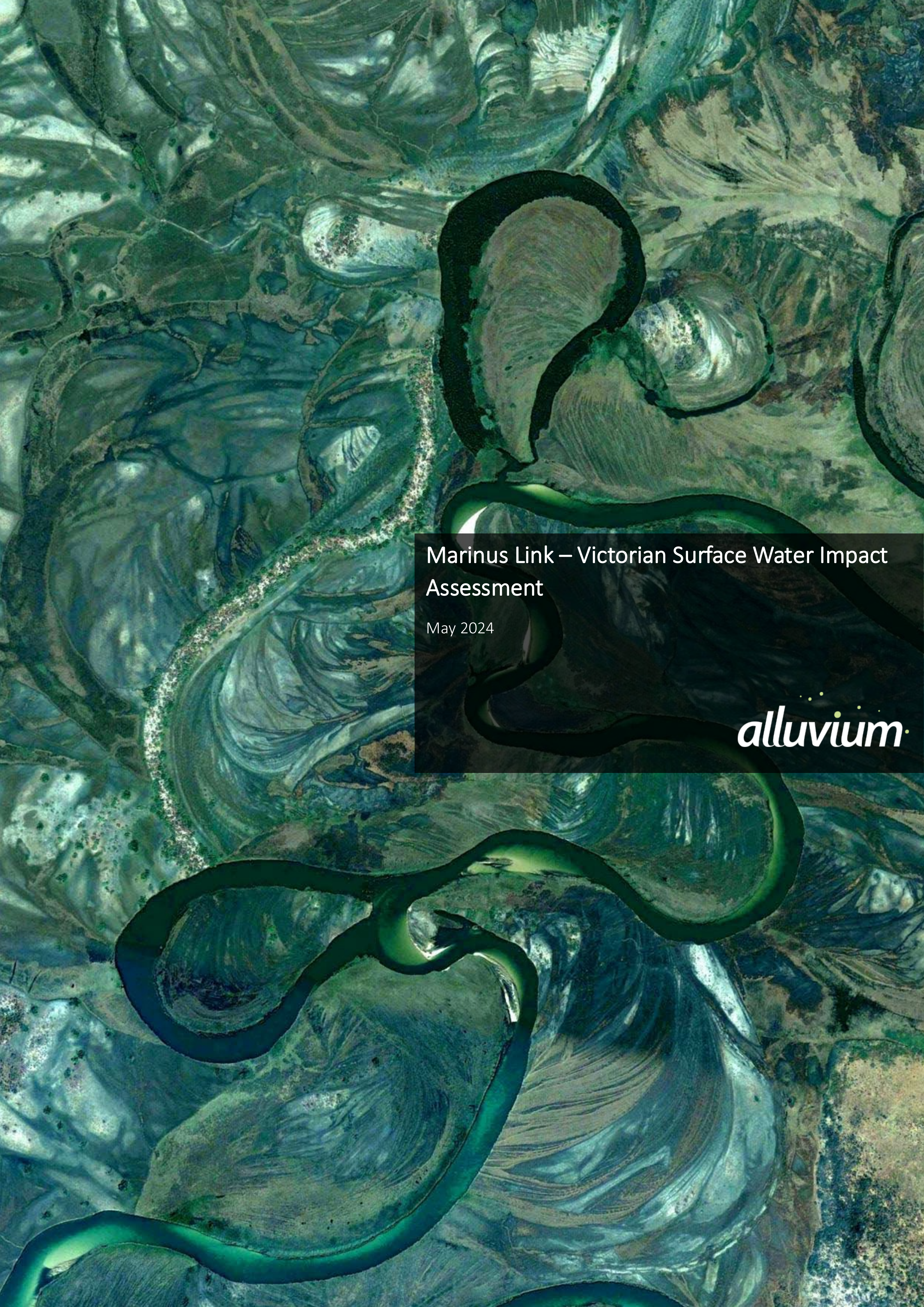
Environmental Impact Statement/Environment Effects Statement

Appendix Q

Surface water

MARINUS LINK



Marinus Link – Victorian Surface Water Impact Assessment

May 2024

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Alluvium recognises and acknowledges the unique relationship and deep connection to Country shared by Aboriginal and Torres Strait Islander people, as First Peoples and Traditional Owners of Australia. We pay our respects to their Cultures, Country and Elders past and present.

Artwork by Vicki Golding. This piece was commissioned by Alluvium and has told our story of water across Country, from catchment to coast, with people from all cultures learning, understanding, sharing stories, walking to and talking at the meeting places as one nation.

This report has been prepared by Alluvium Consulting Australia Pty Ltd for **Tetra Tech Coffey** under the contract titled '**Marinus Link Crossing Assessment**'.

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Abbreviations

Term	Description
%	percent
≤	less than or equal to
°C	degrees Celsius
µg	microgram
µS	micro siemens
4WD	Four-wheel drive
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
AoD	Area of Disturbance
ARR	Australian Rainfall and Runoff
ASS	Acid Sulfate Soils
CIA	Cumulative Impact Assessment
cm	centimetres
CMA	Catchment Management Authority
DCCEEW	Commonwealth Government Department of Climate Change, Energy, the Environment and Water
DEM	Digital Elevation Model
DTP	Department of Transport and Planning (Victoria)
EE Act	*Environment Effects Act 1978* (Vic)
EES	Environment Effects Statement
EIS	Environmental Impact Statement
EMPCA	Environmental Management and Pollution Control Act 1994 (Tas)
EP Act	*Environment Protection Act* 2017 (Vic)
EPA	Environment Protection Authority (Victoria)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPR	Environmental Performance Requirement
ERS	Environmental Reference Standard
FO	Flood Overlay
GIS	Geographic Information System
GLaWAC	Gunaikurnai Land and Waters Aboriginal Corporation
HDD	Horizontal Direction Drilling
HDPE	High density polyethylene
HVAC	High voltage alternating current
HVDC	High voltage direct current
IEA	Independent Environmental Auditor
IPCC	Intergovernmental Panel on Climate Change
ISC	Index of Stream Condition
km	kilometres
km^2	square kilometres
KP	kilometre points
kV	kilovolt
L	litre
LCC	Latrobe City Council
LiDAR	Light Detection and Ranging
LSIO	Land Subject to Inundation Overlay
m	metres
m^2	square metres
MERI	Monitoring, Evaluation, Reporting and Improvement
MLPL	Marinus Link Pty Ltd
mm	millimetres
MNES	Matters of national environmental significance
MW	megawatt
N	newtons
N/m^2	newtons per square metre
NEM	National Electricity Market
NTU	Nephelometric Turbidity Units
NWQMS	National Water Quality Management Strategy
NWTD	North West Transmission Developments

Term	Description
RAP	Registered Aboriginal Party
RCP	Representative Concentration Pathway
SBO	Special Building Overlay
SEPP	State Environment Protection Policies
SGSC	South Gippsland Shire Council
Tasmanian EPA	Tasmanian Environment Protection Authority
TCM	Trenchless Construction Method
TRG	Technical reference group
UFZ	Urban Floodway Zone
VPP	Victorian Planning Provisions
VSC	Voltage source converter
VWMS	Victorian Waterways Management Strategy
W	Watts
W/m^2	Watt Per Square Meter
WGCMA	West Gippsland Catchment Management Authority
WGFMS	West Gippsland Floodplain Management Strategy 2018-2027
WGRCS	West Gippsland Regional Catchment Strategy 2021-2027
WGRWMS	West Gippsland Regional Waterways Management Strategy
WESS	Wooreen Energy Storage System

Glossary

Term	Description
AEP	Annual Exceedance Probability- The probability that a given flow event will be exceeded in any one year
Aggradation	The deposition of material by a river, stream or current.
Avulsion	The abandonment of one stream alignment in favour of an alternate stream course
Anabranch	An old course of the river channel which is no longer the main low-flow channel.
Bedgrade	The grade or slope measured by the ratio of vertical drop in bed elevation of a stream per unit horizontal distance.
Bifurcation	Occurs when a river flowing in a single stream separates into two or more separate streams
Billabong	Sometimes called a meander cut-off or oxbow lake, where the bends of two meander loops meet, bypassing the river bend and creating a lake/wetland.
Confined	The channel abuts the valley margin along more than 90% of its length and occasional floodplain pockets occur on the inside of bends (discontinuous).
Confinement	The degree to which valley margins (sides) abut the waterways channel.
Degradation	The erosion of material by a river, stream or current.
Deposition	Process of sediment being 'dropped' or deposited, generally due to a reduction in transport capacity.
Equilibrium (channel)	The point where channel capacity remains relatively constant for a given flow regime (no net degradation or aggradation). Equilibrium is sometimes described as being 'dynamic' in that small adjustments are constantly being made.
Erosion (fluvial)	Detachment/removal of material on river beds and banks through fluvial (river) processes (e.g., flow conditions)
Floodplain	A relatively flat area, adjacent to a waterways that is likely to be inundated under a maximum flood.
Fluvial	Pertaining to water flow and rivers
Geomorphology (fluvial)	The physical form of the bed and banks of a waterways, including habitat features and physical processes (erosion and deposition)
Grade control structure	A physical reinforcement of the bed of a channel designed to mitigate incision processes. Usually constructed of rock (e.g., rock chute), the structure allows for a controlled drop in bed level that incorporates energy dissipation.
Headcut (or Knickpoint)	Sharp step or small waterfall formed in the channel bed through erosion processes. These steps tend to progress in an upstream direction.
Hydraulic modelling	Computer models that calculate water flow characteristics (velocity, depth, etc.) using information on channel and floodplain geometry, stream slope, land cover/vegetation, man-made factors (bridges, levees, culverts) and different flow (hydrologic) conditions.
Hydrologic modelling	Computer models designed to estimate the amount of runoff or streamflow generated by individual rainfall (or other precipitation) events or by a combination of various rainfall events over a catchment. These models consider different land cover, soil types and topography.
Hyetograph	A graphical representation of the distribution of rainfall intensity over time.
Incision	A process of channel deepening and widening.
Levees	A natural or human made earthen bank that restricts flooding.

Term	Description
LiDAR	Light Detection and Ranging, a remote sensing method that uses light in the form of a pulsed laser to measure distances to the Earth.
Meandering	A sinuous channel form in flatter bed grades formed by the erosion on one side of the channel (pools) and deposition on the other (point bars).
Perched channel	Where the bed of a channel is at higher elevation than adjacent depression lines or channels across the floodplain.
Planform	Shape of a river as seen from the air.
Pool	An area of deeper, slower flowing water in a river channel, often found in sequence with riffles (a pool-riffle sequence)
Riffle	An area of shallower, faster flowing water in a river channel, often found in sequence with pools (a pool-riffle sequence).
Riparian zone	Any land which adjoins, directly influences, or is influenced by a body of water.
Scour	A form of bank erosion caused by sediment being removed from stream banks particle by particle. Scour occurs when the force applied to a bank by flowing water exceeds the resistance of the bank surface to withstand those forces.
Shear stress	The external force acting on an object or surface parallel to the slope or plane in which it lies; the stress tending to produce shear. Measured in Newtons per square metre (N/m^2).
Sinuosity	The tendency of a river to meander. Measured as a ratio between the channel length and straight-line length between two points along a river segment. High sinuosity reaches are typically associated with low energy alluvial floodplains whilst low sinuosity may be associated with steep headwaters and channelised valley fill.
Stream power	The amount of energy the water in a river or stream is exerting on the sides and bottom of the river.
Toe (bank)	Bottom of the bank
Topography	The form and features of land surfaces

Executive summary

Marinus Link (the project) is a proposed 1,500 megawatt (MW) HDVC electricity interconnector between Heybridge in northwest Tasmania and the Latrobe Valley in Victoria.

The project was referred to the Australian Minister for the Environment 5 October 2021. On 4 November 2021, a delegate of the Minister for the Environment determined that the proposed action has the potential to have a significant impact on the environment and requires assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and will be assessed by an environmental impact statement (EIS) under the EPBC Act.

On 12 December 2021, the Victorian Minister for Planning under the *Environment Effects Act 1978* (EE Act) determined that the project requires an Environment Effects Statement (EES) under the EE Act.

As the project is proposed to be located within three jurisdictions, the Victorian Department of Transport and Planning (DTP), Tasmanian Environment Protection Authority (Tasmanian EPA) and Australian Department of Climate Change, Energy, Environment and Water (DCCEEW) have agreed to coordinate the administration and documentation of the three assessment processes. One EIS/EES is being prepared to address the requirements of DTP and DCCEEW. Two EISs are being prepared to address the Tasmanian EPA requirements for the Heybridge converter station and shore crossing.

Surface water includes any natural water on land that has not infiltrated below the ground, including runoff from rainfall, and waterways and wetlands. As well as providing aquatic and riparian habitat, and recreation and amenity values, surface water also provides a valuable resource for domestic, industrial and agricultural use, and supports Aboriginal cultural heritage values. It is therefore important to consider when assessing the impacts of the project.

The surface water impact assessment covers the surface water impact assessment for the portion of the proposed alignment defined as Waratah Bay to Hazelwood in Victoria as part of the EIS/EES being prepared for the whole project. This report has also defined recommended mitigation measures to limit potential risks of the project on surface water through achieving the Environmental Performance Requirements (EPRs) necessary to meet the EES objectives relevant to surface water.

Assessment guidelines overview

DCCEEW have published the guidelines for the EIS: '*Guidelines for the Content of an Environmental Impact Statement – Environment Protection and Biodiversity Conversation Act 1999 - Marinus Link underground and subsea electricity interconnector cable* (EPBC 2021/9053)'.

The final scoping requirements for the Marinus Link Project EES by the Minister for Planning set out the specific environmental matters to be investigated and documented in the project's EES, which informs the scope of the EES technical studies. In particular the EES is to investigate relevant to the surface water assessment:

Effects on freshwater and marine environments and related environmental values, including any changes to stream flows, water quality or sedimentation due to waterway crossings or installation of subsea cables (section 1.2).

The following evaluation objective contained in the Final EES scoping requirements that is relevant to the surface water assessment is:

Avoid and, where avoidance is not possible, minimise adverse effects on land and water (including groundwater, surface water, waterway, wetland, and marine) quality, movement and availability (section 4.2 of the Final EES scoping requirements).

The purpose of this report is to assess the potential surface water impacts associated with the Marinus Link project to inform the preparation of the Environment Effects Statement (EES) and *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) assessments required for the project.

Study area

This study focuses on eight major waterways that the proposed Project alignment crosses in Victoria:

- Morwell River, near Hazelwood
- Little Morwell River, near Darlimurla
- Tarwin River East Branch, near Dumbalk
- Tributary of the Tarwin River East Branch, near Dumbalk (northern tributary)
- Tributary of the Tarwin River East Branch, near Dumbalk (southern tributary)
- Stony Creek, near the town of Stony Creek
- Buffalo Creek, near the town of Buffalo
- Fish Creek, south of the town of Buffalo

In addition to the eight major waterways, the potential surface water impact of the two proposed converter stations and a transition station have been assessed:

- Hazelwood converter station
- Driffield converter station
- Waratah Bay transition station

Baseline characterisation (Existing conditions)

Desktop assessments were undertaken to identify and document water related environmental values relevant to the alignment. Assessments were made of geomorphology, hydrology and water quality.

Field inspection of waterway crossing sites and a short distance upstream/downstream was undertaken to gain an appreciation of:

- Waterway form, health and geomorphic value/habitat
- Flow behaviour and flow pathways
- Evidence of channel change causes of change, and potential for future change.

Impact assessment

The impact assessment has considered the potential for the construction and operation of the project to influence water quality, geomorphology and flooding within their associated floodplains. Impacts associated with decommissioning will need to be assessed at the time of decommissioning. From these key surface water values, a range of potential risks associated, including their respective hazards and pathways for these risks were identified, with a risk assessment approach adopted for the purposes of determining these potential effects of the project.

The assessment identified activities such as excavation or stockpiling leading to temporary or permanent alteration of topography will impact the floodplain capacity to store and or transport floodwaters for the key waterways included in the study. This mechanism risks increasing flood frequency, velocity or flood levels which affects users or assets within the floodplain.

The risk of a flood event occurring during the construction of the joint pits, Horizontal Directional Drilling (HDD) drill pads, access roads and trenches causing inundation of assets and sediment liberation during construction was identified through the pathway where an open excavation or exposed soil is inundated in a flood event. Although, unlikely given the construction period within floodplains is condensed, the consequence of such an event will be moderate, leading to an overall risk rating of low.

Typical mitigation measures and EPRs

Typical mitigation measures have been identified below to help guide the selection of EPRs in Section 6.6. These standard mitigation measures should be implemented in line with the hierarchy for controlling hazards and associated risks outlined in EPA Victoria Publication 1695.1 *Assessing and controlling risk for business* (Victoria, 2018).

The hierarchy of controls to minimise impacts to surface water quality and flow regime involves use of avoidance or mitigation measures in the following order (Victoria, 2018):

1. Measures that eliminate impacts altogether.
2. Measures that minimise the magnitude of the impact through substitution or engineering controls.
3. Measures that change the behaviour of people in order to minimise the magnitude of impact (administrative controls).

The risk assessment process was used to identify mitigation measures, minimisation measures and the subsequent environmental performance requirements (EPRs) as part of the surface water impact assessment.

EPRs and their development are presented in Section 6.6. With the EPRs in place there are no remaining high risks and all have been reduced to a low residual risk rating.

Residual construction risk ratings that are subject to final detailed modelling include:

- Construction activities causing an increase in flood frequency, velocity or level which affects users or assets within the floodplain.
- Construction activities on existing flow paths including piped flow, causing a change in flow.
- Construction activities causing unintended damage to waterways (including drainage channels) resulting in changed flow behaviour, bed or bank erosion, and/or physical habitat.
- Construction activities resulting in bed or bank erosion and sediment release.
- Construction activities causing sediment or contaminants to be released into the waterways.

Residual operation risk ratings that are subject to final detailed modelling include:

- Project assets causing an increase in flood frequency or level which affect users or assets within the floodplain
- Diversion of stormwater, drainage alignment or flow pathways causing a change in flow to downstream.
- Diversion of stormwater, drainage alignment or flow pathways leading to bed or bank erosion causing instability of assets adjacent to the waterway and/or increased sediment loads.
- Increase in impervious area leading to an increase in sediment or contaminants released into the waterways

Risks associated with decommissioning will need to be assessed at the time of decommissioning.

Cumulative impacts

This surface water assessment includes a Cumulative Impacts Assessment (CIA) of multiple projects occurring at similar times and within proximity to each other. Proposed and reasonably foreseeable projects have been identified based on their potential to contribute to cumulative impacts by overlapping with the proposed Marinus Link project location and timeframe. An assessment of these in regard to its cumulative impact on flooding, water quality and geomorphology is presented.

Conclusion

This report has been prepared within the limitations and identified data gaps of the work outlined in Section 4.6.

Based on the identified risks and their associated mechanisms, a series of Environmental Performance Requirements (EPRs) have been developed to effectively manage these potential risks, including the requirement to develop of a Surface Water Management Plan (SW01) that will specify the measures the construction process will be required to adhere to, so that flood risk was minimised. While this report focused on 8 major waterways these EPRs are to be adopted in the vicinity of any waterway.

While the flood mapping indicates that the proposed converter and transition stations will result in minor increases in flood depth and extent as a result of the works, this is generally limited to less than 50mm, contained to the immediate area resulting in low risk of change/impacts to flood behaviour. However, additional detailed flood modelling through the design phase should be undertaken to confirm the flood impact of the final design on adjacent infrastructure (such as roads), refine migration options and seek acceptance from WGCMA (as per EPR SW02).

The implementation of the EPRs proposed within this report directly addresses the impacts identified and provides a means to manage the identified risks associated with the construction and operation phases to a low risk level.

1 Introduction

1.1 Background

The proposed Marinus Link (the project) comprises a high voltage direct current (HVDC) electricity interconnector between Tasmania and Victoria, to allow for the continued trading and distribution of electricity within the National Electricity Market (NEM).

The project was referred to the Australian Minister for the Environment 5 October 2021. On 4 November 2021, a delegate of the Minister for the Environment determined that the proposed action is a controlled action as it has the potential to have a significant impact on the environment and requires assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) before it can proceed. The delegate determined that the appropriate level of assessment under the EPBC Act is an environmental impact statement (EIS).

On 12 December 2021, the former Victorian Minister for Planning under the *Environment Effects Act 1978* (Vic) (EE Act) determined that the project requires an environment effects statement (EES) under the EE Act, to describe the project's effects on the environment to inform statutory decision making.

In July 2022, a delegate of the Director of the Environment Protection Authority Tasmania determined that the project be subject to environmental impact assessment by the Board of the Environment Protection Authority (the Board) under the *Environmental Management and Pollution Control Act 1994 (Tas)* (EMPCA).

As the project is proposed to be located within three jurisdictions, the Victorian Department of Transport and Planning (DTP), Tasmanian Environment Protection Authority (Tasmanian EPA) and Australian Department of Climate Change, Energy, Environment and Water (DCCEEW) have agreed to coordinate the administration and documentation of the three assessment processes. One EIS/EES is being prepared to address the requirements of DTP and DCCEEW. Two EISs are being prepared to address the Tasmanian EPA requirements for the Heybridge converter station and shore crossing.

This report has been prepared by Alluvium Consulting Australia Pty Ltd (Alluvium) for the Commonwealth and Victorian jurisdictions as part of the EIS/EES being prepared for the project.

1.2 Project overview

The project is a proposed 1500 megawatt (MW) HVDC electricity interconnector between Heybridge in northwest Tasmania and the Latrobe Valley in Victoria (Figure 1). Marinus Link is proposed to provide a second link between the Tasmanian renewable energy resources and the Victorian electricity grids enabling efficient energy trade, transmission and distribution from a diverse range of generation sources to where it is most needed, and will increase energy capacity and security across the National Electricity Market (NEM).

Marinus Link Pty Ltd (MLPL) is the proponent for the project and is a wholly owned subsidiary of Tasmanian Networks Pty Ltd (TasNetworks). TasNetworks is owned by the State of Tasmania and owns, operates and maintains the electricity transmission and distribution network in Tasmania.

Tasmania has significant renewable energy resource potential, particularly hydroelectric power and wind energy. The potential size of the resource exceeds both the Tasmanian demand and the capacity of the existing Basslink interconnector between Tasmania and Victoria. The growth in renewable energy generation in mainland states and territories participating in the NEM, coupled with the retiring of baseload coal-fired generators, is reducing the availability of dispatchable generation that is available on demand.

Tasmania's existing and potential renewable resources are a valuable source of dispatchable generation that could benefit electricity supply in the NEM. Marinus Link will allow for the continued trading, transmission and distribution of electricity within the NEM. It will also manage the risk to Tasmania of a single interconnector across Bass Strait and complement existing and future interconnectors on mainland Australia. Marinus Link is expected to facilitate the reduction in greenhouse gas emissions at a state and national level.

Interconnectors are a key feature of the future energy landscape. They allow power to flow between different regions to enable the efficient transfer of electricity from renewable energy zones to where the electricity is needed. Interconnectors can increase the resilience of the NEM and make energy more secure, affordable and sustainable for customers. Interconnectors are common around the world including in Australia. They play a critical role in supporting Australia's transition to a clean energy future.

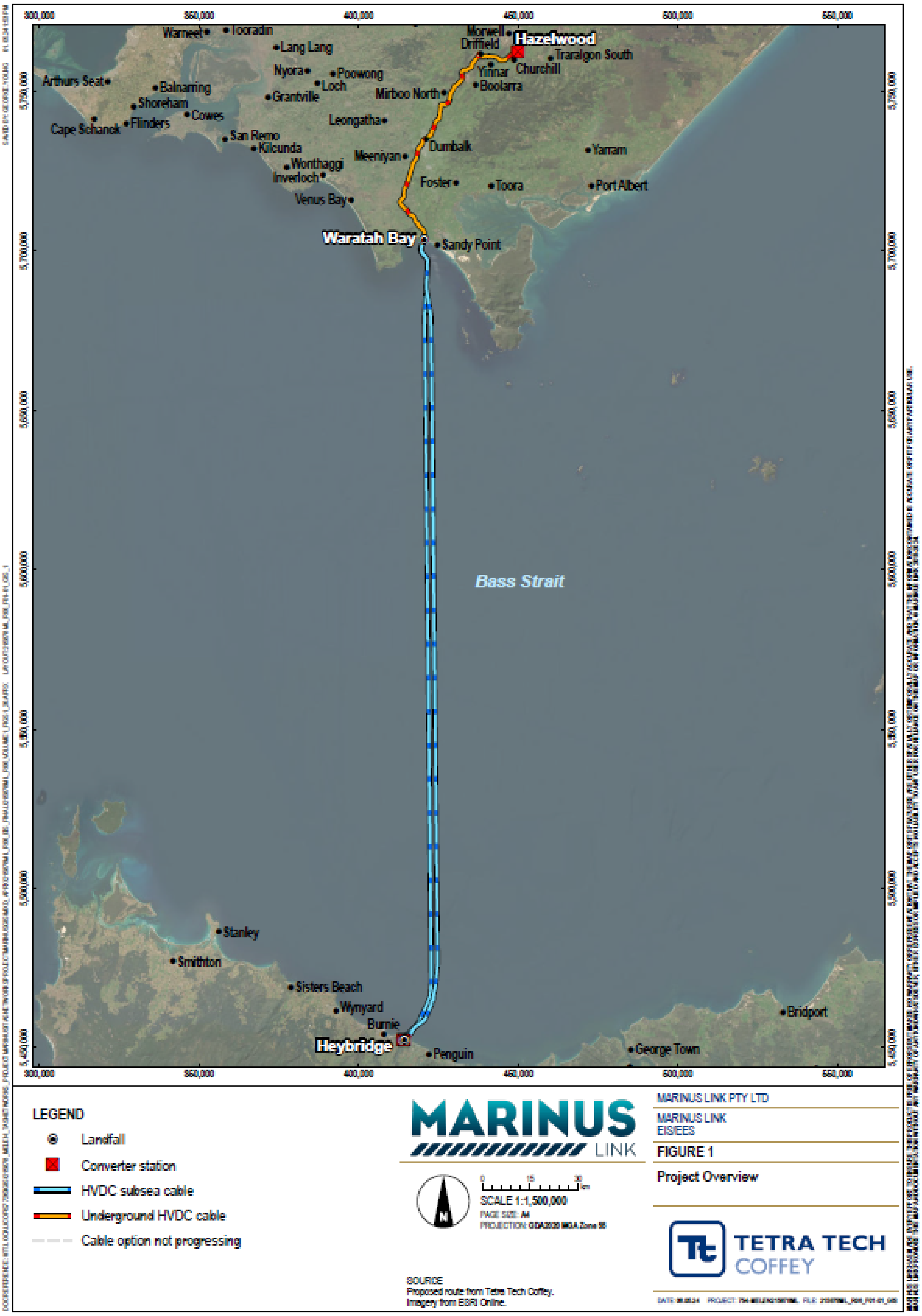

Figure 1. *Project Overview*

1.3 Purpose of this report

The purpose of this report is to assess the potential surface water impacts associated with the project to inform the preparation of the Environment Effects Statement (EES) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Cwlth) assessments required for the project.

Assessment context

Surface water includes any natural water on land that has not infiltrated below the ground, including runoff from rainfall, and waterways and wetlands. Aside from providing aquatic and riparian habitat, and recreation and amenity values, surface water also provides a valuable resource for domestic, industrial and agricultural use, and supports Aboriginal cultural heritage values. It is therefore important to consider when assessing the impacts of the project.

Healthy waterways can be described in numerous different ways. Key components of waterway health include:

- Flow – the volume, timing, frequency and characteristics (e.g., velocity) of water flow
- Connectivity – both longitudinally up and down a waterway and laterally across the floodplain
- Water quality – parameters such as temperature, dissolved oxygen, pollutants, nutrients and turbidity that support waterway ecosystems
- Geomorphology – the physical form of the bed and banks of a waterway, including habitat features and physical processes (erosion and deposition)
- Fringing riparian and floodplain vegetation – providing shading, nutrient inputs and physical habitat

Although this report focuses on the 8 major waterway crossings crossed by the alignment for detailed assessment, the key issues, likely impacts, and mitigation strategies will apply more broadly to all the 82 waterways and floodplains where crossings or other works are proposed for the project (study area detail is provided in Section 4.1). It is important to recognise that the region's waterways and catchments, as with much of Victoria, have been impacted by past land use and river management practices associated with European settlement (refer to Technical Appendix S: Land use and planning for land use).

These changes include:

- Clearing of floodplain and riparian vegetation for grazing, agricultural production, industry and settlement (estimated 86% loss of the pre-European vegetation cover on freehold land in West Gippsland Catchment Management Authority (WGCMA, 2023))
- Regulation of rivers and extraction of water for industrial, agricultural and domestic use
- Introduction of invasive species
- Nutrient pollution and sedimentation
- Physical modification of channels through straightening, de-snagging and constructed drainage channels

These changes can impact on waterway processes through:

- Changed runoff regimes and initiation of incision processes through increased runoff.
- Bed and bank erosion associated with incision and meander development on straightened waterway channels.
- Changed sediment regimes and increases in sediment supply from cleared land.

It is important to apply the findings and recommendations of this report to all waterways and floodplains where crossings or other works are proposed, as surface water and waterways is also important to human values through provision of water for domestic and stock use; social, cultural, and recreational uses of surface water; and minimised flood impacts on property and assets. Additionally, changes in floodplain extents and flood behaviour due to physical landscape changes (e.g., drainage channels) can have significant impacts on the environment and human populations, highlighting the importance of considering the broader implications of the project on waterways and floodplains study objectives

The study objectives are to identify and evaluate the potential impacts on surface water values that the proposed project may pose and propose appropriate measures to avoid, minimise, mitigate and manage identified impacts, as far as reasonably practicable. This includes the scoping requirements marine and catchment values evaluation objective:

> *"Avoid and, where avoidance is not possible, minimise adverse effects on land and water (including groundwater, surface water, waterway, wetland, and marine) quality, movement and availability."* (section 4.2 of the Final EES Scoping Requirements).

Final Scoping Requirements: Marinus Link Environment Effects Statement
(Department of Environment, Land, Water and Planning, 2022)

Potential impacts

Potential impacts from the project on the surface water environment have been identified in the EIS guidelines and EES Scoping Requirements and are considered further by this impact assessment. These potential impacts were also identified based on the professional experience of Alluvium's hydrologists and their environmental team on other similar linear infrastructure projects and is informed by the understanding of the existing conditions presented in Section 5.

The project has potential to impact on these waterways during construction and operation through the following process:

- Changed flood behaviour, either reducing flood extents (impacting on floodplain connectivity) or increasing flood extents, increasing risk to property or assets.
- Reduced water quality through release of pollutants or sediment to waterways, impacting on waterway ecosystems and human uses.
- Altered geomorphic condition resulting in changes in physical habitat, erosion, deposition or waterway stability.

Potential impacts to flood behaviour, water quality and geomorphic conditions are further discussed in sections 6.2 to 6.4.

The loss of water availability or storage is not considered through this assessment, given no dams or water storages are proposed. Impacts associated with decommissioning will need to be assessed at the time of decommissioning. Surface water also has potential to impact on the project and create risk through:

- Flooding of built infrastructure, e.g., joint pits
- Physical waterway processes interacting with project infrastructure, e.g., through erosion

These risks are explored further in Attachment 4.

2 Assessment guidelines

This section outlines the assessment guidelines relevant to this surface water impact assessment and the linkages to other EIS/EES technical assessments. A single consolidated EIS/EES is being prepared to address the requirements of the Commonwealth and Victorian jurisdictions, including the requirement for an EES. This report will use the term EIS/EES going forward.

Technical studies, engagement with government agencies and development of the EES and EIS will be integrated, including public comment on final scoping documents (EES/EIS) and assessment documentation (EES/EIS) and utilising a Technical Reference Group (TRG) established and chaired by DTP to advise on the development of the EES/EIS.

The TRG comprises Victorian and Commonwealth government agencies, the Tasmanian EPA, Registered Aboriginal Parties (RAPs), regional authorities and local councils for this EES process to advise DTP and the proponent on:

- applicable policies, strategies and statutory provisions;
- EES scoping requirements;
- the design and adequacy of EES technical studies;
- the proponent's public information and stakeholder consultation program for the EES process;
- responses to issues arising from the EES investigations
- the technical adequacy and completeness of EES documentation; and
- coordination of statutory processes.

Including those agencies on the TRG, several agencies play a role in administering and implementing various legislation, policy, and guidelines relevant to this assessment. These agencies include:

- Commonwealth Government Department of Climate Change, Energy, the Environment and Water (DCCEEW)
- Victorian Department of Transport and Planning (DTP)
- Environment Protection Authority (EPA)
- West Gippsland Catchment Management Authority (WGCMA)
- Gunaikurnai Land and Waters Aboriginal Corporation (GLaWAC)
- South Gippsland Shire Council (SGSC)
- Latrobe City Council (LCC)

2.1 Commonwealth

DCCEEW have published the following guidelines for the EIS: '*Guidelines for the Content of a Draft Environmental Impact Statement – Environment Protection and Biodiversity Conservation Act 1999* – Marinus Link underground and subsea electricity interconnector cable (EPBC 2021/9053)'.

EIS requirements

Table 1 outlines the relevant EIS requirements for identification and management of impacts and risks to surface water. Specific impacts to EPBC listed species, including aquatic and riparian species that are surface water dependent are considered in the Terrestrial Ecology Impact Assessment (ELA, 2023).

Table 1. Relevant EIS requirements

Relevant requirement	Relevant report/section
Description of the existing environment	
Terrestrial and aquatic ecosystems, including key vegetation communities and relevant waterways	Technical report: Terrestrial Ecology Impact Assessment (ELA, 2023) Section 4.1 Study area
Surface water and groundwater hydrology and quality where relevant	Section 5.2 Existing flooding conditions Section 5.3 Existing water quality conditions
Native flora and fauna, both terrestrial, aquatic and aerial	Technical report: Terrestrial Ecology Impact Assessment (ELA, 2023)
Aquatic and terrestrial pest species and weeds	Technical report: Terrestrial Ecology Impact Assessment (ELA, 2023)
Description of the protected matters	
Protected matters must be described at an ecologically relevant scale (local, regional) so that the relative value / importance of the area that will be affected (directly and indirectly) is understood.	Technical report: Terrestrial Ecology Impact Assessment (ELA, 2023)
Relevant impacts	
The EIS must provide a detailed assessment of any likely impact that this proposed action may facilitate on the following (as described in section 4.3) at the local, regional, state and national scale: • Listed threatened species and ecological communities; • Listed migratory species; • The Commonwealth marine environment;	Technical report: Terrestrial Ecology Impact Assessment (ELA, 2023)
Proposed mitigation measures	
The EIS must provide information on proposed environmental performance requirements (EPRs), and any specific mitigation measures to deal with the relevant impacts of the proposed action on MNES, including those required by other Commonwealth, State, and local government approvals.	Technical report: Terrestrial Ecology Impact Assessment (ELA, 2023) Section 6.6

Other Commonwealth legislation, regulation, policies and guidelines

Several items of Commonwealth legislation, regulations, policy and guidelines are relevant for this surface water impact assessment. The legislation and documents that apply to the surface water assessment are summarised in Table 2.

Table 2. Commonwealth legislation, regulations, policies and guidelines relevant to this assessment.

Legislation, regulation, policy, or guideline	Description
National Water Quality Management Strategy (2018) (NWQMS)	First introduced in 1992, the purpose of the NWQMS is to protect the nation's water resources by maintaining and improving water quality so that it is 'fit for purpose', while supporting dependent aquatic and terrestrial ecosystems, agricultural and urban communities, and industry. Under the NWQMS, there are a range of tools and guiding documents to assist in improving water quality and reducing pollution. In Australia, the primary responsibility for water quality management lies with state and territory governments, except for areas like Commonwealth marine waters.
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG)	The Water Quality Guidelines provide authoritative guidance on the management of water quality for natural and semi-natural water resources in Australia and New Zealand. This includes setting water and sediment quality objectives designed to sustain current, or likely future, community values.
Australian Rainfall and Runoff (ARR) (Ball, et al., 2019)	Australian Rainfall and Runoff (ARR) is a national guideline document, data and software suite that can be used for the estimation of design flood characteristics in Australia. The 1st edition was released in 1958, with the latest (4th) edition published in 2019. The ARR2019 guidelines contain the currently adopted methods for hydrologic flow (flood) estimation including updates to rainfall intensities, rainfall losses and temporal patterns. The approaches presented in ARR are essential for policy decisions and projects involving infrastructure and estimation of flood levels.
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (Cwlth)	The EPBC Act is the main national environmental law and Act that applies to 'controlled actions' which have potential to impact on a matter of national environmental significance or Commonwealth land. It has been determined that the project is a controlled action and will require assessment (by an EIS) and approval under the EPBC Act. This surface water impact assessment will inform the EIS. The Act is administered by the DCCEEW.

2.2 Victoria

The EES Scoping Requirements issued by the Minister for Planning (February 2023) outline the specific matters to be assessed across a number of environmental and social disciplines relevant to the project, and to be documented in the EES for the project.

The EES Scoping Requirements inform the scope of the EES technical studies and define the EES evaluation objectives. The EES evaluation objectives identify the desired outcomes to be achieved and provide a framework for an integrated assessment of the environmental effects of a proposed project.

EES evaluation objective

The EES evaluation objective contained in section 4.2 of the EES scoping requirements that is relevant to this surface water assessment is:

Avoid and, where avoidance is not possible, minimise adverse effects on land and water (including groundwater, surface water, waterway, wetland, and marine) quality, movement and availability (Section 4.2 of the EES Scoping Requirements).

EES Scoping Requirements

In particular the EES is to investigate relevant to the surface water assessment:

Effects on freshwater and marine environments and related environmental values, including any changes to stream flows, water quality or sedimentation due to waterway crossings or installation of subsea cables (Section 1.2).

The requirements for the EES includes defining and assessing:

- key issues,
- existing environment,
- likely effects,
- mitigation, and
- performance criteria.

The relevant sections of the EES scoping requirements that this surface water impact assessment has addressed are summarised in Table 3, below.

Table 3. Final scoping requirements for the EES relating to the surface water assessment.

Requirement	Relevant report/section
Key issues	
The potential for adverse effects on freshwater, coastal and marine ecosystems, including changes to marine and coastal processes as a result of construction, operation and decommissioning of infrastructure.	Section 4.3 and 6.
The potential for adverse effects on the functions, and environmental values of surface water environments, such as interception or diversion of flows or changed water quality or flow regimes.	Section 4.3 and 6.
The potential for adverse effects on nearby and downstream water environments due to changed flow regimes, floodplain storage, run-off rates, water quality changes, or other waterway conditions, including in the context of climate change projections.	Section 6
The potential for disturbance of contaminated, saline, dispersive or acid sulphate soils	Section 5.3 and 6.3
Potential effects to environmental values through spills, disturbance of contaminated materials or the introduction of or spread of invasive species.	Section 5.3 and 6.3
Existing environment	
Describe marine, estuarine, intertidal, and freshwater waters and their environmental values that could be affected by the project, such as from changed water quality, or water movement.	Section 5
Likely effects	
Identify and evaluate potential effects of the project on groundwater, waterway, wetland, and marine waters, including with appropriate consideration of climate change scenarios and cumulative effects.	Section 6
Identify and assess potential effects of the project on soil stability, erosion and the exposure and disposal of contaminated or hazardous soils (e.g., acid sulphate soils).	Section 6, also covered in other reports (as outlined in section 2.4)
Identify potential effects resulting from the generation, storage, treatment, transport, and disposal of solid and liquid wastes, including soil.	Section 6, also covered in other reports (as outlined in section 2.4)
Apply a systems-based assessment where appropriate, for example, integrated marine water quality, hydrodynamics, marine ecology, and resource use studies.	Covered in broader EES

Requirement	Relevant report/section
Mitigation	
Identify and evaluate aspects of project works and operations, and proposed design refinement options or measures, that could avoid or minimise significant effects on groundwater, waterway, wetland, estuarine, intertidal, and marine waters.	Section 6.6
Describe further potential and proposed design options and measures that could avoid or minimise significant effects on groundwater, waterway, wetland, and marine waters during the project's construction and operation, including response measures for environmental incidents.	Section 6.6
Performance criteria	
Describe the framework for monitoring and evaluating the measures implemented to mitigate impacts on water, soils and landforms and contingencies.	Section 6.6

Other Victorian legislation, regulation, policies and guidelines

Several items of Victorian legislation, regulations, policy and guidelines are relevant for this surface water impact assessment. The legislation and documents that apply to the surface water assessment are summarised in Table 4.

Table 4. Victorian legislation, regulations, policies and guidelines relevant to this assessment.

Legislation, regulation, policy, or guideline	Description
Environment Effects Act 1978 (Vic) (EE Act)	In Victoria, assessments of the environmental impact of proposed development projects are conducted through the Environment Effects Statement process under the *Environment Effects Act 1978* (Vic) (EE Act). DTP coordinate the process, implementing Ministerial guidelines that set out the processes and requirements under the Act. The Minister for Planning determined that the project requires an EES.
Water Act 1989 (Vic)	The *Water Act 1989* (Vic) provides the legal framework for managing Victoria's water resources. The main purpose of the Act is to: • promote the equitable and efficient use of our water resources • make sure our water resources are conserved and properly managed for the benefit of all Victorians • increase community involvement in conserving and managing our water resources The Act requires a works on waterways permit for all works and activities within the bed and banks of waterways. For the study area, these permits are administered by the WGCMA.
Victorian Waterway Management Strategy (VWMS)	The VWMS provides a detailed policy for managing Victoria's waterways over an eight-year period. The strategy provides a framework for government, in partnership with the community, to maintain or improve the condition of rivers, estuaries and wetlands so that they can continue to provide environmental, social, cultural, and economic values for all Victorians. The framework is based on regional planning processes and decision-making, within the broader system of integrated catchment management in Victoria.
Environment Protection Act 2017 (Vic) (EP Act)	This Act requires Victorians and businesses to minimise harm to the environment and human health from pollution or waste. It includes a General Environmental Duty (GED), a Duty to Notify the EPA of prescribed notifiable contamination, and a Duty to Manage contamination. The Environment Reference Standard (ERS 2021) sets benchmarks to assess and report on environmental conditions, including surface water, using indicators and objectives to determine whether environmental values are being maintained or threatened.
Environment Reference Standard 2021 (ERS) under the EP Act (Vic)	The ERS is made under section 93 of the EP Act, and outlines the environmental values, indicators and objectives for ambient air, ambient sound, land and water environments that are sought to be achieved or maintained in Victoria and standards to support those values. It plays a key role in environmental protection and guides the standards and management of surface water in Victoria.
Catchment and Land Protection Act 1994 (Vic)	The *Catchment and Land Protection Act 1994* (Vic) established Catchment Management Authorities (CMAs) and details specific natural resource management functions which each CMA is required to undertake as well as outlining governance requirements specific to CMAs. The Minister has issued a Statement of Obligations under the Act setting out these responsibilities.

Legislation, regulation, policy, or guideline	Description
Planning and Environment Act 1987 (Vic)	The *Planning and Environment Act 1987* (Vic) provides a framework for urban planning and the use and development of land in the State. The Act sets out procedures for preparing and amending the Victoria Planning Provisions (VPP) and planning schemes. The main functions of the Act are to: Set the broad objectives for planning in Victoria. Set the main rules and principles for how the Victorian planning system works. Set up the key planning procedures and legal instruments in the Victorian planning system. Define the roles and responsibilities of the Minister, councils, government departments, the community, and other stakeholders in the planning system. The VPP set out a framework from which all Victorian Planning Schemes are constructed. Planning schemes are enacted through local governments.
Climate Change Act 2017 (Vic)	The *Climate Change Act 2017* (Vic) provides Victoria with the legislative foundation to manage climate change risks. The Act includes a new set of policy objectives and an updated set of guiding principles to embed climate change in government decision making. Under the Act, Adaptation Action Plans across 7 systems have been developed to verify Victoria's climate resilience. Relevant Adaptation Action Plans for the project include those for Built Environment and Water Cycle.

The Water Act 1989 (Vic)

The *Water Act 1989* (Vic) requires a works on waterways permit for all works and activities within the bed and banks of waterways. For the study area, these permits are administered by the WGCMA. A permit is required for works including:

- the obstruction of, or interference with, a waterway;
- the construction, alteration, operation, removal or decommissioning of any works on a waterway;
- the obstruction of, or interference with, any works on a waterway;
- the erosion or damaging of the surrounds of a waterway;

These works include crossings, deviations/waterway realignments, extractions, stabilisation, vegetation removal/revegetation, and other works, including service crossings.

Under the Act, Catchment Management Authorities (CMAs) also have a range of floodplain management functions. These include:

- controlling developments that have occurred or that may be proposed for land adjoining waterways
- declaring a flood level- this flood level is defined as the best estimate, based on the available evidence, of a flood event which has a probability of occurrence of 1 per cent in any one year i.e., a 1% annual exceedance probability (AEP) event
- issuing consent/permits for regulated works within an area of land declared to be liable to flooding or declared to be a floodway area, that may have the effect of controlling or mitigating floodwaters, discharging stormwater, excluding tidal water, or concentrating or diverting floodwater or stormwater.

Victorian Waterway Management Strategy

The Victorian Waterway Management Strategy (VWMS) provides the policy for managing Victoria's waterways. The VWMS uses a values and condition-based approach where environmental, social, cultural and economic values of waterways are supported by environmental conditions (Figure 2). These conditions include habitat, water quality, water regime and connectivity. The overarching management objective of the Strategy is to maintain or improve the condition of our waterways so they can support these values. Through this impact assessment, we will determine impacts on waterways through determining risks to these conditions and risks to the implementation of the VWMS.

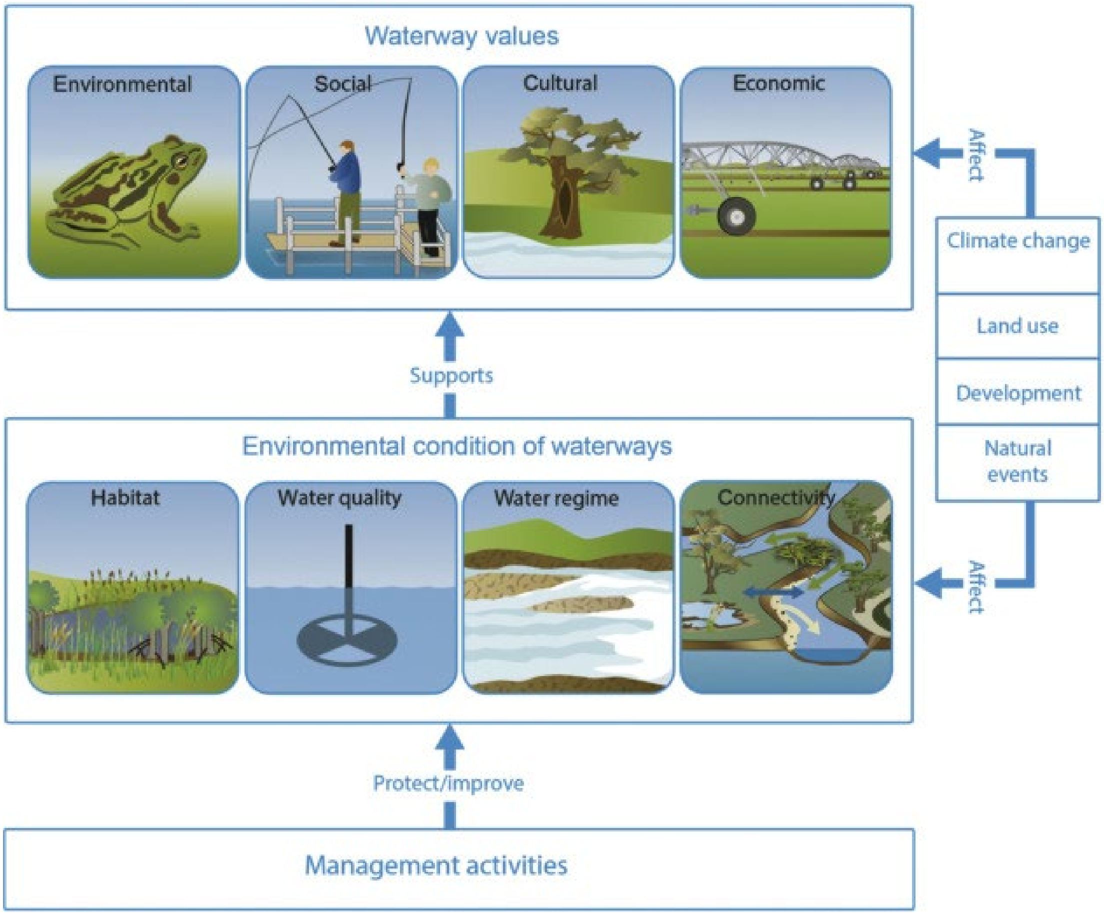

Figure 2. *Environmental conditions supporting waterway values* (Department of Environment and Primary Industries, 2013)

Environmental Reference Standards 2021 (ERS)

The Environment Reference Standard (ERS) is made under Section 93 of the *Environment Protection Act 2017*. It sets out the environmental values of the ambient air, ambient sound, land and water environments that are sought to be achieved or maintained in Victoria and standards to support those values. The ERS also specifies indicators and objectives to be used to measure, determine or assess whether environmental values are being achieved, maintained or threatened. For this Surface Water Impact Assessment, the 'Waters' Section (Part 5) and specifically Divisions 1 and 3 (all waters and surface waters) are relevant.

This ERS is not a compliance standard. Its primary function is to provide an environmental assessment and reporting benchmark. However, the Act specifically requires EPA to consider the environmental values in the ERS when deciding whether or not to issue development, operating and pilot project licences, when reviewing operating licences and when deciding whether or not to issue development and operating licence exemptions and specified prescribed permits.

The environmental values relevant for surface waters are detailed in Table 5.

Table 5. ERS environmental values relevant for surface waters

Environmental value	Description of environmental value
Water dependent ecosystems and species	Water quality that is suitable to protect the integrity and biodiversity of water dependent ecosystems. This integrity and biodiversity includes— the integrity of riparian vegetation as it contributes to the health of water dependent ecosystems and bank stability; maintenance of fish passage.
Human consumption after appropriate treatment	Surface water quality that is suitable for use by drinking water suppliers for delivery, after appropriate treatment, to consumers of drinking water.
Agriculture and irrigation	Water quality that is suitable for agricultural activities such as stock watering and irrigation, as well as a range of other uses such as the irrigation of domestic gardens, commercial agriculture, parks, and golf courses.
Human consumption of aquatic foods	Surface water quality that is suitable to support the availability and safe human consumption of fish and any other aquatic plant, algae or invertebrate from natural populations, commercial and recreational catch.
Aquaculture	Surface water quality that is suitable to produce fish and any other aquatic plant, algae or invertebrate for human consumption via aquaculture.
Industrial and commercial use	Water quality that is suitable for industrial and commercial use.
Water-based recreation	Water quality that is suitable for primary contact recreation (for example swimming, diving, water skiing, caving, and spas), secondary contact recreation (for example boating and fishing) and for aesthetic enjoyment.
Traditional Owner cultural values	Water quality that protects the cultural values of Traditional Owners, having recognised primary responsibility for protecting the values of water for cultural needs, to verify that Traditional Owner cultural practices can continue. Values may include traditional aquaculture, fishing, harvesting, cultivation of freshwater and marine foods, fish, grasses, medicines, and filtration of water holes.
Navigation and shipping	Surface water quality that is suitable for the transportation of passengers and cargo by ship and for harbour facilities.

Regional policy and strategy

Regional and local legislation, regulation, policies and guidelines

Several items of regional and local legislation, regulations, policy and guidelines are relevant for this surface water impact assessment. The legislation and documents that apply to the surface water assessment are summarised in Table 6.

Table 6. Regional and local legislation, regulations, policies and guidelines relevant to this assessment.

Legislation, regulation, policy, or guideline	Description
Regional	
West Gippsland Regional Catchment Strategy 2021-2027 (WGRCS)	CMAs have specific responsibilities for waterway management under the *Water Act 1989*. For the study area the CMA is the WGCMA. The West Gippsland Regional Catchment Strategy 2021-2027 (WGRCS) provides a vision for integrated catchment management in the West Gippsland region. The Strategy is prepared by the WGCMA and is the overarching strategy for all involved in land, water, and biodiversity management. The WGRCS provides a framework to coordinate effort, identifying strategic management directions and describing a set of regional outcomes under different themes, including water.
West Gippsland Regional Waterway Management Strategy 2014-2022 (WGRWMS)	Waterway managers (CMAs) have the lead role in developing and delivering regional programs for waterway management. Regional Waterway Strategies are a single planning document for river, estuary and wetland management in each region and drive implementation of the management approach outlined in the Victorian Waterway Management Strategy. The West Gippsland Regional Waterway Management Strategy 2014-2022 (WGRWMS) is currently due for renewal.
West Gippsland Floodplain Management Strategy 2018-2027 (WGFMS)	Prepared by the WGCMA, together with local government and Victorian State Emergency Service, the Floodplain Management Strategy identifies parts of the region with significant flood risk, possible actions to mitigate risks and priority actions. The strategy seeks to: Build a flood resilient community – through effective sharing of current information about flood behaviour Reduce existing flood risks – through emergency management, flood mitigation infrastructure works and activities, and risk management Avoid future flood risks – through effective land use planning and building controls that account for the impacts of climate change Manage residual flood risks – through flood insurance, provision of flood risk information, integrated flood emergency management and incident control.
West Gippsland Flood Guidelines: Guidelines for development in flood prone areas (West Gippsland Catchment Management Authority, 2020)	The West Gippsland Guidelines for development in flood prone areas provide guidance to promote safe and appropriate development in flood prone areas within West Gippsland. This includes objectives for development in flood prone areas, design responses and decision guidelines. These guidelines build off the State-wide Guidelines for Development in Flood Affected Areas (Department of Environment, Land, Water and Planning, 2019).
Local Government	

Legislation, regulation, policy, or guideline	Description
Local planning schemes (South Gippsland Shire Council, Latrobe City Council)	Local council planning schemes identify the presence of surface water and control development through the application of overlays and related policies such as Land Subject to Inundation Overlay (LSIO), Floodway Overlay (FO), Special Building Overlay (SBO), and Urban Floodway Zone (UFZ). A permit is required to construct or carry out works within a defined planning scheme. A planning scheme amendment is required to amend the South Gippsland and La Trobe City Councils planning schemes to seek to obtain a consistent planning control for the whole project, and for the Minster for Planning to be the responsible authority for administering the planning schemes as they relate to the use and development of land for the project.

West Gippsland Waterway Strategy 2014-2022

The West Gippsland Waterway Strategy 2014-2022 (West Gippsland Catchment Management Authority, 2014) provides the framework to guide WGCMA to manage rivers, wetlands, and estuaries to support environmental, social, cultural and economic values.

Regional goals in the Strategy are to:

- Maintain and improve the habitat and condition of waterways to support water dependent animals and plants.
- Reduce future impacts to public infrastructure resulting from physical changes to a waterway associated with floods and storms.
- Maintain the ecological character of significant wetlands and estuaries.
- Provide system connectivity between rivers, estuaries, and wetlands.
- Improve the condition of urban waterways in partnership with local government.
- Maximise the ecological outcomes from the available environmental water.
- Support community use, participation, advocacy, and stewardship in the region's waterways.
- Maintain and improve the values of Heritage Rivers.
- Provide appropriate environmental conditions to support the economic values of waterways in the region.

The West Gippsland Waterway Strategy is currently being renewed and will be guided by the West Gippsland Regional Catchment Strategy 2021-2027 (West Gippsland Catchment Management Authority, 2021). Any impacts of the project on surface waters should not inhibit WGCMA in delivering the goals, actions, and desired outcomes from these strategies.

West Gippsland Floodplain Management Strategy 2018-2027

The West Gippsland Floodplain Management Strategy (West Gippsland Catchment Management Authority, 2017) details key threats to floodplains in the region, these include:

- Development within floodplains which increases the flood risk to life and property
- Extractive and other industries which can alter flood behaviour and damage environmental values such as water quality and river banks
- Land clearing which can increase runoff and decrease the quality of water being received by waterways
- Agricultural activities which can result in:
    - Land clearing

- Modification of landform and waterways
  - Introduction of chemicals
  - Loss of native habitat
  - Changes to groundwater
- Changes to natural flow regimes via regulating structures
- Floodplain management activities such as channel modification and construction of levees
- Climate change implications that can reduce rainfall overall, increase the severity of flood events and lead to rising sea levels.

The Strategy also advocates for an Integrated Catchment Management approach. Floodplain management in the past has often focussed on channel modification, levee construction, straightening and de-snagging to increase channel capacity and reduce flooding in certain areas. However, these management techniques often increase flooding downstream and impact on environmental values by disconnecting the waterway from its floodplain, affecting riparian vegetation and habitat. Integrated Catchment Management now focusses on floodplain-scale management incorporating aspects of environmental watering, vegetation management and protection of floodplain values, including slowing floodwaters and reducing downstream impacts.

This impact assessment will need to consider the changes to flood behaviour that may be caused by the project activities.

West Gippsland Guidelines for development in flood prone areas

The West Gippsland Flood Guidelines (West Gippsland Catchment Management Authority, 2020) provide a series of objectives for development in flood prone areas as a guide to assessing development proposals. These seven objectives are:

1. Site safety- Development must not be located where the depth and flow of floodwaters is hazardous.
2. Site access- Development must not be located where the depth and flow of floodwaters along the access to or from the property is hazardous.
3. Flood damage- Development must be designed to minimise the potential damage to property due to flooding.
4. Flood flow- Works or structures must not adversely affect floodwater flow capacity or the physical form of a waterway.
5. Flood storage- Works or structures must not reduce floodwater storage capacity.
6. Floodplain and waterway condition- Development must verify protection of floodplains and the maintenance or improvement of waterway condition including vegetation and physical form.
7. Water quality- Development must maintain or improve the quality of stormwater and catchment run-off in rural and urban areas.

Proposals for development in Victoria are assessed against a 1 % Annual Exceedance Probability (AEP) flood for the above criteria. This is a flood that has a 1% chance of occurring in any given year. Floods larger than the 1 %AEP flood can and do occur.

Local Government

Planning Schemes

Flood controls in Planning Schemes include policies addressing flood risks within a municipality, zones, overlays, and schedules. These are detailed in Planning Practice Note 12: Applying the Flood Provisions in Planning Schemes (Department of Environment, Land, Water and Planning, 2015).

The overall objectives of floodplain management are to assist the protection of:

- Life, property, and community infrastructure from flood hazard
- The natural flood carrying capacity of rivers, streams, and floodways
- The flood storage function of floodplains and waterways
- Floodplain areas of environmental significance or of importance to river health.

Key zones and overlays implemented through planning schemes to appropriately manage flood risk include:

- **Urban Floodway Zone (UFZ)**- applies to riverine flooding in urban areas. Unlike overlays, the UFZ controls land use as well as development, with land use being restricted to low intensity uses such as recreation and agriculture. Development is generally not encouraged in the UFZ.
- **Floodway Overlay (FO)**- applies to riverine flooding in both rural and urban areas where there is a flood risk and there is a reduced need to control land use. Most types of development are not encouraged but buildings and works associated with low intensity uses such as agriculture may be permitted. Key considerations are whether the development will obstruct flood flows or increase flood risk.
- **Land Subject to Inundation Overlay (LSIO)**- applies to riverine flooding in both rural and urban areas, as well as coastal inundation. Areas covered by the LSIO may have similar or lower flood risk than those covered by UFZ or FO, depending on whether mapping has been developed to delineate the floodway. The planning permit process verifies that the use and development of land in this overlay is compatible with the level of flood risk at the site.
- **Special Building Overlay (SBO)**- applies to stormwater flooding in urban areas. The purpose of the SBO is to confirm that flood waters are not obstructed or diverted by development. The SBO is only used in limited areas in Gippsland due to a lack of mapping of overland flow paths.

The Planning Scheme also requires the consideration of flood issues for all planning applications regardless of whether a site is affected by a relevant zone or overlay.

2.3 Tasmania

The Tasmanian component of the project is being assessed in accordance with the EIS guidelines issued by EPA Tasmania for the converter station and shore crossing (September 2022). This assessment is documented in a separate report: *Marinus Link – Tasmania Surface Water Impact Assessment* report (Alluvium, 2023)

2.4 Linkages to other technical studies

This report informs or is informed by other technical studies outlined in Table 7.

Table 7. Relevant technical studies

Technical study	Relevance to this assessment
Climate and Climate Change Assessment (Katestone, 2023)	Climate change has potential to impact on rainfall and surface water runoff. The Climate and Climate Change Assessment report outlines these predicted changes and impact on surface water runoff. A climate change scenario has also been modelled for the converter and transition stations in this surface water report.
Aboriginal and historical cultural heritage assessment (Ecological Australia Pty Ltd (ELA), 2023)	Impacts to surface waters can also impact on Aboriginal Cultural Heritage. The impact of the project on relevant cultural heritage matters is considered in other technical studies , most notably the Cultural Heritage Assessment: *Marinus Link EIS/EES Cultural Heritage Technical Study - Victorian Terrestrial Component*.
Contaminated land and acid sulfate soils (Tetra Tech Coffey, 2023)	Disturbance of contaminated land, storage of spoil associated with the project and disturbance of acid sulfate soils are a potential source of contamination to surface waters, including potential water quality issues that could arise from contaminated land around the converter and transition stations. This has been considered in the Contaminated Land and Acid Sulfate Soils Assessment report.
Terrestrial Geomorphology and Geology Impact Assessment (Environmental GeoSurveys Pty Ltd (Environmental GeoSurveys), 2023)	The terrestrial geomorphology impact assessment details baseline conditions and potential impacts on terrestrial geomorphology, geology and soils. Surface water and hydrology both influences and is influenced by geomorphology and geology. This surface water impact assessment has considered geomorphology and soils aspects where relevant. Further geomorphology and soil related impacts and management are addressed in the Terrestrial Geomorphology and Geology Impact Assessment Report by Environmental GeoSurveys (2023).
Victorian Groundwater Impact Assessment (Tetra Tech Coffey, 2023)	Impacts to groundwater environments can impact surface waters (and vice versa) due to the interconnected nature of surface water and groundwater systems. Surface waters are a potential receptor for disposal of groundwater from de-watering activities or seepage associated with the project. This has been considered in the Groundwater Impact Assessment Report.
Planning and Land Use Impact Assessment (Tetra Tech Coffey, 2023)	Impacts to flooding regimes; that is, creating adverse impacts to existing property (commercial and residential), infrastructure and the environment, can be mitigated through available planning controls such as Urban Floodway Zone (UFZ) and Land Subject to Inundation Overlay (LSIO). These planning instruments are discussed above. This has been considered in the Planning and Land Use Impact Assessment Report.
Terrestrial Ecology Impact Assessment (ELA, 2023)	Disturbance to surface waters including impacts to water quality or flow regime can impact on aquatic and riparian flora and fauna species that rely on those surface water ecosystems (water-dependent species). This could include EPBC listed species. This has been considered in the Ecological Impact Assessment report.

3 Project Description

This section discusses the key components and details of the Project Description and activities that are relevant to this surface water impact assessment.

3.1 Overview

Marinus Link is proposed to be implemented as two 750 MW circuits to meet transmission network operation requirements in Tasmania and Victoria. Each 750 MW circuit will comprise two power cables and a fibre-optic communications cable bundled together in Bass Strait and laid in a horizontal arrangement on land. The two 750 MW circuits will be installed in two stages with the western circuit being laid first as part of stage one, and the eastern cable in stage two.

The key project components for each 750 MW circuit, from south to north, are:

- HVAC switching station and HVAC-HVDC converter station at Heybridge in Tasmania. This is where the project will connect to the North West Tasmania transmission network being augmented and upgraded by the North West Transmission Developments (NWTD).
- Shore crossing in Tasmania adjacent to the converter station.
- Subsea cable across Bass Strait from Heybridge in Tasmania to Waratah Bay in Victoria.
- Shore crossing at Waratah Bay approximately 3 km west of Sandy Point.
- Land-sea cable joint where the subsea cables will connect to the land cables in Victoria.
- Land cables in Victoria from the land-sea joint to the converter station site in the Driffield or Hazelwood areas.
- HVAC switching station and HVAC-HVDC converter station at Driffield or at Hazelwood, where the project will connect to the existing Victorian transmission network.

A transition station at Waratah Bay may also be required if there are different cable manufacturers or substantially different cable technologies adopted for the land and subsea cables. The location of the transition station will also house the fibre optic terminal station in Victoria. However, regardless of whether a transition station is needed, a fibre optic terminal station will still be required in the same location.

Approximately 255 km of subsea HVDC cable will be laid across Bass Strait. The preferred technology for Marinus Link is two 750 MW symmetrical monopoles using ±320 kV, cross-linked polyethylene insulated cables and voltage source converter technology. Each symmetrical monopole is proposed to comprise two identical size power cables and a fibre-optic communications cable bundled together. The cable bundles for each circuit will transition from approximately 300 m apart at the HDD (offshore) exit to 2 km apart in offshore waters.

In Victoria, the shore crossing is proposed to be located at Waratah Bay with the route crossing at the Waratah Bay–Shallow Inlet Coastal Reserve. From the land-sea joint located behind the coastal dunes, the land cable will extend underground for approximately 90 km to the converter station. From Waratah Bay the cable will run northwest to the Tarwin River Valley and then travel to the north to the Strzelecki Ranges. The project alignment crosses the ranges between Dumbalk and Mirboo North before descending to the Latrobe Valley where it turns northeast to Hazelwood. The Victorian converter station will be at either a site south of Driffield or Hazelwood adjacent to the existing terminal station.

The land cables will be directly laid in trenches or installed in conduits in the trenches. A construction area of 20 to 36 m wide will be required for laying the land cables and construction of joint bays. Temporary roads for accessing the construction area and temporary laydown areas will also be required to support construction. Where possible, existing roads and tracks will be used for access, for example, farm access tracks or plantation forestry tracks.

Land cables will be installed in ducts under major roads, railways, major watercourses and substantial patches of native vegetation using trenchless construction methods (e.g., HDD), where geotechnical conditions permit. A larger area than the 36 m construction area will be required for the HDD crossings.

This assessment is focused on the Victorian section of the project. This report will inform the EIS/EES being prepared to assess the project's potential environmental effects in accordance with the legislative requirements of the Commonwealth and Victorian governments (see Figure 3).

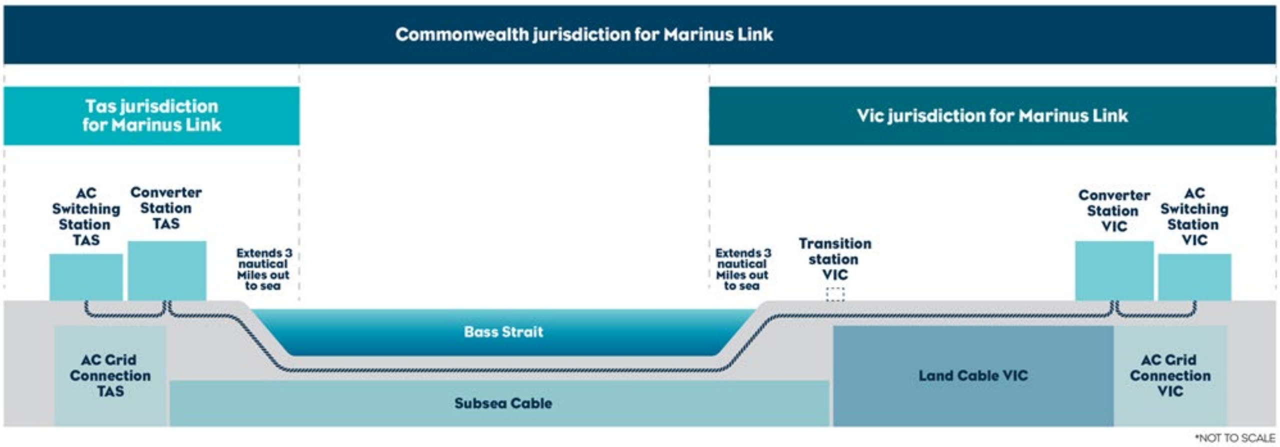

Figure 3. *Project components considered under applicable jurisdictions (Marinus Link Pty Ltd 2022).*

Marinus Link is proposed to be constructed in two stages over approximately five years following the award of works contracts to construct the project. On this basis, Stage 1 of the project is expected to be operational by 2030, with Stage 2 to follow, with final timing to be determined by market demand. The project will be designed for an operational life of at least 40 years.

3.2 Construction

Waterway crossing (HDD) construction

HDD will be used at targeted crossing sites where geotechnically feasible, where less ground disturbance is preferred to minimise risk to local environment and/or where more practical or cost-effective than trenching, e.g., fifteen of the eighty-two waterways including seven of the eight major waterways crossings will be undertaken by HDD. HDD or trenchless construction methods generally have the lowest impact on waterways, compared trench or pipe bridge methods, due to the method offering less ground disturbance, and disruption on traffic, the public, business activities and neighbourhood, lower restoration cost, less noise, dust and minimum import/export of the construction materials and ability to avoid sensitive areas (Norizam, 2017). Sections 4.1 and 6.2 provide further detail as to the classification of waterways and why HDD was chosen in some locations over other waterway crossings.

HDD lengths are generally less than 100 m in length, with a maximum length of approximately 300 m. Construction of the HDD crossings involves drill pads being established at the entry and exit points. The workspaces for these drill pads are 70 m by 70 m, with a minimum of 40 m by 40 m for shorter HDD crossings. A typical arrangement of HDD entry and exit workspaces is provided in Figure 4. As per this figure, the arrangement includes stockpiles of soil within the construction area.

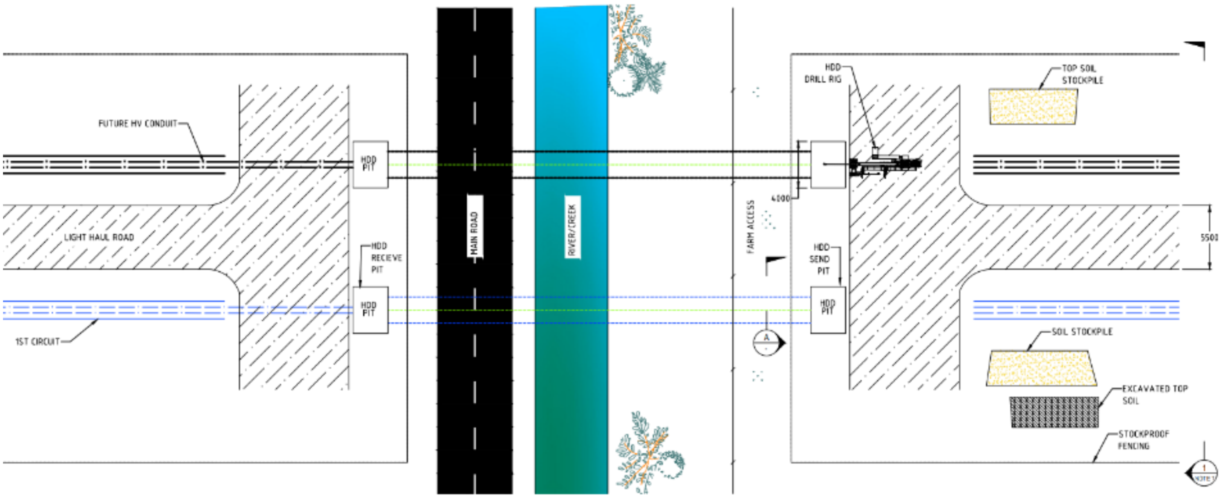

Figure 4. *Typical HDD arrangement (concept)*

HDD construction includes:

- Access track construction to HDD drill entry and exit pads
- Preparing hardstands at entry and exit points
- Installing erosion and sediment controls
- Digging entry and exit pits
- Delivery and set up of HDD drill rig and associated equipment
- Drilling of pilot hole under feature (e.g., waterway)
- Ream borehole to required diameter
- Weld high density polyethylene (HDPE) duct lengths together
- Pull duct through borehole and set with bentonite

After construction the site is rehabilitated through:

- Removing all equipment and drill cuttings
- Removing hardstand and reinstating/rehabilitating entry and exit pads

Each HDD construction is estimated to take up to two weeks, plus mobilisation and demobilisation. Each HDD will be a continuous 24/7 operation to confirm borehole stability. A heavy rigid truck, water truck and 4WD vehicles are required to set up and operate an HDD. The locations of HDD crossings and drill pads has been provided to Alluvium in a spatial (GIS) layer. The depth of HDD was not specified.

Joint pits and cable construction (including open trench through waterways)

Land cables are supplied in standard section lengths of either 800 m or 1.2 km. For areas not required HDD, cables will be installed in trenches. The cable lengths will be joined at joint pits. Joint pits are around 12 m long, 2.5 m wide and 2.5 m deep, buried at least 0.5 m below the surface. The key construction activities for land cables and joint pits include:

- Establishing laydown areas, site offices and amenities
- Site establishment (site entries, gates, access, weed control, stock proof fencing, etc.)
- Topsoil stripping and stockpiling (around 300 to 400 mm in depth)
- Constructing haul roads along construction working corridors
- HDD and duct installation at road, waterway and third-party infrastructure crossings.
- Excavation of trenches and stockpiling of subsoil – trenches to be a nominal width of 1 m and typical depth of greater than 1.2 m to the top of the duct from ground level
- Installation of ducts and thermal backfill where required.
- Backfilling trenches with subsoil and topsoil and reinstatement except at cable joint pits and where equipment required to assist cable installation, e.g., at bends and HDD crossings.
- Construction (in-situ) or installation (pre-cast modules) of cable joint pits.
- Pulling of cables through ducts.
- Cable jointing.
- Backfilling and reinstatement of cable installation and cable joint pit workspaces.

Cable joint pits will be constructed in-situ or prefabricated using precast concrete modules and brought to site for installation. The area to accommodate the cable joint pit and associated works including jointing will be topsoil stripped. The joint bay itself will be excavated and suitable drainage installed to prevent moisture ingress during the works. All spoil will be separated and stockpiled on the construction working corridor.

A spatial layer of the construction area of disturbance for the joint pits was not available at the time of this assessment. For the purposes of this assessment, joint pits were assumed to be at least 12 m long, 2.5 m wide and 2.5 m deep.

3.3 Operation

The project will ideally be operational 24 hours a day, 365 days per year over a minimum lifespan of 40 years. Operational and maintenance activities in the Victoria land portion of the project are likely to include:

- Routine inspection across the easement for operational and maintenance issues.
- Servicing, testing and repair of the land cables, transition station and converter stations equipment and infrastructure including scheduled minor and major outages.
- Maintenance of access tracks

In general, maintenance requirements for land cables are minimal with routine maintenance being limited to a number of smaller activities around the jointing pits. These activities will be sheathing tests every five years involving two workers for one day at each joint bay. They will have a standard 4WD vehicle and use handheld testing equipment. A route drive over will also occur around once a fortnight to verify that no unknown construction activities or non-permitted activities are occurring above the cables.

Easement conditions on title will set out restrictions on activities on the easement. Most farming and cropping activities can continue. No buildings or trees will be allowed on the easement.

3.4 Decommissioning

The operational lifespan of the project is a minimum 40 years. At this time the project will be either decommissioned or upgraded to extend its operational lifespan.

Decommissioning will be planned and carried out in accordance with regulatory and landowner or land manager requirements at the time. A decommissioning plan in accordance with approvals conditions will be prepared prior to planned end of service and decommissioning of the project.

Requirements at the time will determine the scope of decommissioning activities and impacts. The key objective of decommissioning is to leave a safe, stable and non-polluting environment, and minimise impacts during the removal of infrastructure.

In the event that the project is decommissioned, all above-ground infrastructure will be removed, and associated land returned to the previous land use or as agreed with the landowner or land manager.

Decommissioning activities required to meet the objective will include, as a minimum, removal of above ground buildings and structures. Remediation of any contamination and reinstatement and rehabilitation of the site will be undertaken to provide a self-supporting landform suitable for the end land use. Decommissioning and demolition of project infrastructure will implement the waste management hierarchy principles being avoid, minimise, reuse, recycle and appropriately dispose. Waste management will accord with applicable legislation at the time.

Decommissioning activities may include recovery of land and subsea cables and removal of land cable joint pits. Recovery of land cables would involve opening the cable joint pits and pulling the land cables out of the conduits, spoiling them onto cable drums and transporting them to metal recyclers for recovery of component materials. The conduits and shore crossing ducts would be left in-situ as removal would cause significant environmental impact.

The concrete cable joint pits would be broken down to at least one metre below ground level and buried in-situ or excavated and removed. Subsea cables would be recovered by water jetting or removal of rock mattresses or armouring to free the cables from the seabed.

A decommissioning plan will be prepared to outline how activities will be undertaken and potential impacts managed.

4 Assessment method

To address the scoping requirements and legislative and policy requirements outlined in Section 2, this assessment seeks to detail the existing surface water conditions, key issues, likely impacts, and mitigation strategies (including performance criteria) for the project.

Impacts and risks that were considered include:

- Consideration of risks presented by the project to surface water, including waterway hydrology (flood), water quality and geomorphology (main report).
- Consideration of risks to the project presented by existing hydrological conditions and processes, including flooding, erosion, and avulsion (Attachment 4).

Attachment 2 also provides information on physical waterway processes such as erosion, incision and avulsion processes. The remainder of this report covers potential risks to the existing surface water environment posed by the project activities. Three main aspects relating to surface water have been considered in this assessment:

- Flooding: the potential for the project to affect waterways and hydrology with respect to flooding and future climate change scenarios
- Water quality: the potential for contaminated runoff or sediment to be transported into surface waters
- Geomorphology: the study of landforms and their origin. The assessment focused on the banks and beds of waterways, for example, the potential for the project to contribute to or initiate erosion

Relevant sections of this report for each aspect are:

- Project description- Section 3
- Study area and baseline characterisation (existing conditions) – Section 4.1, Section 5 and Attachment 3
- Impact assessment – Section 6, including:
    - Risk assessment – Section 4.3 and Section 6
    - Environmental Performance Requirements (EPRs) – Section 6.6
    - Residual risk – Section 6.7
    - Cumulative impacts – Section 6.8
- Risks to the project presented by existing hydrological conditions and processes – Attachment 4.

4.1 Study area

The study area for this assessment extended approximately 90 km onshore from the shore crossing at Waratah Bay to the converter stations at Driffield and Hazelwood.

The proposed project alignment through Victoria intersects 82 waterways within the study area.

Detailed assessments of each of the 82 waterways have been prioritised based on their topographic definition, categorisation within the VicMap Lite 1:250,000 to 1:5,000,000 waterways network layer[1] and HIERARCHY attribute within the VicMap Hydro 1:25,000 waterways network layer.

Of the 82 waterways along the project alignment, eight defined major waterway crossings within a catchment area of more than 5 km^2 were considered for this surface water impact assessment. The remaining identified 74 waterways were not considered further in this assessment due to their lack of definition (i.e., small and ephemeral nature), smaller catchment scale, and classification as low or minor importance according to the HIERARCY attribute within the VicMap Hydro waterways network layer.

Regarding the proposed crossing methods, among the 82 waterways along the project alignment, 15 are proposed to be crossed with trenchless construction method (TCM), such as HDD while the remaining 67 waterways will be crossed by open cut trench construction method. Open trench construction through waterways has also been assessed as an alternative to HDD. Open cut trench construction involves excavating a narrow, shallow, or deep trench in the ground for the installation, maintenance or inspection of conduits, cables, and other utilities.

While general environmental/protection recommendations required in the EPRs (Section 6.6) will be implemented in the vicinity of any waterways, the study has focused on eight major waterway crossings that the proposed project alignment crosses in Victoria:

- Morwell River, near Hazelwood
- Little Morwell River, near Darlimurla
- Tarwin River East Branch, near Dumbalk
- Tributary of the Tarwin River East Branch, near Dumbalk (northern tributary)
- Tributary of the Tarwin River East Branch, near Dumbalk (southern tributary)
- Stony Creek, near the town of Stony Creek
- Buffalo Creek, near the town of Buffalo
- Fish Creek, south of the town of Buffalo

In addition to the waterways, the potential surface water impact of the two proposed converter stations and one transition station have been assessed in detail:

- Hazelwood converter station
- Driffield converter station
- Waratah Bay transition station

[1] https://discover.data.vic.gov.au/dataset/vicmap-lite-watercourse-line-1-250000-to-1-50000001

A review of the VicMap Lite 1:250,000 to 1:5,000,000 waterways network layer and available aerial imagery and LiDAR has been used to categorise the 82 waterways into defined and undefined waterways:

- Undefined waterway – the waterway could not be defined on aerial imagery and/or LiDAR (44 waterways identified)
- Defined waterway – the waterway can be defined on aerial imagery and/or LiDAR and is either:
  - Not identified on the VicMap Lite 1:250,000 to 1:5,000,000 waterways network layer (28 waterways identified)
  - Identified on the VicMap Lite 1:250,000 to 1:5,000,000 waterways network layer (10 waterways identified)

The results of this classification can be seen in Figure 52 in Attachment 1.

The 44 undefined waterways and 28 waterways not included in the VicMap Lite 1:250,000 to 1:5,000,000 waterways network layer have not been assessed in further detail due to lack of definition, smaller scale, and therefore a lower potential to be impacted by the proposed works. These waterways are also listed as low or minor importance features in the HIERARCHY attribute within the VicMap Hydro 1:25,000 waterways network layer. However, general environmental/protection recommendations through the outlined surface water EPRs should be in place in the vicinity of any waterways(see Section 6.6).

Further categorisation of the 10 defined waterways included in the VicMap Lite 1:250,000 to 1:5,000,000 waterways network layer has been undertaken based on the VicMap Hydro 1:25,000 waterways network layer HIERARCHY attribute and contributing upstream catchment area, which provides an indication of the importance/size of a waterway. HIERARCHY attributes as defined in the 1:25,000 waterways network layer dataset include:

- H=High or major importance feature
- M=Medium or moderate importance feature
- L=Low or minor importance feature

This was used identify those waterways listed high or medium importance feature and/or waterways with catchments greater than 5km^2 requiring further detailed assessment:

1. Defined waterways with low or minor importance feature classification and/or catchment area less than 5 km^2 (2 waterways identified).
2. Defined major waterways with High or major and/or Medium or moderate importance feature classification and/or catchment area greater than 5 km^2 (8 major waterway crossings identified).

The results of this classification can be seen in Figure 52 in Attachment 1 and summarised in Table 8.

As per the undefined waterways no further detailed assessments have been undertaken for the low/ minor feature defined waterways. However, general environmental/protection recommendations (Section 6.5) should be in place in the vicinity of any waterways.

Table 8. Waterway classification, based on available waterway data, aerial imagery and LiDAR interpretation.

Waterway classification	Description	Number of waterways
Defined major waterway (assessed and detailed in this report)	Waterways that: • Can be defined on aerial imagery and/or LiDAR • Are included in VicMap Lite 1:250,000 to 1:5,000,000 waterways network layer • Have a catchment area greater than 5 km^2 These waterways have been investigated in further detail.	8
Defined waterway	Waterways that: • Can be defined on aerial imagery and/or LiDAR • Are included in VicMap Lite 1:250,000 to 1:5,000,000 waterways network layer • Have a catchment area less than 5 km^2 • Have a HIERACHY classification of low or minor importance	2
Small defined waterway	Waterways that: • Can be defined on aerial imagery and/or LiDAR • Are not included in VicMap Lite 1:250,000 to 1:5,000,000 waterways network layer • Have a HIERACHY classification of low or minor importance	28
Undefined waterway	The waterway: • Cannot be defined on aerial imagery and/or LiDAR • Have a HIERACHY classification of low or minor importance	44
Total		**82**

The eight waterways identified for further detailed assessment are the Morwell River, Little Morwell River, Tarwin River East Branch, two tributaries of the Tarwin River East Branch, Stony Creek, Buffalo Creek, and Fish Creek (Table 9, Figure 5). For each of these waterway crossings, the study area includes the waterway channel and banks, floodplain and a distance up and downstream at which waterway processes could potentially be affected.

The Little Morwell River and Morwell River drain to the north into the Latrobe system which eventually flows into Lake Wellington in the Gippsland Lakes. The Tarwin River East Branch and tributaries, Stony Creek, Buffalo Creek, and Fish Creek flow generally southwest towards the main Tarwin River which flows into Anderson Inlet near Tarwin Lower, which then enters the Bass Strait near Inverloch.

The scale of channel change in river systems is in part a function of channel size, which is largely determined by catchment area. Larger catchments generally exhibit a greater scale of channel change. Table 9 provides an overview of the total catchment sizes and waterway lengths for the eight major waterways considered in this study, along with the catchment size and waterway length upstream of the crossing with the proposed Project alignment.

Table 9. Approximate catchment area and waterway length for total waterway and upstream of crossing with the proposed project alignment.

Crossing	Catchment size (km^2)		Waterway length (km)	
	Total	Upstream of crossing	Total	Upstream of crossing
Morwell River (KP 78.05)	674	457	83	58
Little Morwell River (KP 61.55)	87	30	21	11
Tarwin River East Branch (KP 40.65)	269	160	66	44
Tributary of Tarwin River East Branch (north) (KP 36.6)	24	18	12.3	11.7
Tributary of Tarwin River East Branch (south) (KP 34.9)	36	27	14	13
Stony Creek (KP 29.4)	72	47	29	17
Buffalo Creek (KP 21.5)	38	8.7	10	4
Fish Creek (KP 17.7)	170	127	44	31

This section provides an overview of each of the waterways assessed from north to south and their environmental values that could be affected by the project. Further detail around the catchment setting, soils, land use, topography and analysis of the project crossing points is provided in Attachment 3.

Figure 5. *Victorian waterway crossings across the proposed project alignment assessed in this project.*

Converter and transition stations

The study area also includes the area surrounding two proposed converter stations and one transition station in Victoria.

Hazelwood converter station

Converter stations consists of a HVAC-HVDC converter station and expansion of the Hazelwood Terminal Station in Victoria, where the project will connect to the existing Victorian transmission network. The proposed Hazelwood converter station is located near Traralgon and covers an area of 32 hectares.

Driffield converter station

A second alternative converter station to the south of Driffield comprising an area of approximately 96.5 hectares has also been included in the study area.

Waratah Bay transition station

The shore crossing at Waratah Bay is approximately 3 km west of Waratah Bay. Here, the subsea cables will connect to the land cables in Victoria, with a fibre optic terminal station.

4.2 Baseline characterisation (existing conditions)

A baseline characterisation of the existing surface water conditions within the study area has been conducted based on desktop assessments to identify and document water related environmental values relevant to the proposed project alignment. Assessments were made of geomorphology, hydrology and water quality.

The following data was used as input to this study:

- Aerial photography from various sources, including:
  - ESRI
  - Google
  - Nearmap
  - Historic photo maps (http://mapshare.vic.gov.au/webmap/historical-photomaps/)
- Topographic (LiDAR) data sourced from WGCMA, including:
  - Coastal LiDAR (2007)
  - South Gippsland and Morwell LiDAR (2018)
  - River and floodplain LiDAR (2010)
- Waterway mapping – based on State waterway layers in VicMap Hydro mapping- https://discover.data.vic.gov.au/dataset/waterways-network-1-25000-vicmap-hydro1
- Index of Stream Condition assessment reports, GIS layers and supporting information
- State-wide geology, land use, soil and geomorphological mapping
- Flood mapping of the 1 % AEP flood extent, sourced from WGCMA
  - Where a mapped 1 % AEP flood extent is not available, a potential flood extent has been estimated through interpretation of floodplain topography, slope and vegetation across multiple aerial images.
- Water quality monitoring data from WaterWatch (http://www.vic.waterwatch.org.au/cb_pages/view_waterwatch_data.php) and the Victorian Water Measurement Information System gauges (https://data.water.vic.gov.au/)
- Rainfall and climate data, including climate change projections
- Review of available project impact assessments for other disciplines:
  - Contaminated Land and Acid Sulfate Soils Assessment (Tetra Tech Coffey, 2023)
  - Climate and Climate Change Assessment (Katestone Environmental, 2023)

Flood mapping note for waterway crossings:
For the waterway crossing assessment, flooding has been assessed by analysing the 1 % AEP flood extent, sourced from the WGCMA. Estimation of the 1 % AEP flood for an area is determined using flood modelling, recorded flood extents and levels, and on-ground verification. There is always a possibility that a flood event greater (higher flow rate) than the 1 % AEP flood may occur in the future. As detailed in Section 6, climate change will result in changes to rainfall and therefore flood extents. The WGCMA sourced flood extents does not include consideration of climate change. These extents also do not provide information on the depth and velocity of flood waters, which can influence the impacts of a flood.

Where potential impacts have been identified in the risk assessment further flood modelling will be required to assess flood depths, velocities, and the impacts of climate change on flood extents and behaviour and proposed mitigation actions must be developed in consultation with WGCMA (drainage authority).

Field inspection of waterway crossing sites was undertaken to gain an appreciation of:

- Waterway form, health and geomorphic value/habitat
- Flow behaviour and flow pathways
- Evidence of channel change causes of change, and potential for future change.

Site inspection was undertaken by Alluvium's technical specialists (James McMillian and Emma Hodson) on 21^{st} and 22^{nd} March 2022. Due to site access limitations, it was not possible visit the waterway crossing sites for the Little Morwell River and Fish Creek. For these waterways available photos, along with desktop GIS data were used to characterise and assess the waterway.

4.3 Impact assessment

A surface water impact assessment has been completed to identify likely impacts on flood levels and depths, water quality , flow regime and waterway stability from construction and operation of the project. Mitigation measures are proposed where necessary. As the methods used for the flooding impact assessment differed to those used for the water quality and geomorphology impact assessment, the impact assessment approaches are described separately.

The risk assessment identifies and ranks the risk of potential harm, based on likelihood and consequence of harm to the environment. This risk rating is identified for both pre-mitigation and post-mitigation scenarios.

The approach to the risk assessment includes (Figure 6):

1. Identifying existing surface water conditions and values (Section 5)
2. Identifying potential hazards and risks
3. Assessing the likelihood of a change to values occurring, prior to implementation of risk controls and measures (Section 6.5)
4. Assessing the consequence (impact) of identified risks prior to implementation of risk controls and measures (Section 6.5)
5. Calculating risks ratings (Section 6.5)
6. Identifying risk controls and EPRs to reduce the residual risk of environmental harm (Section 6.6)
7. Assessing residual risk (Section 6.7).

A qualitative assessment will be used to assess the likelihood, consequence and resulting risk of harm to values from construction, operation and maintenance activities.

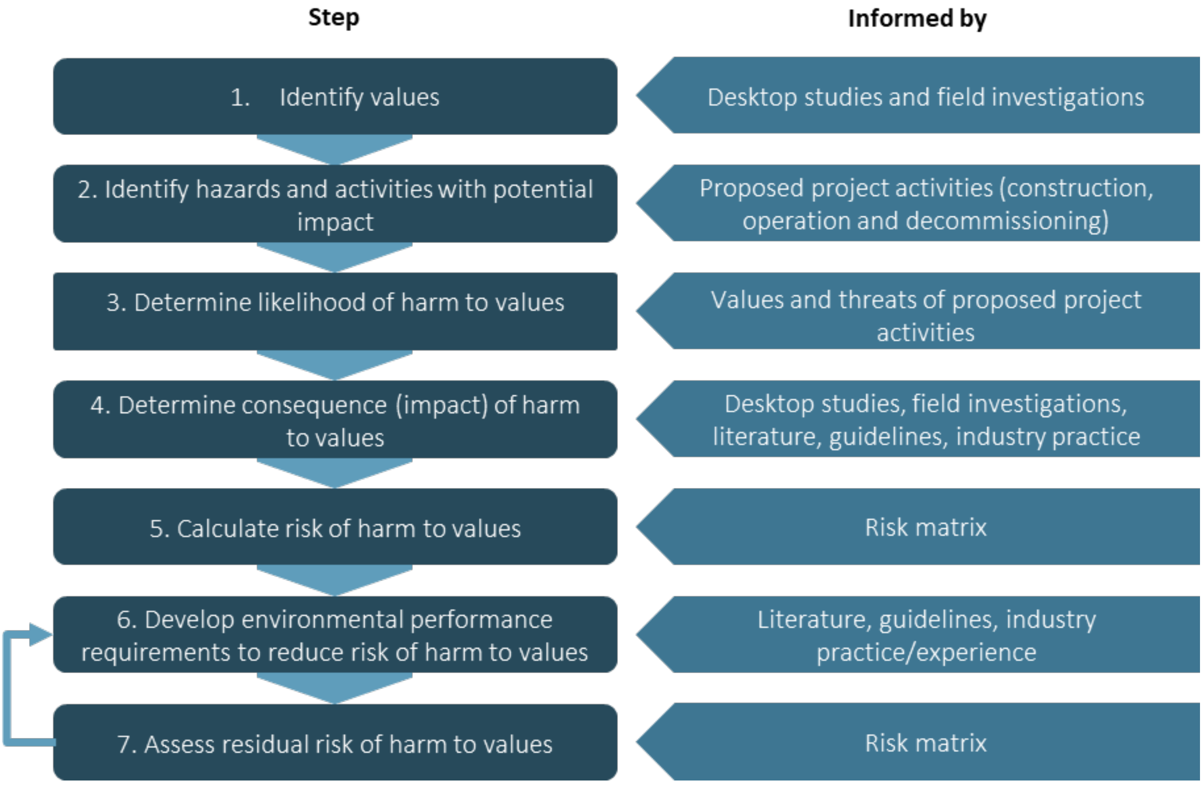

Figure 6. *Risk-based assessment approach.*

Works associated with the project have potential to impact on surface water in three main ways: flooding, water quality and geomorphology. A risk assessment approach has been adopted for the purposes of determining these potential effects of the project. The risk assessment addresses the potential impacts on surface water through changed flooding/connectivity, water quality and fluvial geomorphology/physical form.

Flood impact assessment

The flood impact assessment in the context of surface water and fluvial flooding for the waterway crossings has considered the location of project construction or operation assets and likely areas of disturbance within previously documented 1 % AEP flood extents. This includes a review of the proposed project assets or construction areas currently located within the 1 % AEP flood extent for each waterway crossing, and their area of disturbance (AoD) and potential to impact on flood behaviour.

The flood impact assessment for the converter and transition station locations has been based on site specific developed flood models used to undertake a comparison of flood levels and shear stress in the existing and post-development conditions. The resultant changes in water level are herein referred to as ‘afflux’. The assessment of afflux has focussed on the 1 % AEP and the 1 % AEP climate change events.

Potential flooding impact pathways

Potential flooding impact pathways from the project include:

- The design for converter and transition station locations causing the displacement of flood waters that lead to adverse flood impacts to surrounding property, key infrastructure and the environment (construction and operation).
- The design for converter and transition station locations reducing the volume of temporary storage within the floodplain that lead to adverse flood impacts to surrounding property, key infrastructure and the environment (construction and operation).
- The design for converter and transition station locations constricting the passage of flows passing through the site along the river channel or flow path that lead to increased shear stress values and increased scour of adjacent bed and banks (construction and operation).
- Floodwaters inundating the critical converter and transition station infrastructure that lead to operational safety hazards or failure of system infrastructure (operation).

Modelling methodology

A separate assessment was undertaken for the two converter stations at Hazelwood and Driffield, and a transition station at Waratah Bay. The adopted hydrologic and hydraulic modelling approach for the project has assessed the relevant catchment areas for the three individual sites, with their immediate catchments considered for the purposes of assessing their potential impact.

Due to the nature of the upstream catchments, and the location of the proposed infrastructure sites largely outside the floodplain, a direct-rainfall (or rain-on-grid) approach has been adopted to simulate flooding in the subject areas. With this approach, rainfall is applied directly to the Digital Elevation Model (DEM) of the entire hydraulic model extent. Under this methodology, hydrologic analysis is limited to the development of the rainfall hyetographs which are used as boundary conditions in the hydraulic model. Rainfall hyetographs have been developed for the 1 % AEP and 1 % AEP plus climate change events only. Noting that the Climate and Climate Change Assessment prepared for the project (Katestone Environmental, 2023) provided details on variability of total precipitation, the surface water impact assessment required further analysis of variation in peak rainfall under a changed climate.

The Guidelines for Assessing the Impact of Climate Change on Water Availability in Victoria (Department of Environment, Land, Water and Planning, 2020) indicate that the Australian Rainfall and Runoff (ARR) (Ball, et al., 2019) is the industry guideline for design flood estimation.

DTP (2020) indicates that climate change induced peak rainfall increases will have little impact on total water availability as rainfall intensities are only increased on days where the rainfall depth is greater than or equal to the rainfall exceeded once per year.

The ARR national guideline document contains a guide for estimating the impacts of climate change on rainfall, leading to changes in streamflow (Ball, et al., 2019). The methodology outlined in Ball et al. (2019) is based on the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5). The ARR guideline document outlines an approach to develop emissions scenarios, where the prescribed pathways for greenhouse gas and aerosol concentrations over time, or representative concentration pathways (RCPs), combined with land use change, are consistent with a set of broad climate outcomes used by the climate modelling community.

The four RCPs are characterised by the extra heat that the lower atmosphere will retain as a result of additional greenhouse gases (Jubb, et al., 2013) produced by the end of the 21st century relative to pre-industrial values.

These concentration pathways (RCP8.5, RCP6, RCP4.5 or RCP2.6) are then used to simulate how the climate will change around the world using global climate models. The four climate change pathways have been extrapolated to 2100 based on the predicted increases in emissions and are presented in Figure 7. The RCP scenarios are labelled according to their assumed radiative forcing in the year 2100. For example, the RCP8.5 trajectory assumes a radiative forcing of 8.5 W/m^2, while the RCP2.6 trajectory assumes a radiative forcing of 2.6 W/m^2. RCP8.5 is the highest concentration scenarios available (Figure 7) and is broadly described by the IPCC as "a scenario with very high greenhouse gas emissions […] without additional efforts to constrain emissions" (Intergovernmental Panel on Climate Change, 2015).

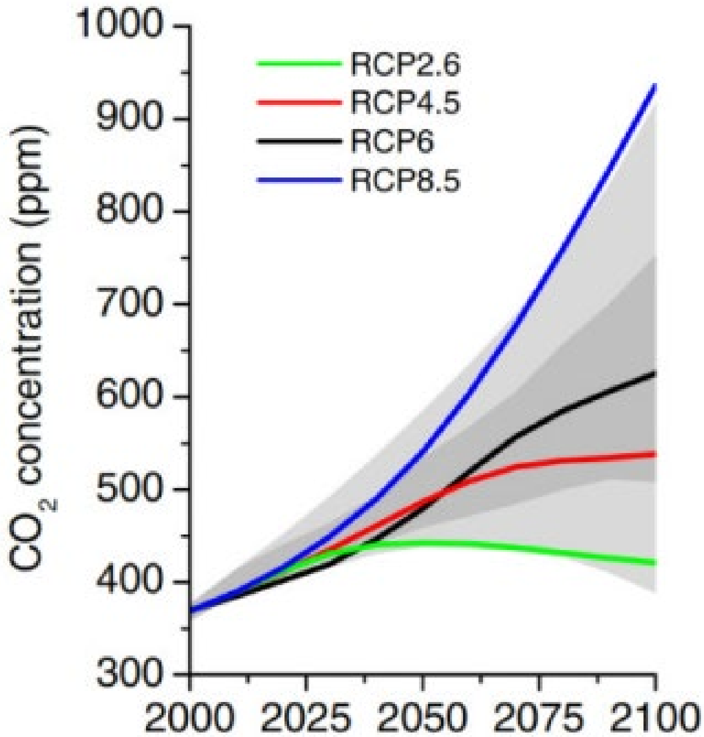

Figure 7. *Four representative concentration pathways and their expected increase in emissions up to 2100. Grey bands indicate the 98th and 90th percentiles (light/dark grey) of an earlier modelling study. Source:* (van Vuuren, et al., 2011).

To prepare for a range of climate conditions, modelling a range of flood events provides information about a floodplain's sensitivity to changes in climate. Policy 9a in the *Victorian Floodplain Management Strategy* (Department of Environment, 2016) stipulates that flood studies use rarer flood events to assess sensitivity to climate change, and that further climate change scenarios may be considered where this sensitivity is significant.

In line with recommendations for impact assessment contained *within Book 1 – Scope and Philosophy Australian Rainfall and Runoff: A Guide to Flood Estimation* (Ball, et al., 2019) and for the purposes of undertaking a sensitivity analysis on the implications of climate change on the rainfall and flooding expected in the region, the RCP4.5 or RCP8.5 scenarios have been adopted. These scenarios assume a marginal increase to more frequent flood events, while more rare events, such as the 1 % AEP, result in an increase in peak rainfall of 7.6 % (RCP 4.5) or 15.4 % (RCP8.5). This scenario represents the current trajectory of increases in greenhouse gas concentrations in the atmosphere without any significant mitigating actions. In the context of this assessment, it represents a conservative assessment of climate change impacts on rainfall over the life of the infrastructure.

Inputs

The following data was used to develop the detailed modelling:

- Aerial photography from various sources, including:
  - ESRI
  - Google
  - Nearmap
  - Historic photo maps (http://mapshare.vic.gov.au/webmap/historical-photomaps/)
- Topographic (LiDAR) data sourced from WGCMA, including:
  - Coastal LiDAR (2007)
  - South Gippsland and Morwell LiDAR (2018)
  - River and floodplain LiDAR (2010)
- Waterway mapping – based on State waterway layers in VicMap Hydro mapping- https://discover.data.vic.gov.au/dataset/waterways-network-1-25000-vicmap-hydro1
- Tetra Tech Coffey provided data:
  - LiDAR collected along the proposed project alignment (February 2021)
  - Hazelwood converter station design lines and design surface, dated 19 October 2022
  - Driffield converter station design lines and design surface, dated 19 October 2022
  - Waratah Bay transition station design lines and design surface, dated 18 November 2022
- State-wide land use, soil and geomorphological mapping
- State-wide VicMap 10m DEM

Water quality and geomorphology impact assessment

Suitable habitat for waterway ecosystems relies on water availability and flow characteristics, water quality, and physical habitat characteristics such as the form of waterway bed and banks. Human social, cultural and economic uses and values also rely on water availability, good water quality and manageable flood risk.

Note: Given this assessment focuses on surface water alone and not aquatic or terrestrial ecology, we have focussed our analysis on waterway processes, conditions and functions that generally support water-dependent species and healthy waterway ecosystems. It is understood that analysis of species presence, value and impacts of the project on these will be covered in separate ecological assessments.

A separate risk assessment of the risk to project infrastructure posed by waterway processes is also included in Attachment 4. These processes include flooding and waterway processes such as erosion, incision and avulsion development.

Potential water quality and geomorphology impact pathways

Potential surface water quality and geomorphology impact pathways from the project include:

- Altered fluvial geomorphic processes, initiation of bed and bank scour and sediment delivery, which can result in habitat loss and ecosystem decline (construction)
  - disturbance to the bed or banks of waterways through ground disturbance activities (excavation, trenching, clearing, vehicular traffic etc.) within the riparian zone or instream.
- Changes to water quality, such as increased sediment loads, nutrient loads, addition of metals, hydrocarbons or other chemicals from spills that can lead to degradation in water quality, ecosystem health/reproduction or aesthetics through:

  - Spill or release events (construction or operation).
  - Dewatering activities that discharge directly to waterways (construction and operation).
  - Contaminated surface water runoff following rainfall (construction).
  - Stormwater runoff both concentrated and increased volume from new impervious surfaces (operation).
- Alteration of the flow regime, such as diversion, duration, frequency, duration and timing of high and/or low flow events have potential to initiate bed and bank scour, resulting in habitat loss, sediment delivery which could have both ecological and physical form consequences:
  - Reinstatement of waterways to alternative shape/form and leading to altered fluvial geomorphic process initiating bed and bank scour (construction or operation)
  - Concentrated discharge of wastewater from de-watering activities initiating bed and bank scour (construction or operation)
  - Concentrated stormwater runoff across disturbed ground (construction) or impervious surfaces (operation) initiating scour/sediment runoff.

Risk assessment

Once the risk pathway has been identified, the risk of harm rating can be assessed. The risk of harm is the change to the identified value as a result of the hazard, mechanism, and pathway.

Likelihood

Likelihood is the chance of a risk and impact to values occurring. Table 10 outlines the qualitative criteria used to define likelihood. Likelihood can be determined both prior to and post implementation of risk controls and measures.

Table 10. Qualitative criteria utilised to define likelihood

Likelihood	Description
Almost certain	A hazard, event and pathway exist, and harm has occurred in similar environments and circumstances elsewhere and is expected to occur more than once over the duration of the project activity, project phase or project life.
Likely	A hazard, event and pathway exist, and harm has occurred in similar environments and circumstances elsewhere and is likely to occur at least once over the duration of the project activity, project phase or project life.
Possible	A hazard, event and pathway exist, and harm has occurred in similar environments and circumstances elsewhere and may occur over the duration of the project activity, project phase or project life.
Unlikely	A hazard, event and pathway exist, and harm has occurred in similar environments and circumstances elsewhere but is unlikely to occur over the duration of the project activity, project phase or project life.
Rare	A hazard, event and pathway are theoretically possible on this project and has occurred once elsewhere, but not anticipated over the duration of the project activity, project phase or project life.

Consequence

Consequence is the impact of identified risks on values. Table 11 outlines the qualitative criteria used to define consequence. Consequence can be determined both prior to and post implementation of risk controls and measures.

Table 11. Qualitative criteria utilised to define consequence

Consequence	Description
Severe	An effect that causes permanent changes to the environment and irreversible harm to physical, ecological, or social environmental surface water values or consequences of the impact are unknown and management controls are untested. Causes major public outrage, sustained widespread community complaints. Prosecution by regulatory authorities. Avoidance through appropriate design responses is required to address the impact
Major	An effect that is widespread, long lasting and results in substantial change to surface water values either temporary or permanent. Can only be partially rehabilitated or uncertain if it can successfully be rehabilitated. Appropriate design responses are required to address the impact. Causes major public outrage, possible prosecution by regulatory authorities. Receives widespread local community complaints.
Moderate	An effect that extends beyond the operational area to the surrounding area but is contained within the region where the project is being developed. The harm is short-term and result in changes that can be ameliorated with specific management controls
Minor	A localised effect that is short-term and could be effectively mitigated through standard management controls. Remediation work and follow-up required.
Negligible	A localised effect that is temporary and does not extend beyond operational area. Either unlikely to be detectable or could be effectively mitigated through standard management controls. Full recovery expected.

Risk rating

The risk of harm is determined by combining likelihood and consequence using the matrix in Table 12. The risk assessment guides the avoidance, mitigation and management measures proposed to manage these risks. Higher risks require specific controls or management, whereas lower risks can be managed using standard controls.

Table 12. Risk evaluation matrix

		Likelihood				
		Rare	Unlikely	Possible	Likely	Almost certain
Cor	Negligible	Very low	Very low	Very low	Low	Moderate
	Minor	Very low	Low	Low	Moderate	Moderate
	Moderate	Low	Low	Moderate	High	High
	Major	Low	Moderate	High	Very high	Very high
	Severe	Moderate	High	Very high	Very high	Very high

Cumulative impact assessment

The EIS guidelines and EES scoping requirements both include requirements for the assessment of cumulative impacts. Cumulative impacts result from incremental impacts caused by multiple projects occurring at similar times and within proximity to each other.

To identify possible projects that could result in cumulative impacts, the International Finance Corporation (IFC) guidelines on cumulative impacts have been adopted. The IFC guidelines (IFC, 2013) define cumulative impacts as those that 'result from the successive, incremental, and/or combined effects of an action, project, or activity when added to other existing, planned, and/or reasonably anticipated future ones.'

The approach for identifying projects for assessment of cumulative impacts considers:

- Temporal boundary: the timing of the relative construction, operation and decommissioning of other existing developments and/or approved developments that coincides (partially or entirely) with Marinus Link.
- Spatial boundary: the location, scale and nature of the other approved or committed projects expected to occur in the same area of influence as Marinus Link. The area of influence is defined as the spatial extent of the impacts a project is expected to have.

Proposed and reasonably foreseeable projects were identified based on their potential to credibly contribute to cumulative impacts due to their temporal and spatial boundaries. Projects were identified based on publicly available information at the time of assessment. The projects considered for cumulative impact assessment in Victoria are:

- Delburn Wind farm
- Star of the South Offshore Wind farm
- Offshore wind development zone in Gippsland including Greater Gippsland Offshore Wind Project (BlueFloat Energy), Seadragon Project (Floatation Energy), Greater Eastern Offshore Wind (Corio Generation).
- Hazelwood Rehabilitation Project
- Wooreen Energy Storage System

The projects relevant to this surface water impact assessment have been determined based on the potential for cumulative impacts to surface water values (flooding, water quality and geomorphology).

These projects are occurring concurrently and/or are situated in close proximity to the Marinus Link project. The assessment of the potential cumulative impacts draws on the findings from the impact assessment (see Section 6) and the identification of where effects from these credible projects and their associated activities may overlap, interact and accumulate, and therefore result in a cumulative impact on surface water values within the study area. Stakeholder engagement has not been undertaken as part of this assessment.

The projects assessed as relevant to this surface water impact assessment are:

- **Star of the South Offshore Wind farm**: This project is located 70 km from the proposed Marinus Link project alignment, and the transmission line connecting the Marinus Link project to this project closely follows the Bass Link project alignment, connecting at Hazelwood.
- **Hazelwood Rehabilitation Project**: This project is located in the Latrobe Valley in Victoria near the town of Morwell. The Marinus Link project has two options for connecting to the electricity grid; one at Driffield near the existing transmission lines and the other at

Hazelwood, adjacent to the Hazelwood terminal station. It's worth noting that the Hazelwood terminal station is also in close proximity to the Hazelwood Rehabilitation Project.

- **Delburn Wind farm**: This project is located along side of the proposed project alignment, within the Driffield area.
- **Wooreen Energy Storage System (WESS)**: The WESS project and the proposed Marinus Link converter station at Hazelwood, although not directly connected, are situated in close proximity, potentially leading to cumulative effects and interactions.

The assessment of cumulative impacts on surface water values is further detailed in Section 6.8.

4.4 Typical mitigation measures and EPRs

Typical mitigation measures have been identified below to help guide the selection of EPRs in Section 6.6. These standard mitigation measures should be implemented in line with the hierarchy for controlling hazards and associated risks outlined in EPA Victoria Publication 1695.1 *Assessing and controlling risk for business* (Victoria, 2018).

The hierarchy of controls to minimise impacts to surface water quality and flow regime involves use of avoidance or mitigation measures in the following order (Victoria, 2018):

1. Measures that eliminate impacts altogether.
2. Measures that minimise the magnitude of the impact through substitution or engineering controls.
3. Measures that change the behaviour of people in order to minimise the magnitude of impact (administrative controls).

The risk assessment process was used to identify mitigation measures, minimisation measures and the subsequent EPRs as part of the surface water impact assessment.

EPRs and their development are presented in Section 6.6.

Flooding typical mitigation measures

Standard mitigation measures to minimise the potential flooding impacts of the project include:

- Implementing appropriate flood mitigation measures in the design for each converter/transition station site to minimise adverse flood impacts to surrounding property, key infrastructure and the environment.
- Implementing appropriate erosion control measures in the design for each converter/transition station site to minimise adverse scour/stability impacts to surrounding waterways and potential to impact on adjacent property, key infrastructure and the environment.
- Implementing appropriate flood immunity requirements for key converter/transition station infrastructure to eliminate impacts and protect the health and safety workers, operational staff, and the public.

Water quality and geomorphology typical mitigation measures

Standard measures to minimise the potential water quality and geomorphology impacts of the project include:

- Develop and implement an Erosion and Surface Water Management Plan (as per EPR SW01 in section 6.6) based on available guidelines including:

- Surface water runoff and erosion controls for construction as outlined in *EPA Victoria Publication 275 Construction techniques for sediment pollution control* (EPA Victoria, 1991)*, and EPA Victoria Publication 1834.1 Civil construction, building and demolition guide* (EPA Vctoria, 2023) *(or similar)*.
- Liquid handling and storage controls as outlined in *EPA Victoria Publication 1698 Liquid storage and handling guidelines* (EPA Victoria, 2018) *(or similar)*.
- Contaminated surface water runoff controls as outlined in *EPA Publication 978 Reducing stormwater pollution a guide for industry* (EPA Victoria, 2005)*, and EPA Victoria Publication 1834.1 Civil construction, building and demolition guide* (EPA Vctoria, 2023)*, (or similar)*.
- Implementing best available techniques and technologies for working within or adjacent to waterways as outlined in *EPA Victoria Publication 1896 Working within or adjacent to waterways* (EPA Victoria, 2020)*, (or similar)*
- Implementing best available techniques and technologies for managing bed and bank stability as outlined within *DSE Technical Guidelines for Waterway Management* (Department of Sustainability and Environment (DSE), 2007) *(or similar)*.

4.5 Stakeholder engagement

Stakeholders and the community are being consulted throughout the development of the project and the EES process. Formal engagement with landholders and stakeholders has not been undertaken specifically for the purposes of the surface water assessment.

For this surface water assessment, informal discussions were held with some landholders during site inspection (on 21st and 22nd March 2022), where available. The landholder discussions provided additional context on:

- The history of land use and management
- The flooding behaviour of waterways and history of flooding
- Fluvial processes, history and key locations of channel change
- Waterway management history and management interventions (e.g. bank protection)

Anecdotal landholder comments on flood extents and behaviour were cross-checked with mapped flood extents and observed geomorphic character. No landholders raised concerns about potential changes to waterways or flood behaviour, depths or extents as a result of the project.

4.6 Assumptions and limitations

The following limitations, uncertainties and assumptions apply to this study:

- Impact and risk assessments are largely qualitative constraints, including, but not limited to lack of complete, long-term, consistent quantitative data and field site access constraints. To overcome this multiple data sets (i.e. repeat aerial photography from multiple data sources to fill in sites unable to be inspected) have been used to help inform the impact assessment process.
- For waterway crossing analysis, flood extents have been based on existing available information, further hydrologic and/or hydraulic modelling has not been undertaken. This is assumed to be sufficiently accurate for identifying potential impacts covered in this impact assessment.

- Any use which a third party makes of this document, or any reliance on or decision to be made based on this document, is the responsibility of such third parties. The client and the project team accept no responsibility for damages, if any, suffered by any third party as a result of decisions or actions made based on this document
- Information and data such as GIS layers, models and other data have been obtained from a range of external sources including Tetra Tech Coffey, WGCMA, DTP, other authorities and groups. It is only practical to verify or independently review some of this information. The data is sometimes provided with caveats or with missing or obviously inconsistent information. These indicated limitations have been considered, and known limitations addressed and or documented adequately and the data has been considered suitable for the specific purpose of informing the EIS/EES. While care has been taken in interpreting the provided data, neither the original provider nor the project team take any responsibility for incorrect or inaccurate information or make any representation as to its suitability for other purposes.
- Flood modelling developed specifically for the project is assumed to be sufficiently accurate for informing the investigations covered in this impact assessment.
- Flood modelling has been undertaken based upon limited available information including limited feature and topographic survey and incomplete spatial data from third parties (including pit and pipe data). Where adverse pit and pipe gradients and invert inconsistences were encountered, nominal depths were assumed from LiDAR, or gradients were calculated from surface profiles.
- Water quality monitoring data is only available for five of the eight major waterway crossings assessed. The available data is incomplete, with one of the five having no data available for total phosphorus and nitrogen. Further water quality assessment will be required as part of the surface water monitoring plan and program outlined in the EPRs.

The study acknowledges the above limitations for the surface water impact assessment of the project and the level of detail has been considered suitable to support the specific purpose of informing the EIS/EES.

5 Existing conditions

This section describes the existing conditions and values within the study area based on the information obtained from the baseline assessment.

The study area for the baseline characterisation assessment is concerned with major waterway crossings and the area surrounding converter and transition stations associated with the project. This section outlines the existing flooding, water quality and geomorphic conditions in these major waterway crossings and areas surrounding the converter and transition stations, based on available data and information from desktop assessments and targeted field investigations.

Input data used to inform the baseline condition assessment is outlined in Section 4.2 and reliability of flood modelling data in Section 4.3. It is noted that the reliability of the flood data being used in this assessment varies and should be refined during the design phases. For the purposes of the impact assessment, it is assumed to be sufficiently accurate for identifying the intersection with the proposed transmission route and assessment of potential impacts.

5.1 Waterway crossing overview

Morwell River

Formed by the confluence of the West Branch and East Branch and part of the broader Latrobe Basin, the Morwell River rises in the Strzelecki Ranges. The river flows for around 83 km, generally in a northerly direction, before joining the Latrobe River near Yallourn. The total catchment is around 674 km^2.

Several environmental values of the Morwell River and broader Latrobe system are identified in the environmental watering requirements (Alluvium, 2020). These include freshwater and migratory fish, frogs, platypus, rakali, turtles, and waterbirds, along with emergent, riparian and floodplain vegetation. These values are supported by physical habitat (driven by geomorphology / physical form) and water quality.

The Morwell River has been heavily impacted by past management activities. The upper catchment is forested, however agricultural activities have had an influence in the downstream reaches. The biggest impact on the Morwell River has been through mining activities with multiple channel diversions. Riparian vegetation is dominated by exotic herbs and grasses as well as some willows. Banks are steep but appear stable and consist of very fine silts (Alluvium, 2020). The West Gippsland Waterway Strategy (WGCMA, 2014) identifies the subject reach of the Morwell River as a high value waterway for environmental, social and economic values, however, does not list it as a priority waterway.

The 2010 Index of Stream Condition (ISC) assessment also rates the reach as ‘Moderate’ condition (Department of Environment, Land, Water and Planning (DELWP), 2010). The Morwell River in this reach scores well for hydrology and aquatic life and physical form, but not so high for streamside zone, with riparian vegetation lacking.

Little Morwell River

The Little Morwell River rises near Mirboo North in the Strzelecki Ranges and flows northeast for around 21 km before meeting the Morwell River just downstream of Boolarra. The Little Morwell River is a small, largely spring (groundwater) fed stream with a small catchment around 87 km^2. The Little Morwell River is not a priority reach under the West Gippsland Waterway Strategy and does not have an ISC score (WGCMA, 2014).

The Little Morwell is reported to have a predominantly sandy bed, with good habitat features including pools, snags and riffles. This habitat supports fish such as short-finned eel, river blackfish, shorthead lamprey and small Gippsland spiny crayfish (Victorian Fisheries Authority, 2022).

Tarwin River East Branch

The Tarwin River East Branch rises in the Strzelecki Ranges and flows first northeast, then northwest, and then at the town of Mirboo flows southwest towards the confluence with the Tarwin River. The East Branch is around 66 km long with a catchment of 269 km^2. The Tarwin River is the largest river in the South Gippsland basin. The Tarwin and its tributary waterways provide important unregulated flows to the nationally important Anderson Inlet.

The broader Tarwin catchment is reported to support Australian grayling, estuary perch, long-finned eel, river blackfish and short-finned eel, as well as smaller fish such as Australian smelt, climbing galaxias, common galaxias, congoli, flathead gudgeon, mountain galaxias, pouch lamprey, shorthead lamprey, southern pygmy perch and trout galaxias (Victorian Fisheries Authority, 2022).

The West Gippsland Waterway Strategy identifies the subject reach of the Tarwin River East Branch as a high value waterway for environmental, social and economic values, and lists it as a priority waterway (WGCMA, 2014). The 2010 Index of Stream Condition (ISC) assessment also rates the reach as 'Moderate' condition (DELWP, 2010).

Tributaries of Tarwin River East Branch

Two tributaries of the Tarwin River East Branch, located south of the town of Dumbalk flow largely east, from the Strzelecki Ranges. The northern tributary meets the Tarwin River East Branch just upstream of Sweeneys Road, southwest of Dumbalk. The southern tributary joins the Tarwin River East Branch further downstream near the junction of Meeniyan-Mirboo North Road and Dumbalk-Stony Creek Road and upstream of Parrys Road.

Part of the broader Tarwin River system, the northern tributary is around 12.3 km in length, with a catchment of around 24 km^2. The southern tributary is around 14.1 km in length, with a catchment of around 36 km^2. These tributaries support the broader Tarwin River system, with key values listed above.

Stony Creek

Stony Creek rises near Foster North, just south of Stony Creek-Dollar Road. It flows generally west, following the South Gippsland Highway route, then heads southwest to join the Tarwin River near Meeniyan. The waterway is around 29 km long, with a catchment of around 72 km^2.

As a small headwater stream, little is known about the environmental values of Stony Creek. It is not listed as a priority reach under the West Gippsland Waterway Strategy and does not have an ISC score (WGCMA, 2014).

Buffalo Creek

Buffalo Creek is a small waterway, around 10 km in total length, with a catchment around 38 km^2. The waterway flows through low relief hills and into riverine plains near Meeniyan-Promontory Road, before reaching the broader floodplain of the Tarwin River.

As a small headwater stream, little is known about the environmental values of Buffalo Creek. It is not listed as a priority reach under the West Gippsland Waterway Strategy and does not have an ISC score (WGCMA, 2014).

Fish Creek

From its headwaters to the confluence with the Tarwin River, Fish Creek is around 44 km long, with a catchment area of around 170 km^2. Fish Creek rises on the southern slopes of the Tarra Bulga National Park, just south of the South Gippsland highway. The creek flows generally southwest through the town of Fish Creek, eventually joining the Tarwin River, which flows through to Andersons Inlet. The river flows through uplands and high-level terraces of sedimentary rock, before entering the riverine plains at the project crossing point and flowing through the alluvial floodplain.

The West Gippsland Waterway Strategy identifies the subject reach of Fish Creek as a high value waterway for environmental and social values and lists it as a priority waterway (WGCMA, 2014). Specific works for Fish Creek include reduce bank erosion through earthworks, bank armouring and grade control. The 2010 Index of Stream Condition (ISC) assessment rates the reach as 'Moderate' condition (DELWP, 2010). The reach scores high for physical form, but not as high for streamside zone and hydrology, suggesting poor riparian vegetation and an altered flow regime.

5.2 Existing flooding conditions

Waterway crossings

Morwell River

The 1 % AEP flood extent for the reach of the Morwell River surrounding the proposed project alignment extends across a 300-900 m floodplain width (Figure 8). At the site of the crossing, the flood extent is narrowest at around 300 m, where the valley sides narrow. This reduced flood width could indicate higher velocity and/or increased flood depth. Further modelling will be required to determine if this is the case.

The Latrobe Environmental Flow Recommendations report (Alluvium, 2020) indicates that overbank flows are important for the Morwell River to:

- Create aquatic habitat for macroinvertebrates and zoo plankton and stimulate production
- Provide moisture to riparian and floodplain vegetation to support growth and as habitat for birds
- Disperse riparian and floodplain seeds
- Fill floodplain depressions and billabongs to support growth of seasonal and emergent wetland vegetation
- Promote carbon and sediment exchange to and from the river.

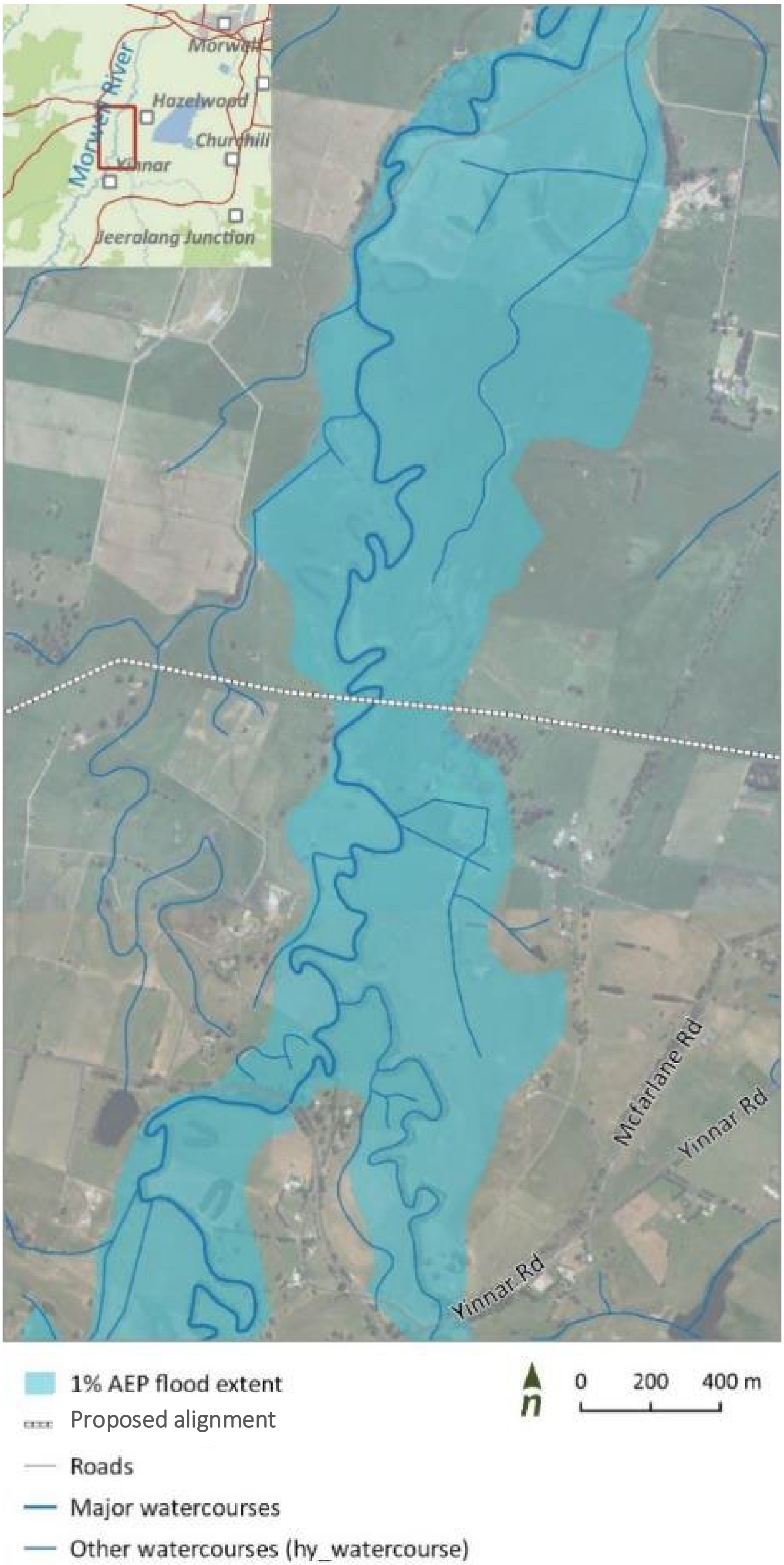

Figure 8. *1% AEP flood extent for the Morwell River surrounding the proposed project alignment.*

Little Morwell River

There is no mapped 1% AEP flood extent at the proposed project alignment crossing with the Little Morwell River. Flooding is likely to be confined to valley margins. A potential maximum flood extent has been estimated based on valley topography, slope, and vegetation types over multiple aerial images (Figure 9). Further flood modelling will be required to refine this flood extent for detailed project design.

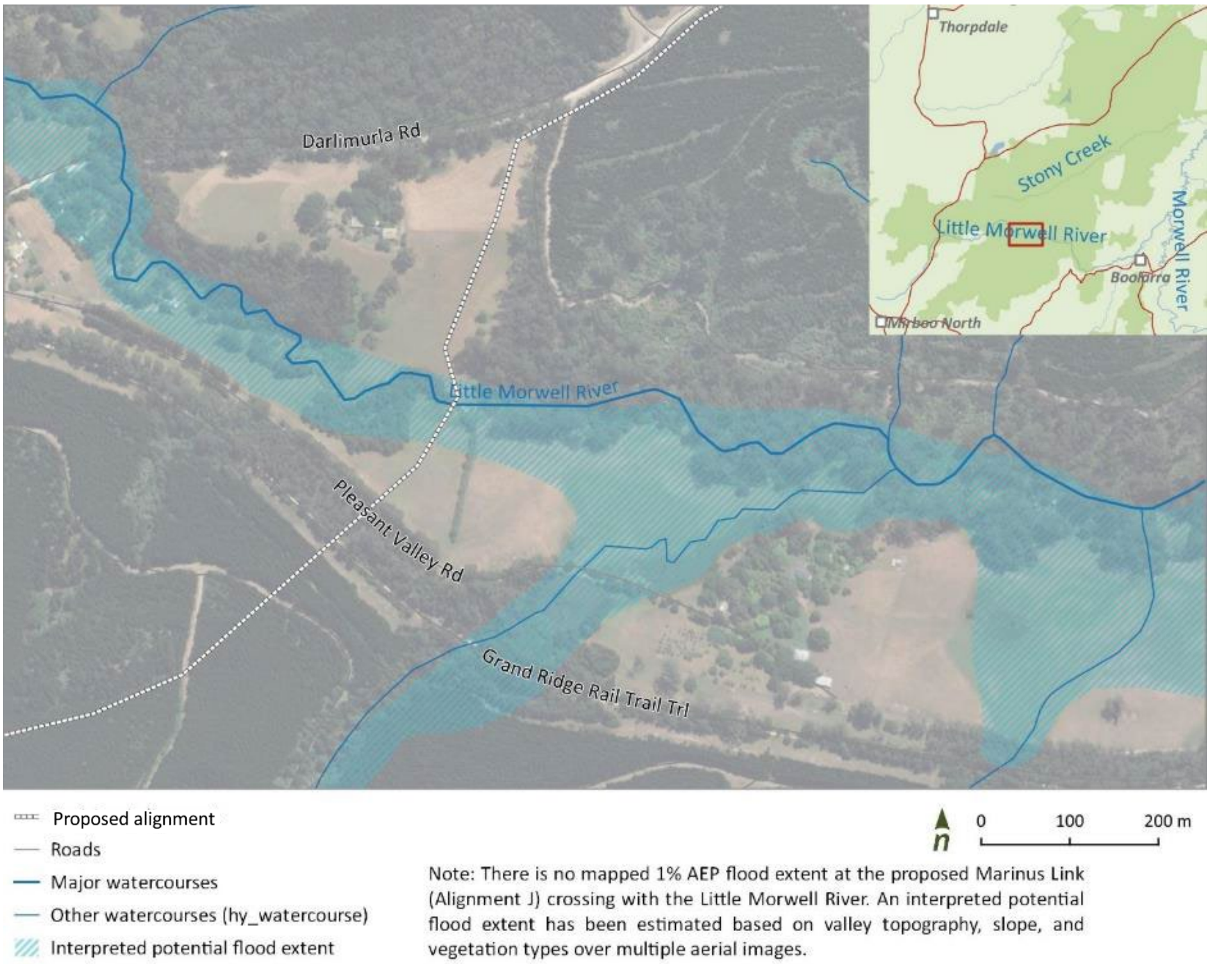

Figure 9. *Potential maximum flood extent for the Little Morwell River surrounding the project alignment. Estimated based on valley topography, slope and vegetation over multiple aerial images. Note: not to be used for detailed design or planning.*

Tarwin River East Branch

The 1 % AEP flood extent for the reach of the Tarwin River East Branch surrounding the proposed project alignment is confined within the narrow valley upstream but begins to extend onto the floodplain in the vicinity of Meeniyan-Mirboo North Road and the proposed Marinus Link crossing (Figure 10). Upstream, floodplain inundation is within the 20-30 m width of the valley, increasing to around 200-250 m downstream. Flooding covers a greater area on the left (south) bank of the waterway due to the valley topography.

Figure 10. *1 % AEP flood extent for the Tarwin River East Branch surrounding the proposed project alignment.*

Tributaries of Tarwin River East Branch

In the vicinity of the Marinus Link crossing, floodplain inundation extends across a width of around 850 m. Flooding covers a large area due to the valley topography, with the Marinus Link crossing multiple tributaries of Tarwin River East Branch across the floodplain. Of the major tributaries the 1 % AEP flood extent for the northern tributary of the Tarwin River East Branch surrounding the proposed project alignment is confined within the narrow valley upstream but extends onto the broad floodplain in the vicinity of Dollar Road and where the waterway turns from flowing north west to south west (Figure **11**).

The 1% AEP flood extent for the southern tributary of the Tarwin River East Branch surrounding the proposed project alignment extends onto the broad floodplain (Figure **11**). In the vicinity of the Marinus Link crossing, floodplain inundation extends across a width of around 750 m. Flooding covers a large area due to the valley topography, with multiple drainage channels across the floodplain.

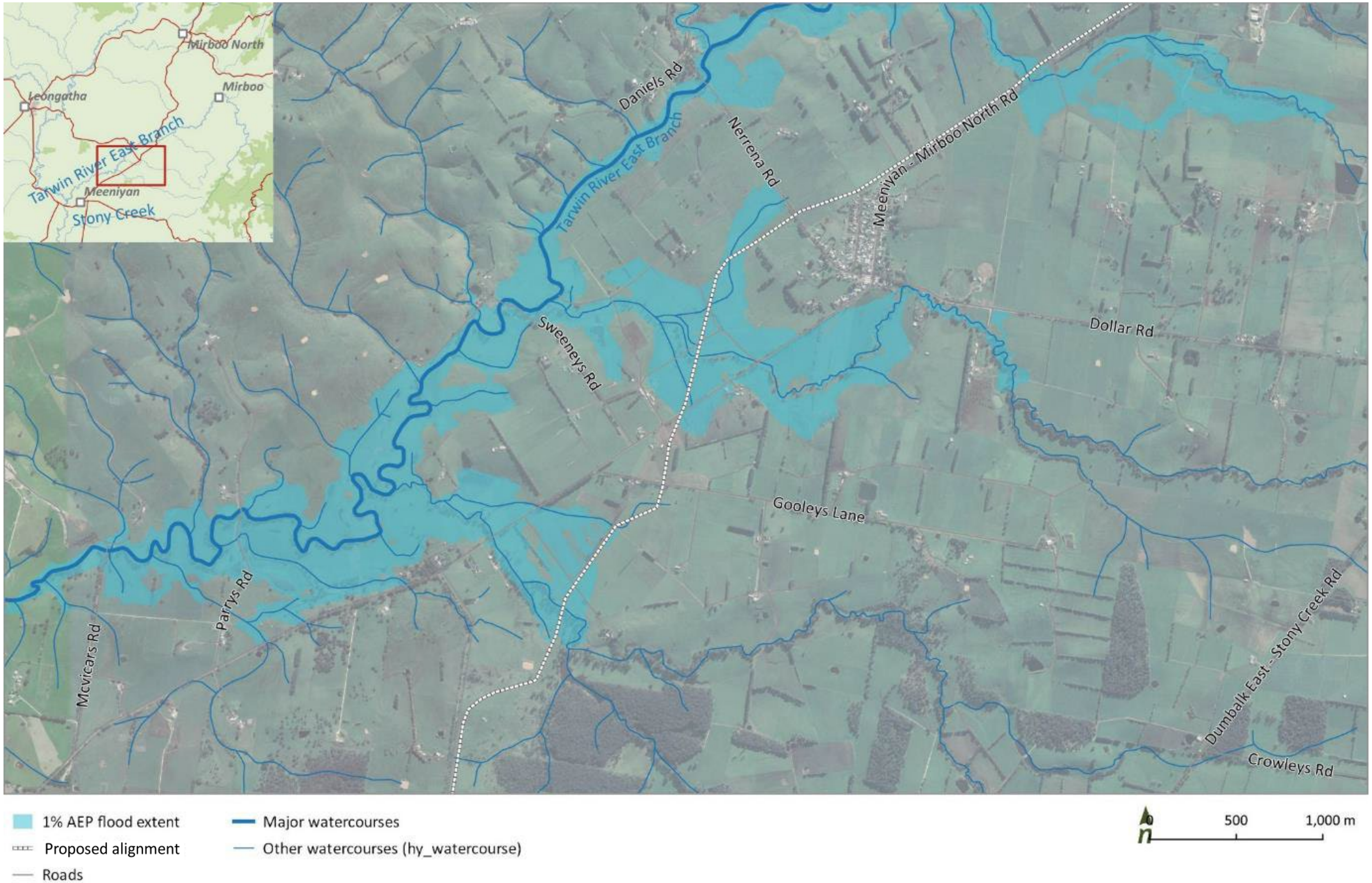

Figure 11. *1 % AEP flood extent for the tributaries of the Tarwin River East Branch surrounding the proposed project alignment*

Stony Creek

The 1 % AEP flood extent for the reach of Stony Creek surrounding the proposed Marinus Link crossing varies in width from around 100 to 400 m (Figure 12). The project alignment runs through the 1 % AEP extent for almost 1 km before turning south west of the Great Southern Rail Trail. Flooding covers a greater area on the left (south east) bank of the waterway due to the valley topography and appears to extend to the smaller creek to the south of Stony Creek. Anecdotes from landholders also suggested that in flood events water escapes the channel and travels in a southerly direction over the floodplain towards Buffalo-Stony Creek Road.

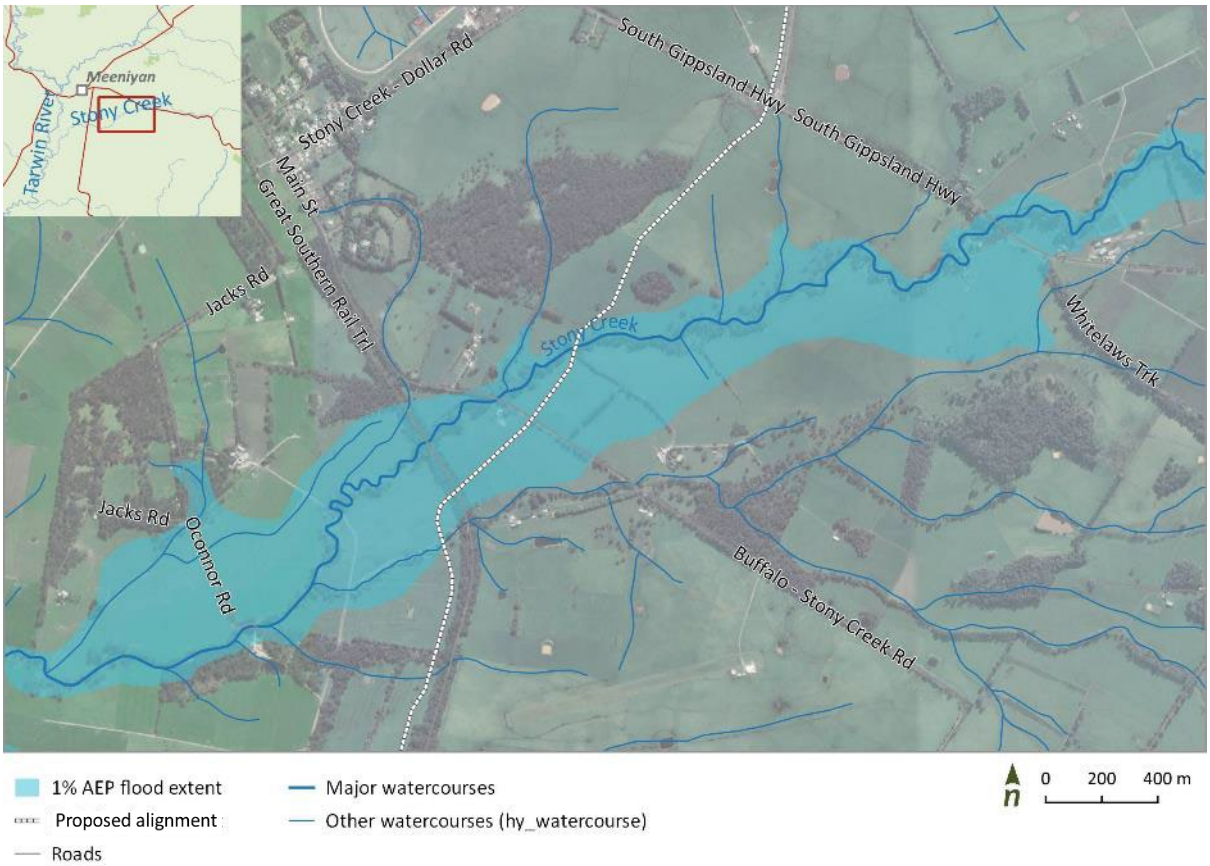

Figure 12. *1 % AEP flood extent for Stony Creek surrounding the proposed project alignment.*

Buffalo Creek

There is no mapped 1 % AEP flood extent at the proposed project alignment with Buffalo Creek. In the absence of a mapped 1 % AEP flood extent for Buffalo Creek, an estimated flood extent of 418,902 m^2 was determined by interpreting the valley topography, slope and vegetation trends over multiple aerial images (Figure 13). Further flood modelling will be required to refine this flood extent for detailed project design. This waterway does exhibit levee banks which generally increases the energy slope (and erosive potential) of floodwater spilling from the channel and across the floodplain.

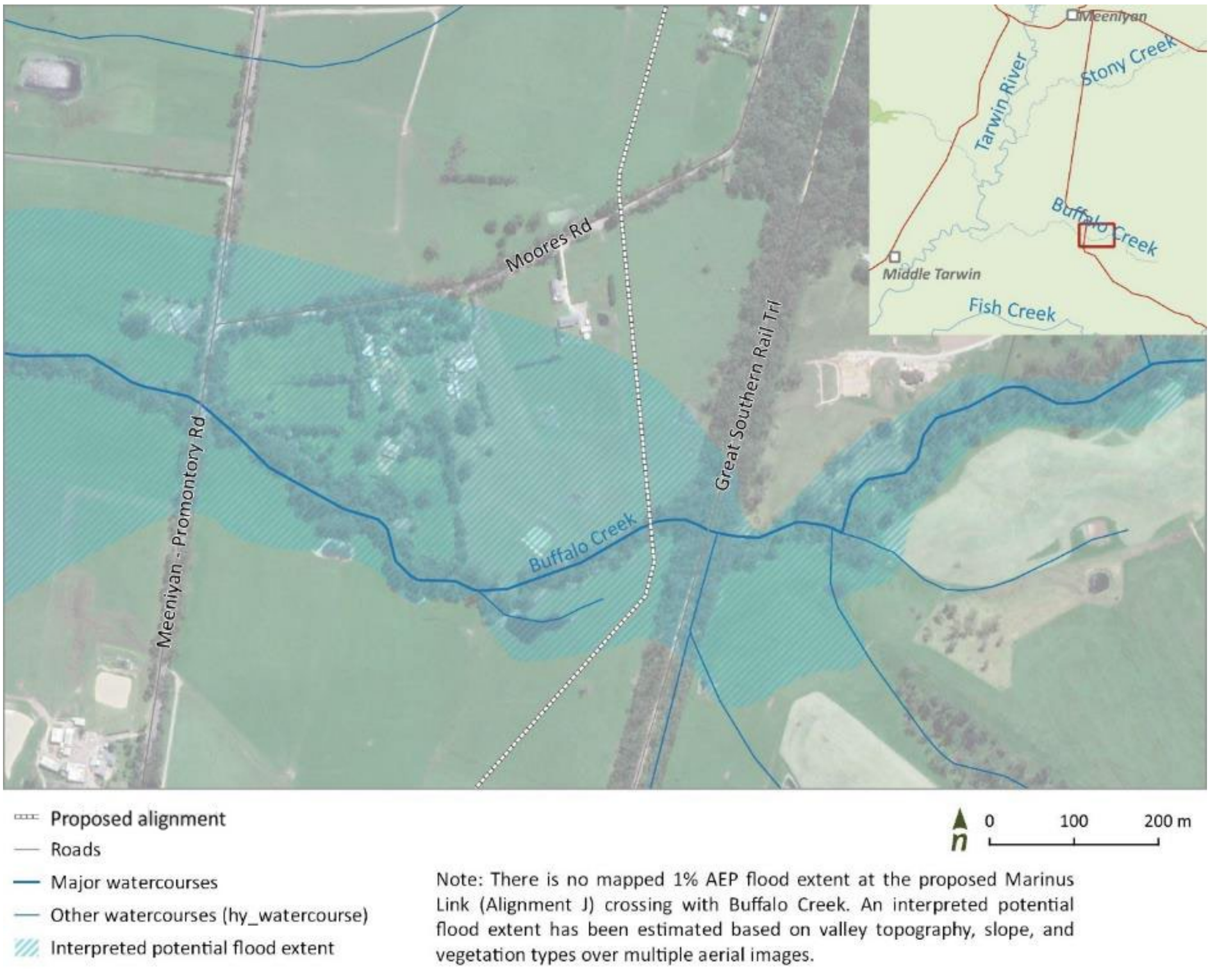

Figure 13. *Potential maximum flood extent for Buffalo Creek surrounding the proposed project alignment. Estimated based on valley topography, slope and vegetation over multiple aerial images. Note: not to be used for detailed design or planning.*

Fish Creek

The 1 % AEP flood extent for the reach of Fish Creek surrounding the proposed project alignment is confined to around 100-200 m in width in upstream sections but extends across the broad floodplain downstream stretching over 400-600 m in width (Figure 14). The soils are thought to be highly dispersive white clays, in this area with anecdotal evidence suggesting around 30 cm of topsoil was washed away in the last flood event in 2022 (Barton Napier, pers. Comm).

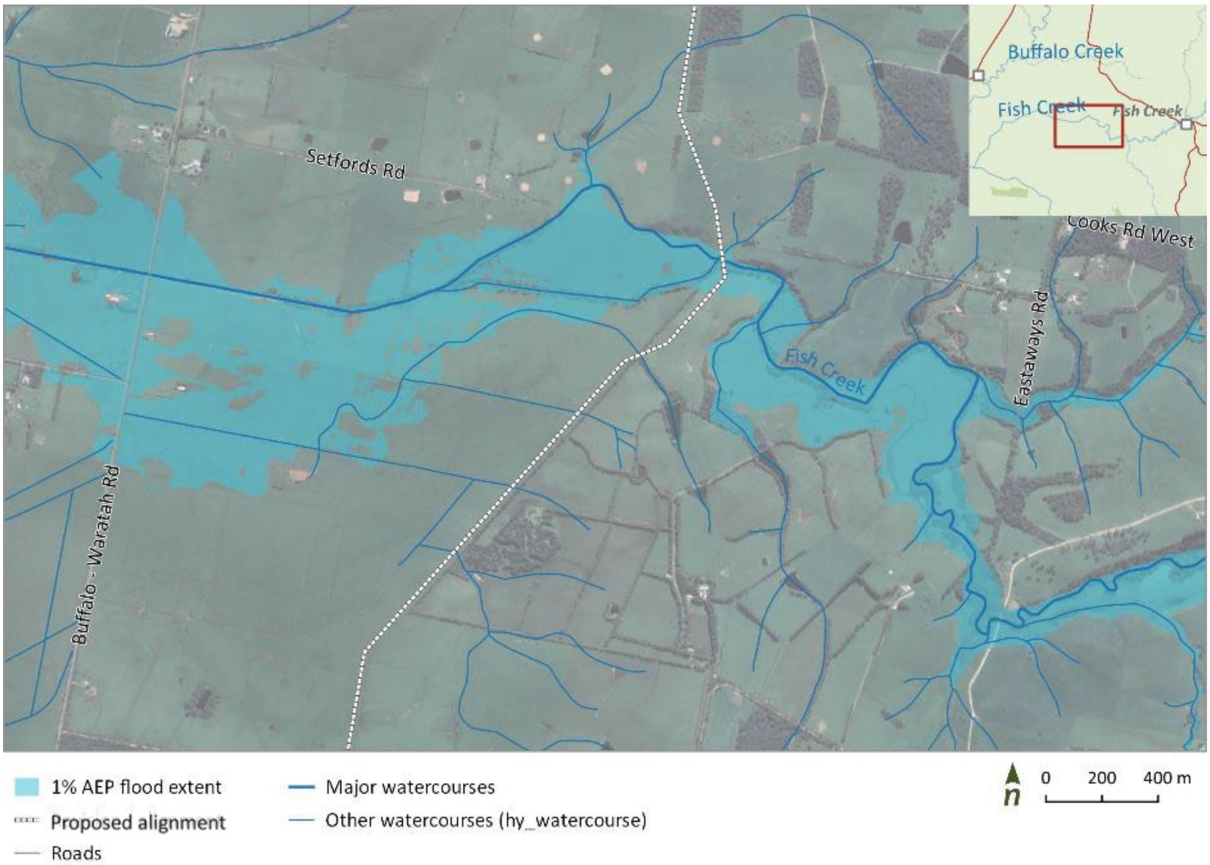

Figure 14. *1 % AEP flood extent for Fish Creek surrounding the proposed project alignment.*

Reliability of flood data

As informed by the WGCMA, it should be noted the reliability of the flood data being used in this assessment varies and should be refined during the design phases:

- Morwell River – 1 % AEP extent is low reliability based on historic observation and ground truthing
- Little Morwell River – No mapping- potential maximum flood extent has been estimated based on valley topography, slope, and vegetation types over multiple aerial images
- Tarwin River East Branch – Medium reliability, WGCMA internal flood study (student project)
- Tribs of Tarwin East Branch – Medium reliability, WGCMA internal flood study (student project)
- Stony Creek – 1 % AEP extent is low reliability based on ground truthing
- Buffalo Creek – no mapping- potential maximum flood extent has been estimated based on valley topography, slope, and vegetation types over multiple aerial images
- Fish Creek – Medium reliability – internal flood study done during transition to ARR

Converter and transition stations

Hazelwood converter station

Flood mapping and subsequent assessment of the Hazelwood converter station has been developed from outputs of the flood modelling in accordance with the methodology detailed in Section 4.3. Figure 15 highlights the roughness parameters selected and shows that the proposed development area is situated on top of a high point in the terrain, overlooking the township of Churchill and Bennetts Creek, to the east of Tramway Road. The existing Bennetts Creek enters the model upstream of Boldings Road and splits its flow into two directions, known as bifurcation. One flow path directs flows to the north adjacent to Tramway Road, continuing as Bennetts Creek, while the other to the west via a series of irrigation channels across Churchill-Traralgon Road, becoming Eel Hole Creek. Eel Hole Creek continues west across Monash Way where it makes its way to the former Hazelwood mine cooling pond.

The direct rainfall runoff for the baseline characterisation 1 % AEP event drains towards the north, where the existing Hazelwood Terminal Station is located, and to the north-west where a chain of farming dams is located adjacent to Monash Way (Figure 16). Most of overland runoff either ponds adjacent to the existing infrastructure (up to 0.2 m deep) or converges through natural swales (up to 0.4 m deep) at the intersection of Bonds Lane and Monash Way.

To the west of the Hazelwood Terminal Station, the chain of ponds is filled and spills against Monash Way where water approximately 1.2 m deep can be observed, spilling over the roadway and exiting the model. Similarly, the north-western natural drainage areas experience the same flooding behaviour. In the baseline scenario, higher risks associated with flooding can be observed within the retaining dams, as well as within and adjacent the natural drainage system of the existing complex. Under the climate change 1 % AEP scenario represented in Figure 17, flood depths and extents are marginally increased across the site.

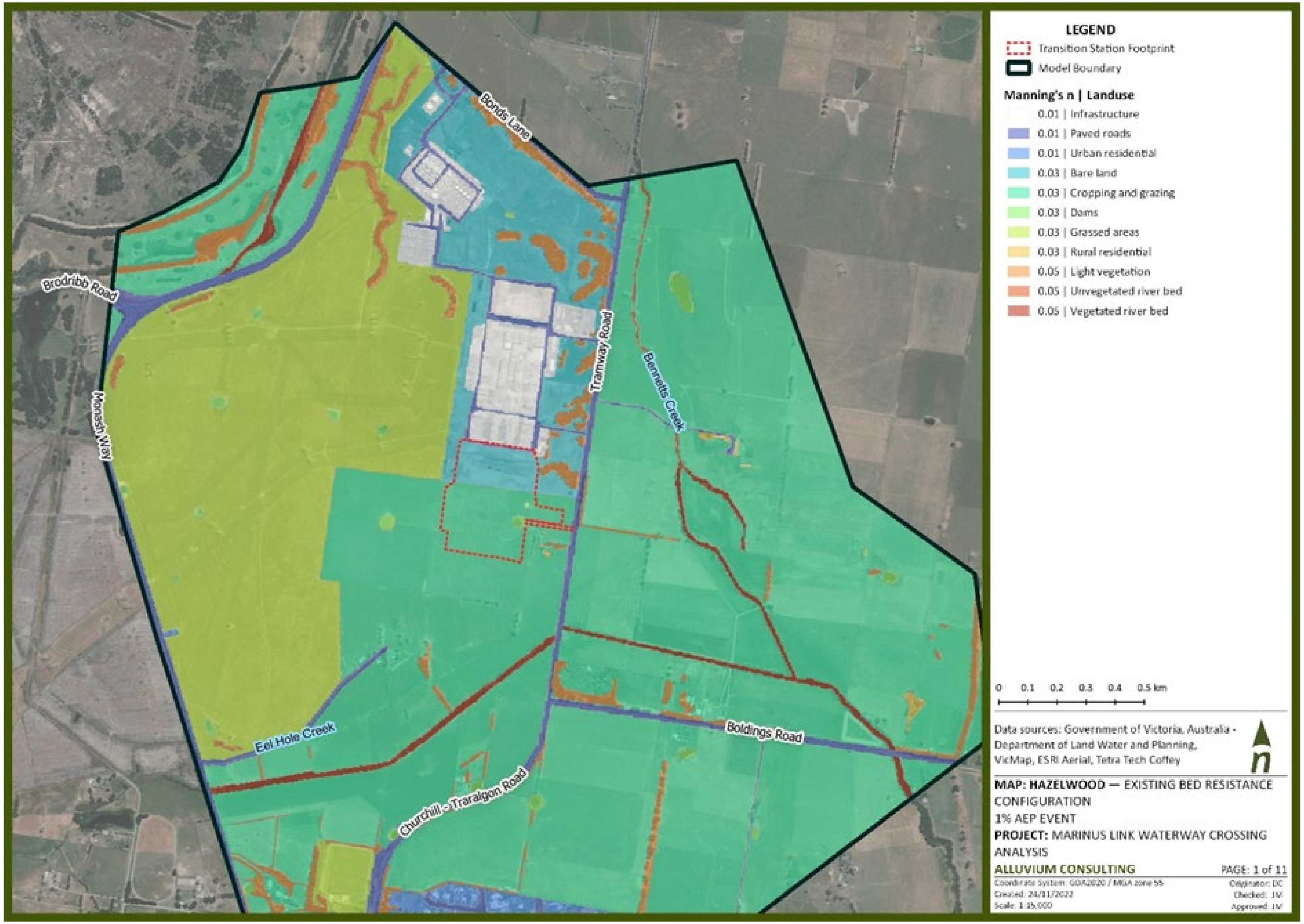

Figure 15. *Hazelwood baseline characterisation bed resistance configuration (Mannings' n)*

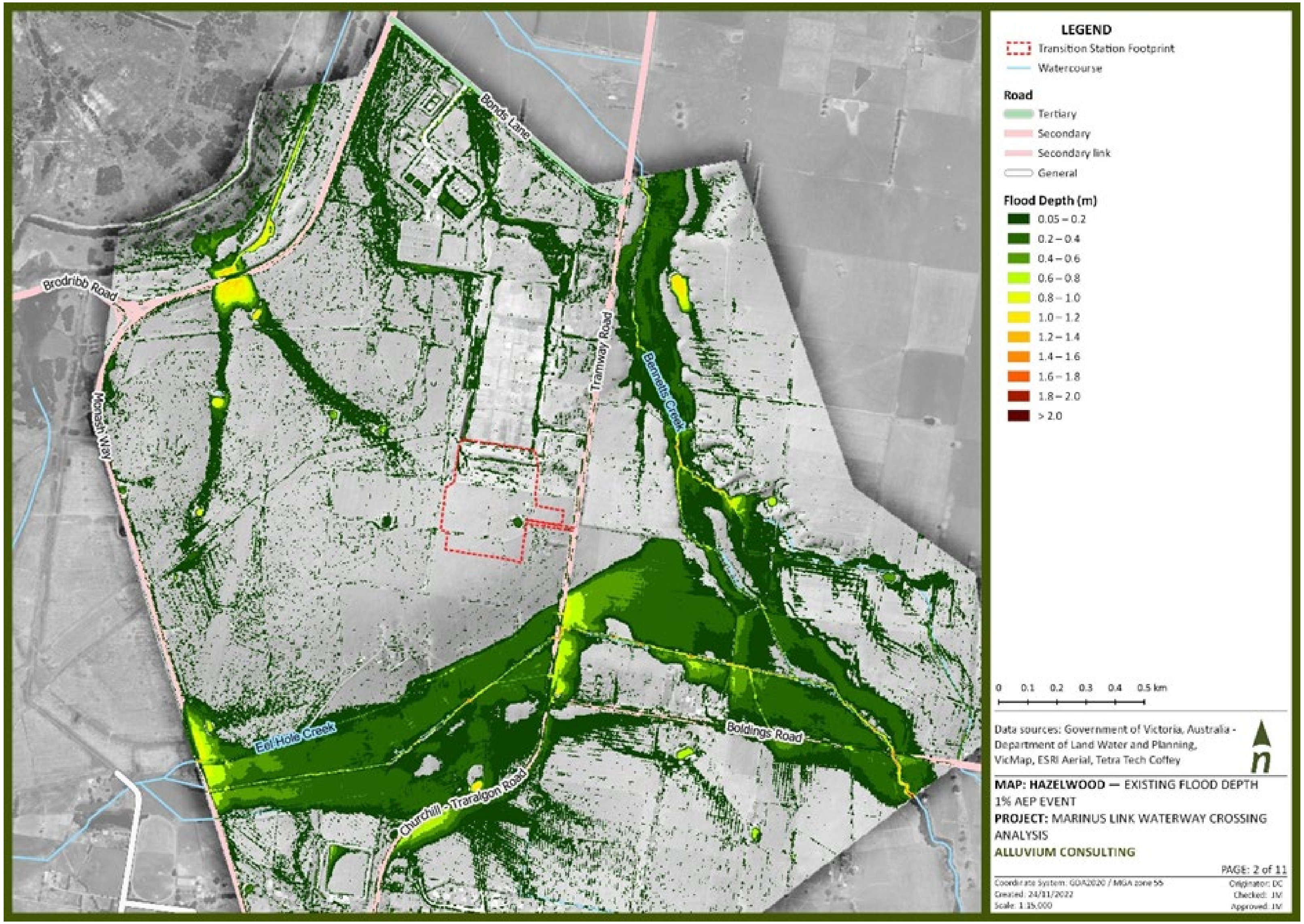

Figure 16. *Hazelwood baseline characterisation 1 % AEP flood depth*

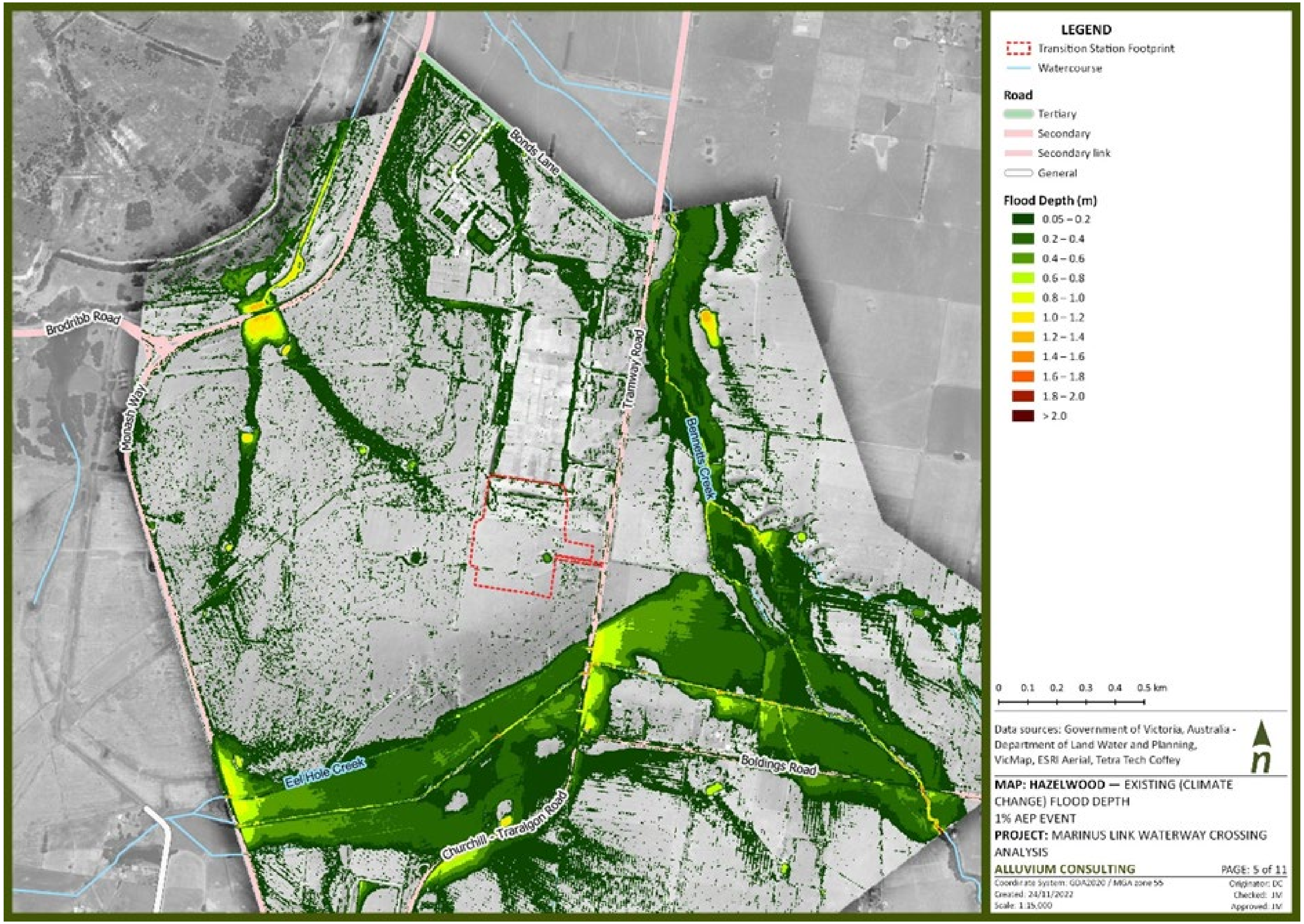

Figure 17. *Hazelwood baseline characterisation climate change 1 % AEP flood depth*

Driffield converter station

Flood mapping and subsequent assessment of the Driffield converter station has been developed from outputs of the detailed flood modelling in accordance with the methodology detailed in Section 4.3, with the roughness parameters selected for the baseline characterisation shown in Figure 18. The Driffield infrastructure footprint is sited on top of a hilly area, currently used for hardwood and softwood production. From aerial photography, the predominant vegetation is relatively dense with intermittent patches of harvested timber. The aerial also indicated that Fords Road is used by harvesting teams as an access road. The Strzelecki Highway separates two plantation lots and further fragments the sub catchment of interest by separating the left-hand side area proposed for the construction of the Driffield converter station and the rest of the sub catchment to the south of the highway.

In the baseline characterisation flood modelling the 1 % AEP event efficiently drains excess runoff downstream through natural drainage paths based on the existing sloping nature of the terrain (Figure 19). The natural waterway running from the south to the northwest to the north of the study area quickly accumulates runoff with depths of approximately 1 m observed, whereas shallower 0.2-0.3 m depths are recorded in the small drains leading to it. The development footprint itself is subject to runoff, draining both to the west, where it joins the drainage channel, and to the east directing it to the Strzelecki Highway.

The climate change 1 % AEP scenario shown in Figure 20 illustrates that an increase in depth across the development footprint is to be expected, along with scattered increases in depth, and extent to the remainder of the study area.

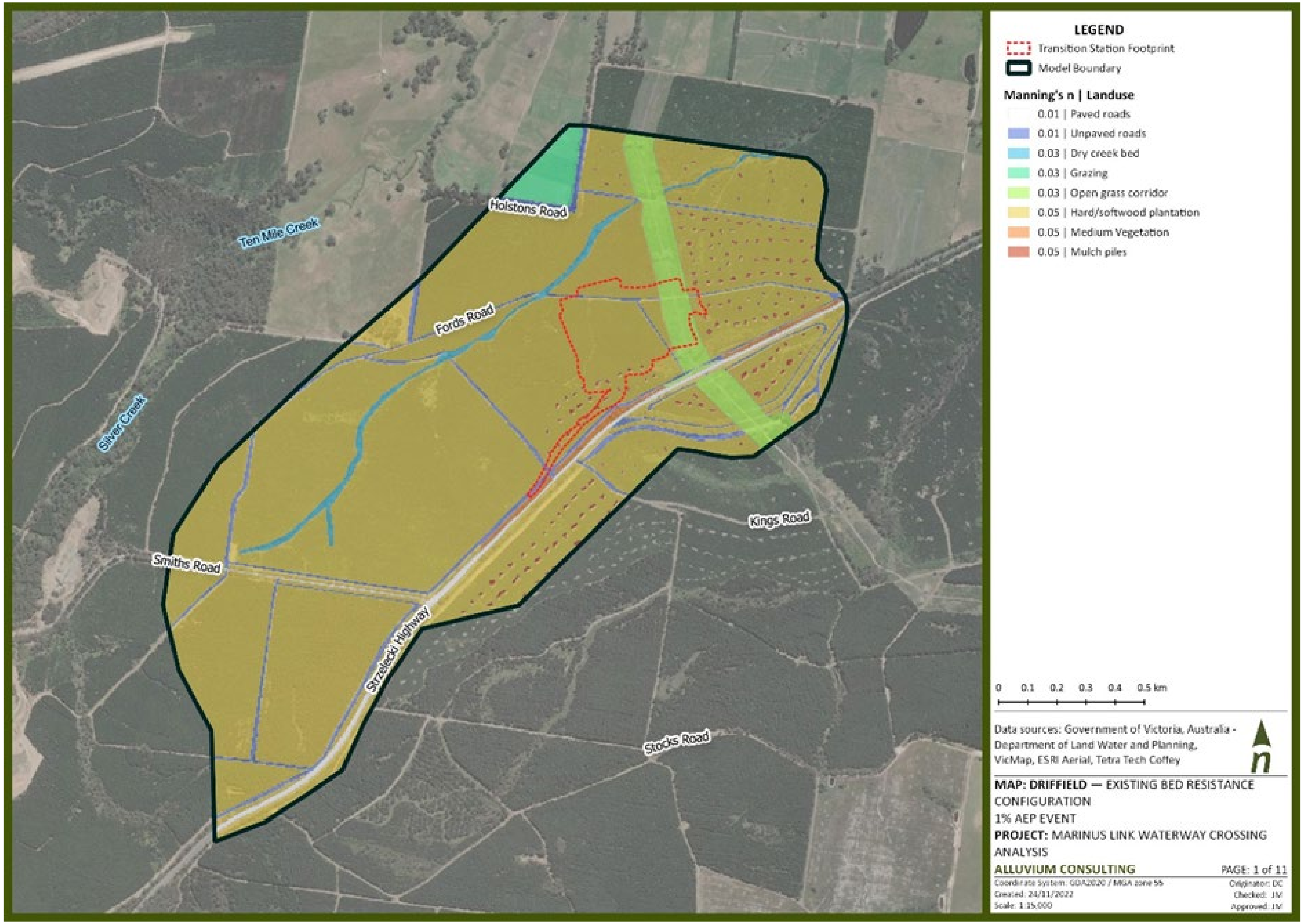

Figure 18. *Driffield baseline characterisation bed resistance configuration (Mannings' n)*

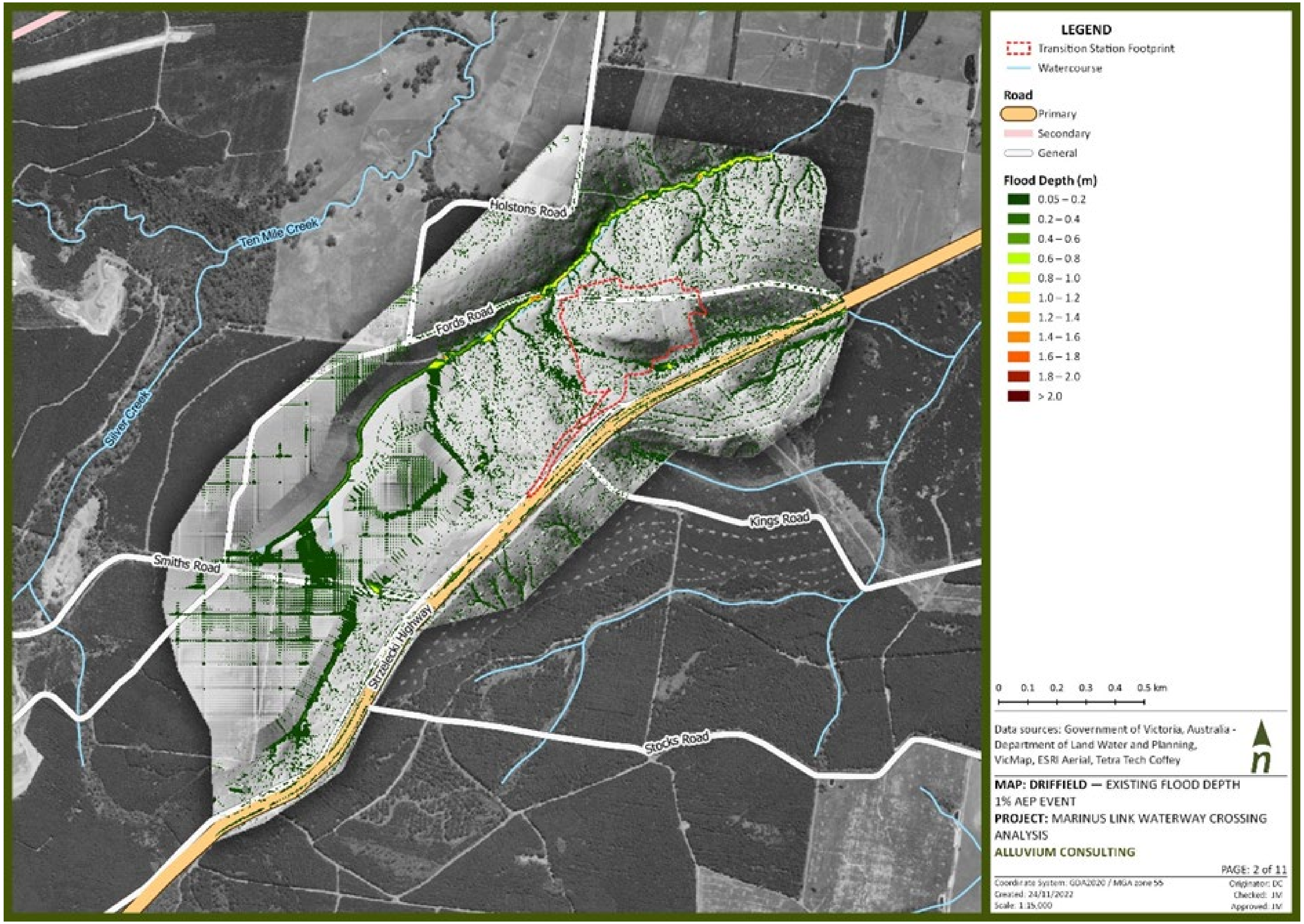

Figure 19. *Driffield baseline characterisation 1% AEP flood depth*

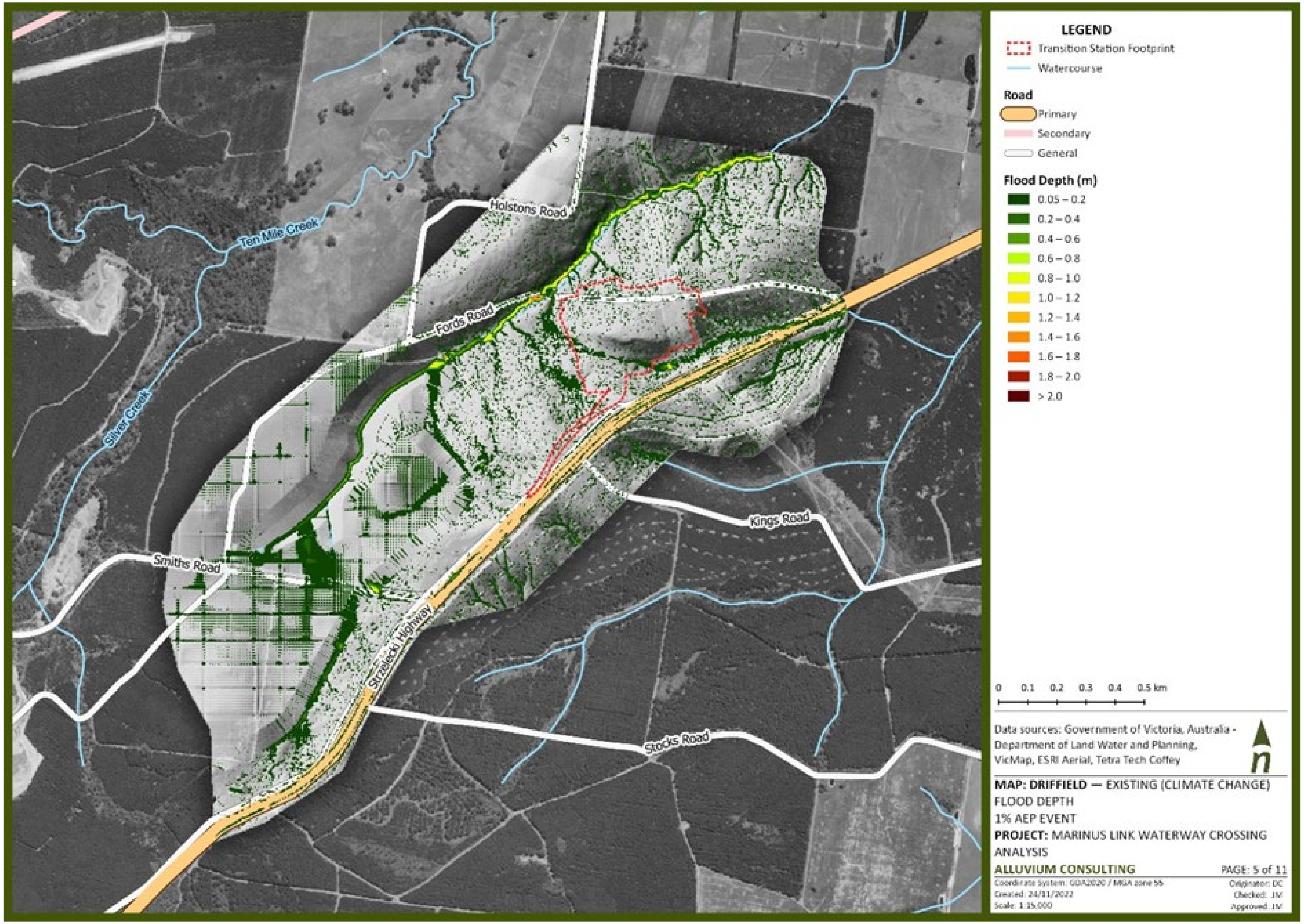

Figure 20. *Driffield baseline characterisation climate change 1% AEP flood depth*

Waratah Bay transition station

Flood mapping and subsequent assessment of the Waratah Bay transition station has been developed from outputs of the detailed flood modelling in accordance with the methodology detailed in Section 4.3. The proposed transition station at Waratah Bay is located approximately 850 m from the coastline and is situated just off the 90-degree bend of Waratah Road, 3.5 km northwest from the Sandy Point settlement.

Existing condition flood depth results for Waratah Bay indicate that under both the 0.5 % AEP (Figure 21) and climate change 0.5 % AEP event (Figure 22) the proposed converter station is located outside the main floodplain, however given the considerable flooding across the model, the site is impacted by overland flows. Flood depths within the footprint are relatively shallow in both cases, up to 0.6 m, and are largely influenced by overland flows from the north making their way to the main irrigation channel that runs west to east to the south of the subject site. The climate change scenario results in more inundation across the site, however this increase is relatively shallow (0.2-0.4 m). The climate change scenario indicates that more of the main floodplain in the irrigation channel to the south of the site is subject to inundation and increased depths, however these changes don't compound and influence depths across the subject area.

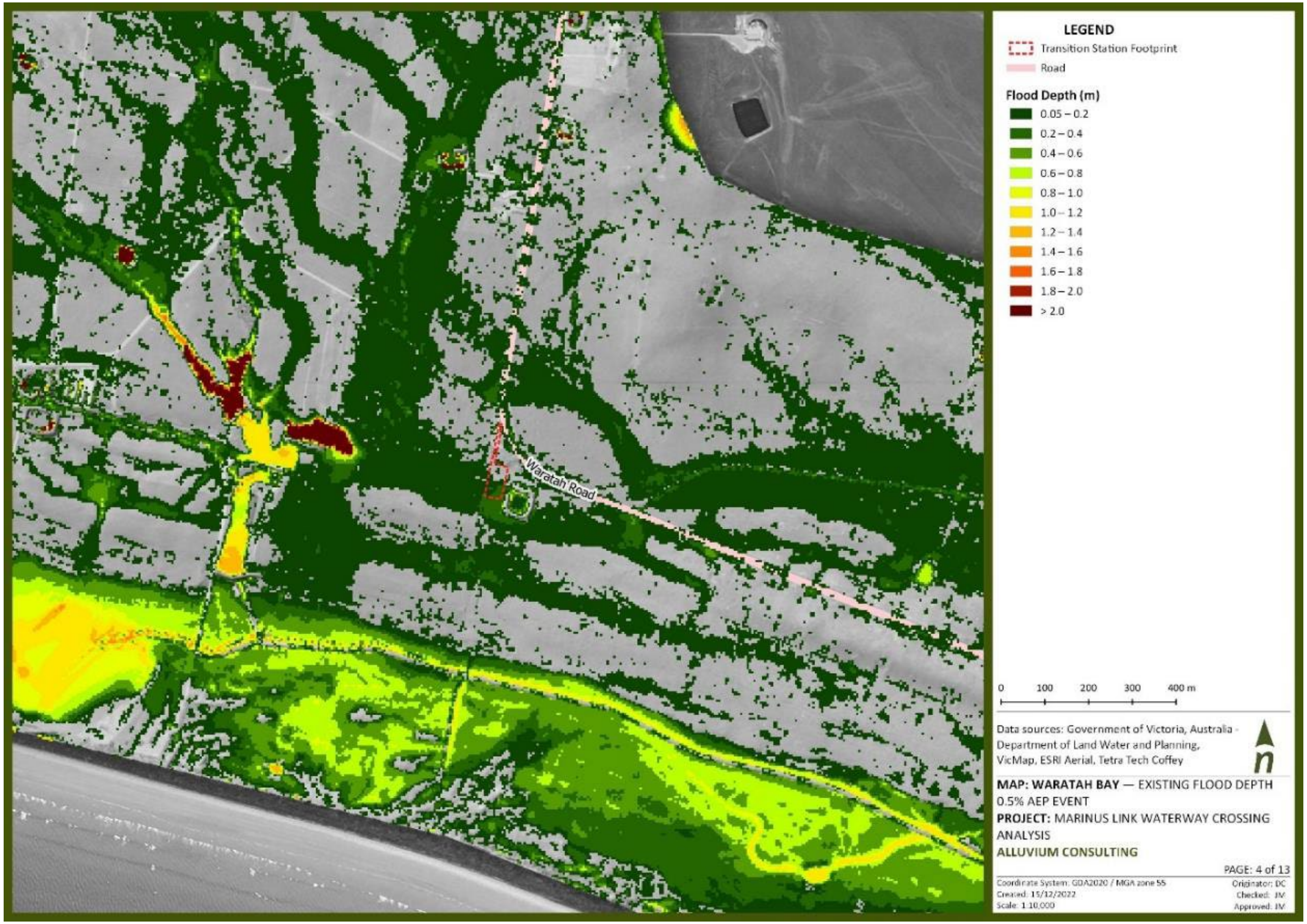

Figure 21. *Waratah Bay baseline characterisation 0.5 % AEP flood depth*

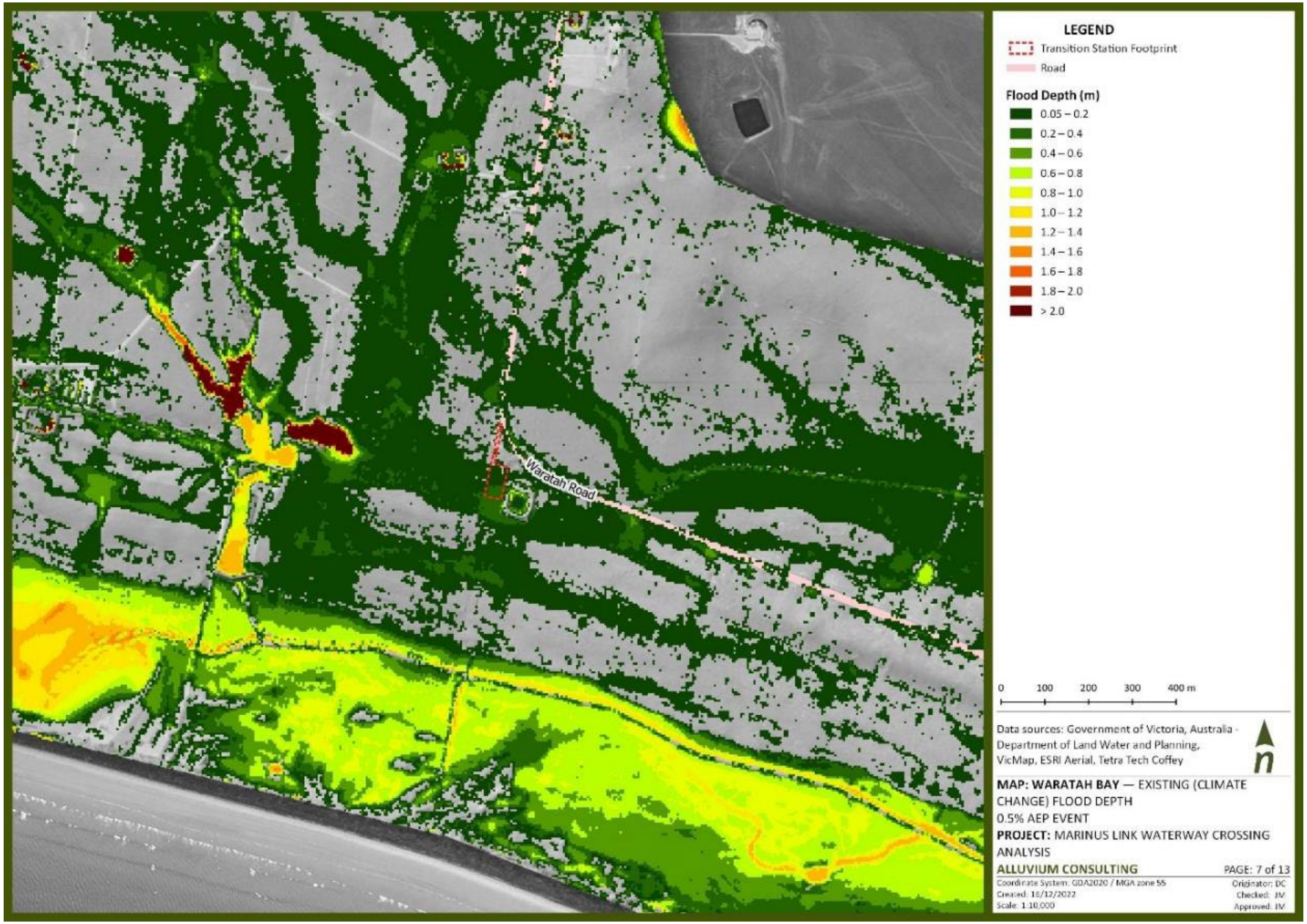

Figure 22. *Waratah Bay baseline characterisation climate change 0.5 % AEP flood depth*

5.3 Existing water quality conditions

Waterway crossings

Water quality varies naturally across landscapes, with climate, landform, soil type, vegetation and location within a stream system all influencing water quality at a location. These influences are reflected in Victoria's surface water segments presented in the ERS (2021)[1].

Each surface water segment has its own set of water quality objectives that reflect the effects of the natural environment. Although the surface water segments in Victoria are largely defined by these natural features, the water quality objectives within each segment also reflect the effects of land use changes within the segment. Accordingly, each of the segments are classified into a 'level of protection' either largely unmodified; slightly to moderately modified; or highly modified (Table 13).

Table 13. Segments and level of protection for each waterway crossing

Reach	ERS Segment	Level of protection
Morwell River	Central Foothills and Coastal Plains	Slightly to moderately modified
Little Morwell River	Central Foothills and Coastal Plains	Slightly to moderately modified
Tarwin River East Branch and tributaries	Uplands A	Largely unmodified
Stony Creek	Central Foothills and Coastal Plains	Slightly to moderately modified
Buffalo Creek	Central Foothills and Coastal Plains	Slightly to moderately modified
Fish Creek	Central Foothills and Coastal Plains	Slightly to moderately modified

Each surface water segment has its own set of water quality objectives within the environmental reference standard (Table 14).

Table 14. Indicators and objectives for rivers and streams in the Uplands A and Central Foothills and Coastal Plains segments.

Indicator	Parameter	Uplands A *Upper Thomson, Latrobe, South Gippsland, Bunyip and Yarra basins*	Central Foothills and Coastal Plains *Lowlands of Yarra, South Gippsland, Bunyip, Latrobe, Thomson, Mitchell, Tambo and Snowy basins*
Total phosphorus (µg/L)	75th percentile	≤35	≤55
Total nitrogen (µg/L)	75th percentile	≤900	≤1100
Dissolved oxygen (percent saturation)	25th percentile	≥80	≥75
	Maximum	130	130
Turbidity (NTU)	75th percentile	≤15	≤25
Electrical conductivity (µS/cm @25°C)	75th percentile	≤100	≤250
pH (pH units)	25th percentile	≥6.4	≥6.7
	75th percentile	≤7.6	≤7.7

There is a relatively long but intermittent record of surface water quality data in the study area. This is due to the monitoring sites being inactive or only have a few measurements recorded within the

[1] Environmental Reference Standard - http://www.gazette.vic.gov.au/gazette/Gazettes2021/GG2021S245.pdf

waterways (1994 to 2022). Available water quality monitoring exists at six stream gauges within two geographical areas along the project alignment, namely: upstream and downstream areas.

Upstream of proposed construction areas includes stream gauges located in waterways, north of the project alignment. The major waterway crossings in the upstream area with available monitoring data, include the Little Morwell River and the Morwell River. The downstream of proposed construction areas include waterways that flow within and downstream of the project alignment that generally drains towards the south coast at Waratah Bay. The major waterway crossings in the downstream area with available monitoring data, include Stony Creek, Fish Creek and the Tarwin River East Branch.

Only five of the waterway crossings incorporated in this study have available gauge data that includes water quality parameters. WaterWatch Victoria's data portal (http://www.vic.waterwatch.org.au/water_data_portal.php), provides data gathered from the WaterWatch community engagement program, however many of the sites are now inactive or only have a few measurements. Table 15 outlines available water quality statistics from gauges and WaterWatch data available (location shown in Figure 23).

No data was available for Buffalo Creek, the tributaries of the Tarwin River East Branch, and for any dissolved oxygen measurements. The Index of Stream Condition water quality index is also not available for any of the subject reaches due to data constraints. Given these constraints it is difficult to determine current water quality trends in the subject reaches and therefore only a qualitative assessment of changes in water quality can be given, based on previous experience of water quality impacts associated with projects of this nature.

Table 15. Water quality statistics for available stream gauges and WaterWatch sites against indicators specified in the Environmental Reference Standard (Table 14). Red shading indicates result does not meet the ERS. No data is available for the tributaries of the Tarwin River East Branch.

Indicator	Parameter	Morwell River		Little Morwell River	Tarwin River East Branch	Stony Creek		Fish Creek
Measurement site / source		*Gauge (226407)*	*Water-watch (MOR040)*	*Water-watch (LMR050)*	*Water-watch (TWN001)*	*Gauge (227275)*	*Water-watch (STN002)*	*Water-watch (FSC002)*
No. of visits/readings (dates of readings)		*(1999-2002)*	*163 (2008-2022)*	*1 (2005)*	*216 (1995-2009)*	*12-14 (2021-2022)*	*119 (1995-2002)*	*41 (1994-1995)*
Total P (µg/L)	75th percentile	No data	No data	No data	No data	340	0.2	No data
Total N (µg/L)	75th percentile	No data	No data	No data	No data	2500	No data	No data
Turbidity (NTU)	75th percentile	47.5	24	33*	No data	41.4	25	41
EC (µS/cm @25°C)	75th percentile	No data	320	270*	580	679.5	777.5	492#
pH (pH units)	25th percentile	No data	6.6	6.5*	7.3	6.5	7.1	7.6#
	75th percentile	No data	7.1		7.7	7.1	7.4	

*Only one reading available in 2005
#Only one reading available in 2002
Red shading indicates result does not meet the ERS.

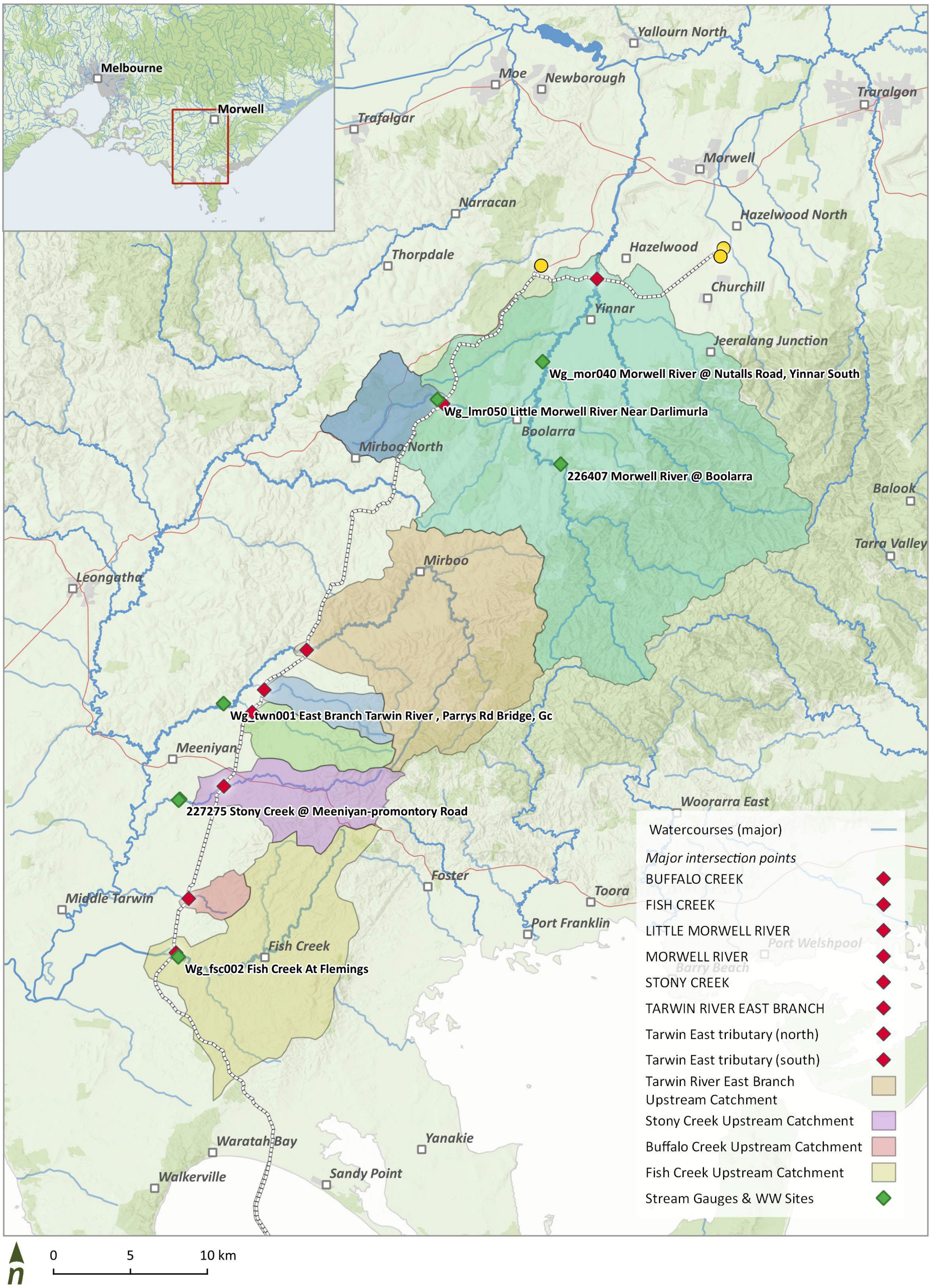

Figure 23. *Stream Gauge and WaterWatch Sites*

Converter and transition stations

This study has not included water quality analyses for any of the converter and transition stations due to the absence of existing water quality data.

Contaminated land and acid sulfate soils

The Contaminated Land and Acid Sulfate Soils report (Tetra Tech Coffey, 2023) identifies a range of existing potential contaminating activities and site history that could influence surface water quality. These include:

- Acid sulfate soils – generally low to extremely low probability that acid sulfate soils exist, except at:
  - the Waratah Bay Beach area
  - Hazelwood pondage (where the project alignment crosses Eel Hole Creek
  - Soils that are permanently waterlogged (e.g. sediments in streams, floodplains around river systems, wetlands or areas with shallow groundwater)
- Industrial activities associated with Hazelwood mine site and power station
- Former railway line
- Hazelwood landfill
- Per- and poly- fluoroalkyl substances (PFAS) – potential sources include:
  - Hazelwood pondage
  - Landfill sites such as Hazelwood Landfill
  - Isolated areas around CFA stations and at the site of vehicles accidents on roadways.
  - Hazelwood and Morwell power stations and mine sites, including the Hazelwood Mine fire area.
- Petrol station at 1 Nerrena Road, Dumbalk (400 m away from project alignment)
- Agricultural and development activities, including:
  - Dairy and cattle farming
  - Stockpiling of industrial or agricultural materials
  - Other soil disturbance or earthworks
  - Land use change or changed farming intensity
  - Logging and forestry operations
  - Construction of residences, farming infrastructure or other buildings
  - Cropping, potential application of pesticides, fertilisers, etc.
  - Other agriculture, e.g. poultry

5.4 Existing geomorphic conditions

Waterway crossings

Fluvial geomorphology describes the size, shape and diversity of the river channel and the processes by which these elements of the stream system form and change through time. The geomorphology (or physical form) of a river can be described at a range of spatial scales, from the catchment to the microhabitat scale (Sear, 1996), which can each correlate with habitat types (Frissel, et al., 1986). A diversity of habitat types provides the physical basis for a diversity of biota (Treadwell, et al., 2006; Newson, 2002), and consequently is an important factor in providing a healthy river.

Factors included in physical form characteristics include the bed and bank material and shape, sediment supply and presence of erosional and depositional environments, large woody debris, riparian vegetation and instream obstructions that could reduce fish passage. The Index of Stream Condition (ISC) includes a physical form sub-index which includes consideration of instream barriers

(barriers to instream fish/other faunal movement), instream large wood and bank condition. These ratings are available for Morwell River, Tarwin River East Branch and Fish Creek (Table 16).

These sub-indices show that overall physical form in these rivers is good but does not consider other factors such as instream habitat features (pools and riffles). While a good indicator of overall stream health, the ISC physical form sub-index has not been completed for all major waterway crossings that have been assessed for the project. Therefore, only a qualitative assessment of changes to physical form can be given, based on available data, field assessment and experience with similar waterways.

Table 16. Index of Stream Condition (ISC) physical form sub-index scores as described in (Department of Environment and Primary Industries (DEPI), 2014)

Waterway	ISC reach ID	ISC physical form sub-index scores			*Total ISC score for Physical Form (max. 10)*
		Instream barriers	*Instream Large Wood*	*Bank Condition*	
Morwell River	26_19	3	5	3	7
Tarwin River East Branch	27_15	5	4	5	9
Fish Creek	27_13	5	3	4	8

In addition to formal assessments, geomorphic and habitat value was assessed through other desktop information, reports, literature, LiDAR and field assessments. Table 17 describes geomorphic features and values of the waterway crossings. Further detail on the catchment setting, soils, land use, topography, stability and site inspections for waterway crossings in available in Attachment 3.

Table 17. Waterway crossing geomorphic descriptions and values

Waterway	Channel description	Bed and bank stability	Riparian and bank vegetation	In-channel habitat features	Floodplain features	Associated processes and stability	Site photo
	Cross section, sinuosity, confinement	*Evidence of lateral or vertical erosion and/or accretion*	*Over-, mid- and under-storey vegetation cover*	*Pools, riffles, benches, bars, large wood, etc.*	*Floodplain habitat features, wetlands, other drainage and flow pathways*	*Vertical and lateral stability*	
Morwell River	Deep, unconfined, high sinuosity meandering channel with steep levee banks	Lateral (bank) erosion evident, with undercut tree collapses	Very sparse vegetation, only grasses with scattered shrubs and trees	Large wood evident due to tree collapse, some deep pools	Cut-offs and billabongs evident, landholder drainage channels	Long term gradual lengthening of meanders is expected, that will increase sinuosity (meander migration), however process is gradual over many decades to 100's of years.	
Little Morwell River	Partially confined to confined, moderate sinuosity channel	No evidence of major erosion, sandy bed with basalt outcrops likely limit erosion	Dense to moderately dense vegetation with some discontinuity, narrow riparian buffer	Uncertain, basalt outcrops and thought to have good pools, riffles and large wood habitat features	Small floodplain pockets	Laterally active across limited floodplain extent, floodplain is discontinuous as the channel occasionally abuts the valley margin.	Site not accessible
Tarwin River East Branch	Partially confined (right bank confined), moderate sinuosity channel	No evidence of major erosion	Moderate cover on right bank (narrow riparian buffer), sparse on left bank, with some ground cover	Some bars, pools and instream wood present, limited.	Limited connectivity on right bank, some drainage lines.		
Tributaries of Tarwin River East Branch	Partially confined upstream, moving to unconfined meandering channel, perched.	No evidence of major erosion	Some riparian vegetation cover, with some discontinuity and sparse covers in areas	Uncertain	Connectivity across the floodplain		Site not accessible
Stony Creek	Partially confined (right bank confined), moderate sinuosity channel	Only minor bank erosion evident	Good cover along banks, narrow riparian buffer	Pools, riffles, large wood present	Limited connectivity on right bank, some drainage to south west.		
Buffalo Creek	Partially confined to confined (upstream), moderate sinuosity channel with shallow levee banks, unconfined downstream	No evidence of major erosion	Good cover along banks, narrow riparian buffer in places	Large wood and pools evident	Catchment dams and drainage lines	Laterally active across limited floodplain extent, floodplain is discontinuous as the channel occasionally abuts the valley margin or is limited by levees.	
Fish Creek	Transition from partially confined low sinuosity channel to unconfined straightened channel	Evidence of major incision (deepening and widening), bed and bank erosion.	Narrow, sporadic vegetation cover, exotic species (e.g., willow)	Uncertain, potentially poor habitat value	Connectivity with northern flow pathway, overland flow	Limited by confinement upstream, prone to / undergoing phases of incision after landscape disturbance.	Site not accessible

Converter and transition stations

Streams and waterways adjust dynamically over time in response to the temporal sequence of sediment and water flows delivered from the upstream catchment (Bledsoe, 2002). Erosion occurs when the shear stress associated with water movement is greater than the shear resistance of the bed and bank materials. In general, disturbance in the mobilisation of sediments can often result in waterway instability and erosion and is typically assessed and represented through shear stress assessments and modelling.

Shear stress is calculated as the multiple of the unit weight of water, hydraulic radius and friction slope. These values are described in further detail in *Technical Guidelines for Waterway Management* (Department of Sustainability and Environment (DSE), 2007). Typical values for various channel boundary materials have been selected to provide a representation of the shear stress required to initiate erosion in Table 18.

Table 18. Maximum shear stress for various channel boundary materials (Fischenich, 2001).

Parameter	Shear stress (N/m^2)
Sand	1.44
Gravel	3.59
Grass	4.55
Clay	12.45
Cobble	32.08
Wattle	47.88
Long native grasses	81.40
Gravels (D50 = 150 mm)	95.76
Structurally diverse hardwood and understory planting	150.00
Rock (D50 = 300 mm)	244.19
Concrete	598.50

Existing geomorphic conditions and relative erosion potential at the converter and transition stations have been established through hydraulic modelling, with the methodology described in Section 4.3. Hydraulic modelling was used to establish typical shear stress values across the sites.

Hazelwood

The shear stress analysis for the 1 % AEP (Figure 24) and the 1 % AEP climate change (Figure 25) events indicate that the areas of higher shear stress are concentrated at the bifurcation of Bennetts Creek and Eel Hole Creek. Given the existing land use of the area, the bed material is predominately concrete and other electrical infrastructure to the north of the development footprint, erosion is not expected under the current or climate change scenarios as the values through these areas does not typically exceed 80 N/m^2. From aerial imagery, the surrounding area appears to be grassland or grazing, which from Table 18, has a shear resistance value of 4.55 N/m^2. Under the current and climate change scenarios, it is expected that erosion to the west of the development footprint are expected to have shear stress values at least 10-20 N/m^2 in the drainage channels, with areas of 20-40 N/m^2 and isolated patches up to 80 N/m^2.

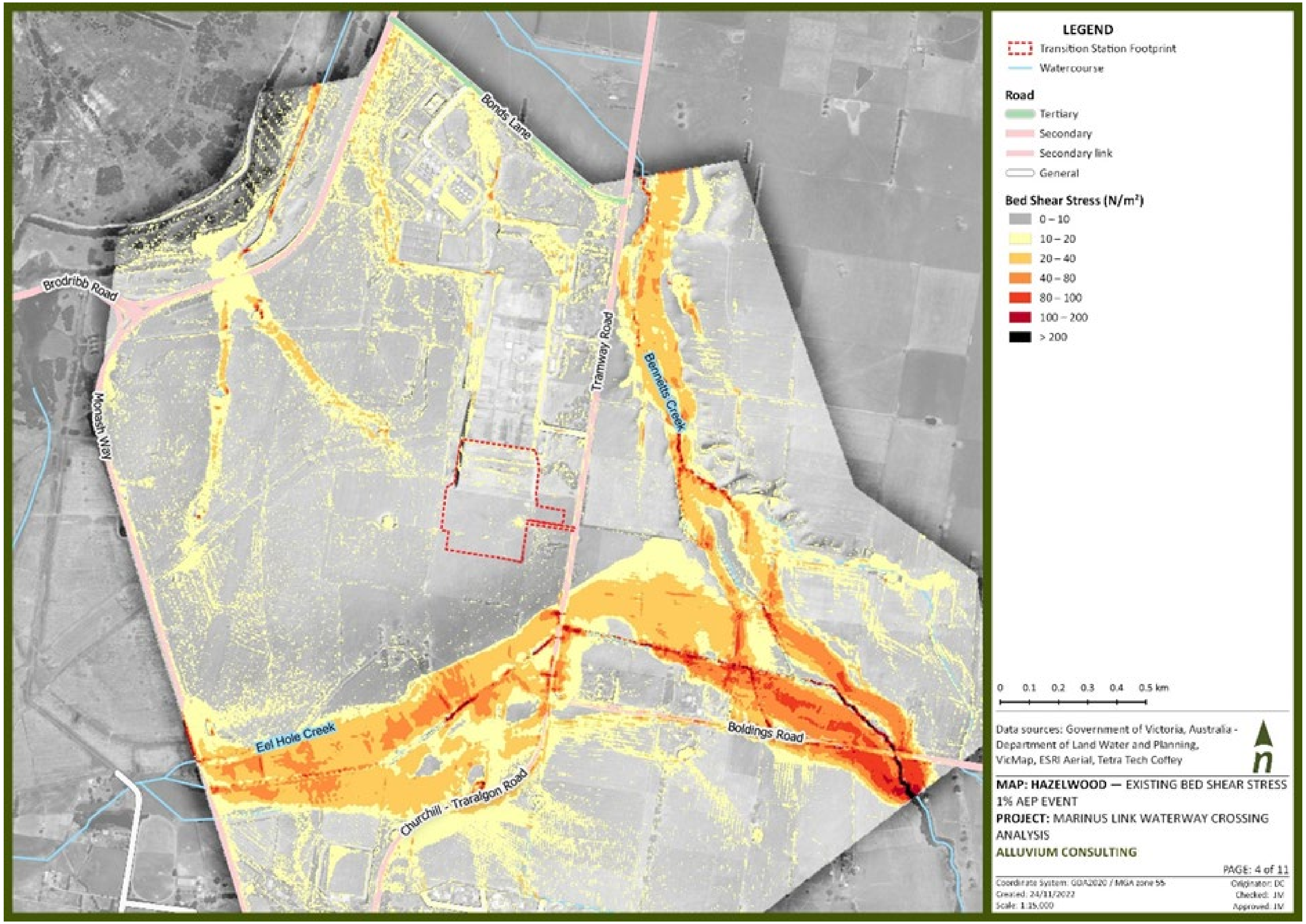

Figure 24. *Hazelwood baseline characterisation bed shear stress for 1 % AEP*

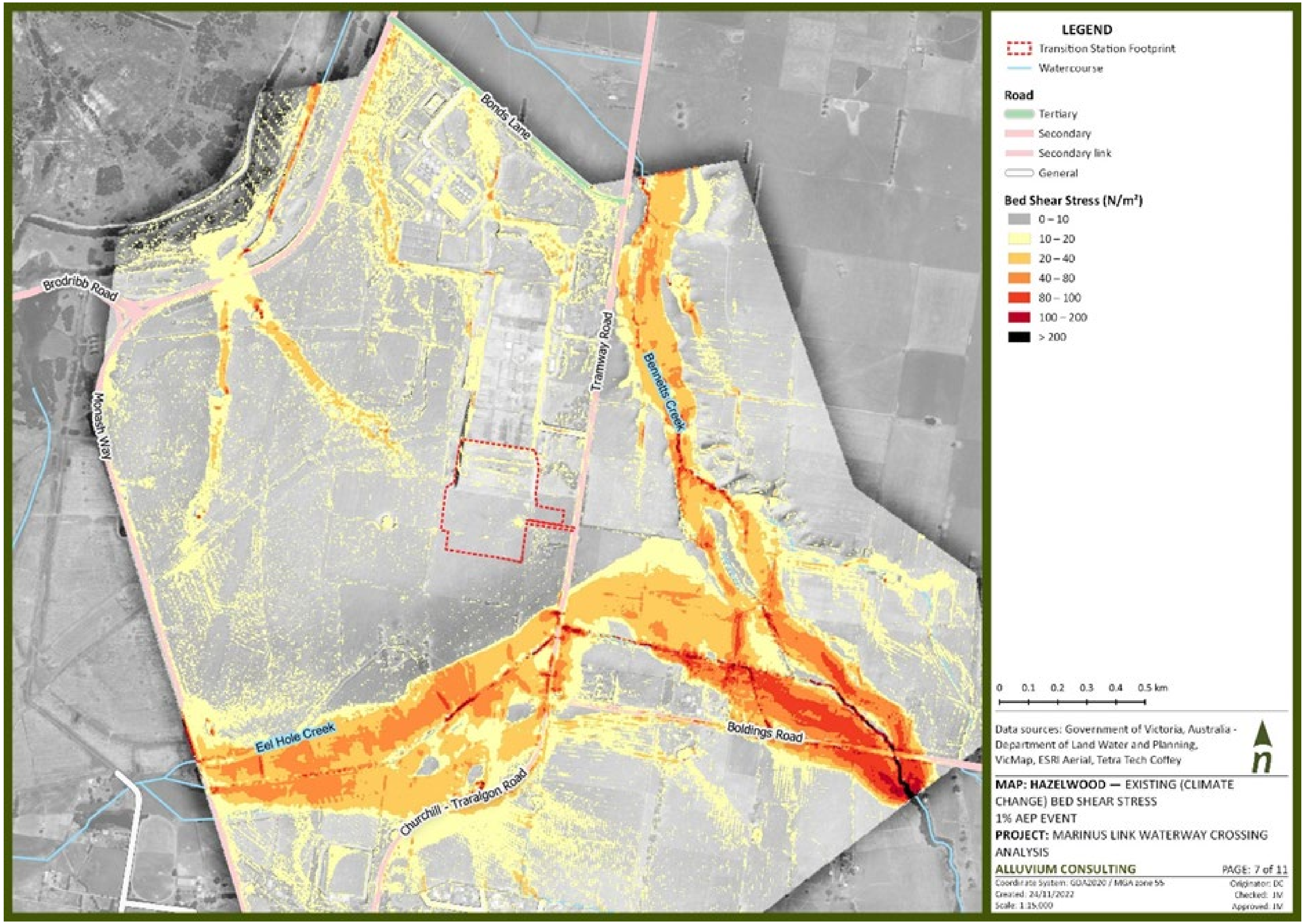

Figure 25. *Hazelwood baseline characterisation bed shear stress for climate change 1 % AEP*

Driffield

At Driffield, the direct rainfall model for both the 1 % AEP (Figure 26) and the 1 % AEP climate change scenario (Figure 27) indicate that shear stress is typically restricted to the natural drainage channels across the site. The development footprint, in the existing 1% AEP event, is subjected to shear stress of up to 80 N/m^2, while this increases to 80-100 N/m^2 under the climate change scenario (Figure 27). Aerial imagery indicates that most of the surrounding area is hardwood or softwood plantations. From Table 18, hardwood is likely to have a shear stress threshold below the 150 N/m^2 identified given the understorey will be devoid of vegetation. Without detailed field surveys to identify the predominate understorey, it is likely that channel erosion under the existing or predeveloped climate change scenarios would be expected.

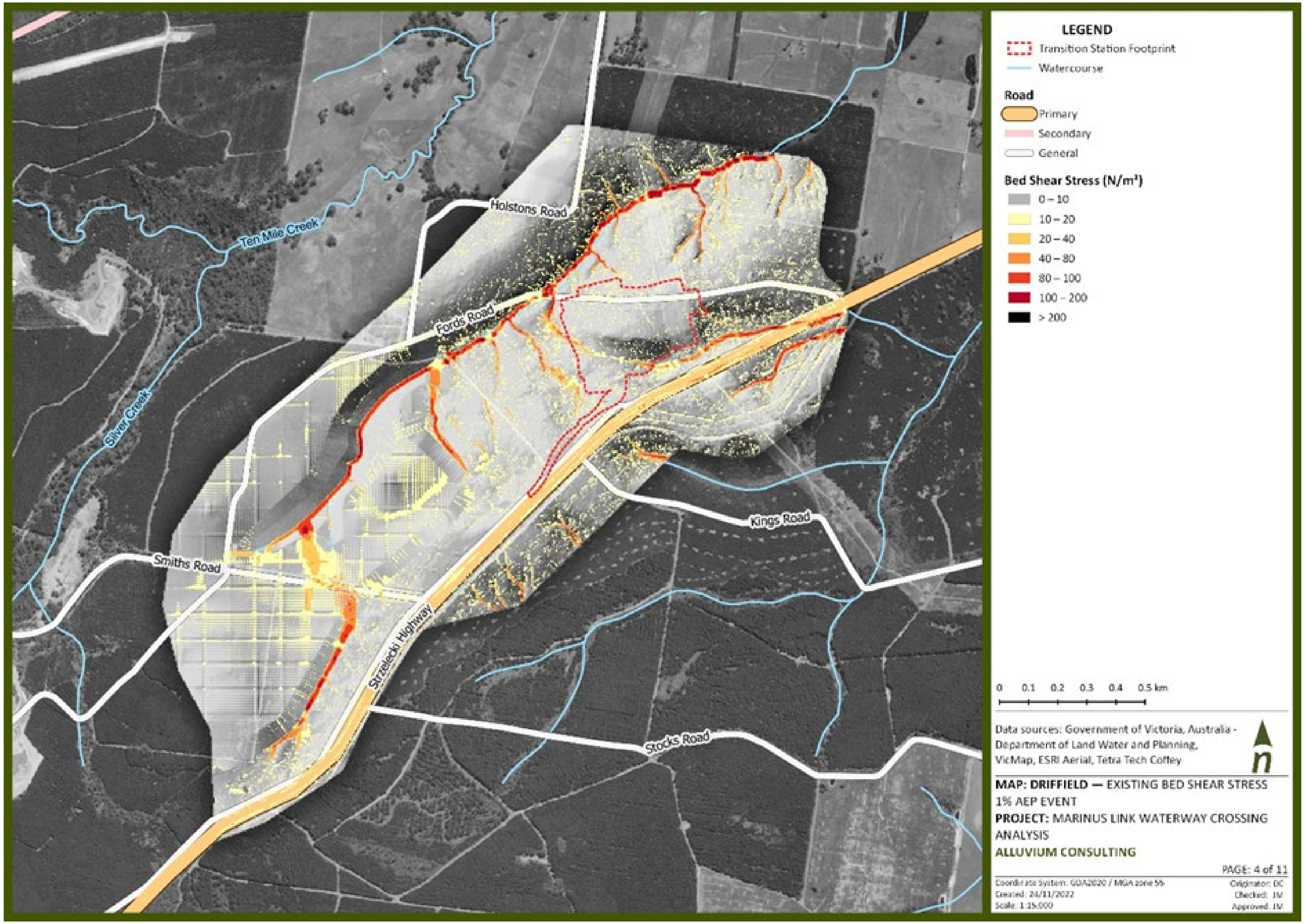

Figure 26. *Driffield baseline characterisation bed shear stress for 1 % AEP*

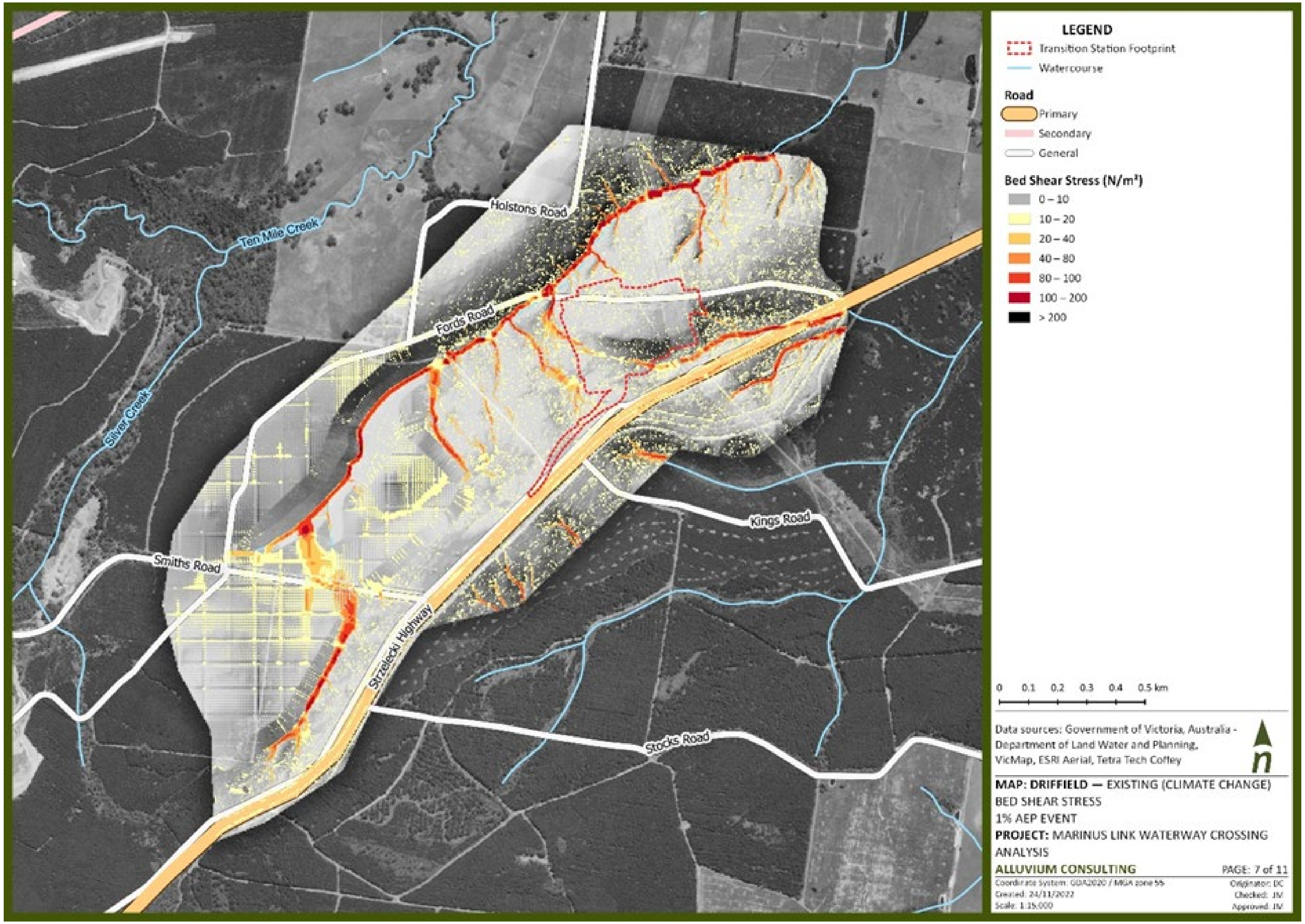

Figure 27. *Driffield baseline characterisation bed shear stress for climate change 1 % AEP*

Waratah Bay

Figure 28 highlights existing shear stress conditions for a 0.5 % AEP event at the site are in the order of 10-20 N/m^2, indicating relatively slow-moving surface water. Shear stress conditions under a changed climate shown in Figure 29 show very similar results, with a very slight increase in shear stress throughout the model extent. Land use for these regions is typically grazing, or grass, which from Table 18 has a shear stress threshold of 4.55 N/m^2. This indicates that some level of erosion in the 0.5 % AEP will be expected across the site, depending on the ground cover at the time. The results indicate that this erosion will likely be minor, although widespread in the region given the extent of surface water flows. In the defined channel to the west of the subject site, shear stress for both existing and climate change scenarios is typically 80-100 N/m^2, however there were peaks at over 200 N/m^2.

The channel was noted to be vegetated from aerial imagery analysis, with native long grasses likely and wattles the likely channel boundary materials. From Table 18, this results in a shear stress threshold of between 47 and 81.4 N/m^2. From this it is likely that the shear resistance of the channel boundary will be exceeded under the 0.5 % % AEP and the climate change 0.5 % % AEP scenarios, leading to some erosion at the channel boundary. In areas of higher shear stress, such as above 100 N/m2, comparatively high erosion will be expected, however this is outside the project extents (refer to Figure 29).

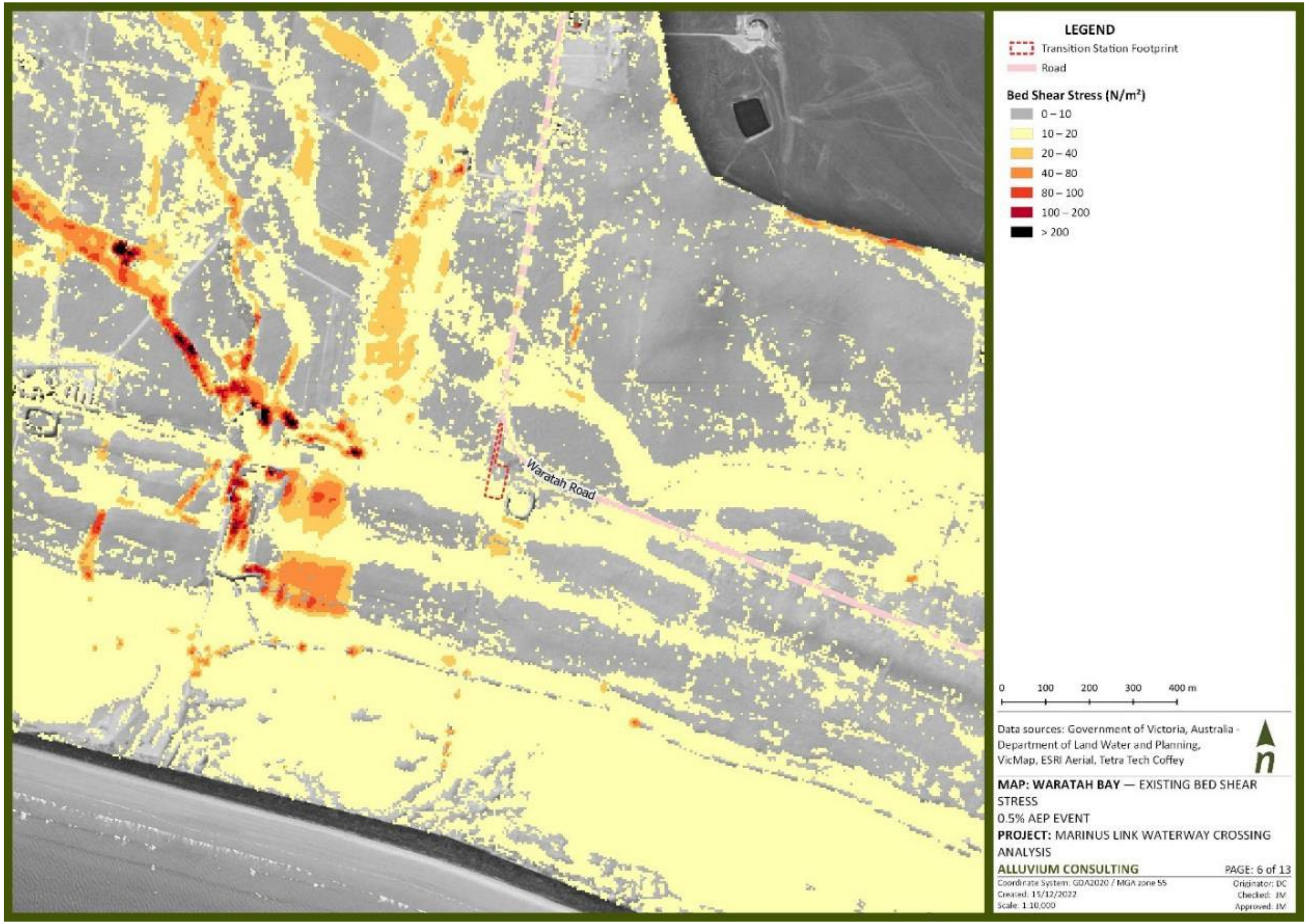

Figure 28. *Waratah Bay baseline characterisation 0.5 % AEP shear stress*

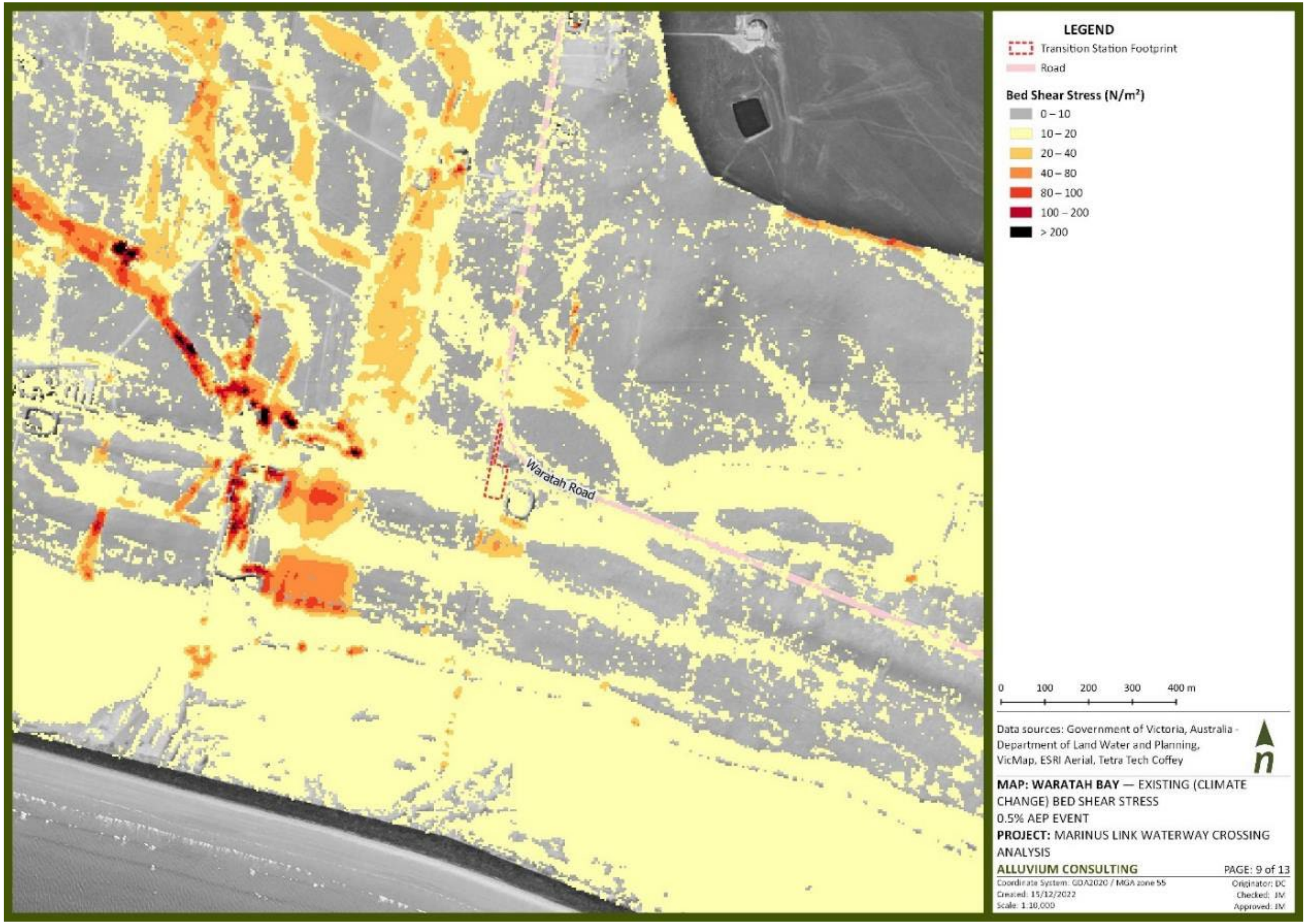

Figure 29. *Waratah Bay baseline characterisation climate change 0.5 % AEP shear stress*

6 Impact assessment

The following sections present the surface water impact assessment for the project.

6.1 Key issues on environmental values

Key issues relevant to project impacts on surface water have been identified through an assessment of the effects on surface water as a result of construction and operation activities of the project. In relation to the EES scoping requirements these key issues have considered the potential for adverse effects on the following environmental values:

- Freshwater ecosystems
- The functions and environmental values of surface water environments, such as interception or diversion of flows or changed water quality or flow regimes
- Nearby and downstream water environment due to changes in flow regimes, floodplain storage, run-off rates, water quality changes, or other waterway conditions, including in the context of climate change projections

Sections 6.2, 6.3 and 6.4 provides an assessment of the key potential impacts on surface water in regards to flooding, water quality and geomorphology as a result of construction and operational activities of the project.

6.2 Flooding impacts

This section identifies the potential flooding impacts of the project on the major waterway crossings during construction and operation phases on identified surface water environmental values.

Waterway crossings

Floodplains temporarily store floodwaters and allow for the passage of flood peaks downstream. The conveyance and storage functions of floodplains and flow paths interact to control the timing, duration and level of flooding at a site (Department of Environment, Land, Water and Planning, 2019). Development in flood affected areas can affect flow conveyance and flood storage. This causes flood levels and flow velocities to increase and may divert floodwater onto other land. Works within the floodplain can alter flood behaviour by:

- Diverting flows to areas of land not previously subject to flooding.
- Constricting the passage of flows passing through the site along the river channel or flow path. This causes flood levels and flow velocities to rise at and upstream of the site.
- Reducing the volume of temporary storage within the floodplain. This results in a more rapid passage of floodwaters and an increase in peak flow in downstream reaches. Increasing the flow increases flood levels and flow velocities

Of the 82 waterways along the project alignment, HDD is initially proposed to be used to cross 15 waterways including seven of the eight of the major waterway crossings. Little Morwell River is the only major waterway that will not be crossed with HDD. The Little Morwell River is not proposed to be crossed using HDD but rather will be trenched. Open trench construction through waterways has also been assessed as an alternative to HDD.

The proposed trenching method at the Little Morwell River, and other waterways where HDD is not adopted, is based on the current land use within the river crossing, which is mainly cattle crossing, the absence of riparian vegetation and the lack of evidence of erosion. Furthermore, it is found that there limited spacing available for the HDD drill pads and bore length under the river crossing will be constrained.

In contrast, HDD will be employed for crossing the Grand Ridge rail trail and the hill on the north side of the river crossing. The drill pads for these crossings will be situated above the floodplain, which is relatively narrow at the river crossing location. As such, the impact assessment indicates that the initial flooding risks associated with open cut trench construction at the Little Morwell River crossing are higher prior to the implementation of mitigation measures.

Assessment of impacts on flooding has considered the location of project construction or operation assets and areas of disturbance within the 1 % AEP flood extent. Table 19 provides an overview of proposed project assets or construction areas currently located within the 1 % AEP flood extent for each waterway crossing, and their area of disturbance (AoD). Mapping of these assets for each waterway crossing is provided below.

Table 19. Overview of proposed assets or construction areas within 1% AEP flood extent

Waterway	Total area of disturbance within flood extent (m^2)	Proposed assets or construction areas within/close to flood extent	IDs	Comments/aspect
Morwell River (KP 78.05)	4,790 (refer to Figure 30)	McFarlane Rd access track	AT153	Upgrading existing track and permanent/temporary new track.
		Morwell River flood runner TCM AOD	TCM053	
Little Morwell River* (KP 61.55)	10,624 (refer to Figure 31)	Steep slope above Little Morwell River and Grand Ridge Rail Trail and Pleasant Valley Road TCM AODs	TCM046, TCM045	TCM AOD for steep slope and road crossing, not waterway crossing.
		Pleasant Valley Road access tracks	AT127, AT128	Open trench construction and access track upgrade through waterway. Culvert design details uncertain.
		Open trench construction	n/a	
Tarwin River East Branch (KP 40.65)	8,461 (refer to Figure 33)	Meeniyan – Mirboo North Rd access track	AT076, AT077	Upgrade of existing and new permanent/temporary tracks.
		Tarwin River East Branch TCM AOD	TCM029A	
		Joint pit around 20 m away from 1% AEP flood extent	JP37A	Joint pit may be within extent, depending on size/orientation and construction area required.
		Areas of open trench construction		Areas of open trench construction within flood extent
Tributaries of Tarwin River East Branch	Total: 68,613 (refer to Figure 34) North: 38,887 (KP 36.6) South: 29,726 (KP 34.9)	Meeniyan – Mirboo North Rd access tracks and other access tracks	AT068, AT066, AT065, AT064, AT060, AT059, AT058	Upgrade of existing and new permanent/temporary tracks.
		Meeniyan – Mirboo North Road, unnamed waterway and farm infrastructure, and shelter belt and farm infrastructure TCM AODs	TCM070 (x2), TCM069 (x2), TCM027A (x2), TCM026 (x2).	
		Joint pits	JP34A, JP33A, JP32A	Joint pit may be within extent, depending on size/orientation and construction area required.
		Area of open trench construction		Areas of open trench construction within flood extent
Stony Creek (KP 29.4)	33,904 (refer to Figure 35)	Buffalo-Stony Creek Rd and O'Connor Rd access tracks	AT043, AT044, AT045, AT046, AT047	Mix of existing track upgrade and new permanent/temporary tracks.
		Great Southern Rail Trail, Stony Creek and Buffalo-Stony Creek Rd TCM AODs	TCM021, TCM022A, TCM067	
		Joint pits within 50m of flood extent	JP26, JP27A	Joint pits may be within extent, depending on size/orientation and construction area required.
		Areas of open trench construction		Areas of open trench construction within flood extent.
Buffalo Creek* (KP 21.5)	2,523 (refer to Figure 36)	Meeniyan – Promontory Rd and Moores Rd access track	AT034, AT035, AT036	Access track and TCM AOD within floodplain vicinity.
		Buffalo Creek TCM AOD	TCM018 (x2)	Two drill pads for Buffalo Creek TCM
		Joint pit	JP20	
		Areas of open trench construction		Areas of open trench construction within flood extent.
Fish Creek	4,649	Harding Lawson Rd access track	AT028	New temporary track.

Waterway	Total area of disturbance within flood extent (m²)	Proposed assets or construction areas within/close to flood extent	IDs	Comments/aspect
(KP 17.7)	(refer to Figure 38)	Fish Creek TCM AOD	TCM016A	
		Small area of open trench construction		Small area of open trench construction within flood extent

*Note: flood extents for Little Morwell River and Buffalo Creek are interpreted from valley topography, slope, and vegetation types over multiple aerial images and are not the mapped 1% AEP flood extents provided by WGCMA.

Morwell River

Figure 30 shows the 1 % AEP flood extent for the Morwell River at the intersection of the proposed project alignment. This shows that access tracks and HDD trenchless (or potentially trenched) construction method areas of disturbance (drill pads) are located within the 1% AEP flood extent at this crossing. A joint pit is also located around 160 m east of the 1% AEP flood extent. The total area of disturbance within the 1 % AEP flood extent is 4,790 m^2.

As it is anticipated that drill pads and any trenches associated with construction will be reinstated to match the existing condition and surface levels post construction – no impact on the 1 % AEP flood behaviour (extent, levels and storage) is anticipated.

Should a major flood occur during construction, construction areas of disturbance could be inundated with changes to flood behaviour, liberation of sediment and contamination of flood waters.

Flood events during the operation and maintenance project phase are unlikely to have major impacts except those associated with access road inundation including potential erosion, sediment liberation and contaminant runoff.

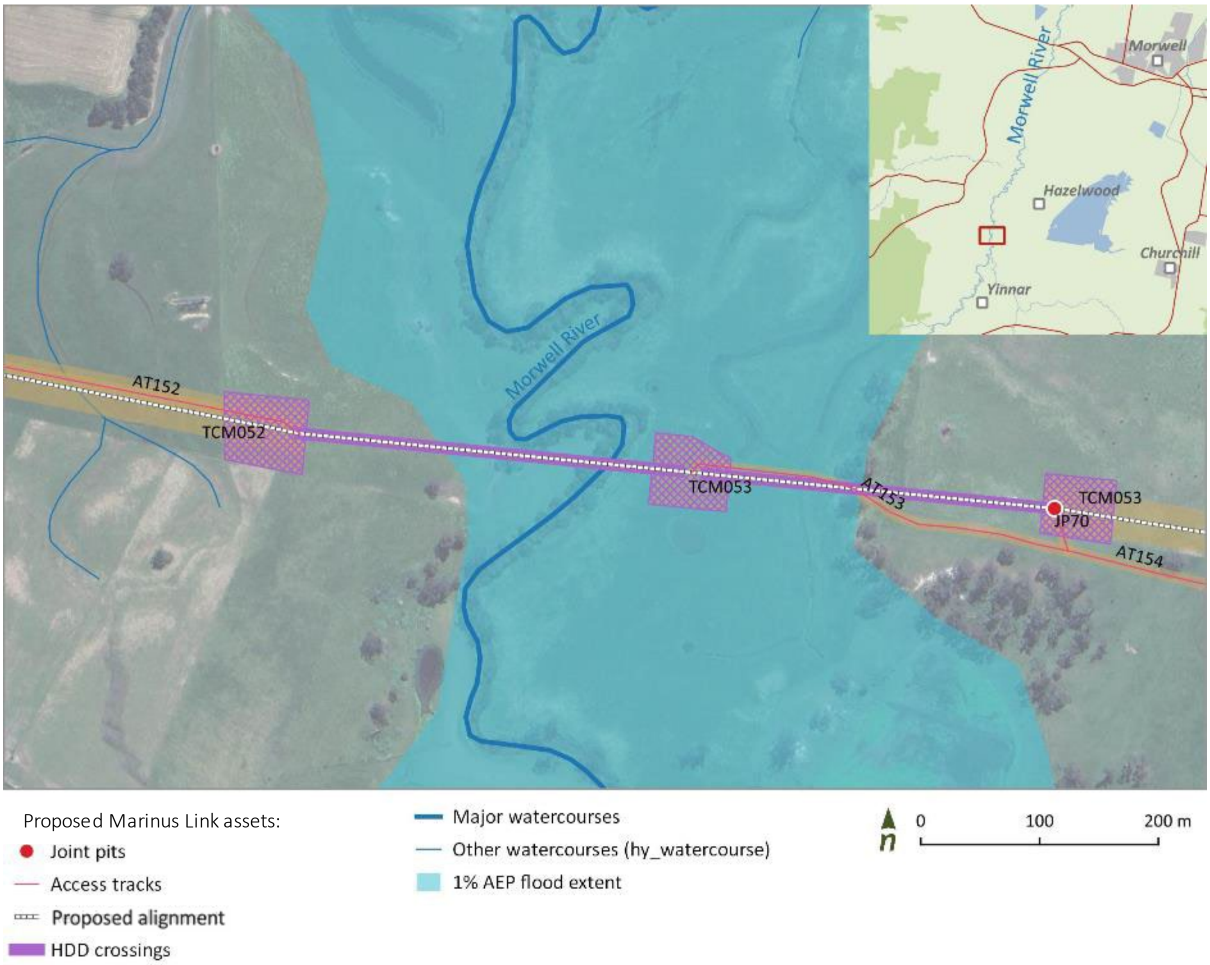

Figure 30. *Morwell River 1 % AEP flood extent with proposed project assets or construction areas*

Little Morwell River

There is no mapped 1 % AEP flood extent at the proposed project alignment crossing with the Little Morwell River. A potential maximum flood extent has been estimated based on valley topography, slope, and vegetation types over multiple aerial images. In the site layout (Figure 31) it appears HDD drilling is not proposed across the Little Morwell River, with the HDD trenchless construction (or potentially trenched) method areas of disturbance (drill pads) for other crossings of roads to the south and a steep slope north of the Little Morwell River. At the waterway crossing an open trench construction and access track is proposed. The proposed access track is an upgrade of an existing track and exact construction (including culvert provisions) is uncertain.

In lieu of a formal mapped flood extent, Figure 32 presents a schematic cross section layout of the proposed construction assets and techniques at the Little Morwell crossing along with an estimated flood extent. This shows an open trench method through the floodplain with HDD drill pads on the steep slopes above. Given the topography, riverine flooding could reach the edge of drill pads. A normal waterway flow (and any flooding that should occur during construction) is also likely to interact with an open trench. During construction, this could result in major changes in flood behaviour/routing, potentially causing channel instability through erosion and liberation of sediment.

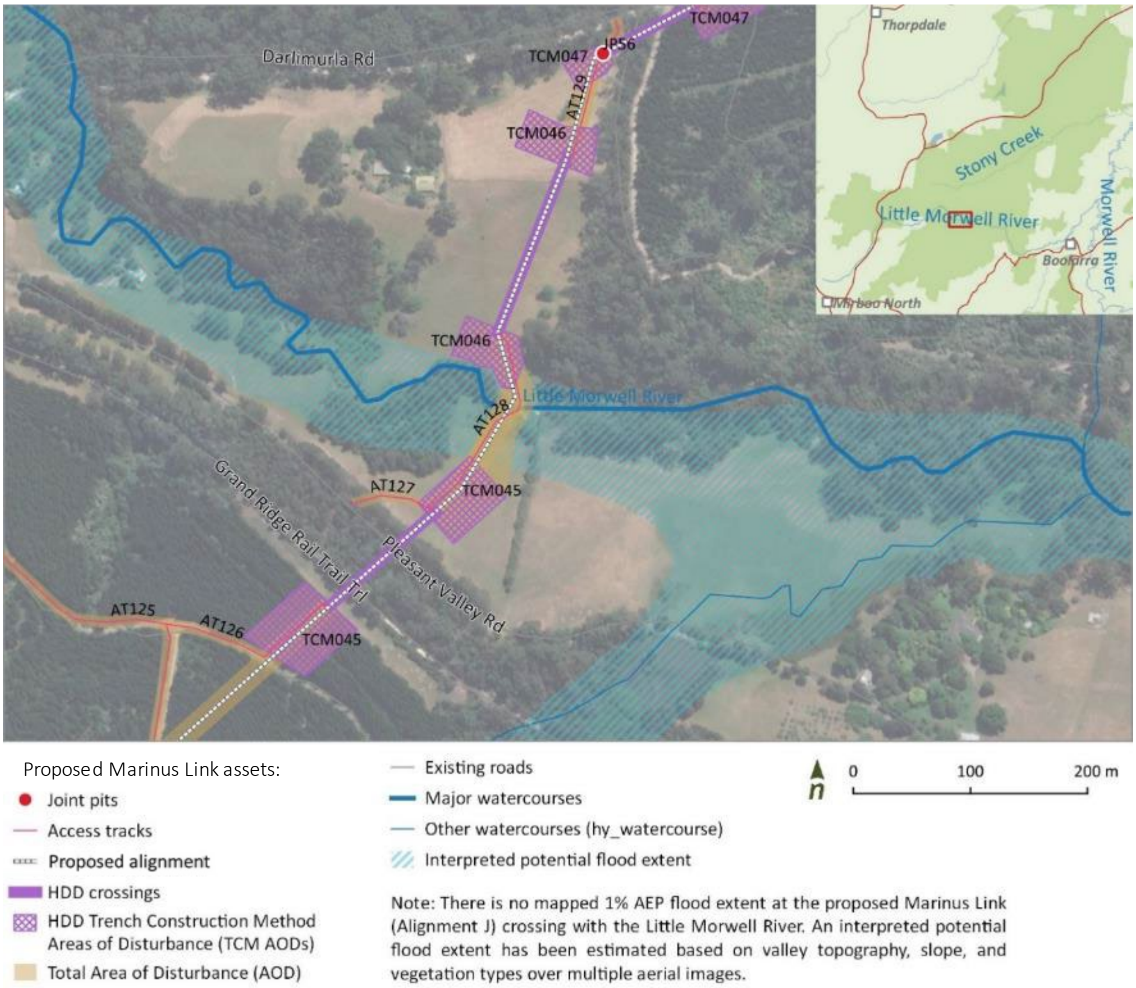

Figure 31. *Proposed Marinus Link assets or construction areas surrounding the Little Morwell River with estimated potential flood extent.*

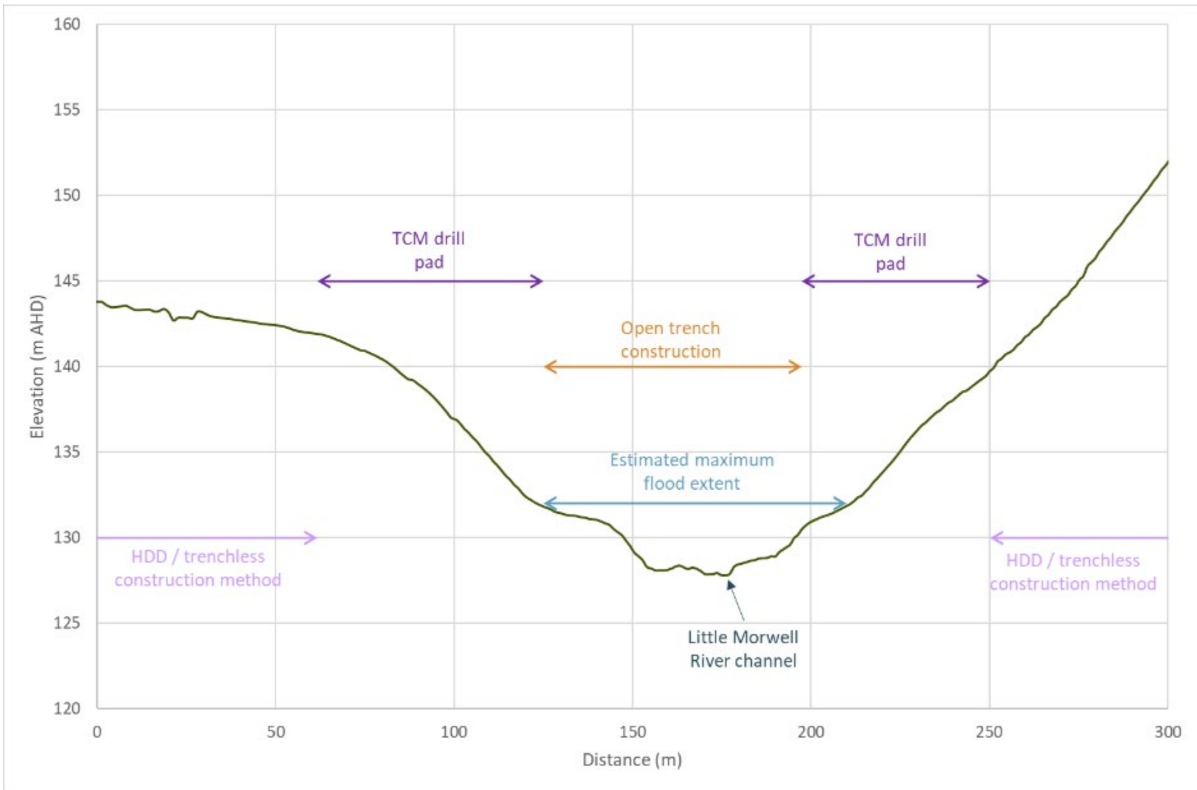

Figure 32. *Schematic cross section layout of construction assets surrounding Little Morwell River crossing, looking downstream along proposed project alignment*

As it is anticipated that drill pads and trench construction will be reinstated to match the existing condition and surface levels post construction – no impact on the 1% AEP flood behaviour (extent, levels and storage) is anticipated.

It is uncertain what the permanent access track arrangements will be and how this may influence flow behaviour. Further flood modelling is required to inform detailed design of the project and met the requirements of the EPRs (refer to Section 6.6).

Flood events during the operation and maintenance project phase are unlikely to have major impacts except those associated with access road inundation including potential erosion, sediment liberation and contaminant runoff.

Tarwin River East Branch

Figure 33 shows the 1 % AEP flood extent for the Tarwin River East Branch at the proposed project alignment intersection. This shows that access tracks, the HDD trenchless construction (or potentially trenched) method areas of disturbance (drill pads) and an area of open trench construction (i.e., not HDD) are located within the 1 % AEP flood extent at this crossing. A joint pit is also located close to the 1 % AEP flood extent. The total area of disturbance within the 1 % AEP flood extent is 8,461 m^2.

As it is anticipated that drill pads and any trenches associated with construction will be reinstated to match the existing condition and surface levels post construction – no impact on the 1% AEP flood behaviour (extent, levels and storage) is anticipated.

Should a major flood occur during construction, construction areas of disturbance including drill pads and tranches could be inundated, causing changes to flood behaviour, liberation of sediment and contamination of flood waters.

Flood events during the operation and maintenance project phase are unlikely to have major impacts except those associated with access road inundation including potential erosion, sediment liberation and contaminant runoff.

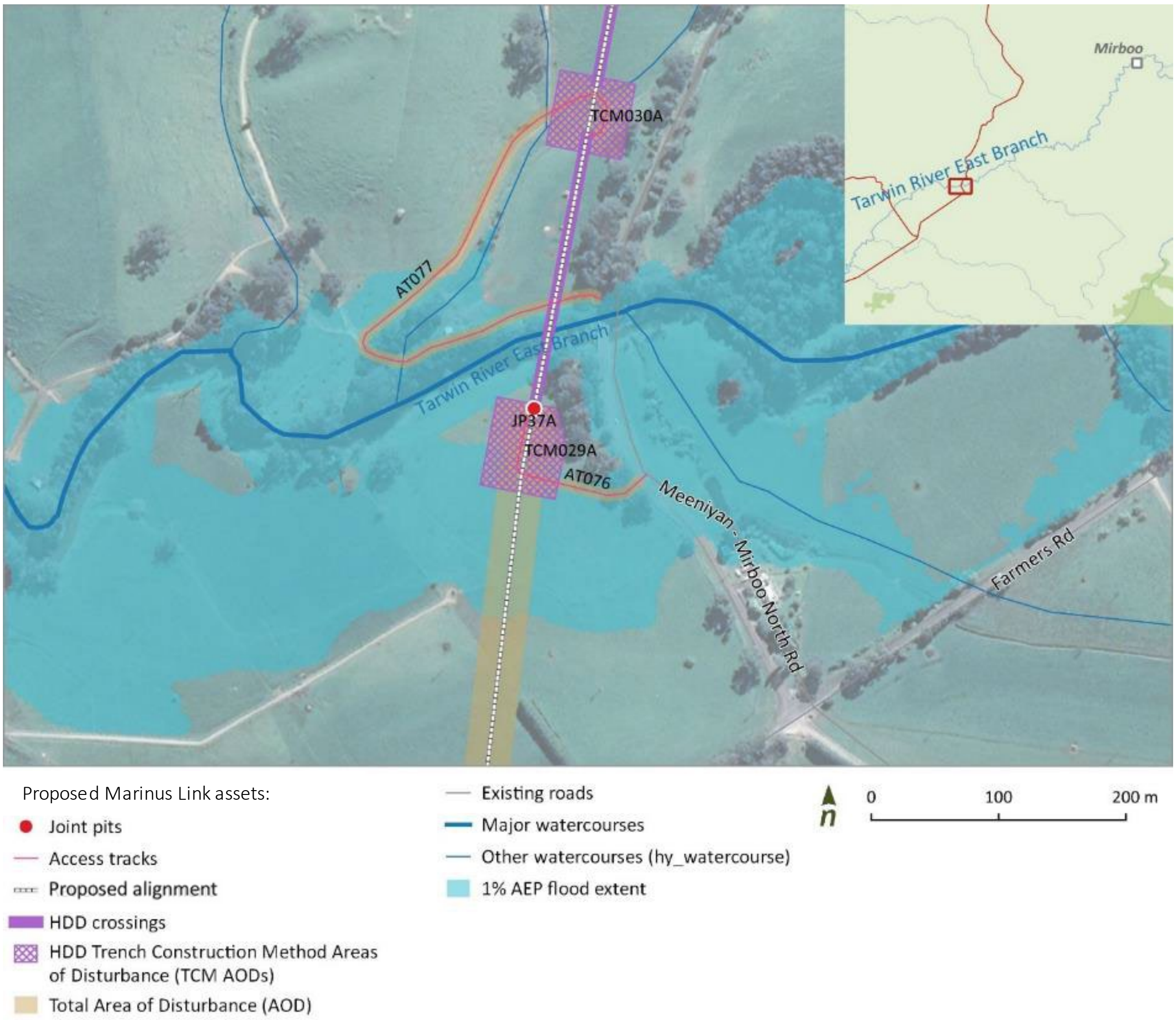

Figure 33. *Tarwin River East Branch 1 % AEP flood extent with proposed Marinus Link assets or construction areas*

Tributaries of Tarwin River East Branch

Figure 34 shows the 1% AEP flood extent for the tributaries of the Tarwin River East Branch at the proposed project alignment intersection. This shows that access tracks, the HDD trenchless construction (or potentially trenched) method areas of disturbance (drill pads) and areas of open trench construction (i.e., not HDD) are located within the 1% AEP flood extent at this crossing. Three joint pit is also located close to the 1% AEP flood extent. The total area of disturbance within the 1% AEP flood extent is 68,613 m^2, with 38,887 m^2 across the northern tributary and 29,726 m^2 across the southern tributary.

As it is anticipated that drill pads and any trenches associated with construction will be reinstated to match the existing condition and surface levels post construction – no impact on the 1% AEP flood behaviour (extent, levels and storage) is anticipated.

Should a major flood occur during construction, construction areas of disturbance including drill pads and tranches could be inundated, causing changes to flood behaviour, liberation of sediment and contamination of flood waters.

Flood events during the operation and maintenance project phase are unlikely to have major impacts except those associated with access road inundation including potential erosion, sediment liberation and contaminant runoff.

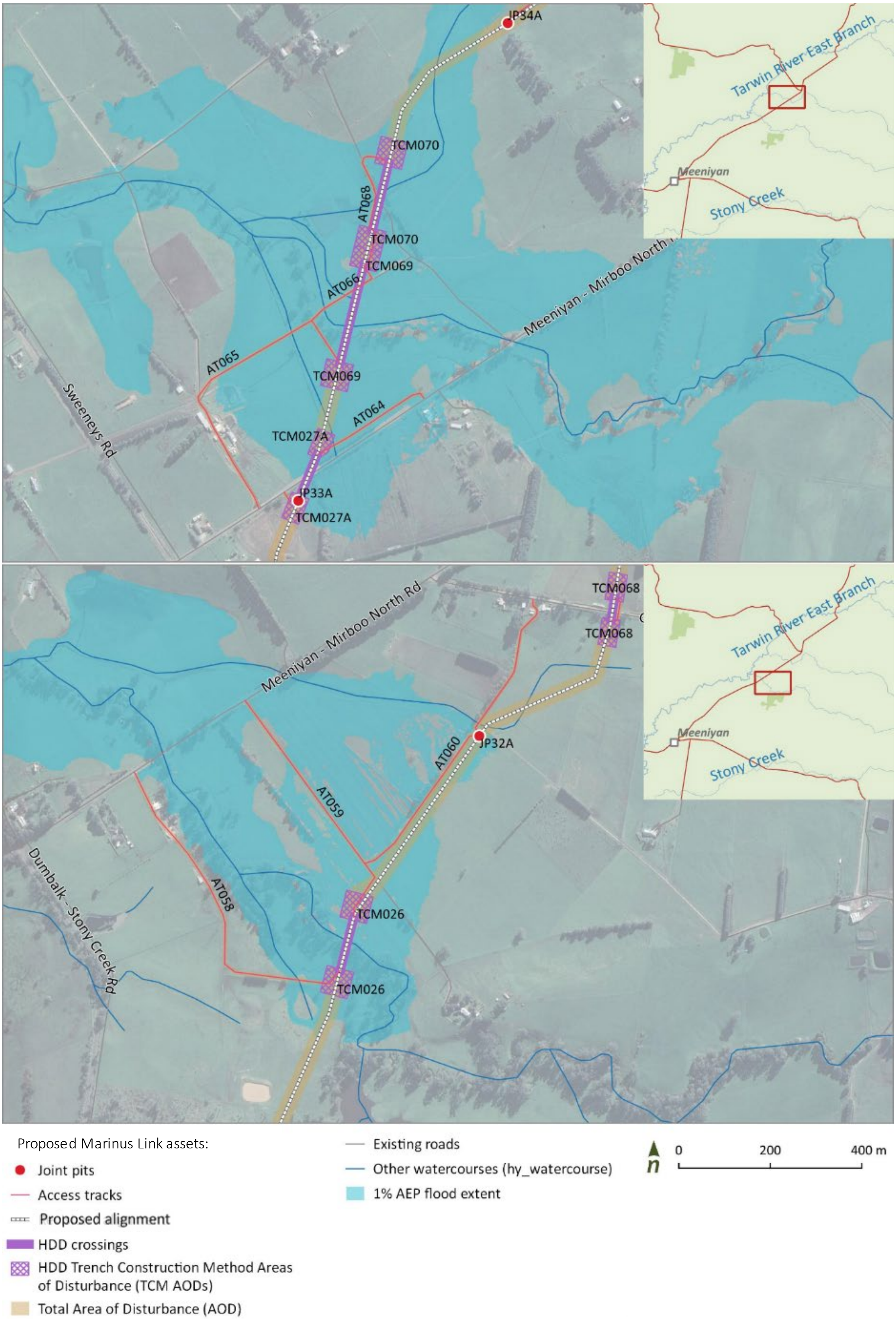

Figure 34. *Northern (top) and southern (bottom) tributaries of the Tarwin River East Branch 1% AEP flood extent with proposed Marinus Link assets or construction areas*

Stony Creek

Figure 35 shows the 1 % AEP flood extent for Stony Creek at the proposed project alignment intersection. This shows that access tracks and HDD trenchless construction (or potentially trenched) method areas of disturbance (drill pads) are located within the 1 % AEP flood extent at this crossing. Two joint pits are also located within around 50 m of the flood extent. The proposed project alignment crosses, and then runs alongside Stony Creek for some distance, meaning multiple construction locations are within the 1 % AEP flood extent, including open trench construction. The total area of disturbance within the 1 % AEP flood extent is 33,904 m^2.

As it is anticipated that drill pads and any trenches associated with construction will be reinstated to match the existing condition and surface levels post construction – no impact on the 1% AEP flood behaviour (extent, levels and storage) is anticipated.

Should a major flood occur during construction, construction large areas of disturbance including drill pads and trenches could be inundated, causing changes to flood behaviour, liberation of sediment and contamination of flood waters.

Flood events during the operation and maintenance project phase are likely to have impacts associated with access road inundation including potential changes to flow behaviour, erosion, sediment liberation and contaminant runoff.

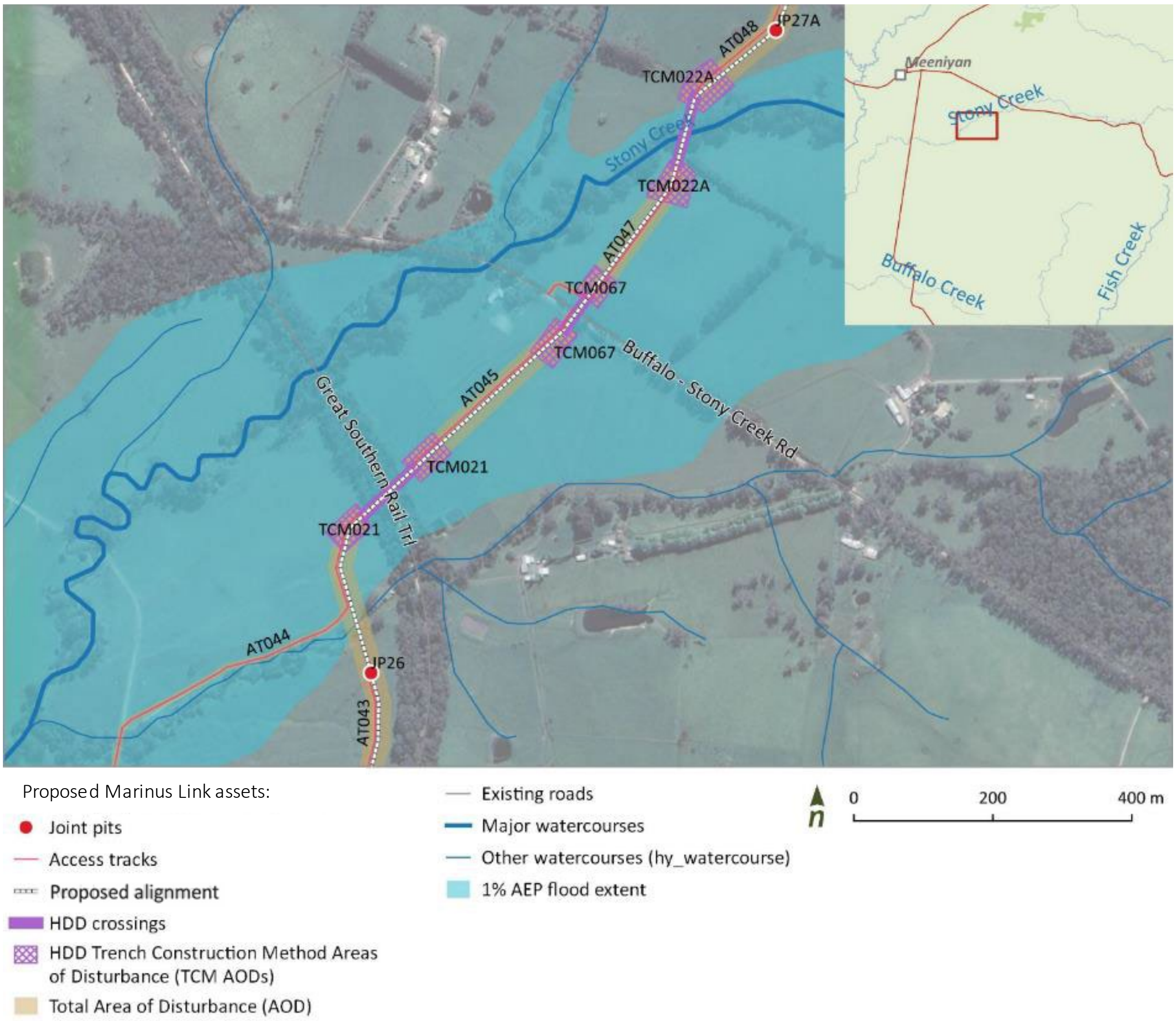

Figure 35. *Stony Creek 1 % AEP flood extent with proposed Marinus Link assets or construction areas*

Buffalo Creek

There is no mapped 1 % AEP flood extent at the proposed Project alignment crossing with Buffalo Creek (Figure 36). A potential maximum flood extent has been estimated based on valley topography, slope, and vegetation types over multiple aerial images. The site layout (Figure 36) shows HDD trenchless construction (or potentially trenched) method areas of disturbance (drill pads) around 15 m away from the top of stream bank to the south and 50 m from top of bank to the north. A proposed joint pit is also located around 150 m north. Given the levees around this waterway and topography of the floodplain, any overbank flows are likely to impact on these areas of disturbance.

In lieu of a formal mapped flood extent, Figure 37 presents a schematic cross section layout of the proposed construction assets and techniques at the Little Morwell crossing along with an estimated flood extent. The creek through this section has levee banks around 0.5 to 1 m high. Should flows overtop these banks or overland flow travel across the floodplain, the HDD drill pads, and open trenches are sitting lower in the floodplain and could be inundated. This will cause impacts associated with inundation including potential changes to flow behaviour, erosion, sediment liberation and contaminant runoff. Permanent joint pit infrastructure could also be inundated.

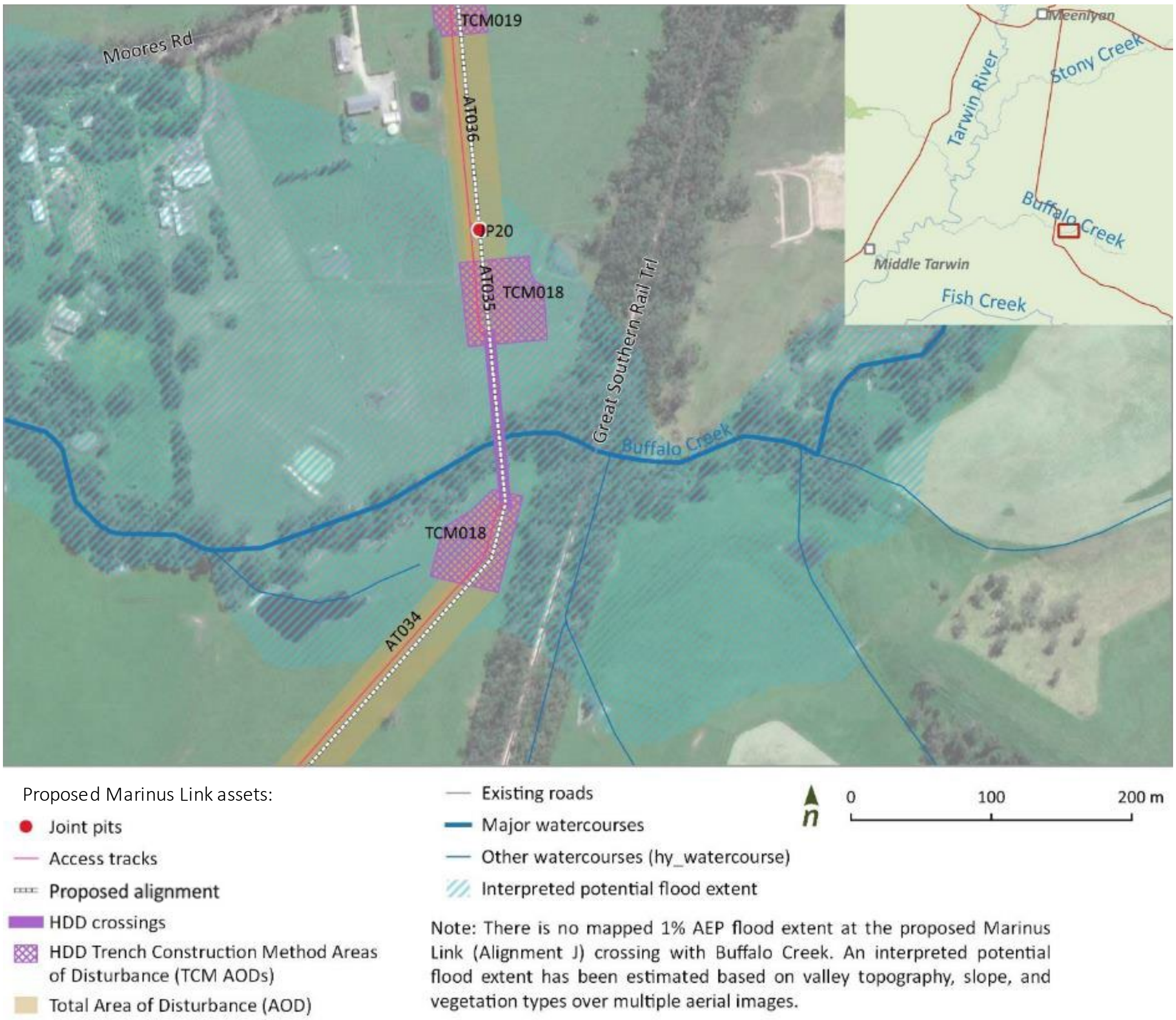

Figure 36. *Proposed Marinus Link assets or construction areas surrounding Buffalo Creek with estimated potential flood extent.*

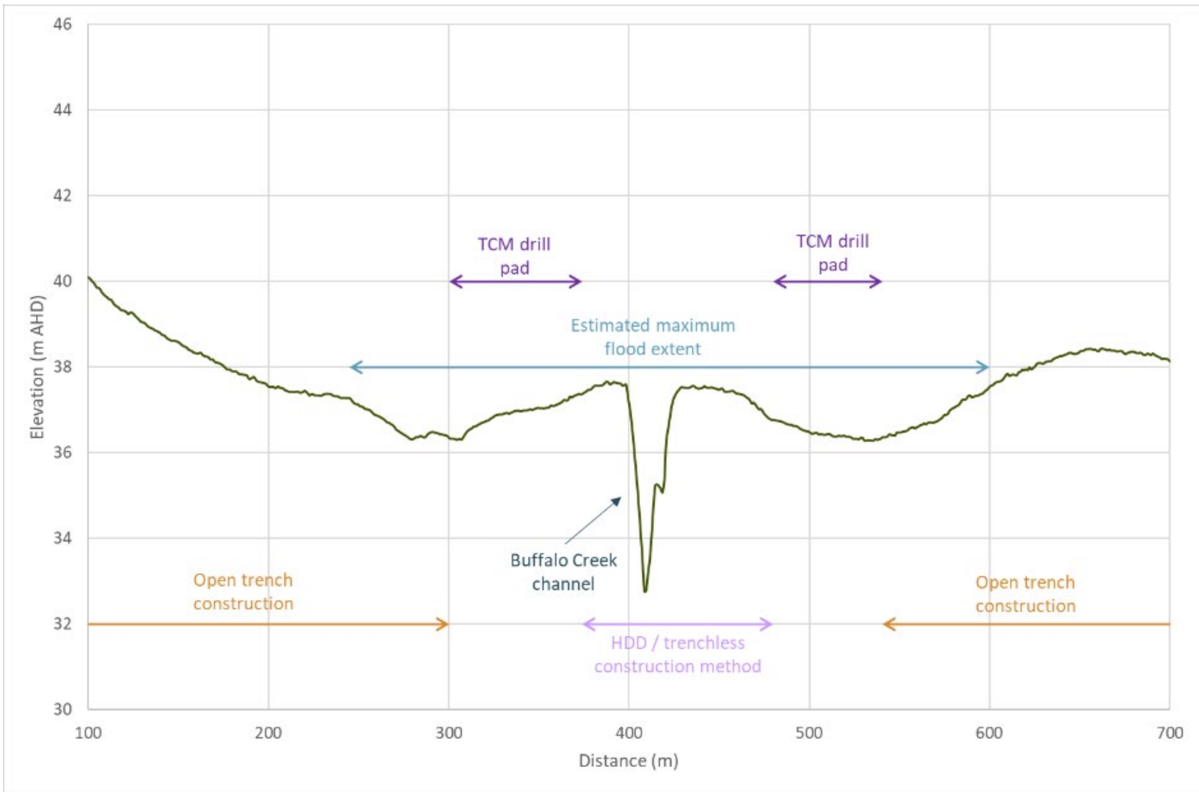

Figure 37. *Schematic cross section layout of construction assets surrounding Buffalo Creek crossing, looking downstream along proposed project alignment*

As it is anticipated that drill pads and any trenches associated with construction will be reinstated to match the existing condition and surface levels post construction – no impact on the 1% AEP flood behaviour (extent, levels and storage) is anticipated.

Flood events during the operation and maintenance project phase are unlikely to have major impacts except those associated with access road inundation including potential erosion, sediment liberation and contaminant runoff.

Fish Creek

Figure 38 shows the 1 % AEP flood extent for Fish Creek at the proposed project alignment intersection. This shows that access tracks and HDD trenchless construction (or potentially trenched) method areas of disturbance (drill pads) are located within the 1 % AEP flood extent at this crossing. The total area of disturbance within the 1 % AEP flood extent is 4,649 m^2.

As it is anticipated that drill pads and any trenches associated with construction will be reinstated to match the existing condition and surface levels post construction – no impact on the 1% AEP flood behaviour (extent, levels and storage) is anticipated.

Should a major flood occur during construction, construction areas of disturbance including drill pads and tranches could be inundated, causing changes to flood behaviour, liberation of sediment and contamination of flood waters.

Flood events during the operation and maintenance project phase are unlikely to have major impacts except those associated with access road inundation including potential erosion, sediment liberation and contaminant runoff.

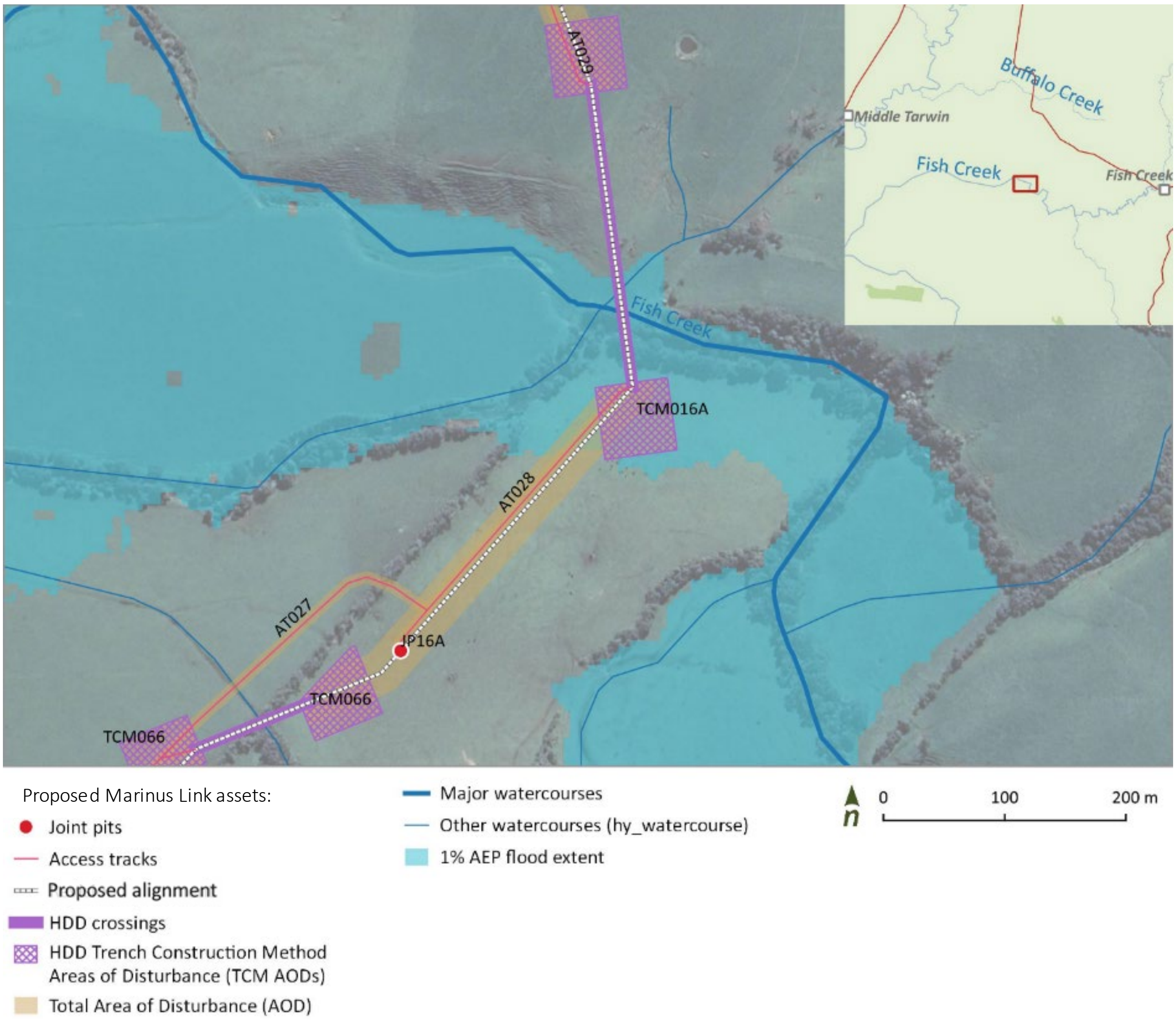

Figure 38. *Fish Creek 1 % AEP flood extent with proposed Marinus Link assets or construction areas*

Other areas of disturbance within the 1% AEP flood extent

In addition to the waterway crossings listed above, the mapped 1 % AEP flood extent also intersects with the proposed project alignment areas of disturbance in the following areas:

- Near TCM060 and Nadenbouschs Lane including areas of access track construction, and open trench construction.
- An additional left bank tributary of the Tarwin River East Branch along Farmers Road.
- At the Waratah Bay transition station.

Converter and transition stations

Hazelwood converter station

Impacts to flooding from the construction and operation of the converter station at Hazelwood was assessed as part of detailed, site-specific flood modelling. Results from the flood modelling indicate as a result of the proposed converter station, flood levels are expected to increase by 0.02-0.05 m in isolated patches to the west of the station footprint, and downstream of Monash Way under the current 1 % AEP scenario (Figure 39). Minor increases in areas that "were dry, now wet" were identified to the immediate west of the development footprint. Under climate change projections, the increase in flood depths is concentrated to the north of the footprint, parallel to Tramway Road (Figure 40). Depth increases are typically in the order of 0.02-0.05 m increases, with one isolated area subject to 0.05-0.1 m increase in depth.

While the flood mapping indicates minor increases in flood depth and extent as a result of the works, generally less than 50 mm, impacts are contained to the immediate area and are considered low risk change/impacts to flood behaviour.

However, additional detailed modelling through the design phase should be undertaken to confirm the flooding impact of the final design, its impact on Monash Way and Tramway Road and seek acceptance from WGCMA (drainage authority).

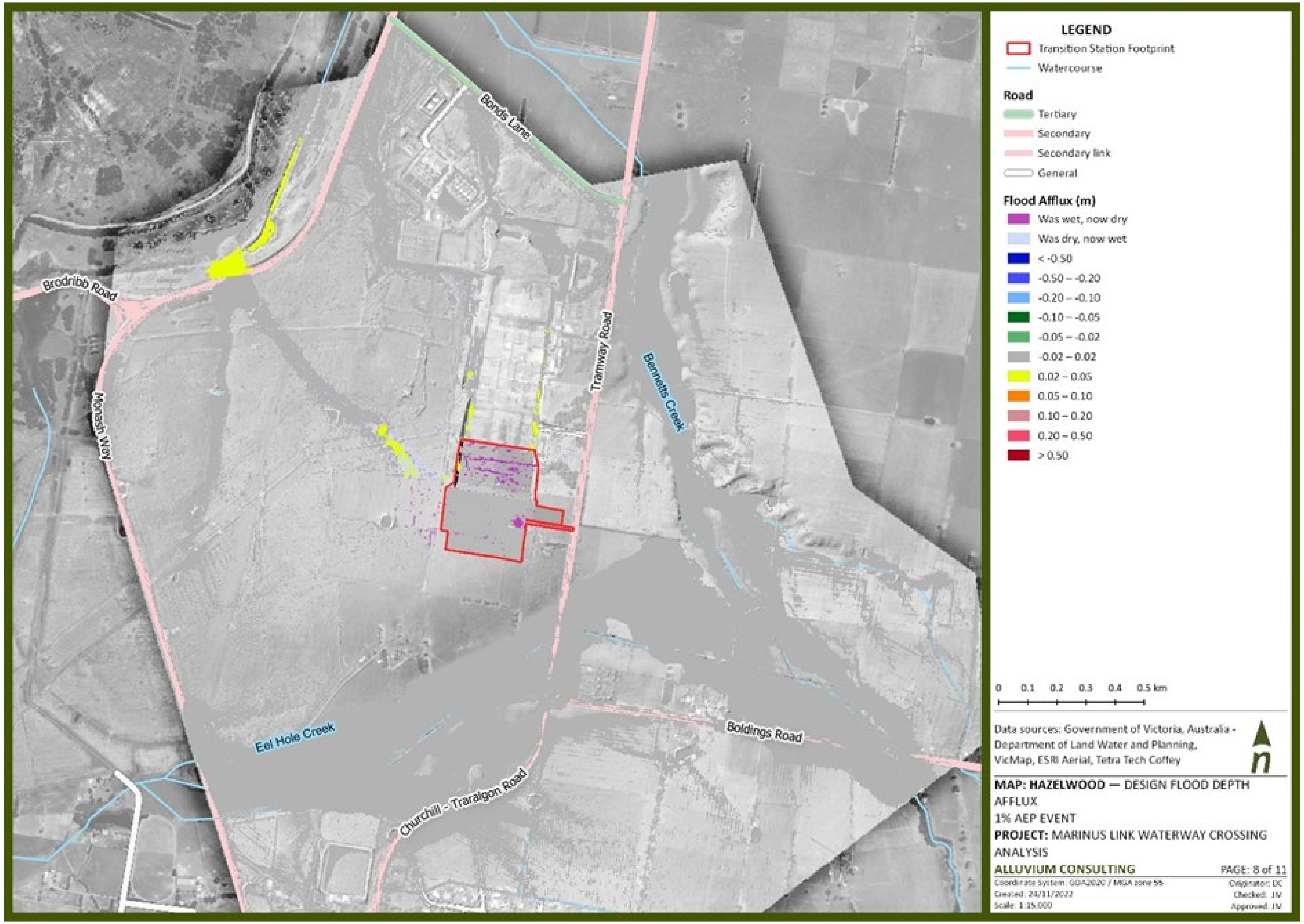

Figure 39. *Hazelwood 1 % AEP afflux*

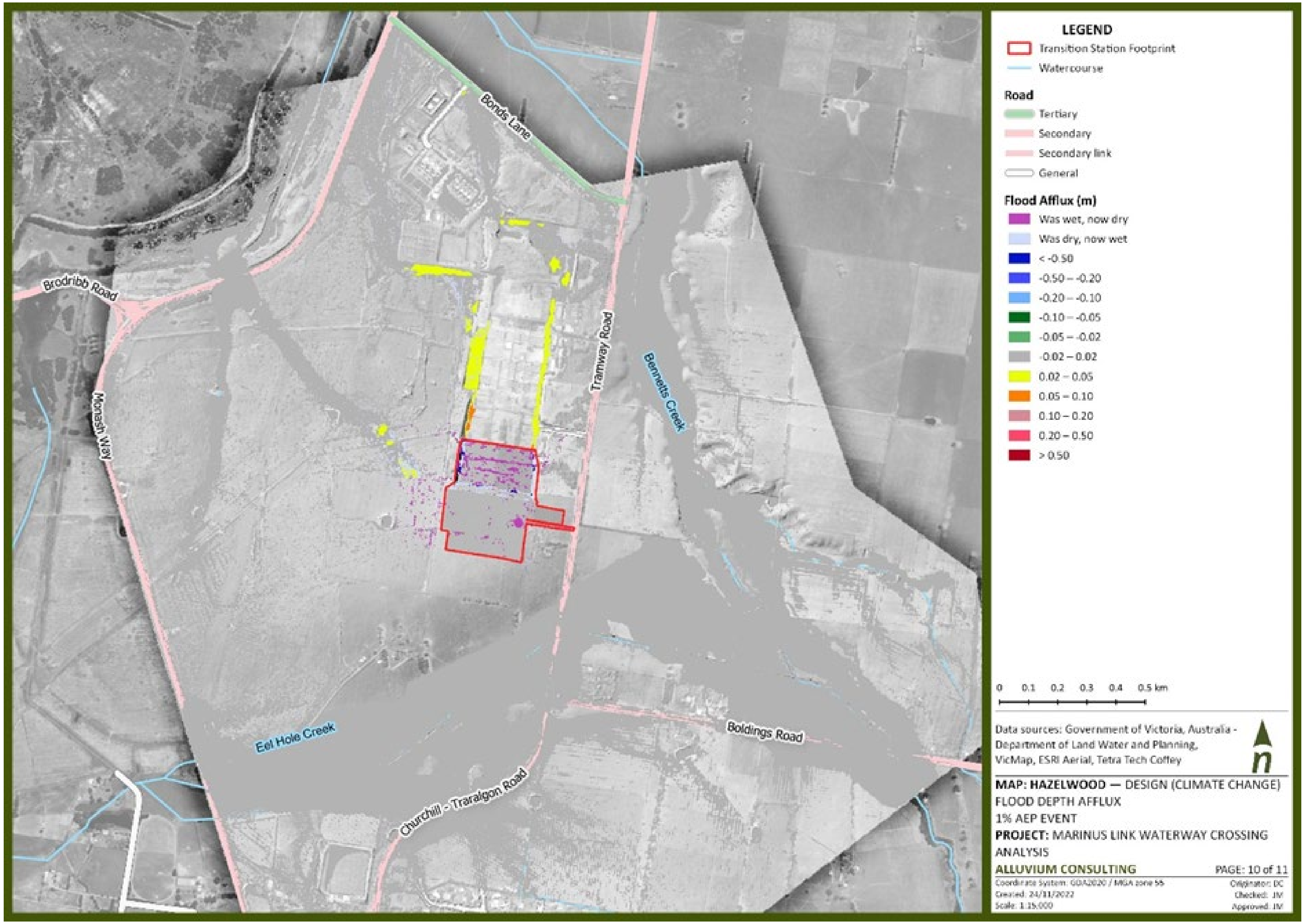

Figure 40. *Hazelwood climate change 1 % AEP afflux*

Driffield converter station

Flood modelling was used to assess the impacts to flooding from the construction and operation of the Driffield converter station. Results from the flood modelling show that the development footprint will largely be devoid of flood depths below 0.05 m, shown by the was wet, now dry patches in Figure 41. Downstream of the site, surface runoff was noted to increase by up to 0.1m in the drainage channel to the north, and 0.02 – 0.05 m to the west as a result of the proposed works. A reduction in flood depths in the main drainage channel running from the southwest to the northwest of 0.02 – 0.1 m is also shown in Figure 41. The impact to flooding under climate change projections shown in Figure 40, shows very similar results, with the exception of reducing flood depths in the main drainage channel running from the southwest to the northwest.

While the flood mapping indicates minor increases in flood depth and extent as a result of the works, generally less than 100 mm, impacts are contained to the immediate area and are considered low risk change/impacts to flood behaviour.

However, additional detailed modelling through the design phase should be undertaken to confirm the flooding impact of the final design, its impact on Fords Road and seek acceptance from WGCMA (drainage authority).

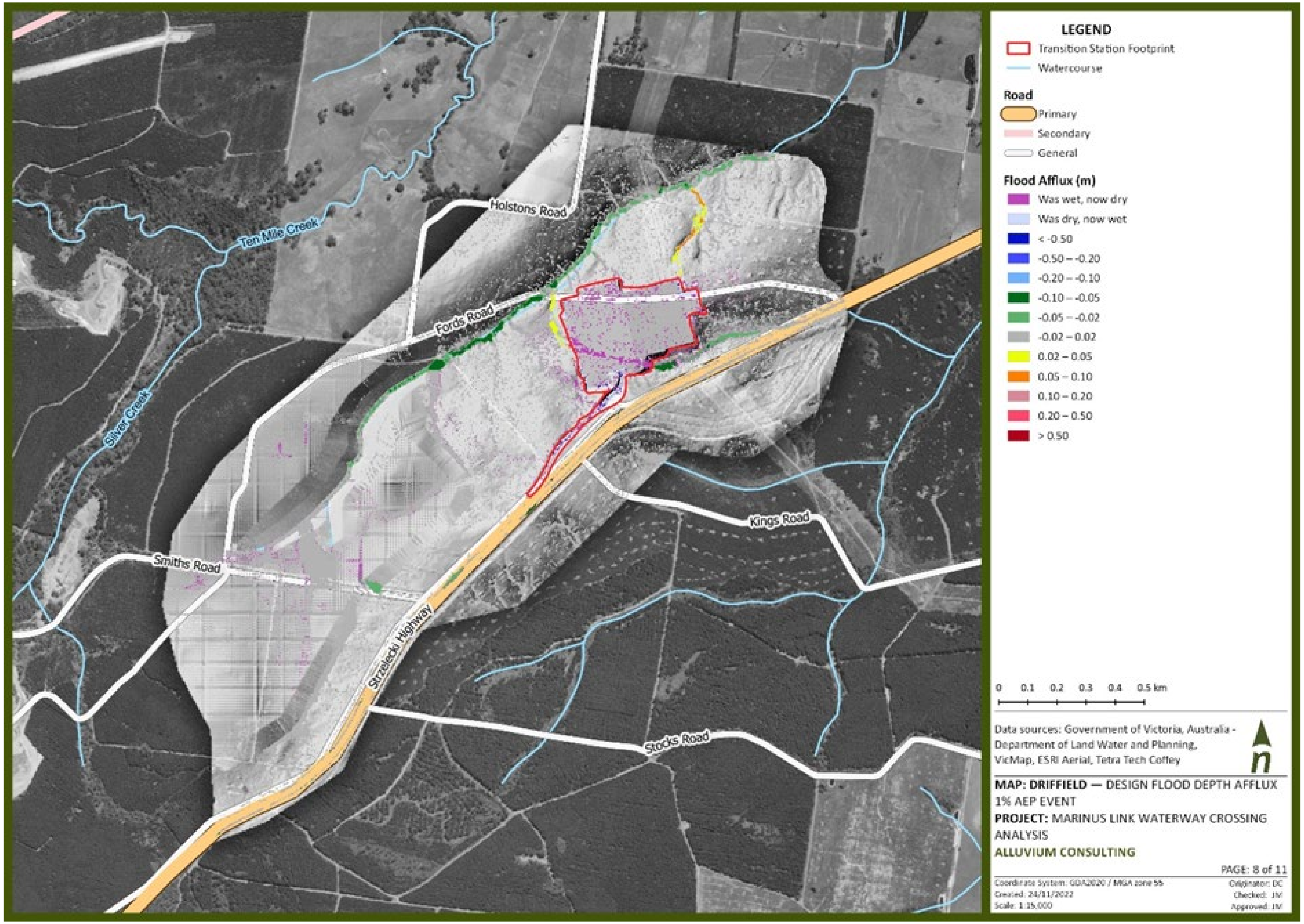

Figure 41. *Driffield 1 % AEP afflux*

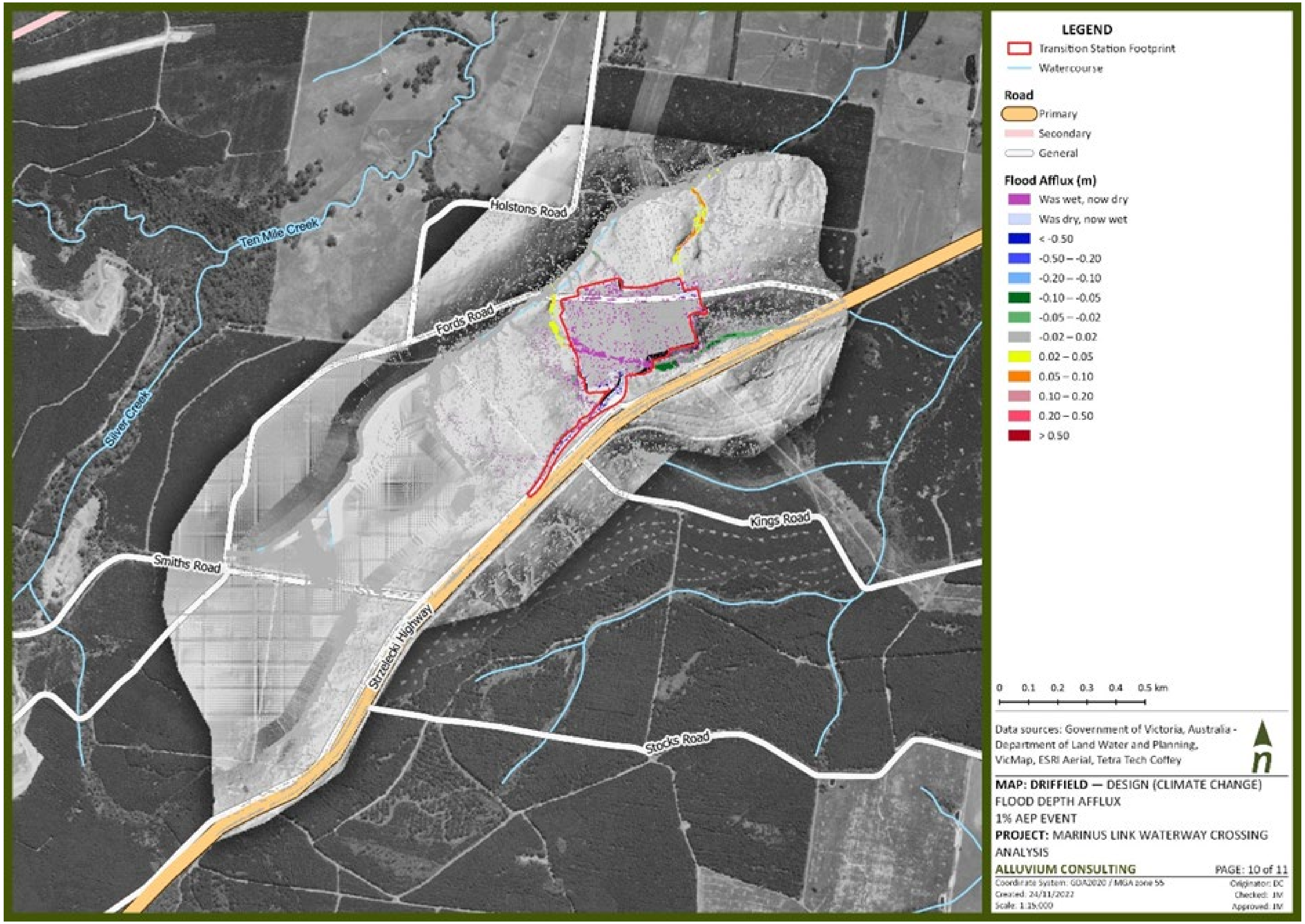

Figure 42. *Driffield climate change 1 % AEP afflux*

Waratah Bay transition station

Afflux, or change in flood depth as a result of the proposed transition station at Waratah Bay is confined to the immediate surrounds of the development footprint for both the 0.5 % AEP event (Figure 43) and the climate change 0.5 % AEP (Figure 44). Both scenarios show areas that were wet, now dry indicating that the proposed earthworks for the site divert surface water flows, however the resultant afflux in the 0.5 % AEP event results in an increase of up to 0.1 m. The was wet, now dry category in the climate change scenario is slightly more distributed but is also indicative of the site profile impacting surface flows and changing their courses slightly.

While the flood mapping indicates minor increases in flood depth and extent as a result of the works, generally less than 100 mm, impacts are contained to the immediate area and are considered low risk change/impacts to flood behaviour.

However, additional detailed modelling through the design phase should be undertaken to confirm the flooding impact of the final design, its impact on Waratah Road and seek acceptance from WGCMA (drainage authority).

Figure 43. *Waratah Bay 0.5 % AEP afflux*

Figure 44. *Waratah Bay climate change 0.5 % AEP afflux*

Flooding risks identified

Based on the flooding assessment several risks were identified, the hazard and pathways/mechanism for these risks are outlined in Table 20.

Table 20. Identified risks associated with flood behaviour and associated functions, including hazard and pathway/mechanism.

Risk ID	Hazard	Impact pathway/mechanism	Risk
C.1	Construction activities	Temporary activities such as excavation, stockpiling and alteration of topography or change in impervious surfaces alters floodplain storage capacity to store/transport floodwaters and/or diverts flow.	Increase in flood inundation frequency, velocity or level which affects users or assets within the floodplain.
C.2	Construction activities	Excavation, filling or other interference with existing overland/surface flow pathways leading to changes in flow conveyance behaviour, direction, velocity or other characteristics.	Construction activities, such as trenching, on existing flow paths including piped flow, causing a change in flow.
C.3	Construction activities	Direct alteration of waterways that alters flow behaviour, initiates/increases erosion and/or disrupts physical waterway habitat (e.g., bank disturbance).	Construction activities such as trenching, causing unintended damage to waterways resulting in changed flow behaviour, bed or bank erosion, and/or physical habitat.
O.1	Operation/ permanent assets	Permanent project assets including bunds, access roads, drains and modification to surface levels leading to changes in flow conveyance behaviour, direction, velocity or other characteristics.	Diversion of stormwater, drainage alignment or flow pathways causing a change to flow downstream.
O.2	Operation/ permanent assets	Changes to current land use from permanent project assets such as access tracks, joint pits, or other hardstand areas are created which reduce the ability for water to infiltrate into the ground, causing increase in surface runoff, changes to flow discharge, and/or bed and bank erosion, increasing sediment supply to waterways.	Land use changes, where an increase in impervious area results in an increase in flow discharge leading to bed or bank erosion.
O.3	Operation/ permanent assets	Road/access track drainage is insufficient to convey rainfall associated with increase rain intensities as a result of climate change. Reduced drainage capacity may lead to diversion of water/flooding elsewhere, erosion of waterways and liberation of sediment travelling in surface water to waterways.	Insufficient capacity of maintenance access road drainage design due to increased rainfall intensities from climate change resulting in an impact to flooding and sediment runoff.
O.4	Operation/ permanent assets	Permanent project assets such as access tracks, bunds, joint pits, or other modified areas causes diversion of runoff routes or flow pathways which leads to a loss of floodplain storage capacity to store/transport floodwaters and/or diverts flow.	Diversion of stormwater, drainage alignment or flow pathways leading to bed or bank erosion causing instability of assets adjacent to the waterway and/or increased sediment loads.

6.3 Water quality impacts

This section identifies the potential water quality impacts of the project on the major waterway crossings during construction and operation phases on identified surface water environmental values.

Soil washed from land development or construction sites has potential to be deposited as sediment in waterways. This process can greatly increase the concentration of materials suspended and dissolved in streams and the durations and frequencies for which downstream waters remain turbid. Water pollution can also include contaminants such as suspended, dissolved, floatable and settleable soil, oils, cements materials and other chemicals.

Increased sediment supply and pollutants from construction activities can impact on waterways in the following ways:

- Reduce visibility for aquatic fauna to hunt for prey
- Reduce growth of aquatic vegetation through lack of light due to increased turbidity
- Increase turbidity such that it impacts on aesthetic values
- Impact on safe water uses such as stock and domestic supply, recreation, consumption of fish and other human water uses

The pathway for sediment and pollutants to impact on waterways is either through travelling in runoff as a result of rainfall or interacting with floodwaters in flood events. An appreciation of the impacts on water quality has been gathered through understanding the area of disturbance within the 1 % (or estimated) flood extent. For the construction phase, this provides an appreciation of the disturbed area (assumed to be exposed soil) that could be inundated in a flood event, with sediment liberated. The impact area at Waratah Bay (Figure 22) provides a conservative estimate of the area of impact and assumes that during the 1 % AEP flood event, the mapped flood extent may come into contact with exposed topsoil. This may be reduced with progressive rehab during the project implementation. The scale of area within the flood extents relates to the consequence of impact (i.e., the more sediment is liberated, the more impact on waterway values)(Table 21).

Permanently waterlogged soils, such as waterways, floodplains, rivers, wetlands, and shallow groundwater, have an increased potential of containing acid sulfate soils. Therefore, disturbance of contaminated land and potential acid sulfate soils sites, such as those at Waratah Bay and the section of Eel Hole Creek feeding into the Hazelwood pondage area, may impact surface water quality due to the presence of such features. However, there is low to extremely low possibility that ASS exists within most of the study area (Tetra Tech Coffey, 2023). Further details regarding the impact assessment that informs the management of contaminated land and acid sulfate soils are discussed in the *Marinus Link Project: Contaminated Land and Acid Sulfate Soils Assessment* (Tetra Tech Coffey, 2023).

Frac out during HDD is the release of drilling fluids to the ground surface. It typically occurs when the pressure in the drilling hole is greater than the pressure in the surrounding ground and there is a pathway such as fissure that allows for seepage of drilling fluid from drilling hole to the surface. This is a risk will be managed through construction and proponent are also required to use nontoxic drilling fluids (Tetra Tech Coffey, 2023).

After construction, exposed soil will be rehabilitated and/or covered, meaning sediment liberation during the operation phase will likely be minimal and not of a scale that could impact on surface water values.

Table 21. Construction areas and their associated Area of Disturbance (AoD) within 1 % AEP flood extent.

Waterway	Total area of disturbance within flood extent (m^2)
Morwell River	4,790
Little Morwell River*	10,624
Tarwin River East Branch	8,461
Tributaries of the Tarwin River East Branch	38,887 (northern tributary) 29,726 (southern tributary)
Stony Creek	33,904
Buffalo Creek*	2,523
Fish Creek	4,649

*Note: flood extents for Little Morwell River and Buffalo Creek are interpreted from valley topography, slope, and vegetation types over multiple aerial images and are not the mapped 1% AEP flood extents provided by WGCMA.

Water quality risks identified

Based on the water quality assessment several risks were identified, the hazard and pathways or mechanism for these risks are outlined in Table 22.

Table 22. Identified risks associated with water quality, including hazard and pathway/mechanism.

ID	Hazard	Impact pathway/mechanism	Risk
C.4	Construction activities	Spill of hazardous or potentially polluting chemicals or materials used in construction are released into the waterway during rainfall event (runoff or resulting from a flood event).	Hazardous materials and potential contamination of land and acid sulfate soils during construction of the project being released into the waterways.
C.5	Construction activities	Direct or indirect activities that cause damage to the bed or bank of the waterway, such as bank slumping/collapse e.g., heavy machinery on channel banks, operations within the channel, including trenching. Sediment release impacts water quality and waterway stability through aggradation.	Construction activities resulting in bed or bank erosion and sediment release.
C.6	Construction activities	Open excavation or exposed soil is inundated in a flood event within construction period, causing sediment to be liberated and travel through surface water into waterways, impacting on water quality and waterway stability through aggradation.	A flood event occurring during the construction of the joint pits, HDD drill pads, access roads or trenches causing inundation of assets and sediment liberation.
C.7	Construction activities	Direct rainfall or a flood event inundates soil stockpiled as part of construction activities, causing sediment to be liberated and travel through surface water into waterways, impacting on water quality and waterway stability through aggradation.	Direct rainfall/ flood event occurring during construction, inundating soil stockpiles and resulting in sediment release.
C.8	Construction activities	Horizonal directional drilling results in frac out- where the clays used to line the tunnel walls leech into a waterway impacting on water quality.	Hazardous materials and potential contamination of land and acid sulfate soils during construction of the project being released into the waterways.

ID	Hazard	Impact pathway/mechanism	Risk
O.2	Operation/ permanent assets	Changes to current land use from permanent project assets such as access tracks, joint pits, or other hard stand areas are created which reduce the ability for water to infiltrate into the ground, causing increase in surface runoff, changes to flow discharge, and/or bed and bank erosion, increasing sediment supply to waterways.	Land use changes, where an increase in impervious area results in an increase in flow discharge leading to bed or bank erosion.
O.3	Operation/ permanent assets	Road/access track drainage is insufficient to convey rainfall associated with increase rain intensities as a result of climate change. Reduced drainage capacity may lead to diversion of water/flooding elsewhere, erosion of waterways and liberation of sediment travelling in surface water to waterways, impacting on water quality and waterway stability through aggradation.	Insufficient capacity of maintenance access road drainage design due to increased rainfall intensities from climate change resulting in an impact to flooding and sediment runoff.
O.5	Operation/ permanent assets	Permanent project assets such as access tracks, bunds, joint pits, or other modified areas causes diversion of runoff routes or flow pathways which leads to ongoing redirection of flow, initiation/ acceleration of waterway bed/bank erosion and increased sediment supply to waterways.	Diversion of stormwater, drainage alignment or flow pathways leading to bed or bank erosion causing instability of assets adjacent to the waterway and/or increased sediment loads.
O.6	Operation/ permanent assets	Spill of hazardous or potentially polluting chemicals or materials used during operation are released into the waterway during rainfall event (runoff or resulting from a flood event).	Hazardous materials and potential contamination of land and acid sulfate soils during operation of the project being released into the waterways.

6.4 Geomorphic impacts

This section identifies the potential geomorphology related impacts of the project on major waterways crossings during construction and operation phases on identified surface water environmental values.

Waterway crossings

The diversity and complexity of habitats that support ecological values in streams and waterways, such as pools, riffles, and benches, are maintained by the geomorphic processes that shape the channel and floodplain. The physical form of a stream depends on its flow regime, the characteristics of its bed and bank sediment, the riparian and instream vegetation, valley controls (such as confinement and valley slope) and the sediment inflow regime. The geomorphic processes and form change over time if any of the factors are altered, for example, changes in the flow regime, removal of riparian vegetation and interruptions or increases in the sediment supply from upstream.

Sediment aggradation, transport, and deposition are determined by a number of factors, as outlined in Lane's balance diagram (Figure 45) (Lane, 1955) including sediment size (and volume), stream slope and discharge (or flow). If any of these factors change, the balance will be disrupted, and a waterway may experience degradation (erosion) or aggradation (sediment deposition). For example:

- If sediment supply is increased through liberation of sediment during construction activities, but the flow (i.e., capacity of the waterway to transport sediment) remains the same, deposition (aggradation) will occur, conversely
- If water volume or velocity (associated with slope) increases, there is a higher capacity for the waterway to transport sediment. If sediment supply remains stable, erosion (degradation) could be initiated or accelerated.

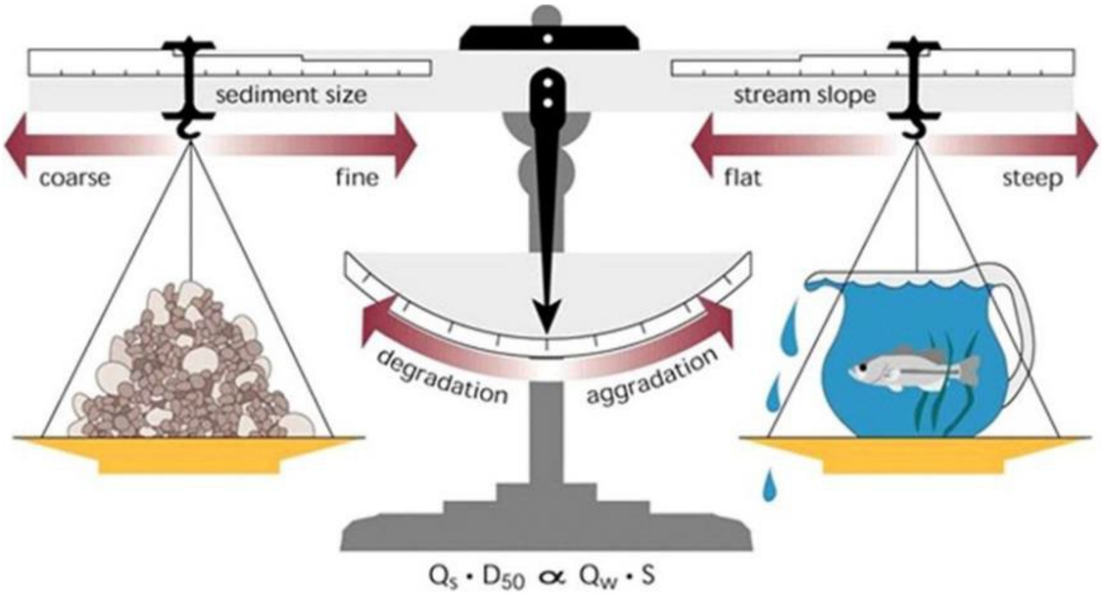

Figure 45. *Lane's balance diagram*

'Stable' waterways are in a dynamic equilibrium where these factors may alter slightly, but the channel naturally adjusts. If these factors are altered to a greater degree, it can push the waterway into becoming unstable and initiate incision, avulsion or other waterway processes. These processes are described further in Attachment 2.

The pathways through which geomorphology (physical form and waterway processes) could be impacted by the project is through changes to:

- Flood, flow routing and hydraulic behaviour causing increased erosion or incision
- Sediment supply changes causing aggradation
- Direct modification of the channel

The stability of waterways was assessed for the eight major waterways crossings. All of the waterways except for the Morwell River were identified to be laterally active which means they are moving horizontally across the landscape. The Morwell River, however, is subject to potential long-term changes, including gradual meander lengthening. Vertically, all eight major water crossings were deemed stable, except for Fish creek, indicating that this waterway crossing are not expected to erode downward towards the HDD crossings.

Notably, evidence of waterway bank erosion was observed in both the Morwell River and Fish Creek, with minor bank erosion noted in Stony Creek. Any potential risks to the stability of Fish Creek during construction will be effectively managed through the implementation of EPRs (i.e, SW01 and SW03).

Open trench construction of the Little Morwell River crossing will have a higher impact than HDD crossing of all other major waterway crossings. Open trench construction through waterways has also been assessed as an alternative to HDD. Channel instability and erosion due to trenching could impact the geomorphology of the river without application of mitigation measures.

Hydraulic impacts
An increase in impervious areas associated with project activities could increase flow discharges leading to bed and bank erosion and instability of the waterway.

Sediment supply changes
Potential impacts identified by Environmental Geosurveys (2023) include:

- Creation of unstable landforms in the short-term during construction.
- Potential for creation of long-term instability through changes to one or more of the geomorphic attributes of the present landscape.
- Potential change to channel dynamics of trenched waterways.
- Lost or degraded soil structure and other physical properties.
- Changed surface flow condition (run-on and runoff) and infiltration through changes to land use.
- Locally altered groundwater dynamics.
- Changed vegetation communities.

These impacts identified by Environmental Geosurveys (2023), can lead to sedimentation which can be the basis for changes to geomorphology, including aggradation (infilling) of channel beds, which can lead to:

- Smothering of stream beds, reduced aquatic habitat, and impacts on macroinvertebrates and fish reproduction
- Changed hydrology/flood behaviour, including increased flooding elsewhere, changes in flow routing and increased erosion
- Increased potential for avulsion (scour and development of a new channel and abandonment of the original channel)
- Altered rates of bank erosion due to altered sediment balance

Direct disturbance

Instream geomorphology could also be impacted by direct ground disturbance, change in drainage alignment or discharge location and subsequent erosion of disturbed areas and sediment delivery. These alterations of hydrology and hydraulic conditions could initiate incision or changes hydrology/drainage of floodplain wetlands.

For each waterway, the dominant waterway processes and the project's potential to impact on these processes is detailed in Table 23.

Table 23. Waterway crossing description and stability (from Table 17) including project potential to impact waterway processes.

Waterway	Channel description	Bed and bank stability	Associated processes and stability	Project potential to impact waterway processes
	Cross section, sinuosity, confinement	*Evidence of lateral or vertical erosion and/or accretion*	*Vertical and lateral stability*	
Morwell River	Deep, unconfined, high sinuosity meandering channel with steep levee banks	Lateral (bank) erosion evident, with undercut tree collapses	Long term gradual lengthening of meanders is expected, that will increase sinuosity (meander migration), however process is gradual over many decades to 100's of years.	Trench excavation in floodplain and channel, potential impacts on flow behaviour, bed/bank erosion and sediment release. Changed flow routing and potential increased bank erosion due to project assets located within floodplain (e.g., access tracks, drill pads).
Little Morwell River	Partially confined to confined, moderate sinuosity channel	No evidence of major erosion, sandy bed with basalt outcrops likely limit erosion	Laterally active across limited floodplain extent, floodplain is discontinuous as the channel occasionally abuts the valley margin.	Trench excavation in channel, potential impacts on flow behaviour, bed/bank erosion and sediment release. Changed flow routing and potential increased bank erosion due to project assets located within floodplain (e.g., access tracks, drill pads).
Tarwin River East Branch	Partially confined (right bank confined), moderate sinuosity channel	No evidence of major erosion		Trench excavation in floodplain and channel, potential impacts on flow behaviour, local erosion and sediment release. Changed flow routing and potential increased bank erosion due to project assets located within floodplain (e.g., access tracks, drill pads).
Tributaries of Tarwin River East Branch	Partially confined upstream, moving to unconfined meandering channel, perched.	No evidence of major erosion		Trench excavation in floodplain and channel, potential impacts on flow behaviour, local erosion and sediment release. Changed flow routing and potential increased bank erosion due to project assets located within floodplain (e.g., access tracks, drill pads).
Stony Creek	Partially confined (right bank confined), moderate sinuosity channel	Only minor bank erosion evident		Trench excavation in floodplain and channel, potential impacts on flow behaviour, local erosion and sediment release. Changed flow routing and potential increased bank erosion due to project assets located within floodplain (e.g., access tracks, drill pads).
Buffalo Creek	Partially confined to confined (upstream), moderate sinuosity channel with shallow levee banks, unconfined downstream	No evidence of major erosion	Laterally active across limited floodplain extent, floodplain is discontinuous as the channel occasionally abuts the valley margin or is limited by levees.	Trench excavation in floodplain and channel, potential impacts on flow behaviour, local erosion and sediment release. Changed flow routing and potential increased bank erosion due to project assets located within floodplain (e.g., access tracks, drill pads).
Fish Creek	Transition from partially confined low sinuosity channel to unconfined straightened channel	Evidence of major incision (deepening and widening), bed and bank erosion.	Limited by confinement upstream, prone to / undergoing phases of incision after landscape disturbance.	Trench excavation in floodplain and channel, potential impacts on flow behaviour, local erosion and sediment release. Changed flow routing and potential increased bank erosion due to project assets located within floodplain (e.g., access tracks, drill pads). Any potential risk to the stability of Fish Creek during construction will be managed through the implementation of the EPRs (EPR SW01 and EPR SW03 (see section 6.6)).

Converter and transition stations

Hazelwood converter station

Analysis of the shear stress results from the detailed flood modelling for the proposed works at the Hazelwood converter station indicate that shear stress is expected to increase in both the current, and climate change scenarios. Figure 46 and Figure 47 indicate that the magnitude of increases is up to 5 N/m^2 across the main drainage channels to the north of the proposed development footprint, with the climate change scenario not resulting in a significant variation to the magnitude. Results indicate that the proposed development will also result in some isolated increases in shear stress of up 10 N/m^2 to the west of the site under the existing and climate change scenarios. Increases of this magnitude have the potential to initiate erosion beyond existing conditions.

The existing Hazelwood Terminal Station will be subject to increases in shear stress of 5 N/m^2 in both the current, and projected climate change scenario, however the concrete areas are not anticipated to be subject to erosion, given their threshold of almost 600 N/m^2. The drainage channels to the north that are located outside the terminal station footprint are currently grassed and will likely be subject to additional erosion under both the current and climate change scenarios as result of the proposed works.

Erosion control works along this channel boundary will be required to mitigate the impact of the development on the stability of the drainage channels. This will need to be undertaken in consultation with the WGCMA (drainage authority) during the Works on Waterway permit stage and may include rock and or vegetation to help reduced erosion potential.

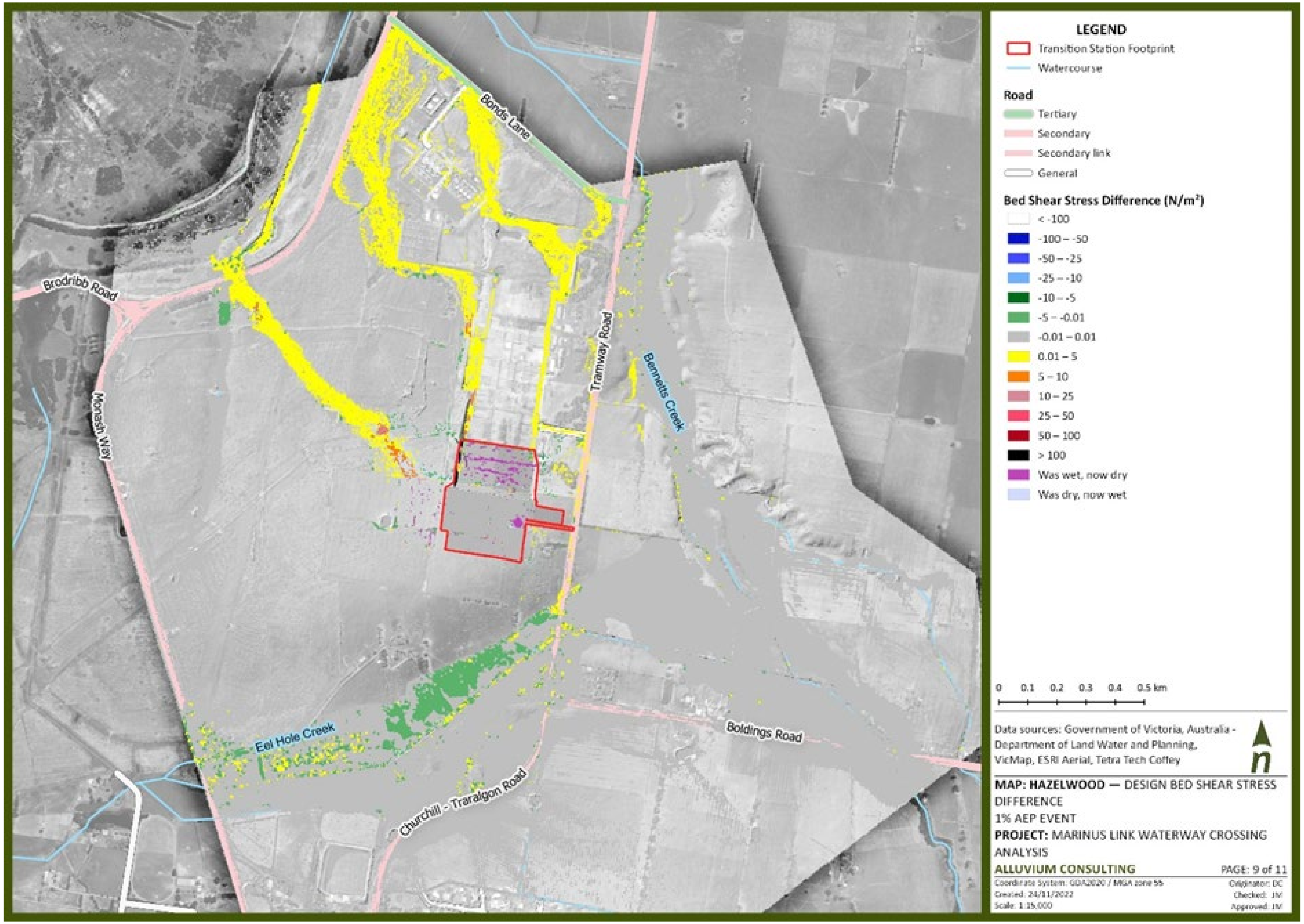

Figure 46. *Hazelwood 1 % AEP shear stress difference to design case*

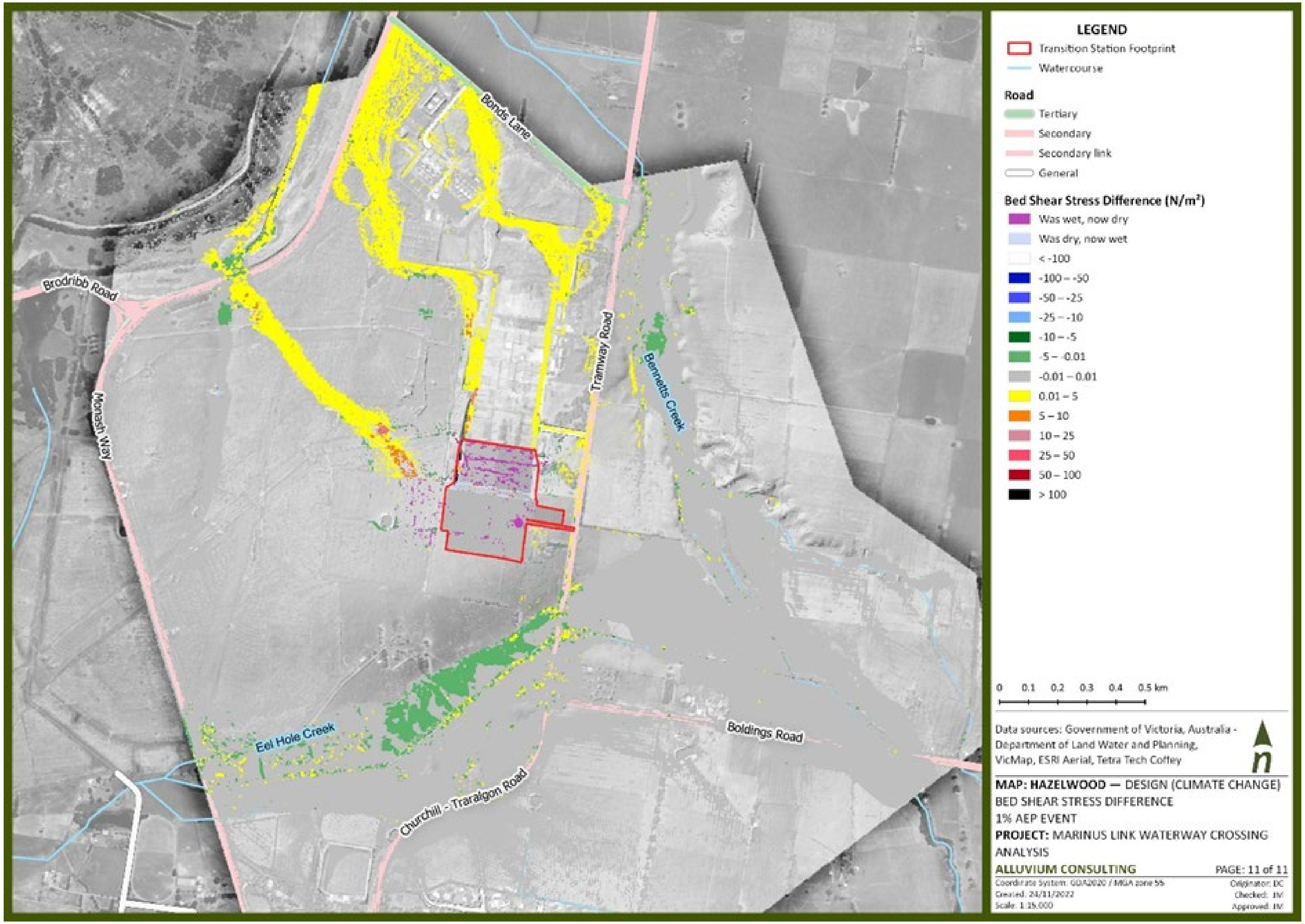

Figure 47. *Hazelwood climate change 1 % AEP shear stress difference to design case*

Driffield converter station

Analysis of the shear stress results from the detailed flood modelling for the proposed works at the Hazelwood converter station indicate that shear stress is expected to increase in both the current, and climate change scenarios. Figure 48 and Figure 49 indicate that the magnitude of increases is up to 10 N/m^2 in the drainage channel immediately to the west of the development footprint in both the current and climate change scenarios. To the north of the site, three drainage lines show increases in shear stress in both the current and climate change scenarios, typically in the order of up to 5 N/m^2. The centre of the three lines appears as a well-defined channel, with the modelling indicating increases in shear stress of greater magnitude, generally up to 50 N/m^2 with isolated pockets of increases up to 100 N/m^2 in both current and under climate change projections.

The designated drainage channel to the north, and the channel immediately to the west of the footprint will require erosion control works to mitigate the impact of the development on the stability of the drainage channels. This will need to be undertaken in consultation with the WGCMA (drainage authority) during the Works on Waterway permit stage and may include rock and or vegetation to help reduced erosion potential.

Upstream (to the south) of Smiths Road, under the current scenario, the proposed development will result in increases of shear stress of up to 5 N/m^2. Shear stresses in the baseline characterisation are in the order 80-100 N/m^2, with some isolated pockets of up to 200 N/m^2.

In its current form, shear stresses along this “channel” will likely exceed the shear resistance of the boundary materials presented in Table 18 and will require erosion control works to mitigate the impacts of the project. This will need to be undertaken in consultation with the WGCMA (drainage authority).

Results from south of Smiths Road may be as a result of terrain errors at the boundary of the LiDAR collected specifically for this project, and LiDAR provided by the WGCMA. Along this boundary, the DEM prepared for the modelling appears to show a channel, however aerial imagery indicates otherwise. Further modelling may resolve this issue, however, may only reduce the extent of erosion control works required to mitigate the impacts.

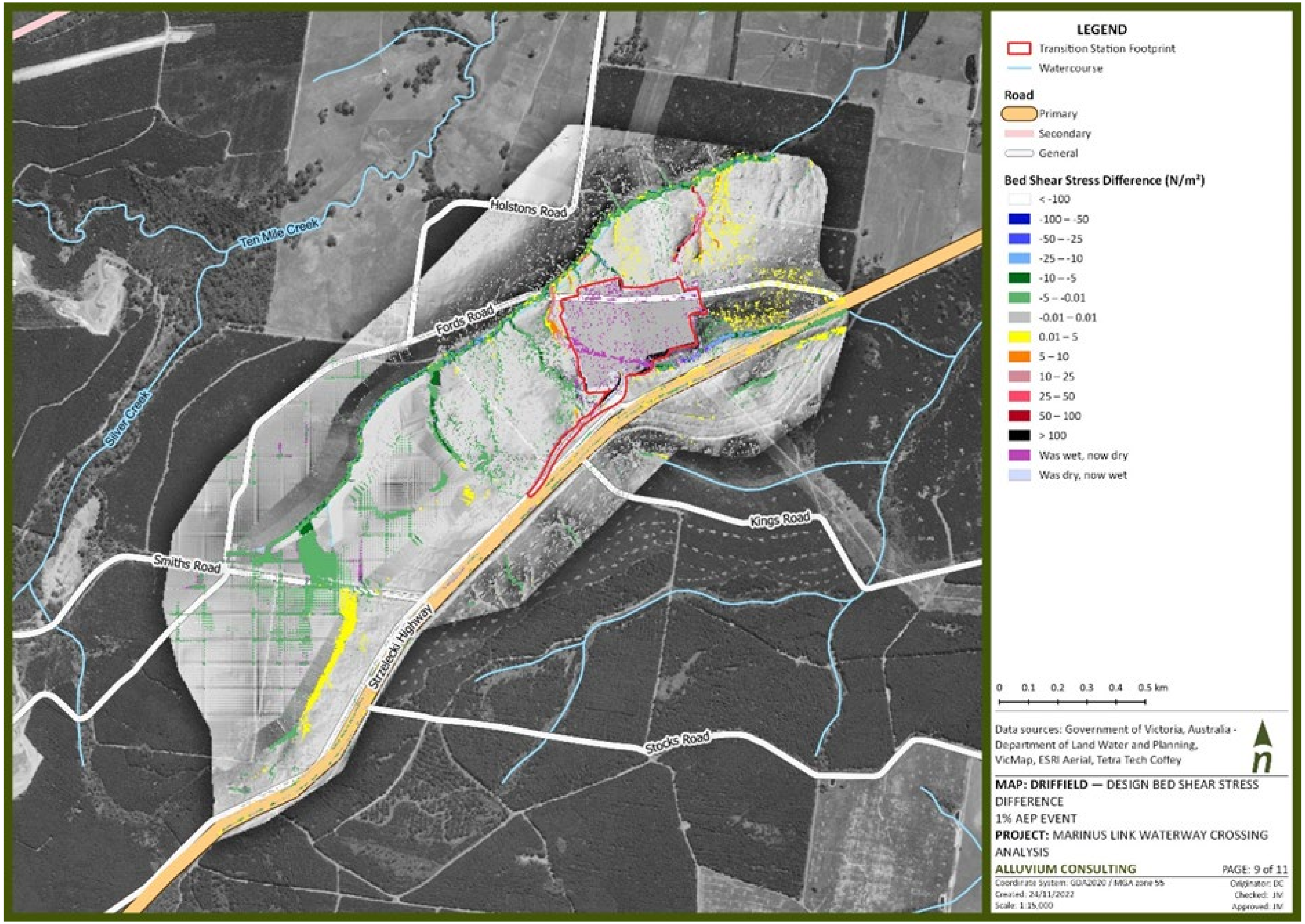

Figure 48. *Driffield 1% AEP shear stress difference to design case*

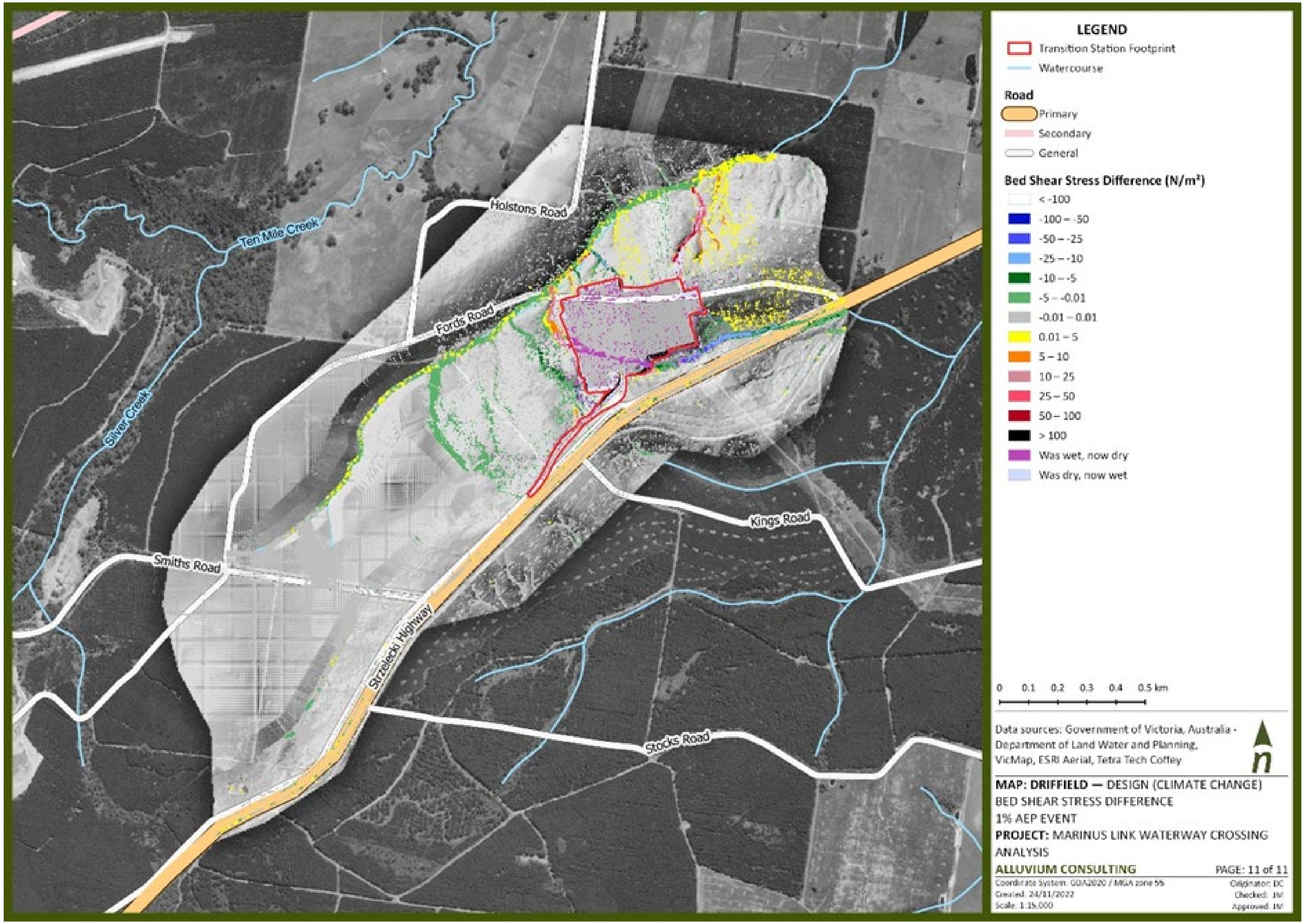

Figure 49. *Driffield climate change 1% AEP shear stress difference to design case*

Waratah Bay transition station

Impacts to shear stress as a result of the proposed transition station are presented in Figure 50 for the 0.5 % AEP event and in Figure 51 for the climate change 0.5 % AEP event. The results indicate that adjacent to the site, shear stress drops as a result of the works, which is a symptom of the increased flood depths in these locations. Other areas in the model show increases in the overland flow paths of between 0.1-5 N/m^2.

Given the erosion threshold of 4.55 N/m^2 for the channel boundary material of grazing, or grass, and taking into account the erosion expected under existing conditions, the associated increase to shear stress is likely to be inconsequential for both the design, and climate change design scenarios.

Figure 50. *Waratah Bay 0.5 % AEP shear stress difference to design case*

Figure 51. *Waratah Bay climate change 0.5 % AEP shear stress difference to design case*

Geomorphology risks identified

Based on the geomorphology assessment several risks were identified, the hazard and pathways/ mechanism for these risks are outlined in Table 24.

Table 24. Identified risks associated with geomorphology, including hazard and pathway/mechanism.

ID	Hazard	Impact pathway/mechanism	Risk
C.3	Construction activities	Direct alteration of waterways that alters flow behaviour, initiates/increases erosion and/or disrupts physical waterway habitat (e.g., bank disturbance).	Construction activities causing unintended damage to waterways resulting in changed flow behaviour, bed or bank erosion, and/or physical habitat.
C.5	Construction activities	Direct or indirect activities that cause damage to the bed or bank of the waterway, such as bank slumping/collapse e.g., heavy machinery on channel banks, operations within the channel, including trenching. Sediment release impacts water quality and waterway stability through aggradation.	Construction activities resulting in bed or bank erosion and sediment release.
C.6	Construction activities	Open excavation or exposed soil is inundated in a flood event within construction period, causing sediment to be liberated and travel through surface water into waterways, impacting on water quality and waterway stability through aggradation.	A flood event occurring during the construction of the joint pits, HDD drill pads, access roads or trenches causing inundation of assets and sediment liberation.
C.7	Construction activities	Direct rainfall or a flood event inundates soil stockpiled as part of construction activities, causing sediment to be liberated and travel through surface water into waterways, impacting on water quality and waterway stability through aggradation.	A flood event occurring during construction, inundating soil stockpiles and resulting in sediment release.
O.2	Operation/ permanent assets	Changes to current land use from permanent project assets such as access tracks, joint pits, or other hardstand areas are created which reduce the ability for water to infiltrate into the ground, causing increase in surface runoff, changes to flow discharge, and/or bed and bank erosion, increasing sediment supply to waterways.	Landuse changes, where an increase in impervious area results in an increase in flow discharge leading to bed or bank erosion.
O.3	Operation/ permanent assets	Road/access track drainage is insufficient to convey rainfall associated with increase rain intensities as a result of climate change. Reduced drainage capacity may lead to diversion of water/flooding elsewhere, erosion of waterways and liberation of sediment travelling in surface water to waterways.	Insufficient capacity of maintenance access road drainage design due to increased rainfall intensities from climate change resulting in an impact to flooding and sediment runoff.
O.4	Operation/ permanent assets	Diversion of stormwater, drainage alignment or flow pathways leading to bed or bank erosion causing instability of assets adjacent to the waterway and/or increased sediment loads.	Diversion of stormwater, drainage alignment or flow pathways leading to bed or bank erosion causing instability of assets adjacent to the waterway and/or increased sediment loads.

6.5 Summary of risk assessment

Based on the initial risks identified in Sections 6.2 6.3 and 6.4, a combined risk assessment for surface water was undertaken with respect to the construction and operation project stages. Table 25 outlines this risk assessment, prior to development of the EPRs. The residual risk assessment takes into account the implementation of the specified EPRs, which is summarised in section 6.7.

Risks associated with decommissioning will need to be assessed at the time of decommissioning.

Table 25. Surface water risk assessment prior to implementation of mitigation measures and controls.

Risk ID	Impact pathway/mechanism	Risk identified	Values impacted	Sites	Likelihood	Consequence	Risk rating	Comment
Construction and operation								
C.1	Temporary activities such as excavation, stockpiling and alteration of topography or change in impervious surfaces alters floodplain storage capacity to store/transport floodwaters and/or diverts flow.	Increase in flood inundation frequency, velocity or level which affects users or assets within the floodplain.	Flood storage behaviour and associated functions (flooding)	All waterway crossings, converter station and transition stations	Possible	Moderate	Moderate	Through increases in impervious areas and changes to existing surface levels.
C.2	Excavation, filling or other interference with existing overland/surface flow pathways leading to changes in flow conveyance behaviour, direction, velocity or other characteristics.	Construction activities, such as trenching on existing flow paths including piped flow, causing a change in flow.	Flood conveyance behaviour and associated functions (flooding)	Open trench construction waterway crossings (i.e., Little Morwell River)	Likely	Moderate	High	Open trench construction through waterway.
				Trenchless construction waterway crossings, converter station and transition stations	Possible	Moderate	Moderate	Diversion of floodplain flows during construction (e.g., access tracks, bunding).
C.3	Direct alteration of waterways that alters flow behaviour, initiates/increases erosion and/or disrupts physical waterway habitat (e.g., bank disturbance).	Construction activities such as trenching, causing unintended damage to waterways resulting in changed flow behaviour, bed or bank erosion, and/or physical habitat.	Flood conveyance behaviour, waterway stability and associated functions (flooding)	Open trench construction waterway crossings (i.e., Little Morwell River)	Likely	Moderate	High	Direct alteration of waterway through trench and access track construction.
				Trenchless construction waterway crossings, converter station and transition stations	Possible	Moderate	Moderate	No AoD within channel.
C.4	Spill of hazardous or potentially polluting chemicals or materials used in construction are released into the waterway during rainfall event (runoff or resulting from a flood event).	Hazardous materials during construction of the project being released into the waterways.	Water quality	All waterway crossings, converter station and transition stations	Possible	Major	High	

Risk ID	Impact pathway/mechanism	Risk identified	Values impacted	Sites	Likelihood	Consequence	Risk rating	Comment
C.5	Direct or indirect activities that cause damage to the bed or bank of the waterway, such as bank slumping/collapse e.g., heavy machinery on channel banks, operations within the channel, including trenching. Sediment release impacts water quality and waterway stability through aggradation.	Construction activities resulting in bed or bank erosion and sediment release.	Water quality, waterway stability, flood behaviour and associated functions (geomorphology)	Open trench construction waterway crossings (i.e., Little Morwell River)	Possible	Major	High	Sediment or contaminant release in major flood event during construction.
				Trenchless construction waterway crossings, converter station and transition stations	Possible	Major	High	
C.6	Open excavation or exposed soil is inundated in a flood event or direct rainfall within construction period, causing sediment to be liberated and travel through surface water into waterways, impacting on water quality and waterway stability through aggradation.	A flood event occurring during the construction of the joint pits, HDD drill pads, access roads or trenches causing inundation of assets and sediment liberation.	Water quality, waterway stability (geomorphology)	All major waterway crossings, converter station and transition stations	Possible	Moderate	Moderate	
C.7	Direct rainfall or a flood event inundates soil stockpiled as part of construction activities, causing sediment to be liberated and travel through surface water into waterways, impacting on water quality and waterway stability through aggradation.	Direct rainfall/ flood event occurring during construction, inundating soil stockpiles and resulting in sediment release.	Water quality, waterway stability (geomorphology)	All major waterway crossings, converter station and transition stations	Possible	Moderate	Moderate	
C.8	Horizonal directional drilling results in frac out- where the clays used to line the tunnel walls leech into a waterway impacting on water quality.	Hazardous materials during construction of the project being released into the waterways.	Water quality	All waterway crossings where HDD is utilised	Possible	Major	High	
Operation								
O.1	Permanent project assets including bunds, access roads, drains and modification to surface levels leading to changes in flow conveyance behaviour, direction, velocity or other characteristics.	Diversion of stormwater, drainage alignment or flow pathways causing a change to flow downstream	Flood conveyance behaviour and associated functions (flooding), Water quality	All major waterway crossings, converter station and transition stations	Unlikely	Major	Moderate	
O.2	Changes to current land use from permanent project assets such as access tracks, joint pits, or other hardstand areas are created which reduce the ability for water to infiltrate into the ground, causing increase	Land use changes, where an increase in impervious area results in an increase in flow	Flood behaviour and associated functions (flooding), water	Driffield converter station	Almost certain	Moderate	High	Increases in shear stress beyond boundary material shear threshold

Risk ID	Impact pathway/mechanism	Risk identified	Values impacted	Sites	Likelihood	Consequence	Risk rating	Comment
	in surface runoff, changes to flow discharge, and/or bed and bank erosion, increasing sediment supply to waterways.	discharge leading to bed or bank erosion.	quality, waterway stability (geomorphology)	All other major waterway crossings, converter station and transition station	Possible	Moderate	Moderate	
O.3	Road/access track drainage is insufficient to convey rainfall associated with increase rain intensities as a result of climate change. Reduced drainage capacity may lead to diversion of water/flooding elsewhere, erosion of waterways and liberation of sediment travelling in surface water to waterways.	Insufficient capacity of maintenance access road drainage design due to increased rainfall intensities from climate change resulting in an impact to flooding and sediment runoff.	Flood behaviour and associated functions (flooding), water quality, waterway stability (geomorphology)	All major waterway crossings, converter station and transition stations	Possible	Moderate	Moderate	
O.4	Permanent project assets such as access tracks, bunds, joint pits, or other modified areas causes diversion of runoff routes or flow pathways which leads to a loss of floodplain storage capacity to store/transport floodwaters and/or diverts flow.	Diversion of stormwater, drainage alignment or flow pathways leading to bed or bank erosion causing instability of assets adjacent to the waterway and/or increased sediment loads.	Flood storage behaviour and associated functions (flooding)	Open trench construction waterway crossings (i.e., Little Morwell River)	Almost certain	Moderate	High	Access track proposed through waterway
				All other major waterway crossings, converter station and transition stations	Possible	Moderate	Moderate	
O.5	Permanent project assets such as access tracks, bunds, joint pits, or other modified areas causes diversion of runoff routes or flow pathways which leads to ongoing redirection of flow, initiation/ acceleration of waterway bed/bank erosion and increased sediment supply to waterways. .	Diversion of stormwater, drainage alignment or flow pathways leading to bed or bank erosion causing instability of assets adjacent to the waterway and/or increased sediment loads	Flood behaviour and associated functions (flooding), water quality, waterway stability (geomorphology)	Open trench construction waterway crossings (i.e., Little Morwell River)	Almost certain	Moderate	High	Access track proposed through waterway
				All other major waterway crossings, converter station and transition stations	Possible	Moderate	Moderate	

Risk ID	Impact pathway/mechanism	Risk identified	Values impacted	Sites	Likelihood	Consequence	Risk rating	Comment
O.6	Spill of hazardous or potentially polluting chemicals or materials used during operation are released into the waterway during rainfall event (runoff or resulting from a flood event).	Hazardous materials during operation of the project being released into the waterways.	Water quality	All major waterway crossings, converter station and transition stations	Likely	Moderate	High	

6.6 Environmental Performance Requirements

In order to reduce the risks posed by the project on surface water, the project is applying an outcomes-based approach to environmental management through the preparation of EPRs.

The EPRs set out the environmental outcomes that must be achieved during the design, construction, operation and decommissioning phases of the project.

The flexibility of these surface water EPRs extends to the construction methods and design, with the techniques able to be varied, provided the environmental outcomes of the EPRs are achieved and all EPRs are reviewed prior to works commencing, as required.

The following EPRs have been informed by the example mitigation measures discussed in the impact assessment (Section 6). The EPRs have also been developed with consideration of industry standards and relevant legislation, guidelines and policies.

The proponent will be responsible for implementing the EPRs and Independent Environmental Auditor (IEA) appointed to verify compliance. This will be documented in the environment management framework within the EIS/EES.

The recommended EPRs and associated mitigation measures for construction and operation phases of the project are presented in Table 26.

Table 26. Surface water environmental performance requirements

EPR No.	Environmental Performance Requirement

SW01	**Develop and implement an erosion and surface water management plan**
	Prior to commencement of project works, develop a plan to manage erosion and surface water.
	The plan must:
	- Be developed in consultation with West Gippsland Catchment Management Authority.
	- Document the existing condition of all waterways and drainage lines potentially affected by construction (including their immediate surrounds) to establish baseline conditions and inform development of measures to manage potential impacts.
	- Describe sediment and erosion controls and monitoring requirements in accordance with EPA Victoria Publication 1834.1 Civil construction, building and demolition guide, and with reference to the IECA Best Practice Erosion and Sediment Control Guidelines 2008.
	- Identify controls to:
	  • Maintain the key hydrologic and hydraulic functionality and reliability of existing flow paths and drainage channels.
	  • Retain existing flow characteristics to maintain waterway stability downstream of construction.
	  • Minimise erosion and acceleration of stream processes to protect bank stability of waterways and drainage channels that could be affected by directly or indirectly affected by construction activities, in accordance with West Gippsland Catchment Management Authority requirements.
	- Details of measures for revegetation and reinstatement of the beds and banks of waterways and drainage lines in accordance with West Gippsland Catchment Management Authority requirements. The measures should be appropriate for the different categories of waterways and drainage channels considering if they are subject to shear stress that exceeds the boundary material resistance thresholds, and the extent of existing native vegetation in and around the stream that will be impacted.
	- Location for storage of contaminated material, hazardous substances or stockpiled soil outside an appropriate flood level and to the requirements of EPA Victoria and the relevant drainage authority.
	- Protocol for scheduling of works to minimise or avoid flood related risks (see EPR SW03).
	- Details of the stormwater drainage system and spills containment measures for construction areas to manage the risk of hazardous spills and runoff to waterways from paved or trafficable surfaces. This must include requirements for bunding of excavations including joint pits to avoid contamination of stormwater.
	- Measures for minimising, the handling, classifying, treating, disposing and otherwise managing wastewater. Wastewater from the site may be subject to approval by the relevant authority prior to discharges occurring and subject to classification under the Environment Reference Standard requirements in accordance with the EP Act.
	- Emergency response protocol for flooding events and frac out during HDD construction under waterways. Methods for HDD drilling to prevent frac out and the use of non-toxic drilling fluids are described in EPR GW03.
	- Review and update of the plan annually to address the outcomes of water quality monitoring as required by EPR SW03.
	- The plan must be a sub plan to the CEMP and implemented during construction.

EPR No.	Environmental Performance Requirement
SW02	**Minimise flood risk due to permanent infrastructure** Prior to commencement of project works, develop a design for permanent infrastructure to address the requirements outlined in the *Guidelines for Development in Flood Prone Areas* (West Gippsland Catchment Management Authority, 2020), that demonstrates how the project has been designed to mitigate the overall flood risk and incorporate flood protection measures where required. The design must: - Be developed in consultation with West Gippsland Catchment Management Authority. - Be assessed and informed by a hydraulic flood model prepared for the design of permanent works to assess overall flood risk to the community and the project, predict changes to flow regimes, and to demonstrate the resultant flood levels and risk profile. - Include a flood modelling report prepared to document the modelling and how it has addressed current climate conditions and the potential effects of climate change considering pre and post work scenarios as predicted at the end of assets design life using RCP4.5 and RCP8.5 projections (Ball, et al., 2019). The repot must also outline how the hydraulic modelling has been scoped in consultation with West Gippsland Catchment Management Authority. - Document the measures to manage overland stormwater flows and provide protection of joint pits, the converter station, transition station and any other permanent works from flood waters. - Document the events and scenarios modelled to inform the overall flood risk to the community and the project, and assess potential flood damage to permanent works. - Document mitigation measures develop to address areas of predicted increase flood risk and the engagement undertaken with the relevant drainage authority or asset owner to seek acceptance of the measures.
SW03	**Minimise impacts due to flooding during construction** Prior to commencement of project works, develop a flood risk management plan to address the requirements outlined in the *Guidelines for Development in Flood Prone Areas* (West Gippsland Catchment Management Authority, 2020), that demonstrates how the project has been designed to mitigate the overall flood risk and incorporate flood protection measures where required. The plan must: - Be developed in consultation with West Gippsland Catchment Management Authority. - Be assessed and informed by a hydraulic model prepared to assess overall flood risk and flow regime that could affect temporary work sites, and to demonstrate the resultant flood levels and risk profile during construction. - Include a flood modelling report that document the events and scenarios modelled to inform the overall flood risk to the community and the project and assess potential flood damage to construction works. - Document the measures and work scheduling requirements to minimise or avoid or minimise flood related risks for construction sites and temporary structures. The flood risk management plan must be a subplan to the CEMP and implemented during construction.

EPR No.	Environmental Performance Requirement

SW04	**Develop and implement a surface water monitoring program**
	Prior to commencement of project works develop a surface water monitoring program to assess water quality and waterway conditions during construction. The monitoring program must:
	- Be developed in consultation with the EPA Victoria and West Gippsland Catchment Management Authority.
	- Include monitoring locations at suitable distances both upstream and downstream of works to establish baseline conditions prior to construction.
	- Include parameters, frequency, durations of water quality monitoring and waterway condition inspections.
	- Be implemented for up to 12 months after commencement of operation, or a lesser period agreed with EPA Victoria (EPR SW05)
	- Outline requirements for data to be reviewed to assess the discharges and runoff from the project against Environment Reference Standard requirements and confirm the effectiveness of environmental controls.
	- Monitor the condition of reinstated waterway crossings and riparian vegetation to confirm the re-establishment of vegetation (EPR SW01).
	- Be developed with reference to applicable policies and guidelines, including:
	    o the EP Act
	    o Environment Reference Standard
	    o Victorian Stormwater Committee's Victoria *Best Practice Environmental Management Guidelines for Urban Stormwater* (as published by CSIRO in 1999 with assistance from EPA Victoria and others)
	    o EPA Victoria Publication 596 *Point source discharges to streams: protocol for in-stream monitoring and assessment*
	    o *Industrial Waste Resource Guideline 701 Sampling and analysis of waters, wastewaters, soils and wastes*.
	The surface water monitoring program must be implemented during construction with results used to inform the development, review and updating of the plan prepared to manage erosion and surface water (EPR SW01).

SW05	**Develop and implement measures to manage potential impacts to surface water in operation** As part of the OEMP, develop and implement measures to avoid or minimise impacts to surface water during the operation, in accordance with West Gippsland Catchment Management Authority requirements. The measures must include: - Ongoing surface water quality monitoring requirements, as outlined in the surface water monitoring program (EPR SW03) - Controls for management of sites and materials to prevent erosion, runoff of contamination and sediments entering waterways - Requirements for monitoring the establishment of revegetation at waterway crossings.

In addition to the surface water EPRs outlined in Table 26, the other EPRs that would reduce the potential impacts due to surface water resulting from the project, including:

- Groundwater;
- Contaminated land; and
- Terrestrial ecology.

A decommissioning management plan will be prepared to outline how activities will be undertaken and potential surface water impacts will be managed including risks and addressing the items outlined in these surface water EPRs. The EPR for the decommissioning management plan is provided in EIS/EES Volume 5, Chapter 2 – Environmental Management Framework.

6.7 Residual risk summary

Following the implementation of the EPRs developed in Section 6.6, a residual risk assessment has been prepared with the results presented in Table 27. Risk assessment as per methodology detailed in Section 4 and Table 12 of this report.

Table 27. Residual risk assessment

Initial risk (prior to implementation of EPRs, refer to Table 25)					EPR control to be implemented	Residual risk (with EPR successfully implemented)			
Risk ID	Impact pathway/mechanism	Values impacted	Sites	Risk rating	(refer to Table 26)	Likelihood	Consequence	Risk rating	Description
Construction									
C.1	Temporary activities such as excavation, stockpiling and alteration of topography or change in impervious surfaces alters floodplain storage capacity to store/transport floodwaters and/or diverts flow.	Flood storage behaviour and associated functions (flooding)	All waterway crossings, converter station and transition stations	Moderate	SW01, and SW03	Unlikely	Moderate	Low	Implementation of EPRs SW01 and SW03 can reduce the likelihood of impacting flood storage behaviour over the duration of the project activity to unlikely, with short-term impacts extending beyond the operational area that can be ameliorated. Standard management controls may include: locating stockpiles outside floodplains, earthwork cut/fill balance to maintain floodplain storage.
C.2	Excavation, filling or other interference with existing overland/surface flow pathways leading to changes in flow conveyance behaviour, direction, velocity or other characteristics.	Flood conveyance behaviour and associated functions (flooding)	Open trench construction waterway crossings	High	SW01, and SW03	Unlikely	Moderate	Low	Implementation of EPRs SW01, and SW03 can reduce the likelihood of impacting flood conveyance behaviour over the duration of the project activity to unlikely, with short-term impacts extending beyond the operational area that can be ameliorated. Standard management controls may include: earthwork design to maintain overland / surface flow pathway capacity and include erosion control armouring where required.
			Trenchless construction waterway crossings, converter station and transition stations	Moderate		Unlikely	Moderate	Low	

Initial risk (prior to implementation of EPRs, refer to Table 25)					EPR control to be implemented	Residual risk (with EPR successfully implemented)			
Risk ID	Impact pathway/mechanism	Values impacted	Sites	Risk rating	(refer to Table 26)	Likelihood	Consequence	Risk rating	Description
C.3	Direct alteration of waterways that alters flow behaviour, initiates/increases erosion and/or disrupts physical waterway habitat (e.g., bank disturbance).	Flood conveyance behaviour (flooding), waterway stability and associated functions (geomorphology)	Open trench construction waterway crossings	High	SW01 and SW03	Unlikely	Moderate	Low	Implementation of EPRs SW01 and SW03 can reduce the likelihood of impacting flood conveyance behaviour and waterway stability over the duration of the project activity to unlikely, with short-term impacts extending beyond the operational area that can be ameliorated. Standard management controls may include: earthwork design to maintain overland / surface flow pathway alignment and protect/reinstate physical waterway habitat where required.
			Trenchless construction waterway crossings, converter station and transition stations	Moderate		Unlikely	Moderate	Low	
C.4	Spill of hazardous or potentially polluting chemicals or materials used in construction are released into the waterway during rainfall event (runoff or resulting from a flood event).	Water quality	All waterway crossings, converter station and transition stations	High	SW01, SW04	Rare	Major	Low	Implementation of EPRs SW01 and SW04 can reduce the likelihood of spill of hazardous or potentially polluting chemicals over the duration of the project activity to rare (not anticipated), with widespread, long lasting and results in substantial change to surface water values requiring design responses. Standard management controls include: use of spill kits, bunding, dewatering procedures, emergency response and monitoring.

Initial risk (prior to implementation of EPRs, refer to Table 25)					EPR control to be implemented	Residual risk (with EPR successfully implemented)			
Risk ID	Impact pathway/mechanism	Values impacted	Sites	Risk rating	(refer to Table 26)	Likelihood	Consequence	Risk rating	Description
C.5	Direct or indirect activities that cause damage to the bed or bank of the waterway, such as bank slumping/collapse e.g., heavy machinery on channel banks, operations within the channel. Sediment release impacts water quality and waterway stability through aggradation.	Water quality, waterway stability (geomorphology), flood behaviour and associated functions (flooding)	Open trench construction waterway crossings	High	SW01, SW04	Unlikely	Moderate	Low	Implementation of EPRs SW01 and SW04 can reduce the likelihood of direct or indirect activities casing damage to the bed or bank of the waterway over the duration of the project activity to unlikely, with short-term impacts extending beyond the operational area that can be ameliorated. Standard management controls may include: limiting machinery movement to designated areas, sediment controls, erosion protection, monitoring.
			Trenchless construction waterway crossings, converter station and transition stations	High		Unlikely	Moderate	Low	
C.6	Open excavation or exposed soil is inundated in a flood event or direct rainfall within construction period, causing sediment to be liberated and travel through surface water into waterways, impacting on water quality and waterway stability through aggradation.	Water quality, waterway stability (geomorphology)	All major waterway crossings, converter station and transition stations	Moderate	SW01, SW03 and SW04	Unlikely	Moderate	Low	Implementation of EPRs SW01, SW03 and SW04 can reduce the likelihood of sediment liberation from open excavation/bare soils over the duration of the project activity to unlikely, with short-term impacts extending beyond the operational area that can be ameliorated. Standard management controls may include: sediment controls, limiting bare soil exposure, erosion protection, monitoring.

Initial risk (prior to implementation of EPRs, refer to Table 25)					EPR control to be implemented	Residual risk (with EPR successfully implemented)			
Risk ID	Impact pathway/mechanism	Values impacted	Sites	Risk rating	(refer to Table 26)	Likelihood	Consequence	Risk rating	Description
C.7	Direct rainfall or a flood event inundates soil stockpiled as part of construction activities, causing sediment to be liberated and travel through surface water into waterways, impacting on water quality and waterway stability through aggradation.	Water quality, waterway stability (geomorphology).	All major waterway crossings, converter station and transition stations	Moderate	SW01, SW03 and SW04	Unlikely	Moderate	Low	Implementation of EPRs SW01, SW03 and SW04 can reduce the likelihood of sediment liberation from stockpiles over the duration of the project activity to unlikely, with short-term impacts extending beyond the operational area that can be ameliorated. Standard management controls may include: sediment controls, limiting bare soil exposure, erosion protection, monitoring.
C.8	Horizonal directional drilling results in frac out- where the clays used to line the tunnel walls leech into a waterway impacting on water quality.	Water quality	All major waterway crossings where HDD is utilised	High	SW01, SW04	Rare	Major	Low	Implementation of EPRs SW01 and SW04 can reduce the likelihood of frac out over the duration of the project activity to rare (not anticipated), with widespread, long lasting and results in substantial change to surface water values requiring design responses. Standard management controls may include: emergency response procedures, monitoring.

Initial risk (prior to implementation of EPRs, refer to Table 25)					EPR control to be implemented	Residual risk (with EPR successfully implemented)			
Risk ID	Impact pathway/mechanism	Values impacted	Sites	Risk rating	(refer to Table 26)	Likelihood	Consequence	Risk rating	Description
Operation									
O.1	Permanent project assets including bunds, access roads, drains and modification to surface levels leading to changes in flow conveyance behaviour, direction, velocity or other characteristics.	Flood conveyance behaviour and associated functions (flooding) Water quality	All major waterway crossings, converter station and transition stations	Moderate	SW01, SW02, SW04 and SW05	Unlikely	Moderate	Low	Implementation of EPRs SW01, SW02, , SW04 and SW05 can reduce the likelihood of impacting flood conveyance behaviour and water quality over the duration of the project activity to unlikely, with short-term impacts extending beyond the operational area that can be ameliorated. Standard management controls may include: access track/road design to maintain overland / surface flow pathway capacity and include erosion control armouring where required.
O.2	Changes to current land use from permanent project assets such as access tracks, joint pits, or other hardstand areas are created which reduce the ability for water to infiltrate into the ground, causing increase in surface runoff, changes to flow discharge, and/or bed and bank erosion, increasing sediment supply to waterways.	Flood behaviour and associated functions (flooding), water quality, waterway stability (geomorphology)	Driffield converter station	High	SW01, SW02, SW04 and SW05	Unlikely	Moderate	Low	Implementation of EPRs SW01, SW02, SW04 and SW05 can reduce the likelihood of impacting flood behaviour, waterway stability and water quality over the duration of the project activity to unlikely, with short-term impacts extending beyond the operational area that can be ameliorated. Standard management controls may include: access track/road, hard surface areas design to minimise change surface flow discharge rates and volumes.
			All other major waterway crossings, converter station and transition station	Moderate	SW01, SW02, SW04 and SW05	Unlikely	Moderate	Low	

Initial risk (prior to implementation of EPRs, refer to Table 25)					EPR control to be implemented	Residual risk (with EPR successfully implemented)			
Risk ID	Impact pathway/mechanism	Values impacted	Sites	Risk rating	(refer to Table 26)	Likelihood	Consequence	Risk rating	Description
O.3	Road/access track drainage is insufficient to convey rainfall associated with increase rain intensities as a result of climate change. Reduced drainage capacity may lead to diversion of water/flooding elsewhere, erosion of waterways and liberation of sediment travelling in surface water to waterways.	Flood behaviour and associated functions (flooding), water quality, waterway stability (geomorphology)	All major waterway crossings, converter station and transition stations	Moderate	SW01, SW02, SW04 and SW05	Unlikely	Moderate	Low	Implementation of EPRs SW01, SW02, SW04 and SW05 can reduce the likelihood of impacting flood behaviour, waterway stability and water quality over the duration of the project activity to unlikely, with short-term impacts extending beyond the operational area that can be ameliorated. Standard management controls may include: road/access track drainage design to consider climate change scenarios.
O.4	Permanent project assets such as access tracks, bunds, joint pits, or other modified areas causes diversion of runoff routes or flow pathways which leads to a loss of floodplain storage capacity to store/transport floodwaters and/or diverts flow.	Flood storage behaviour and associated functions (flooding)	Little Morwell River (KP 61.55)	High	SW01, SW02	Unlikely	Moderate	Low	Implementation of EPRs SW01, and SW02 can reduce the likelihood of impacting flood storage behaviour and waterway stability over the duration of the project activity to unlikely, with short-term impacts extending beyond the operational area that can be ameliorated. Standard management controls may include: road/access track drainage design and earthwork cut/fill balance to maintain floodplain storage.
			All other major waterway crossings, converter station and transition stations	Moderate	SW01, SW02	Unlikely	Moderate	Low	
O.5	Diversion of stormwater, drainage alignment or flow	Flood behaviour and associated	Little Morwell River (KP 61.55)	High	SW01, SW02, SW04	Unlikely	Moderate	Low	Implementation of EPRs SW01, SW02, SW04 and SW05 can

Initial risk (prior to implementation of EPRs, refer to Table 25)					EPR control to be implemented	Residual risk (with EPR successfully implemented)			
Risk ID	Impact pathway/mechanism	Values impacted	Sites	Risk rating	(refer to Table 26)	Likelihood	Consequence	Risk rating	Description
	pathways leading to bed or bank erosion causing instability of assets adjacent to the waterway and/or increased sediment loads.	functions (flooding), water quality, waterway stability (geomorphology)	All other major waterway crossings, converter station and transition stations	Moderate	SW01, SW02, SW04 and SW05	Unlikely	Moderate	Low	reduce the likelihood of impacting flood behaviour, waterway stability and water quality over the duration of the project activity to unlikely, with short-term impacts extending beyond the operational area that can be ameliorated. Standard management controls may include: access track/road, hard surface areas design to maintain flow pathways and consider outfall arrangements that minimise erosion potential.
O.6	Spill of hazardous or potentially polluting chemicals or materials used during operation are released into the waterway during rainfall event (runoff or resulting from a flood event).	Water quality	All major waterway crossings, converter station and transition stations	High	SW01, SW04 and SW05	Rare	Major	Low	Implementation of EPRs SW01, SW04 and SW05 can reduce the likelihood of spill of hazardous or potentially polluting chemicals over the duration of the project activity to rare (not anticipated), with widespread, long lasting and results in substantial change to surface water values requiring design responses. Standard management controls include: use of spill kits, bunding, dewatering procedures, emergency response and monitoring.

6.8 Cumulative impact assessment

A cumulative impact assessment has been completed for the project in line with the impact assessment method outlined in Section 4.3. Four credible projects were identified that each might have potential the potential to affect surface water values in close proximity to the and/or within the project alignment. A summary of these projects is outlined in Table 28 below. No additional projects were identified.

Table 28. CIA potential projects for assessment

Proposal / proponent	Description	Location	Timing
Delburn Wind Farm https://osmi.com.au/planning/	Wind farm with up to 33-turbines Project site covers a total area of 4,778 hectares	Located in the Strzelecki Ranges, south of the Latrobe Valley. The routes for the two projects run in close alignment through the Hancock Victorian Plantations P/L (HVP) pine timber plantation at Delburn. The project alignment intersects the Delburn Wind Farm project area at Pleasant Valley Road in the south and has an interface of approximately 12 km to Driffield, where one of the proposed converter station sites is located for the project. It is not expected that the operation of both projects will interact given Marinus Link is primarily underground. The alignment of Marinus Link cables has sought to avoid cables from Delburn Wind farm and to provide appropriate separation where cables are in the same location.	Current status: Approved* in March 2022 Construction to commence: 2022 – 2023 (18-24months construction) – the PSA is currently being challenged in the court so this timing may be delayed. Specialists should consider impacts if in fact construction of both projects overlaps. Operation to commence: 2025 Design life: 25-30 years * Noting the planning permit is currently being considered in the supreme court.
Star of the South Offshore Wind Farm (SOTS) https://www.starofthesouth.com.au/environment-planning	Offshore wind farm with up to 200 turbines Generation of up to 2,200 MW	7-25 km off the south coast of Gippsland near towns such as Port Albert, McLoughlins Beach and Woodside Beach Located approximately 70km from the Marinus Link shore crossing. The proposed transmission line to connect the SOTS project largely follows the Bass Link project alignment and connects at Hazelwood in the Latrobe Valley. The projects may have an interface at Hazelwood at the existing Hazelwood terminal station. For the SOTS, the project will connect to the gird at the existing Loy Yang Power Station switchyard, and the proponent is also considering a back-up option to connect at Hazelwood terminal station.	Current status: Detailed planning/environmental approvals phase underway. Construction proposed to commence around 2025 Operation to commence: 2030 onwards

Proposal / proponent	Description	Location	Timing
Hazelwood Rehabilitation Project https://www.hazelwoodrehabilitation.com.au/about-the-project/	Rehabilitation of former Hazelwood Mine and Power Station, involving decommissioning of remaining buildings, roads and infrastructure, earthworks to reprofile steep slopes, reinstating some waterways to a more natural alignment, and the proposed creation of a mine lake.	Latrobe Valley in Victoria, near the town of Morwell. The projects will have an interface at Hazelwood. The project will connect to the electricity grid via one of two converter stations at either Driffield, constructed adjacent to the existing 500 kV transmission lines or at Hazelwood, adjacent to the existing terminal station.	Current status: Detailed planning/environmental approvals phase underway. Approval expected in 2024. Assuming construction to commence in 2025. Operation expected to commence: 2029 onwards
Wooreen Energy Storage System (WESS) https://www.energyaustralia.com.au/about-us/what-we-do/new-energy-projects/wooreen-energy-storage-system	Four-hour utility scale battery Storage capacity of up to 350 MW	Located at Jeeralang gas-fired power station in Victoria's Latrobe Valley. The projects will not be directly connected, however will be located in close proximity. The proposed energy storage system in Hazelwood North and Marinus Link converter station option at Hazelwood	Current status: Detailed planning/environmental approvals phase underway. Planning application expected to be made to DTP in 2022. Operation to commence end of 2026

An assessment of these in regard to its cumulative impact on surface water values, including flooding, water quality and geomorphology is outlined below.

CIA – Flooding, water quality and geomorphology

Of the proposed Initial Works, activities such as site establishment, ground improvement or site levelling works could of themselves create adverse flooding impacts. The other Initial Works will have a negligible impact due to the nominal change to existing conditions as a result of the works. These impacts have been considered in the impact assessments for the individual project components.

Potential pathways through which the identified projects in Table 29 could impact flooding, water quality and geomorphology have been analysed in below.

Table 29. CIA potential project impact pathway assessment

Proposal / proponent	Impact pathway assessment
Delburn Wind Farm https://osmi.com.au/planning/ Star of the South Offshore Wind Farm (SOTS) https://www.starofthesouth.com.au/environment-planning Hazelwood Rehabilitation Project https://www.hazelwoodrehabilitation.com.au/about-the-project/ Wooreen Energy Storage System (WESS) https://www.energyaustralia.com.au/about-us/what-we-do/new-energy-projects/wooreen-energy-storage-system	These major projects are likely to have similar impacts to surface water quality, geomorphology and flooding as identified in this impact assessment (Sections 6.2, 6.3 and 6.4). As an example, these include: • displacement of flood waters/volume that led to adverse flood impacts to surrounding property, key infrastructure and the environment • constricting the passage of flows passing through the site along the river channel or flow path that lead to increased shear stress values and increased scour of adjacent bed and banks • altered fluvial geomorphic processes, initiation of bed and bank scour and sediment delivery, which can result in habitat loss and ecosystem decline • disturbance to the bed or banks of waterways through ground disturbance activities (excavation, trenching, clearing, vehicular traffic etc.) within the riparian zone or instream. • changes to water quality, such as increased sediment loads, nutrient loads, addition of metals, hydrocarbons or other chemicals from spills that can lead to degradation in water quality, ecosystem health/reproduction or aesthetics alteration of the flow regime, such as diversion, duration, frequency, duration and timing of high and/or low flow events have potential to initiate bed and bank scour, resulting in habitat loss, sediment delivery which could have both ecological and physical form consequences

While these nearby projects have the potential to impact waterways in their vicinity during construction, it is not expected these projects will generate impacts that will affect the waterways in the project area due to their location.

In addition, it is expected that these nearby projects will adhere to their standard management measures such as those outlined in Section 4.4, as well as the Marinus Link project complying with its surface water EPRs, as those proposed in Section 6.6, which will mitigate the impacts.

As such it is considered unlikely that there will be potential for cumulative impacts to surface water values (flooding, water quality and geomorphology) or pose an increased health and safety risk to tunnel workers or operational staff within the project area.

6.9 Monitoring and review

The proposed EPRs should be accompanied by the establishment of a monitoring and maintenance program (as per SW04 and SW05 in section 6.6).

During detailed design, a specific surface water monitoring program for each defined major waterway as a minimum should be developed that can be used to monitor condition across all the works which can:

- Prior to commencement of construction: characterise the existing condition of receiving waters; and
- During construction: monitor water quality changes in receiving waters due to project activities.

The monitoring program should, as a minimum:

- Include monitoring locations at suitable distances both upstream and downstream of works to establish existing conditions.
- Include parameters, frequency, durations of water quality monitoring.
- Be implemented for up to 12 months after commencement of operation, or a lesser period agreed with the EPA (EPR SW04).
- Outline requirements for data to be reviewed to assess the discharges and runoff from the project against the ERS (2021) water quality objectives and confirm the effectiveness of environmental controls.
- Monitor the condition of reinstated waterway crossing and riparian vegetation, as required by EPR SW01, to confirm the re-establishment of vegetation.
- Be developed in consultation with the EPA Victoria and WGCMA with reference to applicable policies and guidelines, including the ERS (2021) requirements under the EP Act (Vic) , Victorian Stormwater Committee's Victoria Best Practice Environmental Management Guidelines for Urban Stormwater (as published by CSIRO in 1999 with assistance from EPA Victoria and others), EPA Victoria Publication 596 Point source discharges to streams: protocol for in-stream monitoring and assessment and Industrial Waste Resource Guideline 701 Sampling and analysis of waters, wastewaters, soils and wastes.

The monitoring program must outline conditions under which changes to water quality parameters need to be investigated, when works on-site need to be stopped in response to changes in parameters and what action is required to rectify changes in water quality if they are attributable to the site construction.

The monitoring program should include sufficient detail to confirm that information on target metrics can be routinely assessed and progress towards the project objectives can be tracked.

7 Conclusion

This report presents the results of the surface water impact assessment for the Victorian portion of the Marinus Link project.

Three key surface water values were identified that the proposed works may have adverse effects on: flooding, water quality and geomorphology. In assessing the potential impacts on these three values, the report has considered the impact under existing surface water conditions and those posed by climate change. The risk assessment has included the development of recommended surface water EPRs through applying mitigation measures to avoid and minimise adverse effects on surface water. The flexibility of these surface water EPRs extends to the construction methods and contractor design, with the techniques able to be varied, provided the environmental outcomes of the EPRs are achieved and all EPRs are reviewed prior to works commencing, as required.

Of the 82 waterways along the project alignment, HDD is proposed to be used to cross 15 waterways including seven of the eight major waterway crossings within the study area. Little Morwell River is the only major waterway that will not be crossed with HDD. The remaining 67 waterways will be crossed by open cut trench construction method.

The project has the potential to impact a number of the major waterway crossings including the Morwell River, Little Morwell River, Stony Creek, Tarwin River East Branch and tributaries, Buffalo Creek and Fish Creek, as well as the drainage channels downstream of the proposed converter stations at Hazelwood and Driffield, and transition station at Waratah Bay. The impact assessment has considered the risk of construction and operation of the project, adversely impacted flooding of the above waterway crossings and their floodplains and impacts to their water quality and geomorphology.

All surface water impacts relating to an elevated risk identified in this study have been considered and EPRs that either reduce or mitigate the impact proposed. While this report focused on 8 major waterway crossings these EPRs are to be adopted to all 82 waterway crossings identified and in the vicinity of any waterway that might have potential impacts from the project.

With the surface water EPRs in place there are no remaining high risks, and a small number of risks require additional flood modelling to confirm impacts can be mitigated. These are summarised below.

7.1 Construction

Residual construction risk ratings that are subject to final detailed modelling include:

- Construction activities causing an increase in flood frequency, velocity or level which affects users or assets within the floodplain.
- Construction activities on existing flow paths including piped flow, causing a change in flow.
- Construction activities causing unintended damage to waterways (and drainage channels) resulting in changed flow behaviour, bed or bank erosion, and/or physical habitat.
- Construction activities resulting in bed or bank erosion and sediment release.
- Construction activities causing sediment or contaminants to be released into the waterways.

7.2 Operation

Residual operation risk ratings that are subject to final detailed modelling include:

- Project assets causing an increase in flood frequency or level which affect users or assets within the floodplain.
- Diversion of stormwater, drainage alignment or flow pathways causing a change in flow to downstream.
- Diversion of stormwater, drainage alignment or flow pathways leading to bed or bank erosion causing instability of assets adjacent to the waterway and/or increased sediment loads.
- Increase in impervious area leading to an increase in sediment or contaminants released into the waterways.

While the flood mapping indicates that the proposed converter and transition stations will result in minor increases in flood depth and extent as a result of the works, this is generally limited to less than 50mm, contained to the immediate area and considered low impact. However, additional detailed flood modelling through the design phase should be undertaken to confirm the flood impact of the final design on adjacent infrastructure (such as roads), refine migration options and seek acceptance from WGCMA (as per EPR SW02 and SW03).

The implementation of the EPRs proposed within this report directly addresses the impacts identified and provides a means to manage the identified risks associated with the construction and operation phases to a low risk level.

Risks associated with decommissioning will need to be assessed at the time of decommissioning.

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Attachment 1. Waterway crossings summary

Waterway crossings summary

A GIS analysis of the intersections between the State waterways layer (hy_waterways) and the proposed project alignment was undertaken to identify all waterways the alignment crosses. A description of the attributes of the State waterways layer is provided in Table 30. Figure **52** maps the waterway crossings, with Table 31 providing a list of all 82 waterways intersected by the proposed project alignment including:

- Attributes of the State waterways layer (as described in Table 30)
- A comment on the waterway crossing as follows:
  - **Defined major waterways** (8 waterways) – Waterways that:
    - Can be defined on aerial imagery and/or LiDAR
    - Are included in VicMap Lite 1:250,000 to 1:5,000,000 waterways network layer
    - Have a catchment area greater than 5 km2
  - **Defined waterways** (2 waterways) – Waterways that:
    - Can be defined on aerial imagery and/or LiDAR
    - Are included in VicMap Lite 1:250,000 to 1:5,000,000 waterways network layer
    - Have a catchment area less than 5 km2
    - Have a HIERACHY classification of low or minor importance
  - **Small defined waterways** (28 waterways) – Waterways that:
    - Can be defined on aerial imagery and/or LiDAR
    - Are not included in VicMap Lite 1:250,000 to 1:5,000,000 waterways network layer
    - Have a HIERACHY classification of low or minor importance
  - **Undefined waterways** (44 waterways) – Waterways that:
    - Cannot be defined on aerial imagery and/or LiDAR
    - Have a HIERACHY classification of low or minor importance
- Coordinates of intersection with the proposed project alignment in GDA2020 zone 55 projection.

The State waterways layer can be found at: discover.data.vic.gov.au/dataset/vicmap-hydro-waterways-line1

Table 30. Metadata attributes of the State waterways layer (hy_waterways)

Column Name	Column Name 10	Definition
PFI	PFI	Persistent Feature Identifier. Assigned at the creation of the feature and is retained for the life of the feature.
UFI	UFI	Database wide Unique Feature identifier. Assigned at every feature creation or edit, superseded by each edit to the feature.
FEATURE_TYPE_CODE	FTYPE_CODE	Feature Code Includes: • waterways_river=RIVER • waterways_stream=STREAM • waterways_channel=CHANNEL/AQUEDUCT (Major) • waterways_channel_drain=DRAIN/CHANNEL • waterways_drain=DRAIN • connector_river=Connector through natural water (river) areas • connector_stream=Connector through natural water (stream) areas • connector_channel=Connector through man-made double-sided channels • connector_drain=Connector through man-made double-sided drains • connector_structure=Connector through water structures (pipes & spillways)
NAME	NAME	Name of a feature
NAMED_FEATURE_ID	NFEAT_ID	Unique identifier for feature name
ORIGIN	ORIGIN	Code to indicate whether a waterways is natural or man-made. ORIGIN Options: • 1=natural • 2=man-made
CONSTRUCTION	CONST	Code to indicate whether a waterways is a drain or channel. CONSTRUCTION Options: • 1=drain • 2=channel
USAGE	USAGE	Code to indicate the use made of the waterways USAGE Options: • 1=drainage • 2=irrigation • 3=water supply
HIERARCHY	HIERARCHY	Code to indicate the importance/size of a waterways HIERARCHY Options: • H=High or major importance feature • M=Medium or moderate importance feature • L=Low or minor importance feature
FEATURE_QUALITY_ID	FQID	Identifier for the feature quality record
CREATE_DATE_PFI	CRDATE_PFI	Date of original Creation of Feature
SUPERCEDED_PFI	SUPER_PFI	PFI of feature prior to merge or split operation
CREATE_DATE_UFI	CRDATE_UFI	Date of Creation of Feature

Figure 52. *Waterway crossings of the proposed project alignment.*

Table 31. Attributes of waterways that intersect the proposed project alignment.

				Hy_waterways attributes									Categorisation	Coordinates of intersection	
PFI	UFI	FTYPE_CODE	NAME	NFEAT_ID	ORIGIN	CONST	USAGE	HIERARCHY	FQID	CRDATE_PFI	SUPER_PFI	CRDATE_UFI		GDA20Z55_X	GDA20Z55_Y
9603139	3602264	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Defined major waterways	420062.909	5734091.736
9600175	3599300	waterways_river	TARWIN RIVER EAST BRANCH	9131	1		1	H	4762	4/04/2001	0	4/04/2001	Defined major waterways	422826.560	5736685.687
9566812	43056007	waterways_river	MORWELL RIVER	7730	1		1	H	4762	4/04/2001	0	16/02/2012	Defined major waterways	441715.272	5760839.308
9619736	18987748	waterways_stream	BUFFALO CREEK	5401	1		1	L	4762	4/04/2001	0	31/01/2008	Defined major waterways	415153.206	5720508.694
9611216	18987031	waterways_stream	STONY CREEK	9016	1		1	L	4762	4/04/2001	0	31/01/2008	Defined major waterways	417440.226	5727820.487
9576118	18984392	waterways_river	LITTLE MORWELL RIVER	7331	1		1	M	4762	4/04/2001	0	31/01/2008	Defined major waterways	431703.355	5752718.464
9622420	18987977	waterways_stream	FISH CREEK	1226	1		1	M	4762	4/04/2001	0	31/01/2008	Defined major waterways	414334.941	5717001.170
9604778	3603903	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Defined major waterways	419288.402	5732638.302
9574155	18984219	waterways_stream	STONY CREEK	9016	1		1	L	4762	4/04/2001	0	31/01/2008	Defined waterways	432578.549	5754409.339
9567600	3566720	waterways_channel_drain		0	2			L	4762	4/04/2001	0	4/04/2001	Small defined waterways	443724.774	5760341.708
9587130	3586250	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	427273.351	5745741.761
9566509	3565629	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	438742.597	5760699.915
9584192	3583312	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	428549.825	5747622.441
9587529	3586649	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	425752.570	5745429.041
9599942	3599067	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	422862.271	5736870.122
15915173	43048810	waterways_stream		0	1		1	L	4762	16/02/2012	9602586	16/02/2012	Small defined waterways	420133.286	5734379.850
15910897	43044207	waterways_stream		0	1		1	L	4762	16/02/2012	9586448	16/02/2012	Small defined waterways	428093.732	5746237.084
15911552	44748170	waterways_stream		0	1		1	L	4762	16/02/2012	9589322	24/01/2013	Small defined waterways	425681.865	5744306.554
15911925	43045338	waterways_stream		0	1		1	L	4762	16/02/2012	9590925	16/02/2012	Small defined waterways	425544.213	5743366.888
9625952	3625077	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	420413.783	5706161.575
9614639	3613764	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	416475.550	5725101.537
9626368	3625493	waterways_channel		0	2	2		L	4762	4/04/2001	0	4/04/2001	Small defined waterways	420456.870	5703703.249
9602515	3601640	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	420253.593	5734657.834
9571700	3570820	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	433373.054	5756542.036
9572043	3571163	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	433738.366	5756488.396
9584415	3583535	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	428494.918	5747426.516
9587240	3586360	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	427071.703	5745659.792
9618238	3617363	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	415794.541	5722701.513
9625620	3624745	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	419273.700	5707488.061
9612167	3611292	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	416968.179	5727117.519
9613277	3612402	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	416758.558	5726094.459
9624602	3623727	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	417312.211	5710644.684
9622308	3621433	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	414332.535	5717018.625
9621296	3620421	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	414308.446	5718395.858
9623525	3622650	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	413311.192	5714388.828
9622579	3621704	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	414037.551	5716663.041
9601176	3600301	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Small defined waterways	421973.679	5735714.812
9590659	3589779	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	425550.953	5743409.736
9566471	3565591	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	441084.738	5760938.266
9622042	3621167	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	414211.481	5717750.297
9591960	3591080	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	425428.217	5742629.454
9603177	3602302	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	420013.889	5733891.041
9587836	3586956	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	425803.243	5745293.317

				Hy_waterways attributes									Categorisation	Coordinates of intersection	
PFI	UFI	FTYPE_CODE	NAME	NFEAT_ID	ORIGIN	CONST	USAGE	HIERARCHY	FQID	CRDATE_PFI	SUPER_PFI	CRDATE_UFI		GDA20Z55_X	GDA20Z55_Y
9592569	3591689	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	425384.132	5742349.183
16597554	44748490	waterways_stream		0	1		1	L	4762	24/01/2013	15916043	24/01/2013	Undefined waterways	418563.102	5731037.125
16597427	44748260	waterways_stream		0	1		1	L	4762	24/01/2013	9594795	24/01/2013	Undefined waterways	424375.460	5740669.664
16588225	44732817	waterways_stream		0	1		1	L	4762	24/01/2013	15918368	24/01/2013	Undefined waterways	416028.663	5723527.196
16585904	44729236	waterways_stream		0	1		1	L	4762	24/01/2013	9585822	24/01/2013	Undefined waterways	428278.962	5746545.379
9625494	44733656	waterways_stream		0	1		1	L	4762	4/04/2001	0	24/01/2013	Undefined waterways	418815.098	5707841.752
9595064	18985982	waterways_stream	TOOMEY CREEK	9278	1		1	L	4762	4/04/2001	0	31/01/2008	Undefined waterways	424225.402	5740442.074
15920903	43055014	waterways_stream		0	1		1	L	4762	16/02/2012	9625286	16/02/2012	Undefined waterways	418123.894	5708915.982
15920854	43054959	waterways_stream		0	1		1	L	4762	16/02/2012	9625162	16/02/2012	Undefined waterways	418074.104	5708959.893
9566477	3565597	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	440337.436	5760769.350
9622629	3621754	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	413818.738	5716456.491
9624470	3623595	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	416746.225	5711037.021
9626403	3625528	waterways_channel_drain		0	2			L	4762	4/04/2001	0	4/04/2001	Undefined waterways	420453.023	5703679.355
9618342	3617467	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	415579.984	5721945.184
9605666	3604791	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	418681.002	5731769.981
9618695	3617820	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	415515.111	5721716.512
9625495	3624620	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	418789.511	5707865.303
9566306	3565426	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	441267.316	5760902.283
9603936	3603061	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	419591.255	5733107.365
9603896	3603021	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	419835.835	5733237.462
9624950	3624075	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	417732.852	5709600.863
9587750	3586870	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	425794.686	5745306.238
9594259	3593379	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	425133.167	5741083.276
9613451	3612576	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	416732.917	5726004.501
9614411	3613536	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	416507.351	5725213.112
9612595	3611720	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	416915.343	5726644.532
9608037	3607162	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	418360.860	5730135.291
9609059	3608184	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	418294.445	5729699.371
9603896	3603021	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	419676.280	5733148.029
9620527	3619652	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	414483.452	5719640.383
9625551	3624676	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	419039.861	5707634.873
9622899	3622024	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	413375.024	5715959.076
9624379	3623504	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	416056.166	5711274.879
9625552	3624677	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	418996.673	5707674.626
9624421	3623546	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	416644.505	5711079.412
9624542	3623667	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	417131.144	5710731.867
9623348	3622473	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	413094.554	5714758.154
9622834	3621959	waterways_stream		0	1		1	L	4762	4/04/2001	0	4/04/2001	Undefined waterways	413582.737	5716191.939

Attachment 2. Physical waterway processes

Physical waterway processes

The following provides understanding of physical waterway processes that could interact with the proposed project infrastructure or construction. These are

- Small- to moderate-scale erosion of the channel and floodplain
- Larger scale channel incision that occurs at the reach scale
- Moderate- to large-scale channel avulsion, including:
    - Meander cut offs
    - Reach-scale avulsion

Small to moderate scale erosion of the channel and floodplain

Erosion of the channel bed and banks has the potential to expose the buried cables or other floodplain infrastructure to both stream flow and debris. The scale of change is generally of centimetres to a few metres a year, however erosion can also be episodic and occur at a greater rate during high flow or flood events. These smaller-scale processes can also be combined with larger-scale channel change, described below.

Streambank (lateral) erosion can occur as a result of meander migration and/or channel widening. Meander migration causes erosion on the outside of the meander bend whereas channel widening causes erosion on both channel banks. Both meander migration and channel widening processes are episodic in un-regulated, non-tidal streams and often occur during flood events. The rate of meander migration and channel widening are also influenced by the extent and type of bedrock confinement and vegetation coverage. The presence of erosion resistant bedrock, or vegetation on the channel banks, tend to slow the rate of meander migration. Meander migration and channel widening may also be triggered by a larger-scale episode of incision. When considering the impact of streambank erosion on buried infrastructure, we consider the potential for lateral (sideways) migration or widening of the river and the buffer width required.

Streambed (vertical) erosion can occur as a result of local and/or bend scour erosion, or as a result of reach scale incision. The likelihood of bed scour through local processes, for example in natural pools in the channel bed, or reach scale incision is a function of the resistance of the bed material, the flow regime and how the balance between stream power and erosion resistance changes over time. Two factors are important when considering the impact of local scale erosion on buried infrastructure: the maximum depth of scour during a single flow event (and whether this scour depth is likely to expose buried pipes), and the likelihood of lower magnitude but more frequent bed scour that progressively exposes buried pipes over time.

Floodplain erosion also has the potential to expose buried cables, and to damage joint pits, access tracks or other floodplain infrastructure. Floodplain erosion could comprise stripping of floodplain soils in flood events or more catastrophic meander cutoffs and channel avulsions. Channel avulsions are the abandonment of one stream alignment in favour of an alternate stream course across the surrounding floodplain and are discussed further below. The likelihood of floodplain scour, meander cut-offs and avulsion are related to the type of alluvial floodplain sediment, the type and extent of vegetation cover on the floodplain and the relative difference in stream power between the channel and floodplain during floods.

Larger scale channel incision that occurs at the reach scale

Channel incision is a process of channel deepening and associated widening (Figure 53). Channel incision is a natural process, but in many of Victoria's waterways historic and contemporary incision has been triggered or accelerated as a result of human interventions across the landscape, including vegetation clearance, channel straightening, sediment extraction and changes to the flow regime. Incising channels generally pass through a well understood sequence of changes, and those channel changes usually proceed in an upstream direction, so that downstream reaches are further along the trajectory of change than upstream reaches. Schumm *et al.* (1984) identified six stages of channel incision (Schumm, et al., 1984):

1. The pre-modified or undisturbed waterway in equilibrium
2. The constructed or disturbed channel
3. The deepening of the channel as incision initiates
4. Deepening slows, and channel widening becomes dominant
5. Cessation of deepening and initiation of infilling, with continued channel widening
6. Development of an inset, meandering channel with some active aggradation of sediment

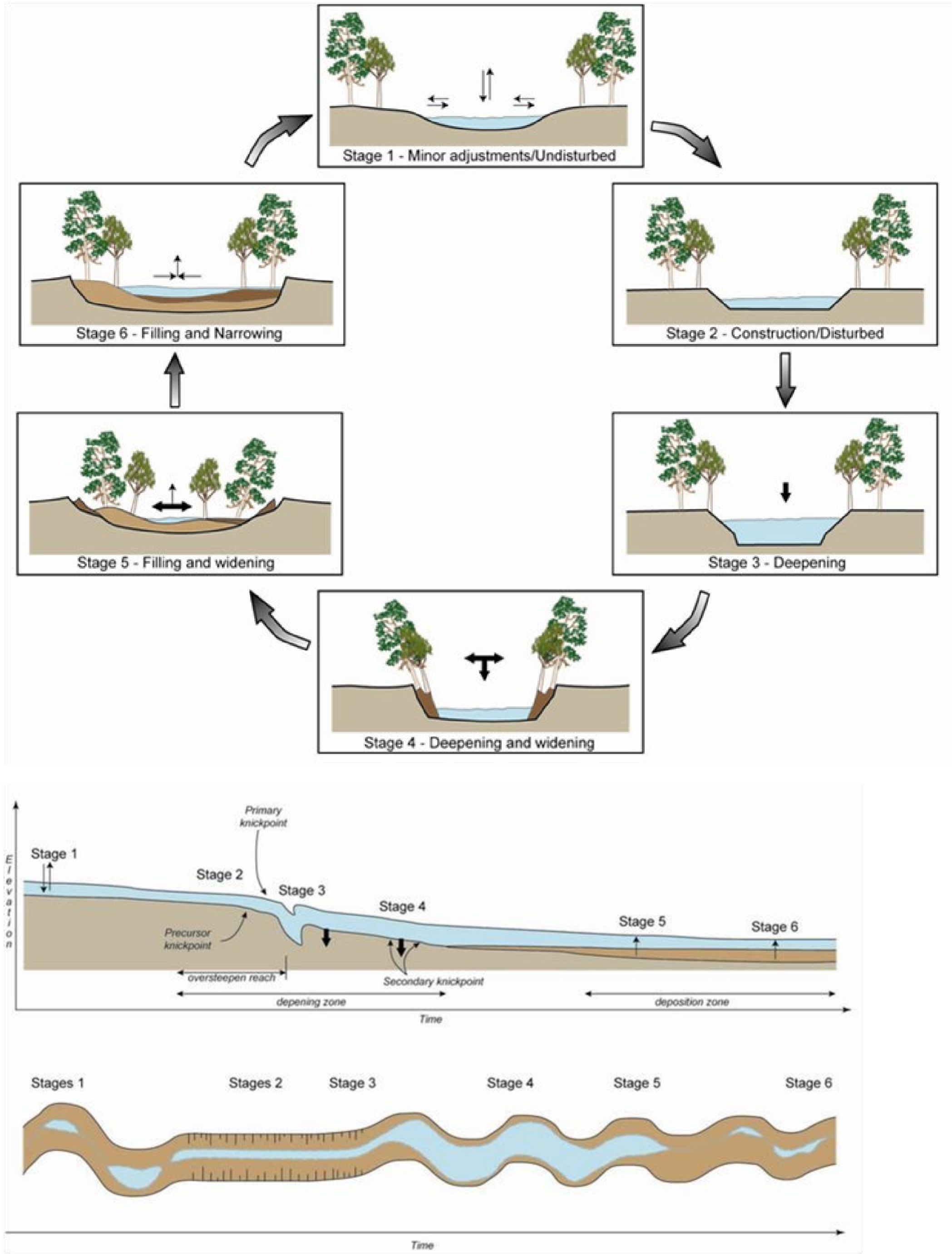

Figure 53. *Stages of channel incision in cross section (top), longitudinal profile (middle) and planform (bottom).*

Identifying reaches undergoing incision, the relative scale of the incision, and the stage of the incision cycle the channel is in allows the trajectory of channel change to be predicted, and suitable management interventions identified. Downstream reaches that have already adjusted to incision as it has progressed upstream can provide an indication as to the depth and width the new channel will adjust to, and therefore appropriate burial depths or waterway setbacks required to protect infrastructure in upstream reaches. Monitoring of waterway condition, and progression of any incision, can mean instabilities are recognised early. In response, management actions such as revegetation and rock chutes or grade control structures can stabilise the waterway, reducing the likelihood of subsequent deepening and widening.

Moderate- to large-scale channel avulsion

Channel avulsion is the abandonment of one river channel and formation of a new river channel. Flow diverts out of the established or 'parent' river channel in favour of a new 'daughter' river channel. Exactly how and over what time and spatial scale a channel avulses is highly uncertain.

Historically, the initiation of avulsion has been discussed in terms of *thresholds* and *triggers* ((Jones & Schumm, 1999; Makaske, 2001)An avulsion will occur once the avulsion threshold, usually expressed as the ratio of the conveyance of the parent to the daughter channel, is reached and a triggering event of sufficient magnitude, commonly a flood, forces an avulsion. The processes that move a river towards the avulsion threshold are varied. The progression toward an avulsion threshold can happen relatively rapidly in response to a sudden change in hydrology or sediment loads, however, in other cases, the progression toward an avulsion threshold is a relatively slow and incremental process over long timeframes (100s of years).

Avulsions can also occur over varying spatial scales from a cut off of one meander loop to large-scale abandonment of an entire reach of river. These different scales of avulsion are discussed below.

Meander cut offs

Through erosion on the outside of meander bends and deposition on the inside of meander bends, meanders can migrate such that two outside bends eventually meet. When two meander loops intersect, the river cuts a new, more direct path through the bank, and the original meander course is abandoned (Figure 54). The old river course is eventually infilled with sediment, forming a billabong or meander cut off (also called an oxbow lake). Meander cut offs can occur for one meander loop (Figure 55) or multiple loops, with a longer reach of river cut off from the main channel (Figure 56). The full abandonment of one channel in preference to another over a reach scale (kilometres) is discussed below.

Meander cut offs result in an overall shortening of the river, with a straighter channel. This straighter, shorter channel is steeper and conveys flow at higher velocities. Depending on the length of river that is cut off, this can result in deepening at the cut off site which then migrates upstream. The new channel will also eventually develop meanders of its own and so the process continues.

Evidence of this process can be seen across floodplains of meandering rivers, including the Morwell River (Figure 55, Figure 56).

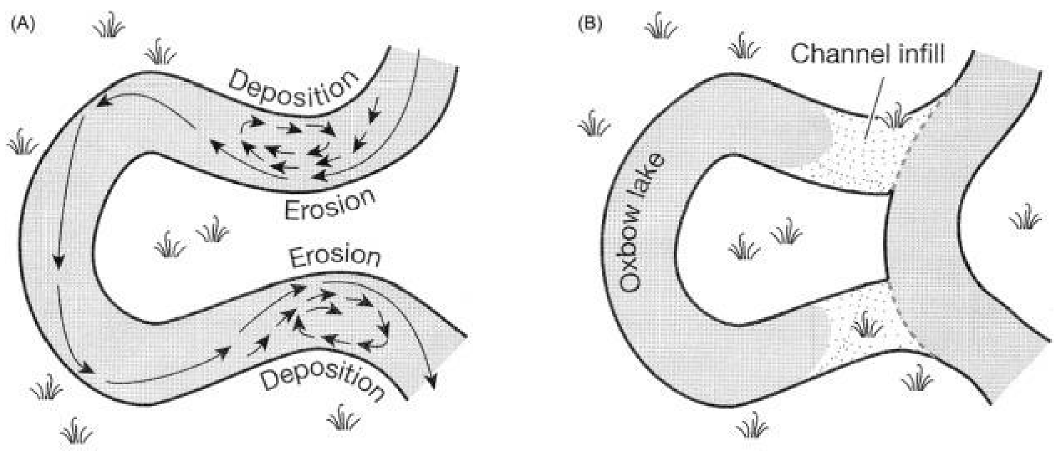

Figure 54. *Meander cut off formation showing (A) erosion on outer bends and deposition on inner bends and (B) eventual cut off and infilling* **(Branstrator, 2009)**.

Figure 55. *Aerial imagery of the Morwell River showing multiple meander cut offs.*

Figure 56. *Aerial imagery of the Morwell River showing large historic meander cut off*

Meander cut off indicators

In practice, signs of nearing a meander cut off within management timeframes typically include evidence of active bank erosion on two nearby meander loops. Cut offs often occur during a flood event, with particular risk if a narrow neck exists and banks are unvegetated and/or have uncontrolled stock access.

Reach-scale abandonment

In addition to single or multiple meander cut offs, an avulsion can occur at a reach-scale, with a new avulsion pathway developing over kilometres. With these avulsion processes, there is considerable uncertainty as to how the changes will be expressed, where such changes will be concentrated, and the period of time over which changes will occur. Schumm, *et al.* (1996) describe reach-scale avulsion processes (Schumm, et al., 1996), which are summarised in Figure 57, below.

In a larger reach-scale abandonment of the channel, the efficiency of the main channel to convey flow can reduce due to meander lengthening and sediment aggradation, making the channel less steep and less efficient, with higher frequency of overbank flow. This overbank flow promotes creation of alluvial ridges (levees) along the bank where sediment is deposited during these overbank flow events. When this occurs, over the long-term (decades to centuries) a 'daughter' channel (new avulsion pathway) can be expected to develop both in an up valley and down valley direction through the following processes:

- Down valley extension can occur where an alluvial ridge on the floodplain (or natural/man-made levee) is breached by flood flows and a 'break out' point is established. Flow is concentrated through this point, causing deepening, and widening of a new channel in a down valley direction.
- Up valley extension can occur where floodwaters re-enter the main channel. The new channel is deepened and widened through the incision processes described above, moving in an upstream direction.

Once the daughter and parent channel connect, both water and sediment from the main channel divert into the new channel, and the cycle begins again.

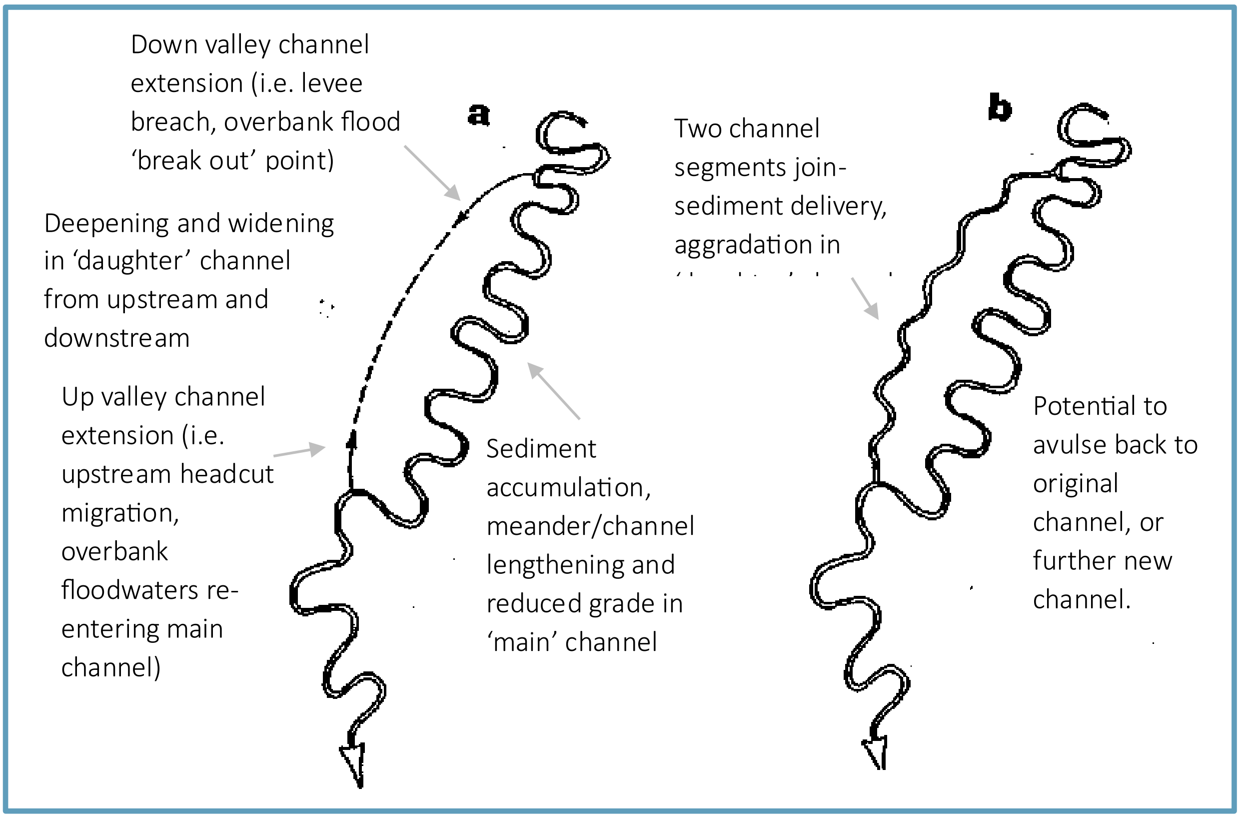

Figure 57. *(a) early stages of 'daughter channel' development before up-valley and down-valley segments join and (b) new 'daughter channel' bypassing a sinuous, ineffective reach of the main channel.*

Reach-scale avulsion indicators

In practice, signs of nearing an avulsion threshold within management timeframes typically require the following factors to be present:

1. Active erosion in the floodplain channel/s, including the presence of headcuts in the potential new course (step-drops in bed elevation).
2. Flood flows engage the developing floodplain channel/s (i.e., are not intercepted and diverted away from the potential new course).
3. Streambed aggradation (which reduces channel capacity) occurring in the main channel.

An imminent avulsion would be anticipated if, in addition to the above factors, the following situation was observed:

4. The presence of a less-sinuous channel/s on the floodplain with greater capacity and with a lower bed elevation than the current main course.

The next sections (4 to 9), step through each waterway crossing and describes the catchment setting and dominant waterway processes which may pose a threat to buried infrastructure.

Attachment 3. Waterway crossing characterisation

Waterway crossing characterisation

The following outlines background information to characterise major waterways crossed by the project alignment. This includes catchment setting, soils, land use, and topography.

Morwell River

Catchment setting

Formed by the confluence of the West Branch and East Branch, the Morwell River rises in the Strzelecki Ranges. The river flows for around 83 km, generally in a northerly direction, before joining the Latrobe River near Yallourn.

The proposed project alignment crosses the Morwell River around 2.2 km downstream of Yinnar-Driffield Road and around 24 km upstream of the confluence with the Latrobe River (Figure 58). Based on discussion during site inspection, the mapped alignment for assessment was updated, moving around 30 metres upstream to avoid crossing the waterway twice.

The Morwell River headwaters flow through high relief ranges of sedimentary rock, before transitioning moderate relief terraces and then entering the alluvial riverine plains. A reach of the Morwell River downstream of the crossing with the proposed project alignment has been diverted around Hazelwood open-cut mine.

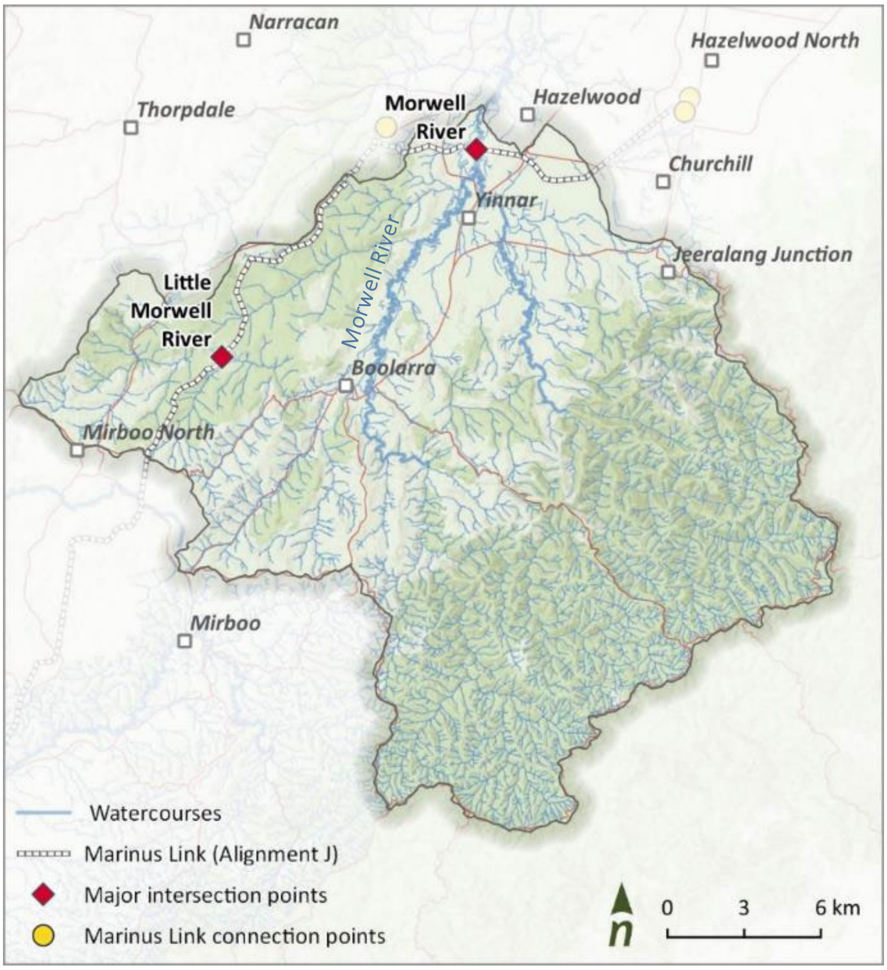

Figure 58. *Morwell River upstream catchment and Project alignment crossings.*

Geology

Geology is varied across the Morwell River catchment with the headwaters of the east and west branches dominated by Wonthaggi formation sandstone. Moving to a mix of Latrobe Valley group sedimentary rock, Thorpdale basalt, and the sand, gravel and silt deposits associated with alluvial terraces, alluvium and the Haunted Hills formation (Figure 59). At the proposed project alignment crossing, geology is dominated by Haunted Hills formation and alluvium.

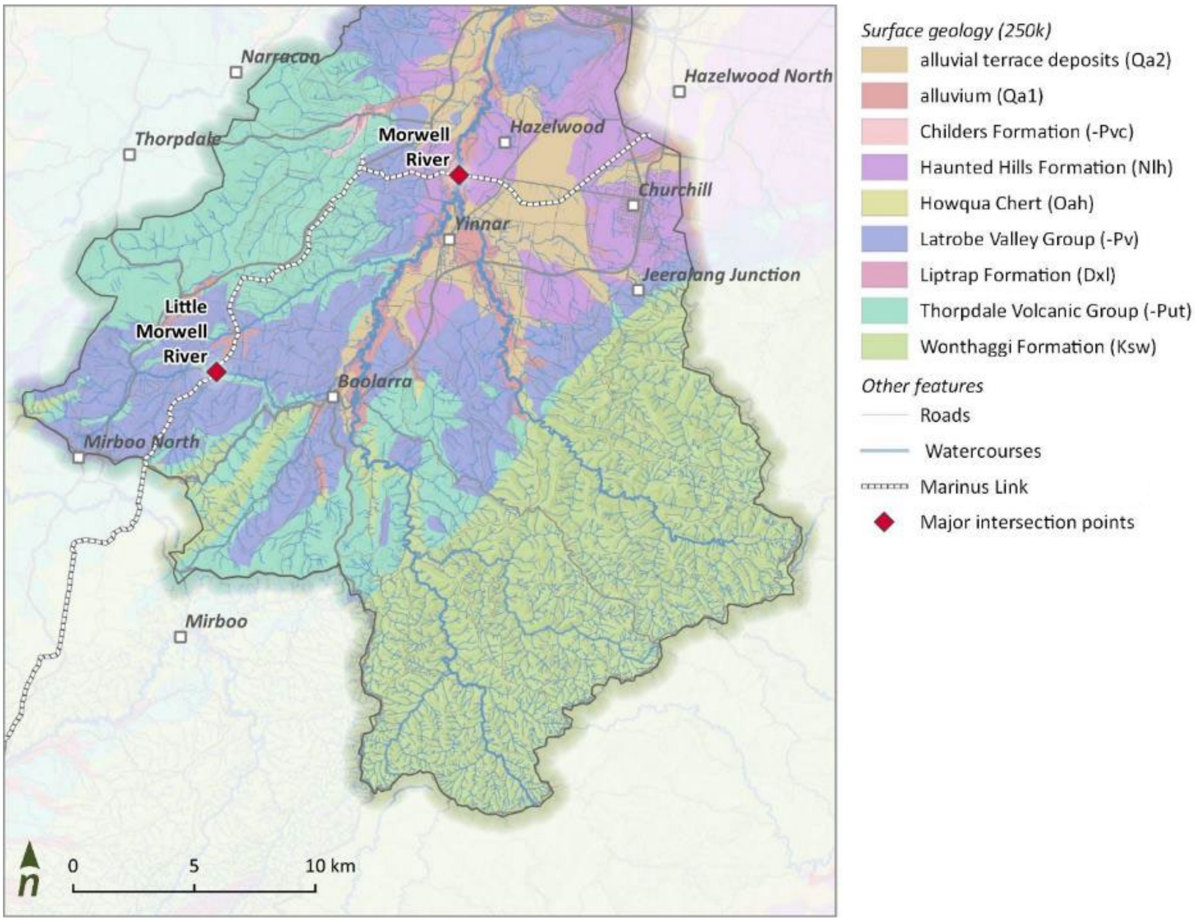

Figure 59. *Surface geology for the Morwell River catchment* **(Department of Jobs, Precincts and Regions, 2018)**.

Soils

The Morwell River generally drains the dermosols of the sedimentary ranges, with some pockets of iron oxide rich ferrosols, before hydrosols and chromosols become dominant across the floodplain, downstream of Boolarra (Figure 60). Dermosols are generally non-cracking clay to clay loam soils. Chromosols have a neutral texture and a strong contrast between the loamy surface (A) horizons and the clayey upper subsoil (B2) horizon. Hydrosols are waterlogged soils that are either seasonally or permanently inundated.

Dermosols are generally non-dispersive but can be susceptible to rill and sheet erosion when left exposed to heavy rainfall or near waterways. Chromosols generally have a hard setting surface that may have poor infiltration and a high runoff potential. While not generally dispersive, these soils can be susceptible to rill, sheet, and stream bank erosion. Hydrosols are not generally dispersive but can also be susceptible to streambank erosion (Ipswich City Council (ICC) and Ipswich Rivers Improvement Trust (IRIT), 2014).

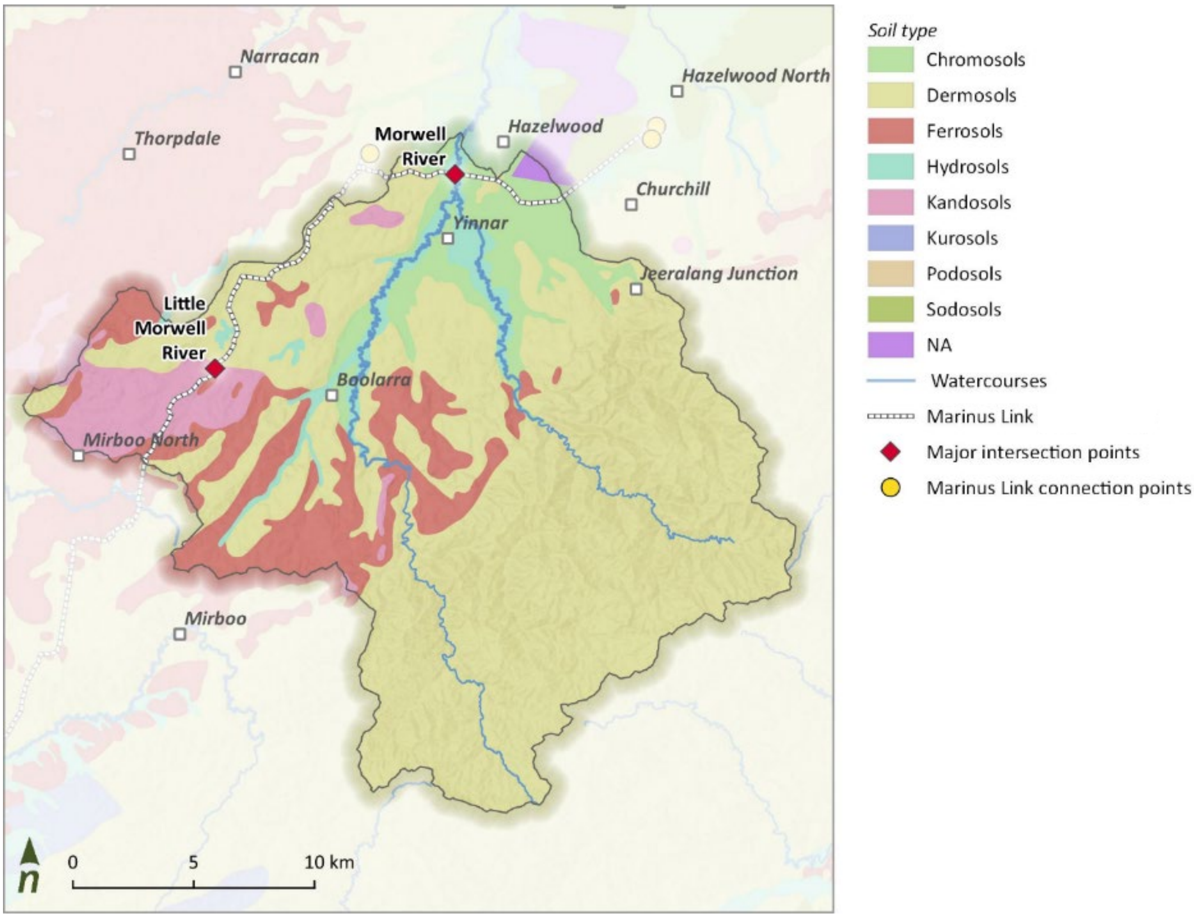

Figure 60. *Soil types within the Morwell catchment upstream of the proposed project alignment crossing* (Department of Jobs, Precincts and Regions (DJPR), 2018)

Land use

Across the Morwell catchment, land use is dominated by plantation forests, generally in the upper catchment and western catchment, and grazing modified pastures in the mid and lower catchment (Figure 61). There is some residential land use and cropping, with pockets of nature conservation. More seasonal horticulture is seen to the west, in the Little Morwell catchment. Downstream of the proposed project alignment crossing point on the Morwell River, land use also includes the mining and power generation facilities near Hazelwood and Yallourn.

At the intersection with the proposed project alignment, land cover around the Morwell River is pasture and grasslands, with generally dairy or meat cattle.

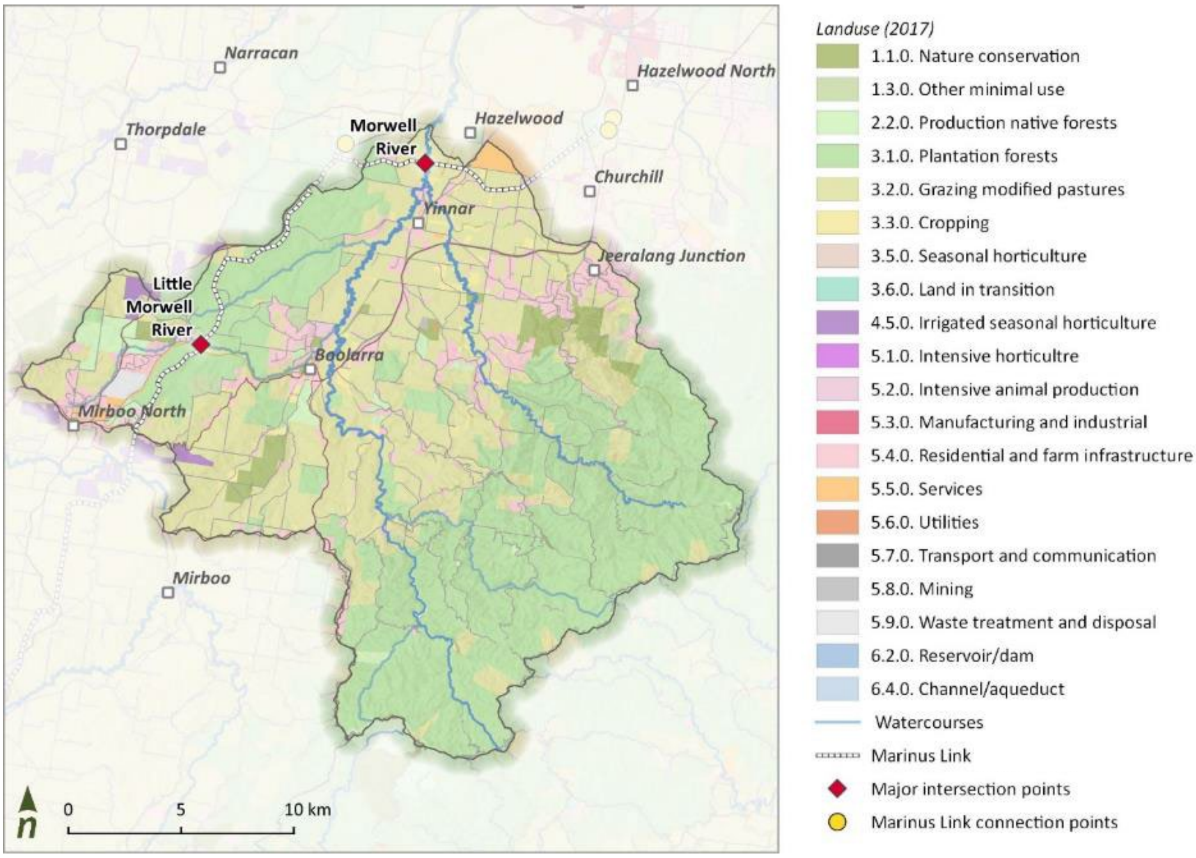

Figure 61. *2017 land use within the Morwell catchment* (Department of Jobs, Precincts and Regions (DJPR), 2017).

Topography interpretation

The Morwell River at the intersection with the proposed project alignment is a largely unconfined river with a meandering platform (Figure 62). The channel is around 18 m wide, 4 m deep, with a floodplain that varies in width between 300 and 600 m (Figure 63). The channel occasionally abuts the valley margins throughout the reach. The reach has high sinuosity, with numerous billabongs and remnant meander cut offs seen on the floodplain. The main channel has well developed levee banks with an average height of ~ 1 m (Figure 63). Levee development increases the energy slope (and erosive potential) of floodwater spilling from the channel and across the floodplain. Should an alternative, lower elevation flow pathway form on the floodplain, there is potential for an avulsion to develop.

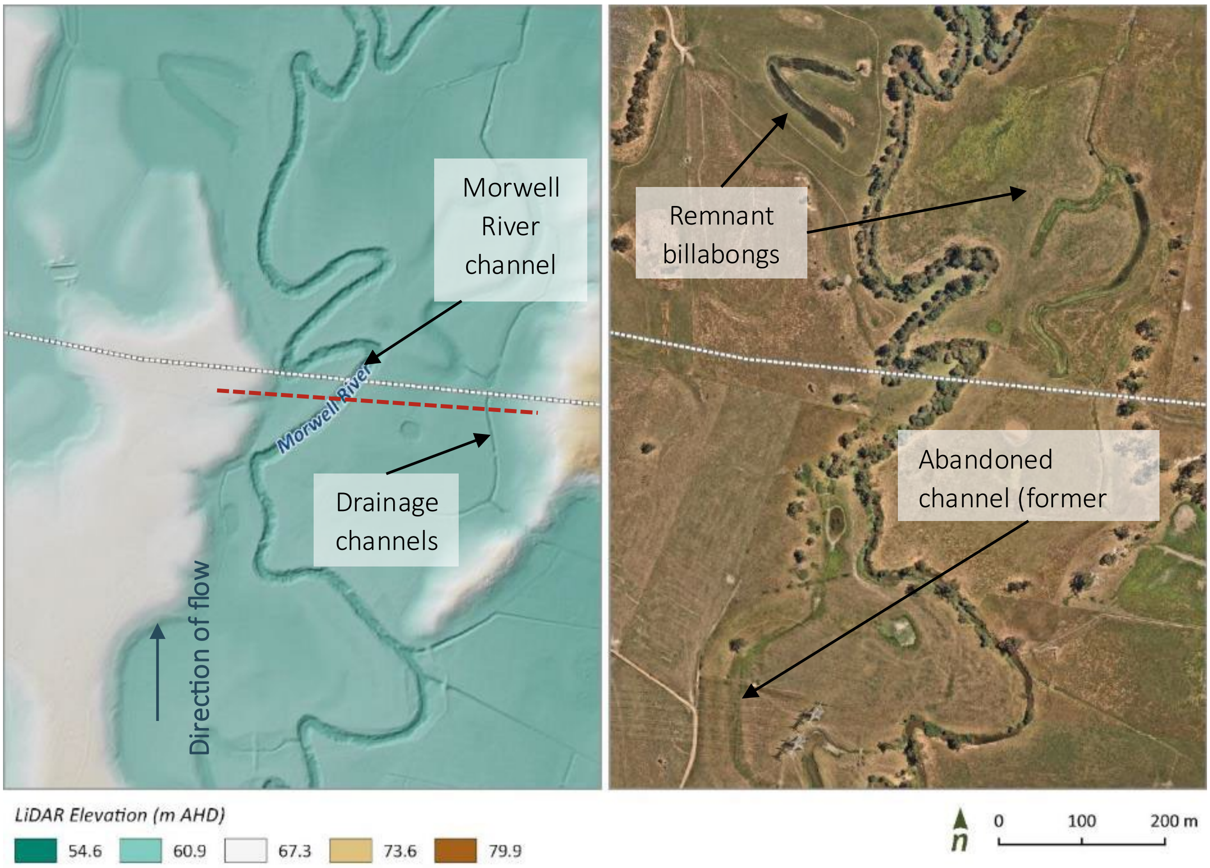

Figure 62. *LiDAR (2018) and aerial imagery (2021) for the Morwell River at the intersection with the approximate proposed project alignment. Note: Cross section in Figure 63 approximately at dotted red line to avoid double waterway crossing at meander bend.*

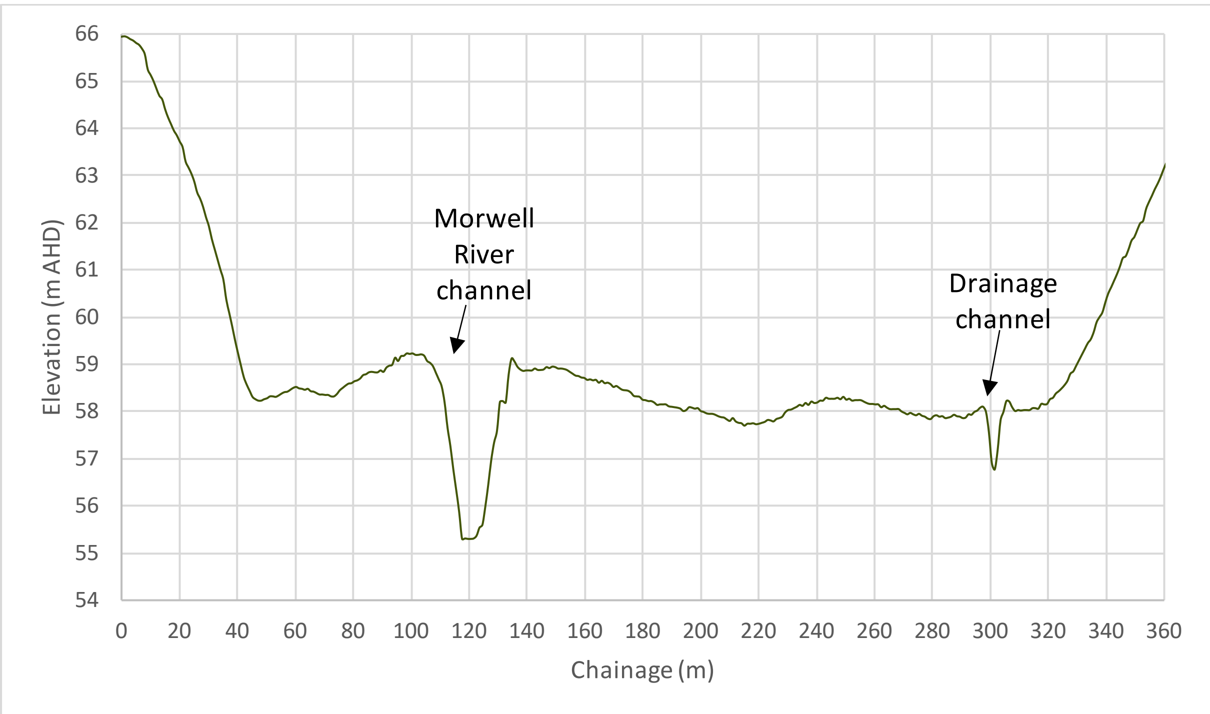

Figure 63. *Cross section at the Morwell River derived from LiDAR, dotted red line in Figure 62 (looking downstream).*

Bed grade analysis

A longitudinal profile extracted from the available LiDAR (2018) and the Index of Stream Condition (ISC) centreline alignment of the Morwell River (Figure 64) shows a stable bed grade of up to 0.0050 m/m. There does not appear to be any major steepened sections, with the grade downstream of CH 12,000 being largely controlled by the constructed Morwell River diversion.

Bed grade and chainages relative to Figure 64 are presented in Table 32. Bed grade was compared with a database of bed grades drawn from stable alluvial rivers in south east Australia (Department of Sustainability and Environment (DSE), 2007; Hardie, 1993), calculated design bed grades relative to the 2 yr. ARI flow, and to upstream and downstream reaches of the Morwell River that are not incising. Bed grades were classed as acceptable or not acceptable as follows:

- ✓ Bed grade is within the bounds of a stable waterway, not substantially steeper than upstream or downstream grade of stable reaches.
- ✓ Bed grade is steeper than the bounds of a stable waterway, but other factors mean this is acceptable e.g., steepening is upstream of waterway crossing, other infrastructure (e.g., road crossings) control bed grade.
- ✗ Bed grade is unacceptable, and incision is likely.

Table 32. Bed grade at various segments of the Morwell River near the crossing, relative to Figure 64

Chainage (m)	Bed grade (m/m)	Acceptable?
12000- 12500	0.0000	✓
12500- 13900	0.0014	✓
13900- 15000	0.0000	✓
15000- 16500	0.0002	✓
16500- 17000	0.0009	✓
17000- 18700	0.0002	✓
18700- 18800	0.0050	✓
18800- 24000	0.0011	✓

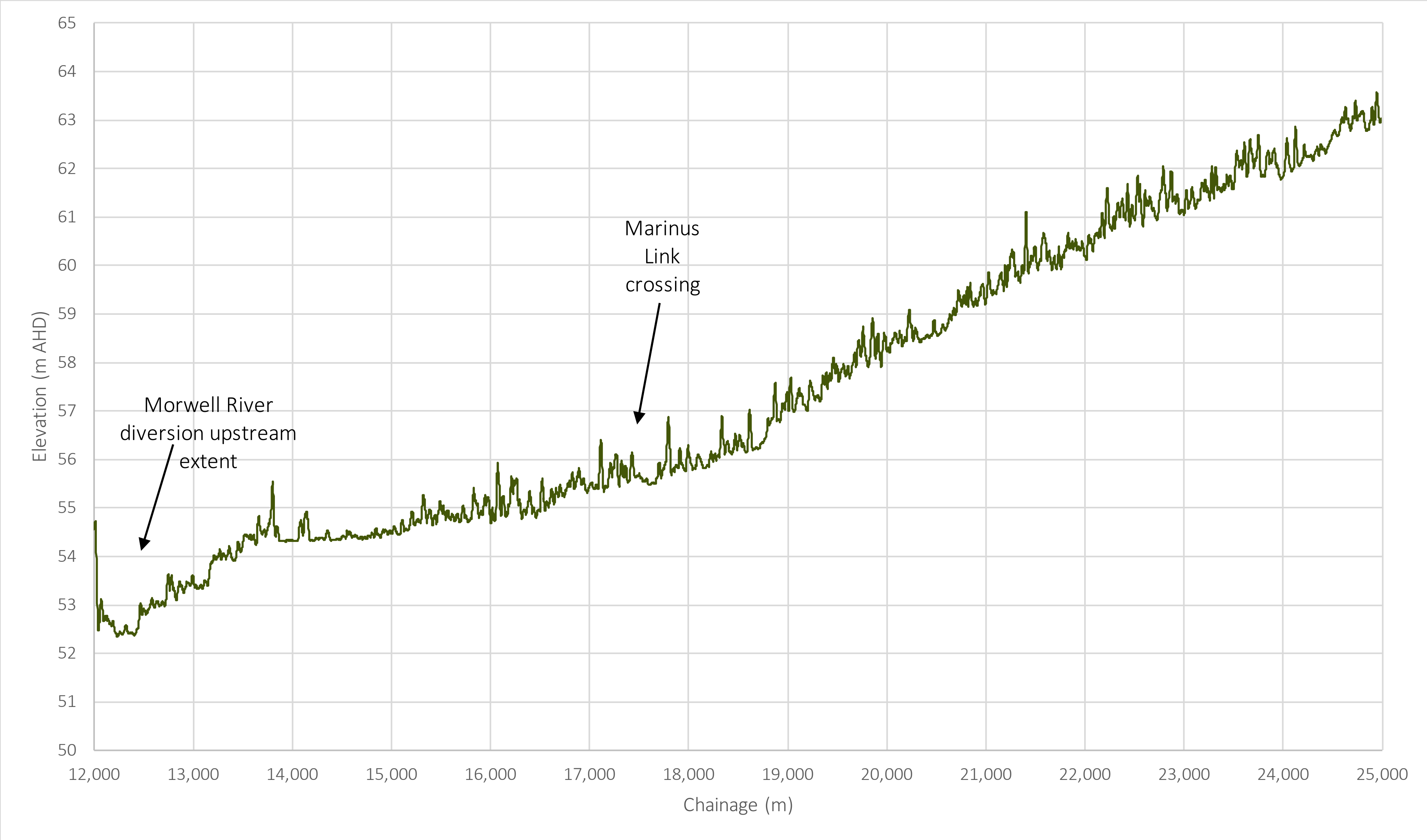

Figure 64. *Smoothed longitudinal profile (20-point moving average) of the Morwell River surrounding the proposed project alignment, derived from LiDAR (2010) along ISC centreline alignment.*

Aerial imagery analysis
Some bank erosion is evident on recent (September 2021) high resolution aerial imagery (Figure 65). The lack of riparian vegetation and unrestricted stock access to the river increases the likelihood of bank erosion.

Available past aerial imagery (Figure 66) shows that despite the numerous remnant meander cut offs and billabongs on the floodplain, the channel alignment has remained largely unchanged over the last ~75 years, with no major cut offs occurring. Some meanders do appear to have lengthened during this time, although the resolution of historic imagery and geo-referencing process makes it hard to quantify the rate. Vegetation cover is sparse but appears to have increased somewhat along the channel in recent years, which will increase bank stability

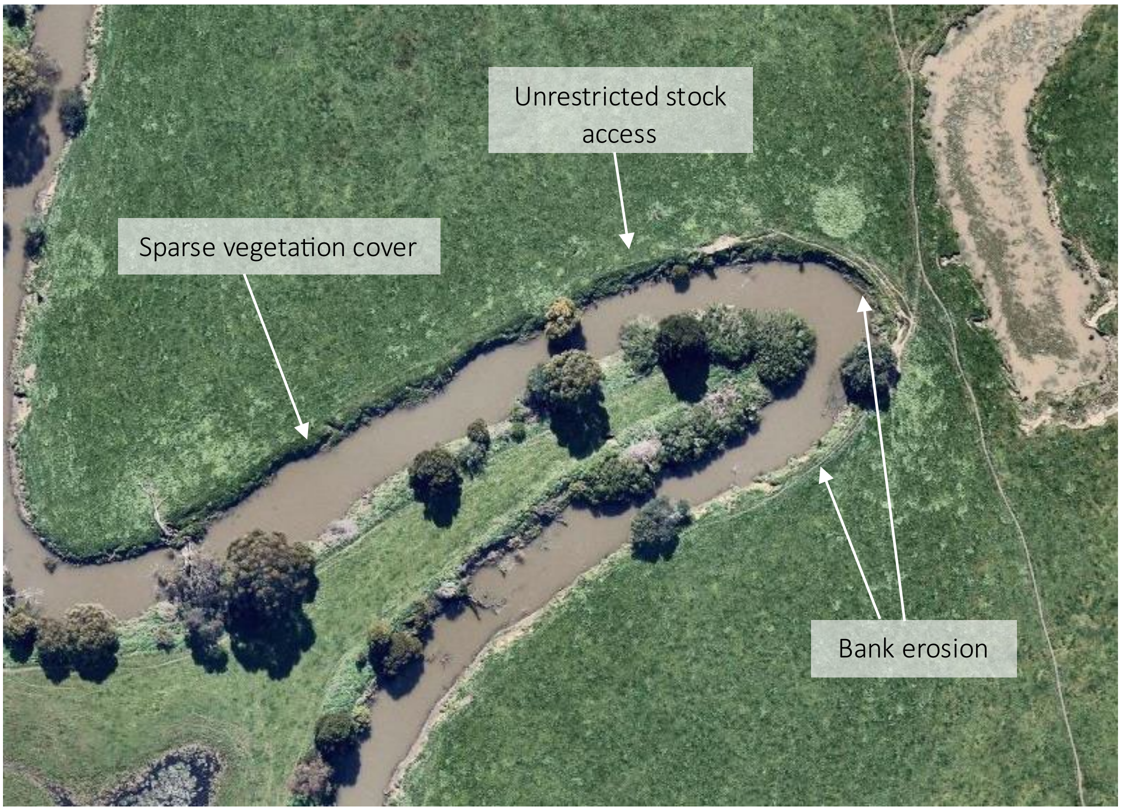

Figure 65. *September 2021 aerial imagery of meander bend downstream of proposed project alignment (Nearmap).*

Figure 66. *Available aerial imagery for the Morwell River at the intersection with the approximate proposed project alignment (project alignment for 2021, 2010 and 1945.*

Site inspection

Site inspection of the Morwell River at the crossing with the proposed project alignment was undertaken on 22nd March 2022.

The inspection found that there were some consecutive meander loops with only a narrow (<25 m) strip of land between, with evidence of stream bank erosion, largely on the outside of meander bends. This erosion had resulted in the undermining of large trees in some cases (Figure 67). While some vegetation was present on the riverbanks, it was sparse, only comprising of a few remnant trees and shrubs (Figure 68). Fencing was either non-existent or at the top of bank, with no buffer between the fence line and the top of the bank. Stock had unrestricted access in some areas.

Some remnant billabongs were visible on the floodplain; however, these did not appear to create any alternative flow pathway with no clear break out or re-entry points evident in the area visited.

Figure 67. *Morwell River in the vicinity of the proposed project alignment crossing showing recent collapse of trees resulting from erosion/undercutting.*

Figure 68. *Looking downstream along Morwell River in vicinity of proposed project alignment (fence line near bottom of image)*

Little Morwell River

Catchment setting

The Little Morwell River rises near Mirboo North and flows northeast for around 21 km before meeting the Morwell River just downstream of Boolarra.

On the Little Morwell River, the proposed project alignment crossing is around 700 m downstream of the Darlimurla Road crossing, around 10.5 km upstream of the confluence with the Morwell River (Figure 69).

The Little Morwell River generally flows through dissected plains and high-level terraces, before reaching lower relief areas and the broader floodplain of the Morwell River.

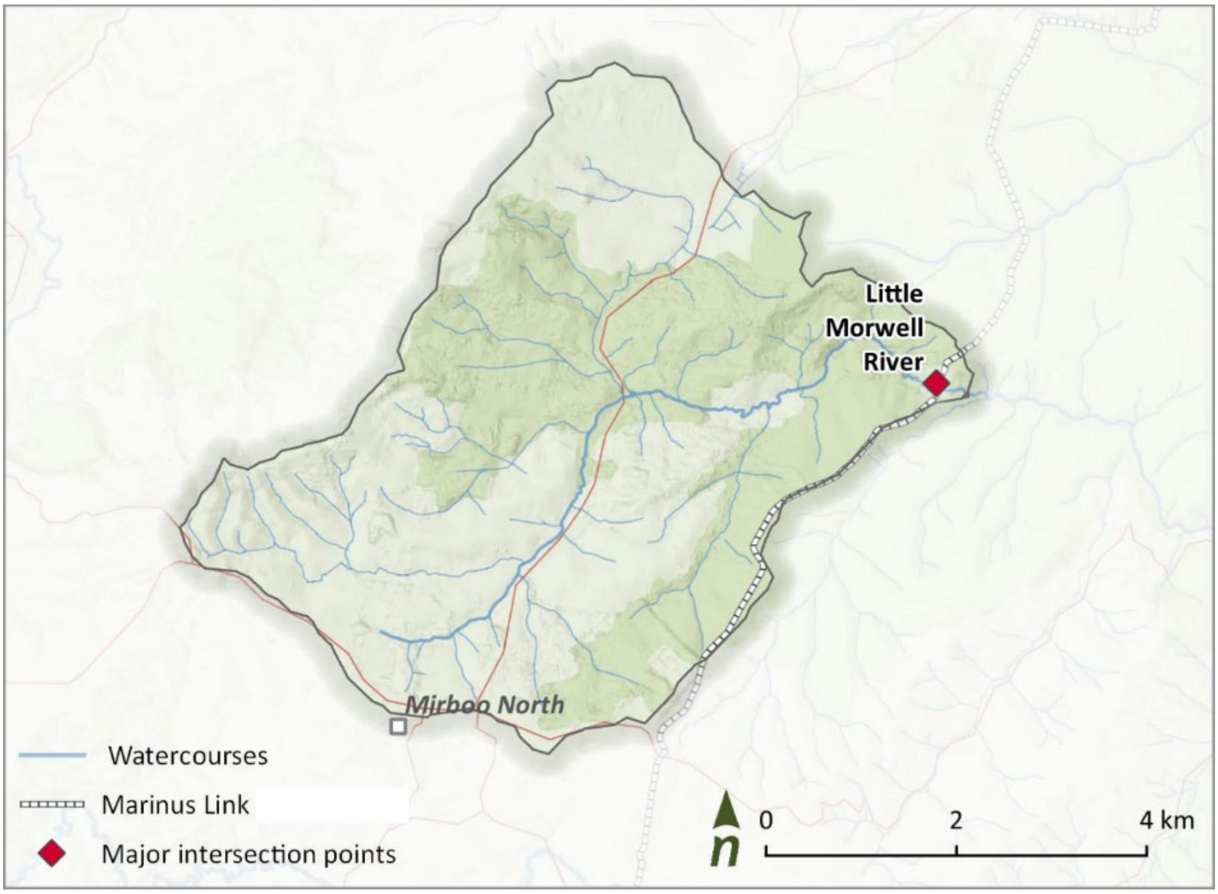

Figure 69. *Little Morwell River upstream catchment and proposed project alignment crossing*

Geology

Geology of the Little Morwell catchment is dominated by Latrobe Valley Group sedimentary rock and Thorpdale volcanic basalt (Figure 70). At the proposed project alignment crossing, geology is a narrow strip of basalt along the waterway and sedimentary rock surrounding.

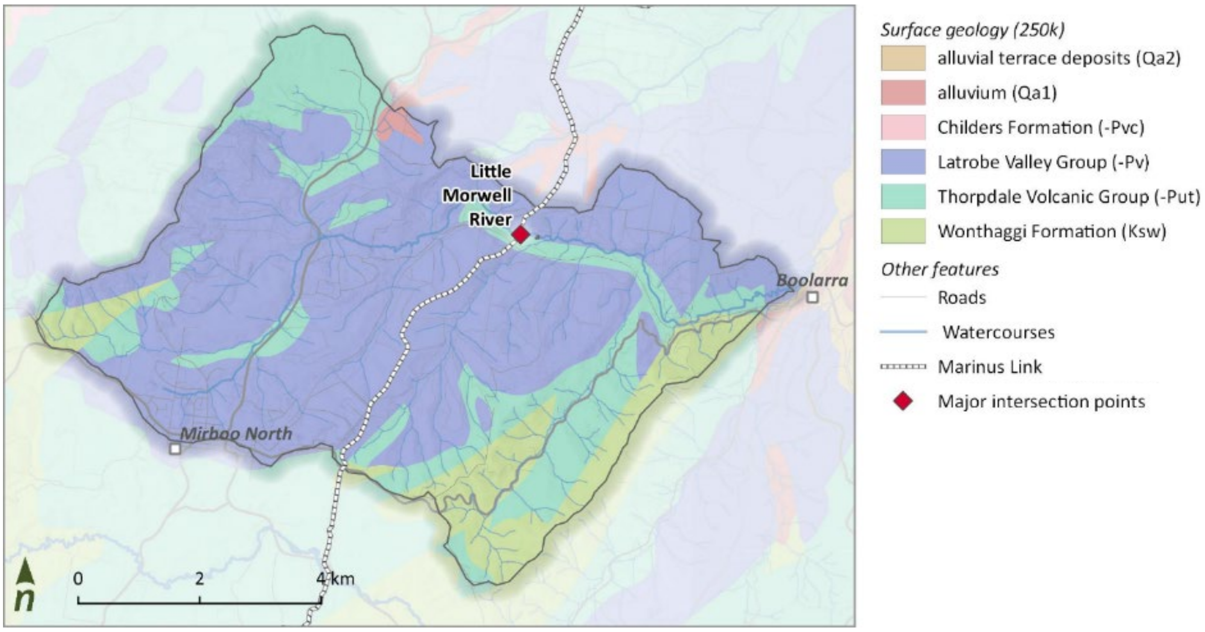

Figure 70. *Surface geology for the Little Morwell catchment* (Department of Jobs, Precincts and Regions, 2018).

Soils

The Little Morwell River drains generally kandosols and ferrosols (Figure 71). Kandosols are leached soils that are generally well-drained, sandy, permeable and have low fertility. They have generally structureless or weakly structured subsoils (B horizon) with a clay content of more than 15%. Although not dispersive, the reduced cohesion of these dominantly sandy soils means they are susceptible to rill, sheet, and stream bank erosion (Ipswich City Council (ICC) and Ipswich Rivers Improvement Trust (IRIT), 2014).

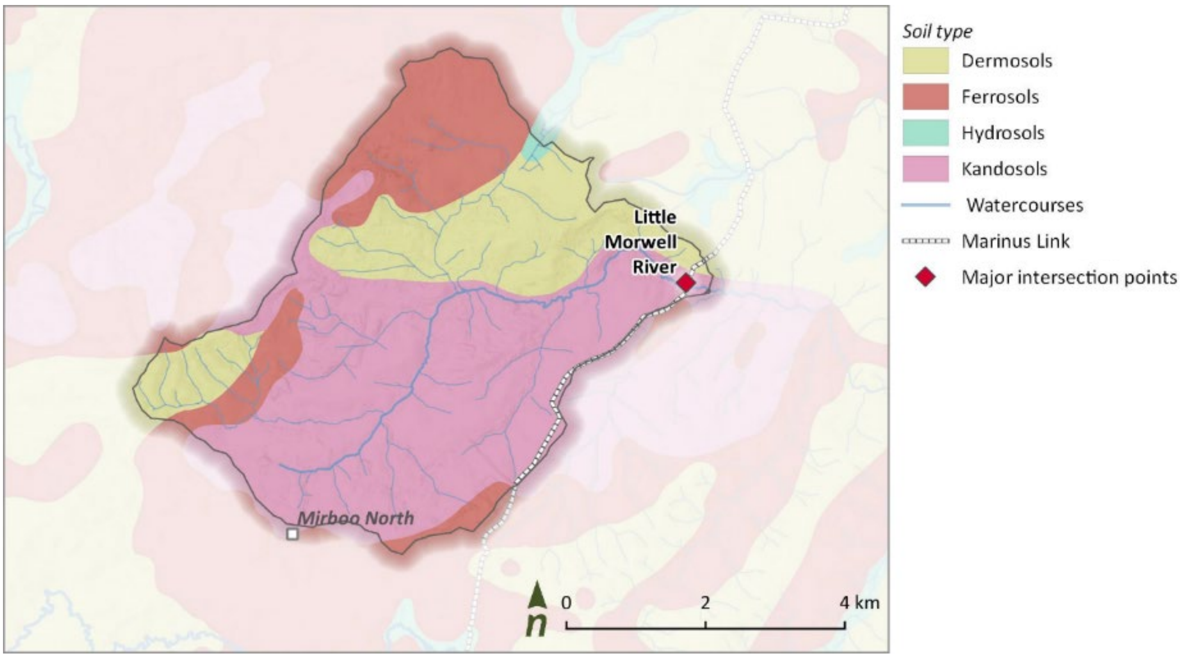

Figure 71. *Soil types within the Little Morwell catchment upstream of the proposed project alignment crossing* (Department of Jobs, Precincts and Regions (DJPR), 2018)

Land use

Land use in the Little Morwell catchment is varied with residential areas, farm infrastructure, and services around Mirboo North (Figure 72). Seasonal horticulture is found in the north of the catchment, with the remainder either mixed farming and grazing or production forests and hardwood plantations.

At the intersection with the proposed project alignment, land cover around the Little Morwell River includes softwood plantations on the adjoining hills and rural residential properties nearer the river.

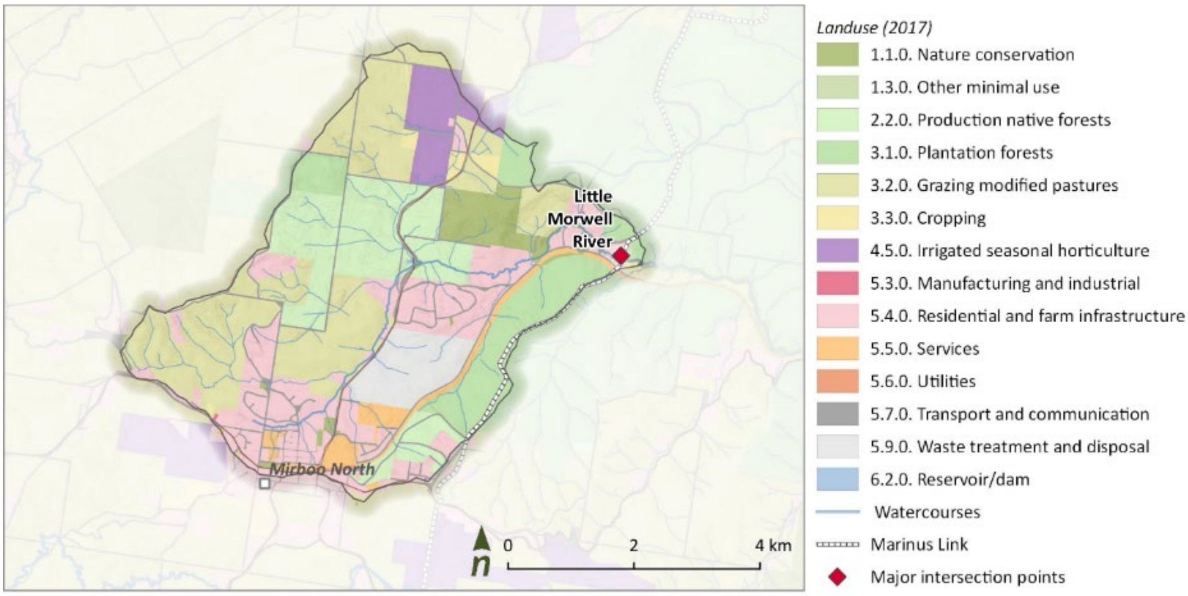

Figure 72. *2017 land use within the Little Morwell catchment* (Department of Jobs, Precincts and Regions (DJPR), 2018)

Topography interpretation

The Little Morwell River at the intersection with the proposed project alignment is a partially confined with a meandering planform (Figure 73). The channel is around 6 m wide, 0.6 m deep and sits within a floodplain around 20 to 30m wide (Figure 74). The channel abuts the valley margins in places and is also constrained by the Pleasant Valley Road, running to the south.

Figure 73. *LiDAR (2018) and aerial imagery (2020) for the Little Morwell River at the intersection with the proposed project alignment.*

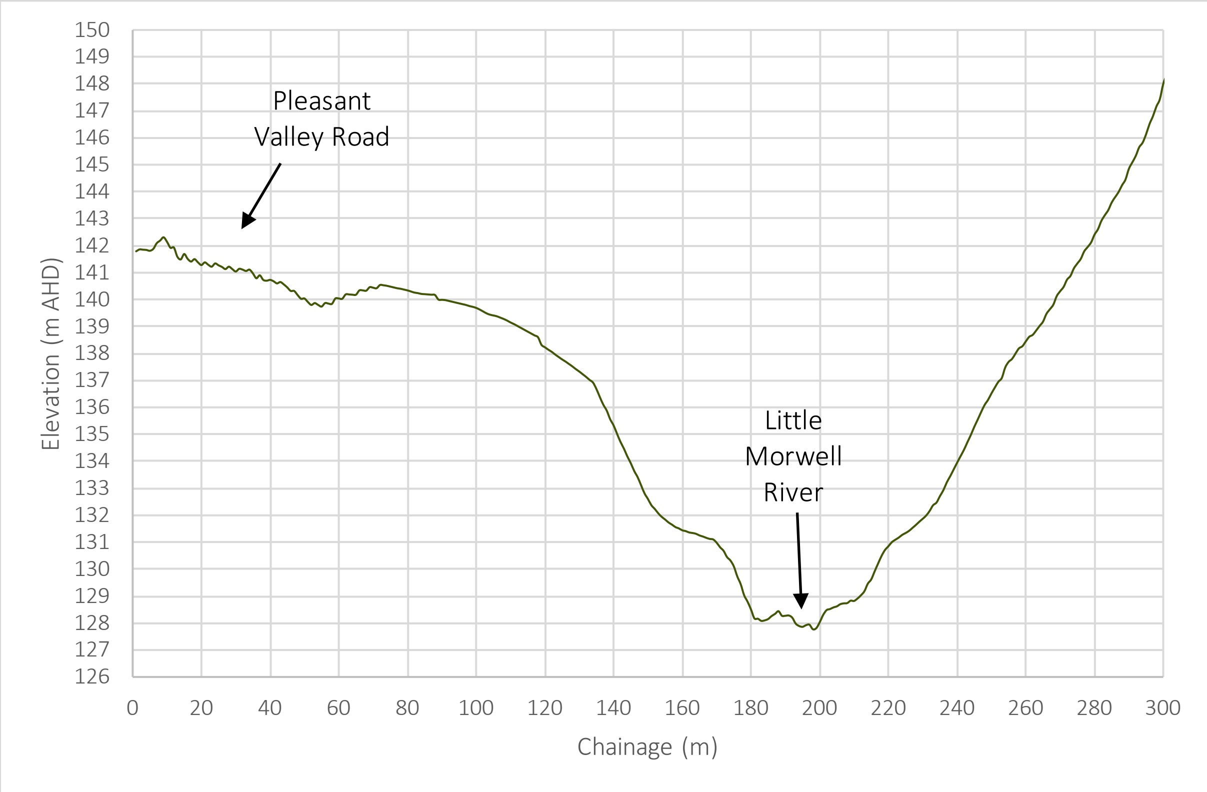

Figure 74. *Cross section of the proposed project alignment at the Little Morwell River, derived from LiDAR (looking downstream).*

Bed grade analysis

A longitudinal profile extracted from the available LiDAR (captured in 2018) and State waterway alignment of the Little Morwell River (Figure 75) shows a relatively stable bed grade of between 0.006 and 0.008 m/m, with two steeper sections around CH 0-500 and CH 4000-4250. The potential steepening around CH 4100 is located upstream of the proposed project alignment crossing, and the reach containing the proposed crossings is likely to have already adjusted to the passage of the headcut and moved into Stage 5/6 of the cycle of incision (Figure 53).

Bed grade and chainages relative to Figure 75 are presented in Table 33. Bed grade was compared with a database of bed grades drawn from stable alluvial rivers in SE Australia (Department of Sustainability and Environment (DSE), 2007; Hardie, 1993), calculated design bed grades relative to the 2 yr. ARI flow, and to upstream and downstream reaches of the Little Morwell River that are not incising. Bed grades were classed as acceptable or not acceptable as follows:

- ✓ Bed grade is within the bounds of a stable waterway, not substantially steeper than upstream or downstream grade of stable reaches.
- ✓ Bed grade is steeper than the bounds of a stable waterway, but other factors mean this is acceptable e.g., steepening is upstream of waterway crossing, other infrastructure (e.g., road crossings) control bed grade.
- ✗ Bed grade is unacceptable, and incision is likely.

Table 33. Bed grade at various segments of the Little Morwell River near the crossing, relative to Figure 75.

Chainage (m)	Bed grade (m/m)	Acceptable?
0- 500	0.0127	✓
500- 2500	0.0057	✓
2500- 4000	0.0057	✓
4000- 4250	0.0240	✓
4250- 5700	0.0085	✓
5700- 7000	0.0060	✓

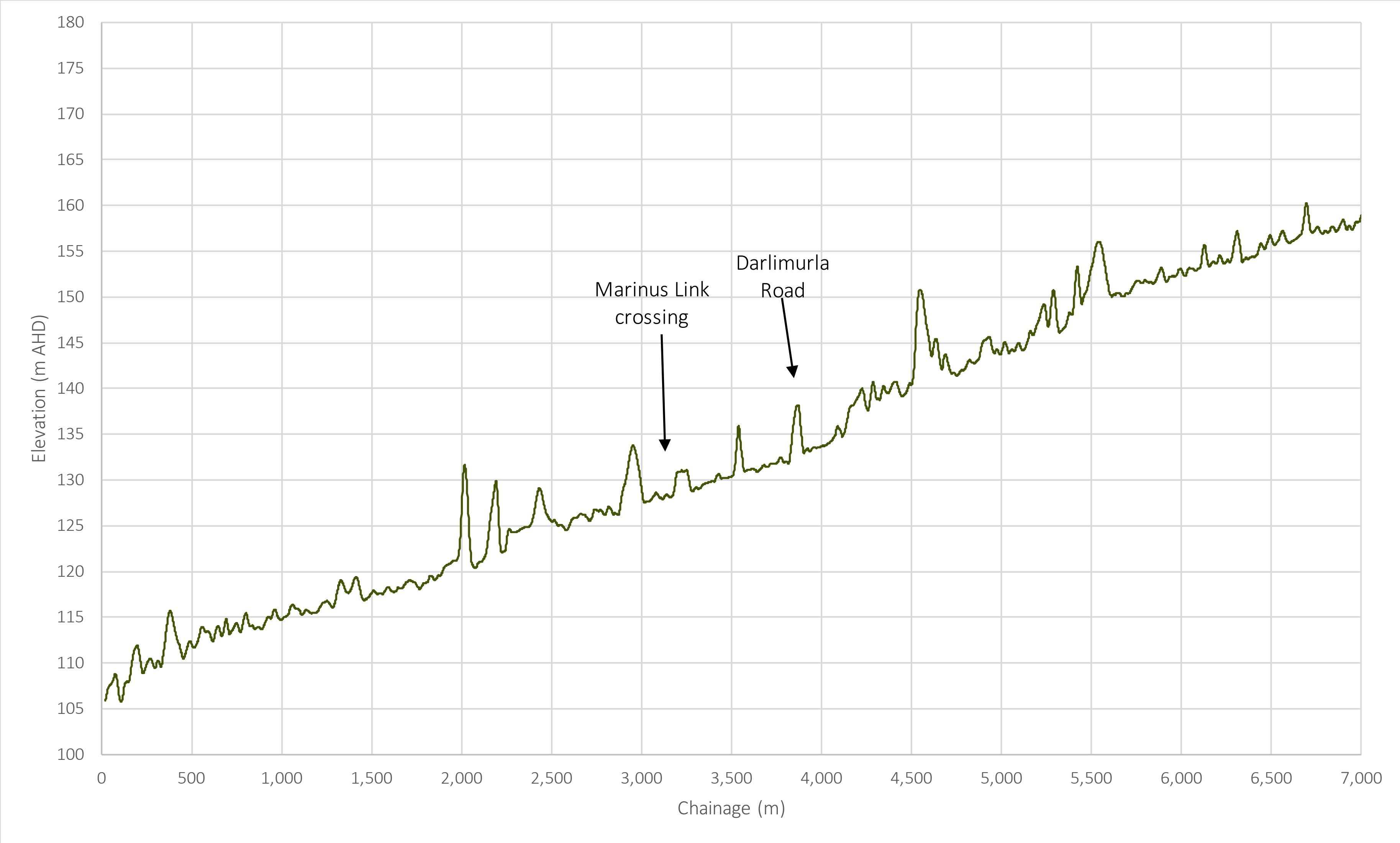

Figure 75. *Smoothed longitudinal profile (20-point moving average) of the Little Morwell River surrounding the proposed project alignment, derived from LiDAR along State waterway alignment*

Aerial imagery analysis

Available past aerial imagery (Figure 76) shows the alignment of the Little Morwell River in this area appears to have been largely unchanged, without major channel change over the last 12 years. Vegetation cover does appear to have increased. Historic aerial imagery earlier than 2010 is not available or of high enough resolution to determine channel change. The channel is also obstructed by vegetation, so determining lateral channel change by aerial imagery alone is difficult.

Figure 76. *Available aerial imagery for the Little Morwell River at the intersection with the proposed project alignment for 2022 and 2010.*

Site inspection

Site inspection of the Little Morwell River at the crossing with the proposed project alignment was not possible due to lack of landholder access. However, discussions with other consultants who have visited the site (Barton Napier, Pers comms) indicate that:

- No major erosion evident
- The channel has a sandy bed with basalt outcrops which, if present, would likely prevent incision.

Tarwin River East Branch

Catchment setting

The Tarwin River East Branch rises in the Strzelecki Ranges and flows first northeast, then northwest, and then at the town of Mirboo flows southwest towards the confluence with the Tarwin River (Figure 77). The Tarwin River East Branch is around 66km long, with a catchment area of 269 km^2.

The proposed project alignment crosses the Tarwin River East Branch near Dumbalk, around 1 km downstream of the Meeniyan-Mirboo North Road crossing and 22 km upstream of the confluence with the Tarwin River.

The river flows through high relief sedimentary rock, before entering the lower relief riverine plains, downstream of Mirboo.

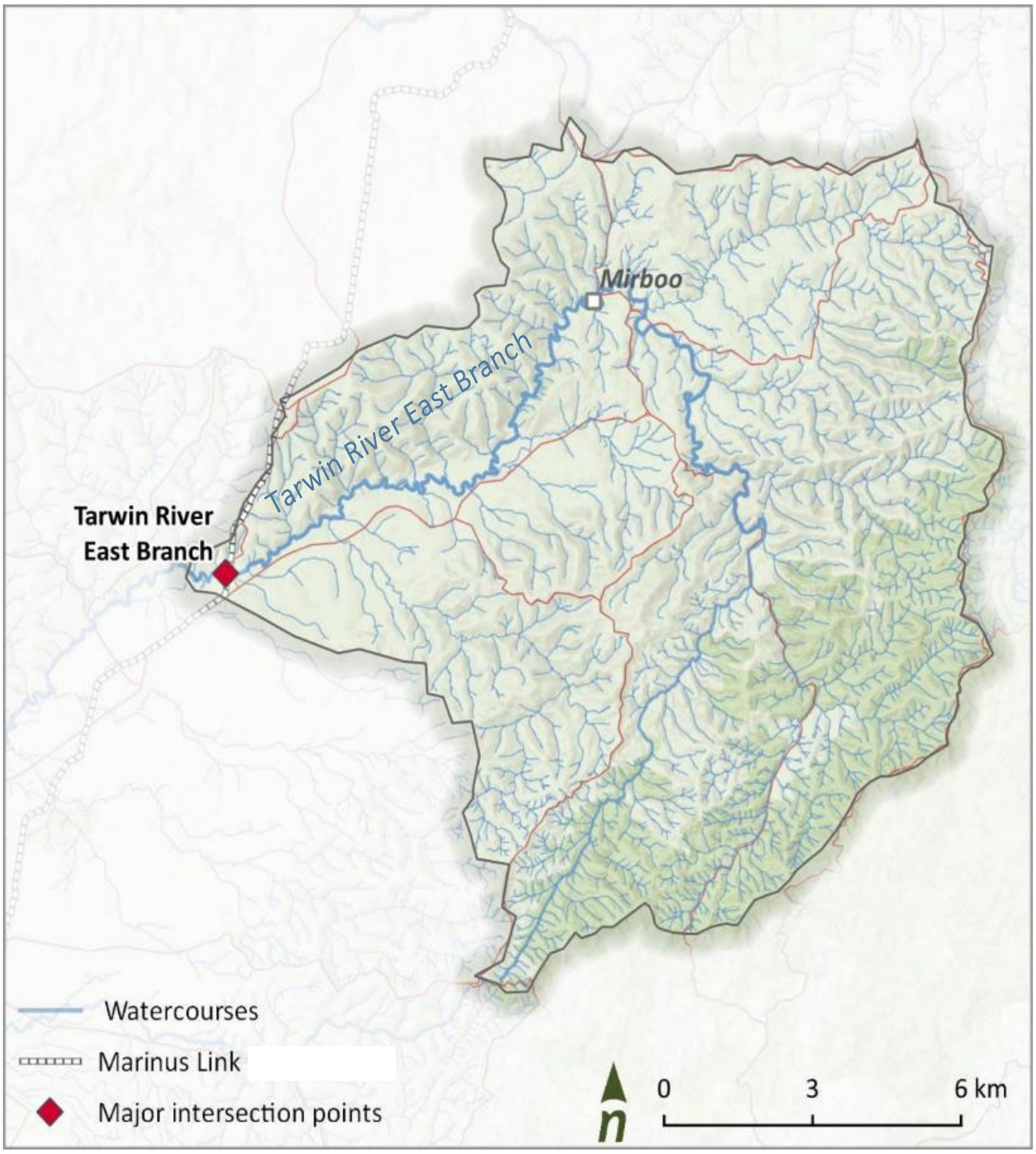

Figure 77. *Tarwin River East branch upstream catchment and proposed project alignment crossing.*

Geology

Geology of the Tarwin River East Branch catchment is dominated by sandstone of the Wonthaggi formation. Further downstream in the catchment geology becomes dominated by basalt of the Thorpdale volcanic group and alluvium (Figure 78). Where the proposed project alignment crosses, the waterway is through alluvium, with sandstone to the north (right bank) and volcanic basalt to the south (left bank).

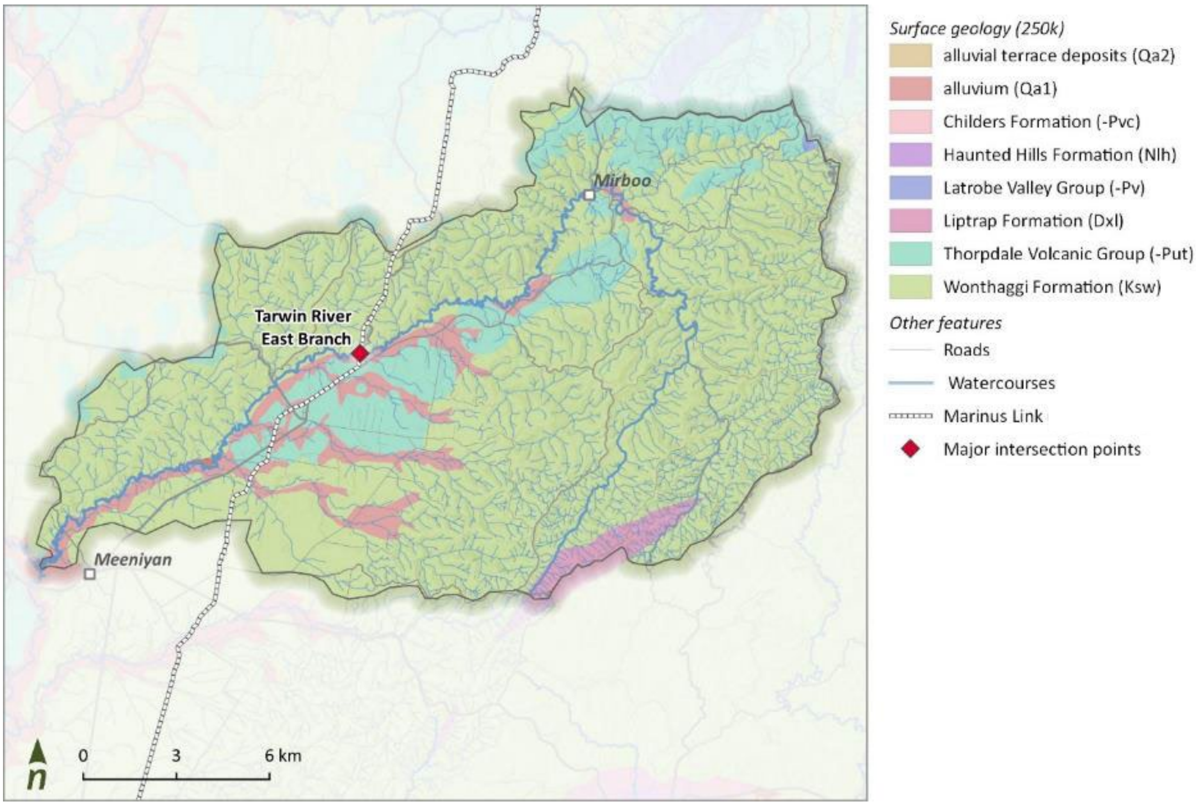

Figure 78. *Surface geology for the Tarwin River East Branch catchment* (Department of Jobs, Precincts and Regions, 2018).

Soils

Soils in the Tarwin River East Branch catchment are largely dermosols and ferrosols, becoming saturated hydrosols throughout the lower catchment floodplain (Figure 79). Dermosols are generally non-dispersive but can be susceptible to rill and sheet erosion when left exposed to heavy rainfall or near waterways (Ipswich City Council (ICC) and Ipswich Rivers Improvement Trust (IRIT), 2014). Ferrosols are well-drained iron oxide-rich soils, generally associated with volcanic basalts. Hydrosols are not generally dispersive but can also be susceptible to streambank erosion (Ipswich City Council (ICC) and Ipswich Rivers Improvement Trust (IRIT), 2014).

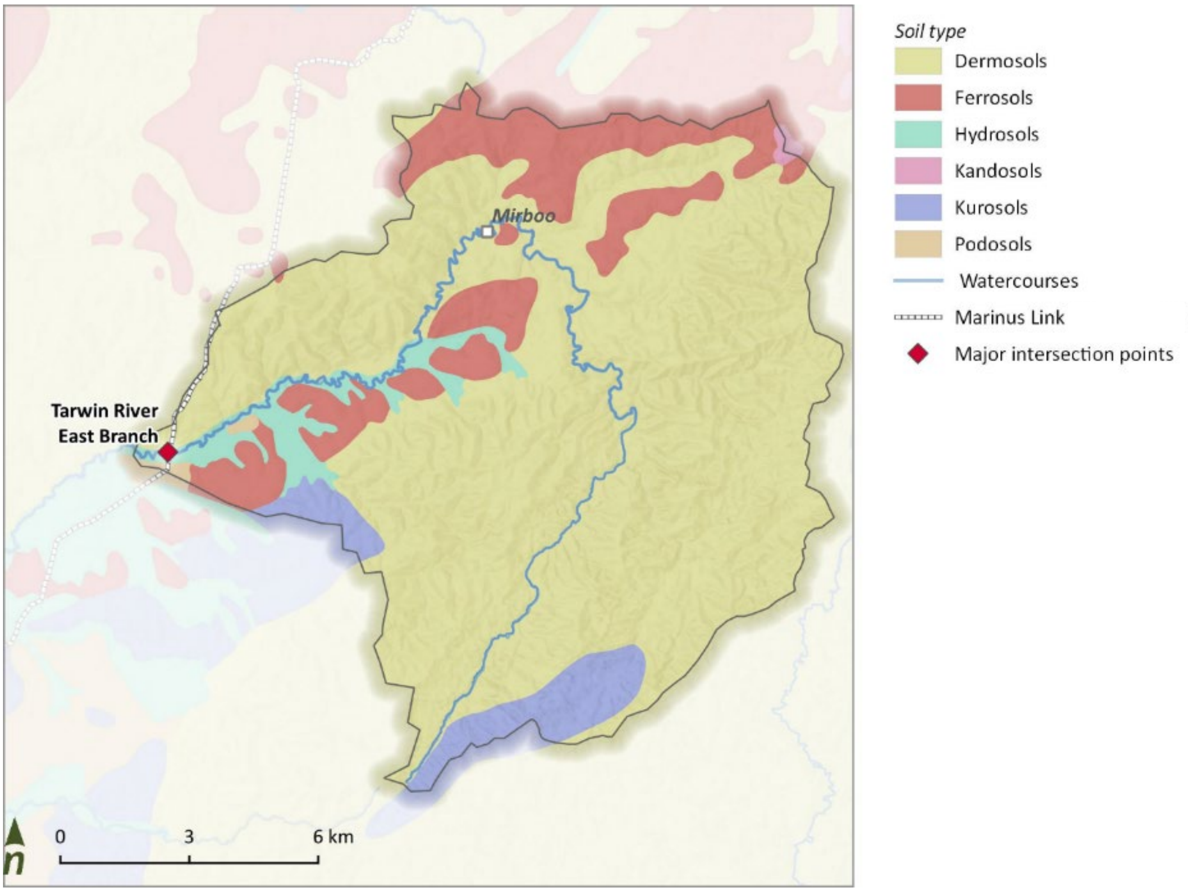

Figure 79. *Soil types within the Tarwin River East Branch catchment upstream of the proposed project alignment crossing* (Department of Jobs, Precincts and Regions (DJPR), 2018).

Land use

Land use in the Tarwin River East Branch catchment is dominated by plantation forests in the upper catchment and grazing modified pastures, with pockets of residential, cropping and nature conservation (Figure 80). At the intersection with the proposed project alignment, land cover around the waterway is pasture and grasslands.

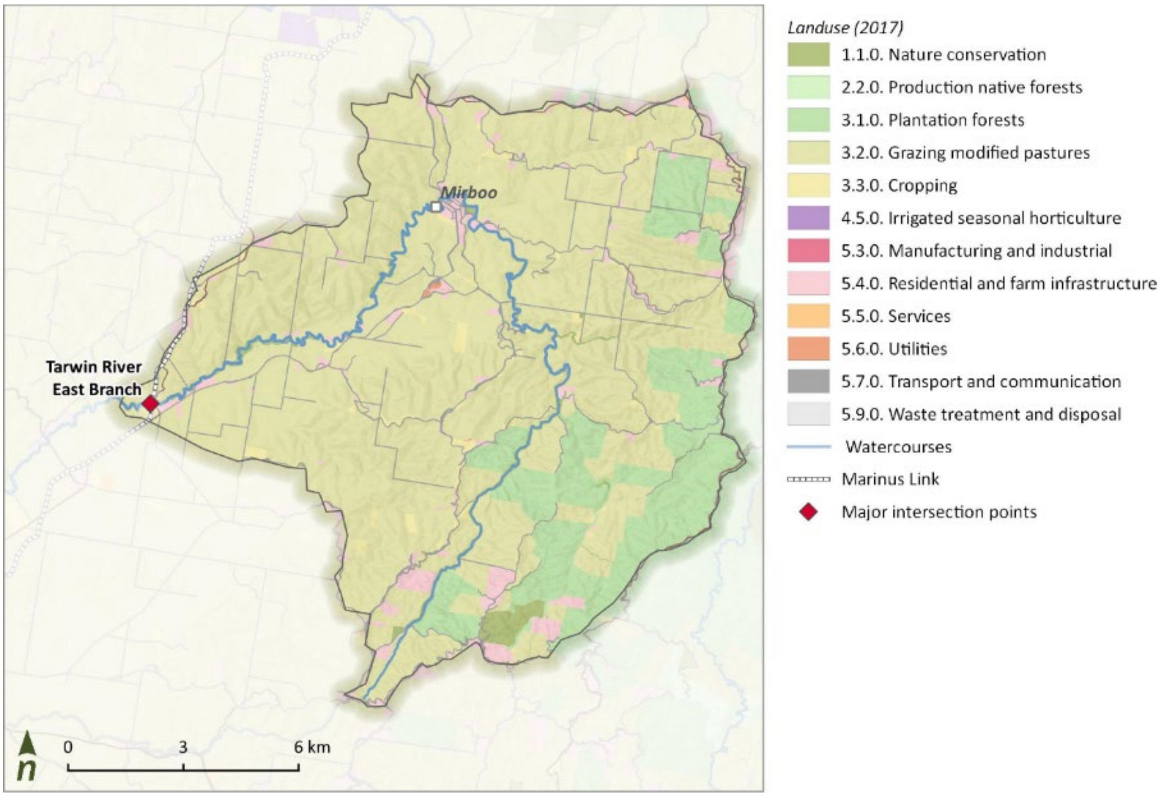

Figure 80. *2017 land use within the Tarwin River East Branch catchment upstream of the proposed project alignment crossing* (Department of Jobs, Precincts and Regions (DJPR), 2017).

Topography interpretation

The Tarwin River East Branch at the intersection with the proposed project alignment is a meandering river partially confined on one side (Figure 81). The channel is around 15 m wide, 3 m deep, with a floodplain that varies between 500 and 600 m wide (Figure 82). The river is constrained to the north by steeper slopes, with a gentler gradient to the south. The waterway is intersected by numerous farm access tracks with several tributaries and drainage channels. There is unrestricted stock access to the waterway in some areas, which may result in some bank slumping, trampling and erosion.

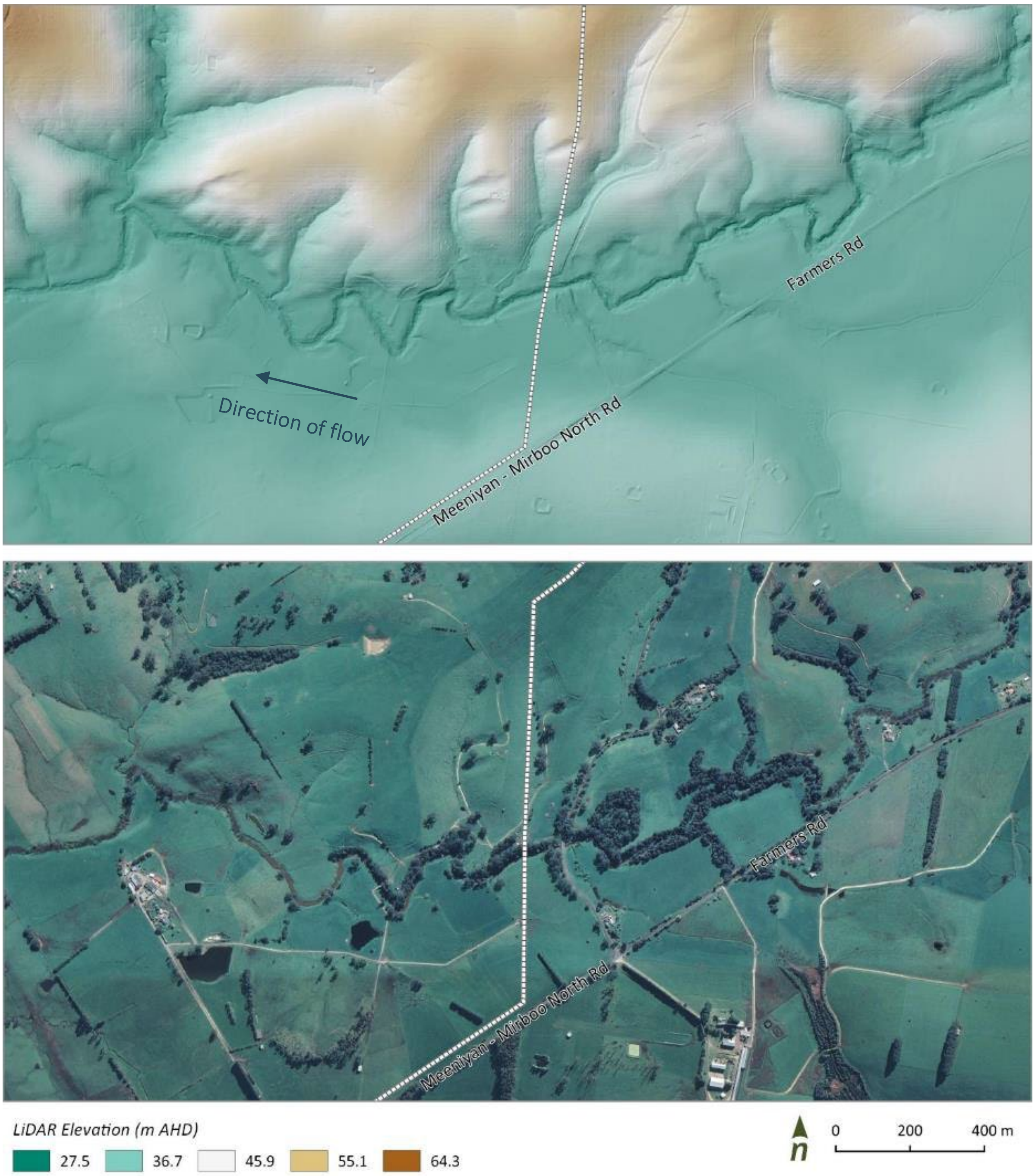

Figure 81. *LiDAR (2018) and aerial imagery (2020) for the Tarwin River East Branch at the intersection with the approximate proposed project alignment.*

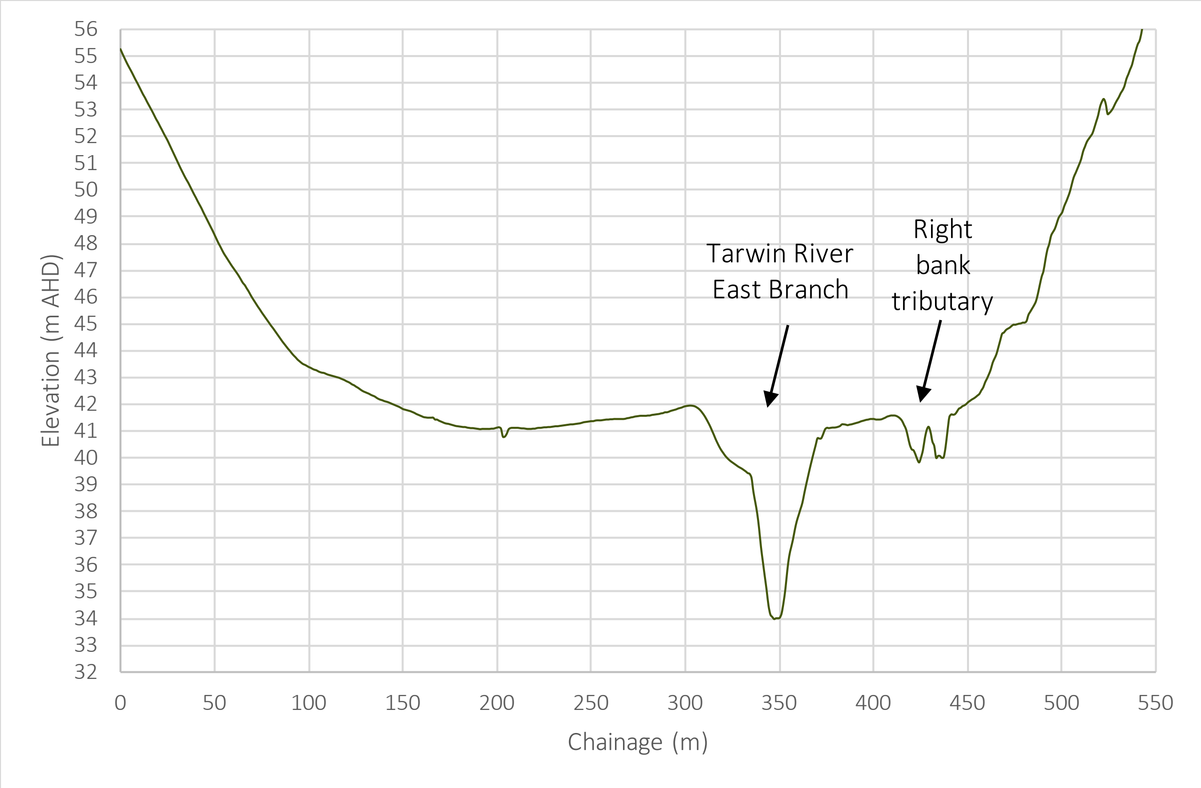

Figure 82. *Cross section of the approximate proposed project alignment at the Tarwin River East Branch, derived from LiDAR (looking downstream).*

Bed grade analysis

A longitudinal profile extracted from the available LiDAR (2018) and the ISC centreline alignment of the Tarwin River East Branch (Figure 83) shows a relatively stable bed grade between 0.006 and 0.01 m/m in the vicinity of the proposed project alignment. There are some steepened areas upstream of the intersection with the crossing, however the location of the proposed project alignment crossing is between two road crossings, where the grade of the bed or any vertical instabilities should be controlled.

Bed grade and chainages relative to Figure 83 are presented in Table 34. Bed grade was compared with a database of bed grades drawn from stable alluvial rivers in SE Australia (Department of Sustainability and Environment (DSE), 2007; Hardie, 1993), calculated design bed grades relative to the 2 yr. ARI flow, and to upstream and downstream reaches of the Tarwin River East Branch that are not incising. Bed grades were classed as acceptable or not acceptable as follows:

- ✓ Bed grade is within the bounds of a stable waterway, not substantially steeper than upstream or downstream grade of stable reaches.
- ✓ Bed grade is steeper than the bounds of a stable waterway, but other factors mean this is acceptable e.g., steepening is upstream of waterway crossing, other infrastructure (e.g., road crossings) control bed grade.
- ✗ Bed grade is unacceptable, and incision is likely.

Table 34. Bed grades at various segments of the Tarwin River East Branch near the crossing, relative to Figure 83

Chainage (m)	Bed grade (m/m)	Acceptable?
0- 4000	0.0010	✓
4000- 6000	0.0023	✓
6000- 10000	0.0007	✓
10000- 11500	0.0004	✓
11500- 12000	0.0060	✓
12000- 13500	0.0013	✓
13500- 13800	0.0020	✓
13800- 14300	0.0076	✓
14300- 15100	0.0000	✓
15100- 17200	0.0005	✓
17200- 20000	0.0017	✓

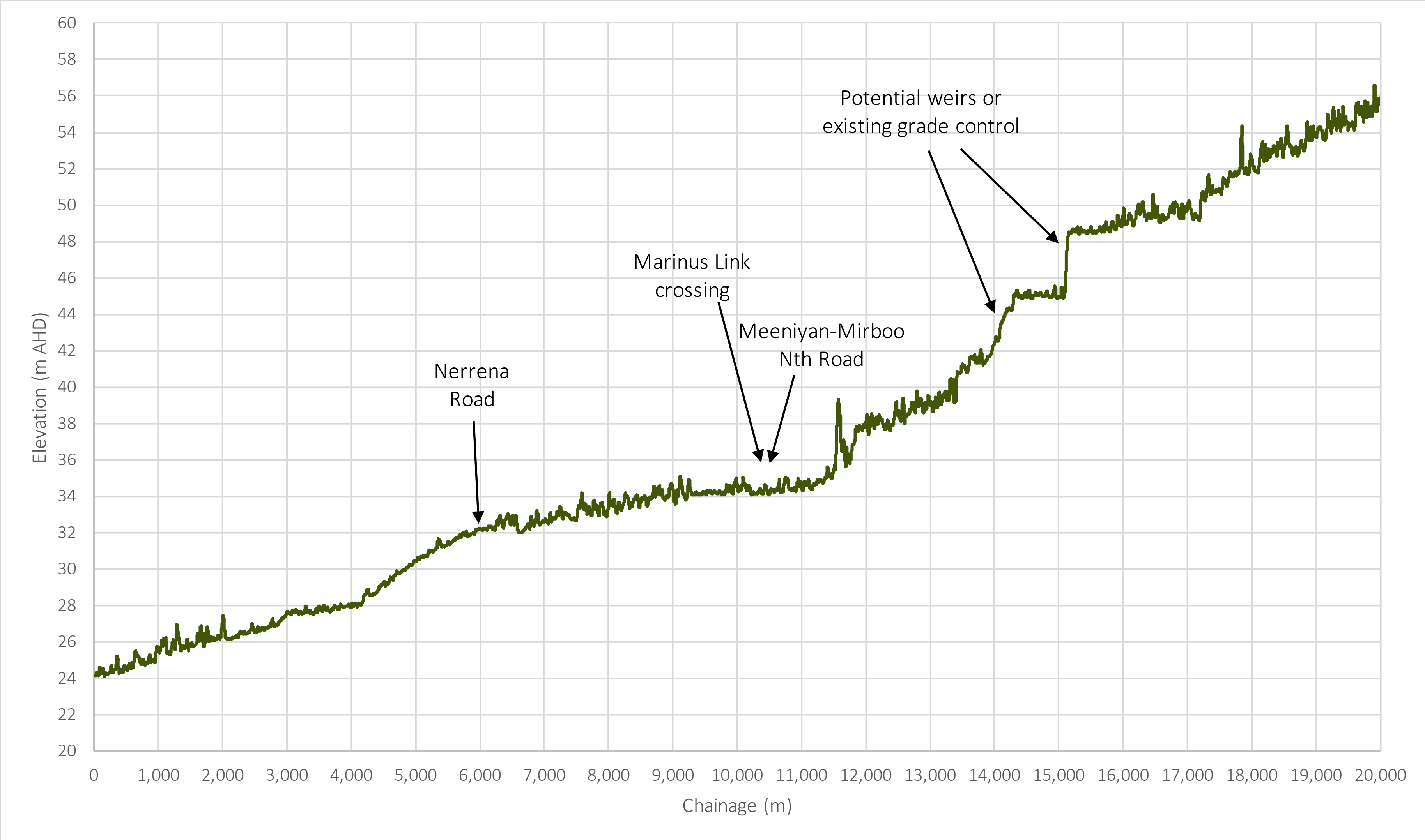

Figure 83. *Smoothed longitudinal profile (20-point moving average) of the Tarwin River East Branch surrounding the proposed project alignment, derived from LiDAR along ISC centreline alignment.*

Aerial imagery analysis

Available past aerial imagery (Figure 84) shows that the channel alignment has remained largely unchanged over the last 10 years. However, historic aerial imagery earlier than 2010 is not available or of high enough resolution to determine channel change. The channel is also obstructed by vegetation in some places, so it is difficult to determine lateral channel change by aerial imagery alone.

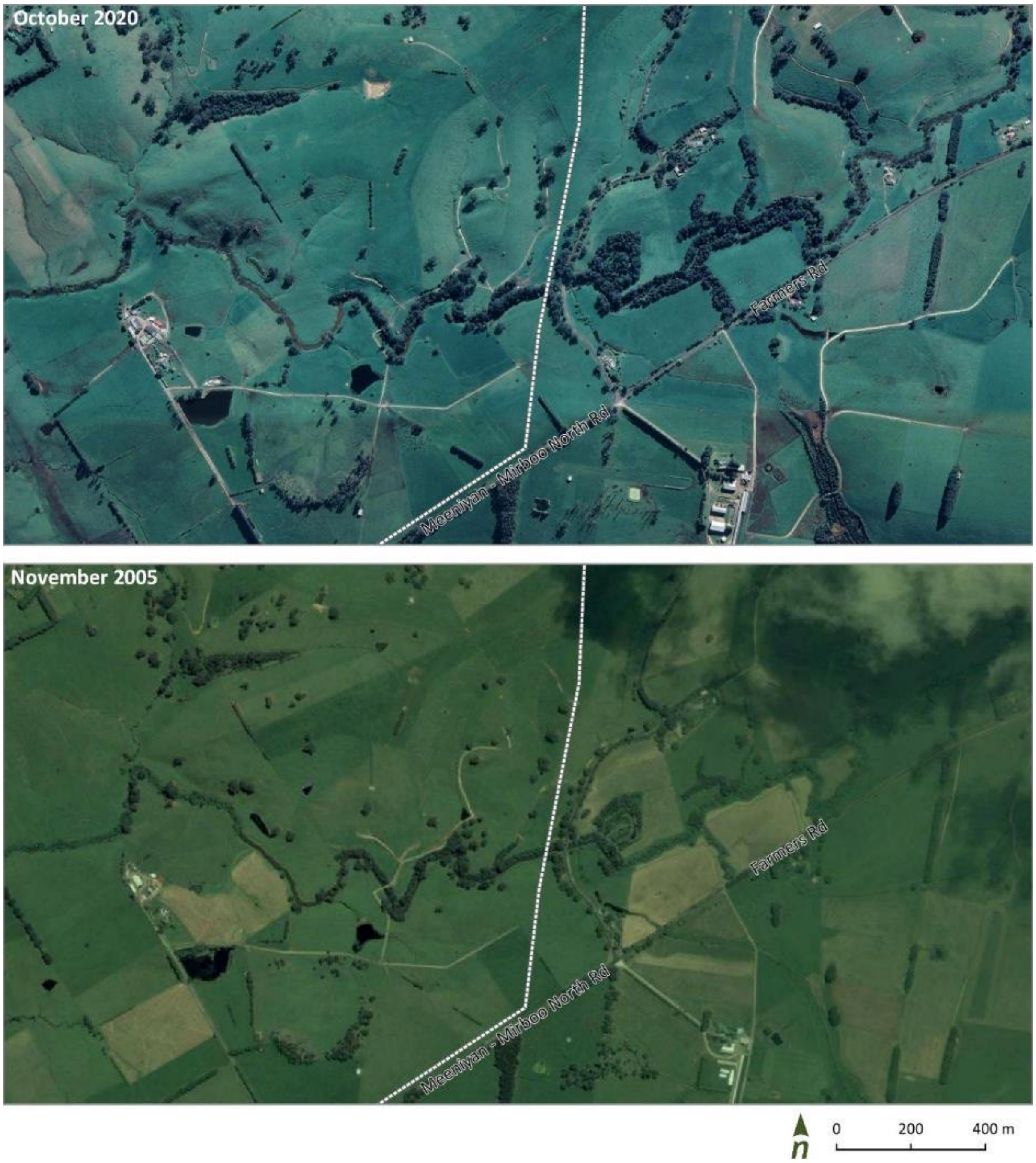

Figure 84. *Available aerial imagery for the Tarwin River East Branch at the intersection with the proposed project alignment for 2020 and 2005.*

Site inspection

Site inspection of the Tarwin River East Branch at the crossing with the proposed project alignment was undertaken on 22nd March 2022.

The inspection found that there was no evidence of major bank erosion or bed scour (Figure 85). The right bank (looking downstream) was characterised by coarse woody debris, with recent high wind events and storms leaving these scattered through the right bank zone between the channel and the fence line. The site inspection also revealed flood debris upstream of the proposed project alignment at the bridge crossing on Meeniyan-Mirboo North Road (Figure 86). The bridge piers appeared to be in working order, with no evidence of incision or exposure below their abutments. Although riparian vegetation was sparse, there was no evidence of bank erosion, with established ground cover to the toe of the banks. On the right bank (looking downstream) vegetation was more established with some remnant trees and shrubs, while on the left bank, vegetation comprised of only phragmites and other ground cover species.

Figure 85. *Tarwin River East Branch in the vicinity of the proposed project crossing looking downstream (top) and upstream (bottom)*

Figure 86. *Looking downstream at the Tarwin River East Branch bridge crossing on Meeniyan-Mirboo North Road with flood debris in channel and on left bank*

Tarwin East tributaries (north and south)

Catchment setting

Two tributaries of the Tarwin River East Branch, located south of the town of Dumbalk flow largely east, from the Strzelecki Ranges. The northern tributary meets the Tarwin River East Branch just upstream of Sweeneys Road, south west of Dumbalk (Figure 87). The southern tributary joins the Tarwin River East Branch further downstream near the junction of Meeniyan-Mirboo North Road and Dumbalk-Stony Creek Road and upstream of Parrys Road.

Part of the broader Tarwin River system, the northern tributary is around 12.3 km in length, with a catchment of around 24 km^2. The southern tributary is around 14.1 km in length, with a catchment of around 36 km^2. These tributaries support the broader Tarwin River system, with key values listed above.

The tributaries rise in high relief sedimentary rock, before entering the lower relief riverine plains and terraces.

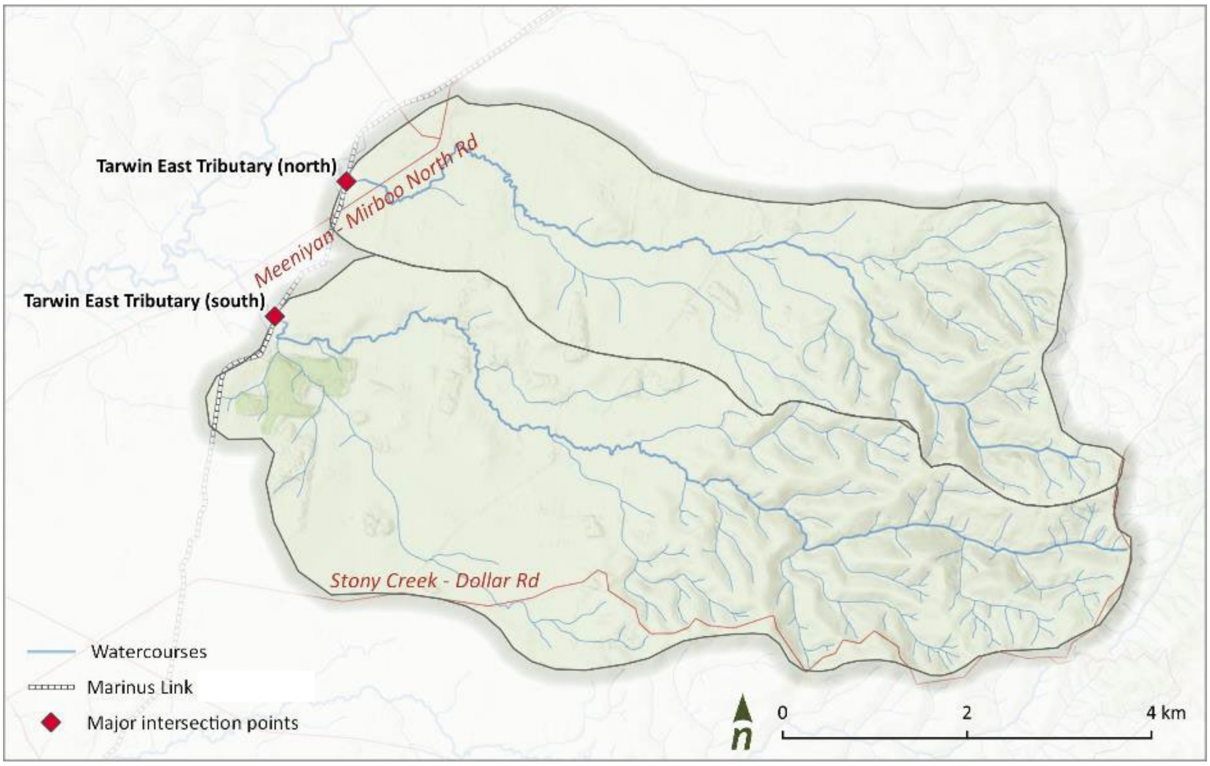

Figure 87. *Tributaries of the Tarwin River East branch upstream catchment and proposed project alignment crossing.*

Geology

Geology of the Tarwin River East Branch catchment is dominated by sandstone of the Wonthaggi formation. Further downstream in the catchment geology becomes dominated by basalt of the Thorpdale volcanic group and alluvium (Figure 88). Where the proposed project alignment crosses, the two tributaries is through alluvium, with volcanic basalt surrounding the northern tributary and sandstone surrounding the southern portion of the south tributary and basalt to the north (right bank).

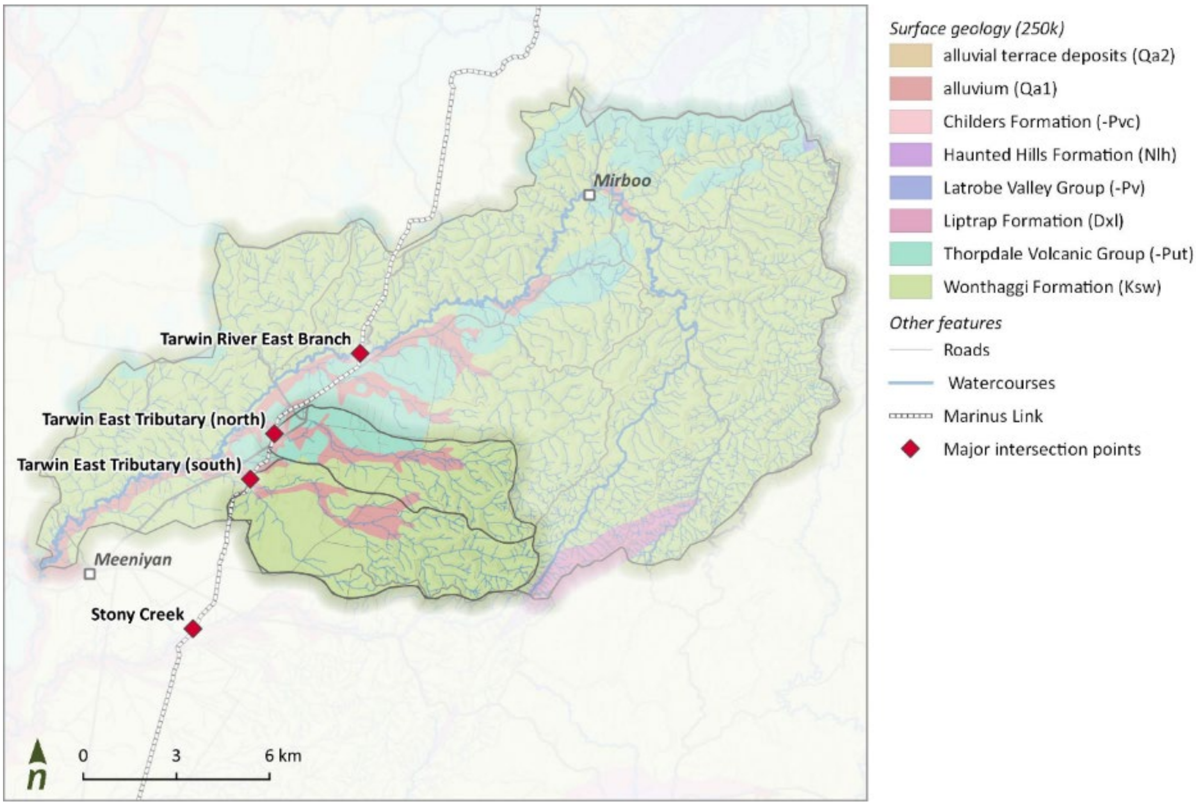

Figure 88. *Surface geology for the Tarwin River East Branch catchment with tributaries highlighted* (Department of Jobs, Precincts and Regions, 2018).

Soils

Soils in the upper catchment of the tributaries are largely dermosols, becoming saturated hydrosols throughout the lower catchment floodplain (Figure 89). Dermosols are generally non-dispersive but can be susceptible to rill and sheet erosion when left exposed to heavy rainfall or near waterways (Ipswich City Council (ICC) and Ipswich Rivers Improvement Trust (IRIT), 2014).

Across the lower catchment, soils are a mix of Ferrosols, Hydrosols, Kurosols, and Podosols. Ferrosols are well-drained iron oxide-rich soils, generally associated with volcanic basalts. Hydrosols are not generally dispersive but can also be susceptible to streambank erosion (Ipswich City Council (ICC) and Ipswich Rivers Improvement Trust (IRIT), 2014). Kurosols are acidic and have a strong texture contrast between loamy surface (A) horizons and clayey subsurface (B) horizons and generally occur in higher rainfall regions (Agriculture Victoria, 2021). Podosols are mainly sandy with a subsurface (B horizon) dominated by accumulations of organic matter and aluminium, sometimes called 'coffee rock'. These soils retain little water and are well-drained, meaning they can be prone to wind erosion without vegetation cover (Agriculture Victoria, 2021).

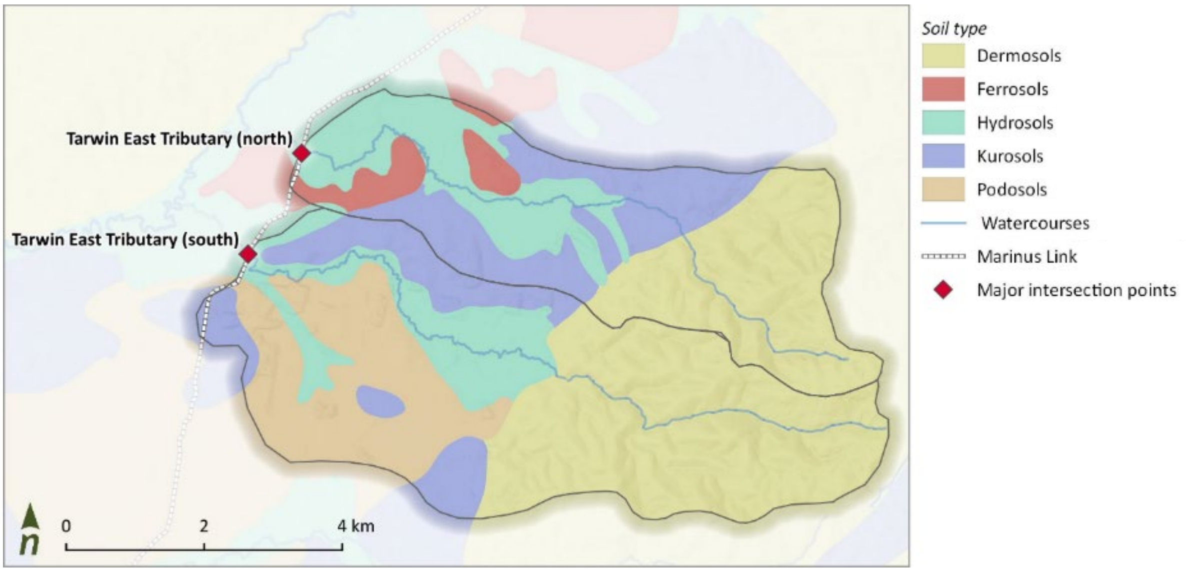

Figure 89. *Soil types within the Tarwin River East Branch tributary catchment upstream of the proposed project alignment crossing* (Department of Jobs, Precincts and Regions (DJPR), 2018).

Land use

Land use in the catchments of the tributaries is dominated by grazing modified pastures, with pockets of residential, cropping and nature conservation (Figure 90). At the intersection with the proposed project alignment, land cover around the waterway is pasture and grasslands.

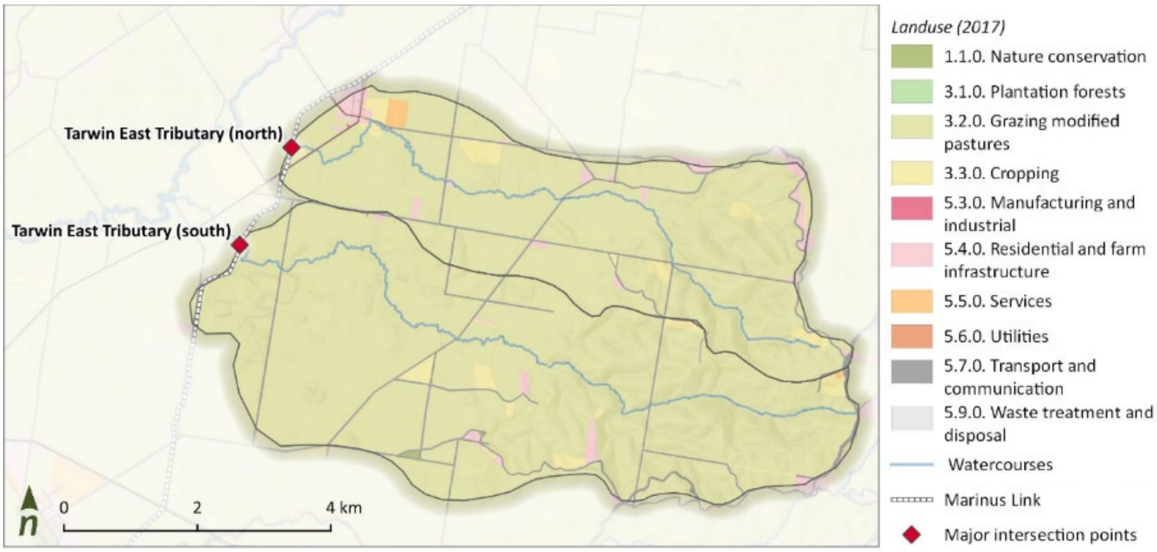

Figure 90. *2017 land use within the Tarwin River East Branch catchment upstream of the proposed project alignment crossing* (Department of Jobs, Precincts and Regions (DJPR), 2017).

Topography interpretation

The northern tributary of the Tarwin River East Branch at the intersection with the proposed project alignment is a meandering, unconfined river (Figure 91). The channel is around 10 m wide, 1 m deep, with a broad floodplain around 800 m wide at the intersection point. The river channel is perched within the floodplain with numerous floodplain drainage channels (Figure 92).

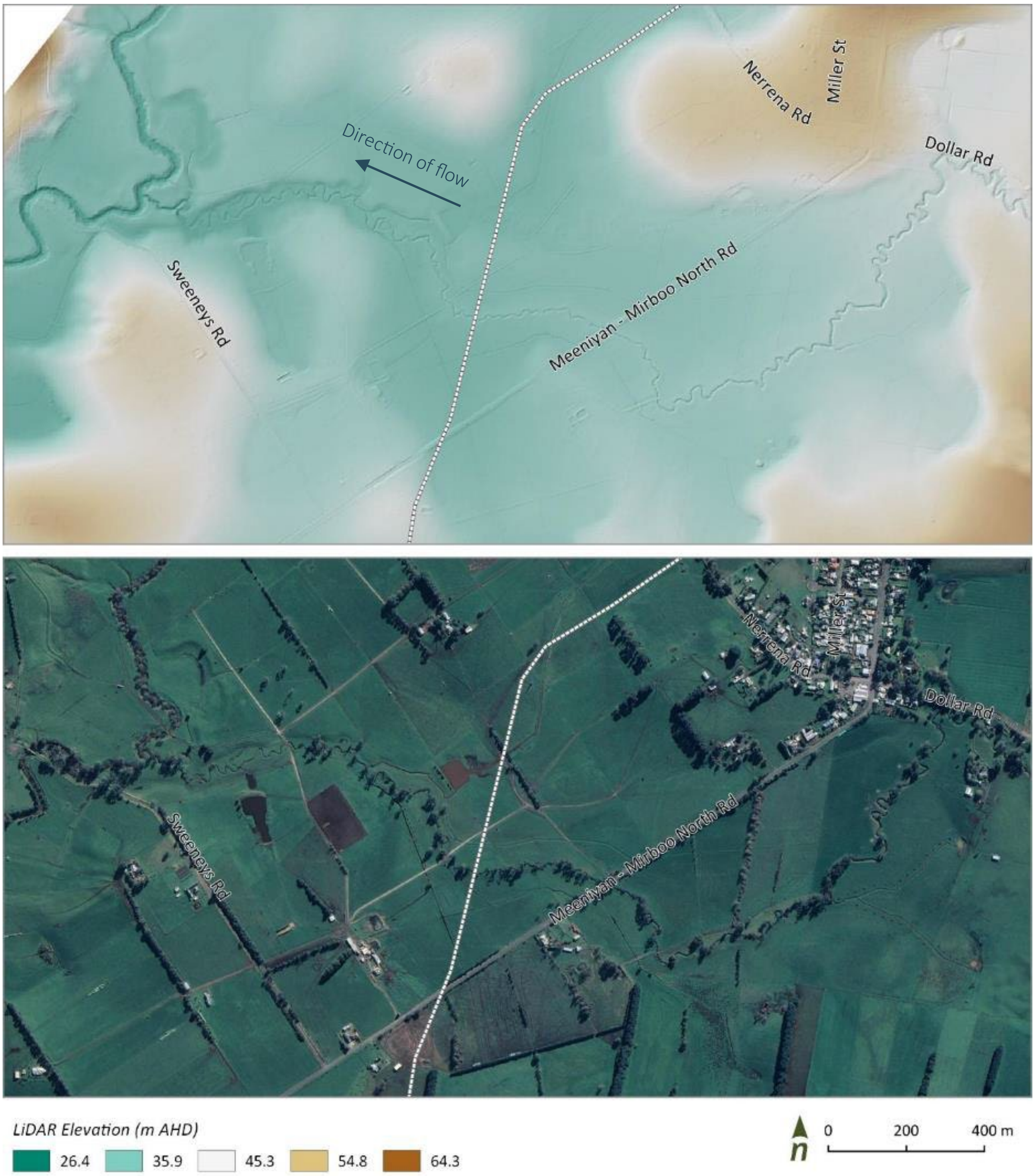

Figure 91. *LiDAR (2018) and aerial imagery (2020) for the northern tributary of the Tarwin River East Branch at the intersection with the approximate proposed project alignment.*

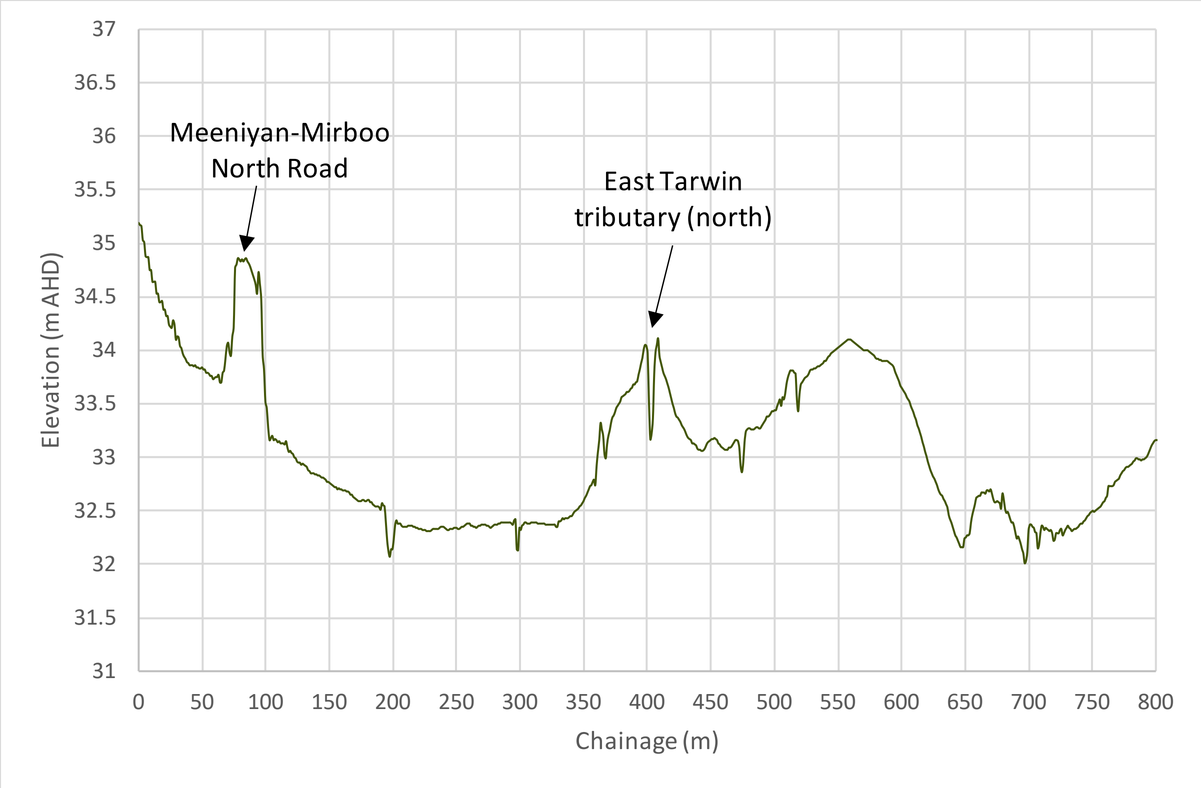

Figure 92. *Cross section of the approximate proposed project alignment at the northern tributary of the Tarwin River East Branch, derived from LiDAR (looking downstream).*

The southern tributary of the Tarwin River East Branch at the intersection with the proposed project alignment is a meandering, unconfined river (Figure 93). The channel is around 20 m wide, 2 m deep, with a broad floodplain over 500 m wide at the intersection point. The channel itself is perched with the floodplain sloping away to the north towards a farm track. (Figure 94).

Figure 93. *LiDAR (2018) and aerial imagery (2020) for the southern tributary of the Tarwin River East Branch at the intersection with the approximate proposed project alignment.*

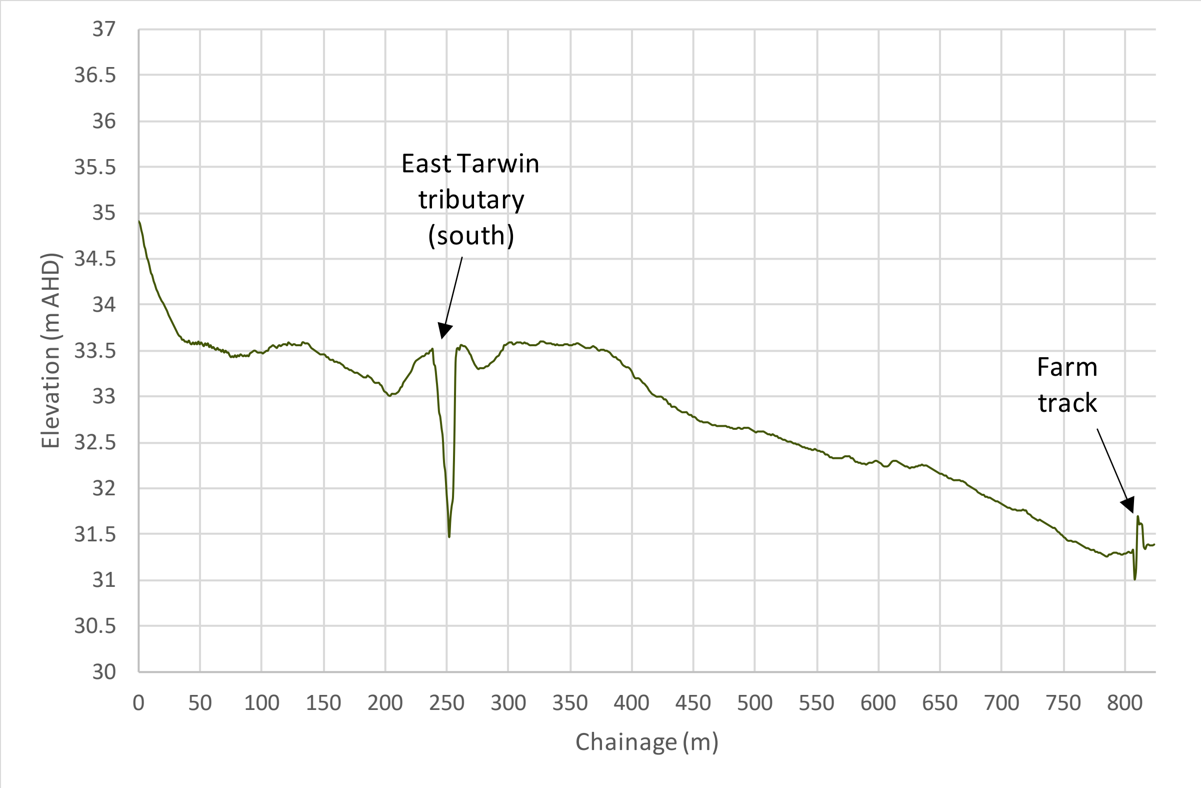

Figure 94. *Cross section of the approximate proposed project alignment at the southern tributary of the Tarwin River East Branch, derived from LiDAR (looking downstream).*

Bed grade analysis

Figure 95 and Figure 96 show longitudinal profiles extracted from the available LiDAR (2018) and the State waterway alignment of the northern and southern tributaries of the Tarwin River East Branch, respectively. For the northern tributary (Figure 95), this profile shows a relatively stable bed grade around 0.002 m/m in the vicinity of the proposed project alignment and steepening upstream with a grade of around 0.006 m/m. Similarly or the southern tributary (Figure 96), this profile shows a relatively stable bed grade around 0.003 m/m in the vicinity of the proposed project alignment and steepening upstream with a grade of around 0.005 m/m

Bed grade and chainages relative to Figure 95and Figure 96 are presented in Table 35 and Table 36, respectively. While a design bed grade relative to the 2 year ARI flow cannot be calculated due to lack of flow modelling, there is no evidence of steepening in the bed grade or areas of incision. Bed grades were classed as acceptable or not acceptable as follows:

- ✓ Bed grade is within the bounds of a stable waterway, not substantially steeper than upstream or downstream grade of stable reaches.
- ✓ Bed grade is steeper than the bounds of a stable waterway, but other factors mean this is acceptable e.g., steepening is upstream of waterway crossing, other infrastructure (e.g., road crossings) control bed grade.
- × Bed grade is unacceptable, and incision is likely.

Table 35. Bed grades at various segments of the northern tributary of the Tarwin River East Branch near the crossing, relative to Figure 95

Chainage (m)	Bed grade (m/m)	Acceptable?
0- 3300	0.0020	✓
3300- 4000	0.0060	✓

Table 36. Bed grades at various segments of the southern tributary of the Tarwin River East Branch near the crossing, relative to Figure 96

Chainage (m)	Bed grade (m/m)	Acceptable?
0- 1700	0.0030	✓
1700- 4000	0.0050	✓

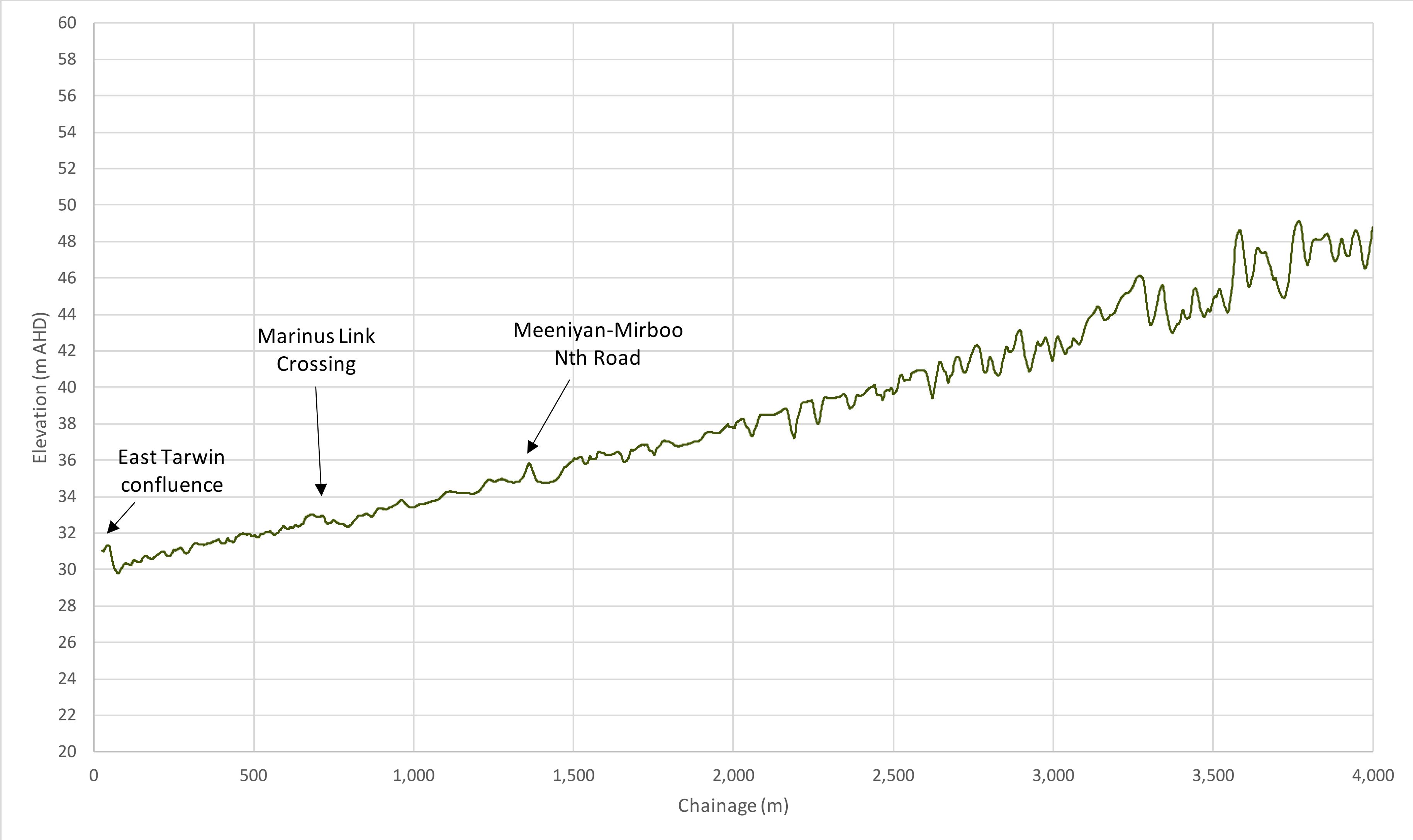

Figure 95. *Smoothed longitudinal profile (20-point moving average) of the northern tributary of the Tarwin River East Branch surrounding the proposed project alignment, derived from LiDAR along State waterway alignment.*

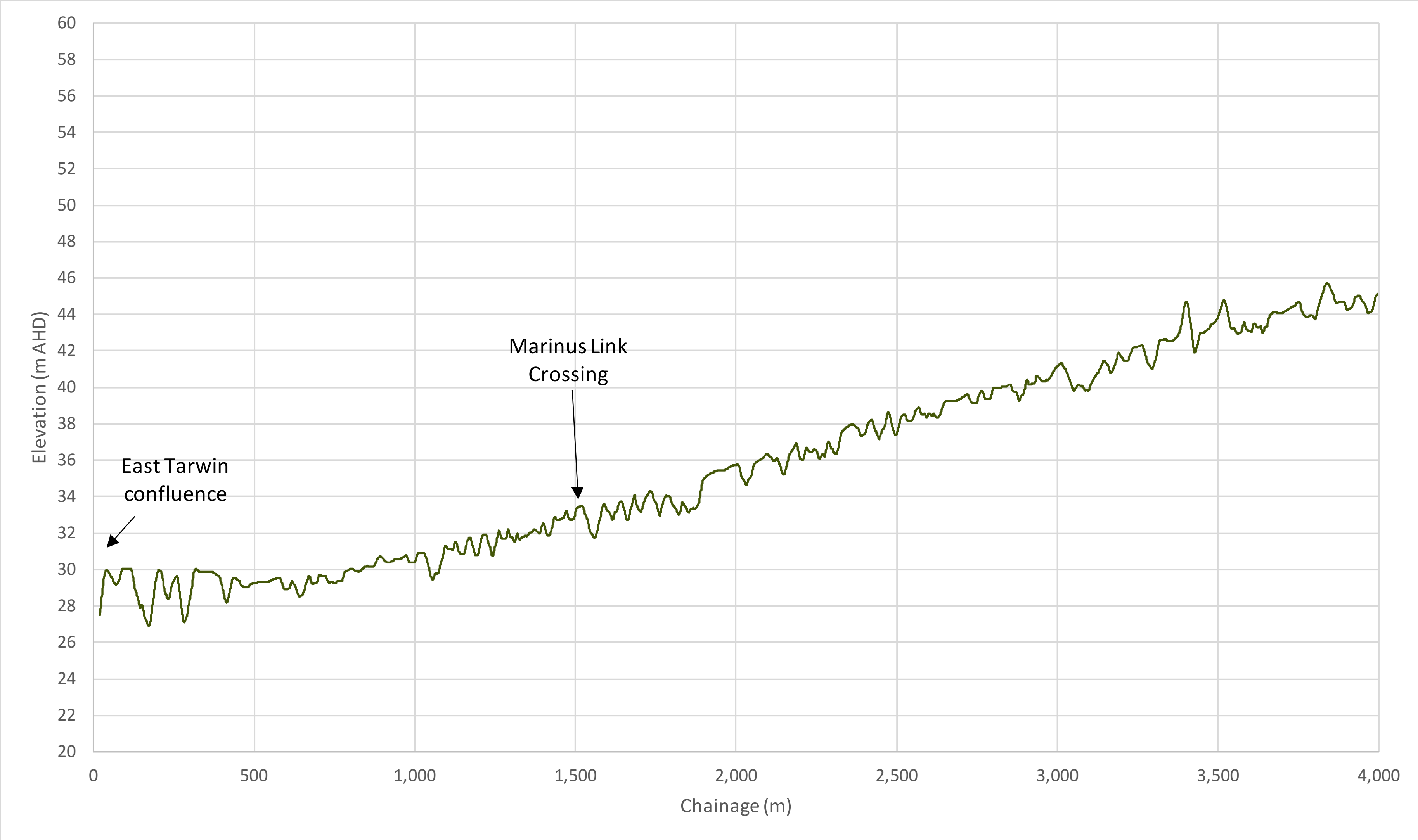

Figure 96. *Smoothed longitudinal profile (20-point moving average) of the northern tributary of the Tarwin River East Branch surrounding the proposed project alignment, derived from LiDAR along State waterway alignment.*

Aerial imagery analysis

Available past aerial imagery (Figure 97, Figure 98) shows that the channel alignment for both tributaries has remained largely unchanged over the last 10 to 15 years. However, historic aerial imagery earlier than 2005 (northern tributary) and 2010 (southern tributary) is not available or of high enough resolution to determine channel change. The channel is also obstructed by vegetation in some places, so it is difficult to determine lateral channel change by aerial imagery alone.

Figure 97. *Available aerial imagery for the northern tributary of the Tarwin River East Branch at the intersection with the proposed project alignment for 2020 and 2005.*

Figure 98. *Available aerial imagery for the southern tributary of the Tarwin River East Branch at the intersection with the proposed project alignment for 2020 and 2010.*

Site inspection

Site inspection of the tributaries of the Tarwin River East Branch at the crossing with the proposed project alignment was not possible due to lack of landholder access.

Stony Creek

Catchment setting

Stony Creek rises near Foster North, just south of Stony Creek-Dollar Road. It flows generally west, following the South Gippsland Highway route, then heads southwest to join the Tarwin River near Meeniyan (Figure 99).

The river flows through high relief ranges, before entering the low relief hills and riverine ranges near the South Gippsland Highway. With the waterway around 29 km in length, the Stony Creek catchment is relatively small at around 72 km^2. Approximately 42 km^2 of the catchment is upstream of the crossing with the proposed project alignment which is located around 350m upstream of the Buffalo-Stony Creek Road crossing and around 12 km upstream of the confluence with the Tarwin River.

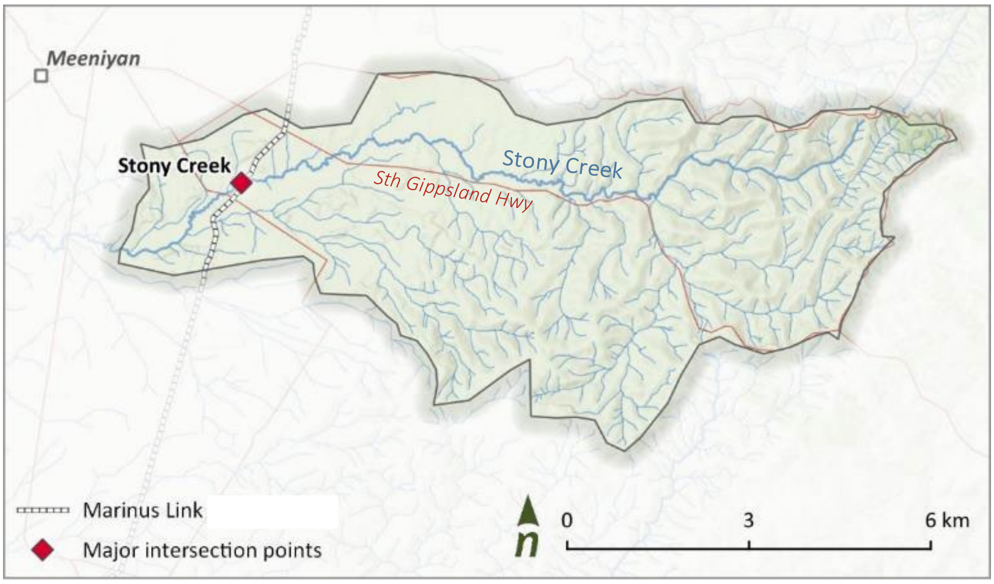

Figure 99. *Stony Creek upstream catchment and proposed project alignment crossing*

Geology

Geology across the Stony Creek catchment is dominated by Wonthaggi formation sandstone and alluvial deposits around the waterway (Figure 100). This geology is evident at the proposed project alignment crossing.

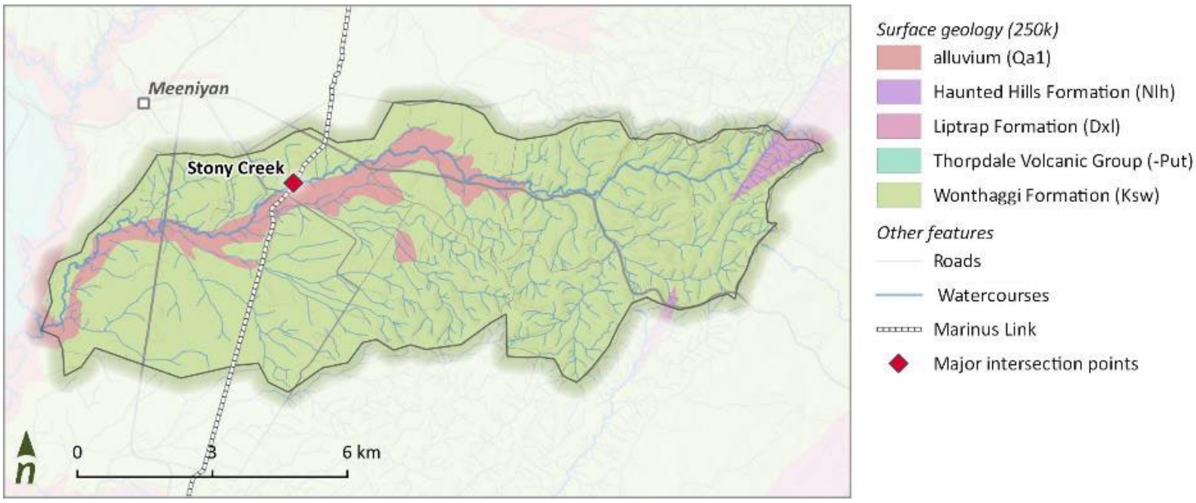

Figure 100. *Surface geology of the Stony Creek catchment* (Department of Jobs, Precincts and Regions, 2018).

Soils

The soils change from dermosols in the upper catchment, through kurosols and then podosols in the lower catchment, with saturated hydrosols around the waterway (Figure 101).

Dermosols are generally non-cracking clay to clay loam soils (Agriculture Victoria, 2021)They are generally nondispersive but can be susceptible to rill and sheet erosion when left exposed to heavy rainfall or near waterways (ICC, 2014). Kurosols are acidic and have a strong texture contrast between loamy surface (A) horizons and clayey subsurface (B) horizons and generally occur in higher rainfall regions (Agriculture Victoria, 2021). Kurosols have a firm to hard setting surface with poor initial infiltration resulting in a large proportion of water running off, causing erosion (Ipswich City Council (ICC) and Ipswich Rivers Improvement Trust (IRIT), 2014).

Podosols are mainly sandy with a subsurface (B horizon) dominated by accumulations of organic matter and aluminium, sometimes called 'coffee rock'. These soils retain little water and are well-drained, meaning they can be prone to wind erosion without vegetation cover (Agriculture Victoria, 2021). Hydrosols are not generally dispersive but can be susceptible to streambank erosion (Ipswich City Council (ICC) and Ipswich Rivers Improvement Trust (IRIT), 2014).

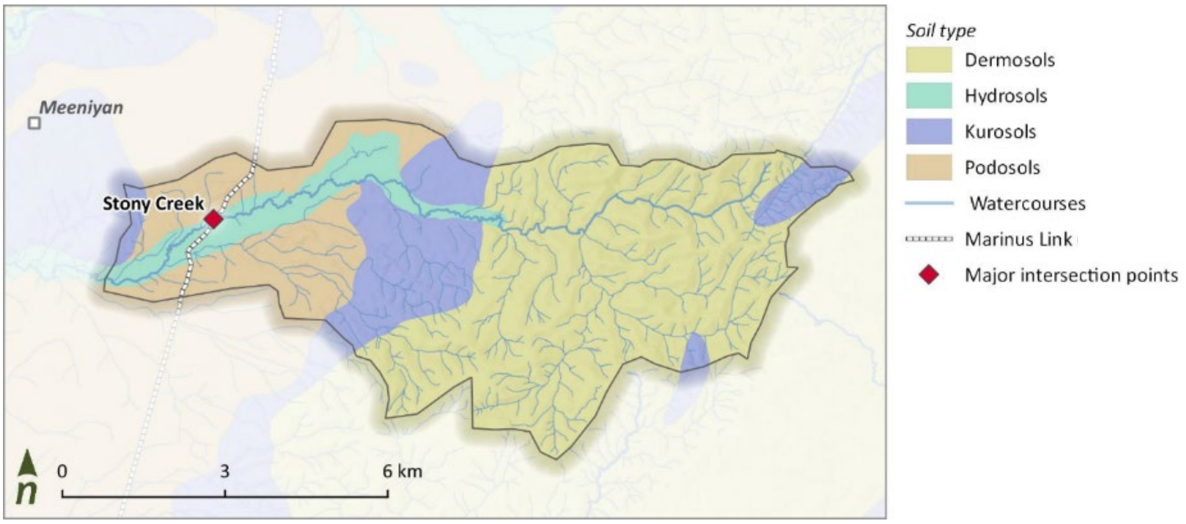

Figure 101. *Soil types within the Stony Creek catchment upstream of the proposed project alignment crossing* (Department of Jobs, Precincts and Regions (DJPR), 2018).

Land use

Land use in the Stony Creek catchment upstream of the proposed project alignment crossing is dominated by grazing modified pastures (Figure 102). There are smaller pockets of residential and farm infrastructure and cropping land. At the intersection with the proposed project alignment, land cover around Stony Creek is pasture and grasslands.

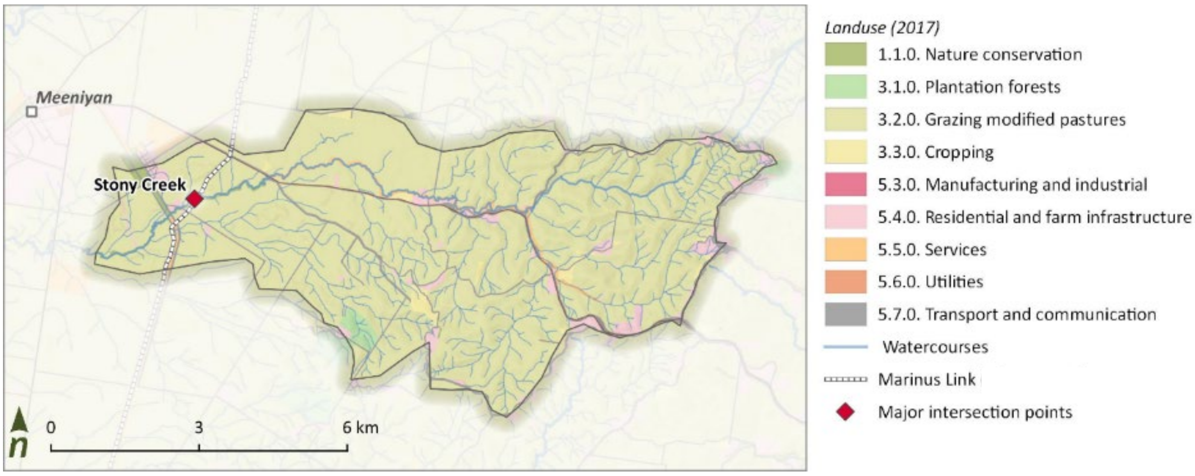

Figure 102. *2017 land use within the Stony Creek catchment upstream of the proposed project alignment crossing* (Department of Jobs, Precincts and Regions (DJPR), 2017).

Topography interpretation

Stony Creek at the intersection with the proposed project alignment is a partially confined stream within a floodplain around 500 m wide (Figure 103). The channel at the crossing is around 15 m wide and around 4 m deep (Figure 103). Gradient is steeper on the northern right bank, with the left bank floodplain sloping down towards the south and a smaller creek. Numerous small tributaries join Stony Creek, draining the hills to the north. There is riparian vegetation coverage along the whole reach.

Figure 103. *LiDAR (2010) and aerial imagery (2020) for Stony Creek at the intersection with the proposed project alignment.*

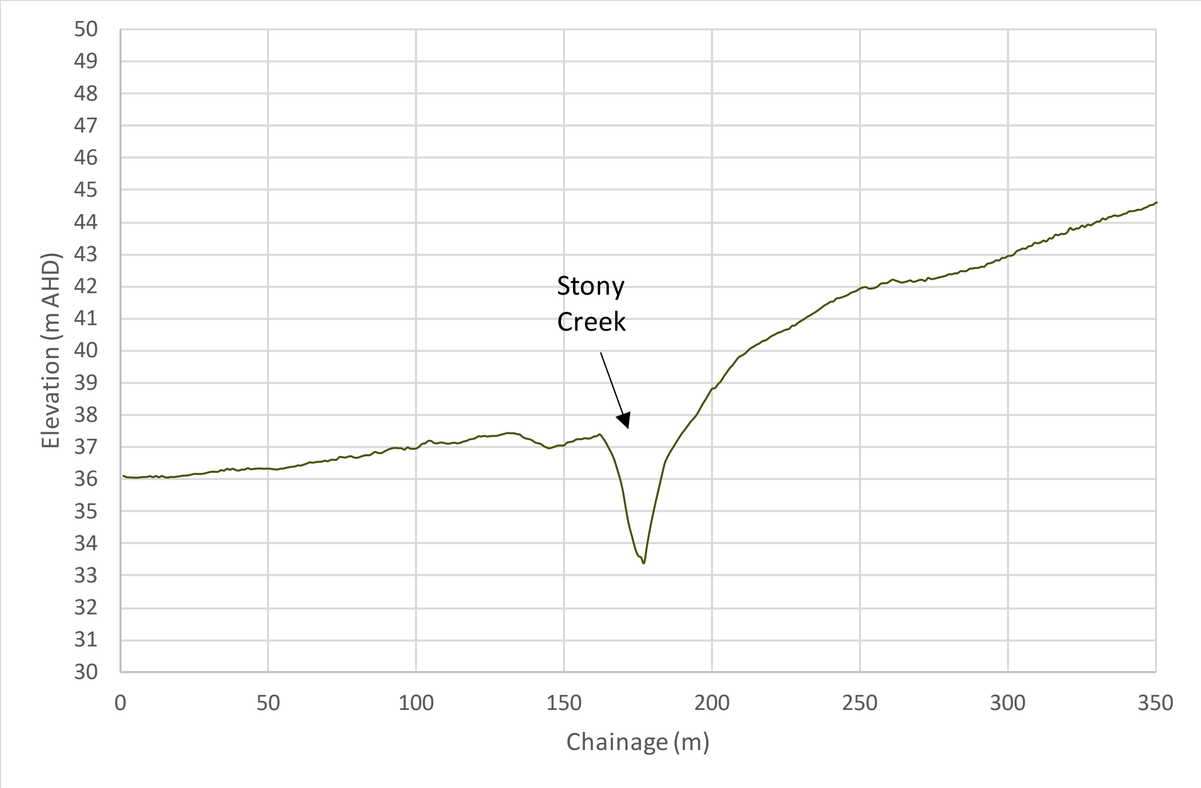

Figure 104. *Cross section of the proposed project alignment at Stony Creek, derived from LiDAR (looking downstream)*

Bed grade analysis

A longitudinal profile extracted from the available LiDAR (2010) and the ISC centreline alignment of Stony Creek (Figure 105) shows a relatively stable bed grade between 0.0034 and 0.0055 m/m in the vicinity of the proposed Marinus Link crossing. There do not appear to be any major instabilities or areas of incision, with the location of the Marinus Link crossing between two road crossings, where the grade of the bed or any vertical instabilities should be controlled.

Bed grade and chainages relative to Figure 105 are presented in Table 37. Bed grade was compared with a database of bed grades drawn from stable alluvial rivers in SE Australia (DSE, 2007; Hardie, 1993), calculated design bed grades relative to the 2 yr. ARI flow, and to upstream and downstream reaches of Stony Creek that are not incising. Bed grades were classed as acceptable or not acceptable as follows:

- ✓ Bed grade is within the bounds of a stable waterway, not substantially steeper than upstream or downstream grade of stable reaches.
- ✓ Bed grade is steeper than the bounds of a stable waterway, but other factors mean this is acceptable e.g., steepening is upstream of waterway crossing, other infrastructure (e.g., road crossings) control bed grade.
- × Bed grade is unacceptable, and incision is likely.

Table 37. Bed grades at various segments of the Tarwin River East Branch near the crossing, relative to Figure 105

Chainage (m)	Bed grade (m/m)	Acceptable?
0- 8000	0.0034	✓
8000- 13500	0.0055	✓

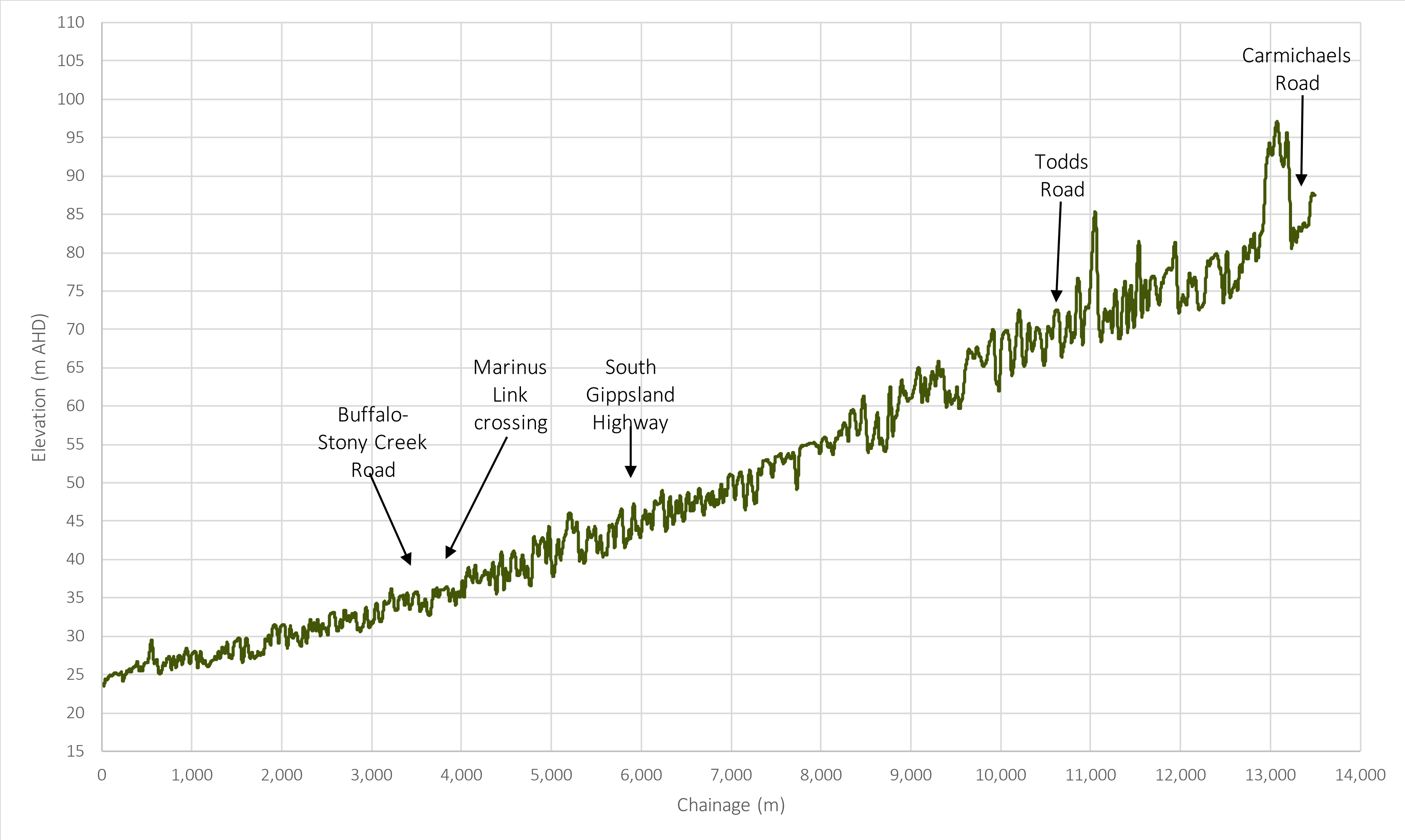

Figure 105. *Smoothed longitudinal profile (20-point moving average) of Stony Creek surrounding the proposed project alignment, derived from LiDAR along State waterway alignment.*

Aerial imagery analysis

Available past aerial imagery (Figure 106) shows the alignment of Stony Creek has changed little in this area, without major channel change or meander migration over the last 10 years. However, historic aerial imagery earlier than 2010 is not available or of high enough resolution to determine channel change. The channel is also obstructed by vegetation, so it is difficult to determine lateral channel change by aerial imagery alone.

Figure 106. *Available aerial imagery for Stony Creek at the intersection with the proposed project alignment for 2020 and 2010.*

Site inspection

Site inspection of Stony Creek at the crossing with the proposed project alignment was undertaken on 21st March 2022.

The inspection found that banks appeared stable with no signs of erosion or incision (Figure 107). Banks were well-vegetated with trees, shrubs, and ground cover. The stream was fenced at top of bank with little riparian buffer, but no apparent stock access. Some large wood was seen in the river after recent high wind events/storms, which could promote bank erosion in the vicinity of fallen timber as water attempts to outflank the obstruction. Anecdotes from landholders suggested that in flood events water escapes the channel and travels in a southerly direction over the floodplain. There were no signs of active floodplain scour or obvious breakout point, with dense vegetation cover, making a reach-scale avulsion unlikely.

Figure 107. *Stony Creek in the vicinity of the proposed project alignment looking upstream (top) and downstream (bottom).*

Buffalo Creek

Catchment setting

Buffalo Creek is a small waterway, around 10km in total length, with a catchment around 38 km^2 (Figure 108).

The waterway flows through low relief hills and into riverine plains near Meeniyan-Promontory Road, before reaching the broader floodplain of the Tarwin River.

The crossing with the proposed project alignment is around 650 m upstream of the Meeniyan-Promontory Road crossing, near the Great Southern Rail Trail. This is around 5.8 km upstream of the confluence with the Tarwin River.

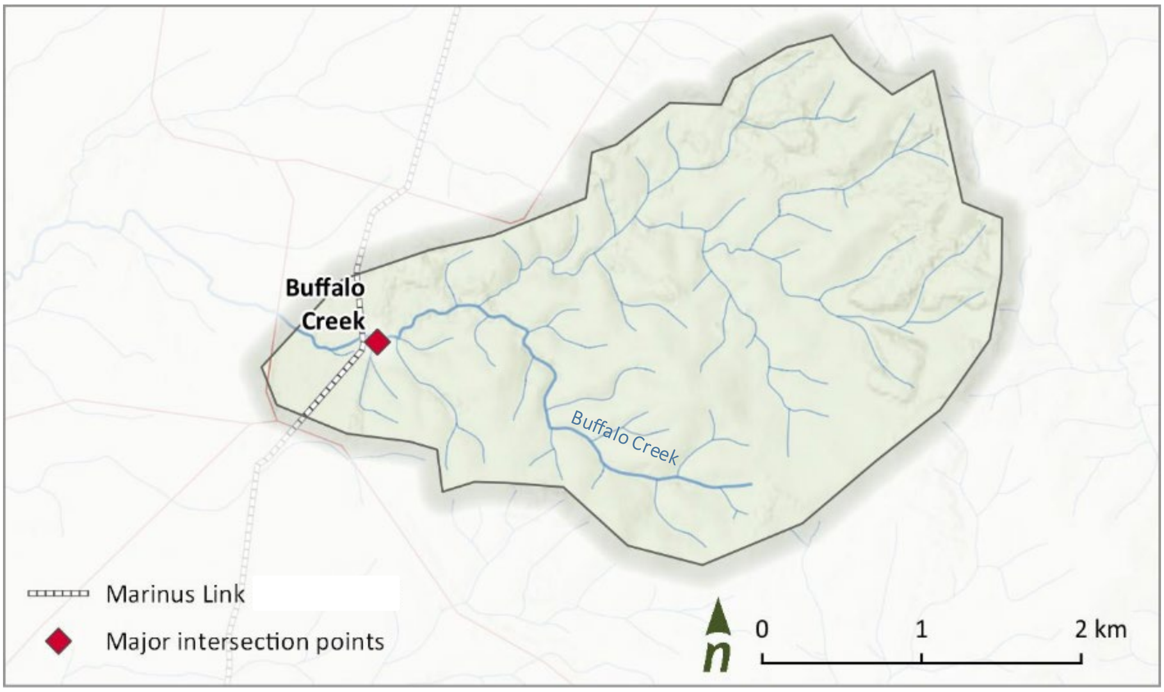

Figure 108. *Buffalo Creek catchment upstream and proposed project alignment crossing.*

Geology

Geology across the Buffalo Creek catchment is dominated by Wonthaggi formation sandstone in the upper catchment, moving to sand, gravel and silt associated with the Haunted Hills formation, alluvium and alluvial terrace deposits in the lower catchment. This break in geology is located around the location of proposed project alignment crossing (Figure 115).

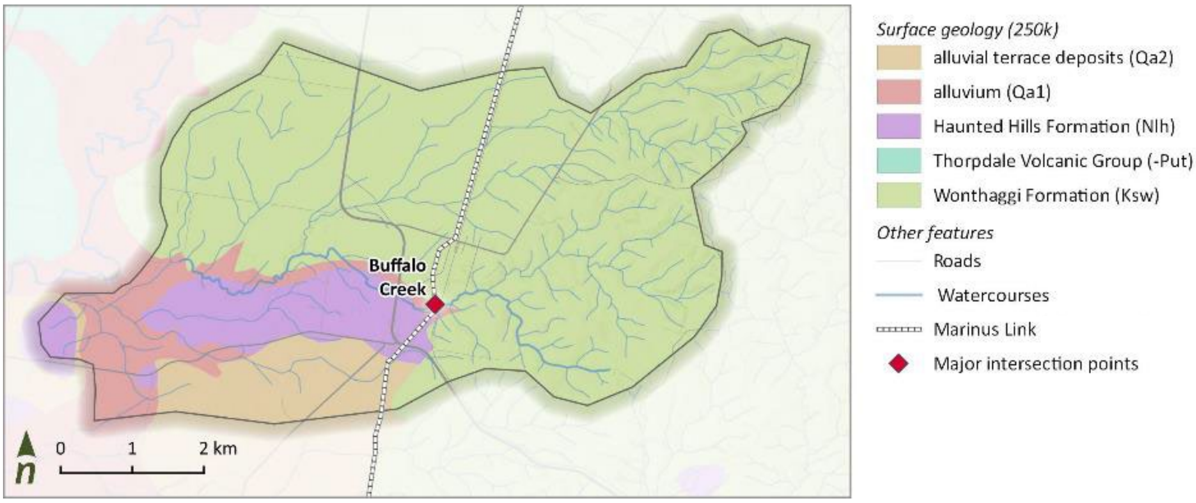

Figure 109. *Surface geology of the Buffalo Creek catchment* (Department of Jobs, Precincts and Regions, 2018).

Soils

The Buffalo Creek catchment upstream of the crossing with the proposed project alignment is dominated by kurosols (Figure 110). Kurosols are acidic and have a strong texture contrast between loamy surface (A) horizons and clayey subsurface (B) horizons and generally occur in higher rainfall regions (Agriculture Victoria, 2021). They have a firm to hard setting surface with poor initial infiltration resulting in a large proportion of water running off, causing erosion. Nearer the intersection point, the soils turn to hydrosols and podosols.

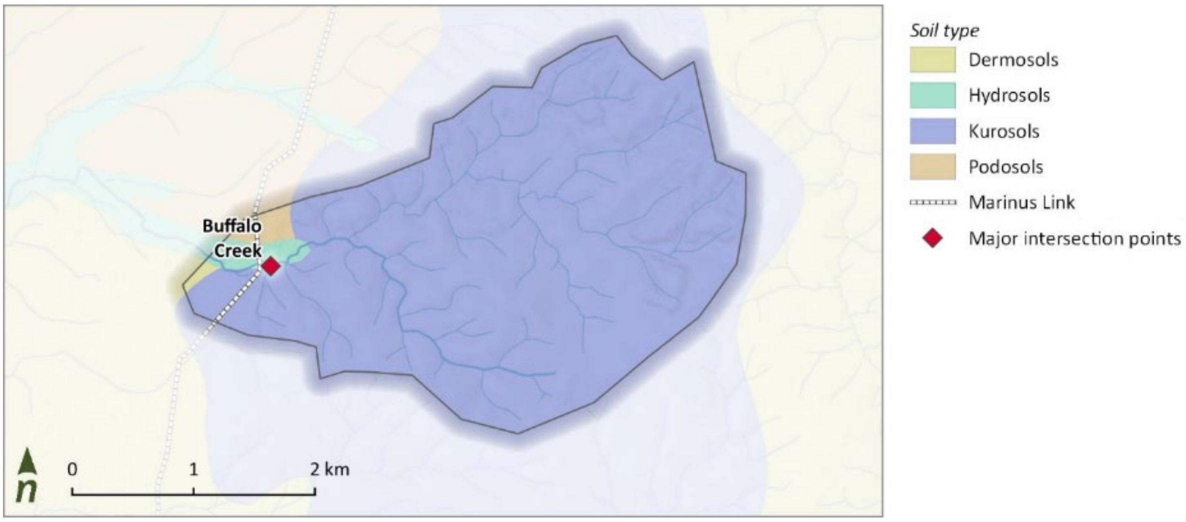

Figure 110. *Soil types within the Buffalo Creek catchment upstream of the proposed project alignment crossing* (Department of Jobs, Precincts and Regions (DJPR), 2018)

Land use

Land use across the small Buffalo Creek catchment is dominated by grazing modified pastures with some residential and farm infrastructure and nature conservation. At the intersection with the proposed project alignment, land use around Buffalo Creek is rural residential with pasture and grasslands (dairy cattle) (Figure 111).

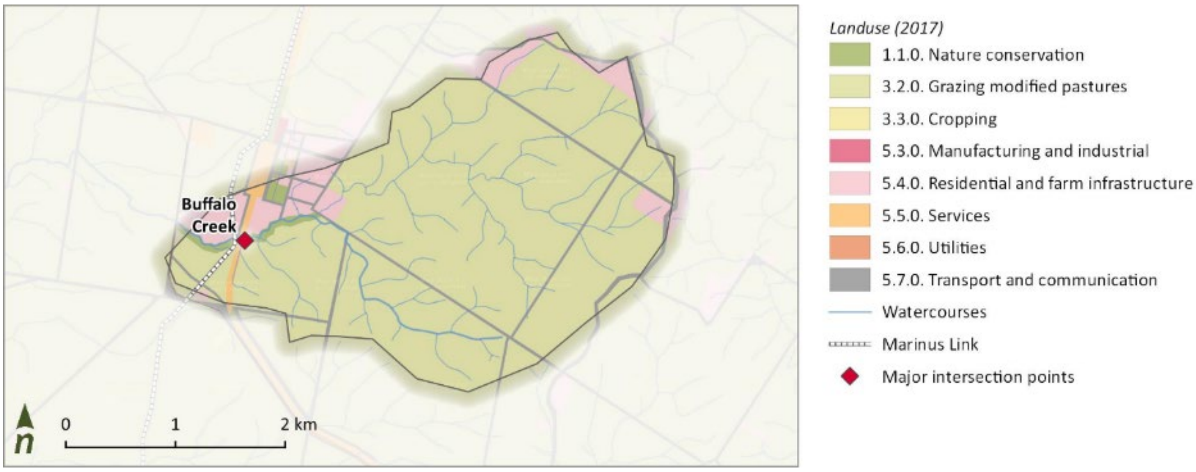

Figure 111. *2017 land use within the Buffalo Creek catchment upstream of the proposed project alignment crossing* (Department of Jobs, Precincts and Regions (DJPR), 2017)

Topography interpretation

Buffalo Creek upstream of the intersection with the proposed project alignment is a confined stream, which enters the floodplain close to the proposed project alignment (Figure 112). The channel at the crossing is around 17 m wide and around 4 m deep (Figure 113). The crossing with the proposed project alignment is around 50 m downstream of the Great Southern Rail trail and around 600 m upstream of Meeniyan-Promontory Road. The river exhibits around 0.5 to 1m high levee banks, with some small farm dams close to the channel.

Figure 112. *LiDAR (2010) and aerial imagery (2020) for Buffalo Creek at the intersection with the proposed project alignment.*

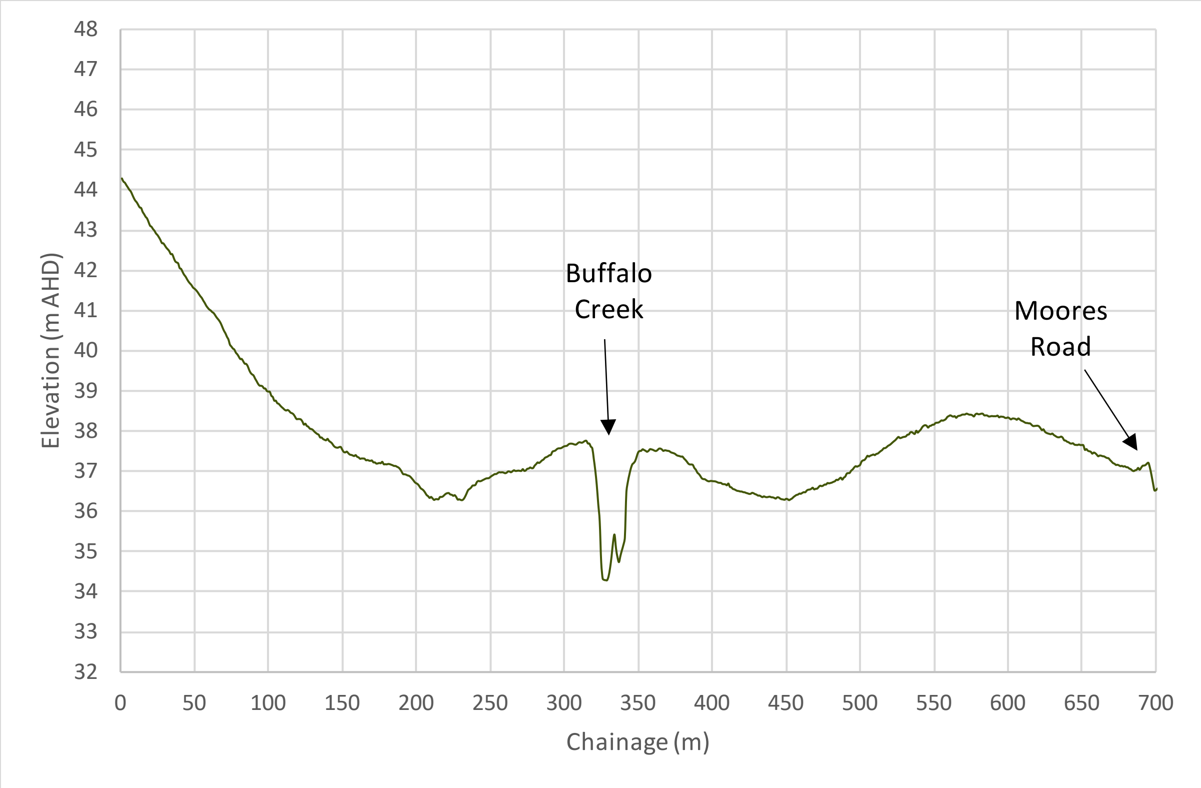

Figure 113. *Cross section of the proposed project alignment at Buffalo Creek, derived from LiDAR (looking downstream).*

Bed grade analysis

A longitudinal profile extracted from the available LiDAR (2010) and the State waterway alignment of Buffalo Creek (Figure 114) shows a relatively stable bed grade of around 0.0088 m/m in the vicinity of the proposed project alignment. The bed grade steepens upstream of the crossing, owing to the more confined headwater stream form of the creek through this reach. There do not appear to be any major instabilities or areas of incision, with the location of the proposed project alignment crossing between the rail trail and a road crossing, where the grade of the bed or any vertical instabilities should be controlled.

Bed grade and chainages relative to Figure 114 are presented in Table 38. Bed grade was compared with a database of bed grades drawn from stable alluvial rivers in SE Australia (Department of Sustainability and Environment (DSE), 2007; Hardie, 1993), calculated design bed grades relative to the 2 yr. ARI flow, and to upstream and downstream reaches of Buffalo Creek that are not incising. Bed grades were classed as acceptable or not acceptable as follows:

- ✓ Bed grade is within the bounds of a stable waterway, not substantially steeper than upstream or downstream grade of stable reaches.
- ✓ Bed grade is steeper than the bounds of a stable waterway, but other factors mean this is acceptable e.g., steepening is upstream of waterway crossing, other infrastructure (e.g., road crossings) control bed grade.
- × Bed grade is unacceptable, and incision is likely.

Table 38. Bed grades at various segments of Buffalo Creek near the crossing, relative to Figure 114

Chainage (m)	Bed grade (m/m)	Acceptable?
0- 3300	0.0088	✓
3300- 3800	0.0333	✓
3800- 5200	0.0180	✓
5200- 5700	0.0350	✓

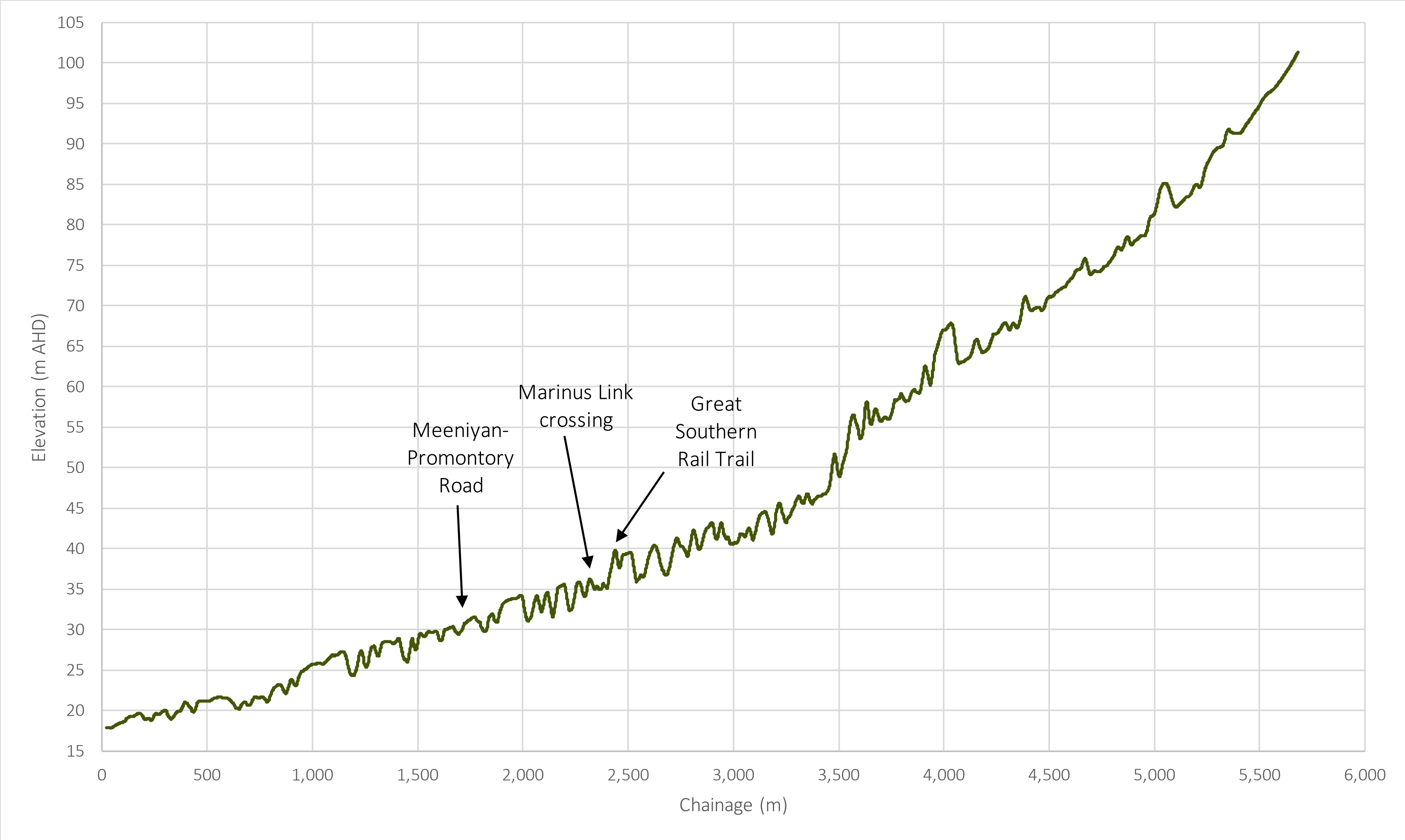

Figure 114. *Smoothed longitudinal profile (20-point moving average) of Buffalo Creek surrounding the proposed project alignment, derived from LiDAR along State waterway alignment.*

Aerial imagery analysis

Available past aerial imagery (Figure 115) shows the alignment of Buffalo Creek in this area appears to have been largely unchanged, without major channel change or meander migration over the last 11 years. However, historic aerial imagery earlier than 2010 is not available or of high enough resolution to determine channel change. The channel is also obstructed by vegetation, so it is difficult to determine lateral channel change by aerial imagery alone.

Figure 115. *Available aerial imagery for Buffalo Creek at the intersection with the proposed project alignment for 2021 and 2010.*

Site inspection

Site inspection of Buffalo Creek at the crossing with the proposed project alignment was undertaken on 21st March 2022. Access into the channel was not possible during site inspection at the crossing location, however the site was inspected from top of bank and further upstream in the channel at the Great Southern Rail Trail crossing.

The inspection found no signs of active erosion or incision (Figure 116). Banks were well-vegetated, with a narrow riparian buffer and fenced from stock access. Providing that the exiting stands of vegetation are retained, there is a low likelihood of waterway incision or sustained bank erosion being triggered in this reach without major changes to flow regime.

Figure 116. *Buffalo Creek in the vicinity of the proposed project alignment from fence at top of bank (top) and from the rail trail culvert looking downstream (bottom)*

Fish Creek

Catchment setting

From its headwaters to the confluence with the Tarwin River, Fish Creek is around 44 km long, with a catchment area of around 170 km^2. The proposed project alignment crosses Fish Creek around 1.7 km upstream of Buffalo-Waratah Road and around 13 km upstream of the confluence with the Tarwin River (Figure 117).

Fish Creek rises on the southern slopes of the Tarra Bulga National Park, just south of the South Gippsland highway. The creek flows generally southwest through the town of Fish Creek, eventually joining the Tarwin River, which flows through to Andersons Inlet.

The river flows through uplands and high-level terraces of sedimentary rock, before entering the riverine plains near the intersection point and flowing through the alluvial floodplain.

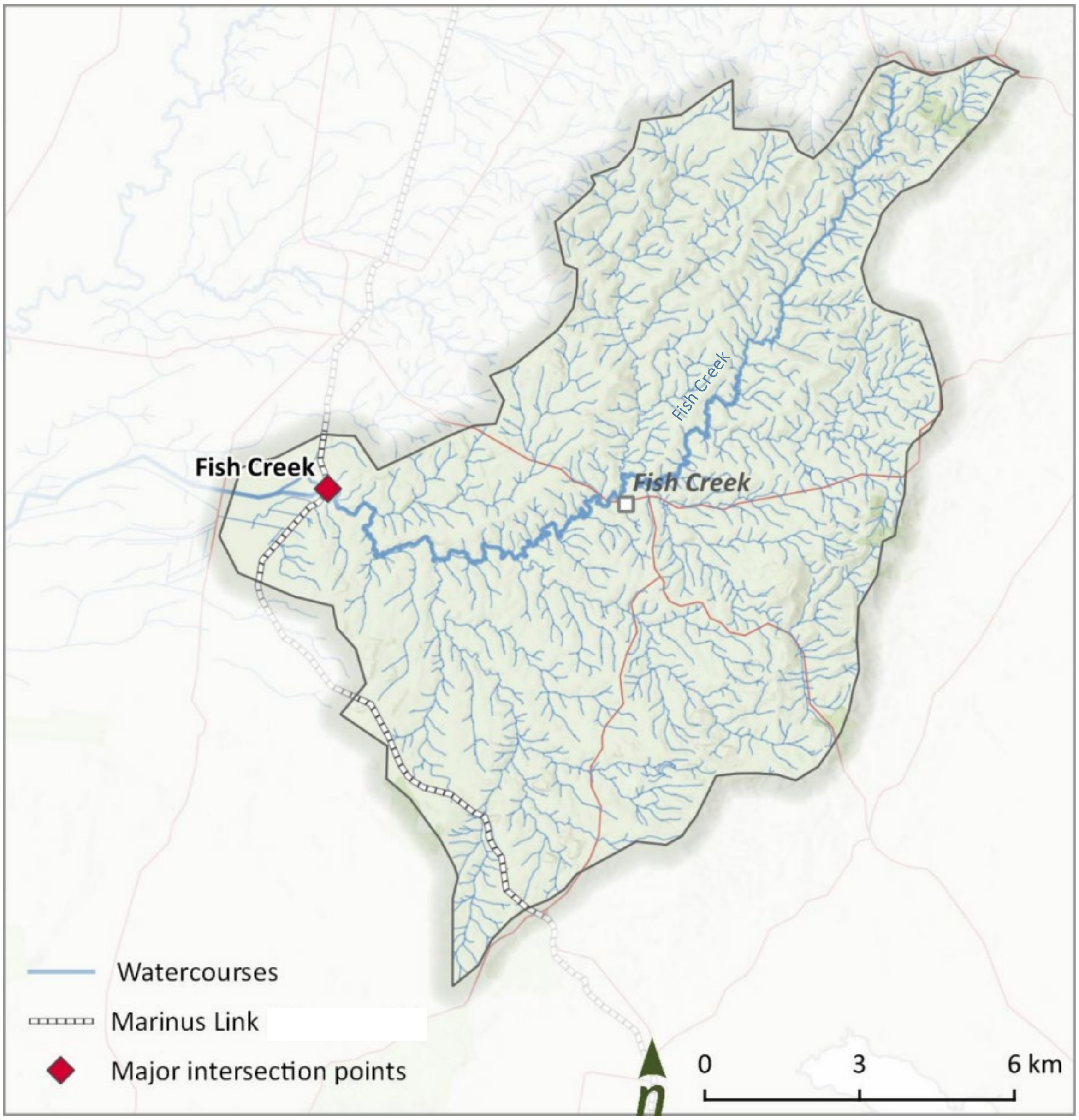

Figure 117. *Fish Creek upstream catchment and proposed project alignment crossing.*

Geology

Geology of the upper Fish Creek catchment is dominated by Wonthaggi formation sandstone to the east with areas of Haunted Hills formation to the south. At the proposed project alignment crossing, the geology changes to sand, gravel and silt alluvium and alluvial terrace deposits associated with waterways (Figure 118).

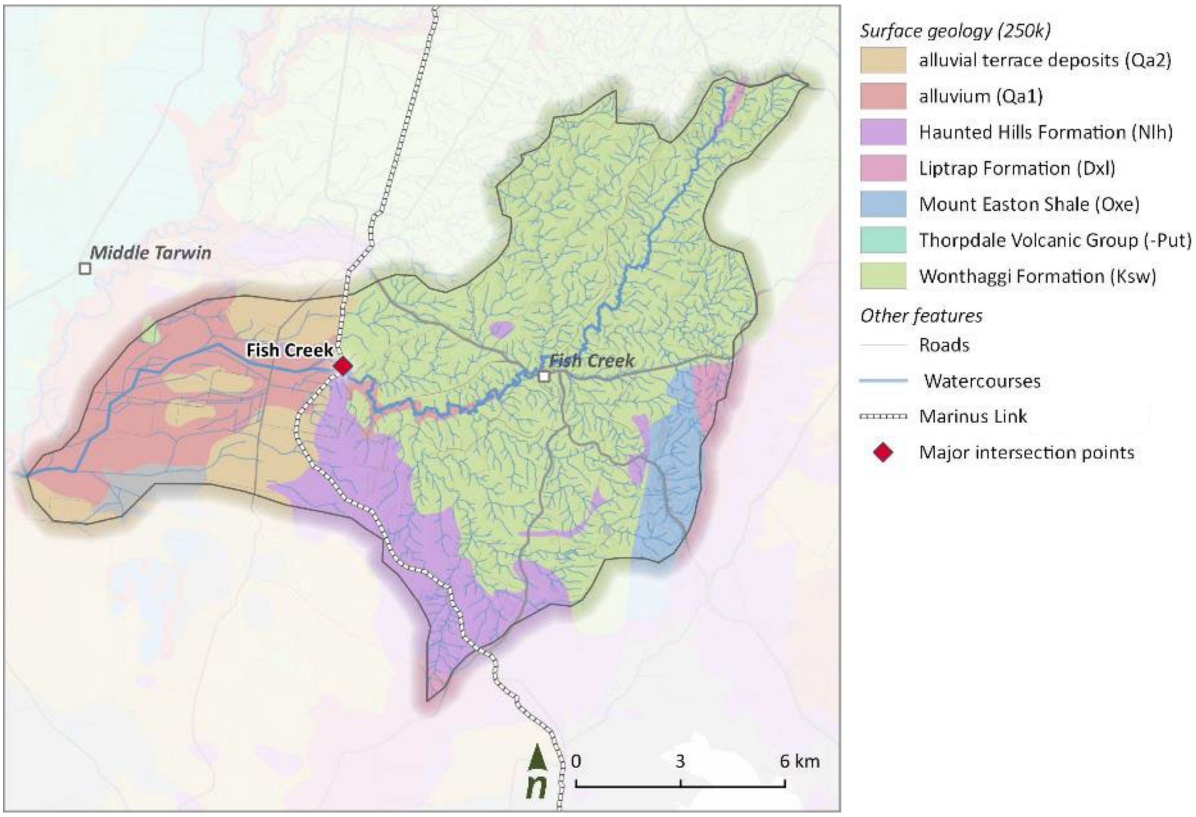

Figure 118. *Surface geology of the Fish Creek catchment* (Department of Jobs, Precincts and Regions, 2018)

Soils

Across the catchment upstream of the proposed project alignment crossing, soils are generally dermosols and kurosols, with the hydrosols around the river itself, indicating seasonally or permanently saturated soils (Figure 119). Dermosols in the catchment are characterised by a lack of strong texture contrast and are strongly acid throughout the profile. Kurosols are also acidic but have a strong texture contrast between loamy surface (A) horizons and clayey subsurface (B) horizons and generally occur in higher rainfall regions (Agriculture Victoria, 2021).

Dermosols are generally non-dispersive but can be susceptible to rill and sheet erosion when left exposed to heavy rainfall or near waterways. Kurosols have a firm to hard setting surface with poor initial infiltration resulting in a large proportion of water running off, causing erosion. Hydrosols are not generally dispersive but can also be susceptible to streambank erosion (ICC, 2014).

Discussions with Tetra Tech Coffey consultants (Barton Napier, pers comm.) suggested soils in the region of the proposed crossing are dispersive white clays. These soils are said to be very erosive and covered by a thin layer of topsoil.

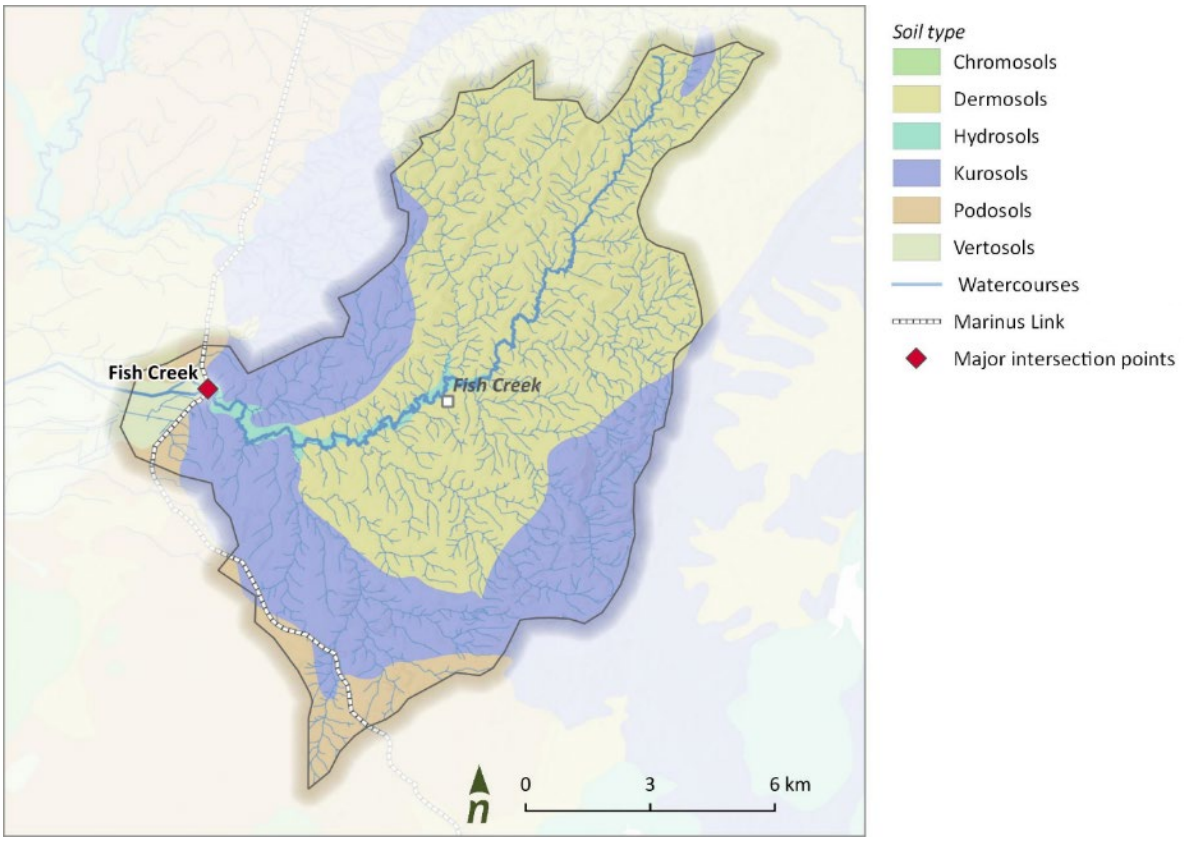

Figure 119. *Soil types within the Fish Creek catchment upstream of the proposed project alignment crossing* (Department of Jobs, Precincts and Regions (DJPR), 2018)

Land use

Land use across the upstream catchment is dominated by grazing modified pastures, with smaller pockets of residential and farm infrastructure along with some mining operations (Figure 120). At the intersection with the proposed project alignment, land use around Fish Creek is pasture and grasslands (mixed farming and grazing).

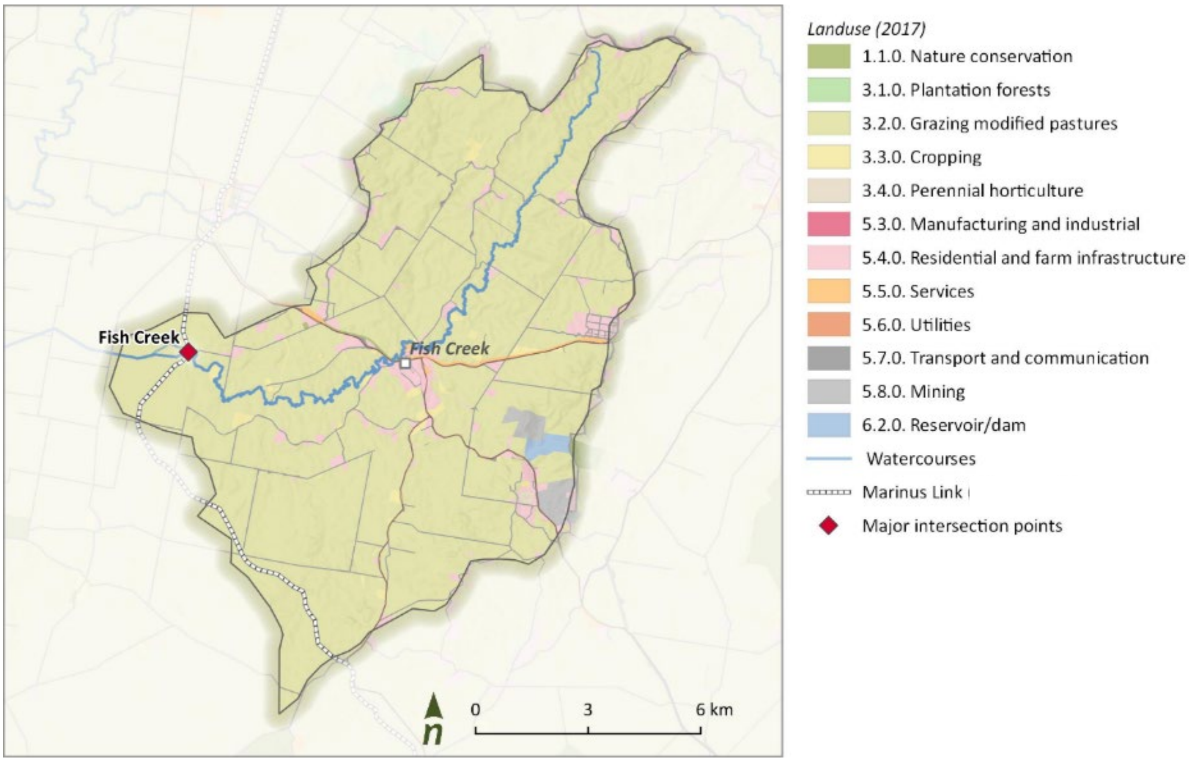

Figure 120. *2017 land use within the Fish Creek catchment upstream of the proposed project alignment crossing* (Department of Jobs, Precincts and Regions (DJPR), 2017)

Topography interpretation

Fish Creek at the intersection with the proposed project alignment transitions from a headwater stream draining the hills to the east and enters the floodplain (Figure 121). At the crossing, the Fish Creek channel is around 15 m wide and 2 m deep (Figure 122). Immediately downstream of the crossing, Fish Creek splits into two channels, the northern of which appearing to be the historic alignment, with a straightened anthropogenic channel to the south. The anthropogenic channel appears to be much deeper and the main flow pathway of the creek, with more riparian vegetation than the historic northern channel. This deeper channel is around 20 m wide and 4 m deep (Figure 123) and sits largely unconfined on the floodplain.

Straightening a channel in this manner means the channel is shorter and steeper, with therefore higher velocities of water and stream power. This causes deepening and eventual widening of the channel in line with the incision cycle, described in Figure 53. Comparing the depths of the channel in the upstream portion (~2m) and downstream anthropogenic channel (~4m) shows there is around 2 metres of deepening through this reach.

Figure 121. *LiDAR (2010) and aerial imagery (2020) for Fish Creek at the intersection with the proposed project alignment. Red dotted line details cross section in Figure 123.*

Figure 122. *Cross section of the proposed project alignment at Fish Creek, derived from LiDAR (looking downstream) along proposed project alignment (Figure 121).*

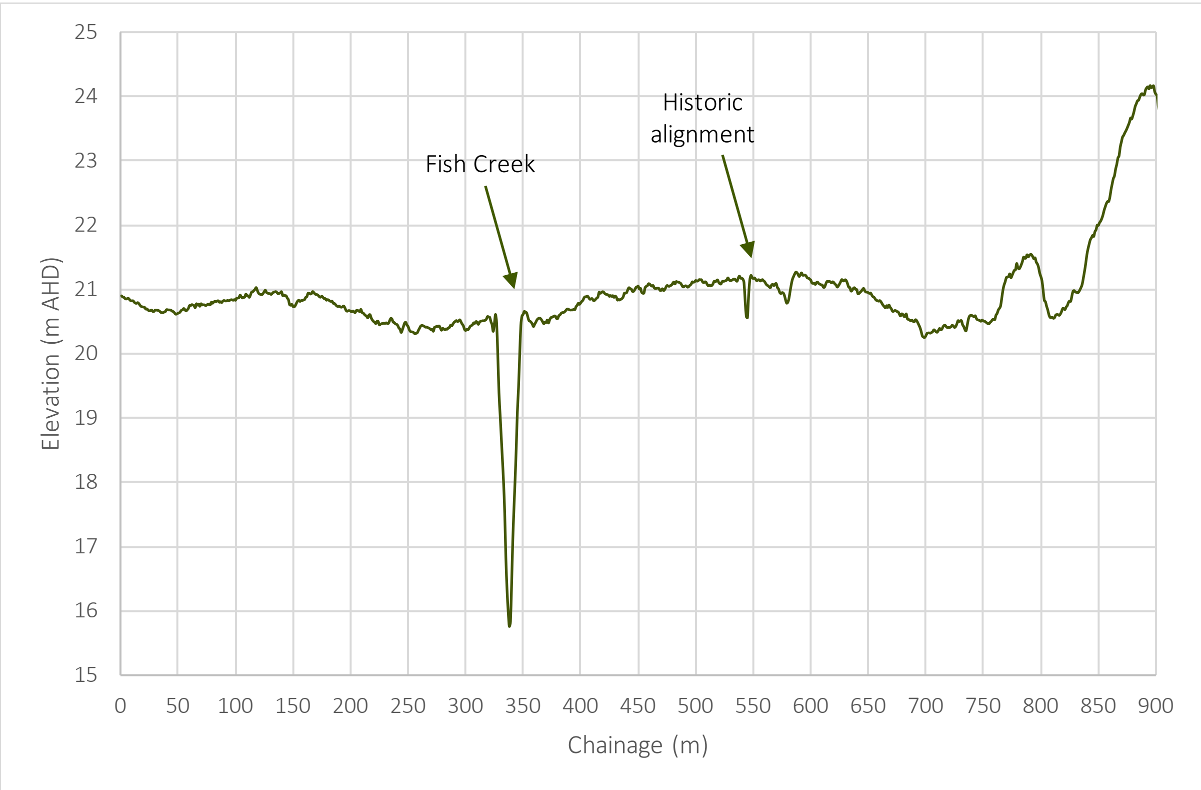

Figure 123. *Cross section of Fish Creek around 500 m downstream of crossing (red dotted line in Figure 121), derived from LiDAR (looking downstream).*

Bed grade analysis
A longitudinal profile extracted from the available LiDAR (2010) and the ISC centreline alignment of Fish Creek (Figure 124) shows a stable bed grade of around 0.0012 m/m downstream of the proposed project alignment, with noticeable steepening of the grade to around 0.008 m/m around the crossing. This steepening is likely a headcut, formed after straightening of the channel around the time of European settlement. The headcut has migrated upstream, with evidence of deepening and widening downstream of the proposed project alignment crossing. The exact location of the headcut, or series of headcuts, and therefore potential for future channel adjustment in the vicinity of the proposed project alignment crossing is difficult to determine without site inspection, however, there appears to be around an 8-10 metre drop in grade over around 500 m.

Bed grade and chainages relative to Figure 124 are presented in Table 39. Bed grade was compared with a database of bed grades drawn from stable alluvial rivers in SE Australia (Department of Sustainability and Environment (DSE), 2007; Hardie, 1993), calculated design bed grades relative to the 2 yr. ARI flow, and to upstream and downstream reaches of the Fish Creek that are not incising. Bed grades were classed as acceptable or not acceptable as follows:

- ✓ (green) Bed grade is within the bounds of a stable waterway, not substantially steeper than upstream or downstream grade of stable reaches.
- ✓ (orange) Bed grade is steeper than the bounds of a stable waterway, but other factors mean this is acceptable e.g., steepening is upstream of waterway crossing, other infrastructure (e.g., road crossings) control bed grade.
- ✗ Bed grade is unacceptable, and incision is likely.

Table 39. Bed grade at various segments of Fish Creek near the crossing, relative to Figure 124

Chainage (m)	Bed grade (m/m)	Acceptable?
0- 1600	0.0008	✓ (green)
1600- 4000	0.0012	✓ (green)
4000- 7200	0.0017	✓ (orange)
7200- 8000	0.0080	✗
8000- 9200	0.0023	✗
9200- 13000	0.0010	✓ (green)

Incision could potentially be limited from moving upstream by the change in geology from alluvium and alluvial terrace deposits downstream to sandstone of the Wonthaggi formation upstream (Figure 118). Further investigation and site assessment would be required to determine if the incision has halted.

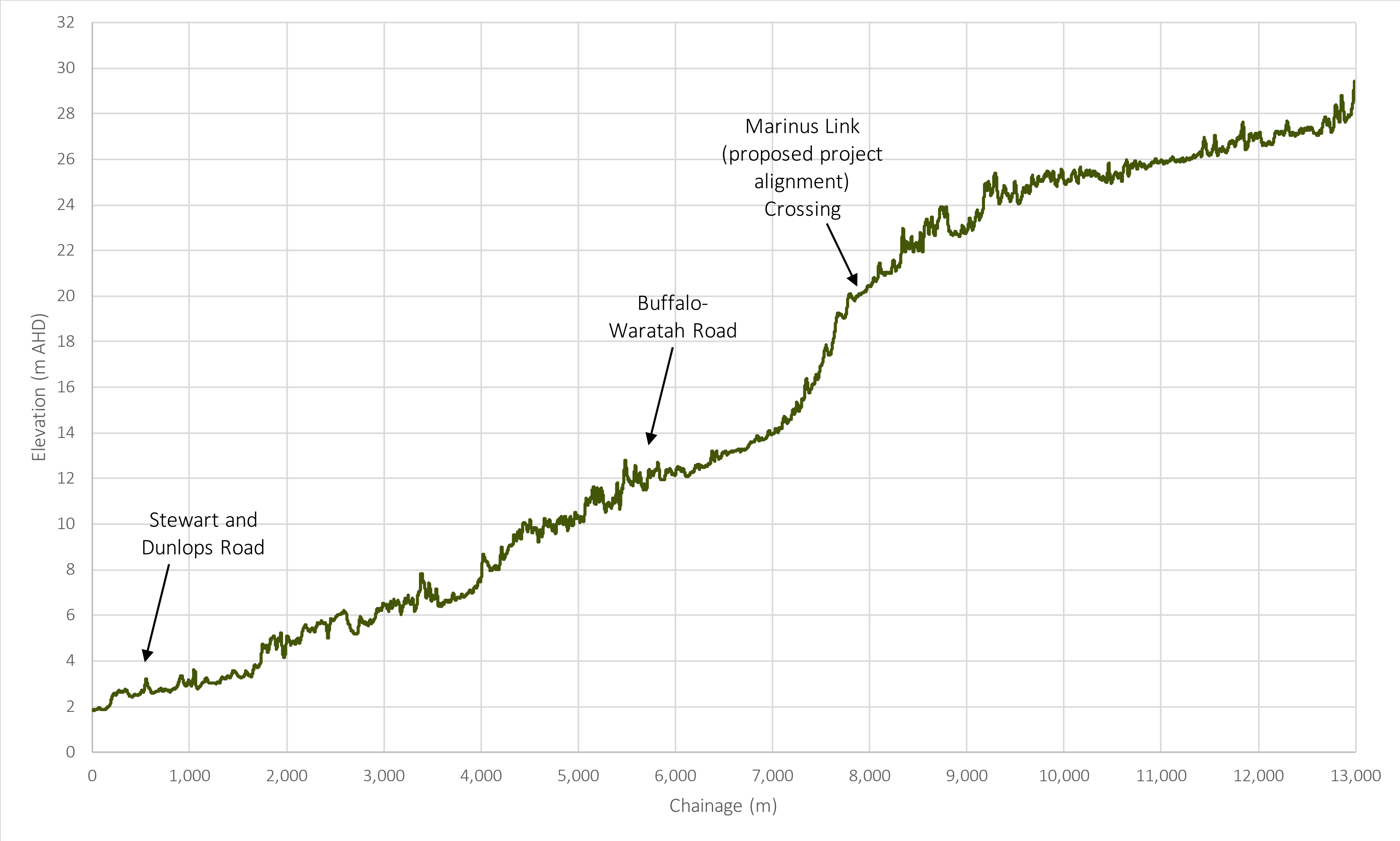

Figure 124. *Smoothed longitudinal profile (20-point moving average) of Fish Creek surrounding the proposed project alignment, derived from LiDAR along the ISC centreline alignment.*

Aerial imagery analysis

Available past aerial imagery (Figure 125) shows this straightened channel was present in 1965, however since then, vegetation coverage appears to have reduced on the previous northern alignment. There appears to have been some widening of the channel, with evidence of bank erosion and meander initiation. Vegetation cover of this anthropogenic channel does appear to have increased in the most recent aerial imagery.

Figure 125. *Available aerial imagery for Fish Creek at the intersection with the proposed project alignment for 2020, 2010 and 1965.*

Site inspection

Site inspection at the crossing with the proposed project alignment was not possible due to lack of landholder access. An inspection of Fish Creek at Buffalo-Waratah Road, around 1.6 km downstream of the proposed project crossing was undertaken on 21st March 2022.

The inspection found that downstream of the road, there was relatively good vegetation cover on the banks and fewer signs of active bank erosion than upstream. Upstream of the road crossing, vegetation was sparse, with little to no vegetation on the left bank (right of bottom photo, Figure 126) and active bank erosion and widening. This is consistent with Stage 4 of incision (Figure 53) with historic headcut migration upstream and ongoing widening adjustment to deepening.

Without inspection of the proposed project crossing, it is difficult to know how far this incision has progressed. However, this downstream condition can provide an estimation of the scale of deepening and widening the channel will undergo. Based on LiDAR analysis, the waterway at the proposed crossing is around 20 m wide, whereas downstream, the channel can be up to 30 m wide, with active bank erosion still evident.

Figure 126. *Fish Creek at Buffalo-Waratah Road, looking downstream from the bridge (top) and looking upstream from the bridge (bottom). Note little to no vegetation cover and active bank erosion on left bank (right of bottom photo).*

Discussions with Tetra Tech Coffey consultants who have visited the site (Barton Napier, Pers comms) indicate that:

- The upstream section (upstream of the divergence of the two channels) is confined with no reported breakouts
- The anthropogenic channel was cut in around 1913 to promote drainage for agriculture
- During flood events, water flows across the floodplain, but is concentrated in the southern channel
- During the last flood event, around 30 cm of topsoil was washed away
- Incision is evident in both the southern, straighter channel and the northern, historic channel
- The southern channel is around 4-5 m deep with large scour holes evident
- Previous works to limit incision have included:
    - Landholder planting and revegetation after major flood events
    - Informal landholder grade and bank erosion control using rubble (cars, tires, etc.)
    - Formal grade control by the West Gippsland Catchment Management Authority (CMA), estimated to be around 10 years ago, including two main grade control structures on the southern channel.

Attachment 4. Risks of waterways processes impacting on built infrastructure

Risks of waterway processes impacting on built infrastructure

In addition to assessing risks posed by the project to environmental values, we have also undertaken a risk assessment of waterway processes impacting on project-built infrastructure. This risk assessment is for a selection of major waterway crossings along the proposed project alignment in Victoria. The risk arising from interactions between waterways and infrastructure is a combination of the likelihood (probability/chance) of an impact/damage occurring and the potential consequence.

Threats to infrastructure

Infrastructure associated with the project could be threatened through flooding and/or physical waterway processes (erosion, incision, sedimentation, avulsion). These processes are described below.

Flooding

For the waterway crossing assessment and assessing risk to project assets, flooding has been assessed by mapping the 1% AEP flood extent, as provided by WGCMA. Estimation of the 1% AEP flood for an area is determined using flood modelling, recorded flood extents and levels, and on-ground verification. There is always a possibility that a flood larger in height and extent than the 1% AEP flood may occur in the future. For the waterways where a 1% AEP flood extent has not been mapped (Little Morwell River and Buffalo Creek), a potential flood extent has been estimated by interpreting the valley topography, slope and vegetation trends over multiple aerial images. See Sections 5.1 and 0 for mapping of flood extents and details of proposed assets/construction areas within the flood extents.

As detailed in Section 5.2 of the main report, climate change will result in changes to rainfall and therefore flood extents. This flood extent does not include consideration of climate change. These extents also do not provide information on the depth and velocity of flood waters, which can influence the impacts of a flood. Further flood modelling would be required to assess flood depths, velocities and the impacts of climate change on flood extents, behaviour and risk to project assets.

Potential impacts of a flood event during construction could include:

- Inundation of open trenches, including potential erosion of trenches in high flows
- Inundation of drill pads and HDD drilling machinery and tunnels
- Inundation of stock piles and soil stores
- Inundation of joint pit construction sites
- Inundation of other construction assets and equipment
- Inundation of access roads and lack of construction access due to either flooding or erosion.

Potential impacts of a flood event during operation and maintenance could include:

- Inundation of joint pit infrastructure
- Inundation of access roads and lack of maintenance access due to either flooding or erosion of access roads
- Inundation of permanent infrastructure and/or damage through exposure of assets to water

Physical waterway processes

A geomorphic and hydraulic assessment helps identify the dominant fluvial processes at each waterway crossing and the likelihood of channel change over time. These fluvial processes may include scour of the channel bed, banks, or adjacent floodplain, along with avulsion, sedimentation and/or incision processes. This process-based analysis is used to identify likely areas of instability, to predict future channel changes and potential impacts at each crossing. This analysis will then be used to identify mitigation measures to minimise the risks waterway processes pose to the proposed linear infrastructure.

Channel erosion and sediment deposition are a natural and important part of healthy waterways. Natural erosion or sediment deposition is only problematic when it is severe enough to impact on human values and assets, such as pipelines buried beneath the streambed, or joint pits adjacent to the channel banks. By establishing the existing range of erosion and deposition in waterways crossed by the proposed project alignment, the risk waterway processes pose to infrastructure, and that infrastructure poses to waterway health, can be minimised and appropriate mitigation measures identified.

Three categories of channel change that have potential to impact the Marnus Link land cable waterway crossings have been identified:

1. **Small to moderate scale erosion of the channel and floodplain**- may expose buried infrastructure where erosion occurs directly above the alignment of the buried cables or undermine infrastructure (such as joint pits) when lateral erosion occurs adjacent to buried pipes or joint pits.
2. **Larger scale channel incision that occurs at the reach scale**- channel incision can directly impact buried infrastructure by exposing pipes or undermining the banks that separate the channel from adjacent joint pits, or indirectly by altering the channel gradient and making smaller-scale erosion more likely. Incision at this scale can occur over kilometres of waterway.
3. **Channel avulsion at the moderate (meander) scale or large (reach) scale**- channel avulsion can impact buried infrastructure by scouring a new channel across the floodplain, which exposes buried pipes and undermines joint pits. Avulsions occur at multiple scales, from single meander chute cut-offs to reach scale avulsion that results in a completely new river alignment.

The rate of meander migration and the scale of channel widening, local scour and reach scale incision is a function of channel size, which in turn is a function of catchment area. Larger catchments produce higher flows, which have greater stream power and are capable of eroding and transporting more sediment. Therefore, all other things being equal, waterway crossings located in deeper, wider channels are more likely to experience channel changes that impacts the proposed pipeline or adjacent joint pits. Each of these processes of channel change is described further in Attachment 3.

Risk assessment approach

In flood events and as channel change through physical waterway processes, there is the potential for damage to buried and floodplain infrastructure, for example by the exposure of buried pipes. This interaction between waterway processes and project infrastructure poses a threat to buried and floodplain infrastructure, and to the environment, namely through:

- Flood inundation of infrastructure not designed/suited to inundation
- Serious damage or destruction of Marius Link infrastructure buried beneath the waterway or located on the adjacent floodplain.
- The need to physically intervene in a waterway to protect from imminent damage to, or the adverse consequences of, loss or serious damage to buried or floodplain infrastructure. Waterway intervention may have consequences for waterway health and riparian vegetation.
- The introduction of foreign material (e.g., concrete, steel, plastics) from damaged infrastructure to the waterways or floodplains which leads to a reduction in waterway health.

Our assessment relies on both field survey and desktop analysis and expert judgment regarding the type and rate of waterway processes at each waterway crossing to assign likelihood and consequence scores to each waterway process. For this assessment, the likelihood (probability/chance) of the defined event occurring has been determined through the assessments for each waterway crossing, utilising various assessment tools (i.e., catchment setting data review, LiDAR interpretation, bed grade analysis and historical aerial imagery analysis, as per Table 43 and Table 44). Likelihood has been considered for flooding and each of the threatening processes outlined in Attachment 2. The five-point likelihood scale is presented in Table 40 below and has been adapted from the risk assessment methodology of the main report.

Table 40. Likelihood ratings used in this assessment.

Likelihood	Description
Rare	Interaction between waterway processes and project infrastructure, causing a hazard is theoretically possible, but not anticipated over the duration of the project activity, project phase or project life.
Unlikely	Interaction between waterway processes and project infrastructure, causing a hazard is unlikely to occur over the duration of the project activity, project phase or project life.
Possible	Interaction between waterway processes and project infrastructure, causing a hazard may occur over the duration of the project activity, project phase or project life.
Likely	Interaction between waterway processes and project infrastructure, causing a hazard is likely to occur at least once over the duration of the project activity, project phase or project life.
Almost certain	Interaction between waterway processes and project infrastructure, causing a hazard is expected to occur more than once over the duration of the project activity, project phase or project life.

The consequence of these threatening processes has been considered qualitatively. The five-point consequence scale is presented in Table 41, below and has been adapted from the risk assessment methodology of the main report.

Table 41. Consequence ratings used in this assessment

Consequence	Description
Negligible	A localised effect on infrastructure that is temporary and does not extend beyond operational area. Either unlikely to be detectable or could be effectively mitigated through standard management controls. Full recovery expected.
Minor	A localised effect on infrastructure that is short-term and could be effectively mitigated through standard management controls. Remediation work and follow-up required.
Moderate	An effect on infrastructure that extends beyond the operational area to the surrounding area but is contained within the region where the project is being developed. The harm is short-term and result in changes that can be ameliorated with specific management or design controls.
Major	An effect that is widespread, long lasting and results in substantial change to the infrastructure either temporary or permanent. Can only be partially rehabilitated or uncertain if it can successfully be rehabilitated. Appropriate design responses are required to address the impact. Causes major public outrage, possible prosecution by regulatory authorities. Receives widespread local community complaints.
Severe	An effect that causes permanent changes to infrastructure and irreversible harm to physical, ecological, or social environmental values. Consequences of the impact are unknown and management controls are untested. Causes major public outrage, sustained widespread community complaints. Prosecution by regulatory authorities. Avoidance through appropriate design responses is required to address the impact.

Combining the likelihood and consequence ratings in a risk matrix (presented in Table 42, below) is used to assign a risk score to each waterway crossing for each waterway process. Mitigation measures are generally suitable for a certain waterway process. By assigning risk for each waterway process, the relevant reduction in risk through mitigation measures can be determined.

Table 42. Risk matrix relating likelihood and consequence

		Likelihood				
		Rare	Unlikely	Possible	Likely	Almost certain
Consequence	Negligible	Very low	Very low	Very low	Low	Moderate
	Minor	Very low	Low	Low	Moderate	Moderate
	Moderate	Low	Low	Moderate	High	High
	Major	Low	Moderate	High	Very high	Very high
	Severe	Moderate	High	Very high	Very high	Very high

The outcome of our risk assessment is described in more detail below. The risk assessment is used to identify mitigation measures for each waterway crossing that can be used to reduce the risk to infrastructure.

Assessment tools and limitations

There are several tools and assessment methodologies used to characterise waterway types, assess evidence of channel change, the cause of that change, and help evaluate the likely trajectory of each stream system in the context of risk to linear infrastructure. Table 44 outlines these assessment tools and their use in determining likely threats to buried infrastructure posed by waterway processes, as described in Section 3 below.

Some limitations of this assessment exist based on data availability and access, including site /landholder access. We have therefore aimed to utilise multiple lines of evidence, where possible, to build the picture of the dominant processes and risks associated with each site. We have also taken a conservative approach to assessment where information was lacking and/or site investigation was not possible. The assessment tools utilised for each waterway crossing are outlined in Table 43.

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Table 43. Assessment tools applied to each of the eight major waterways.

Assessment tool	Waterway: Little Morwell River	Morwell River	Tarwin River East Branch	Tarwin East tributary (north)	Tarwin East tributary (south)	Stony Creek	Buffalo Creek	Fish Creek	Comment
Catchment setting data review	✓	✓	✓	✓	✓	✓	✓	✓	
LiDAR interpretation	✓	✓	✓	✓	✓	✓	✓	✓	
Bed grade analysis	✓	✓	✓	✓	✓	✓	✓	✓	
Historical aerial imagery analysis	✓ (orange)	✓	✓ (orange)	✓ (orange)	✓ (orange)	✓ (orange)	✓ (orange)	✓	Historical aerial imagery only available to 2010 for several waterways.
Site inspection	✗	✓	✓	✗	✗	✓	✓ (orange)	✓ (orange)	Site access not possible at Little Morwell River and the tributaries of the Tarwin River East Branch. At Buffalo Creek and Fish Creek access was only available downstream
1% AEP flood mapping	✓ (orange)	✓	✓	✓	✓	✓	✓ (orange)	✓	Mapped 1% AEP flood mapping not available for Little Morwell River and Buffalo Creek. Used valley topography, slope and vegetation trends over multiple aerial images to estimate flood extent for these waterways.

✓ (green) Assessment undertaken

✓ (orange) Partial analysis undertaken with available data/access

✗ (red) Analysis not undertaken due to data and site access constraints

Table 44. Assessment tools used in these investigations (waterway processes are described further in Section 3, below and Attachment 3).

Assessment tool	Description	Flooding	Categories of channel change used to determine waterway processes		
			Small / moderate scale erosion	Large scale incision	Avulsion
Catchment setting data review	State-wide and regional spatial data review to gain understanding of waterway type, catchment setting, land use, geology, and potential for channel change.	• Available flood mapping (1% AEP mapping)	• Soil type susceptibility to erosion • Vegetation and land use mapping to determine bank / floodplain erosion resistance	• Level of confinement, geology, soils, and susceptibility to large-scale incision	• Vegetation and land use mapping to determine floodplain resistance to erosion and potential for floodplain scour
LiDAR interpretation	Desktop review of available LiDAR data (2010-2018) to determine channel and floodplain form and potential for/evidence of channel change.	• Interpretation of topography, flow routing and flow obstructions	• Evidence of local bank and floodplain scour • Channel form and confinement (potential for lateral migration)	• Evidence of reach-scale deepening and/or widening (banks slumps)	• Level of confinement and waterway type (susceptibility to avulsion) Presence of alternative flow pathways on floodplain • Evidence of meander cut-offs, billabongs, remnant channels, etc.
Bed grade analysis	Extraction of longitudinal profile from available LiDAR to determine grade and identify potential areas of instability	• Appreciation of flood control and obstructions to flow	• n/a	• Evidence and location of deepening, instability, incision • Location of bed grade controls and identification of stable bed grade	• n/a
Historical aerial imagery analysis	Desktop review of available historic aerial imagery to determine extent/evidence of historic channel change and likely causes.	• n/a	• Evidence of historic channel change (meander migration)	• Evidence of historic deepening/widening • Evidence of historic channel straightening or land use change which could initiate incision	• Evidence of historic channel alignment changes/avulsion
Site inspection	Field inspection of waterway crossing sites and upstream/ downstream to determine evidence of channel change, causes of change and potential for future change. Undertaken on 21st and 22nd March 2022.	• Observations of water movement / flow pathways • Landholder perspectives on historic floods	• Vegetation and land use setting (resistance to erosion) • Evidence of recent channel change (bank, bed, or floodplain erosion)	• Evidence of incision (deepening/widening) and stage of incision	• Evidence of avulsion indicators (e.g., floodplain scour, alternative flow pathways, bed aggradation)
Hydrologic modelling	Estimation of the 50% AEP flow event for each waterway	Estimated flood extent, velocity and other parameters	Used to inform the identification of stable bed grade		

n/a = not applicable

Waterway process threats summary

A summary of threatening processes for each waterway crossing is provided below. This summary is based on the background information and analysis in Attachment 2 and informs the likelihood and consequence outlined in the risk assessment. The threat of flooding is based on the 1% AEP flood extent, detailed in Sections 5.1 and 0 of the main report.

Morwell River summary

Threatening process	Summary for the Morwell River
Flooding (1% AEP extent)	Access track and TCM AOD within flood extent. Total 4,790 m2 area of disturbance within 1% AEP flood extent.
Small to moderate scale erosion of the channel and floodplain	Some stream bank erosion is already evident, particularly on the outside of meander bends, consistent with meander migration processes. Poorly vegetated banks and unrestricted stock access does not provide good protection for stream banks.
Larger-scale incision	Downstream boundary bed grade is controlled by the Morwell River diversion at Hazelwood mine. Upstream migration of reach-scale incision is unlikely, although could be influenced by meander cut offs.
Moderate- to large-scale channel avulsion	No evidence of a breakout or re-entry point for large-scale avulsion, however, historic meander cut offs are evident, with ongoing meander migration/lengthening.

Little Morwell River summary

Threatening process	Summary for the Little Morwell River
Flooding (1% AEP extent)	Flood extent not mapped, with open trench construction and access track upgrade proposed through waterway. TCM AOD on steep slopes surrounding floodplain. Total 10,624 m2 area of disturbance within interpreted flood extent.
Small to moderate scale erosion of the channel and floodplain	Potential for minor erosion, however confined nature of stream suggests this would be minimal.
Larger-scale incision	Stable bed grade in vicinity of crossing, no signs of active incision. Potential past incision and adjustment.
Moderate- to large-scale channel avulsion	Confined nature of stream means channel avulsion is highly unlikely.

Some uncertainties in the assessment for the Little Morwell River exist due to lack of site access and mapped flood extents.

Tarwin River East Branch summary

Threatening process	Summary for the Tarwin River East Branch
Flooding (1% AEP extent)	Access track, TCM AOD and areas of open trench construction within flood extent. Joint pit around 20m away from 1% AEP flood extent. Total 8,461 m2 area of disturbance within 1% AEP flood extent.
Small to moderate scale erosion of the channel and floodplain	No evidence of major erosion, banks appeared stable, although could be susceptible to slumping with stock access. Localised erosion may occur around obstruction (e.g., dead wood)
Larger-scale incision	No evidence of incision in vicinity of proposed project alignment. Grade should largely be controlled by road crossings.
Moderate- to large-scale channel avulsion	Confined nature of stream means channel avulsion is highly unlikely.

Tributaries of the Tarwin River Each Branch summary

Threatening process	Summary for the Tarwin River East Branch
Flooding (1% AEP extent)	Access track, TCM AOD and areas of open trench construction within flood extent. Joint pits close to or within 1% AEP flood extent. Total 68,613 m2 area of disturbance within 1% AEP flood extent (38,887 m2 northern tributary, 29,726 m2 southern tributary).
Small to moderate scale erosion of the channel and floodplain	No evidence of bank erosion, but lack of site access makes this uncertain. Some slumping may occur in areas with stock access
Larger-scale incision	Stable bed grade in vicinity of crossing, no signs of active incision.
Moderate- to large-scale channel avulsion	No evidence of a breakout or re-entry point for large-scale avulsion; however, perched and unconfined nature of waterways increases potential for avulsion.

Some uncertainties in the assessment for the tributaries of the Tarwin River Each Branch exist due to lack of site access.

Stony Creek summary

Threatening process	Summary for Stony Creek
Flooding (1% AEP extent)	Multiple access tracks and TCM AOD within flood extent. Open trench construction within 1% AEP flood extent. Joint pits within 50 m of 1% AEP flood extent. Total 33,904 m^2 area of disturbance within 1% AEP flood extent.
Small to moderate scale erosion of the channel and floodplain	Very minor erosion or slumping may occur resulting from instream obstructions and/or stock access
Larger-scale incision	Stable bed grade, no signs of major incision, deepening or widening.
Moderate- to large-scale channel avulsion	Some evidence of flow escaping the channel in flood events and travelling southwest across the floodplain. No active localised erosion observed, meaning large-scale avulsion is unlikely.

Buffalo Creek summary

Threatening process	Summary for Buffalo Creek
Flooding (1% AEP extent)	Flood extent not mapped, access track and TCM AOD within floodplain vicinity. Total 2,523 m2 area of disturbance within interpreted flood extent.
Small to moderate scale erosion of the channel and floodplain	No evidence of bank erosion, some slumping may occur in areas with stock access
Larger-scale incision	Stable bed grade, no signs of major incision, deepening or widening.
Moderate- to large-scale channel avulsion	No evidence of alternative flow pathway, although presence of levees may concentrate flow in breaches of banks, creating a breakout point. No defined daughter channel evident, overall low likelihood of avulsion over management timeframes.

Some uncertainties in the assessment for Buffalo Creek exist due to lack of mapped flood extents.

Fish Creek summary

Threatening process	Summary for Fish Creek
Flooding (1% AEP extent)	Access track, TCM AOD and small area of open trench construction within flood extent. Total 4,649 m2 area of disturbance within 1% AEP flood extent.
Small to moderate scale erosion of the channel and floodplain	Evidence of bed and bank erosion, associated with broader incision processes. Widening in the order of 10-15 m.
Larger-scale incision	Major incision processes ongoing, with steepening of bedgrade, bed scour and bank erosion associated with ongoing deepening and widening of channel. Deepening in the order of 4-5 m. Uncertain if headcut will continue to migrate headward with change in geology upstream.
Moderate- to large-scale channel avulsion	Alternative flow pathway (historic channel), but most flow appears to be conveyed in anthropogenic (southern) channel. Overall low likelihood of avulsion over management timeframes.

Pre-mitigation risk assessment results

Risk assessment

Risk can be assessed at various spatial and temporal scales, from a regional level to individual sites/assets and from long term (>100 years) to immediate short-term (<5 year) threats. We have considered the risk for each major waterway crossing, for each threatening process, and for management timeframes (<50 years). Risk ratings have been determined for each waterway crossing and each waterway process (Table 45), using the likelihood and consequence ratings outlined above.

Table 45. Pre-mitigation risk ratings for each waterway crossing and each waterway process.

Reach	Threats to infrastructure	Likelihood	Consequence	Risk
Morwell River	Flooding (within 1% AEP)	Likely	Moderate	High
	Small to moderate scale erosion	Likely	Minor	Moderate
	Large-scale incision	Unlikely	Major	Moderate
	Moderate scale avulsion (meander cut offs)	Possible	Moderate	Moderate
	Large scale avulsion (reach-scale abandonment)	Rare	Major	Low
Little Morwell River	Flooding (within 1% AEP)	Likely	Moderate	High
	Small to moderate scale erosion	Possible	Minor	Low
	Large-scale incision	Rare	Major	Low
	Moderate scale avulsion (meander cut offs)	Rare	Moderate	Low
	Large scale avulsion (reach-scale abandonment)	Rare	Major	Low
Tarwin River East Branch	Flooding (within 1% AEP)	Likely	Moderate	High
	Small to moderate scale erosion	Possible	Minor	Low
	Large-scale incision	Rare	Major	Low
	Moderate scale avulsion (meander cut offs)	Rare	Moderate	Low
	Large scale avulsion (reach-scale abandonment)	Rare	Major	Low
Tributaries of Tarwin River East Branch	Flooding (within 1% AEP)	Likely	Moderate	High
	Small to moderate scale erosion	Possible	Minor	Low
	Large-scale incision	Rare	Major	Low
	Moderate scale avulsion (meander cut offs)	Rare	Moderate	Low
	Large scale avulsion (reach-scale abandonment)	Unlikely	Major	Moderate
Stony Creek	Flooding (within 1% AEP)	Likely	Moderate	High
	Small to moderate scale erosion	Likely	Minor	Moderate
	Large-scale incision	Rare	Major	Low
	Moderate scale avulsion (meander cut offs)	Rare	Moderate	Low
	Large scale avulsion (reach-scale abandonment)	Rare	Major	Low
Buffalo Creek	Flooding (within 1% AEP)	Possible	Moderate	Moderate
	Small to moderate scale erosion	Unlikely	Minor	Low
	Large-scale incision	Rare	Major	Low
	Moderate scale avulsion (meander cut offs)	Rare	Moderate	Low
	Large scale avulsion (reach-scale abandonment)	Rare	Major	Low
Fish Creek	Flooding (within 1% AEP)	Likely	Moderate	High
	Small to moderate scale erosion	Likely	Minor	Moderate
	Large-scale incision	Possible	Major	High
	Moderate scale avulsion (meander cut offs)	Rare	Moderate	Low
	Large scale avulsion (reach-scale abandonment)	Unlikely	Major	Moderate

Risk tolerance and response

Quantifying risk provides a basis to prioritise and manage risk through mitigating measures. It may be that we can 'live with' or cope with a certain level of risk, provided we have adequate monitoring, or risk may already be at unacceptable levels and require action to reduce (mitigate) this risk through either reducing the likelihood of the threatening process, or the consequence of that process. Risk ratings and the relevant responses are outlined in Table 46.

Table 46. Risk tolerance ratings and response.

<table>
<tr><th>Risk rating</th><th>Response</th></tr>
<tr><td>Very low</td><td rowspan="2">Can allow this level of risk without feeling the necessity to reduce the risks any further. Management and monitoring of risk as part of business-as-usual operations, including periodic review.</td></tr>
<tr><td>Low</td></tr>
<tr><td>Moderate</td><td>Can allow this level of risk, but as much as is reasonably practical should be done to reduce risks further.</td></tr>
<tr><td>High</td><td rowspan="2">Cannot allow this level of risk, action is required to treat, eliminate, or reduce risk to acceptable levels through mitigation measures.</td></tr>
<tr><td>Very high</td></tr>
</table>

Mitigation measures and residual risk assessment

A number of mitigation measures can be utilised to minimise the risk. Mitigation measures contribute to minimising the likelihood of the threatening process occurring/progressing or reduce the consequence of a process/threat if it does occur. While all waterways, including those assessed in this study, undergo changes in width, depth, and alignment over time, one of the most effective means of limiting the rate of this change (and the threat such change poses to buried and floodplain infrastructure) is to (re)establish and maintain a corridor of structurally diverse native riparian vegetation. Riparian, and where it can establish, instream vegetation, increases the erosion resistance of the bed and banks, which slows the rate of channel change and decreases the likelihood of severe erosion during floods. The mitigation measures listed for each waterway process in Table 47 should all be used to support, and in some cases supplement, the establishment of a riparian vegetation corridor.

Most mitigation measures work to reduce the likelihood of infrastructure being impacted by waterway processes.

Table 47. Available mitigation measures for each waterway process.

Waterway process	Mitigation measure	Impact on risk (likelihood or consequence)
Waterway process management tools		
Flooding	In order to avoid changes to flood behaviour which may impact downstream users, mitigation measures associated with minimises flooding at the waterway crossings (e.g., levees) are not recommended	n/a
Small to moderate scale erosion	Establish and maintain a riparian corridor of structurally diverse native vegetation	Reduces likelihood of impact on infrastructure by increasing resistance of bank material to erosion, which reduces the frequency and intensity of small to moderate scale erosion.
	Fencing and stock management	Reduce likelihood of impact by decreases trampling and browsing of riparian vegetation, increasing likelihood of vegetation establishment/maintenance, which reduces the frequency and intensity of small to moderate scale erosion.
	Rock beaching	Reduce likelihood of impact by reducing (or eliminating) small to moderate scale erosion of channel banks by shielding bank material from flow.
	Timber/brush armouring	
Large-scale incision	Rock chute / grade control structures	Reduces the likelihood of large-scale channel incision reaching waterway crossing by limiting progression of headward incision, including arresting deepening and associated widening.

Waterway process	Mitigation measure	Impact on risk (likelihood or consequence)
	Rock beaching	Reduces likelihood of channel widening, sediment delivery downstream and meander establishment. Does not reduce likelihood of deepening and further incision upstream.
	Meander reinstatement or waterway construction	Reduces likelihood of incision and meander migration/bank erosion by reducing bed grade through lengthening of waterway.
Moderate scale avulsion (meander cut offs)	Establish and maintain a riparian corridor of structurally diverse native vegetation	Reduces rates and likelihood of meander migration by increased resistance of bank material to erosion.
	Fencing and stock management	Reduces meander migration likelihood/rates, as above, by decreases trampling and browsing of riparian vegetation, which increases likelihood of vegetation establishment/maintenance.
	Rock armouring to prevent meander migration	Reduces rates and likelihood of meander migration by protecting bank material.
	Pile fields on eroding banks to trap sediment and promote vegetation establishment.	Reduces likelihood of further meander migration by promoting depositional environment on meander bend, which aids vegetation establishment which increases bank strength.
Large scale avulsion (reach-scale abandonment)	Spillways at daughter channel breakout points	Reduces likelihood of avulsion occurring by creating a defined spill location, creating predictability within the system that presents an uncontrolled breakout forming, restricting the volume of water diverted from the parent channel.
	Grade control structures within the daughter channel	Reduces likelihood of avulsion occurring by controlling bed grade of daughter channel, reducing likelihood of headward incision migrating up daughter channel.
	Floodplain vegetation establishment and maintenance	Reduces likelihood of avulsion by increasing roughness across the floodplain or along daughter channels, decreases the likelihood of floodplain scour and daughter channels forming.
Project design		
Flooding	Where possible, locate construction areas and permanent infrastructure outside of 1% AEP flood extent.	Reduces likelihood of flooding reaching and impacting on project assets. Reduced construction times reduces the likelihood of a flood occurring during construction.

Waterway process	Mitigation measure	Impact on risk (likelihood or consequence)
	Where possible, reduce length of open construction (i.e., exposed soil and pits.	
Small to moderate scale erosion	Appropriate buffer width for location of infrastructure Appropriate burial / depth of infrastructure Appropriate materials for protection of infrastructure Changed location of Marinus Link alignment Additional assessment and appropriate design for additional flow pathway/waterway crossings	These mitigation measures can act to reduce the likelihood of exposure to waterway processes (e.g. infrastructure is located further away so is less likely to be exposed to erosion) or the consequence (e.g., infrastructure is adequately designed such that it is capable of withstanding exposure to erosion without detrimental impacts to infrastructure or the environment).
Large-scale incision		
Moderate scale avulsion (meander cut-offs)		
Large scale avulsion (reach-scale abandonment)		

Waterway process management tools

Waterway process management tools generally work to reduce the likelihood of waterway processes occurring through reduction in rates of change. These tools are further described below.

Establishing a riparian buffer of structurally diverse native vegetation

Establishing a buffer of native vegetation is one of the simplest and most effective means of slowing the rate of channel change that would otherwise threaten buried or floodplain infrastructure.

There are various methods for determining an appropriate buffer width, based on the purpose of the buffer (e.g., erosion mitigation, water quality improvement, river health outcomes), stream type/order and landscape type. For example, Melbourne Water recommend buffer width based on stream order (i.e., 20 m buffer for a first/second order stream, 30 m setback for a third order stream and 50 m setback for fourth and greater order stream) (Melbourne Water, 2013). A standard recommended buffer width used in Victorian catchment management would be 30 metres plus a bank migration rate.

For bank stability and erosion control purposes, *Guidelines for stabilising streambanks with riparian vegetation* (Abernathy & Rutherfurd, 1999) provides a calculated width, where the buffer distance is the sum of the bank height, the migration distance expected during vegetation establishment, and the vegetation buffer (Figure 127):

Bank height (m) + bank erosion/migration over establishment phase (m) +
ongoing corridor width required to maintain a suitable structurally diverse vegetation community (m)

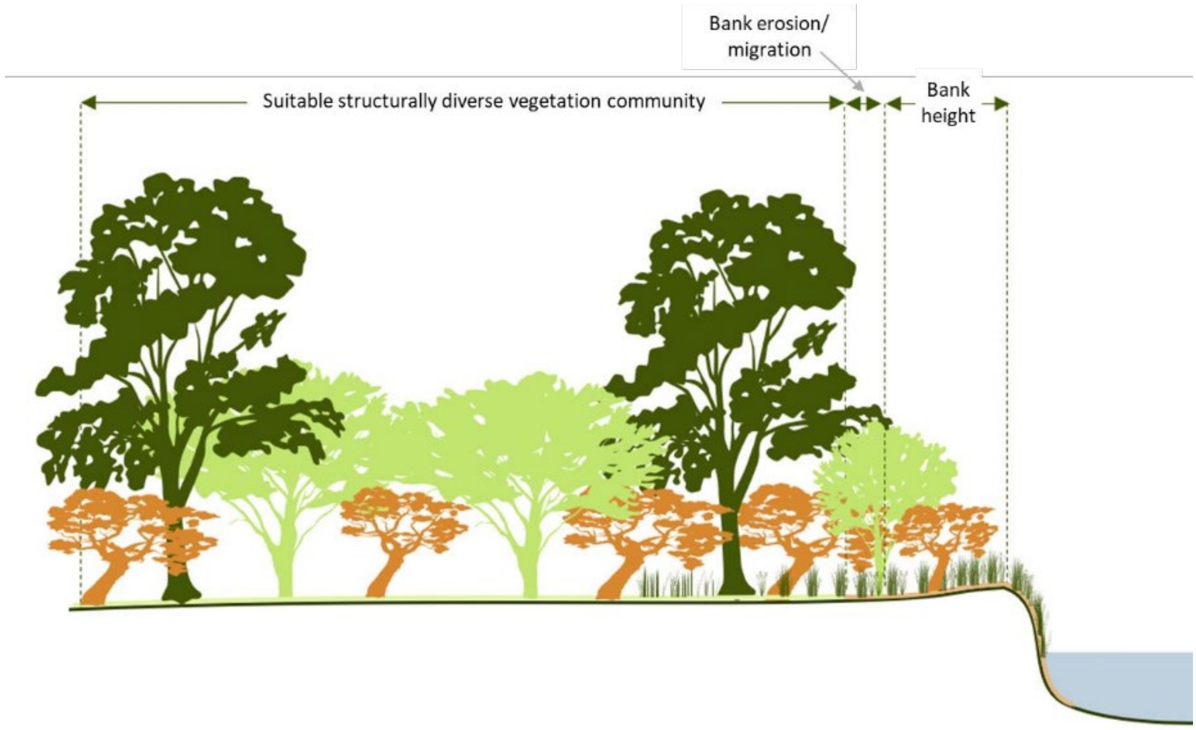


Figure 127. *Riparian zone buffer width breakdown. Example only, not to scale.*

Fencing and stock management

A lack of fencing and/or unrestricted stock access can increase rates of erosion through reduced vegetation cover (and therefore bank resistance) and direct trampling from livestock. Fencing and/or stock management helps to improve bank resistance to erosion by increasing roughness through increased vegetation cover. These management techniques often form part of a wider waterway management program and while largely focussed on waterway health outcomes, can help to limit, or mitigate the scale of waterway processes.

Rock beaching

Rock beaching (Figure 128) can be utilised to limit stream bank erosion associated with meander migration and channel widening, i.e., if a bank needs to be held in a specific location. Rock beaching can, however, be expensive and limit waterway health outcomes by reducing available habitat for instream fauna. Rock beaching involved placement of rock on stream banks, usually at a battered angle. The level of protection offered will depend on the rock size, battering angle and height of rock up the bank. This technique provides localised protection of stream banks and does not address system-wide or reach-scale processes.

Figure 128. *Example rock beaching*

Timber or brush armouring

Timber piles or armouring with timber and brush (Figure 129) can be used as a bank erosion control technique, however rock beaching will provide longer-term bank protection. Timber can often be cheaper to source, can be sourced from fallen trees in the river and realigned to provide bank protection. Timber also provides for better waterway health outcomes. Timber or brush armouring provides a lower certainty of successfully holding bank position than rock armouring.

Figure 129. *Example of realigned timber to provide bank protection*

Grade control structures

Where local bed instabilities or head-cuts are migrating upstream, resulting in bed deepening, these can be addressed through a grade control program such as rock chutes (Figure 130). Grade control structures are most useful where erosion is associated with incision and accompanying channel widening. Grade control can be used to limit incision in a waterway or contribute to limiting up valley extension of an avulsion pathway / "daughter" channel. A rock chute involves excavation of the bed and banks and placement of graded rock, forming a small ramp in the stream.

Figure 130. *Example grade control structure (rock chute)*

Spillways

Construction of spillways (Figure 131) at a breakout point for an avulsion both block the breach and provide a controlled point for water from the main channel to engage the flow path during flood events. The crest elevation (or sill) of the spillway can be set to control the level of flows that engage the floodplain. This helps to limit down valley extension of a "daughter" channel by limiting deepening and widening of the new channel associated with a breakout point.

Figure 131. *Example of a rock ramp spillway*

Project design

Mitigation measures associated with the design of the project infrastructure can aim to reduce the likelihood of exposure to waterway processes or the consequence of exposure to these processes. It is assumed that detailed design of the project will include design of appropriate buffer width, burial depth, and design materials. There are instances where the risk posed by waterway processes for a crossing is so high that a changed alignment or further assessment is recommended.

Appropriate buffer width

An appropriate buffer width would allow for estimated lateral channel changes to occur, without impacting on built infrastructure. Locating infrastructure further from waterway and outside the 1% AEP flood extent also reduce the likelihood of a flood impacting on infrastructure. This could include the distance of horizontal drilling and the location of accompanying infrastructure such as joint pits. The buffer width should consider rates of bank erosion (both ongoing and episodic/event-based), likelihood of incision and subsequent widening of waterways, and the mapped flood extent. A buffer width may also include other flow pathways and potential avulsion channels, covering an entire floodplain, where appropriate and possible. An appropriate buffer width reduces the likelihood that infrastructure will be exposed to waterway processes and flooding.

Appropriate burial depth

Appropriate burial depths need to account for any predicted channel deepening. This could be incision in the main channel and/or deepening of an avulsion pathway on the floodplain. An appropriate burial depth reduces the likelihood that infrastructure will be exposed to waterway processes.

Appropriate materials for protection

It may be possible that exposure of infrastructure to waterway processes is acceptable in some areas. Appropriate materials and design of protection for this infrastructure could reduce the consequence of exposure to waterway processes. This would include both prevention of damage to waterway health and to built infrastructure.

Changed location of project alignment

In some cases, risk may be so high and not manageable with mitigation measures. In this scenario, a change in the alignment of the project infrastructure may be required to reduce this risk.

Residual risk assessment

This section summarises the change in risk rating for each waterway process, for each waterway crossing assuming the relevant mitigation measures have been applied. This follows the same definitions of likelihood, consequence and risk calculation as detailed above in Table 40, Table 41 and Table 42. For this assessment, only a reduction in likelihood associated with waterway process management tools has been considered. It is assumed that relevant reduction in consequence associated with project design will be determined through detailed design of the infrastructure.

We have highlighted in Table 48 where the risk posed by waterway processes for a crossing is so high that a changed alignment or further assessment is recommended. We have proposed the intervention that provides the most certainty in preventing channel change (for example rock armouring), but we note more detailed investigations as part of detailed design may identify smaller scale works are sufficient to reduce risk. More detailed investigations as part of detailed project design are required to properly assess the design and scale of such works. Figure 132 provides a summary of pre-mitigation and post-mitigation risk ratings for waterway crossings.

Table 48. Recommended mitigation measures and residual likelihood, consequence, and risk of waterway processes

Reach	Waterway process threats to infrastructure	Pre-mitigation			Recommended mitigation methods to reduce likelihood	With mitigation measures		
		Likelihood	Consequence	Risk		Likelihood	Consequence	Residual risk
Morwell River	Flooding (within 1% AEP)	Likely	Moderate	High	Where possible move TCM drill pads outside of flood extent. Could include moving TCM52 further west to allow TCM53 to be located outside flood extent within max. 400 m distance of HDD	Possible	Moderate	Moderate
	Small to moderate scale erosion	Likely	Minor	Moderate	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management	Possible	Minor	Low
	Large-scale incision	Unlikely	Major	Moderate	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management	Rare	Major	Low
	Moderate scale avulsion (meander cut offs)	Possible	Moderate	Moderate	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management. Rock armouring to prevent meander migration	Unlikely	Moderate	Low
	Large scale avulsion (reach-scale abandonment)	Rare	Major	Low	n/a	Rare	Major	Low
Little Morwell River	Flooding (within 1% AEP)	Likely	Moderate	High	Modification of open trench construction to TCM construction at waterway crossing. Adequate access track culvert design.	Unlikely	Moderate	Low
	Small to moderate scale erosion	Possible	Minor	Low	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management	Unlikely	Minor	Low
	Large-scale incision	Rare	Major	Low	n/a	Rare	Major	Low
	Moderate scale avulsion (meander cut offs)	Rare	Moderate	Low	n/a	Rare	Moderate	Low

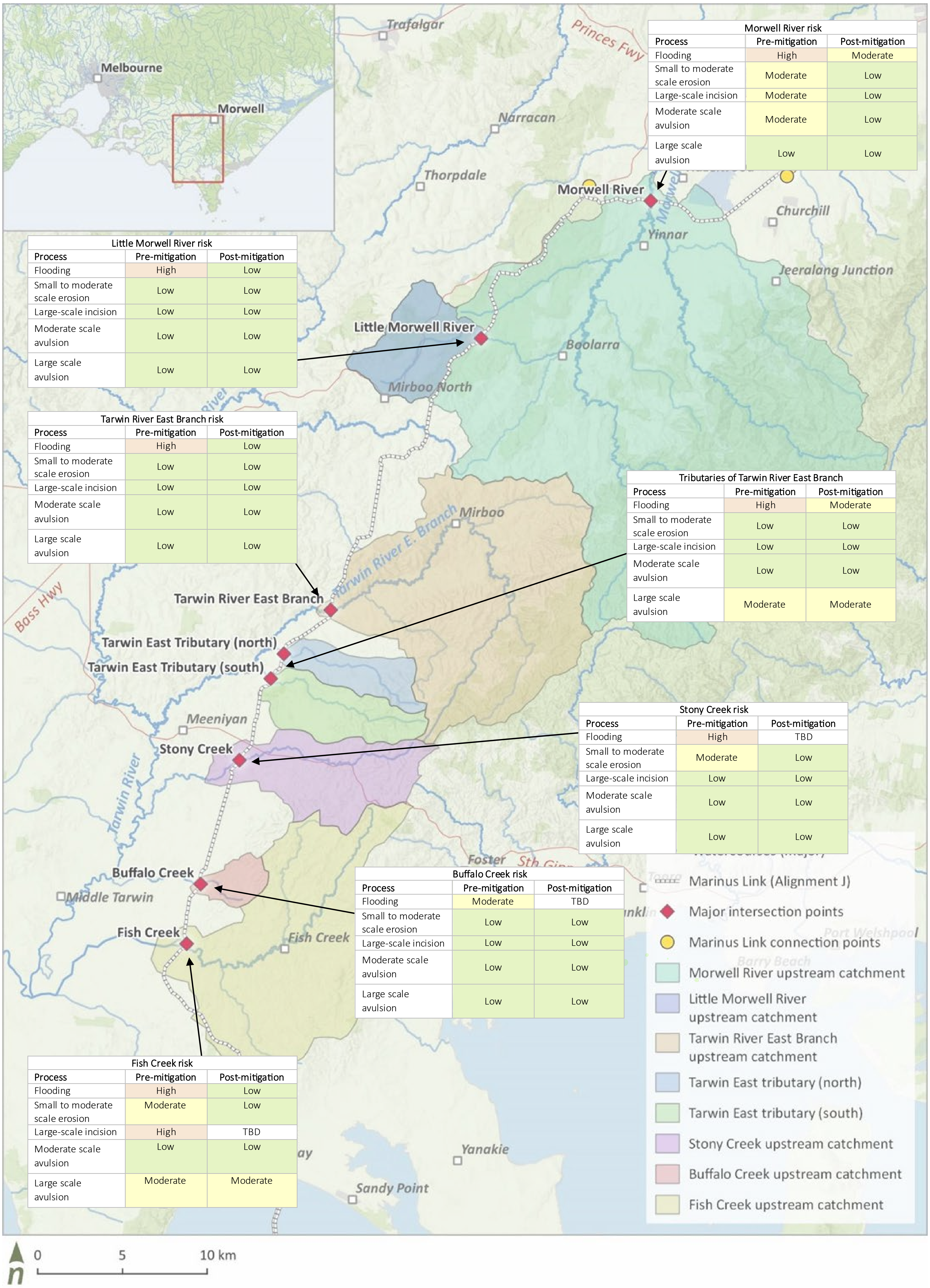
Reach	Waterway process threats to infrastructure	Pre-mitigation Likelihood	Consequence	Risk	Recommended mitigation methods to reduce likelihood	With mitigation measures Likelihood	Consequence	Residual risk
	Large scale avulsion (reach-scale abandonment)	Rare	Major	Low	n/a	Rare	Major	Low
Tarwin River East Branch	Flooding (within 1% AEP)	Likely	Moderate	High	TCMs and joint pits located outside 1% AEP extent. HDD length increased to 400 m across full flood extent.	Possible	Moderate	Moderate
	Small to moderate scale erosion	Possible	Minor	Low	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management	Unlikely	Minor	Low
	Large-scale incision	Rare	Major	Low	n/a	Rare	Major	Low
	Moderate scale avulsion (meander cut offs)	Rare	Moderate	Low	n/a	Rare	Moderate	Low
	Large scale avulsion (reach-scale abandonment)	Rare	Major	Low	n/a	Rare	Major	Low
Tributaries of Tarwin river East Branch	Flooding (within 1% AEP)	Likely	Moderate	High	Where possible move TCM drill pads outside of flood extent. HDD in areas of open trench construction through flood extent, i.e. between TCM069 and TCM027A, between TCM070 and JP34A, and increased HDD extent surrounding TCM026.	Possible	Moderate	Moderate
	Small to moderate scale erosion	Possible	Minor	Low	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management	Unlikely	Minor	Low
	Large-scale incision	Rare	Major	Low	n/a	Rare	Major	Low
	Moderate scale avulsion (meander cut offs)	Rare	Moderate	Low	n/a	Rare	Moderate	Low

Reach	Waterway process threats to infrastructure	Pre-mitigation			Recommended mitigation methods to reduce likelihood	With mitigation measures		
		Likelihood	Consequence	Risk		Likelihood	Consequence	Residual risk
	Large scale avulsion (reach-scale abandonment)	Unlikely	Major	Moderate	Monitoring indicators of nearing avulsion. Establish and maintain a riparian corridor of structurally diverse native vegetation.	Unlikely	Major	Moderate
Stony Creek	Flooding (within 1% AEP)	Likely	Moderate	High	Where possible include HDD TCM construction through flood extent. Further investigate flood behaviour and impact. Investigate alternate alignment to reduce length of alignment within flood extent, based on findings.	To be determined after further investigation as part of detailed design.		
	Small to moderate scale erosion	Likely	Minor	Moderate	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management	Possible	Minor	Low
	Large-scale incision	Rare	Major	Low	n/a	Rare	Major	Low
	Moderate scale avulsion (meander cut offs)	Rare	Moderate	Low	n/a	Rare	Moderate	Low
	Large scale avulsion (reach-scale abandonment)	Rare	Major	Low	n/a	Rare	Major	Low
Buffalo Creek	Flooding (within 1% AEP)	Possible	Moderate	Moderate	Investigate flood extent and likelihood through further modelling. Potentially change project infrastructure location, based on findings.	To be determined after further investigation as part of detailed design.		
	Small to moderate scale erosion	Unlikely	Minor	Low	n/a	Unlikely	Minor	Low
	Large-scale incision	Rare	Major	Low	n/a	Rare	Major	Low
	Moderate scale avulsion (meander cut offs)	Rare	Moderate	Low	n/a	Rare	Moderate	Low

Reach	Waterway process threats to infrastructure	Pre-mitigation			Recommended mitigation methods to reduce likelihood	With mitigation measures		
		Likelihood	Consequence	Risk		Likelihood	Consequence	Residual risk
	Large scale avulsion (reach-scale abandonment)	Rare	Major	Low	n/a	Rare	Major	Low
Fish Creek	Flooding (within 1% AEP)	Likely	Moderate	High	Move open trench and HDD drill pads outside 1% AEP flood extent, moving further south.	Unlikely	Moderate	Low
	Small to moderate scale erosion	Likely	Minor	Moderate	Establish and maintain a riparian corridor of structurally diverse native vegetation	Possible	Minor	Low
	Large-scale incision	Possible	Major	High	Additional assessment required. Grade control structure	To be determined after further investigation as part of detailed design.		
	Moderate scale avulsion (meander cut offs)	Rare	Moderate	Low	n/a	Rare	Moderate	Low
	Large scale avulsion (reach-scale abandonment)	Unlikely	Major	Moderate	Monitoring indicators of nearing avulsion. Establish and maintain a riparian corridor of structurally diverse native vegetation.	Unlikely	Major	Moderate

n/a = Not applicable

TBD = To be determined based on updated alignment and additional assessment



Morwell River risk

Process	Pre-mitigation	Post-mitigation
Flooding	High	Moderate
Small to moderate scale erosion	Moderate	Low
Large-scale incision	Moderate	Low
Moderate scale avulsion	Moderate	Low
Large scale avulsion	Low	Low

Little Morwell River risk

Process	Pre-mitigation	Post-mitigation
Flooding	High	Low
Small to moderate scale erosion	Low	Low
Large-scale incision	Low	Low
Moderate scale avulsion	Low	Low
Large scale avulsion	Low	Low

Tarwin River East Branch risk

Process	Pre-mitigation	Post-mitigation
Flooding	High	Low
Small to moderate scale erosion	Low	Low
Large-scale incision	Low	Low
Moderate scale avulsion	Low	Low
Large scale avulsion	Low	Low

Tributaries of Tarwin River East Branch

Process	Pre-mitigation	Post-mitigation
Flooding	High	Moderate
Small to moderate scale erosion	Low	Low
Large-scale incision	Low	Low
Moderate scale avulsion	Low	Low
Large scale avulsion	Moderate	Moderate

Stony Creek risk

Process	Pre-mitigation	Post-mitigation
Flooding	High	TBD
Small to moderate scale erosion	Moderate	Low
Large-scale incision	Low	Low
Moderate scale avulsion	Low	Low
Large scale avulsion	Low	Low

Buffalo Creek risk

Process	Pre-mitigation	Post-mitigation
Flooding	Moderate	TBD
Small to moderate scale erosion	Low	Low
Large-scale incision	Low	Low
Moderate scale avulsion	Low	Low
Large scale avulsion	Low	Low

Fish Creek risk

Process	Pre-mitigation	Post-mitigation
Flooding	High	Low
Small to moderate scale erosion	Moderate	Low
Large-scale incision	High	TBD
Moderate scale avulsion	Low	Low
Large scale avulsion	Moderate	Moderate

Figure 132. *Summary of pre-mitigation and post-mitigation risk ratings for waterway crossings.*

Monitoring

In addition to these physical mitigation measures, an appropriate monitoring program can provide early warning of potential hazards/risk. A monitoring program could include pre-defined trigger points where a mitigation measure is implemented and include a program of regular monitoring of gradual channel change over time to verify cumulative impacts of small-scale erosion do not progressively undermine banks or expose buried infrastructure. A surface water monitoring program could be developed with WGCMA and be based on their recommendations for a project of this nature. Monitoring impacts of physical waterway processes on built infrastructure could include:

- Quantification of bank erosion rates or identification of erosion hotspots
- Monitoring of rates of headward migration of incision downstream and around waterway crossings (e.g., steepening of bed grade, bed deepening, and widening)
- Signs of nearing smaller scale avulsions and meander cutoffs including distances between meander bends, active bank erosion and potential for meander cut offs to occur
- Signs of reach-scale avulsion processes and triggers such as bed aggradation in the parent channel, floodplain scour and development of daughter channels.

A monitoring program must also include ad hoc monitoring after large flood or extreme weather events. Channel change can be event-based and occur sporadically or gradual over time. A monitoring program should incorporate monitoring of both. Monitoring should occur at the site of the crossing and at appropriate distances up and downstream, and across the floodplain to assess any increasing risk. Monitoring would be recommended for risks identified that remain greater than moderate, following further investigation and detailed design. The monitoring program including monitoring activities, frequency and other requirements can be further defined in a Monitoring, Evaluation, Reporting and Improvement (MERI) plan to be developed as part of detailed design and construction.

Monitoring for impacts of the project on surface waters are discussed in Section 6.9 of the report.

Risks to built infrastructure summary

This attachment summarises the surface water processes operating at five locations where the proposed project transmission route crosses waterways. A combination of desktop analyses and field visits have been used to describe the waterway processes operating at each site, the risk those processes pose to buried and floodplain infrastructure, and the mitigation measures that can be implemented to reduce risk at each waterway crossing site.

Further, more detailed investigations are required as part of detailed design and meeting the EPRs to:

- Identify the minimum burial depth and buffer width for buried infrastructure that crosses beneath waterways.
- Identify where flood risk may pose an unacceptable risk to project infrastructure, particularly at Stony Creek and Buffalo Creek, where 1% AEP flood mapping is not available.
- Identify residual risk and mitigation actions that may be required to address incision in Fish Creek.
- Identify the type and scale of instream works required to prevent channel change from undermining buried or floodplain infrastructure at high and moderate risk sites.

Table 49 provides an overview of each waterway crossing description, current risk of waterway process threats to buried infrastructure, mitigation strategies and residential risk rating.

Table 49. Overview of each waterway crossing description, current risk of waterway process threats to buried infrastructure, mitigation strategies and residential risk rating

Reach	Reach description	Waterway process threats to buried infrastructure	Risk	Mitigation measures	Residual risk
Morwell River	Medium-sized, largely unconfined meandering channel with evidence of past channel change and meander cut offs. Flowing through grassland and pastures. Poor riparian vegetation cover with unrestricted stock access. Bank erosion evident and potential lateral instabilities through channel migration and meander cut offs.	Flooding (1% AEP)	High	Where possible move TCM drill pads outside of flood extent. Could include moving TCM52 further west to allow TCM53 to be located outside flood extent within max. 400 m distance of HDD	Moderate
		Small to moderate scale erosion	Moderate	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management	Low
		Large-scale incision	Moderate	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management	Low
		Moderate scale avulsion (meander cut offs)	Moderate	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management. Rock armouring to prevent meander migration	Low
		Large scale avulsion (reach-scale abandonment)	Low	n/a	Low
Little Morwell River	Small, partially confined meandering channel through rural residential properties and abutted by softwood plantations. Some riparian vegetation, with unrestricted stock access. Stable bed grade, constrained by downstream road crossing. No evidence of lateral channel migration.	Flooding (1% AEP)	High	Modification of open trench construction to HDD TCM construction at waterway crossing. Adequate access track culvert design.	Low
		Small to moderate scale erosion	Low	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management	Low
		Large-scale incision	Low	n/a	Low
		Moderate scale avulsion (meander cut offs)	Low	n/a	Low
		Large scale avulsion (reach scale abandonment)	Low	n/a	Low

Reach	Reach description	Waterway process threats to buried infrastructure	Risk	Mitigation measures	Residual risk
Tarwin River East Branch	Medium-sized, partially confined, meandering channel through pasture and grasslands. Poor riparian vegetation cover and unrestricted stock access. Stable bed grade, constrained by other infrastructure crossings, no evidence of lateral instabilities.	Flooding (1% AEP)	High	TCMs and joint pits located outside 1% AEP extent. HDD length increased to 400 m across full flood extent.	Low
		Small to moderate scale erosion	Low	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management	Low
		Large-scale incision	Low	n/a	Low
		Moderate scale avulsion (meander cut offs)	Low	n/a	Low
		Large scale avulsion (reach scale abandonment)	Low	n/a	Low
Tributaries of Tarwin River Each Branch	Unconfined and perched waterways through pasture and grasslands. Moderate riparian cover, sparse in areas, with direct stock access. Stable bed grade, no evidence of major lateral instabilities or migration.	Flooding (1% AEP)	High	Where possible move TCM drill pads outside of flood extent. HDD in areas of open trench construction through flood extent, i.e. between TCM069 and TCM027A, between TCM070 and JP34A, and increased HDD extent surrounding TCM026.	Moderate
		Small to moderate scale erosion	Low	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management	Low
		Large-scale incision	Low	n/a	Low
		Moderate scale avulsion (meander cut offs)	Low	n/a	Low
		Large scale avulsion (reach scale abandonment)	Moderate	Monitoring indicators of nearing avulsion. Establish and maintain a riparian corridor of structurally diverse native vegetation.	Moderate
Stony Creek	Small, partially confined stream through pasture and grasslands. Good riparian vegetation cover, and no direct stock access. Stable bed grade, constrained by other infrastructure crossings, no evidence of lateral instabilities.	Flooding (1% AEP)	High	Where possible include HDD construction through flood extent. Further investigate flood behaviour and impact. Investigate alternate alignment to reduce length of alignment within flood extent, based on findings.	TBD
		Small to moderate scale erosion	Moderate	Establish and maintain a riparian corridor of structurally diverse native vegetation, fencing and stock management	Low
		Large-scale incision	Low	n/a	Low
		Moderate scale avulsion (meander cut offs)	Low	n/a	Low

Reach	Reach description	Waterway process threats to buried infrastructure	Risk	Mitigation measures	Residual risk
		Large scale avulsion (reach-scale abandonment)	Low	n/a	Low
Buffalo Creek	Small, confined stream, entering the floodplain, somewhat perched on the floodplain. Flowing through pastures and rural residential properties with good riparian vegetation cover. Fenced from stock access. Stable bed grade, constrained by other infrastructure crossings, no evidence of lateral instabilities.	Flooding (1% AEP)	Moderate	Investigate flood extent and likelihood through further modelling. Potentially change project infrastructure location, based on findings.	TBD
		Small to moderate scale erosion	Low	n/a	Low
		Large-scale incision	Low	n/a	Low
		Moderate scale avulsion (meander cut offs)	Low	n/a	Low
		Large scale avulsion (reach scale abandonment)	Low	n/a	Low
Fish Creek	Small to medium-sized anthropogenically modified channel through pasture and grasslands. Some riparian vegetation, with likely unrestricted stock access. Evidence of major incision and adjustment to historic channel straightening, headward headcut migration. Deepening and widening in the order of 4-5 m and 10-15 m, respectively.	Flooding (1% AEP)	High	Move open trench and HDD drill pads outside 1% AEP flood extent, moving further south.	Low
		Small to moderate scale erosion	Moderate	Establish and maintain a riparian corridor of structurally diverse native vegetation	Low
		Large-scale incision	High	Additional assessment required. Grade control structure	TBD
		Moderate scale avulsion (meander cut offs)	Low	n/a	Low
		Large scale avulsion (reach scale abandonment)	Moderate	n/a	Moderate

n/a = Not applicable