CHAPTER

13

Surface water and hydrology

Helidon to Calvert Environmental Impact Statement

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

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13.1 Summary

This chapter outlines matters relating to surface water and hydrology as a result of the construction and operation of the Helidon to Calvert (H2C) Project (the Project). An assessment has been completed to identify the existing environment, potential impacts and mitigation measures to protect the environmental values of the water quality and hydrology environment.

A construction and operation surface water quality impact assessment and an assessment of flooding impacts has been completed in accordance with the Project Terms of Reference (ToR). The impact assessment considered sensitive receptors potentially affected by the Project. These receptors were identified from an assessment of the existing environment, based on a combination of desktop and field data.

The water quality study area was based on a 1 km buffer extending horizontally from either side of the permanent operational and temporary construction footprint (as the Project disturbance footprint). The water quality study area was established to provide spatial coverage of key water sources intersections with the Project disturbance footprint.

The water quality study area covers two hydrological catchments: the Lockyer Creek catchment between Helidon and east of Laidley, and the Bremer River catchment between Grandchester and Calvert. Both catchments are located within the wider Moreton hydrological basin. Sub-catchments are as defined by the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (Water and wetland biodiversity)).

A number of watercourses, waterways and waterbodies occur within the water quality study area, including Sandy Creek, Lockyer Creek, Laidley Creek and Western Creek, in conjunction with existing tributaries and drainage. Within each of the catchments environmental values (EVs) include aquatic ecosystems, irrigation, farm supply/use, stock water, human consumer, secondary recreation, visual recreation and cultural and spiritual values. Water quality objectives (WQOs) for relevant sub-catchments have been determined by the Queensland Government. Within these WQOs, the most stringent protections are provided for aquatic ecosystems and these were selected as the basis for assessment.

To maintain a conservative approach, all waterways within the water quality study area were nominated as moderate sensitivity water quality receptors. The moderate sensitivity was used as a general indicator for the identification of potential impacts. This then guided selection of relevant mitigation measures and identification of residual impact (after implementation of mitigation).

Due to the potential presence of matters of national environmental significance (MNES) species—Australian lungfish (*Neoceratodus forsteri*) and Mary River cod (*Maccullochella mariensis*)—and two matters of state environmental significance (MSES)—wetlands within the Lower Lockyer Creek sub-catchment and Western Creek sub-catchment—both sub-catchments were identified as highly sensitivity water quality receptors. Therefore, the defined watercourses of Upper Lockyer Creek and Western Creek sub-catchments—Lockyer Creek and Western Creek—are identified as highly sensitive water quality receptors.

The construction, and operation of the Project has the potential to impact on water quality receptors and/or flood sensitive receptors through:

- Increase in debris
- Changes to receiving water quality and hydrology
- Increase in salinity
- Increases in erosion and sedimentation
- Increase in contaminants
- Exacerbation of potential impacts from inadequate rehabilitation processes
- Modifications to the existing hydrology (flood regime) include:
  - Changes in peak water levels and associated areas of inundation
  - Concentration of flows
  - Redirection of flows or changes to flood flow patterns
  - Increased velocities leading to localised scour and erosion
  - Changes to duration of inundation or increased depth of water affecting land or the trafficability of roads.

A range of measures will be implemented during the construction and operation phases to mitigate potential Project impacts to surface water and hydrology.

The proposed mitigation measures (after design considerations) for the Project were identified to reduce the initial magnitude and ultimately the significance of the potential impacts upon identified receptors. Following the application of the mitigation hierarchy (i.e. avoid, minimise, mitigate) that included a range of mitigation measures and management plans, the residual impacts to the identified receptors were reduced.

Mitigation measures associated with surface water impacts include:

- Developing and implementing the following plans: Erosion and Sediment Control Plan, Reinstatement and Rehabilitation Plan, Soil Management Sub-plan, Surface Water Management Sub-plan and a Stormwater Management Sub-plan
- Hydraulic modelling and analysis to ensure that mitigation measures are appropriately sized
- Minimising the Project's temporary disturbance footprint, while still allowing for sufficient erosion and sediment control measures
- A surface water monitoring program assessing mitigation strategies to monitor the effectiveness of mitigation measures (in relation to water quality objectives)
- Tunnel-dewatering treatment strategy in line with the surface water monitoring program to prevent and minimise impacts to receiving aquatic environment from discharge.

Measures associated with hydrology impacts include:

- Designing the Project to achieve a 1% Annual Exceedance Probability (AEP) flood immunity to formation level, while at the same time minimising the potential for unacceptable impacts on the existing flooding and drainage regime
- Designing and locating bridge and culvert structures, including new culverts under the existing Queensland Rail (QR) line, to:
  - Maintain existing surface water flow paths and flood flow distributions
  - Avoid unacceptable increases in peak water levels, flow distribution, velocities and duration of inundation
  - Improve existing conditions.
- Installing scour and erosion protection measures in areas determined to be at risk
- Ongoing stakeholder engagement to agree on acceptable design outcomes in terms of impacts on the existing flood regime.

13.1.1 Independent International Panel of Experts

The Australian and Queensland governments established an Independent International Panel of Experts (the Panel) for flood studies, to provide advice to the Commonwealth and the Queensland Governments on the flood models and structural designs developed by ARTC for Inland Rail in Queensland.

As an advisory body to government, The Panel is independent of the ARTC in respect of the development, public consultation and approvals for the Inland Rail EIS process. Relevant submissions received from public notification of the draft EIS will be provided to The Panel for consideration as part of its review.

Information on The Panel may be viewed at: tmr.qld.gov.au/projects/inland-rail/independent-panel-of-experts-for-flood-studies-in-queensland.

13.2 Scope of chapter

This chapter includes a description of the surface water quality impact assessment and the hydrology and flooding impact assessment undertaken for the Project.

Surface water quality (and resources) includes an assessment of the use of surface waters EVs and the WQOs that have been established to protect these values.

Hydrology and flooding involves undertaking a detailed hydraulic assessment. The existing flooding regime on the floodplains of Lockyer Creek, Laidley Creek, Bremer River and Western Creek was established. This work includes understanding the performance of the existing West Moreton System rail corridor under flood conditions. Consideration of the proposed works and refinement of the flood drainage structures was then undertaken to minimise impacts to acceptable levels.

The existing environment is described, and an assessment is made of the potential impacts of the Project. Potential short- and long-term impacts on local and regional surface waterways have been assessed based on a review of the Project's construction and operation phases. The results of the impact assessment and recommended mitigation measures have been outlined, along with potential cumulative impacts.

Within this assessment, the water quality study area reflects the EIS investigation corridor for the Project, including the proposed Project alignment, road reconfigurations, laydown areas and stockpile locations. Spatially, it is based on an approximate 1 km buffer either side from the Project alignment. The water quality study area provide spatial coverage of all directly or indirectly potentially affected receptors.

Full details of the surface water quality assessment are in Appendix L: Surface Water Quality Technical Report. Full details of the hydrology and flooding assessment are in Appendix M: Hydrology and Flooding Technical Report.

13.3 Terms of Reference

This chapter addresses the water section of the ToR for the Project. The ToR sets out the key requirements in relation to surface water and hydrology. Table 13.1 identifies the key requirements and a reference to where the relevant ToR requirements are addressed. Appendix B: Terms of Reference Compliance Table.

TABLE 13.1: TERMS OF REFERENCE—SURFACE WATER AND HYDROLOGY

Terms of Reference requirements		Where addressed
Site description		
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 13.6.2 Appendix L: Surface Water Quality Technical Report, Sections 5.4.1, 5.4.2, 5.4.3 and 5.9 Chapter 9: Land resources
Proposed construction and operations		
10.11	Describe the following information about the proposed project: d) location, design and capacity of water supply, wastewater conveyance and treatment, telecommunications, power generation, accommodation of site facilities and transmission infrastructure q) proposed upgrades, realignments, relocation, deviation or restricted access to roads and other infrastructure (e.g. water, electricity, telecommunications, sewerage)	d) Section 13.8.1 Appendix L: Surface Water Quality Technical Report, Sections 2.1, 2.3, 2.7, 7.1.1 and 7.1.2 Chapter 5: Chapter 5: Stakeholder Chapter 6: Project description Appendix C: Consultation Report q) Section 13.8 Chapter 6: Project description
Information requirements		
11.24.	The EIS must also provide details on the current state of groundwater and surface water in the region as well as any use of these resources.	Sections 13.6.2 to 13.6.5 Appendix L: Surface Water Quality Technical Report, Sections 5 and 6 Chapter 14: Groundwater Appendix J: Matters of National Environmental Significance Technical Report Appendix N: Groundwater Technical Report
Existing environment—General		
11.36.	Identify the water-related EVs and describe the existing surface water and groundwater regime within the study area and the adjoining waterways in terms of water levels, discharges and freshwater flows.	Sections 13.4.2 and 13.6.2 to 13.6.5 Appendix L: Surface Water Quality Technical Report, Sections 3.2.4, 5.1 to 5.11 and 6.1 to 6.3 Chapter 14: Groundwater Appendix N: Groundwater Technical Report
11.37.	With reference to the EPP (Water and Wetland Biodiversity) 2009, section 9 of the EP Act, and SPP State Interest Guideline - Water Quality, identify the EVs of surface water within the project area and immediately downstream that may be affected by the project, including any human uses of the water and any cultural values.	Sections 13.4.2 and 13.6 Appendix L: Surface Water Quality Technical Report, Sections 3.2.4, 5 and 6
11.38.	At an appropriate scale, detail the chemical, physical and biological characteristics of surface waters and groundwater within the area that may be affected by the project. Include a description of the natural water quality variability within the study area associated with climatic and seasonal factors, and flows.	Sections 13.6.2 and 13.6.3 Appendix L: Surface Water Quality Technical Report, Sections 5 and 6 Chapter 14: Groundwater Appendix N: Groundwater Technical Report Appendix W: Geotechnical Factual Report
11.39.	Describe any existing and/or constructed waterbodies adjacent to the preferred alignment.	Section 13.6.2.2 Appendix L: Surface Water Quality Technical Report, Section 5.5.4

Terms of Reference requirements		Where addressed
Impact assessment—Water quality		
11.41.	The assessment of impacts on water will be in accordance with the DEHP Information guideline for an environmental impact statement – ToR Guideline – Water, where relevant, located on the DEHP website.	Sections 13.7 and 13.9 Appendix L: Surface Water Quality Technical Report, Sections 4.1 and 4.2 Chapter 14: Groundwater Appendix N: Groundwater Technical Report
11.42.	Identify the quantity, quality and location of all potential discharges of water and wastewater by the project, whether as point sources (such as controlled discharges) or diffuse sources (such as irrigation to land of treated sewage effluent).	Section 13.7.1 Appendix L: Surface Water Quality Technical Report, Sections 7 and 8.3.1 Chapter 6: Project description
11.43.	Assess the potential impacts of any discharges on the quality and quantity of receiving waters taking into consideration the assimilative capacity of the receiving environment and the practices and procedures that would be used to avoid or minimise impacts.	Sections 13.7.1, 13.8.1 and 13.9.1 Appendix L: Surface Water Quality Technical Report, Section 7
11.44.	Where significant cuttings or tunnelling is proposed, identify the presence of any sulphide minerals in rocks with potential to create acidic, metalliferous and saline drainage. Should they be found present, describe the practicality of avoiding their disturbance. If avoidance is not practicable, characterise the potential of the minerals to generate contaminated drainage and describe abatement measures that will be applied to avoid adverse impacts to surface and groundwater quality.	Sections 13.7.1 and 13.8.1 Appendix L: Surface Water Quality Technical Report, Sections 5.4.2, 5.4.3, 7.1 and 8
11.45.	Describe the potential impacts of in-stream works on hydrology and water quality.	Section 13.7 Appendix L: Surface Water Quality Technical Report, Section 7.1
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 13.6.2.5 and 13.7 Appendix L: Surface Water Quality Technical Report, Sections 5.9 and 7.1 Chapter 9: Land resources
Mitigation measures—Water quality		
11.47.	Describe how the WQOs identified above would be achieved, monitored and audited, and how environmental impacts would be avoided, or minimised and corrective actions would be managed.	Sections 13.8.1 Appendix L: Surface Water Quality Technical Report, Sections 7.1 and 8 Chapter 14: Groundwater Chapter 23: Draft Outline Environmental Management Plan, Appendix N: Groundwater Technical Report
11.48.	Describe appropriate management and mitigation strategies and provide contingency plans for: a) potential accidental discharges of contaminants and sediments during construction and operation b) stormwater run-off from the project facilities and associated infrastructure during construction and operation, including the International Erosion Control Association, Best Practice Erosion & Sediment Control – November 2008, and the separation of clean stormwater run-off from disturbed and operational areas of the site c) flooding of relevant river systems, the effects of tropical cyclones and other extreme events d) management of acid sulfate soils and acid producing rock and associated leachate from excavations and disturbed areas.	Section 13.8.1 Appendix L: Surface Water Quality Technical Report, Section 8 Chapter 9: Land resources Chapter 14: Groundwater Chapter 23: Draft Outline Environmental Management Plan Appendix N: Groundwater Technical Report

Terms of Reference requirements		Where addressed
11.49.	Describe treatment processes for all waste water produced as a result of the project.	Sections 13.8.1.2 and 13.8.1.3 Appendix L: Surface Water Quality Technical Report, Sections 8.2 and 8.3.2 Chapter 6: Project Description
11.50.	Propose suitable measures to avoid or mitigate the impacts of in-stream works on water quality and the stabilisation and rehabilitation of any such works.	Section 13.8 Appendix L: Surface Water Quality Technical Report, Section 8 Chapter 23: Draft Outline Environmental Management Plan
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 (DERM) 2011.	Sections 13.8.1.2 and 13.8.1.3 Appendix L: Surface Water Quality Technical Report, Section 8 Chapter 9: Land Resources
Impact assessment—Water resources		
11.52.	Provide details of any proposed impoundment, extraction (i.e. volume and rate), discharge, use or loss of surface water or groundwater. Identify any approval or allocation that would be needed under the Water Act.	Sections 13.4.1 and 13.8.1.3 Appendix L: Surface Water Quality Technical Report, Sections 2.7, 3.1 and 7.2 Chapter 3: Project approvals Chapter 6: Project description Chapter 14: Groundwater Appendix N: Groundwater Technical Report
11.53.	Detail any significant diversion or interception of overland flow. Include maps of suitable scale showing the location of diversions and other water-related infrastructure.	Section 13.6.2.2 and Figure 13.3 Appendix L: Surface Water Quality Technical Report, Section 2.5 and Figure 2.1
11.54.	Develop hydrological models as necessary to describe the inputs, movements, exchanges and outputs of all significant quantities and resources of surface water and groundwater that may be affected by the project. The models should address the range of climatic conditions that may be experienced at the site, and adequately assess the potential impacts of the project on water resources. This should enable a description of the project's impacts at the local scale and in a regional context including proposed: a) changes in flow regimes from structures and water take b) alterations to riparian vegetation and bank and channel morphology c) direct and indirect impacts arising from the project. d) impacts to aquatic ecosystems, including groundwater-dependent ecosystems and environmental flows.	Sections 13.5.2, 13.7.1, 13.7.2 and 13.9.2 Appendix L: Surface Water Quality Technical Report, Sections 7.1 and 7.2 Appendix M: Hydrology and Flooding Technical Report, Sections 6 to 9 Chapter 14: Groundwater Appendix N: Groundwater Technical Report Appendix W: Geotechnical Factual Report
11.55.	Provide information on the proposed water usage by the project, including: a) details of the estimated supply required to meet the demand for construction and full operation of the project, including timing of demands b) details of the quality and quantity of all water supplied to the site during the construction and operational phases based on minimum yield scenarios for water re-use, rainwater re-use and any bore water volumes c) a plan outlining actions to be taken in the event of failure of the main water supply d) sufficient hydrogeological information to support the assessment of any temporary water permit applications.	Section 13.8.1.3 Appendix L: Surface Water Quality Technical Report, Sections 2.7 and 7.2 Chapter 6: Project description Chapter 14: Groundwater Appendix N: Groundwater Technical Report

Terms of Reference requirements		Where addressed
11.56.	Describe proposed sources of water supply given the implication of any approvals required under the Water Act. Estimated rates of supply from each source (average and maximum rates) must be given and proposed water conservation and management measures must be described.	Section 13.8.1.3 Appendix L: Surface Water Quality Technical Report, Sections 2.7 and 7.2 Chapter 3: Project approvals Chapter 6: Project description
11.57.	Determination of potable water demand must be made for the project, including the temporary demands during the construction period. Include details of any existing town water supply to meet such requirements. Detail should also be provided to describe any proposed onsite water storage and treatment for use by the site workforce.	Section 13.8.1.3 Appendix L: Surface Water Quality Technical Report, Sections 2.7 and 7.2 Chapter 6: Project description
11.58.	Identify relevant Water Plans and Resources Operations Plans under the Water Act. Describe how the project will impact or alter these plans. The assessment should consider, in consultation with the Department of Natural Resources and Mines (DNRM), any need for: a) a resource operations licence b) an operations manual c) a distribution operations licence d) a water licence e) a water management protocol.	Sections 13.6.3.2 and 13.8.1.3 Appendix L: Surface Water Quality Technical Report, Sections 2.7, 5.10 and 7.2 Chapter 3: Project approvals Chapter 14: Groundwater, Appendix N: Groundwater Technical Report
11.59.	Identify other water users that may be affected by the proposal and assess the project's potential impacts on other water users.	Sections 13.6.2.3 and 13.8.1.3 Appendix L: Surface Water Quality Technical Report Sections 2.7, 5.10 and 7 Chapter 14: Groundwater Appendix N: Groundwater Technical Report
11.60.	Identify and quantify likely activities involving the excavation or placement of fill that will be undertaken in any watercourse, lake or spring.	Section 13.7.1.1 Appendix L: Surface Water Quality Technical Report, Sections 2.3, 2.4, 2.5 and 7
Mitigation measures—Water Resources		
11.61.	Provide designs for all infrastructure utilised in the treatment of onsite water including how any onsite water supplies are to be treated, contaminated water is to be disposed of and any decommissioning requirements and timing of temporary water supply/treatment infrastructure is to occur.	Section 13.8.1.3 Appendix L: Surface Water Quality Technical Report Sections 2.1 and 8
11.62.	Describe measures to minimise impacts on surface water and ground water resources.	Section 13.8 Appendix L: Surface Water Quality Technical Report Section 8
11.63.	Provide a policy outline of compensation, mitigation and management measures where impacts are identified.	Section 13.8 Appendix L: Surface Water Quality Technical Report Section 8 Chapter 14: Groundwater Chapter 23: Draft Outline Environmental Management Plan Appendix N: Groundwater Technical Report
Existing environment—Flood management		
11.64.	A desktop assessment of the rail line and surrounding catchments must be undertaken and the potential for flooding qualitatively described. The desktop assessment must also identify any high-risk watercourse crossing or floodplain locations that warrant further detailed quantitative assessment.	Sections 13.6.4 and 13.9.2 Appendix M: Hydrology and Flooding Technical Report, Sections 3 and 5

Terms of Reference requirements		Where addressed
Impact assessment—Flood management		
11.65.	For the locations assessed under paragraph 11.64, a flood study must be included in the EIS that includes: a) quantification of flood impacts on properties and existing infrastructure surrounding and external to the preferred alignment from redirection or concentration of flows b) identification of likely increased flood levels, increased flow velocities or increased time of flood inundation as a result of the project c) details of all calculations along with descriptions of base data and any potential for loss of flood plain storage.	Section 13.9.2 a) Appendix M: Hydrology and Flooding Technical Report, Section 10 b) Appendix M: Hydrology and Flooding Technical Report, Section 10 c) Appendix M: Hydrology and Flooding Technical Report, Sections 6 to 10
11.66.	The flood study should address any requirements of local or regional planning schemes and current accepted practice and statutory requirements in relation to flood plain management. The method of modelling used in the study should be described and justified.	Section 13.5.2 Appendix M: Hydrology and Flooding Technical Report, Sections 3 to 5 and 7 to 10
11.67.	Describe flood risk for a range of annual exceedance probabilities (including probable maximum flood) for the site and assess how the project may change flooding characteristics Include a discussion of historical events and findings of the 'Big Flood Study'.	Section 13.9.2 Appendix M: Hydrology and Flooding Technical Report, Sections 6, 8 and 9
11.68.	The study should consider all infrastructure associated with the project including levees, roads and linear infrastructure.	Sections 13.6.4 and 13.9.2 Appendix M: Hydrology and Flooding Technical Report, Section 9
11.69.	The EIS should describe the consultation that has taken place with landholders along the alignment regarding modelled potential impacts of the project on flooding. It should also include a discussion of how the results of consultation have been considered by the proponent in the EIS process.	Sections 13.5.2.4 and 13.9.2 Appendix M: Hydrology and Flooding Technical Report, Section 7.10 Chapter 5: Stakeholder engagement Appendix C: Consultation Report
11.70.	Reference must be made to relevant studies published by local governments.	Appendix M: Hydrology and Flooding Technical Report, Section 5.1
Mitigation measures—Flood management		
11.71.	Identify all proposed measures to avoid or minimise risks to life, property, infrastructure, community (including damage to other properties) and the environment as a result of project impacts during flood events—particularly flood risks on individual properties and businesses, including in and around Grantham, Gatton, Forest Hill, Laidley, Grandchester and Calvert.	Sections 13.8.2 and 13.9.2 Appendix M: Hydrology and Flooding Technical Report, Section 9
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 13.7.1 Appendix L: Surface Water Quality Technical Report, Section 2 Chapter 9: Land resources There are no soil conservation property plans within the EIS investigation corridor
Climate		
11.166.	Describe the climate patterns with particular regard to discharges to water and air and the propagation of noise related to the project.	Section 13.6.2.1 Appendix L: Surface Water Quality Technical Report, Section 5.3
11.167.	Climate information should be presented in a statistical form including long-term averages and extreme values, as necessary.	Section 13.6.2.1 Appendix L: Surface Water Quality Technical Report, Section 5.3

13.4 Legislation, policy, standards and guidelines

This section describes:

- The legislative framework that applies to the assessment of surface water quality and hydrology applicable to the Project at the Commonwealth, State and local levels, and provides the statutory context in which the assessment has been undertaken
- Statutory approvals that may be required as a result of potential impacts, based on consideration of the overall approvals pathway for the Project and the scope of applicable exemptions under Queensland legislation.

13.4.1 Commonwealth and State legislation

The Environmental Impact Statement (EIS) has been prepared in accordance with the State and Commonwealth regulatory context described within Chapter 3: Project approvals. The legislation, policies and guidelines relevant to the Project with respect to surface water and hydrology are in Table 13.2.

TABLE 13.2: LEGISLATION AND POLICIES RELEVANT TO THE SURFACE WATER QUALITY VALUES OF THE PROJECT

Legislation, policy or guideline	Relevance to the Project
Commonwealth	
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The EPBC Act is applicable to Projects that involve or have the potential to impact upon nationally and internationally important flora, fauna, ecological communities and heritage places—defined under the Act as MNES. The Project is a controlled action (EPBC 2017/7883) as a result of the Project's potential impacts on listed threatened species and communities. The Project will be assessed under the bilateral agreement between the Queensland Government and the Australian Government. Aquatic fauna MNES are noted from the Project and are assessed within EIS Chapter 11: Flora and fauna. Water quality impacts are associated with the predicted habitat for MNES fauna and are considered applicable to assessment of aquatic MNES fauna habitat (as a threatening process). Project activities do not involve coal seam gas and large coal mining development and are exempt from the trigger for MNES water resources.
State	
Planning Act 2016 (Planning Act)	The Project will trigger the requirement to obtain approval for aspects of development that are assessable under Schedule 10 of the Planning Regulation (and integrated through other legislation as part of the development application rules process) following completion of the EIS process.
Environmental Protection Act 1994 (EP Act)	The EVs of Queensland waterways, including those located within the water quality study area, are protected under the EP Act and subordinate legislation. The Project triggers subordinate legislation under the EP Act, in regard to quality of Queensland waters.
Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (Water and Wetland Biodiversity))	The quality of Queensland waters is protected under the EPP (Water and Wetland Biodiversity). The EPP (Water and Wetland Biodiversity) seeks to achieve the objective of the EP Act in relation to Queensland waters. The EPP (Water and Wetland Biodiversity) lists the EVs and WQOs that are considered by planners and managers when making decisions about development that may impact on waters and/or water quality. The Project will be required to assess the water quality within the area against the EPP (Water and Wetland Biodiversity) EVs and WQOs.
Water Supply (Safety and Reliability) Act 2008	The Project will need to achieve the purpose of the *Water Supply (Safety and Reliability) Act 2008*. The key purpose of relevance to the Project will involve the protection of consistency in terms of supply of recycled water, impacts on water supply and interests of 'service providers' in regard to water quality of surface waters from Project activities.
Water Act 2000 (Water Act)	The Project involves works within defined watercourses. The provisions of the Water Act may therefore apply. The Project also involves the removal of vegetation, excavation or placing fill in a waterway, lake or spring. This will require a Riverine Protection Permit to authorise excavation and the Project will apply for licensing under the Riverine Protection Permit as necessary. The Australian Rail Track Corporation Ltd (ARTC) is listed as an entity under Schedule 2 of the Riverine protection permit exemption requirements (WSS/2013/726). Project activities that involve diversion of watercourses will require approval under works that take or interfere with watercourse, lake or spring (for interference with overland flow).

Legislation, policy or guideline	Relevance to the Project
Fisheries Act 1994 (Fisheries Act)	The Fisheries Act provides for the management, use, development and protection of fish habitats and resources, together with the management of aquaculture activities. The Project transverses mapped waterways for waterway barrier works and therefore may trigger the requirement to obtain a Development Permit for Operational Works involving constructing or raising temporary and permanent waterway barrier works. The Project may require licensing for major risk of impact waterways to maintain connectivity and water quality.
South East Queensland (SEQ) Regional Plan 2017 (*ShapingSEQ*) (Department of Infrastructure, Local Government and Planning (DILGP) 2017a))	*ShapingSEQ* is the Queensland Government's plan to guide the future for the SEQ region and is based on the understanding that the region relies on its environmental assets to support our communities and lifestyles. *ShapingSEQ* provides strategies to protect and sustainably manage the region's catchments to ensure the quality and quantity of water in our waterways, aquifers, wetlands, estuaries, Moreton Bay and oceans, meets the needs of the environment, industry and community. The Project has been identified as a key priority in the region and is considered to be consistent with *ShapingSEQ*.
State Planning Policy 2017 (SPP) (DILGP, 2017b)	The SPP is applicable to the Project across various aspects, including terrestrial and aquatic ecology which is represented by the State interest of biodiversity. The biodiversity State interest requires development to be located in areas to avoid significant impacts to MNES, avoid and minimise impacts to MSES and Matters of Local Environmental Significance (MLES), maintaining or enhancing ecological processes and connectivity by avoiding fragmentation and conserving and enhancing koala habitat extent and condition.
State Planning Policy 2017 (including State Planning Policy—State Interest Guideline (Water Quality) (DILGP, 2017c)	While no components of the Project are assessable under the provisions of a local government planning schemes, State approval requirements will trigger the chief executive of the Department of State Development, Infrastructure, Local Government and Planning (DSDILGP) (formerly Department of State Development, Tourism and Innovation (DSDTI)) as a referral agency for a number of applications. As such, relevant provisions of the SPP will require to be addressed as part of the supporting application materials to be submitted (around water quality performance outcomes with discharge from tunnel infrastructure) and will be considered in the assessment process.

13.4.2 Water quality guidelines

Various water quality guidelines were used to assess the quality of surface waters within the water quality study area against defined reference conditions. This enabled comparison of existing environment performance against WQOs. Applicable guidelines, in addition to the EPP (Water and Wetland Biodiversity) are described below and are used as an assessment tool for existing water quality conditions.

13.4.2.1 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), 2000/2018) provide a method for assessing water quality through comparison with guidelines derived from local reference values.

The guideline values were developed based on the following criteria:

- Level of environmental disturbance of surface waters (i.e. highly or slightly/moderately disturbed waters)
- Freshwater or saline surface water
- Waterbody elevation (i.e. upland or lowland aquatic environments)
- Biogeographic region (i.e. south-east or tropical Australia).

The ANZECC/ARMCANZ 2000/2018 Guideline values can be regarded as guideline trigger values that can be modified into regional, local or site-specific guidelines. The variability of the subject environment, soil type, rainfall and contaminant exposure is considered. Exceedances of the guideline trigger values indicate a potential environmental issue and trigger an environmental management response.

13.4.2.2 Queensland Water Quality Guidelines

The *Queensland Water Quality Guidelines* (QWQG) (DEHP, 2009) provide a framework for assessing water quality in Queensland via the setting of WQOs.

The QWQG are intended to address the need identified in the ANZECC/ARMCANZ 2000 and 2018 guidelines by providing:

- Guideline values (numbers) that are tailored to Queensland region and water types
- A process/framework for deriving and applying more locally specific guidelines for waters in Queensland.

13.4.2.3 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The *EPP (Water and Wetland Biodiversity)* provides a framework for:

- Identifying EVs for Queensland waters, and identifying the WQOs to protect or enhance those EVs
- Including the identified EVs and WQOs under Schedule 1 of the *EPP (Water and Wetland Biodiversity)*.

13.4.3 Project-relevant water quality objectives and environmental values

The Queensland Department of Environment and Science (DES) has published two reports, aligning with the EPP (Water and Wetland Biodiversity) and relevant to the Project alignment, listing EVs and WQOs, including:

- Bremer River environmental values and water quality objectives: Basin No 143 (part) including all tributaries of the Bremer River (Bremer River EV and WQOs) (DERM, 2010b)
- Lockyer Creek environmental values and water quality objectives: Basin No 143 (part) including all tributaries of the Lockyer Creek (Lockyer Creek EVs and WQOs) (DERM, 2010a).

The Project alignment traverses through five sub-catchments of the Bremer River and Lockyer Creek catchments that have varying applicable EVs as outlined in Table 13.3.

Within EPP (Water and Wetland Biodiversity), watercourses within each of these catchments are classified as moderately disturbed and corresponding WQOs are used to assess the existing condition. Due to the watercourses' definition across the water quality study area (slightly to moderately disturbed, as per ANZECC/ARMCANZ 2000/2018)), default guideline values for heavy metals (under ANZECC/ARMCANZ 2000/2018) were conservatively based on 95 per cent species protection.

Under the Bremer River EV and WQOs and Lockyer Creek EVs and WQOs document (DERM 2010a; 2010b) EVs are identified for protection for particular waters (refer Table 13.3).The aquatic ecosystem EV is the default applying to all waters. Further, WQOs are identified for the aquatic ecosystem EVs and for EVs other than the aquatic ecosystem (e.g. human use). Water quality objectives have been developed under the provisions of the *EPP (Water and Wetland Biodiversity)* and EP Act. These WQOs have been developed to support and protect waters within both the Lockyer Creek and Bremer River catchment areas. Under the EVs, it is expected that the achievement of each WQO is required to maintain existing water quality standards (or aspirational water quality standards), where present. Typically, WQOs are assessed against a median assessment of the existing environment; however, for this assessment, grab samples were assessed against the WQO with reference to prevailing conditions and trending data in regard to seasonal conditions.

The applicable WQO for waterways (based in the Bremer River and Lockyer Creek catchments) within the water quality study area are outlined in Table 13.4 and Table 13.5.

TABLE 13.3: WATER QUALITY STUDY AREA SUB-CATCHMENT ENVIRONMENTAL VALUES

Environmental Values	Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumer	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
Bremer River sub-catchment												
Western Creek (Site 9A, 10A, 18A)	✓	✓	✓	✓	–	–	–	✓	✓	–	–	✓
Lockyer Creek sub-catchments												
Sandy Creek (Grantham) (Site 1A)	✓	✓	✓	✓	✓	✓	✓	✓	✓	–	–	✓
Sandy Creek (Forest Hill) (Site 5A, 16A)	✓	✓	✓	✓	–	✓	✓	✓	✓	✓	–	✓
Upper Lockyer Creek (Site 2A, 3A. 4A, 11A, 12A, 15A)	✓	✓	✓	✓	–	✓	✓	✓	✓	✓	–	✓
Laidley Creek (Site 7A, 8A, 13A, 14A, 17A)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Source: DERM, 2010a; DERM, 2010b

Table notes:
Blank cells (-) indicate no Environmental Values alignment with the particular parameter for the respective sub-catchment.
Site locations are shown in Figure 13.1.

TABLE 13.4: WATER QUALITY OBJECTIVES FOR MODERATELY DISTURBED SURFACE WATER ECOSYSTEMS INTERSECTED BY THE PROJECT

Sub-catchment	Management intent	Turbidity (NTU)	Total P (μgL^{-1})	FRP (μgL^{-1})	Chlorophyll-*a* (μgL^{-1})	Total N (μgL^{-1})	Oxidised nitrogen (μgL^{-1})	Ammonia N (μgL^{-1})	Dissolved oxygen (% saturated)	pH	Organic N (μgL^{-1})	TSS (mgL^{-1})	Conductivity (μScm^{-1})
Lockyer Creek sub-catchments													
Laidley Creek	Moderately disturbed	< 6	< 30	< 20	< 5	< 500	< 60	< 20	85–110	6.5–8.0	< 200	< 6	< 520
Lower Lockyer Creek	Moderately disturbed	< 6	< 30	< 20	< 5	< 500	< 60	< 20	85–110	6.5–8.0	< 200	< 6	< 520
Sandy Creek—Grantham	Moderately disturbed	< 6	< 30	< 20	< 5	< 500	< 60	< 20	85–110	6.5–8.0	< 200	< 6	< 520
Tenthill Creek	Moderately disturbed	< 6	< 30	< 20	< 5	< 500	< 60	< 20	85–110	6.5–8.0	< 200	< 6	< 520
Upper Lockyer Creek	Moderately disturbed	< 6	< 30	< 20	< 5	< 500	< 60	< 20	85–110	6.5–8.0	< 200	< 6	< 520
Bremer River sub-catchment													
Western Creek	Moderately disturbed	< 17	< 50	< 20	< 5	< 500	< 60	< 20	85–110	6.5–8.0	< 420	< 6	< 770

Source: DERM, 2010a; DERM, 2010b

Table notes:
NTU = Nephelometric Turbidity Units
μgL^{-1} = micrograms per litre
mgL^{-1} = milligrams per litre
μScm^{-1} = microSiemens per centimetre
FRP = Filterable Reactive Phosphorus
Total N = Total Nitrogen
Total P = Total Phosphorus
pH = standard unit for expression of concentration of hydrogen ions in solution
TSS = Total Suspended Solids

TABLE 13.5: WATER QUALITY OBJECTIVES FOR 95% LEVEL OF SPECIES PROTECTION HEAVY METALS AND OTHER TOXIC CONTAMINANTS FOR THE PROJECT

Sub-catchment	Arsenic (mgL^{-1})	Cadmium (mgL^{-1})	Chromium (mgL^{-1})	Copper (mgL^{-1})	Lead (mgL^{-1})	Mercury (mgL^{-1})	Nickel (mgL^{-1})	Zinc (mgL^{-1})	Naphthalene (mgL^{-1})
Lockyer Creek sub-catchments									
Laidley Creek	0.024	0.0055	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016
Lower Lockyer Creek	0.024	0.0055	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016
Sandy Creek–Grantham	0.024	0.0055	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016
Tenthill Creek	0.024	0.0055	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016
Upper Lockyer Creek	0.024	0.0055	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016
Bremer River sub-catchment									
Western Creek	0.024	0.0055	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016

Source: ANZECC/ARMCANZ, 2000/2018

13.4.4 Hydrology-related design guidelines

The design standards and guidelines applicable for the hydrologic and hydraulic investigation are:

- AS7637:2014: Railway Infrastructure—Hydrology and Hydraulics (Standards Australia, 2014a).
- Austroads (2013) *Guide to Road Design Part 5: Drainage—General and Hydrology Considerations*, Sydney.
- Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (eds). *Australian Rainfall and Runoff: A Guide to Flood Estimation*. (Commonwealth of Australia, 2016).
- Richardson, E.V. and Davis, S.R. (2001). *Evaluating Scour at Bridges, Hydraulic Engineering Circular Number 18* (HEC-18), Fourth Edition, US Department of Transport—Federal Highway Administration, Virginia, USA.
- Thompson, P.L. and Kilgore, RT. (2006). *Hydraulic Design of Energy Dissipaters for Culverts and Channels, Hydraulic Engineering Circular Number 14* (HEC-14), Third Edition, US Department of Transport—Federal Highway Administration, Virginia, USA.
- Department of Transport and Main Roads (DTMR) (2013c) *Bridge Scour Manual* www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Bridge-scour-manual.

13.5 Methodology

13.5.1 Surface water quality

Existing surface water conditions have been based on a desktop study from publicly available data, complemented by field water quality samples (with seasonal variation). The approach allowed description and assessment of existing environmental conditions.

While periods of minimal watercourse flow were observed in the water quality study area during the Project assessment phase, these periods were considered to be indicative of regional cyclic hydrological regimes (periods of minimal rain). The field data gathered during this assessment was therefore considered representative of existing environmental conditions and relevant for assessment under the ToR.

The assessment methodology has been designed to provide sufficient information to determine:

- Existing receiving surface water condition (with reference to Schedule 1 of EPP (Water and Wetland Biodiversity)) required for investigation of potential Project impacts
- Mitigation measures
- Residual and cumulative impacts.

The desktop and field assessments (as a description of the existing environment) were used to determine the quality of receiving waters. The baseline conditions were used to assess the risk significance (qualification of potential contaminants) of specific potential impacts expected from the Project.

To assess the surface water quality in the water quality study area, the following approach was adopted:

- A desktop and review of relevant databases, search area parameters, existing literature and previous study reports was undertaken.
- Surface water sampling sites were defined. Sites were initially identified during a gap analysis conducted as part of the desktop phase. Sites targeted watercourses that cross the proposed alignment, with additional sites located upstream and downstream of the alignment crossing (refer Figure 13.1 for locations).
- Three sampling events were undertaken to collect surface water samples from selected waterbodies to account for temporal and seasonal variability. These were used as a complementary assessment alongside historic data.
- In-situ water quality field data and samples for laboratory analysis were collected. Sampling was undertaken by a suitably qualified and experienced environmental scientist.
- Samples were collected from 12 water quality monitoring locations (nine within Lockyer Creek catchment and three within Bremer River catchment). It was not possible to collect water samples at all 12 locations during each of the three sample events due to the sites being dry and/or inaccessible at the time of the site visit.
- The following water quality parameters were measured in situ:
  - pH
  - Temperature
  - Electrical conductivity (actual and specific)
  - Salinity
  - Dissolved oxygen (dissolved and saturated)
  - Turbidity.
- Additionally, the following qualitative data was collected regarding visual water quality indicators:
  - Time
  - Water flow (none/low/mod/high/flood/dry)
  - Clarity (clear/slight/turbid/opaque/other)
  - Odour (normal/sewage/hydrocarbon/chemical)
  - Surface condition (none/dust/oily/leafy/algae)
  - Algae cover (none/some/lots)
  - Other visual observations/comments (colour, fish, presence of litter)
  - Water quality samples were collected in accordance with industry-accepted standards and quality assured procedures, including the *Queensland Monitoring and Sampling Manual* (DES, 2018b). Field quality control included sample collection, storage, decontamination procedures (where appropriate), and documentation. One duplicate sample was collected per sampling visit for quality assurance and quality control purposes.

- The collected samples were submitted to a National Association of Testing Authorities (NATA)-accredited laboratory for analysis of:
  - pH
  - Suspended solids
  - Turbidity
  - Total phosphorus
  - Reactive filterable phosphorus
  - Speciated nitrogen: ammonia, nitrate, nitrite, organic nitrogen, total kjeldahl nitrogen, total nitrogen
  - Dissolved metals: arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc
  - Salinity
  - Electrical conductivity
  - Chlorophyll *a*
  - Polycyclic aromatic hydrocarbons (PAH).

The selected parameters established a preliminary assessment of the existing water quality.

No additional sampling for specific hydrocarbon or biocide was completed due to:

- Qualitative assessment of other hydrocarbon through olfactory/visual assessments during field sampling
- A specific mitigation requirement of aquatic-friendly pesticides, nullifying the need for biocide assessment and assimilative capacity of the receiving environment.

Field and laboratory results were compared against respective Logan River catchment WQOs, Bremer River catchment WQOs and ANZECC/ARMCANZ guidelines as outlined in Section 13.4.3.

Laboratory results are included in Appendix V: EMR Search Certificates and Laboratory Certificates.

13.5.1.1 Impact assessment methodology

The surface water quality assessment used a significance-based impact assessment framework to identify and assess Project-related impacts.

For the purposes of the assessment, a significant impact depends on the sensitivity of the water quality receptor; the quality of the environment that is impacted; and on the intensity, duration, magnitude and potential spatial extent of the potential impacts. Determining the sensitivity or vulnerability of the surface water value/receptor and the magnitude of the potential impacts allows significance to be assessed.

Refer Chapter 4: Assessment methodology for further information on the impact assessment methodology.

The magnitude and sensitivity criteria are further detailed in Appendix L: Surface Water Quality Technical Report.

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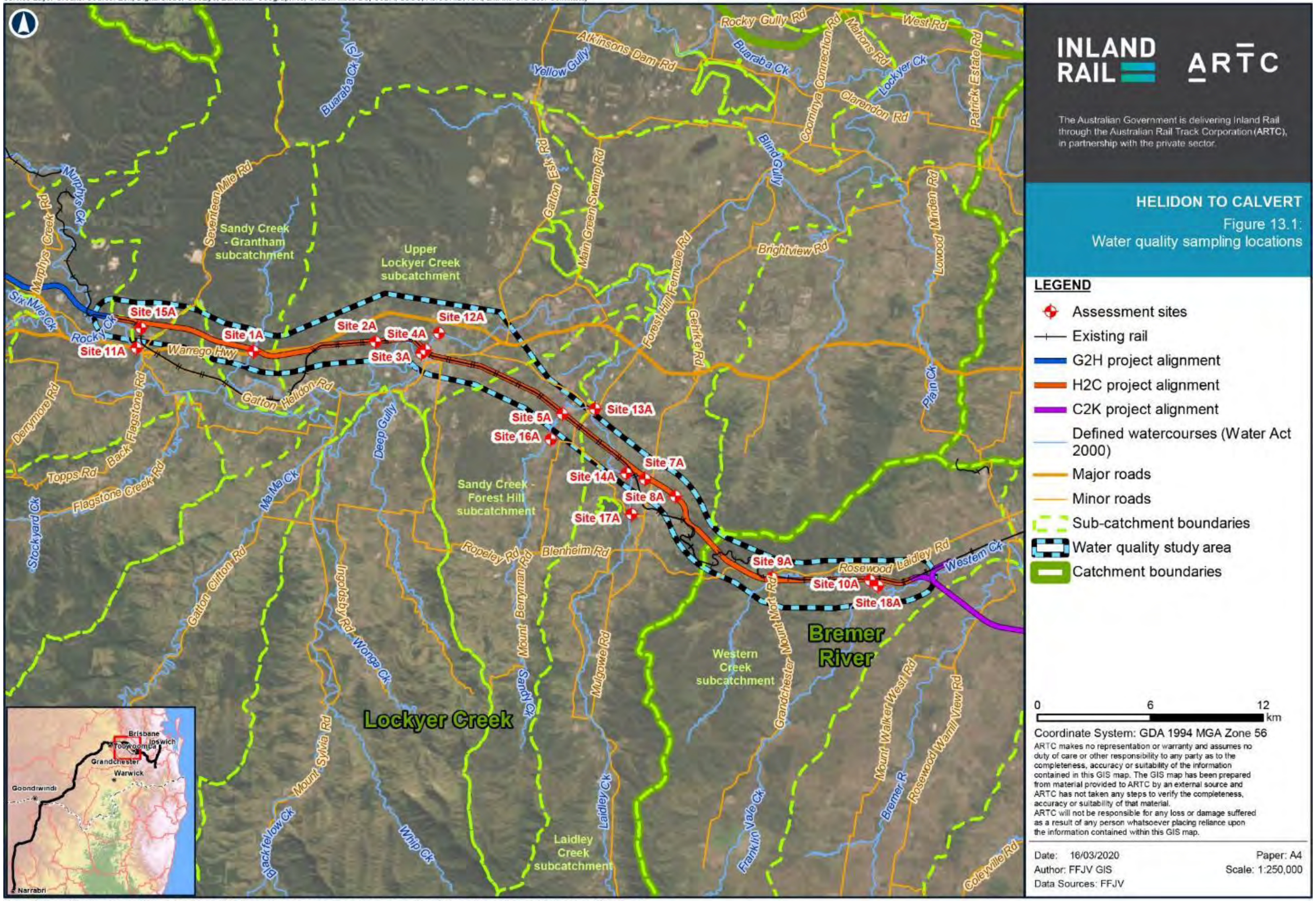

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13.5.2 Hydrology and flooding

The Project design has been guided and refined through the hydraulic design criteria and flood impact objectives as detailed below.

13.5.2.1 Hydraulic design criteria

Table 13.6 outlines the hydraulic design criteria that have guided the Project design. Detailed hydrologic and hydraulic modelling has been undertaken to meet these design criteria with a series of iterations undertaken to incorporate design refinement and stakeholder and community feedback. The outcomes relative to these design criteria are detailed in Appendix M: Hydrology and Flooding Technical Report.

TABLE 13.6: PROJECT HYDRAULIC DESIGN CRITERIA

Performance criteria	Requirement
Flood immunity	Rail line—1% AEP flood immunity with 300 mm freeboard to formation level. Tunnel portals—1 in 10,000 AEP event flood immunity.
Hydraulic analysis and design	Hydrologic and hydraulic analysis and design to be undertaken based *on Australian Rainfall and Runoff* (ARR 2016) (Commonwealth of Australia, 2016), and State/local government guidelines. *ARR 2016 Interim Climate Change Guidelines* are to be applied with an increase in rainfall intensity to be considered. No sea level change consideration required due to location outside tidal zone. *ARR 2016 Blockage Assessment Guidelines* applied.
Scour protection of structures	All bridges and culverts designed to reduce the risk of scour with events up to 1% AEP event considered. Mitigation to be achieved through providing appropriate scour protection or energy dissipation or by changing the drainage structure design.
Structural design	1 in 2,000 AEP event to be modelled for bridge design purposes.
Extreme events	Damage resulting from overtopping to be minimised.
Flood flow distribution	Locate structures to maintain efficient conveyance and spread of floodwaters.
Sensitivity testing	Consider climate change and blockage in accordance with ARR 2016. Understand risks posed and Project design sensitivity to climate change and blockage of structures.

13.5.2.2 Flood impact objectives

The potential impact of the Project on existing flood regimes was quantified and compared against flood impact objectives detailed in Table 13.7. These objectives address the requirements of the ToR and have been used to guide the Project design. Acceptable impacts will ultimately be determined on a case-by-case basis with interaction with stakeholders/landholders through the community engagement process using these objectives as guidance. This will consider flood sensitive receptors and land use within the floodplains.

The flood impact assessment outcomes are outlined in Section 13.9.2 with additional detail in Appendix M: Hydrology and Flooding Technical Report.

TABLE 13.7: FLOOD IMPACT OBJECTIVES

Parameter	Objectives				
Change in peak water levels	Existing habitable and/ or commercial and industrial buildings/ premises (e.g. dwellings, schools, hospitals, shops)	Residential or commercial/ industrial properties/lots where flooding does not impact dwellings/ buildings (e.g. yards, gardens)	Existing non-habitable structures (e.g. agricultural sheds, pump-houses)	Roadways	Agricultural and grazing land/forest areas and other non-agricultural land
	≤ 10 mm	≤ 50 mm	≤ 100 mm	≤ 100 mm	≤ 200 mm with localised areas up to 400 mm
	Changes in peak water levels are to be assessed against the above proposed limits. It is noted that changes in peak water levels can have varying impacts on different infrastructure/land and flood impact objectives were developed to consider the flood sensitive receptors in the vicinity of the Project. It should be noted that in many locations the presence of existing buildings or infrastructure limits the change in peak water levels.				
Change in duration of inundation	Identify changes to time of inundation through determination of time of submergence (ToS). For roads, determine the average annual time of submergence (AATOS) (if applicable) and consider impacts on accessibility during flood events. Justify acceptability of changes through assessment of risk with a focus on land-use and flood sensitive receptors.				
Flood flow distribution	Aim to minimise changes in natural flow patterns and minimise changes to flood flow distribution across floodplain areas. Identify any changes and justify acceptability of changes through assessment of risk with a focus on land-use and flood sensitive receptors.				
Velocities	Maintain existing velocities where practical. Identify changes to velocities and impacts on external properties. Determine appropriate scour mitigation measures taking into account existing soil conditions. Justify acceptability of changes through assessment of risk with a focus on land-use and flood sensitive receptors.				
Extreme event risk management	Consider risks posed to neighbouring properties for events larger than the 1% AEP event to minimise unexpected or unacceptable impacts.				
Sensitivity testing	Consider risks posed climate change and blockage in accordance with ARR 2016. Undertake assessment of impacts associated with Project alignment for both scenarios.				

Table note:

1. These flood impact objectives apply for events up to, and including, the 1% AEP event.

13.5.2.3 Assessment methodology

The hydrology and flooding assessment of the Project uses a quantitative approach to impact assessment and included:

- Collation and review of available background information including existing hydrologic and hydraulic models, survey, rainfall and streamflow data, calibration information and anecdotal flood related data. This review established which datasets were suitable to use for the EIS
- Determination of critical flooding mechanisms for waterways and drainage paths in the area surrounding the Project, i.e. regional flooding versus local catchment flooding
- Determination of high-risk watercourses that the alignment crosses, qualitatively considering:
  - Catchment size, resulting flood flows and velocities
  - Land use in the vicinity of the rail alignment
  - Extent and depth of flood inundation
  - Duration of flood events and catchment response time
  - Proximity to and nature of flood sensitive receptors (e.g. houses, sheds, roads)
- Adoption of the Brisbane River Catchment Flood Study hydrologic modelling for the Project
- Update of the existing Lockyer Valley Regional Council (LVRC) Lockyer Creek hydraulic model, and development of a localised hydraulic model for Western Creek, for use in the assessment
- Validation of the hydrologic and hydraulic models against available recorded data for five historical flood events (1974, 1996, 1999, 2011 and 2013)
- Community and stakeholder engagement to validate model performance and gain acceptance of modelling and calibration outcomes
- Update of hydrologic and hydraulic models to include ARR 2016 design events
- Simulation of ARR 2016 design events without the Project (existing case) and comparison to previous studies to confirm drainage paths, waterways, and associated floodplain areas, and establish the existing flood regime in the vicinity of the Project—the range of flood event magnitudes assessed included the 20%, 10%, 5%, 2%, 1%, 1 in 2,000, 1 in 10,000 AEP and Probable Maximum Flood (PMF) events
- Inclusion of proposed Project alignment and drainage structures (developed case) in the hydraulic models and simulation of ARR 2016 design events
- Assessment of impacts of proposed alignment using the suite of design floods including consideration of change in flood levels, flow distributions, velocities and inundation periods
- Determination of appropriate mitigation measures to manage potential impacts including refinement of location and dimensions of major drainage structures under the Project alignment— hydraulic model iterations were undertaken to achieve a design that meets the design criteria and flood objectives
- Community and stakeholder engagement in accordance with the ARTC engagement plan and consultation requirements.

Details of the hydrologic and hydraulic modelling undertaken are in Appendix M: Hydrology and Flooding Technical Report.

13.5.2.4 Stakeholder engagement

Community consultation has been undertaken at key milestones, including:

- Data collection
- Feedback on hydrologic and hydraulic modelling calibration results
- Periodic updates to the community via newsletters and community sessions
- Updates on flood modelling progress at Community Consultative Committee (CCC) meetings
- Feedback on design flood modelling results—community feedback on preliminary design solutions have been used during design development and refinement
- One-on-one consultation with landowners affected by changes in flooding behaviour—this information has been considered as part of the EIS process.

Information collected during the consultation sessions informed the development of the hydrologic and hydraulic models and provided validation of the performance of each model. This information was collated by ARTC from the consultation sessions.

In addition to the community information and engagement sessions, input was sought from key landowners during the flood model calibration process on a one-on-one basis in relation to historical flood events (Existing Case). Meetings were conducted with landowners within the floodplains upstream and downstream of the Project alignment to gather further anecdotal flood data, which was used to improve the model validation process.

One-on-one meetings were held with a number of landowners to discuss the impacts on the flooding regime associated with the Project alignment (Developed Case). The one-on-one landowner meetings were used to discuss:

- Existing 1% AEP flood depths
- Predicted 1% AEP changes in peak water levels
- Potential impacts to houses and other infrastructure
- Potential mitigation options.

Stakeholder engagement meetings held to discuss potential flood impacts on State and council-controlled assets include meetings with the DTMR, QR, LVRC and Ipswich City Council (ICC).

Details of the stakeholder and community sessions undertaken are documented in Chapter 5: Stakeholder engagement and Appendix C: Consultation Report.

13.5.2.5 Terminology

The hydrologic and flooding assessment has adopted the latest approach to design flood terminology as detailed in ARR 2016. All design events are quoted in terms of AEP with the adopted terminology for the simulated design events shown in bold in Table 13.8.

TABLE 13.8: EVENT NOMENCLATURE

Exceedances per year	AEP (%)	AEP (1 in x)	Average Recurrence Interval
0.22	20	5	4.48
0.11	10	10	9.49
0.05	5	20	20
0.02	2	50	50
0.01	1	100	100
0.0005	0.05	2,000	2,000
0.0001	0.01	10,000	10,000

Source: ARR, 2016

Table note:
Values bolded adopted in simulation design events.

As an example, in general terms, a 1% AEP event means that there is a 1% chance of an event of that magnitude occurring in any given year.

13.6 Existing environment

13.6.1 Local government areas

The Project alignment travels through the local government areas (LGAs) of LVRC, between Helidon and Grandchester, and ICC between Grandchester and Calvert.

13.6.2 Catchment overview

The Project alignment travels through the Lockyer Creek and Bremer River catchments. Both catchments are located within the wider Moreton hydrological basin (refer Figure 13.2).

The Bremer River catchment is situated west of Brisbane within the LGAs of Ipswich and Scenic Rim and expands to an area of approximately 2,030 square kilometres (km^2) with the main Bremer River channel surrounded by smaller sub-catchments (DES, 2016a).

Rainfall in the catchment is considered higher 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 millimetres per year (mm/yr). The catchment supports a diverse range of land uses including agriculture, grazing and urban areas as well as featuring steep slopes (DES, 2016a).

The Lockyer Creek catchment is located west of Brisbane and east of Toowoomba, within the LGAs of Lockyer Valley, Somerset, Ipswich and Toowoomba. The catchment covers an area of approximately 3,000 km^2 with the main Lockyer Creek surrounded by several sub-catchments (DES, 2015b). The Lockyer Creek catchment experiences high rainfall in the south and parts of the north. The rest of the catchment has moderate to low rainfall. However, due to the steep slopes in the upper reaches of the catchment, many streams can experience high flows despite the relatively low rainfall (DES, 2015b). Dominant land uses within the Lockyer catchment include native bush, grazing, intensive agriculture and rural residential. The upper catchment remains mostly forested whereas the mid and lower catchment has been largely cleared.

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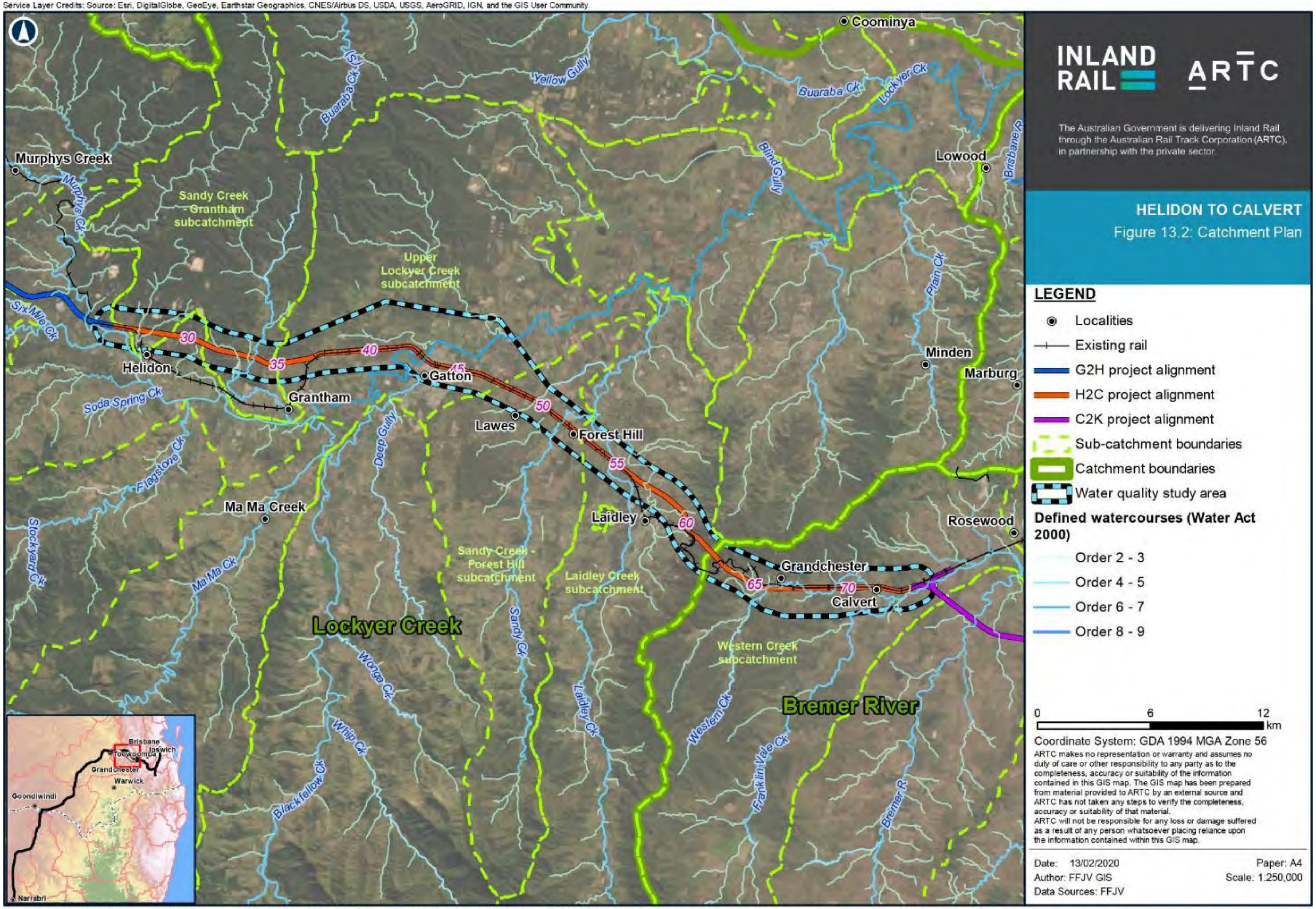

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13.6.2.1 Climate

A review of the Bureau of Meteorology (BoM) climate data was undertaken, and information was sourced from the nearest monitoring stations at The University of Queensland, Gatton campus (monitoring station number 040082) approximately 6.7 km east of Gatton centre. The region has atypical hot and dry climate and experiences warm to hot summers and mild to cool winters. Rainfall is seasonally distributed with a distinct wet season occurring during the summer months of December through to February and an extended dry season during the months of April through September. Mean maximum monthly temperatures typically range from 31.2 °C (summer) to 21.5 °C (winter).

Key climate characteristics for the region corresponding to the water quality study area include the:

- Heaviest amount of rainfall is generally received in the summer months with an annual average rainfall is approximately 807 millimetres (mm)
- Average maximum temperature is 31.2 °C and the average minimum temperature of 21.5 °C
- Water quality study area generally consists of higher evaporation in the summer months where the mean evaporation rate is 7.4 mm compared to the winter months where the mean evaporation rate is 3.5 mm.

13.6.2.2 Watercourses and waterbodies

Under the Water Act, a watercourse is defined as a river, creek or other stream, which includes a stream in the form of an anabranch or a tributary where water flows either permanently or intermittently regardless of flow frequency. A watercourse, however, does not include any section of a feature that has a tidal influence or is upstream or downstream from a defined limit (Department of Natural Resources, Mines and Energy (DNRME), 2014).

Several watercourses and waterbodies occur within the water quality study area (refer Figure 13.3). Tenthill Creek crosses into the water quality study area for a total of 200 metres (m), however does not intersect the Project alignment. Defined watercourses intersected by the Project alignment include:

- Sandy Creek (Grantham)—at chainage (Ch) location Ch 33.70 km
- Lockyer Creek—at Ch 43.20 km
- Sandy Creek (Forest Hill)—at Ch 51.40 km
- Laidley Creek—at Ch 54.80 km
- Western Creek—at Ch 65.70 km, Ch 67.60 km, Ch 69.30 km and Ch 71.10 km.

Unmapped waterways that are intersected by the Project alignment are quantified using waterways barrier works mapping and stream order mapping (refer Appendix L: Surface Water Quality Technical Report). The unmapped waterways will be required to be verified during the detailed design phase to determine status under the Water Act.

To facilitate the Project, the current design includes the five potential alterations to existing unmapped watercourses. Details of the potential changes follow and the potential five alterations are indicated by the highlighted chainages:

- An overland flow path will be altered from Ch 59.57 km to Ch 59.67 km. The overland flow path is not identified as a waterway under the DAF *Queensland Waterways for Waterway Barrier Works* spatial mapping.
- An overland flow path will be altered from Ch 61.77 km to Ch 62.02 km. The overland flow path (draining to the Laidley Creek sub-catchment) runs on the top of the western portal of the proposed Little Liverpool Range tunnel (Ch 61.84 km) and drains into the rail corridor. A proposed diversion drain will intercept and divert part of the flow to the original receiving waterway as to minimise runoff flowing into the rail corridor. The proposed diversion drain will intercept and divert part of the flow to the cut drain at Ch 61.77 km where the drain is 2.5 m deep and has adequate capacity to contain the overland flow. The overland flow path is not identified as a waterway under the DAF *Queensland Waterways for Waterway Barrier Works* spatial mapping.
- The Project alignment crosses an unmapped feature (as defined under the Water Act) flowing into an unnamed tributary of Western Creek between chainages Ch 63.44 km to Ch 63.53 km and Ch 63.53 km to Ch 63.75 km (two totaling 310 m) and Ch 64.05 km to Ch 64.17 km (130 m). The diversion of the drainage features from Ch 63.44 km to Ch 63.75 km are identified as low risk of impact and moderate risk of impact waterway under the DAF Queensland Waterways for Waterway Barrier Works spatial mapping. The diversion from Ch 64.05 km to Ch 64.17 km is identified as a moderate risk of impact waterway under the DAF *Queensland Waterways for Waterway Barrier Works* spatial mapping.

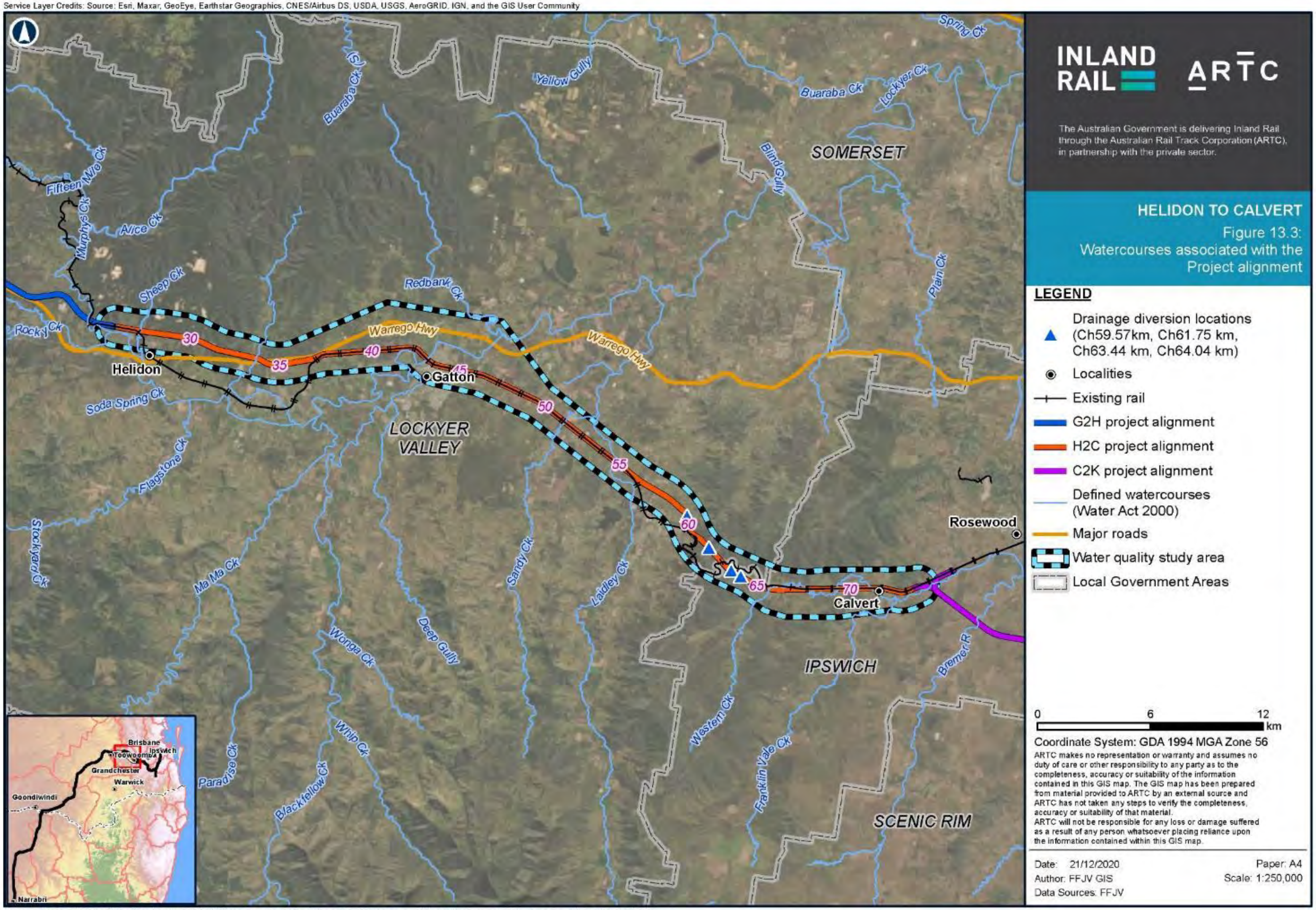
These drainage diversions will require approval under State code 10 in the State Development Assessment Provisions as a diversion for works that take or interfere with watercourse, lake or spring. Under the Planning Act 2016 (Qld) (Planning Act), the diversion may require approval as an assessable development under waterway barrier works (in accordance with DAF requirements and the Planning Act).

There are a number of artificial/constructed waterbodies (a total of 21) located within the water quality study area that are intersected by the Project alignment. These artificial/constructed waterbodies are predominantly rural farm dams used by stock and typically occur along unnamed drainage features. The artificial/ constructed waterbodies that are intersected by the Project alignment are in Table 13.9.

TABLE 13.9: ARTIFICIAL WATERBODIES INTERSECTED BY THE PROJECT ALIGNMENT

Artificial Waterbody (approximate chainage (km))	Associated waterway
Ch 27.00 km, Ch 27.95 km, Ch 28.21 km, Ch 28.50 km (4 of 21)	Unmapped waterway of Lockyer Creek
Ch 32.50 km, Ch 33.90 km (2 of 21)	Unmapped waterway of Sandy Creek (Grantham)
Ch 36.85 km (1of 21)	Unmapped waterway of Lockyer Creek
Ch 47.40 km, Ch 49.95 km (2of 21)	Drainage feature (Water Act) of Laidley Creek
Ch 58.15 km, Ch 58.25 – 58.45 km, Ch 58.80 km (3of 21)	Unmapped waterway of Lagoon Creek
Ch 60.30 km, Ch 60.95 km (2of 21)	Unmapped waterway of Laidley Creek
Ch 63.20 km, Ch 66.00 km, Ch 66.35 km, Ch 67.00 km, Ch 70.55 km, Ch 70.90 km, Ch 71.00 km (7of 21)	Unmapped waterway of Western Creek

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



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13.6.2.3 Surface water resource and use

The Water Act provides a framework under which catchment-based Water Plans and Water Management Protocols (previously Resource Operations Plans) are developed in Queensland. Water Plans establish a framework for sharing water between human consumptive needs and EVs. Water Management Protocols are developed in parallel with the Water Plans and provide a framework for the implementation of water allocations and administrative directions.

Surface water resources within the water quality study area are primarily managed by the Water Plan (Moreton) 2007 (Moreton Water Plan). The Moreton Water Plan includes performance indicators and objectives such as:

- Environmental flow objectives: assessing periods of low flow and medium to high flow
- Water allocation security objectives.

The Moreton Water Management Protocol implements the Moreton Water Plan. The Water Management Protocol defines the rules that govern the allocation and management of water to achieve the Water Plan outcomes.

Significant changes to the hydraulic regime of the watercourses are not expected to occur with design practices which account for typical hydrological flow to which the water plans pertain. Ecological and general outcomes for the Moreton Water Plan (i.e. achieving ecological outcomes consistent with supporting natural outcomes by minimising changes to natural flow regimes) will not be impacted with minimal variance to typical hydrological flow. As such, the Project is expected to comply with the Moreton Water Plan.

The current Moreton Water Plan has a total supplemented surface water allocation of 397,495 megalitres (ML) and an un-supplemented surface water allocation of 28,502 ML. Un-supplemented groundwater allocation is currently 137 ML. To identify immediate impacts on surface water resource users, the number of water access licences relative to the water quality study area (as a proximal assessment for downstream water users) were accessed to identify potential water quality receptors (refer Table 13.10).

Within the water quality study area, licensed (refer Section 13.2) and unlicensed water usage comprises recreational, commercial and domestic uses. The area provides opportunity for various recreational activities that use the waterways including canoeing, water skiing and fishing. Water usage within the water quality study area is dominated by stock use, farming and rural domestic uses. Stock water is supplied from rivers in the wet season and for the rest of the year by groundwater, natural waterholes or constructed artificial waterbodies.

Water resource catchments (and water supply buffer area) associated with the water quality study area (refer Appendix H of Appendix L: Surface Water Quality Technical Report) are limited to the Lockyer Creek Catchment. Human requirements for drinking water quality supply are considered to be covered by the protection of aquatic ecosystem environmental values (due to stringency of water quality objectives).

TABLE 13.10: WATER LICENCE DATA RELEVANT TO THE WATER QUALITY STUDY AREA (UNDER WATER REGULATION 2016), 2018–2019

Water source	No. of water licences
Helidon Sandstone (groundwater source)	4
Laidley Creek (surface water source)	1
	8
Laidley Creek (alluvial aquifer source)	35
Lockyer Creek (surface water source)	22
Lockyer Creek (alluvial aquifer source)	45
Redbank Creek (alluvial aquifer source)	3
Sandy Creek (alluvial aquifer source)	6
TOTAL	124

Source: DNRME, 2019d

13.6.2.4 Sensitive environmental areas

Identified sensitive environmental areas for the Project include wetlands areas, identified fish habitat and groundwater dependent ecosystems (GDEs). Sensitive environmental areas are those areas specifically protected by legislative framework. Sensitive environmental areas were included within the impact assessment as a 'high' sensitive category (refer Section 13.9.1).

For further detail refer Appendix I: Terrestrial and aquatic ecology technical report and Appendix L: Surface Water Quality Technical Report.

Wetlands

There are no Wetlands of International Importance (Ramsar wetlands) in, or within 10 km, of the water quality study area. Several high ecological significance wetlands (under the *EPP (Water and Wetland Biodiversity)*), are present within the water quality study area with some intersecting with the Project alignment, specifically at the western end of the water quality study area, proximal to Lockyer Creek (Ch 27.40 km). Two high ecological significance wetlands (MSES) are located at the eastern end of the water quality study area, proximal to Western Creek (Ch 72.40 km and Ch 73.20 km). These are located less than 100 m from the Project alignment.

Of the approximately 11,870 hectares (ha) of the water quality study area, approximately 87 ha (0.73 per cent) are either State significant, high ecological significance wetlands or high ecological value wetlands. Of the potential 87 ha, a minimum of 6.44 ha is anticipated to be potentially disturbed by Project works.

Fish habitat

Under the Fisheries Act, a declared fish habitat is an area protected against physical disturbance from coastal development, while still allowing legal fishing. There are no declared fish habitat areas mapped within the water quality study area. The nearest gazetted fish habitat area is located approximately 120 km downstream of the water quality study area.

Groundwater dependent ecosystems

GDE are ecosystems that require access to groundwater on a permanent or periodic basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services.

The Groundwater Dependent Ecosystems Atlas (GDE Atlas) (BoM, 2020) identifies three types of ecosystems:

- Aquatic ecosystems that rely on the surface expression of groundwater—this includes surface water ecosystems which may have a groundwater component (i.e. rivers, wetlands, springs)
- Terrestrial ecosystems that rely on the subsurface groundwater—this includes vegetation ecosystems
- Subterranean ecosystems—this includes cave and aquifer ecosystems.

As the assessment using the BoM atlas is modelled at a large scale, identification of potential GDEs in the Atlas does not confirm that a particular ecosystem is groundwater dependent. Noting this, the Atlas has identified several potential aquatic and terrestrial groundwater-dependent systems, including wetland systems and watercourses.

A review of refined scale potential GDE mapping (BoM, 2020) has been undertaken and the following GDE aquifer categories have the potential to occur within the water quality study area:

- Unconsolidated sedimentary aquifers
- Consolidated sedimentary aquifers
- Metamorphic rock aquifers.

Surface water expression areas (aquatic groundwater dependent ecosystems) are considered to be the aspect of relevance to the surface water quality environment and are described alongside terrestrial groundwater dependent environments below. As a conservative approach has been used to consider potential impact to GDEs, moderate and high confidence modelling of surface area has been identified within the existing environment. Terrestrial groundwater dependent and spring ecosystems are considered within this report; however, are not considered further than supporting information.

As no ground-truthing of these particular environments was undertaken, it has been assumed for the purposes of the EIS, that the modelled extent of the aquatic and terrestrial GDEs are accepted for the purposes of the assessment, and thus form a potential sensitive receptor.

Aquatic groundwater dependent ecosystems

There are numerous known, high confidence and moderate confidence aquatic GDEs (from regional studies) associated with the water quality study area, including the Lockyer Creek, Laidley Creek and Western Creek (and their tributaries). Typically, these are modelled as surface area expression wetlands proximal to the disturbance area and 20.53 ha are present within the water quality study area. Noting this, 0.00 ha are intersected by the disturbance footprint.

Terrestrial groundwater dependent ecosystems

Within the water quality study area, several terrestrial GDEs (from regional studies) are either intersected or proximal to the proposed Project alignment. Within the water quality study area, 415.43 ha are present with 8.09 ha intersected by the disturbance footprint.

Springs

No incidental observation of springs occurred during surface water quality field assessments associated with the EIS or identified from the GDE Atlas (BoM, 2020) within the water quality study area. Within the water quality study area, 0.00 ha are present or intersected by the disturbance footprint.

As no ground-truthing of these particular environments were undertaken, it has been assumed for the purposes of the EIS, that the modelled extent of the aquatic and terrestrial GDEs are accepted as true presence, and thus form a potential sensitive receptor. Therefore, GDEs and surface areas have been mapped as occurring within the water quality study area.

13.6.2.5 Salinity hazard

The water quality study area was broken down by the Australian Hydrologic Geospatial Fabric Catchment GIS layer, into smaller sub-catchments to enable a more precise analysis of the potential Project impacts. The sub-catchments were analysed for salinity hazard in accordance with *Part B Investigating Salinity of the Salinity Management Handbook* (DERM, 2011). In particular, consideration was given to how Project construction activities may alter the hydrology of the water quality study area.

Once broken down into sub-catchments, the soils layer was intersected with the sub-catchments layer to identify which soils were dominant in each of the sub-catchments. Soil type characteristics were then applied to give a low, moderate, or high rating to each of the dominant soil types, and provide an indication of inherent salt store.

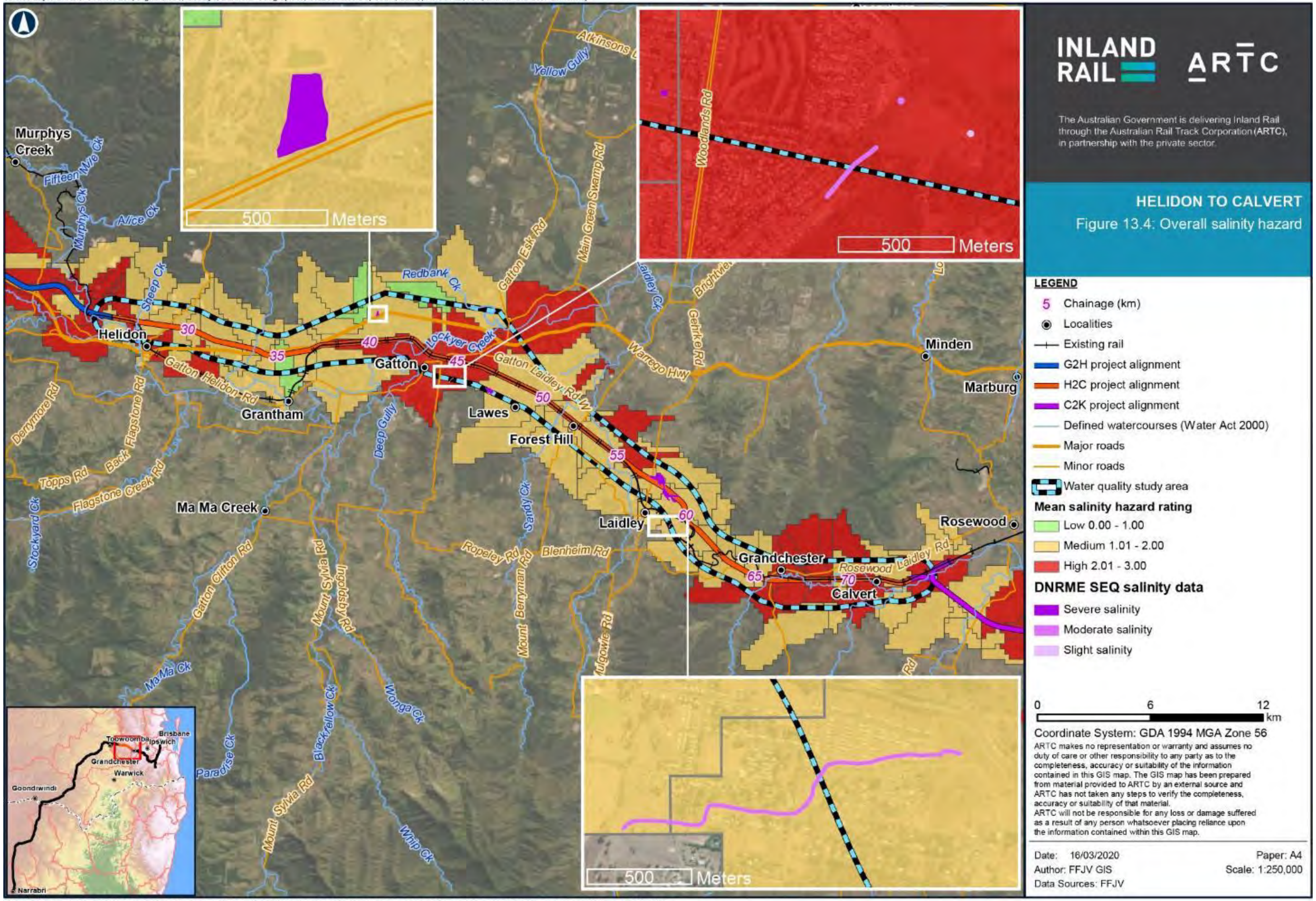
Furthermore, salinity hazard within the water quality study area (relative to soils) was assessed using the EC mapping layer (Fitzpatrick et al. 2011). The map revealed that the area underlying Helidon to Ringwood begins with high conductivity soil (1.0 deciSiemens per metre (dS/m) to 2.0 dS/m), which declines in conductivity approaching Ringwood to very low (0.05 dS/m to 0.1 dS/m) conductivity soil. The water quality study area between Gatton and Grandchester predominantly features high conductivity soil becoming mildly conductive (0.25 dS/m to 0.5 dS/m) from Laidley onward. An area of very low conductivity soil occurs through Grandchester and north of Calvert which directly correlates with more sandy soil.

The water table occurs in the alluvial sediments of Laidley Creek and Lockyer Creek and Western Creek alluvial sediments east of Little Liverpool Range. Depths to groundwater in the alluvial sediments are anticipated to be between 5 m and 15 m, with shallow groundwater typically occurring near active watercourses where fill/embankments and/or bridges are proposed. No cuttings are proposed through alluvial sediments, but groundwater mounding may occur below significant embankments in areas of shallow groundwater and compressible materials.

Sections of the Project alignment directly intersect moderate to high salinity hazard rating areas (refer Figure 13.4).

Details of potential impact from the Project to the overall salinity hazard and actions for mitigation are in Chapter 9: Land resources.

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



Map by: CS/RB/GN/DTH/NCW Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201908191155_WQ_100pc\330-EAP-201908191155_Fig13.4_ARTC_Salinity_Rev3.mxd Date: 17/03/2020 10:10

13.6.3 Surface water quality and existing conditions

13.6.3.1 Summary of field and laboratory assessed surface water quality data

Across the three sampling events, pH values within both the Lockyer Creek (9 sampling events) and Bremer River (3 sampling events) catchment assessment sites varied between meeting WQOs and exceeding WQOs (refer Table 13.11, Table 13.12 and Table 13.13). Due to the presence of low-flow conditions throughout the majority of the water sampling events, the observed pH values were considered typical of the prevailing environmental conditions.

Turbidity values were typically above threshold levels for most of the assessed waterways (refer Table 13.11). Most water sampling was conducted during the first round of sampling (October 2017) and turbidity values were typically low (in association with limited flow at sites of collection), while still exceeding threshold levels. Within the first round of sampling (October 2017), exceedances were noted in waterways associated with the Lockyer Creek and Bremer River catchments. Due to limited flow conditions during the second round of sampling (March 2018), a limited number of waterways were sampled; however, turbidity values indicated potential overland sedimentation movement and potential liberation of sediment within these waterways. Within the third round of sampling (March 2019), turbidity values were typically elevated in pooled samples.

Electrical conductivity levels during all sampling events were mostly elevated but are not considered to be atypical, given the low-flow conditions experienced during the water sampling events, and historic data from gauging stations. Notably, electrical conductivity values were significantly outside WQOs and suggest limited assimilative capacity of the environment to further salinity impact, specifically with low-flow conditions (refer Table 13.11).

In line with other physico-chemical parameters, dissolved oxygen concentrations within the waterways demonstrated the disparity in flow conditions, with a high number of sites not meeting WQOs (within both the Lockyer Creek and Bremer River catchments) (refer Table 13.11). Within the water quality monitoring data, optimal dissolved oxygen concentrations that met WQO were observed in two separate water quality sampling sites and events.

Additionally, chlorophyll *a* concentrations typically failed to meet WQOs for both the Lockyer Creek and Bremer River catchment waterways (refer Table 13.12). The heightened chlorophyll *a* concentration coincided with low-flow conditions, suspended solids and elevated nutrient concentrations (specifically heightened phosphate, total nitrogen and organic nitrogen concentrations), which may contribute to an increase in phytoplankton biomass within the waterways.

In line with the Healthy Waterways (Healthy Land and Water, 2020) assessment of both catchments, the waterways assessed within the water quality study area contained indicators of anthropogenic degradation, noting that assessments were made during periods of low-flow (i.e. outside of first flush conditions) and the corresponding physico-chemical conditions within the catchment (refer Table 13.11 and Table 13.12). Specifically, with the exception of site 17A, nutrient concentrations (of either Total P, Total N or Ammonia) did not meet WQOs for the Lockyer Creek catchment while the Bremer River catchment sites did not exhibit the same level of elevated nutrients (as Total P, ammonia, nitrate, nitrite, organic nitrogen and total nitrogen). Elevated nutrients were only observed at site. Noting this, existing conditions (low-flow conditions) are likely to have facilitated higher TN and organic nitrogen levels and are not explicitly considered outside of WQO guidelines.

Four WQO exceedances in dissolved metal concentrations were noted within the water quality study area (refer Table 13.13). Minor WQO exceedances were observed in dissolved copper concentrations, while below levels required for physiological impact on aquatic organisms were observed at site 2A and site 13A and additional minor WQO exceedances in zinc were observed in site 4A and site 14A. Laboratory analysis of PAH concentrations at all sites were below detection limits, indicating no continued point-source contamination of sampled sites, although it is recognised that these compounds are volatile and may not be very persistent in the environment. Dissolved metals and PAH concentrations typically adhered to the water quality objective for both the Lockyer Creek and Bremer River catchments, indicating limited contamination or naturally elevated concentrations from surrounding land use. Noting this, only the water column was assessed and the absence of anoxic conditions, and high nutrient concentrations within the waterways, have the potential to mask specific dissolved metal concentrations. As noted previously, the results obtained are specific to low-flow conditions.

From the three rounds of sampling at the 12 sites, it is evident that current conditions within Project waterways do not currently meet WQOs during low-flow conditions, principally for electrical conductivity, chlorophyll *a*, turbidity (and associated total suspended solids), nitrogen species and phosphorus for the Lockyer Creek and Bremer River catchment. There was evidence of potentially anthropogenic impact on nutrient concentrations and sub-optimal physico-chemical conditions were present across the water quality study area.

13.6.3.2 Field-assessed water quality results

The in-situ water quality results for the field assessed assessments are in Table 13.11.

TABLE 13.11: FIELD-ASSESSED WATER QUALITY DATA MEASURED IN SITU FOR WATER QUALITY MONITORING SITES

Site	Date	pH	EC	Temperature	Turbidity	Salinity	Dissolved oxygen	Dissolved oxygen
		-	(µscm^{-1})	(°C)	(NTU)	(ppt)	(mgL^{-1})	(%)
Lockyer Creek catchment								
Lockyer Creek WQO	-	6.5–8.0	< 520	n/a	< 6	n/a	n/a	85–110
H2C 2A Un-named	11/10/2017	Dry at time of sampling						
	01/03/2018	7.39	3,600	32.8	5.4	2.08	4.8	69.3
	11/03/2019	Dry at time of sampling						
H2C 3A Lockyer Creek	12/10/2017	7.52	870	24.3	0.2	7.44	3.32	41.5
	01/03/2018	Dry at time of sampling						
	12/03/2019	9.21	1,065	29.4	13.5	0.48	15.55	205.4
H2C 4A Lockyer Creek	09/10/2017	7.5	510	23.9	2.7	1.04	4.56	54
	01/03/2018	Dry at time of sampling						
	12/03/2019	8.94	866	29.2	62	0.39	13.54	176.6
H2C 7A Un-named	11/10/2017	7.0	740	22.9	6.6	1.54	2.35	27.0
	02/03/2018	Dry at time of sampling						
	12/03/2019	No access at time of sample						
H2C 11A Lockyer Creek	09/10/2017	9.32	1,400	26.7	46.1	1.24	9.61	120.8
	01/03/2018	8.44	1,100	24.7	53.5	0.65	5.1	61.4
	11/03/2019	Dry at time of sampling						
H2C 12A Lockyer Creek	10/10/2017	8.33	970	24.7	33.8	1.56	6.35	76.0
	01/03/2018	Dry at time of sampling						
	12/03/2019	Dry at time of sampling						
H2C 13A Laidley Creek	13/10/2017	Dry at time of sampling						
	02/03/2018	7.96	310	25.2	24	0.16	5.15	63
	12/03/2019	Dry at time of sampling						
H2C 14A Laidley Creek	13/10/2017	Dry at time of sampling						
	02/03/2018	8.14	300	24.7	19.7	0.16	4.9	60
	12/03/2019	Dry at time of sampling						
H2C 17A Laidley Creek	13/01/2017	7.62	850	23.5	0.1	5.86	3.02	32.5
	02/03/2018	8.05	340	25.1	13.7	0.18	7.32	86.5
	12/03/2019	Dry at time of sampling						

Site	Date	pH -	EC (µscm-1)	Temperature (°C)	Turbidity (NTU)	Salinity (ppt)	Dissolved oxygen (mgL-1)	Dissolved oxygen (%)
Bremer River catchment								
Western Creek WQO	-	6.5–8.0	< 770	n/a	< 17	n/a	n/a	85–110
H2C 9A Western Creek	11/10/2017	7.52	2,200	21.9	6.6	2.03	0	0.2
	01/03/2018	Dry at time of sampling						
	12/03/2019	Dry at time of sampling						
H2C 10A Western Creek	11/10/2017	7.62	3,800	21.2	6.7	6.95	0.90	11.8
	01/03/2018	Dry at time of sampling						
	12/03/2019	Dry at time of sampling						
H2C 18A Western Creek	13/10/2017	7.45	2,300	23.2	2.0	6.89	3.03	37.0
	01/03/2018	Dry at time of sampling						
	12/03/2019	6.43	3,381	28.9	13.7	1.63	6.45	85.1

Source: WQOs from DERM, 2010a, DERM, 2010b

Table notes:
Results based on the locations of water sampling identified in Figure 13.1.
Highlighted colour where value is above WQO or outside WQO range where applicable.
1 Saturation of dissolved oxygen *in situ*.
°C Degrees Celsius.
ppt parts per thousand.

13.6.3.3 Laboratory-assessed water quality results

The summary of laboratory results for the water quality sampling events are in Table 13.12 and Table 13.13.

TABLE 13.12: LABORATORY RESULTS FROM WATER QUALITY MONITORING SITES FOR THE WATER QUALITY MONITORING SITES

Site	Date	pH	Chlorophyll *a*	Total Phosphorus	Suspended solids	Filtered Reactive Phosphorus	Turbidity	Ammonia	Nitrate	Nitrite	Organic nitrogen)	Total kjeldahl nitrogen	Total nitrogen
		-	(mgL^{-1})	(mgL^{-1})	(mgL^{-1})	(mgL^{-1})	(NTU)	(mgL^{-1})	(mgL^{-1})	(mgL^{-1})	(mgL^{-1})	(mgL^{-1})	(mgL^{-1})
Lockyer Creek catchment													
Lockyer Creek WQO	-	6.5–8.0	< 5	< 0.03	<6	<0.015	<5	< 0.01	-	-	< 0.2	-	< 0.25
H2C 2A Un-named	11/10/2017	Dry at time of sampling											
	01/03/2018	7.9	< 5	0.32	2.8	0.13	1.7	0.03	37	0.34	1.9	1.9	43
	11/03/2019	Dry at time of sampling											
H2C 3A Lockyer Creek	12/10/2017	8.3	< 10	< 0.05	1.6	<0.05	< 1	0.03	< 0.02	<0.02	0.3	0.3	0.3
	01/03/2018	Dry at time of sampling											
	12/03/2019	9.1	<5	0.06	11	0.05	2.9	0.18	<0.02	<0.02	0.7	0.9	0.88
H2C 4A Lockyer Creek	09/10/2017	8.1	< 10	0.10	< 1	0.1	2.3	0.13	0.43	0.04	< 0.2	0.2	0.7
	01/03/2018	Dry at time of sampling											
	12/03/2019	8.7	6.4	0.10	67	0.01	42	<0.01	<0.02	<0.02	0.67	0.7	0.67
H2C 7A Un-named	11/10/2017	8.1	< 10	0.13	4.4	0.11	1.7	0.13	0.19	< 0.02	0.5	0.6	0.8
	02/03/2018	Dry at time of sampling											
	12/03/2019	No access at time of sample											
H2C 11A Lockyer Creek	09/10/2017	9.3	< 10	0.10	47	<0.05	36	0.11	< 0.02	< 0.02	0.49	0.6	0.6
	01/03/2018	8.5	29	0.19	53		32	< 0.01	< 0.02	< 0.02	0.7	0.7	0.7
	11/03/2019	Dry at time of sampling											
H2C 12A Lockyer Creek	10/10/2017	8.4	87	0.10	19	<0.05	9.6	<0.01	<0.02	<0.02	0.4	0.4	0.4
	01/03/2018	Dry at time of sampling											
	12/03/2019	Dry at time of sampling											
H2C 13A Laidley Creek	13/10/2017	Dry at time of sampling											
	02/03/2018	8.0	< 5	0.44	13	-	17	0.04	0.13	< 0.02	0.6	0.6	0.74
	12/03/2019	Dry at time of sampling											

Site	Date	pH	Chlorophyll *a*	Total Phosphorus	Suspended solids	Filtered Reactive Phosphorus	Turbidity	Ammonia	Nitrate	Nitrite	Organic nitrogen)	Total kjeldahl nitrogen	Total nitrogen
		-	(mgL⁻¹)	(mgL⁻¹)	(mgL⁻¹)	(mgL⁻¹)	(NTU)	(mgL⁻¹)	(mgL⁻¹)	(mgL⁻¹)	(mgL⁻¹)	(mgL⁻¹)	(mgL⁻¹)
H2C 14A Laidley Creek	13/10/2017	Dry at time of sampling											
	02/03/2018	8.1	< 5	0.40	11	-	14	0.02	0.20	< 0.02	0.5	0.5	0.72
	12/03/2019	Dry at time of sampling											
H2C 17A Laidley Creek	11/10/2017	8.2	< 10	0.27	7.0	0.21	2.1	0.02	0.03	< 0.02	0.3	0.3	0.3
	02/03/2018	8.3	6.0	0.39	21	-	8.4	0.02	0.16	0.03	0.3	0.3	0.49
	12/03/2019	Dry at time of sampling											
Bremer River catchment													
Western Creek WQO	-	6.5–8.0	<17	< 0.05	<6	<0.02	< 17	< 0.02	-	-	< 0.42	-	<0.5
H2C 9A Western Creek	11/10/2017	8.2	< 10	0.15	11	<0.05	4.8	< 0.01	0.03	< 0.02	0.2	0.2	0.2
	01/03/2018	Dry at time of sampling											
	12/03/2019	Dry at time of sampling											
H2C 10A Western Creek	11/10/2017	8.4	< 5	0.06	7.2	<0.05	3.3	< 0.01	0.05	<0.02	0.4	0.4	0.4
	01/03/2018	Dry at time of sampling											
	12/03/2019	Dry at time of sampling											
H2C 18A Western Creek	11/10/2017	8.1	< 5	0.05	2.5	<0.05	2.6	0.02	< 0.02	< 0.02	0.6	0.6	0.6
	01/03/2018	Dry at time of sampling											
	12/03/2019	6.3	18	0.01	21	0.01	18	0.2	<0.02	<0.02	1.3	1.3	1.3

Source: WQOs from DERM, 2010a, DERM 2010b

Table note:
Highlighted colour where value is above WQO or outside WQO range where applicable.

TABLE 13.13: DISSOLVED METAL AND INDICATIVE PAH LABORATORY RESULTS FOR WATER QUALITY MONITORING SITES

Site	Date	Arsenic (III) (mgL-1)	Cadmium (mgL-1)	Chromium (VI)) (mgL-1)	Copper (mgL-1)	Lead (mgL-1)	Mercury (mgL-1)	Nickel (mgL-1)	Zinc (mgL-1)	Naphthalene (PAH) (mgL-1)
LoR	-	0.001	0.0002	0.001	0.001	0.001	0.0001	0.001	0.005	0.001
Lockyer Creek catchment										
Lockyer Creek WQO	-	0.024	0.0002	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016
H2C 2A Un-named	11/10/2017	Dry at time of sampling								
	01/03/2018	<0.001	<0.0002	<0.001	0.004	<0.001	<0.0001	0.006	<0.005	<0.001
	11/03/2019	Dry at time of sampling								
H2C 3A Lockyer Creek	11/10/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
	01/03/2018	Dry at time of sampling								
	12/03/2019	0.002	<0.0002	<0.001	0.002	<0.001	<0.0001	0.001	0.005	<0.001
H2C 4A Lockyer Creek	09/10/2017	<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.002	0.011	<0.001
	01/03/2018	Dry at time of sampling								
	12/03/2019	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
H2C 7A Un-named	11/10/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.003	<0.005	<0.001
	02/03/2018	Dry at time of sampling								
	12/03/2019	No access at time of sample								
H2C 11A Lockyer Creek	09/10/2017	0.002	<0.0002	<0.001	0.001	<0.001	<0.0001	0.003	<0.005	<0.001
	01/03/2018	0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
	11/03/2019	Dry at time of sampling								
H2C 12A Lockyer Creek	10/10/2017	<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.005	<0.005	<0.001
	01/03/2018	Dry at time of sampling								
	12/03/2019	Dry at time of sampling								
H2C 13A Laidley Creek	13/10/2017	Dry at time of sampling								
	02/03/2018	<0.001	<0.0002	<0.001	0.003	<0.001	<0.0001	0.006	<0.005	<0.001
	12/03/2019	Dry at time of sampling								

Site	Date	Arsenic (III) (mgL⁻¹)	Cadmium (mgL⁻¹)	Chromium (VI)) (mgL⁻¹)	Copper (mgL⁻¹)	Lead (mgL⁻¹)	Mercury (mgL⁻¹)	Nickel (mgL⁻¹)	Zinc (mgL⁻¹)	Naphthalene (PAH) (mgL⁻¹)
H2C 14A Laidley Creek	13/10/2017	Dry at time of sampling								
	02/03/2018	<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.002	0.012	<0.001
	12/03/2019	Dry at time of sampling								
H2C 17A Laidley Creek	11/10/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
	02/03/2018	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.001	<0.005	<0.001
	12/03/2019	Dry at time of sampling								
Bremer River catchment										
Bremer - Western Creek	-	0.024	0.0055	0.0004	0.0014	0.0034	0.0006	0.011	0.008	0.016
H2C 9A Western Creek	11/10/2017	0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	01/03/2018	Dry at time of sampling								
	12/03/2019	Dry at time of sampling								
H2C 10A Western Creek	11/10/2017	<0.001	<0.002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
	01/03/2018	Dry at time of sampling								
	12/03/2019	Dry at time of sampling								
H2C 18A Western Creek	11/10/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
	01/03/2018	Dry at time of sampling								
	12/03/2019	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.004	<0.005	<0.001

Source: WQOs from ANZECC/ARMCANZ (2000/2018)

Table note: LoR = limit of laboratory reporting.

13.6.3.4 Summary of existing surface water quality condition

On comparison with historical water quality data for Lockyer Creek, Laidley Creek and Purga Creek (refer Appendix L: Surface Water Quality Technical Report), which are considered representative of the water quality study area, water quality values measured during the three sampling rounds typically followed those of the gauging stations. Water quality was typically outside of WQOs with total suspended solids (TSS) exceeding WQOs historically and within the current assessment. Total nitrogen and total phosphorous as atypical anthropogenic contaminant also followed historical data with WQO exceedance noted throughout for each round of sampling.

While WQOs generally do not meet historical mean values, results from the three sampling rounds conducted for the EIS suggest that compliance with WQOs is influenced by highly seasonal flow conditions. At the regional gauging stations, the majority of the quantified water quality parameters (i.e. TSS, ammonia, total nitrogen and total phosphorus) did not meet WQOs. The gauging stations indicate the discharges along Lockyer Creek, Laidley Creek and Purga Creek were highly variable and that the low-flow conditions experienced across periods of the monitoring period are not atypical. Water quality (specifically physico-chemical parameters and laboratory analysed data) was observed to improve with an increase with hydrological flow and the assimilative capacity would be expected to be greatest during high flow conditions.

Moderate Aquascore[1] riverine wetlands have been modelled along the Project alignment and correspond to the healthy water assessment of each catchment. The assessment indicates typical processes are 'good' with poor riparian condition throughout the catchment. While exceedances of WQO were noted within particular parameters throughout the entire assessment period, water quality is generally considered to be meeting broad WQOs (including metals and PAH analysis).

Habitat conditions during assessment were not considered atypical (in terms of periods of low surface hydrological flow); however, clear impacts of diminished flow conditions were noted. In regard to the field assessment, water quality parameters improved with a higher surface hydrological flow during the second sample round (March 2018) , where water persisted, and decreased during the third sample round (March 2019).

13.6.3.5 Surface water quality receptors

A receptor is a feature (including utilisation by human and ecological components), area or structure that may be affected by direct or indirect changes to the environment. The water quality receptors were assessed against relevant legislation (refer Section 13.4) and the overarching ecological values used to assess potential impacts, which included:

- Queensland's natural environment (including utilisation by native flora and fauna)
- Finite natural resources, with specific regard to wetlands
- Watercourses conducive to the maintenance of existing land forms, ecological health and biodiversity.

Due to the interconnected nature of the watercourses intersecting the Project alignment, and residing within the greater water quality study area, the water quality receptors for the existing environment (as a whole of package) were assigned a sensitivity based on several factors:

- Protection by State legislation (with acknowledgement of potential habitat for MNES species)
- Important for biodiversity
- Existing moderate sensitivity, high exposure to impacts (as per *EPP (Water and Wetland Biodiversity)*) categorisation).

To maintain a conservative approach to assessment, all waterways within the water quality study area were nominated as moderate sensitivity water quality receptors (due to their classification of disturbance under *EPP (Water and Wetland Biodiversity)*). The moderate sensitivity was used a general indicator to assess potential impacts, associated mitigation measures and identification of residual impact after implementation of mitigation.

Due to the presence of the MNES species, Mary River Cod (*Maccullochella mariensis*) and Australian Lungfish (*Neoceratodus forsteri*) and two MSES wetlands within the Lower Lockyer Creek sub-catchment and Western Creek sub-catchment, respectively, both sub-catchments were identified as high sensitivity water quality receptors. Therefore, the defined watercourses of Upper Lockyer Creek and Western Creek sub-catchments: Lockyer Creek and Western Creek are identified as highly sensitive water quality receptors.

1. The Aquascore is the overall conservation value of a wetland unit based on eight separate criteria, based on DES recommended measures and indicators.

13.6.4 Existing floodplain infrastructure

Key existing infrastructure on floodplain areas near the Project alignment includes:

- Burgess Road
- Smithfield Road
- Old College Road
- Dodt Road
- Hunt Street
- Old Laidley Forest Hill Road
- Laidley Plainland Road
- Grandchester Mount Mort Road
- West Moreton System rail corridor
- Levees and dams used for farming practices.

The Project connects into the West Moreton System rail corridor, which is operated by QR. The West Moreton System rail corridor crosses several creeks including:

- Lockyer Creek at Gatton
- Sandy Creek at Forest Hill
- Laidley Creek near Laidley.

The West Moreton System rail corridor also runs parallel to Western Creek between Grandchester to Calvert with multiple crossing locations. Under a 1% AEP event, the Queensland Rail (QR) rail line is inundated at several locations including near Gatton, Forest Hill and Calvert, with further details in Section 13.6.5.2.

Burgess Road, Smithfield Road and Old College Road are located near the existing Gatton West Moreton System rail corridor bridge. Smithfield Road and Old College Road are elevated compared to the surrounding floodplain areas and only start to be impacted by flooding under the 2% AEP event. Burgess Road starts experiencing flood inundation under the 1% AEP event.

Dodt Road runs parallel to the West Moreton System rail corridor on its southern side. Dodt Road traverses a number of low lying areas and is prone to overtopping under events as frequent as the 20% AEP event. Dodt Road is a primary evacuation route for a number of local rural residencies.

Hunt Street forms a level crossing with the West Moreton System rail corridor in Forest Hill. This level crossing has up to 1% AEP flood immunity; however, the West Moreton System rail corridor is overtopped to the east of the level crossing.

Old Laidley Forest Hill Road is located in Laidley North and runs north-west from its intersection to Laidley Plainland Road. Old Laidley Forest Hill Road is inundated by frequent flood events while Laidley Plainland Road has 1% AEP event flood immunity.

Grandchester Mount Mort Road crosses Western Creek in Grandchester. To the south of Western Creek this road is low-level and is inundated by overbank flow during frequent flood events.

Waters Road runs parallel to the West Moreton System rail corridor as it nears Calvert. This road is low-level and is inundated during frequent flood events.

13.6.5 Existing flooding regime

Flooding in the vicinity of the Project occurs through two mechanisms, or a combination of both mechanisms, being:

- Rainfall over the waterway catchment areas upstream of the Project alignment
- Backwater from downstream major systems, e.g. Western Creek is affected by flooding in the Bremer River system.

In addition to the major waterways there are several small local drainage catchments that are intersected by the Project alignment.

Available data and previous studies were collected and reviewed to support the development and calibration of the hydrologic and hydraulic models for the Project. For Lockyer Creek and its tributaries (including Sandy Creek and Laidley Creek), and Western Creek (a tributary of Bremer River), the hydrologic modelling developed for the Brisbane River Catchment Flood Study (Aurecon, 2015) was adopted for the Project. Minor modifications were made to the hydrologic models to produce flow estimates at waterway crossings on the Project alignment.

The hydraulic model previously developed for LVRC for the purposes of development control and assessment of flood mitigation options (updated by Jacobs (2016)) was used to assess waterway crossings on the Project alignment between Gatton and Laidley. A localised hydraulic model was developed for Western Creek (tributary of Bremer River) based on available data and previous studies. The extents of each of the hydraulic models are in Figure 13.5.

13.6.5.1 Calibration to historical flood events

Available background information was sourced to support validation of the hydrologic models and calibration of the hydraulic models. Background information included existing models, streamflow data and available anecdotal flood data. This data was sourced from a wide range of stakeholders.

Modelling of each waterway catchment was calibrated against historical events with results matched to recorded data from a number of stream gauges, community feedback as well as anecdotal flood data. Lockyer Creek and its tributaries, and Western Creek (tributary of Bremer River) were calibrated against the 1974, 1996, 1999, 2011 and 2013 historical flood events.

The historical events were selected to represent a range of event magnitudes and durations. A good calibration was achieved for all catchments and the hydrologic and hydraulic models were considered suitable for assessment of the Project.

The magnitude of each of the historical events has been estimated at each of the major stream gauges in the waterway catchments. The estimated AEP of each event is outlined in Table 13.14 and Table 13.15 for the Lockyer Creek and Bremer River catchments respectively.

TABLE 13.14: AEP OF HISTORICAL EVENTS—LOCKYER CREEK CATCHMENT

Stream gauge	Estimated AEP of historical event (%)				
	1974	1996	1999	2011	2013
Gatton Weir	2.4	3.2	21	1.8	29
Gatton	2.4	3.2	21	1.8	29
Glenore Grove	2.5	4	25	1.1	2.5

TABLE 13.15: AEP OF HISTORICAL EVENTS—BREMER RIVER CATCHMENT

Stream gauge	Estimated AEP of historical event (%)				
	1974	1996	1999	2011	2013
Walloon	0.5	10	30	0.6	8

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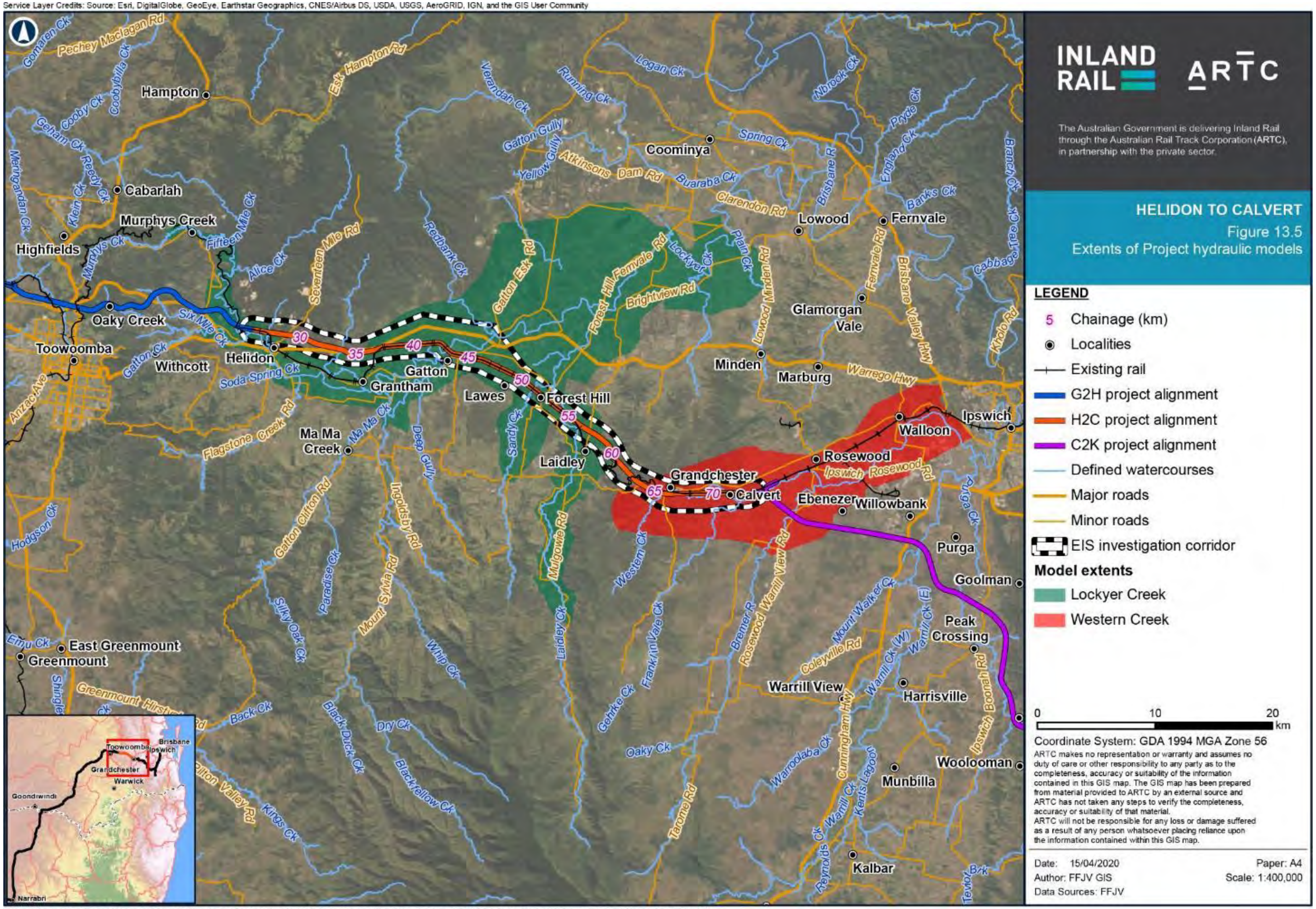

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13.6.5.2 Existing case results

Modelling of the existing case, i.e. current state of development, has been undertaken to provide a base case against which the introduction of the Project alignment and associated drainage structures can be assessed. The Existing Case extent of inundation and peak water levels for the 1% AEP event for the modelled waterways are in Figure 13.16a to Figure 13.16e with 1% AEP event peak velocities in Figure 13.7a to Figure 13.7e. Details of the existing flood regime on each floodplain in the vicinity of the Project alignment are discussed in the following sections.

Helidon to Lawes

Between Helidon and Lawes, Lockyer Creek meanders through and around several key pieces of infrastructure, high-value agricultural land and densely populated communities. Under the 1% AEP event around Gatton, the peak depth of water is approximately 19 m in the Lockyer Creek channel with the inundated floodplain varying between 300 m and 1 km wide. Upstream of Gatton around Grantham and Placid Hills, the floodplain inundation extents are in excess of 1.6 km wide. Directly downstream of the Project alignment, the Lockyer Creek floodplain is significantly wider, with breakout flows running southeast towards Lawes and College View under the 2% AEP event.

While the majority of the West Moreton System rail corridor is above the 1% AEP flood level from Gatton to Lawes, the West Moreton System rail corridor overtops approximately 2.7 km south-east of the Lockyer Creek rail bridge. The West Moreton System rail corridor is inundated over a length of approximately 350 m as shown in Figure 13.16a.

Table 13.16 presents a summary of overtopping depths for key roads and the existing West Moreton System rail corridor near the Project alignment under a range of design events.

TABLE 13.16: HELIDON TO LAWES—EXISTING CASE—OVERTOPPING DEPTHS OF KEY INFRASTRUCTURE

Infrastructure	Location	Approximate overtopping depth (m)				
		1% AEP	2% AEP	5% AEP	10% AEP	20% AEP
Burgess Road	Intersection with proposed alignment	1.32	Dry	Dry	Dry	Dry
Smithfield Road/Old College Road area	Intersection with proposed alignment	1.62	0.69	Dry	Dry	Dry
West Moreton System rail corridor	East of Gatton	0.18	Dry	Dry	Dry	Dry
Dodt Road	West of Forbe Road	2.00	1.67	1.34	1.10	0.64

Peak existing case velocities on floodplain areas are generally low, in the order of 0.5 metres per second (m/s) to 1.0 m/s as shown in Figure 13.7a. Velocities increase in the Lockyer Creek channel with velocities near Project alignment for the 1% AEP event range from 1 m/s to 4 m/s.

Lawes to Laidley

Under the 1% AEP event, the peak water depth in the Sandy Creek channel is between 3 m to 4 m deep and the inundated floodplain is over 1 km wide with the average depth of water on the floodplain varying between 0.5 m upstream of Forest Hill to 1.5 m around the Forest Hill township. The existing West Moreton System rail corridor bisects Sandy Creek and the Forest Hill township. While the majority of the West Moreton System rail corridor is above the 1% AEP flood level in this area, there are two locations where the West Moreton System rail corridor overtops. This occurs close to the town centre around the Hunt Street level crossing and approximately 1.5 km south-east of Hunt Street, where the existing West Moreton System rail corridor is inundated for approximately 100 m and 900 m respectively (refer Figure 13.16b and Figure 13.16c).

Under the 1% AEP event, the peak flood depth in the Laidley Creek channel is between 5 m to 7 m and the inundated floodplain upstream of the existing West Moreton System rail corridor is over 600 m wide with an average depth of approximately 1 m. Complex braiding and breakout flow patterns are prevalent around Mulgowie and continue downstream through Laidley. The existing West Moreton System rail corridor crosses Laidley Creek and runs south-east through Laidley towards the Little Liverpool Range. Old Laidley Forest Hill Road is flood prone and is inundated by Laidley Creek breakout flow, and associated tributary flows, during frequent flood events.

Table 13.17 presents a summary of overtopping depths for key roads and the existing rail in the vicinity of the Project alignment under a range of design events.

TABLE 13.17: FOREST HILL TO LAIDLEY—EXISTING CASE—OVERTOPPING DEPTHS OF KEY INFRASTRUCTURE

		Approximate overtopping depth (m)				
Infrastructure	Location	1% AEP	2% AEP	5% AEP	10% AEP	20% AEP
West Moreton System rail corridor	East of Hunt Street	0.02	Dry	Dry	Dry	Dry
West Moreton System rail corridor	East of Forest Hill	0.07	0.04	Dry	Dry	Dry
Old Laidley Forest Hill Road	Creek crossing west of Laidley Plainland Road	0.72	0.66	0.46	0.37	Dry
Laidley Plainland Road	Junction of Laidley Plainland Road and Hardy Drive	0.14	0.10	Dry	Dry	Dry

Peak Existing Case velocities on the floodplain areas are generally low, in the order of 0.5 m/s to 1.0 m/s as shown in Figure 13.7b and Figure 13.7c. Velocities increase in the creek channels with velocities near the Project alignment for the 1% AEP event in Table 13.18.

TABLE 13.18: FOREST HILL TO LAIDLEY—EXISTING CASE—1% AEP EVENT PEAK VELOCITIES

Waterway	1% AEP existing case peak velocities (m/s)
Sandy Creek/Floodway east of Sandy Creek	1.0 to 4.2
Laidley Creek	1.0 to 2.1

Grandchester to Calvert

Western Creek meanders through and around several key pieces of infrastructure, high-value agricultural land and densely populated communities. Under the 1 % AEP event the peak depth of water is approximately 3 m to 5 m in the Western Creek channel at Grandchester and the inundated floodplain varies between 300 m and 1 km wide. Downstream of Grandchester, the peak water depth under the 1% AEP event ranges from 4 m to 8 m within the Western Creek channel, with the inundated floodplain split either side of the West Moreton System rail corridor.

Between Grandchester and Calvert, the West Moreton System rail corridor overtops around the western end of Neuman Road. The length of West Moreton System rail corridor that is inundated under the 1% AEP event is approximately 300 m as shown in Figure 13.16d and Figure 13.16e.

Table 13.19 presents a summary of overtopping depths for key roads and the existing rail near the Project alignment under a range of design events.

TABLE 13.19: GRANDCHESTER TO CALVERT—EXISTING CASE—OVERTOPPING DEPTHS OF KEY INFRASTRUCTURE

		Approximate overtopping depth (m)				
Infrastructure	Location	1% AEP	2% AEP	5% AEP	10% AEP	20% AEP
Grandchester Mount Mort Road	Between School Road and Western Creek	0.39	0.35	0.30	0.28	0.26
West Moreton System rail corridor	Between Grandchester and Calvert	0.10	0.08	Dry	Dry	Dry
Waters Road	Intersection of Waters Road and Kuss Road*	0.25	0.21	0.15	0.08	0.07

Table note:
* Waters Road runs parallel to Western Creek and is inundated under frequent to larger events over its entire length.

Peak Existing Case velocities on the floodplain areas are generally low, in the order of 0.5 m/s to 1.0 m/s as shown in Figure 13.7d and Figure 13.7e. Velocities increase in the creek channel with velocities near the Project alignment for the 1% AEP event shown in Table 13.20.

TABLE 13.20: WESTERN CREEK—EXISTING CASE—1% AEP EVENT PEAK VELOCITIES

Waterway	1% AEP existing case peak velocities (m/s)
Western Creek (Grandchester)	1.0 to 3.0
Western Creek (Calvert)	1.0 to 4.6

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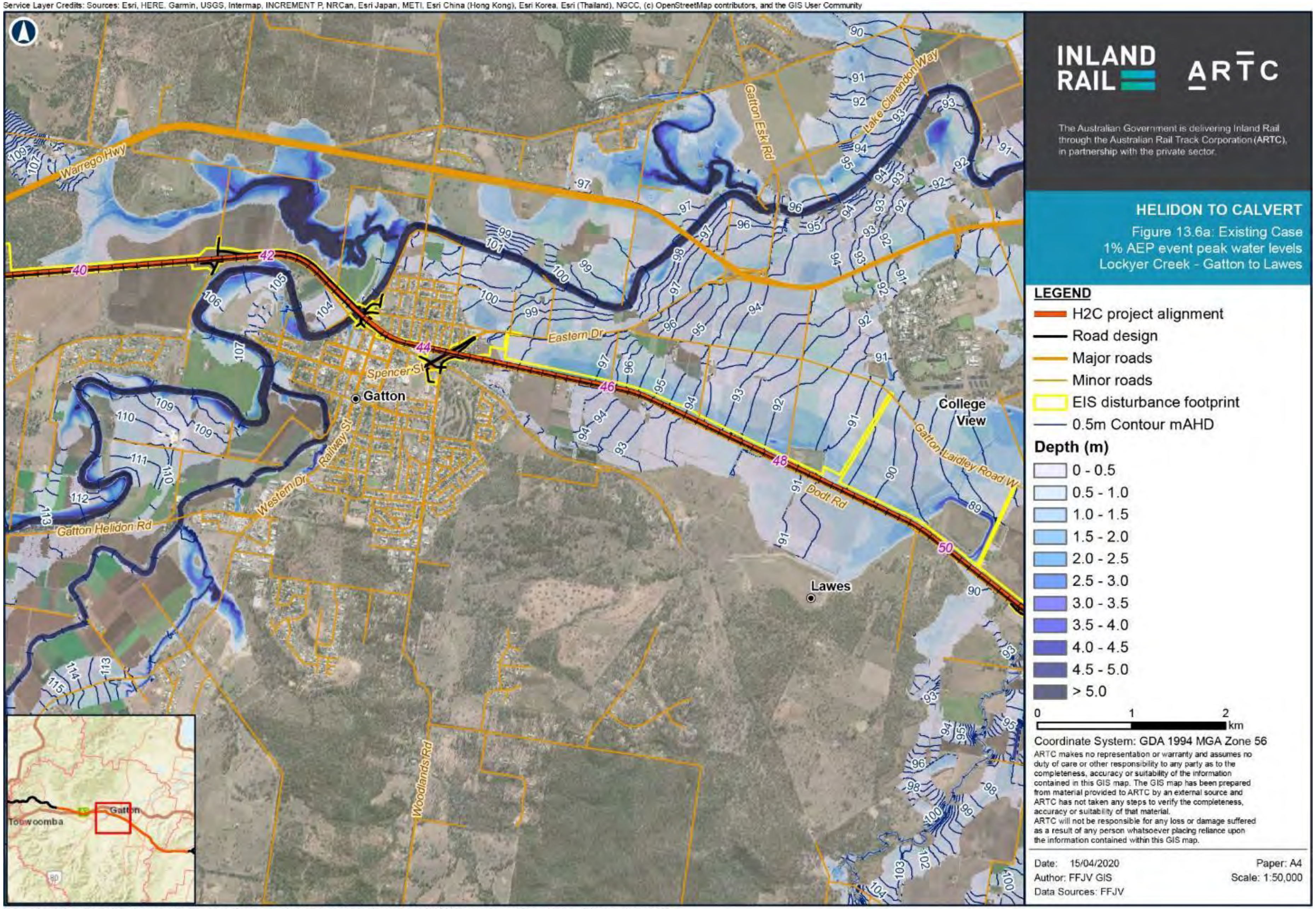

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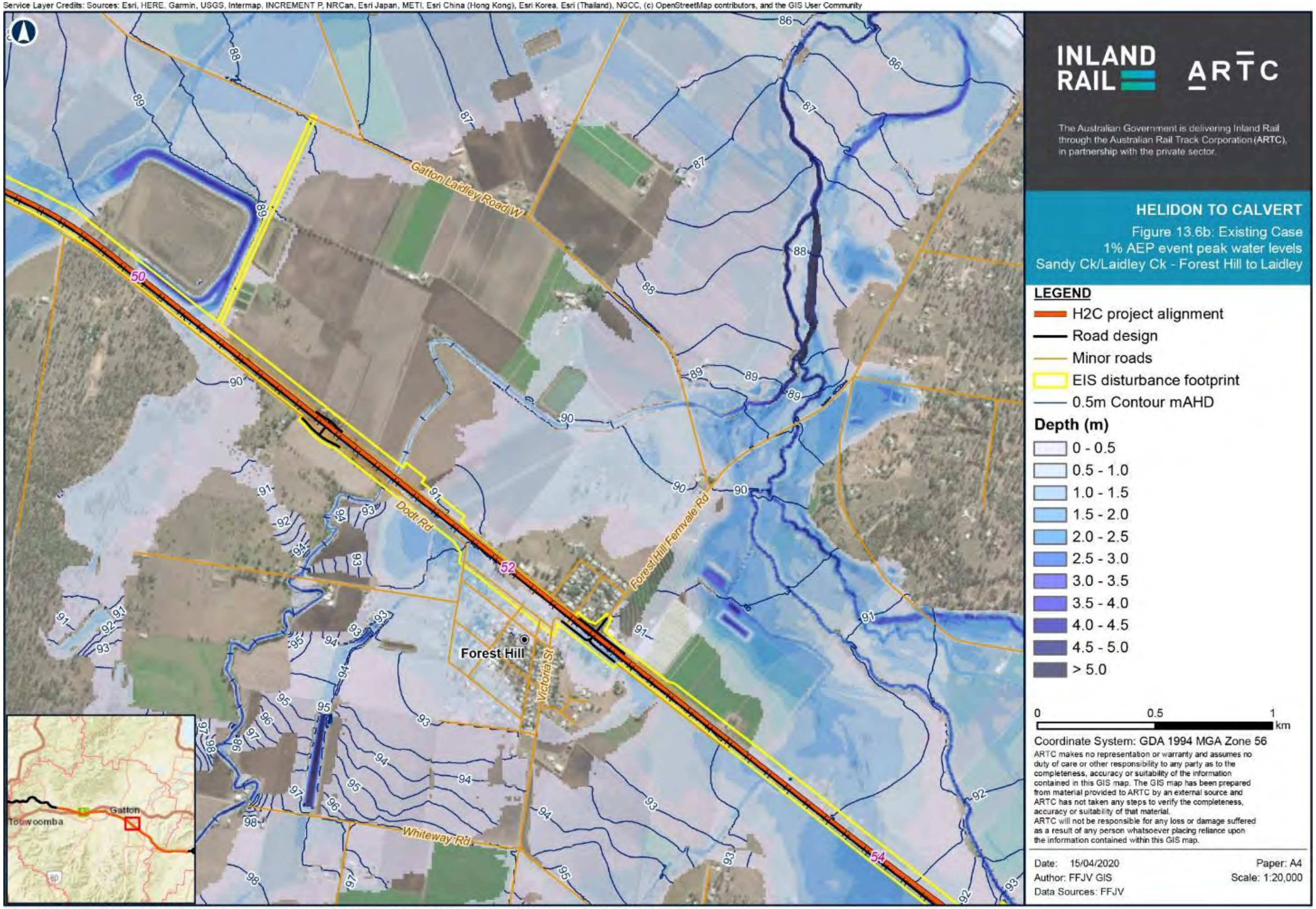

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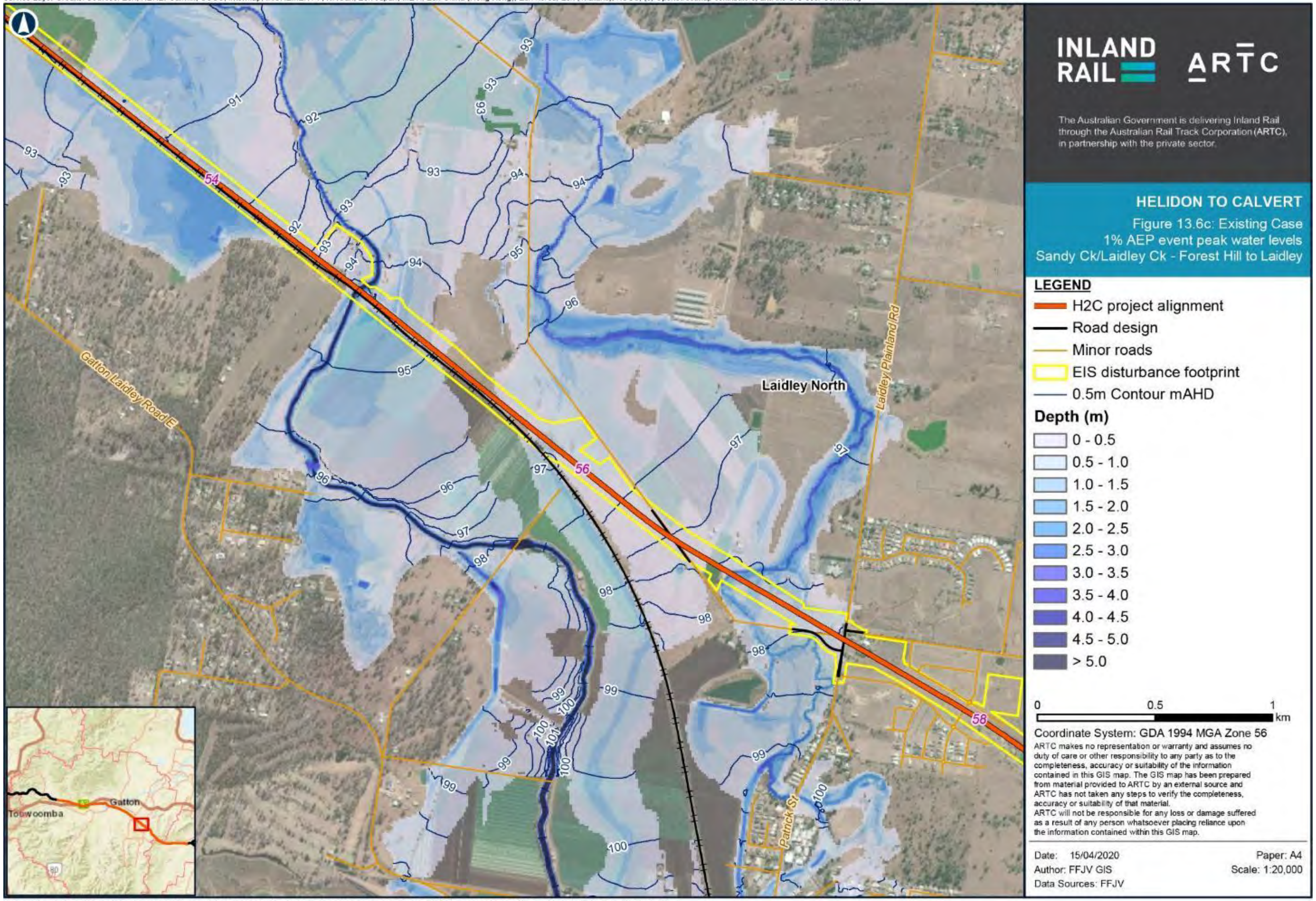

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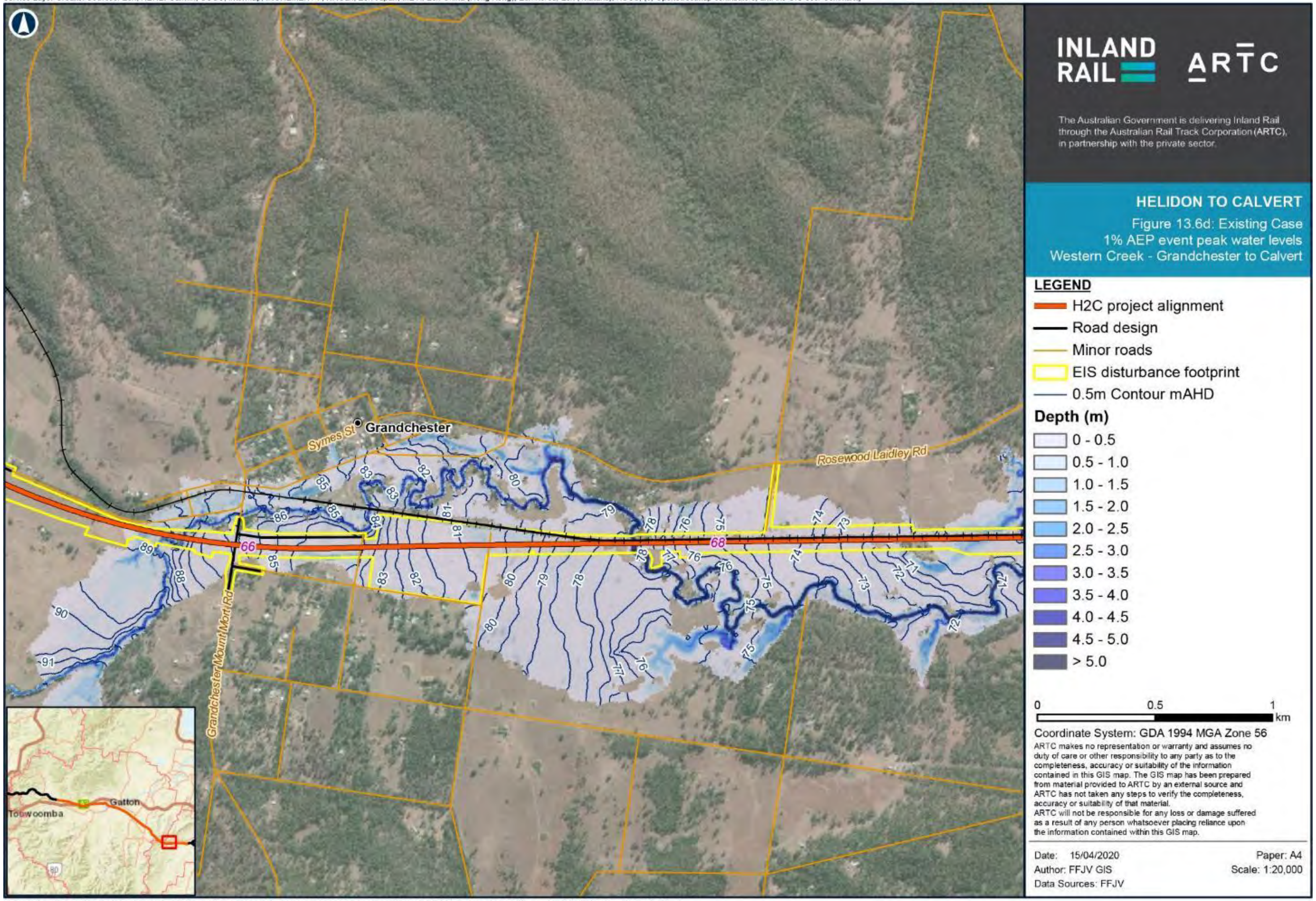

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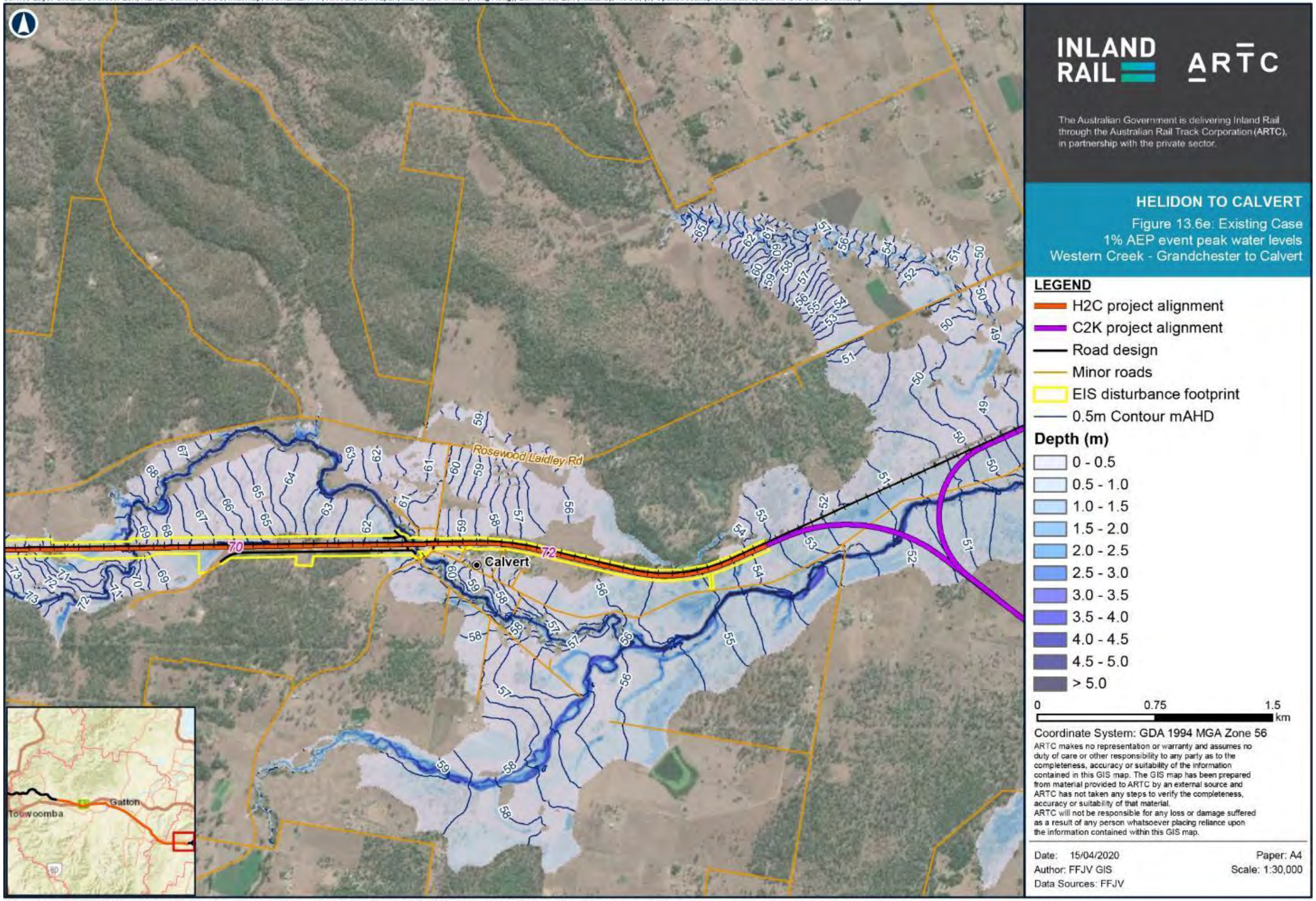

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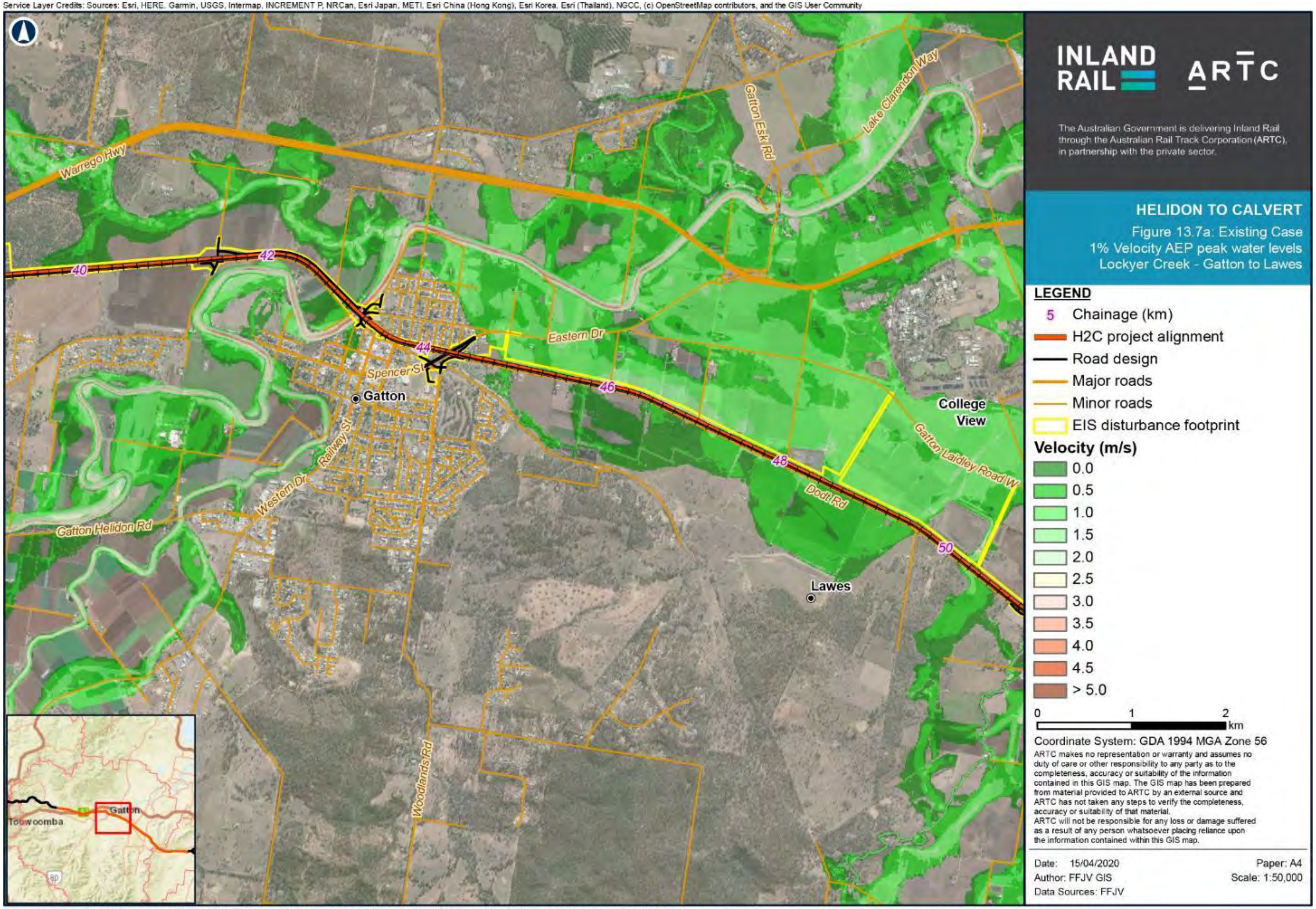

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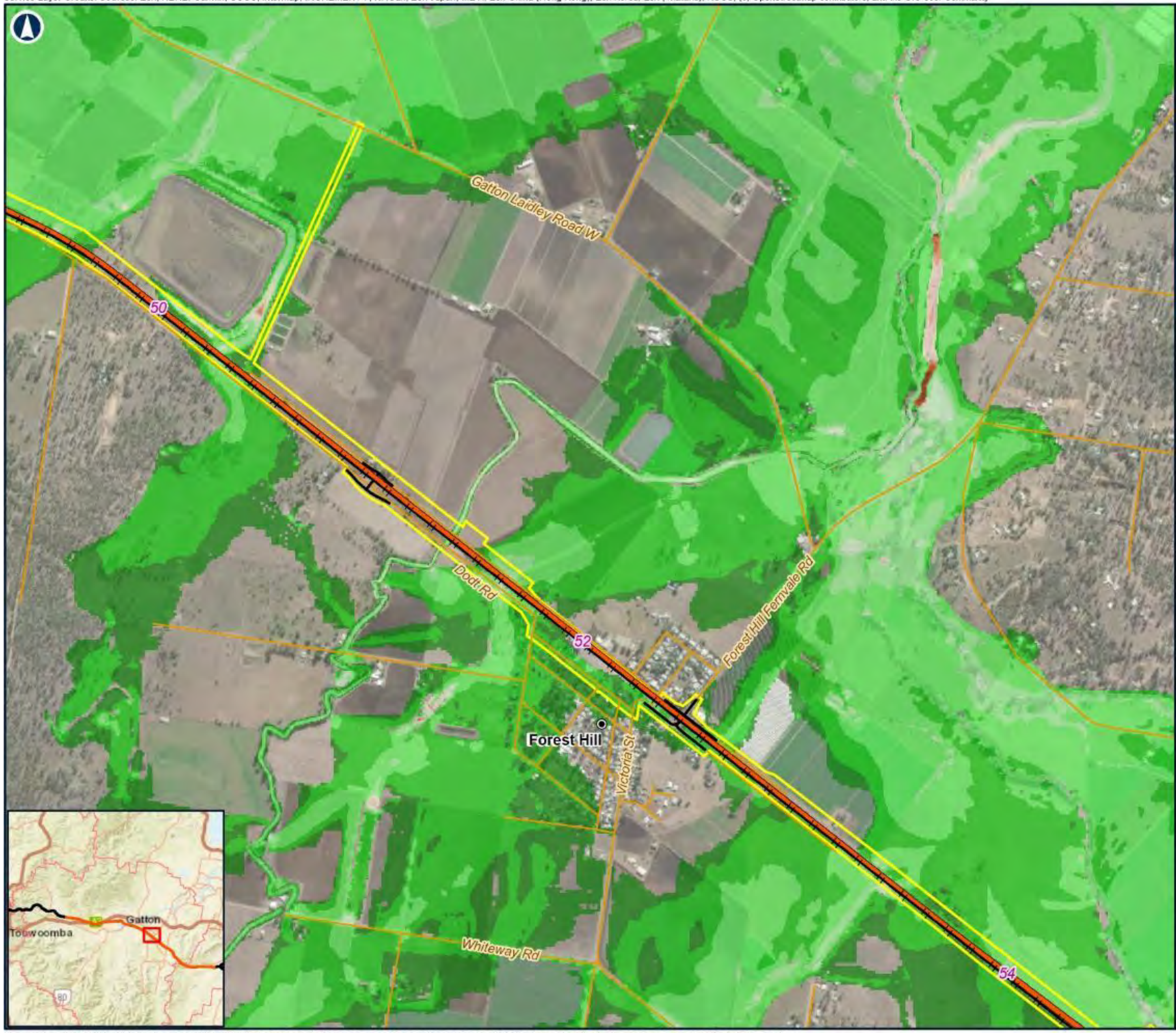

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HELIDON TO CALVERT

Figure 13.7b: Existing Case
1% Velocity AEP peak water levels
Sandy Ck/Laidley Ck - Forest Hill to Laidley

LEGEND

- 5 Chainage (km)
- H2C project alignment
- Road design
- Minor roads
- EIS disturbance footprint

Velocity (m/s)

- 0.0
- 0.5
- 1.0
- 1.5
- 2.0
- 2.5
- 3.0
- 3.5
- 4.0
- 4.5
- > 5.0

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 56

Date: 15/04/2020 Paper: A4
Author: FFJV GIS Scale: 1:20,000
Data Sources: FFJV

Map by: DMcP Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201908191528_H2C_EIS_Surface_Water_figures\330-EAP-201908191528_Fig13.7_Velocity_ARTC_A4.mxd Date: 15/04/2020 17:22

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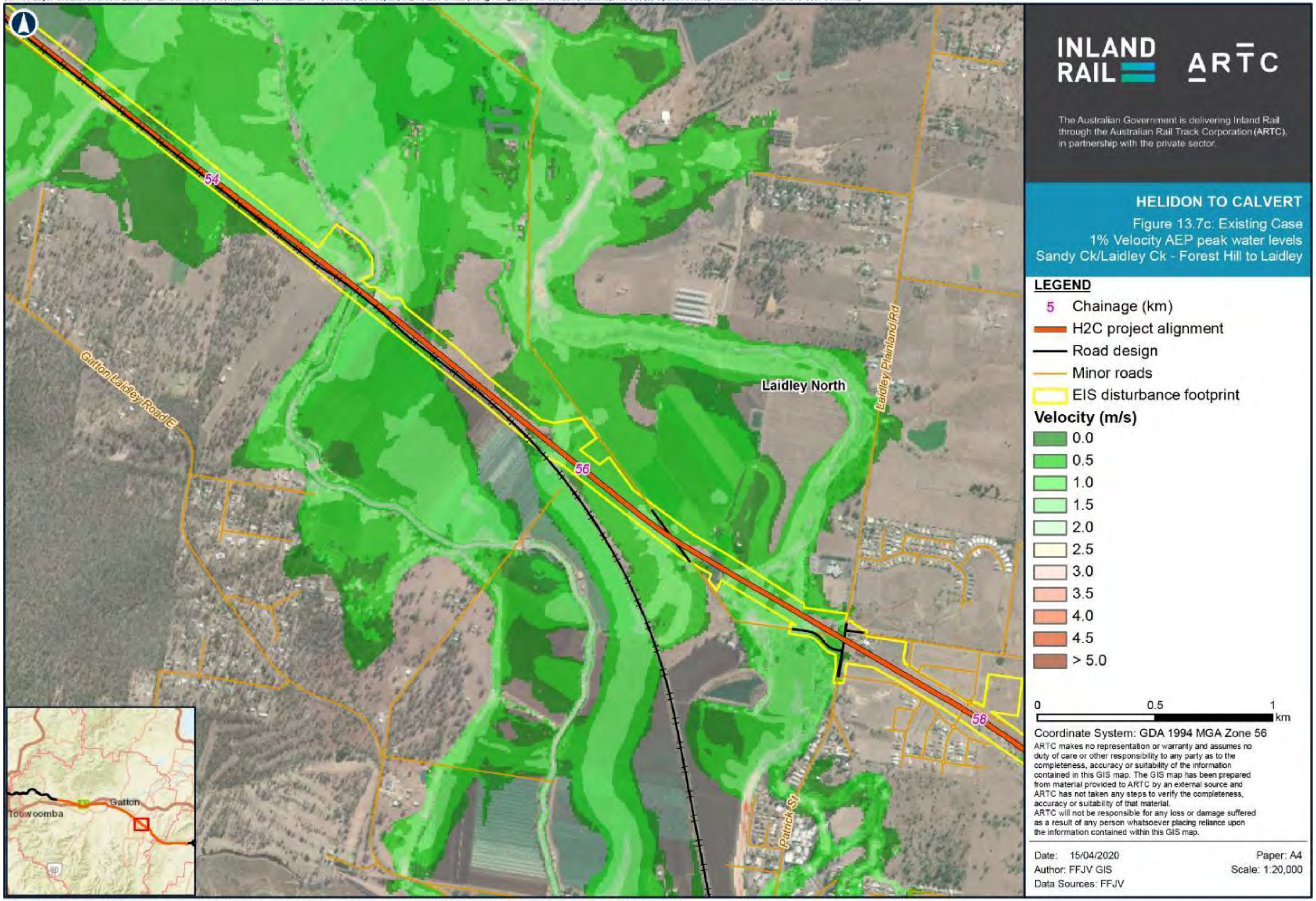

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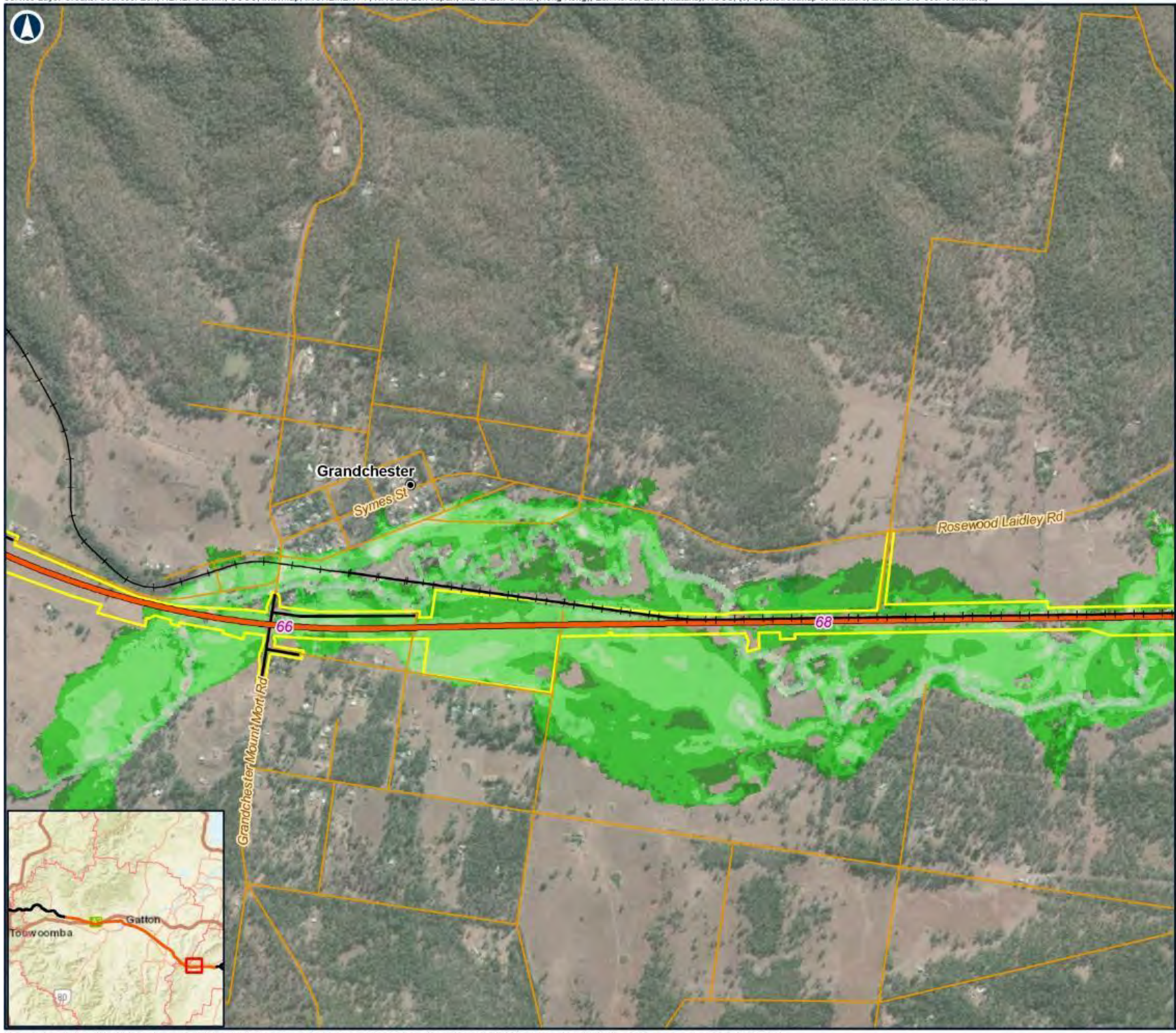

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HELIDON TO CALVERT

Figure 13.7d: Existing Case 1% Velocity AEP peak water levels Western Creek - Grandchester to Calvert

LEGEND

- 5 Chainage (km)
- H2C project alignment
- Road design
- Minor roads
- EIS disturbance footprint

Velocity (m/s)

- 0.0
- 0.5
- 1.0
- 1.5
- 2.0
- 2.5
- 3.0
- 3.5
- 4.0
- 4.5
- > 5.0

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 56

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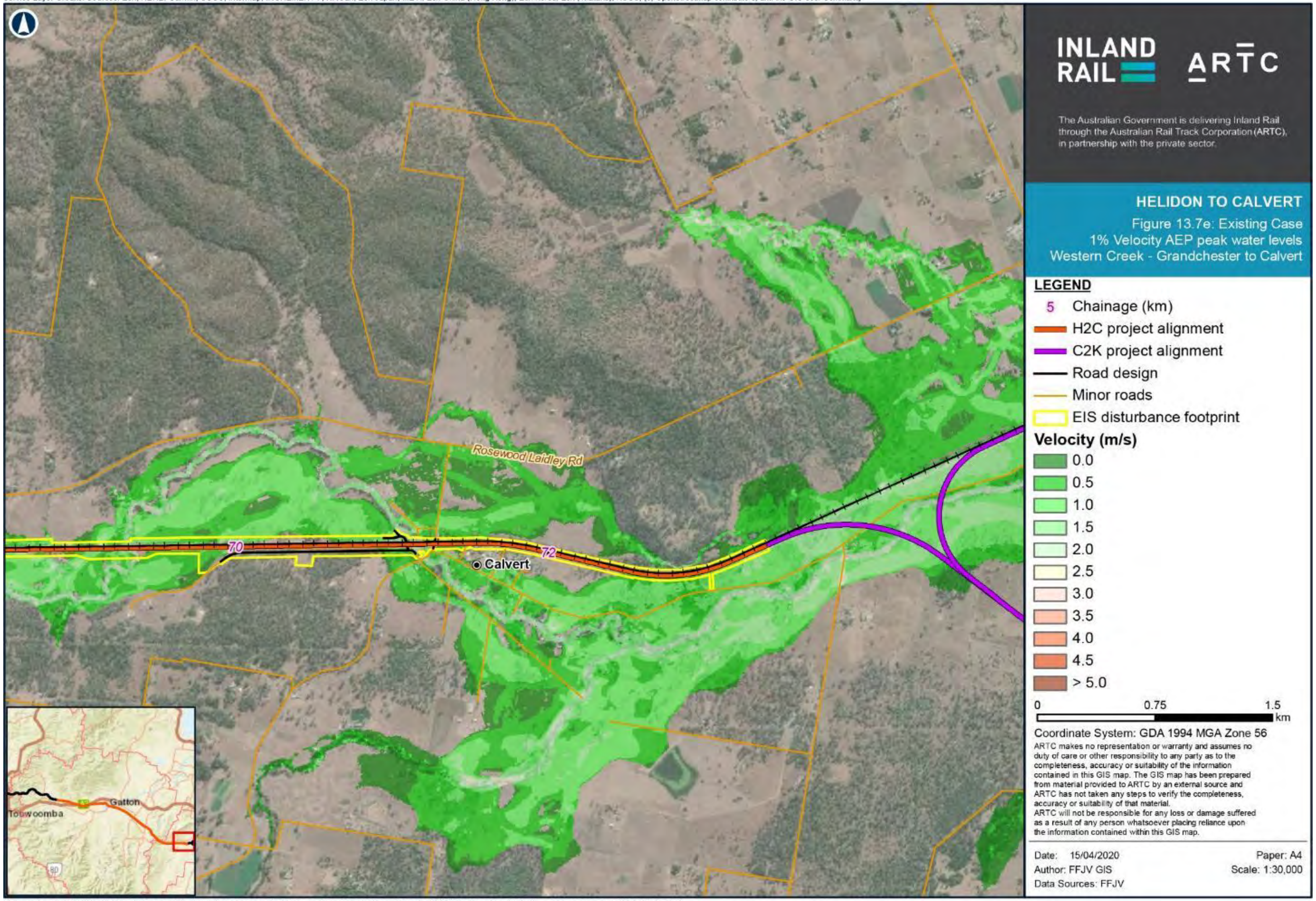

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13.7 Potential impacts

The location and type of the primary infrastructure associated with the Project has been determined through the design process. To have a consistent impact assessment process, a standardised approach has been applied (refer Section 13.5.1.1). Potential Project-related impacts are described in the following sections.

13.7.1 Surface water quality

Surface water quality impacts (refer Section 13.7.1.1 and Section 13.7.1.2) have been identified as potential impacts that will require management to avoid/ minimise with design measures and further in-situ mitigation measures. Potential impacts were assessed with consideration to existing surface water quality condition, sensitivity of water quality receptors—including acknowledgment of downstream impacts and the assimilative capacity of the surrounding catchment.

The assimilative capacity of the receiving environment was considered through historical and existing compliance with existing WQOs and input from the existing surface water environment assessment from a variety of watercourses within both the Bremer River and Lockyer Creek catchments. Currently, the existing environment does not meet all the WQO criteria for each catchment; as such, the assimilative capacity was assessed within qualitative risk of degradation of water quality (against WQO) from potential Project impacts. It is noted that electrical conductivity at high flow significantly decreases and it is considered likely that assimilative capacity of the watercourses within the water quality study area will be higher during higher flow conditions (refer Appendix E and Appendix F within Appendix L: Surface Water Quality Technical Report). In contrast, the lowest assimilative capacity and highest realisation of impact would occur during periods of extended low flow (such as those currently experienced). Noting this, potential impacts from the Project would likely occur with periods of continued rainfall, resulting in higher hydrological flow and greater assimilative capacity in regard to potential impacts.

Within this impact assessment, the total quantity of wastewater (across the disturbance footprint) was not calculated as the quantities are only considered for tunnel wastewater discharge during construction and operational works. Wastewater is considered to fall within two categories: onsite and offsite produced. Onsite wastewater is considered to be produced by the Project and relates to construction and operational phases. Offsite wastewater is considered to be produced from overland flow passing through the disturbance footprint associated with Project (including through longitudinal drainage to cross-drainage infrastructure) with export through drainage away from the site. Onsite wastewater is considered to be contained by the six sediment control basins utilised for construction.

Point source discharge for the Project is anticipated only to occur along cut-and-fill lines. The principal discharges are considered to occur at cross-drainage infrastructure points associated with potential upward seepage from aquifers. Given discharges will be reliant on the water quality and quantity of overland flows at these points, any impacts are likely to be minor.

A long-term inflow of approximately 0.54 L/s has been estimated for the tunnel using the analytical method. Under the scenario of elevated groundwater levels (+ 10 m), the estimated long-term inflow rate increased from 0.54 L/s to 1.30 L/sec for the length of the Little Liverpool Range tunnel (approximately 850 m long). These are considered the principal wastewater discharge from the Project. Risk of water quality impacts was incorporated as part of the impact assessment across several facets, including dewatering of artificial impoundments and overland flow of construction water.

Water quality sensitive receptors within the receiving environment (refer Section 13.6.3.4), which have the potential to be subject to significant impacts, have been identified. These sensitive receptors are considered for the identification of potential impacts, associated mitigation measures and assessment of residual impact after implementation of mitigation. All the waterways within the water quality study area identified as moderate sensitivity water quality receptors. Due to the presence of the MNES species, Mary River Cod (*Maccullochella mariensis*) and Australian Lungfish (*Neoceratodus forsteri*) and two MSES wetlands within the Upper Lockyer Creek sub-catchment and Western Creek sub-catchment, respectively, both sub-catchments were identified as high sensitivity water quality receptors.

13.7.1.1 Construction phase impacts

Construction phase (including pre-construction) activities that are likely to impact the surface water quality are discussed below:

- Increased debris is considered to have the potential to impact all watercourses and waterbodies along the Project disturbance footprint. This is due to conveyance through overland flow pathways to both static waterbodies and flowing watercourses and unmapped waterways. Increased debris and rubbish is considered to have the potential to result in a degradation of surface water quality receptors via both direct and indirect impacts. The potential impact to surface water quality values includes: a reduction in water flow (via mechanical blockages); loss of ecosystem values (via smothering and aquatic ecological value impact); and direct leachate impacts (via the accumulation of rubbish and debris blown off or washed away from a construction area into nearby waterways).

- Changes to receiving surface water quality and hydrology (principally from increased water turbidity and sedimentation load) are considered to result in indirect and direct impacts on surface water quality receptors. Without adequate mitigation measures in place, the indirect potential impact from changes to overland flow pathways and diversions are considered a high risk. Impacts to surface water quality receptors, associated with both flowing watercourses and unmapped waterways, and static waterbodies occurring downstream of the Project works may occur. Indirect surface water quality changes may occur downstream as a result of increased turbidity and sedimentation associated with an increase in mobilisation of sediment-bound metals and other substances. The mobilised substances have an increased potential to directly impact surface water quality values and indirectly impact aquatic ecosystem values. In addition, increased water turbidity and sedimentation may also result in significant changes to localised hydrological regimes, especially in pinch points (such as existing culverts), which may result in smothering of aquatic flora receptors, leading to a direct impact on surface water quality. Alteration of surface water quality and hydrology from increased turbidity and sedimentation load may occur from a variety of Project activities such as:
    - Construction works resulting in elevated sediment concentrations in surface water runoff from inadequate erosion sediment controls
    - Construction works involving disturbance to the riparian corridor may result in erosion and scouring of streambanks
    - Physical disturbance of stream beds and banks leading to a reduction in stability during construction of creek crossings
    - Erosion of cleared riparian areas and inadequate rehabilitation processes
    - Altered hydrological regimes from drainage flow change due to diversions
    - Dewatering works resulting in an increase of sediment loads from dewatering activities near excavations and water quality issues from dewatering activities associated with tunnel infrastructure works. Dewatering associated with decommissioning artificial waterbodies that intersect the Project disturbance footprint may cause an increase in erosion and sedimentation of watercourses and drainage features if dewatering activities are not adequately managed
    - Vegetation clearing, which could leave exposed soils prone to erosion
    - Bank-cutting to re-direct the drainage feature at the western tunnel portal
    - Potential erosion risk associated with soils exposed during topsoil stripping, earthworks, excavation and trenching activities required for infrastructure development
    - Changes to the physical attributes of waterways from removal of buffering vegetation.
- Altered hydrology and subsequent water chemistry changes are considered potential direct and indirect impacts from Project activities. Alteration to the hydrological regime of the Western Creek catchment associated with tunnel dewatering is a potential direct impact on surface water quality receptors through potential changes in wetting and drying regimes. This is considered to indirectly impact surface water quality receptors downstream of the dewatering release through diversion changes to overland flow pathways and through potential changes to aquatic ecological values. Potential surface water quality changes from Project activities are considered a direct impact and have potential to impact all surface water quality receptors associated with the Project. Potential impact is expected to occur from all Project activities associated with potential changes to hydrology, especially those resulting in the liberation of contaminants (typically associated with problematic soils). The direct impact on surface water quality receptors is considered to have a localised indirect impact on aquatic ecological receptors through degradation of water quality parameters. Project activities considered to cause a potential impact on hydrology and water chemistry are:
    - Clearing activities and construction of infrastructure, resulting in changes to habitat form (biotic and abiotic) through alteration of hydrological regime (flow and quality)
    - Accidental spills and leaks of chemicals or fuels from construction equipment or fuel storages, which could introduce chemicals into overland flows
    - Overland flow diversions (i.e. Ch 59.57 km, Ch 61.77 km, Ch 63.44 km, Ch 63.53 km and Ch 64.05 km)
    - Introduction of exotic weed species
    - Increase of sediment loads from dewatering activities near excavations and surface water quality issues from dewatering activities associated with tunnel infrastructure works, including the removal of wastewater from the tunnel during construction and operation. Dewatering associated with decommissioning artificial waterbodies that intersect the Project disturbance footprint may cause an increase in erosion and sedimentation of watercourses and drainage features if dewatering activities are not adequately managed

    - Subsoil exposure within excavations that have the potential to result in the leachate of acid rock drainage from the soil into overland flow
    - The erosion of stockpiled materials, which could lead to increased nutrient concentrations in overland flow
    - Impact to proximal wetlands, with high sensitivity receptor areas associated with Lockyer Creek and Western Creek
    - Dewatering of tunnel infrastructure may result in changes to water quality within Western Creek tributaries due to potential disparity in groundwater discharge from tunnel construction, resulting in potentially high impact to aquatic ecology and surface water quality.
- Increase in salinity at a localised and regional scope are considered potential indirect impacts from the Project activities. Salinity impacts on surface water quality receptors are considered to potentially occur from a variety of Project activities and have the capacity to result in regional impacts derived from point source impacts associated with the Project works. Salinity issues are considered to have a direct impact on surface water quality receptors within the Project disturbance footprint and are further considered to have an indirect impact on ecosystem services (and water quality receptors) downstream of the point source salinity impact. Project activities considered to cause a potential increase in localised and regional salinity are due to:
    - Project alignment directly intersecting moderate to high salinity hazard rating areas potentially resulting in discharge of saline runoff into proximal waterways, particularly within the high salinity hazard rating areas that may occur along the Project alignment
    - Disturbance of saline soils during construction, which may increase salinity pressures in overland flows through identified high risk salinity hazard areas.
- Erosion and sedimentation increases are considered a direct impact from Project activities. These are considered to have a direct impact on surface water quality receptors at a localised scope. At a regional scope after transport downstream from the point source, the impact is considered to be indirect. Transport of sediment and eroded material can be washed off into cleared areas or stockpiled areas during rainfall events. This may increase sediment loads and turbidity within waterways and potentially increase nutrient loads. Direct impact from degradation of surface water quality will be realised from changes to light conditions and loss of ecosystem services due to changes to aquatic flora and fauna structure.

  Project activities considered to potentially increase sedimentation and erosion primary involve:
    - In-stream earthworks leading to changes in surface water quality due to the number of new bridge structures and culverts that will be required for the Project
    - Stockpiling of sediment (e.g. from cut and fill processes), mulch or other materials near waterways has the potential for runoff during rain events and impacts to the water quality of nearby waterways
    - Inappropriate rehabilitation of riparian vegetation work areas.
- Introduction of contaminants from a variety of sources during construction is considered to be a direct impact from Project activities. The direct changes to surface water quality parameters are considered to have the potential for indirect changes to aquatic ecosystem services, leading to the potential for further impacts on surface water quality receptors. Project activities considered to increase the potential introduction of contaminants include:
    - Chemical, fuel and oil spills due to inappropriate storage controls and refuelling/maintenance procedures
    - Heavy metals entering waterways from rail grinding and welding
    - Compounds leaching from ballast materials
    - Spills associated with train derailments or breakdowns
    - Salts mobilised from surface soils or shallow groundwater changes
    - Dewatering activities leading to liberation of toxicants from potentially contaminated land
    - Disturbance of contaminated lands near waterways resulting in contaminated runoff entering waterways
    - Inadequately treated dewatering of tunnel infrastructure may result in hydrocarbons being introduced to the Laidley Creek and Western Creek tributaries during Project activities, resulting in a potentially high impact to surface water quality.

13.7.1.2 Operation phase impacts

Potential impacts and the operational phase activities likely to impact the surface water quality include:

- Increased debris due to:
  - Potential for rubbish and debris from operations to be blown off or washed away from the Project into proximal watercourses.
- Altered hydrology and water chemistry (increase in salinity) from changes to:
  - Receiving water quality from tunnel dewatering discharge and point discharge from culvert locations along the alignment. Principally, the intrusion of groundwater into the tunnel, and, the associated dewatering regime may impact on the receiving watercourse, particularly in regard to salinity
  - Hydrological regime with Western Creek catchment associated with tunnel discharge due to improper hydrological flows from the treated discharge water.
- Introduction of contaminants from a variety of sources during operation due to:
  - Oil and grease spills—there is the potential for oil and grease from rolling stock to enter the waterways after heavy rainfall events without appropriate controls
  - Heavy metals from maintenance rail grinding and welding
  - Compounds leaching from ballast materials
  - Accidental spills from freight carriages during routine operations
  - Chemicals, including fuels and oils used for construction machinery (as an artefact of potential construction impact)
  - Structural failure—with the introduction of bridge or culverts within waterways, should these structures fail, there is the potential for impacts to water quality either from potential contaminants (debris) or from detained water flushing from collapsed structures. Structural failure also has the capacity to alter flow regimes and increase potential secondary salinity issues, with flow-on issues resulting in surface water quality degradation
  - Maintenance of the rail line or machinery near waterways (such as the crossing loops associated with Laidley Creek at approximately Ch 55.09 km to Ch 57.29 km) has the potential to mobilise sediments from disturbed areas and increase the potential for litter or rubbish to enter waterways. Oils and greases and other contaminants such as metals have the potential to enter waterways from spills, and for impact from the use of environmental toxicants (such as biocides) to maintain operating infrastructure areas. Maintenance activities may result in the potential introduction of biocides, resulting in a loss of ecosystem service and subsequent direct and indirect impacts on water quality. These activities have the potential to impact nearby waterways, through discharge points without appropriate mitigation.
- Increase in erosion and sedimentation resulting from:
  - Earthworks and erosion of exposed soils (as an artefact of potential construction impact)
  - Construction of culverts and bridges within or nearby waterways. Potential for continued erosion and sedimentation without appropriate rehabilitation in these areas exists. This can increase sediment loads and turbidity within waterways. Increased sedimentation may then also impact the functioning of culverts should deposition become too high.

13.7.2 Hydrology and flooding

In terms of the flooding regime, there are a similar range of potential impacts associated with all phases (construction and operation) of the Project. These impacts may affect existing dwellings, sheds, farm buildings and infrastructure, crops, roads. These flood sensitive receptors have been identified in the vicinity of the Project and are shown in Figure 13.8.a to Figure 13.8e.Potential impacts include:

- Changes in peak water levels and associated areas of inundation
- Concentration of flows, redirection of flows and/or changes to flood flow patterns
- Increased velocities leading to localised scour and erosion
- Changes to duration of inundation
- Increased depth of water affecting trafficability of roads and tracks.

The quantified flooding impacts associated with the Project alignment and drainage structures are detailed in Section 13.9.2.

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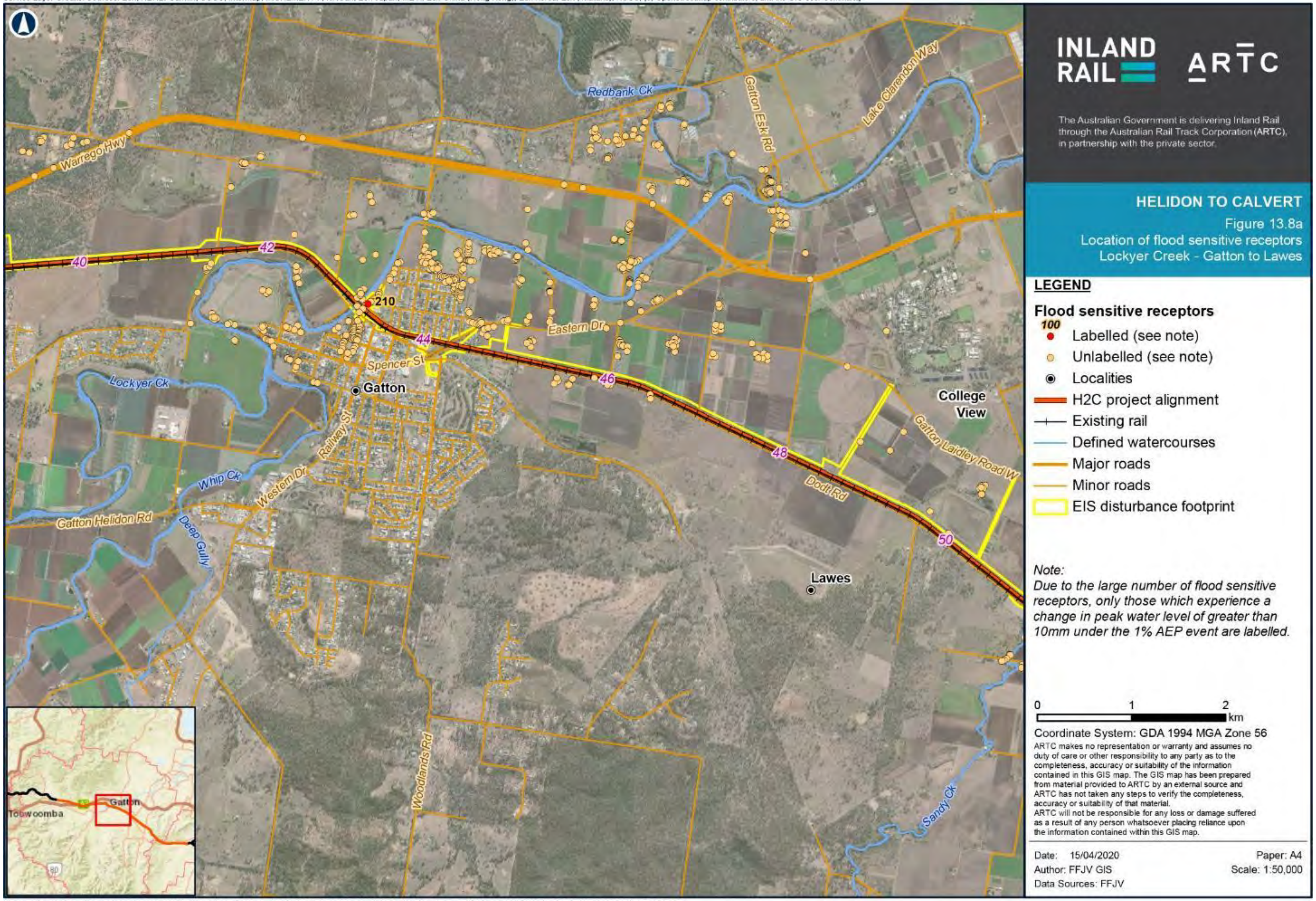

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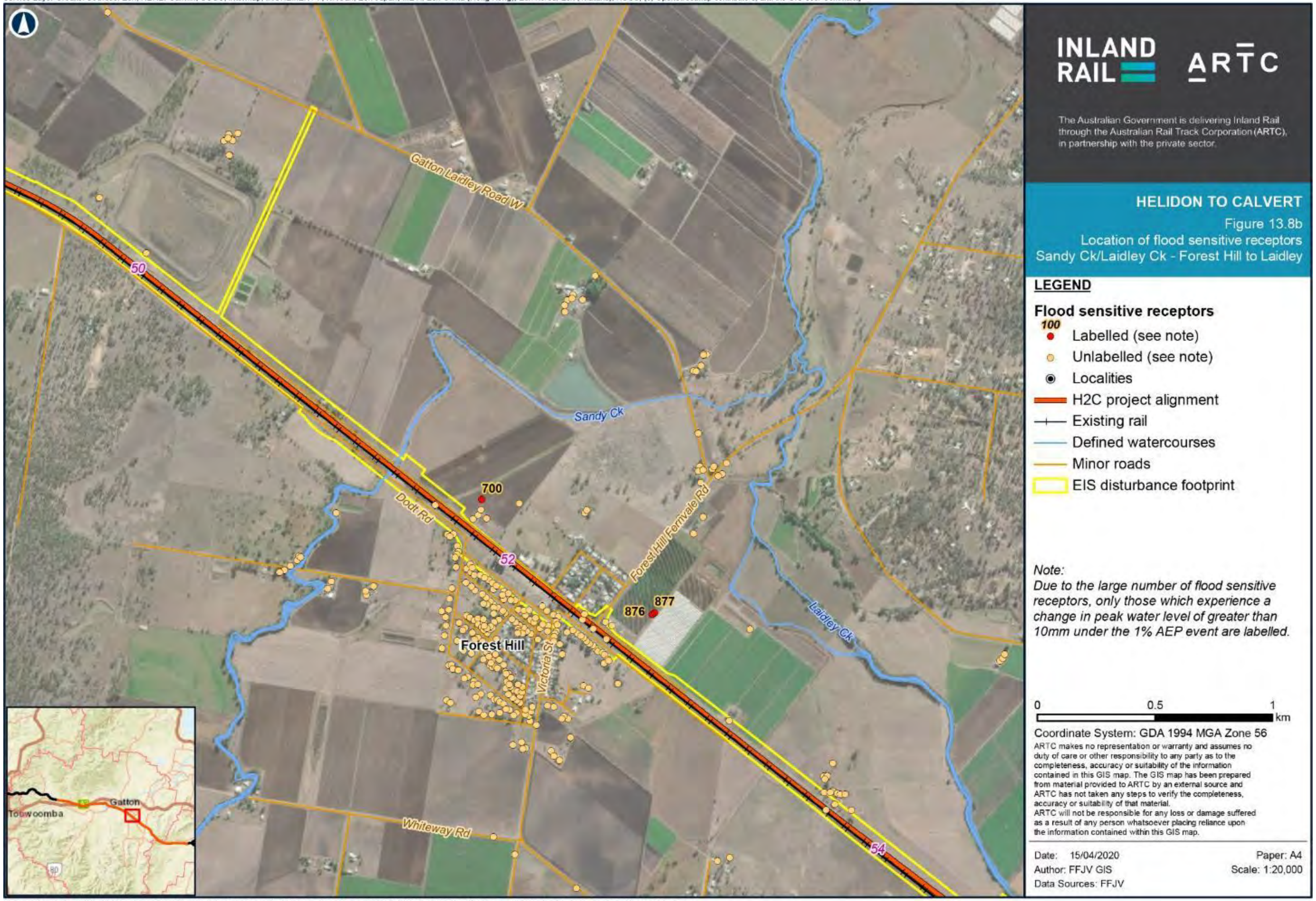

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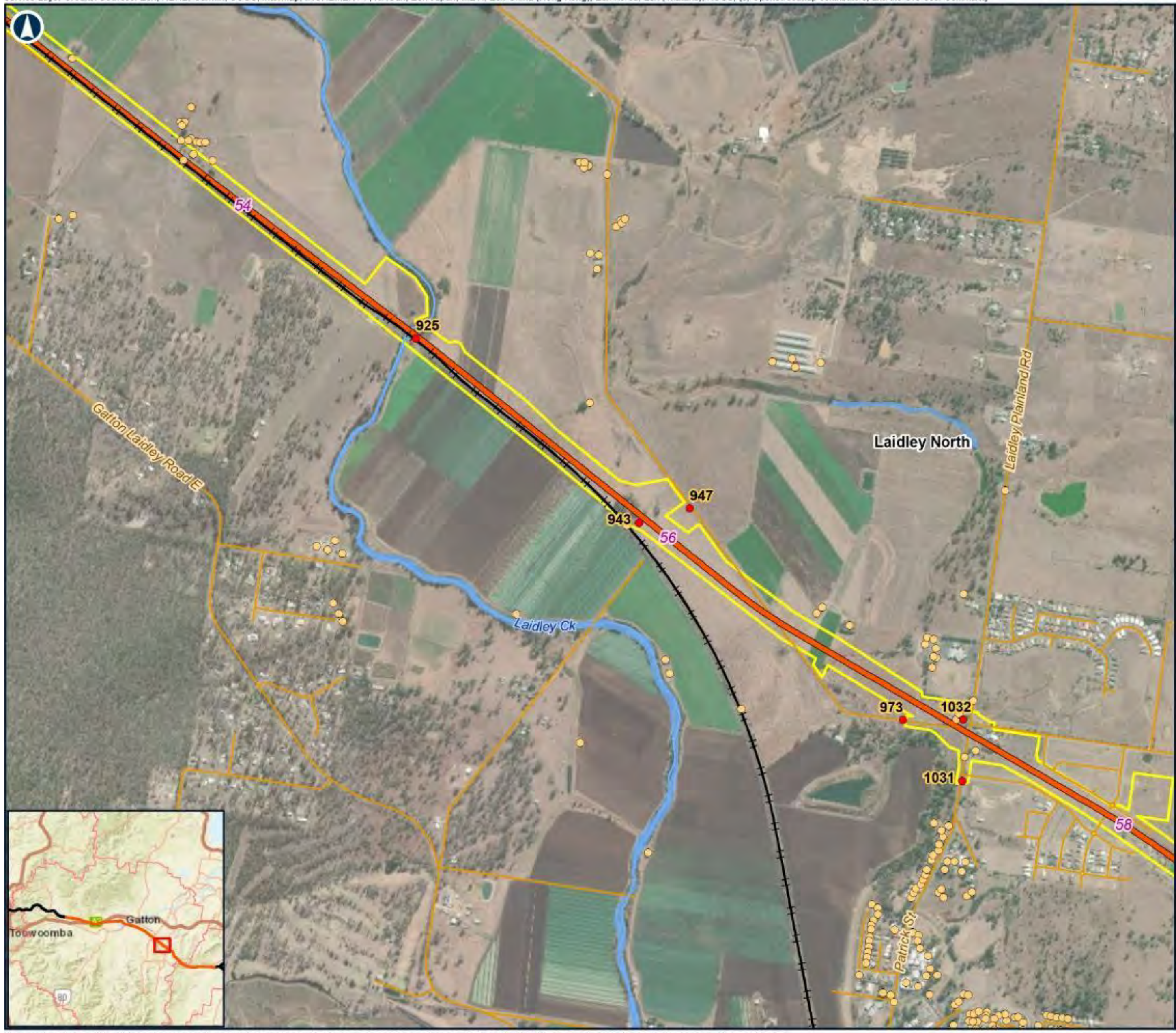

INLAND RAIL

ARTC

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

HELIDON TO CALVERT

Figure 13.8c
Location of flood sensitive receptors
Sandy Ck/Laidley Ck - Forest Hill to Laidley

LEGEND

Flood sensitive receptors

- 100 Labelled (see note)
- Unlabelled (see note)
- H2C project alignment
- Existing rail
- Defined watercourses
- Minor roads
- EIS disturbance footprint

Note:
Due to the large number of flood sensitive receptors, only those which experience a change in peak water level of greater than 10mm under the 1% AEP event are labelled.

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 56

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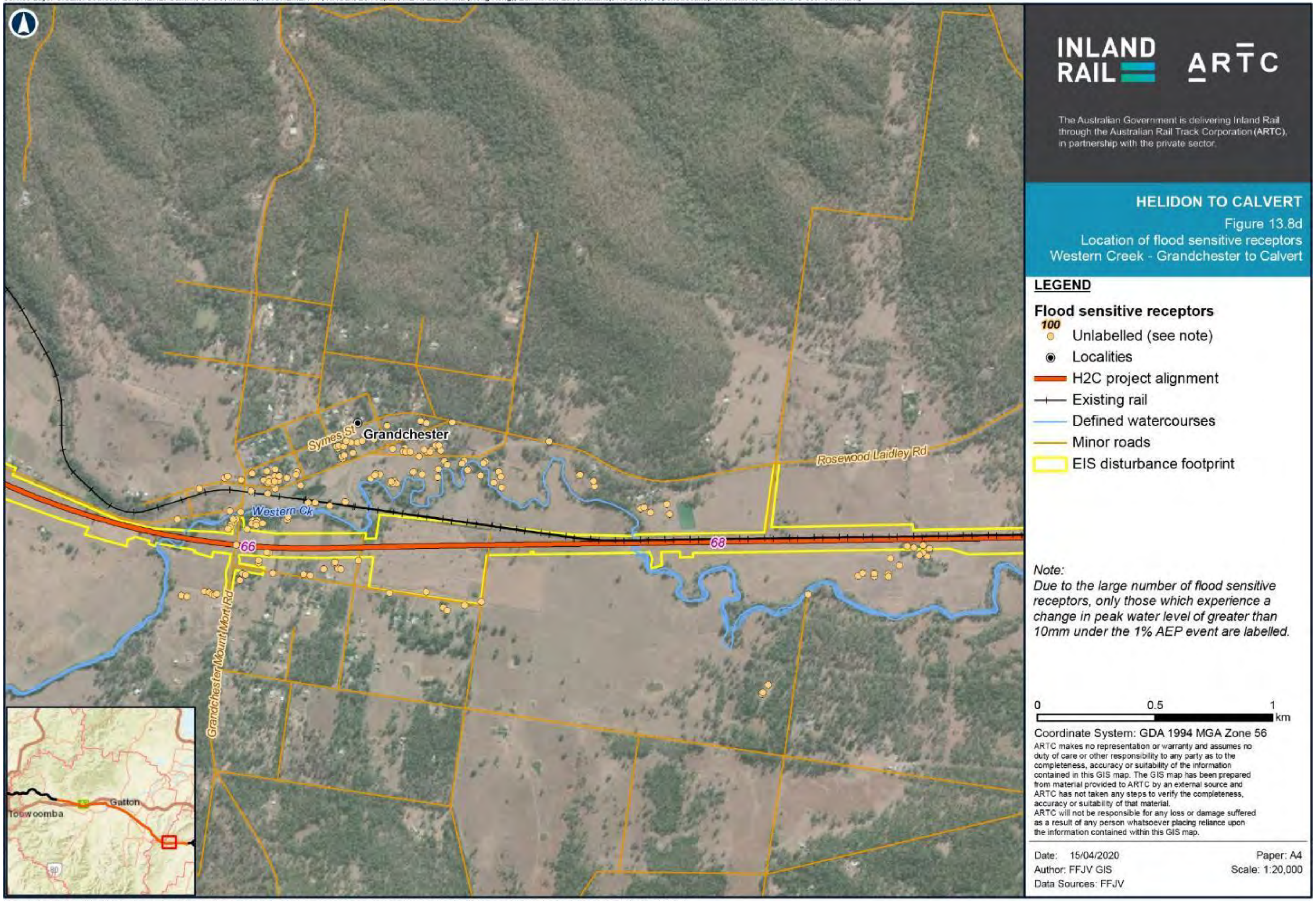

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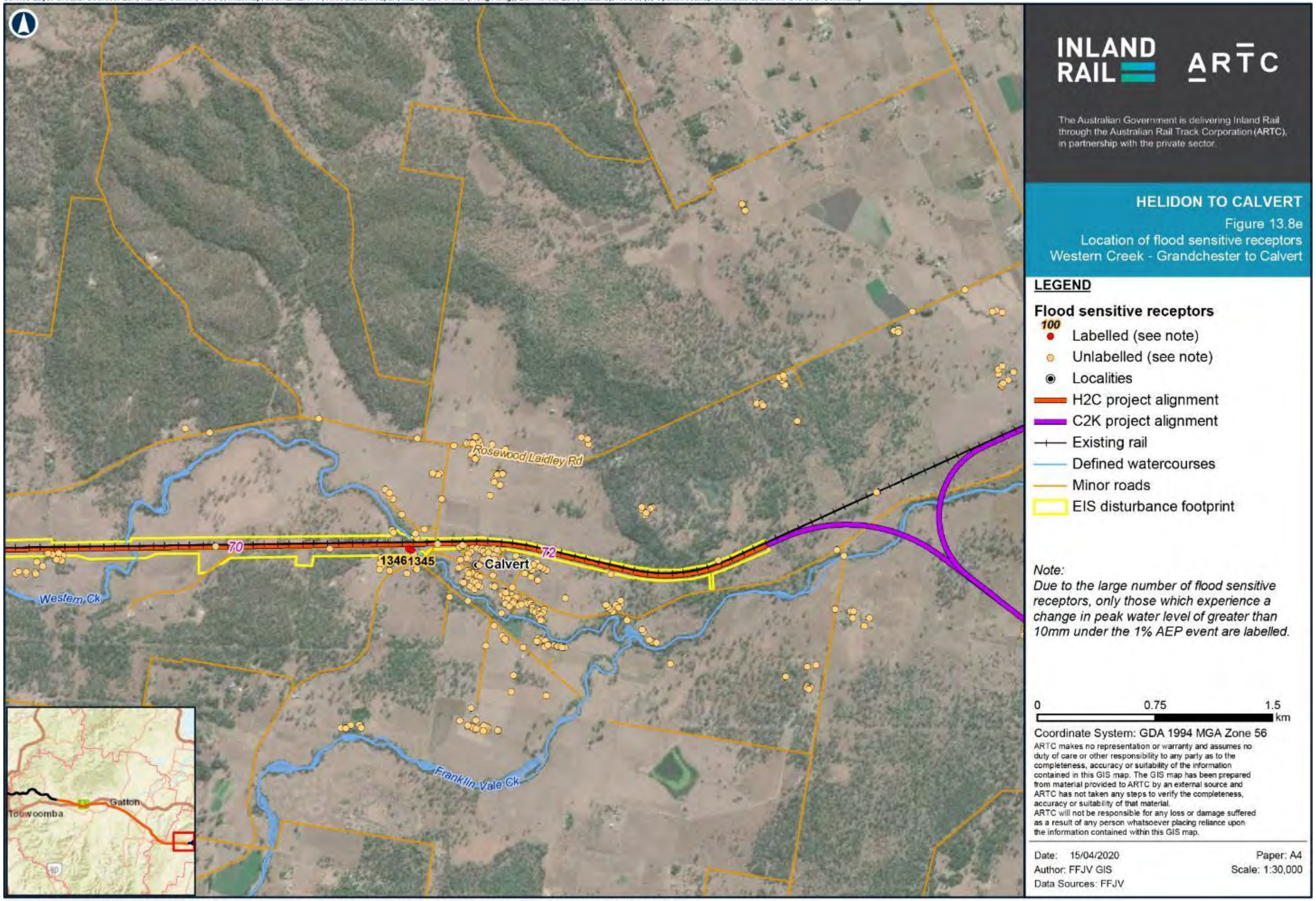

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13.8 Mitigation measures

13.8.1 Surface water quality

This section outlines both the mitigation measures included as part of the design and the mitigation measures that are proposed for application in future phases the Project to manage predicted impacts to water quality. Mitigation measures have been developed to minimise impacts associated with construction and operation of the Project. Mitigation strategies have been developed based on the following hierarchical criteria:

- Primary: avoid potential impacts where possible during Project design considerations
- Secondary: minimise the severity and/or duration of the impact during Project design considerations
- Last: apply mitigation measures for unavoidable impacts.

13.8.1.1 Design considerations

The mitigation measures and controls in Table 13.21 are factored into the design and will be further implemented during the detailed design phases 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 before the application of in-situ mitigation (refer Table 13.22).

TABLE 13.21: INITIAL MITIGATION FOR SURFACE WATER QUALITY

Aspect	Initial design measures
Interference with existing surface water and water quality	▸ The Project uses the existing sections of the West Moreton rail system as much as possible to avoid introducing a new linear infrastructure corridor across watercourses and floodplains, where feasible ▸ Watercourse crossing structures (including culverts, viaducts and bridges) are designed to minimise the need for ongoing maintenance and inspection to maintain aquatic fauna (e.g. fish) passage and minimise the risk of blockages in reference to *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (1 October 2018) (DAF, 2018a) ▸ Bridges, viaducts and waterway crossings are designed to minimise impacts to bed, banks and environmental flows, in accordance with relevant regulatory requirements (as per requirements of DAF and the Fisheries Act) ▸ The design has been developed to avoid the need to permanently divert watercourses, as defined and mapped under the Water Act (it is noted that three discrete unmapped waterways are currently subject to diversion) ▸ The design has been developed to minimise impacts to watercourses, riparian vegetation and in-stream flora and habitats by adopting a crossing structure hierarchy where viaducts and bridges are preferred to culverts ▸ Bridge structures are in the design over the following watercourses, to minimise disturbance of aquatic habitats: Sandy Creek (Grantham), Lockyer Creek, Laidley Creek, Sandy Creek (Forest Hill) and Western Creek ▸ Scour and erosion protection measures have been incorporated into the design in areas determined to be at risk, such as around culvert headwalls, drainage discharge pathways and bridge abutments ▸ Scour protection measures have been included around culvert entrances and exits, on disturbed stream banks and around waterfront land to avoid erosion ▸ Cross-drainage structures have been incorporated into the design where the Project intercepts existing drainage lines and watercourses. The type of cross-drainage structure in the design depends on various factors such as the natural topography, rail formation levels, design flow and soil type ▸ The design includes six sediment basins (for construction). All sediment basins are passive which allows surface runoff from a catchment to flow into the sediment basin without the need for pumping.

13.8.1.2 Proposed mitigation measures

To manage Project risks during construction, a number of mitigation measures have been proposed for implementation in future phases of Project delivery, as in Table 13.22. These proposed mitigation measures have been identified to address Project specific issues and opportunities, address legislative requirements, accepted government plans, policy and practice.

Table 13.22 identifies the relevant Project phase, the aspect to be managed, and the proposed mitigation measure, which is then factored into the assessment of residual significance in Table 13.26.

Within the water quality assessment of impacts and risk significance, pre-construction has been grouped with construction due to the similarity in potential impact. In addition to the standard in-situ mitigation measures in Table 13.22, further management frameworks are proposed for discharge and runoff management, tunnel dewatering treatment, surface water quality (receiving environment) monitoring and salinity management.

In addition to the mitigation measures identified, and as part of the detailed design phase, when positions of infrastructure elements (e.g. abutments/piers) are finalised and detailed soil studies are complete, geomorphological assessment of identified risk locations will be undertaken.

Chapter 23: Draft Outline Environmental Management Plan provides further context and the framework for the implementation of these proposed mitigation and management measures through the Draft Outline Environmental Management Plan (draft Outline EMP) and the Construction Environmental Management Plan (CEMP).

TABLE 13.22: ADDITIONAL (IN SITU) SURFACE WATER QUALITY MITIGATION MEASURES

Delivery phase	Aspect	Proposed mitigation measures
Detailed design	Water quality of waterways	Seek to further refine the disturbance footprint identified and assessed in the EIS, to avoid, and where avoidance is not possible, further minimise impacts to all waterways including defined watercourses, currently unmapped waterways and drainage features (defined by the *Water Act 2000* (Qld) and water quality of Sandy Creek (Grantham), Lockyer Creek, Sandy Creek (Forest Hill), Laidley Creek, Western Creek their tributaries and downstream impoundments or users by: - Avoiding, then minimising the extent and duration of temporary waterway diversions - Avoiding, then minimising the extent of permanent waterway diversions or realignments. Where unavoidable, permanent waterway realignment/diversion design to include simulation of natural features e.g. meanders, pools, riffles, shaded and open sections, deep and shallow sections and different types of sub-strata, depending on the pre-disturbance environmental values - Planning and defining maintenance activity locations, construction compounds and storage areas, and management procedures - Undertaking preconstruction water quality monitoring and detailed design hydraulic modelling to inform temporary and permanent drainage design. Requirements for treatment controls, scour protection., to be incorporated where necessary to achieve compliance with established objectives. Temporary and permanent measures must be appropriate to the site conditions, responding to the erosion risk assessment, environmental receptors, climatic zone and seasonal factors - Developing Erosion and Sediment Control Plans (ESCPs), in accordance with International Erosion Control Association's *Best Practice Erosion and Sediment Control* (IECA, 2008), for implementation during pre-construction, construction and commissioning, which will establish and specify the monitoring and performance objectives for handover on completion of construction - Ensuring the disturbance footprint defined during detailed design allows enough space for provision of the required temporary and permanent erosion and sediment control measures/pollution control measures - Designing batters, cuts and other exposed surfaces to reduce erosion risk - Designing watercourse crossing structures (including culverts and bridges) to minimise the need for ongoing maintenance and inspection to maintain aquatic fauna (e.g. fish) passage and minimise the risk of debris deposition during large flow events in accordance with relevant regulatory requirements.
	Monitoring	Develop the surface water monitoring framework to inform the development of the CEMP and the construction water quality monitoring program. It will identify monitoring locations including upstream, downstream and at the intersection of the Project disturbance footprint and watercourses where works are being undertaken. It will include the relevant water quality objectives, parameters, and criteria, and specific monitoring locations, frequency and duration identified in consultation with relevant regulators to reduce impacts to surface water quality. The water quality monitoring program will include (as a minimum): - Analysis of the representative background monitoring dataset - Identification of Project works and activities including runoff, emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways and riparian land (via discharge points) - A risk management framework for evaluation of the risks to surface water quality and ecosystems in the receiving environment, including definition of impacts that trigger contingency and ameliorative measures - The identification of location-specific and construction activity erosion and sediment control and stormwater management requirements relating to surface waters during all phases.

Delivery phase	Aspect	Proposed mitigation measures

Detailed design (continued)	Monitoring (continued)	- The presentation of Water Quality Objective (WQO) trigger values, standards and parameters against which changes to water quality will be assessed, having regard to the ANZECC/ARMCANZ 2000/2018 Guidelines, or other suitable guidelines. As a minimum this should include values for:
		  - Total Suspended Solids—Equivalent to corresponding background (milligrams per litre (mg/L))
		  - Turbidity—Equivalent to corresponding background (Nephelometric Turbidity Units (NTU))
		  - pH 6.5–8
		- Oils and grease (no visible films)—if oils and grease are visually evident, a sample will be forwarded to the laboratory for analysis
		- Establishment of construction surface water monitoring locations including waterways, waterbodies and wetlands (e.g. upstream of, downstream of, and at the intersection of the Project disturbance footprint and watercourse and tunnel dewatering into the Purga Creek sub-catchment) and discharge points, which are representative of the potential extent of impacts from the Project, including relevant analytes and frequency of monitoring
		- Identification of seasonal factors with the potential to influence water quality at the monitoring sites
		- A minimum monitoring period following the completion of construction completion criteria. Surface-water quality during baseflow conditions, that meet representative pre-construction up and downstream background monitoring, and/or WQOs will confirm adequate rehabilitation
		- The post-construction monitoring will assess the efficacy of constructed water control measures, as defined as part of drainage during detailed design of the Project, such as vegetated buffer strips basins and vegetated swales
		- Contingency and ameliorative measures if adverse impacts to water quality are identified, with reference to the impact triggers defined as part of the water quality monitoring program
		- Surface water quality samples are to be collected and analysed in accordance with industry-accepted standards and quality assured procedures, with laboratory analysis undertaken by NATA-accredited facilities
		- Commence water quality monitoring in accordance with the surface water quality monitoring framework for an adequate period of time to acquire representative data prior to construction at waterway crossing locations (e.g. Lockyer Creek—upstream of, downstream of, and at the intersection of the Project disturbance footprint and watercourse) to establish baseline water conditions and provide a sufficient seasonal dataset prior to the commencement of construction.

	Drainage design, erosion sediment control	Water-quality matters will inform permanent drainage design for the rail and road realignments (i.e. requirements for treatment controls where necessary to comply with established water quality objectives through scour protection) and to inform erosion and sediment control plans. Design defines temporary and permanent stormwater, erosion and sediment/pollution control measures in ESCPs and Reinstatement and Rehabilitation Plan, that each comply with IECA *Best Practice Erosion and Sediment Control* (IECA, 2008). The plans will establish and specify the monitoring and performance objectives for handover on completion of construction.

Delivery phase	Aspect	Proposed mitigation measures
Detailed design (continued)	Construction water	Develop a dewatering strategy where dewatering of artificial impoundments is required (artificial impoundments within the disturbance footprint) to comply with the *Biosecurity Act 2014* (Qld) to take reasonable measure to avoid the spread of pest species (with capacity to affect water quality) and in accordance with any required aquatic fauna species management plans. Requirements for construction water (volumes, quality, demand curves, approvals requirements and lead times) will be defined during detailed design and construction planning. This will include identification of opportunities to utilise dewatered artificial impoundments (where impacted along the disturbance footprint) for construction purposes. Construction water sources and demand will use a hierarchical approach to confirm the suitability of water sources, with a focus on utilising existing sustainable allocated water entitlements. Licences, approvals and agreements to access water from sources identified in the finalised construction water strategy will be obtained. These may include water licences under the Water Act or access agreements with bulk water suppliers or private landowners. Specify performance criteria in the CEMP for construction water requirements to minimise the risk of adverse water quality, environmental or health impacts and avoid the use of potable water where non-potable sources can be applied.
	Tunnel dewatering	Groundwater quality and modelling works will be undertaken to inform the design for the Little Liverpool Range tunnel dewatering treatment facility. Develop a treatment and discharge plan, consistent with the tunnel dewatering treatment framework for implementation at the tunnel dewatering plant. The collected water will be required to meet the water quality objectives (to be established during baseline water quality monitoring) for release, and schedule release periods to minimise changes in hydrological regime, physical and chemical characteristics and ecological processes. The treatment and discharge plan will also establish criteria and protocols if releases during no-flow conditions is required.

Pre-construction	Erosion and sediment control (water quality related)	ESCPs will be developed for the Project as part of the CEMP, in accordance with the International Erosion Control *Association's Best Practice Erosion and Sediment Control* (IECA, 2008). The ESCPs will include the following procedures and protocols relevant to potential impacts on water quality values:
		- Soil/land conservation objectives for the Project
		- Management of problem soils, such as:
		  - Acid sulfate soils, which may occur in proximity to water storages
		  - Erosive or dispersive soils, such as sodosols that are expected to be encountered at approximately Ch 62.0 km to Ch 70.0 km (associated with Grandchester)
		  - Cracking clays (vertosols) that are expected to be encountered in the disturbance footprint associated with the alignment in proximity of Forest Hill and Laidley (principally associated with waterways)
		  - Saline soils, particularly in high salinity hazard areas.
		- Specification of the type and location of erosion and sediment controls. The erosion and sediment control measures will be reviewed by a CPESC and be in accordance with the International Erosion Control Association's Best Practice Erosion and Sediment Control (IECA, 2008).

Delivery phase	Aspect	Proposed mitigation measures
Pre-construction (continued)	Erosion and sediment control (water quality related) (continued)	A Project Soil Management Plan that will include: ▸ Locations for specific temporary/permanent erosion and sediment control measures ▸ Sediment retention basins (six included in the design) ▸ Scour protection (included in the design) ▸ Sediment fencing ▸ Berms and other surface flow redirection through disturbance areas. Nomination of location-specific erosion controls will include consideration of site conditions, proximity to environmental receptors, adjoining land uses and climatic and seasonal factors, and will be based on an erosion risk assessment. Minimise the area of disturbance during each stage to that required to enable the safe construction, operation and maintenance of the rail corridor: ▸ Scheduling and management of works in areas proximal to waterways (as risk water quality receptors) with consideration to periods of higher rainfall (summer months), where practical ▸ Establish and specify the monitoring and performance objectives for handover on completion of construction ▸ Stockpiling and management/segregation of topsoil where it contains native plants seedbank or weed material ▸ Vehicle, machinery and imported fill hygiene protocols and documentation, in accordance with the requirements of the Biosecurity Act 2014 (Qld) ▸ 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 ESCPs are to include a process for site- and activity-specific preparation when forecast large or high-intensity wet weather events are predicted. This plans may include, but not be limited to, removing plant and equipment out of riparian zones, stabilising/covering live work areas, additional application of soil binders/veneers and pre-event treatment and dewatering of sediment basins.
	Water quality	Review and adjust (as required) the surface water monitoring framework and develop the water quality monitoring program as part of the Surface Water Sub-plan of the CEMP, with reference to the baseline (representative background) monitoring dataset. Dewatering/extraction of water from artificial impoundments will be undertaken after consultation with relevant stakeholders. To the extent possible and where required, stage Project works to use dewatered artificial impoundments to reduce external water requirements. Dewatering strategies will be required to comply with the *Biosecurity Act 2014* (Qld) to take reasonable measure to avoid the spread of pest species (with capacity to affect water quality). Undertake site inspections before the construction of cuts, including visual examination of surface outcrops for sulfide minerals or evidence of sulfide mineralisation. Use the information from these inspections to inform the management of potential ARD from cuttings prior to Project works. If ARD-contaminated discharge water is found to be generated from the deep cuts, this water will be impounded in ponds and neutralised via treatment (hydrated lime or dilution or similar) prior to release into the surrounding catchment or other discharge mechanism. Identification and/or reuse of contaminated, hazardous or potentially contaminated material on site (i.e. soil, ballast) will be subject to a risk assessment and managed accordingly.

Delivery phase	Aspect	Proposed mitigation measures
Construction and commissioning	Erosion and sediment control	Clearing extents are limited to the disturbance footprint, and clearing is scheduled to minimise the exposure time of unprotected materials to prevent sedimentation of receiving waterways. Appropriate erosion and sediment control measures will be implemented for each stage or element of the Project works, in accordance with the progressive revisions of the ESCPs that are undertaken by a CPESC in accordance with the International Erosion Control Association's *Best Practice Erosion and Sediment Control* (IECA, 2008). Stages/elements are expected to include (but not be limited to): - Vegetation clearing and grubbing - Temporary access tracks and/or temporary waterway crossings - Early installation of stormwater drainage and clean water catch drains to divert clean water flows through/around the construction site - Bulk earthworks and interim topography changes - Waterway diversions - Bridge and culvert works - Ballast placement - Reinstatement activities - Rehabilitation and landscape activities. Temporary waterway crossings are rehabilitated in accordance with the Reinstatement and Rehabilitation Plan. Where practical and/or in accordance with specific flora and fauna management plans, vegetation clearing, and ground-disturbing works will be staged sequentially/across the Project to minimise areas exposed to erosion and sediment risk of receiving waterways and drainage lines in accordance with the general environmental duty of the *Environmental Protection Act 1994* (Qld).
	Water quality	Implementation of the Surface Water Sub-plan. The surface water monitoring framework will include the relevant water quality objectives, parameters, and criteria, and specific monitoring locations, frequency and duration identified in consultation with relevant regulators to reduce impacts to surface water quality. To the extent possible, schedule works to use dewatered artificial impoundments along the disturbance footprint to reduce external water requirements. Dewatering strategies will be required to comply with the *Biosecurity Act 2014* (Qld) to take reasonable measure to avoid the spread of pest species (with capacity to affect water quality). In the event that water quality objectives cannot be achieved for waters to be released, alternate treatment/disposal options are to be implemented prior to release or re-use. Water will need to meet the established water quality objectives for receiving waterways before being released/discharged into local waterways. Water that does not comply with relevant water quality objectives will either be: - Treated onsite to enable discharge - Used for construction water purposes that is not quality dependent, if safe to do so and adequate environmental controls are in place - Removed from site for disposal at an appropriately licensed facility.

Delivery phase	Aspect	Proposed mitigation measures
Construction and commissioning (continued)	Water quality (continued)	Bulk storage areas for dangerous goods and hazardous materials will be located away from areas of social and environmental receptors such that offsite impacts or risks from any foreseeable hazard scenario will not exceed the dangerous dose for the defined land use zone, i.e. either sensitive, commercial/community, or industrial, in accordance with the intent of the SPP. Appropriate register and records of chemicals, hydrocarbons and hazardous substances and materials onsite will be maintained up-to-date as required by the CEMP. Where appropriate this should include a relevant risk assessment prior to the substance coming to, and being used onsite, plus a dangerous goods manifest and Safety Data Sheet Register. Licensed transporters operating in compliance with *Australian Code for the Transport of Dangerous Goods by Road & Rail* (National transport commission, 2018) will be used for the transportation of dangerous goods.
		Chemicals stored and handled as part of construction activities will be managed in accordance with: - Work Health Safety Act 2011 (Qld) and Regulation - AS 2187:1998 *Explosives—storage, transport and use* (Standards Australia, 1998) - AS 1940:2017 Storage and Handling of Flammable and Combustible Liquids (Standards Australia, 2017) - AS 3780:2008 The Storage and Handling of Corrosive Substances (Standards Australia, 2008) - Requirements of chemical safety data sheets - Any relevant ERA conditions. Procedures will be established for safe and effective fuel, oil and chemical storage and handling. This includes storing these materials within roofed, bunded areas. The bunding will have floors and walls that are lined with an impermeable material to prevent leaching and spills. Construction tasks will be scheduled to avoid, where possible, bulk earthwork activities within the 1% AEP during periods of elevated flood risk. Where works cannot be scheduled outside of this time period, activity-specific flood readiness and response planning will be required. This planning will be developed in consultation with the relevant local government and Queensland Fire and Emergency Services. Laydown areas and other construction facilities that are located within the 1% AEP will be temporary. Their planning and function in supporting construction will reflect the local flood risk. For example, hazardous goods will not be bulk stored in these locations. Mobile plant will not be stored in the 1% AEP when not scheduled to be in use for construction purposes. Plant maintenance and refuelling will be carried out with appropriate interception measures in place to avoid impacts to waterways, aquatic habitats and groundwater. Appropriate spill control materials including booms and absorbent materials will always be onsite at refuelling facilities. Appropriate spill control materials including booms and absorbent materials will always be onsite at refuelling facilities. Appropriate waste bins will be in laydown areas to facilitate segregation and suitable containment of waste materials.
	Construction water	The extraction of water will occur in accordance with licences, approvals and/or agreements. Volume monitoring during extraction will be required for each source point, with extraction logs maintained. Extraction reporting will occur, as required, in accordance with requirements of relevant licences, approvals and/or agreements obtained to cover this activity.

Delivery phase	Aspect	Proposed mitigation measures
Construction and commissioning (continued)	Waterways	Maintenance activities and refuelling will be carried out at an appropriate distance from riparian vegetation and waterways, with appropriate measures in place to avoid impacts to surface water quality. Where this is not achievable due to type of activities (e.g. piling activities within a riparian zone), additional mitigation measures must be implemented to prevent impacts on water quality. Appropriate selection and use of aquatic-friendly pesticides.
Operation	Water quality	Operational tunnel dewatering into the Western Creek sub-catchment will be required to meet the established water quality objectives (or interim water quality guidelines) for receiving waterways before being released/discharged into local waterways. Water that does not comply with relevant water quality objectives will either be: ▸ Treated onsite to enable discharge ▸ Removed from site for disposal at an appropriately licensed facility. The effectiveness of permanent erosion controls (e.g. scour protection or vegetated swales) will be monitored as part of the maintenance inspection schedule for the Project, as prescribed in the Operation Environmental Management Plan (Operation EMP): ▸ Controls that are found to be failing or not performing as intended will either be modified or replaced, as required ▸ Vegetation on the rail embankment slopes will be maintained to prevent slope face degradation. Maintenance of surface and subsurface drains will be required to ensure continued effectiveness and to minimise risk of impact to surrounding and downstream environments and structures.

13.8.1.3 Management framework strategy

The management frameworks described in this section will be developed during detailed design with implementation under pre-construction/construction phase and continuation into operation as required.

Discharge and runoff management

Under the surface water monitoring framework to be developed, discharge and runoff will be monitored as part of the surface water monitoring required for the Operation EMP. It will identify monitoring locations at discharge points, and selected locations in waterways where works are being undertaken.

Particular discharge and runoff management will be required for the release of collected water from within the tunnel infrastructure and will require specific management in regard to release into receiving waters. As discharge will likely involve a drainage feature proximal to the western tunnel portal, specific management of the hydrological regime of release will be required, in the form of periods of water/dewatering releases into the drainage feature to minimise a change in hydrological regime and ecological processes.

In the event that WQOs cannot be achieved for receiving waters, alternate treatment/disposal options as adaptive management actions (i.e. disposal options in line with potential down-time of water treatment plant) are to be implemented in accordance with any relevant and applicable conditions or legislation and regulations in place.

Tunnel dewatering treatment

Water quality characteristics of groundwater tunnel drainage are expected to generally meet (EPP (Water and Wetland Biodiversity)) discharge criteria as regional WQOs for Western Creek. Further assessment will be required during the detailed design phase. This water will likely be processed through a Water Treatment Plant (WTP) and include hydrocarbon and first-flush separation before being released to Western Creek. The discharged water will be expected to meet the WQOs for the protection of aquatic ecosystems of Western Creek (under Schedule 1 of the EPP (Water and Wetland Biodiversity)) (refer Section 13.4.3).

A typical WTP is proposed as the base design for consideration as part of the area footprint and power consumption requirements. Particular discharge and runoff management will be required for the release of collected water from within the tunnel infrastructure. Specific management will be required in regard to release into receiving waters.

The water treatment facilities that may be required could include:

- Screening treatment
- Detention tanks
- Aeration/flocculation tanks
- Chemical treatment
- Water pumping facilities
- Sludge storage.

As discharge will likely involve a drainage feature (as an overland flow route to Western Creek) proximal to the western portal, specific management of the hydrological regime of release will be required. This is expected in the form of periods of water/dewatering releases into the drainage feature (an overland flow path under Water Act to minimise a change in hydrological regime and ecological processes.

The collected water (currently estimated at 0.01 L/s to 0.1L/s) will be required to meet the WQOs for Western Creek (refer Table 13.4) and will likely require processing through a WTP include hydrocarbon separation.

Water from the WTP may require further adjustments pre-discharge to meet WQOs, as the water may become overtreated. To mitigate significant impact on the receiving waters, discharge will need to be monitored to ensure over-cleaned is not released (water that is not representative of localised water quality parameters under WQO) into the receiving waters.

Surface water quality (receiving environment) monitoring recommendations

A Water Quality Monitoring Program (WQMP) (as part of the Operation EMP surface water sub-plan) is proposed to monitor the effectiveness of mitigation measures for surface water quality. This will be conducted prior to and throughout construction and decommissioning (as related to construction) phases of the Project. During operations, it is expected the WQMP will be limited to monitoring discharge from the WTP into Western Creek.

The WQMP will be developed concurrently with the detailed CEMP and include:

- Identification of works and activities during construction and operation of the Project, including runoff, emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways and riparian land (via discharge points)
- A risk management framework for evaluation of risks to surface water quality and ecosystems in the receiving environment, including definition of impacts that trigger contingency and ameliorative measures

- The identification of environmental management measures relating to surface waters during construction, and operation including erosion and sediment control and stormwater management measures
- The presentation of WQO trigger values, standards and parameters against which any changes to water quality will be assessed, having regard to the relevant water quality guidelines and ANZECC/ ARMCANZ 2000/2018 guidelines—where alternate guidelines are used to establish water quality goals, justification for this will be provided
- Representative background monitoring data for surface water quality to establish baseline water conditions prior to the commencement of construction
- Identification of construction and operational phase surface water monitoring locations (if the EIS surface water monitoring locations are not continued) including waterways, waterbodies and wetlands, which are representative of the potential extent of impacts from the Project, including relevant analytes and frequency of monitoring—analytes are considered to be those relevant to identified impacts including turbidity, EC, hydrocarbons and dissolved metals
- Commitment to a monitoring period following the completion of construction or until the affected waterways and/or groundwater quality are certified by a suitably qualified and experienced independent professional as being rehabilitated to an acceptable condition, unless otherwise approved or directed by regulatory authorities—surface water quality during baseflow conditions that meet background monitoring and/or WQOs will confirm adequate rehabilitation
- The monitoring will also confirm the establishment of operational water control measures, which will be identified as part of drainage during detailed design of the Project (such as vegetated buffer strips basins and vegetated swales)
- Contingency and ameliorative measures in the event that adverse impacts to water quality are identified, with reference to the impact triggers defined as part of the water quality monitoring program
- Surface water quality samples will be collected in accordance with industry-accepted standards and quality assured procedures, including the *Queensland Monitoring and Sampling Manual* (DES, 2018b).

Salinity management

Salinity management (in regard to surface water quality) will be addressed by implementation of the Erosion and Sediment Control Plan and through characterisation of soil conditions across the water quality study area. This will be undertaken at a suitable scale in accordance with the CEMP prior to construction to inform design and environmental management measures. This includes identification of potential/ actual acid sulfate soils, reactive soils, erosive soils, dispersive soils, saline soils, acidic soils, alkaline soils and contaminated land. The characterisation is considered to be used within the ESCP to identify problematic soils and assist the management of salinity during works and following the implementation of the Reinstatement and Rehabilitation Plan.

Surface water resources

Water will be required for construction activities including dust control, site compaction and reinstatement during construction (refer Table 13.23). Potential water sources have been investigated, including extraction of groundwater and/or surface water, private bores and watercourses. This will be further explored prior to construction in consultation with local councils and landowners. Where water is not available, it will be transported to the site via tanker truck and stored in temporary storage tanks.

Potable water for human consumption will be supplied via bottled water or potable water tanks. Non-potable wash water will be supplied using trailer-mounted storage tanks. Portable toilet facilities will be used where existing infrastructure is unavailable and sewage pump-out services will be used to remove waste offsite.

Activities during the construction phase with the highest water demand are:

- Soil conditioning
- General dust suppression
- Dust suppression and maintenance of laydown areas and haul roads.

Overall, an allowance in the range of 190 litres per cubic metre (L/m^3) of earthworks has been made in building up the estimated water demand requirements (100 L/m^3 for compaction of embankment, 50 L/m^3 for dust suppression and 40 L/m^3 for hail road maintenance). This is a conservative estimate based on actual requirements recorded on the Toowoomba Second Range Crossing project during 2018.

Further to the allowances for earthworks compliance, an additional 10 litres per track metre is expected to be required. For tunnel construction 40 m^3/day may be required. Bulk concrete batching has an expected allowance of 200 L/m^3.

Water sourcing and availability is a critical pathway within the construction program for the Project.

Sources of construction water will be finalised as the construction approach is refined during the detailed design phase of the Project (post-EIS) and will be dependent on:

- Climatic conditions in the lead up to construction
- Confirmation of private water sources made available to the Project by landowners under private agreement.

The hierarchy of preference for accessing of construction water is generally anticipated to be as follows:

- Commercial water supplies where capacity exists—existing infrastructure, well understood water systems, available water volumes known, licensing in place
- Public surface water storages, i.e. dams and weirs
- Permanently (perennial) flowing watercourses
- Privately held water storages, i.e. dams or ring tanks, under private agreement
- Existing registered and licensed bores
- Treated water, e.g. from waste water treatment plants, coal seam gas plants, or desalination plants
- Drilling of new bores (least preferred option).

An assessment of the suitability of each source will need to be made for each construction activity requiring water, based on the following considerations:

- Legal access
- Volumetric requirement for the activity
- Water quality requirement for the activity
- Water source location relative to the location of need.

Extraction of water from a watercourse typically requires:

- A water entitlement, water allocation, water licence or water permit.
- A development permit for use of water that is assessable development under the Planning Act.

The DNRME (now Department of Resources) maintains *Exemption requirements for construction authorities for the take of water without a water entitlement* (WSS/2013/666) (DNRME, 2019a). These exemption requirements may only be used by a constructing authority defined under schedule 2 of the *Acquisition of Land Act 1967* and includes State government departments and local government regulations. The maximum permissible volume under these exemptions is 50 ML). At present these guidelines do not directly apply to ARTC and a water entitlement would be required for the extraction of water from a watercourse. The applicability of these guidelines to the Project will be reassessed when the constructing authority has commenced the land acquisition process and the rail corridor (where the Project falls outside of the existing rail corridor) is a protected future State transport corridor purposes in accordance with the *Transport Planning and Coordination Act 1994* (Qld) process.

The use of surface water and groundwater to supplement the construction demand for the Project may be considered if private owners of registered bores have capacity under their existing sustainable allocated entitlements that they wish to sell to ARTC or the construction contractor under private agreement. Note that not all licences will be volumetric, and a number of users (stock and domestic) may not have licences. If the licence states a certain use, such as irrigation, the water will not be able to be taken and used for construction purposes without an application for change of use.

Further options may need to be investigated depending on engagement with water resource owners and the following aspects:

- Water is available to be provided from existing dams and weirs
- Water supply (bulk supply) to meet the expected demand may be available from the Lake Clarendon and Lake Dyer (Bill Gunn Dam); however, both of these dams are below 10 per cent capacity (as of February 2020)
- Seqwater operates both of these bulk water supply points—further engagement will be undertaken during future stages of design and construction planning to confirm availability and supply arrangements
- If water is to be sourced from local town supplies, then an agreement will have to be made with the local councils on supply conditions
- If water is to be drawn from creeks and rivers crossing the disturbance footprint, then approvals will be required under the Water Act
- Further approvals will also be required to draw water from groundwater bores.

It is estimated that up to 564 ML may be required for the duration of construction.

Project water requirements for the construction workforce impact will be negligible due to no requirement for camp water. Onsite water consumption (from toiletries) will be expected to be provided for portable lavatories.

TABLE 13.23: CONSTRUCTION WATER REQUIREMENTS

Construction activity/ process/phase	Uses/requirement	Approximate quantity (ML)	Quality	Flow rate	Supply
Earthworks	Material conditioning, general dust suppression and general maintenance	480, 240, 190	Low	High	River, dam or bore
Concrete (by concrete supplier)	Bridge and culvert locations	To be determined	High	Low	Town mains due to quality requirements
Concrete) H2C specific)	Bulk batching	Not yet quantified (medium quantity)	High	Low	Priority town mains
Track works	Ballast dust suppression during ballasting and regulating activities	28	Low	Low	River, dam or bore

There is the potential to impact licensed users of surface water if the quality of water or the flow of water changes within offtake locations on Warrill Creek (as a proximal identifier of further impacts to downstream surface water users). The design of the alignment will ensure that the changes to flow are minimised and will not impact users. Additionally, the Project occurs immediately upstream of diversions into Lake Clarendon, with potential surface water resource impacts from any alteration to water quality or hydrological regime.

Significant changes to the hydraulic regime of the watercourses are not expected to occur with design practices that account for typical hydrological flow to which the water plans pertain. Ecological and general outcomes for the Moreton Water Plan (i.e. achieving ecological outcomes consistent with supporting natural outcomes by minimising changes to natural flow regimes) will not be impacted with minimal variance to typical hydrological flow. As such, the Project is expected to comply with the Moreton Basin Water Plan.

The current Moreton Water Plan has a total supplemented surface water allocation of 397,495 ML and an un-supplemented surface water allocation of 28,502 ML. Un-supplemented groundwater allocation is currently 137 ML. To identify immediate impacts on surface water resource users, the number of water licences were accessed to identify potential water quality receptors.

Within the water quality study area, licensed water users (refer Table 13.10) and unlicensed water usage comprises recreational, commercial and domestic uses. The area provides opportunity for various recreational activities that use the waterways including canoeing, water skiing and fishing. Water usage within the water quality study area is dominated by stock use, farming and rural domestic uses. Stock water is supplied from rivers in the wet season and for the rest of the year by groundwater, natural waterholes or constructed artificial waterbodies.

Water resource catchments (and water supply buffer area) associated with the water quality study area (refer Appendix H of Appendix L: Surface Water Quality Technical Report) are limited to the Project water quality study area associated with the Lockyer Creek Catchment. Human requirements for drinking water quality supply are considered to be covered by the protection of aquatic ecosystem environmental values (due to stringency of water quality objectives).

The impact to water plans (supply and conveyance) within the disturbance footprint will be minimal due to limited overland flow interference and no diversions of high-stream order defined watercourses (i.e. those used for conveyance and/or water harvesting). The current drainage diversions will be directed towards existing drainage feature and are not considered to reduce current hydrological regimes with the Laidley Creek and Western Creek sub-catchments. The affected waterway flow paths involve those related to a proposed diversion drain at Ch 59.57 km to Ch 59.67 km, Ch 61.77 km to Ch 52.02 km within the Laidley Creek sub-catchment and a waterway diversion at chainages Ch 63.44 km to Ch 63.75 km (310 m) and Ch 64.04 km to Ch 64.17 km (130 m) within the Western Creek sub-catchment.

Potential further impact to water plans may be expected due to the requirement for construction water; however, this is expected to be regulated by the necessary authorities and will be conducted in accordance with the strategy for sourcing construction water.

Project construction water supply requirements have been further identified to be potentially available from Wivenhoe Dam. It is expected that any proposed offtake of water from this impoundment will comply with water plans and will not result in a change in water quality, from unregulated use of surface water resources, due to Project activities. Should water be required from the proximal perennial watercourses—Murphys Creek, Lockyer Creek, Laidley Creek or the Bremer River—it is expected that approvals will be sought with the relevant agency under the Water Act.

Impact to surface water users will revolve principally around the impact on water quality from the identified potential impacts in Section 13.7, including increased debris, altered water quality and hydrology, altered water chemistry, salinity increase, an increase in erosion and sedimentation and introduction of contaminants. When considered using a conservative approach, impacts to water quality as a result of Project activities during construction may have transient impacts to local water users, potentially restricting access to human drinking water, stock water and crop irrigation. As significant hydraulic changes are not expected from take or conveyance of construction water, impact to surface water users are limited to those mentioned above.

Water quality protection of aquatic ecosystems will confer protection to current existing conditions within the water quality study area, and water users downstream of the alignment. Therefore, identification of potential impact, mitigation measures (refer Section 13.8) and resulting impact assessment (refer Section 13.9) identifies any impact to surface water users. Noting that significant impacts on water quality of surface water users are not considered to occur within Project activities, the resource licence holder (Seqwater) may require to be informed when works are to occur in proximity to surface water offtakes (i.e. Laidley Creek and Lockyer Creek).

13.8.2 Hydrology and flooding

13.8.2.1 Design considerations

The Project has been designed to achieve the hydraulic design criteria (refer Table 13.6) including 1% AEP flood immunity to Project rail formation level. At the same time the design seeks to avoid impacts that do not meet the flood impact objectives (refer Table 13.7) for the flooding and drainage regime. Key strategies that have been adopted in developing the Project design are detailed in Table 13.24.

TABLE 13.24: INITIAL MITIGATION OF RELEVANCE TO HYDROLOGY AND FLOODING

Aspect	Initial design mitigation

Flooding and hydrology	▸ The Project has been designed to achieve the hydraulic design criteria (refer Section 13.5.2.1), and key design criteria including:
	  ▸ 50-year design life for formation and embankment performance
	  ▸ Track drainage ensures that the performance of the formation and track is not affected by water
	  ▸ Earthworks designed to ensure that the rail formation is not overtopped during a 1% AEP flood event
	  ▸ Embankment cross section can sustain flood levels up to the 1% AEP.
	▸ Bridges are designed to withstand flood events up to and including the 1 in 2,000 AEP event.
	▸ Where possible, the Project uses existing rail corridors as much to avoid introducing a new linear infrastructure corridor across floodplains. For the Project, this is limited to the section near Calvert, with the remainder of the alignment in greenfield areas.
	▸ The Project incorporates bridge and culvert structures to maintain existing flow paths and flood flow distributions.
	▸ Bridge and culvert structures have been located and sized to avoid increases in peak water levels, velocities and/or duration of inundation, and changes flow distribution in accordance with the flood impact objectives (refer Section 13.5.2.2).
	▸ Progressive refinement of bridge extents and culvert banks (number of barrels and dimensions) has been undertaken as the Project design has evolved. This refinement process has considered engineering requirements as well as progressive feedback from stakeholders to achieve acceptable outcomes that address the flood impact objectives.
	▸ Scour and erosion protection measures have been incorporated into the design in areas determined to be at risk, such as around culvert headwalls, drainage discharge pathways and bridge abutments.
	▸ A climate change assessment has been incorporated into the design of cross drainage structures for the Project in accordance with ARR 2016 for the 1% AEP design event to determine the sensitivity of the design, and associated impacts, to the potential increase in rainfall intensity.
	▸ Identification of flood sensitive receptors and engagement with stakeholders to determine acceptable design outcomes.

Details of the Project design performance against the flood impact objectives is in Section 13.9.2. For further details regarding the hydrologic and hydraulic modelling approach and design outcomes refer Appendix M: Hydrology and Flooding Technical Report, and for further details on engagement with stakeholders regarding hydrology refer Chapter 5: Stakeholder engagement and Appendix C: Consultation Report.

13.8.2.2 Future mitigation measures

To manage and mitigate Project risks, mitigation measures have been proposed for implementation in future phases of Project delivery. These proposed mitigation measures have been identified to address Project-specific issues and opportunities including legislative requirements and accepted government plans, policy and practices.

Table 13.25 identifies the relevant Project phase, the aspect to be managed and the proposed mitigation measure.

TABLE 13.25: HYDROLOGY AND FLOODING MITIGATION MEASURES

Delivery phase	Aspect	Proposed mitigation measure
Detailed design	Hydrology and flooding	▶ Incorporate outcomes from consultation with stakeholders including directly impacted landowners, local government authorities, State government departments and recognised subject matter experts to inform and refine the Project design. ▶ Continue to refine Project design in response to hydraulic modelling outcomes. This includes addressing flood impact objectives which include consideration of peak water levels, flow distribution, velocities and duration of inundation. This will confirm bridge lengths, culvert sizing and numbers, localised scour and erosion protection measures for both rail, road and other permanent Project infrastructure. ▶ ARTC will continue to consult with impacted landowners in regard to the results of local catchment modelling through finalisation of the EIS and development of the detail design. The purpose of this consultation will be to ensure that impacts to property-scale water balance features, such as irrigation channels and dams, are appropriately considered in the EIS and Project design. Feedback from this consultation will be used to update flood modelling for the Project, if appropriate to do so. Outcomes of this consultation and revised local catchment modelling will be incorporated into the Final EIS. ▶ Undertake a Project flood risk assessment to inform the siting and scale of temporary construction areas (including stockpiles, construction compounds, access, laydown areas). ▶ Construction planning reviews of the design to locate plant and equipment maintenance activities and chemical/hazardous goods storage facilities in accordance with the risk assessment and incorporate appropriate location specific controls and procedures to minimise the risk and avoid impacts to waterways, aquatic habitats, and groundwater. ▶ Impacts must be determined at all drainage structures and waterways affected by Project works. The change in flood levels and impacts on infrastructure and properties outside the rail corridor must be justified for a range of events up to and including the 1% AEP event. ▶ Incorporate outcomes from consultation with stakeholders including directly impacted landholders, local government authorities, State government departments and recognised subject matter experts to inform and refine the Project design.
Pre-construction	Hydrology and flooding	▶ Impacts must be determined at all drainage structures and waterways affected by Project works. Afflux must be calculated. The change in flood levels and impacts on infrastructure and properties outside the Project disturbance footprint must be justified for a range of events up to and including the 1% AEP event. ▶ Construction works must not cause adverse flooding impacts to private land or public infrastructure.

Delivery phase	Aspect	Proposed mitigation measure
Construction and commissioning	Hydrology and flooding	▶ Inspection of cross drainage structures to verify placement, structural integrity and confirm expected performance.
Operation	Hydrology and flooding	▶ Inspections will be carried out of cross-drainage structures in accordance with ARTC's *Structures Inspection Engineering Code of Practice* (ETE-09-01) to identify defects and conditions that may affect waterway and drainage system capacity or indicate increased risk of flooding such as: ▶ Scour ▶ Blockages due to debris build up ▶ Indication of floods overtopping a structure ▶ Culvert or drain damage or collapse.

13.9 Impact assessment

13.9.1 Surface water quality significance impact assessment

A surface water quality significance assessment has been undertaken following the impact assessment framework (refer Section 13.5.1). The significance impact assessment was generated using the precautionary principle aligned with a conceptual model of projected impacts. This was coupled with all Project activities that may have a detrimental impact to surface water quality via proximal discharge points associated with the Project alignment.

The high sensitivity value of MNES and MSES associated environments (refer Section 13.6.3.5) within the Project have been assessed separately with the remainder of the Project environments in relation to water quality, resulting in two discrete sensitivity assessments (refer Table 13.26). To account for habitat disturbance to MNES through changes to water quality, the high sensitivity is linked to sections of Sandy Creek, Western Creek and Lockyer Creek that intersect with the Project alignment.

Impacts on water quality are based on a model of expected occurrences, regarding projected impacts (potential and specific) from Project activities. As such, critical failure of infrastructure is not considered a viable impact for impact significance assessment.

Potential impacts from Project activities resulting in potential adverse effects on surface water quality included:

- Increased debris
- Changes to receiving water quality and hydrology
- Increase in salinity
- Increases in erosion and sedimentation
- Increase in contaminants
- Exacerbation of listed impacts above, from inadequate rehabilitation processes.

It is expected these categories may interface and have the capacity to compound existing/new impacts as they arise (e.g. increased erosion resulting in compounding effect of contaminant leachate and water chemistry changes).

Within Table 13.26, the specific impact (sectioned under the potential impact category) are assessed as a qualitative significance of impact with the design considerations (or initial mitigation) factored into the design phase.

Additional mitigation and management measures (in-situ mitigation), including those listed in relevant sub-plans (refer Section 13.8), 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 after mitigation and management measures were applied. The pre-mitigated risk levels were compared to the residual risk levels to assess the effectiveness of the mitigation and management measures.

TABLE 13.26: SIGNIFICANCE ASSESSMENT INCLUDING POST-STANDARD MITIGATION MEASURES RELEVANT TO SURFACE WATER QUALITY

					Initial impact		Residual impact	
Aspect	Potential impact	Specific impact	Phase	Sensitivity	Magnitude	Significance	Magnitude	Significance
Erosion and sediment control	Increased debris	Contamination of waterway from debris from the Project to be blown into or washed into waterway	Pre-construction and construction	Moderate	Low	Low	Negligible	Low
			Operation					
			Pre-construction and construction	High	Low	Moderate	Negligible	Low
			Operation					
		Restriction of flow within the waterways if too much debris is introduced to waterway or is stuck in culverts or creek crossings	Pre-construction and construction	Moderate	Moderate	Moderate	Negligible	Low
			Operation					
			Pre-construction and construction	High	Moderate	High	Negligible	Low
			Operation					
Water quality Waterways	Changes to receiving water quality and hydrology	Routine tunnel dewatering operations resulting in a reduction of receiving water quality and changes to hydrological regimes specific to tributary of Western Creek	Pre-construction and construction	Moderate	Major	High	Negligible	Low
			Operation					
		Diversion of overland flow influencing local hydrological regime and subsequent water quality specific to tributary of Laidley Creek	Pre-construction and construction	Moderate	Moderate	Moderate	Low	Low
			Operation					
		Diversion of overland flow influencing local hydrological regime and subsequent water quality specific to tributaries of Western Creek	Pre-construction and construction	Moderate	Moderate	Moderate	Low	Low
			Operation					
		Changes to receiving water quality from dewatering of artificial waterbodies	Pre-construction and construction	Moderate	Low	Low	Low	Low
			Pre-construction and construction	High	Low	Moderate	Low	Low
Erosion and sediment control Water quality	Increase in salinity	Increased salinity in proximal watercourses from land disturbance	Pre-construction and construction	Moderate	High	High	Negligible	Low
				High	High	Major	Negligible	Low

Aspect	Potential impact	Specific impact	Phase	Sensitivity	Initial impact		Residual impact	
					Magnitude	Significance	Magnitude	Significance
Erosion and sediment control General interference with existing surface water	Increases in erosion and sedimentation	Disturbance of the bed, banks and riparian zone of waterways	Pre-construction and construction	Moderate	High	High	Negligible	Low
			Operation		Moderate	Moderate	Negligible	Low
			Pre-construction and construction	High	High	Major	Negligible	Low
			Operation		Moderate	High	Negligible	Low
		Increased turbidity and sedimentation; and potential mobilisation of contaminants through erosion from disturbance activities near waterways	Pre-construction and construction	Moderate	High	High	Negligible	Low
			Operation		Moderate	Moderate	Negligible	Low
			Pre-construction and construction	High	High	Major	Negligible	Low
			Operation		Moderate	High	Negligible	Low
		Increased turbidity and potential mobilisation of contaminants from stockpiled areas	Pre-construction and construction	Moderate	Moderate	Moderate	Negligible	Low
			Pre-construction and construction	High	Moderate	High	Negligible	Low
		Increased turbidity and potential mobilisation of contaminants from dewatering activities near excavations	Pre-construction and construction	Moderate	Moderate	Moderate	Negligible	Low
			Pre-construction and construction	High	Moderate	High	Negligible	Low
		Increased sedimentation can impact the function of culverts/creek crossing and impede flow of the waterway	Pre-construction and construction	Moderate	Moderate	Moderate	Negligible	Low
			Operation		Low	Low	Negligible	Low
			Pre-construction and construction	High	Moderate	High	Negligible	Low
			Operation		Low	Moderate	Negligible	Low
Erosion and sediment control Water quality Waterways	Increase in contaminants	Contamination of waterway from inadequate storage of fuels, oils and contaminants	Pre-construction and construction Operation	Moderate	Low	Low	Negligible	Low
			Pre-construction and construction Operation	High	Low	Moderate	Negligible	Low
		Runoff from areas of disturbed contaminated lands nearby waterways	Pre-construction and construction	Moderate	Low	Low	Negligible	Low
			Pre-construction and construction	High	Low	Moderate	Negligible	Low
		Introduction of contaminants from stockpiled areas	Pre-construction and construction	Moderate	Low	Low	Negligible	Low
			Pre-construction and construction	High	Low	Moderate	Negligible	Low

Aspect	Potential impact	Specific impact	Phase	Sensitivity	Initial impact		Residual impact	
					Magnitude	Significance	Magnitude	Significance
Erosion and sediment control Water quality Waterways (continued)	Increase in contaminants (continued)	Contaminants can enter waterways after rainfall events from rolling stock or after weed control activities	Operation	Moderate	Moderate	Moderate	Negligible	Low
			Operation	High	Moderate	High	Negligible	Low
		Potential contamination of waterways from failed equipment or from failed infrastructure	Pre-construction and construction Operation	Moderate	Moderate	Moderate	Negligible	Low
			Pre-construction and construction Operation	High	Moderate	High	Negligible	Low
Erosion and sediment control	Exacerbation of listed impacts above, from inadequate rehabilitation processes	Potential for sedimentation and increased turbidity within waterways if areas are either not rehabilitated or inadequate rehabilitation occurs	Pre-construction and construction Operation	Moderate	Moderate	Moderate	Negligible	Low
			Pre-construction and construction Operation	High	Moderate	High	Negligible	Low
		Inadequate rehabilitation increasing erosion and sedimentation within waterways impacting the function of culverts/creek crossing and impeding flow of the waterway	Pre-construction and construction Operation	Moderate	Moderate	Moderate	Negligible	Low
			Pre-construction and construction Operation	High	Moderate	High	Negligible	Low

Table notes:

1. Includes implementation of design mitigation specified in Section 13.8.1.1.
2. Includes proposed mitigation measures specified in Section 13.8.1.2.
3. Defined watercourses of Lower Lockyer Creek and Western Creek sub-catchments: Lockyer Creek and Western Creek.

13.9.2 Hydrology and flooding

The Project alignment embankment, drainage structures and associated works were included in each of the hydraulic models to form the developed case. Progressive mitigation of impacts was undertaken through refinement of the design as detailed in Table 13.24 to arrive at the adopted design including bridges and culverts. A range of flood events, including extreme events, were modelled and resulting flood impacts associated with the adopted design were identified along the Project alignment and at flood sensitive receptors and neighbouring localities including Grantham, Gatton, Forest Hill, Laidley, Grandchester and Calvert.

The impact of the Project design has been mitigated with resulting impacts upon the existing flood regime quantified and compared against the flood impact objectives listed in Table 13.7. These criteria address the requirements of the ToR and have been used to guide and refine the Project design. The following sections present the outcomes of the flood impact assessment for each of the floodplains crossed by the Project alignment.

Detailed results are in Appendix M: Hydrology and Flooding Technical Report.

13.9.2.1 Helidon to Lawes

Between Helidon and Lawes, the Project includes the following structures that convey flood flows:

- Two rail bridges
- Two road bridges
- Eight rail reinforced concrete box culverts (RCBC) banks
- Nine rail reinforced concrete pipe (RCP) banks.

Due to the proximity of the Project alignment to the existing West Moreton System rail corridor and the flood immunity requirements for the Project, refinement of the existing drainage structures and introduction of new drainage structures underneath the West Moreton System rail corridor was required.

The West Moreton System rail corridor directly to the east of Gatton is overtopped under the 1% AEP event in the vicinity of Ch 45.68 km. At this location there are no existing drainage structures under the West Moreton System rail corridor and flow from Lockyer Creek inundates the area south of the West Moreton System rail corridor when the West Moreton System rail corridor is overtopped. This flow over the West Moreton System rail corridor introduces a significant level of complexity to the flow regime that was considered when designing the Project.

Over this portion of the Project alignment, the extension of twelve existing West Moreton System rail corridor banks of culverts and the introduction of five new banks of culverts under both the Project alignment and the West Moreton System rail corridor is required.

A summary of how the top of rail levels for the Project alignment compares with the West Moreton System rail corridor is in Table 13.27.

TABLE 13.27: HELIDON TO LAWES—COMPARISON OF PROJECT AND EXISTING TOP OF RAIL LEVELS

Location	Comparison of top of rail levels
West of Gatton	Project alignment varies between 0.2 m and 2.0 m higher than West Moreton System rail corridor
Through Gatton	Project alignment varies between 0.2 m and 1.0 m higher than West Moreton System rail corridor
Eastern Drive	Project alignment varies between 0.7 m lower and 0.7 m higher than West Moreton System rail corridor
East of Gatton to Lawes	Project alignment varies between 0.2 m and 1.0 m higher than West Moreton System rail corridor

Details of the floodplain structures required to convey Lockyer Creek flood flows in this area are in Table 13.28 with structure locations in Figure 13.9. In addition, Table 13.29 presents details of road structures which convey flood flows under extreme events.

From Helidon to Ch 40.05 km there are no structures required for flood flows under the Project alignment. Local drainage structures are included in the design to cater for local catchment runoff in this area. Details of the local drainage culverts are provided in Appendix M: Hydrology and Flooding Technical Report.

TABLE 13.28: HELIDON TO LAWES—FLOOD STRUCTURE LOCATIONS AND DETAILS

Chainage	Structure name	Structure type	No of cells	Diameter or width (m)	Height (m) or Soffit level (m AHD)	Bridge length (m)
Ch 40.05 km	C40.05	RCP[2]	2	1.50	-	-
Ch 40.33 km	C40.33	RCBC[1]	4	2.082	1.98	-
Ch 41.07 km	C41.07	RCP[1]	2	0.425	-	-
Ch 41.99 km	C41.99	RCP[1]	2	0.75	-	-
Ch 42.60 km	C42.60	RCP[1]	2	1.00	-	-
Ch 43.15 km	330-BR06	Bridge	-	-	104.41	122.0
Ch 43.15 km	330-BR31	Bridge	Matching existing rail bridge			
Ch 43.58 km	C43.58	RCBC[1]	1	0.06	0.375	-
Ch 43.94 km	C43.94	RCP[1]	3	0.45	-	-
Ch 44.45 km	C44.45	RCBC[2]	8	2.40	0.90	-
Ch 44.90 km	C44.90	RCP[1]	2	0.90	-	-
Ch 45.76 km	C45.76	RCP[1]	1	0.90	-	-
Ch 46.49 km	C46.49	RCBC[1]	1	0.75	0.90	-
Ch 47.22 km	C47.22	RCBC[1]	1	2.90	1.94	-
Ch 47.24 km	C47.24	RCP[2]	10	1.20	-	-
Ch 47.57 km	C47.57	RCP[2]	2	1.20	-	-
Ch 47.81 km	C47.81	RCBC[1]	1	2.40	1.80	-
Ch 48.46 km	C48.46	RCBC[1]	1	1.60	1.40	-
Ch 49.52 km	330-BR10	Bridge	-	-	90.22	28.0
Ch 49.57 km	C49.57	RCBC[2]	6	2.40	1.20	-

Table notes:
1. The Project alignment runs parallel to the West Moreton System rail corridor rail embankment at this location. The existing culvert(s) is proposed to be extended and matched through the proposed rail embankment.
2. The Project alignment runs parallel to the West Moreton System rail corridor embankment at this location. A new culvert(s) is proposed to be inserted through the West Moreton System rail corridor rail embankment and the proposed Project rail embankment.

TABLE 13.29: HELIDON TO LAWES—ROAD STRUCTURE LOCATIONS AND DETAILS

Road name	Structure name	Structure type	Soffit level (m AHD)	Bridge length (m)
Eastern Drive—northbound	330-BR09N	Bridge	106.97	103.0
Eastern Drive—southbound	330-BR09S	Bridge	107.81	103.0

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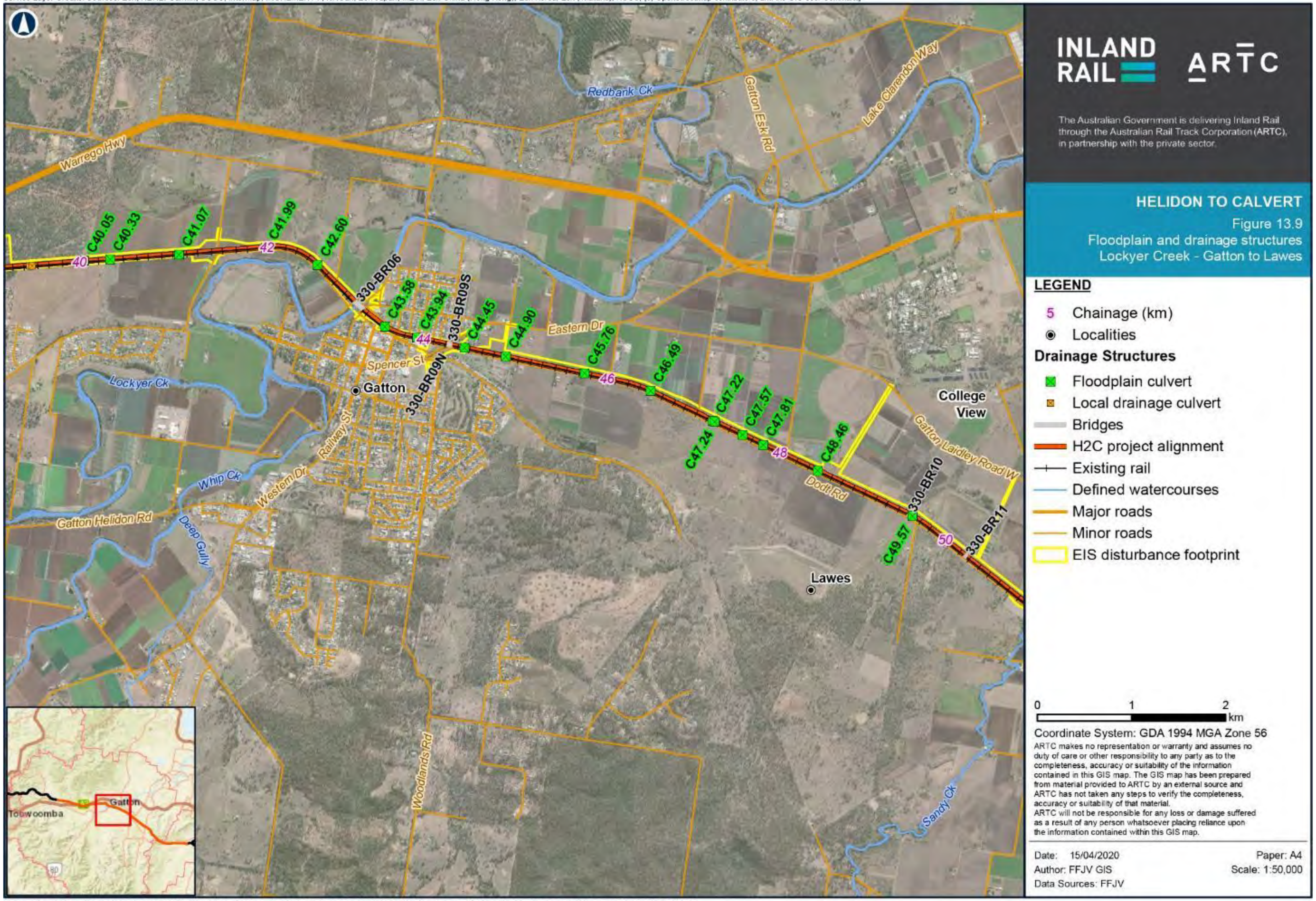

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Change in peak water levels

Figure 13.10 presents the change in peak water levels under the 1% AEP event and Table 13.30 presents details of where the changes in peak water levels lie outside the flood impact objectives. In this case, only Dodt Road experiences a change in peak water levels above the flood impact objectives as discussed in Table 13.30. Elsewhere, the changes in peak water levels under the 1% AEP event comply with the flood impact objectives (refer Section 13.5.2.2). This includes at the localities of Grantham, Helidon and Gatton.

TABLE 13.30: HELIDON TO LAWES—1% AEP EVENT—CHANGE IN PEAK WATER LEVELS OUTSIDE FLOOD IMPACT OBJECTIVES

Chainage / Location	Flood impact objectives for 1% AEP event	Change in peak water level (mm)	Comment
Ch 47.22 km Dodt Road	≤100 mm*	+200	This is a localised increase in peak water levels and is due to the overtopping of the existing West Moreton System rail corridor being eliminated through the inclusion of additional culverts and extension of existing culverts to pass under the Project alignment. This increase is located at the culvert outlet (C47.22) and is above the flood impact objectives. The impact reduces to less than 100 mm immediately downstream of Dodt Road.

Table note:
* Maximum, but may be less if identified from consultation.

Analysis of the 20%, 10%, 5% and 2% AEP events was also undertaken and figures showing the change in peak water levels are in Appendix M: Hydrology and Flooding Technical Report. For events up to the 5% AEP, flood flows are generally contained in the Lockyer Creek channel and defined flow paths. No increases in peak water levels occur under these events along this section of the Project alignment. Under the 2% AEP event, flood waters break out of Lockyer Creek to the east of Gatton and flow along the Project alignment towards Lawes. No increases in peak water levels above the flood impact objectives have been identified.

Change to duration of inundation

The change in duration of inundation is quantified by assessing and comparing the ToS for the Existing Case and Developed Case. The ToS under the 1% AEP event is in Table 13.31 for locations where changes in peak water levels lie outside the flood impact objectives. There is only a minor change occurring on Dodt Road and it does not affect the existing trafficability of the roadway. There are no adverse impacts at the localities of Grantham, Helidon and Gatton.

TABLE 13.31: HELIDON TO LAWES—1% AEP EVENT—CHANGE IN TIME OF SUBMERGENCE

Chainage/ Location	Existing Case ToS (hrs)	Developed Case ToS (hrs)	Comment
Ch 47.22 km Dodt Road	39.3	39.7	There is a maximum increase in ToS along Dodt Road of +0.4 hrs (+24 minutes). The trafficability of Dodt Road is controlled by a low point near Ch 49.50 km and there is no change in ToS at that location.

The AAToS for the 1% AEP event has been determined for Dodt Road and is in Table 13.32. AAToS is a measurement of the estimated time per year of submergence of a roadway due to flooding. This change in conditions does not result in a change to AAToS and hence the amenity of the roadway is unchanged.

TABLE 13.32: AVERAGE ANNUAL TIME OF SUBMERGENCE COMPARISON AT DODT ROAD

Location	AAToS Existing Case (hrs/yr)	AAToS Developed Case (hrs/yr)	Difference (hrs/yr)
Dodt Road	1.3	1.3	Nil

Flood flow distribution

Overall, the Project has minimal impacts on flood flows and floodplain conveyance/storage with significant floodplain structures included to maintain or improve the existing flood regime.

Velocities

Figure 13.11 presents the changes in peak velocities under the 1% AEP event associated with the Project alignment. In general, the changes are minor, with most changes in velocities experienced between approximately Ch 46.0 km and Ch 49.5 km. This is where new and extended culvert structures are introduced to address flow complexity where the existing West Moreton System rail corridor is overtopped. There are no adverse impacts at the localities of Grantham, Helidon and Gatton.

Peak water levels, flows and velocities from the hydrology and flooding investigation have been used to inform the scour protection design. The scour protection has been designed in accordance with *AGRD Part 5B: Drainage* (Austroads, 2013). Scour protection was specified where the outlet velocities for the 1% AEP event exceed the allowable soil velocities for the particular soil type for each location, which was identified from published soil mapping.

Desktop analysis and the geotechnical investigations did not contain sufficiently detailed information for a refined scour assessment at the bridge sites. A conservative scour estimation based on the 1 in 2,000 AEP event has been undertaken for the pier substructure design based on available information and will be refined during detailed design.

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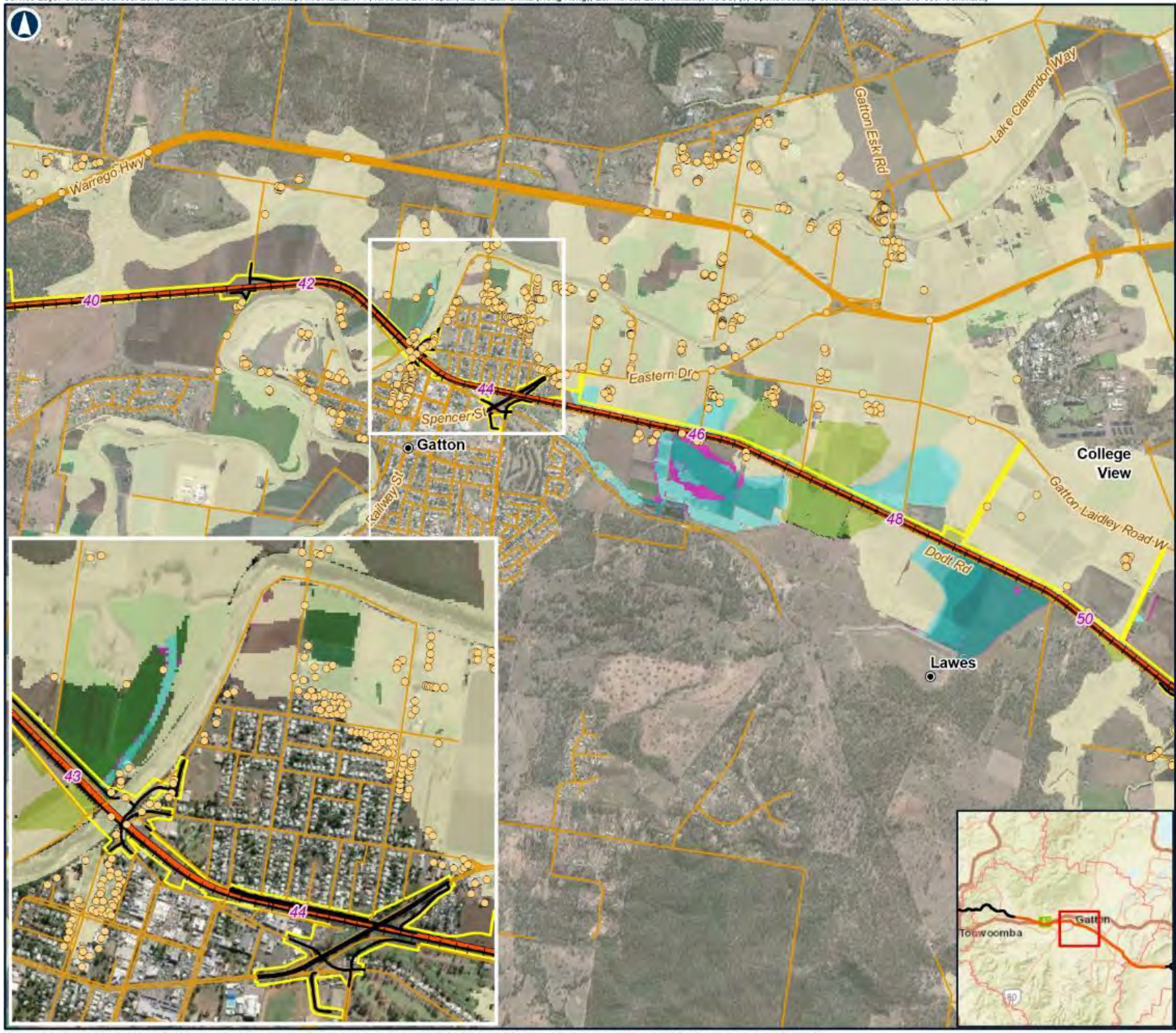

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HELIDON TO CALVERT

Figure 13.10: Developed Case
1% AEP event: Change in peak water levels
Lockyer Creek - Gatton to Lawes

LEGEND

- Flood sensitive receptors
- H2C project alignment
- Road design
- Major roads
- Minor roads
- EIS disturbance footprint

Change in peak water levels (m)

- < -0.5
- -0.5 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet

0 1 2 km

Coordinate System: GDA 1994 MGA Zone 56

Date: 15/04/2020
Author: FFJV GIS
Data Sources: FFJV

Paper: A4
Scale: 1:50,000

Map by: DMcP Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201908191528_H2C_EIS_Surface_Water_figures\330-EAP-201908191528_Fig13.10_Afflux100_Inset_ARTC_A4.mxd Date: 15/04/2020 17:37

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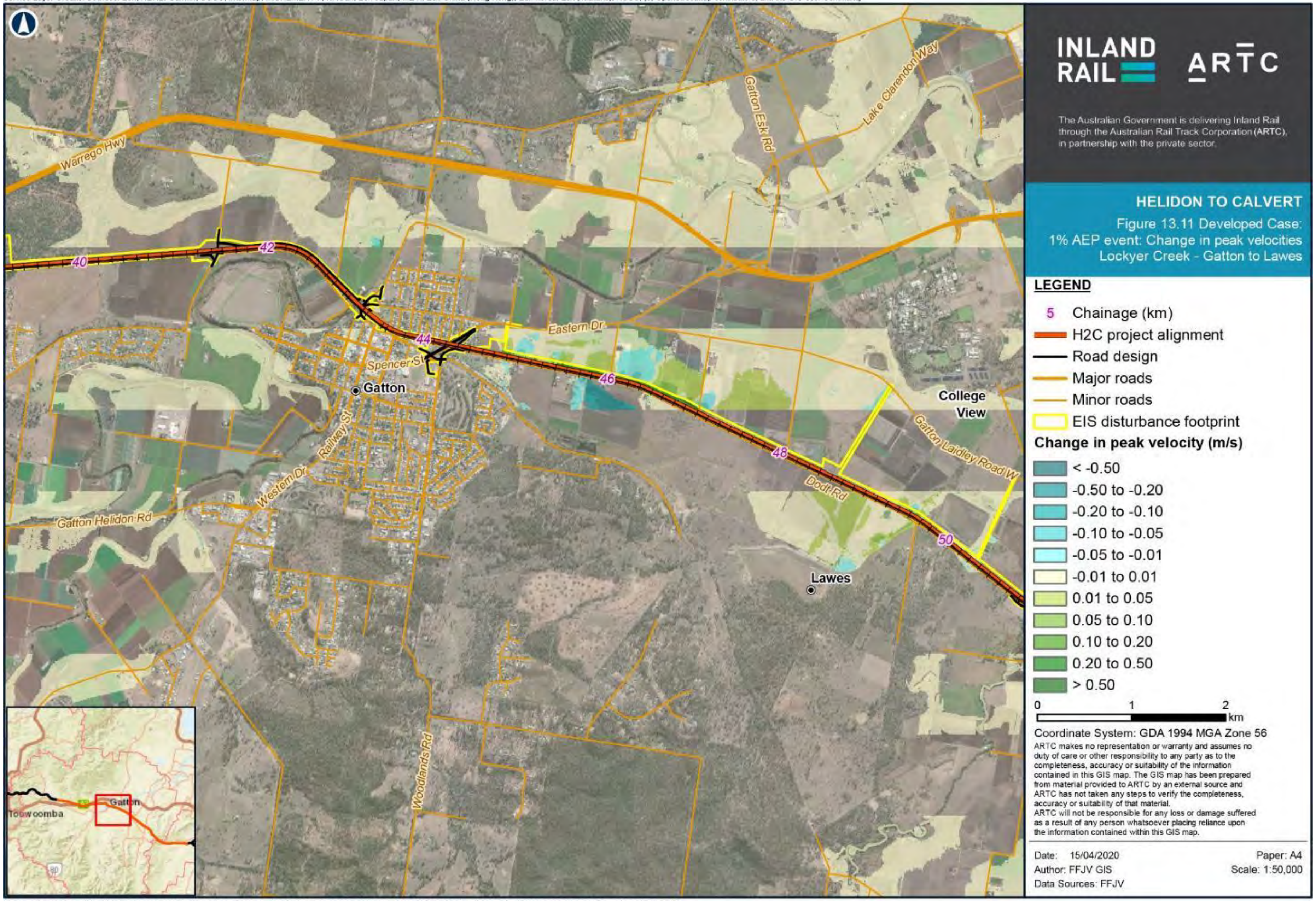

HELIDON TO CALVERT

Figure 13.11 Developed Case: 1% AEP event: Change in peak velocities Lockyer Creek - Gatton to Lawes

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Extreme events

Several design events larger than the 1% AEP event, including the 1 in 2,000 AEP, 1 in 10,000 AEP and PMF, have been modelled to assess the performance of the Project and to review impacts on the flooding regime.

Figure 13.12, Figure 13.13 and Figure 13.14 present the change in peak water levels for the 1 in 2,000 AEP, 10,000 AEP and PMF events respectively.

The flood inundation extent and peak water levels increase across the floodplain between Helidon and Lawes as the severity of the flood event increases. Review of changes in peak water levels at flood sensitive receptors indicates that the potential increases associated with the Project alignment are a small percentage change as compared to the flood depth (<10% for most locations). Larger impacts occur under the PMF event where there are already high flood depths as would be expected under such a rare event. The depth of inundation for each of the extreme events is in Appendix M: Hydrology and Flooding Technical Report. No new flow paths or significant additional areas of inundation are created due to the Project alignment under these extreme events.

The Project alignment runs parallel to the existing West Moreton System rail corridor for approximately 50 per cent of the proposed Project alignment. The West Moreton System rail corridor governs the existing flood conditions. With the Project alignment in place, modelling has shown that there are no significant changes in flood inundation extents or velocities, and flow behaviour is consistent with the existing conditions. There are changes in peak water levels, which is attributed to the height of the proposed Project alignment required to achieve the desired flood immunity design criteria. Mitigation of impacts has been carried out through the extension of West Moreton System rail corridor culverts under the Project alignment and inclusion of new culverts under both the Project and West Moreton System rail corridor alignments.

The risk of overtopping along the Project alignment has been assessed for the modelled extreme events. During these extreme events the Project alignment is inundated at a number of locations. Table 13.33 outlines the overtopping locations and depths.

TABLE 13.33: HELIDON TO LAWES—PROJECT ALIGNMENT—EXTREME EVENT TOP OF TRAIL OVERTOPPING DETAILS

Chainage	1 in 2,000 AEP overtopping depth (m)[1]	1 in 10,000 AEP overtopping depth (m)[1]	PMF overtopping depth (m)[1]
Ch 38.48 km to Ch 41.79 km	0.30	0.50	4.30
Ch 44.05 km to Ch 44.26 km	0.60	1.00	4.20
Ch 44.47 km to Ch 46.24 km	0.50	0.65	1.65
Ch 48.09 km to Ch 49.90 km	0.25	0.45	2.20

Table note:
1. The length of Project alignment overtopped (i.e. above top of rail level) varies between locations and events.

Under these rare events, the bridge structures and culverts have been designed to allow adequate passage of flow during the flood events and ʻdammingʻ effects are therefore not expected to occur. In addition, failure of the embankment during a flood event is not predicted to result in a dam failure type event as the water level on both sides of the embankment is predicted to be similar. No redirection of flood flows under these extreme events is expected.

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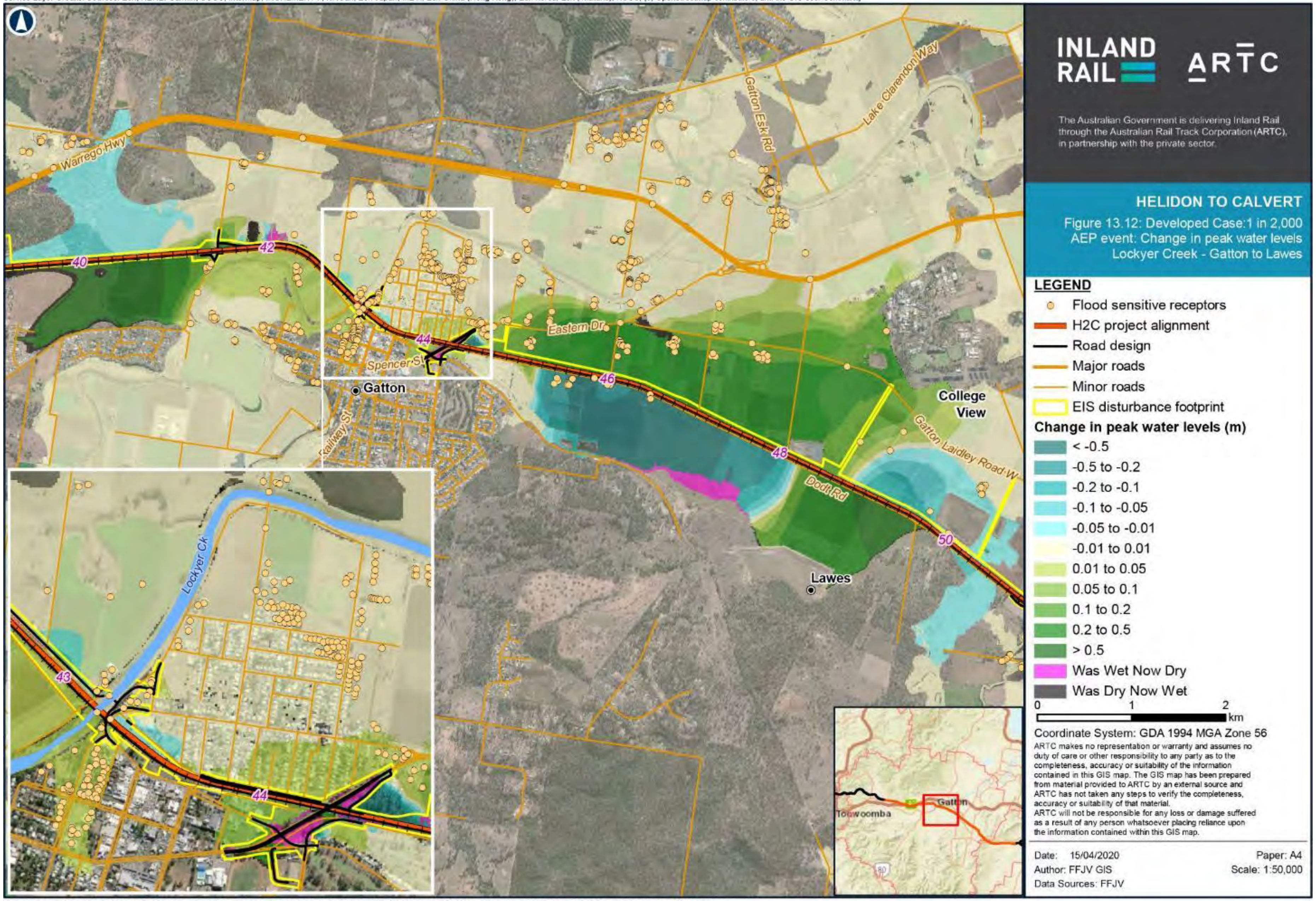

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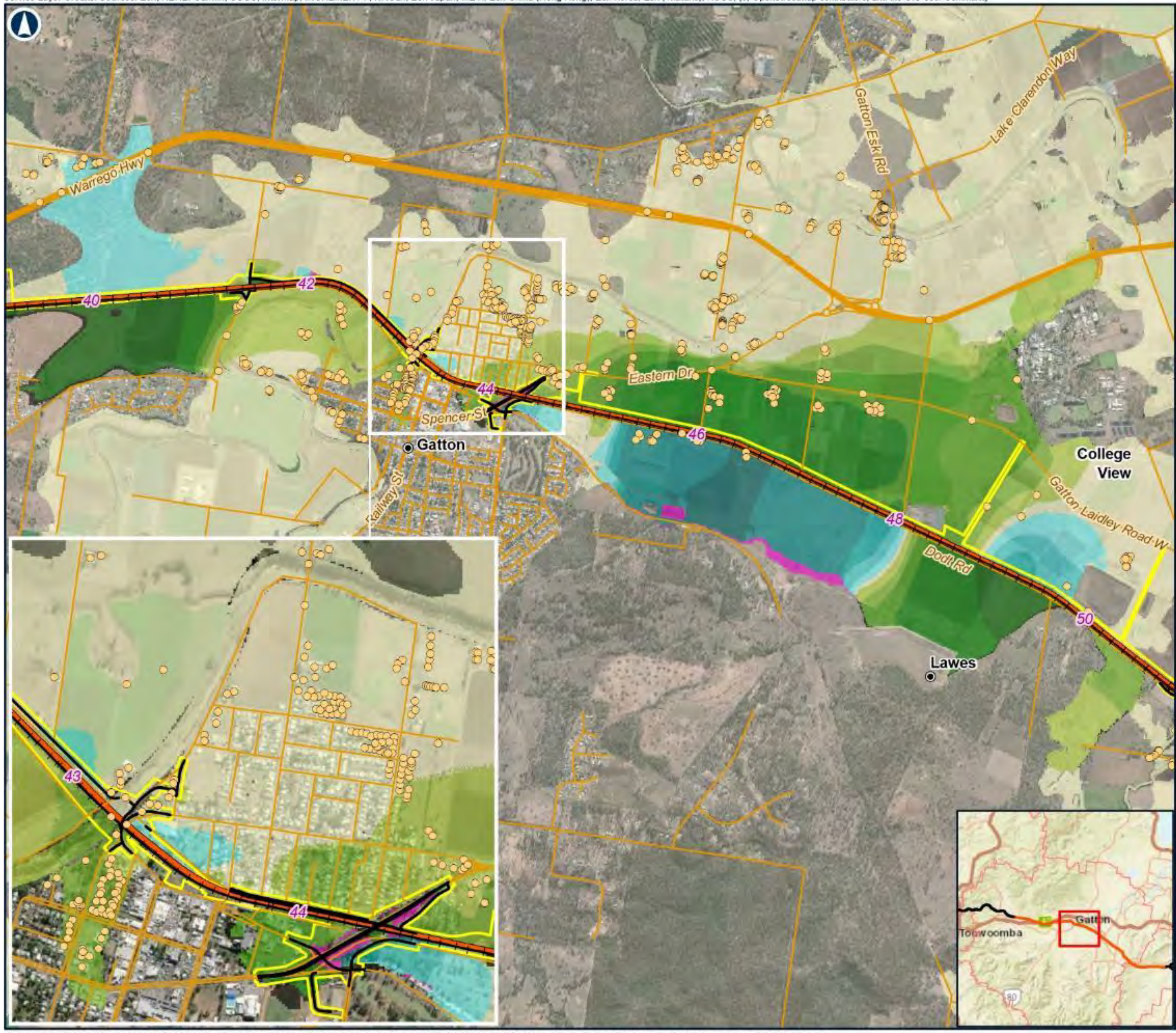

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HELIDON TO CALVERT

Figure 13.13: Developed Case: 1 in 10,000 AEP event: Change in peak water levels Lockyer Creek - Gatton to Lawes

LEGEND

- Flood sensitive receptors
- H2C project alignment
- Major roads
- Minor roads
- Road design
- EIS disturbance footprint

Change in peak water levels (m)

- < -0.5
- -0.5 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet

0 1 2 km

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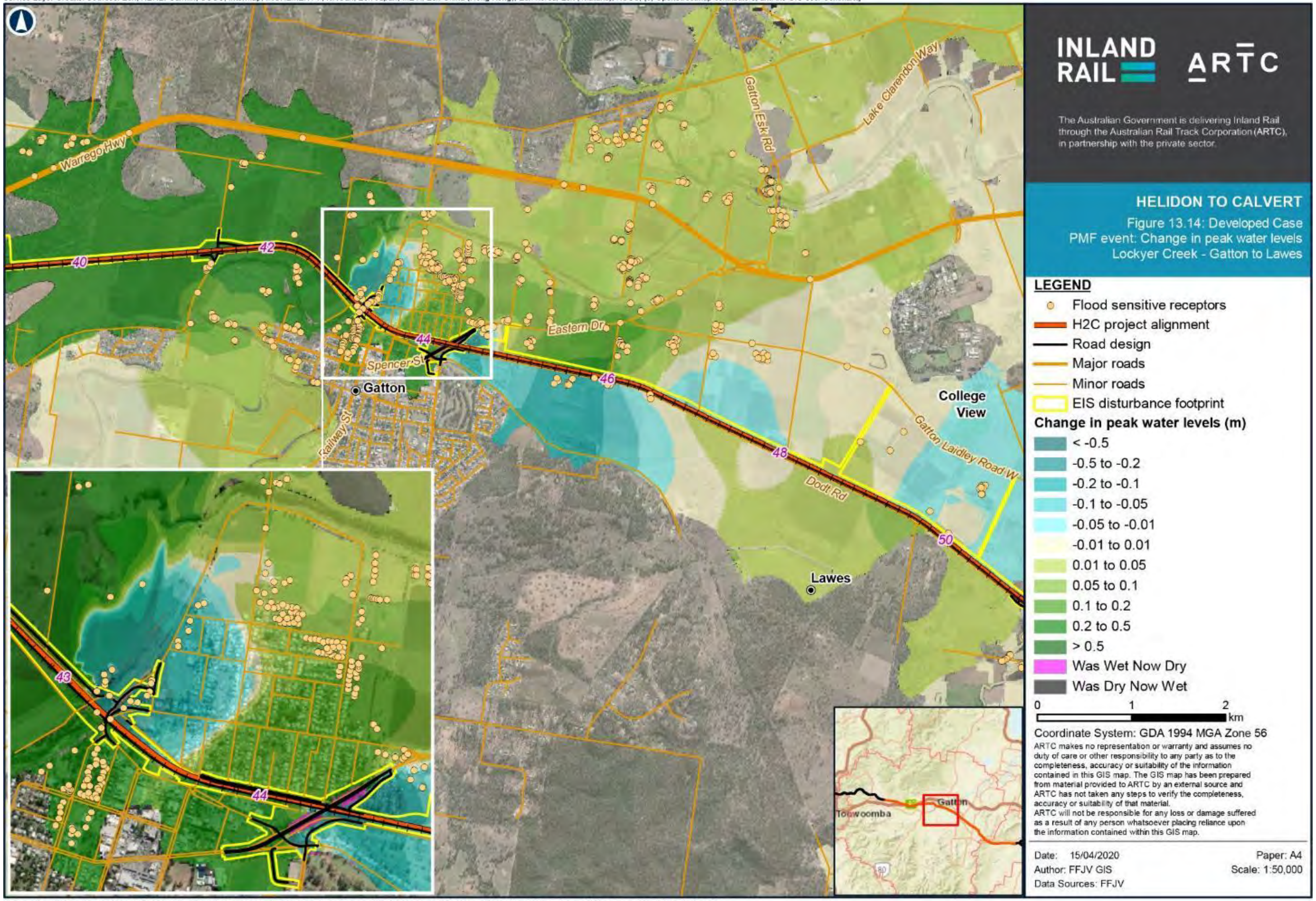

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Climate change

The climate change guidelines set out in ARR 2016 have been followed and used to assess the potential impact of increased rainfall on peak water levels in the vicinity of the Project.

The Representative Concentration Pathways 8.5 (2090 horizon) climate change scenario has been adopted for the Project with an associated increase in rainfall intensity of 18.7 per cent across catchment area. Climate change results in increased peak water levels of between 0.3 m and 1.0 m in the vicinity of the Project alignment under the 1% AEP event.

Appendix M: Hydrology and Flooding Technical Report includes figures that show the change in peak water levels associated with the Project alignment for the 1% AEP event with climate change . The inclusion of climate change increases the flows in Lockyer Creek and this increases the extent of inundation to the west of Gatton as compared to the 1% AEP event. This leads to some minor redistribution of flood flows and a lowering in peak water levels of up to 100 mm immediately downstream of Gatton. No flood sensitive receptors are adversely affected by these changes.

To the west of Gatton, towards Lawes, there in an increase in peak water levels of up to 500 mm on the floodplain area along the northern side of the Project alignment. This change in flood depth impacts on two properties with impacts at the house on each property summarised in Table 13.34. As can be seen with climate change the depth of inundation increases significantly. An open drainage channel is proposed along the Project alignment in this area and while this conveys the 1% AEP event flows, it does not cater for the increased flows under the climate change scenario. The predicted changes associated with climate change will progressively occur up to the 2090 horizon. Refinement of this area could be undertaken during detailed design.

TABLE 13.34: HELIDON TO LAWES—CHANGE IN PEAK WATER LEVELS 1% AEP EVENT WITH CLIMATE CHANGE

	1% AEP event with climate change		1% AEP event	
Sensitive receptor number	Change in peak water level (mm)	Flooded depth (m)	Change in peak water level (mm)	Flooded depth (m)
380 (House)	+135	0.94	+6	0.24
440 (House)	+258	0.99	-6	0.55

There is a further location near a culvert bank under the Project alignment where peak water levels locally increase by up to 2.7 m. This increase in peak water levels is a result of varying floodplain flow conditions. Under the 1% AEP event (without climate change), these culverts are affected by backwater from Lockyer Creek. Under the 1% AEP event (with climate change) breakout from Lockyer Creek reaches these culverts and creates a higher upstream peak water level.

Blockage

Blockage of drainage structures has been assessed in accordance with ARR 2016 requirements. The blockage assessment resulted in no blockage factor being applied to bridges and a blockage factor of 25 per cent being applied to culverts. A minimum culvert size of 900 mm diameter was also adopted to reduce potential for blockage and for ease of maintenance.

ARR 2016 guidelines focus on blockage of small bridges and culverts. The floodplain bridges proposed for the Project alignment are all multi-span large bridges. ARR 2016 notes that there are limited instances of multiple span bridges being observed with blockages similar to those seen at single-span bridges or culverts.

Two blockage sensitivity scenarios were tested with both 0 per cent and 50 per cent blockage of all culverts. The change in peak water levels on Dodt Road between Ch 47.08 km and Ch 47.81 km increases from 200 mm to 220 mm in the 0 per cent blockage scenario and reduces to 140 mm in the 50 per cent blockage scenario. These minor changes do not affect the existing trafficability of the roadway.

Desktop analysis and the geotechnical investigations did not contain sufficiently detailed information for a refined scour assessment at the bridge sites. A conservative scour estimation based on the 1 in 2,000 AEP event has been undertaken for the pier substructure design based on available information and will be refined during detailed design.

13.9.2.2 Lawes to Laidley

Between Lawes and Laidley (including Forest Hill), the Project includes the following structures that convey flood flows:

- Nine rail bridges
- Eleven rail RCBC banks
- Five road RCBC banks
- Three rail RCP banks.

Due to the proximity of the Project alignment to the existing West Moreton System rail corridor and the flood immunity requirements for the Project, refinement of the existing drainage structures underneath the West Moreton System rail corridor was required.

There are two portions of the West Moreton System rail corridor (near Hunt Street—Ch 52.33 km and east of Forest Hill—Ch 53.22 km to Ch 54.19 km) that are overtopped under the 1% AEP event. In these locations, flow over the West Moreton System rail corridor introduces a significant level of complexity to the flow regime that was considered when introducing the Project alignment.

Over the Lawes to Laidley section of the Project alignment, the extension of eight existing banks of culverts under the West Moreton System rail corridor and the introduction of five new banks of culverts under both the Project alignment and the West Moreton System rail corridor was required.

A summary of how the top of rail levels for the Project alignment compares with the West Moreton System rail corridor is in Table 13.35.

TABLE 13.35: LAWES TO LAIDLEY—COMPARISON OF PROJECT AND EXISTING TOP-OF-RAIL LEVELS

Location	Comparison of top of rail levels
West of Forest Hill	Project alignment varies between 0.2 m and 1.2 m higher than West Moreton System rail corridor
Forest Hill	Project alignment varies between 0.2 m and 1.5 m higher than West Moreton System rail corridor
East of Forest Hill	Project alignment varies between 0.2 m and 1.5 m higher than West Moreton System rail corridor
West of Laidley	Project alignment varies between 2.0 m and 3.0 m higher than West Moreton System rail corridor

Details of the floodplain structures required to convey floodplain flood flows are in Table 13.36. In addition, Table 13.37 presents details of road structures that convey flood flows under extreme events.

Floodplain structure locations, and the location of local culverts for road and local catchment drainage, are in Figure 13.15a and Figure 13.15b. Details of the local drainage culverts are provided in Appendix M: Hydrology and Flooding Technical Report.

TABLE 13.36: LAWES TO LAIDLEY—FLOOD STRUCTURE LOCATIONS AND DETAILS

Chainage	Structure name	Structure type	No of cells	Diameter or width (m)	Height (m) or Soffit level (m AHD)	Bridge length (m)
Ch 50.26 km	330-BR11	Bridge	-	-	90.24	28.0
Ch 51.37 km	330-BR12	Bridge	-	-	94.04	29.0
Ch 51.57 km	C51.57	RCBC2	15	2.40	1.20	-
Ch 51.60 km	330-BR13	Bridge	-	-	92.97	44.0
Ch 52.55 km	C52.55	RCBC[1]	1	1.15	1.20	-
Ch 52.67 km	C52.67	RCBC2	15	2.40	1.20	-
Ch 52.68 km	C52.68	RCP[1]	1	0.90	-	-
Ch 53.39 km	C53.39	RCBC2	15	2.40	1.20	-
Ch 53.48 km	C53.48	RCBC[2]	6	2.40	1.20	-
Ch 53.50 km	C53.50	RCBC[1]	2	2.215	2.01	-
Ch 53.97 km	C53.97	RCBC[2]	8	2.40	1.20	-
Ch 53.99 km	C53.99	RCBC[1]	2	2.05	1.99	-
Ch 54.74 km	330-BR14	Bridge	-	-	95.95	128.0
Ch 54.81 km	C54.81	RCBC[1]	8	2.10	2.10	-
Ch 54.83 km	C54.83	RCBC[1]	8	2.10	2.10	-
Ch 54.84 km	C54.84	RCBC[1]	9	2.10	2.10	-
Ch 55.45 km	C55.45	RCP[1]	1	0.90	-	-
Ch 55.82 km	330-BR26/ 330-BR27[3]	Bridge	-	-	99.65	760.0
Ch 55.85 km	C55.85	RCP	15	1.20	-	-
Ch 56.71 km	330-BR28/ 330-BR29[3]	Bridge	-	-	103.00	437.0
Ch 57.30 km	330-BR16	Bridge	-	-	103.96	75.0

Table notes:
1. The Developed Case alignment runs parallel to the West Moreton System rail corridor rail embankment at this location. The existing culvert(s) is proposed to be extended and matched through the proposed rail embankment.
2. The Developed Case alignment runs parallel to the West Moreton System rail corridor embankment at this location. A new culvert(s) is proposed to be inserted through the West Moreton System rail corridor rail embankment and the proposed H2C rail embankment.
3. A crossing loop is included at this location leading the presence of a second bridge structure.

TABLE 13.37: LAWES TO LAIDLEY—ROAD STRUCTURE LOCATIONS AND DETAILS

Road name/structure	Structure type	No of cells	Width x height (m)
Gordon Street at level crossing	RCBC	2	1.80 x 0.90
Gordon Street Culvert 1	RCBC	2	1.80 x 0.90
Gordon Street Culvert 2	RCBC	3	1.20 x 0.45
Gordon Street Culvert 3	RCBC	1	1.50 x 0.60
Old Laidley Forest Hill Road	RCBC	3	1.80 x 0.90

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Figure 13.15a
Floodplain and drainage structures
Sandy Ck/Laidley Ck - Forest Hill to Laidley

LEGEND

- 5 Chainage (km)
- Localities

Drainage Structures

- Floodplain culvert
- Road culvert
- Bridges
- H2C project alignment
- Existing rail
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint

0 0.5 1 km

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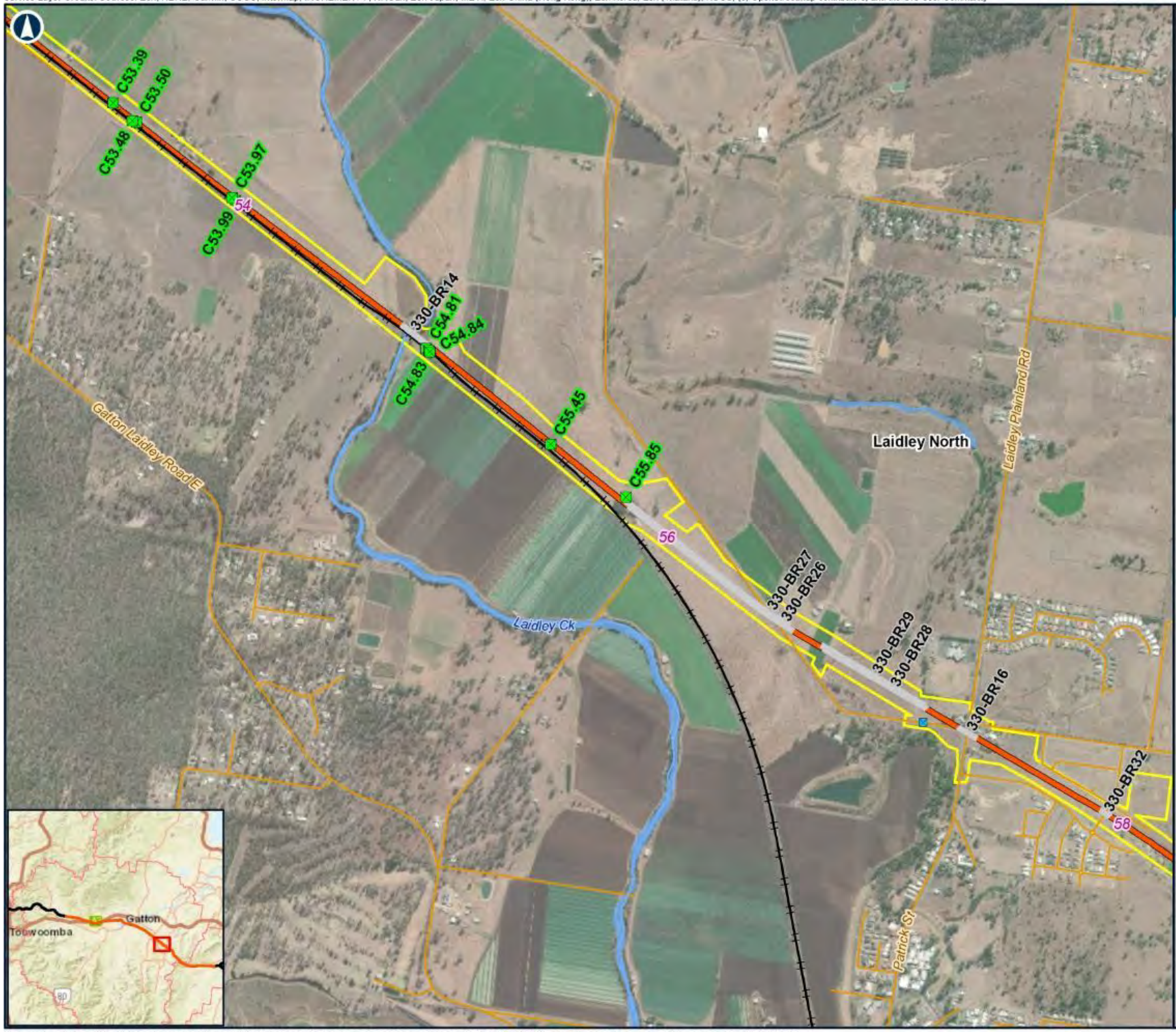

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Figure 13.15b
Floodplain and drainage structures
Sandy Ck/Laidley Ck - Forest Hill to Laidley

LEGEND

5 Chainage (km)

Drainage Structures

- Floodplain culvert
- Road culvert
- Bridges
- H2C project alignment
- Existing rail
- Defined watercourses
- Major roads
- Minor roads
- EIS disturbance footprint

0 0.5 1 km

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Change in peak water levels

Figure 13.16a and Figure 13.16b presents the change in peak water levels under the 1% AEP event and Table 13.38 presents details of where the changes to peak water levels lie outside the flood impact objectives. Except for these locations, the changes in peak water levels under the 1% AEP event comply with the flood impact objectives (refer Section 13.5.2.2). This includes at the localities of Forest Hill and Laidley.

TABLE 13.38: LAWES TO LAIDLEY—CHANGE IN PEAK WATER LEVELS OUTSIDE DESIGN CRITERIA

Chainage/ location	Design criteria for 1% AEP event	Change in peak water level (mm)	Comment
Ch 51.57 km Agricultural land	≤200 mm* (localised increases of up to 400 mm)	+400	This increase is concentrated against the Project embankment and dissipates to less than 100 mm within 70 m of the Project disturbance footprint. This localised increase in peak water level is a result of including additional culverts to help mitigate impacts on habitable dwellings (in Forest Hill) upstream of the West Moreton System rail corridor in extreme flood events.
Ch 52.55 km Residential or commercial/industrial properties. Habitable dwelling	≤50 mm* ≤10 mm for habitable dwelling	+10 to +40	The western corner of the property, near the habitable dwelling, experiences shallow sheet flow. With the introduction of the Project alignment, peak water levels increase in this area by up to 40 mm. Under the 1% AEP event flood waters do not reach the habitable dwelling.
Ch 52.68 km Agricultural land	≤100 mm	+100	This agricultural land is a mixture of open cropping land and raised outdoor hydroponics under scaffold-shade coverings. This localised increase in peak water level is a result of including culverts under the Project alignment and additional culverts under the West Moreton System rail corridor to mitigate impacts on habitable dwellings in Forest Hill in extreme flood events. These culverts also eliminate overtopping of West Moreton System rail corridor rail level.
Ch 53.40 km Hall Road	≤100 mm*	+200	This localised increase in peak water level is a result of including culverts under the Project alignment and additional culverts under the West Moreton System rail corridor to mitigate impacts on habitable dwellings in Forest Hill in extreme flood events. These culverts also eliminate overtopping of West Moreton System rail corridor rail level.
Ch 55.85 km West Moreton System rail corridor	≤100 mm*	+160	This increase is due to shallow sheet flow trapped behind the Project alignment where it joins the West Moreton System rail corridor. This is a localised impact only.
Ch 56.72 km Agricultural land	≤100 mm*	+125	This increase in peak water levels is within the proposed Project disturbance footprint (i.e. nominally 30 m from the toe of embankment). This increase dissipates to below 115 mm within the Old Laidley Forest Hill Road easement and drops to below 100 mm within 50 m of the road easement.
Ch 57.15 km Old Laidley Forest Hill Road diversion	≤100 mm*	+180	This increase is 80 mm above the 100 mm criteria for roads. However, the average ground level of the road diversion has increased by approximately 100 mm as compared to the existing road levels. This results in a reduction of time of inundation whilst maintaining the existing flood immunity level.

Chainage/ location	Design criteria for 1% AEP event	Change in peak water level (mm)	Comment
Ch 57.25 km Agricultural land (Between Old Laidley Forest Hill Road and West Moreton System rail corridor)	≤200 mm* (localised increases of up to 400 mm)	+360	This increase is concentrated against the Project embankment and dissipates to less than 100 mm within the Project disturbance footprint. The Project embankment provides a reduction in peak water levels of up to 125 mm, which benefits the local community facilities (cricket pitch and associated grounds) and local access.
Ch 57.45 km Residential lot—2RP25655	≤10 mm	+90	This residential dwelling is located within the Project disturbance footprint and is assumed to be resumed as part of the Project.

Table note:
* Maximum, but may be less if identified from consultation.

Analysis of the 20%, 10%, 5% and 2% AEP events was also undertaken and figures showing the change in peak water levels are in Appendix M: Hydrology and Flooding Technical Report. Each of the events have increasing levels of overbank flood flows outside the defined creek channels with significant floodplain inundation by the 10% AEP event.

Under the 20% AEP only minor changes in peak water levels occur. Changes in peak water levels gradually spread as the flood magnitude increases with impacts focussed along the alignment. All events demonstrate a reduction in peak water levels to the east of Forest Hill associated with inclusion of culverts under the Project alignment and new culverts under the West Moreton System rail corridor.

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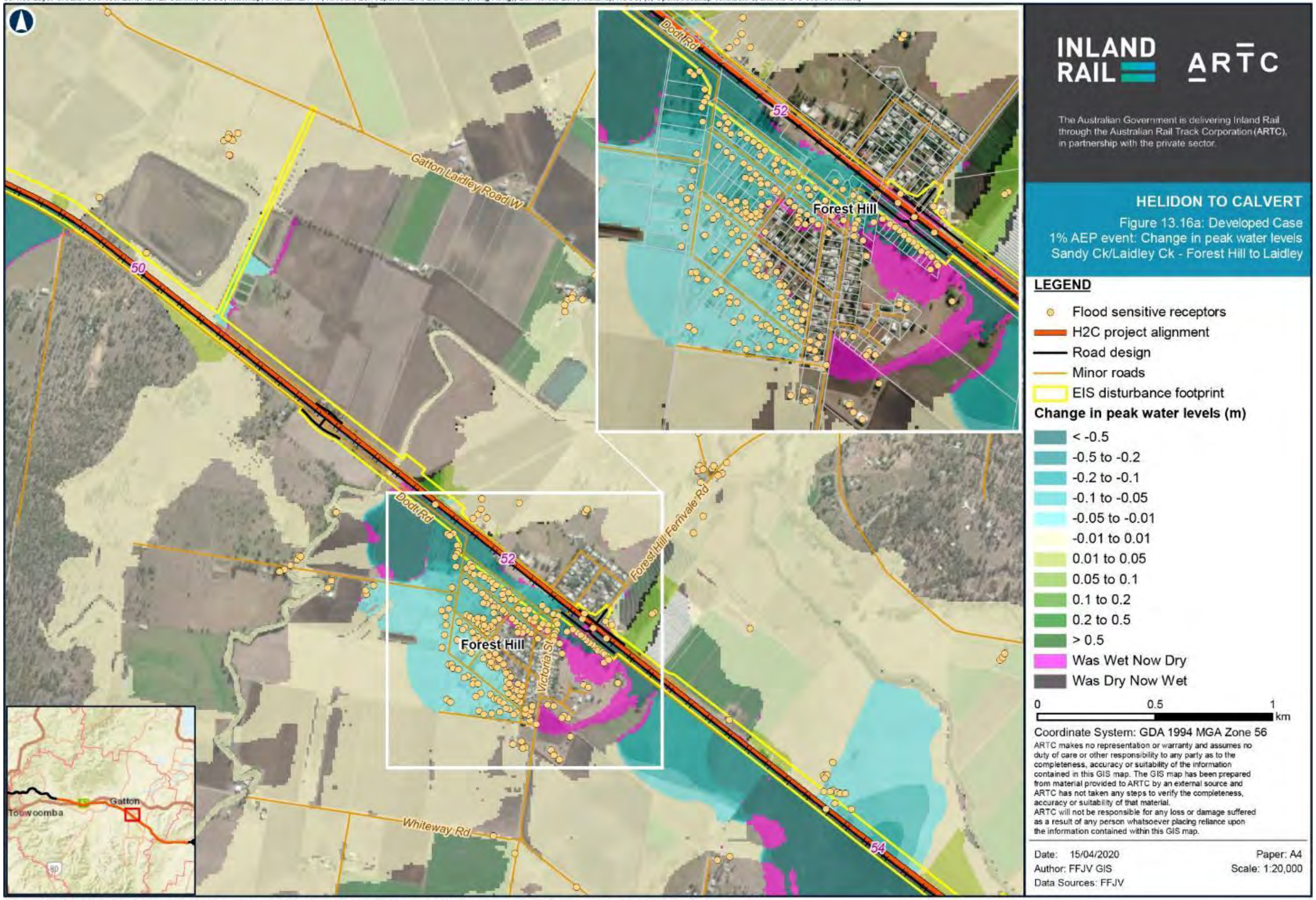

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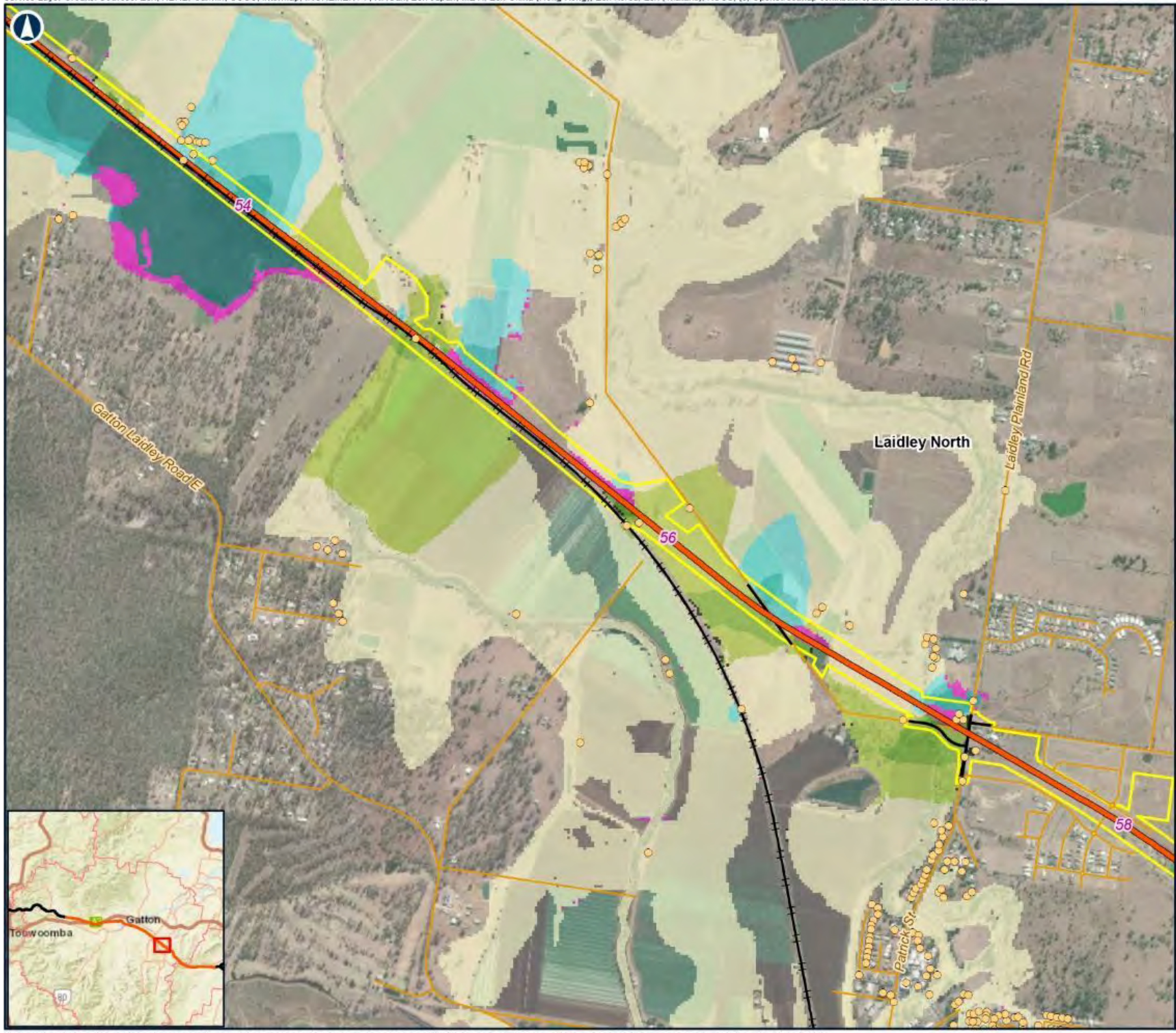

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Figure 13.16b: Developed Case
1% AEP event: Change in peak water levels
Sandy Ck/Laidley Ck - Forest Hill to Laidley

LEGEND

- Flood sensitive receptors
- H2C project alignment
- Road design
- Minor roads
- EIS disturbance footprint

Change in peak water levels (m)

- < -0.5
- -0.5 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet

0 0.5 1 km

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Change to duration of inundation

The change in duration of inundation is quantified by assessing and comparing the ToS for the Existing and Developed cases. The ToS for the 1% AEP event is in Table 13.39 for locations where changes in peak water levels lie outside the flood impact objectives. There are no adverse impacts at the locality of Laidley.

TABLE 13.39: LAWES TO LAIDLEY—1% AEP EVENT—CHANGE IN TIME OF SUBMERGENCE

Chainage/ Location	Existing Case ToS (hrs)	Developed Case ToS (hrs)	Comment
Ch 51.57 km Agricultural land	50.8	51.7	This is a localised increase in ToS and is due to the inclusion of additional culverts under the Project alignment to mitigate impacts on habitable dwellings in extreme flood events.
Ch 52.68 km High Quality Agricultural land	48.3	48.4	This is a localised increase in ToS and is due to the overtopping of the existing West Moreton System rail corridor being eliminated through the inclusion of additional culverts and extension of existing culverts to pass under the Project alignment.
Ch 53.40 km Hall Road, Forest Hill	48.3	57.4	This is a localised increase in ToS and is due to the overtopping of the existing West Moreton System rail corridor being eliminated through the inclusion of additional culverts and extension of existing culverts to pass under the Project alignment. These culverts also mitigate impacts on habitable dwellings under extreme flood events. The trafficability of Hall Road is controlled by a low point near Ch 53.99 km and this location does not experience any change in ToS.
Ch 55.85 km Agricultural land (southern side of the Project alignment tie-in to the existing West Moreton System rail corridor)	33.4	43.2	This increase is localised around the Project alignment tie-in with the West Moreton System rail corridor where sheet flow is concentrated.
Ch 57.15 km Old Laidley Forest Hill Road realignment works	56.5	32.5	The ground level of the road diversion is higher than the existing road by approximately 100 mm and this results in a reduction in ToS.

The AAToS for the 1% AEP event has been determined for Hall Road and is detailed in Table 13.40. AAToS is a measurement of the estimated time per year of submergence of a roadway due to flooding. This change in duration of inundation results only in a minor change to AAToS and hence the amenity the roadway is maintained.

TABLE 13.40: AVERAGE ANNUAL TIME OF SUBMERGENCE COMPARISON AT HALL ROAD (FOREST HILL)

Location	AAToS Existing Case (hrs/yr)	AAToS Developed Case (hrs/yr)	Difference (hrs/yr)
Hall Road	14.1	16.8	+2.7

Flood flow distribution

Overall, the Project has minimal impacts on flood flows and floodplain conveyance/storage with significant floodplain structures included to maintain or improve the existing flood regime.

Velocities

Figure 13.17a and Figure 13.17b present the change in peak velocities under the 1% AEP event associated with the Project alignment. In general, the changes are minor and located close to the Project alignment. The area with the most changes in peak velocities is between approximately Ch 53.0 km and Ch 54.0 km where new and extended culvert structures are required to address flow complexity where the existing West Moreton System rail corridor rail line is overtopped. There are no adverse impacts at the localities of Forest Hill and Laidley.

Peak water levels, flows and velocities from the hydrology and flooding investigation have been used to inform the scour protection design. The scour protection has been designed in accordance with AGRD Part 5B: Drainage (Austroads 2013). Scour protection was specified where the outlet velocities for the 1% AEP event exceed the allowable soil velocities for the particular soil type for each location, which was identified from published soil mapping.

Desktop analysis and the geotechnical investigations did not contain sufficiently detailed information for a refined scour assessment at the bridge sites. A conservative scour estimation based on the 1 in 2,000 AEP event has been undertaken for the pier substructure design based on available information and will be refined during detailed design.

Extreme events

Several design events larger than the 1% AEP event, including the 1 in 2,000 AEP, 1 in 10,000 AEP and PMF, have been modelled to assess the performance of the Project and to review impacts on the flooding regime. Figure 13.18a and Figure 13.18b, Figure 13.19a and Figure 13.19b and Figure 13.20a and Figure 13.20b present the change in peak water levels for the 1 in 2,000 AEP, 10,000 AEP and PMF events respectively. As can be seen the flood inundation extent and peak water levels increase across the floodplain between Lawes and Laidley as the severity of the flood event increases. The depth of inundation for each of the extreme events is in Appendix M: Hydrology and Flooding Technical Report.

The Project alignment runs parallel to the existing West Moreton System rail corridor (for approximately 50 per cent of the proposed Project alignment) which governs the existing flood conditions. Under the extreme events, with the Project alignment in place, there are no significant changes in flood inundation or velocities, and flow behaviour is consistent with the existing conditions. There are changes in peak water levels which are attributed to the height of the proposed Project alignment required to achieve the desired flood immunity design criteria. Mitigation of impacts has been carried out through the extension of West Moreton System rail corridor culverts under the Project alignment and inclusion of a significant number of new culvert banks under both the Project alignment and the West Moreton System rail corridor. A number of these culvert banks have been included to specifically mitigate impacts under the extreme events. This has resulted in slight decreases in peak water levels in Forest Hill under the 1 in 2,000 AEP and 1 in 10,000 AEP events.

Review of changes in peak water levels at flood sensitive receptors indicates that the increases associated with the Project alignment for the PMF event are a small percentage change as compared to the flood depth. Under the PMF event there are already high flood depths as would be expected under such a rare event.

The risk of overtopping along the Project alignment has been assessed for the modelled extreme events. During the PMF event the Project alignment is inundated at two locations. Table 13.41 outlines the overtopping depths at these locations.

TABLE 13.41: LAWES TO LAIDLEY—PROJECT ALIGNMENT—EXTREME EVENT TOP OF RAIL OVERTOPPING DETAILS

Chainage	1 in 2,000 AEP overtopping depth (m)	1 in 10,000 AEP overtopping depth (m)	PMF overtopping depth (m)[1]
Ch 51.95 km to Ch 52.16 km	-	-	0.30
Ch 53.29 km to Ch 54.19 km	-	-	0.50

Table note:
The length of Project alignment overtopped (i.e. above top of rail level) varies between locations.

Under these rare events, the bridge structures and culverts have been designed to allow adequate passage of flow during the flood events and 'damming' effects are therefore not expected to occur. In addition, failure of the embankment during a flood event is not predicted to result in a dam failure type event as the water level on both sides of the embankment is predicted to be similar. No redirection of flood flows under these extreme events is expected.

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HELIDON TO CALVERT

Figure 13.17a Developed Case: 1% AEP event: Change in peak velocities Sandy Ck/Laidley Ck - Forest Hill to Laidley

LEGEND

- 5 Chainage (km)
- H2C project alignment
- Road design
- Minor roads
- EIS disturbance footprint

Change in peak velocity (m/s)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

0 0.5 1 km

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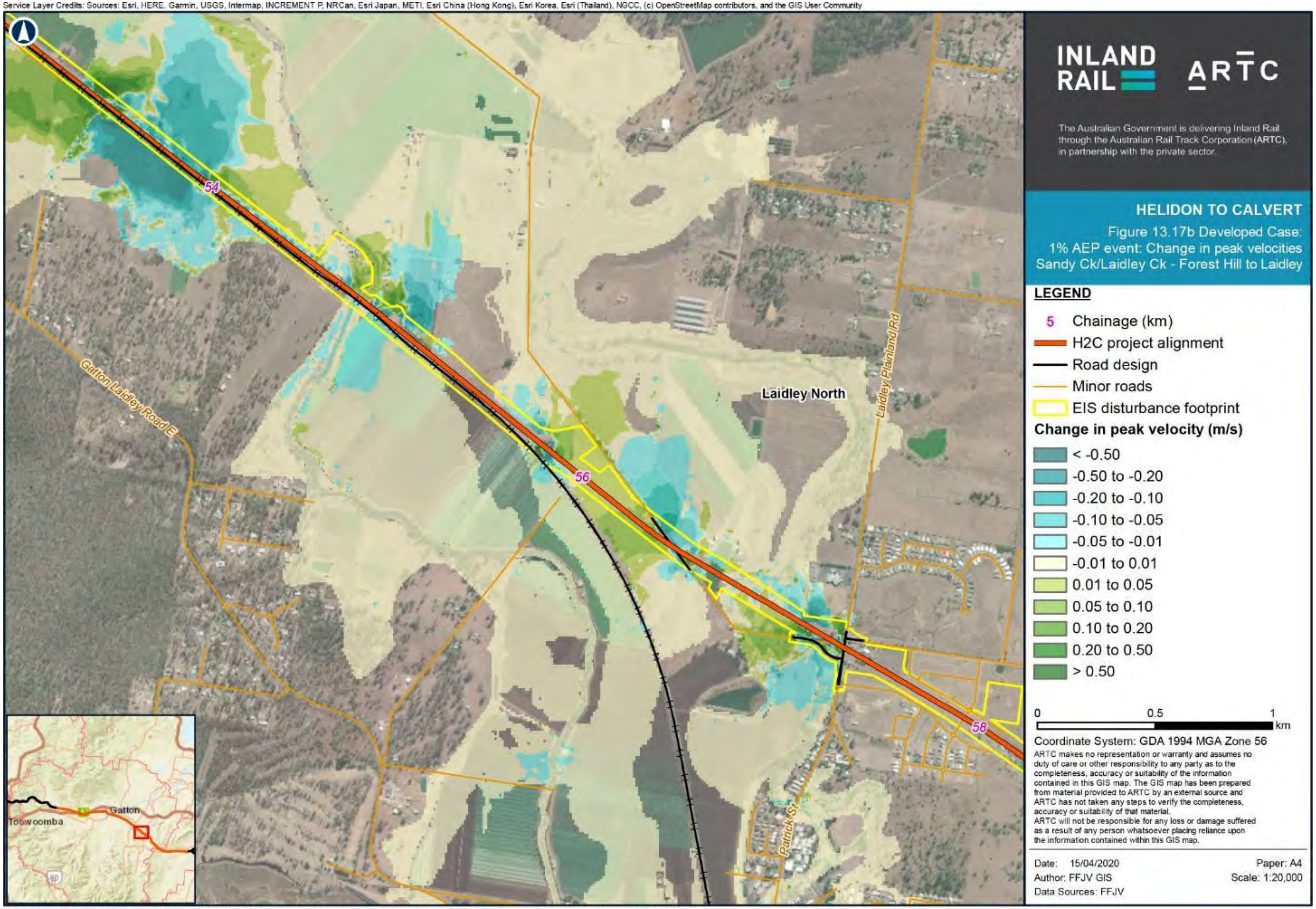

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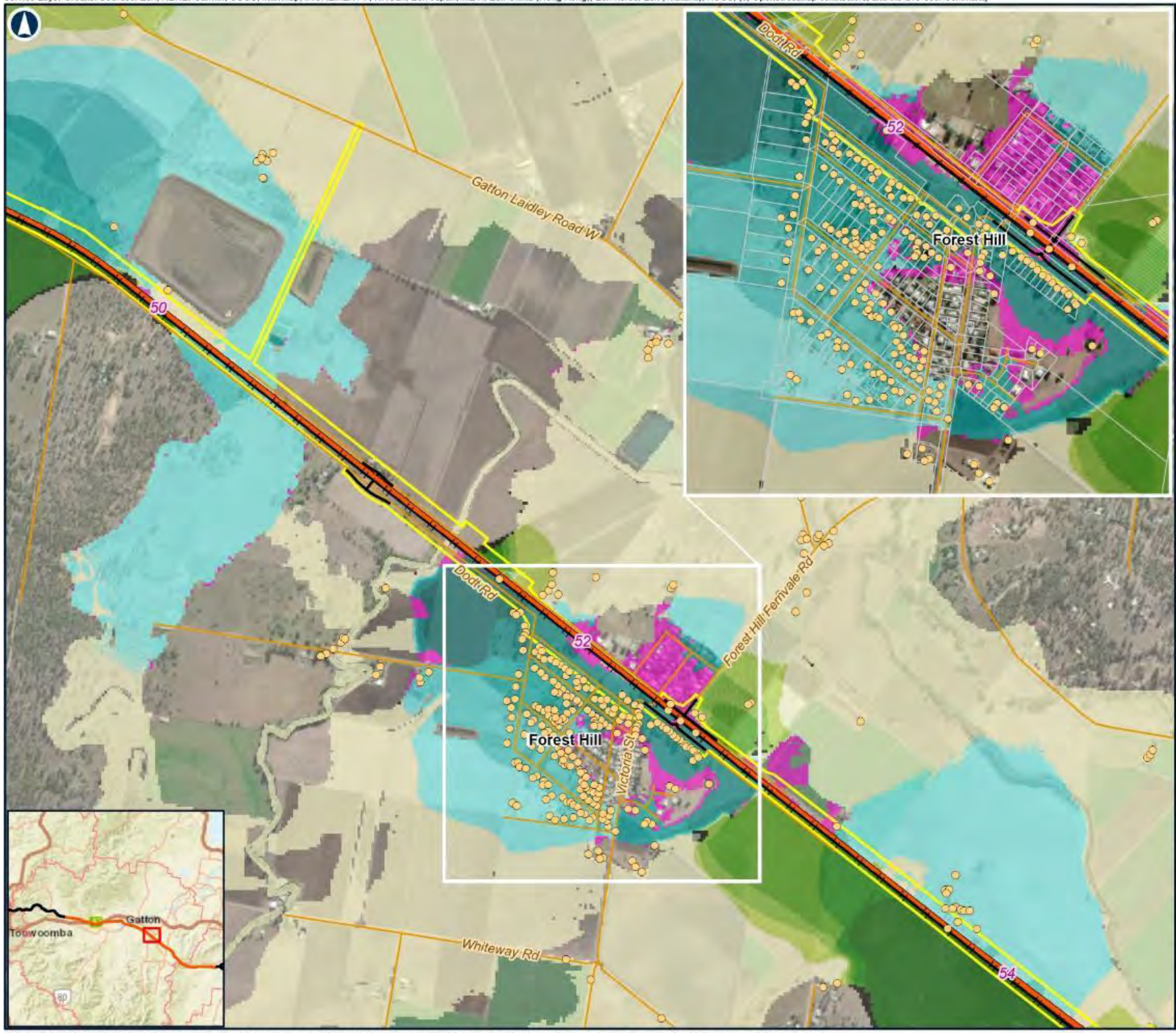

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HELIDON TO CALVERT

Figure 13.18a: Developed Case:1 in 2,000 AEP event: Change in peak water levels Sandy Ck/Laidley Ck - Forest Hill to Laidley

LEGEND

- Flood sensitive receptors
- H2C project alignment
- Road design
- Minor roads
- EIS disturbance footprint

Change in peak water levels (m)

- < -0.5
- -0.5 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 56

Date: 15/04/2020 Paper: A4
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Data Sources: FFJV

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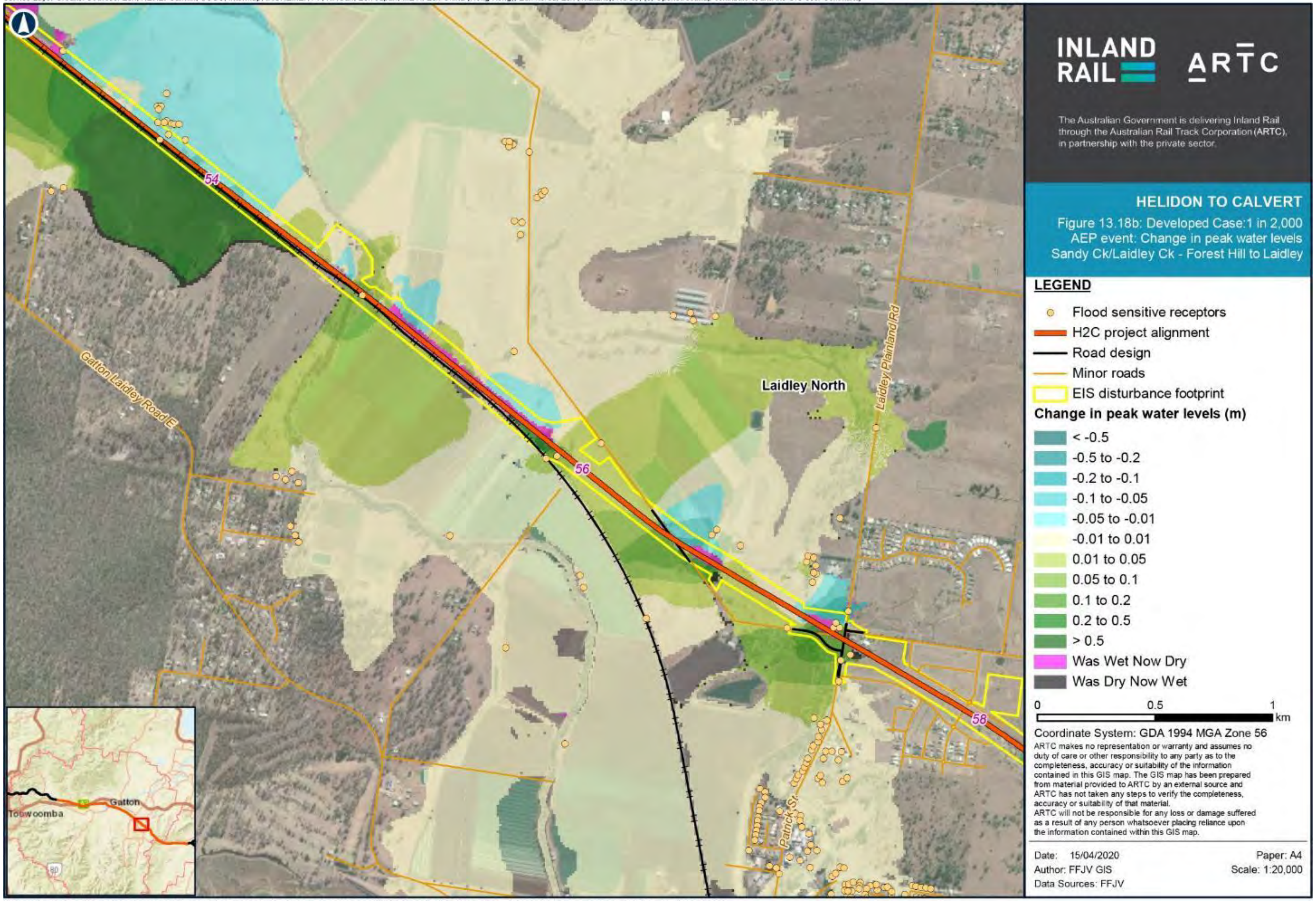

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HELIDON TO CALVERT

Figure 13.19a: Developed Case: 1 in 10,000 AEP event: Change in peak water levels Sandy Ck/Laidley Ck - Forest Hill to Laidley

LEGEND

- Flood sensitive receptors
- H2C project alignment
- Road design
- Minor roads
- EIS disturbance footprint

Change in peak water levels (m)

- < -0.5
- -0.5 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 56

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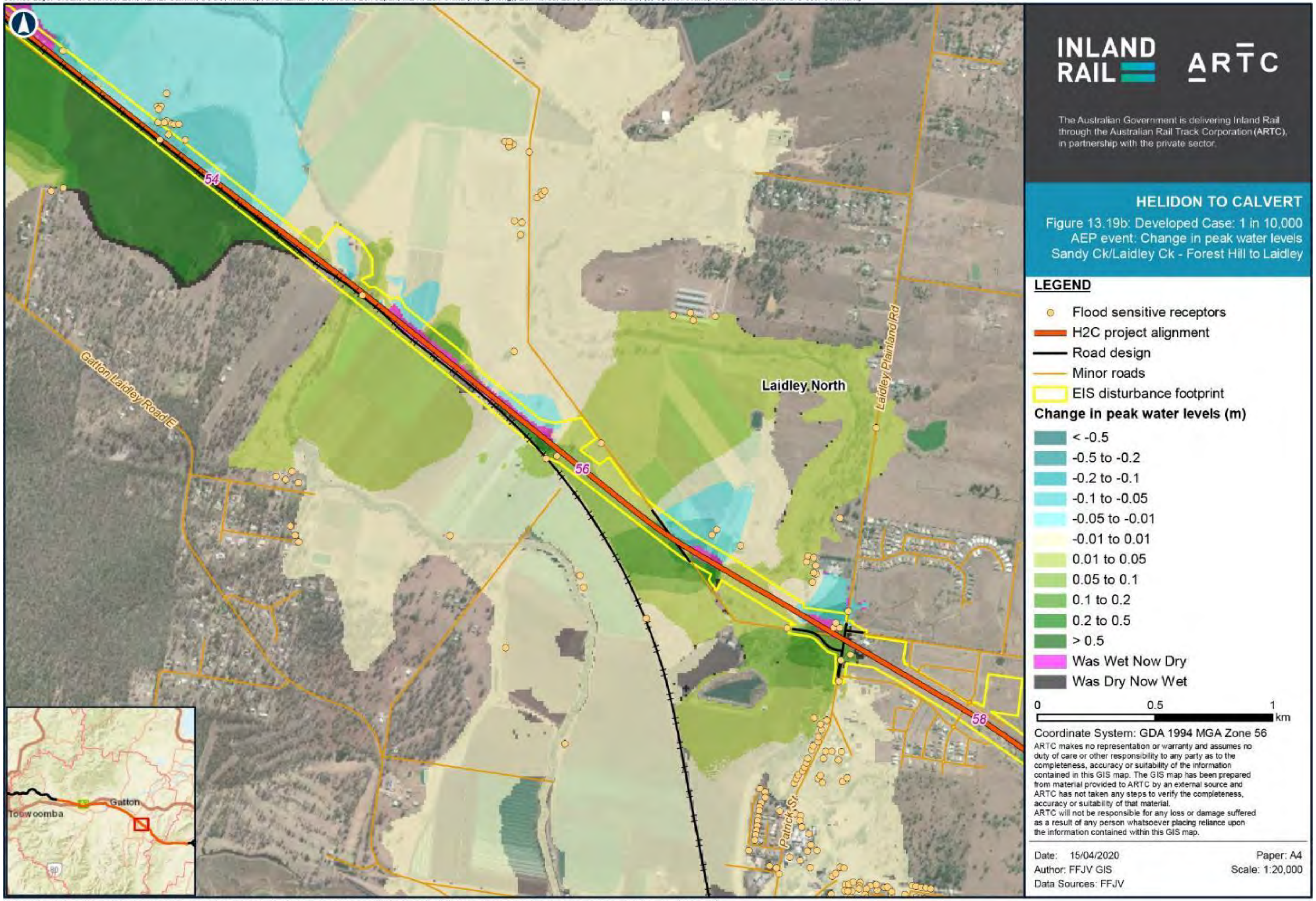

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HELIDON TO CALVERT

Figure 13.20a: Developed Case PMF event: Change in peak water levels Sandy Ck/Laidley Ck - Forest Hill to Laidley

LEGEND

- Flood sensitive receptors
- H2C project alignment
- Road design
- Minor roads
- EIS disturbance footprint

Change in peak water levels (m)

- < -0.5
- -0.5 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 56

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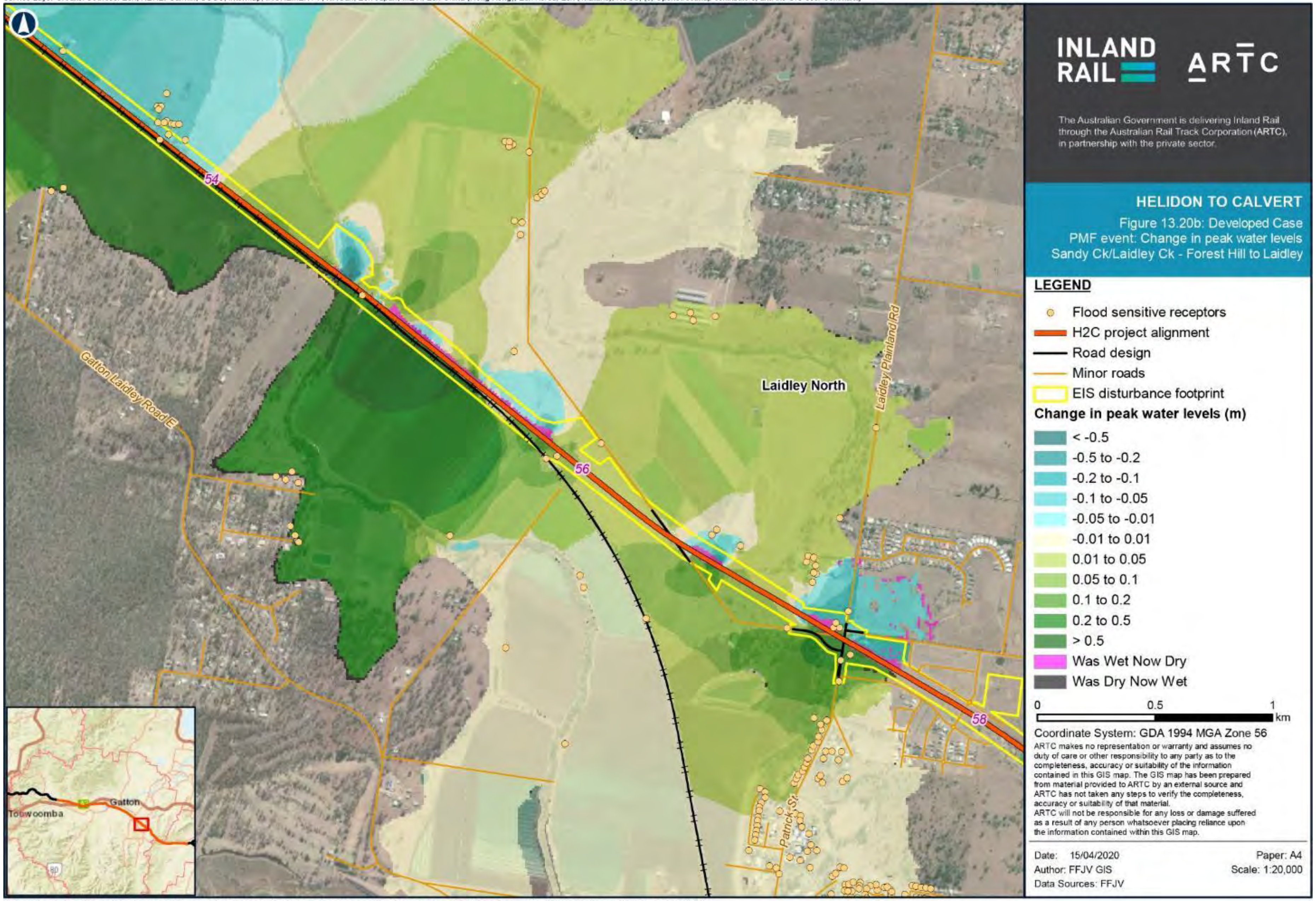

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Climate change

The climate change guidelines set out in ARR 2016 have been followed and used to assess the potential impact of increased rainfall upon peak water levels in the vicinity of the Project alignment.

The Representative Concentration Pathways 8.5 (2090 horizon) climate change scenario has been adopted for the Project with an associated increase in rainfall intensity of 18.7 per cent across catchment area. Climate change results in increased peak water levels of up to 0.46 m in the vicinity of the Project alignment under the 1% AEP.

Appendix M: Hydrology and Flooding Technical Report includes figures which present the change in peak water levels associated with the Project alignment for the 1% AEP event with climate change . The inclusion of climate change does not significantly alter the impacts between Forest Hill and Laidley and does not affect any flood sensitive receptors. Downstream of Forest Hill near the confluence of Lockyer Creek and Laidley Creek there is minor increase in peak water levels (< 50 mm) which is associated with the changes the flow distribution and timing on Lockyer Creek.

Blockage

Blockage of drainage structures has been assessed in accordance with ARR 2016 requirements. The blockage assessment resulted in no blockage factor being applied to bridges and a blockage factor of 25 per cent being applied to culverts A minimum culvert size of 900 mm diameter was also adopted to reduce potential for blockage and for ease of maintenance.

ARR 2016 guidelines focus on blockage of small bridges and culverts. The floodplain bridges proposed for the Project alignment are all multi-span large bridges. ARR 2016 notes that there are limited observed instances of multiple span bridges with blockages similar to those at single-span bridges or culverts.

Two blockage sensitivity scenarios were tested with both 0 per cent and 50 per cent blockage of all culverts. The following changes to sensitive receptors were identified for peak water levels on:

- The agricultural land around Ch 51.57 km increases from 400 mm to 410 mm in the 0 per cent blockage scenario and reduces to 350 mm in the 50 per cent blockage scenario
- The western corner of the property at Ch 52.55 km reduces from 40 mm to 31 mm in the 0 per cent blockage scenario and increases to 53 mm in the 50 per cent blockage scenario
- The agricultural land around Ch 52.68 km decreases from 100 mm to 80 mm in the 0 per cent blockage scenario and increases to 125 mm in the 50 per cent blockage scenario
- Hall Road at Ch 53.40 km increases from 200 mm to 260 mm in the 0 per cent blockage scenario and reduces to 120 mm in the 50 per cent blockage scenario
- The West Moreton System rail corridor at Ch 55.85 km reduces from 160 mm to 145 mm in the 0 per cent blockage scenario and increases to 175 mm in the 50 per cent blockage scenario.

The outcomes of blockage sensitivity scenarios indicate that peak water levels only change by small amounts with varying the culvert blockage levels and that the resulting impacts are similar.

Desktop analysis and the geotechnical investigations did not contain sufficiently detailed information for a refined scour assessment at the bridge sites. A conservative scour estimation based on the 1 in 2,000 AEP event has been undertaken for the pier substructure design based on available information and will be refined during detailed design.

13.9.2.3 Grandchester to Calvert

From Grandchester to Calvert, the Project includes the following structures that convey flood flows:

- Five rail bridges
- Ten rail RCBC banks
- Four road RCBC banks
- Twenty rail RCP banks.

Due to the proximity of the Project alignment to the existing West Moreton System rail corridor and the flood immunity requirements for the Project, refinement of the existing drainage structures under the West Moreton System rail corridor was required. In this location this requires the extension of eight existing West Moreton System rail corridor banks of culverts and the introduction of three new banks of culverts under both the Project alignment and the West Moreton System rail corridor.

A summary of how the top of rail levels of for the Project alignment compares with the West Moreton System rail corridor is in Table 13.42.

TABLE 13.42: GRANDCHESTER TO CALVERT—COMPARISON OF PROJECT AND QUEENSLAND RAIL TOP OF RAIL LEVELS

Location	Comparison of top of rail levels
East of Grandchester	Project alignment varies between 0.7 m and 2.0 m higher than West Moreton System rail corridor
West of Calvert	Project alignment varies between 0.2 m and 1.0 m higher than West Moreton System rail corridor
Calvert (tie-in to Calvert to Kagaru Project)	Project alignment varies between 1.0 m and 3.0 m higher than West Moreton System rail corridor

Details of the floodplain structures required to convey floodplain flows are in Table 13.43. In addition, Table 13.44 presents details of road structures that convey flood flows under extreme events. Figure 13.21a and Figure 13.21b present the location of floodplain structures, road and local catchment drainage structures. Details of the local drainage culverts are provided in Appendix M: Hydrology and Flooding Technical Report.

TABLE 13.43: GRANDCHESTER TO CALVERT—FLOOD STRUCTURE LOCATIONS AND DETAILS

Chainage	Structure name	Structure type	No of cells	Diameter or width (m)	Height (m) or Soffit level (m AHD)	Bridge length (m)
Ch 65.29 km	330-BR20	Bridge	-	-	88.24	516.0
Ch 65.90 km	C65.90	RCP	7	1.20	-	-
Ch 66.00 km	C66.00	RCP	15	1.20	-	-
Ch 66.04 km	C66.04	RCP	15	1.20	-	-
Ch 66.25 km	C66.25	RCP	30	1.20	-	-
Ch 66.43 km	C66.43	RCP	20	1.20	-	-
Ch 66.48 km	C66.48	RCP	10	1.20	-	-
Ch 66.52 km	C66.52	RCP	10	1.20	-	-
Ch 66.55 km	C66.55	RCP	10	1.20	-	-
Ch 66.58 km	C66.58	RCP	10	1.20	-	-
Ch 66.61 km	C66.61	RCP	10	1.20	-	-
Ch 66.76 km	C66.76	RCP	10	1.20	-	-
Ch 66.82 km	C66.82	RCP	10	1.20	-	-
Ch 66.93 km	C66.93	RCP	30	1.20	-	-
Ch 67.04 km	C67.04	RCP	10	1.20	-	-
Ch 67.25 km	C67.25	RCP	5	1.20	-	-
Ch 67.31 km	C67.31	RCP	25	1.20	-	-
Ch 67.36 km	C67.36	RCP	5	1.20	-	-
Ch 67.41 km	C67.41	RCP	5	1.20	-	-
Ch 67.69 km	330-BR21	Bridge	-	-	78.68	32.0
Ch 68.69 km	C68.69	RCBC[1]	2	1.20	1.20	-
Ch 69.10 km	330-BR25	Bridge	-	-	70.60	56.0
Ch 69.29 km	330-BR22	Bridge	-	-	69.93	84.0
Ch 69.90 km	C69.90	RCBC[2]	3	1.20	0.90	-
Ch 69.91 km	C69.91	RCBC[1]	2	1.20	0.90	-
Ch 69.98 km	C69.98	RCP[2]	15	0.90	-	-
Ch 70.02 km	C70.02	RCP[2]	5	0.90	-	-
Ch 70.05 km	C70.05	RCBC[1]	1	1.40	1.00	-
Ch 70.98 km	C70.98	RCBC[1]	4	1.50	1.50	-
Ch 71.12 km	330-BR23	Bridge	-	-	60.00	473.0
Ch 71.53 km	C71.53	RCBC[2]	1	1.50	1.20	-
Ch 71.54 km	C71.54	RCBC[1]	1	1.50	1.20	-
Ch 71.90 km	C71.90	RCBC[1]	1	1.20	1.20	-
Ch 72.43 km	C72.43	RCBC[1]	1	1.80	0.90	-
Ch 73.21 km	C73.21	RCBC[1]	2	1.20	1.20	-

Table notes:

1. The Developed Case alignment runs parallel to the West Moreton System rail corridor embankment at this location. The existing culvert(s) is proposed to be extended and matched through the proposed H2C rail embankment.
2. The Developed Case alignment runs parallel to the West Moreton System rail corridor embankment at this location. A new culvert(s) is proposed to be inserted through the West Moreton System rail corridor embankment and the proposed Project rail embankment.

TABLE 13.44: GRANDCHESTER TO CALVERT—ROAD STRUCTURE DETAILS

Location	Structure type	No of cells	Width x height (m)
Grandchester Mount Mort Road—Access Road	RCBC	10	2.40 x 0.90
Grandchester Mount Mort Road—North	RCBC	6	2.40 x 1.20
Grandchester Mount Mort Road—South	RCBC	13	2.40 x 1.20
Newmann Road East	RCBC	7	2.40 x 1.20

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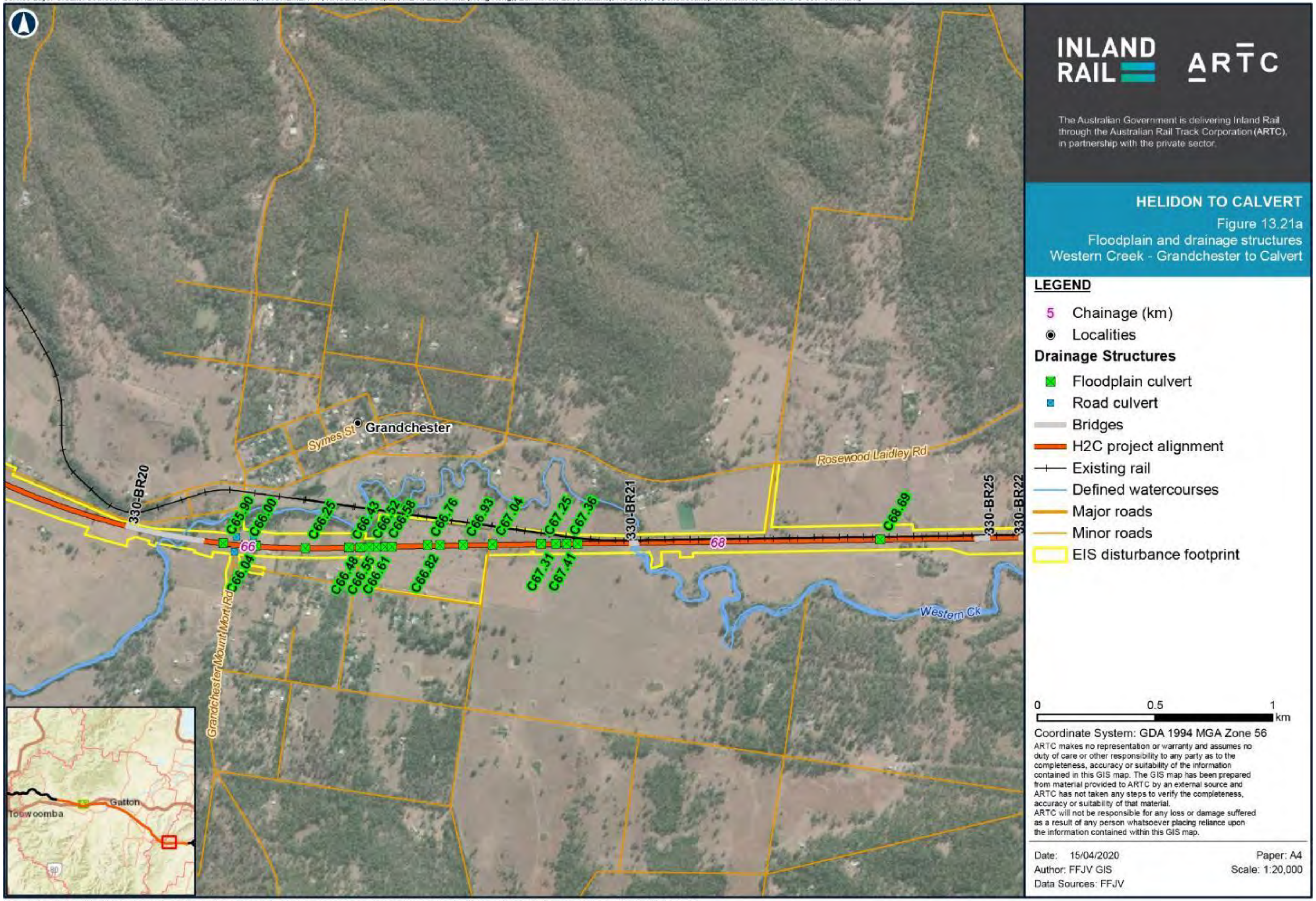

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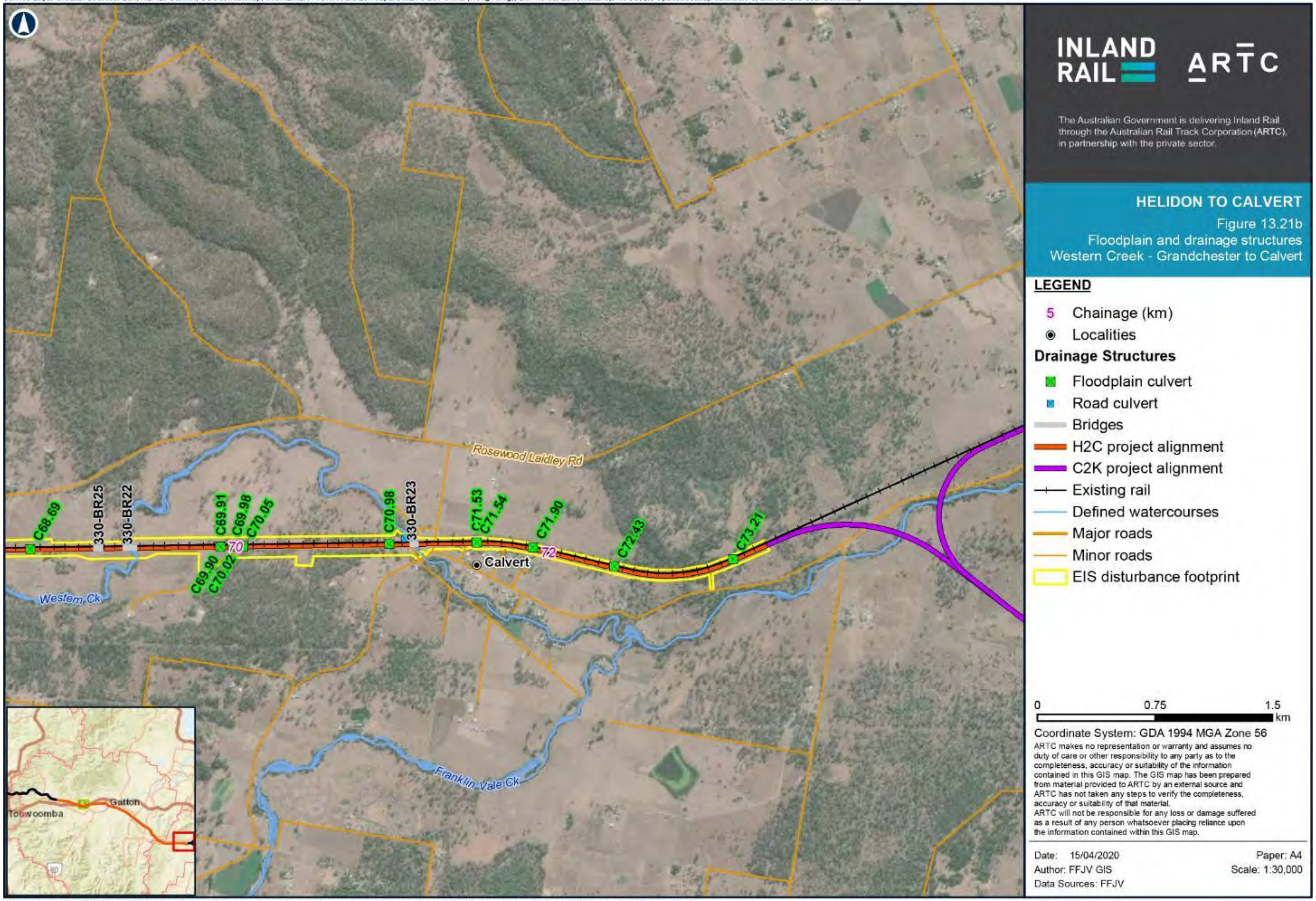

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Change in peak water levels

Figure 13.22a and Figure 13.22b presents the change in peak water levels under the 1% AEP event and Table 13.45 presents details of where the changes to peak water levels lie outside the flood impact objectives. Except for these locations, the change in peak water levels under the 1% AEP event comply with the flood impact objectives (refer Section 13.5.2.2). This includes at the localities of Grandchester and Calvert.

TABLE 13.45: GRANDCHESTER TO CALVERT—CHANGE IN PEAK WATER LEVELS OUTSIDE DESIGN CRITERIA

Chainage/ Location	Design criteria for 1% AEP event	Change in peak water level (mm)	Comment
Ch 65.88 km Agricultural land	≤200 mm (localised increases of up to 400 mm)	+370	This localised area experiences an increase in peak water levels of up to 370 mm due to the raised level crossing. This reduces to less than 200 mm within 30 m of the toe of the road embankment.
Ch 66.12 to Ch 66.50 km Agricultural land	≤200 mm (localised increases of up to 400 mm)	+285	In this locality, there is an access road to Mt Grandchester Mt Mort Road for local residents. This low-level road currently has limited drainage and leads to localised increases in peak water levels near the Project alignment.
Ch 67.30 km West Moreton System rail corridor	≤100 mm	+330	This change in peak water level is within the Project disturbance footprint and caused by shallow sheet flow being trapped behind the proposed embankment.
Ch 69.44 to Ch 69.92 km Agricultural land	≤200 mm (localised increases of up to 400 mm)	+390	This increase of 390 mm extends up to 480 m from the existing culvert under the West Moreton System rail corridor upstream towards bridge 330-BR22. The cause of this change in peak water levels is that overtopping of the West Moreton System rail corridor is prevented. The proposed Project alignment and associated drainage structures were selected to balance peak flows during frequent events and additional storage requirements for the 1% AEP event.

Analysis of the 20%, 10%, 5% and 2% AEP events was also undertaken and figures showing the change in peak water levels are in Appendix M: Hydrology and Flooding Technical Report. Each of these events have increasing levels of overbank flood flows outside the defined creek channel with significant floodplain inundation even under the 20% AEP event.

Changes in peak water levels spread as the flood magnitude increases with impacts focussed along the alignment. In all events the first three locations identified in Table 13.45 experience peak water level increases that exceed the flood impact objectives. Under the 2% AEP event all locations experience peak water level increases that exceed the flood impact objectives. These increases are all lower than the 1% AEP event impacts.

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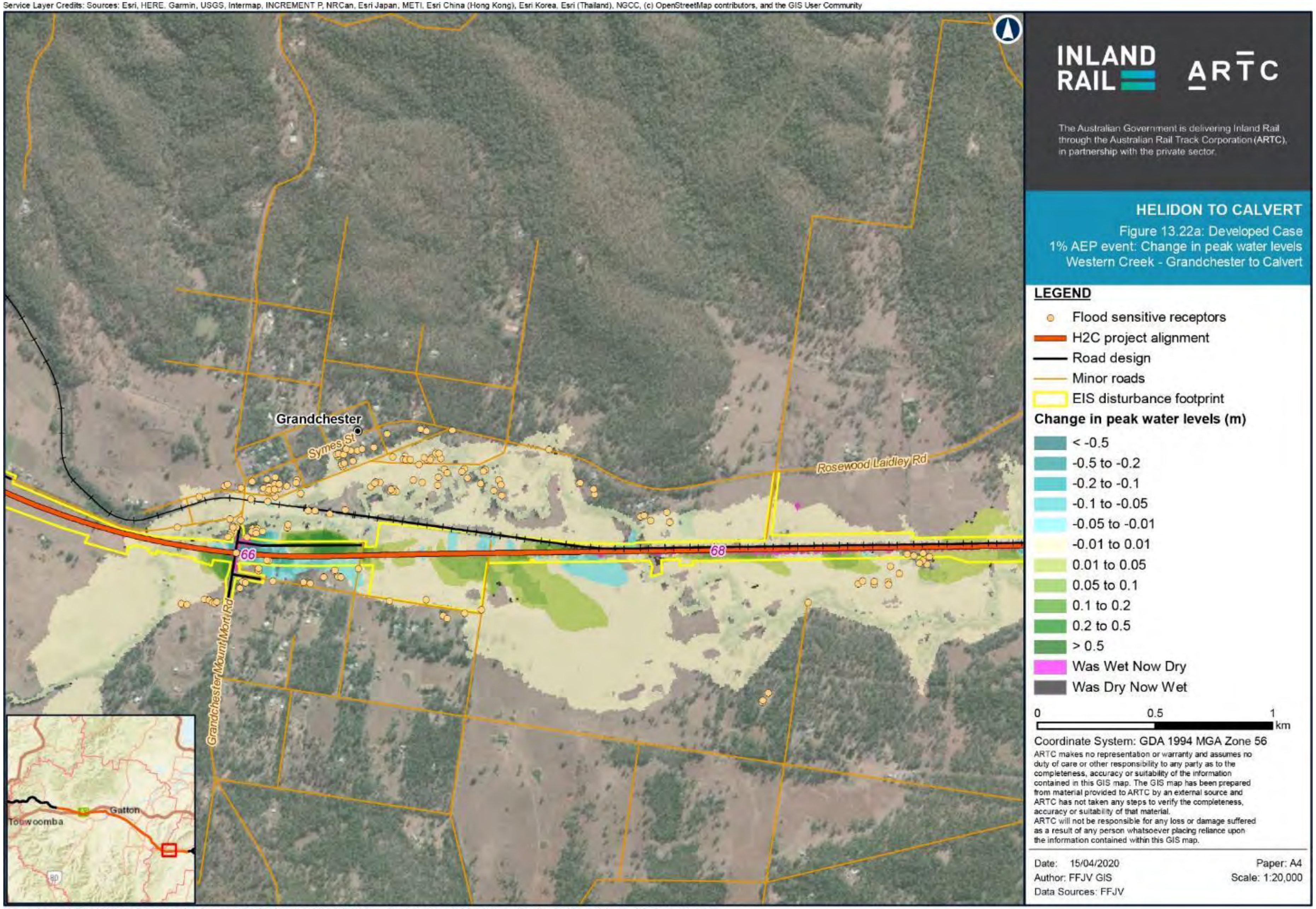

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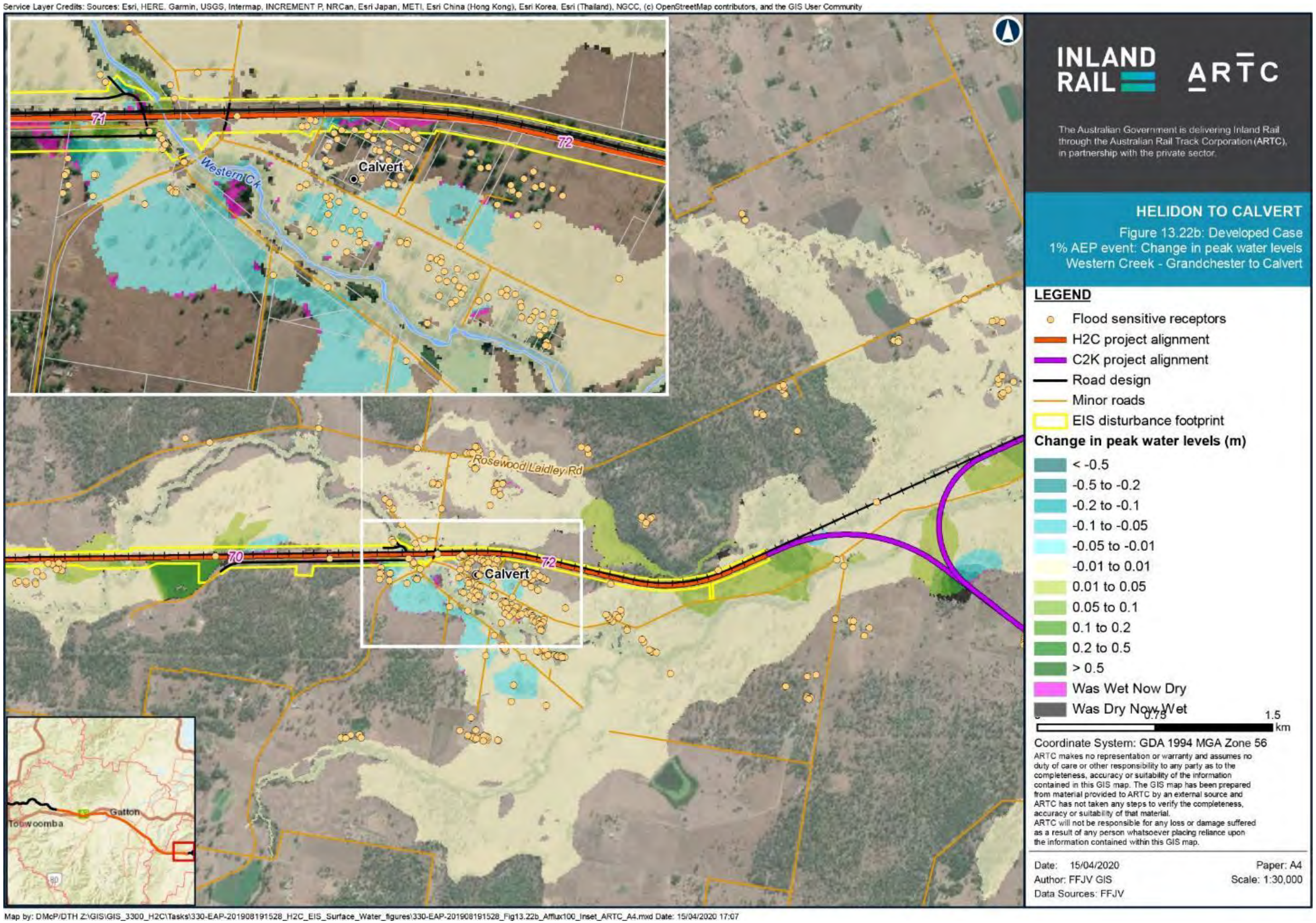
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HELIDON TO CALVERT
Figure 13.22b: Developed Case
1% AEP event: Change in peak water levels
Western Creek - Grandchester to Calvert
LEGEND
Flood sensitive receptors
H2C project alignment
C2K project alignment
Road design
Minor roads
EIS disturbance footprint
Change in peak water levels (m)
< -0.5
-0.5 to -0.2
-0.2 to -0.1
-0.1 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.1
0.1 to 0.2
0.2 to 0.5
> 0.5
Was Wet Now Dry
Was Dry Now Wet
0
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Calvert
Western Ck
71
72
70
Rosewood Laidley Rd
Gatton
Toowoomba
Map by: DMcP/DTH Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201908191528_H2C_EIS_Surface_Water_figures\330-EAP-201908191528_Fig13.22b_Afflux100_Inset_ARTC_A4.mxd Date: 15/04/2020 17:07

Change to duration of inundation

The change in duration of inundation is quantified by assessing and comparing the ToS for the Existing and Developed cases. The ToS for the 1% AEP event is in Table 13.46 for locations where changes in peak water levels lie outside the flood impact objectives. There are no adverse impacts at the localities of Grandchester and Calvert.

TABLE 13.46: GRANDCHESTER TO CALVERT—1% AEP EVENT—CHANGE IN TIME OF SUBMERGENCE

Chainage/ Location	Existing Case ToS (hrs)	Developed Case ToS (hrs)	Comment
Ch 65.88 km Agricultural land	61.6	28.0	This reduction in ToS is due to the upgrade of the culverts under Grandchester Mount Mort Road which increases low-flow drainage capacity.
Ch 66.12 to Ch 66.50 km Agricultural land	51.6	69.0	In this locality, there is an access road to Grandchester Mt Mort Road for local residents. This low-level road currently has limited drainage and leads to localised increases in ToS of up to 17.5 hrs.
Ch 67.30 km West Moreton System rail corridor	26.0	50.5	This increase in ToS is within the Project disturbance footprint and caused by shallow sheet flow being trapped behind the Project embankment.
Ch 69.44 and Ch 69.92 km Agricultural land (upstream of Project alignment)	21.2	17.6	In the Existing Case the West Moreton System rail corridor overtops to the east of this location. This reduction in ToS is due to upgrading the culverts under the West Moreton System rail corridor, which eliminates overtopping and addresses downstream impacts.
Ch 70.00 km Agricultural land (downstream of Project alignment)	15.7	14.0	In the Existing Case the West Moreton System rail corridor overtops at this location. This reduction in ToS is due to upgrading the culverts under the West Moreton System rail corridor, which eliminates overtopping and addresses downstream impacts.

Flood flow distribution

Overall, the Project has minimal impacts on flood flows and floodplain conveyance/storage with significant floodplain structures included to maintain or improve the existing flood regime.

Velocities

Figure 13.23a and Figure 13.23b present the changes in peak velocities under the 1% AEP event associated with the Project alignment. In general, the changes are minor and located close to the Project alignment. There are no adverse impacts at the localities of Grandchester and Calvert.

Peak water levels, flows and velocities from the hydrology and flooding investigation have been used to inform the scour protection design. The scour protection has been designed in accordance with *AGRD Part 5B: Drainage* (Austroads, 2013). Scour protection was specified where the outlet velocities for the 1% AEP event exceed the allowable soil velocities for the particular soil type for each location, which was identified from published soil mapping.

Desktop analysis and the geotechnical investigations did not contain sufficiently detailed information for a refined scour assessment at the bridge sites. A conservative scour estimation based on the 1 in 2,000 AEP event has been undertaken for the pier substructure design based on available information and will be refined during detailed design.

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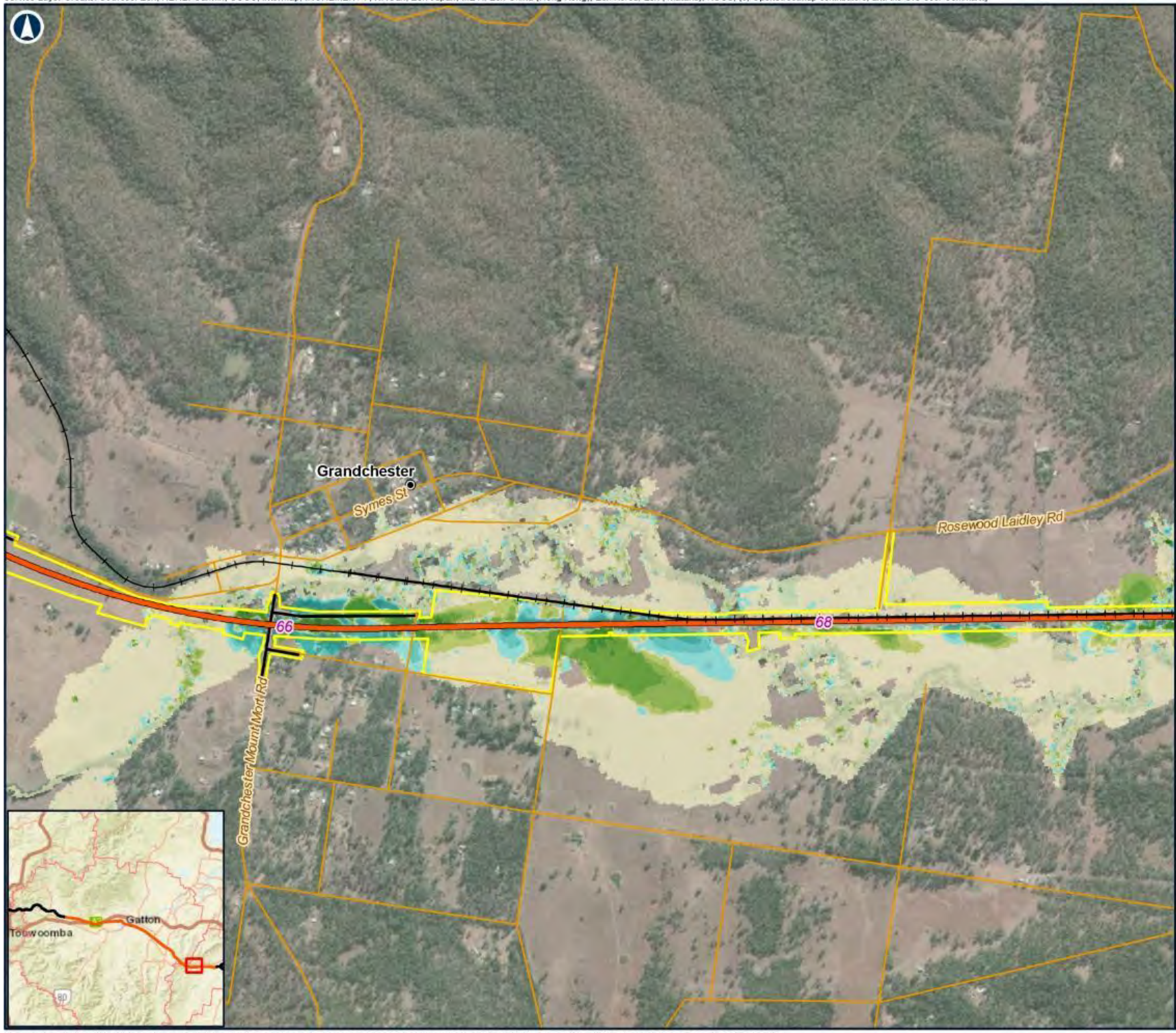

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HELIDON TO CALVERT

Figure 13.23a Developed Case: 1% AEP event: Change in peak velocities Western Creek - Grandchester to Calvert

LEGEND

- 5 Chainage (km)
- H2C project alignment
- Road design
- Minor roads
- EIS disturbance footprint

Change in peak velocity (m/s)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

0 0.5 1 km

Coordinate System: GDA 1994 MGA Zone 56

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Data Sources: FFJV
Paper: A4
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Map by: DMcP Z:\GIS\GIS_3300_H2C\Tasks\330-EAP-201908191528_H2C_EIS_Surface_Water_figures\330-EAP-201908191528_Fig13.X_DeltaV_ARTC_A4.mxd Date: 15/04/2020 10:54

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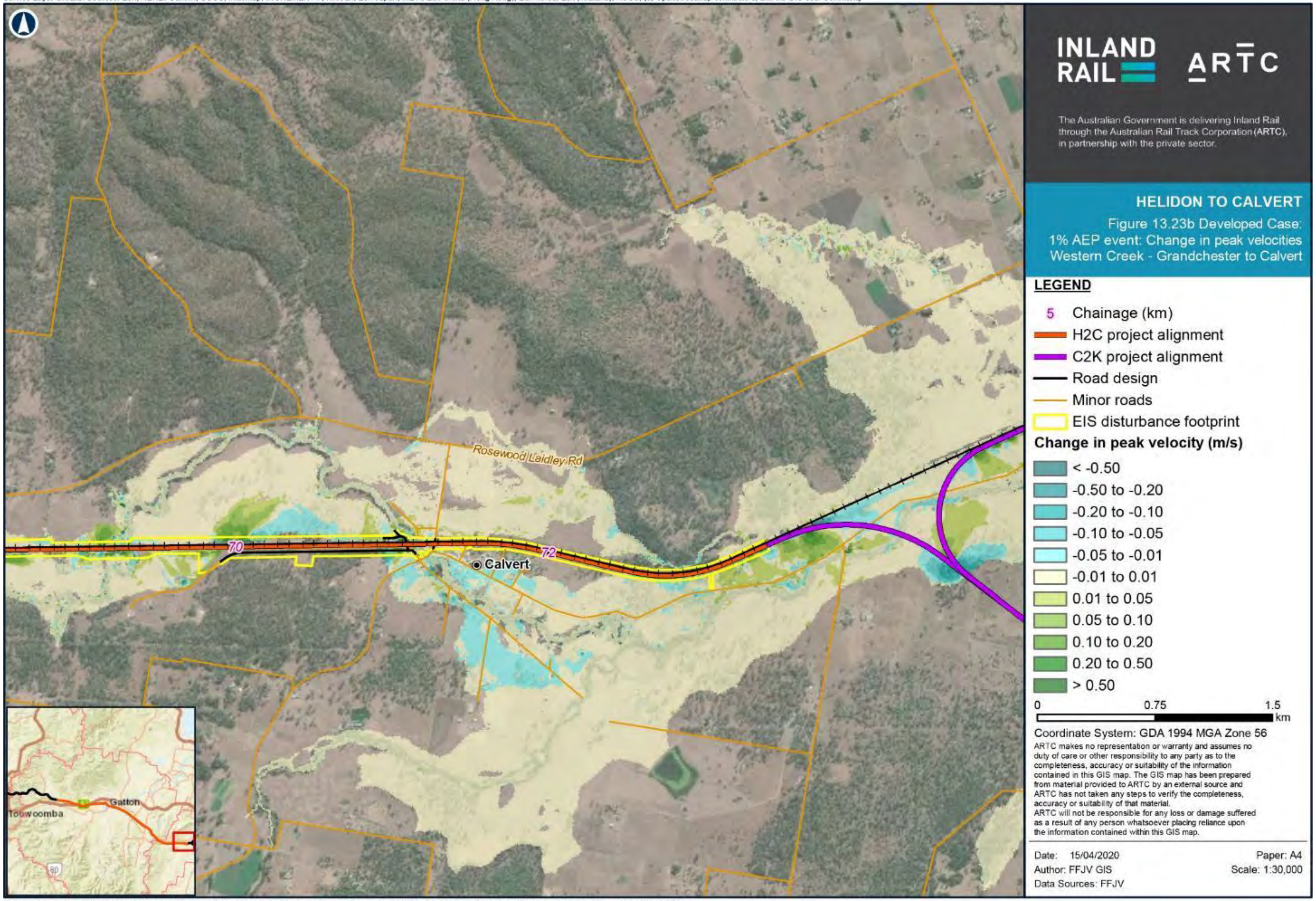

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Extreme events

Several design events larger than the 1% AEP event, including the 1 in 2,000 AEP, 1 in 10,000 AEP and PMF, have been modelled to assess the performance of the Project and to review impacts on the flooding regime.

Figure 13.24a, Figure 13.24b, Figure 13.25a, Figure 13.25b, Figure 13.26a and Figure 13.26b present the change in peak water levels for the 1 in 2,000 AEP, 10,000 AEP and PMF events respectively. The flood inundation extent and peak water levels increase across the floodplain between Grandchester and Calvert as the severity of the flood event increases. The depth of inundation for each of the extreme events is in Appendix M: Hydrology and Flooding Technical Report.

From the outskirts of Grandchester, the Project alignment runs parallel to the existing West Moreton System rail corridor for approximately 50 per cent of the proposed Project alignment. The existing West Moreton System rail corridor influencing the existing flood conditions. Under the extreme events, with the Project alignment in place, there are no significant changes in flood inundation or velocities, and flow behaviour is consistent with the existing conditions. There are changes in peak water levels that are attributed to the height of the proposed Project alignment required to achieve the desired flood immunity design criteria. Mitigation of impacts has been carried out through the extension of West Moreton System rail corridor culverts under the Project alignment and inclusion of new culvert banks under both the Project alignment and the West Moreton System rail corridor.

Review of changes in peak water levels at flood sensitive receptors indicates that the increases associated with the Project alignment are generally small (<50 mm) under the 1 in 2,000 AEP and 1 in 10,000 AEP events. Larger impacts occur under the PMF event where there are already high flood depths as would be expected under such a rare event.

The risk of overtopping along the Project alignment has been assessed for the modelled extreme events. During these extreme events the Project alignment is inundated at a number of locations. Table 13.47 outlines the overtopping depths at these locations.

Under these rare events, the bridge structures and culverts have been designed to allow adequate passage of flow during the flood events and 'damming' effects are therefore not expected to occur. In addition, failure of the embankment during a flood event is not predicted to result in a dam failure type event as the water level on both sides of the embankment is predicted to be similar. No redirection of flood flows under these extreme events is expected.

TABLE 13.47: GRANDCHESTER TO CALVERT—PROJECT ALIGNMENT APPROXIMATE OVERTOPPING DEPTHS

Chainage	1 in 2,000 AEP overtopping depth (m)	1 in 10,000 AEP overtopping depth (m)	PMF overtopping depth (m)[1]
Ch 66.07 km to Ch 66.57 km	-	-	0.15
Ch 66.98 km to Ch 67.23 km	-	-	0.10
Area around Ch 70.00 km	-	-	0.37

Table note:

1. The length of Project alignment overtopped (i.e. above Top of Rail level) varies between locations.

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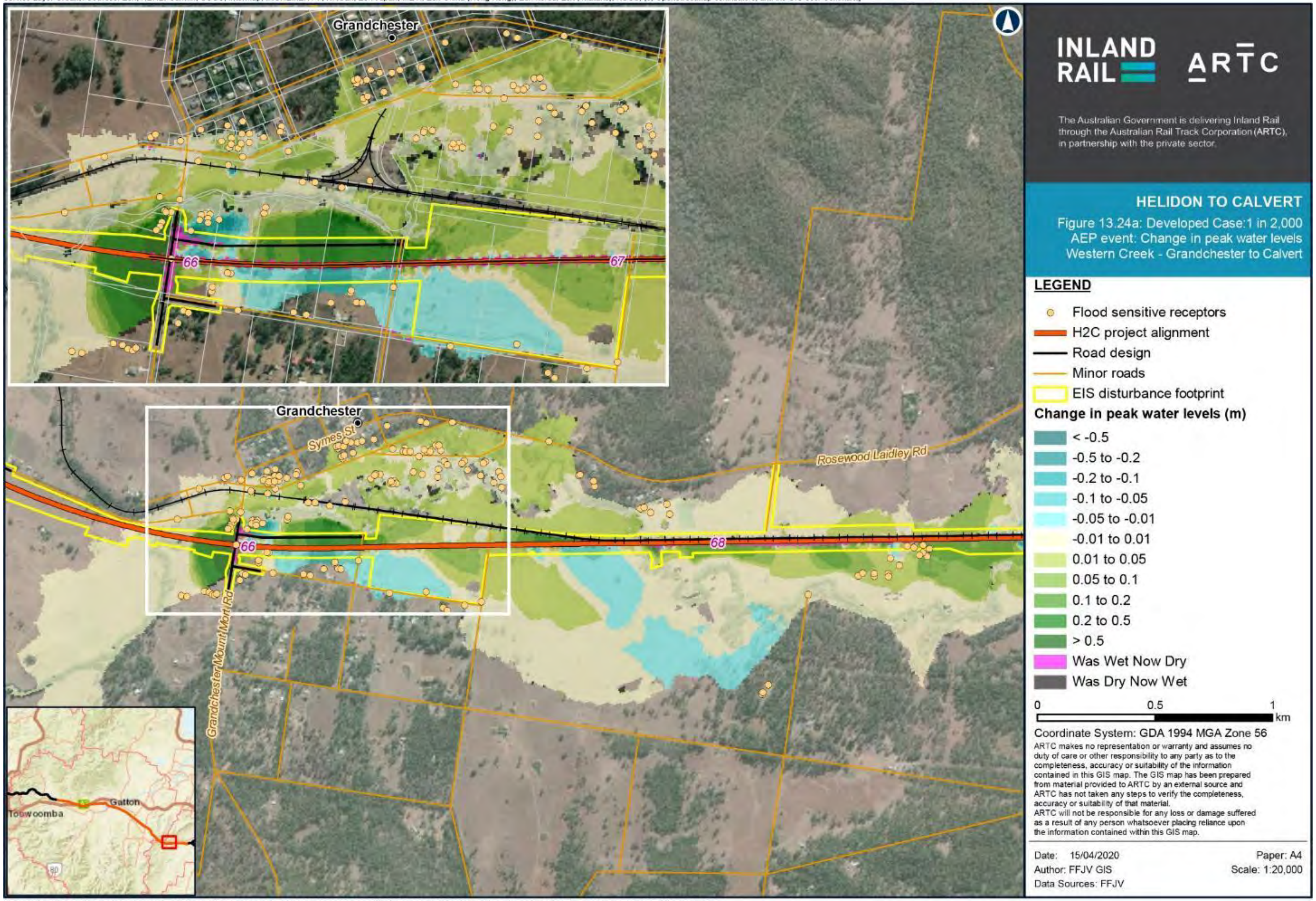

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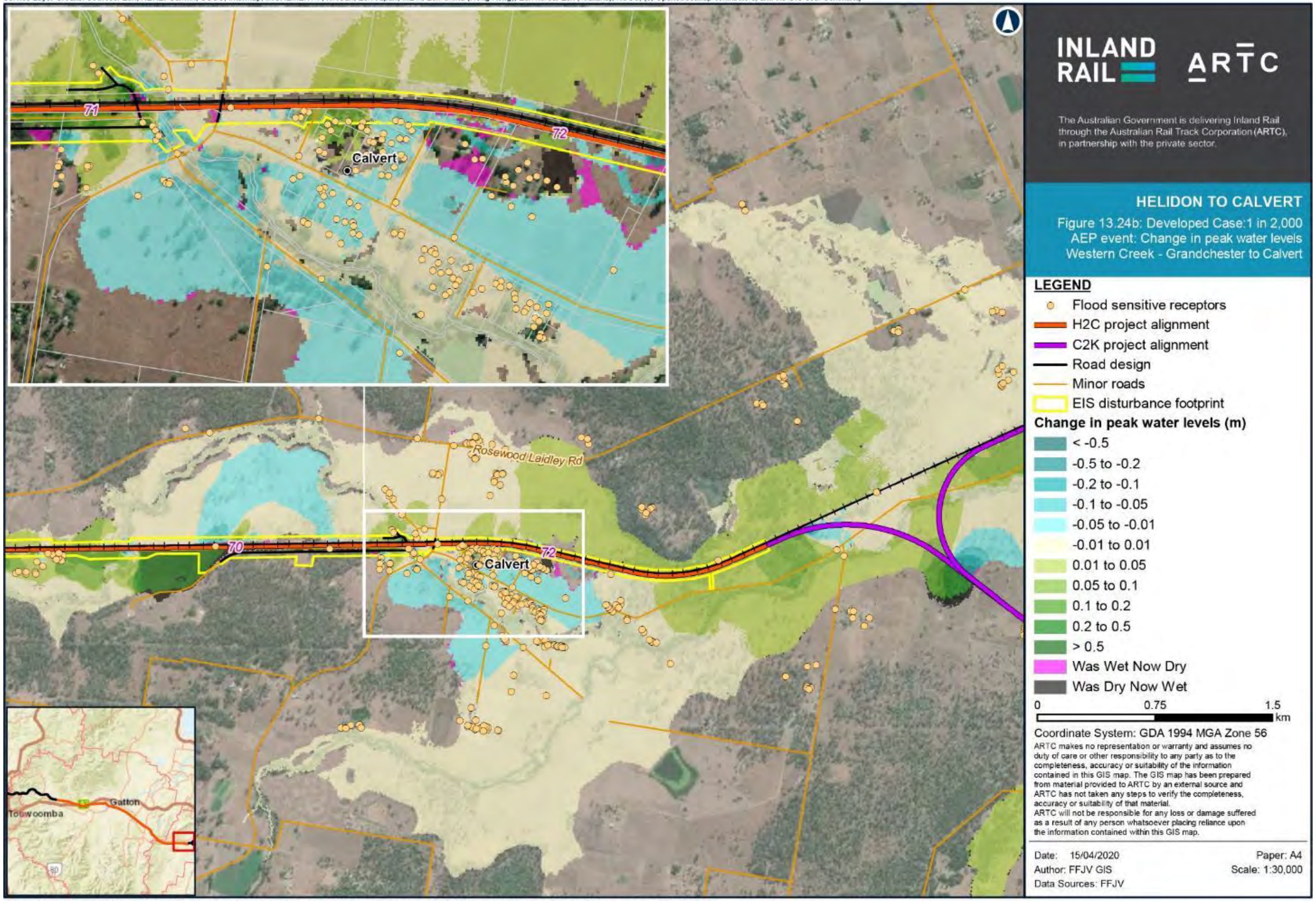

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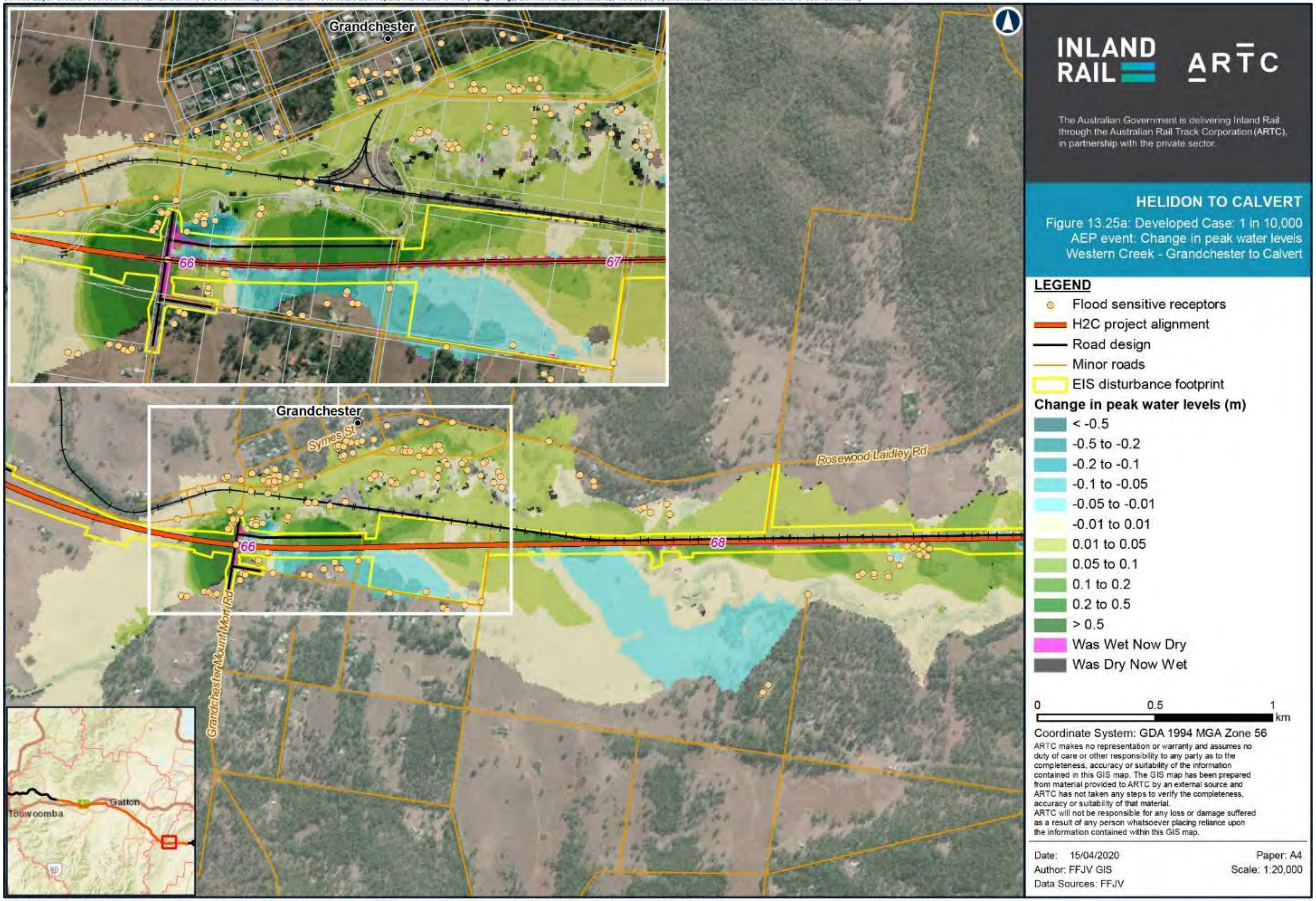

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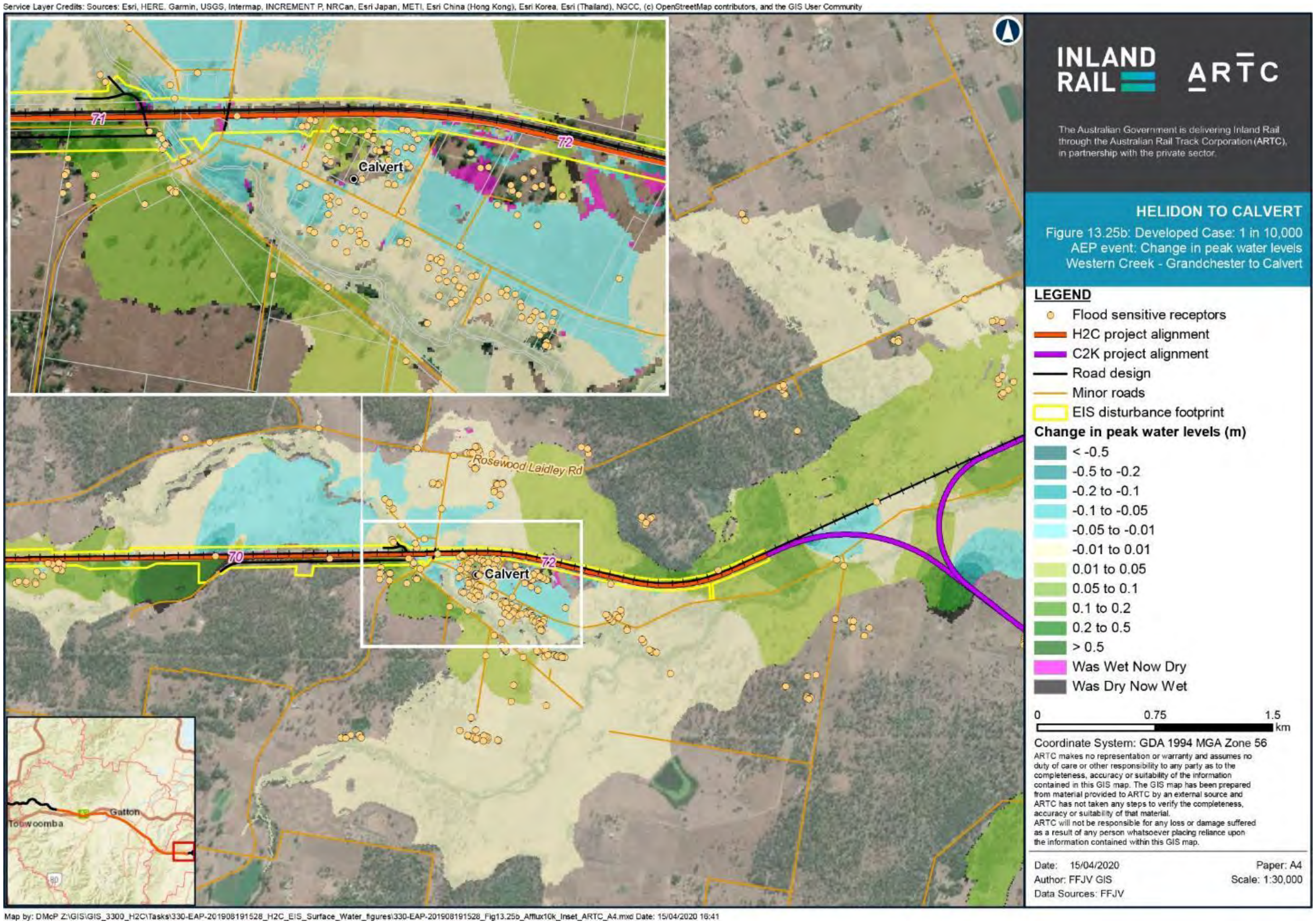
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HELIDON TO CALVERT
Figure 13.25b: Developed Case: 1 in 10,000 AEP event: Change in peak water levels Western Creek - Grandchester to Calvert
LEGEND
Flood sensitive receptors
H2C project alignment
C2K project alignment
Road design
Minor roads
EIS disturbance footprint
Change in peak water levels (m)
< -0.5
-0.5 to -0.2
-0.2 to -0.1
-0.1 to -0.05
-0.05 to -0.01
-0.01 to 0.01
0.01 to 0.05
0.05 to 0.1
0.1 to 0.2
0.2 to 0.5
> 0.5
Was Wet Now Dry
Was Dry Now Wet
0
0.75
1.5
km
Coordinate System: GDA 1994 MGA Zone 56
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Author: FFJV GIS
Data Sources: FFJV
Paper: A4
Scale: 1:30,000
Calvert
71
72
70
Rosewood Laidley Rd
Toowoomba
Gatton
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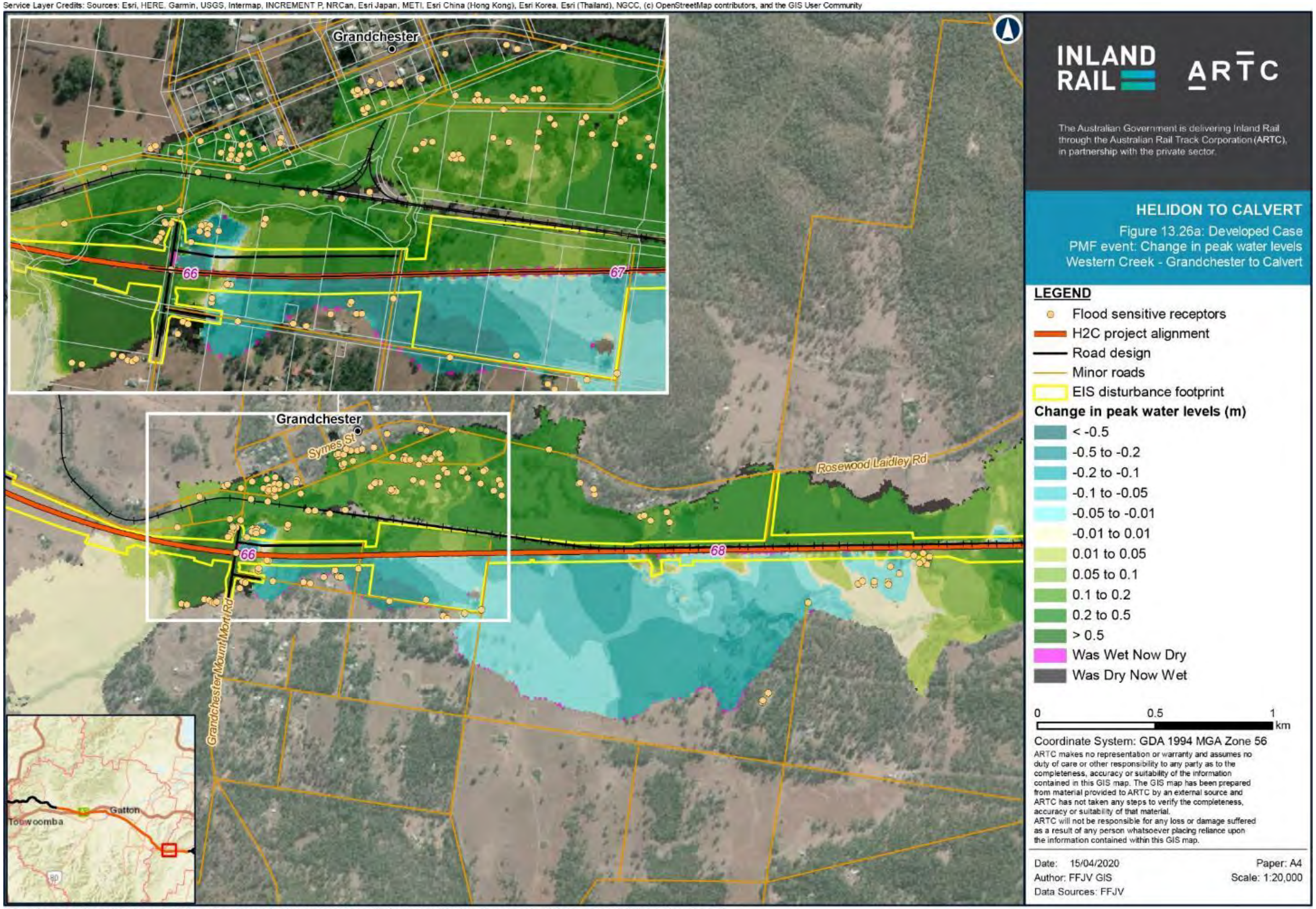

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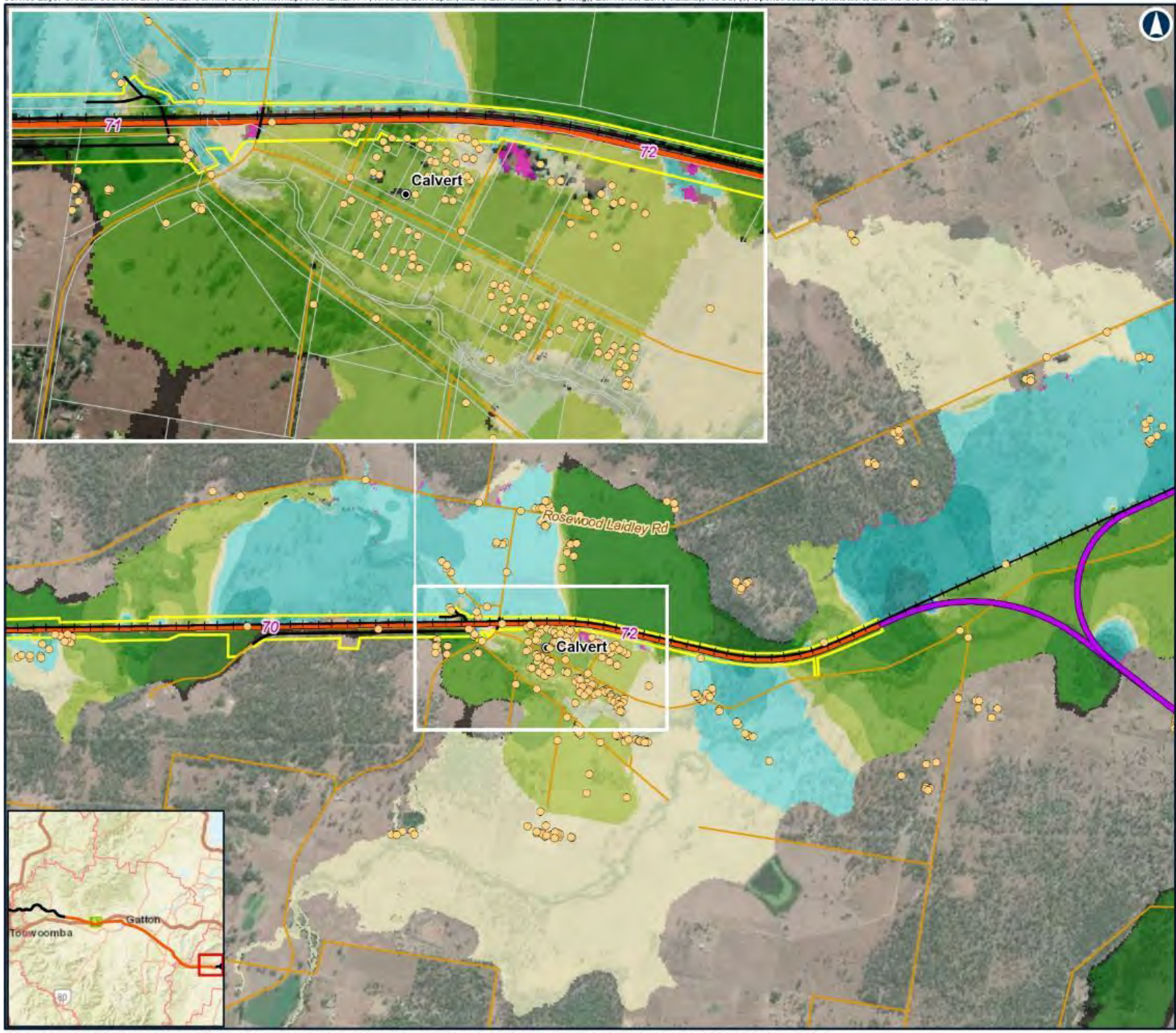

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HELIDON TO CALVERT

Figure 13.26b: Developed Case PMF event: Change in peak water levels Western Creek - Grandchester to Calvert

LEGEND

- Flood sensitive receptors
- H2C project alignment
- C2K project alignment
- Road design
- Minor roads
- EIS disturbance footprint

Change in peak water levels (m)

- < -0.5
- -0.5 to -0.2
- -0.2 to -0.1
- -0.1 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.1
- 0.1 to 0.2
- 0.2 to 0.5
- > 0.5
- Was Wet Now Dry
- Was Dry Now Wet

0 0.75 1.5 km

Coordinate System: GDA 1994 MGA Zone 56

Date: 15/04/2020 Paper: A4
Author: FFJV GIS Scale: 1:30,000
Data Sources: FFJV

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Climate change

The climate change guidelines set out in ARR 2016 have been followed and used to assess the potential impact of increased rainfall on peak water levels in the vicinity of the Project alignment.

The Representative Concentration Pathways 8.5 (2090 horizon) climate change scenario has been adopted for the Project with an associated increase in rainfall intensity of 18.7 per cent across the catchment area. Climate change results in increased peak water levels of up to 300 mm in the vicinity of the Project alignment under the 1% AEP event.

Appendix M: Hydrology and Flooding Technical Report includes figures that present the change in peak water levels associated with the Project alignment for the 1% AEP event with climate change . On Western Creek, the inclusion of climate change does not significantly alter the predicted changes in peak water levels around the Project alignment and therefore does not affect flood-sensitive receptors.

Blockage

Blockage of drainage structures has been assessed in accordance with ARR 2016 requirements. The blockage assessment resulted in no blockage factor being applied to bridges and a blockage factor of 25 per cent being applied to culverts. A minimum culvert size of 900 mm diameter was also adopted to reduce potential for blockage and for ease of maintenance.

ARR 2016 guidelines are focused on blockage of small bridges and culverts. The floodplain bridges proposed for the Project alignment are all multi-span large bridges and ARR 2016 notes that there are limited instances of multiple span bridges being observed with blockages similar to those seen at single-span bridges or culverts.

Two blockage sensitivity scenarios were tested with both 0 per cent and 50 per cent blockage of all culverts. The following changes to sensitive receptors were identified:

- On the eastern abutment toe of the Western Creek level crossing (Ch 65.88 km) the change in peak water levels increases from 370 mm to 560 mm in the 50 per cent blockage scenario and reduces to 265 mm in the 0 per cent blockage scenario
- North of Ch 65.89 km there is a residential dwelling which has up to a 2 mm increase in peak water levels in the Developed Case (25 per cent blockage). In the 50 per cent blockage scenario this property has an increase in peak water levels of 45 mm and in the 0 per cent blockage scenario it has a reduction of up to 40 mm
- The change in peak water levels on the agricultural land around Ch 66.12 to Ch 66.50 km increases from 285 mm to 290 mm in the 0 per cent blockage scenario and reduces to 275 mm in the 50 per cent blockage scenario
- Between existing West Moreton System rail corridor embankment and the proposed embankment (around Ch 67.30 km) the change in peak water levels increases from 330 mm to 345 mm in the 50 per cent blockage case and reduces to 305 mm in the 0 per cent blockage case
- East of bridge 330-BR22 (between Ch 69.25 km and Ch 69.92 km) the change in peak water levels increases from 390 mm to 510 mm in the 50 per cent blockage case and reduces to 265 mm in the 0 per cent blockage case
- North of the Newmann Road realignment (around Ch 71.00 km) there is a residential dwelling which has up to a 3 mm increase in peak water levels in the Developed Case (25 per cent blockage). In the 50 per cent blockage scenario this property has an increase in peak water levels of 12 mm and in the 0 per cent blockage scenario it has a reduction of up to 4 mm.

The outcomes of blockage sensitivity scenarios indicate that peak water levels only change by small amounts with varying the culvert blockage levels and that the resulting impacts are similar.

Desktop analysis and the geotechnical investigations did not contain sufficiently detailed information for a refined scour assessment at the bridge sites. A conservative scour estimation based on the 1 in 2,000 AEP event has been undertaken for the pier substructure design based on available information and will be refined during detailed design.

13.10 Cumulative impacts

Due to the broad nature of surface water catchments, all of the Projects considered in Chapter 22: Cumulative impacts could potentially contribute to cumulative surface water quality and hydrology impacts. Cumulative impacts to the surface water quality and hydrology of the Project will be largely the product of:

- Riparian vegetation loss from vegetation clearing/removal
- Potential impacts to aquatic fauna species both through impacts to water quality and barrier works
- Displacement of flora and fauna species from invasion of weed and pest species
- Reduction in the connectivity of waterways
- Increase in erosion and sedimentation in the waterways
- Increase in litter (waste)
- Saline discharge into proximal waterways
- Increases in surface salinity around alluvial waterways.

The assessment of the significance of cumulative impacts relating to surface water quality is in Chapter 22: Cumulative impacts and provided that all of the assessable projects apply appropriate mitigation measures during construction, including CEMPs and salinity management plans, no material cumulative impacts are expected during the construction, operation or decommissioning phases of the Project.

13.10.1 Water quality cumulative impact assessment

Cumulative impacts were assessed using the methodology identified in 13.5.1.1 (and within Appendix L: Surface Water Quality Technical Report), incorporating the projects detailed in Table 13.48.

The cumulative impacts of multiple projects occurring in the vicinity of the water quality study area may contribute to impacts to water quality if not managed appropriately. The major potential impacts identified as a result of the Project are common to all projects throughout the region and are therefore cumulative in nature. Seven projects have been identified within the cumulative impact area of influence that are either currently underway or are going through the EIS process, all of which will likely result in some extent of:

- Riparian vegetation loss from vegetation clearing/removal
- Potential impacts to aquatic fauna species both through impacts to water quality and barrier works
- Displacement of flora and fauna species from invasion of weed and pest species
- Reduction in the connectivity of waterways
- Increase in erosion and sedimentation in the waterways
- Increase in litter (waste)
- Saline discharge into proximal waterways
- Increase in surface salinity around alluvial waterways.

The list of potential projects mostly comprises rail and road upgrades and high-density industrial infrastructure development. As such, it is expected that the principal source of cumulative impacts will occur from the proximal Inland Rail Projects—Gowrie to Helidon (G2H) and Calvert to Kagaru (C2K).

Noting that proximal projects within the cumulative area of influence have been assessed as operating/constructing as business-as-usual (i.e. likelihood of occurrence of impact with standard operating procedures), the cumulative impact assessment (CIA) was generated without regard for cumulative impact resulting from critical failures within other projects. Due to the distributed nature and likely stable landforms for the operation of these projects, it is unlikely that there would be long-term cumulative impacts; however, assessment was conducted to identify potential impact.

As no additive impact is considered from the projects, construction water demand is considered within the Project and not as part of the cumulative impact assessment.

The results of the significance assessment of these cumulative impacts are in Table 13.49 and Table 13.50.

ARTC propose to access construction water from existing water plans issued under the Water Act. ARTC and/or the selected Contractor may also elect to source water from a commercial water provider. Individual water supply plans will be prepared for each Inland Rail project in consultation with regulatory agencies, local government authorities and other stakeholders. These individual plans will identify specific water supply options applicable to each project, including relevant approval requirements. ARTC propose to consult with both the Department of Resources and the Department of Regional Development, Manufacturing and Water (former DNRME) to discuss the overall water demand for the Inland Rail Projects, highlight the relevant options that are being considered once they have been determined and discuss how any stakeholder concerns can be mitigated. Consultations will be ongoing during detailed design.

As construction water will be acquired only after relevant agreements and approvals (post-EIS), it is considered that no potential cumulative impact exists as full detail of potential impact on water supply would be considered once final details are fully known and understood (during detailed design). Applying for an approval within the relevant water plans issued under the *Water Act 2000* (Qld) will ensure that impact of water demand between the projects (and potential impact to water resources and users) will be avoided.

TABLE 13.48: PROJECTS CONSIDERED WITHIN THE CUMULATIVE ASSESSMENT

Project and proponent	Location	Description	Assessment status	Construction dates	Construction jobs	Operation years	Operation jobs	Relationship to the Project
G2H (ARTC)	Project alignment from Gowrie to Helidon	26 km single-track, dual-gauge freight railway as part of the ARTC Inland Rail Program	Draft EIS being prepared by ARTC	2021–2026	Peak of 596 FTE, average of 264 FTE	>50 years	~20 FTE	Potential overlap of construction for the Project and G2H
C2K (ARTC)	Project alignment from Calvert to Kagaru	53 km single-track, dual-gauge freight railway as part of the ARTC Inland Rail Project	Draft EIS being prepared by ARTC	2021–2026	Peak of 620 FTE, average of 271 FTE	>50 years	~20 FTE	Potential overlap of construction for the Project and C2K
Bromelton State Development Area (SDA) (Queensland Government)	Bromelton, Qld	Delivery of critical infrastructure within the Bromelton SDA will support future development and economic growth. This includes a trunk water main and the Beaudesert Town Centre Bypass. This infrastructure provides opportunities to build on the momentum of current development activities by major landowners in the SDA	Scheme created in 2012. Approved by Governor in Council, December 2017	2016–2031	TBA	>50 years	TBA	Ongoing development approximately 55 km at the Bromelton SDA may compete for construction resources. There may also be an increase in heavy vehicles using the surrounding highways
Ipswich Motorway Upgrade Rocklea to Darra (remaining sections) (Department of Transport and Main Roads)	Western Brisbane, Qld	Addressing of congestion and extensive delays in the Ipswich Motorway corridor by a range of road upgrades along 7 km of Ipswich Motorway between Rocklea and Darra	Project listen on Queensland Infrastructure Initiative List – EIS not yet initiated	2016/17 to 2020–2021	TBA	TBA	TBA	Construction periods may overlap resulting in competition for construction resources and increased traffic on surrounding highways
RAAF Base Amberley future works (Department of Defence)	RAAF Base Amberley	White paper dedicated future upgrades to RAAF Base Amberley at a cost of $1b	N/A	2016–2022	7,000	>50 years	TBA	Ongoing development at RAAF Base Amberley may see increase in road traffic with heavy vehicles and further increase as the Project construction occurs

Project and proponent	Location	Description	Assessment status	Constructio n dates	Constructio n jobs	Operatio n years	Operatio n jobs	Relationship to the Project
Gatton West Industrial Zone (GWIZ) (Lockyer Valley Regional Council)	3 km north west Gatton	Industrial development including a transport and logistics hub on the Warrego Highway	N/A	2019–2024	13.5 FTE	>50 years	~37	May increase road traffic and increase need for rail resources
InterLinkSQ (InterLinkSQ)	13 km west of Toowoomba	200 ha of new transport, logistics and business hub. Located on the narrow-gauge regional rail network and interstate network. Located at the junction of the Gore, Warrego and New England Highways		2017–2037	TBA	>50 years	1500	Ongoing development could compete for of construction resources. There may also be an increase of heavy vehicles using the surrounding highways

TABLE 13.49: POTENTIAL CUMULATIVE WATER QUALITY IMPACTS

Potential cumulative impact	Gowrie to Helidon (ARTC) and Calvert to Kagaru (ARTC)
Riparian vegetation loss from vegetation clearing/removal	Potential overlapping loss of sensitive receptor (riparian vegetation communities) with works involving watercourse and associated crossings. Impact may be compounded with interface between current Project and other listed projects in regard to decreased resilience to biotic and abiotic factors. Potential consequence involves loss of bank stability, loss of diversity and consequential reduction in water quality values due to decreased performance of localised 'whole-system'.
Potential impacts to aquatic fauna species both through impacts to water quality and barrier works	Potential for cumulative downstream impacts (from overlapping projects—in regard to watercourses flowing within and between projects) from water quality issues associated with overland works and waterway barrier works. Cumulative impacts would be expected to occur in relatively short spatial distances (as cumulative point-source impacts) and would be expected to 'dilute' with increasing distance downstream from point source impact.
Displacement of flora and fauna species from invasion of weed and pest species	Potential for significant cumulative impacts between Projects, with increasing risk associated with impact occurring on single watercourse (sub-catchment). Displacement from invasive species will result in further impact on aquatic water quality values downstream. Limited spatial interface between projects is not considered to be an inherent mitigating factor in regard to this impact, as cumulative impact will be increased (specifically in regard to proliferation of invasive flora downstream of impact) with each progressive source of impact associated with these projects.
Reduction in the connectivity of waterways	Potential for impact to be realised with improper work practices associated with waterway crossings, with progressive accumulation of impact between each Project. Whole catchment may be impacted from separate Projects on separate watercourses; however, the greatest cumulative impacts would be expected with spatial interface between separate projects. Water quality degradation likely from impediment of waterway connectivity with associated decrease in ecosystem resilience.
Increase in erosion and sedimentation in the waterways	Potential of cumulative impact of watercourse sedimentation increase from simultaneous activities within hydrological catchments (particularly de-watering activities and stockpiling of spoil/resources). Cumulative impacts in regard to erosion may arise from impaction of watercourse structure/hydrological regimes and may be further impacted by cumulative impacts on riparian vegetation loss. Cumulative impact is expected to gain in potential and magnitude with downstream movement of impact, particularly in regard to erosive process and associated sedimentation impacts on hydrological regime change, increasing further impacts.
Increase in litter (waste)	Potential for cumulative impact from waste on water quality issues, in regard to contamination of watercourse from in-blow or direct deposition of waste into watercourses. Expectation of cumulative impacts associated with similar hydrological catchments (primarily sub-catchments) with greatest potential for cumulative impact with spatial interface between projects. Expectation of reduced environmental resilience with increasing waste load and waste type within watercourses.
Saline discharge into proximal waterways	Overlapping construction activities related to high-salinity risk rating area along the alignment with potential for poor erosion and sediment control management to increase potential of erosive sodosol discharge. Limited spatial difference between the Projects increases potential cumulative impact.
Increase in surface salinity around alluvial waterways	Overlapping construction activities in regard to clearing of vegetation within alluvial-based watercourses increases potential of highly localised groundwater rise and salinity risk during high-rainfall events. Limited spatial difference between the Projects increases potential cumulative impact.

TABLE 13.50: SUMMARY OF THE CUMULATIVE IMPACT ASSESSMENT

Cumulative impact	Phase	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Magnitude	Duration	Sensitivity		
Riparian vegetation loss from vegetation clearing/removal	Construction	2	1	2	2	7	Medium
	Operations	1	1	1		5	Low
	Decommissioning	1	1	1		5	Low
Potential impacts to aquatic fauna species both through impacts to water quality and barrier works	Construction	1	1	2	2	6	Low
	Operations	1	1	2		6	Low
	Decommissioning	1	1	2		6	Low
Displacement of flora and fauna species from invasion of weed and pest species	Construction	1	1	2	2	6	Low
	Operations	1	1	2		6	Low
	Decommissioning	1	1	2		6	Low
Reduction in the connectivity of waterways	Construction	1	1	2	2	6	Low
	Operations	1	1	2		6	Low
	Decommissioning	1	1	2		6	Low
Increase in erosion and sedimentation in the waterways	Construction	1	1	2	2	6	Low
	Operations	1	1	2		6	Low
	Decommissioning	1	1	2		6	Low
Increase in litter (waste)	Construction	1	1	1	2	5	Low
	Operations	1	1	1		5	Low
	Decommissioning	1	1	1		5	Low
Saline discharge into proximal watercourses	Construction	1	1	2	2	6	Low
	Operations	1	2	1		6	Low
	Decommissioning	1	2	1		6	Low
Increase in surface salinity around alluvial watercourses	Construction	1	1	2	2	6	Low
	Operations	1	1	2		6	Low
	Decommissioning	1	1	2		6	Low

Table notes:

1. Impact significance ratings are as follows:
   Low (sum of relevance factors = 1 to 5): Negative impacts need to be managed by standard environmental management practices. Special conditions unlikely to be necessary. Monitoring to be part of general Project monitoring program
   Medium (sum of relevance factors = 6 to 9): Mitigation measure likely to be necessary and specific management practices to be applied. Specific conditions are likely. Targeted monitoring program required.
   High (sum of relevance factors = 10 to 12): Alternative actions will be considered and/or mitigation measures applied to demonstrate improvement. Specific conditions expected to be required. Targeted monitoring program necessary.

13.10.2 Hydrology and flooding cumulative impact assessment

The hydrologic and hydraulic investigation (refer Appendix M: Hydrology and Flooding Technical Report) has included all existing infrastructure in the Existing Case. The Existing Case has been used as the basis to compare the Developed Case against to determine potential impacts and then derive appropriate mitigation measures. This process is followed for all infrastructure projects that have the potential to impact on this investigation with projects required to mitigated and minimise impacts to acceptable levels. Therefore, cumulative impacts have been addressed.

The exception is the C2K and G2H project alignments, which are being concurrently developed. The C2K and G2H projects have been included in the Developed Case for the Project to enable cumulative impacts to be considered and addressed.

13.11 Conclusion

13.11.1 Water quality

The water quality study area covers the Bremer River and Lockyer Creek catchments, with several sub-catchments intersecting the Project alignment. Historic and field-assessed water quality was found to not be meeting WQOs for the protection of aquatic ecosystems, within each catchment.

All waterways within the water quality study area have been identified as sensitive receptors within the receiving environment. These were nominated as moderate water quality receptors for:

- Identification of potential impacts
- Associated mitigation measures
- Identification of residual impact (after implementation of mitigation).

Due to the sensitivity of the water quality receptors within the water quality study area, significance of impact was assessed against moderate and high criteria.

A significance assessment was undertaken and assessed the residual impact of identified potential impacts after assessment of design considerations and additional mitigation measures. The assessment identified:

- During the construction phase, the combination of design considerations and mitigation measures relevant to surface water quality would be sufficient to mitigate potential impacts—the residual significance would be low
- For the operational phase, the combination of design considerations and mitigation measures relevant to surface water quality would be sufficient to mitigate potential impacts—the residual significance would be low.

It is expected that significant residual impacts on surface water quality will not occur as a result of the Project.

A cumulative impact assessment considering the impact of other Projects was considered. The cumulative impacts of several projects within the water quality study area included: riparian vegetation loss from vegetation clearing/removal, potential impacts to aquatic fauna species both through impacts to water quality and barrier works, displacement of flora and fauna species from invasion of weed and pest species, reduction in the connectivity of waterways, an increase in erosion and sedimentation in the waterways, an increase in litter (waste), saline discharge into proximal waterways and an increase in surface salinity around alluvial waterways.

The cumulative impact assessment identified a medium risk of potential impact occurring during construction phase activities through riparian vegetation loss from vegetation clearing/removal. The riparian vegetation loss was considered to have potential to impact water quality through erosion and sedimentation. It is considered that mitigation measures are likely to be necessary and specific management practices will need to be applied.

Overall potential surface water quality impacts during construction, operation and decommissioning (as related to construction) can be managed to a low residual risk level using the proposed design and mitigation measures.

13.11.2 Hydrology and flooding

The Project alignment crosses the floodplains of two major waterways being Lockyer Creek, and its tributaries, and Western Creek, a tributary of the Bremer River. To address the requirement of the ToR, detailed hydrologic and hydraulic assessments have been undertaken due to the catchment size and substantial floodplain flows associated with each of these watercourses. Both of these waterways form part of the larger Brisbane River system.

A review has been carried out of previous flood investigations including available hydrologic and hydraulic models. This led to the adoption and refinement of the *Brisbane River Catchment Flood Study URBS hydrologic models* (Aurecon, 2015) and the Lockyer Valley TUFLOW hydraulic model. A new hydraulic model was developed for Western Creek.

Calibration of the models was undertaken to multiple historical events, with models being validated against stream gauges records, stakeholder and community feedback and available anecdotal flood data. Based on the outcomes of this validation process, the validated hydrologic and hydraulic models were used to assess the potential impacts associated with the Project on the existing flooding regime.

Design event hydrology was developed using the calibrated (and validated) hydrologic models using ARR 2016 flood flow estimation techniques. The hydraulic models were run for a suite of design events from the 20% AEP event to the 1 in 10,000 AEP and PMF events.

Modelling of the current state of development (Existing Case) was undertaken and details of the existing flood regime were determined for the modelled design events. The proposed works associated with the Project were incorporated into the hydraulic models (Developed Case) and assessment of the potential impacts on the existing flood regime was undertaken. Changes in peak water levels, velocities, flow patterns and flood inundation extents and durations have been identified and mapped.

Consultation with stakeholders, including landowners, was undertaken at key stages including validation of the performance of the modelling in replicating experienced historical flood events and presentation of the design outcomes and impacts on properties and infrastructure.

The Project alignment runs adjacent to the West Moreton System rail corridor rail line (for approximately 50 per cent of the proposed Project alignment) as well as through, or close to, the townships of Helidon, Grantham, Gatton, Forest Hill, Laidley, Grandchester and Calvert. A significant portion of these localities, including properties and infrastructure, and the West Moreton System rail corridor, are sensitive to flood conditions with flood sensitive receptors identified.

Hydraulic design criteria were adopted and used to guide mitigation of impacts through refinement of the hydraulic design, including adjustment of the numbers, dimensions and locations of major drainage structures.

Flood impact objectives have been established and used to guide the Project design including mitigation of impacts through refinement of the hydraulic design, including adjustment of the numbers, dimensions and location of major drainage structures. Table 13.51 summarises how the Project design performs against each of the established flood impact objectives.

13.11.3 Independent International Panel of Experts

The Australian and Queensland governments established an Independent International Panel of Experts (the Panel) for flood studies, to provide advice to the Commonwealth and the Queensland Governments on the flood models and structural designs developed by ARTC for Inland Rail in Queensland.

As an advisory body to government, the Panel is independent of the ARTC in respect of the development, public consultation and approvals for the Inland Rail EIS process. Relevant submissions received from public notification of the draft EIS will be provided to The Panel for consideration as part of its review.

Information on the Panel can be viewed at: tmr.qld.gov.au/projects/inland-rail/independent-panel-of-experts-for-flood-studies-in-queensland.

TABLE 13.51: FLOOD IMPACT OBJECTIVES AND OUTCOMES

Parameter	Objectives and outcomes				
Change in peak water levels	Existing habitable and/or commercial and industrial buildings/ premises (e.g. dwellings, schools, hospitals, shops)	Residential or commercial/industrial properties/lots where flooding does not impact dwellings/buildings (e.g. yards, gardens)	Existing non-habitable structures (e.g. agricultural sheds, pump-houses)	Roadways	Agricultural and grazing land/forest areas and other non-agricultural land
	≤ 10 mm	≤ 50 mm	≤ 100 mm	≤ 100 mm	≤ 200 mm with localised areas up to 400 mm
	Objective: Changes in peak water levels are to be assessed against the above proposed limits. Outcome: Generally, the Project design meets the above limits with number of localised areas along the Project alignment where these limits are slightly exceeded. These areas are generally agricultural land or local roadways. No existing flood sensitive receptors are impacted by the changes in peak water levels under the 1% AEP event.				
Change in duration of inundation	Objective: Identify changes to time of inundation through determination of ToS. For roads, determine AATOS (if applicable) and consider impacts on accessibility during flood events. Outcome: There are localised increases in duration of inundation (ToS) at the same locations where peak water levels are increased. These changes in inundation duration do not affect flood sensitive receptors except for two local roads being Dodt Road and Hall Road. Dodt Road has a very minor increase in ToS and hence no increase in AAToS. Hall Road experiences an increase in AAToS (+2.7 hrs/yr), which is considered a negligible impact on the amenity of the roadway.				
Flood flow distribution	Objective: Aim to minimise changes in natural flow patterns and minimise changes to flood flow distribution across floodplain areas. Identify any changes and justify acceptability of changes through assessment of risk with a focus on land use and flood sensitive receptors. Outcome: The Project has minimal impacts on flood flows and floodplain conveyance/storage with significant floodplain structures included to maintain the existing flood regime.				
Velocities	Objective: Maintain existing velocities where practical. Identify changes to velocities and impacts on external properties. Determine appropriate scour mitigation measures taking into account existing soil conditions. Outcome: In general, changes in velocities are minor, with most changes in velocities experienced immediately adjacent to the Project alignment and no existing flood sensitive receptors impacted. Scour protection has been specified where the outlet velocities for the 1% AEP event exceed the allowable soil velocities for the particular soil type for each location, which was identified from published soil mapping.				
Extreme event risk management	Objective: Consider the risks posed to neighbouring properties for events larger than the 1% AEP event to minimise unexpected or unacceptable impacts. Outcome: A review of impacts under the 1 in 2,000 AEP, 1 in 10,000 AEP and PMF events has been undertaken. Between Helidon and Lawes, the changes in peak water levels at flood sensitive receptors are a small percentage change as compared to the existing flood depth (<10% for most locations). Larger impacts occurring under the PMF event where the Existing Case modelling demonstrated there are already high flood depths. In the vicinity of Forest Hill there are slight decreases in peak water levels under the 1 in 2,000 AEP and 1 in 10,000 AEP events due to the mitigation culvert banks included under the Project alignment and West Moreton System rail corridor. Under the PMF event there is a small percentage increase in overall depth due to the Project alignment with high flood depths occurring as would be expected under such a rare event. At flood sensitive receptors between Grandchester and Calvert, increases associated with the Project alignment are generally small (<50 mm) under the 1 in 2,000 AEP and 1 in 10,000 AEP events. Larger impacts occur under the PMF event where there are already high flood depths as would be expected under such a rare event. No new flow paths or significant additional areas of inundation are created due to the Project alignment under these extreme events.				

Parameter	Objectives and outcomes
Sensitivity testing	Objective: Consider risks posed by climate change and blockage in accordance with ARR 2016. Undertake assessment of impacts associated with Project alignment for both scenarios. Outcome: Climate change—Climate change has been assessed in accordance with ARR 2016 requirements with the RCPs 8.5 (2090 horizon) scenario adopted giving an increase in rainfall intensity of 18.7 per cent across the catchment areas. Potential impacts resulting from changes in peak water levels under the 1% AEP event with climate change are generally similar to those seen under the 1% AEP event. There is one exception to this between Gatton and Lawes where there are two properties (houses and sheds) experience increases under the climate change scenario that will be looked at further during detailed design. The flood depth at both locations is approximately 1 m under the 1% AEP event with climate change and further information regarding the existing infrastructure is required to refine the outcomes. Blockage—blockage of drainage structures has been assessed in accordance with ARR 2016 requirements. The blockage assessment resulted in no blockage factor being applied to bridges and a blockage factor of 25 per cent being applied to culverts. Two blockage sensitivity scenarios were tested with both 0 per cent and 50 per cent blockage of all culverts assessed. The resulting changes in peak water levels associated with the Project alignment remain localised and do not impact on any flood sensitive receptors. During detailed design the blockage factors will be reviewed in line with the final design and local catchment conditions. This may result in a varied and/or lower blockage factors being applied along the proposal alignment.

The hydrologic and flooding assessment demonstrates that the potential Project impacts will generally comply with the flood impact objectives. Calibrated and validated model predictions indicate that no adverse impacts to existing flood regimes are expected.

Best practice flood risk management, including sensitivity testing, has been applied in developing the Project design. The design used as the basis for the EIS minimises risk to life, property, infrastructure, the community and environment. This includes consideration of flood risk for properties and businesses, including in and around Grantham, Gatton, Forest Hill, Laidley, Grandchester and Calvert.

A consultation exercise has been undertaken to provide the community with detailed information and certainty around the flood modelling and the Project design.

Throughout the detailed design, construction and operational phases of the Project, ARTC will continue to work with:

- Landowners concerned with hydrology and flooding
- Directly impacted landowners affected by the alignment
- Local councils, State departments and local specialists.