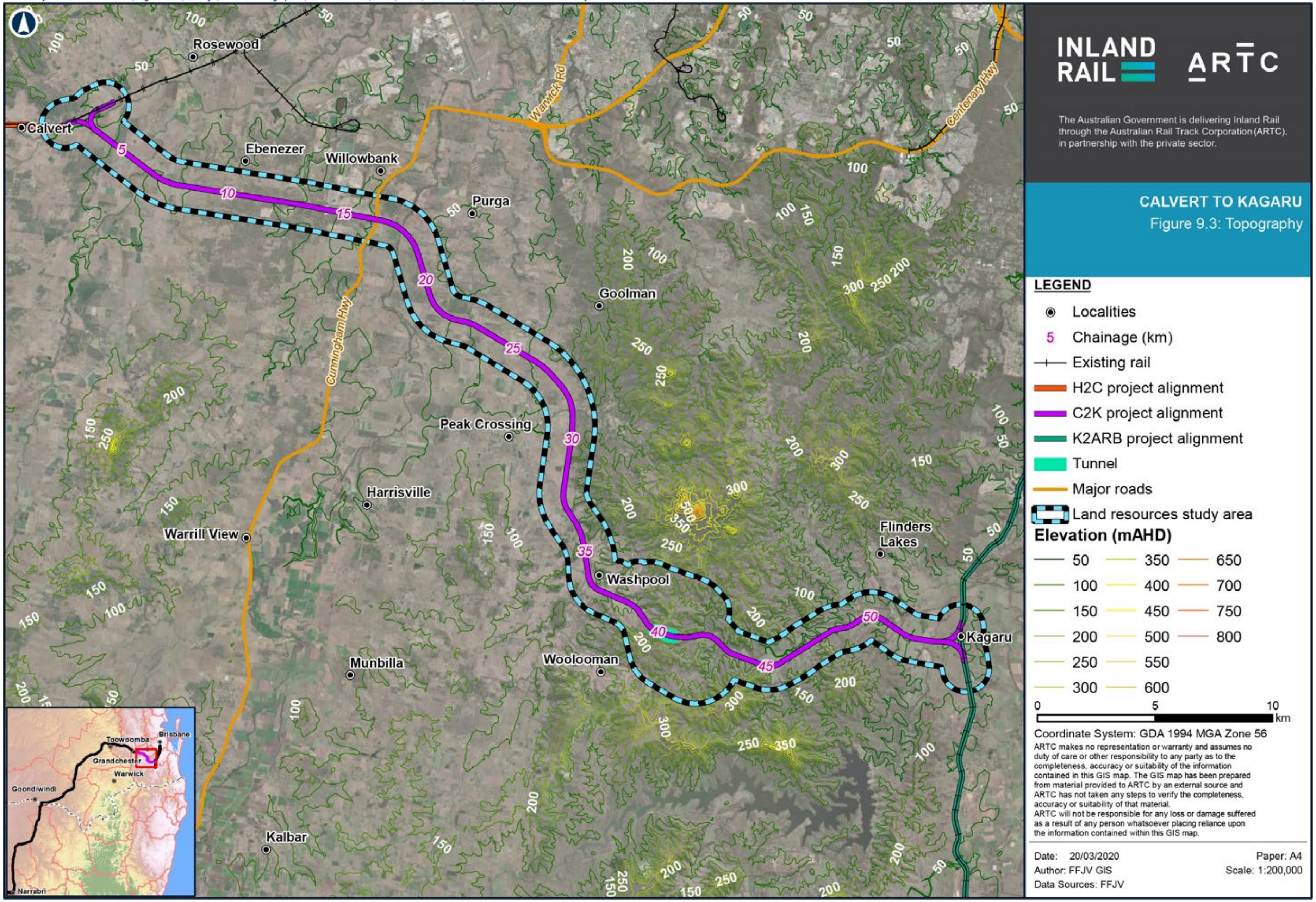

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The western part of the land resources study area falls within the Brisbane River basin, which covers an area of approximately 13,570 km^2. The primary watercourses in this area include the Bremer River and Warrill Creek, which cross the proposed rail alignment as they drain north and northeast to the Brisbane River.

The central and eastern parts of the land resources study area are in the Logan–Albert River basin, which covers an area of approximately 4,141 km^2. There are several watercourses in the land resources study area including Undullah and Woollaman creeks, and Teviot Brook, which crosses the proposed rail alignment as it drains northward to the Logan River. The topography along the proposed rail alignment is illustrated in Figure 9.3.

The proposed rail alignment does not have any significant peaks but rather undulates with many areas of steep slopes. An elevation profile of the proposed rail alignment revealed a maximum elevation of approximately 200 m AHD as it passes through the terrain between Mount Welcome and Ivorys Knob near Woolooman, while the lowest point of approximately 26 m AHD occurred as it passes over the Teviot Brook waterway approaching Kagaru.

9.5.1.2 Geological setting

The 1:100,000 scale detailed surface and solid geology mapping (DNRME, 2017) indicated the disturbance footprint is underlain by several geological layers, as illustrated in Figure 9.4 and described in Table 9.3. A cross-section schematic distribution of the main geological units between Toowoomba and Kagaru is presented in Figure 9.5.

TABLE 9.3: GEOLOGICAL UNITS

Geological unit	Location	Age	Description
Quaternary alluvium	▸ Teviot Brook ▸ Purga Creek ▸ Franklin Vale Creek ▸ Warrill Creek	Quaternary	Clay, silt, sand and gravel layer on a flood-plain dominated by alluvium
Heifer creek sandstone member	Near Kagaru	Middle Jurassic	Sublabile to quartzose sandstone, siltstone and shale dominated by arenite
Walloon Coal Measures	▸ Near Kagaru ▸ Between Washpool and Calvert	Middle Jurassic	Shale, siltstone, sandstone and coal seam dominated by arenite-mudrock
Koukandowie formation	Near Kagaru and Washpool	Early to Middle Jurassic	Lithofeldspathic labile and sublabile to quartzose sandstone, siltstone, shale, minor coal, ferruginous oolite marker dominated by arenite-mudrock
Gatton sandstone	Between Kagaru and Washpool	Early Jurassic	Lithic labile and feldspathic labile sandstone dominated by arenite
TQw-QLD	Small pocket near Hillside and Ebenezer	Late Tertiary-Quaternary	Pediment slope wash, clay, scree, soil dominated by alluvium
Ts/1-SEQ	Small pocket near Willowbank	Tertiary	Claystone, siltstone and sandstone dominated by arenite-mudrock
Tv/1-SEQ	Small pocket near Willowbank	Tertiary	Basalt as part of the Amberley Basin
Tid-SEQ	Small pocket at the Boral Quarry (Purga)	Tertiary	Dolerite, basalt (dyke or plug) dominated by gabbroid rock
Tit-SEQ	Small pocket near Washpool	Oligocene to Miocene	Tachyte (anorthoclase and riebeckite) dominated by felsites (lavas, clastics and high level intrusive)

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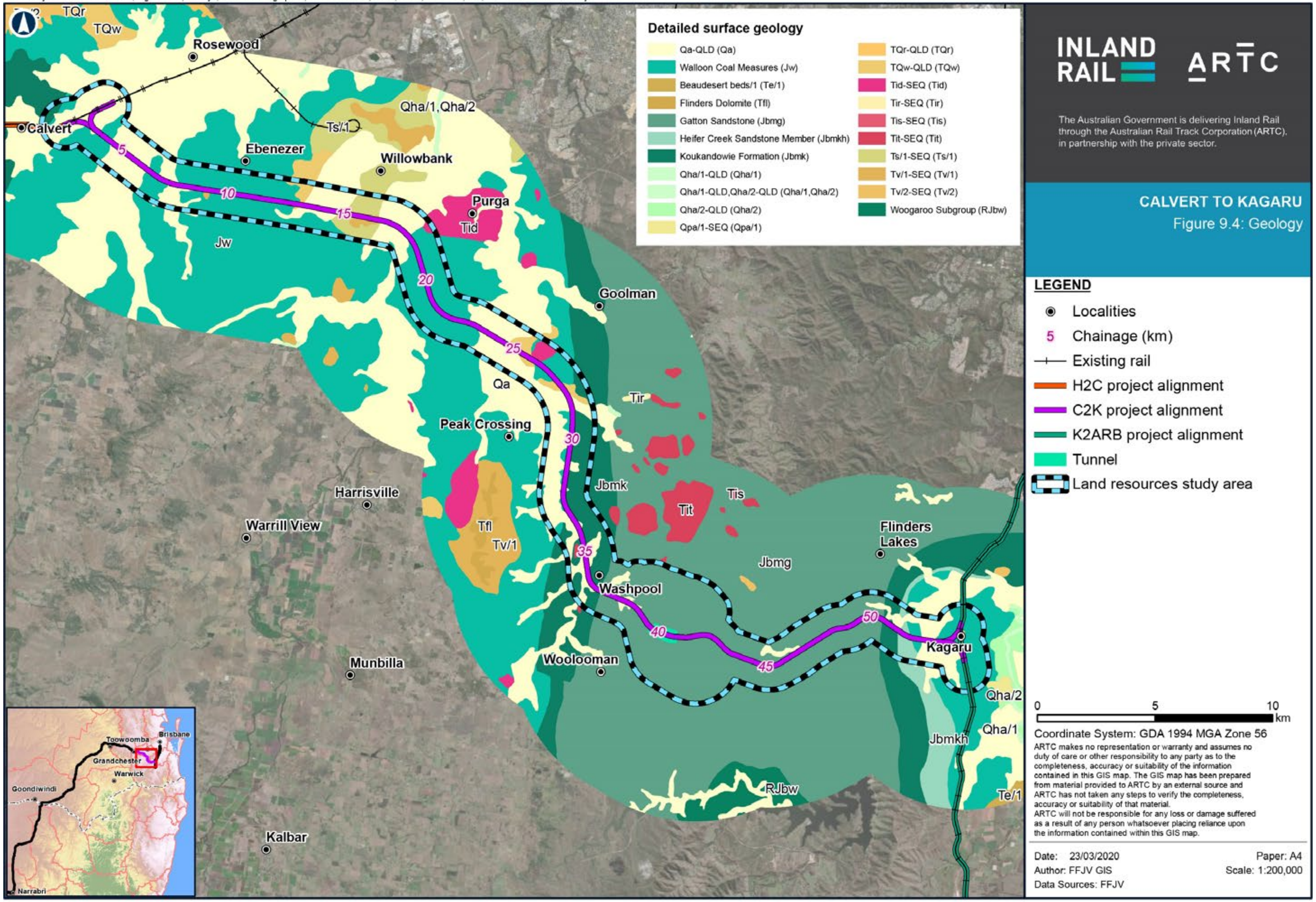

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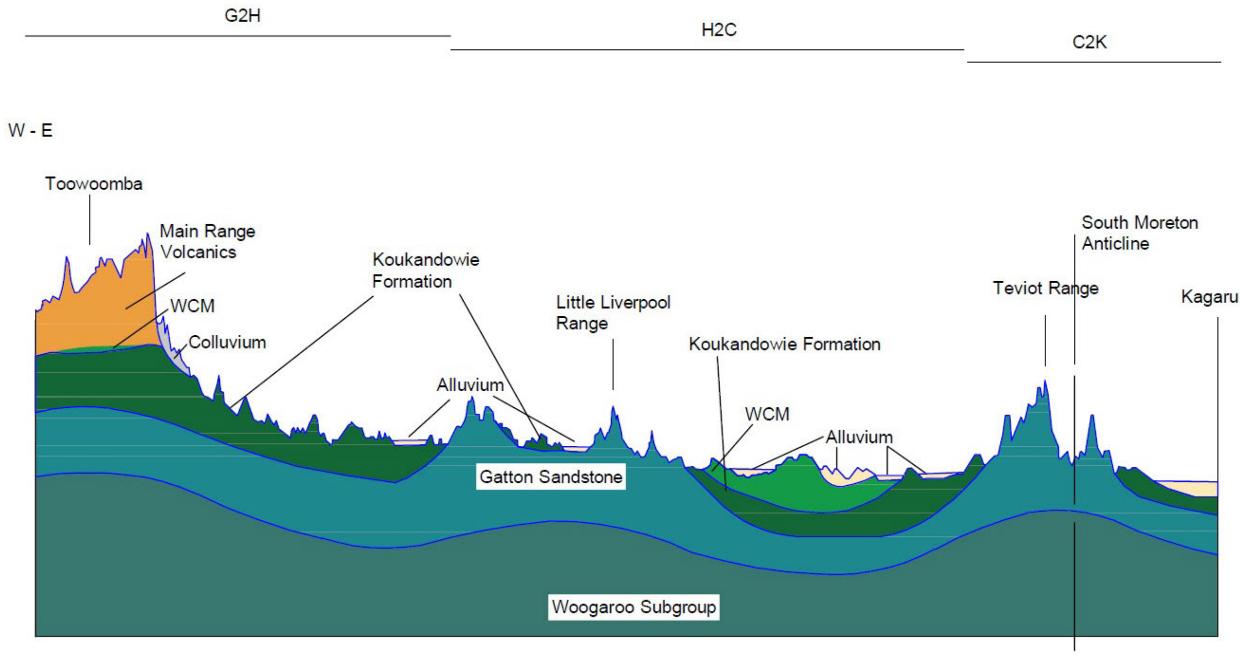

Legend: G2H—Gowrie to Helidon; H2C—Helidon to Calvert; C2K—Calvert to Kagaru

FIGURE 9.5: SCHEMATIC DISTRIBUTION OF THE MAIN GEOLOGICAL UNITS BETWEEN TOOWOOMBA AND KAGARU

Results from the topographical and surface geology study indicate the disturbance footprint is comprised of a central anticline, the South Moreton anticline, where the Triassic-Jurassic Bundamba and Marburg Group sandstone layers are exposed. The South Moreton anticline is flanked by complementary synclines featuring the Jurassic Walloon Coal Measure and Tertiary sedimentary and igneous rocks. As a result, rocks, such as arenite, which dominate the geological layers of the region, form rugged hills while the flanking synclines give rise to gently undulating lowlands.

Arenites are identified as texturally clean matrix-free or matrix-poor sandstone that allow cement precipitates to form in what were originally empty intergranular pores (University of Puerto Rico-Mayaguez Geology Department, 2012). Another major unit dominating the geology of the disturbance footprint are alluvium deposits, associated with sediments deposited through the transportation of channelled stream water. The main form of alluvium deposit in the region was likely caused by prairie soils, black earths and grey clays, which have developed on finer-grained sediment. Alluvium deposits in the region will potentially result in deposits of sand, silt or silty clay on low ridges along floodplains (Department of Science, Information Technology, Innovation and the Arts (DSITIA), 2012). A study of the soil distribution and physical properties indicated that parent material strongly influences soil development in the area.

9.5.1.3 Naturally occurring asbestos

A review of available geological mapping (DNRME, 2017) indicated no naturally occurring asbestos within the land resources study area. The geotechnical investigation undertaken within the land resources study area also found no naturally occurring asbestos to be present (Golder Associates, 2018).

9.5.2 Surface water

The land resources study area travels through two catchment areas: the Bremer River, between Calvert and east of Woolooman as the Project reaches the peak of the Scenic Rim mountain range, and the Logan River catchment area, as the Project descends the mountain range towards Kagaru (DES, 2018a).

The Bremer River catchment is situated west of Brisbane within the local government boundaries of Ipswich City Council (ICC) and the Scenic Rim Regional Council (SRRC) and expands to an area of approximately 2,030 km^2 with the main Bremer River channel surrounded by smaller sub-catchments. The Project predominantly traverses through the Bremer River, Lower Bremer River, Lower Warrill Creek, Western Creek and Purga Creek sub-catchments. Rainfall in the catchment is considered high along its steeper sections, which are situated to the south and east while the remainder of the catchment experiences average rainfall of under 1,000 mm/year (SEQ Catchments, 2006). The catchment supports a diverse range of land uses including agriculture, grazing and urban areas as well as featuring steep slopes (DES, 2016a).

The Logan River catchment is situated to the south of Brisbane with its headwater in the McPherson and Main Ranges. A majority of the catchment is located in the local government areas (LGAs) of the SRRC and Logan City Council (LCC) but also includes small sections in other LGAs. The catchment area expands over 3,000 km^2 with an approximate 5,500 km of stream network. The Project intercepts the sub-catchment area of the Lower Teviot Brook along the catchment. Rainfall in the catchment is very high especially in the eastern headwaters which, combined with good recharge of groundwater associated with basalt geology, leads to permanent flow (SEQ Catchments, 2017). Land use in the catchment is used mainly for grazing on pastures and includes large areas of alluvium (DES, 2015).

An assessment of hydrology and flood modelling of the area concluded the Project may have changes to hydraulic regimes (due to new infrastructure) at 1% annual exceedance probability (AEP) conditions. Changes, however, to base-flow and low-flow conditions are not expected due to design waterway diversions occurring in low-order drainage features (defined under the *Water Act 2000*) (refer Appendix N: Hydrology and Flooding Technical Report). As no significant changes to flow paths (base and low) are expected from Project activities, contaminant migration through hydrologic pathways will not be materially affected within the land resources study area. Potential contaminant impacts on surface water from the Project were assessed in Appendix M: Surface Water Quality Technical Report, using a Model for Urban Stormwater Improvement Conceptualisation (MUSIC). The contaminant discharge load was calculated against the drainage basins parallel to the disturbance footprint, as discharge was likely to consist of overland flow from precipitation. Impacts to the receiving environment was also assessed using a conservative approach. Further details are provided within Appendix M: Surface Water Quality Technical Report.

9.5.3 Groundwater

The water table underlying the land resources study area is typically a subdued version of topography, with the depth to groundwater increasing beneath topographic highs (for example the Teviot Range), and shallower groundwater in lower-lying reaches (such as close to surface water drainage lines). The presence of shallow aquitards, surface water features, and groundwater extraction would locally affect depths to groundwater. Regional mapping indicates the mean groundwater depth in the Bremer River basin alluvium for a wet period in 2008 to 2012 is between 5 to 15 m (Raiber et al., 2016).

Groundwater quality in the alluvial sediments is generally fresher than the underlying sediments (primarily the Walloon Coal Measures in the land resources study area). Groundwater in the Bremer River and Warrill River alluvium gradually becomes more saline (i.e. the quality decreases) down gradient, likely due to increasing influence of Walloon Coal Measures connectivity in the lower reaches.

Water quality in the bedrock sediments varies from fresh to saline across the region due to lithological variability, relative position in the basin, recharge processes, depth, and surface water interaction (Rassam et al., 2014).

A desktop survey of registered groundwater bores was conducted via a search of the DNRME groundwater database. A total of 65 groundwater bores were identified within a 1 km radius of the proposed rail alignment: 43 bores were designated 'existing' and 22 bores reported as 'abandoned' (17 reported as destroyed, 5 reported to still be usable). No registered bores with allocations/extraction licence (required for bores with extraction other than domestic and stock watering purposes) were identified within 1 km of the proposed rail alignment.

The main potential long-term impacts identified beyond the construction stage of the Project on groundwater are:

- Changes to groundwater levels and flow associated with loading from embankments and ongoing dewatering/draining of Teviot Range tunnel and deep cuts
- Management of discharge from dewatering/drainage of the Teviot Range tunnel and deep cuts.

9.5.4 Soil

9.5.4.1 Soil descriptions

The Australian Soil Resource Information System (CSIRO, 2014) Level 5 (1:100,000 or better quality) Australian Soil Classification mapping indicated five distinct soil types including vertosols, sodosols, dermosols, chromosols and rudosols to occur in the land resources study area (refer Figure 9.6).

Both sodosols and vertosols featured strongly between Calvert and the Purga Nature Reserve. The landform around Calvert is terraced valley plains defined by brown and red self-mulching cracking clays, which transitions to gently rolling areas of the subcoastal lowlands with hard pedal mottled-yellow duplex soils.

The cracking clays, vertosols, are a clay field, textured soil with a crusty surface horizon at a depth of 0.03 m or less in thickness (Isbell & National Committee on Soil and Terrain, 2016). Vertosols are often found in imperfectly drained sites with annual rainfall up to 1,150 mm and in well-drained sites with annual rainfall up to 900 mm. As the soil has a strong water holding capacity and high chemical fertility, the soil is considered to have a high agricultural potential. A majority of vertosols have neutral or alkaline soil pH and generally have high cation exchange capacity between 30 and 80 millequivalents per 100 grams of soil (meq/100 g) (Gray & Murphy, 2002).

Sodosols, however, are predominately found in poorly drained sites (annual rainfall between 50 mm and 1,100 mm) and are defined by a clear or abrupt textural B horizon soils with a major part of the upper 0.2 m of the B horizon being sodic and not strongly acidic (pH > 5.5) (Isbell & National Committee on Soil and Terrain, 2016). The high sodicity of the soil makes it highly erodible with poor structure and low permeability and is often associated with saline soils (Gray & Murphy, 2002). As such, sodosols have very low agricultural potential.

As the Project traverses through the Peak Crossing area into the Scenic Rim mountain range, the soils are predominately dermosols and chromosols. Sodosols are also present along Woollaman Creek. The landform of the Scenic Rim mountain range is described as hilly country with hard pedal mottled-red duplex soils. These soils are chromosols, which are defined as strong textual contrast soils that are neither strongly acidic or sodic in the upper B horizon. In imperfectly drained sites, chromosols can be found in areas of annual rainfall between 250 mm and 900 mm, while in well-drained sites, annual rainfall between 350 mm and 1,400 mm is necessary for chromosols to be present. Chromosols have a moderate agricultural potential, chemical fertility and water holding capacity, although chromosols can be susceptible to soil acidification and structure decline (Gray & Murphy, 2002).

The landform around Washpool is described as gently rolling areas of subcoastal lowland with black self-mulching cracking clays. These soils are dermosols, which are defined by the absence of a strong texture contrast, although they have a well-structured B2 horizon containing low levels of free iron.

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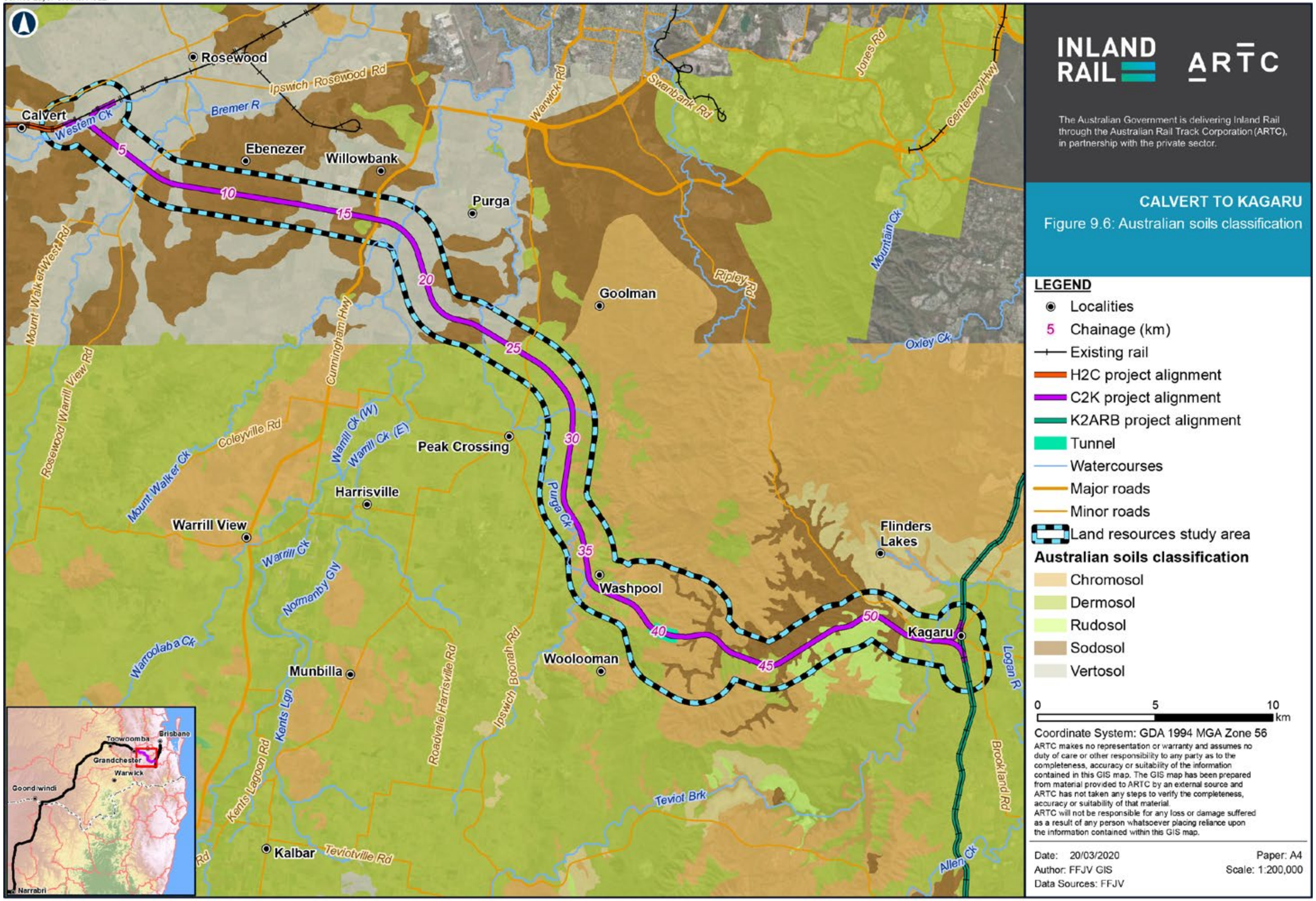

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The soils are normally found in areas of imperfectly drained sites with annual rainfall between 550 mm and 1,350 mm and in well-drained sites, with annual rainfall between 450 mm and 1,200 mm. Dermosols generally have a high agricultural potential given their good structure, moderate to high chemical fertility and high-water holding capacity (Gray & Murphy, 2002).

As the Project descends towards Kagaru, a small area of rudosols is present. Rudosols are defined by their negligible pedologic organisation and can potentially be highly saline. They are usually young soils as formation has had little time to pedologically modify parent rocks or sediments (Isbell & National Committee on Soil and Terrain, 2016). Rudosols have good infiltration capacity and low water holding capacity.

A comparison of soil pH between soil samples collected, from a single location south-east of Willowbank Raceway, during geotechnical investigations indicated a correlation with Australian Soil Classification mapping in the area. Soil classification mapping identified the location of BH2215 to be underlain by vertosols, which was reflected in the laboratory results indicating the soil contained a neutral to alkaline soil pH as well as a cation exchange capacity ranging between 25.1 and 32.8 meq/100 g, generally characteristic of the soil type.

A summary of the available soil chemistry for the land resources study area is provided in Table 9.4.

TABLE 9.4: SOIL CHEMISTRY INVESTIGATION RESULTS

Soil parameter	Range
pH[1]	6.3 to 8.7
Sodium adsorption ratio	10.8 to 26.4
Electrical conductivity (µS/cm)	144 to 493
Exchangeable calcium (meq/100 g)	9.3 to 10.7
Exchangeable magnesium (meq/100 g)	10.8 to 14.6
Exchangeable sodium (meq/100 g)	4.5 to 7.4
Exchangeable sodium per cent (%)	17.9 to 22.6
Cation exchange capacity (meq/100 g)	25.1 to 32.8

Table notes:

1 Soil pH included a single laboratory result from BH2215 between depths of 2 m and 2.45 m below ground level from geotechnical investigations

µs/cm = microsiemens per centimetre

meq/100g = millequivalents per 100 grams of soil

It should be noted that variations between geotechnical investigation results and mapping are potentially attributed to scale of mapping, the natural heterogeneity of soil, soil chemistry changing across a landscape due to various factors (e.g. climate, land use) and sampling only capturing a specific point along the land resources study area.

9.5.4.2 Soil acidity

An assessment of surface soil pH, using the Australian Soil Resource Information System mapping (CSIRO, 2014), revealed the soil acidity of the land resources study area to range between 3.0 and 7.5 pH. A large area of high acidic soils (pH 3.0 to 4.8) exists within the land resources study area south of Ebenezer, while smaller patches of acidic soils underlay the land resources study area near Willowbank, Queensland Raceway and south of Purga Nature Reserve on land used for irrigated cropping as well as modified grazing pastures (Queensland Government, 2018a).

9.5.4.3 Acid sulfate soils

ASS are often associated with low-lying areas below 5 m AHD, such as alluvial plains, where groundwater generally is close to the surface and materials are in reducing condition along coastal regions. ASS can also be found in parts of central QLD at elevations above 5 m AHD if an anoxic, aqueous environment that consists of sulfate-reducing bacteria and available sulfate ions exist (Dear et al., 2014).

The probability of encountering ASS is generally considered low to no known occurrence for a majority of the land resources study area, as mapped by the *Atlas of Australian Acid Sulphate Soils* (Fitzpatrick et al., 2011). The exception is a dam within the land resources study area located immediately to the east of the Cunningham Highway, which is mapped as having a high probability of containing ASS (refer Figure 9.7). Low probability of ASS occurring was evident in small patches both north of the Purga Nature Reserve and along the land resources study area traversing Willowbank and Queensland Raceway.

Geotechnical investigations within the land resources study area, which included site walkovers and geotechnical sampling, did not identify the presence of ASS or acid rock, which occur naturally when sulfide minerals are exposed to air and water and accelerated through excavation activities which increase rock exposure to air, water, and microorganisms. Furthermore, due to the underlying geology of the land resources study area, the elevation (>20 m AHD lowest point) as well as existing ASS mapping concluding no to low risk, it is considered to be a low to no risk of inland ASS or potential inland ASS present within the land resources study area.

However, in the unlikely event ASS is present during the construction phase of the Project, an unexpected finds protocol/procedure will be implemented (refer Section 9.7.2).

9.5.4.4 Soil texture

A range of soil textures exist within the land resources study area ranging from heavy clays to sands, as indicated by the Australian Soil Resource Information System textural and clay content mapping layer (CSIRO, 2014).

The Calvert to Peak Crossing extent of the Project generally contains more clay content (>20 per cent), while the soils around the Scenic Rim mountain range and associated watercourses (e.g. Woollaman Creek) contain more sand, with clay content of less than 10 per cent.

Geotechnical investigations undertaken along the Project around the area between Calvert and Purga consist of alluvial plains along the outcrops. The alluvial plains are dominated by clayey sand, while the flat, low-lying areas have a superficial cover of sand.

In the Teviot Range area, from Purga to Kagaru, geotechnical investigations found alluvial soils in each of the creek and tributary valleys to be dominated by sand. The hillslopes in the Teviot Range area consisted of clay, gravel cobbles and boulders of sandstone.

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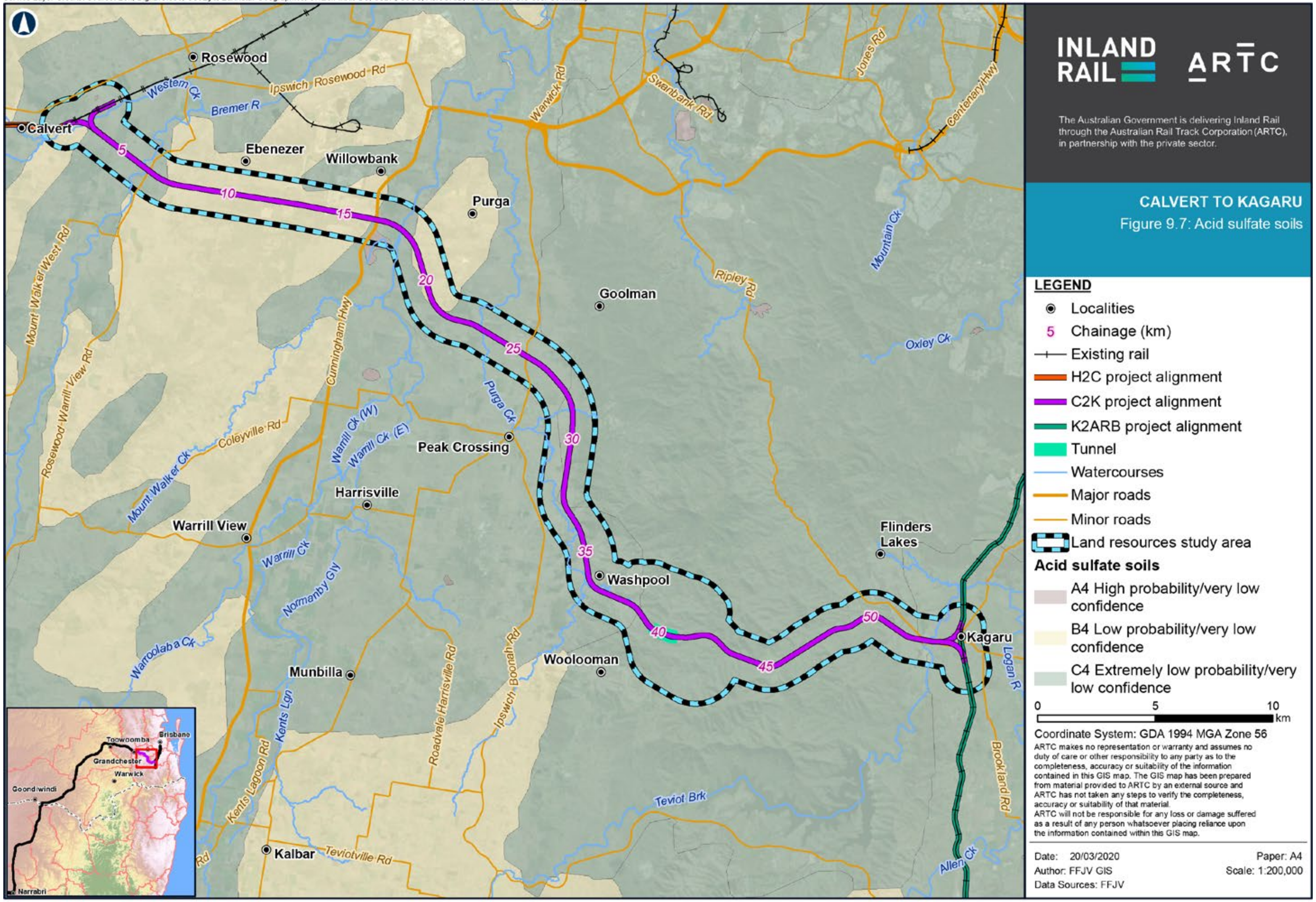

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9.5.4.5 Soil salinity

Salinity presents a major land degradation issue that can impact on land salinisation, in-stream salt loads and concentrations. Salinity expresses itself in the landscape in a variety of ways. Some landscapes are more hydrologically sensitive and susceptible to salting than others. Identification of these landscapes helps to determine which management strategies will be effective in combating salinity. The *Salinity Management Handbook* (DERM, 2011) describes several models that provide an excellent conceptual basis for describing different landscapes and different forms of salinity. These models provide and aid both the prediction of where salinity may occur, and the description of possible contributing factors. However, they do not provide a definitive answer to the cause of all salt outbreaks, and for conclusive proof, detailed site investigations will always be required.

A salinity hazard assessment was undertaken within the land resources study area to meet the requirements of Part B of the *Salinity Management Handbook* and understand the existing primary salinity within the landscape, as well as potential for secondary salinity formation as a result of Project activities.

Primary salinity is the presence of salts within a landscape where salts are stored within the geology or soils and moved by the water that flows through a catchment area. Each catchment has a different level of stored salts, and how each landscape is managed will depend on the severity of salinity. Predicting areas at risk from salinity is a complex exercise, which requires both determining the inherent salinity hazard in a landscape and the effects of past, present and future land management practices.

A desktop salinity hazard assessment was conducted adopting the assessment methodology described in *Strategic Salinity Risk Assessment for the Condamine Catchment* (Searle et al., 2007), which meets the requirements of Part B of the *Salinity Management Handbook*.

The approach adopted for the Project to find overall salinity hazard included collecting and analysing data that relates salinity risk to biophysical hazard. Biophysical hazard is the inherent capacity of the landscape to develop salinity and often determined through factors such as geology, soil, topography, and groundwater availability or flow. Five factors were used to relate salinity risk to biophysical hazard which included: soil salt store, basalt contact potential expression areas (PEA), catena PEA, artificial restriction PEA and confluence of streams PEA.

The land resources study area was broken down by the Australian Hydrologic Geospatial Fabric Catchment Geographical Information System (GIS) layer (Bureau of Meteorology, 2015), into smaller sub-catchments to enable a more precise analysis of the Project. Consideration was given to how Project construction activities may alter the hydrology of the land resources study area.

Inherent soil salt store

The Australian Soil Classification map (CSIRO, 2014) was intersected with the sub-catchments layer to identify which soils were dominant in each of the sub-catchments. The dominant soil type in each sub-catchment was derived through GIS analysis. Inherent salt store ratings for each soil type were adopted from Searle et al. (2007) and applied to give a low, moderate, or high rating. This salt store categorisation is summarised in Table 9.5 and illustrated in Figure 9.8.

TABLE 9.5: SOIL TYPE AND SOIL SALT STORE

Soil type	Soil salt store risk category
Black dermosols	Low
Brown kandosol	Low
Black vertosol	Moderate
Brown sodosol	Moderate
Grey vertosol	High

Source: Searle et al. 2007

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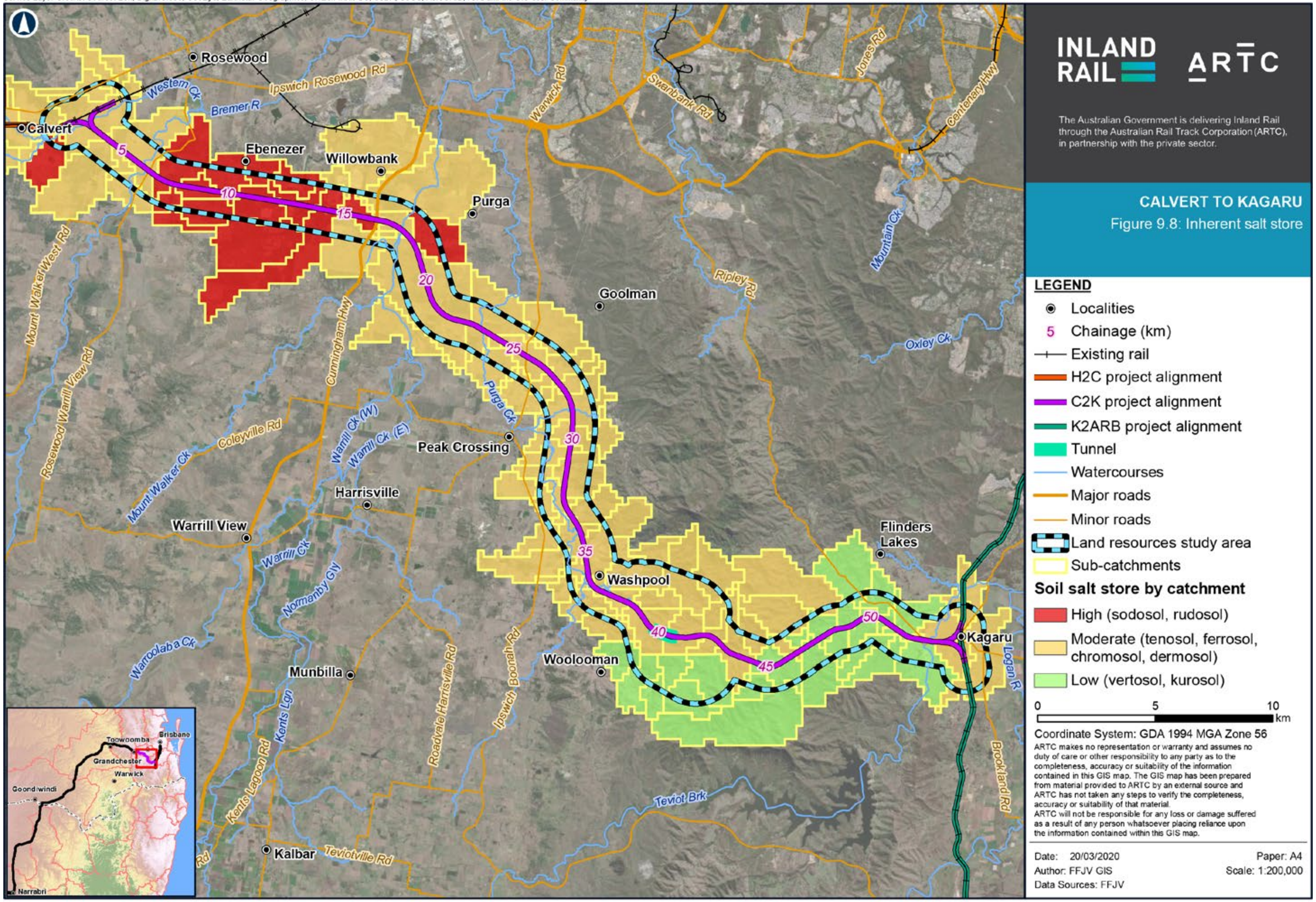

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Potential expression area: Basalt and sandstone contact

The underlying geology of the land resources study area features PEAs of basalt and sandstone contact. These PEAs result in salts being transported through underlying basalt layers towards surface soils in an area of basalt and sandstone contact (DERM, 2011). Salinity in a basalt layer forms when both recent and highly weathered layers overlay a less permeable sandstone and mudstone layer at fairly shallow depths. Seepage and the visible expression of salt occurs at the contact point between the two rock types.

The percentage of basalt and sandstone contact PEAs for each sub-catchment within the land resources study area was calculated and is illustrated in Figure 9.9 with further detail in Table 9.6.

Calculation of basalt and sandstone contact was based on an analysis of the 25 m digital elevation model developed for the Project. Three derivatives were used: tangential curvature, relative elevation (kernel size 90) and slope percentage. These derivatives were calculated using ArcGIS Spatial Analyst functions.

The analysis was only applied to the Main Range Volcanics, Walloon Coal Measures, Koukandowie Formation, and the Gatton Sandstone geology, which were identified as the main geological layers where salinity may be a potential issue.

The basalt and sandstone contact PEAs are predicted to be where the following occurs (Searle et al., 2007):

- Tangential curvature is less than 0 (i.e. the downhill slope shape is concave—flow tends to slow and converge)
- Relative elevation is greater than two (i.e. there is typically a distinct break of slope)
- Slope is greater than one per cent and less than 10 per cent (i.e. typically mid-slope positions).

TABLE 9.6: POTENTIAL EXPRESSION AREA: BASALT AND SANDSTONE CONTACT

Percentage of each sub-catchment containing basalt and sandstone contact PEAs (%)	Risk category
0	None
0 to 2	Low
2 to 5	Moderate
Greater than 5	High

Source: Searle et al. 2007

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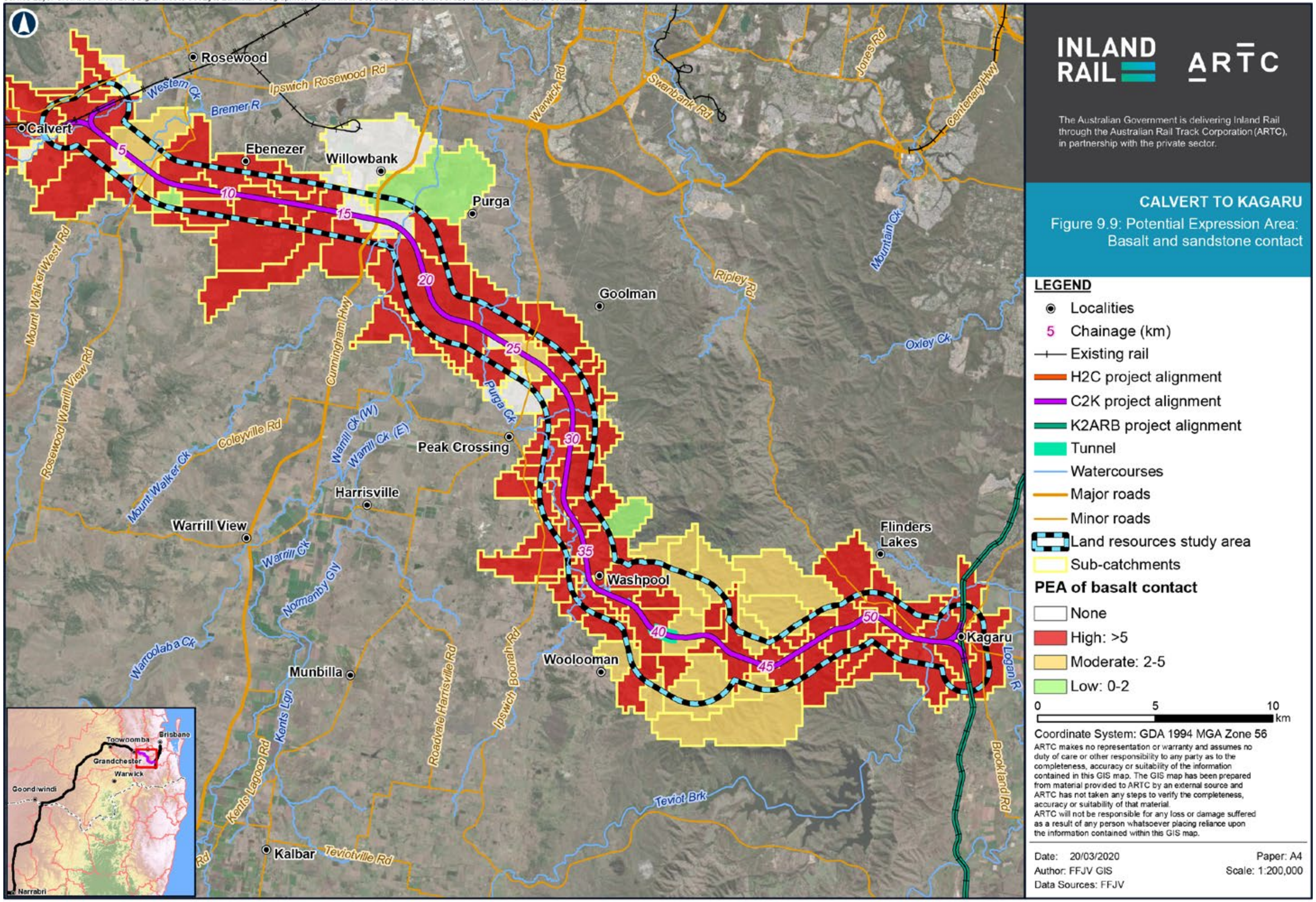

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Potential expression area: Catena form

The land resources study area also features PEA of catena form. Catena form occurs when shallow soils located upslope overlie weathered parent material that then extend out into flat heavy clay alluvial areas. These alluvial areas are characterised by high sodicity due to restricted permeability and result in the formation of salt as well as changing soil properties and water movement (DERM, 2011).

The percentage of catena-form PEA for each sub-catchment within the land resources study area was calculated and is shown on Figure 9.10. Calculation of catena form was based on an analysis of the 20 m digital elevation model developed for the Project. Two digital elevation model derivatives were used in this analysis being slope per cent and a Multi- Resolution Valley Bottom Floor Index, which was described by Gallant and Dowling (2003). The Multi Resolution Valley Bottom Floor Index identifies areas that are both relatively flat and low in the landscape at different scales, which is interpreted as a map of valley bottom areas. This index is used to separate upland terrain dominated by erosional processes from lowland depositional terrain (Searle et al., 2007).

The analysis was only applied to the Main Range Volcanics, Walloon Coal Measures, Koukandowie Formation, and the Gatton Sandstone as these are the geological layers most susceptible to catena form salinity. When analysing the risk of the catena landform within the sub-catchments, a low to high hazard category rating was applied as shown in Table 9.7.

TABLE 9.7: POTENTIAL EXPRESSION AREA OF CATENA FORM

Percentage area of sub-catchments containing catena PEAs (%)	Hazard category
0	None
1–3	Low
4–5	Moderate
Greater than 5	High

Source: Searle et al. 2007

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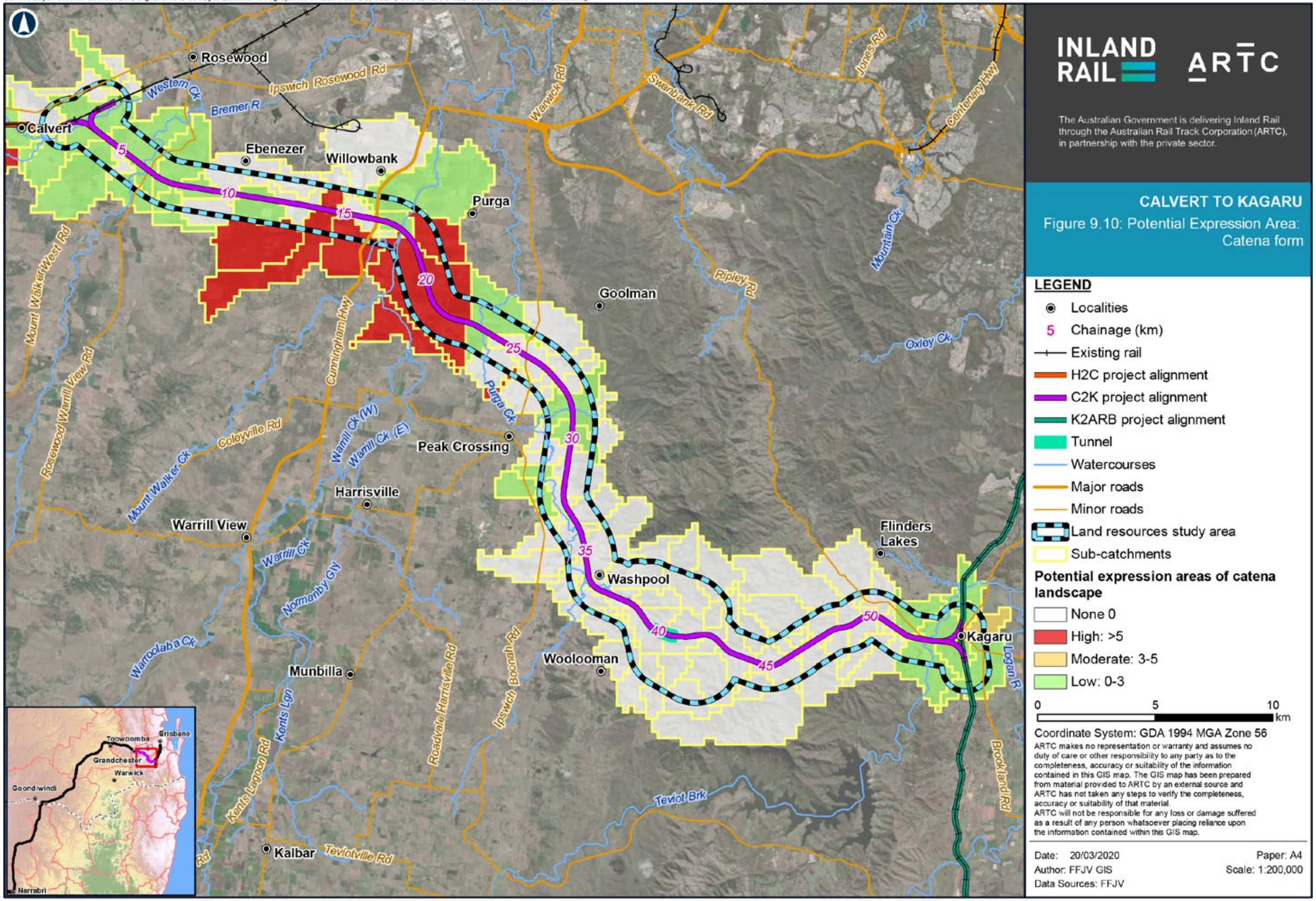

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Potential expression area: Roads

The placement of roads within a landscape can restrict water flow as well as impede the soils ability to transmit water, leading to the uprising of groundwater with dissolved salts and waterlogging. This form of salinity is often associated with hillslopes consisting of textural contrast soils or shallow, sandy soils within drainage lines (Searle et al., 2007).

A 25 m digital elevation model was used with two derivatives to derive where the construction of roads in the landscape could potentially create salinity. The two derivatives are (Searle et al., 2007):

- Compound Topographic Index. The Compound Topographic Index delineates those areas in a landscape that have high-contributing area and relatively low slopes. In a general sense, these would tend to be the wetter areas within a landscape.
- Slope (per cent).

The digital elevation model was generalised to 200 m for the slope calculations and 1,000 m for the Compound Topographic Index calculations. The analysis selected the areas that are generally low slope and where there is a general convergence of flow, low in the landscape. These areas are predicted to occur where:

- Slope is greater than one per cent
- Compound Topographic Index is greater than two.

Figure 9.11 presents the potential risk of salinity development as a result of road placements. The hazard category of the artificial restrictions were given a low to high rating, and these ratings are presented in Table 9.8.

TABLE 9.8: NUMBER OF ROAD POTENTIAL EXPRESSION AREAS ALONG LAND RESOURCE STUDY AREA CATEGORIES

Number of road PEAs within sub-catchments	Hazard category
0	None
1 to 50	Low
51 to 100	Moderate
>100	High

Source: Searle et al., 2007

Potential expression area: Confluence of streams

The confluence of streams form of salinity relates to where a major stream intersects with a minor stream. This intersection can create a reduction in flow velocity and a resultant deposition of the suspended particles at the junction including a precipitation of salts (Searle et al., 2007).

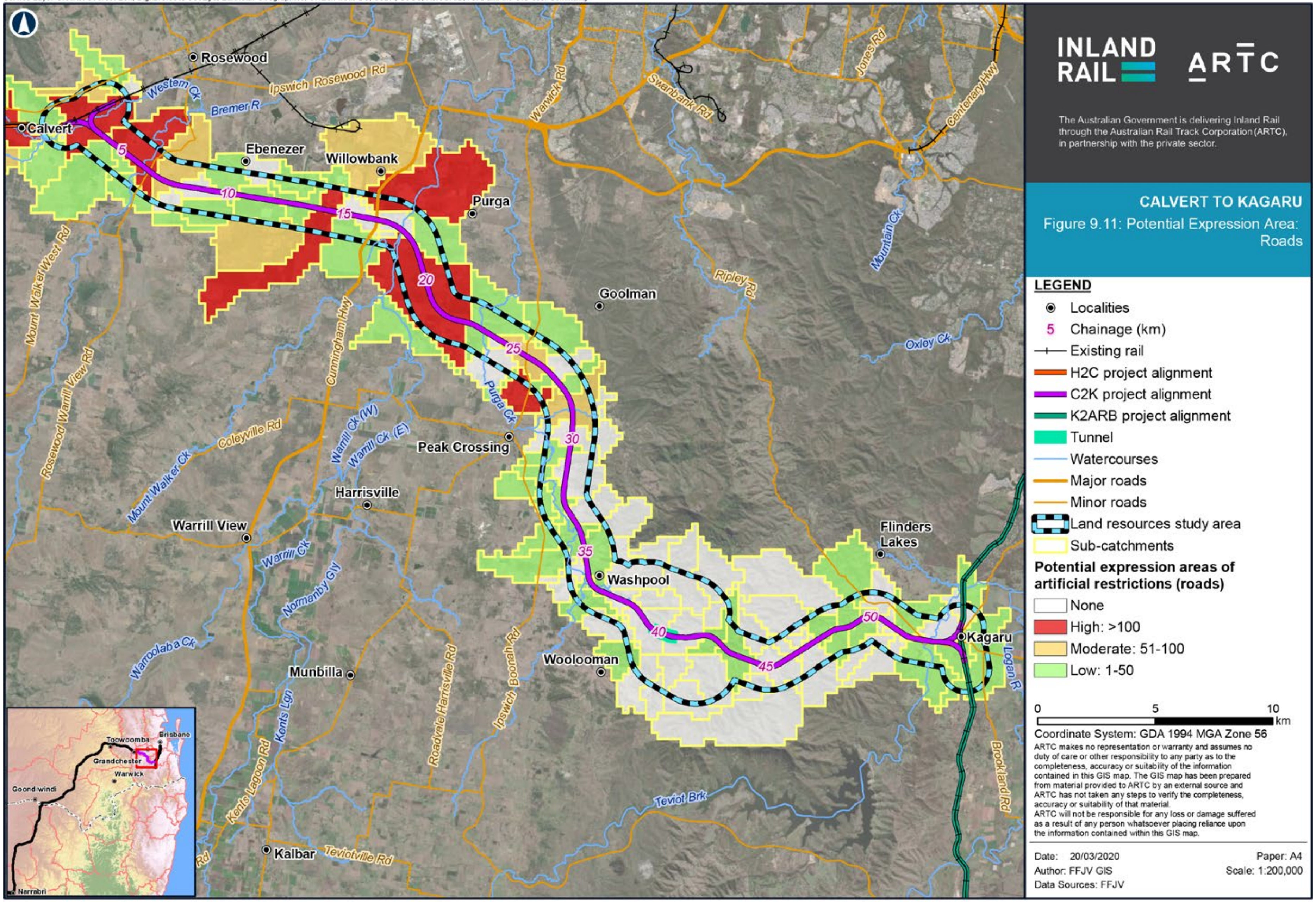
Within each sub-catchment the number of PEAs were identified, and each sub-catchment was given a rating from low to high as shown in Figure 9.12 and Table 9.9.

TABLE 9.9: POTENTIAL EXPRESSION AREA: CONFLUENCE OF STREAMS

Percentage of each sub-catchment containing confluence of streams (%)	Hazard category
0	None
1 to 3	Low
4 to 5	Moderate
Greater than 5	High

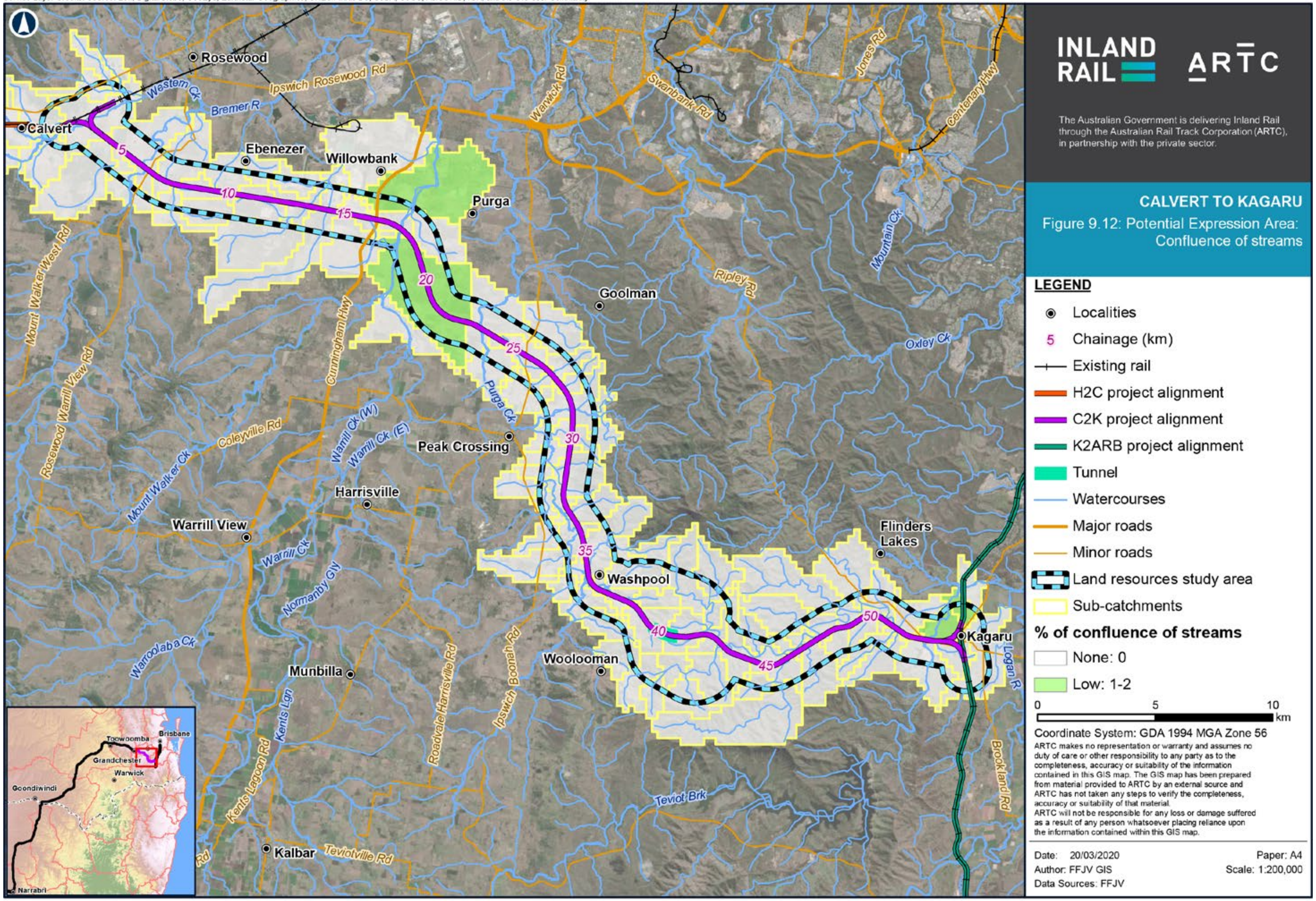
Source: Searle et al., 2007

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: DMeP/LUC/RB/MF/MEF/CB Z:\GIS\GIS_3400_C2K\Tasks\340-EAP-201906050844_Land_Resources_Figures\340-EAP-201906050844_ARTC_Fig9.11_PEA_Roads_rev4.mxd Date: 22/03/2020 19:47

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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Electrical conductivity

Salinity hazard within the land resources study area was also assessed using the CSIRO (2014) electrical conductivity mapping layer. In general, the land resources study area contained low electrical conductivity between 50 µS/cm and 100 µS/cm, with two distinct patches of high electrical conductivity (500 to 1,000 µS/cm) meandering through the land resources study area as the Project crosses Western Creek, at Calvert, and the Bremer River, located west of Ebenezer.

Geotechnical investigation results revealed the electrical conductivity of the soil from BH2215, underlain by vertosols, to range between 144 µS/cm and 493 µS/cm, indicating low electrical conductivity. The bore log from BH2215 indicates the area is underlain by clay soils, between 0 m to 1.10 m below ground level, which are known to hold salts within the soil compared to other soil textures.

Overall salinity hazard

Overall salinity hazard of the land resources study area was assessed using a desktop assessment of five factors, potential expression areas, and laboratory results from soil samples collected during geotechnical investigations.

The desktop assessment of salinity hazard was developed with consideration of inherent soil salt store, basalt and sandstone contact, catena form, artificial restrictions and confluence of streams. The desktop assessment indicated a general medium to high potential hazard of salinity occurring within the land resources study area, when risks from each of the five individual potential expression areas was combined (refer Figure 9.13).

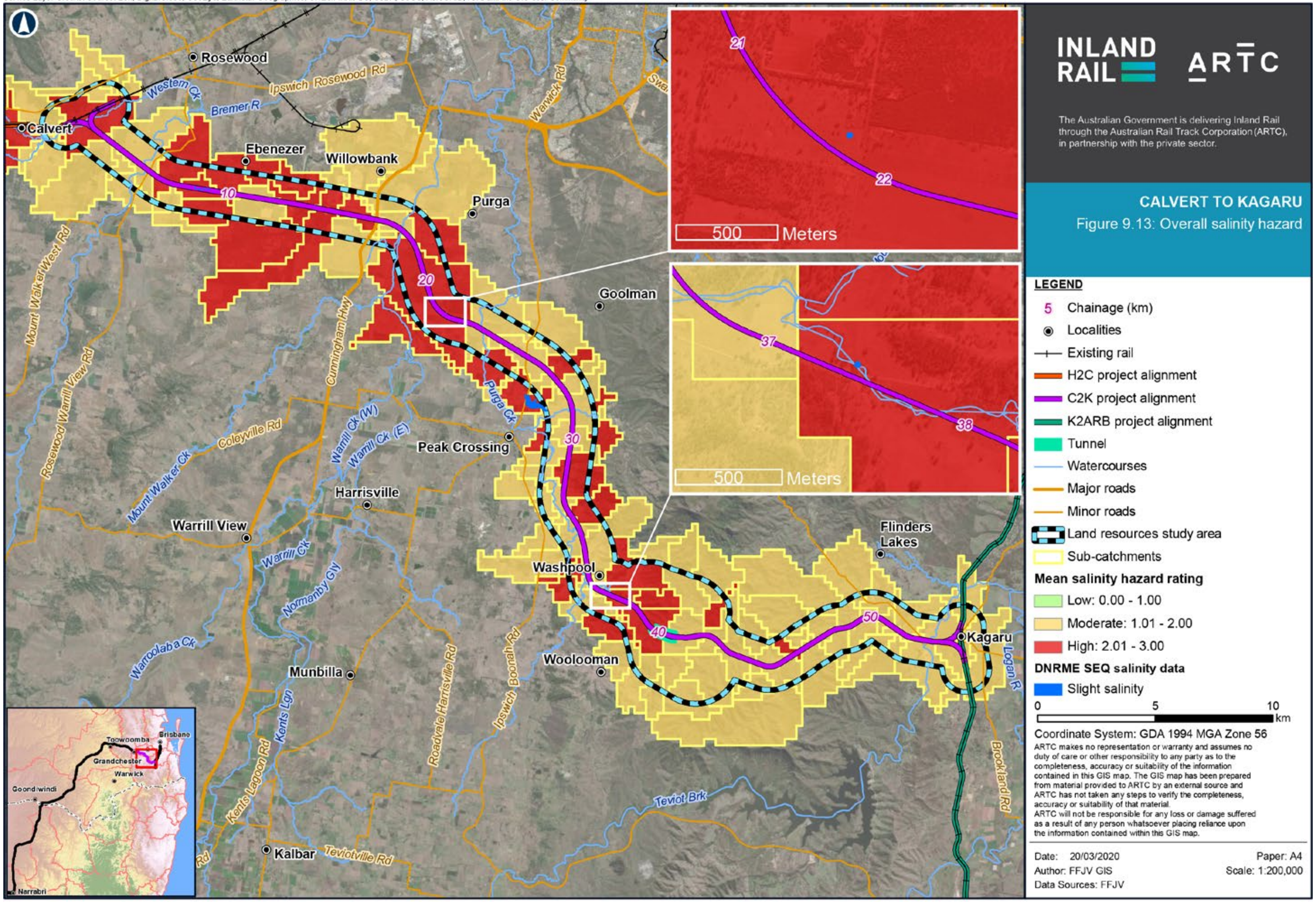
Soil sample results from the geotechnical investigation analysed exchangeable sodium, calcium and magnesium in soil samples, as these salts generally are responsible for salinity. Soil sample results identified an availability of all three salinity causing salts to exist at generally high concentrations (refer Table 9.4).

The salinity hazard assessment also considered additional data from the DNRME (received March 2020) of known salinity sites in South East Queensland (SEQ). Four small areas of 'Slight' salinity were identified within the study area and two of the four sites were located within the Project disturbance footprint (refer Figure 9.13). Table 9.10 provides a summary of the four known salinity areas.

TABLE 9.10: SUMMARY OF DEPARTMENT OF NATURAL RESOURCES, MINES AND ENERGY KNOWN SALINITY AREAS

Location	Salinity risk	Salinity type	Area (ha)
Ebenezer—adjacent Mount Forbes Road	Slight	Alluvial valley	1.64 (within disturbance footprint)
Purga—adjacent Purga Nature Reserve	Slight	Alluvial valley — catchment restriction (natural)	0.07 (within study area)
Peak Crossing—adjacent Ipswich Boonah Road	Slight	Alluvial valley—confluence of streams and catchment restriction (artificial)	~ 0.7 (within study area)
Washpool—adjacent Washpool Road	Slight	Alluvial valley	0.07 (within disturbance footprint)

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



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9.5.5 Agricultural land

The Queensland Agricultural Land Audit 2013 (the Audit) identifies land important to current and future agricultural production in QLD. The Audit identified agricultural potential using a rule-based approach that combines biophysical characteristics of the land, such as soil, climate and landform as well as native vegetation, and socio-economic spatial data. The characteristics of land/soil resources are a fundamental determinant of potential for most agricultural land uses. Soils are classified using a four-tier hierarchy ranging from Class A (arable land) through to Class D (land that is unsuitable for agriculture) (DAFF), 2013).

Agricultural land classified as Class A or Class B land is the most productive land in QLD, with soil and land characteristics that allow successful crop and pasture production.

The Audit also identified IAAs. IAAs are defined as land that has all the requirements for agriculture to be successful and sustainable, is part of a critical mass of land with similar characteristics and is strategically significant to the region or the State.

The land resources study area intersects two areas of IAAs at Peak Crossing, along the western portion, and at Kagaru. Class A and Class B agricultural land also features in several small patches, scattered along the study area surrounding Calvert, south of Willowbank, west of the Boral Quarry at Goolman, along the western portion of the study area at Peak Crossing, a small area at Undullah in the Teviot Range and at Kagaru (refer Figure 9.14).

Using the Queensland Agricultural Land Audit (DAFF, 2013) results for the SEQ region, agricultural land in the region is used for the following activities:

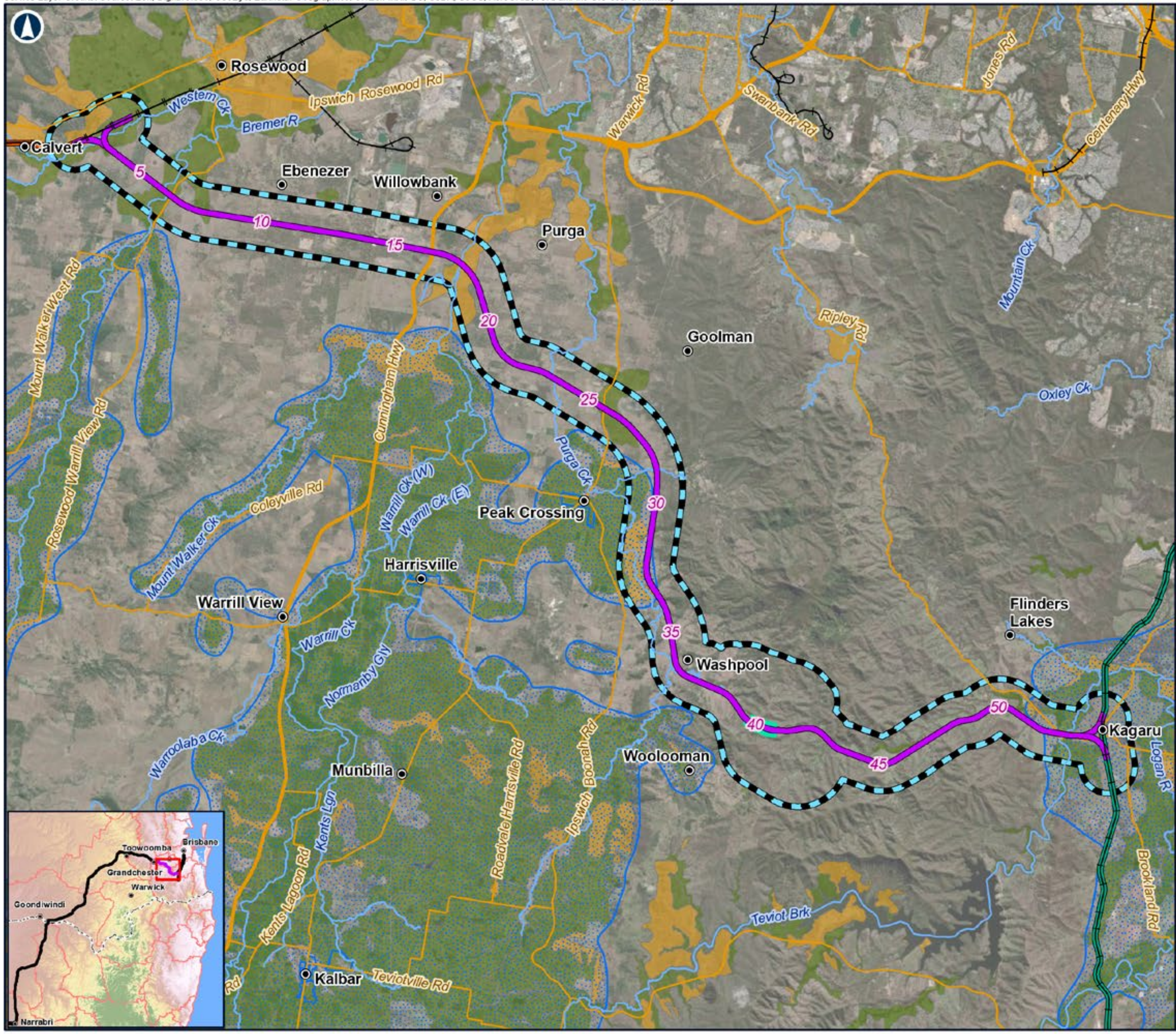
- Sown pastures
- High pasture production (>3,500 kg/ha)
- Annual horticulture
- Broadacre cropping
- Intensive livestock.

Further details on agricultural uses and activities is provided in Chapter 8: Land Use and Tenure.

The Audit (DAFF, 2013) also found the SEQ region to support a range of agricultural industries with horticulture, poultry, cattle, dairy and cultivated turf the largest industries. The soils of the SEQ region allow for a wide range of agricultural uses due to its fertile nature as identified in Section 9.5.4.1 (DAFF, 2013).

Other significant land uses identified through the Audit (DAFF, 2013) include a cattle feedlot located within the land resources study area at Kagaru along the banks of the Teviot Brook—a concentrated cluster of medium-potential forest for saw-log production situated in the Scenic Rim mountain range and high-pasture production land between Calvert and Peak Crossing becoming medium-pasture production as the Project approaches Kagaru.

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



INLAND RAIL

ARTC

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

CALVERT TO KAGARU

Figure 9.14: Important agricultural areas

LEGEND

- Localities
- Chainage (km)
- Existing rail
- H2C project alignment
- C2K project alignment
- K2ARB project alignment
- Tunnel
- Watercourses
- Major roads
- Minor roads
- Land resources study area
- Important agricultural area
- Class A land
- Class B land

0 5 10 km

Coordinate System: GDA 1994 MGA Zone 56

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9.5.6 Soil erosion

Preventing and managing erosion is important to consider when a change to the land use will occur. Erosion, the transport of sediment and eventual deposition by water, wind or both occurs across virtually all landscapes in Australia, even those on very low slopes and is a potential risk for the Project as the rail infrastructure requires a stable base to operate safely.

The soil variability in the region is typically a reflection of the dominant presence of erosional and transportation surfaces on the slopes as opposed to the depositional environments of valleys and floodplains. The transitional zones of these soil environments can increase the complexity and variability of the soil types (Lobb, 2011).

The types of erosion that have potential to occur within the land resources study area due to landforms and underlying geology include:

- Sheet: occurs on hill slopes when thin layer of topsoil is removed over a whole hillside
- Rill: occurs on hill slopes when surface runoff forms small channels as it concentrates down a slope
- Aeolian: occurs predominantly in arid grazing lands of inland QLD when winds blow over light textured soils
- Tunnel: removal of subsoil when water travels through a soil crack or hole where a root decay has caused the soil to disperse.

Erosion risks within the land resources study area, based on landform type and geology, are summarised in Table 9.11.

TABLE 9.11: EROSION RISK

Landform type	Geology	Erosion type	Erosion risk
Floodplains and river terraces subject to fairly regular overbank flooding, sandy banks and poorly defined levees and cobble plains. Supports grassy eucalypt woodlands and tussock grasslands	Quaternary alluvium	Sheet	Moderate
		Aeolian	Moderate
Erosional surfaces; ridges and plateaux remnants on basalt with steep stony slopes, restricted lower slopes, stony interfluves.	Koukandowie formation	Sheet	Moderate
		Rill	Moderate
	Heifer creek sandstone member	Tunnel	Low
		Aeolian	Moderate

Source: Damara Pty Ltd, 2013; Biggs et al., 2010

Erosion can cause loss of soil resources, change to landscape and topography and even an increased risk of salinity. The erodibility of soil can be associated with two key factors: dispersibility and sodicity of the soil type. Dispersive soils were identified as being present in the residual and alluvial soils, which are derived from the underlying sedimentary rocks within the land resources study area. Sodosols, chromosols and dermosols within the land resources study area were found to be the most susceptible to dispersion and have potential for severe erosion along hillsides.

As part of the Project geotechnical investigations (Golder Associates, 2018) Emerson Aggregate Tests were undertaken, which measure the dispersive characteristics of a soil when exposed to water (Standards Australia, 2006a). The investigations identified an Emerson class range between two (high dispersion potential), to six (typically not dispersive), with more than 50 per cent of results categorised as highly to moderately dispersive.

In addition to dispersibility, soil sodicity is another key indicator of a soil's erodibility. Sodicity of a soil is the presence of a high proportion of sodium ions relative to other cations. An excessive amount of sodium degrades soil properties by weakening the bond between soil particles (Queensland Government, 2016). Soil sampling investigations for the Project found exchangeable sodium percentages between 17.9 per cent and 22.6 per cent. Levels of sodicity above six per cent are regarded as high. The pH of soils sampled also ranged between 6.3 and 8.7, reflecting slightly acidic to alkaline soils (refer Table 9.4).

The results identified high levels of exchangeable calcium and magnesium within the soil sampled, which in high percentages, increases a soils capacity to disperse by reducing its ability to maintain structure.

9.5.6.1 Soil conservation plans

Soil conservation plans may be approved under the *Soil Conservation Act 1986* which intends to facilitate the implementation of soil erosion control measures by land holders in QLD through the use of property plans and project area plans. Approved soil conservation plans may cover the whole of a property or just part of it (DSITI, 2015). The Act allows for two types of plans: property plans and project plans. Soil conservation plans aim to ensure soil capability is not exceeded and no adverse impacts occur onsite as well as offsite, such as polluting water resources and degrading aquatic habitats.

Approved property and project area plans are binding on all present and future owners and the Crown. Both approved property plans and project area plans can be modified to accommodate circumstances that differ from those applying at the time of approval. Plans may be amended, or their approval may be revoked.

The Project has assessed existing soil conservation plans (property and project) through a review of current plans within the land resources study area (provided by DNRME), and no approved soil conservation plans (property or project) exist in the land resources study area.

9.5.7 Contaminated land

9.5.7.1 Contaminated land methodology

An assessment of contaminated land within the land resources study area was undertaken using a contaminated land risk assessment based on a contaminant source–pathway–receptor methodology whereby:

- **Contaminant (source):** A substance present in or on land, water or site at above background concentrations that presents, or has the potential to present, a risk to human health, the environment or any environmental value.
- **Pathway:** The route by which the source is brought into contact with the receptor. This can include the transport of contamination via water (surface and groundwater), aeolian deposition, vapours, excavation and deposition.
- **Receptor:** Humans, other living organisms, physical systems and built structures that could be affected by the source. A receptor will only be affected if a pathway from the source to the receptor is present. Groundwater and surface water systems can be considered as receptors in their own right as their quality is regulated by statutory bodies, as well as being pathways for contaminant migration to other receptors.

The source–pathway–receptor relationship allows an assessment of potential environmental risk to be determined, based on the nature of the source, the degree of exposure of a receptor to a source, and the sensitivity of the receptor.

The fundamental concept of contaminated land risk assessment is that an exposure pathway linking the source of contamination and the exposed population (humans or the environment) must be present for a risk to exist (NEPM, 2013).

Identification of potential sources of contamination within the land resources study area was assessed through site inspections (including walkover) of the land resources study area, undertaken as part of the geotechnical investigations, including bore logs and a desktop assessment.

The desktop assessment identified potential sources of contamination within the land resources study area through:

- A search of ERAs listed on the environmental authorities register
- A search of Queensland mining leases
- A search of the EMR and CLR for those ERAs identified
- An assessment of historical aerial imagery from areas of interest (e.g. potentially contaminated sites, infrastructure, environmentally significant areas etc.)
- A search of the Department of Defence online mapping for UXO
- A search for key resource areas (KRA) and other resource interests.

Potential sources of contamination identified from the assessment are detailed below as well as results from desktop assessments.

9.5.7.2 Potential sources

Based on the land uses within the land resources study area, findings of a desktop assessment and field investigations, the potential sources of contamination in the vicinity of the Project are considered to include:

- Agricultural activities: hydrocarbons (fuel and oil storage and use), pesticides and herbicides, asbestos and lead paint, arsenic (cattle dips), landfilling
- Quarries: hydrocarbons (fuel and oil storage and use), metals/metalloids, hazardous materials
- Queensland Raceway, Willowbank: hydrocarbons (fuel and oil storage and use)
- Landfilling, waste disposal: hazardous materials, hydrocarbons, metals/metalloids, phenols, polychlorinated biphenyls, phthalates, volatiles and pesticides and herbicides
- Existing rail corridor: metals, asbestos, hydrocarbons, pesticides/herbicides
- Road crossings: metals and hydrocarbons
- Unknown fill material: asbestos, metals/metalloids, hydrocarbons.

During the geotechnical site investigation, no visual contamination was identified, and no anthropogenic material was observed (Golder Associates, 2018). A targeted contaminated land investigation will be undertaken following completion of detailed design, where the Project (disturbance footprint) intersects areas of medium to high risk to determine the likelihood of contaminated soils, the potential for risks to human health and the environment and required management measures.

Environmentally relevant activities

An assessment of potential sources of contamination found six prescribed ERAs—properties identified as having potential to be contaminated due to activities being undertaken on property—within the land resources study area. These are discussed further detailed in Chapter 8: Land Use and Tenure.

As part of the Southern Freight Railway Corridor (SFRC) Study, (AECOM, 2010b), 514 identified properties were searched on the QLD EMR or CLR database, which identifies properties of known contamination. Only 24 were recorded on the EMR, while none were listed on the CLR. These properties were recorded for the following activities (AECOM, 2010b):

- Operating a livestock dip or spray race facility
- Hazardous contaminants
- Fertiliser manufacture
- Petroleum product or oil storage
- Area Management Advice for UXOs.

Properties within the land resources study area identified during the SFRC Study as properties with potentially contaminating activities, and current properties listed on the Environmental Authorities Register were also searched on the EMR and CLR. The searches undertaken, between October 2018 and February 2019, concluded 17 properties within the land resources study area, which include 11 properties within the disturbance footprint, were currently registered on the EMR (refer Figure 9.15), with further details provided in Table 9.12.

The level of risk pertaining to each property was categorised with consideration of distance to the land resources study area and potential for adverse impact (no potential, potential, or likely). The potential for adverse impact considered concentration of likely contamination at the source, type of contamination, contaminant mobility and potential transport pathways.

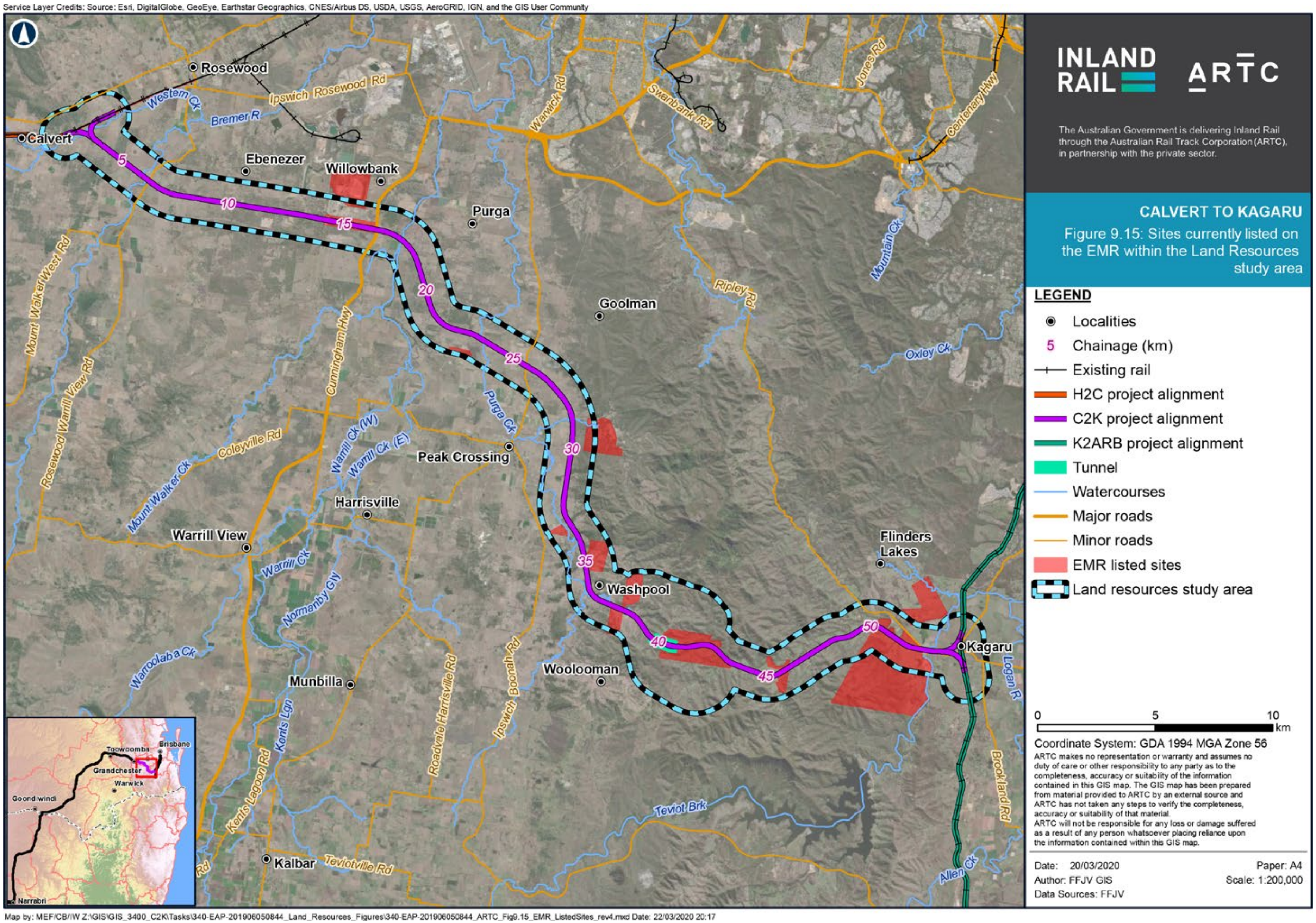


Figure 9.15: Sites currently listed on the EMR within the Land Resources study area

TABLE 9.12: PROPERTIES LISTED IN THE ENVIRONMENTAL MANAGEMENT REGISTER LOCATED WITHIN THE LAND RESOURCES STUDY AREA

Lot and Plan	Location	Listing details	Distance of activity to land resources study area	Risk potential
25 SP108209	South of Queensland Raceway and Willowbank Raceway	Manufacturing agriculture fertiliser	Within study area	Medium
54 SP243512	South of Willowbank Raceway	Manufacturing agriculture fertiliser	Within study area	Medium
53 SP243512	South of Willowbank Raceway	Manufacturing agriculture fertiliser	Within study area	Medium
13 RP892026	East of Pelford Road, Peak Crossing	Operating a livestock dip or spray race facility	Within study area	Medium
2 RP61267	Southeast of Dunrad Road and Mount Flinders Road intersection at Peak Crossing	Operating a livestock dip or spray race facility	Within study area	Medium
18 RP21384	East of Washpool Road and Ipswich Boonah Road intersection at Peak Crossing	Operating a livestock dip or spray race facility	Within study area	Medium
76 SP131580	East of Washpool	Operating a livestock dip or spray race facility	Within study area	Medium
6 SP131580	East of Washpool	Operating a livestock dip or spray race facility	Within study area	Medium
45 RP22590	East of Washpool	Operating a livestock dip or spray race facility	Within study area	Medium
50 RP22590	Southeast of Washpool	Operating a livestock dip or spray race facility	Within study area	Medium
259 RP809310	Southeast of Washpool	Operating a livestock dip or spray race facility	Within study area	Medium
1 SP163227	North of Undullah	Operating a livestock dip or spray race facility	Within study area	Medium
19 W31189	West of Kagaru	Operating a livestock dip or spray race facility	Within study area	Medium
22 SP164832	East of Wyatt Road and Undullah Road intersection, Kagaru	Operating a livestock dip or spray race facility	Activity located 750 m from the land resources study area but considered	Low
232 SP130091	Along Interstate railway line at Kagaru	Site subject to hazardous contaminant - arsenic	Within study area	Medium
251 SP130171	Along West Moreton System railway line at Calvert	Site subject to hazardous contaminant – arsenic	Within study area	Medium
3 SP167885	North of Queensland and Willowbank Raceway	Landfill and mine wastes	Bordering study area	Low

Table notes:
Low risk: 1.5 km to 2 km from proposed rail alignment and/or with no potential adverse impact
Medium risk: 1.0 km to 1.5 km from proposed rail alignment and/or with potential for adverse impact
High risk: < 1.0 km from proposed rail alignment (i.e. within the land resource study area) and/or with likely adverse impact

All properties with a current environmental authority for ERAs have been included in Chapter 8: Land Use and Tenure. Appendix H: EMR Searches and Lab Certificates identifies properties, which were listed on the register.

Unexploded ordnances

A search of the Department of Defence (2017) online mapping for UXO identified a large area of 'slight occurrence' just west of Kagaru, extending into the Scenic Rim mountain range, as well as an additional extent of 'slight occurrence' just north of Peak Crossing.

The Department of Defence defines areas of 'slight occurrence' as: areas with a confirmed history of military activities that have resulted in residual UXO but Defence considers it inappropriate to assess as substantial. Department of Defence advice for areas of 'slight disturbance' is: all land usage and development, within these areas, should continue without further UXO investigation or remediation.

Resource areas

Purga Quarry is a key resource area (KRA No. 82), which contains important extractive resources of State or regional significance worthy of protection for future use (DILGP, 2016a), located within the land resources study area, east of Boonah Road at Peak Crossing. The quarry is, however, considered a low risk of contaminant source due to existing environmental licences and management processes implemented onsite.

The Bremer View East coal resource area also intercepts the land resources study area at Ebenezer, while the Ebenezer coal resource area runs parallel to the study area, north of Willowbank Raceway.

A historical mining lease (ML 4712) for the non-operational Ebenezer Mine features within the land resources study area, as the proposed rail alignment traverses south of Willowbank. There are no current granted coal or mineral exploration permits within the land resources study area. There are also no applications for mining permits within the land resources study area.

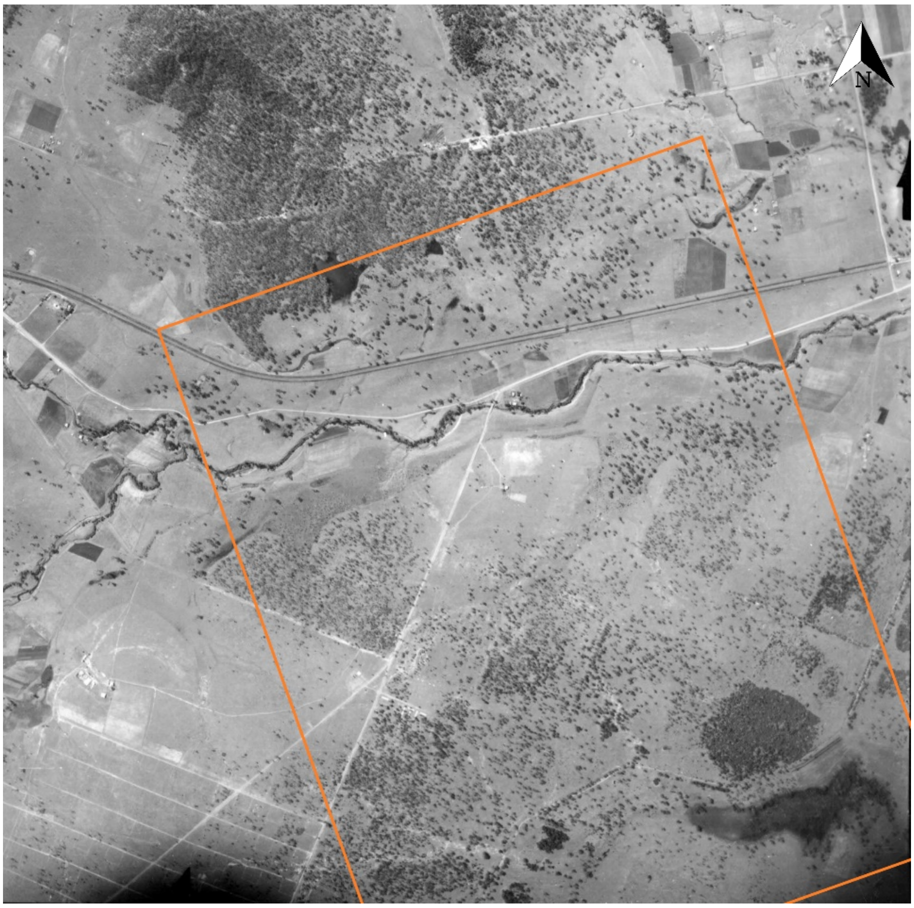
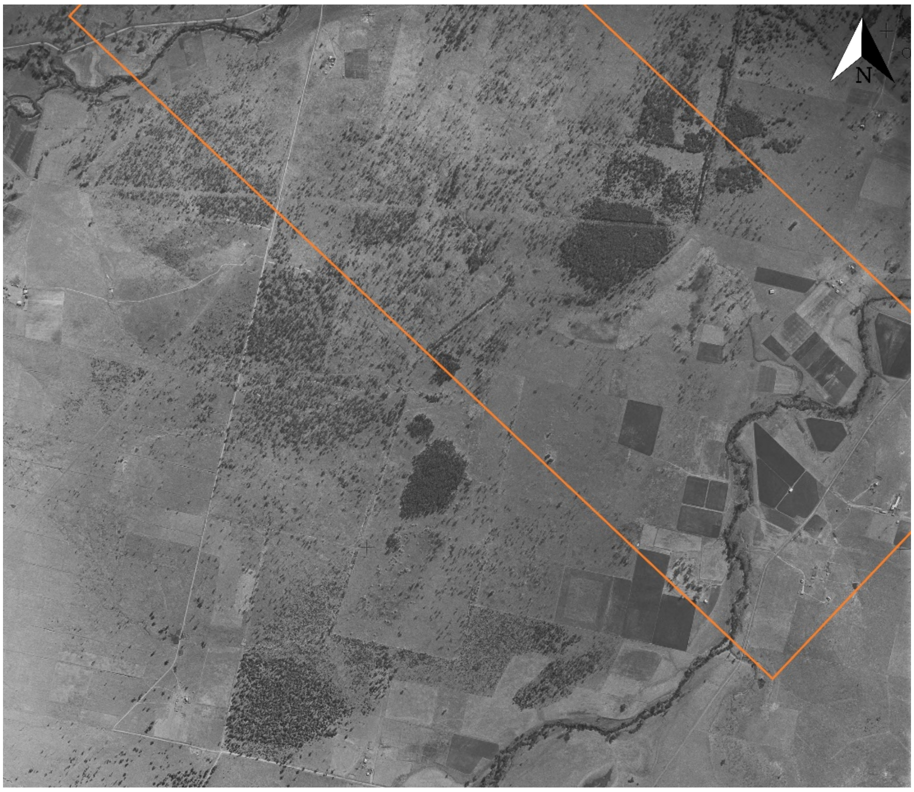
The land resources study area also intersects two authority to prospect permits (ATP) for petroleum exploration (ATP641 and ATP644), as well as two current applications for potential commercial areas (PCA) for petroleum (PCA 223 and PCA 198), located over the ATP permits. There is one petroleum licence located within land resources study area. This pipeline licence is associated with the Moonie to Brisbane (PPL 1) pipeline.

Further detail regarding all resource areas are provided in Chapter 8: Land Use and Tenure.

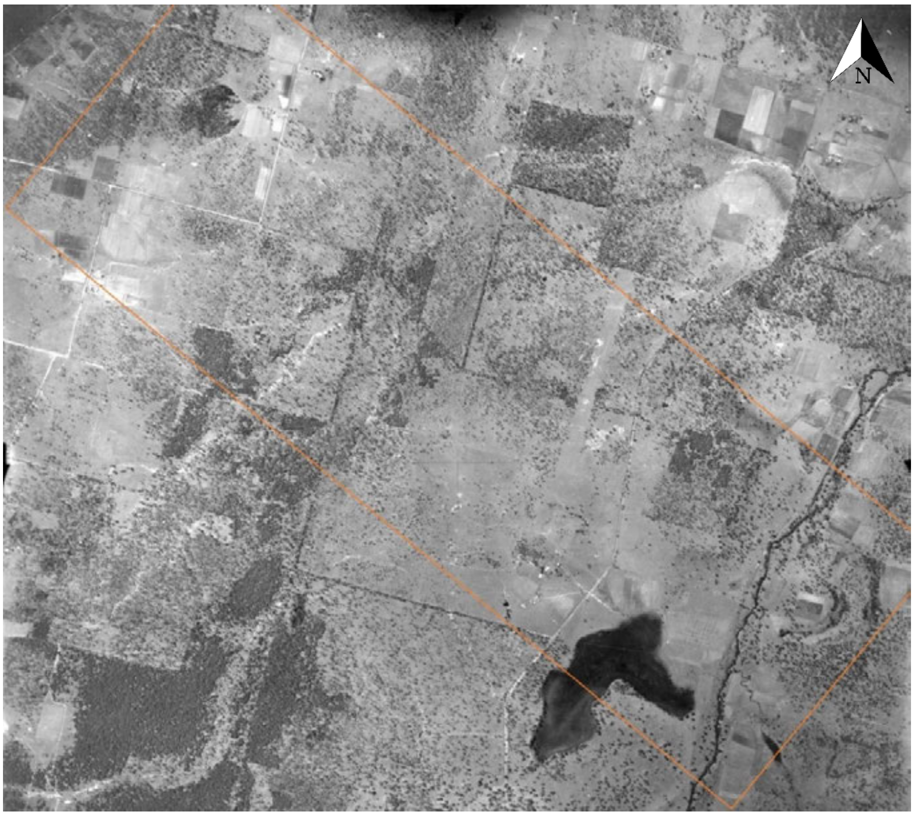
9.5.7.3 Historical aerial imagery

An assessment of historical aerial imagery from areas of interest (e.g. potentially contaminated sites, infrastructure, environmentally significant areas) was undertaken to explore current potential sources, as well as historical sources of contamination within the study area (refer Table 9.13).

TABLE 9.13: HISTORICAL AERIAL PHOTOGRAPHS

Study area (approximate study area indicated in orange)	Details
Calvert area	
	**Year:** 1948 **Direction:** Aerial **Details:** The aerial image displays the existing West Moreton System rail corridor running through Calvert towards Rosewood. It is evident from the aerial image that grazing pastures and scattered dense bushland are the dominant land use in the region. A seasonal water body can be observed to the south-east. Road networks have been established in the region with several residential properties spread across the land resources study area. **Source:** QImagery (2019)
	**Year:** 1958 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Calvert and the Bremer River, approaching Ebenezer. The aerial image indicates a growth in cropping pasture land use since 1948 along the banks of the Bremer River. The seasonal water body, north-west of the Bremer River, within the approximate land resources study area has dried with no further significant changes to be observed. **Source:** Department of Natural Resources and Water (2007)

Study area (approximate study area indicated in orange)	Details
	**Year:** 1975 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Calvert and Ebenezer. No significant changes have occurred to the area since 1958 with the exception of more residential housing being constructed and the seasonal water body, north-west of the Bremer River, once again containing water with heavy vegetation growth. An increase in cropping land in the area can also be observed along the banks of the Bremer River as well as north of the West Moreton Rail Corridor. **Source:** Department of Natural Resources and Water (2007)
	**Year:** 1990 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Calvert and Ebenezer. No significant changes have occurred to the area since 1975 with cropping pastures increasing in land use in the region. **Source:** QImagery (2019)

Study area (approximate study area indicated in orange)	Details
	**Year:** 2019 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Calvert and Ebenezer. No significant changes have occurred in the region since 1990 with cropping pastures increasing in land use to the north, south and east and a greater density of residential properties emerging. **Source:** Environmental Systems Research Institute (ESRI) (2019)
Willowbank area	
	**Year:** 1948 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Ebenezer and Willowbank. The landscape consists of grazing pastures and scattered bushland. Several residential properties feature throughout the approximate study area as well as Ten Mile Swamp, west of Warrill Creek. Road networks have been established in the region, with small areas of cropping pastures evident to the north of the aerial image. **Source:** QImagery (2019)

Study area (approximate study area indicated in orange)	Details

Year: 1958

Direction: Aerial

Details: The aerial image displays the land resources study area between Ebenezer and Willowbank.

An increase in cropping land and residential properties has occurred to the north and east of Warrill Creek. Access roads have also been constructed within the approximate study area in the current location of Ebenzer Mine as well as a potential small tailings dam, located north-west of the Cunningham Highway.

Ten Mile Swamp has dried with floral growth evident on the surface.

Source: Department of Natural Resources and Water (2007)

Year: 1975

Direction: Aerial

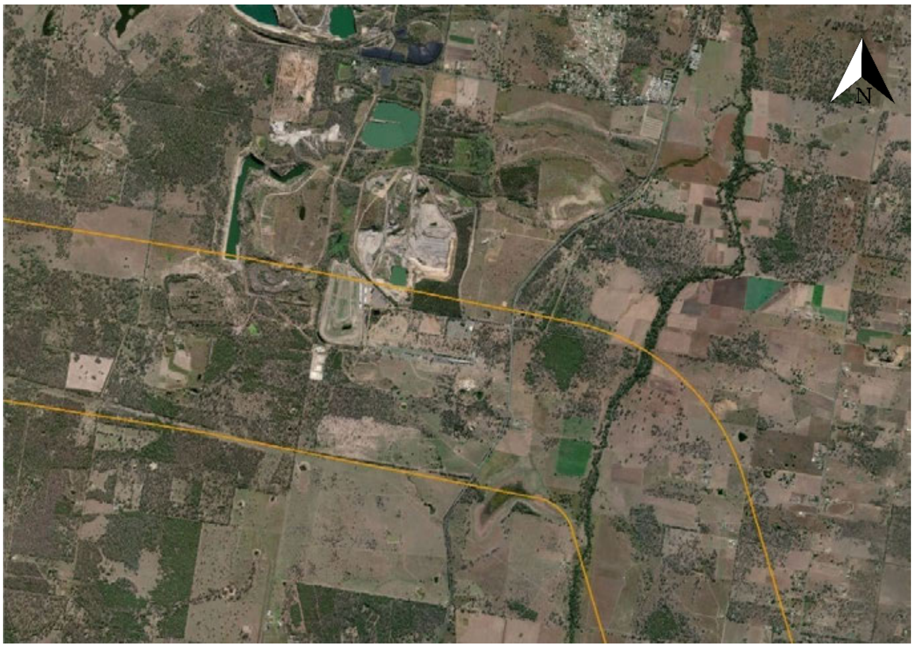
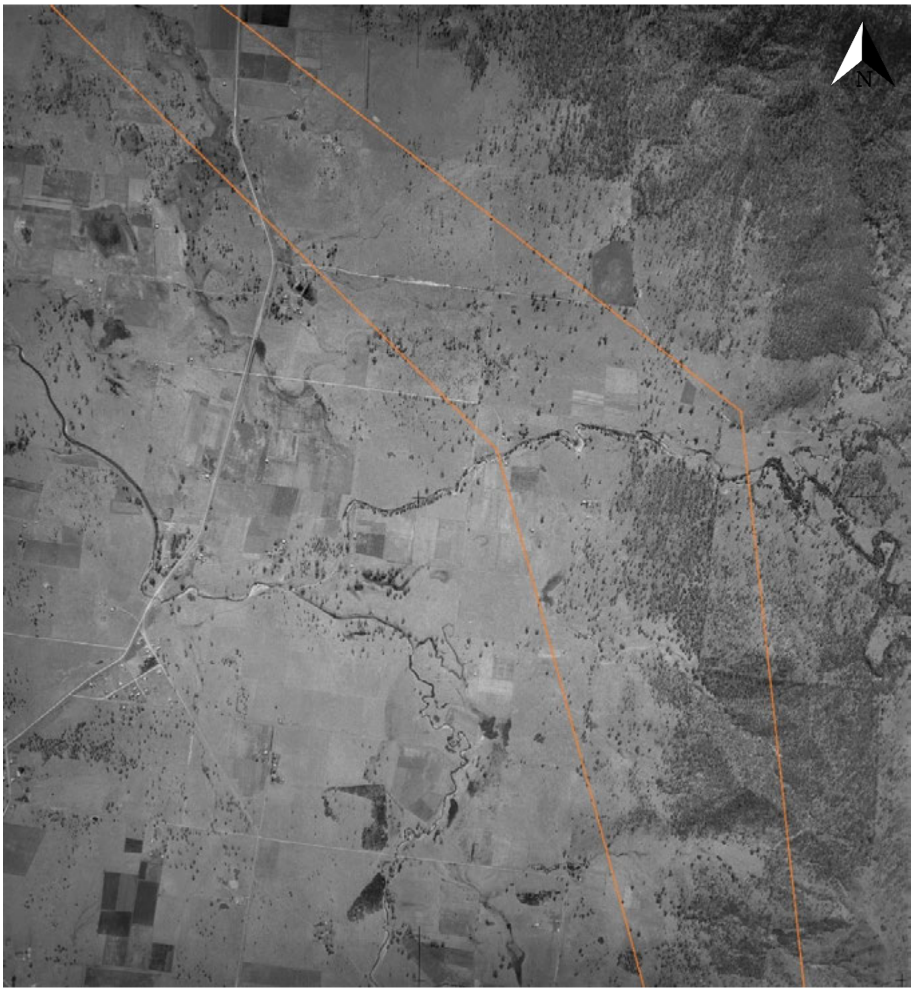
Details: The aerial image displays the land resources study area between Ebenezer and Willowbank.

Ebenzer Mine has begun clearing works with more access roads constructed. Further cropping pastures to the south of the aerial image have emerged.

No other significant changes can be observed since 1958 within the land resources study area.

Source: Department of Natural Resources and Water (2007)

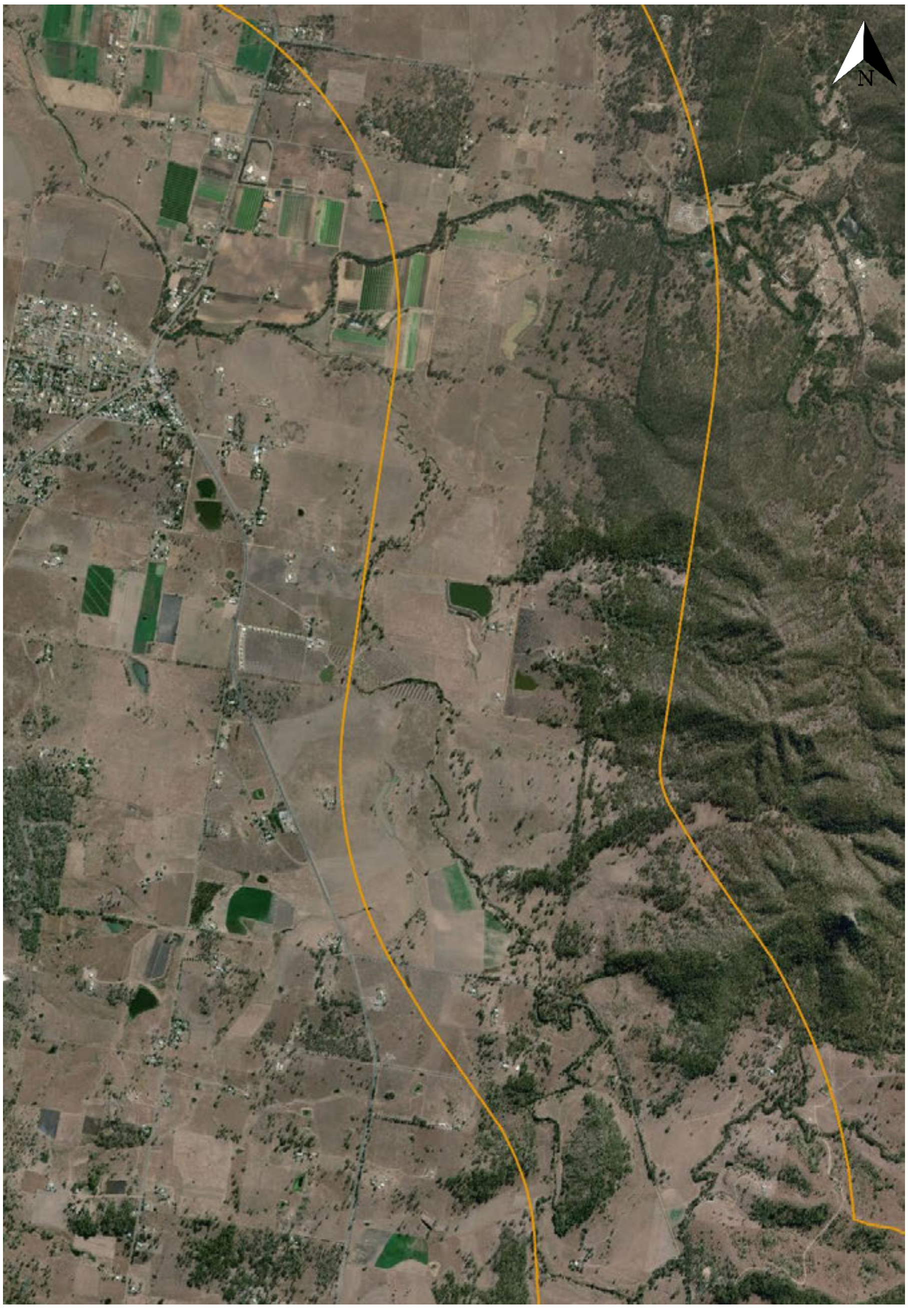
Study area (approximate study area indicated in orange)	Details
	**Year:** 1987 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Ebenezer and Willowbank. Ebenzer Mine has expanded operations with mining works underway. Residential dams and residential properties populate the landscape. Cropping pastures have emerged north of Ten Mile Swamp. No other significant changes can be observed since 1975 within the land resources study area. **Source:** Department of Natural Resources and Water (2007)
	**Year:** 1997 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Ebenezer and Willowbank. Ebenzer Mine dominates the landscape to the north. South of the mine, Willowbank Raceway and several other racing tracks are emerging. Cropping pastures now dominate the banks of Warrill Creek. No other significant changes can be observed since 1987 within the approximate land resources study area. **Source:** Department of Natural Resources (1997)

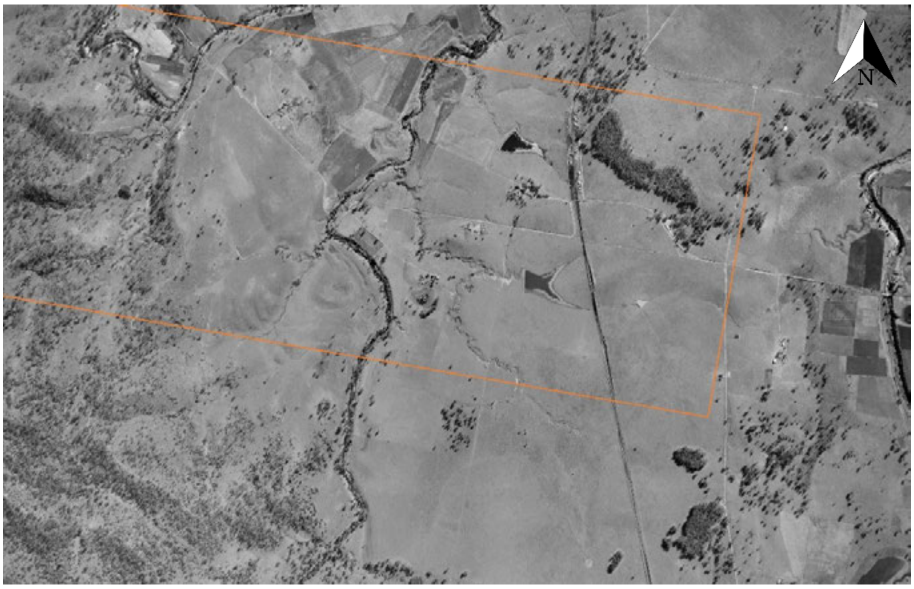
Study area (approximate study area indicated in orange)	Details
	**Year:** 2019 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Ebenezer and Willowbank. Ebenzer Mine, Willowbank and the Queensland Raceways as well as smaller racing tracks dominate the landscape at Willowbank. Clearing of land is evident to the west and south of Ebenzer Mine. No other significant changes can be observed within the land resources study area. **Source:** ESRI (2019)
Peak Crossing area	
	**Year:** 1955 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Peak Crossing and Washpool. The Flinders Peak Conservation Park slopes dominate, with Sandy Creek intersecting on its descent from the hillside. Cropping pastures adjoining residential properties feature throughout the region, with a particular concentration at the intersection of Sandy and Purga Creek. Potential floodplains and an ephemeral waterway exists to the north-west, adjoining Sandy Creek. **Source:** Department of Natural Resources and Water (2007)

Study area (approximate study area indicated in orange)	Details
	**Year:** 1970 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Peak Crossing and Washpool. Land use from cropping pastures has significantly increased and become the major land use in the region. Several residential properties, residential dams and road infrastructure has also been constructed in the area. No other significant changes can be observed within the land resources study area. **Source:** Department of Natural Resources and Water (2007)

Study area (approximate study area indicated in orange)	Details
	**Year:** 1987 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Peak Crossing and Washpool. Rapid development can be observed in the aerial image compared to 1970, as the Peak Crossing township begins to develop, west of the land resources study area. No other significant changes can be observed within the approximate land resources study area. Further to the west, a small mine or quarry is emerging. **Source:** QImagery (2019)

Study area (approximate study area indicated in orange)	Details
	**Year:** 1997 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Peak Crossing and Washpool. Several residential dams can be seen to contain white sediment, which was not evident in the previous aerial image. Furthermore, cropping pastures have continued to develop within the study area. No other significant changes can be observed within the land resources study area. **Source:** Department of Natural Resource (1997)

Study area (approximate study area indicated in orange)	Details
	**Year:** 2018 **Direction:** Aerial **Details:** The aerial image displays the land resources study area between Peak Crossing and Washpool. A large noticeable waterbody has emerged east of Dwyers Road. No other significant changes can be observed within the land resources study area. **Source:** ESRI (2018)

Study area (approximate study area indicated in orange)	Details
Kagaru area	
	**Year:** 1944 **Direction:** Aerial **Details:** The aerial image shows the land resources study area between Undullah and Kagaru. Cropping pastures are the dominant land use in the region, particularly along the banks of the Logan River and the Teviot Brook. Road and rail infrastructure, the Interstate Line, in the region has already been well established. Areas of scattered remnant vegetation also feature. Residential infrastructure is minimal; however, properties have been cleared for potential construction. **Source:** QImagery (2019)
	**Year:** 1970 **Direction:** Aerial **Details:** The aerial image shows the land resources study area between Undullah and Kagaru. No significant changes can be observed except for concentrated cluster of buildings having been erected alongside the existing Interstate Line, as it passes through Kagaru. Several residential dams have also been constructed. **Source:** Department of Natural Resources and Water (2007)

Study area (approximate study area indicated in orange)	Details
	**Year:** 1997 **Direction:** Aerial **Details:** The aerial image shows the land resources study area between Undullah and Kagaru. A small number of residential properties have been constructed in the region as well as cropping pastures expanding in land use. Clearing of land along the banks of Woollaman Creek, at the foothills of Mount Wilbraham, is evident. Several more residential dams have also been constructed. No other significant changes can be observed from the aerial image. **Source:** Department of Natural Resources (1997)
	**Year:** 2019 **Direction:** Aerial **Details:** The aerial image shows the land resources study area between Undullah and Kagaru. A sand and soil quarry has commenced operation along the western side of the Teviot Brook. An ERA 16—Extractive and Screening Activity was issued for this area in 2011. Refer Chapter 8: Land Use and Tenure for further information. No other significant changes can be observed from the aerial image. **Source:** ESRI (2019)

Table note:

1. Approximate study area indicated in orange.

9.5.8 Contamination risk summary

Table 9.14 provides a summary of activities or risks identified and considered to be potential sources of contamination within the land resources study area. For the potential impacts to present a risk, there must be a linkage between the three following components:

- Source of contamination
- An exposure pathway
- Environmental values (receptor) that may be affected by this exposure.

If one or more of these components are unavailable, or there is no complete linkage between the three, the risk of exposure to an environmental value is likely to be either minimal or non-existent, due to a break in the linkage between source, pathway and receptor. Where activities pose potential risks, these activities or risks have been advanced through to the impact assessment. Should further information be obtained during the detailed design stage of the Project, indicating a potential risk is present for any of the activities, further assessment will be required if mitigation measures presented do not adequately address potential risk.

TABLE 9.14: POTENTIAL EXISTING SOURCES AND IDENTIFIED CONTAMINATION RISKS

Activity	Location	Potential contaminants	Potential risk (based on desktop study)
Within study area			
Agricultural land	Multiple throughout land resources study area	Hydrocarbons (fuel and oil storage and use) (agricultural storage and use)	Potential risk, due to distance to agricultural buildings
		Pesticides and herbicides (agricultural storage and use)	Potential risk, due to proximity to cropping land and EMR listed properties (Manufacturing agriculture fertiliser): - 25 SP108209 - 54 SP243512 - 53 SP243512
		Asbestos and lead paint (agricultural buildings/structures)	Potential risk, due to distance to agricultural buildings
		Livestock dips or spray races arsenic, dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethylene (DDE), dichlorodiphenyldichloroethane (DDD) (agricultural storage and use)	Potential risk, due to EMR listed properties (livestock dips or spray races): - 13 RP892026 - 2 RP61267 - 18 RP21384 - 76 SP131580 - 6 SP131580 - 45 RP22590 - 50 RP22590 - 259 RP809310 - 1 SP163227 - 19 W31189 - 22 SP164832
		Landfilling (agricultural)	Low risk, historical aerials did not identify presence of agricultural landfills (historic or current)
Housing/ sheds	Multiple throughout land resources study area	Hydrocarbons (fuel and oil storage and use), pesticides and herbicides, lead paint and asbestos (agricultural and residential storage and use)	Potential risk, due to houses/ shed distance to study area
Landfilling	Multiple throughout land resources study area	Hazardous materials, hydrocarbons, metals/metalloids, phenols, polychlorinated biphenyls, phthalates, volatiles and pesticides and herbicides (local council or commercial enterprise)	Low risk, due to EMR listed property 3 SP167885 (for landfilling) only bordering study area

Activity	Location	Potential contaminants	Potential risk (based on desktop study)
Rail corridor	▸ Interstate Line at Kagaru ▸ West Moreton System at Calvert	Metals/metalloids, asbestos, hydrocarbons, pesticides/herbicides (Railway land use)	Potential risk, due to identified presence (historic or current) and EMR listed properties for arsenic contamination: ▸ 232 SP130091 ▸ 251 SP130171
Roads	Rosewood Warrill View Road, Cunningham Highway, Ipswich Boonah Road, Washpool Road, Wild Pig Creek Road, Undullah Road, Waters Road, Hayes Road, Coveney Road, Mount Forbes Road, M Hines Road, Middle Road, Castle Hill Lane, Shepard Road, Mount Flinders Road	Metals, hydrocarbons, pesticides/herbicides (public roads)	Potential risk, due to identified presence
Unknown fill material	Existing rail corridor	Asbestos, metals/metalloids, hydrocarbons. (Railway land use)	Low risk, anthropogenic materials not observed during geotechnical investigation

Level of risk for EMR listed properties has been assessed in Table 9.12.

9.6 Potential impacts

The construction, operation and decommissioning phases of the Project has the potential to result in impacts to land resources within the land resources study area. Potential impacts to land resources associated with the Project are related to:

- Permanent change to landform and topography
- Loss of soil resources
- ASS
- Degradation of soil resources through invasive flora and fauna
- Salinity hazard
- Disturbance of existing contaminated land
- Creation of contaminated land.

9.6.1 Permanent change to landform and topography

Landform and topography are valuable for their ability to retain and move water within a soil catchment system. Project activities have the potential to permanently change the landform and topography of each catchment the Project traverses, through increased erosion and landslip associated with specific landscapes. Project activities may also alter localised contours within the landscape.

Changes to landform and topography may cause secondary impacts to surface water, such as changes to flow patterns and infiltration, as well as groundwater and flow direction, particularly in floodplain areas where railway infrastructure can significantly impede floodwaters and potentially redirect waters to sensitive receptors (refer Chapter 13: Surface Water and Hydrology).

9.6.2 Loss of soil resources

Construction of rail infrastructure within (or adjacent to) Class A, Class B and IAAs will result in the loss of natural soil resources and affect farming activities. Poor land management practice decisions can also cause loss of ground cover, leading to erosion from wind or water and increased dust levels and declining regional soil fertility over time.

Project activities can also lead to dust, compaction, contamination via foreign material, nutrient loss, soil leaching soil, secondary salinisation of good quality soil and soil inversion, where mixing subsoils and surface soils can potentially impact on natural soil processes and productivity and introduce contaminants into soil horizons.

Of the land within the disturbance footprint, located outside of the SFRC and existing rail and road corridors, 4.9 per cent of land is classified as Class A, 2.0 per cent of land classified as Class B and 12.3 per cent of land is classified as IAAs (refer Chapter 8: Land Use and Tenure). As the land resources study area only contains a relatively small area of Class A, Class B or IAAs, impact to soil resources is expected to be limited. Furthermore, the Project has been designed to minimise loss of soil resources through minimisation of impact to fertile soils where possible.

9.6.3 Degradation of soil resources through invasive flora and fauna

During the construction, operation and decommissioning phases of the Project, introduction of weed seed material through human actions may present a potential risk to land resources, through soil degradation. Weed species have the potential to adversely impact soil, influencing critical factors such as soil stability and fertility. Weeds are known to increase the rate of erosion in soil through inadequate soil protection, alter the soil's physical structure and change soil nutrient status (Weidenhamer & Callaway, 2010).

The Project may also encounter potential impacts from feral animals burrowing or tunnelling in soil, causing soil degradation. Erosion of the soil, as well as adverse impacts to groundwater flow and/or infiltration of rainfall may result from invasive fauna activity. Eight non-native fauna species have the potential to occur within the land resources study area, including:

- Cane toad (*Rhinella marina*)
- Dog (*Canis lupus*)
- Pig (*Sus scrofa*)
- Fox (*Vulpes vulpes*)
- European hare (*Lepus europaeus*)
- European rabbit (*Oryctolagus cuniculus*)
- Black rat (*Rattus rattus*)
- Eastern mosquitofish (*Gambusia holbrooki*).

Further detail is provided in Chapter 11: Flora and Fauna.

9.6.4 Acid sulfate soils and acid rock drainage

The desktop assessment and field investigations concluded a low probability of encountering ASS and/or acid rock drainage (ARD). ASS have the potential to degrade or destroy ecosystems as under acidic conditions, metals such as iron and aluminium, along with trace heavy metals/metalloids including arsenic, become increasingly mobile and allow infiltration into soil (Hicks et al., 1999). Project activities may expose potential ASS to oxygen through soil disturbance, creating damaging levels of sulfuric acid with the potential to corrode infrastructure built from concrete, steel as well as other material. Potential ASS may be located within the land resources study area, however under general conditions, residing below the water table and present a risk during excavation of cuts.

ARD occurs when sulfide minerals are exposed to air and water. This process is accelerated through excavation activities that increase rock exposure to air, water, and microorganisms. The resulting drainage may be neutral to acidic with dissolved heavy metals and significant sulfate levels. The intersection of sulfide-bearing rocks in cuts and the Teviot Range tunnel or use of sulfide-bearing materials in embankment fill, could present an ARD risk during Project activities, and subsequent runoff impacting on environmental values (i.e. aquatic groundwater dependent ecosystems (GDEs) and groundwater users).

Based on the surface geology traversed by the Project, the following conclusions can be made:

- Alluvium—generally low risk due to young age of material and lack of sulfide minerals
- Main Range Volcanics—the Tertiary Main Range Volcanics are considered low risk given their primary mineralogy is sulfide poor
- Sedimentary units—the Jurassic age Walloon Coal Measures, Koukandowie Formation and Gatton Sandstone, in which cuts and the tunnel are proposed, may host disseminated sulfide minerals (i.e. pyrite).

Rainfall infiltration into cuttings with sulfide-bearing minerals above the saturated zone may also pose an ARD risk even if the entire cut is in the unsaturated zone (above groundwater).

In the unlikely event ASS/ARD is encountered during construction phase of the Project, an unexpected finds protocol/procedure will be implemented (refer Section 9.7.2). Furthermore, site inspections prior to the construction of cuts would provide an opportunity to visually examine surface outcrops for sulfide minerals or remnant products indicative of sulfide mineralisation. This would inform the management of potential ARD cuttings in the sedimentary units prior to construction works.

Any excavated material that is suspected to contain sulfate/sulfides should be stockpiled, lined and covered and managed so as to minimise rainfall infiltration and leaching. Where possible, treatment and onsite reuse are preferred to offsite disposal. A case-by-case assessment of the suitability of material for treatment and reuse will be required.

Requirements for inspections and periodic sampling of discharge waters from deep cuts is discussed further in Chapter 14: Groundwater. If ARD-contaminated discharge water is found to be generated from the deep cuts, this water may need to be impounded in ponds and neutralised via treatment with hydrated lime or dilution prior to release into the surrounding catchment or other discharge mechanism.

9.6.5 Salinity hazard

Project activities have the potential to cause secondary salinisation, which is salting resulting from human activities, through processes such as the removal of vegetation, altering waterways and general land use changes. Secondary salinisation can cause water table salting, irrigation water salting and erosion scalding (DERM, 2011).

Geological features and past patterns of weathering result in some landforms having more potential to express salinity through the presence of restrictions to groundwater flow that may cause the water table to rise to near the soil surface, resulting in a discharge area with evaporative salts. During the desktop salinity hazard assessment (refer Section 9.5.4.5), potential landforms (naturally occurring and currently present) were identified within the land resources study area with a risk for salinity formation and are further detailed in Table 9.15.

TABLE 9.15: LANDFORMS WITH SALINITY FORMATION RISK IDENTIFIED DURING DESKTOP SALINITY HAZARD ASSESSMENT

Feature	Information contributing to salinity investigations	Potential impact	Existing salinity formation risk within land resources study area
Landform feature identification: Geology Waters	PEA: Basalt over sandstone interface	Potential to have a more permeable basalt layer contacting with a less permeable sandstone geology underneath. This landform type can cause a restriction to downward water movement with seepages occurring at the interface area.	High
	PEA: Confluence of streams	Potential for the junction of a minor steam with a major stream to have a reduction in flow velocity and resultant deposition of suspended particles and salts.	Low
	PEA: Catena	Potential to have a change in hydraulic gradient similar to a barrier in water movement. Salting arising from infiltration of water into the soil and lateral movement through the weathered parent horizon or through more permeable soil.	Medium
Soil properties	PEA: Soil salt store	Potential for soluble salts to be sitting within the soil profile.	Medium
	PEA: Artificial restriction, roads	Potential to have a reduction in water transmission, sufficient to cause salting upslope of the road.	Low
Known salinity expressions	Known salinity expressions	Active or stable sites along the rail corridor.	Low
Overall salinity hazard	Total PEAs	Potential for various methods of salt build up and transportation.	Medium to high

Identified landforms (refer Table 9.15) pertaining a medium to high risk of salinity formation were considered at risk from Project activities. The residual risk of Project activities to salinity hazard is presented in Section 9.8.

Salinity also presents a risk to infrastructure in saline areas through predominantly corrosion (Searle et al., 2007). A number of naturally occurring, as well as man-made, assets within the land resources study area, or adjacent, could potentially be affected if salinity was to occur (or increase) as a result of Project activities. A summary of asset types, potential impact from salinity and likelihood of occurrence (as a result of Project activities) is provided in Table 9.16.

TABLE 9.16: ASSET TYPE, POTENTIAL SALINITY IMPACT AND LIKELIHOOD

Asset type	Potential impact from salinity	Likelihood
Gum Tips Nature Refuge	Salinity affecting land surrounding these areas or the clearing of forested areas potentially leads to spreading of dryland salinity. In turn the spread of dryland salinity can potentially lead to further loss of native bushland, native habitats and loss of biodiversity within World Heritage Areas, National Parks, State Forests and Wildlife Corridors.	Unlikely
Disused Ebenezer coal mine (Zedemar Holdings Pty Ltd)	Dispersion of soils, increased likelihood of pond wall degradation. Threat of rust to pipelines, storage tanks, and weakened foundations of onsite buildings. Loss of biodiversity onsite. It is noted that as of January 2020 there is a proposal to transform the disused site into a resource recovery hub (refer Chapter 8: Land Use and Tenure).	Unlikely
Ipswich Motorsport Precinct	Dispersion of soils, increased likelihood of pond wall degradation. Threat of rust to pipelines, storage tanks, and weakened foundations of onsite buildings. Loss of biodiversity onsite.	Unlikely
JNJ Resources—Bentonite product production	Dispersion of soils, increased likelihood of pond wall degradation. Threat of rust to pipelines, storage tanks, and weakened foundations of onsite buildings. Loss of biodiversity onsite.	Unlikely
Purga Nature Reserve	Salinity affecting land surrounding these areas or the clearing of forested areas potentially leads to spreading of dryland salinity. In turn the spread of dryland salinity can potentially lead to further loss of native bushland, native habitats and loss of biodiversity within World Heritage Areas, National Parks, State Forests and Wildlife Corridors.	Unlikely
Cattle feedlot (Yackatoon Grazing Co)	Animal health decline, pasture land, productivity decline. Income lost to landholders. Sheds, fencing, farming equipment and other equipment can be damaged and is expensive to replace.	Unlikely
Irrigated cropping and modified pastures	Loss of viable cropping land.	Unlikely
Poultry farming (Purga Breeder Farm)	Animal health decline, pasture land, productivity decline. Income lost to landholders.	Unlikely
KRA 82—Purga Quarry	Dispersion of soils, increased likelihood of pond wall degradation. Threat of rust to pipelines, storage tanks, and weakened foundations of onsite buildings. Loss of biodiversity onsite.	Unlikely
Ivory's Rock Convention and Events Centre	Pavement failure, structure decline.	Unlikely
Teviot Range	Dispersion of soils, increased likelihood of pond wall degradation. Threat of rust to pipelines, storage tanks, and weakened foundations of onsite buildings. Loss of biodiversity onsite.	Unlikely
Sand and soil quarry (SEQ Sand and Soil)	Dispersion of soils, increased likelihood of pond wall degradation. Threat of rust to pipelines, storage tanks, and weakened foundations of onsite buildings. Loss of biodiversity onsite.	Unlikely
Roads	Pavement failure. Increased frequency of repair. Increased construction costs.	Unlikely
Groundwater bores	Loss of viable drinking, stock and irrigation waters.	Unlikely
Vegetation types and wildlife dependent on these	Threat increases in low rainfall areas; species unlikely to grow in scalded/highly saline/high sodicity areas. Loss of biodiversity.	Unlikely
Railway	Loss of structural integrity. Increased maintenance. Damage to culverts, pipes etc.	Unlikely
Landing strips	Loss to landing strip structure and stability. Increased maintenance.	Unlikely
Power supply (below ground)	Increased maintenance and cost of installation.	Unlikely

Asset type	Potential impact from salinity	Likelihood
Power supply (above ground), mobile phone towers, water pipelines, treatment works, pump stations	Increased maintenance. Decrease in lifespan of structure.	Unlikely
Fences	Decreased lifespan. Increased maintenance and installation costs.	Unlikely
Historical buildings	Threatens foundations. Loss of heritage value.	Unlikely
Urban areas	Property can be damaged through weakening of building foundations. Playgrounds can rust, infrastructure can be affected.	Unlikely
Bridges	Weakens structure, expensive maintenance.	Unlikely
Rivers/streams	Decreases usefulness of water for stock watering and irrigated crops thus lowering agricultural productivity. Even low-salt concentrations can adversely affect vegetation and fauna (both native and non-native), leading to a loss of biodiversity. Salt loads can be transported downstream	Unlikely
Naturally saline areas	Increased salt levels may affect salt-tolerant biodiversity.	Unlikely
Recreation areas. National Trail	Area may become boggy, scalds will prevent grasses from growing. Damage to sporting equipment.	Unlikely

Due to the low (unlikely) risk of salinity formation as a result of Project activities, and adequate mitigation measures implemented through design, construction, operation and decommissioning (refer Section 9.5.4.5), the likelihood of assets being affected by salinity formation as a result of Project activities is considered unlikely.

Generally, the problems of salinity or sodicity are greatest in drier climates where rates of evaporation are usually very high (refer Chapter 13: Surface Water and Hydrology). Excessive amounts of water applied during construction or operational phases of the Project can have the potential to move past the root zone and contribute to rising water tables. Leakage from water storages may also contribute to rising water tables.

Sodic waters used during construction or operation may contain higher levels of sodium salts compared to calcium and magnesium salts and can result in soil dispersion, with consequent soil surface sealing, crusting, erosion and poor water entry.

The desktop salinity hazard assessment adopted a precautionary approach and limitations existed in the quantity/quality of data available as well as interpretation method. A salinity hazard assessment of potential existing naturally occurring salinity was also undertaken in accordance with Part B of the Salinity Management Handbook. Soil sampling undertaken as part of geotechnical investigations were also limited as only a single location was sampled and reflects only a specific point along the land resources study area where salts are available in soil.

9.6.6 Disturbance of existing contaminated land

Project activities have the potential to disturb existing contaminated land resources during each of the phases of Project development: construction, operation and decommissioning. The disturbance of contaminated soil or groundwater during Project activities have the potential to contaminate previously unaffected soil or groundwater and affect human health through ingestion as well as dermal contact with contaminants.

On review of existing contaminated land in Section 9.5.7 and identifying potential sources of contamination within the land resources study area as well as their relative risk in Section 9.5.8, Table 9.17 links the identified potential sources, pathways and receptors derived from existing contaminated land, which may be further exacerbated through Project activities.

TABLE 9.17: POTENTIAL EXISTING CONTAMINATED LAND SOURCE, PATHWAY AND RECEPTOR LINKAGES

Potential source	Contaminants	Potential pathway	Potential receptor
Existing potential contamination			
Agricultural land	Pesticides and herbicides ▸ 25 SP108209 ▸ 54 SP243512 ▸ 53 SP243512	▸ Direct contact ▸ Dispersion of soil and dust from wind and water ▸ Surface water runoff	Human health: ▸ Ingestion, inhalation, dermal contact ▸ Current and future site users, construction workers, site visitors, surrounding land users. ▸ Ecological: ▸ Terrestrial—direct contact and consumption (including bioaccumulation) ▸ Aquatic ecosystems—direct contact and consumption (including bioaccumulation)
	Hydrocarbons (fuel and oil storage and use)	▸ Direct contact ▸ Dispersion of soil and dust from wind and water ▸ Surface water runoff	Human health: ▸ Current and future site users, construction workers, site visitors, surrounding land users. Ecological: ▸ Potential risk to surrounding cropping lands. ▸ Aquatic ecosystems
	Asbestos and lead paint	▸ Direct contact ▸ Ingestion ▸ Inhalation ▸ Dispersion of soil and dust from wind and water ▸ Surface water runoff	Human health: ▸ Current and future site users, construction workers, site visitors, surrounding land users. Ecological: ▸ Terrestrial ecosystem ▸ Aquatic ecosystem
	Livestock dips or spray races arsenic, DDT, DDE, DDD ▸ 13 RP892026 ▸ 2 RP61267 ▸ 18 RP21384 ▸ 76 SP131580 ▸ 6 SP131580 ▸ 45 RP22590 ▸ 50 RP22590 ▸ 259 RP809310 ▸ 1 SP163227 ▸ 19 W31189 ▸ 22 SP164832	▸ Direct contact ▸ Ingestion ▸ Dispersion of soil and dust from wind and water ▸ Surface water runoff	Human health: ▸ Current and future site users, construction workers, site visitors, surrounding land users. Ecological: ▸ Terrestrial ecosystem ▸ Aquatic ecosystem
Housing/sheds	Hydrocarbons (fuel and oil storage and use); pesticides and herbicides, lead paint and asbestos	▸ Direct contact ▸ Ingestion ▸ Inhalation ▸ Dispersion of soil and dust from wind and water ▸ Surface water runoff	Human health: ▸ Landholders, current and future site users, construction workers, site visitors, surrounding land users Ecological: ▸ Terrestrial—direct contact and consumption ▸ Aquatic ecosystems—direct contact and consumption (including bioaccumulation)

Potential source	Contaminants	Potential pathway	Potential receptor
Roads	Metals, hydrocarbons, pesticides/herbicides	Direct contact Ingestion Inhalation Dispersion of soil and dust from wind and water Surface water runoff	Human health: Landholders, current and future site users, construction workers, site visitors, surrounding land users. Ecological: Aquatic ecosystem in down-gradient receiving
Existing rail corridor	Metals/metalloids, asbestos, hydrocarbons, pesticides/herbicides 232 SP130091 251 SP130171	Direct contact Ingestion Inhalation Dispersion of soil and dust from wind and water Surface water runoff	Human health: Ingestion, inhalation, dermal contact Current and future site users, construction workers, site visitors, surrounding land users. Ecological Terrestrial—direct contact and consumption Aquatic ecosystems—direct contact and consumption (including bioaccumulation)
'Slight Occurrence' UXO areas	UXO	Surface water runoff Groundwater flow Dispersion of soil from excavation, water and wind	Human health: Inhalation, dermal contact Current and future site users, construction workers, site visitors, surrounding land users. Ecological: Terrestrial—direct contact Aquatic ecosystems—direct contact and consumption (including bioaccumulation).

Many of the potential sources identified in Table 9.17 do not impede on the disturbance footprint and as a result are unlikely to be a potential source of contamination during Project activities. The residual risk of Project activities to existing contaminated land is presented in Section 9.8.

9.6.7 Creation of contaminated land

The following Project activities during the construction and operational phases of the Project have the potential to contaminate land resources through:

- Transport or movement of existing contaminated soil (including spoil)/groundwater leading to migration of contaminants to previously uncontaminated soil/groundwater and affecting human health through contact with contaminants
- Leaks or spills leading to migration of contaminants through surface water/soil/groundwater or exposure to human health risks through ingestion/dermal contact to contaminants from:
  - Permanent/mobile fuel/chemical storage
  - Waste storage areas/facilities (including storage tanks, sewage).

Table 9.18 further details identified potential sources, pathways and receptor linkages resulting from Project activities during the construction and operational phases of the Project.

TABLE 9.18: POTENTIAL CREATION OF CONTAMINATED LAND SOURCE, PATHWAY AND RECEPTOR LINKAGES

Potential source	Contaminants	Potential pathway	Potential receptor
Construction			
Hydrocarbon leaks and/or spills	Hydrocarbons	▸ Direct contact	Human health: ▸ Ingestion, inhalation, dermal contact ▸ Current and future site users, construction workers, site visitors, surrounding land users Ecological: ▸ Terrestrial—direct contact and consumption ▸ Aquatic ecosystems—direct contact and consumption
		▸ Overland flow/runoff to surface water bodies ▸ Migration to groundwater	Human health: ▸ Ingestion, dermal contact ▸ Current and future site users, construction workers, site visitors, surrounding land users (drinking water supply impacts) Ecological: ▸ Terrestrial—direct contact and consumption ▸ Aquatic ecosystems—direct contact and consumption
Leaks and or spills from waste storage areas/facilities (including storage tanks, sewage)	Biological waste (sewage), other wastes	▸ Direct contact	Human health: ▸ Ingestion, inhalation, dermal contact ▸ Current and future site users, construction workers, site visitors, surrounding land users Ecological: ▸ Terrestrial—direct contact and consumption ▸ Aquatic ecosystems—direct contact and consumption
		▸ Overland flow/runoff to surface water bodies ▸ Migration to groundwater	Human health: ▸ Ingestion, dermal contact ▸ Current and future site users, construction workers, site visitors, surrounding land users (drinking water supply impacts) Ecological: ▸ Terrestrial—direct contact and consumption ▸ Aquatic ecosystems—direct contact and consumption
Operation			
Hydrocarbon leaks and/or spills	Metals and hydrocarbons	▸ Direct contact	Human health: ▸ Ingestion, inhalation, dermal contact ▸ Current and future site users, construction workers, site visitors, surrounding land users Ecological: ▸ Terrestrial—direct contact and consumption ▸ Aquatic ecosystems—direct contact and consumption
		▸ Overland flow/runoff to surface water bodies ▸ Migration to groundwater	Human health: ▸ Ingestion, dermal contact ▸ Current and future site users, construction workers, site visitors, surrounding land users (drinking water supply impacts) Ecological: ▸ Terrestrial—direct contact and consumption ▸ Aquatic ecosystems—direct contact and consumption

On conclusion of the desktop assessment, the soil in the West Moreton System rail corridor may potentially be suitable for reuse within the same area. Reuse of the soil, where contamination is suspected, will be dependent on sampling and laboratory analysis of soil samples, along with a comparison with applicable health and ecological guidance values/screening criteria.

Chapter 20: Hazard and Risk provides details on contamination that may arise as a result of Project activities and provides an assessment of impacts as well as mitigation measures.

9.7 Mitigation

This section outlines both the land resources mitigation measures included as part of the design and the mitigation measures that are proposed for the Project to manage predicted environmental impacts. The impacts are initially assessed with consideration of the design mitigation measures and then reassessed to determine residual risk after the inclusion of the proposed mitigation measures.

9.7.1 Design considerations

The mitigation measures and controls presented in Table 9.19 have been factored into the design of the Project. These design considerations are proposed to minimise the environmental impacts of the Project and therefore contribute to a lowering of the initial impact risk rating for each potential impact.

TABLE 9.19: INITIAL MITIGATION THROUGH DESIGN RESPONSES

Aspect	Initial design measures
Land resources	▸ The Project is generally located within the existing SFRC, which was gazetted as a future rail corridor in 2010. The design has been developed to utilise the existing rail corridor protection and minimise impacts to land resources to the greatest extent possible. ▸ The rail corridor is a minimum of 40 m wide and designed to minimise disturbance to existing land resources ▸ Cut and fill balance and minimisation of transport requirements for import/disposal of spoil considered.

9.7.2 Proposed mitigation measures

In order to manage Project risks during construction, a number of mitigation measures have been proposed for implementation in future phases of Project delivery, as presented in Table 9.20. These proposed mitigation measures have been identified to address Project-specific issues and opportunities and address legislative requirements, accepted government plans, policy and practice.

Table 9.20 identifies the relevant Project phase, the aspect to be managed, and the proposed mitigation measure, which is then factored into the assessment of residual risk in Table 9.21.

Chapter 23: Draft Outline Environmental Management Plan provides further context and the framework for implementation of these proposed mitigation and management measures.

TABLE 9.20: PROPOSED MITIGATION MEASURES

Delivery phase	Aspect	Proposed mitigation measures
Detailed design	Erosion and sediment control	Project clearing extents are limited to the disturbance footprint which must be minimised to that required to safely construct, operate and maintain the Project. An Erosion and Sediment Control Plan (ESCP) will be prepared by a Certified Professional in Erosion and Sediment Control (CPESC) in accordance with the *International Erosion Control Association Best Practice Erosion and Sediment Control* (IECA, 2008). The plan will detail the following procedures and protocols relevant to potential impacts identified within this chapter (refer Section 9.6.2): ▸ Soil/land conservation objectives for the Project ▸ Temporary/permanent drainage, erosion and sediment control measures ▸ Workplace health and safety requirements relating to management of contamination and unexploded ordnance risk ▸ Management of problem soils (e.g. ASS, erosive, dispersive, reactive, acidic, sodic, alkaline soils) ▸ Stockpiling and management/segregation of topsoil where it contains native plants seedbank or weed material ▸ Vehicle, machinery and imported fill hygiene protocols and documentation ▸ Requirements for training, inspections, corrective actions, notification and classification of environmental incidents, record keeping, monitoring and performance objectives for handover on completion of construction. The ESCP will be reviewed prior to the commencement of preconstruction activities, when the construction methodology is finalised, and to document location-specific controls.
	Hazardous materials handling and storage	A Contaminated and Hazardous Materials Management Plan will be included as a component of the Construction Environmental Management Plan (CEMP) to eliminate, minimise and manage spills. Design of bunding containment is to be in accordance with *Australian Standard (AS) 1940:2017 The storage and handling of flammable and combustible liquids*.
	Reinstatement and/or rehabilitation	The ESCP will align with the Reinstatement and Rehabilitation Plan and will include progressive stabilisation of earth materials and soil consolidation to prevent erosion and sedimentation in areas within the disturbance footprint that do not form part of the permanent works (e.g. temporary construction compounds and laydown areas etc.).
	Land and soil	Soil conditions across the disturbance footprint will be appropriately characterised at a suitable scale through additional soil surveys during the detailed design phase of the Project to inform design and environmental management measures. This includes identification of potential/actual ASS, acid rock, reactive soils, erosive soils, dispersive soils, salinity, acidic soils, alkaline soils, wetness, depth and contaminated land. Minimise risks through implementation of appropriate detailed design processes where reactive or problem soils are present or suspected. Cut and fill balance and minimisation of transport requirements for import/disposal of spoil will be considered as part of the design process. Detailed design to demonstrate assessment and viability of opportunities for: ▸ Re-use of local sources of aggregate and treatment of dispersive and reactive materials to improve mass haul ▸ Re-use of material excavated below the rail embankment for less critical parts of infrastructure ▸ Re-use of excavated material as a stabilised structural fill.

Delivery phase	Aspect	Proposed mitigation measures
Detailed design (continued)	Land and soil (continued)	A Soil Management Plan will be developed to provide the framework for the stripping, storage, treatment and reuse of topsoil. Develop and implement a Biosecurity Management Plan as part of the CEMP to include: ▶ Compliance requirements including relevant biosecurity surveillance or prevention program authorised under the *Biosecurity Act 2014* (Qld) and any requirements of the *Vegetation Management Act 1999* (Qld) (VM Act), the *Planning Act 2016* (Qld) and the *Agricultural Chemicals Distribution Control Act 1966* (Qld) (ACDC Act) ▶ Requirement for pre-clearing survey to determine the risk of weeds or pest animals being present ▶ Map of the existing severity and extent of weed infestations and weed management requirements, including land adjacent to the disturbance footprint and construction access tracks ▶ Pest animal management (including fire ants and fire ant biosecurity zones) ▶ Site hygiene and waste management procedures to deter pest animals ▶ Weed surveillance and treatment during construction and rehabilitation activities ▶ Requirements in relation to pesticide and herbicide use and documentation, including any limitations on use, such as restrictions on use in sensitive environmental areas; agricultural areas; drainage lines that flow to waterways and aquatic habitats; and ensuring that broad-scale use does not result in an increase erosion and sediment risk ▶ Vehicle, machinery and imported fill hygiene protocols and documentation ▶ Erosion and sediment control risk associated with broad-scale weed removal or treatment ▶ Mitigation or remediation measures contained in the Biosecurity Management Plan will be developed in accordance with relevant agencies and local government.
	Contamination, land and soil	As required, a Contaminated Land Management Strategy will be developed and implemented by a suitably qualified professional, incorporating consultation outcomes from landholders and other relevant stakeholders. This strategy will include a review of the EMR and CLR to identify lots within the disturbance footprint, to assess the potential contamination risk, and to develop contaminated site management plan/s as outlined in Section 9.7.2.1.
Pre-construction	Materials handling and storage, hazardous waste	The CEMP must contain the following provisions relevant to potential impacts of land resources: ▶ A Pollution Incident Response Plan for accidental spills, leaks and other polluting incidents. The supervisor or person in charge of the work activity must be notified immediately. The matter will be recorded on the reportable environmental incident checklist ▶ All bunding, hydrocarbon and chemical storage areas must be routinely checked, and their integrity and functionality maintained as per design capacity ▶ Appropriate controls to prevent environmental incidents, including leaks/spills from refuelling activities and to protect the environment in the event that incidents occur.

Delivery phase	Aspect	Proposed mitigation measures
Pre-construction (continued)	Materials handling and storage, hazardous waste (continued)	Personnel involved in ground-disturbing works must be familiar with the unexpected finds protocol/procedure and trained in: ▶ The identification of potential contaminated soil/material and relevant controls such as how to recognise potential contaminated material (colour, texture, odour, presence of asbestos, metal, ash) from inert waste or materials ▶ Stop work and corrective/containment actions ▶ Classification and notification of incidents procedures. Identification of contaminated, hazardous or potentially contaminated material onsite (i.e. soil/formation etc) will be subject to a risk assessment. Assessment of contaminated, hazardous or potentially contaminated material encountered during Project works will be undertaken and recorded. Transportation of hazardous substances, wastes and/or dangerous goods are to be undertaken by appropriately licensed contractors and a register of waste transfer certificates to be maintained for the Project.
	Spoil management/ excavated material	A Construction Spoil Management Plan will be developed and implemented to document and manage the stockpiling and storage, on-site reuse, removal, transport and disposal of excavated material. Any imported fill material will be clean, certified pest and contaminant free.
	Erosion and sediment control, land and water, water quality	The ESCP prepared during detailed design will be reviewed and updated by a CPESC, incorporating further construction methodology details as required. The ESCP will include water quality monitoring requirements as defined in the Surface Water Management Plan to assess the effectiveness of erosion and sediment controls and reinstatement and rehabilitation programs.
	Land and soil	Closure or realignments of local roads will be undertaken in accordance with the Reinstatement and Rehabilitation Plan. Wherever practical, topsoil will be transferred directly to placement as planting media. Where stockpiling of topsoil is required, it will be carried out in accordance with the Soil Management Plan, and in a manner that ensures that the properties of the topsoil are not permitted to degrade such that it becomes unsuitable as planting media. The Soil Management Plan will establish: ▶ Limitation for height of stockpiles ▶ Limits for the width of the base of stockpiles ▶ Requirements for adopting batter slopes, protective covers and drainage which reduce potential for erosion and/or segregation ▶ Limits for the period of stockpiling to a minimum practical time ▶ Requirements for carrying out herbicide spraying or other treatment of the stockpile at intervals required to prevent weed growth and ensure the stockpile faces are weed-free prior to use.
	Hazardous waste	A contaminated and hazardous material survey will be undertaken prior to demolition of structures. In the event that asbestos or other hazardous materials are identified in these structures, a Contaminated and Hazardous Materials Management Plan will be developed and implemented. The Contaminated and Hazardous Materials Management Plan will contain procedures to ensure that removal is undertaken in accordance with *How to Safely Remove Asbestos Code of Practice* (Safe Work Australia, 2018).

Delivery phase	Aspect	Proposed mitigation measures
Construction and commissioning	Erosion and sediment control, land and water, water quality	Appropriate erosion and sediment control measures are to be implemented and the ESCPs continuously reviewed and updated for effectiveness and to reflect changing site conditions as construction progresses.
	Contamination	For work activities undertaken within the 11 properties identified on the EMR, as documented in the EIS within the disturbance footprint, or any other sites identified as part of the actions under the Contaminated Land Strategy, a Contaminated Site Management Plan will be developed and implemented to reduce the risk of adverse impacts to the existing and surrounding environments. If suspected contaminated land or material in drums, tanks, bags or plastic containers are encountered during excavation works, all work must stop in the affected area and measures to manage the contamination will be implemented, as per the Contaminated Site Management Plan. The reuse or retention of contaminated or potentially contaminated material encountered onsite (i.e. soil, ballast) will be subject to a risk assessment.
	Materials handling and storage	Appropriate registers and records of chemicals, hydrocarbons and hazardous substances and materials onsite will be maintained up to date. Where appropriate this will include a relevant risk assessment prior to the substance coming to, and being used onsite, plus a Safety Data Sheet (SDS) Register. Where an incident occurs that threatens or causes unlawful environmental harm, the contractor must take all reasonable steps, including allocation of additional trained resources or specialists, to remediate and manage the incident.
	Rehabilitation	Reinstatement, stabilisation and rehabilitation of temporarily disturbed areas (such as laydown, site offices and temporary access tracks) will be undertaken progressively, consistent with the Project Reinstatement and Rehabilitation Plan and the Landscape and Rehabilitation Management Plan.
	Unexploded ordnance	Although unlikely, based on the UXO assessment for the Project, where a risk of encountering known or possible UXO is identified, assessment and identification of management options shall be carried out by a suitably qualified person.
	Hazardous waste	Hazardous and/or dangerous waste (e.g. asbestos, chemicals, oils) must be correctly stored and managed on site and/or correctly disposed of by a licensed contractor to a registered waste facility and in accordance with the CEMP.
Operation	Land and soil contamination	Ongoing management and maintenance of the corridor to be accordance with existing Inland Rail Environmental Management System (EMS) and corridor management procedures.

9.7.2.1 Disturbance of existing contaminated land

The disturbance of existing contaminated land through Project activities presents a medium risk. As a result, additional mitigation measures will need to be implemented during the construction of the Project, which is presented in Figure 9.16. The contaminated land management strategy builds on the mitigation measures provided in Table 9.20.

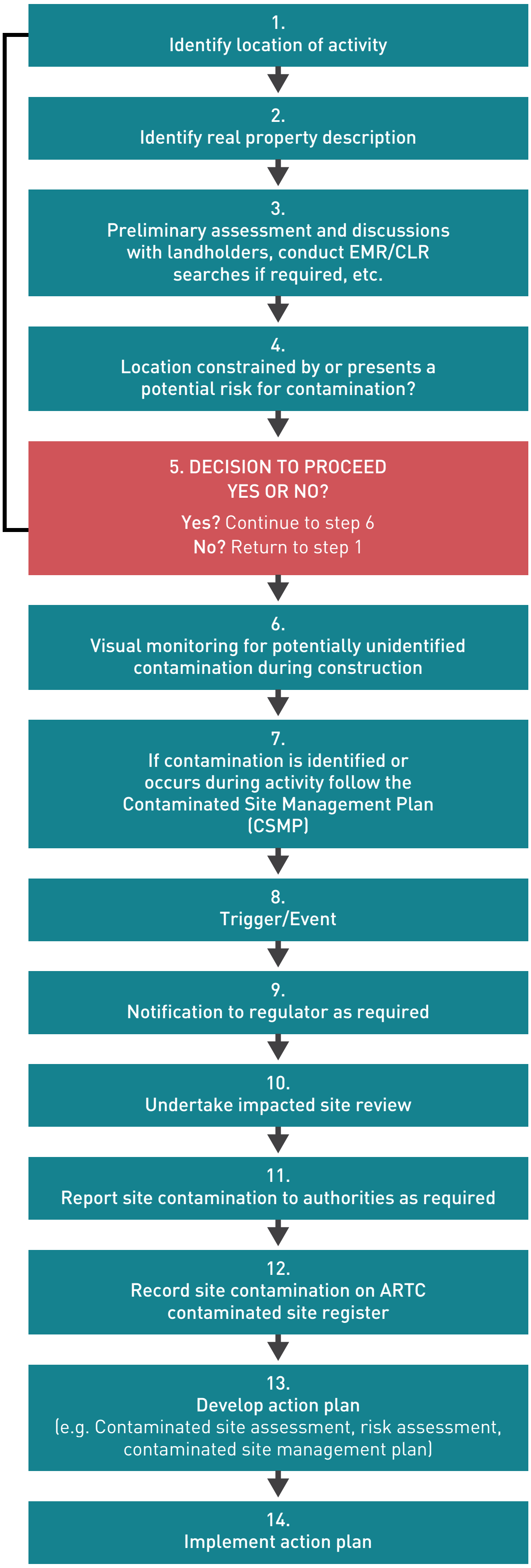


FIGURE 9.16: CONTAMINATED LAND MANAGEMENT PLAN STRATEGY

9.8 Impact assessment

Potential impacts to land resources associated with the Project in the construction and operation phases are outlined in Table 9.21. These impacts have been subjected to a risk assessment as per the methodology detailed in Chapter 4: Assessment Methodology.

The initial risk assessment is undertaken on the assumption that the design considerations (or initial mitigation measures) have been incorporated into the design (refer Table 9.19).

Proposed mitigation measures, including those listed in relevant management plans, were then applied as appropriate to the phase of the Project to reduce the level of potential impact.

The residual risk level of the potential impacts was then reassessed. The initial risk levels were compared to the residual risk levels in order to assess the effectiveness of the mitigation and management measures.

TABLE 9.21: IMPACT ASSESSMENT FOR POTENTIAL IMPACTS ASSOCIATED WITH LAND RESOURCES

			Initial risk[1]			Residual risk[2]		
Aspect	**Potential impact**	**Phase**	**Likelihood**	**Consequence**	**Risk**	**Likelihood**	**Consequence**	**Risk**
Land and soil	Change to landform and topography: ▸ Erosion ▸ Loss of natural contours ▸ Landslip	Construction	Likely	Moderate	High	Likely	Minor	Medium
		Operation	Possible	Minor	Low	Possible	Minor	Low
Erosion and sediment control, land and soil	Loss of soil resources: ▸ Loss of Class A, Class B and IAAs within the disturbance footprint ▸ Decline in soil fertility ▸ Loss of groundcover ▸ Soil inversion	Construction	Likely	Moderate	High	Likely	Minor	Medium
		Operation	Possible	Minor	Low	Possible	Minor	Low
Land and soil	Disturbance of: ▸ Existing ASS ▸ Potential ASS ▸ Acid rock ▸ ARD	Construction	Unlikely	Moderate	Low	Unlikely	Minor	Low
		Operation	Unlikely	Moderate	Low	Unlikely	Minor	Low

Aspect	Potential impact	Phase	Initial risk[1] Likelihood	Initial risk[1] Consequence	Initial risk[1] Risk	Residual risk[2] Likelihood	Residual risk[2] Consequence	Residual risk[2] Risk
Erosion and sediment control	Disturbance of soil resources through invasive flora and fauna: ▶ Invasion ▶ Reuse of soil ▶ Erosion ▶ Disturb native species ▶ Alter soil properties or groundwater flow ▶ Infiltration	Construction	Likely	Minor	Medium	Likely	Not significant	Low
		Operation	Likely	Minor	Medium	Likely	Not significant	Low
Land and soil	▶ Salinity hazard ▶ Basalt over sandstone interface ▶ Catena form ▶ Soil salt store	Construction	Possible	Moderate	Medium	Possible	Minor	Low
		Operation	Possible	Minor	Low	Possible	Minor	Low
Contamination, land and soil	Disturbance of existing contaminated land: ▶ EMR listed properties ▶ Roads ▶ Housing/sheds ▶ Existing rail ▶ Agricultural activities	Construction	Likely	Moderate	High	Likely	Minor	Medium
		Operation	Possible	Moderate	Medium	Possible	Minor	Low
Material handling and storage	Creation of contaminated land: ▶ Leaks or spills ▶ Permanent and mobile fuel and chemical storage ▶ Waste storage areas and facilities ▶ Project infrastructure	Construction	Possible	Moderate	Medium	Possible	Minor	Low
		Operation	Possible	Minor	Low	Possible	Minor	Low

Table notes:

1 Includes implementation of initial mitigation measures specified in Table 9.19.

2 Assessment of residual risk once the land mitigation measures and controls identified in Table 9.20 have been applied.

9.9 Cumulative impacts

The cumulative impacts of the identified assessable projects in the vicinity of the Project may contribute to impacts on land resources if not managed appropriately. Five projects have been identified as having the potential to contribute to cumulative impacts on land resources. These include:

- Kagaru to Acacia Ridge and Bromelton (K2ARB)
- Helidon to Calvert (H2C)
- Greater Flagstone Priority Development Area (PDA)
- Bromelton State Development Area
- Ripley Valley PDA.

Although these projects may have different land resource impacts to the Project, the following impacts are likely to be common to each project, if not effectively managed:

- Disturbance (and possible disposal) of existing contaminated land
- Leaks or spills leading to migration of contaminants
- Disturbance of ASS
- Salinity and sodicity
- Changes to landform and topography
- Increase in erosion leading to increased total dissolved solids (TDS) in run off
- Increase in weed migration.

Based on the assessment of the above listed potential impacts within the land resources study area, the risk of the Project impacting in a cumulative manner on land resources is expected to be of low significance.

Further information on the potential cumulative impact of the Project relating to land resource aspects is presented in Chapter 22: Cumulative Impacts.

9.10 Conclusions

This chapter has been prepared to evaluate potential impacts of the Project on land resources and has identified existing conditions of the study area in accordance with industry standard methodology and relevant legislation. Through an assessment of existing conditions, Project impacts with the potential to adversely impact land resources were identified. Various Project activities at different stages of the Project can impact land resources via:

- Permanently changing landform and/or topography
- Causing the loss of soil resources on farming and other economically valuable land
- Degrading soil resources through an introduction of invasive flora and fauna altering physical and chemical properties of soil
- Expose potential ASS and acid rock to oxygen during excavation and earthworks
- Exacerbating existing soil salinity and sodicity or creating new impacts
- Disturbing existing contaminated land
- Contributing to creation of contaminated land.

A majority of potential impacts to land resources through Project activities were found to have low residual risk upon implementation of initial mitigation measures during the design phase and additional mitigation measures implemented during detailed design, construction and operation phases. Change to landform and topography, loss of soil resources and disturbance of existing contaminated land during the construction phase of the Project, all remained a medium residual risk.

The mitigation measures detailed in Section 9.7 are intended to sufficiently manage all identified potential impacts for land resources as a result of Project activities.