technical report B

surface water.

Environment Effects Statement | May 2021

western outer ring main

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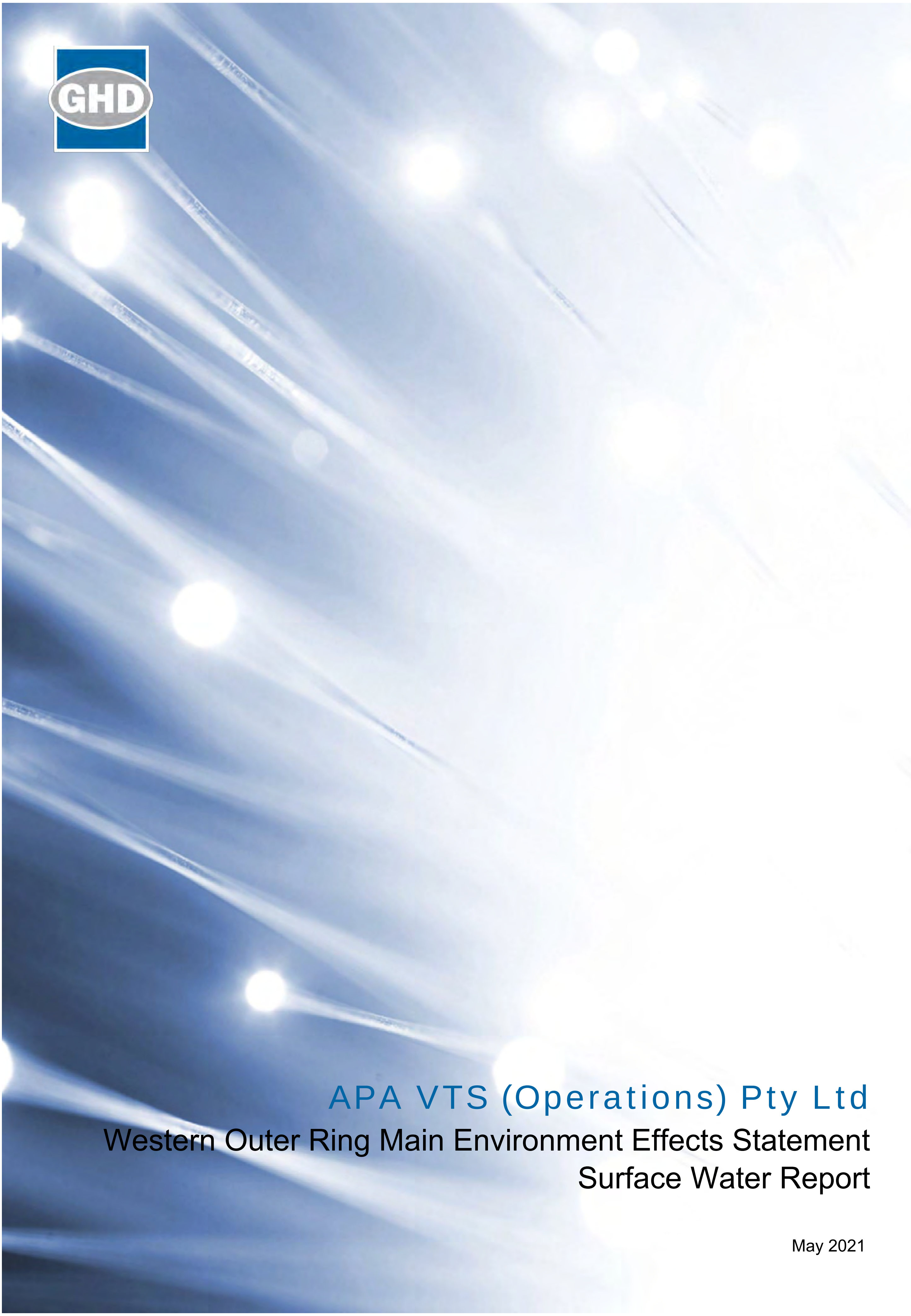

APA VTS (Operations) Pty Ltd

Western Outer Ring Main Environment Effects Statement
Surface Water Report

May 2021

This Surface Water Report (Report):

1. Has been prepared by GHD Pty Ltd ("GHD") for APA VTS (Operations) Pty Ltd (APA);
2. May only be used for the purpose of informing the Environment Effects Statement and Pipeline Licence Application for the Western Outer Ring Main Project (and must not be used for any other purpose); and
3. May be provided to the Department of Environment, Land, Water and Planning for the purpose of public exhibition as part of the Environment Effects Statement and Pipeline Licence Application for the Western Outer Ring Main Project

The services undertaken by GHD in connection with preparing this Report were limited to those specifically detailed in section 5 of this Report. The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report (Assumptions), as specified in section 5.9 and throughout this Report. GHD excludes liability for errors in, or omissions from, this Report arising from or in connection with any of the assumptions being incorrect. Subject to the paragraphs in this section of the Report, the opinions, conclusions and any recommendations in this Report are based on conditions encountered and information reviewed at the time of preparation. GHD has not, and accepts no responsibility or obligation to update this Report to account for events or changes occurring subsequent to the date that the Report was signed.

Executive summary

This technical report is an attachment to the Western Outer Ring Main Project Environment Effects Statement (EES). It provides the Surface Water existing conditions and impact assessment for the Project, and defines the environmental management measures necessary to meet the EES evaluation objectives.

Overview

The Western Outer Ring Main Project (the Project) is a buried 600 millimetre nominal diameter high pressure gas transmission pipeline between APA's existing Plumpton Regulating Station (approx. 38 kilometres north west of Melbourne's CBD) and Wollert Compressor Station (approx. 26 kilometres north east of Melbourne's CBD), providing a high pressure connection between the eastern and western pipeline networks of the Victorian Transmission System (VTS).

The Project includes a new buried pipeline, three above-ground mainline valves along the pipeline alignment, and an additional compressor unit and regulating station at the existing APA Wollert Compressor Station.

APA is the proponent for the Project.

On 22 December 2019, the Minister for Planning determined that the Project would require an Environment Effects Statement (EES) under the *Environment Effects Act 1978* (EE Act).

GHD was commissioned to undertake a surface water impact assessment for the purpose of the EES.

Surface Water context

Surface water quality and hydrology plays an important role in maintaining the health and sustainability of river systems, urban creeks and floodplains. As the proposed alignment and construction corridor of the Project will interface with existing waterways and floodplains, it is important that the Project is designed to maintain water quality and floodplain function during both construction and operation. Obstruction of flow paths and construction activities due to the Project has the potential to alter flow characteristics and have an impact on water quality within the waterways and receiving waters if they are not managed appropriately.

It is important to understand existing conditions of the waterways and environmental values that require protection in order to develop construction methods that will minimise or prevent impacts to waterways.

The scoping requirements for the EES issued by the Minister for planning set out the specific environmental matters to be investigated and documented in the Project's EES, which informed the scope of the EES technical studies. The technical requirements relevant to the surface water assessment are:

- **Water and catchment values**: Maintain the functions and values of groundwater, surface water and floodplain environments and minimize effects on water quality and beneficial uses

Existing conditions

The assessment consisted of a two tiered assessment with a preliminary assessment undertaken for all waterways as a screening assessment to identify the potentially higher risk or more "complex" waterways.

Building on an earlier surface water assessment scope of work completed by GHD Pty Ltd (2020), the EES assessment has been undertaken based on a two tiered assessment approach outlined below:

- Phase 1 - Screening assessment of identified waterways (23 waterways) - Review of previous screening assessment to confirm the potentially higher risk waterways
- Phase 2 - Detailed assessment of the waterways identified with potentially higher risks (6 of 23 waterways previously identified) - More rigorous detailed assessments of the confirmed higher risk waterways

From the detailed assessments of the existing conditions, the summary in Table ES 1 has been compiled providing an overview of the main waterways applicable to the Project.

Table ES 1 Detailed assessment summary of the main waterways

Waterway	Geotechnical Interpretation	Hydrology & Flooding	Channel & Floodplain Hydraulics
Tame Street Drain	Shallow basalt (2 m depth)	Ephemeral, standard flood risk	Velocities < 2 m/s Stream Powers < 300 Nm2 Stable channel condition
Jacksons Creek	Erosive soils in upper profile, and no depth to basalt was encountered	Perennially flowing, preferred timing summer-autumn	Velocities > 2 m/s Stream Powers > 300 Nm2 Active erosion evident, and expected over geomorphic trajectories
Deep Creek	Erosive soils in upper profile, and no depth to basalt was encountered	Perennially flowing, preferred timing summer-autumn	Velocities > 2 m/s Stream Powers > 300 Nm2 Active erosion evident, and expected over geomorphic trajectories
Kalkallo Creek	Presence of clays within first 10 m from surface, to where basalt is encountered	Ephemeral, higher apparent flood risk being within RB – the periphery flood risk could be managed	Velocities < 2 m/s Stream Powers < 300 Nm2 Stable channel condition
Tributary to Merri Creek	Shallow basalt (2 m depth)	Ephemeral, standard flood risk	Velocities - 1 m/s Stream Powers < 100 Nm2 Stable channel condition, no sign of incision
Merri Creek	Shallow basalt (2 m depth)	Ephemeral, standard flood risk	Velocities < 1 m/s Stream Powers expected to be low Stable rehabilitated channel condition

Further detailed assessments including additional site inspections, interpretation of geotechnical information, further hydraulic modelling, geomorphology and water quality assessment of the main waterways of Jacksons Creek, Deep Creek and Merri Creek were undertaken. A summary of this additional assessment is provided in Table ES 2.

Table ES 2 Further detailed assessment of key waterways

Waterway	Summary of Findings
Jacksons Creek	**Geotechnical** - Erosive soils (sands/gravels) in upper profile, and no depth to basalt was encountered. **Waterway** – Ford crossing on basalt outcrop providing d/s control. High velocities & stream powers at site. **Water Quality and beneficial uses -** Water quality samples from Jacksons Creek at Sunbury exceeded the guideline values for turbidity, nitrate, oxidised nitrogen, filtered reactive phosphate, total phosphorous, chromium, copper, lead, nickel and zinc. The gauge data downstream at Keilor presented similar results to the upstream gauge with total nitrogen also exceeding the guideline values. It should be noted that the results are likely influenced by the Sunbury Water Treatment Plant which is located between the upstream gauge and pipeline crossing location. Beneficial Uses downstream may include water dependent ecosystems and species, agriculture and irrigation, water-based recreation (aesthetic enjoyment) and Traditional Owner cultural values **Geomorphology** - Lateral erosion evident, but no significant change in stream morphology in the last 50 years. Whilst long term expected average rates of bed incision is low, and the downstream ford control may offer "protection" to the site of interest, the presence of the alluvial sediments in both channel and floodplain indicate potential future erosion, particularly if disturbed.
Deep Creek	**Geotechnical** – Erosive soils (gravels) in upper profile, and no depth to basalt was encountered. **Waterway** - Perennially flowing, generally passive flow conditions with minor riffle sequences along the reach defined by a rock outcrop control ~200m downstream. **Water Quality and beneficial uses –**Water quality samples collected from the upstream gauges had elevated concentrations of turbidity, nitrate, total nitrogen, phosphate, total phosphorus, chromium, copper, lead, nickel and zinc. The upstream gauges are located within an agricultural catchment where elevated levels of nitrogen and phosphorus may be present. The downstream gauge provided similar results to the upstream gauges but with noncompliant electrical conductivity and pH. Beneficial Uses downstream may include water dependent ecosystems and species, agriculture and irrigation, water-based recreation (aesthetic enjoyment) and Traditional Owner cultural values **Geomorphology** – Stable configuration of stream, with some minor lateral widening, but no significant change in stream morphology in 50 years. Slightly meandering low flow with stable bar configuration and ephemeral parallel secondary channel occupied in moderate floods. Deep scour common in secondary channels and if disturbed could trigger a permanent change in the main flow path.
Merri Creek	**Geotechnical** – Basalt within 2m depth, with weathered to fresh basalt exposed at the surface along downstream reach. **Waterway** - Ephemeral waterway, tightly meandering channel, and stable banks with the notable steepening of the gradient downstream of the pipe location. Low velocities near site although increasing downstream, and presence of shallow bed rock and exposed boulders suggest low potential for erosion. Easement area has recovered from previous pipe trenching works well. **Water Quality and beneficial uses –** There is limited water quality data available for Merri Creek and there is no stream gauge site upstream of the pipeline. Water quality data from the downstream gauge indicated elevated pH, dissolved oxygen, electrical

Waterway	Summary of Findings
	conductivity, turbidity, ammonia, nitrate, total nitrogen, phosphate, total phosphorus, chromium, copper and zinc. Results from this gauge may be influenced by a housing estate located proposed pipe line and the gauge. Beneficial Uses downstream may include water dependent ecosystems and species, agriculture and irrigation, water-based recreation (aesthetic enjoyment) and Traditional Owner cultural values **Geomorphology** - No significant change in stream morphology evident, and little potential for incision or lateral erosion given shallow/exposed underlying rock.

Construction impact assessment

The construction impact assessment involved identifying the potential impacts related to surface water based on the existing conditions of the waterways. The primary considerations when assessing the construction impact comprised the following:

- Runoff from general construction activities and dewatering impacting on the waterway health and beneficial uses downstream
- Construction activities causing the flood regime and floodplain function to change leading to potential flood impacts to surrounding properties and infrastructure
- Construction works causing riverbed or bank erosion that could affect river health and potentially impact surrounding properties and infrastructure
- Open trench construction activities within and near waterways that have potential for dispersive (sodic) soil behaviour leading to long-term erosion of dispersive soils
- Potential for ongoing erosion due to the disturbance caused to the waterway and/or floodplain from the construction of the pipeline works

This was based on the open trench construction method proposed for all waterway crossings, except for Deep Creek crossing which will be adopting a trenchless method using Horizontal directional Drilling (HDD). The impact assessment informed on additional management measures that would be required to reduce the residual impact of the above risks where practicable. In general, successful implementation of the recommended management measures is considered to reduce risk ratings to ‘low’ or ‘negligible’ for most of the risks identified, with the exception of the residual impact that remains in operation associated with the disturbance from trenching of Jacksons Creek.

The residual impacts associated with erosion due to open trench construction in operation are potentially more significant for Jacksons Creek due to complexities of the geomorphological processes and the exposure to more highly erodible materials below the surface. Additional controls relating to site specific construction management and rehabilitation measures, as well as development and implementation of a monitoring program for Jacksons Creek, are considered to minimise the impact and reduce the likelihood of unexpected erosion occurring at this waterway crossing during operation. This was considered to reduce the risk rating from 'high' to 'medium'.

The additional controls and management measures would protect property and infrastructure, and mitigate potential future erosion and prevent permanent changes to Jacksons Creek. This will involve greater protection of the pipes through design interventions, increased restrictions and requirements in the construction management plan and site-specific rehabilitation plan developed for Jacksons Creek. In addition, periodic visual monitoring during operation of the disturbed and rehabilitated Jacksons Creek waterway and floodplain will be important to achieve sustained stability. Appropriate implementation of design, construction and rehabilitation measures specific to Jacksons Creek will reduce the potential for operational risk. The successful application of the above management measures at Jacksons Creek crossing is considered to minimise the likelihood of ongoing erosion following the completion of the construction and during operation.

Environmental management measures

In undertaking the surface water impact assessment, environmental management measures have been identified to reduce the impact of construction and operation associated with the Project.

Key environmental management measures to minimise the impact associated with the construction and operation of the Project include:

- Manage runoff from adjacent construction areas, discharge from dewatering activities and spills/leaks to minimise impact on downstream environments due to construction activities and potential runoff
- Manage placement and storage of stockpiled materials on site and re-establish the land to pre-work conditions to allow flow to be conveyed across the construction area and minimise the impacts to the function of waterways and floodplains during construction
- Develop and implement an appropriate site rehabilitation plan as part of the Construction Environment Management Plan (CEMP) that takes into consideration the waterway and floodplain functions during post-construction phase and operation to minimise the potential for permanent changes to the waterways and floodplain functions
- Develop and implement an appropriate CEMP and site rehabilitation plan which includes erosion sediment controls for the construction sites, measures to control timing and duration of construction activities and appropriate rehabilitation of the waterway to minimise the impacts associated with bed or bank erosion
- Develop and implement a monitoring program for Jacksons Creek and Merri Creek to establish background conditions prior to construction and undertake ongoing water quality monitoring during construction to monitor potential impacts to water quality and beneficial uses downstream
- Develop and implement periodic routine observations to monitor site conditions during operation for Jacksons Creek and Merri Creek

- Develop and implement site specific design, construction management measures for Jacksons Creek to manage and mitigate the potential high risk associated with construction activities at this site
- Develop and implement site specific rehabilitation measures for Jacksons Creek to minimise the potential for permanent changes or ongoing erosion during construction, post-construction and operation
- Develop and implement a Flood Management and Response Plan (FMRP) for Jacksons Creek, Deep Creek, Kalkallo Creek and Merri Creek that considers the flood response within the floodplain and basin during construction to manage and respond appropriately during flood events
- Manage pipeline design solution for waterway crossings that are within a Drainage Services Scheme (DSS), such as the crossings at Kalkallo Creek and Tributary to Merri Creek, to minimise potential impacts to the pipeline and any future development that may have an effect on the waterway.

Conclusion

The impacts assessed for the Project are generally low with the implementation of both standard control measures and additional site specific control measures.

The potential residual impacts associated with erosion for both construction and operation are potentially more significant for Jacksons Creek due to complexities of the geomorphological processes and the exposure to more highly erodible materials below the surface. Additional controls relating to site specific construction management and rehabilitation measures, as well as development and implementation of a monitoring program for Jacksons Creek, are considered to achieve minimisation of the impact and reduce the likelihood of unexpected erosion occurring at this waterway crossing. The adequate management of the risk relies significantly on the additional measures to be implemented and managed accordingly.

Overall, with the appropriate implementation of the key environmental management measures outlined in this report, the residual impact of the Surface Water risks is not considered to result in any significant adverse environmental effects and the evaluation objective for the Project in terms of maintaining surface water and floodplain environments and minimising impacts on water quality and beneficial uses can be achieved.

Abbreviations

Abbreviation	Definition
AEMO	Australian Energy Market Operator
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australia and New Zealand Guidelines
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
AUAV	Australian Unmanned Aerial Vehicle
BH	Borehole
CaLP	Catchment and Land Protection
CBD	Central Business District
CEMP	Construction Environment Management Plan
CHMP	Cultural Heritage Management Plan
CMA	Catchment Management Authorities
DELWP	Department of Environment, Land, Water and Planning
DIWA	Department of Environment and Primary Industries Directory of Important Wetlands in Australia
DoT	Department of Transport
DSS	Drainage Services Scheme
EES	Environment Effects Statement
EP	Environmental Protection
EPA	Environment Protection Authority
EPBC	Environment Protection Biodiversity Conservation
ESC	Erosion and Sediment Controls
EVC	Ecological Vegetation Classes
FMRP	Flood Management and Response Plan
FO	Floodway Overlay
GDEs	Groundwater dependent ecosystems
GIS	Geographic Information System
HDD	Horizontal Directional Drilling
HEC-RAS	Hydraulic Engineering Centre - River Analysis System
IECA	International Erosion Control Association
LiDAR	Light Detection and Ranging
LSIO	Land Subject to Inundation Overlay
MLV	Mainline Valves
MSA	Melbourne Strategic Assessment

Abbreviation	Definition
MWC	Melbourne Water Corporation
N m2	Newton Square Metre (units)
OEMP	Operation Environmental Management Plan
OMR	Outer Metropolitan Ring
PSP	Precinct Structure Plan
RB	Retarding Basin
RCP	Representative Concentration Pathway
RFFE	Regional Flood Frequency Estimation
RORB	Runoff Routing (on Burroughs computer)
SBO	Special Building Overlay
SEPP	State Environmental Protection Policy
UFZ	Urban Floodway Zone
VTS	Victorian Transmission System
VVG	Visualising Victoria's Groundwater
WMS	Work Method Statement
WORM	Western Outer Ring Main
WSL	Water Surface Level
WSUD	Water-Sensitive Urban Design

Glossary

Term	Definition
APA	APA VTS (Operations) Pty Ltd, a subsidiary of APA Group, the proponent for the Project
Project	The Western Outer Ring Main Project
Environmental management measure	Approaches, requirements or actions to avoid, mitigate or manage potential adverse impacts
Scoping requirements	The EES Scoping requirements for the Project issued by the Minister for Planning in August 2020.
“Complex” waterway	The term “Complex” has been used to specifically reference Jacksons Creek, Deep Creek and Merri Creek, either individually or as a collective
Reach	A section or length of a stream or river

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1. Introduction

1.1 Purpose of this report

The Western Outer Ring Main (WORM) gas pipeline project (the Project) is a proposed 600 millimetre nominal diameter high pressure gas transmission pipeline that will provide a high pressure connection between the eastern and western pipeline networks of the Victorian Transmission System (VTS).

APA is the proponent for the Project. APA is Australia's largest natural gas infrastructure business. In Victoria, the VTS is owned and maintained by APA and consists of some 2,267 kilometres of gas pipelines. The VTS serves a total consumption base of approximately two million residential consumers and approximately 60,000 industrial and commercial users throughout Victoria.

The Project has been designed to provide critical infrastructure for Victoria's gas supply, distribution, and consequent security, efficiency and affordability. The key objectives of the Project are to:

- Improve system resilience and security of gas supply
- Increase the amount of natural gas that can be stored for times of peak demand
- Improve network performance and reliability
- Address potential gas shortages as forecasted by AEMO in the March 2020 Victorian Gas Planning Report update

The Minister for Planning determined on 22 December 2019 that APA and the Western Outer Ring Main (WORM) gas pipeline project (the Project) would require an Environment Effects Statement (EES) under the *Environment Effects Act 1978* (EE Act). The EES will inform assessment of approvals required for the Project including under the *Pipelines Act 2005*, *Aboriginal Heritage Act 2006* and *Environment Protection and Biodiversity Conservation Act 1999*.

The purpose of this report is to assess the potential surface water impacts associated with the Project and to define the environmental management measures necessary to meet the EES evaluation objectives.

1.2 Why understanding surface water is important

Surface water is water that is located above ground including rivers, creeks, lakes and wetlands. Some waterbodies are perennial which means flow is present throughout the year, while others are ephemeral where flow is present only for part of the year. These waterways are either naturally formed or they are constructed by humans such as lakes, dams and other water storage bodies.

The surface water quality and hydrology plays an important role in maintaining the health and sustainability of river systems, urban creeks and floodplains. As the proposed alignment and construction corridor of the Project will interface with existing waterways and floodplains, it is important that the Project is designed to maintain water quality and floodplain function during both construction and operation. Obstruction of flow paths and construction activities due to the Project has the potential to alter flow characteristics and have an impact on water quality within the waterways and receiving waters if they are not managed appropriately.

It is important to understand existing conditions of the waterways and environmental values that require protection in order to develop construction methods that will minimise or prevent impacts to waterways.

2. EES scoping requirements

2.1 EES evaluation objectives

The scoping requirements for the EES, released by the Minister for Planning, set out the specific environmental matters to be investigated and documented in the Project's EES, and informs the scope of the EES technical studies. The scoping requirements include a set of evaluation objectives. These objectives identify the desired outcomes to be achieved in managing the potential impacts of construction and operating the Project.

The following draft evaluation objective is relevant to the surface water assessment:

- Water and catchment values – To maintain the functions and values of groundwater, surface water and floodplain environment and minimise adverse effects on water quality and beneficial uses

2.2 EES scoping requirements

The scoping requirements relevant to the draft evaluation objectives for surface water are shown in Table 2-1, as well as the location where these items have been addressed in this report.

Table 2-1 Scoping requirements relevant to surface water

Scoping requirement	Section addressed
Key issues The potential for adverse effects on the functions, values and beneficial uses of surface water environments, such as interception or diversion of flows or changed water quality or flow regimes during construction and operation.	Section 8 (Impact Assessment) EES Technical Report E Contamination
The potential for adverse effects on the functions, values and beneficial uses of groundwater due to the Project on groundwater dependent ecosystems (GDEs) due to changes in groundwater levels, behaviour or quality.	EES Technical Report C Groundwater
Potential erosion, sedimentation and landform stability effects during construction and operation.	EES Technical Report D Land stability and *ground movement*
Existing environment Describe surface and groundwater conditions and their beneficial uses that could be affected from changed water quality, or water movement, due to the Project	Section 6 (Existing conditions) EES Technical Report C *Groundwater*
Identify and describe nearby wetlands/swamps and floodplains that could be affected by the Project (e.g. Merri Creek catchment/Inverloch Swamp).	Section 6 (Existing conditions) EES Technical Report C *Groundwater*
Characterise the local groundwater quality and behaviour, including the protected beneficial uses and values and identifying any GDEs that might be affected by the Project.	EES Technical Report C *Groundwater*
Characterise the interaction between surface water and groundwater within the Project and broader area.	Section 6.2.2 EES Technical Report C *Groundwater*

Scoping requirement	Section addressed
Mitigation measures Identify and evaluate aspects of Project works and operations, and proposed design refinement options or measures that could avoid or minimise significant effects on water, waterway or wetland environments.	Section 7 (Risk assessment) Section 8 (Impact assessment) Section 9 (Mitigation measures) EES Technical Report A Biodiversity and habitats EES Technical Report C Groundwater
Likely effects Identify and evaluate effects of the Project and alternatives on groundwater, surface water, waterways and wetlands near the Project works, including the likely extent, magnitude and duration (short and long term) of changes to water quality, water level, temperature or flow paths during construction and operation, considering appropriate climate change scenarios and possible cumulative effects resulting in combination with other existing or proposed projects of actions.	Section 8 (Impact assessment) EES Technical Report A Biodiversity and habitats EES Technical Report C Groundwater
Assess potential impacts on water availability and quality for farming and other uses.	Section 8 (Impact assessment) EES Technical Report C Groundwater
Assess potential erosion, sedimentation and landform stability effects of the Project.	EES Technical Report D Land stability and ground movement
Performance objectives and management Describe monitoring programs and specific monitoring activities to be implemented to ensure prompt detection of surface water and groundwater effects associated with the Project.	Section 9 (Mitigation measures) EES Technical Report A Biodiversity and habitats EES Technical Report C Groundwater
Identify possible contingency actions to respond to foreseeable changes that may be identified through the monitoring program.	Section 9 (Mitigation measures)

2.3 Linkages to other reports

This report relies on or informs the technical assessments as indicated in Table 2-2.

Table 2-2 Linkages to other technical reports

Specialist report	Relevance to this technical study
EES Technical Report A Biodiversity and habitats	Provides an assessment of the potential changes and impacts on the wetlands and swamps affected by the Project.
EES Technical Report E Contamination	Provides an assessment of potential impacts to water-related values due to spills or other incidents during construction or operation.
EES Technical Report C Groundwater	Provides an assessment of changes to groundwater and the interaction with surface water that may be affected from the changes to water movement and water quality due to the Project.
EES Technical Report D Land stability and ground movement	Provides an assessment of potential erosion, sedimentation and landform stability effects during construction and operation.

3. Project description

The Project provides a new link between APA's existing Plumpton Regulating Station (approx. 38 kilometres north west of Melbourne's CBD) and Wollert Compressor Station (approx. 26 kilometres north east of Melbourne's CBD). The Project includes the following key components:

- **A new pipeline**: The pipeline would be approximately 51 kilometres in length. The pipeline would be within a 15 metre wide permanent easement and be buried for its entire length to a minimum depth of cover of 750 millimetres.
- **Mainline valves**: Three mainline valves (MLV) would be located along the pipeline alignment. The area required for mainline valves would be subdivided and acquired by APA to provide ongoing access for any maintenance or inspection activities from the existing roads. The mainline valves would be spaced at intervals of approximately 15 kilometres, and located at approximately KP 6, KP 22 and KP 35.
- The **Wollert Compressor Station upgrade**: The installation of a new Solar Centaur 50 compressor, an end of line scraper station and a pressure regulating station within the existing APA facility at Wollert.

A schematic illustration of the Project context is shown in Figure 3-1.

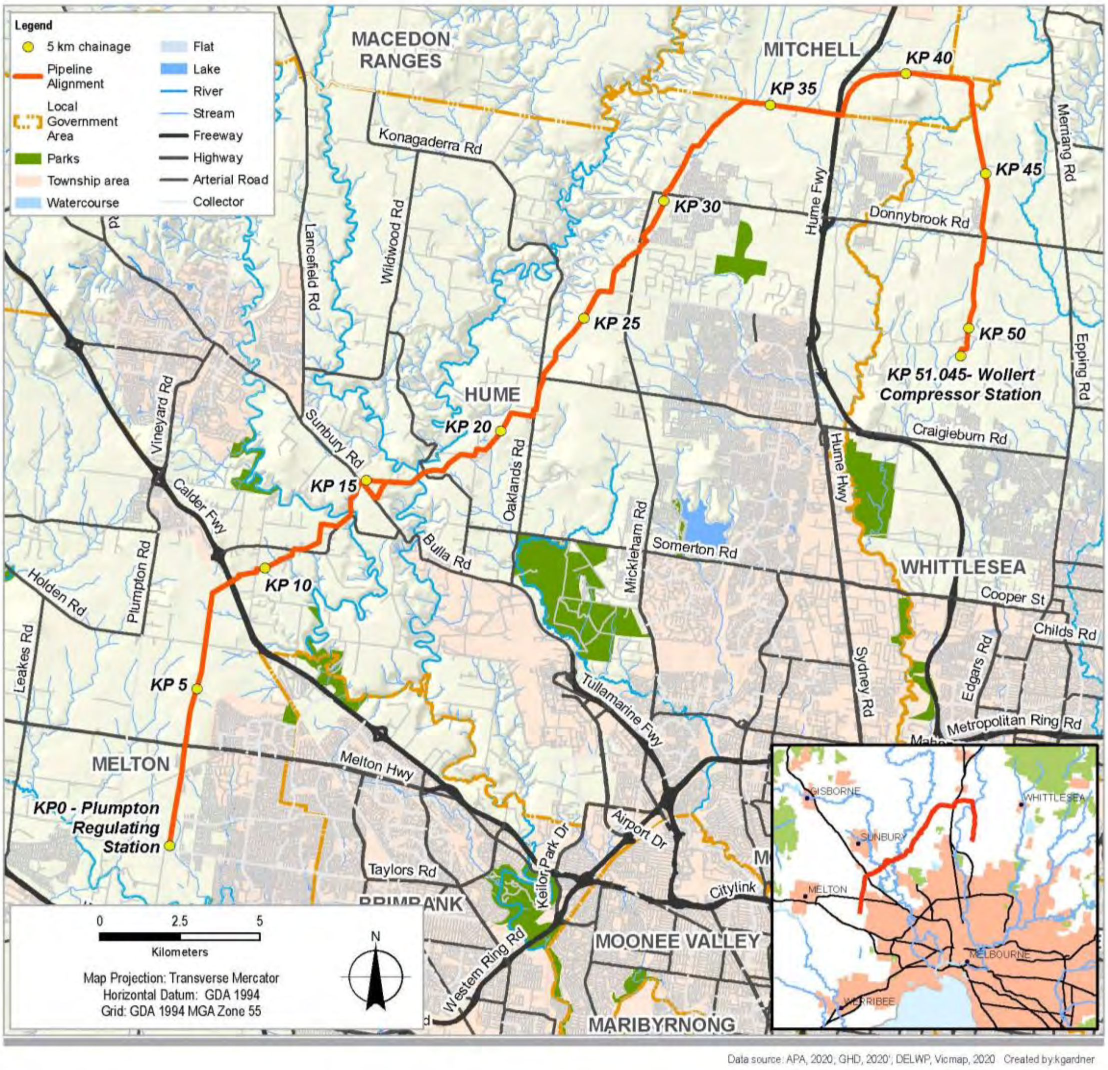


Figure 3-1 Western Outer Ring Main (WORM) overview

3.1 Construction

Subject to the staging of the works, construction for the entire Project is expected to take approximately nine months. Key construction activities for the Project include:

- Establishing offsite construction sites and construction/laydown areas
- Constructing the pipeline
- Constructing three mainline valves
- Construction of upgrades associated with the Wollert compressor station
- Rehabilitation

3.1.1 Construction

Construction sites

Two temporary construction sites would be established for construction.

One offsite compound for pipeline works, nominally 200 metres x 200 metres, include laydown and storage areas. This would be located on a site where the activity is permitted under the relevant Planning Scheme, most likely within an existing industrial area.

The second temporary laydown area and construction offices would be established for the Wollert Compressor Station construction works. The construction offices and site laydown area for the compressor station equipment would be located within the existing compressor site area at Wollert.

Pipeline construction area

The Project would require a construction area for the pipeline, which would typically comprise a 30 metre wide corridor along the pipeline alignment. Most construction activity would be located within this construction area. The activities and facilities within the construction corridor would include access tracks and additional work areas such as vehicle turn around points and additional work spaces for crossings, stockpiling of materials and storage of pipe. Additional work areas up to 50 m x 50 m or 50 m x 100 m (such as for vehicle turn-around points areas to accommodate HDD) would be required in some locations.

Pipeline construction methodology

The techniques used to construct the underground pipeline would include various methods including, open trenching and alternative techniques at certain locations such as horizontal directional drilling (HDD) or horizontal boring.

Where crossing watercourses, major roads, rail line reserves or other constraints, the pipeline may be constructed using trenchless construction techniques such as HDD or shallow horizontal boring, to avoid construction disturbance within the sensitive area.

The pipeline construction sequence starts with survey works and continues with site establishment (including laydown area), clearing and grading, pipe stringing, pipe bending, welding and coating, trenching, lowering pipe into trench, hydrostatic testing, commissioning, and finally rehabilitation. Where the pipeline may be constructed using open trenching across waterways, the construction period including rehabilitation works is likely to span up to two weeks for most waterways. For open trenching at complex waterways (such as Jacksons Creek and Merri Creek), the works directly in the watercourse are likely to take between two to four weeks. Further details of construction methodology, sequence and activities are outlined in EES Chapter 4 Project Description. There would be dedicated access points into the construction corridor with vehicular movements along the Project alignment kept within the construction corridor.

Construction of other facilities

The construction sequence for the Wollert Compressor Station works starts with survey works and continues with site establishment (including laydown area), bulk earthworks, civil works (concrete slab and footings), mechanical works, electrical and instrumentation works, hydrostatic testing, commissioning, and site completion.

Various components of the compressor are assembled offsite. When delivered to site the various components are assembled together in-situ. Cranes are used to lift the compressor into place with all connecting pipework fitted.

3.2 Operation

Following the reinstatement of land as part of the pipeline construction, the land would be generally returned to its previous use. When commissioned, the pipeline would be owned and maintained by APA. The pipeline would be contained within a 15 metre wide permanent easement corridor (within the area that formed the 30 metre construction corridor). Routine corridor inspections would be undertaken in accordance with APA procedures and AS2885 to monitor the pipeline easement for any operational or maintenance issues.

Excavating or erecting permanent structures, buildings, large trees or shrubs over the underground pipeline would be prohibited in accordance with the *Pipelines Act 2005* and pursuant to easement agreements with landowners.

Maintenance and inspections of the MLVs and the Wollert Compressor Station would also be conducted periodically in accordance with APA procedures. The activities usually include vegetation management, valve and compressor operation and corrective maintenance.

The key operation and maintenance phase activities include:

- Easement maintenance (vegetation control, weed management, erosion and subsidence monitoring)
- Pipeline, MLVs and compressor station maintenance
- Specialist pigging operations
- Cathodic protection surveys for mechanical and electrical preventative and corrective maintenance
- Monitoring and routine inspections and surveillance

3.3 Design, construction and operation considerations relevant to surface water

The method of construction for each waterway crossing has the potential to have a significant impact on surface water. The two types of construction techniques used in pipeline construction include open trenching and trenchless construction method. As each waterway crossing location may have its own set of complexities and water characteristics, it is important to consider which option is appropriate for open trenching and where it will be necessary to adopt a trenchless construction method. The trenchless method is desirable where minimum surface disruption is to be achieved and to avoid the need for excavation at a crossing. This may include under or through major transport corridors, some major watercourses, environmentally sensitive areas or where access may be restricted due to existing vegetation or infrastructure.

There are three methods to construct the pipeline below the waterway crossings and these include:

- Horizontal Directional Drilling (HDD)
- Horizontal boring
- Open trench

3.3.1 Horizontal directional drilling (HDD)

HDD may be used in areas such as major transport corridors and major waterways. The use of a HDD methodology will be subject to geology, environmental topographical, construction constraints and land access requirements. The HDD construction methodology will require the excavation of entry and exit pits, typically an approximate size of three metres x three metres. The drilling will be conducted by a specific HDD rig which is operated by a specialist contractor. The size of the HDD rig and its associated footprint has been based on the size of the pipe, the nature of the subsurface geology and the length of the section to be drilled. A typical HDD work area set up is shown in Figure 3-2. Further details of HDD construction methodology, sequence and activities are outlined in EES Chapter 4 Project Description.

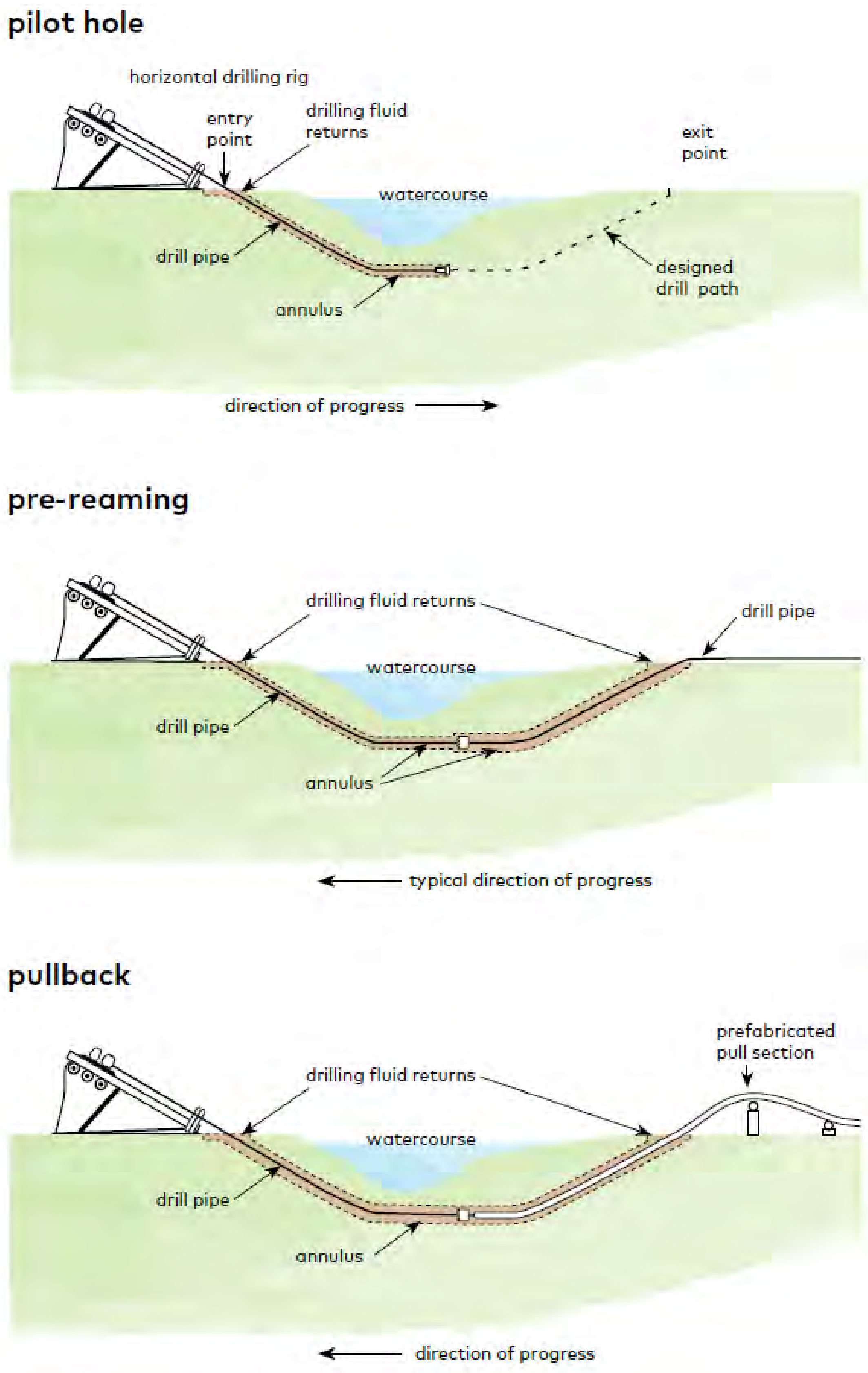


Figure 3-2 Typical HDD work area

3.3.2 Horizontal boring

The methodology for horizontal boring (referred to as thrust boring or micro-tunnelling) involves excavation of a horizontal bore hole for installation of a pipeline beneath sensitive surface features, roads and underground services. Pits are excavated with an approximate area of minimum four metres wide by eight metres long on both sides of the sensitive feature to the depth of the adjacent trench and graded to match the proposed slope of the pipeline. A boring machine operates within this bell hole to tunnel under the relevant constraint. The boring machine is located within the entry pit, which uses a hydraulic ram to jack the pipe section, behind a cutting head, in a straight line through the ground to the receiving pit. A typical set up for a thrust bore crossing is shown in Figure 3-3. Further details of shallow horizontal boring construction methodology, sequence and activities are outlined in EES Chapter 4 Project Description.

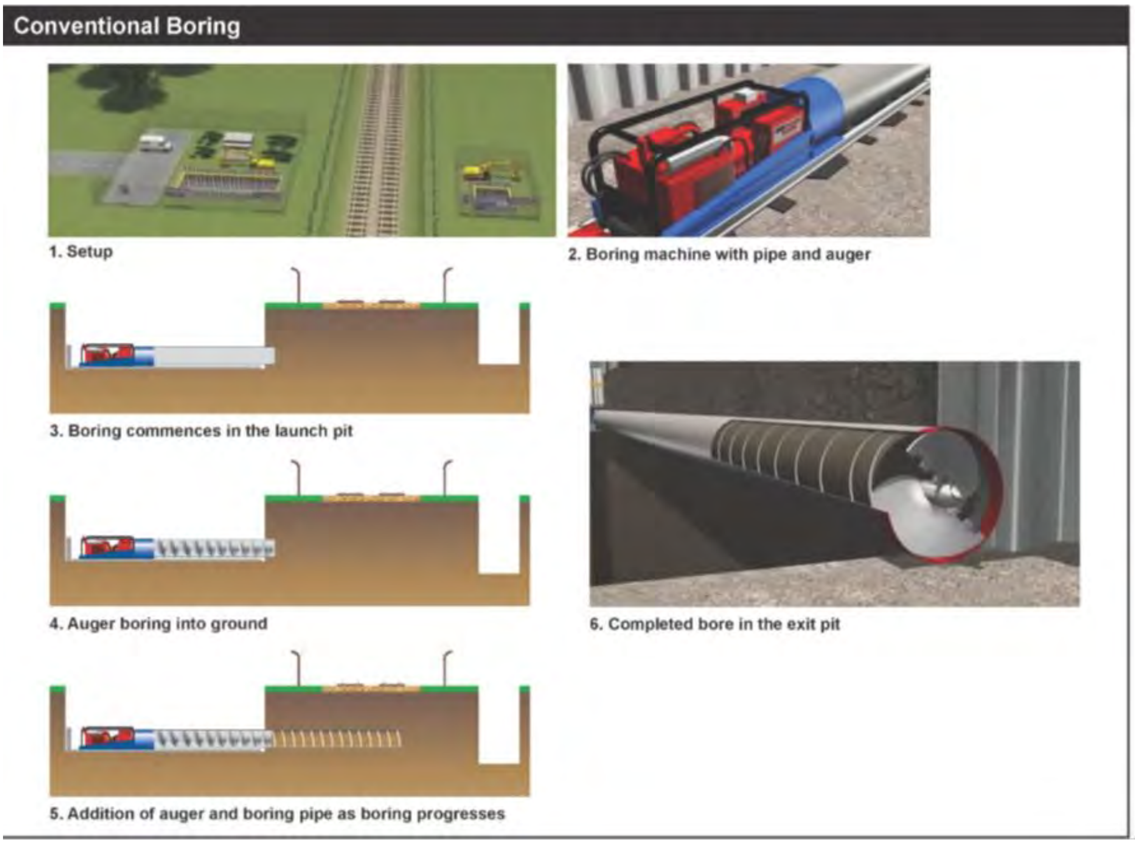


Figure 3-3 Horizontal boring construction method

3.3.3 Open trench

Specialised trenching machines and excavators will be used to excavate the trench to a depth of approximately 2 metres and approximate width of 1 metre. Spoil generated during trench excavation will be stockpiled separate from vegetation and topsoil stockpiled earlier in the construction program. Rock breaking processes such as the use of rock saws/hammers and/or blasting is expected to be required to excavate the trench in areas of rock. Typical trenching activity within the construction corridor is shown in Figure 3-4. Further details of open trenching construction methodology, sequence and activities are outlined in EES Chapter 4 Project Description.

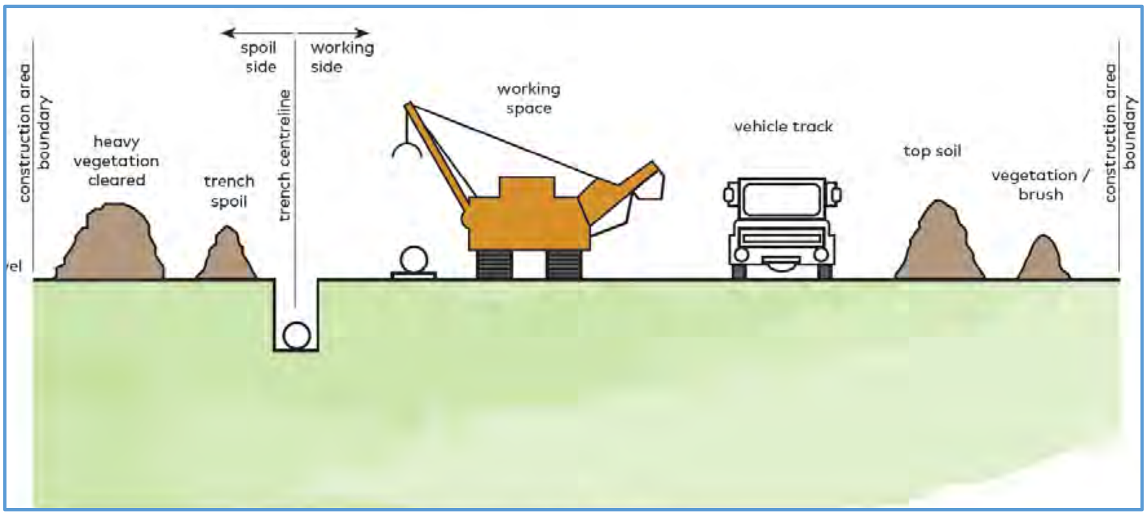


Figure 3-4 Typical trenching activity within construction corridor

4. Legislation, policy and guidelines

4.1 Legislation, policy and guidelines

The EES is prepared under the EE Act and will inform assessment of approvals required for the Project. The legislation relevant to the principal approvals required for the Project is:

- Commonwealth approval under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). For the component of the Project that is located outside of the MSA, the Project requires assessment and approval under the EPBC Act, under the assessment bilateral agreement with Victoria made under section 45 of the EPBC Act. Areas within the approved Melbourne Strategic Assessment (MSA) area occur between approximately KP 0 to KP 3.2, KP 28.16 to KP 28.57, and KP 32 to KP 51. Areas outside of the MSA occur approximately between KP 3.2 to KP 28.1, and KP 28.57 to KP 32.
- Pipeline Licence approval is required under the Pipelines Act 2005 (Vic) (Pipelines Act) for the Western Outer Ring Main Project. The Pipeline Licence application is exhibited with the EES.

  Section 49 of the Pipelines Act requires that the following matters be considered before granting a licence:

  a) *the potential environmental, social, economic and safety impacts of the proposed pipeline;*

  f) *the assessment of the Environment Effects Minister in relation to the proposed pipeline, if an assessment has been made;*

  g) *any written comments received from the Planning Minister or the relevant responsible authority on the effect of the proposed pipeline on the planning of the area through which it is to pass;*

  h) *any written comments received from the Water Minister and from the relevant Crown Land Minister on the impact of the proposed pipeline.*

  Section 3 of the Pipelines Act state the objectives of the Act, including:

  a) *to facilitate the development of pipelines for the benefit of Victoria;*

  e) *to protect the public from environmental, health and safety risks resulting from the construction and operation of pipelines;*

  f) *to ensure that pipelines are constructed and operated in a way that minimises adverse environmental impacts and has regard for the need for sustainable development.*

  Section 4 of the Pipelines Act sets out the principles of sustainable development to be given regard in implementing the Act including that decision-making should be guided by a careful evaluation to avoid serious or irreversible damage to the environment wherever practicable and an assessment of the risk-weighted consequences of various options.

  Section 54(c) of the Pipelines Act states that conditions on a licence may include conditions concerning the protection of the environment.

- Cultural Heritage Management Plan (CHMP) under the *Aboriginal Heritage Act 2006* (Vic) (AH Act). Two CHMPs are currently in progress for the Project (CHMP 16593 and CHMP 16594).

4.2 Victorian and Commonwealth legislation, policy and guidelines

A number of State and Commonwealth legislative, policy, guidance and standard documents were found to be relevant to this surface water impact assessment and are discussed further in this report. The key legislation, policy and guidelines that apply to the surface water impact assessment for the Project are summarised in Table 4-1 and Table 4-2.

Table 4-1 State legislation, policy and guidelines

Legislation/policy/ guidelines/standards	Relevance to this impact assessment
***Water Act 1989* (Water Act)** The Water Act provides the legal framework for the integrated management of Victoria's water resources. The main purpose of the Water Act is to promote the efficient and equitable use of water resources and ensure water resources are conserved and appropriately managed for sustainable use. The Water Act provides a formal means of protecting and enhancing waterway flow, water quality and catchment conditions. The Water Act also governs the entitlements of water authorities. Melbourne Water is the authority responsible for managing Melbourne's waterways and major drainage systems. The Project must adhere to Melbourne Water standards for infrastructure projects in flood prone areas.	Under the Water Act, Melbourne Water have been given the power to implement by-laws which apply within a specific area under their responsibility. By- law No. 2: Waterways, Land and Works Protection and Management prohibits certain activities without authorisation from Melbourne Water. Approval from Melbourne Water would be required for any works on, over or under a designated waterway, and is subject to the Land Subject to Inundation Overlay (LSIO). Approval is required before the construction works start. Consent for minor waterway work would be required for each crossing of a waterway by the Pipeline Works.
***Planning and Environment Act 1987* (P and E Act)** The Planning and Environment Act provides a legal framework for planning the use, development and protection of land in Victoria in the present and long-term interest of all Victorians. Local planning schemes provide useful information on the planning overlays.	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), Urban Floodway Zone (UFZ)).
***Environment Protection Act 1970* (EP Act)** The Environment Protection Act provides a legal framework to protect the environment in Victoria, including the protection of air, land and water from pollution. The Environment Protection Act is outcome oriented, with a basic philosophy of preventing pollution and environmental damage by setting environmental quality objectives and establishing programs to meet them. The Act establishes the EPA Victoria to administer the Act and any regulations and orders made under the Act, The State Environment Protection Policy (Waters) (hereafter referred to as the SEPP (Waters)) guides the management of environmental pollution to surface water (see below).	The Environment Protection Act regulates discharges to land, surface water or groundwater by a system of licences and Works Approvals. Any groundwater disposal from dewatering will need to be managed in accordance with Environment Protection Act 1970. There are many options available for groundwater disposal (i.e. to waterway, reinjection, irrigation, sewer) and the selected option will have different regulatory requirements (e.g. disposal to waterway would need to meet the water quality criteria of the SEPP Waters).

Legislation/policy/ guidelines/standards	Relevance to this impact assessment
***Pipelines Act 2005* (Pipelines Act)** The Pipelines Act is the primary Act governing the construction and operation of pipelines in Victoria. The Pipelines Act covers ‘high transmission’ pipelines for the conveyance of gas, oil and other substances. DELWP and Energy Safe Victoria are responsible for administering the Pipelines Act and the Pipelines Regulations 2017.	The Project requires a pipeline licence under the Pipelines Act for the construction and operation of the Pipeline Works.
Victorian Waterway Management Strategy (2013) The Victorian Waterway Management Strategy provides a detailed policy for managing Victoria’s waterways over an eight-year period. The strategy aims to maintain and improve the condition of wetlands, rivers and estuaries so they can continue to provide environmental, social, cultural and economic value for all Victorians.	Regulatory authorities would have regard to the strategy when assessing the Project’s impacts on fresh water quality through the approvals required under the Water Act.
Healthy Waterways Strategy (2018 to 2028) The Healthy Waterways Strategy is a shared strategy across Melbourne Water, state and local government, water corporations and the community. The strategy provides direction towards a regional vision for the health of rivers, estuaries and wetlands in the Port Phillip and Westernport region.	Regulatory authorities would have regard to the strategy when assessing the Project’s impacts on waterways through the approvals required under the Water Act.
SEPP (Waters) (2018) SEPPs are subordinate to the Environment Protection Act. SEPP (Waters) provides a framework for the protection and management of water resources in Victoria, covering surface waters, estuarine and marine waters and groundwater across the State. SEPP (Waters) aims to protect the beneficial uses of water resources, set water quality indicators and objectives, and establish rules and obligations to achieve these objectives. The appropriate objectives outlined in SEPP (Waters), or ANZG (2018) / ANZECC (2000) guidelines, must be met in order to protect the ecological health of the receiving environment. However, if the receiving environment itself does not meet the SEPP (Waters) this becomes the benchmark in which discharge waters need to meet. The guideline values are presented in 5.5.4.	Compliance with SEPP (Waters) is required under the *Environment Protection Act 2018*. The SEPP (Waters) requires the Project to minimise the potential for adverse impacts on surface water quality so that existing beneficial uses are protected, with priority given to maintaining beneficial uses of areas of high conservation value. Water quality data from gauges upstream and downstream of the pipeline crossing were compared against SEPP (Waters) and ANZG (2018) guideline values. Where there is a guideline value for both SEPP (Waters) and ANZG (2018), the SEPP Waters guideline values take precedence over the ANZG 2018 values (Victorian Government, 2018). SEPP (Waters) is expected to be replaced with Environmental Reference Standards, where beneficial uses will be known as environmental values, under the *Environment Protection Act 2017* (as amended by the Environment Protection Amendment Act 2018) in July 2021. These changes are unlikely to impact this assessment.

Table 4-2 Commonwealth legislation and policy applicable

Legislation/policy	Relevance to this impact assessment
Australian and New Zealand Guidelines (ANZG, 2018) The Australian and New Zealand Guidelines (ANZG) set the water quality objectives required to sustain current environmental values for natural or semi-natural water resources in Australia and New Zealand. The document identifies limits to acceptable change in water quality that would continue to protect the associated environmental value. ANZG supersedes the previous guidelines ANZECC (2000).	Regulatory authorities would have regard for these guidelines when assessing the Project's impacts on receiving water quality.

5. Methodology

5.1 Overview of method

This section describes the method that was used to assess the potential impacts of the Project. A risk based approach was applied to prioritise the key issues for assessment and inform measures to avoid, minimise and offset potential effects. Figure 5-1 shows an overview of the assessment method.

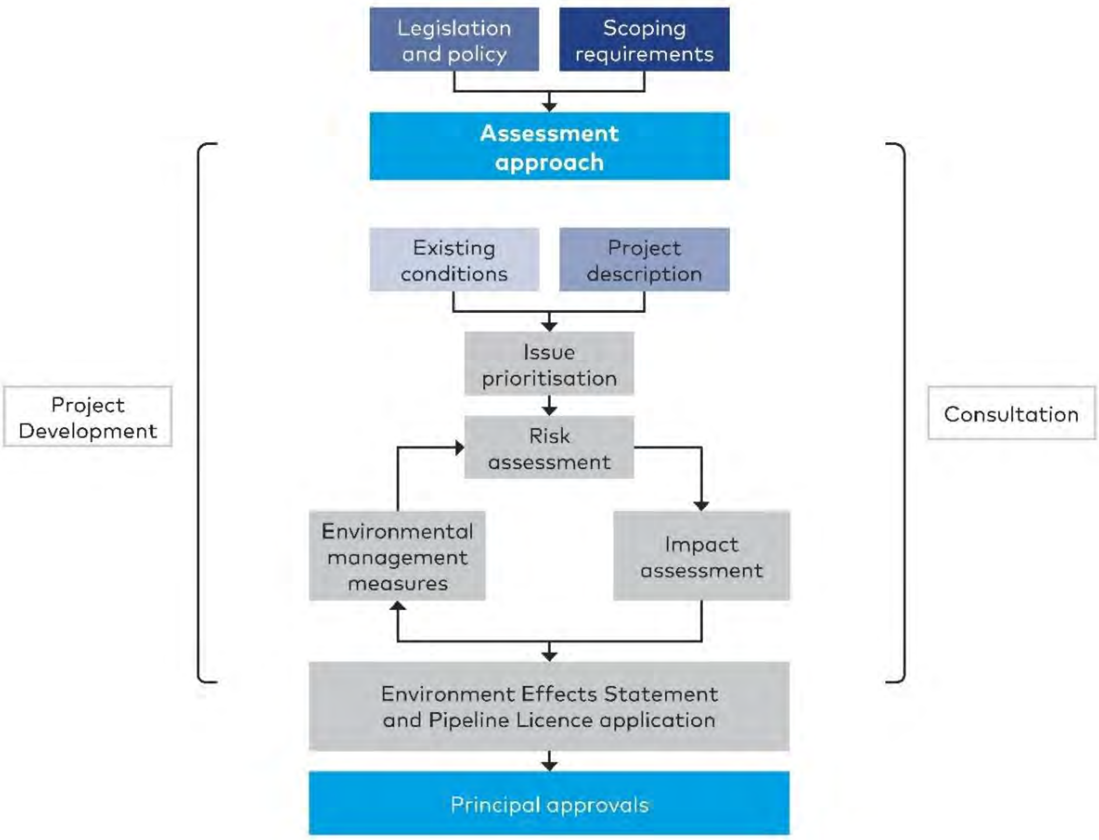


Figure 5-1 Overview of assessment method

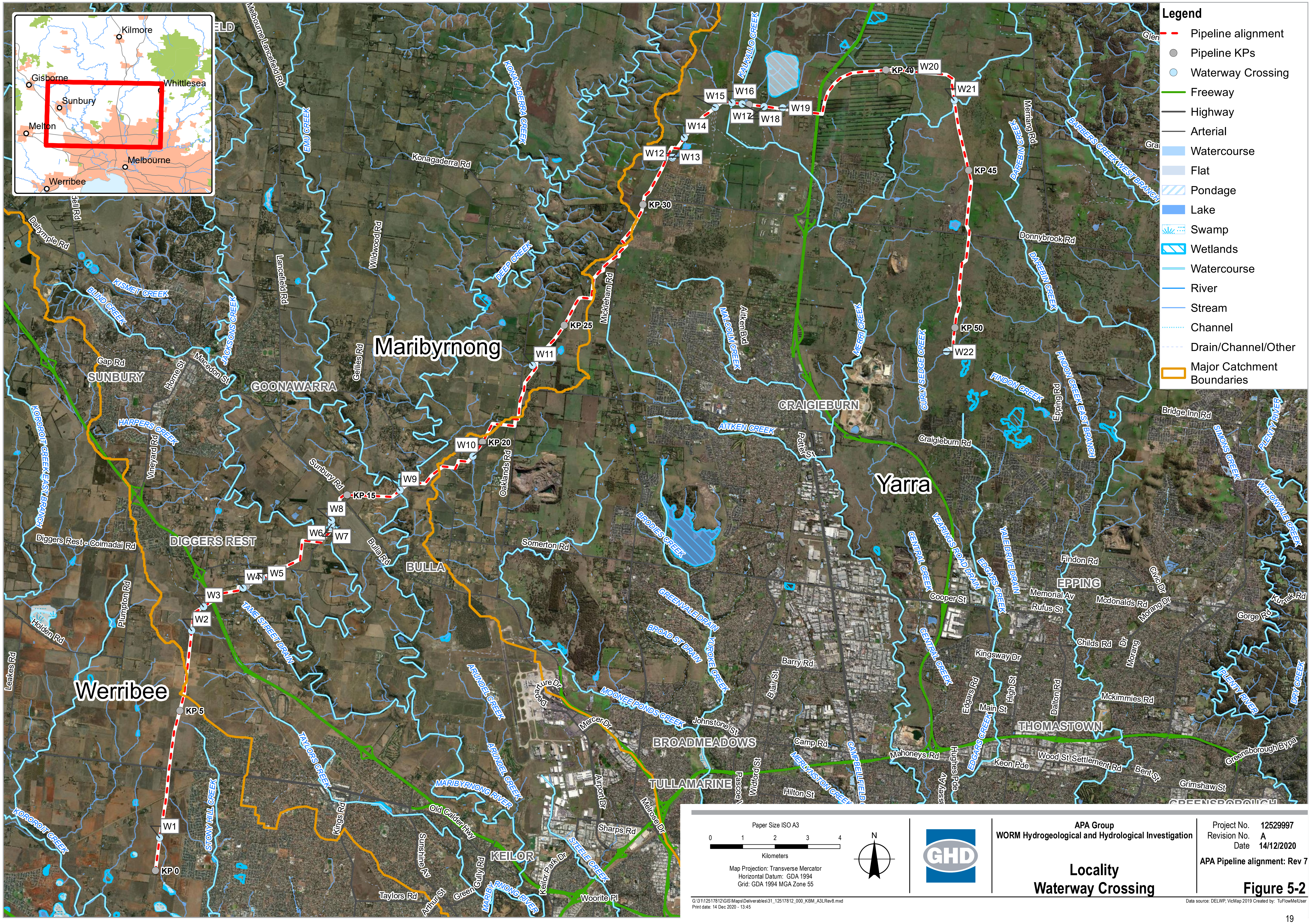
5.2 Study area

For surface water, the study area includes the region within the construction corridor and the assessment extends upstream and downstream of each waterway crossing where possible to allow for a reach scale assessment of each waterway.

The construction corridor along the pipeline alignment typically comprise a 30-metre wide corridor. Where the construction occurs within an existing APA easement, the additional construction corridor is limited to between 5 metres to 15 metres wide from the existing easement boundary. The Project alignment is within the Werribee River, Maribyrnong River and Yarra River catchments and crosses the following main watercourses:

- Jacksons Creek, Deep Creek and Tame Street Drain (Maribyrnong River catchment)
- Kalkallo Creek, Tributary of Merri Creek and Merri Creek (Yarra River catchment)

No watercourses are crossed by the Project in the Werribee catchment. In addition to the above waterways, the pipeline alignment is proposed to cross another 16 minor watercourses and surface drains. An overview of the Project area showing the proposed pipeline alignment and the waterway crossings are presented in Figure 5-2.



Paper Size ISO A3

0 1 2 3 4

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

APA Group
WORM Hydrogeological and Hydrological Investigation

Project No. 12529997
Revision No. A
Date 14/12/2020

APA Pipeline alignment: Rev 7

Locality
Waterway Crossing

Figure 5-2

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Print date: 14 Dec 2020 - 13:45

Data source: DELWP, VicMap 2019 Created by: TuFlowMelUser

5.3 Existing Conditions Assessment Method Overview

The assessment consists of a two tiered assessment with a preliminary assessment undertaken for all waterways as a screening assessment to identify the potentially higher risk (flooding and erosion) or more "complex" waterways.

Building on an earlier surface water assessment scope of work completed by GHD in 2019 - 2020, the EES assessment has been undertaken based on a two tiered assessment approach outlined below:

- Phase 1 - Screening assessment of identified waterways (23 waterways) - Review of previous screening assessment to confirm the potentially higher risk waterways
- Phase 2 - Detailed assessment of the waterways identified with potentially higher risks (6 of 23 waterways previously identified) - More rigorous detailed assessments of the confirmed higher risk waterways

The intent of the preliminary assessment was to identify the lower risk waterways where standard construction techniques (e.g. trenching) and standard controls and environmental management measures can be applied. The waterways with potentially higher risks associated with erosion and flooding were assessed in more detail. The intent of the more detailed assessment is to enable an impact assessment to be undertaken to determine preferred construction methods, site specific controls that extend beyond standard controls with additional mitigation, and site rehabilitation. In line with a risk assessment approach for the Project, this has enabled more focus and attention towards identifying and mitigating risks associated with the potentially higher risk waterways.

5.3.1 Waterways

There are 23 designated waterways as identified in the VicHydro information (DELWP) that the Project pipeline alignment will need to cross under. The 23 waterways are associated with the three major Melbourne Water Corporation (MWC) catchments described in Section 6.1.

The waterways within the construction corridor are characterised based on the type of waterway (i.e. "complex" waterway, minor tributary, main drain channel, constructed drains, wetland) and the classification of the channel type, such as whether it is an incised channel, straightened channel, intact valley fill or confined discontinuous channel that are typical of minor gully tributaries.

The location of all waterway crossings based on the Project pipeline alignment is presented in Figure 5-2.

A summary of the identified designated waterways is provided in Table 5-1.

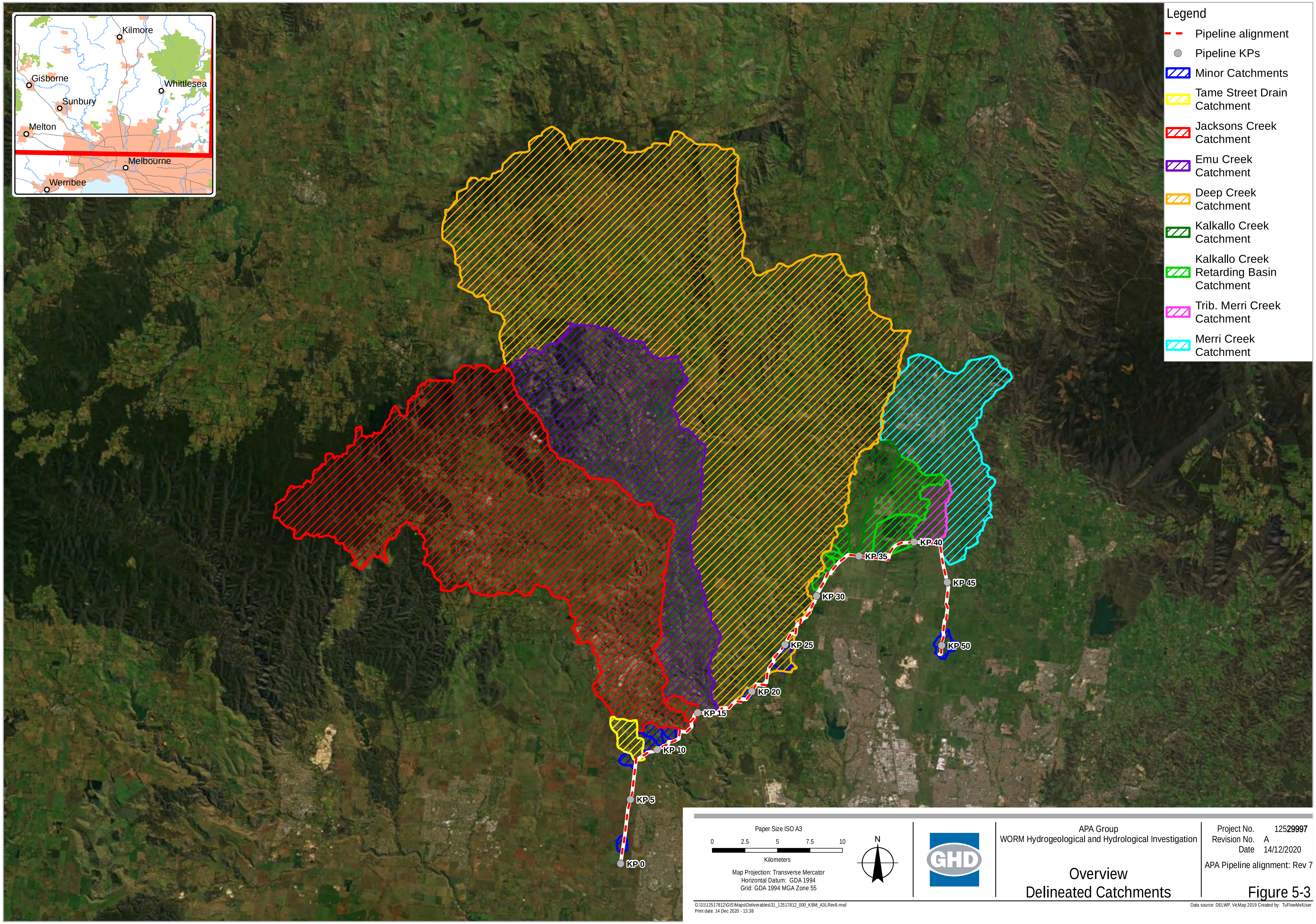
Table 5-1 Waterway Characteristics

	Name	Waterway Status	Location (KP)	Crossing Alignment	Stream Type Classification
01	Unnamed	Minor gully tributary to Kororoit Creek	1	Longitudinal	laterally unconfined, headwater channel
02	Unnamed Tributary	Minor gully tributary to Tame St Drain	7.5	Perpendicular	Confined headwater channel
03	Tame Street Drain	MWC Main Drain channel	8.36	Skewed	Confined headwater channel
04	Unnamed	Minor gully tributary to Jacksons Creek	9.74	Perpendicular	laterally unconfined, headwater channel

	Name	Waterway Status	Location (KP)	Crossing Alignment	Stream Type Classification
05	Unnamed	Minor gully tributary to Jacksons Creek	10.6	Perpendicular	Confined headwater channel
06	Unnamed	Minor gully tributary to Jacksons Creek (farm dam at crossing)	11.7	Perpendicular	confined headwater channel
07	Jacksons Creek	“Complex” Waterway	13.7	Perpendicular	confined valley with bedrock-controlled discontinuous floodplain
08	Unnamed	Gully tributary to Jacksons Creek	13.9	Skewed	Low sinuosity, confined gully
09	Deep Creek	“Complex” Waterway	16.7	Perpendicular	confined valley with bedrock-controlled discontinuous floodplain
10	Unnamed	Upper gully tributary to Moonee Ponds Creek	19.47	Skewed	Confined headwater channel
11	Unnamed	Minor gully tributary to Deep Creek (farm dam at crossing)	23.4	Perpendicular	Laterally unconfined, headwater channel
12	Unnamed	Minor tributary to Kalkallo Creek	31.5-31.7	Skewed	discontinuous channel
13	Unnamed	Minor tributary to Kalkallo Creek	32.6	Skewed	discontinuous channel
14	Unnamed	Minor tributary to Kalkallo Creek	33.5	Perpendicular	discontinuous channel
15	Unnamed	Tributary constructed drains (x3) to Kalkallo Creek	33.8-34	Skewed	Straightened channelised
16	Kalkallo Creek	Channelised Creek	34.5	Perpendicular	Straightened channelised
17	Unnamed	Tributary constructed drain to Kalkallo Creek	34.8	Perpendicular	Straightened channelised
18	Unnamed	Tributary constructed drain to Kalkallo Creek	35.5	Perpendicular	Straightened channelised
19	Unnamed	Tributary constructed drain to Kalkallo Creek	36.2	Perpendicular	Straightened channelised
20	Tributary of Merri Creek	Tributary to Merri Creek	40.8	Perpendicular	Intact valley fill
21	Merri Creek	“Complex” Waterway	42.9	Perpendicular	bedrock-controlled sinuous valley with discontinuous floodplain
22	Seasonal wetlands	Seasonal freshwater marsh or meadow (Palustrine wetland)	44.8	n/a	seasonal wetland (offline)
23	Unnamed	Tributary to Curl Sedge Creek (Tributary to Merri Creek)	50.8	Both	Intact valley fill

The catchments have been delineated from the available terrain data (LiDAR, Vic topographic data). The delineated catchments are presented in Figure 5-3.

There are sections of the proposed Project that do not have defined waterways or catchments, where the pipeline runs along ridge lines or near the top of catchment boundaries. Catchments have only been delineated for the designated waterways as defined by the Victorian topographic maps.



APA Group
WORM Hydrogeological and Hydrological Investigation

Overview
Delineated Catchments

Project No. 12529997
Revision No. A
Date 14/12/2020

APA Pipeline alignment: Rev 7

Figure 5-3

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Print date: 14 Dec 2020 - 13:38

Data source: DELWP, VicMap 2019 Created by: TuFlowMelUser

5.4 Existing Conditions Assessment Method (Phase 1 – Screening Assessment)

An outline of the preliminary assessment methodology is provided below.

5.4.1 Waterway Assessment

For each of the 23 identified waterways, visual desktop assessment of the waterway conditions and surrounding vegetation, in the vicinity of the pipeline crossing location based on the updated pipeline alignment (Rev 6), was undertaken using the following available information:

- Desktop visual assessment using available aerial imagery and Google street view
- Interpretation of LiDAR information

5.4.2 Hydrology & Hydraulics

The preliminary desktop assessment was completed using GIS data obtained through the VicPlan data base (DELWP, 2019). This provided 1 metre contours, major and minor defined waterways, roads and points of interest. QGIS was used to interrogate the GIS layers to interpret relevant information for each waterway assessment. This included:

- Hydrology - For each of the 23 waterway crossings and their delineated catchments, peak flows were estimated from the Australian Rainfall and Runoff – Regional Flood Frequency Estimation Model (RFFE) (ARR, 2019)
- Floodplain analysis including interpretation of LiDAR information and Land Subject to Inundation Overlays (LSIO) obtained via the VicPlan database and MWC
- Hydraulics - A simple manning's assessment approach was undertaken to estimate the hydraulic parameters. This included using a representative cross-section, assigning a representative manning's and averaged slope of each waterway interpreted from available LiDAR and contour information.

5.4.3 Preliminary screening assessment

The preliminary screening assessment of each waterway intersected by the Project was refined from the previous assessment undertaken by GHD in 2019 - 2020. For each waterway, a semi quantitative but subjective method was used to evaluate the relative erosion and flood risk as described below:

- Potentially Higher risk - Any waterway defined as "complex", or where there was a formed channel or observed erosion, or where velocity equalled or exceeded 1.5 m/s was considered a potentially high erosion risk. Any waterway with an LSIO or located within a retarding basin was potentially high flooding risk
- Lower risk – Any waterway with no defined channel, catchment areas less than 1 km^2 and with velocities less than 1.5 m/s were considered to be low flooding and erosion risk.

The threshold velocity of 1.5 m/s is often referred to by MWC as a limiting velocity before scour may potentially occur, or for above which channel stabilisation measures may be required.

In this refined preliminary screening assessment, the focus was on confirming the waterways that were deemed to be low risk, to then enable the focus on assessing the potentially higher risk waterways. A summary of the outcomes is detailed in Section 6.2.

5.5 Existing Conditions Assessment Method (Phase 2 – Detailed Assessment)

The preliminary screening assessment identified waterways which required detailed assessment based on the potential risk associated with erosion and flooding. This involved initial further investigations at each of the identified waterway crossings which included:

- An initial site inspection conducted on the 23rd of January 2020 of the three "complex" waterways (Jacksons, Deep and Merri Creek) to understand the existing conditions of the waterways at the pipeline crossing location
- Hydrology and hydraulic analysis at the pipeline crossing based on available information
- Interpretation of geotechnical information obtained in the vicinity of each waterway

For the EES existing conditions assessments of these waterways, this has subsequently involved the following:

- Detailed waterway and geomorphology assessments of the three main waterways including more detailed site inspections for Jacksons Creek, Deep Creek and Merri Creek to further understand the existing conditions at the pipeline crossing location as well as the upstream and downstream reaches of the waterways
- Confirmation of the interpretation of geotechnical information obtained in the vicinity of each waterway, including any subsequent additional information
- Review and refinement of the hydrology and hydraulic analysis using the confirmed latest and relevant information from MWC, with the analysis undertaken in accordance with MWC standards. This has included consideration of future conditions of the waterways in the context of expected development within the catchments based on MWC provided information
- Obtaining water quality data from available sources including stream gauges to compare against guideline values

The methods for these assessments are further outlined below.

5.5.1 Waterway and Geomorphology Assessment

Detailed waterway and geomorphology assessments of the three main waterways of Jacksons Creek, Deep Creek and Merri Creek were undertaken. The pipeline crossing locations were assessed in more detail in the context of the reaches of waterway that they are located within. This included more detailed site inspections were undertaken for the complex waterways, as summarised in Table 5-2 below:

Table 5-2 Waterway Site Inspections

Waterway	Inspected by	Date	Waterway Reach Inspected
Jacksons Creek	Ashley Roberts (Waterway) and Brendan Duffy (Geomorphology)	6 July 2020	Inspected to ford crossing (near Bulla-Diggers rest Rd) located 300m downstream, and upstream to property boundary 300m upstream
Deep Creek	Ashley Roberts (Waterway) and Brendan Duffy (Geomorphology)	6 July 2020	Inspected to rock outcrop control located 200m downstream, and upstream to bridge at Wildwood Road crossing
Merri Creek	Simon Harrow and Peter Lind	28 July, 2020	Inspected to rock boulder control located 200m downstream, and upstream by 200m

The waterways assessment focused on the observed condition of the waterway in terms of hydraulic features, bed and bank condition and riparian vegetation.

The geomorphology assessment has considered long term historical land and waterway formation processes, to understand catchment scale and reach scale geomorphological processes. This has been undertaken with a focus of understanding future potential change at the pipeline crossing locations, including geomorphological mapping of the inspected reaches.

Site inspection photos and assessment undertaken for each of the three main waterways are detailed in Section 6 of the report.

5.5.2 Geotechnical Interpretation

Schematic depiction of borehole log data extracted along the pipeline alignment was used to define the distinct layers of soil profile characteristics, determine bedrock depth and inform the assessment of potential riverbed movement.

The bore logs were interpreted at their coordinate locations which have been presented on a schematic cross section derived from LiDAR. The bore logs have been projected from the interpreted natural surface level from LiDAR to their indicated depths. For the EES information the interpretation of this information including new bore logs has been confirmed.

A summary of the geotechnical information interpreted near the waterway locations is provided in Table 5-3 with detailed assessment of the borehole logs in Section 6.

Table 5-3 Available Geotechnical Bore Log Information

Waterway	Bore Logs
Tame Street Drain	Detailed BH's nearby for Bendigo railway & Calder Fwy (BH04 to BH07)
Jacksons Creek	Detailed BH's either side (BH14 to BH16)
Deep Creek	Detailed BH's either side (BH23 to BH26)
Kalkallo Creek	Detailed BH's either side (BH33 to BH36)
Tributary to Merri Creek	Limited - BH's ~200 m to the east near railway crossing
Merri Creek	Limited - BH's 27C, 49

5.5.3 Further hydrological and hydraulic investigations

Where information was available, peak design flow information was extracted from existing RORB models provided by MWC for the hydrology analysis. Where there was no existing RORB hydrology model peak design flows were obtained using a Regional Flood Frequency Estimation (RFFE) model. The RFFE model provided 1%, 5%, 10% and 20% AEP flow rates for each waterway.

Where available, a one-dimensional HEC-RAS model was adopted from a previous flood-mapping or flood assessment project provided by Melbourne Water. Where no existing model was available a new HEC-RAS model was created by extracting cross sections from LiDAR information to enable the determination of water surface levels (WSLs) and other hydraulic outputs. As the hydraulic assessment is based on available models and relevant data provided at the time of the EES, the results obtained from the existing conditions assessment are preliminary for the purpose of informing the EES. Verification of the design flow hydrology and flood modelling will need to be undertaken during detailed design in accordance with MWC standards and requirements.

The hydraulic modelling results was reconciled with field observations and where appropriate extents adjusted to match existing LSIO data if known. The site inspection of waterway reach conditions informed manning's values assigned to various areas of the waterway cross-sections. Interpretation of the results from the hydraulic assessment is summarised in Section 6 for each of the six waterways. A summary of the information used in the hydrological and hydraulic assessments is provided in Table 5-4 below.

Table 5-4 Basis of Hydrological and Hydraulic Assessment

Waterway	Hydrology	Hydraulics
Tame Street Drain	RFFE model	New HEC-RAS model (GHD)
Jacksons Creek	RORB - from MWC	MWC HEC-RAS model
Deep Creek	RORB - from MWC	MWC HEC-RAS model
Kalkallo Creek	RORB - from MWC	MWC HEC-RAS model
Tributary to Merri Creek	RORB - from MWC	MWC HEC-RAS model
Merri Creek	RFFE model	New HEC-RAS model (GHD)

5.5.4 Water Quality and Beneficial Uses

Under the *Water Act 1989* the State Environment Protection Policy (Waters) guides environmental management of waterways. Guideline water quality parameters were assessed against available water quality monitoring data from gauge sites. The background conditions of the Jacksons, Deep and Merri Creek were assessed by comparing water quality monitoring data against the relevant guidelines. The location of these gauges in relation to the Project alignment is presented in Figure 5-4.

Water quality data from gauges upstream and downstream of pipeline crossing were compared against guideline values. The guidelines used were:

- SEPP (Waters), Central Foothills and Coastal Plains, Lowlands of Barwon, Moorabool, Werribee and Maribyrnong basins and the Curdies and Gellibrand Rivers for Jacksons Creek and Deep Creek. These are summarised in Table 5-5
- SEPP (Waters), Central Foothills and Coastal Plains, Lowlands of Yarra, South Gippsland, Bunyip, Latrobe, Thomson, Mitchell, Tambo and Snowy basins for Merri Creek. These are summarised in Table 5-6.

The toxicant parameters referred to in SEPP (Waters) are discussed in ANZG (2018) and these parameters are presented in Table 5-7.

Where there is a guideline value for both SEPP (Waters) and ANZG (2018), the SEPP Waters guideline values take precedence over the ANZG 2018 values (Victorian Government, 2018).

Table 5-5 **SEPP (Waters) 'Centra**l Foothills and Coastal Plains, **Maribyrnong Basin' water q**uality guidelines

Indicator	Unit	Objective statistic / range	Guideline value
Total phosphorus	mg/L	75th percentile	≤0.06
Total nitrogen	mg/L	75th percentile	≤1.1
Turbidity	NTU	75th percentile	≤25
Electrical Conductivity	µS/cm	75th percentile	≤2000
pH	pH units	25th percentile and 75th percentile	≥6.8 and ≤8.0
Toxicants Water	% Protection	ANZG guidelines for toxicants	95

Table 5-6 **SEPP (Waters) 'Central Foothills and Coastal Plains, Yarra Basin'** water quality guidelines

Indicator	Unit	Objective statistic / range	Guideline value
Total phosphorus	mg/L	75th percentile	≤0.055
Total nitrogen	mg/L	75^{th} percentile	≤1.1
Turbidity	NTU	75th percentile	≤25
Electrical Conductivity	µS/cm	75th percentile	≤100
pH	pH units	25^{th} percentile and 75^{th} percentile	≥6.7 and ≤7.7
Toxicants Water	% Protection	ANZG guidelines for toxicants	95

Table 5-7 ANZG (2018) Guideline values – Freshwater 95% of protection

Indicator	Unit	Objective descriptor	Guideline value
Arsenic	mg/L	Toxicant trigger value - 95% species level of protection	0.0013
Cadmium	mg/L	Toxicant trigger value - 95% species level of protection	0.0005
Chromium	mg/L	Toxicant trigger value - 95% species level of protection	0.0004
Copper	mg/L	Toxicant trigger value - 95% species level of protection	0.0014
Lead	mg/L	Toxicant trigger value - 95% species level of protection	0.0034
Manganese	mg/L	Toxicant trigger value - 95% species level of protection	1.9
Mercury	mg/L	Toxicant trigger value - 95% species level of protection	0.0006
Nickel	mg/L	Toxicant trigger value - 95% species level of protection	0.011
Zinc	mg/L	Toxicant trigger value - 95% species level of protection	0.008
Nitrogen (Total Oxidised) as N	mg/L	Default trigger value for slightly-moderately disturbed ecosystems, lowland rivers - Table 3.3.2.	0.015
Nitrogen (Ammonia) as N	mg/L	Toxicant trigger value - 95% species level of protection	0.9
Nitrogen – Nitrate	mg/L	Toxicant trigger value - 95% species level of protection	0.7
Filtered Reactive Phosphate	mg/L	Default trigger value for slightly-moderately disturbed ecosystems, lowland rivers - Table 3.3.2.	0.02

The Water Measurement Information System (DELWP, 2020) as well as additional data provided by Melbourne Water were investigated to analyse water quality background conditions of Deep Creek, Jacksons Creek and Merri Creek. The location and period of record for each gauge is presented in Table 5-8.

The Deep Creek at Bulla gauge (230205) was combined with data from the Melbourne Water gauge MAJAC034 because the two gauges measure different water quality parameters but are located at the same site.

Similarly, the Jacksons Creek @ Sunbury (230202) gauge was used to investigate water quality upstream of the pipeline crossing on Jacksons Creek. The data was combined with Melbourne Water gauge, MADEE0868. Two other gauges were available: Jacksons Creek @ Sunbury (230104) and Jacksons Creek @ Salesian College Sunbury (230240). These were not used because gauge 230104 has only a short period of record and gauge 230240 does not include a range of parameters.

Water quality analysis of Jacksons Creek, Deep Creek and Merri Creek are presented in Section 6.4.7, 6.5.6 and 6.8.6 respectively. A preliminary review of the location of existing gauging stations and available data determined they are only suitable to assess background conditions in Jacksons, Deep and Merri Creek. This is due to there being only one gauge, Deep Creek at Bulla (230205), relevant to the construction area and is the only gauge that is appropriate for monitoring ongoing impacts from the installation of pipeline on water quality. Other gauges are too far away from the construction site and either influenced by confounding factors or they are no longer active. There is also no upstream gauge for Merri Creek. Therefore, using this gauging station data as a before-and-after approach to establish background conditions and investigate potential impacts during or following construction is not feasible.

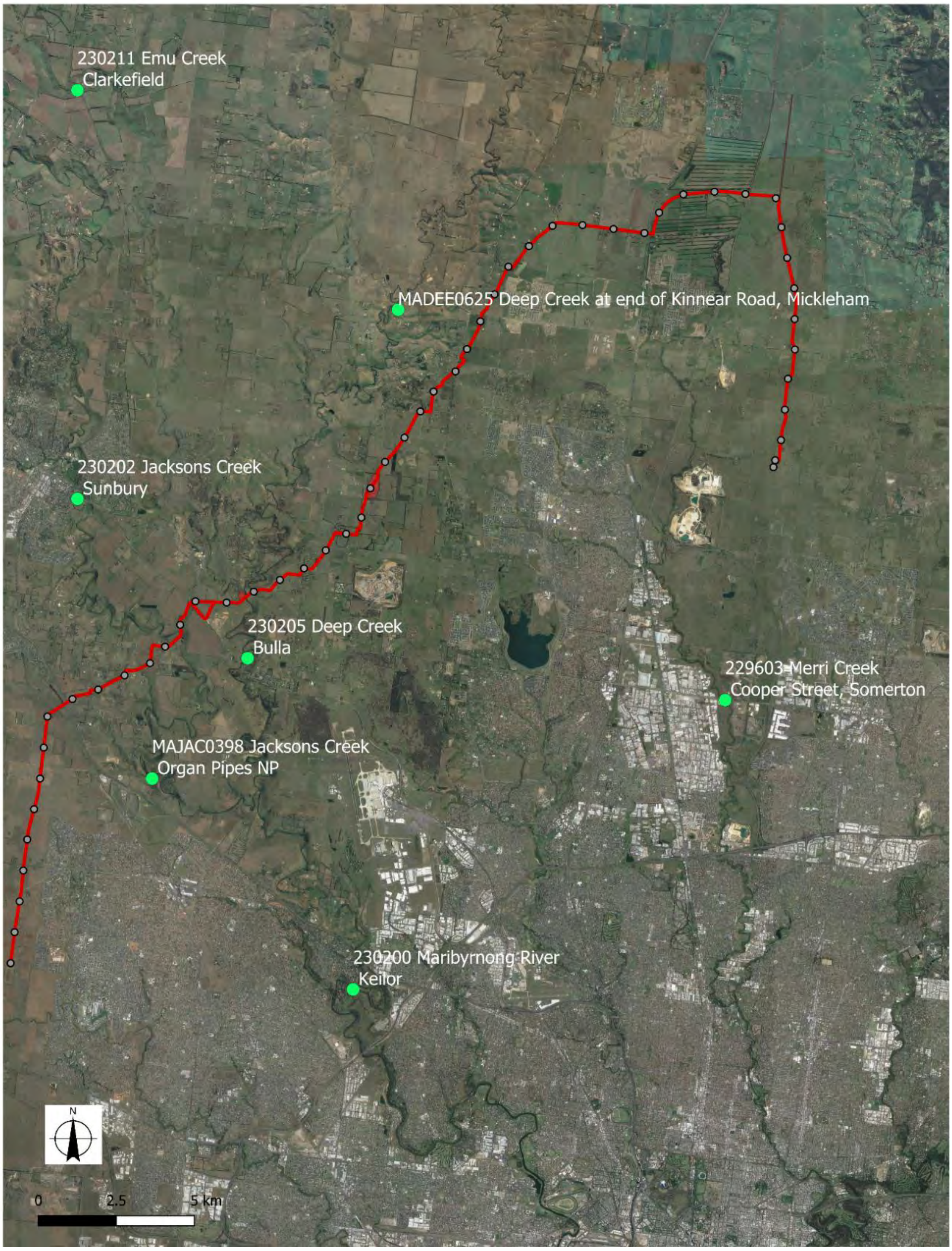


Figure 5-4 Gauge locations in relation to the Project alignment

The gauging station data, however, does indicate there is a high degree of temporal variability in water quality in the waterways. In some cases, the water quality exceeded environmental quality objectives in SEPP (Waters) in the absence of any potential impacts from construction. According to SEPP (Waters), if the background level of an indicator exceeds the objective, the objective does not need to be met but background levels must still be maintained. In this case, control sites (i.e. upstream of construction area) becomes the background level.

The existing water quality is considered for Jacksons Creek, Deep Creek and Merri Creek. All other identified waterways are ephemeral waterways with no water quality data available. The majority of these waterways are tributaries to either Jacksons Creek, Deep Creek and Merri Creek. Therefore, whilst there are potential water quality impacts to these waterways from the Project, the impact assessment has focused on Jacksons Creek, Deep Creek and Merri Creek as the receiving waterways.

Table 5-8 Summary of water quality gauges near the pipeline crossing

Gauge	Approximate distance from pipeline crossing	Period of record
230202 Jacksons Creek @ Sunbury combined with Melbourne Water gauge MADEE0868	7.5 km upstream	1990-2020
MAJAC0398 Jacksons Creek @ Organ Pipes National Park	11 km downstream	2010-2020
230200 Maribyrnong River @ Keilor	16 km downstream	1977-1999
MADEE0625 Deep Creek at end of Kinnear Road, Mickleham	18 km upstream	2010-2020
230211 Emu Creek @ Clarkefield	20.5 km upstream	1975-1998
230205 Deep Creek @ Bulla combined with Melbourne Water gauge MAJAC0342	2.5 km downstream	1990-2020
229603 Merri Creek @ Cooper Street, Somerton	9.7 km downstream	2010-2020

Table 5-9 presents the SEPP (Waters) beneficial uses that are to be protected for inland waters in sub-segments for rivers and streams in the Central Foothills and Coastal Plains. However, Clause 16 states *The Authority may determine that a beneficial use in a surface water segment does not apply:*

a. If the background level of an environmental quality indicator would not provide the protection of the beneficial use, or

b. If it is prohibited by any law or where it is otherwise not a permitted activity

In July 2021, when SEPP (Waters) is replaced with the *Environment Protection Act 2017* (as amended by the Environment Protection Amendment Act 2018) and the latter comes into effect, beneficial uses will be known as “environmental values” and will be provided in the Environment Reference Standards. Subtle changes between “beneficial uses” and “environmental values” are expected. However, these changes are unlikely to impact this assessment.

Table 5-9 Beneficial uses listed in Schedule 2 of the SEPP (Waters)

Beneficial Uses	Water	Rivers and Streams
	Segment	Central Foothills and Coastal Plains
Water dependent ecosystems and species that are:	Largely unmodified	
	Slightly to moderately modified	✓
	Highly modified	
Human consumption after appropriate treatment		✓*
Agriculture and irrigation		✓
Human consumption of aquatic foods		✓

Beneficial Uses	Water	Rivers and Streams
	Segment	Central Foothills and Coastal Plains
Aquaculture		✓**
Industrial and commercial		✓
Water-based recreation (primary contact)		✓
Water-based recreation (secondary contact)		✓
Water-based recreation (aesthetic enjoyment)		✓
Traditional Owner cultural values		✓
Cultural and spiritual values		✓
Navigation and shipping		

** where water is sourced for supply in accordance with the special water supply catchments area set out in Schedule 5 of the Catchment and Land Protection Act 1994 or the Safe Drinking Water Act 2003.*

***where the environmental quality is suitable and an aquaculture licence has been approved in accordance with the Fisheries Act 1995*

The potential beneficial uses of particular relevance to waterways potentially impacted by the Project include:

- Water dependent ecosystems and species
- Agriculture and irrigation
- Water-based recreation (aesthetic enjoyment)
- Traditional Owner cultural values

The previously described environmental quality indicators and objectives in SEPP (Waters) have been developed to align with the nationally agreed approach outlined in the ANZG (2018). It is noted that most of the proposed objectives are designed to protect the beneficial use of water-dependent ecosystems and species, and if this beneficial use is being protected then it is implied that other beneficial uses are assumed to be also protected.

5.6 Risk assessment method

A risk assessment for the Project was carried out using an approach that is consistent with Australian/New Zealand Standard AS/NZS ISO 31000:2018 Risk Management Process.

This risk assessment was used to identify the issues for assessment and apply a structured approach to the level of assessment and analysis undertaken of potential environmental effects within each technical study. Applying the risk framework facilitated an approach for the EES to identify and then investigate issues with a focus proportionate to the risk, and to consider management measures focused on reducing identified risks.

The risk assessment methodology included:

- Defining the context for the risk assessment based on the existing assets, values and uses (baseline) assessments of each technical area and the proposed Project activities which interact with those existing conditions
- Identifying the risk pathways for the Project based on a specific cause and effect

- Identifying standard management/mitigation measures (including those in guidelines and standards) and whether additional mitigation measures may be required
- Analysing the consequence and likelihood of the identified risk based on a consequence guide developed for each technical area and a likelihood guide
- Defining the risk level based on the risk matrix

The identification, analysis and evaluation of risks was conducted within each technical area and across technical areas where there was input or connection across disciplines.

The consequences of a surface water risk occurring were assigned using consequence categories from insignificant to severe developed for surface water based on the existing conditions and values in the study area. The consequence levels and descriptors are provided in Appendix A.

A likelihood rating for each identified risk was assigned ranging from ‘almost certain’ where the event is expected to occur to ‘rare’, where the event may occur only in exceptional circumstances. The likelihood levels and descriptors are provided in Appendix A.

The risk matrix used to define each risk level is also provided in Appendix A.

The risk ratings were revisited during the impact assessment for risk ratings categorised as higher to develop additional environmental management measures. This was applied to identify the residual impacts and risks. The summary of the risk assessment in Section 7 is based on an open trench construction methodology adopted at each of the crossings. Where an alternative construction is proposed, such as HDD, additional mitigation measures were developed as part of this impact assessment.

5.7 Impact assessment method

The methodology for the surface water impact assessment included:

- Identifying key issues or risks (as described in Section 5.6)
- Assessing and summarising the existing conditions of each of the main waterways, including waterway characteristics, geomorphology, hydrological and hydraulic information and water quality based on available desktop information
- Identifying potential impacts of Project construction and operation, including likely extent, magnitude and duration (short and long term) of changes to water quality, water level, temperature or flow paths
- Identifying potential receptors, risk pathways and quantify likely impacts to the waterway and to beneficial uses downstream during construction and operation
- Identifying standard mitigation measures to manage identified risk associated with all waterways and the surrounding floodplains during construction and operation
- Identifying and developing additional mitigation measures for specific waterways that are subject to greater risk due to their existing conditions
- Assessing the potential significance of residual effects on waterway health and surrounding property and infrastructure assuming implementation of mitigation measures by taking into account the likelihood and consequence of these occurring
- Assessing the effectiveness of the additional mitigation measure to mitigate the impact or reduce the risk rating to a level that meets the statutory requirements or guidelines accepted by the responsible authorities

5.7.1 Construction assessment method

The construction assessment involved identifying the potential impacts related to surface water based on the preferred construction method that will be adopted to cross the waterways. The primary considerations when assessing the construction impact included the following:

- Impacts associated with changes to downstream environment and water quality
- Impacts to the existing floodplain and waterway characteristics
- Impacts to the surrounding properties and infrastructure

The preferred construction method for the waterway crossings has been identified by APA as open trench where practicable. The standard mitigation measures were developed based on industry construction guidelines and practices to minimise impacts associated with open trenching. These standard control measures are relevant to all waterway crossings and will need to be applied as standard mitigation and management requirements. Most of the risk items are directly associated with the impacts from construction activities in the waterway or floodplain due to the open trenching. Where relevant some further discussion may be provided on the respective construction methods.

Where a waterway has potentially higher risk associated with bed or bank erosion and floodplain function, site specific controls and additional mitigation measures have been developed based on the assessed impact. Three “complex” waterways have been identified in Section 6 as Jacksons Creek, Deep Creek and Merri Creek. Due to the greater potential for erosion and sensitivity of the floodplain to the construction activities, the potential impacts associated with the “complex” waterways have been assessed separately where it required site specific controls and additional mitigation measures in place compared to the other waterways.

The impact assessment includes discussion on all risk items, with an emphasis on the risk items that require additional design/construction limitations or management measures including:

- Pipe Design - This may include requirements increasing the minimum depth below invert or other criteria, as well as suggesting other design interventions
- Construction – This may include imposing construction limitations on the proposed method as well as site controls measures
- Site Rehabilitation – This may include requirements regarding the site rehabilitation, reinstatement and surface treatment
- Monitoring – Monitoring during and post construction

Many of the identified risk items in the Risk Assessment (outlined in Section 7), could be managed to low by adopting trenchless construction methods as there are less intrusive and require minimal ground disturbance. Along the entire length of the pipeline there are various factors and constraints that have led to APA identifying preferred construction methodologies. Table 5-10 outlines the proposed construction methodology identified for each waterway crossing location and notes the opportunities for combining with other trenchless methods due to other site constraints.

For the perennially flowing waterways of Jacksons Creek and Deep Creek that both have high ecological values and potential for bed and bank erosion, ideally the preferred construction method would be HDD to avoid any direct impacts to the waterways. Based on the surface topography and underlying soil profile, APA confirmed that the only waterway crossing suitable for HDD is Deep Creeks. The possible use of a trenchless construction technique, such as HDD, has been considered for the Jacksons Creek crossing to avoid construction disturbance within this sensitive area. The assessment outcome indicated that crossing Jacksons Creek using trenchless construction technique was not feasible due to the following factors:

- Geotechnical investigations indicated layers of gravelly sand and gravel layers which are considered a significant risk to HDD techniques as it is not conducive to maintaining borehole stability
- The angle of the approach for the creek crossing would require a bore length of more than 460 m to achieve the minimum pipe string radius, and drilling over this length would significantly increase the risk of multiple uncontrolled fluid losses to the surrounding environment, also known as a 'frac-out'
- Hydrofracture is considered a major risk due to the gravelly geological conditions and where there are areas of fractured rock or where the rock is at risk of fracturing, drilling fluid (generally bentonite based fluid) is likely to escape from the drill hole to surface waters or to the surrounding environment during the drilling process
- To facilitate the drill exiting the ground prior to change in alignment direction, a steep exit angle will be required. This will create issues with management of the tail string, as well as overbend management.
- The pipe string will be taken outside of the designated right of way through landowners' paddock due to the long length of pipe (more than 460 m) to achieve a continuous pipe pull operation

Details of the factors in deciding crossing technique for Jacksons Creek are discussed further in EES Chapter 3 Project development.

HDD was also not proposed for the Merri Creek crossing as the existing APA pipeline crossing through Merri Creek was successfully installed adopting an open trench construction method. Furthermore, Merri Creek is ephemeral at the crossing location and given the underlying presence of bed rock the risk of erosion is lower, and therefore open trenching can be readily managed with standard controls applied to open trenching.

Table 5-10 APA proposed construction method at each waterway crossing

Crossing No.	Pipeline Ch (KP)	Waterway Crossing	Construction Method	Comment
1	1	Unnamed tributary	Trenching	
2	7.5	Unnamed tributary	Trenching	
3	8.36	Tame Street Drain	Trenching	Potentially HDD combined with Railway line works
4	9.74	Unnamed tributary	Trenching	
5	10.6	Unnamed tributary	Trenching	
6	11.7	Unnamed dam crossing	Trenching	
7	13.7	Jacksons Creek	Trenching	APA preferred method at waterway crossing
8	13.9	Unnamed tributary	Trenching	
9	16.7	Deep Creek	HDD	APA preferred method at waterway crossing
10	19.47	Unnamed tributary	Trenching	
11	23.4	Unnamed dam crossing	Trenching	
12	31.5-31.7	Unnamed tributaries	Trenching	
13	32.6	Unnamed tributary	Trenching	
14	33.5	Unnamed tributary	Trenching	
15	33.8-34	Three unnamed agricultural drains	Trenching	
16	34.5	Kalkallo Creek	Trenching	
17	34.8	Unnamed agricultural drain	Trenching	
18	35.5	Unnamed agricultural drain	Trenching	
19	36.2	Unnamed agricultural drain	Trenching	
20	40.8	Tributary of Merri Creek	Trenching	
21	42.9	Merri Creek	Trenching	APA preferred method at waterway crossing
22	44.8	Seasonal wetlands	Trenching	
23	50.8	Unnamed tributaries	Trenching	

5.7.2 Operation assessment method

The operation impact assessment focuses on the potential for ongoing erosion due to disturbance to the waterway and/or floodplain from the construction phase of the pipeline. This includes post-construction impacts related to permanent changes to the waterway behaviour and the way it responds to future flood events given that disturbance has been caused. As the pipeline design and construction is intended to minimise and avoid any changes to the existing surface, the Project would be expected to restore the waterway and floodplain to near pre-work conditions. Once the waterway or floodplain has been disturbed, however, there is a potential for this disturbance to trigger a future erosion response if no additional or ongoing mitigation measures are implemented post-construction. This assessment considers specific controls related to the design, construction and rehabilitation of a waterway to be developed for all waterways, as well as the “complex” waterways.

5.8 Stakeholder engagement

Whilst stakeholder and community engagement was undertaken during the preparation of the EES, no community engagement was specifically required to inform this assessment,

EES Attachment III *Community and Stakeholder Consultation Report* provides details of the consultation activities undertaken for the Project more broadly and outcomes from those activities. There has been engagement during the EES process.

5.9 Limitations, uncertainties and assumptions

Assumptions, limitations and uncertainties relating to this existing conditions and impact assessment are provided below:

- The desktop study is based on a snapshot of conditions that existed at the time of the assessment. Any variations to existing conditions that have occurred after completion of this assessment have not been considered.
- Field assessments undertaken were limited to areas of approved land owner access as well as site access conditions at the time
- The pipeline alignment used for the assessment was the Revision 7 alignment
- Flood mapping models obtained from MWC were adopted for use within the hydrology and hydraulic assessments of the applicable waterway. The models have been reviewed and refined including parameter adjustment where required so they are fit for purpose for the assessments.
- The hydrology and hydraulic assessment undertaken in this report is limited to the models and documents made available by MWC and data obtained online for the site of interest. The information is therefore subject to further checking, revision and interpretation during subsequent design stages.
- Where no model was available for the hydrology, the Regional Flood Frequency methods were adopted for deriving flows, and new HEC-RAS models were created from LiDAR information. The interpretation of these models is for the purpose of the EES and not to be used for any other purpose.
- Modelling parameters (e.g. manning’s roughness parameters within HEC-RAS) were based on interpretation of the waterway and floodplain vegetation conditions from the site inspection and aerial images. This information is therefore subject to further checking and refining during subsequent design stages.

- Interpreted long and cross-section profiles for each waterway were derived from VicMap 1 metre contours. There is limited channel detail due to the lack of resolution of the 1 metre contour data and where appropriate, channel profiles were manipulated to better represent the stream bed. Further survey data will need to be obtained for more detailed profiles of waterways where further definition is required to represent the existing conditions.
- Additional LiDAR information was obtained for the area upstream of Merri Creek and its tributary which included a 0.5 m contour data as the VicMap 1 m contour data does not cover some of this area. This provides greater definition in the surface profiles for this area of the Project
- Limited access to some pipeline crossing locations resulted in no photographs of the waterway taken during the site inspection. As a result, screenshots were obtained from google street view to supplement the missing data and as such, any variations to existing conditions that have occurred after completion of this assessment have not been considered.
- The water quality assessment was limited to waterways with stream gauge data including Jacksons Creek, Deep Creek and Merri Creek. The location of some of these stream gauges in relation to the three waterway crossings may not provide representative water quality assessment of the existing conditions.

6. Existing conditions

The existing conditions of the identified waterways in the context of the Project are described in the following sections.

6.1 Catchment Context

The Project spans across three main Melbourne Water Corporation (MWC) catchments (Werribee River, Maribyrnong River and the Yarra River), and from a surface water perspective, it is the potential interaction of the pipeline with waterways within these catchment that is of interest. The desktop assessment identified 23 waterways which would intersect with the Project construction corridor including 8 waterways within the Maribyrnong River catchment and 14 within the Yarra River catchment. No watercourses are crossed by the Project in the Werribee catchment.

6.1.1 Werribee catchment

The Werribee catchment area is located west of Melbourne and covers an area of approximately 2,715 square kilometres. The landscape within Werribee catchment is varied; from flat plains, gorges and steep sided hills. Wetlands and grass lands of regional and national significance are present in the lower area of this catchment. Agricultural practices and urban development have impacted the catchment significantly, resulting in approximately three quarters of natural vegetation being removed (Melbourne Water, 2017).

The construction corridor intersects with the Kororoit Creek Upper sub catchment at the south western tip of the pipeline via an unnamed tributary (east of KP1). The tributary does not cross the pipeline but a small section of the tributary runs through the construction corridor before discharging directly into the Kororoit Creek. The Kororoit Creek is located approximately 1.8 km from the construction corridor and on the edge of Melbourne’s urban fringe. There are numerous wetlands downstream from this area including ephemeral freshwater meadows, instream lacustrine and palustrine wetlands (Alluvium, 2019).

In reference to Visualising Victoria’s Groundwater (VVG) maps, the water table elevation within construction corridor in the Kororoit Creek catchment is less than five metres from natural surface. The shallowest areas appear to correspond with the positioning of rivers and tributaries.

6.1.2 Maribyrnong catchment

The Maribyrnong catchment is located to the north of Melbourne. Covering an overall area of 1,408 square kilometres, this catchment feeds the 41 kilometre long Maribyrnong River which originates from the southern slopes of the Great Dividing Range and discharges into Port Phillip Bay. Approximately 10 per cent of the Maribyrnong catchment is used for urban development, 80 per cent for agricultural use with only 10 per cent of natural vegetation still present. (Melbourne Water, 2019).

The Upper Maribyrnong catchment includes both Jacksons Creek and Deep Creek, both of which directly intersect the pipeline. Where Jacksons Creek meets Deep Creek becomes the start of the Maribyrnong River. The construction corridor that interacts with the Maribyrnong catchment is outside the metropolitan urban fringe, with the predominant land use being agricultural land. Whilst there is a significantly lower risk of erosion than further downstream where there is impacts from increasing urbanisation and the catchment becoming steep in a geomorphic sensitive. The pipeline construction corridor interacts with several smaller tributaries to Jacksons Creek and Deep Creek.

At the stream crossing locations the surface geology consists of New Volcanics (Jacksons Creek) and Deep Creek Siltstone (Deep Creek). Groundwater maps show that the water table elevation underlying the construction corridor within the Maribyrnong catchment is less than 10 metres from natural surface. However, groundwater mapping at the stream crossings of Jacksons and Deep Creek suggest that the water table is significantly shallower, roughly two metres or less, and in some areas potentially recharging into the streams (Alluvium, 2019).

6.1.3 Yarra catchment

The Yarra catchment is located north and east of Melbourne and covers an area of 4,046 square kilometres. The catchment feeds the 245 kilometre long Yarra River which originates east of Warburton in the Great Dividing Ranges and discharges into Port Phillip Bay. Approximately 15 percent of the area is urbanised, 30 per cent is utilised for agriculture with the remaining 55 per cent retaining its natural vegetated state (Melbourne Water, 2019).

The construction corridor intersects with the Merri Creek, which is a major tributary to the Yarra River. Merri Creek is subject to multiple land uses which places pressure on the system. The Merri Creek catchment and this section of the Project exists within the urban growth boundary (Alluvium, 2019). Upstream from the pipeline the catchment consists of predominately agricultural practices whereas downstream from the construction corridor, there is significant pressure placed on Merri Creek due to urbanisation and the corresponding stormwater run-off. Prior to intersecting Merri Creek, the construction corridor crosses a series of agricultural surface drains and ephemeral minor streams including Kalkallo Creek and tributaries, all of which eventually feed into the Merri Creek.

The surface geology in this area is dominated by Quaternary gravels and sands. This section of the Project has been identified as previously being a swamp, though it has been drained in colonial years for use as agricultural land. The Project passes through a seasonal wetland mapped in the Victorian Wetland Inventory, south of the Merri Creek crossing.

6.2 Existing Conditions Assessment (Phase 1)

6.2.1 Waterways

The Phase 1 screening assessment is based on the findings from the previous assessment undertaken by GHD (completed in 2019 – 2020). The desktop assessment of the erosion and flood risk for each of the waterways identified within the Project, has been reviewed including confirming the waterways considered to be low risk and flagging the potentially higher risk waterways.

For the 23 identified waterways outlined in Section 5.3.1 that cross the Project, a 1 page desktop assessment for each of these waterways describing:

- Location along the Project
- Catchment characteristics
- Waterway hydrology and hydraulic characteristics
- High level assessment of Erosion and Flood risk
- Confirming whether further assessment is required

The 1 page desktop assessment has been captured in Appendix D

A summary of the outcomes of the Phase 1 Preliminary Screening Assessment is presented in Table 6-1.

Table 6-1 Preliminary Screening Assessment.

	Name	Waterway Status	Location (KP)	Erosion Risk	Flood Risk	Confirmed Status
01	Unnamed	Minor gully tributary to Kororoit Creek	1	Low	Low	Velocity < 1.5 m/s and not within LSIO No further assessment is required, Low potential risk
02	Unnamed	Minor gully tributary to Tame St Drain	7.5	Low	Low	Velocity < 1.5 m/s and not within LSIO No further assessment is required, Low potential risk
03	Tame Street Drain	MWC Main Drain channel	8.36	Low	High	Velocity < 1.5 m/s, within LSIO and large catchment area Further assessment required to confirm the potential risk
04	Unnamed	Minor gully tributary to Jacksons Creek	9.74	Low	Low	Velocity < 1.5 m/s and not within LSIO No further assessment is required, Low potential risk
05	Unnamed	Minor gully tributary to Jacksons Creek	10.6	High	Low	Velocity > 1.5 m/s, not within LSIO but small catchment area No further assessment is required, Low potential risk.
06	Unnamed	Minor gully tributary to Jacksons Creek (farm dam at crossing)	11.7	Low	Low	Velocity < 1.5 m/s and not within LSIO Pipe alignment to ideally avoid farm dam or be located below. No further assessment is required, Low potential risk
07	Jacksons Creek	“Complex” Waterway	13.7	High	High	Velocity > 1.5 m/s and within LSIO Further assessment of the site is required to inform risk assessment.
08	Unnamed	Gully tributary to Jacksons Creek	13.9	High	Low	Velocity > 1.5 m/s and not within LSIO but within Jacksons Creek site Further assessment to be combined with the Jacksons Creek site assessments.

	Name	Waterway Status	Location (KP)	Erosion Risk	Flood Risk	Confirmed Status
09	Deep Creek	“Complex” Waterway	16.7	High	High	Velocity > 1.5 m/s and within LSIO Further assessment of the site is required to inform risk assessment.
10	Unnamed	Upper gully tributary to Moonee Ponds Creek	19.47	Low	Low	Velocity < 1.5 m/s and not within LSIO No further assessment is required, Low potential risk
11	Unnamed	Minor gully tributary to Deep Creek (farm dam at crossing)	23.4	Low	Low	Velocity < 1.5 m/s and not within LSIO Pipe alignment to ideally avoid farm dam or be located below. No further assessment is required, Low potential risk
12	Unnamed	Minor tributary to Kalkallo Creek	31.5-31.7	Low	Low	Velocity < 1.5 m/s and not within LSIO No further assessment is required, Low potential risk
13	Unnamed	Minor tributary to Kalkallo Creek	32.6	Low	Low	Velocity < 1.5 m/s and not within LSIO No further assessment is required, Low potential risk
14	Unnamed	Minor tributary to Kalkallo Creek	33.5	Low	Low	Velocity < 1.5 m/s and not within LSIO No further assessment is required, Low potential risk
15	Unnamed	Tributary constructed drains (x3) to Kalkallo Creek	33.8-34	Low	High	Velocity < 1.5 m/s and within retarding basin Further assessment to be combined with the Kalkallo Creek site assessments. Flooding risk is high given the site is a retarding basin.
16	Kalkallo Creek	Channelised Creek	34.5	Low	High	Velocity < 1.5 m/s and within LSIO and retarding basin Further assessment of the site is required. Flooding risk is high given the site is a retarding basin.

	Name	Waterway Status	Location (KP)	Erosion Risk	Flood Risk	Confirmed Status
17	Unnamed	Tributary constructed drain to Kalkallo Creek	34.8	Low	High	Velocity < 1.5 m/s but within retarding basin Further assessment to be combined with the Kalkallo Creek site assessments. Flooding risk is high given the site is a retarding basin.
18	Unnamed	Tributary constructed drain to Kalkallo Creek	35.5	Low	High	Velocity < 1.5 m/s but within retarding basin Further assessment to be combined with the Kalkallo Creek site assessments. Flooding risk is high given the site is a retarding basin.
19	Unnamed	Tributary constructed drain to Kalkallo Creek	36.2	Low	Low	Velocity < 1.5 m/s and not within LSIO No further assessment is required, Low potential risk
20	Tributary of Merri Creek	Tributary to Merri Creek	40.8	High	Low	Velocity < 1.5 m/s but within LSIO Further assessment of the site is required to inform risk assessment.
21	Merri Creek	"Complex" Waterway	42.9	High	High	Velocity > 1.5 m/s and within LSIO Further assessment of the site is required to inform risk assessment.
22	Seasonal wetlands	Seasonal freshwater marshes and meadows (Palustrine Wetland)	44.8	Low	Low	Velocity < 1.5 m/s and not within LSIO No further assessment is required, Low potential risk. Refer to Section 6.2.1.
23	Unnamed	Tributary to Curl Sedge Creek (Tributary to Merri Creek)	50.8	Low	Low	Velocity < 1.5 m/s and not within LSIO No further assessment is required, Low potential risk

Based on the Phase 1 assessment and availability of additional information, the following waterways have been assessed in more detail:

- Tame Street Drain (waterway crossing 3)
- Jacksons Creek (waterway crossing 7, as well as waterway crossing 8, tributary to Jacksons Creek nearby)
- Deep Creek (Crossing 9)

- Kalkallo Creek (waterway crossing 16, as well as the various channel drains that discharge towards the Kalkallo Creek retarding basin – waterway crossings 15, 17 and 18)
- Tributary of Merri Creek (Crossing 20)
- Merri Creek (Crossing 21)

The more detailed assessments that follow in Section 6.3 to 6.8 in the report are consistent with the six waterways identified in the previous assessment undertaken by GHD (completed in 2019 – 2020). There are additional waterways that have been identified as “potentially high risk” from the Phase 1 preliminary screening assessment. These additional waterways have been considered in the detailed assessment of the six higher risk waterways, as outlined above. The remaining waterways were assessed as being low risk and therefore no further assessment has been undertaken.

6.2.2 Groundwater Interaction

Surface water has the potential to interact with groundwater systems within the study area through either groundwater inflow, groundwater recharge or both depending on where it is located along the stream. As described in Section 6.1.2 of the EES Technical Report C Groundwater, swamps and wetlands can be sites of groundwater discharge and may represent groundwater dependent ecosystems (GDEs). These sites may be permanent or ephemeral systems that receive seasonal or continuous groundwater contribution to water ponding or shallow water tables. Permanent or ephemeral stream systems may also receive seasonal or continuous groundwater contribution to flow as baseflow. Interaction could depend on the nature of stream bed and the underlying aquifer material and the relative water level heads in the aquifer and the stream. This is discussed in more detail in EES Technical Report C Groundwater. Table 6-2 summarises the identified potential GDEs from the Groundwater report.

Table 6-2 Summary of identified potential GDEs

Approximate kilometre point (km)	Description	Approximate distance from alignment
KP0 – KP5	Scattered wetlands (aquatic GDEs) away from the alignment.	> 0.5 km
KP5 – KP7, KP8 – KP9	Scattered modelled GDEs (as reported in Biosis, 2019)	> 0.5 km
KP10 – KP11	Potential aquatic GDE associated with Jacksons Creek tributary and uncultivated grassland	0.3 km
KP13 – KP14	Jacksons Creek – potential terrestrial and aquatic GDEs	0 km (Jacksons Creek is the mapped GDE)
KP15 – KP 24 KP25 – KP30	Deep Creek – potential terrestrial and aquatic GDEs Potential Terrestrial GDE, will be difficult to avoid if present Along the alignment between Deep Creek and Oaklands Road and scattered potential GDEs between KP25 and KP30 Low potential aquatic GDE west of the alignment, between approximately KP25 and KP30	Most GDEs within 0.5 km of alignment
KP30 – KP31	Potential terrestrial GDE	0.1 km to 0.5 km

Approximate kilometre point (km)	Description	Approximate distance from alignment
KP34 – KP35 KP35 – KP37	Kalkallo Creek; potential aquatic GDE A large potential GDE has been mapped immediately north of the alignment adjacent Kalkallo Creek	0 km (Kalkallo Creek is the mapped GDE) 0.3 km at closest point
KP38 – KP41	Potential terrestrial GDE	0 km to > 0.5 km
KP43	Merri Creek. Potential aquatic GDE	0 km (Merri Creek)
Note: GDEs identified in this assessment and Biosis (2019)		

Following further field investigations as part of the Groundwater study (Section 7.2.4 of the Groundwater report), generally groundwater levels are close to the creek bed level and are indicative that there may be groundwater discharge (i.e. baseflow) to the creeks (i.e. Jacksons, Merri and Deep Creek) during periods of the year.

Further information on the potential GDEs and biodiversity at the creek crossings (i.e. Merri, Jacksons and Deep Creek) is provided in the EES Technical Report C Groundwater. and EES Technical Report A Biodiversity and habitats.

6.2.3 Seasonal Wetlands

Wetland data sets sourced from the Department of Environment and Primary Industries Directory of Important Wetlands in Australia (DIWA), Australian Ramsar Wetlands and DELWP Victorian Wetland Inventory (2017) were interrogated to identify the location of any wetlands along the alignment. The wetlands identified are listed and described in more detail in Section 6.13 of the EES Technical Report C Groundwater. Alluvium (2019) reported three small wetlands between KP44 and KP45, two of which are partially traversed by the pipeline alignment, as shown in Figure 6-1.

These wetlands have been mapped in the Victorian Wetland Inventory as freshwater marsh or meadow that periodically inundate during wet periods. Both the Alluvium report (2019) and the Groundwater report indicate that these wetlands have not been identified as a Groundwater Dependent Ecosystem (GDE). The existing conditions of the wetlands appear to be mostly dry and ephemeral based on aerial imagery. This section of the pipeline is proposed to be installed using open cut trench construction through portion of the mapped wetlands. The larger of the two wetlands interfaces with a minor tributary that flows into a secondary stream before discharging into the Merri Creek.

As such, the groundwater level and interaction with surface water in this area will need to be better understood to enable management of any potential water quality issues.

The Groundwater report highlights the location between KP 40 and KP45 as areas that were considered significant with respect to potential interaction with groundwater due to course regional mapping and potentially shallow groundwater table in this area. It is noted that a monitoring bore was proposed to be installed close to the wetlands but was not able to be undertaken due to poor weather conditions at the time. In the absence of additional site specific data for this area, regional interpretation of groundwater depths has been used for this assessment. Regional data from the Groundwater assessment suggested groundwater depth may be less than 5 metres near these seasonal wetlands. In addition, the Alluvium report (2019) suggested the mapped water table elevation is ~2 to 4 metres. The groundwater level was also interpreted using the two bores installed further north and south of the wetlands which suggests the ground water depth is in the order of 10 metres deep. Interpretation of groundwater levels between the two bores are subject to uncertainties due to the bores being spaced quite far apart from the wetlands.

Based on the Groundwater assessment, it is indicated that the interpreted groundwater level is likely to be deeper than 2 metres and dewatering at this location would not be expected as long as trenching is undertaken during a dry period. Note that the interpreted groundwater depth is based on regional data where the mapping is likely to be coarse and may not provide an adequate representation of the groundwater levels in this area. It is considered that further targeted site investigations could confirm the surface water and groundwater interfaces and dependencies in and around the identified seasonal wetlands.

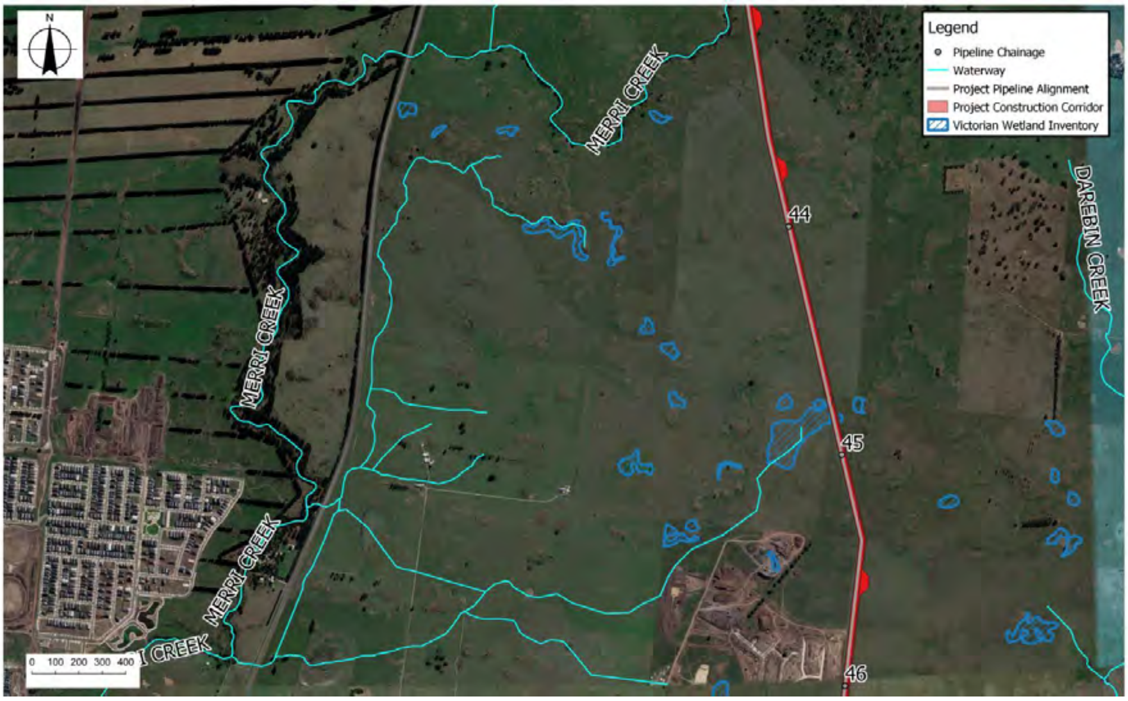


Figure 6-1 Small Seasonal wetlands between KP44 and KP45 mapped in the Victorian Wetland Inventory (2017)

6.2.4 Potential Presence of Gilgai Formation

Gilgai formation describes terrain consisting of mounds and depressions formed over time by expansion and contraction of the clay soil layers during alternating dry and wet weather periods. During hot dry weather, the clay soil contracts forming deep cracks along the surface. Gilgai tend to respond to rainfall events that cause the swelling of the clay material resulting in the formation of natural mounds and depressions. During and following a wet period, gilgai depressions may be filled with water forming shallow wetlands. These shallow wetlands are typically difficult to detect in dry seasons or conversely when vegetation is dense as they are relatively small and ephemeral. Figure 6-2 shows an example of gilgai terrain identified within the Merri Creek catchment in Craigieburn East (Merri Creek Management Committee, 2008) outside of the Project area.

As the mechanisms of gilgai formation are complex and vary across different sites and driven heavily by the characteristics of the clay soil layer, areas with presence of gilgai soils are generally known to be sensitive to ground disturbance due to the potential for the clay to shrink and swell. The Project alignment traverses two private properties between KP 22.093 and KP 24.164 east of the Craigieburn Road, Konagaderra Road and Oaklands Road intersection. This includes the property parcel to the north of Craigieburn Road (Parcel ID 1PS733045) and the property to the south (Parcel ID 1PS733043), shown in Figure 6-3 and Figure 6-4 respectively. Preliminary site and desktop assessment of the two properties indicate small undulating topography and minor depressions that are distinguishable on aerial imagery in the figures below. This unusual phenomenon observed in the terrain suggests that there is potential for natural gilgai formation to be present within the two properties intersected by the Project alignment.

Figure 6-2 Example of Gilgai at Craigieburn East within the Merri Creek Catchment (Merri Creek Management Committee, 2008)

The two properties are identified as agricultural land with relatively flat terrain. A minor gully tributary to Deep Creek traverses the property to the north as shown in Figure 6-3 and a number of farm dams within the two properties. The ground condition is expected to comprise of Newer Volcanics Basaltic soils with possible shallow basalt bedrock, as described in Table 6-3 of the EES Technical Report D: *Ground movement and land stability*. This area of the project lies within the Victorian Volcanic Plain (VVP) region and has been mapped by GHD specialist as Plains Grassy Woodland, as shown in Figure 7.13 of the EES Technical Report A: *Biodiversity and Habitats*. In addition, the two areas have also been mapped as Grassy Eucalypt Woodland of the Victorian Volcanic Plain (GEWVVP) which is listed as a threatened ecological community under the EPBC Act. This is discussed in more detail in EES Technical Report A: *Biodiversity and Habitats*.

The mechanism of gilgai formations and any associated flora species are generally dependent on rainfall and overland flow to support the ecosystem. There may also be certain types of gilgai formations or wetlands which receive seasonal or continuous groundwater contributions and depend on the subsurface presence of groundwater. A groundwater monitoring bore was installed by GHD (WORMBH05) along the southern boundary of the property to the north, as shown in Figure 6-3 below and Figure 21 in the EES Technical Report C: *Groundwater*. This monitoring bore recorded bore depth of 20 m below ground level (bgl) with groundwater depth of 19 m bgl. Water levels in other project bores, with longer monitoring records, suggest groundwater level variations in the order of 0.5 to 1 m. Therefore, the groundwater is unlikely to be shallow enough in this area to support the gilgai formation. This suggests that the gilgai formation if present in the property to the south would be generally dependent on rainfall and wet weather conditions, including stormwater runoff from adjacent roads and properties, and would not be expected to be dependent on subsurface hydrology.

Both sites were surveyed in November 2020 by GHD specialist for native vegetation and additional field observations were documented from a site visit undertaken on the 26th of February 2021. The field observations indicated that the grass across Parcel ID 1PS733045 north of Craigieburn Road is in poor condition and the land is primarily used for grazing. Gilgai formations were not observed and given the species composition, gilgai dependent flora were not considered likely in this area. Field survey undertaken for Parcel ID 1PS733043 to the south, however, observed minor undulation of the ground surface with cracks and depressions formed which could be due to the shrinking and swelling characteristics typical of gilgai soils. No gilgai specific flora features,(e.g. flora dependent on wet depressions), were observed within the gilgai during the time of survey. Both site visits were undertaken during dry weather conditions where gilgai and associated gilgai flora may have been difficult to detect or identify.

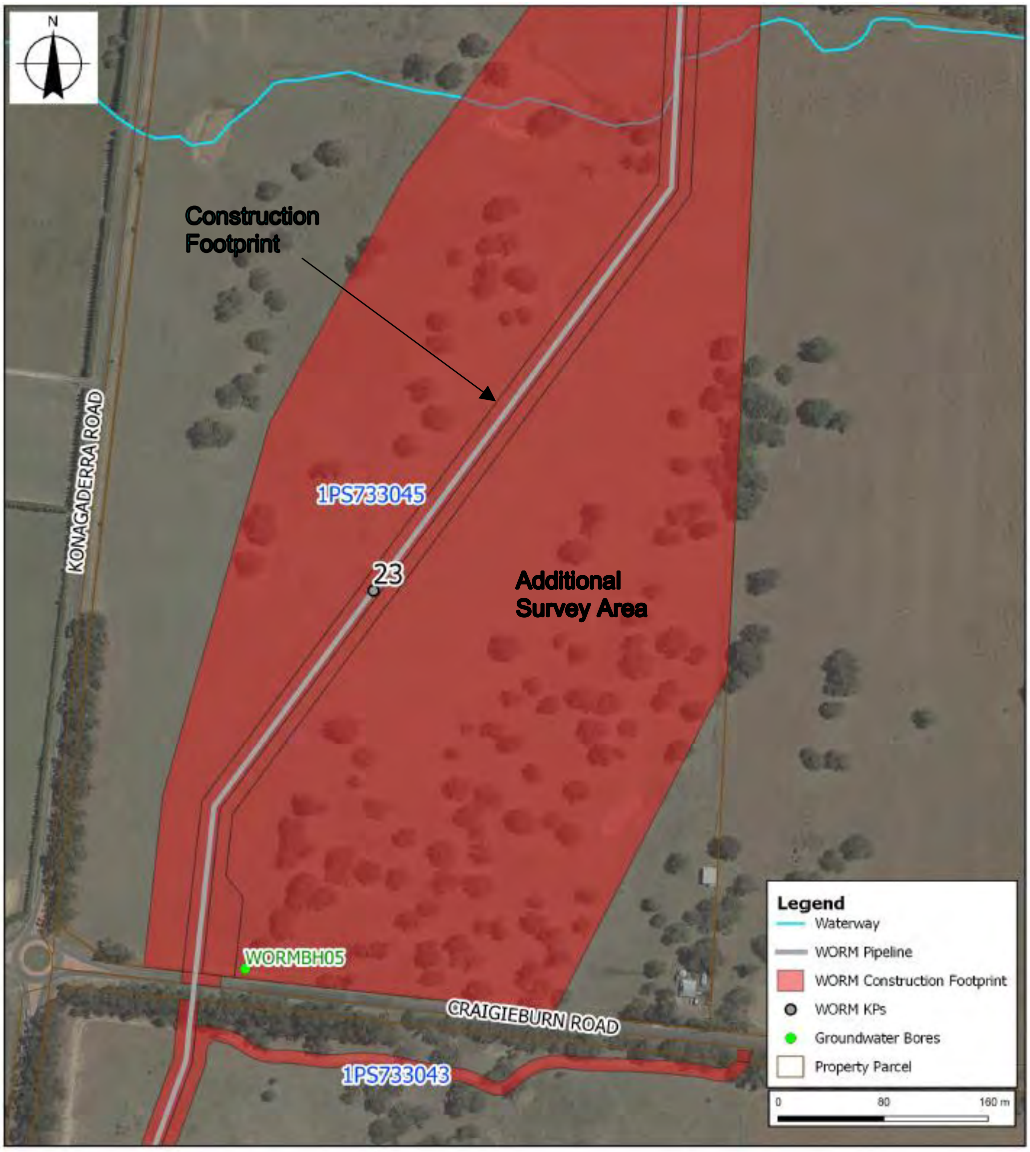


Figure 6-3 Private property north-east of the Craigieburn Road/Oaklands Road/Konagaderra Road intersection

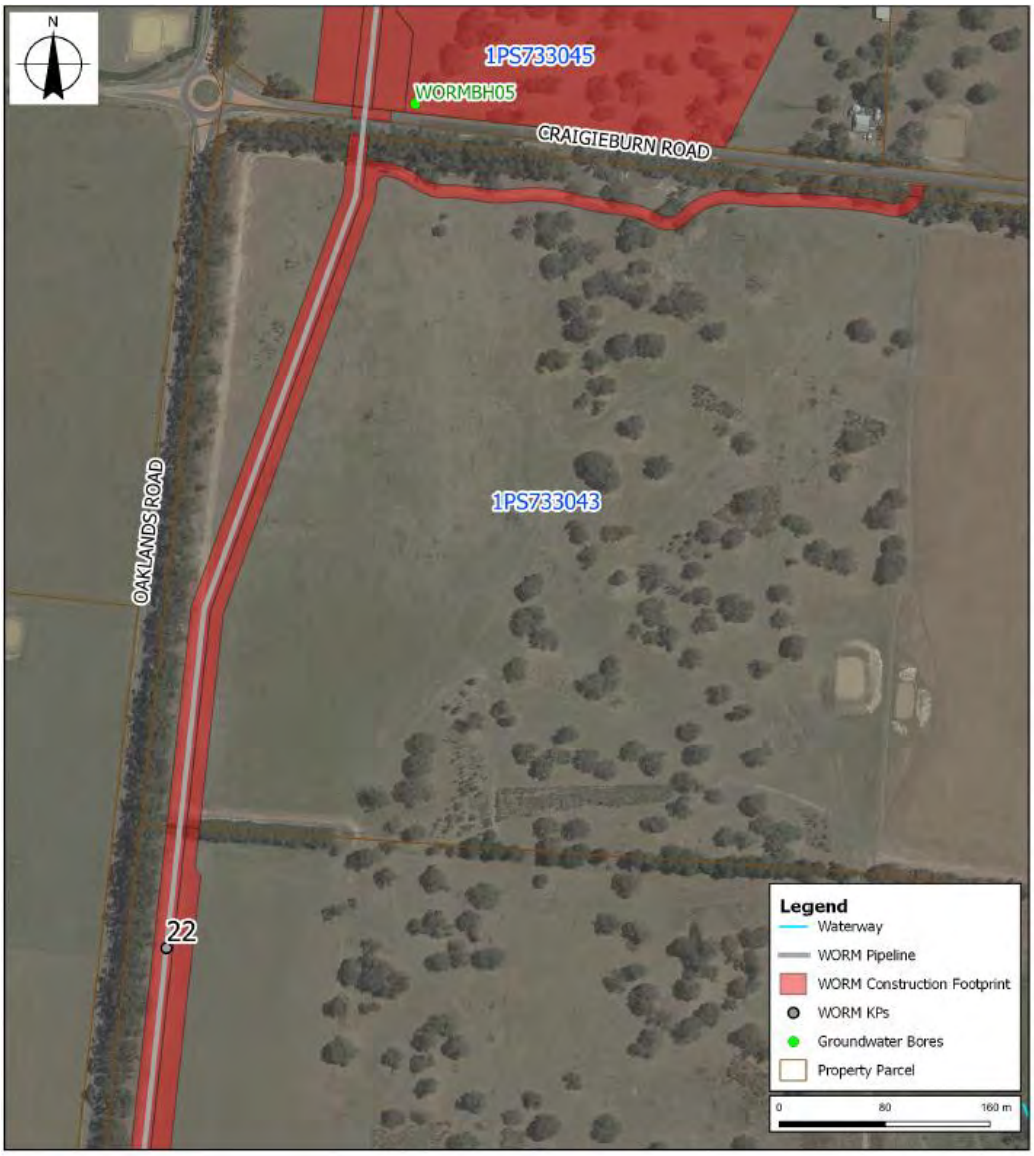


Figure 6-4 Private property south-east of the Craigieburn Road/Oaklands Road/Konagaderra Road intersection

6.3 Tame Street drain (Detailed Assessment)

6.3.1 Waterway Assessment

Tame Street Drain is a natural gully flow path that would be similar to surrounding undisturbed gully drainage lines, but has been directly impacted by urbanisation. The upper catchment extends to Diggers Rest Township and therefore the flow regime will consist of more frequent and higher peak stormwater runoff. This has led to incisions within the invert of the natural flow path, and due to the relatively steep gradient a straightened channelised flow path has formed. The waterway discharges into Jacksons Creek to the southeast and intersects perpendicular with the Project alignment.

No site investigation was undertaken at this location. From google street view images have been captured from the Calder Freeway providing an indication of the existing conditions. Complementing the google street view images, AUAV (Australian Unmanned Aerial Vehicle) captured drone aerial images at each of the main waterway crossing.

Photo	Description
 *Source: Site photo taken (GHD, 2020)*	Tame Street Drain looking upstream from the Calder Fwy – approximately 600 m downstream of the pipeline crossing. Looking North West.
 *Source: Site photo taken (GHD, 2020)*	Tame Street Drain looking downstream from the Calder Fwy – approximately 600 m downstream of the pipeline crossing. Looking South East.

Photo	Description
 Source: *Panosphere Screen Capture (AUAV, 2020)*	Panosphere – Drone aerial imagery looking north east. Upstream of crossing. Red dashed line = Indicative pipeline alignment.
 Source: *Panosphere Screen Capture (AUAV, 2020)*	Panosphere – Drone aerial imagery looking east. Downstream of crossing. Red dashed line = Indicative pipeline alignment.

In terms of the waterway condition in the vicinity of the pipeline crossing, the following is noted:

- The riparian vegetation on both sides of the stream appears to be sparsely vegetated with trees, limited to a dense cover of sedges and grasses along the defined channel. Both banks are open and exposed which could be subjected to grazing activities.
- The crossing location appears to occur where there is ponding within the stream, near a meandering section of the channel noting the presence of scattered deep rooted trees
- The channel appears to be generally stable with no obvious signs of significant active erosion

6.3.2 Streamflow Hydrology

Streamflow data on Tame Street Drain was not obtainable due to there being no gauge station along the waterway. Design flood flows were not available during the desktop assessment for Tame Street Drain. As such, the existing hydrology and estimated flows were based on the RFFE model from ARR2019 for the 1% to 20% AEP events. The method was based on a catchment area of 8.27 km^2 for Tame Street Drain upstream of the pipeline crossing which was estimated through interpreting contours and tributaries. The design flow rates derived from the RFFE model are provided in Table 6-3 for a range of flood events.

6.3.3 Floodplain Management

Melbourne Water did not have any applicable flood mapping information concerning Tame Street Drain. As a result, design flows were estimated using a RFFE model and preliminary hydraulic modelling was completed using HEC-RAS. The HEC-RAS model of Tame Street Drain captures the location of the Project crossing, near cross-section 550.00.

Near the site of interest, the design flow rates, velocities and stream powers are summarised in Table 6-3.

Table 6-3 Tame Street Drain hydraulic results summary table.

AEP	Flow (m^3/s)*	Velocity (m/s)*	Stream Power(Nm^{-2})*
1%	16.9	1.41	53.1
2%	14.0	1.35	48.3
5%	10.4	1.19	34.5
10%	8.2	1.17	35.0
20%	6.0	1.07	28.6
Notes: *Data obtained via HEC-RAS model.			

Design flows were modelled and subsequent flood levels and extents were estimated from HEC-RAS. The modelled channel velocities for the range of design flows do not exceed 2 m/s and the stream powers do not exceed 300 Newton square metre (N m^2) indicating a relatively low potential for stream bed and bank erosion. Flow, Velocity and Stream Power profiles along the modelled reaches are displayed in Appendix E which capture hydraulic changes along the reach.

The HEC-RAS results were interpreted at a representative cross section within the HEC-RAS model nearest to the location of the Project crossing as indicated in Figure 6-5 below.

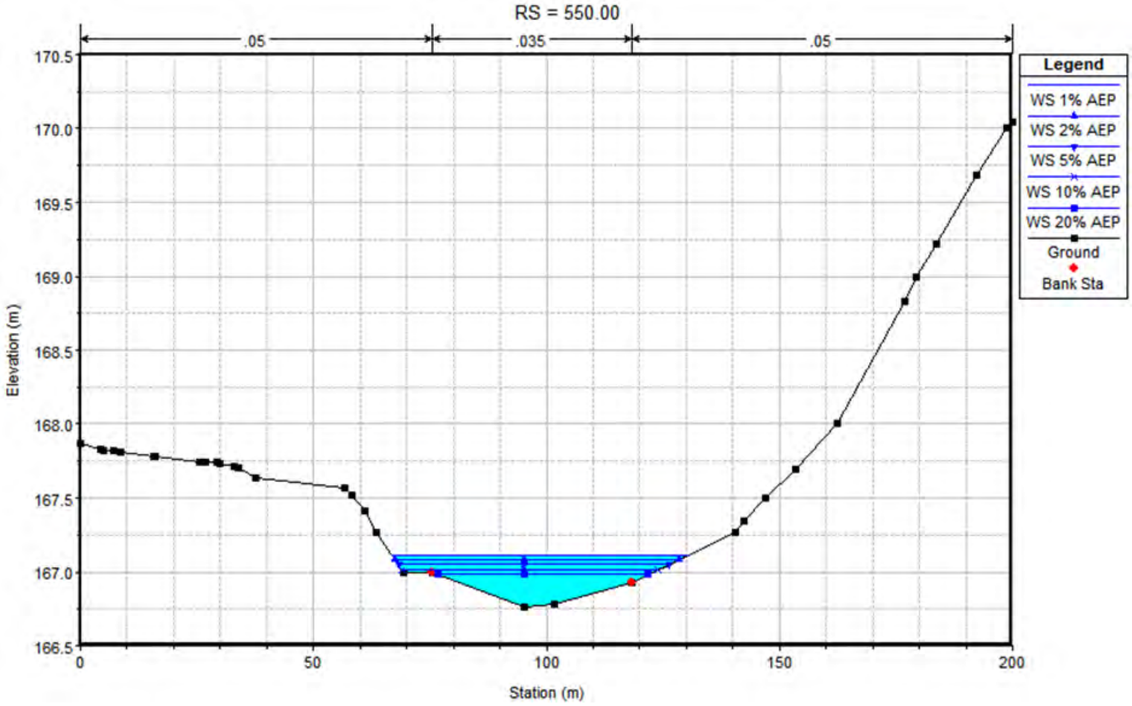


Figure 6-5 Tame Street Drain flood levels at CH 550.00 (5, 10, 20, 50 and 100 year ARI)

The key findings from the interpretation of the estimated flood levels:

- The main channel has a less than 1 in 5 year ARI capacity
- The estimated 1 in 100 year ARI flood level is approximately 167.15 metres AHD (m AHD), and the flood plain is engaged to a width of approximately 65 m

Flood mapping outputs were provided in the MWC data as presented in Figure 6-6.

1:2,500

0 0.02 0.04 0.06 0.08 0.1 km

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 55

N

LEGEND

- Waterway
- 1m Contours
- 100yr ARI Flood Extent
- WORM KPs
- WORM Pipeline
- WORM Construction Footprint

APA VTS Australia
WORM Pipeline
Tame Street Drain - Crossing 3
100yr ARI Flood Extent

Job Number	12529997
Revision	A
Date	04/12/2020

Figure 6-6

\\ghdnet\ghd\AU\Melbourne\Projects\31\12529997\GIS\Maps\Working\Surface_Water_Chapter\Surface Water\Workspace_APA_Pipeline_Clean.qgz

Data Custodian, Data Set Name/Title, Version/Date. Created by: toza

180 Lonsdale St Melbourne VIC 3000 Australia
W www.ghd.com.au E melmail@ghd.com.au T 61 3 8687 8000 F 61 3 8687 8555

6.3.4 Geotechnical Interpretation

Geotechnical bore logs were provided by Construction Sciences at 5 locations near the Tame Street Drain channel and floodplain, as shown in Figure 6-7.

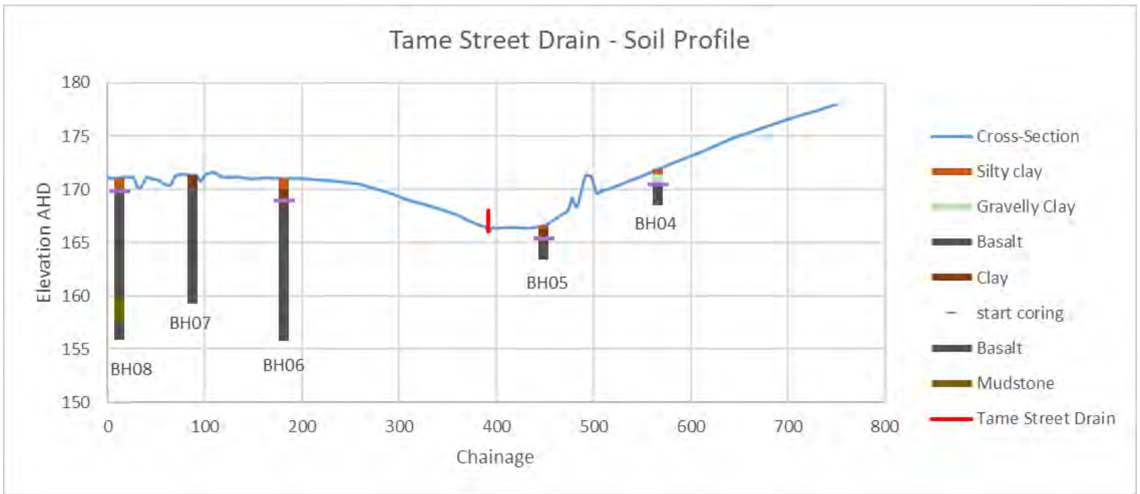


Figure 6-7 Tame Street Drain schematic soil profile cross-section

From the interpretation of the bore logs within the schematic cross sections:

- The soil profile consists of variations of clay for the first one to two metres in all bore holes. Basalt was reached below this point and coring continued for the remainder of the borehole until termination
- Basalt rock occurs shallow (~2 m from natural surface) in profile relative to the natural surface

6.3.5 Summary of detailed assessment

From the detailed assessment of Tame Street Drain, the following is concluded:

- From observed conditions, Tame Street Drain has ephemeral flows that are generally contained within the shallow channel
- The stream condition appears stable, noting there is some minor bed incision within the clay surface layers. The noted stream condition stream velocities and stream powers indicates some potential, albeit relatively low, for erosion
- In larger flood events the flow will spread laterally across the floodplain, with the estimated 1 in 100 year flood level (167.15 m AHD) near the location of interest and engages the floodplain to a width of ~65 m
- Basalt was found at relatively shallow depths (~2 m from natural surface) which would limit the depth of any future bed erosion

6.4 Jacksons Creek (Detailed Assessment)

6.4.1 Waterway assessment

Overview

The Maribyrnong River commences at Bulla where Jacksons Creek and Deep Creek combine, over 10 km downstream of the pipeline crossing. Jacksons Creek was formed on basaltic terrain in the upper plains of the Maribyrnong catchment. In response to volcanic activity and regional uplifting, the waterways in the catchment are typically incised into the basalt resulting in deep valleys and gorges. The stream gradients are controlled by the lithology, and there tends to be steeper gradients associated with basalt. It is noted that the gradient of Jacksons Creek is significantly steeper than Deep Creek projecting from the stream confluence, as indicated in Figure 6-8 below.

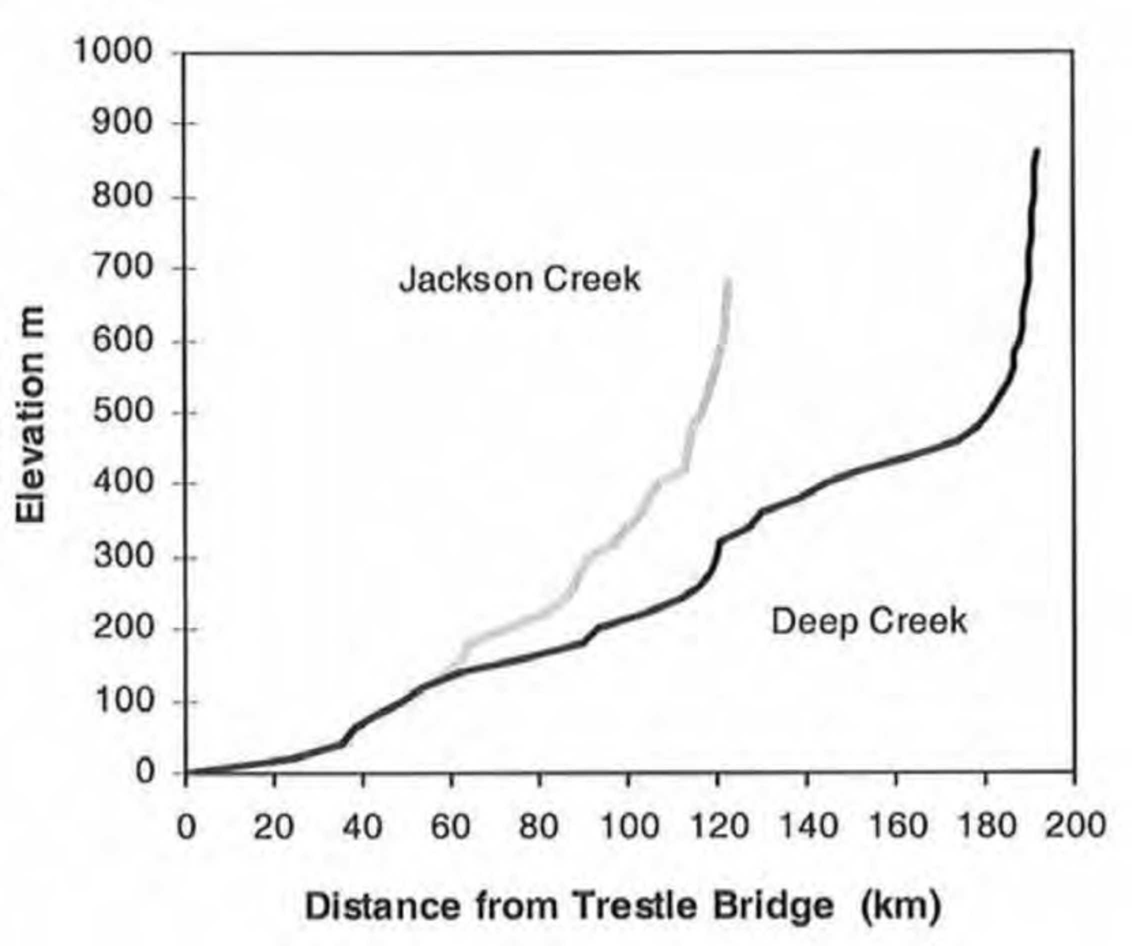


Figure 6-8 Jacksons Creek and Deep Creek Bed Profiles (Gippel & Walsh, 2000)

Site inspection

Jacksons Creek was initially inspected near the location of the pipeline crossing on 23 January 2020 the day immediately following heavy rainfall in the catchment. Complementing the site inspection photos, AUAV captured drone aerial images at each of the main waterway crossing. The photos presented below indicate the pipeline alignment (white stakes).

Photo	Description
 Source: Site photo taken (GHD, 2020)	Jacksons Creek in the background with tributary connection in the foreground. View is looking south.
 Source: Site photo taken (GHD, 2020)	Jacksons Creek crossing and eastern floodplain in the foreground. View is looking south.
 Source: Site photo taken (GHD, 2020)	Jacksons Creek looking immediately downstream of crossing location. View is looking east.

Photo	Description
 Source: Site photo taken (GHD, 2020)	Jacksons Creek looking immediately upstream of crossing location. View is looking west.
 Source: Site photo taken (GHD, 2020)	Ford crossing over basalt rock outcrop observed downstream of the crossing location, directly upstream of the Bulla-Diggers Road crossing (shown in Figure 6-9 as Key Feature 6). View is looking east.
 Source: Site photo taken (GHD, 2020)	Minor Tributary discharging to Jacksons Creek at crossing location looking North. (shown in Figure 6-9 as Key Feature 4)

Photo	Description
 Source: Panosphere screen capture (AUAV, 2020)	Panosphere – Drone aerial imagery Upstream of crossing looking West.
 Source: Panosphere screen capture (AUAV, 2020)	Panosphere – Drone aerial imagery Jacksons Creek looking downstream at crossing location looking East. Red dashed line = Indicative pipeline alignment.

Key observed features/hydraulic controls

A number of key features were identified during the subsequent site inspection on 6 July 2020 in the vicinity of the crossing location, as outlined in Table 6-4. A key hydraulic control was observed approximately 350 m downstream of the crossing location, directly upstream of the Bulla-Diggers Road crossing. The location of this feature is shown in Figure 6-9 as Key Feature 6 and indicated in the longitudinal profile in Figure 6-10. The ford crossing is expected to provide some level of backwater control to the site of interest at the pipeline crossing.

Other relevant features of Jacksons Creek are the meandering sections immediately upstream and downstream of the crossing, tributaries which discharge into waterway and Bulla-Diggers Road bridge structure 400 metres downstream.

Table 6-4 Key features along the waterway in the vicinity of the crossing

Key feature No.	Description
1	200 metre riffle along stream bed
2	300 metre riffle along stream bed
3	Meander with pool in Jacksons Creek
4	Discharging tributary
5	Discharging tributary
6	Ford crossing over basalt rock outcrop (Hydraulic Control)
7	Bulla-Diggers Road crossing and piers

Figure 6-9 Plan view of Jacksons Creek waterway crossing with Key Features.

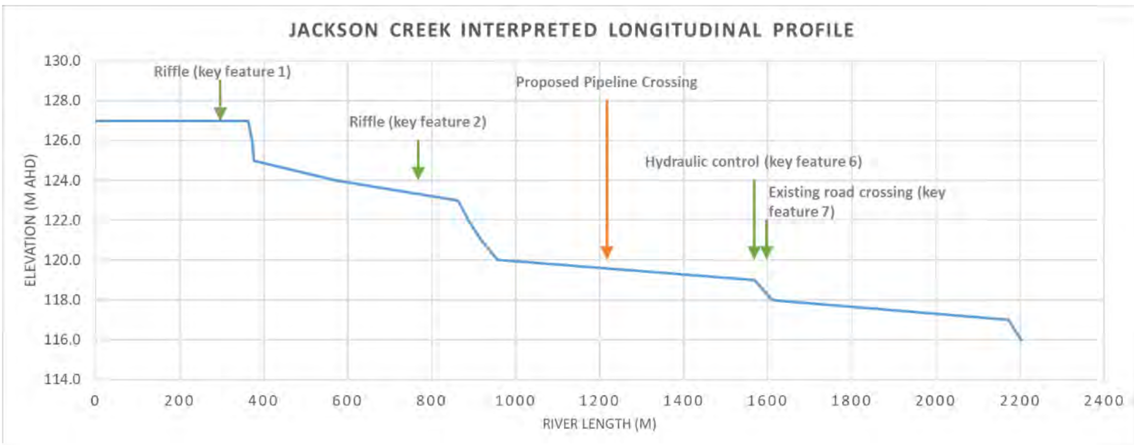


Figure 6-10 Jacksons Creek schematic profile indicating location of pipeline crossing and observed hydraulic control feature

Time series images

Near map images were obtained for Jacksons Creek over a 10 year period, between 2010 and 2020, as shown in Figure 6-11. The time series images below concentrate mainly on the section of Jacksons Creek where the pipeline alignment crosses the waterway.

Figure 6-11 Nearmap images of Jacksons Creek at the crossing location over a 10-year period

On the day of the inspection Jacksons Creek was observed to be fast flowing (near bank full conditions). Immediately upstream was a rock riffle assumed to be placed as a grade control structure in the bed of Jacksons Creek indicating potential previous bed instability.

In terms of the waterway condition at the location and in the immediate reach upstream and downstream of the pipeline:

- Riparian vegetation of the west bank is intact, dense and has a healthy mix of deep rooted trees and ground cover vegetation. The riparian buffer is protected by fencing demarcating the west bank of the waterway. This is evident from both the site photos and aerial imagery captured on Nearmap over a 10 year period
- The east bank is more open and exposed (no immediate fencing) which appears to have been subjected to grazing activities. There is no tree cover and very limited ground storey vegetation
- Within the upstream reach there is sharp meander bend in the creek and some minor erosion of the stream banks was evident. Evident in the Nearmap aerial images (as shown in Figure 37), there is a pool located within the sharp meander which is characterised by deep depths and reduced velocities. A grade rock structure providing protection to the stream bed was observed immediately upstream of the pipeline crossing.
- The crossing location is within a relative straightened reach of stream that continues downstream for at least 200 m before a sharp meander bend
- The two sections of riffles, key feature 1 and 2, upstream of the crossing are characterised by shallow depths with fast, turbulent water agitated by rocks and vegetation. The short segments of riffles have a relatively steep drop in elevation while also widening out the cross section of the channel
- Beneficial Uses downstream may include water dependent ecosystems and species, agriculture and irrigation, water-based recreation (aesthetic enjoyment) and Traditional Owner cultural values

6.4.2 Geomorphology assessment

Geomorphic Development

The construction corridor lies within the easternmost part of the Western Plains geomorphic province of Victoria. The area is characterised by multiple, elevated, Quaternary basalt volcanic eruption points, that protrude above extensive lava shields produced by repeated volcanic episodes over the last c.8Ma (Heath et al., 2020). The Maribyrnong catchment including Deep Creek and Jacksons Creek, contains a deeply incised network of rivers and streams covering 1406 km2 west of Melbourne (Gippel and Walsh, 2000; Joyce et al., 2003). The lava shields, alluvial terraces and modern streambeds provide temporal constraints on the rates and timings of incision and deposition within the Maribyrnong catchment.

Heath et al. (2020)'s map suggests that Jacksons Creek at W6,7,8 is probably incised into c. 4Ma basalts of the Springs Hill / Redstone Hill Flow, as shown in Figure 6-12.

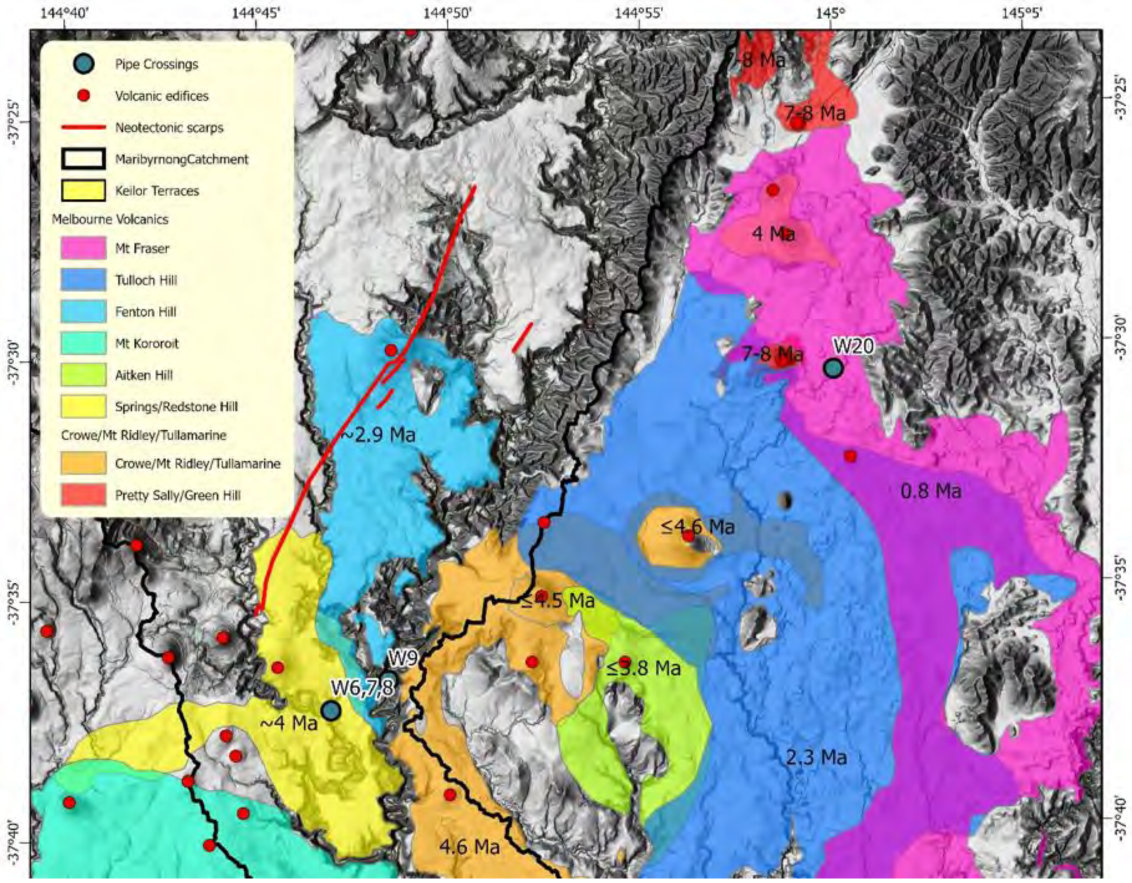


Figure 6-12 Map of Melbourne lava flows by age (based on Heath et al, 2020)

The primary neotectonic structure close to the alignment is the Clarkfield Scarp, a nine metre high scarp that crosses Jacksons Creek and displaces ~4 Ma basalts, ~10.5 km upstream from the pipeline alignment across the creek.

Catchment Scale Geomorphology

On a catchment scale, the gradient of Jacksons Creek is fairly consistent, apart from a marked convex profile anomaly as the creek crosses the neotectonic Clarkefield scarp (Figure 6-13). It is not clear whether this indicates differential lithological control, or whether it is the product of neotectonic derangement. Shorter wavelength gradient anomalies appear to reflect the upstream and downstream sides of meander bends, with generally steeper gradients on the downstream side. The pipeline crossing is in a slightly lower gradient section indicating it is likely to be erosional at the downstream end of the reach and depositional at the upstream end.

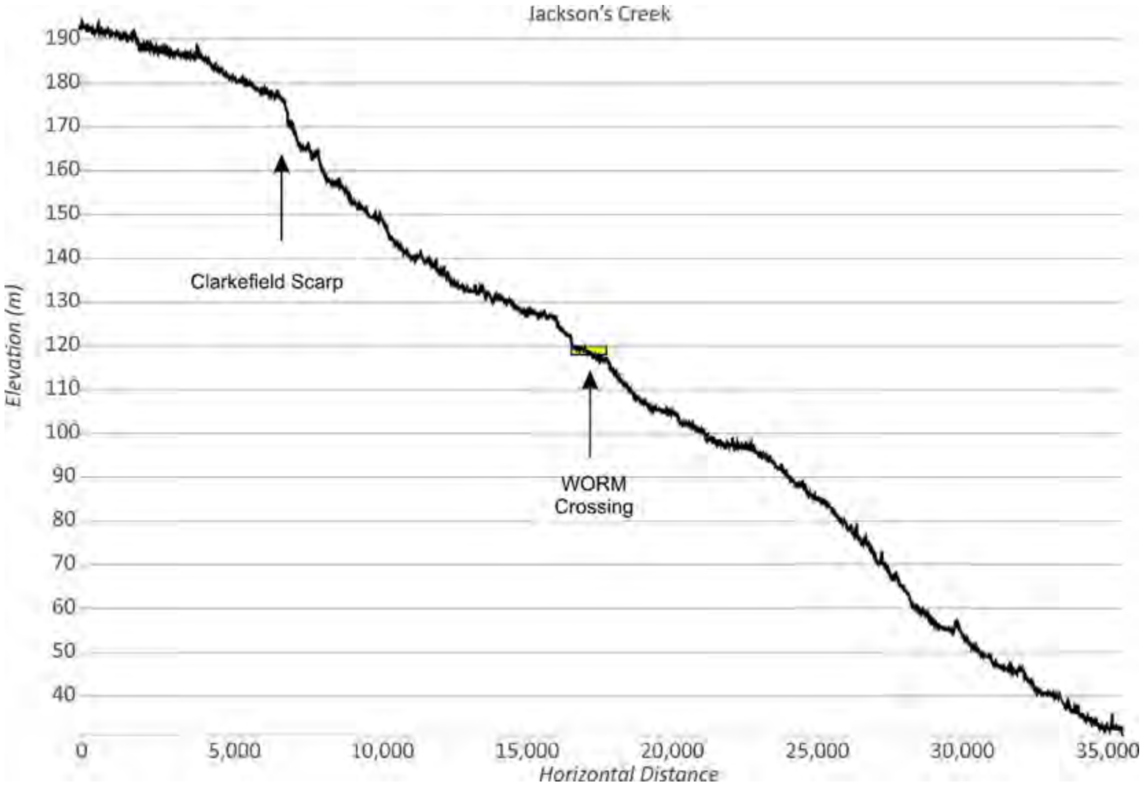
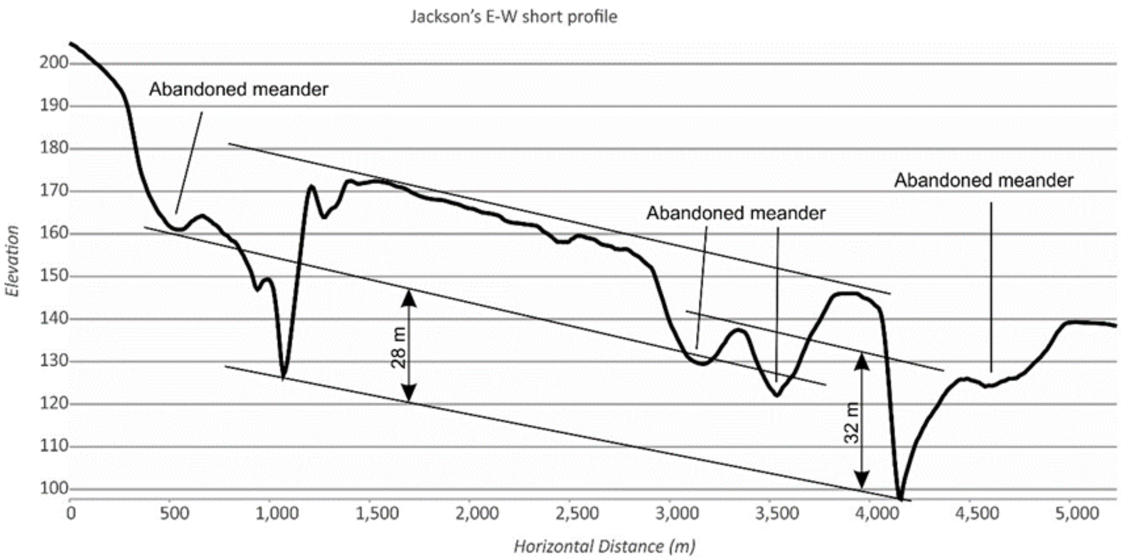


Figure 6-13 Jacksons Creek Stream Bed Profile

The width of the incision into the lava shield is commonly ~500 m wide, and the confining width of the channel at the base of the incised valley is variable from 100-200 m. The width of the active channel appears reasonably consistent at c.10 m wide and c.3-5 m deep.

A sequence of abandoned meanders are occasionally found at 25-35 m above the main channel and roughly similar elevation below the main lava shield (Figure 6-14). One of these is located 1 km upstream of the pipeline crossing.



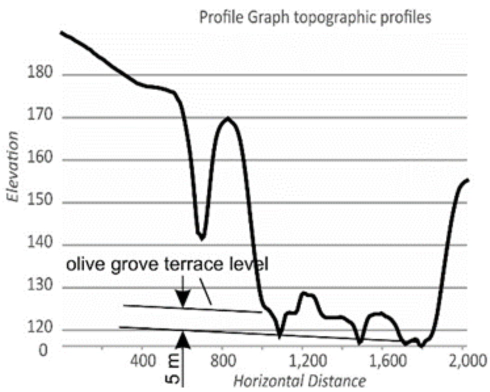


Figure 6-14 Profiles at Jacksons Creek showing levels of major terraces and abandoned meanders

Immediately above the level of the main channel, scraps of alluvial terraces can be found in many places along the river. The majority of these are located at 5 m above the base of the channel, a slightly lower elevation relative to the main channel compared with the lowest (mid-Holocene terraces at Keilor). Incision of these terraces may have occurred much more rapidly initially, after which the incision became controlled by bedrock outcrop in the channel, such as at the ford.

Reach Scale Geomorphology

The Jacksons Creek crossing occurs on an east-west reach of the creek, and the immediate vicinity of the crossing is underlain by alluvium on both sides of the river.

A geomorphological map is provided of Jacksons Creek near the crossing location in Figure 6-15.

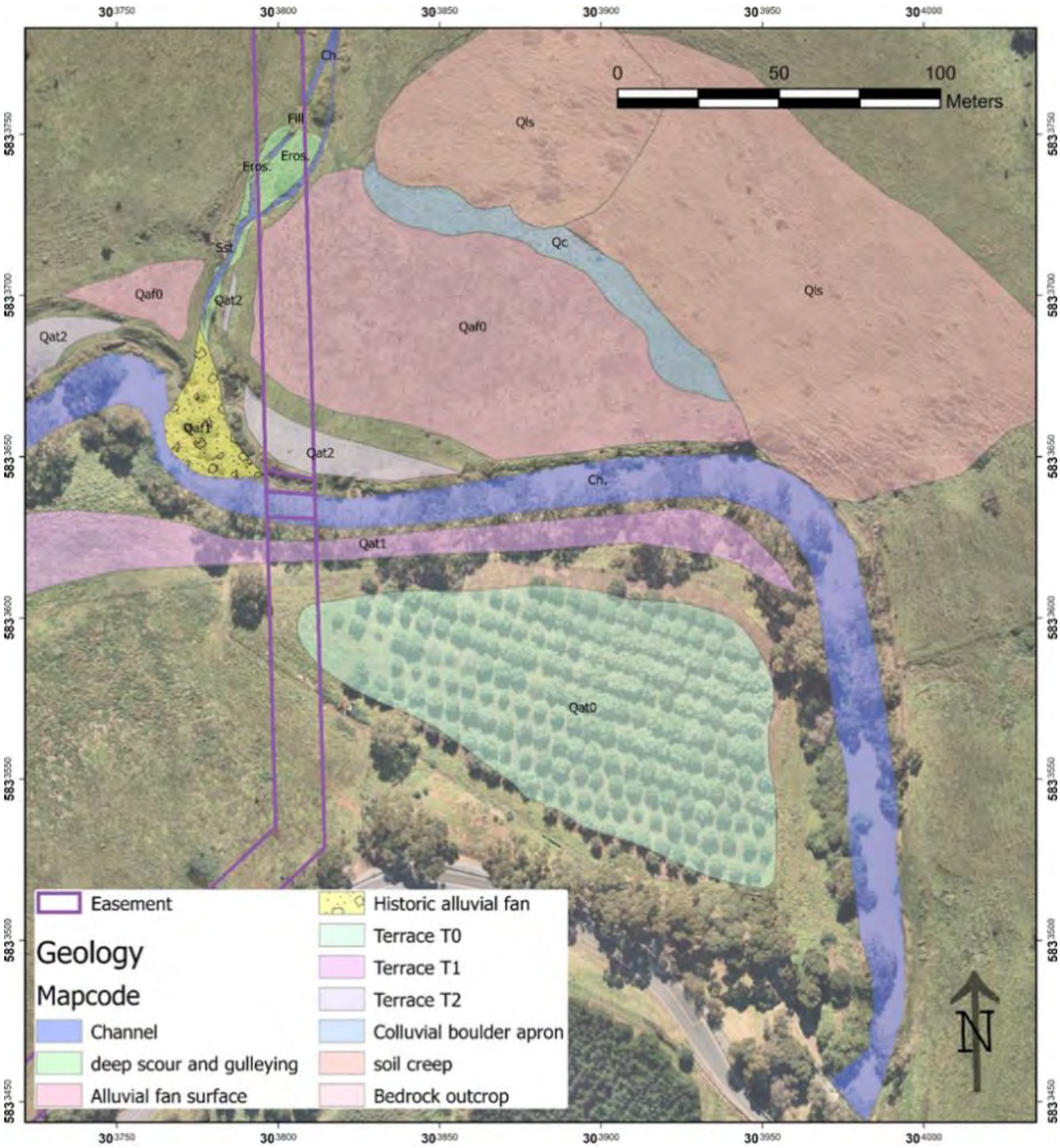


Figure 6-15 Geomorphological map of Jacksons Creek near crossing location

Jacksons Creek has incised through alluvial terraces to a base level that is possibly presently controlled by the ford crossing located about 300 m downstream of the alignment. As noted above the profile is convex towards the downstream end of the alignment reach (essentially at the ford crossing) and therefore is likely to be higher erosion potential downstream, and more likely to be depositional upstream. The ford crossing is located on a natural basalt outcrop control. Any erosion head located downstream migrating upstream will be halted by the basalt outcrop. The river currently abrades hard rock in some locations within the upstream alignment reach, including a series of rock outcrop drops within the alignment gully and at the outside meander bend immediately upstream of the of the pipeline alignment.

Whilst the location of the ford is on a basalt rock outcrop and there appears to be other locations of exposed basalt rock location, the geotechnical information near the waterway encountered no basalt and several metres of alluvial gravel and sand over weathered bedrock.

It is possible the alluvium at depth may represent a paleochannel of the modern Jacksons Creek, from which it has been deflected by the gulley fan. More likely the presence of basalt at stream level at the ford suggests that the gravel intersected in the borehole may be Mio-Pliocene in age and this alluvium might be interpreted as the Mio-Pliocene fluvial sediments of the Brighton Group. This is consistent with the Sunbury geological map indicated in Figure 6-16, which shows basalt to river level in this area, probably infilling a paleochannel eroded into Ordovician and Silurian sedimentary rocks. There are possible implications if the Brighton Group sediments form the substrate of the channel or underlie the terraces along the alignment and these will be expected to be more vulnerable to scour once disturbed.

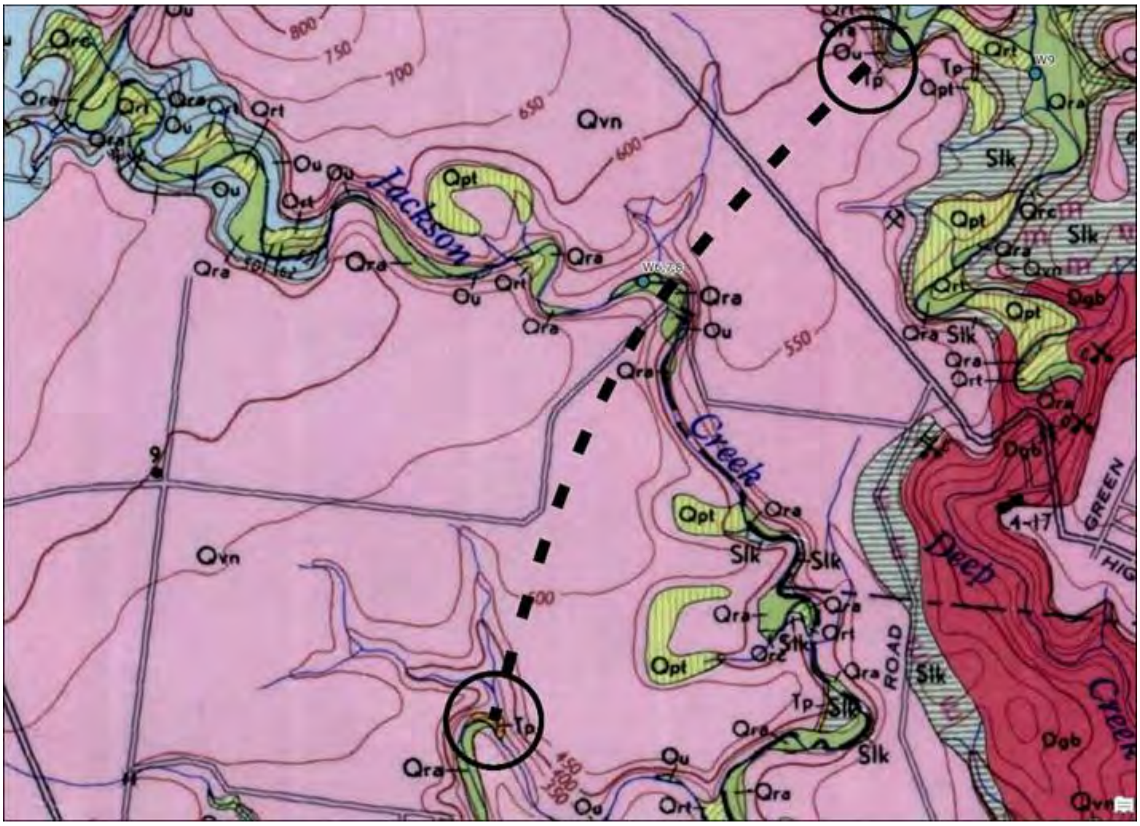


Figure 6-16 Sunbury Geological map of Brighton Group Gravels

The major feature of the alignment area is the presence of alluvial terraces on both sides of the stream. In order of elevation these are:

- On the north side of the stream, as shown in Figure 6-17, the main expanse of terrace slopes up toward the mouth of the alignment gulley and is probably developed on an alluvial fan that has built out of the gulley
- A lower terrace is eroded up to 2 m into the margins across much of the site and tapers out approximately where the alignment crosses the stream and is inset into Qaf0. This terrace will be engaged during moderate flow events, and appears to represent the short-wavelength meandering on the upstream side of the alignment gully.
- A small boulder fan has built out into Jacksons Creek at the mouth of the alignment gulley. Finer sediments may have been removed over time leaving protruding ~400 mm rocks that give the appearance of a placed armoured bank

Figure 6-17 Terrace on north side of the waterway

Comparison of aerial photographs suggests that the alignment has not changed and the 'boulder fan' has been present since at least 1974, as indicated in Figure 6-18.

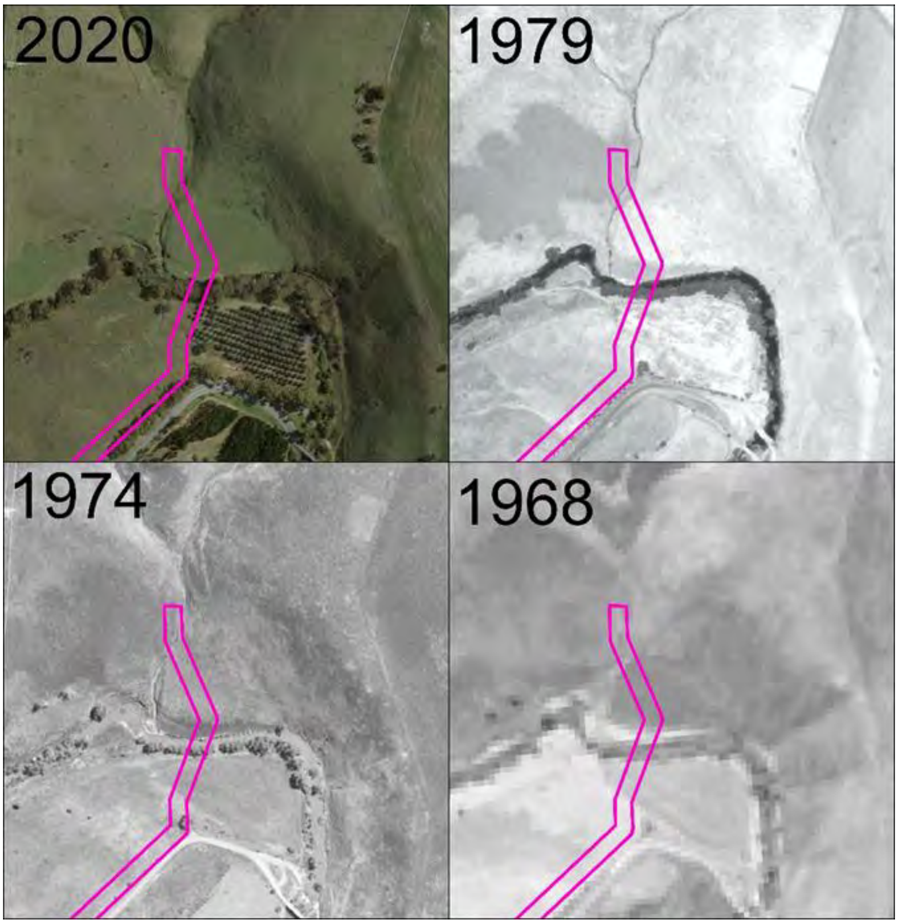


Figure 6-18 Historical Aerial Photos

The left stream bank on the immediate upstream side of the alignment gulley and boulder fan shows exposed sediments and a steep bank. Although this seems like severe erosion, the position of the bank has also changed little in 40 years based on comparison of aerial photographs.

The upstream reach appears to be relatively passive flow due to the hydraulic control of the boulder fan, which has narrowed the stream and formed the rock riffle where there is the increase in flow velocity as shown in Figure 6-19.

Figure 6-19 Historical Aerial Photos highlighting Boulder Fan

6.4.3 Streamflow hydrology

Streamflow data on Jacksons Creek was obtained at Sunbury gauging station. This is located 12 km upstream of the site of the crossing. The period of record at this gauge station is from November 2003 to June 2019.

From Figure 6-20 and Figure 6-21 below, the mean annual flow is 0.1 m^3/sec, and the mean summer-autumn flow is 0.06 m^3/sec.

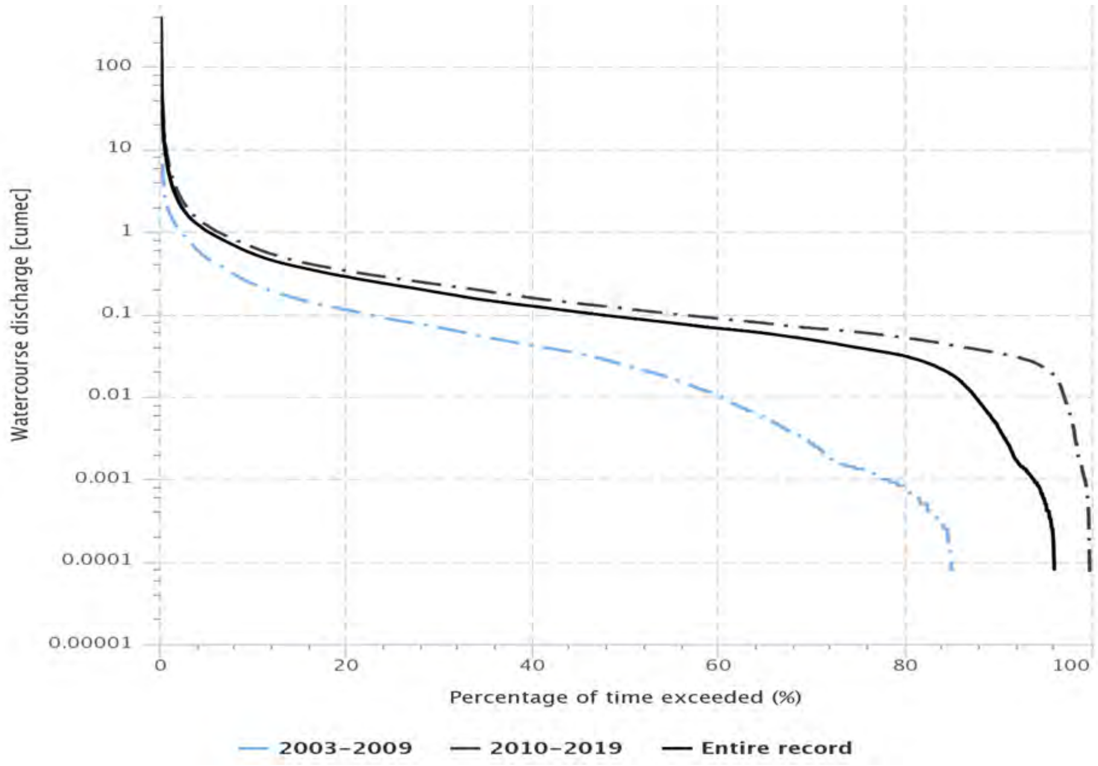


Figure 6-20 Jacksons Creek - Flow Duration Curve

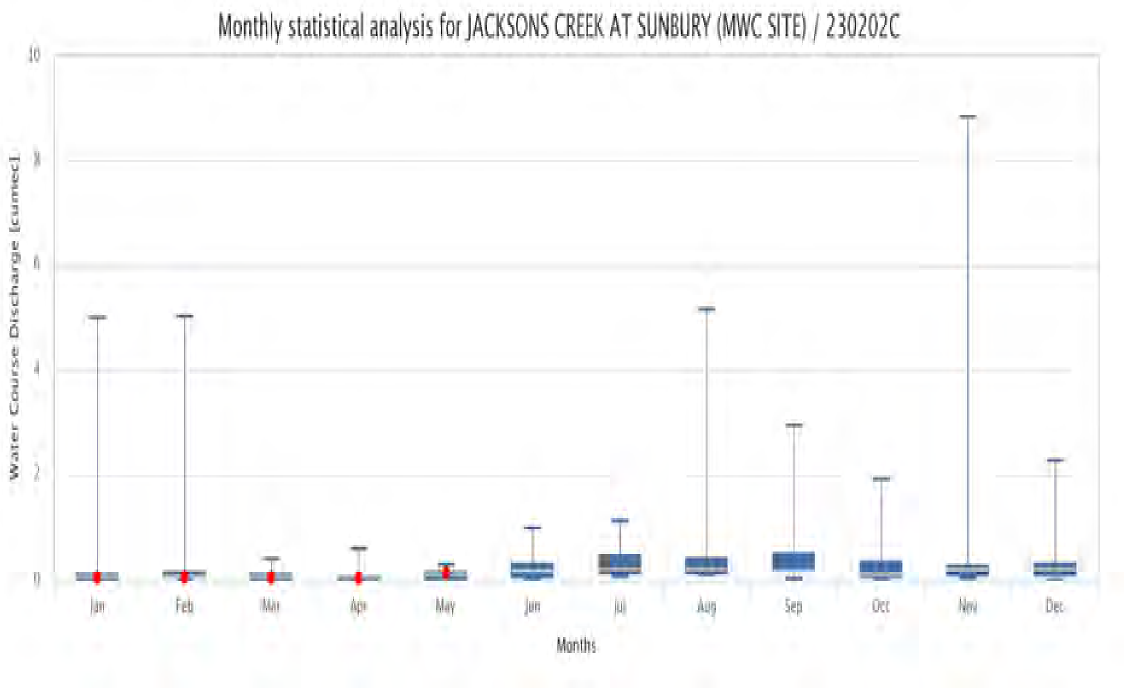


Figure 6-21 Jacksons Creek gauge station - Monthly data.

MWC provided design flood flows for Jacksons Creek and these are outlined in the section below.

6.4.4 Floodplain management

MWC provided a flood mapping report (*Jacksons Creek Flood Mapping – Technical Report*) on Jacksons Creek detailing the modelling completed by MWC in 2013. The construction corridor covers a 22.2 km section of Jacksons Creek, finishing approximately 7.7 km upstream of the Maribyrnong River confluence. The extent of flood mapping captures the Project crossing at cross-section 11,033.05. The modelling software used for the flood-mapping project was RORB, 12D and HEC-RAS, and the results were used for the detailed analysis.

Near the site of interest, the design flow rates, velocities and stream powers are summarised in Table 6-5 below.

Table 6-5 Jacksons Creek hydraulic results summary table.

AEP	Flow (m^3/s)*	Velocity (m/s)*	Stream Power(Nm^{-2})*
1%	420	2.54	340
2%	335	2.43	310
5%	226	2.22	246
10%	153	2.00	91
Notes: *Data obtained via HEC-RAS model.			

Design flows and subsequent flood levels and extents for the 1% to 10% AEP events were adopted from the previous flood-mapping project using HEC-RAS. The channel velocities for the range of design flows exceed 2 m/s, and the stream powers exceed 300 N m^2. These velocities and stream powers indicate a relatively high potential for stream bed and bank erosion. Given the steep gradient of the channel within this reach and steepening of the gradient moving further upstream form the Maribyrnong confluence, there is a higher erosion potential for Jacksons Creek compared to Deep Creek. Flow, Velocity and Stream Power profiles along the modelled reaches are displayed in Appendix E which capture hydraulic changes along the reach.

The design flows were modelled in HEC-RAS and results interpreted at a representative cross section within the HEC-RAS model nearest to the location of the Project crossing as indicated in Figure 6-22 below.

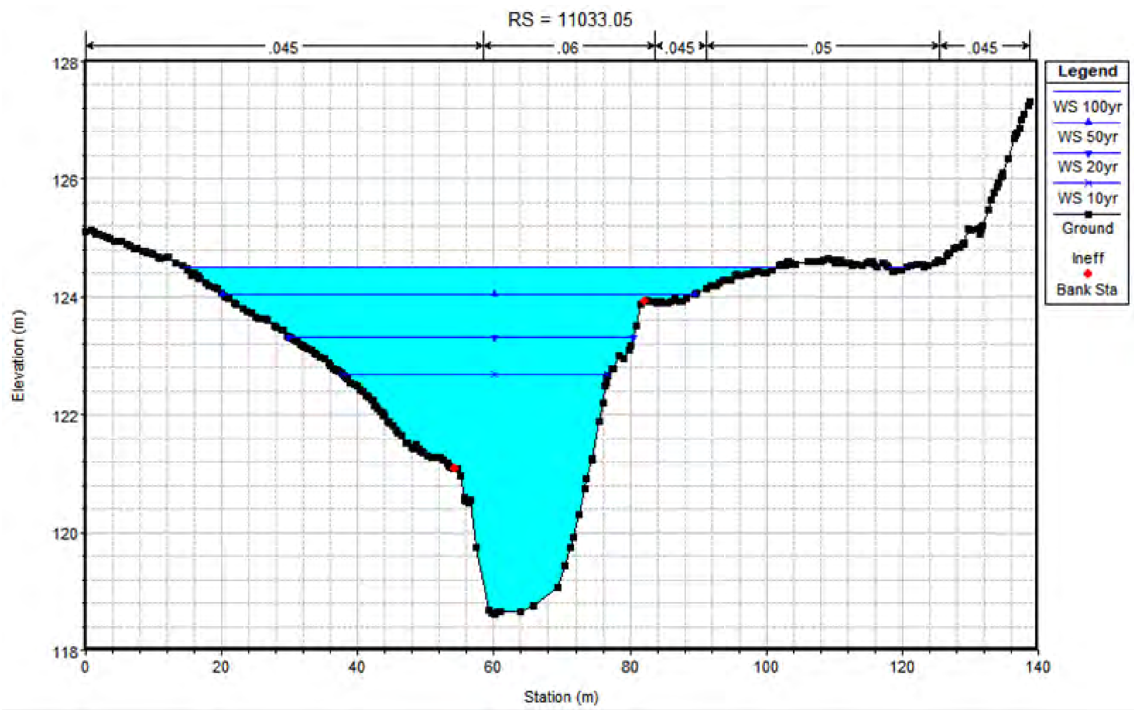
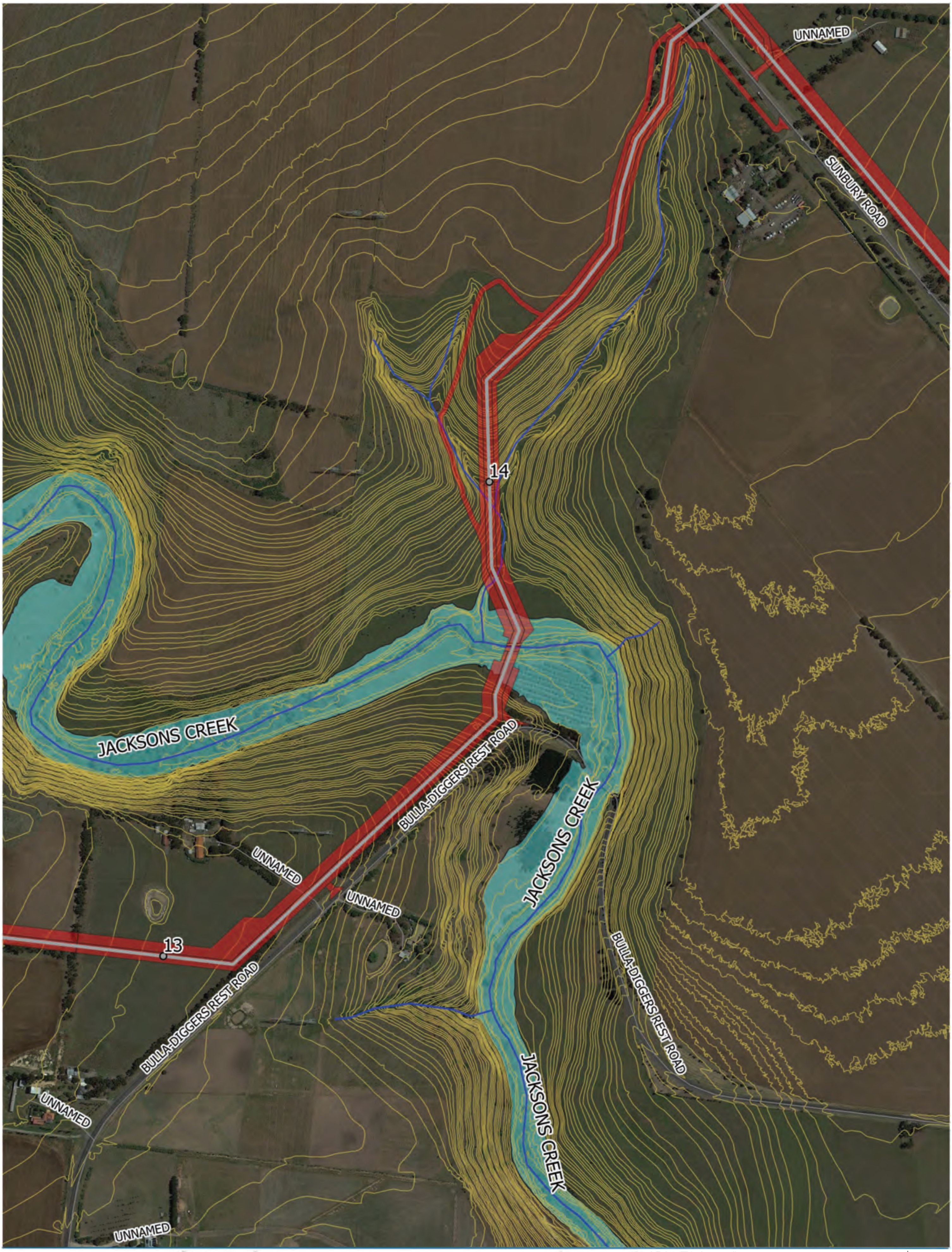


Figure 6-22 Jacksons Creek flood levels at CH 11033.05 (10, 20, 50 and 100 year ARI)

From the interpretation of the estimated flood levels:

- The main channel has a less than 1 in 10 year ARI capacity
- The estimated 1 in 100 year flood level is approximately 124.5 m AHD, and starts to spill into the floodplain terrace

Flood mapping outputs were provided in the MWC data as presented in Figure 6-23 below.



1:5,000

0 0.04 0.08 0.12 0.16 0.2 km

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 55

N

LEGEND

- Waterway
- 1m Contours
- 100yr ARI Flood Extent
- WORM KPs
- WORM Pipeline
- WORM Construction Footprint

APA VTS Australia
WORM Pipeline

Job Number	12529997
Revision	A
Date	04/12/2020

Jacksons Creek - Crossing 7
100yr ARI Flood Extent

Figure 6-23

\\ghdnet\ghd\AU\Melbourne\Projects\31\12529997\GIS\Maps\Working\Surface_Water_Chapter\Surface Water\Workspace_APA_Pipeline_Clean.qgz

Data Custodian, Data Set Name/Title, Version/Date. Created by: toza

180 Lonsdale St Melbourne VIC 3000 Australia
W www.ghd.com.au E melmail@ghd.com.au T 61 3 8687 8000 F 61 3 8687 8555

6.4.5 Additional waterways included in assessment

The assessment of Jacksons Creek includes waterway crossing 8 the unnamed tributary which discharges into Jacksons Creek at the Project crossing. The initial assessment of the gully tributary highlighted a high erosional risk due to a high stream velocity (> 3 m/s which exceeds the threshold of 2.0 m/s). The terrain of the tributary catchment is relatively steep as it runs south of Sunbury Road and intersects the pipeline with a river grade of 1 in 10 at the pipeline crossing.

The gully is crossed by a ford formed from boulders and soil, noticed during the site inspection as shown in Figure 6-24. Some erosion is evident on the downstream side of the ford, with deep potholes and large exposed boulders. This may be part of the original gully fan evident in Jacksons Creek, or be sourced from higher up the gully or from the ford itself. There is an ongoing risk of continued head ward erosion of the gully that will need to be considered.

Figure 6-24 Unnamed tributary waterway crossing on steep terrain

6.4.6 Geotechnical interpretation

Geotechnical bore logs were obtained by Construction Sciences at 3 locations near the Jacksons Creek channel and floodplain. The bore logs based on their coordinate locations have been interpreted on a schematic cross section interpreted from LiDAR which can be seen in Figure 6-25 below. The bore logs have been projected from the natural surface levels to their indicated depths.

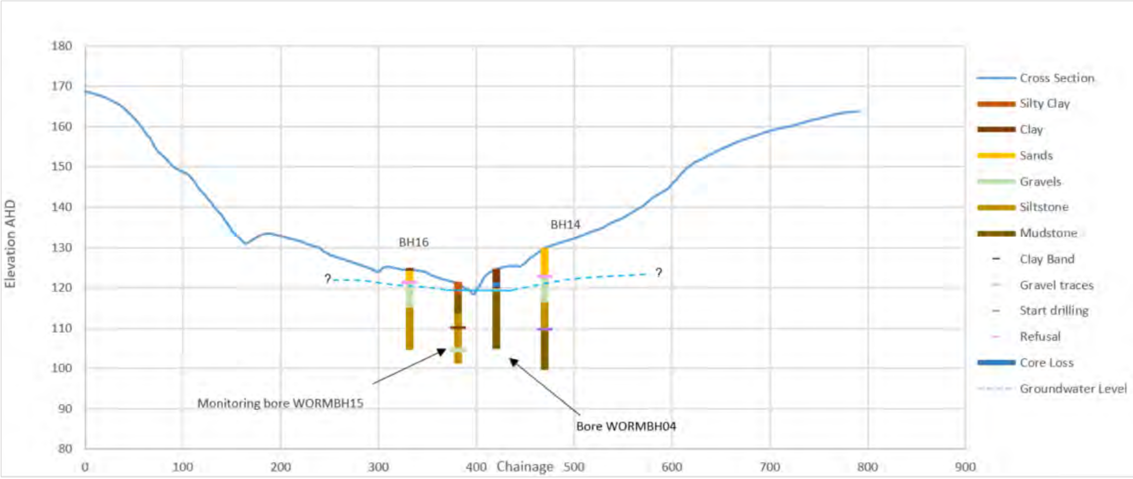


Figure 6-25 Jacksons Creek schematic soil profile cross-section

Derived from interpreting the bore logs within the cross section:

- The soil profile typically consists of various layers of sands, gravels and silty clays in the upper profiles
- The lower profiles (below depths of 8-13 metres) consist of a mixture of siltstone and mudstones and continued for the remainder of the borehole until termination
- No basalt rock was encountered

6.4.7 Water Quality and Beneficial Uses

Water quality data upstream of the pipeline crossing was collected from the Jacksons Creek @ Sunbury (230202) gauge. This data was combined with Melbourne Water gauge, MADEE0868. the two gauges measure different water quality parameters but are located at the same site. Water quality statistics for the gauge upstream of the pipeline crossing is presented in Table 6-6. The gauge is approximately 7.5 km upstream from the proposed pipeline and the samples were collected between 1990 and 2020.

Water quality samples from Jacksons Creek at Sunbury exceeded the guideline values for turbidity, nitrate, oxidised nitrogen, filtered reactive phosphate, total phosphorous, chromium, copper, lead, nickel and zinc.

It should be noted that between the gauge and the pipeline is Sunbury Water Treatment Plant. Discharge from this plant is likely to influence water quality in Jacksons Creek near the pipeline.

Water quality statistics for the Jacksons Creek at Organ Pipes National Park, located approximately 11 km downstream of the proposed pipeline is presented in Table 6-7. The results were similar to the upstream site. The samples were collected between 2010 and 2020. The water quality samples exceeded the guideline values for turbidity, nitrate, filtered reactive phosphate, total phosphorous, chromium, copper, lead, nickel and zinc. They also exceeded the guidelines for total nitrogen.

Data from the Maribyrnong River at Keilor is presented to indicate water quality data further downstream (16 km) of the pipeline crossing (Table 6-8). The data were collected between 1977 and 1999. This gauge is located below the confluence where Jacksons and Deep Creeks converge to become the Maribyrnong River.

Like the upstream gauge, water quality from the Maribyrnong River gauge also exceeded the guideline values for oxidised nitrogen, filtered reactive phosphate, chromium and copper. It should be noted, there was only one data point for chromium and for copper. Unlike the upstream sites, nickel, lead and zinc were below the guideline values. Additionally, total phosphate exceeded the SEPP guideline value and pH was slightly above the guideline value.

There are several possible sources for the non-compliant parameters:

- The elevated nitrogen and phosphate concentrations may be caused by natural sources (e.g. from bacteria or minerals) as well as by human sources (e.g. eroded soil, stormwater runoff and discharges from urban areas, agriculture and the Sunbury Water Treatment Plant.)
- The sources of the elevated metals (e.g. chromium, copper, lead, nickel and zinc) may be natural (from the weathering or rocks and soils) or non-natural (e.g. from agricultural runoff and runoff from urban and industrial areas). The toxicity and bioavailability of metals in rivers is influenced by pH, dissolved oxygen and organic carbon levels. That is, the metals may be present in the stream but not in a form that is available to organisms.
- Turbidity is a measure of the clarity of water. The non-compliant turbidity may be a result of streambank erosion or agricultural runoff upstream
- Changes in pH are also influenced by natural causes as well as by human activity. The pH of waterbodies is influenced by geology, soils, salinity, rainfall and by aquatic organisms such as plants and algae. Human activities which influence pH include changes to the hydrology of rivers, discharges from urban areas and emissions from car exhausts, which react with molecules in the air and lower the pH of rain.

It should be noted that non-compliance with guidelines does not necessarily indicate poor environmental health. ANZG (2018) states that guidelines are concentrations that, if exceeded, would trigger a management response, such as the refinement of the guidelines according to local conditions. ANZG (2018) also recommend that ideally site-specific guideline values that are relevant to local conditions or situations should be used. Given the statistics for some water quality parameters presented in Table 6-6, Table 6-7 and Table 6-8 exceed the relevant SEPP (Waters) and ANZG (2018) guidelines, it is recommended the statistics in the tables below be used to evaluate changes in water quality, as they better reflect the existing water quality in the region.

Table 6-6 Water quality statistics – Jacksons Creek at Sunbury. Pale blue shading indicates samples exceed guideline value

Parameter	Number of samples	min	median	mean	max	25th %ile	75th %ile	SEPP	ANZG
DO (% sat)	129	38.0	88.0	85.3	121.9	78.9	93	25%≥75, max=130	
DO (mg/L)	129	3.2	8.5	8.5	11.24	7.1	10.08		
EC (µS/cm)	129	230.0	610.0	622.6	1,200.0	540	700	75%≤2000	
Turbidity (NTU)	322	1.4	13.0	28.8	470.0	6.5	30	75%≤25	
Water Temperature (°C)	323	5.5	15.0	15.0	27.1	10.5	19		
pH	312	5.4	7.6	7.5	9.2	7.2	7.7	25%≥6.8, 75%≤8.0	
Sus. Solids (mg/L)	129	1.0	10.0	18.1	200.0	6	18		
Ammonia (mg/L)	129	0.001	0.021	0.03	0.14	0.01	0.039		Max≤0.9
NO_2 (mg/L)	336	0.001	0.02	0.1	1.6	0.004	0.09		
NO_3 (mg/L)	129	0.0	0.061	0.2	3.4	0.017	0.2		Max≤0.7
NO_2 + NO_3 (mg/l)	207	0.003	0.06	0.15	1.6	0.02	0.155		Max≤0.04
Kjeldahl Nitrogen (mg/L)	341	0.15	0.69	0.8	2.5	0.57	0.84		
Total Nitrogen (mg/L)	72	0.43	0.765	1.0	3.8	0.6575	1.1	75%≤1.1	
Phosphate - Filtered (mg/L)	129	0.0015	0.005	0.0	0.075	0.0015	0.009		Max≤0.02
Total P (mg/L)	341	0.008	0.04	0.1	0.43	0.03	0.07	75%≤0.06	
As - total (mg/L)	133	0.0005	0.001	0.001	0.005	0.0005	0.002		Max≤0.013
Cd - total (mg/L)	142	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001		Max≤0.0005
Cr - total (mg/L)	142	0.0005	0.001	0.002	0.025	0.0005	0.002		Max≤0.0004
Cu - total (mg/L)	142	0.0005	0.002	0.003	0.03	0.001	0.003		Max≤0.0014

Parameter	Number of samples	min	median	mean	max	25th %ile	75th %ile	SEPP	ANZG
Pb - total (mg/L)	142	0.0005	0.0005	0.001	0.008	0.0005	0.001		Max≤0.0034
Ni - total (mg/L)	142	0.0005	0.002	0.003	0.012	0.002	0.004		Max≤0.011
Zn - total (mg/L)	142	0.002	0.007	0.010	0.072	0.005	0.011		Max≤0.008
E. coli MF (orgs/100mL)	32	10.0	220.0	806.9	9,200.0	120	400		
E.coli MPN (orgs/100mL)	97	5.0	160.0	461.8	6,900.0	98	280		

Blue shading indicates non-compliance with either SEPP or ANZG guideline value

Table 6-7 Water quality statistics – Jacksons Creek at Organ Pipes National Park

Parameter	Number of samples	min	median	mean	max	25th %ile	75th %ile	SEPP	ANZG
DO (% sat)	115	43.6	89.9	86.0	101.9	79.1	94.05	25%≥75, max≤130	
DO (mg/L)	115	3.88	8.69	8.7	11.45	7.2	10.355		
EC (µS/cm)	115	370.0	690.0	701.8	1,100.0	600	800	75%≤2000	
Turbidity (NTU)	115	3.1	19.0	44.9	440.0	7.95	45	75%≤25	
Water Temperature (°C)	115	7.5	16.0	15.6	29.5	10.8	19.95		
pH	115	7.3	7.9	7.9	8.9	7.7	8	25%≥6.8, 75%≤8.0	
Sus. Solids (mg/L)	115	1.0	11.0	19.8	210.0	7	21		
Ammonia (mg/L)	115	0.001	0.011	0.0	0.1	0.005	0.019		Max≤0.9
NO_2 (mg/L)	115	0.001	0.003	0.0	0.022	0.001	0.005		
NO_3 (mg/L)	112	0.0015	0.385	0.440	2.8	0.02625	0.67		Max≤0.7
Kjeldahl Nitrogen (mg/L)	115	0.46	0.77	0.9	2.5	0.63	0.885		
Total Nitrogen (mg/L)	66	0.56	1.1	1.3	3.5	0.7625	1.6	75%≤1.1	
Phosphate - Filtered (mg/L)	115	0.0015	0.013	0.0	0.053	0.0075	0.0255		Max≤0.02
Total Phosphorus (mg/L)	115	0.017	0.068	0.1	0.24	0.041	0.12	75%≤0.06	
As - total (mg/L)	115	0.0005	0.001	0.001	0.004	0.0005	0.002		Max≤0.013
Cd - total (mg/L)	115	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		Max≤0.0005
Cr - total (mg/L)	115	0.0005	0.001	0.003	0.021	0.0005	0.003		Max≤0.0004
Cu - total (mg/L)	115	0.0005	0.002	0.002	0.009	0.001	0.003		Max≤0.0014
Pb - total (mg/L)	115	0.0005	0.0005	0.001	0.009	0.0005	0.001		Max≤0.0034

Parameter	Number of samples	min	median	mean	max	25th %ile	75th %ile	SEPP	ANZG
Ni - total (mg/L)	115	0.002	0.004	0.004	0.014	0.003	0.005		Max≤0.011
Zn - total (mg/L)	115	0.002	0.006	0.009	0.072	0.004	0.01		Max≤0.008
E. coli MF (orgs/100mL)	28	40.0	80.0	314.1	2,400.0	60	230		
E.coli MPN (orgs/100mL)	87	10.0	120.0	259.0	8,200.0	68	215		

Blue shading indicates non-compliance with either SEPP or ANZG guideline value

Table 6-8 Water quality statistics – Maribyrnong River at Keilor

Parameter	Number of samples	min	median	mean	max	25th %ile	75th %ile	SEPP	ANZG
DO (ppm)	269	3.6	9.2	8.8	13.9	7.3	10.4		
EC (µS/cm)	282	51	1200	1276.5	8600	732.5	1600	75%≤2000	
Turbidity (NTU)	278	0.6	5.55	22.80	370	2.6	21.6	75%≤25	
Water Temperature °C)	282	4.5	15.5	15.4	28	10.5	19.5		
pH	267	5.8	7.7	7.7	8.8	7.5	8.1	25%≥6.8, 75%≤8.0	
Colour True (PCU)	154	5	40	55	280	28	60		
Total Alk. (mg/L)	51	31	140	148	300	84	200		
Hardness as $CaCO_3$	51	45	260	272	620	150.5	390		
Total Dis. Solids (mg/L)	50	220	845	853	1900	490	1100		
Sus. Solids (mg/L)	153	1	12	21	350	8	20		
Total Organic Carbon	46	4	9	10.24	29	8	12		
NO_2 + NO_3 (mg/L)	149	0.003	0.44	0.49	2.8	0.17	0.72		0.04
Kjeldahl N (mg/L)	153	0.3	0.8	0.89	2.1	0.7	1		
Phosphate - Filtered (mg/L)	102	0.003	0.007	0.03	2.2	0.004	0.01		0.02
Total Phosphorus (mg/L)	152	0.01	0.06	0.09	2.2	0.0375	0.0925	75%≤0.06	
Ca (mg/L)	51	6.1	27	26.4	52	17.5	35.5		
Cl (mg/L)	51	39	320	323.25	740	165	450.5		
K (mg/L)	50	1.6	4.4	4.19	10	2.75	5.275		
Na (mg/L)	51	26	170	174	380	86	235		
Fluoride (mg/L)	6	0.05	0.175	0.17	0.27	0.1175	0.24		
SO_4 (mg/L)	51	6	37	35.8	78	17.5	49.5		

Parameter	Number of samples	min	median	mean	max	25th %ile	75th %ile	SEPP	ANZG
SiO_2 EG052G (mg/L)	49	0.1	3.7	4.7	12	1.5	7.5		
Cd - total (mg/L)	1	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002		0.0005
Cr - total (mg/L)	1	0.001	0.001	0.001	0.001	0.001	0.001		0.0004
Cu - total (mg/L)	1	0.002	0.002	0.002	0.002	0.002	0.002		0.0014
Fe - total (mg/L)	48	0.03	0.645	1.79	16.5	0.3375	1.275		
Pb - total (mg/L)	1	0.001	0.001	0.001	0.001	0.001	0.001		0.0034
Mg - total (mg/L)	51	7.2	48	50	120	27.5	68		
Mn - total (mg/L)	48	0.02	0.045	0.07	0.79	0.03	0.07		1.9
Hg - total (mg/L)	5	0.00005	0.0002	0.0002	0.0002	0.0002	0.0002		0.0006
Ni - total (mg/L)	1	0.004	0.004	0.004	0.004	0.004	0.004		0.011
Zn - total (mg/L)	1	0.004	0.004	0.004	0.004	0.004	0.004		0.008

Blue shading indicates non-compliance with either SEPP or ANZG guideline value

6.4.8 Summary of detailed assessment

From the detailed assessment for Jacksons Creek the following is concluded:

- From observed conditions Jacksons Creek is a fast-flowing stream, with some observed bed and bank instability (i.e. presence of a graded rock structure and some local bank erosion near upstream meander)
- The stream velocities and stream powers indicate a relatively high potential for bed and bank erosion
- The above is consistent with the steep bed gradient of Jacksons Creek upstream of Maribyrnong, including the reach with the pipeline crossing
- The geomorphology of both the Jacksons Creek and Deep Creek is known to be sensitive, and therefore some ongoing bed and bank erosion processes are to be expected
- There is no basalt indicated within the bore logs that would limit any depth of future bed erosion. There are potential layers of more erodible sands and gravels in the upper soil profile.
- The estimate flood levels near the location of interest starts to extend across the floodplain terrace

Water quality in Jacksons Creek upstream and downstream (including Maribyrnong River) is noncompliant with guideline values for a number of parameters, including oxidised nitrogen, filtered reactive phosphate, total phosphorous, chromium and copper.

6.5 Deep Creek (Detailed Assessment)

6.5.1 Waterway assessment

The Maribyrnong River commences at Bulla where Jacksons Creek and Deep Creek combine over 10 km downstream of the pipeline. Prior to the formation of the newer basalts, the ancestral Deep Creek previously flowed towards Sunbury and was the main stream in the catchment. The course of the river was forced east by lava flows and the formation of newer basalts where streams such as Emu Creek and Jacksons Creek were formed on the basaltic terrain. Further downstream prior to the confluence with Jacksons Creek there is a constriction at Keilor formed by more resistant basaltic rocks, upstream of which lateral river erosion has excavated a wider valley.

Deep Creek is a major waterway within the Maribyrnong River catchment typically flowing southerly towards the confluence with Jacksons Creek, where it becomes the Maribyrnong River. The pipeline crosses Deep Creek immediately downstream of its confluence with Emu Creek. Deep Creek in this reach flows through agricultural land and is becoming increasingly impacted by catchment urbanisation. The current flow regime is characterised by a decrease in low flow conditions compared to the natural regime. The channel in this reach is incised into basalt bedrock, and there appears to be a sequence of deeper pools in the incised channel reach. The riparian vegetation of the representative site is classed as the vulnerable Streambank Shrub land Ecological Vegetation Classes (EVC).

Site inspection

Deep Creek was initially inspected near the location of the pipeline crossing on the 23rd of January 2020 the day immediately following heavy rainfall in the catchment. Complementing the site inspection photos, AUAV captured drone aerial images at each of the main waterway crossing. The photos presented below indicate the pipeline alignment (white stakes).

Photo	Description
 *Source: Site photo taken (GHD, 2020)*	Deep Creek in the background with the wide flood plain on the eastern side in the foreground. View is looking south west.
 *Source: Site photo taken (GHD, 2020)*	Deep Creek crossing looking west with evidence of riparian vegetation and variable terrain
 *Source: Site photo taken (GHD, 2020)*	Deep Creek looking south, immediately downstream of crossing location.

Photo	Description
 *Source: Site photo taken (GHD, 2020)*	Deep Creek at crossing location looking west, noting the relatively slow moving flow
 *Source: Site photo taken (GHD, 2020)*	Deep Creek looking upstream of crossing location including a view of the eastern flood plain looking north west.
 *Source: Site photo taken (GHD, 2020)*	Deep Creek looking downstream of rock outcrop control feature observed (shown in Figure 6-26 as Key Feature 5). View is looking south east.

Photo	Description
 Source: *Panosphere screen capture (AUAV, 2020)*	Panosphere – Drone aerial imagery Upstream of crossing view is looking north. Red dashed line = Indicative pipeline alignment.
 Source: *Panosphere screen capture (AUAV, 2020)*	Panosphere – Drone aerial imagery Downstream of crossing view is looking south. Red dashed line = Indicative pipeline alignment.

Key observed features/hydraulic controls

A number of key features were identified during the subsequent site inspection on 6 July in the vicinity of the crossing location, as outlined in Table 6-9. A key hydraulic control was observed approximately 280 m downstream of the crossing location. The location is marked on the plan view in Figure 6-26 as Key Feature 5 and indicated on the longitudinal profile in Figure 6-27. The rock outcrop feature is expected to increase the Manning's roughness of the channel and provide some level of backwater control to the site of interest at the pipeline crossing.

Other relevant features along Deep Creek in the vicinity of the site of interest include meandering sections immediately upstream and downstream of the crossing, tributaries which discharge into the waterway and the confluence with Emu Creek upstream of the crossing location.

Table 6-9 Key features along the waterway in the vicinity of the crossing

Key feature No.	Description
1	Wildwood Road crossing and piers
2	Meander in Deep Creek
3	Emu Creek Confluence
4	Discharging tributary
5	Hydraulic Rock Outcrop Control
6	Meander in Deep Creek
7	Meander in Deep Creek

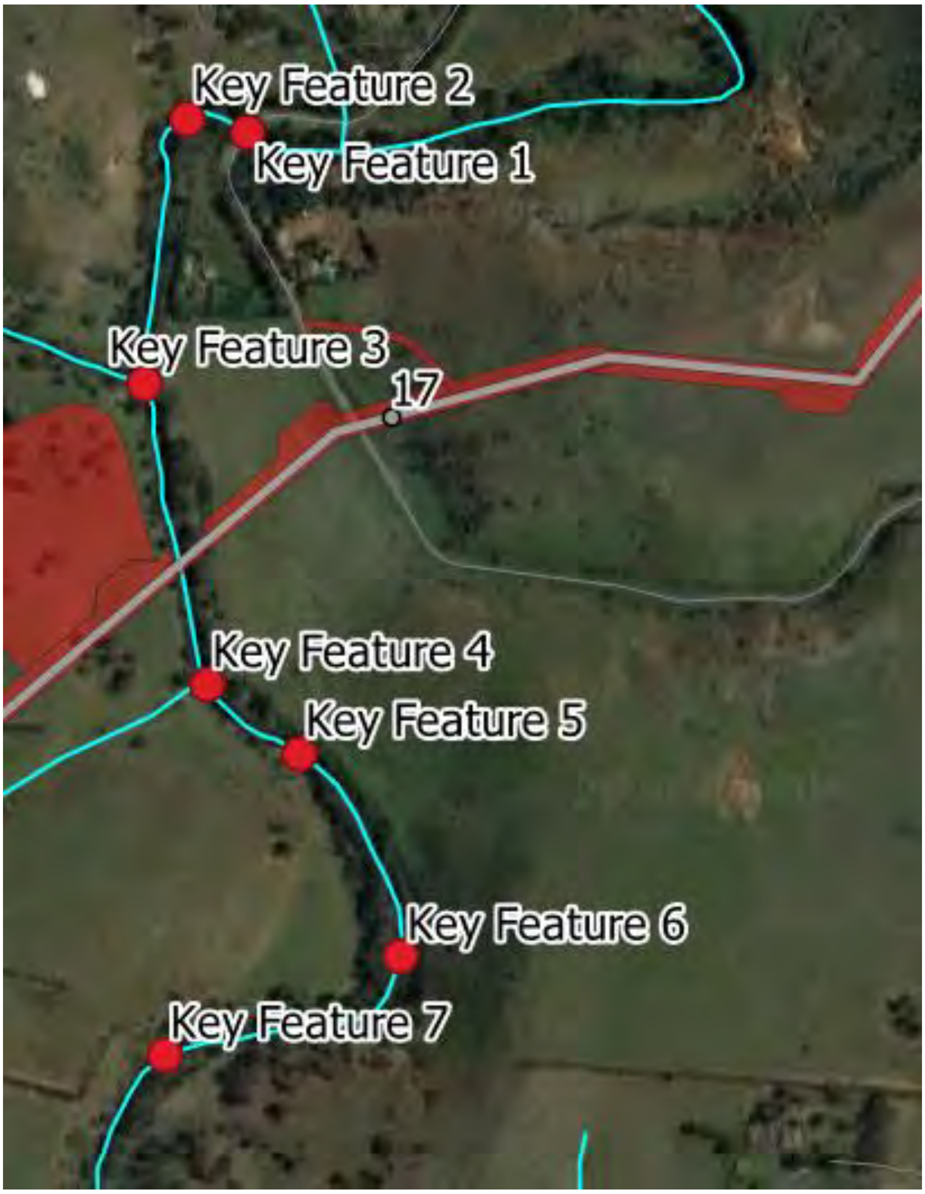


Figure 6-26 Plan view of Deep Creek waterway crossing with Key Features.

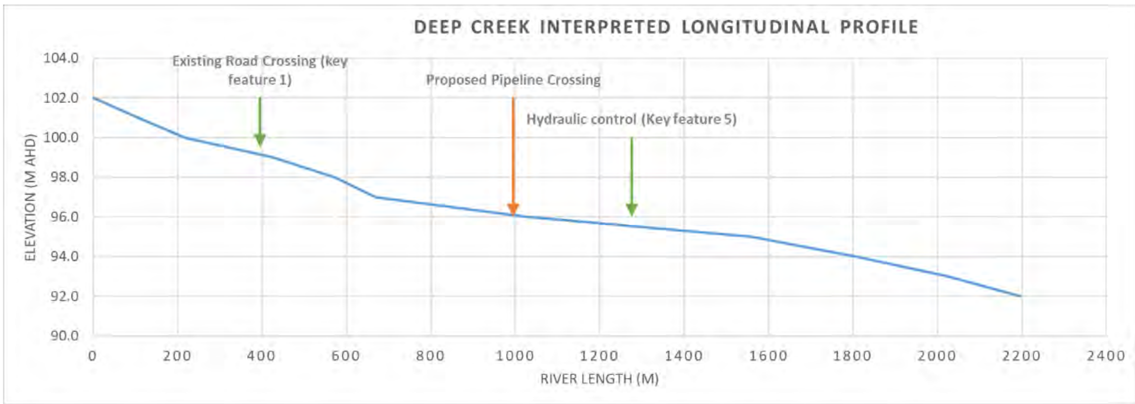


Figure 6-27 Deep Creek schematic profile indicating location of pipeline and hydraulic control feature

Time series images

Near map images were obtained for Deep Creek over a 10 year period, between 2010 and 2020, as shown in Figure 6-28. The time series images below concentrate mainly on the section of Deep Creek where the pipeline alignment crosses the waterway.

Figure 6-28 Nearmap images of Deep Creek at the crossing location over a 10-year period

On the day of the inspection near the pipeline crossing, Deep Creek was observed to be relatively slow moving indicating the reach is within a backwater area.

In terms of the waterway condition at the location and in the immediate reach upstream and downstream of the pipeline:

- Riparian vegetation of both banks is intact, dense and has a healthy mix of deep rooted trees and ground cover vegetation. This is evident from both the site photos and aerial imagery captured on Nearmap over a 10 year period.
- The riparian zone is protected on the west side from grazing via a fence. The east bank is more exposed, with no immediate fencing. It does not appear to be subjected to grazing activities
- The crossing location is within a relatively straightened section of the stream which extends from the Emu Creek confluence upstream and continues downstream
- Key feature 5 highlights the location of a section of riffles characterised by shallow depths with fast, turbulent water agitated by rocks and vegetation
- Beneficial Uses downstream may include water dependent ecosystems and species, agriculture and irrigation, water-based recreation (aesthetic enjoyment) and Traditional Owner cultural values

6.5.2 Geomorphology

Catchment Scale Geomorphology

Stream gradient features in Deep Creek appear to reflect lithological control. Three gradient features are notable within a few km of the crossing, as shown in Figure 6-29. Upstream there is a broad convexity in the channel profile and the crest of that convexity corresponds to the boundary between Ordovician and Silurian rocks. It is likely that this reflective of bulk erodibility, which is lower in the Ordovician rocks. The downstream feature is a much more prominent steepening of the gradient that closely corresponds to the upstream and downstream extent of granite outcrop.

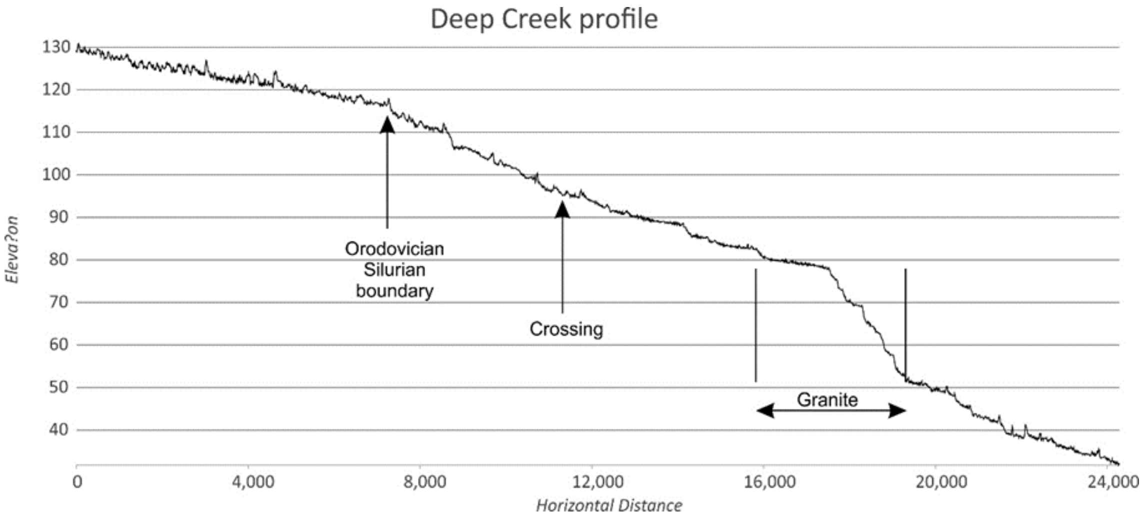


Figure 6-29 Deep Creek Stream Bed Profile

Deep Creek is incised ~80 m below the level of the Fenton Hill lava flow. If the Fenton Hill Flow extended all the way to the east and ponded against the incised edge. The stream is likely to have been present during the flow, and even deranged into its course by the flow.

Similarly to Jacksons Creek, alluvial terraces can be found either side of the river within the major channel confines. Most of these seem to be ~7 m above the base of the channel and thus seem likely to be equivalent to terraces of the same elevation dated to the mid-Holocene at Keilor. Like Jacksons Creek, the downstream end of the reach is presently incising into bedrock, and modern incision rates are likely to be closer to the long-term, rather than short term rates.

Reach Scale Geomorphology

The alignment at Deep Creek crosses a north-south reach of the river, with a relatively straight channel over a length of 500 m, with subtle meanders, riffles and pools within the reach. The reach of interest includes the confluence of Deep Creek and Emu Creek upstream of the crossing.

A geomorphological map is provided of Deep Creek near the crossing location in Figure 6-30.

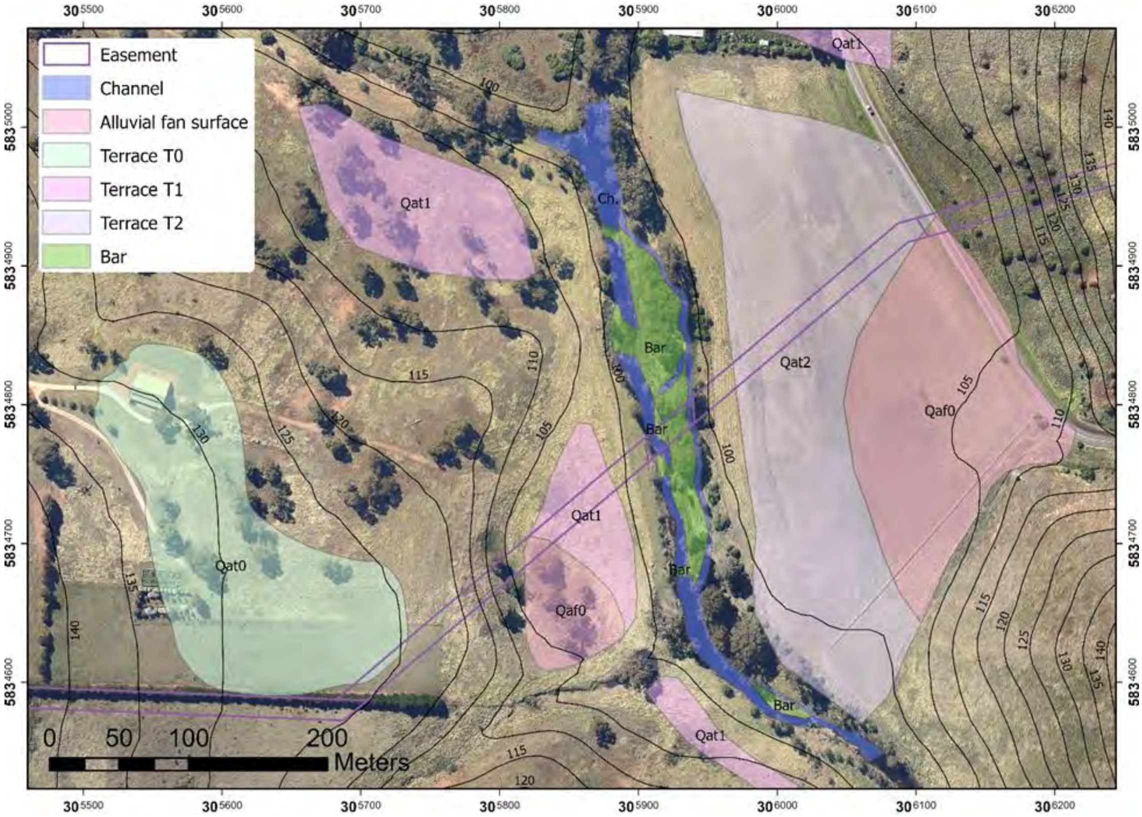


Figure 6-30 Geomorphological map of Deep Creek near crossing location

The Sunbury geological map indicates that the pipeline crosses Deep Creek in an area that is underlain by interbedded Silurian shales, greywackes and mudstones of the Keilor Group. Bedrock outcrops are visible at the southern end of the reach and in the right-bank cliffs at the north end of the reach. The Silurian bedrock is capped by basalts of the Newer Volcanics, and upstream from the mouth of Emu Creek these basalts infill a series of gravel-floored Mio-Pliocene paleochannels that align approximately parallel to the current Deep Creek.

Although the reach is generally straight, it has a slightly meandering planform in detail. The reach is divided into riffles and pool segments, a characteristic of gravel bed rivers, with several channel widths separating each riffle. The riffles appear as shallow gravel bars located in crossovers between opposite facing meanders and seem to be stable. For instance, a riffle can be seen in the same position in photographs from 1951 through to 2020, and the alignment and lateral extent remains similar too, as indicated in Figure 6-31.

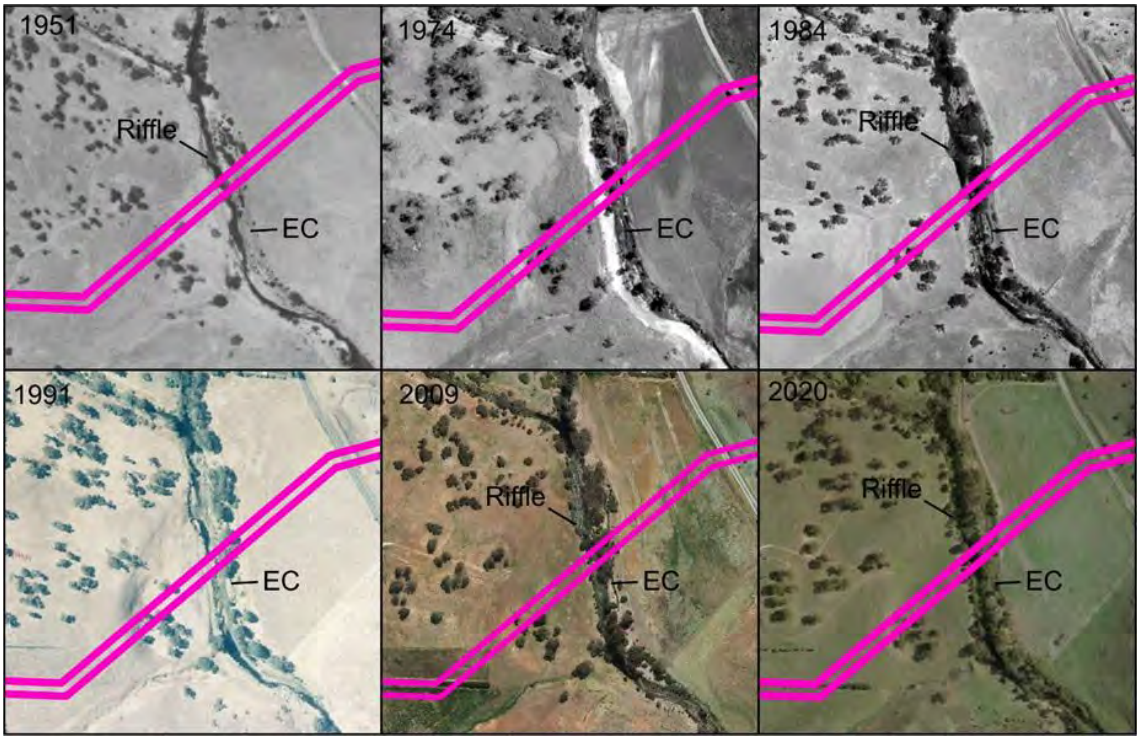


Figure 6-31 Historical Aerial Photo series

From Figure 6-32 below the river planform and lateral extent has not changed in recent years, nor has the riparian vegetation.

Figure 6-32 Recent Historical Aerial Photos

Given the presence of gravel-bed load indicators (riffles and pools), the bed is not expected to have bedrock control along its length. The riffle and pool architecture would indicate the likely presence of a paleochannel. A subtle point bar is developed at the south end of the alignment reach, where the channel bends to the left.

Most of the riffles were observed to be vegetated with long grass. The ephemeral channel and lower terrace consistent of many well-established trees and evidence of debris dams between close-spaced trees accumulating from recent high flow events. On the downstream side of debris dams, there is presence of scour holes. There is also a gravel bar building up on the downstream side of the tree due to flow separation.

Deep Creek is joined about 200 m upstream of the crossing by its large tributary, Emu Creek. The confluence is at a high angle of 60 degrees, and south of the confluence of Emu and Deep Creeks, the left bank is effectively a low gravel bar.

The bar forms a barrier that separates an elongated ephemeral channel from the main creek. Several crossover connections link the main channel and the ephemeral channel. The channel is stable and is visible on all photographs back to 1951 at least. The position of the opening of the channel relative to Emu Creek suggests that it becomes occupied during high flow events exiting Emu Creek.

The ephemeral channel has become increasingly vegetated since the 1950s and large well-established trees now occupy parts of the channel. Much of the bar separating the ephemeral and main channels is covered with a tall grass that also grows in the channel.

The large trees in the ephemeral channel have a dramatic impact during high-flow events. Each tree serves as a flow separator, some developing elongate gravel bars on their downstream sides. Closely spaced trees combine to form barriers to large woody debris, constructing strong debris dams that create standing waves and generate extreme scour on their downstream side.

Alluvial terraces are present on both sides of the stream. In order of elevation these are:

- On the west side of the stream, an old terrace is present >20 m above the stream
- A lower terrace on the east side, is located about 5-7 m above the stream bed

Alluvial fans debouche onto and probably interfinger with the terrace on both sides of the stream.

6.5.3 Streamflow hydrology

Streamflow data on Deep Creek was obtained at Bulla Road gauge station, 4.25 km downstream of the pipeline crossing. The period of record for this gauge station is from 1987 to present day, with some intermittent data from 1955 to 1987.

From Figure 6-33 and Figure 6-34 below, the mean annual flow is 0.06 m^3/sec, and the mean summer-autumn flow is 0.02 m^3/sec.

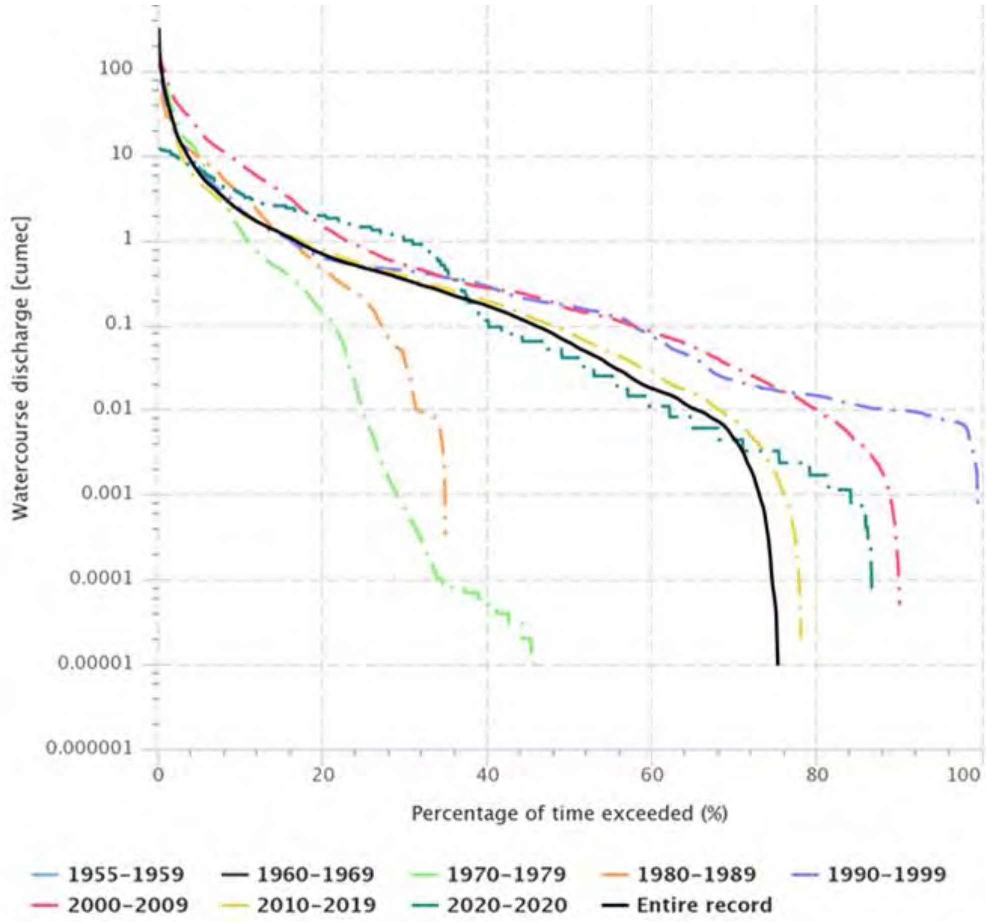


Figure 6-33 Deep Creek gauge station - Flow Duration Curve

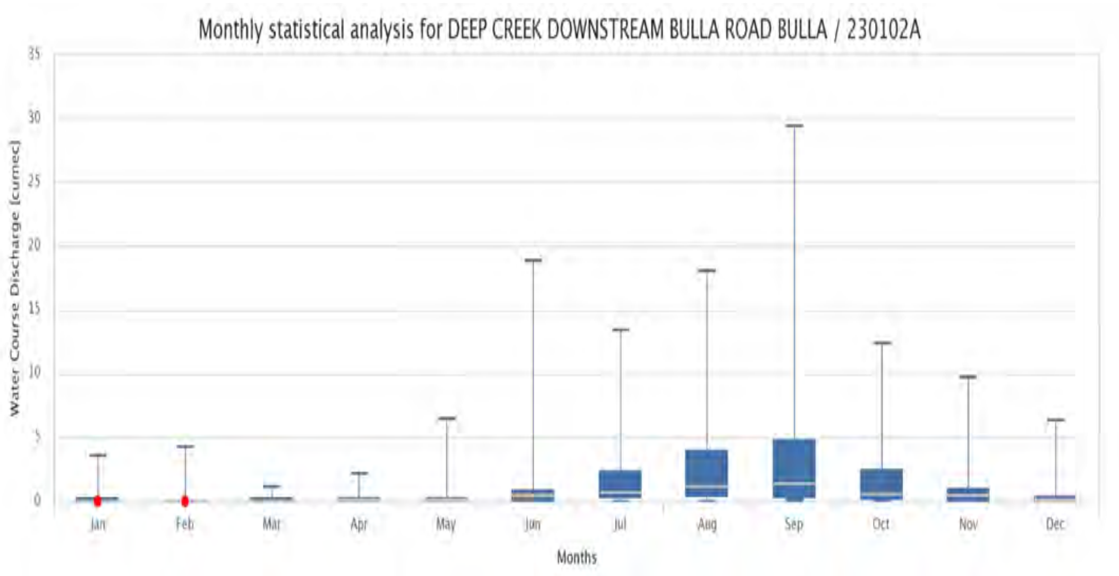


Figure 6-34 Deep Creek gauge station - Monthly data

MWC provided design flood flows for Deep Creek and these are outlined in the section below.

6.5.4 Floodplain Management

MWC provided a flood mapping report (*Flood Mapping Technical Report - Deep Creek*) on Deep Creek detailing the modelling completed by Melbourne Water in 2017 along with HEC-RAS modelling completed in 2013. The extent of flood mapping covers Deep Creek from the most upstream tributaries north in the Lancefield area down to the confluence with Maribyrnong River. The HEC-RAS modelling of Deep Creek captures the location where the Project crossing, at cross-section 12999.92. The modelling software used for the flood-mapping project was Mapinfo, RORB, 12D and HEC-RAS, and the results were used for the detailed analysis.

Near the site of interest, the design flow rates, velocities and stream powers are summarised in Table 6-10 below.

Table 6-10 Deep Creek hydraulic results summary table.

AEP	Flow (m^3/s)*	Velocity (m/s)*	Stream Power(Nm^{-2})*
1%	610	3.27	336
2%	458	3.02	280
10%	203	2.32	151
Notes: *Data obtained via HEC-RAS model.			

Design flows and subsequent flood levels and extents for the 100 year, 50 year and 10 year ARI events was adopted from a previous flood-mapping project using HEC-RAS. The channel velocities for the range of design flows exceed 2 m/s, and the stream powers exceed 300 Nm^2 in the 100 year ARI event. These velocities and stream powers indicate a relatively high potential for stream bed and bank erosion. As stated previously, there is a higher erosion potential for Jacksons Creek compared to Deep Creek due to the steeper channel grade. Flow, Velocity and Stream Power profiles along the modelled reaches are displayed in Appendix E which captures hydraulic changes along the reach.

The design flows were modelled in HEC-RAS and results interpreted at a representative cross section within the HEC-RAS model nearest to the location of the Project crossing as indicated in Figure 6-35 below.

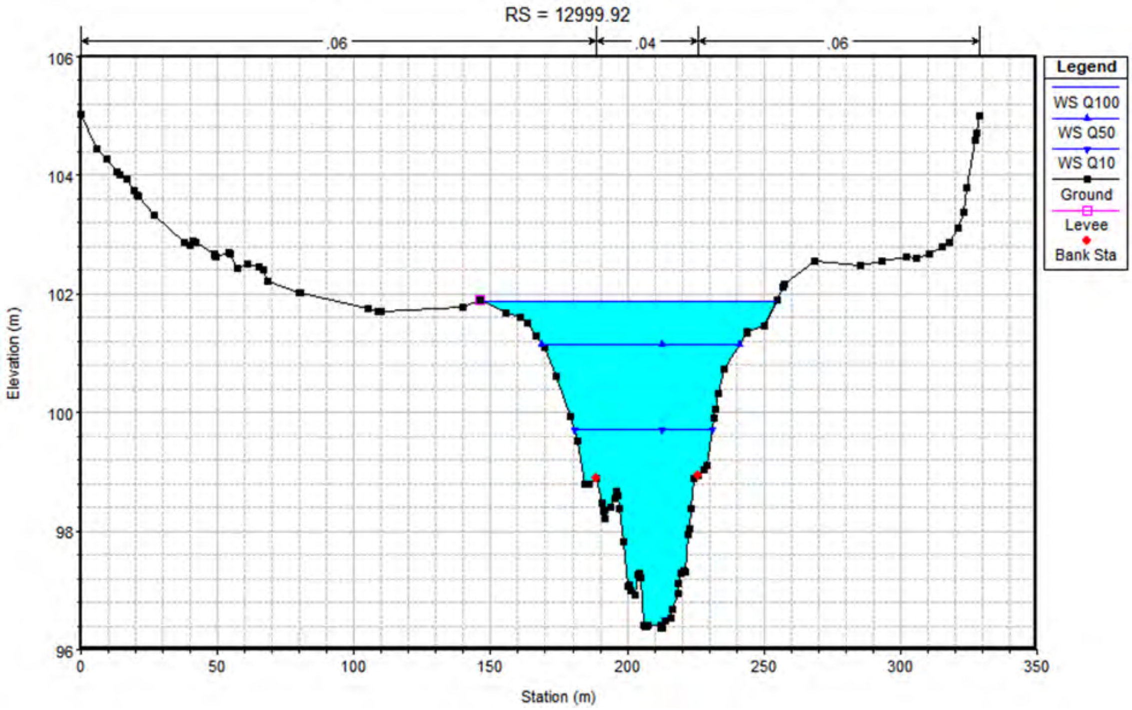


Figure 6-35 Deep Creek flood levels at CH 12,999.92 (10, 50 and 100 year ARI)

From the interpretation of the estimated flood levels:

- The main channel has a less than 1 in 10 year ARI capacity
- The estimated 1 in 100 year flood level is approximately 101.9 m AHD, and has the potential to spill into the floodplain area at certain locations along the east bank

Flood mapping outputs were provided in the MWC data as presented in Figure 6-36 below.

1:4,999.996429

0 0.03 0.06 0.09 0.12 0.15 km

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 55

N

LEGEND

- Waterway
- 1 m Contours
- 100 yr ARI Flood Extent
- WORM KPs
- WORM Pipeline
- WORM Construction Footprint

GHD

APA VTS Australia
WORM Pipeline

Job Number	12529997
Revision	A
Date	04/12/2020

Deep Creek - Crossing 9
100yr ARI Flood Extent

Figure 6-36

\\ghdnet\ghd\AU\Melbourne\Projects\31\12529997\GIS\Maps\Working\Surface_Water_Chapter\Surface Water\Workspace_APA_Pipeline_Clean.qgz

Data Custodian, Data Set Name/Title, Version/Date. Created by: toza

180 Lonsdale St Melbourne VIC 3000 Australia
W www.ghd.com.au E melmail@ghd.com.au T 61 3 8687 8000 F 61 3 8687 8555

6.5.5 Geotechnical interpretation

Geotechnical bore logs were obtained by Construction Sciences at 4 locations near the Deep Creek channel and floodplain. The bore logs based on their coordinate locations have been interpreted on a schematic cross section interpreted from LiDAR. The bore logs have been projected from the natural surface levels to their indicated depths.

Derived from interpreting the bore logs within the cross section, shown in Figure 6-37:

- The soil profile typically consists of various layers of sands, gravels and clays in the upper profiles (first 5-10 m)
- The lower profiles consist of siltstones for most of the bore holes and continues for the remainder of the bore hole until termination
- No basalt rock was encountered

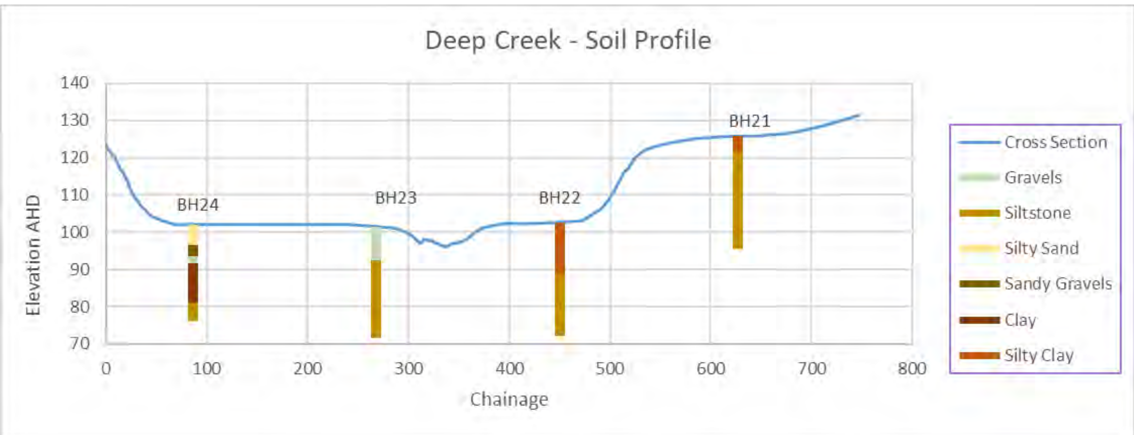


Figure 6-37 Deep Creek schematic soil profile cross-section

6.5.6 Water Quality and Beneficial Uses

Two water quality gauges were available upstream of the pipeline: Deep Creek at Kinnear Rd, Mickleham (MADEE0625) and Emu Creek at Clarkefield (230211). Deep Creek at Kinnear Rd, Mickleham is 18 km upstream of the proposed pipeline and the samples were collected between 2010 and 2020. Emu Creek at Clarkefield is approximately 20.5 km upstream of the proposed pipeline and the samples were taken between 1975 and 1998. The statistics are presented in Table 6-11 and Table 6-12.

Deep Creek at Kinnear Rd, Mickleham was noncompliant for dissolved oxygen, electrical conductivity, nitrate, total nitrogen, total phosphorus, chromium, copper, lead, nickel and zinc.

Water quality at Emu Creek at Clarkefield was compliant for all parameters, except oxidised nitrogen, filtered reactive phosphate and total phosphorus. Total nitrogen and nitrate were also above guideline levels at this site. Both the Emu and Deep Creek gauges are located in agricultural catchments. The elevated levels of nitrogen and phosphorus may be a result of agricultural runoff.

Water quality downstream of the pipeline was measured using the Deep Creek at Bulla (230205) gauge combined with data from the Melbourne Water gauge MAJAC0342. The two gauges measure different water quality parameters but are located at the same site. This gauge is approximately 2.5 km downstream of the proposed pipeline and the data were collected between 1990 and 2020. Statistics for this site are presented in Table 6-13. Like the upstream site, Deep Creek at Bulla had elevated electrical conductivity, nitrate, oxidised nitrogen, total nitrogen, total phosphorus, chromium, copper, lead, nickel and zinc.

Unlike the upstream site, phosphate and pH did not comply with the above guideline values and dissolved oxygen concentrations complied with the guidelines

There are several possible sources for the non-compliant parameters:

- The elevated nitrogen, nitrate, oxidised nitrogen, phosphate and phosphate concentrations may be caused by natural sources (e.g. bacteria or minerals) as well as by human sources (e.g. eroded soil, stormwater runoff and discharges from agriculture)
- The sources of the elevated metals (e.g. chromium, copper, lead, nickel and zinc) may be natural (from the weathering or rocks and soils) or non-natural (e.g. from agricultural runoff and runoff from urban areas). The toxicity and bioavailability of metals in rivers is influenced by pH, dissolved oxygen and organic carbon levels. That is, the metals may be present in the stream but not in a form that is available to organisms.
- Turbidity is a measure of the clarity of water. The non-compliant turbidity may be a result of streambank erosion or agricultural runoff upstream.
- Electrical conductivity indicates the amount of salts dissolved in a waterbody. The elevated electrical conductivity in Deep Creek may be caused by geology, agricultural runoff or groundwater.
- Changes in pH are also influenced by natural causes as well as by human activity. The pH of waterbodies is influenced by geology, soils, salinity, rainfall and by aquatic organisms such as plants and algae. Human activities which influence pH include changes to the hydrology of rivers, discharges from urban areas and emissions from car exhausts, which react with molecules in the air and lower the pH of rain.

ANZG (2018) states that guidelines are concentrations that, if exceeded, would trigger a management response, such as the refinement of the guidelines according to local conditions. ANZG (2018) also recommend that ideally site-specific guideline values that are relevant to local conditions or situations should be used. Given the statistics for some water quality parameters presented in Table 6-11, Table 6-12 and Table 6-13 exceed the relevant SEPP (Waters) and ANZG (2018) guidelines, it is recommended the statistics in the tables below be used to evaluate changes in water quality as they better reflect the existing water quality in the region.

Table 6-11 Water quality statistics – Deep Creek at Kinnear Rd, Mickleham

Parameter	Number of samples	min	median	mean	max	25th %ile	75th %ile	SEPP	ANZG
DO (% sat)	63	6.29	84.0	75.2	100.0	68.05	88.85	25%≥75, max=130	
DO (mg/L)	63	480.0	930.0	1,034.1	3,400.0	625	1300	75%≤2000	
EC (µS/cm)	63	1.0	14.0	56.2	850.0	6	33.5	75%≤25	
Turbidity (NTU)	63	7.8	13.0	13.3	24.0	9.25	16.05		
Water Temperature (°C)	63	7.1	7.7	7.6	8.1	7.5	7.8	25%≥6.8, 75%≤8.0	
pH	63	1.0	7.0	23.7	600.0	4	14.5		
Sus. Solids (mg/L)	63	1.67	8.27	7.9	11.05	6.835	9.755		
Ammonia (mg/L)	63	0.001	0.016	0.029	0.22	0.0075	0.03		Max≤0.9
NO_2 (mg/L)	63	0.001	0.003	0.007	0.059	0.001	0.007		
NO_3 (mg/L)	63	0.0	0.04	0.2	2.5	0.0065	0.235		Max≤0.7
Kjeldahl Nitrogen (mg/L)	63	0.44	0.95	1.0	3.1	0.735	1.2		
Total Nitrogen (mg/L)	23	0.44	0.84	1.0	1.823	0.725	1.36	75%≤1.1	
Phosphate - Filtered (mg/L as P)	63	0.001	0.002	0.003	0.01	0.0015	0.0055		Max≤0.02
Total Phosphorus (mg/L)	63	0.008	0.045	0.1	0.48	0.0285	0.072	75%≤0.06	
As - total (mg/L)	63	0.0005	0.0005	0.0008	0.003	0.0005	0.001		Max≤0.013
Cd - total (mg/L)	63	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		Max≤0.0005
Cr - total (mg/L)	63	0.0005	0.0005	0.0023	0.021	0.0005	0.002		Max≤0.0004
Cu - total (mg/L)	63	0.0005	0.002	0.002	0.012	0.001	0.003		Max≤0.0014
Pb - total (mg/L)	63	0.0005	0.0005	0.0010	0.009	0.0005	0.0005		Max≤0.0034
Ni - total (mg/L)	63	0.001	0.003	0.004	0.014	0.002	0.004		Max≤0.011
Zn - total (mg/L)	63	0.0005	0.004	0.006	0.028	0.003	0.008		Max≤0.008
E. coli MF (orgs/100mL)	28	10.0	110.0	537.9	10,000.0	60	225		
E. coli MPN (orgs/100mL)	35	30.0	130.0	228.3	1,600.0	79.5	165		

Blue shading indicates non-compliance with either SEPP or ANZG guideline value

Table 6-12 Water quality statistics – Emu Creek at Clarkefield

Parameter	Number of samples	min	median	mean	max	25th %ile	75th %ile	SEPP	ANZG
DO (ppm)	262	1	9.8	9.56	15	8.4	10.88	25%≥75, max=130	
EC (µS/cm)	273	170	940	1146	5000	610	1400	75%≤2000	
Turbidity (NTU)	271	0.8	5.6	10.3	80	3.8	11	75%≤25	
Water Temperature (°C)	273	3	13.1	13.95	25.3	9.5	17.5		
pH	261	5.1	7.7	7.63	9.3	7.3	8	25%≥6.8, 75%≤8.0	
Colour True (PCU)	149	5	33	43	220	20	50		
Total Alk. (mg/l)	49	29	83	113	270	62	170		
Hardness as $CaCO_3$ (m	50	44	235	295.4	830	130	392.5		
Total Dis. Solids (mg/L)	49	200	650	855	2800	390	1000		
Sus.Solids (mg/l)	149	1	5	8	110	2	8		
Total Organic Carbon	43	3	6	7	20	4	9		
NO_2 + NO_3 (mg/l)	144	0.003	0.02	0.13	0.82	0.008	0.195		Max≤0.04
Kjeldahl N (mg/l)	148	0.1	0.47	0.6	2.3	0.4	0.6	75%≤1.1	
Phosphate - Filtered (mg/L)	97	0.003	0.004	0.01	0.32	0.003	0.007		Max≤0.02
Total P (mg/l)	146	0.008	0.02	0.03	0.34	0.01	0.03	75%≤0.06	
K (mg/l)	49	1.5	2.9	3.5	11	2.2	4.2		
Na (mg/l)	50	25	120	144	450	65.25	220		
Ca - total (mg/l)	50	5.8	26	29	78	15	38		
Cl (mg/l)	50	42	255	340	1000	140	480		
Fluoride (mg/l)	6	0.07	0.08	0.11	0.19	0.0725	0.1325		
SO_4 (mg/l)	50	3	6.35	9.29	63	5.025	10		
SiO_2 EG052G (mg/l)	48	3.1	12	12	25	10	13		
Fe - total (mg/l)	47	0.27	0.84	1.31	5.6	0.66	1.6		
Mn - total (mg/l)	47	0.01	0.04	0.06	0.75	0.03	0.06		Max≤1.9
Mg - total (mg/l)	50	6.8	42	55	160	23.25	73.25		
Hg - total (mg/l)	5	0.00005	0.0002	0.0002	0.0002	0.0001	0.0002		Max≤0.0006

Blue shading indicates non-compliance with either SEPP or ANZG guideline value

Table 6-13 Water quality statistics – Deep Creek at Bulla.

Parameter	Number of samples	min	median	mean	max	25th %ile	75th %ile	SEPP	ANZG
DO (% sat)	92	36.8	90.2	85.1	120.0	76.725	95.275	25%≥75, max=130	
DO (mg/L)	92	3.59	8.5	8.5	13.8	7.4	10.1375		
EC (µS/cm)	329	280.0	1,800.0	2,103.7	7,700.0	1200	2800	75%≤2000	
Turbidity (NTU)	329	1.0	4.1	16.5	1,100.0	2.4	11	75%≤25	
Water Temperature (°C)	330	5.0	15.4	15.4	28.4	10.575	19.5		
pH	320	6.3	8.1	8.1	9.4	7.8	8.3	25%≥6.8, 75%≤8.0	
Sus. Solids (mg/L)	92	1.0	6.5	17.3	370.0	3	12.5		
Ammonia (mg/L)	92	0.001	0.01	0.02	0.48	0.004	0.02425		Max≤0.9
NO_2 (mg/L)	317	0.001	0.01	0.1	3.7	0.003	0.08		
NO_3 (mg/L)	90	0.0015	0.0075	0.123	1.7	0.0015	0.205		Max≤0.7
NO_2 + NO_3 (mg/l)	351	0.002	0.01	0.16	6.2	0.004	0.165		Max≤0.04
Kjeldahl Nitrogen (mg/L)	322	0.28	0.75	0.8	2.3	0.6	1		
Total Nitrogen (mg/L)	41	0.37	0.79	1.0	2.847	0.65	1.1	75%≤1.1	
Phosphate - Filtered (mg/L)	92	0.001	0.002	0.005	0.034	0.0015	0.006		Max≤0.02
Total Phosphorus (mg/L)	322	0.005	0.03	0.04	0.31	0.02	0.04775	75%≤0.06	
As - total (mg/L)	94	0.0005	0.001	0.001	0.005	0.0005	0.002		Max≤0.013
Cd - total (mg/L)	103	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001		Max≤0.0005
Cr - total (mg/L)	103	0.0005	0.0005	0.002	0.035	0.0005	0.002		Max≤0.0004
Cu - total (mg/L)	103	0.0005	0.002	0.002	0.013	0.0005	0.003		Max≤0.0014
Pb - total (mg/L)	103	0.0005	0.0005	0.0009	0.011	0.0005	0.001		Max≤0.0034
Ni - total (mg/L)	103	0.0005	0.003	0.003	0.02	0.002	0.004		Max≤0.011
Zn - total (mg/L)	103	0.0005	0.004	0.006	0.036	0.003	0.0065		Max≤0.008
E. coli MF (orgs/100mL)	32	10.0	100.0	467.8	4,500.0	55	250		
E. coli MPN (orgs/100mL)	60	5.0	63.0	105.3	1,000.0	38.5	130		

Blue shading indicates non-compliance with either SEPP or ANZG guideline value

6.5.7 Summary of detailed assessment

From the detailed assessment for Deep Creek the following is concluded:

- From observed conditions Deep Creek appeared to be slow moving (within a backwater reach), with no observed bed or bank instability
- The calculated stream velocities and stream powers indicate a high potential for erosion
- The geomorphology of both Jacksons Creek and Deep Creek is known to be sensitive, and therefore some ongoing bed and bank erosion processes are to be expected
- There is no basalt indicated within the bore logs that would limit any depth of future bed erosion. There are potential layers of more erodible sands and gravels in the upper soil profile
- The estimated flood levels near the location of interest starts to extend across the floodplain terrace as shown in Figure 6-36
- Water quality in Deep Creek upstream and downstream is noncompliant with guideline values for a number of parameters, including electrical conductivity, nitrate, oxidised nitrogen, total nitrogen, total phosphorus, chromium, copper, lead, nickel and zinc

6.6 Kalkallo Creek (Detailed Assessment)

6.6.1 Waterway Assessment

Kalkallo Creek above the pipeline is one of several cut drains that have been formed to enable effective drainage of natural swamp areas in the flatter terrain within the catchment. The Kalkallo Creek catchment is within a Drainage Services Scheme and will be subject to ongoing future development with various Precinct Structure Plans within the area. The drainage flow paths including Kalkallo Creek are small capacity trapezoidal cut drains that are all directed to the Kalkallo Creek retarding basin. The Kalkallo retarding basin was originally constructed in 1984 and plays an important role in managing flooding downstream. Recently, upgrade works were undertaken at the outlet, and future works for the retarding basin may include increasing the volume as development continues to occur further upstream. The cut drains continue through the retarding basin floor directing low flows towards the outlet. Downstream of the retarding basin the Kalkallo Creek becomes more natural appearing creek within the defined overland flow path before crossing under the Hume Freeway and discharging into Merri Creek.

The Kalkallo Creek waterway assessment applies to each of the cut drains which cross the Project before entering the Kalkallo Creek retarding basins. This includes Crossing 15, 17 and 18 which are a series of unnamed agricultural drains and Crossing 16 – Kalkallo Creek.

Site inspection

Kalkallo Creek was inspected near the location of the pipeline crossing on the 23rd of January 2020 the day immediately following heavy rainfall in the catchment. The photos presented below indicate the pipeline alignment (white stakes).

Photo	Description
 *Source: Site photo taken (GHD, 2020)*	Kalkallo Creek looking south of Gunns Gully Road crossing at crossing location and a view of the wider flood plain.
 *Source: Site photo taken (GHD, 2020)*	Kalkallo Creek looking south of Gunns Gully Rd crossing at crossing location.
 *Source: Site photo taken (GHD, 2020)*	Kalkallo Creek looking immediately north of Gunns Gully Rd crossing including a view of the flood plain and connecting agricultural drains.

In terms of waterway condition at the location and in the immediate reach upstream and downstream of the pipeline:

- Kalkallo Creek is an open swale drain that runs through agricultural land and is covered in grasses with no trees or ground coverage vegetation. The channel bed is sparsely vegetated with reeds and looks to be mowed for hay at times.
- The Kalkallo Creek channel is one of many cut drainage paths of similar size that enter the Kalkallo Creek retarding basin

- The creek is open and exposed to grazing activities. There is no fencing to protect this channel from animals. Depending on the level of foot traffic, this type of activity heavily increases bed and bank erosion.
- The pipeline alignment is parallel to and just outside of the Gunns Gully Road reserve, and crosses perpendicular to the numerous straightened channels that enter the retarding basin. For each of the channels there are small culvert crossings immediately upstream of the pipeline crossing.

6.6.2 Streamflow hydrology

Streamflow data on Kalkallo Creek was not obtainable due to there being no gauge station along the waterway.

MWC provided design flood flows for Kalkallo Creek and these are outlined in the section below.

6.6.3 Floodplain management

MWC provided two HEC-RAS models which cover the multiple drains that enter the Kalkallo Creek retarding basin. The two models, Kalkallo Creek East drain and Kalkallo Creek West drain, were completed in 2008 and 2013, respectively. The 2013 HEC-RAS model came with a pdf of the flood extent output from the model but neither came with a flood mapping report detailing the modelling completed. The 2008 model results matched the current 100 year ARI flood extent that GHD had already obtained from MWC prior to receiving the HEC-RAS model. Both flood extents relative to Project alignment is presented in Figure 6-40.

Kalkallo Creek and the retarding basin is a complex system of natural and formalised channels that has multiple catchments discharging to it from the North and West. To better understand the flooding characteristics of the channels and retarding basin system a comprehensive two-dimensional (2D) modelling approach would be required which covers the entire catchment entering the retarding basin along with a detailed flood mapping report.

The Kalkallo Creek East drain extent of flood mapping covers the main eastern drain which enters the wider Kalkallo Creek retarding basin from the north at KP 35.9. The Kalkallo Creek East drain HEC-RAS model is split into two main reaches. The first reach covers Kalkallo Creek from Beveridge West, following the main channel for 5.5 km before it discharges into the retarding basin at Gunns Gully Road. It includes many of the contributing tributaries along the reach. The second reach starts at the retarding basin outlet and continues South East for 3.7 km along Kalkallo Creek before it discharges into Merri Creek.

The Kalkallo Creek West drain extent of flood mapping covers the main western drain which enters the retarding basin from the north at KP 34.5. The Kalkallo Creek West drain HEC-RAS model has two main reaches which join south of Gunns Gully Road, downstream of the Project crossing. The west reach is a channelised agricultural drain, 3.7 km’s long beginning at a multiple large farm dams and running relatively straight north to south before discharging into the retarding basin. The east reach, known officially as Kalkallo Creek, begins at Cameron’s Lane and follows the creek for 6.7 km’s before discharging into the retarding basin, south of Gunns Gully Road. The initial 3.5 km of the waterway is a meandering naturally shaped creek which is then formalised into an agricultural channel, running relatively straight for 3.2 km towards Gunns Gully Road.

The HEC-RAS modelling of Kalkallo Creek captures the locations where the Project crosses the multiple waterways entering the retarding basin. To observe stream flow properties, a cross-section from each model was used to assess hydraulic characteristics nearest to the Project. The most applicable from the eastern drain model is cross-section 93.67, roughly a few hundred metres upstream of the crossing location on the northern side of Gunns Gully Road. Cross-section 284 from the western drain model, is located at the pipeline crossing. For the purpose of this study, both HEC-RAS models capture the retarding basin input flows which ultimately characterise the flows and flood levels experienced at the pipeline crossing. Therefore, both modelling results are assessed below.

The modelling software used for the flood-mapping project was RORB for hydrology inputs and HEC-RAS for hydraulic analysis; the results of which are used in this detailed analysis.

Near the site of interest, the design flow rates, velocities and stream powers are summarised in Table 6-14 below.

Table 6-14 Kalkallo Creek hydraulic results summary table.

AEP – Model	Flow (m^3/s)*	Velocity (m/s) +	Stream Power(Nm^{-2}) #
1% - East Drain	34.50	0.83	32.52
10% - East Drain	14.80	0.78	29.33
1% - West Drain	64.50	0.12	0.06
Notes: *Data obtained via HEC-RAS models.			

Design flows and subsequent flood levels and extents for the 10 and 100 year ARI event were adopted from the East Drain flood-mapping project and only the 100 year ARI event for the West Drain model. The channel velocities at the Project crossing for the 100 year ARI flows is under 1 m/s, and the subsequent stream powers are low for all locations. The velocity and stream power indicate a relatively low potential for stream bed and bank erosion. Flow, velocity and stream power profiles along the modelled reaches are displayed in Appendix E which capture hydraulic changes along the reach.

The main drains entering the retarding basin occur at station 1100, 1500 and 2000 in cross-section 93 and at station 1100 in cross-section 284. Results were interpreted at a representative cross section within the HEC-RAS models nearest to the location of the Project crossing. This is shown in Figure 6-38 and Figure 6-39 below for the Kalkallo Creek East and West drain models, respectively.

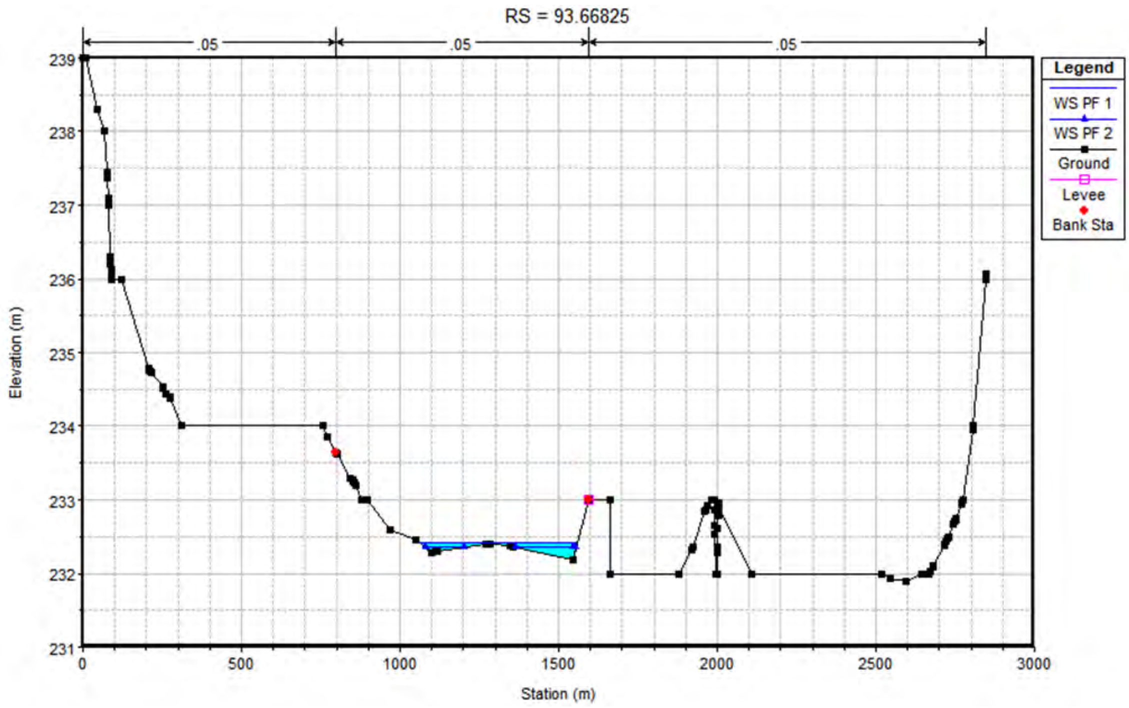


Figure 6-38 Kalkallo Creek flood levels at CH 93 (10 and 100 year ARI (PF2 and PF1 respectively)).

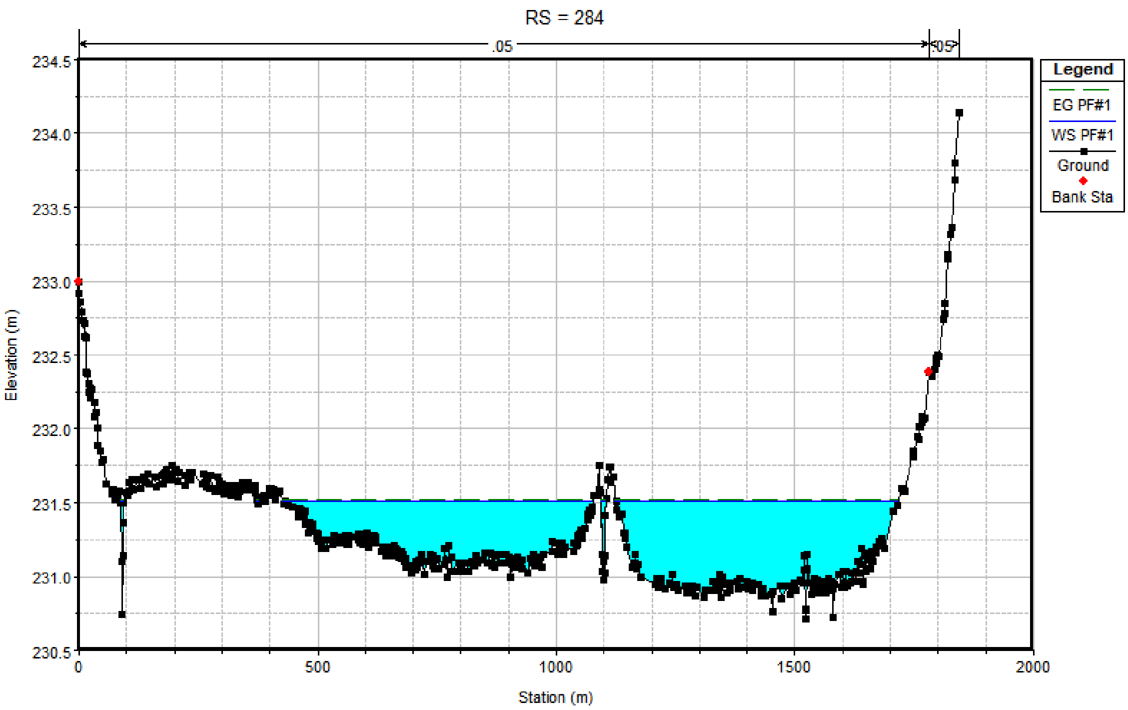


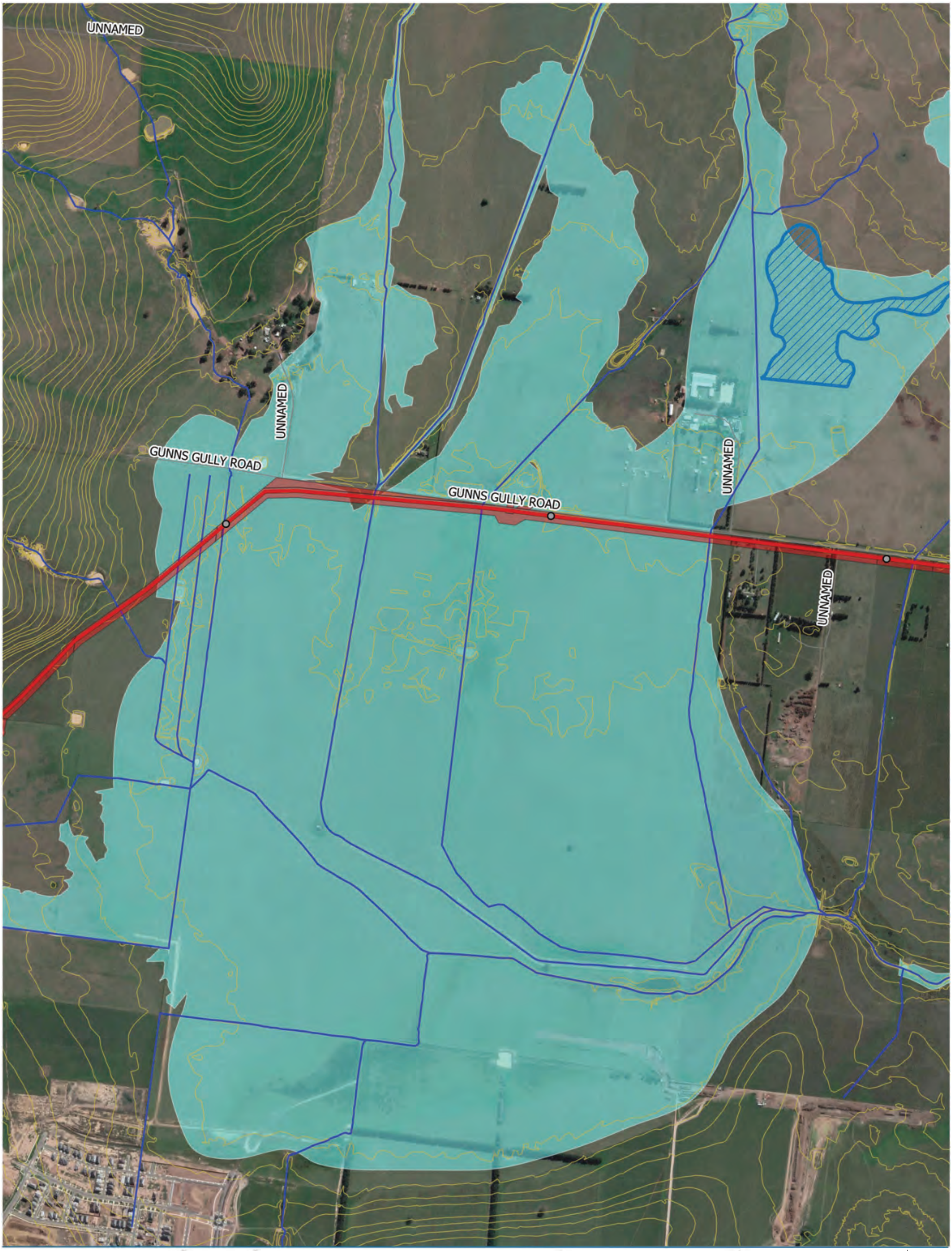
Figure 6-39 Kalkallo Creek flood levels at CH 284 (100 year ARI (PF1))

From the interpretation of the estimated flood levels:

- The HEC-RAS model results confirmed that both the East and West main drains have a less than 1 in 10 year ARI capacity. It is estimated that all channels entering the retarding basin have a less than 1 in 2 year ARI capacity. Further modelling is required to confirm this.

- The channel alignments assessed are alongside the Gunns Gully Road reserve and is just on the periphery of the retarding basin footprint
- The flood extent at the pipeline is roughly 1 km wide as it begins to engage the floodplain across the Kalkallo Creek retarding basin. Channel velocity and stream power are relatively low due to the flat grades as well tailwater effects within the retarding basin.
- The estimated 1 in 100 year flood level for Kalkallo Creek East drain is approximately 232.5 m AHD. It is expected that the flood level drops to 231.5 m AHD as it moves downstream of Gunns Gully Road.
- The estimated 1 in 100 year flood level for Kalkallo Creek West drain is approximately 231.5 m AHD. At this level, the entire Kalkallo Creek retarding basin is engaged with flood levels.

Flood mapping outputs were provided in the MWC data and the extent of flooding across Kalkallo Creek retarding basin is captured in Figure 6-40 below. As shown in Figure 6-40, the flood waters extend from the main Kalkallo Creek and other tributaries form the north and west. It then spreads out across the retarding basin storage area as well as backwater travelling north across Gunns Gully Road and further upstream.



1:9,999.992859

0 0.07 0.14 0.21 0.28 0.35 km

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 55

N

LEGEND

- Waterway
- 100 yr ARI Flood Extent
- 1m Contours
- WORM KPs
- WORM Pipeline
- WORM Construction corridor

APA VTS Australia
WORM Pipeline

Kalkallo Creek - Crossing 16
100yr ARI Flood Extent

Job Number	12529997
Revision	A
Date	16/12/2020

Figure 6-40

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Data Custodian, Data Set Name/Title, Version/Date. Created by: toza

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6.6.4 Additional waterways included in assessment

The Kalkallo Creek waterway assessment applies to each of the cut drains which cross the Project before entering the Kalkallo Creek retarding basins. This includes Crossing 15, 17 and 18 which are a series of unnamed agricultural drains. In frequent rainfall events, flood waters overtop the cut drains and engage the entire Kalkallo Creek retarding basin, an estimated water level of 131.5 m AHD is in the basin for the 1 in 100 year ARI event.

Given the location of the Project with regards to the Kalkallo Creek retarding basin, the waterway assessment establishes a high level of flood risk to the asset.

6.6.5 Geotechnical interpretation

Geotechnical bore logs were obtained by Construction Sciences at 5 locations near Kalkallo Creek channel and floodplain, as shown in Figure 6-41. The bore logs are based on their coordinate locations which have been interpreted on a schematic cross section derived from LiDAR. The bore logs have been projected from the natural surface levels to their indicated depths.

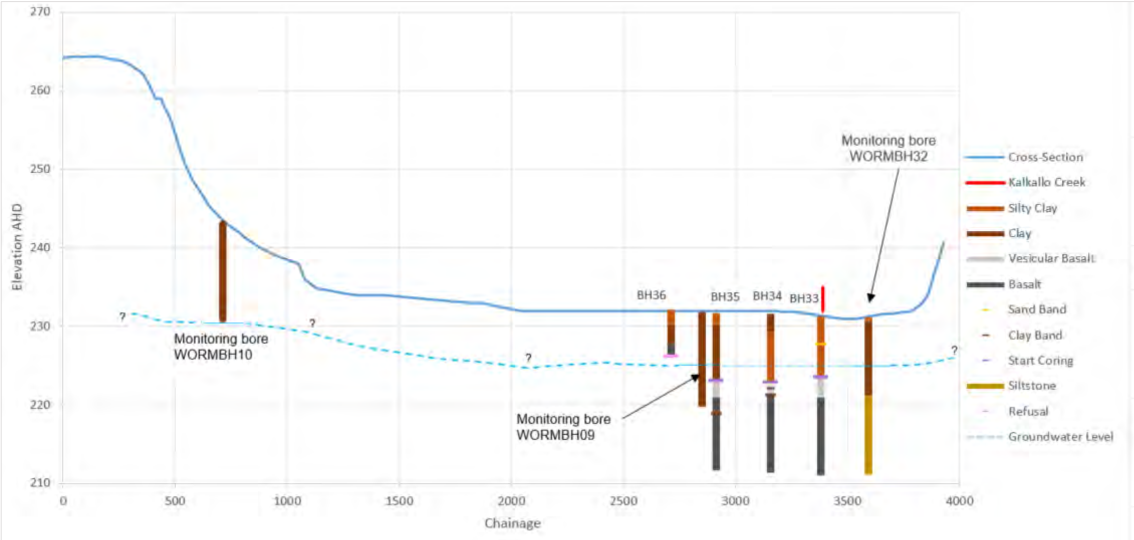


Figure 6-41 Kalkallo Creek schematic soil profile cross section

From the interpretation of the bore logs within the cross sections depicting the edge of the Kalkallo Retarding basin, the following is noted:

- The soil profile consists of variations of clay for the first 7-10 metres in all bore logs. Basalt was reached below this point and continued for the remainder of the borehole until termination.
- Basalt rock is relatively deep in profile at typically 10 m from surface, and coring indicated that the basalt continues for a further ~ 10 m in the profile

6.6.6 Summary of detailed assessment

From the detailed assessment of Kalkallo Creek, the following is concluded:

- From observed conditions, Kalkallo Creek and surrounding channels are ephemeral flow paths, that will regularly spill and cause flows to spread out across the floodplain and fill the retarding basin
- Given the flat terrain and the relatively low estimated velocities, there is a very low potential for erosion
- Basalt was found at relatively deep depth (7-10 m from natural surface), but there is clay material in the upper profiles that would be resistant to any potential erosion
- The pipeline alignment being within the existing retarding basin would suggest a high likelihood of flooding that would need to be considered during construction

6.6.7 Future development implications on waterway

The Kalkallo Creek catchment is within a Drainage Services Scheme (DSS) and will be subject to ongoing future development with various Precinct Structure Plans within the area. There is no explicit timeline for when the future developments will occur as the main purpose of the DSS is to guide the standards in which future developments will need to meet for flood protection, water quality and waterway health. As shown in the latest MWC DSS for Kalkallo Creek Catchment 6550, there is currently a significant amount of urban development occurring in the upper catchment regions. The DSS also presents indicative locations of future drainage assets which includes a number of wetlands, retarding basins and diverted formalised channels located throughout the catchment.

The residential area of Beveridge has altered the catchment conditions and waterways which eventually discharge water to the Kalkallo Creek retarding basin. The Kalkallo retarding basin was originally constructed in 1984 and plays an important role in managing flooding downstream. Recently, upgrade works were undertaken at the outlet of the retarding basin, and future works may include increasing the capacity as development continues to occur.

Much of the waterways that previously ran through Beveridge are now formalised into channels or underground pipe drainage which have been diverted to a realigned and widened channel that discharges into the retarding basin at the far west corner. Figure 6-42 displays the MWC DSS plan for Kalkallo Creek. As a result of the proposed diversion of waterways, many of the current drains will be made redundant, with the majority of Kalkallo Creek catchment flows now entering the retarding basin from the one location

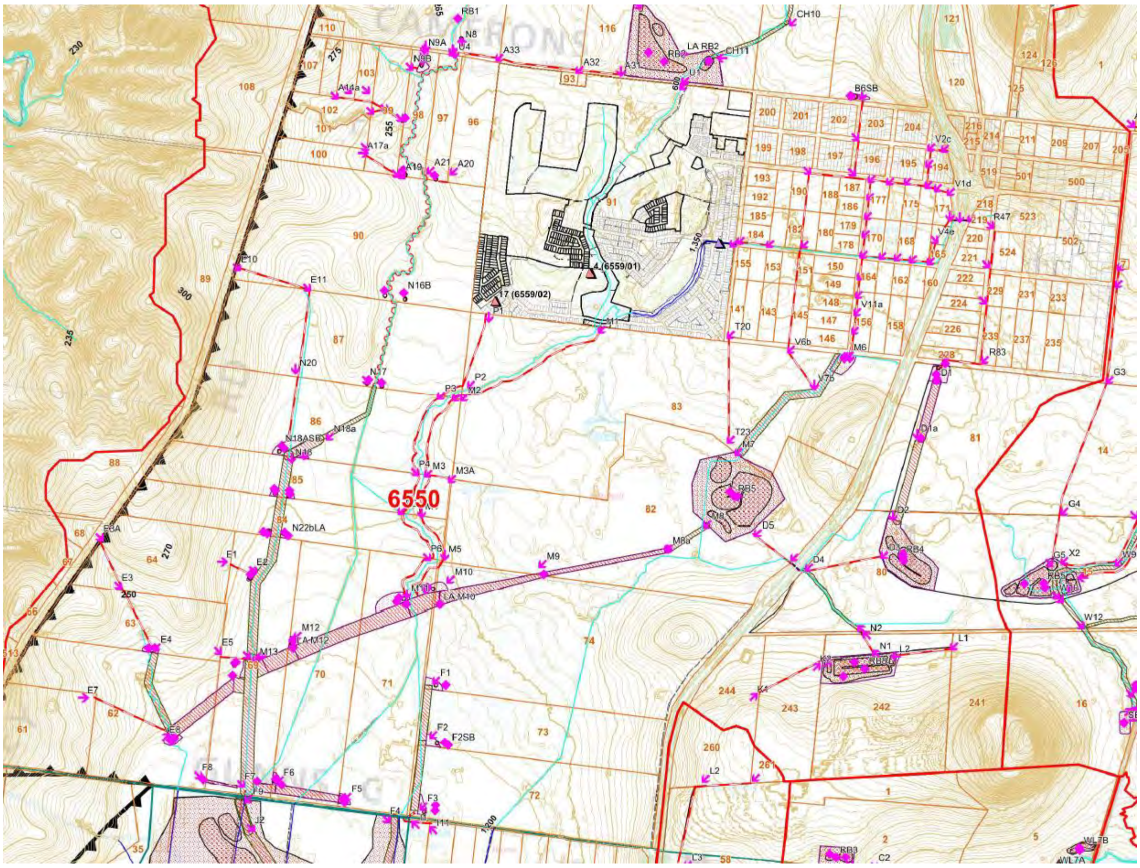


Figure 6-42 Kalkallo Creek DSS plan

The realigned and widen channel mentioned above was modelled in 2013 using HEC RAS. The proposed channel receives flows from Kalkallo Creek diverted further upstream as well as the two main waterways which receives flows discharged from Beveridge.

It should be noted that no report was provided with the Kalkallo Creek HEC RAS model and an interpretation of the model was required to inform the implications of future development. Figure 6-43 below displays the proposed constructed channel at the pipeline crossing which enters the retarding basin.

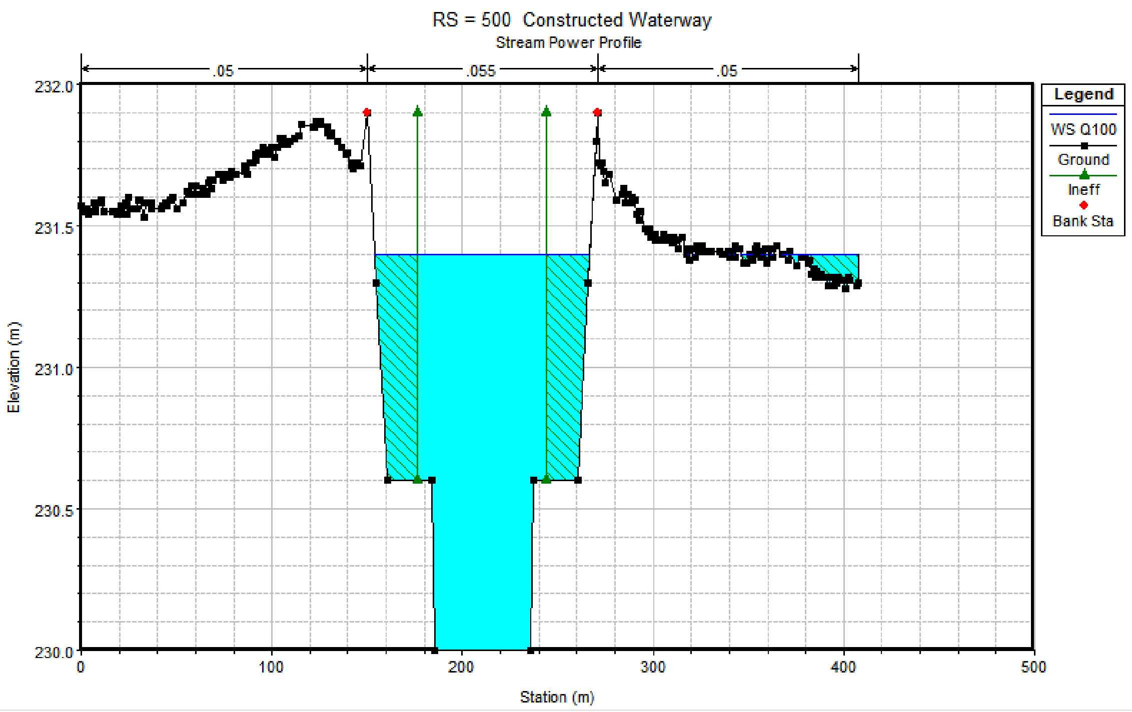


Figure 6-43 Proposed constructed channel entering Kalkallo Creek retarding basin

The trapezoidal channel is 1.8 metres deep and 140 metre wide at the surface and contains flows in the 100 year ARI event with a freeboard of 500 mm. Table 6-15 displays the design flow rates, velocities and stream powers at the pipeline crossing.

Table 6-15 Proposed constructed channel hydraulic results summary table.

AEP	Flow (m^3/s)*	Velocity (m/s) +	Stream Power(Nm^{-2}) #
1%	90	1.06	32.55
Notes: *Data obtained via HEC-RAS models.			

Total flows increased by 25.5 m3/s with close to 1 m/s increase to velocities and 30 Nm^{-2} increase to stream power. The channel velocities for the 100 year ARI flows is 1 m/s, and the subsequent stream powers are low for both locations. The velocity and stream power indicate a relatively low potential for stream bed and bank erosion. It should be noted that the HEC RAS model does not account for all the proposed diversions of the two eastern waterways which is indicated in the DSS plan. Further additions of flows to the proposed constructed channel will increase the hydraulic characteristics of the channel.

Interpretation of the HEC-RAS model suggests that the bed level of the constructed channel will be lowered along the Kalkallo Creek alignment, with the cross section at the pipeline crossing showing the proposed channel approximately 1 metre lower than the existing bed level.

As this area is considered part of the DSS, it is likely that the existing agricultural land will be further developed to accommodate urban growth. As a result of the urbanisation, it is expected that there will be an increase in impervious surfaces. This is likely to be offset by the indicative WSUD treatment assets proposed along the catchment.

6.7 Tributary of Merri Creek (Detailed Assessment)

6.7.1 Waterway assessment

Tributaries of Merri Creek's natural formation have been disturbed since European settlement. Some of the natural interactive processes between the stream and its floodplain have been impacted. This tributary to the west of Merri Creek displays similar characteristics to the channelised systems to Kalkallo Creek. The catchment above the pipeline appears to be over similar flat terrain, and the flow path along the alignment that crosses the pipeline is indistinguishable. In the upper reaches of Merri Creek and its tributaries, changes to stream and floodplain morphology have occurred due to works to improve drainage and mitigate flooding. These involved straightening and channelisation of significant segments of tributaries to Merri Creek.

Site inspection

No site investigation was undertaken at this location. As a result, google street view was used to capture an image of the waterway as close to the crossing as possible. Complementing the google street view images, AUAV captured drone aerial images at each of the main waterway crossing.

Photo	Description
 *Source: Site photo taken (GHD, 2020)*	Tributary of Merri Creek looking north from the Donavan Lane – approximately 170 m north of the pipeline crossing
 *Source: Site photo taken (GHD, 2020)*	Tributary of Merri Creek looking south from the Donavan Lane – approximately 170 m north of the pipeline crossing

Photo	Description
 Source: *Panosphere screen capture (AUAV, 2020)*	Panosphere – Drone aerial imagery Looking north west of rail tracks at Tributary of Merri Creek looking at pipeline crossing location adjacent to Donovans Lane. Red dashed line = Indicative pipeline alignment.

In terms of the waterway condition at the location and in the immediate reach upstream and downstream of the pipeline:

- The tributary is an undefined stream that runs through agricultural land and is covered in grasses with no trees or other ground cover vegetation
- The stream is open and exposed to grazing activities. There is no fencing to protect the stream from animals, and allowing this type of activity can significantly increase bed and bank erosion
- From the imagery there appears to be no active erosion processes, as there is no apparent bed incision within the natural depression overland flow path
- Within the upstream reach there is a culvert crossing underneath Donovans Lane
- The crossing location is within a straightened section of the stream which becomes more defined and meandering downstream before discharging into Merri Creek

6.7.2 Streamflow hydrology

Streamflow data on the Tributary was not obtainable due to there being no gauge station along the waterway.

MWC provided design flood flows for the Tributary of Merri Creek and these are outlined in the section below.

6.7.3 Floodplain management

MWC provided a flood mapping report (Urban Growth Areas Flood Mapping – Package 4) on the Tributary of Merri Creek detailing the modelling completed by GHD in 2012. The construction corridor covers approximately 10.6 km^2 near the township of Beveridge. The models downstream study limit was located at the confluence with Merri Creek. The extent of flood mapping captures the Project crossing, between cross section 1505.35. The modelling software used for the flood-mapping project was RORB, 12D and HEC-RAS. The models received/used for this detailed assessment was the RORB and HEC-RAS models.

Near the site of interest, the design flow rates, velocity and stream powers are summarised in Table 6-16.

Table 6-16 Tributary of Merri Creek hydraulic results summary table.

AEP	Flow (m^3/s)*	Velocity (m/s)*	Stream Power(Nm^{-2})*
1%	26.12	1.08	18.6
Notes: *Data obtained via HEC-RAS model.			

Design flows and subsequent flood levels and extents for the 100 year ARI event were adopted from a previous flood-mapping project using HEC-RAS. The channel velocities for the 100 year ARI flows is just over 1 m/s, and the subsequent stream powers are low. The velocity and stream power indicate a relatively low potential for stream bed and bank erosion. Flow, Velocity and Stream Power profiles along the modelled reaches are displayed in Appendix E which capture hydraulic changes along the reach.

The design flows were modelled in HEC-RAS and results interpreted at a representative cross section within the HEC-RAS model nearest to the location of the Project crossing as indicated in Figure 6-44 below.

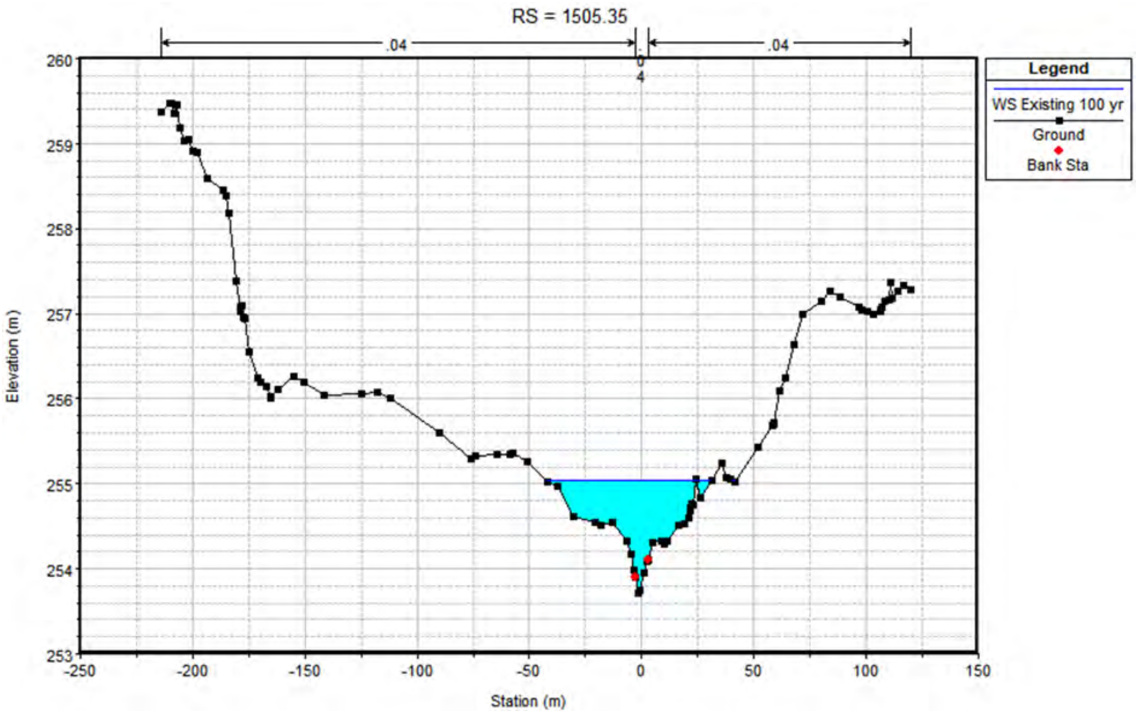
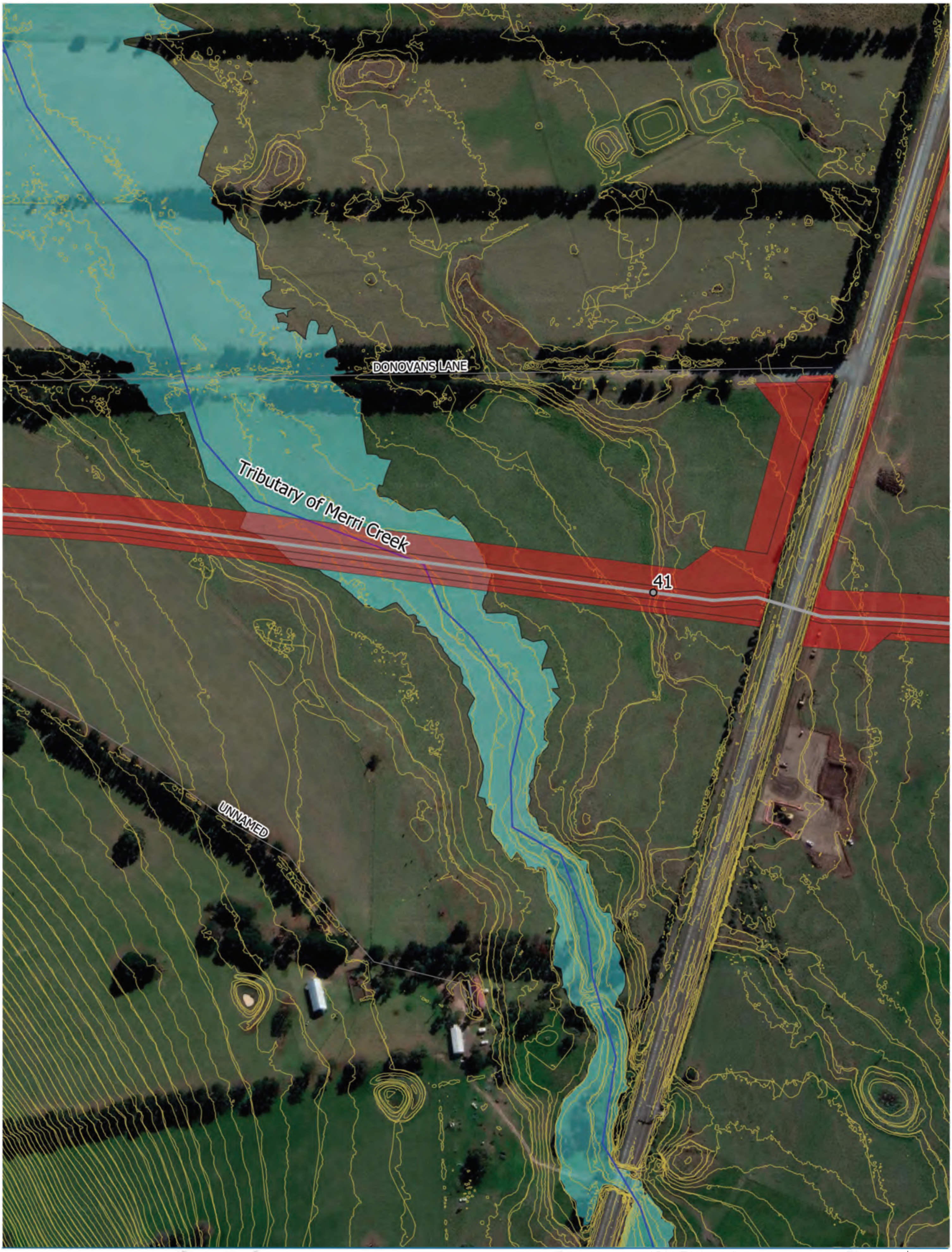


Figure 6-44 Tributary of Merri Creek flood levels at CH 1505.35 (100 year ARI)

From the interpretation of the estimated flood levels:

- There is no defined channel as such and the flows spread across the natural overland flow path and surrounding floodplain
- The estimated 1 in 100 year flood level is approximately 255 m AHD, and spreads across the floodplain terrace over a width of approximately 60 m

The current LSIO mapping was provided by MWC based on the modelling completed by GHD, as presented in Figure 6-45 below.



1:2,499.998215

0 0.010.020.030.040.05 km

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 55

N

LEGEND

- WORM KPs
- WORM Pipeline
- WORM Construction Corridor
- Waterway
- 0.5m Contours
- 100 yr ARI Flood Extent

GHD

APA VTS Australia
WORM Pipeline
Tributary of Merri Creek - Crossing 20
100yr ARI Flood Extent

Job Number	12529997
Revision	A
Date	07/12/2020

Figure 6-45

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Data Custodian, Data Set Name/Title, Version/Date. Created by: toza

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6.7.4 Geotechnical interpretation

Geotechnical bore logs were obtained by Construction Sciences at 2 locations near the Tributary of Merri Creek channel and floodplain. The bore logs based on their coordinate locations have been interpreted on a schematic cross section interpreted from LiDAR as shown in Figure 6-46. The bore logs have been projected from the natural surface levels to their indicated depths.

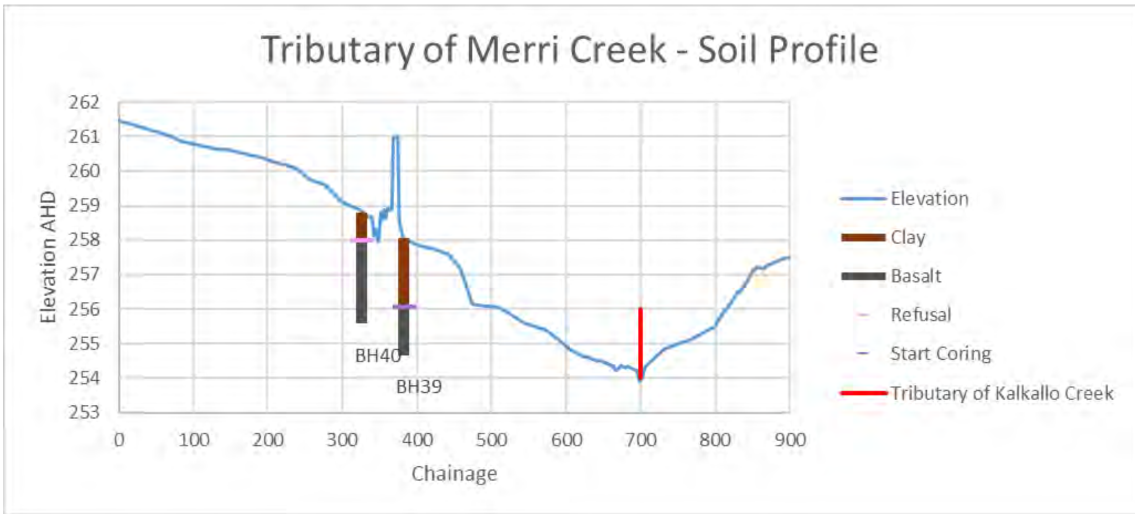


Figure 6-46 Tributary of Merri Creek schematic soil profile cross section

From interpreting the nearest bore logs within the cross section approximately 300 m to the west of ther crossing location:

- The soil profile consists of a shallow clay layers in the upper profile from the surface of clay (~ 2 metres deep)
- Basalt rock is shallow in profile, (depths below ~ 2 metres) and continues for the remainder of the cored borehole until termination

6.7.5 Summary of detailed assessment

From the detailed assessment of the tributary of Merri Creek the following is concluded:

- From observed conditions, the Tributary of Merri Creek consists of ephemeral flows that are generally within the shallow depression of the natural overland flow path, and larger flow events will result in flows laterally spreading out across the floodplain
- Stream velocities and stream powers indicate a low potential for erosion
- Basalt was found at relatively shallow depths (~ 2 metres from natural surface) which would limit the depth of future bed erosion

6.7.6 Future development implications on waterway

The Tributary of Merri Creek catchment is within a Drainage Services Scheme (DSS) and will be subject to ongoing future development with various Precinct Structure Plans within the area. There is no explicit timeline for when the future developments will occur as the main purpose of the DSS is to guide the standards in which future developments will need to meet for flood protection, water quality and waterway health. As shown in the latest MWC DSS for Beveridge East (6513), there is a significant amount of proposed urban development across the entire catchment area of the Tributary. The DSS also presents indicative locations of future drainage assets which includes a number of wetlands, retarding basins and formalised channels located throughout the catchment. The MWC DSS plan for Beveridge East, as shown in Figure 6-47, proposes a formalised channel following the existing waterway alignment including a new constructed channel west of the rail tracks.

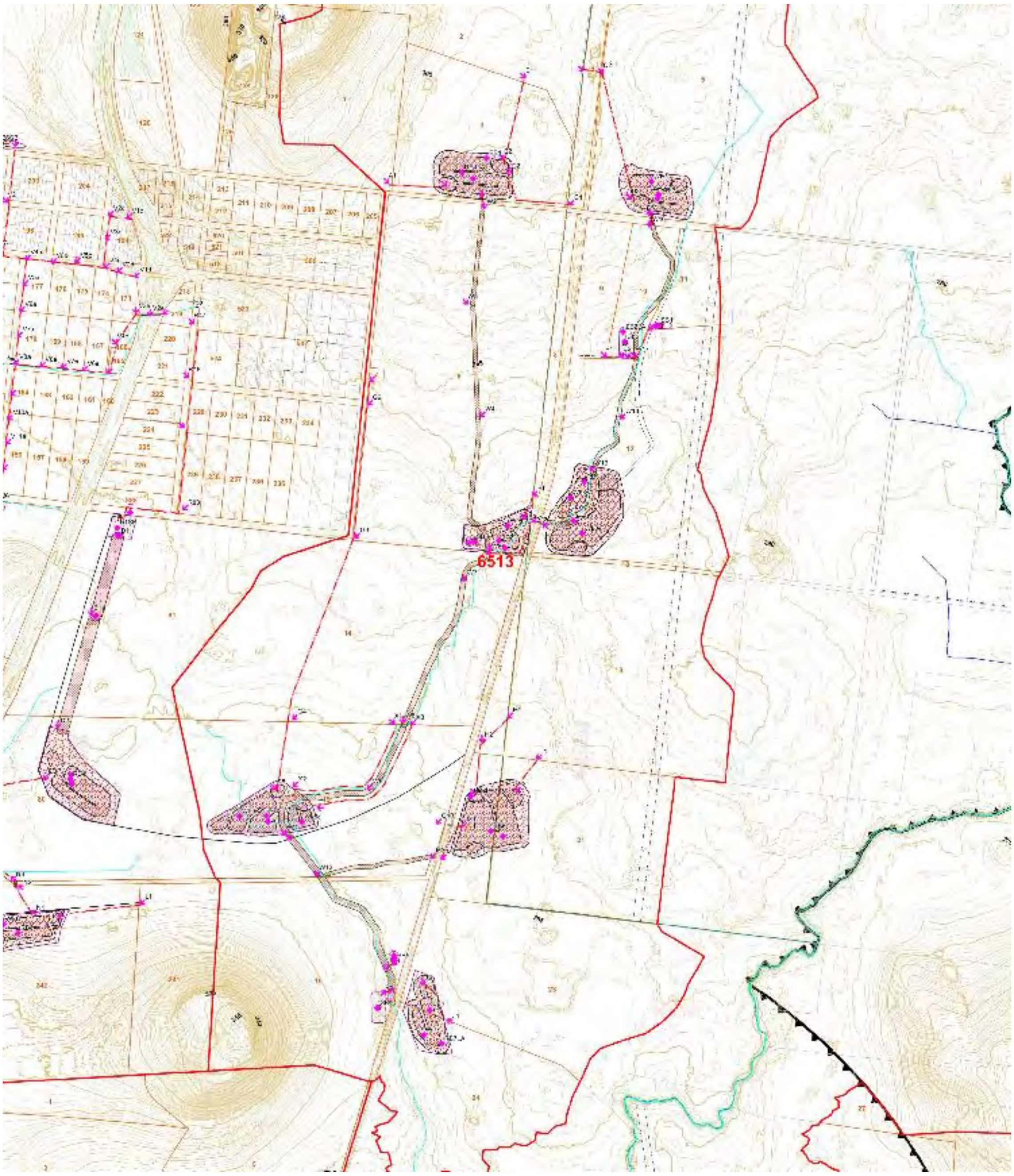


Figure 6-47 Beveridge East (6513) DSS Plan

The formalised channels were modelled in 2012 using HEC-RAS. This included models provided by MWC for the upper and lower channels separated by the retarding basin in the middle of the catchment (RB4).

It should be noted that no report was provided with the Beveridge East HEC-RAS model and an interpretation of the model was required to inform the implications of future development. The proposed retarding basins have also been modelled with the flow reduced at the outlet of the basins to account for storage.

Figure 6-48 presents a representative cross section of the proposed constructed channel at the proposed pipeline crossing.

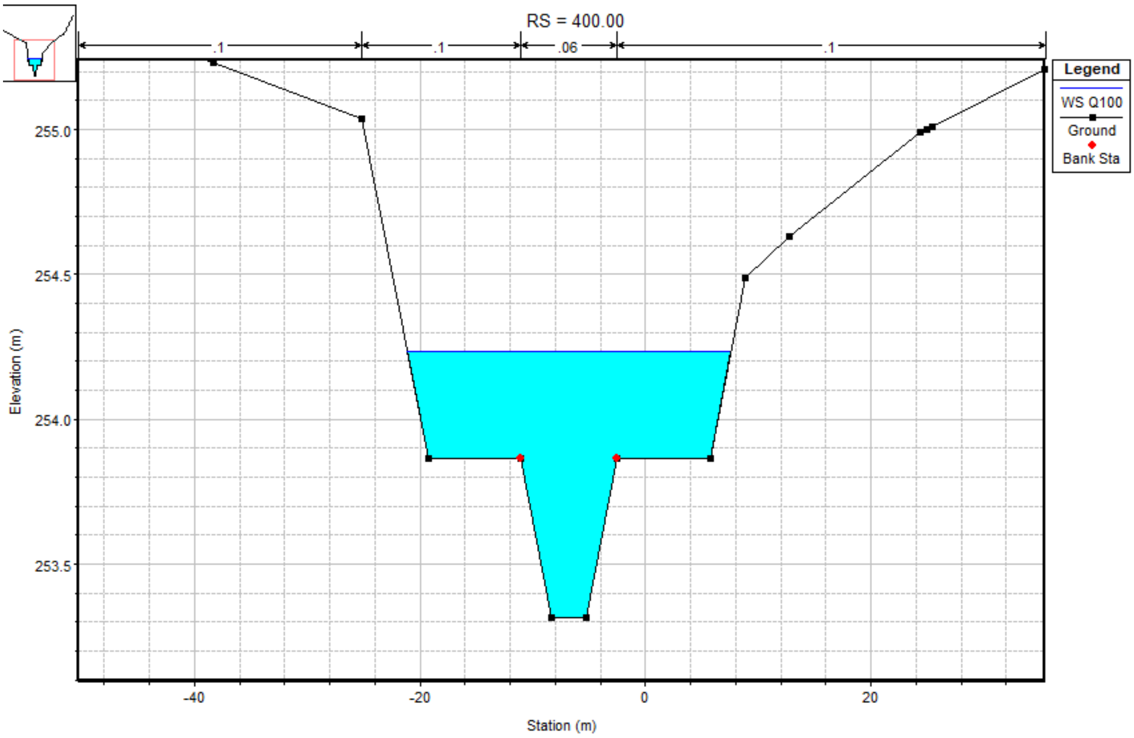


Figure 6-48 Proposed constructed channel at the pipeline crossing

The cross section of the trapezoidal channel at the site of interest is approximately 1.4 metres deep and 30 metre wide at the surface and contains flows in the 100 year ARI event with a freeboard of 300 mm to the top of the incised channel. Table 6-17 presents the design flow rates, velocities and stream powers at the pipeline crossing for the proposed constructed channel.

Table 6-17 Existing waterway and proposed constructed channel hydraulic results summary table.

AEP	Flow (m^3/s)*	Velocity (m/s) +	Stream Power(Nm^{-2}) #
1% - Proposed constructed channel	8.08	0.93	31
Notes: *Data obtained via HEC-RAS models.			

Total flows decreased by approximately 18 m^3/s with little changes to the velocities and stream power. The decrease in flow at the site of interest is expected as there is a proposed retarding basin directly upstream of the Project crossing. The velocity and stream power for the proposed development channel indicate a relatively low potential for stream bed and bank erosion.

Interpretation of the HEC-RAS model suggests that the bed level of the constructed channel will be lowered along the Tributary alignment, with the cross section at the pipeline crossing showing the proposed channel approximately 400 mm lower than the existing bed level.

As this area is considered part of the DSS, it is likely that the existing agricultural land will be further developed to accommodate urban growth. As a result of the urbanisation, it is expected that there will be an increase in impervious surfaces.

6.8 Merri Creek (Detailed Assessment)

6.8.1 Waterway assessment

Merri Creek and its tributaries originated from the uplift of the underlying Silurian siltstones and mudstones that directed flow towards the south. Basalt plains that are characteristic of the catchments north of Melbourne were formed from subsequent lava flows. The creek's course became defined by natural depressions and ridges in the lava surface and by the major fractures and joints in the volcanic rock (Rosengren, 1993). Today, parts of the beds of Merri Creek and its tributaries have cut through the basalt to the underlying Silurian rock. Whilst the upper Merri Creek has been moderately impacted by township scale urbanisation, it has retained its stream form and meandering characteristics through the reach potentially impacted by the Project.

Site inspection

Merri Creek was initially inspected near the location of the pipeline crossing on the 23rd of January 2020 the day immediately following heavy rainfall in the catchment. Complementing the site inspection photos, AUAV captured drone aerial images at each of the main waterway crossing. The photos presented below indicate the pipeline alignment (white stakes).

Photo	Description
 *Source: Site photo taken (GHD, 2020)*	Merri Creek from the southern side highlighting grass coverage of catchment surrounding the creek

Photo	Description
 Source: *Site photo taken (GHD, 2020)*	Merri Creek looking immediately west of crossing location with evidence of dense vegetation within channel and established trees
 Source: *Site photo taken (GHD, 2020)*	Merri Creek at crossing location looking north.
 Source: *Site photo taken (GHD, 2020)*	Merri Creek looking immediately east of crossing location with evidence of dense vegetation within channel and established trees

Photo	Description
 Source: Site photo taken (GHD, 2020)	Merri Creek channel with a rocky base, densely vegetated banks and deeply rooted trees
 Source: Site photo taken (GHD, 2020)	Merri Creek observed rock boulder control feature downstream of the crossing location (shown in Figure 6-49 as Key Feature 4)
 Source: Panosphere screen capture (AUAV, 2020)	Panosphere – Drone aerial imagery Merri Creek looking east of the crossing location. Red dashed line = Indicative pipeline alignment.

Photo	Description
 *Source: Panosphere screen capture (AUAV, 2020)*	Panosphere – Drone aerial imagery Merri Creek looking south-west from crossing location. Red dashed line = Indicative pipeline alignment.

Key observed features/hydraulic controls

A number of key features were identified during the subsequent site inspection on 28 July 2020 in the vicinity of the crossing location, as outlined in Table 6-18. A key hydraulic control was observed approximately 230 m downstream of the crossing location. The location of this feature is marked on the plan view in Figure 6-49 as Key Feature 4 and indicated in the longitudinal profile in Figure 6-50. The rock boulder feature is expected to increase the Manning's roughness of the channel and provide some level of backwater control to the site of interest at the pipeline crossing.

Other relevant features along Merri Creek in the vicinity of the site of interest include a number of meandering sections immediately upstream and downstream of the crossing.

Table 6-18 Key features along the waterway in the vicinity of the crossing

Key feature No.	Description
1	Meander in Merri Creek
2	Meander in Merri Creek
3	Meander in Merri Creek
4	Hydraulic Rock Boulder Control
5	Meander in Merri Creek

Figure 6-49 Plan view of Merri Creek waterway crossing with Key Features.

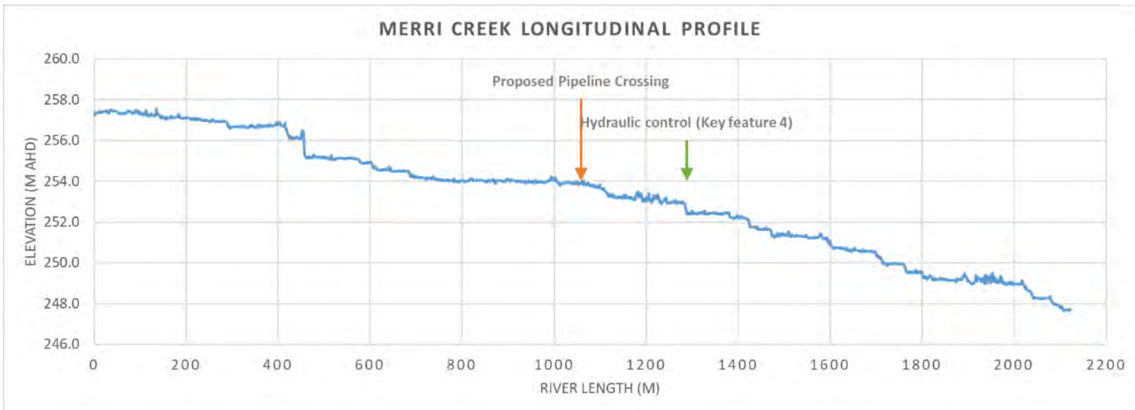


Figure 6-50 Merri Creek schematic profile indicating location of pipeline crossing and hydraulic control feature

Time series images

Near map images were obtained for Merri Creek over a 10 year period, between 2010 and 2020, as shown in Figure 6-51. The time series images below concentrate mainly on the section of Merri Creek where the pipeline alignment crosses the waterway.

Figure 6-51 Nearmap images of Merri Creek at the crossing location over a 10-year period

On the day of the inspection Merri Creek was observed to have little to no flow. In terms of the waterway condition at the location and in the immediate reach upstream and downstream of the pipeline:

- Riparian vegetation of the banks and channel is dense with a healthy mix of deep rooted trees and ground cover vegetation. The riparian vegetation provides protection of both sides of the waterway. This is evident from both the site photos and aerial imagery captured on Nearmap over a 10 year period.
- The waterway appears to be fenced and an effective riparian zone is established which provides protection from grazing activities which occur throughout the adjacent lands
- Within both the upstream and downstream reaches there are sharp meander bends
- The crossing location is meandering section of Merri Creek which continues downstream
- Key feature 4 highlights the location of a section of riffles characterised by shallow depths with fast, turbulent water agitated by rocks and vegetation
- Beneficial Uses downstream may include water dependent ecosystems and species, agriculture and irrigation, water-based recreation (aesthetic enjoyment) and Traditional Owner cultural values
- The crossing location is within an existing APA pipeline easement that was understood to have been previously trenched. The rehabilitation works associated with this previous pipeline construction have been effective and remain stable, where the works are now concealed by vegetation cover.

6.8.2 Geomorphology

Catchment Scale Geomorphology

The upper 10 km of Merri Creek have a very low gradient, related to the stream's oblique traverse of the Mt. Fraser lava flow. This gradient increases abruptly near the location of the crossing, where the river passes across the crest of the lava flow and drains down the south side. This is indicated in Figure 6-52.

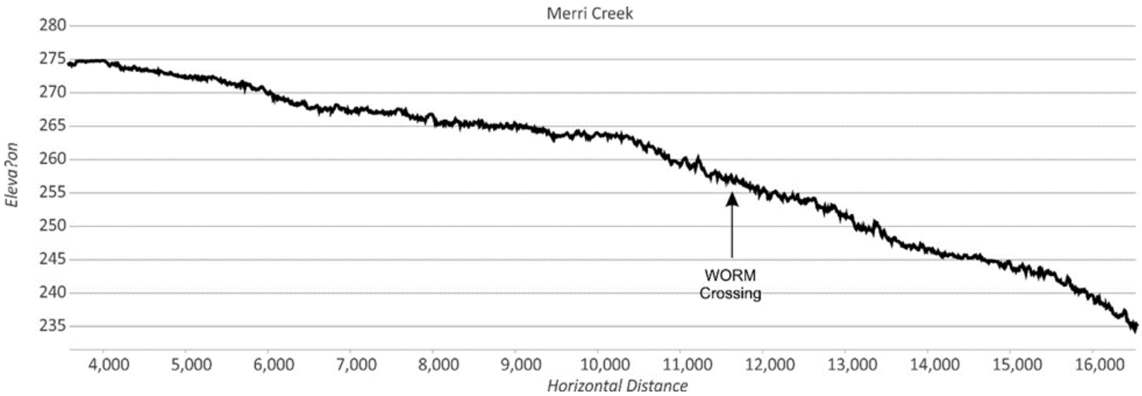


Figure 6-52 Merri Creek Stream Bed Profile

The creek is barely incised into the lava flows, and the full extent of the valley is typically of the order of 4-5 m deep and 40-50 m wide. However, just 100 m upstream of the crossing, a small, 100 m wide abandoned meander, with a bed elevation 2-3 m above the valley floor, locally increases the width of the valley.

The drainage in the upper reaches of Merri Creek and the stream has no significant tributaries in its upper 15 km reach. Incision of 4 m into the lava surface implies that average incision rates over the Pleistocene have been very low.

Reach Scale Geomorphology

Merri Creek assessment has been based on photographs by others and Nearmap aerial imagery that provide some insight into the geomorphic character and trajectory of the site. The reach of interest that was inspected in detail extends approximately 200m both upstream and downstream of the crossing.

Geomorphically, this site is very different to Jacksons and Deep Creek. The site is situated on top of the lava flow and basalt is found everywhere across the site. It is visible in aerial photographs and the channel is notable for the large exposures of basalt in the channel walls, especially the west bank of the south-flowing reach of Merri Creek, downstream of the crossing. A geomorphological map is provided of Merri Creek of the inspected reach near the crossing location in Figure 6-53.

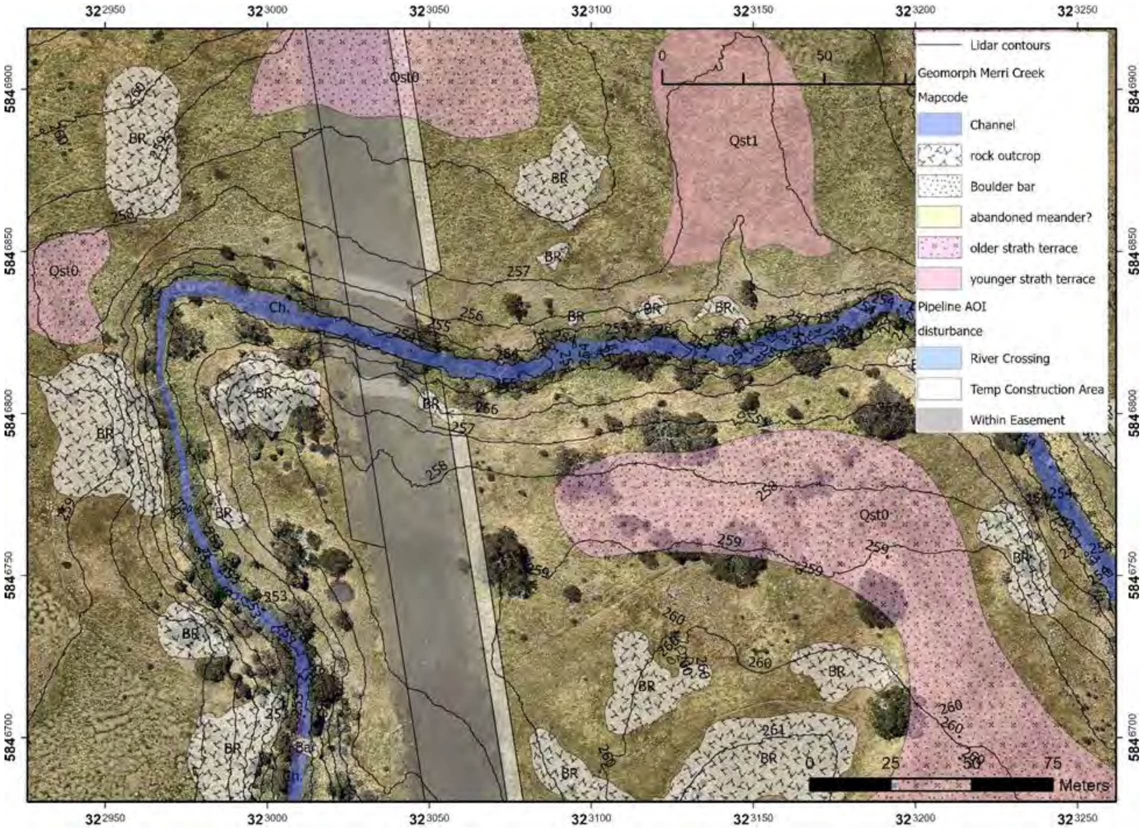


Figure 6-53 Geomorphological map of Merri Creek near crossing location

Overall, the channel has incised very slowly into the basalt. Based on the photographs obtained by an ecology survey in July 2020, the stream at the Merri Creek crossing consists of relatively passive flow conditions flowing through a thickly vegetated stream bed. Closer examination of the LiDAR suggests that the surface into which the stream is incised may be a more extensive abraded meander plain, incised into the basalt (noting the strath terraces are shown on Figure 6-53). Locally, such as 100 m upstream of the crossing, lower meander strath terraces may exist, with a bed elevation 2-3 m above the valley floor. However, none of these terraces appear to have an alluvial cover on them and the basaltic floor and walls of the valley, coupled with the relatively small catchment, make extensive lateral erosion or incision seem unlikely.

No photos show the area upstream of the crossing but many show the downstream area, which has prominent boulder bars. These bars are probably partly constructed by short distance downstream transport of boulders during flash floods, and partly from in-situ weathering and disaggregation of the basalt over which the stream is flowing. These boulder bars create a backwater effect upstream and exert a local control on incision.

An alternative interpretation of the flat, low-lying areas may be as the upper surface of a collapsed lava cavity. The thin soil and irregular topography stony surface in this area, with basalt boulders protruding through a shallow clay soil, is a feature of the ‘stony rise’ geomorphology that is characteristic of the young flows in the western volcanic plains (Joyce et al., 2003). The development of this kind of topography is complex (Grimes, 2002) but irregular hummocks, ridges and depressions in these stony rises are commonly related to collapse of lava cavities formed when flows break out at the front of a lobe and leave an evacuated area behind them (Joyce et al., 2003). The Merri Creek area is older than many of the western volcanics, so its geomorphology is more subdued, but collapsed lava cavities may have formed flat depressed areas such as are seen here. In some cases, these depressions may accumulate sediment through internal drainage. For example, visual assessment of the ground textures on a digital terrain model (derived from 0.5 m LiDAR contours) suggests that a depression like this may be found between 300 and 600 m north of the Merri Creek Crossing.

In other cases, potentially including the Merri Creek crossing site, streams may pass through the depression, possibly following a network of depressions, giving the impression of laterally extensive meanders that are inconsistent with the stream power.

Within the channel, the stream at the Merri Creek crossing consists of relatively quiet water flowing through a thickly vegetated stream bed (Figure 6-54).

Figure 6-54 Riparian Vegetation and Rock Boulders

6.8.3 Streamflow hydrology

Streamflow data on Merri Creek was obtain at Summerhill Road, Craigieburn gauge station. This is located 14.5 km downstream of the crossing. The period of record for this gauge station is from 1977 to present day.

From Figure 6-55 below, the mean annual flow is 0.04 m^3/s, and the mean summer-autumn flow is 0.001 m^3/s.

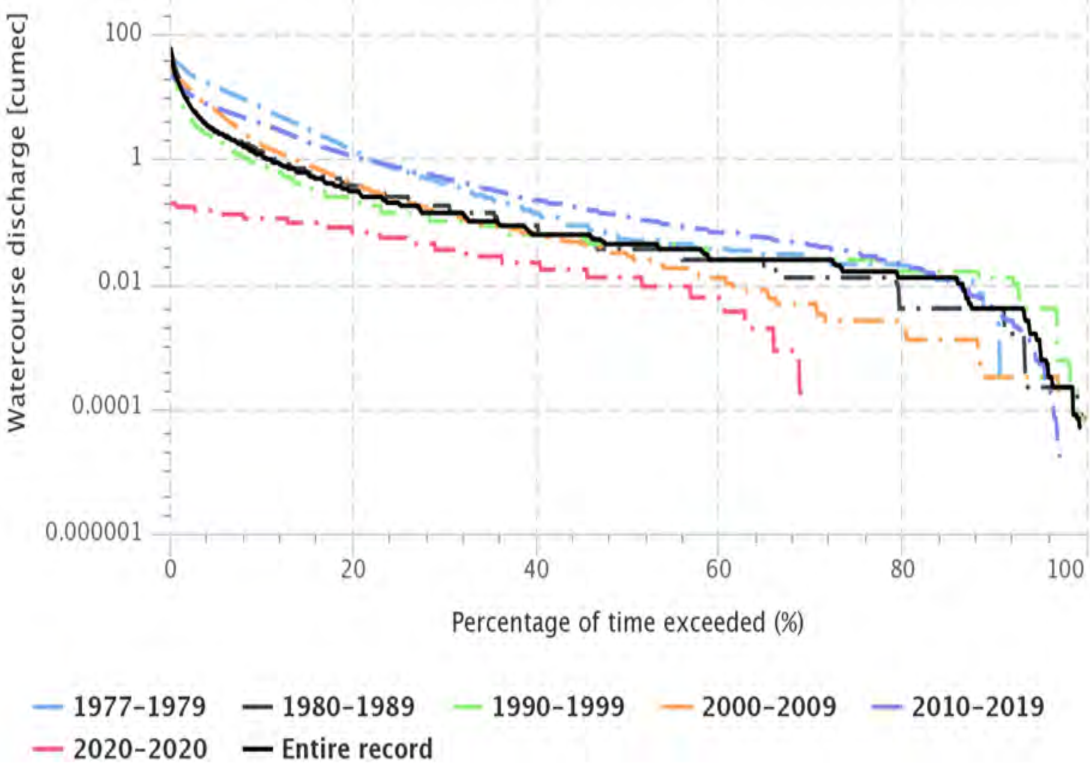


Figure 6-55 Merri Creek gauge station - Flow Duration Curve

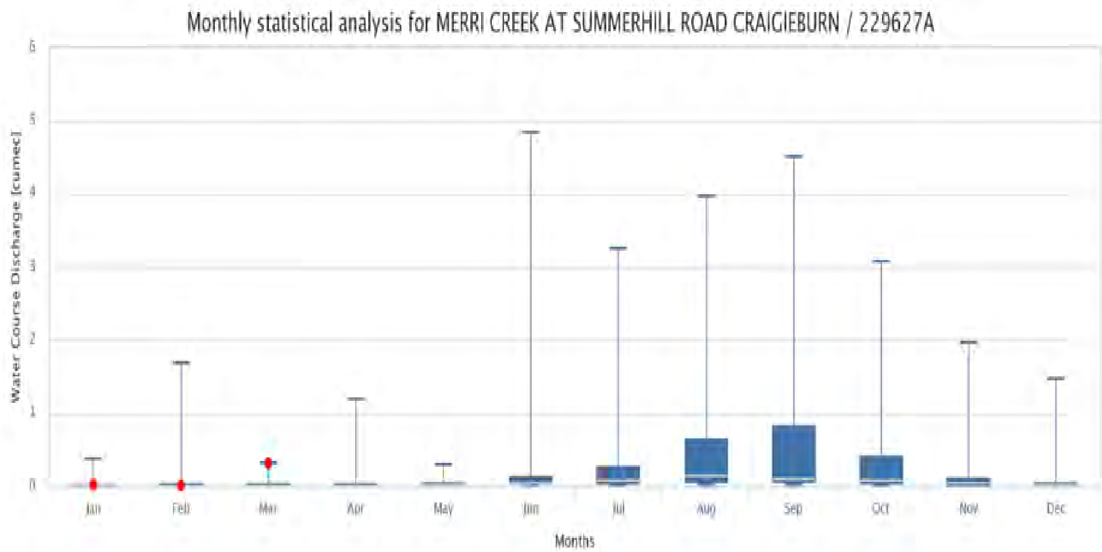


Figure 6-56 Merri Creek gauge station - Monthly Data

Figure 6-56 identifies the monthly flow recorded at this gauge station.

Design flood flows were not available during the desktop study for Merri Creek, therefore GHD's analysis and estimated flows are outlined in the section below.

6.8.4 Floodplain management

Flood mapping information concerning the Merri Creek was not available during the desktop assessment. As a result, design flows were estimated using a RFFE model and hydraulic modelling was completed using HEC-RAS with 50 cm LiDAR contours covering the area. The HEC-RAS model for Merri Creek captures approximately 2 km upstream and downstream of the Project crossing.

Near the site of interest, the design flow rates, velocities and stream powers are summarised in Table 6-19 below.

Table 6-19 Merri Creek hydraulic results summary table.

AEP	Flow (m^3/s)*	Velocity (m/s)*	Stream Power(Nm^{-2})*
1%	150	2.18	213.20
2%	116	2.03	180.13
5%	86.7	1.87	147.58
10%	67.2	1.70	115.28
20%	49.5	1.49	81.51
Notes: *Data obtained via HEC-RAS model.			

Design flows were modelled and subsequent flood levels and extents were estimated from HEC-RAS. The modelled channel velocities for the 1% AEP and 2% AEP exceed 2 m/s with the stream powers less than 300 Nm^2. The velocities indicate a moderate potential for stream bed and bank erosion. Flow, Velocity and Stream Power profiles along the modelled reaches are displayed in Appendix E which capture hydraulic changes along the reach.

The HEC-RAS results were interpreted at a representative cross section within the model nearest to the location of the Project crossing as indicated in Figure 6-57 below.

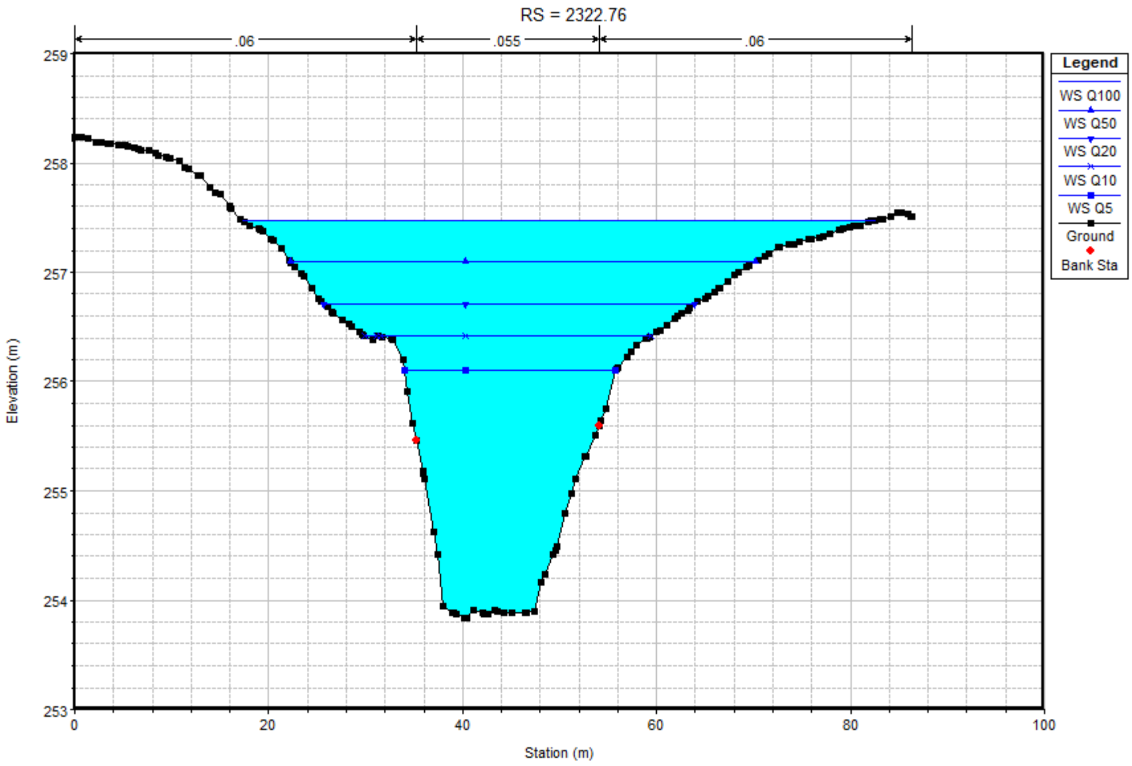
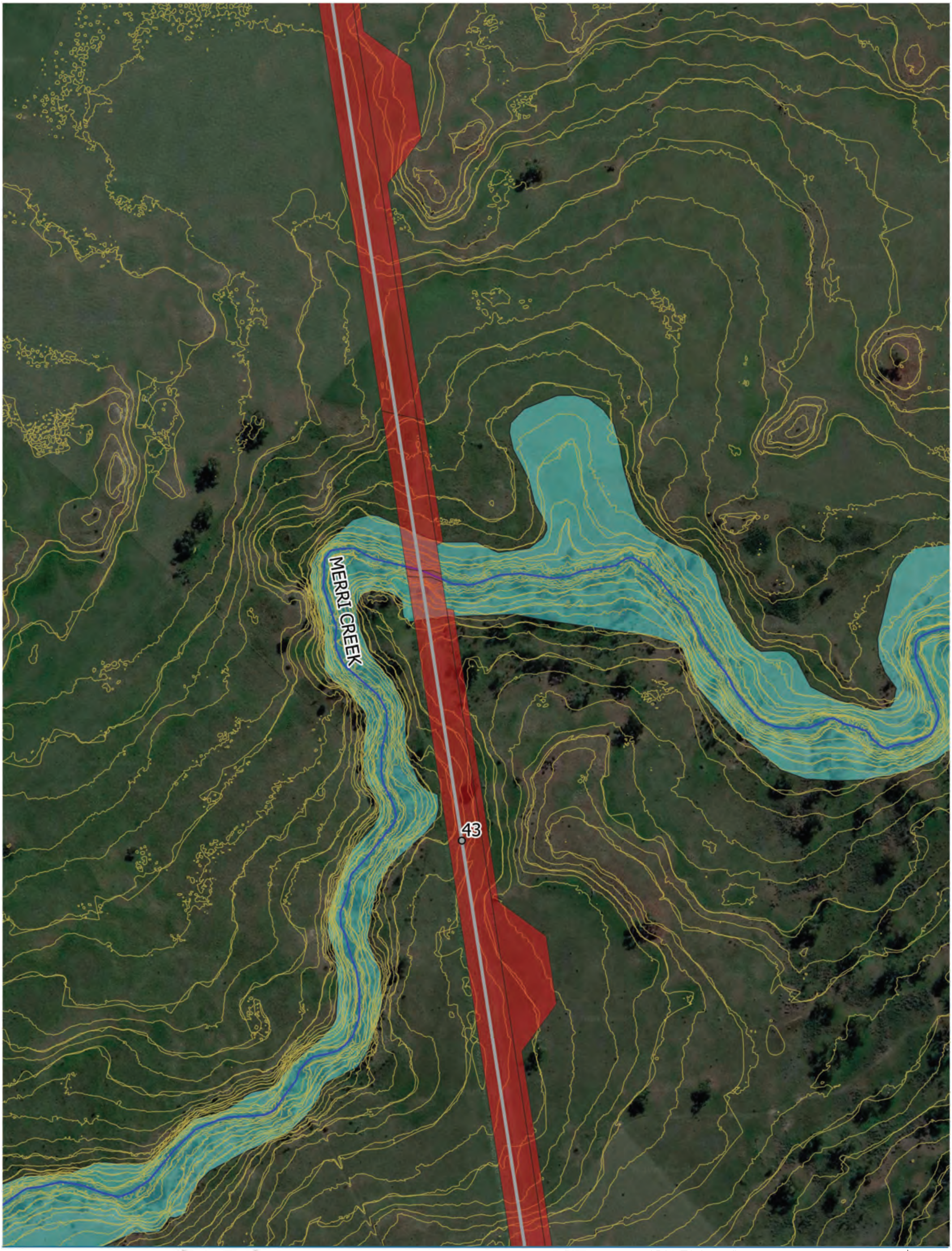


Figure 6-57 Merri Creek flood levels at CH 2322.76 (5, 10, 20, 50 and 100 year ARI)

The key findings from the interpretation of the estimated flood levels:

- The main channel has a less than 1 in 5 year ARI capacity
- The estimated 1 in 100 year ARI flood level is approximately 257.47 m AHD at the site of interest and spilling over the floodplain is expected along the left and right bank
- The floodplain is expected to be engaged frequently

Flood mapping outputs were provided in the MWC data as presented in Figure 6-58 below.



1:2,499.998215

0 0.010.020.030.040.05 km

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994
Grid: Map Grid Of Australia, Zone 55

N

LEGEND

- Waterway
- 0.5m Contours
- 100 yr ARI Flood Extent
- WORM KPs
- WORM Pipeline
- WORM Construction Corridor

APA VTS Australia
WORM Pipeline

Job Number	12529997
Revision	A
Date	07/12/2020

Merri Creek - Crossing 21
100yr ARI Flood Extent

Figure 6-58

\\ghdnet\ghd\AU\Melbourne\Projects\31\12529997\GIS\Maps\Working\Surface_Water_Chapter\Surface Water\Workspace_APA_Pipeline_Clean.qgz

Data Custodian, Data Set Name/Title, Version/Date. Created by: toza

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6.8.5 Geotechnical interpretation

Geotechnical bore logs were obtained by Construction Sciences at 2 locations near the Merri Creek channel and floodplain, as shown in Figure 6-59. The bore logs are based on their coordinate locations which have been interpreted on a schematic cross section derived from LiDAR. The bore logs have been projected from the natural surface levels to their indicated depths. It should be noted that bore hole 27 was terminated after a few metres and borehole 27C was completed at a later date to complete the log.

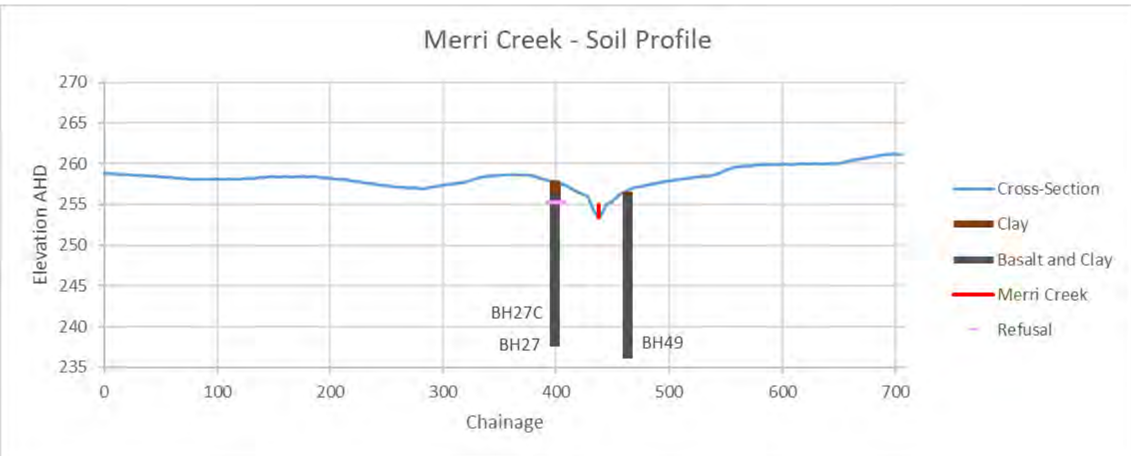

Figure 6-59 Merri Creek schematic soil profile cross-section

6.8.6 Water Quality and Beneficial Uses

There is limited water quality data available for Merri Creek. There is no stream gauge site upstream of the pipeline. Water quality data downstream of the site was taken from Merri Creek at Summerhill Road, Craigieburn (YAMER0195 - MY26)). This gauge is 9.7 km downstream of the proposed pipeline. The samples were collected between 2010 and 2020.

Both the proposed pipeline and the stream gauge are situated in agricultural zones. However, there is housing estate located between the proposed pipeline and the gauge, which was constructed in Kalkallo in 2016. Runoff from the estate may influence the water quality at the gauge.

Water quality statistics are presented in Table 6-20. The pH at Merri Creek was slightly above the SEPP guideline value. Dissolved oxygen, electrical conductivity, turbidity, ammonia, nitrate, total nitrogen, phosphate, total phosphorus, chromium, copper and zinc were noncompliant with the guideline values.

There are several possible sources for the non-compliant parameters:

- The elevated nitrogen, ammonia, nitrate, oxidised nitrogen, phosphate and phosphate concentrations may be caused by natural sources (e.g. bacteria or minerals) as well as by human sources (e.g. eroded soil, stormwater runoff and discharges from agriculture).
- The sources of the elevated metals (e.g. chromium, copper and zinc) may be natural (from the weathering or rocks and soils) or non-natural (e.g. from agricultural runoff and runoff from urban areas). The toxicity and bioavailability of metals in rivers is influenced by pH, dissolved oxygen and organic carbon levels. That is, the metals may be present in the stream but not in a form that is available to organisms.
- Turbidity is a measure of the clarity of water. The non-compliant turbidity may be a result of streambank erosion or agricultural runoff upstream.

- Electrical conductivity indicates the amount of salts dissolved in a waterbody. The elevated electrical conductivity in Merri Creek may be caused by geology, agricultural runoff or groundwater.
- Changes in pH are also influenced by natural causes as well as by human activity. The pH of waterbodies is affected by geology, soils, salinity, rainfall and by aquatic organisms such as plants and algae. Human activities which influence pH include changes to the hydrology of rivers, discharges from urban areas and emissions from car exhausts, which react with molecules in the air and lower the pH of rain.
- The noncompliant dissolved oxygen concentrations may be caused by instream plants, leaf litter from the riparian zone as well as urban runoff and septic tank discharges

ANZG (2018) states that guidelines are concentrations that, if exceeded, would trigger a management response, such as the refinement of the guidelines according to local conditions. ANZG (2018) also recommend that ideally site-specific guideline values that are relevant to local conditions or situations should be used. Given the statistics for some water quality parameters presented in Table 6-20 exceed the relevant SEPP (Waters) and ANZG (2018) guidelines, it is recommended the statistics in the table below be used to evaluate changes in water quality, as they better reflect the existing water quality in the region.

Table 6-20 Water quality statistics – Merri Creek at Cooper Street, Somerton

Parameter	Number of samples	min	median	mean	max	25th %ile	75th %ile	SEPP	ANZG
DO (% sat)	125	32.5	85.8	78.4	117.0	64.8	91.3	25%≥75, max=130	
DO (mg/L)	125	2.92	8.43	7.96	12.9	6.27	9.84		
EC (µS/cm)	125	230	1,400	1,850	6,100	960	2200	75%≤250	
Turbidity (NTU)	125	1.9	14.0	37.2	350.0	5	40	75%≤25	
Water Temperature (°C)	125	6.5	14.6	14.4	24.0	10	17.3		
pH	125	6.8	7.8	7.8	9.7	7.6	8	25%≥6.7, 75%≤7.7	
Sus. Solids (mg/L)	125	1	9	14	140	5	16		
Ammonia (mg/L)	125	0.001	0.013	0.028	1.4	0.007	0.02		Max≤0.9
NO_2 (mg/L)	125	0.001	0.003	0.006	0.079	0.001	0.005		
NO_3 (mg/L)	123	0.0015	0.08	0.352	11.0	0.018	0.295		Max≤0.7
Kjeldahl Nitrogen (mg/L)	125	0.42	0.95	1.14	4.0	0.74	1.3		
Total Nitrogen (mg/L)	69	0.579	0.97	1.26	4.519	0.77	1.5	75%≤1.1	
Phosphate - Filtered (mg/L)	125	0.0015	0.011	0.016	0.078	0.006	0.019		Max≤0.02
Total Phosphorus (mg/L)	125	0.014	0.068	0.090	0.45	0.039	0.12	75%≤0.055	
As - total (mg/L)	125	0.0005	0.003	0.004	0.021	0.002	0.005		Max≤0.013
Cd - total (mg/L)	125	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001		Max≤0.0005
Cr - total (mg/L)	125	0.0005	0.001	0.003	0.017	0.0005	0.004		Max≤0.0004
Cu - total (mg/L)	125	0.0005	0.002	0.002	0.008	0.0005	0.003		Max≤0.0014
Pb - total (mg/L)	125	0.0005	0.0005	0.001076	0.006	0.0005	0.001		Max≤0.0034
Ni - total (mg/L)	125	0.0005	0.004	0.004	0.011	0.003	0.005		Max≤0.011

Parameter	Number of samples	min	median	mean	max	25th %ile	75th %ile	SEPP	ANZG
Zn - total (mg/L)	125	0.0005	0.006	0.008	0.05	0.003	0.011		Max≤0.008
E. coli MF (orgs/100mL)	33	20	320	449	2000	140	540		
E. coli MPN (orgs/100mL)	92	10	350	855	10000	150	632.5		
Crypto % recovered	8	22.0	71.0	62.625	87.0	53.5	80		
Cryptosporidium (cyst/L)	8	0.025	0.075	0.141	0.4	0.05	0.2125		
Giardia (CY/L)	8	0.025	0.0375	0.1	0.55	0.025	0.05		
Giardia % recovered	8	32.0	57.0	55.5	89.0	41.75	61.5		
Adenovirus (D/ND)	8	0.55	0.55	0.55	0.55	0.55	0.55		
Enteric virus by cell culture volume analysed (L)	8	10.0	20.0	18.75	20.0	20	20		
Enterovirus (MPNIU/L)	8	0.55	0.55	0.55	0.55	0.55	0.55		

Blue shading indicates non-compliance with either SEPP or ANZG guideline value

6.8.7 Summary of detailed assessment

From the interpretation of the bore logs within the cross sections:

- The soil profile consists of a shallow (~2 m) layer of clay before reaching basalt which continued until the drilling was terminated
- Basalt rock is shallow in profile

From the detailed assessment of Merri Creek, the following is concluded:

- From observed conditions, Merri Creek has ephemeral flows that are generally contained within the channel. Larger rainfall events will cause flows to spread out across the northern floodplain.
- Stream velocities based on updated modelling indicate a moderate potential for erosion
- Basalt was found at relatively shallow depths (~2 m from natural surface) which would limit the depth of future bed erosion
- The estimated flood levels near the location of interest has engaged the floodplain on either side of the channel
- Water quality in Merri Creek downstream is noncompliant with guideline values for a number of parameters, including pH, dissolved oxygen, electrical conductivity, turbidity, ammonia, nitrate, total nitrogen, phosphate, total phosphorus, chromium, copper and zinc

7. Risk Assessment

A risk assessment of Project activities was performed in accordance with the methodology described in Section 5.6.

The initial risk ratings considered an initial set of mitigation measures (where relevant), which are based on compliance with legislation and standard requirements that are typically incorporated into the delivery of infrastructure projects of similar type, scale and complexity. Risk ratings were applied to each of the identified risk pathways assuming that these mitigation measures were in place.

Where the initial risk ratings were categorised as medium or higher, these risks were a focus of the impact assessment and additional management measures were considered (where possible) as part of the impact assessment.

The assessment of the potential impacts associated with the identified risks during the construction and operation of the Project is presented in the following section of this report. The risk results are based on a trenching construction methodology through the waterways.

The risk register showing the risk pathways and findings of the risk assessment for surface water is attached in Appendix A.

A summary of the risk assessment results is presented in Table 7-1.

Table 7-1 Risk results

Risk ID	Risk description	Construction/ operation	Pipeline/ MLV/ compressor	Initial risk rating	Final risk rating
SW1	**Site runoff (runoff quality)** Construction works within or near the watercourse impacting on downstream environments including due to runoff from adjacent construction areas and discharge from dewatering activities.	Construction	Pipeline	Low	Low
SW2	**Waterway or floodplain function** Construction works including works at waterways, ground disturbance and stockpiling changing flooding or surface water flow paths impacting property or infrastructure.	Construction	Pipeline	Low	Low
SW3	**Waterway or floodplain function** High flow or flood event occurring during construction works including disturbed areas associated with waterways and floodplains impacting river health downstream.	Construction	Pipeline	Low	Low

Risk ID	Risk description	Construction/ operation	Pipeline/ MLV/ compressor	Initial risk rating	Final risk rating
SW4.1	**Waterway or floodplain function – Jacksons Creek** Disturbance caused to the waterway or floodplain from construction and rehabilitation works resulting in permanent changes to the waterway or floodplain function, that could potentially impact the pipeline itself and/or surrounding property/infrastructure	Construction and Operation	Pipeline	High	Medium
SW4.2	**Waterway or floodplain function – Deep Creek** Disturbance caused to the waterway or floodplain from construction and rehabilitation works resulting in permanent changes to the waterway or floodplain function, that could potentially impact the pipeline itself and/or surrounding property/infrastructure	Construction and Operation	Pipeline	Low	Low
SW4.3	**Waterway or floodplain function – Merri Creek** Disturbance caused to the waterway or floodplain from construction and rehabilitation works resulting in permanent changes to the waterway or floodplain function, that could potentially impact the pipeline itself and/or surrounding property/infrastructure	Construction and Operation	Pipeline	Medium	Low
SW5	**Waterway or floodplain function (all other waterways)** Disturbance caused to the waterway or floodplain from construction and rehabilitation works resulting in permanent changes to the waterway or floodplain function, that could potentially impact the pipeline itself and/or surrounding property/infrastructure	Construction and Operation	Pipeline	Medium	Low

Risk ID	Risk description	Construction/ operation	Pipeline/ MLV/ compressor	Initial risk rating	Final risk rating
SW6	**River bed or bank erosion (All other waterways excluding “complex” waterways)** Construction works causing river bed or bank erosion that could affect river health.	Construction	Pipeline	Low	Low
SW7.1	**River bed or bank erosion – Jacksons Creek** Construction works causing river bed or bank erosion that could affect river health.	Construction	Pipeline	Medium	Low
SW7.2	**River bed or bank erosion – Deep Creek** Construction works causing river bed or bank erosion that could affect river health.	Construction	Pipeline	Negligible	Negligible
SW7.3	**River bed or bank erosion – Merri Creek** Construction works causing river bed or bank erosion that could affect river health.	Construction	Pipeline	Medium	Low
SW8	**River bed or bank erosion (All other waterways excluding “complex” waterways)** Construction works causing river bed or bank erosion that could impact surrounding property and infrastructure.	Construction	Pipeline	Low	Low
SW9.1	**River bed or bank erosion - Jacksons Creek** Construction works causing river bed or bank erosion that could impact surrounding property and infrastructure	Construction	Pipeline	Medium	Low
SW9.2	**River bed or bank erosion – Deep Creek** Construction works causing river bed or bank erosion that could impact surrounding property and infrastructure	Construction	Pipeline	Negligible	Negligible

Risk ID	Risk description	Construction/ operation	Pipeline/ MLV/ compressor	Initial risk rating	Final risk rating
SW9.3	**River bed or bank erosion – Merri Creek** Construction works causing river bed or bank erosion that could impact surrounding property and infrastructure	Construction	Pipeline	Low	Low
SW10	**Spills (surface water)** Construction activities such as an oil spill resulting to contaminated discharge, impacting on water quality at local waterway.	Construction	Pipeline	Low	Low
SW11	**Dispersive (Sodic) Soil behaviour** Open trench construction activities within and near waterways that have potential for dispersive (sodic) soil behaviour.	Construction	Pipeline	Medium	Low

The risk results presented in Table 7-1 are based on a trenching construction methodology through all waterways except for Deep Creek. For the potential impacts to waterway or floodplain function during operation and river bed or bank erosion during construction, the risk associated with the “complex” waterways have been assessed as a separate risk item to all other waterways. The majority of waterways are minor waterways or drains with ephemeral flows or are dry most of the time. For all other waterways, trenching and restoration can be completed mitigating any impacts to the environment with the appropriate standard mitigation measures in place these are considered low risk.

The medium to high initial risk rating for Risk ID SW4.1, SW7.1, SW9.1 are associated with Jacksons Creek due to trenching activities that are exacerbated by the exposure to potentially erodible soil layers during construction. The risk of erosion and stability issues associated with the works could have a significant consequence on the waterway health and result in degradation of water quality (Risk ID SW7.1) and impact on the surrounding properties and infrastructure (Risk ID SW9.1). Furthermore, the disturbance caused to Jacksons Creek from trenching through the waterway could result in permanent changes to the waterway and floodplain function following the rehabilitation and restoration of the existing profile (Risk ID SW4.1). Whilst the intent is to rehabilitate and restore the waterway crossing towards pre-existing conditions, there remains potential for ongoing risk of erosion due to the complexities associated with the geomorphological processes of Jacksons Creek. Possible use of HDD technique at Jacksons Creek crossing was considered not feasible due to a number of contributing factors described in Section 5.7.1. The ongoing risk of erosion and stability issues associated with the works could impact significantly on the surrounding properties and infrastructure. As such, an initial risk rating of ‘high’ was identified for Jacksons Creek during construction and operation (Risk ID SW4.1) with consideration of standard mitigation measures in place. The impact assessment for Risk ID SW4.1 is discussed further in Section 8.2.1.

Both Deep Creek and Merri Creek would be considered low risk with the appropriate mitigation measures in place. As discussed in Section 5.7.1, Deep Creek is expected to be crossed using HDD construction method and likely to have minimal impact as no disturbance of the ground surface is required for this trenchless method. The risk rating associated with Merri Creek (SW4.3 and SW7.3) is also considered to be low as the potential for erosion and ongoing impacts during operation is minimal with the appropriate mitigation measures implemented. The impact assessment for these risk items are discussed further in Section 8.

8. Impact assessment

8.1 Construction impacts

This section describes the potential impacts to surface water assets, values and uses from the construction of the Project.

8.1.1 Runoff from general construction activities (Risk ID SW1, SW10)

The risk items discussed in this section are applicable for general construction activities and the potential for contamination of the waterways.

Site runoff (Risk ID SW1)

Runoff from disturbed areas within the construction corridor associated with the pipeline works has the potential to impact receiving waterway environments due to runoff from laydown areas, works along steep terrain adjacent to waterways, stripped surfaces and stockpiled material and discharge from dewatering activities. This may have an adverse impact on the water quality in receiving waters and subsequently impacting on the beneficial uses downstream. Pollutants may include contaminated sediments, oils, solid inert waste, chemicals and nutrient inputs from silt-laden runoff. Soils introduced into waterways would also increase turbidity and sediment loads which would have an impact on aquatic fauna and flora (discussed in the EES Technical Report A Biodiversity and habitats).

To minimise the impacts on beneficial use and downstream environments, the standard construction controls (EMM SW1) including undertaking works on waterways during low flow conditions and monitoring weather forecast. Management of stockpiled materials, flow diversion and temporary access crossings would be in place to allow runoff to be directed away from the construction works.

Site dewatering

Construction dewatering works has the potential to cause mobilisation of soil and other pollutants which may impact on surface water quality and subsequently impact on beneficial uses downstream. It is required that water collected from trenches during or after a rainfall event is to be disposed appropriately without contributing to water pollution. Dewatering of trenches due to rain should be collected and treated if turbidity exceeds EPA requirements prior to discharging and disposed of in accordance with measures outlined in EPA publication 1834 and International Erosion Control Association Best Practice Erosion and Sediment Control, Appendix P – Land Based Pipeline Construction (IECA, 2008), as part of the CEMP. Non-contaminated groundwater and surface water run off that enters the open trenches and bell holes should be managed in accordance with SEPP (Waters). This is managed as part of EMM SW1.

Dewatering of open trenches after a rainfall event would require appropriate disposal without impacting on beneficial use or human health. Discharge to land should not occur within 100 meters of watercourses. There are a number of surface water disposal options that could be considered depending on volumes, surface water quality and nearby infrastructure, including:

- Land; irrigation of private or public land
- Stock watering; i.e. storage in a dam for later use
- Sewer; if present nearby and trade waste agreement would be required
- Offsite; trucked offsite for use, treatment or disposal
- Waterways; i.e. the nearest creek

Discharge from trenchless construction sites

The HDD construction method is to be adopted in various pipe segments throughout the Project to overcome specific site constraints. It may be appropriate for specific waterway crossings where the existing waterway may be highly sensitive. Whilst this construction method is able to significantly reduce the risks to waterways associated with open trenching of waterway crossings, there are other potential impacts associated with HDD such as the management of drilling fluid and runoff from the site. Similar to the open trench construction method, discharge of hazardous drilling fluid produced from the drilling site has a high potential to impact the downstream environments and the water quality discharging into the waterway. To prevent the hazardous drilling fluid from the trenchless drilling site to discharge into the waterway, the installation of earth bunds and drainage channels would be required to divert runoff away from the HDD site works area and prevent it from mixing with drilling fluids (EMM SW1).

The use of temporary drilling fluids (such as bentonite) during trenchless HDD or pipe-jacking operations can result in blow-out (also known as “fracking”), whereby the drilling fluid leaks through the bore into the surrounding soil, surface water or aquifer. Drilling fluids are unlikely to be a risk to human health as the drilling fluids are generally biodegradable and inert. Impacts from blow-out into waterways and across land would be anticipated to be short term, reversible and on a localised scale. The EES Technical Report E Contamination discusses in detail the impact of blow-out to the environment including recommended mitigation measures outlined in EMM C9. The EES Technical Report D Land stability and ground movement also describes implementation of mitigation measures to reduce the likelihood of blow-out occurring based on assessing ground conditions and monitoring of drilling fluids for HDD activities (EMM GM5 and EMM GM6).

Spills (Risk ID. SW10)

There is a potential for spilling of fuels or other hazardous materials used during construction to be released into the waterways and impact on water quality. This may include fuels and liquids used in machinery and equipment for trenching or drilling.

This would need to be managed through the CEMP in accordance with mitigation measures described in EES Technical Report E Contamination assessment (EMM C6). This includes installation of bunds and precautions where storage is required (i.e. generators), availability of spill kits, chemical storage limitations, as well as a contingency and emergency response procedures to handle spills. Impacts associated with spills are considered low with the appropriate mitigation measures applied during construction.

Summary

The following EMMs are required for managing dewatering and general runoff from construction sites:

- EMM SW1 - Managing runoff from adjacent construction areas, discharge from dewatering activities and spills / leaks
- EMM SW5 - Monitoring program developed and implemented for Jacksons Creek and Merri Creek

The application of the above management measures is considered to achieve ‘minimisation’ of the impact according to the mitigation hierarchy. See Section 9 for more detail on the above EMMs.

With successful application of the above EMMs, the overall residual impact to the waterway health and downstream environments due to mobilisation of site runoff and sedimentation impacts are low.

8.1.2 Flooding impacts (Risk ID SW2, SW3)

Flooding impacts on property and infrastructure (risk ID SW2)

Construction activities have the potential to change the flood regime and floodplain function due to impediment of flow resulting in an increase in flood levels. This can be caused by temporary placement of construction materials, structures, or stockpiles within the floodplain. There is also a potential for high flow or flood event to occur during construction which would collect and transfer construction materials and compounds into the waterway and have an effect on the river health downstream.

Where the pipeline is to be trenched across floodplains and waterway crossings, there is a potential for flooding or surface water flow paths to be altered due to the ground disturbance and stockpiling of materials that could impact on existing properties or infrastructure. This includes obstruction of existing flow paths upstream due to construction of temporary access tracks, and placement of materials and equipment within the construction corridor directly in the waterway or floodplain. If a high flow or flood event were to occur during the construction works, there is high potential for existing properties or infrastructure to experience increased flood levels.

To minimise the impacts to the function of waterways and floodplains during construction and allow flow to be conveyed across the construction area, the Project would need to manage stockpiled materials appropriately as per EMM SW2 and minimise the restriction of flow conveyance. All works on designated watercourses must have a Works on Waterways permit and all works to be completed in accordance with the permit requirements.

Where flood risk is a concern for the larger catchment systems and the potential for flows to extend across the floodplain during flood events, a Flood Management and Response Plan (FMRP) is recommended to be prepared and implemented to manage works within waterways during construction including, but not limited to, measures to manage flood risk during construction, limiting area of disturbance of works to the construction corridor within waterways and floodplains, and implementing site controls such as placement of construction equipment and stockpile materials above threshold flood levels (EMM SW9). This includes Jacksons Creek, Deep Creek, Kalkallo Creek and Merri Creek where the flood extent could extend beyond the construction corridor, during a flood event. This would need to consider the temporary access track over Merri Creek which will be present for a longer period of approximately three months. If a high flow event was to occur during this three-month period without appropriate measures applied, there is high potential for unexpected large rainfall to impact on the river health downstream. As such, the access track is to minimise obstructions and impacts on the hydraulic conditions at the site adhering to the following general requirements:

- The effective width of the flume(s) opening is to ideally extend towards the width of the base on the existing channel (e.g. minimum 75%)
- Be constructed as a low level crossing to minimise hydraulic impacts (e.g. track level no higher than 50% of the depth of the channel from existing invert to the top of bank)
- Pipes or culverts to have a minimum height dimension of 900 mm
- The crossing must include the following:
  - Rock rip rap will be required on the downstream batter, crest and upstream transition
  - The downstream batter is to be no steeper than 1(V):4(H)
  - The crest of the access track surface over the crossing is to be covered with a 200 mm thick graded rock (e.g. 20 mm to 150 mm size). No fine materials are to be used (i.e. less than 20 mm) that could readily wash downstream

– Rock rip rap will be required on the bed of creek channel downstream (e.g. extending approximately 5 m)

As part of detailed design, flood modelling of the existing conditions for the waterways would need to be undertaken and verified by MWC to inform the FMRP and to understand the flood response within the floodplain for the range of possible design events. The plan could identify restrictions on construction activities within threshold flood extents, as well as contingency planning if a flood were to occur. A specific FMRP would also need to be prepared for Kalkallo Retarding Basin and the various waterways and drainage lines that enter the Retarding Basin. The proposed pipeline extends for over a kilometre on the periphery of the Retarding Basin, and the FMRP would need to consider the flood response within the basin and incoming waterways during construction.

Overall, the flooding impacts to surrounding properties and infrastructure is considered low with the appropriate standard management measures in place and additional implementation of the FMRP for the four waterways highlighted above.

Flooding Impacts on River Health (Risk ID. SW3)

Where open cut trench construction is proposed and where construction materials and pollutants could be washed downstream during high flow or flood event and impact on the beneficial use in the surrounding area, a water quality monitoring program (EMM SW5) would be developed and implemented throughout the construction phase to monitor the performance of management measures to protect the waterways health. This would include undertaking surface water monitoring at Jacksons Creek and Merri Creek at sites upstream and downstream of the waterway crossings to determine potential impacts due to the construction.

Summary

The following EMMs are required to manage waterway and floodplain function:

- EMM SW2 - Waterway and floodplain function
- EMM SW9 – Flood Management and Response Plan

The application of the above management measures is considered to achieve 'minimisation' of the impact according to the mitigation hierarchy. See Section 9 for more detail on the above EMMs.

With successful application of the above EMMs, the overall residual impact to property or infrastructure due to construction works changing flooding or surface water flow paths are low.

The standard controls and approaches outlined in EMM SW2 would be applied to all waterways with an additional requirement for FMRP to manage the four waterways that are prone to flood risk, as outlined in Table 8-1. The potential impact on increased flood levels is considered minor and potential impacts to river health is low with the application of appropriate mitigation measures, including implementation of the FMRP for the four waterways discussed above and water quality monitoring undertaken for Jacksons Creek and Merri Creek during construction.

Table 8-1 Standard and additional mitigation measures for identified waterway crossings

Crossing No.	Pipeline Ch (KP)	Waterway Crossing	Construction controls	Monitoring
All other waterways			Standard Control (EMM SW2)	N/A
3	8.36	Tame Street Drain	Standard Control (EMM SW2)	N/A
7	13.7	Jacksons Creek	Standard Control (EMM SW2) Additional requirements for FMRP (EMM SW9)	Water quality monitoring program (EMM SW5)
9	16.7	Deep Creek (HDD Construction)	Standard Control (EMM SW1 – HDD) Additional requirements for FMRP (EMM SW9)	N/A
16	34.5	Kalkallo Creek	Standard Control (EMM SW2) Additional requirements for FMRP (EMM SW9)	N/A
20	40.8	Tributary of Merri Creek	Standard Control (EMM SW2)	N/A
21	42.9	Merri Creek	Standard Control (EMM SW2) Additional requirements for FMRP (EMM SW9)	Water quality monitoring program (EMM SW5)

8.1.3 Erosion impacting river health, surrounding property and infrastructure (Risk ID. SW6, SW7, SW8, SW9)

Construction works adjacent or within the waterway has the potential to affect the stability and health of the waterway due to changes to the existing geomorphic conditions. This could result in instability of bed and banks of waterways impacting on existing properties and infrastructure.

For the identified “complex” waterways, it is difficult to predict the consequence related to the potential damage to surrounding properties and infrastructure due to the unpredictable nature of the waterways once it has been disturbed. The impact associated with this risk relies significantly on specific construction measures and controls to be implemented appropriately at these waterways in order for the risk to be reduced. The three “complex” waterways have been assessed separately below.

Erosion Impacts associated with Jacksons Creek (risk ID SW7.1 and SW9.1)

At Jacksons Creek, standard management measures applied to all other waterways alone would not be adequate in minimising the risk of harm from erosion. This is based on the Jacksons Creek crossing being crossed by open trench method while having high potential for bed and bank erosion based on stream characteristics and erodible materials in the upper soil profile near the waterway and floodplain.

Additional control measures would be developed specifically for Jacksons Creek that would require timing of works, flow management, trench exposure, the construction duration, backfilling works and contingency works to be managed and implemented adequately to reduce the likelihood of erosion to occur (EMM SW7). The comparison to standard controls and additional requirements and controls for Jacksons Creek is summarised in Table 8-2. Open trenching and the associated disturbance caused can lead to an ongoing risk due to complexities associated with geomorphological processes and the exposure of more highly erodible materials below the surface. Possible use of HDD technique at Jacksons Creek crossing was considered not feasible due to a number of contributing factors described in Section 5.7.1.

Whilst residual impact would remain during open trench construction activities of Jacksons Creek, the impact and likelihood of unexpected erosion can be managed and minimised with appropriate emphasis on site-specific construction controls. Surface water quality monitoring of Jacksons Creek during construction would be implemented to monitor the effectiveness of control and management measures. Where monitoring identifies residual impacts to water quality and biodiversity values, contingency measures would be implemented as per EMM SW5.

Table 8-2 Open Trenching – Standard verses Additional Control Measures for Jacksons Creek

Management or Mitigation	Standard Controls	Additional Controls (Jacksons Creek)
Construction	**Standard construction management measures may consist of:** **Timing of works:** Preferably summer-autumn but could be managed at other times subject to conditions	**Additional Construction management measures (or Work Method Statements) specific for Jacksons Creek (EMM SW7) may consist of:** **Timing of works:** Summer-autumn only
	Flow management: Open trenching to be undertaken in no flow conditions	**Flow management:** Prepare a flow management work method statement to detail reliance on pumping, cofferdams (partial or full), temporary flume pipes
	Weather Forecast: Monitor to avoid having open trenches when high rainfall events are expected	**Weather Forecast:** Align timing of works with long term weather forecast without significant rain
	Trench exposure: Limit the longitudinal extent of trench exposure	**Trench exposure:** Limit the longitudinal extent of trench exposure (e.g. to what could be backfilled within 24 hours)
	Construction duration: Minimise time for trench exposure and construction duration	**Construction duration:** Impose limits on time for trench exposure and construction duration between bank to bank works (e.g. pre-prepare the pipe works allow for quicker construction)
	Backfilling works: Backfilling in accordance with APA standard drawing	**Backfilling works:** Backfilling in accordance with appropriate MWC standard drawings for pipe trenching and backfilling and compaction testing requirements

Management or Mitigation	Standard Controls	Additional Controls (Jacksons Creek)
	Contingency works: Have available backfill and temporary erosion protection for exposed trench	**Contingency works:** Have available backfill and stockpile of rock beaching to protect exposed trench in lieu of a late change or unexpected forecast weather event
Site Rehabilitation	***Timing***: Waterway bed and banks shall be restored as soon as practicable after pipe installation and backfilling works.	***Timing***: Waterway bed and banks shall be restored in accordance with site-specific requirements (e.g. defined in a Work Method Statement) after pipe installation and backfilling works
	Bank restoration: Banks shall be restored by grading (nominally 1:3 grade and revegetation), and smoothly transitioned to the undisturbed banks (refer to APA standard drawing no. 530-DWG-L-5008).	***Bed & Bank restoration***: Bed and bank rock protection in accordance with MWC "service crossing open trench medium creek crossing guidelines". This may be a combination of lower bank rock beaching and upper bank and floodplain revegetation. The works will need to smoothly transition to upstream and downstream undisturbed conditions. A Site Rehabilitation Plan (EMM SW8) for the waterway and floodplain will need to be prepared as a part of a site specific design for Jacksons Creek.
	Bed restoration: Waterway bed shall be restored to preconstruction profile, and smoothly transitioned to the upstream and downstream undisturbed bed condition	
	Temporary protection: Geofabric or erosion matting should be provided on bed and banks to prevent erosion until vegetation has established	**Temporary protection:** Geofabric or erosion matting should be provided on bed and banks to prevent erosion until vegetation has established
	Monitor civil establishment works: Carry out routine inspections (e.g. minimum every six months plus potentially following any significant flood event) to monitor effectiveness of civil rehabilitation works (earthworks and rock beaching works) during the first 12 months post-construction. Where monitoring identifies defects or deficiency in civil rehabilitation works, appropriate rectification measures will need to be implemented. **Monitor vegetation establishment:** Establishment of vegetation cover within the first three months post construction. Following establishment of vegetation/ground cover, routine maintenance to be undertaken for a period between 12 – 24 months to monitor and manage successful reinstatement.	**Monitor civil establishment works:** Carry out routine inspections (e.g. minimum every two months or following any significant flood event) to monitor effectiveness of civil rehabilitation works (earthworks and rock beaching works) during the first 12 months post-construction. Where monitoring identifies defects or deficiency in civil rehabilitation works, appropriate rectification measures will need to be implemented. **Monitor vegetation establishment:** Establishment of planting and vegetation for the first three months post construction. Following planting and vegetation establishment period, routine maintenance (e.g. monthly during Autumn and Spring) to be undertaken for a period between 12 – 24 months to monitor and manage successful vegetation establishment.

Erosion impacts associated with Deep Creek (risk ID SW7.2 and SW9.2)

As discussed in Section 5.7.1, Deep Creek is expected to be crossed using the HDD construction method and therefore, the impact due to erosion at the Deep Creek crossing would be expected to be negligible as HDD does not require disturbance of ground surface across the waterway and minimises impact to the existing waterway and surrounding infrastructure. As HDD construction method is proposed for the Deep Creek crossing, the mitigation measures outlined in EMM SW1 would be applied as standard controls to minimise erosion impacts due to the trenchless construction activities. Other risks associated with trenchless construction method, such as crossings subject to blow-out risk, have been considered as part of EES Technical Report D Land stability and ground movement and EES Technical Report E Contamination.

Erosion impacts associated with Merri Creek (risk ID SW7.3 and SW9.3)

The erosion impact associated with the Merri Creek crossing would also be low due to basalt being present at relatively shallow depths which would limit the depth and extent of future bed erosion. An existing APA pipeline alignment crossing the Merri Creek within the pipeline easement also adopted an open-cut construction method previously and was successfully installed. The existing APA pipe alignment within the construction corridor also has the potential to be exposed or disturbed due to bed or bank erosion, however, it is expected that the existing pipe may interface with the basalt rock identified. To minimise the impact of disturbing the existing pipe, the new pipe and construction work should be offset from the existing pipe alignment as much as possible within the easement. In addition, there is a potential risk of erosion and sedimentation at Merri Creek due to the construction of the temporary access track that will remain for approximately three months. Standard control measures would be implemented as per all other waterways (EMM SW4) for the Merri Creek crossing and temporary access track to limit the impacts to the waterway stability and health as discussed below.

Surface water quality monitoring of Merri Creek during construction would be undertaken to monitor the effectiveness of control and management measures. Where monitoring identifies residual impacts to water and biodiversity values, contingency measures would be implemented as outlined in EMM SW5. As part of the CEMP and requirements within SW4, construction works associated with Merri Creek would include a management plan for APA approval with the following:

- Site works methodology,
- Access track configuration within the creek (e.g. batters, rip-rap rock), minimum height/dimension of pipes/culverts,
- Construction timeframes and durations, and
- Water quality monitoring frequency and parameters

Erosion Impacts for all waterways (risk ID SW6 and SW8)

For all other waterway crossings, including the seasonal wetlands between KP44 and KP45, an open cut trench construction would be adopted to cross the waterways. This would require construction activities within the waterways or floodplains which has the potential to change the bed or the banks and alter the geomorphic conditions of the waterways. This is likely to result in erosion and sedimentation further downstream that has the potential to impact the water quality of the waterway.

Standard controls and approaches for majority of waterways, as outlined in EMM SW4, would include trenching works to be undertaken during no or low flow conditions and heavy reliance on timing of work and weather forecasts. The period of construction would be limited to minimise the length of time the trench is exposed and reinstated immediately following the installation of the pipes. During construction, temporary measures would be implemented to divert flow around the site and waterway reinstatement would be designed to avoid future erosion over the pipeline alignment. All waterway bed and banks shall be restored as soon as practicable after pipe installation and backfilling works and revegetated with geofabric providing temporary protection until vegetation is established. There may be some steeper gully waterways that warrant additional stabilisation such as rock beaching protection. With the application of the standard construction management measures for all other waterways, the potential impacts to the water quality due to erosion is expected to be small.

As majority of the waterways are small catchments and/or subject to low velocities, there is unlikely to be erosion impacts to the surrounding properties and infrastructure and therefore, the impact is expected to be low. With the application of mitigation measures outlined in EMM SW4, the residual impact associated with all other waterways is low.

Summary

The following EMM is applicable to all waterways, except for Jacksons Creek, where open cut trench construction occurs across waterways:

- EMM SW4 - Develop appropriate control measures as part of the CEMP and Site Rehabilitation for open cut trench construction
- EMM SW5 – Monitoring program (applies to Merri Creek)

The following site specific EMMs are required as additional mitigation measures to manage the trenching works at Jacksons Creek crossing adequately:

- EMM SW7 – Site specific construction management measures
- EMM SW8 – Site Specific rehabilitation measures
- EMM SW5 – Monitoring program

The application of the above management measures is considered to achieve ‘minimisation’ and ‘Rehabilitation/restoration’ of the impact according to the mitigation hierarchy. ‘Avoidance’ of the impact is not considered to be practicably achievable given the uncertainty and variability inherent in geotechnical conditions. See Section 9 for more detail on the above EMMs.

Successful application of the above EMMs is considered to result in negligible to minor impacts to river health and surrounding property and infrastructure due to erosion for all trenched waterway crossings, excluding Jacksons Creek. Successful application of the site-specific EMMs at Jacksons Creek crossing is considered to minimise the likelihood of erosion during construction and therefore limit the residual impact.

The standard controls and approaches outlined in EMM SW4 would be applied to all waterways and additional requirement for construction management would be required for Jacksons Creek as outlined in Table 8-3.

Table 8-3 Standard and additional control measures for identified waterway crossings

Crossing No.	Pipeline Ch (KP)	Waterway Crossing	Construction	Monitoring
All other waterways			Standard Control (EMM SW4)	N/A
3	8.36	Tame Street Drain	Standard Control (EMM SW4)	N/A
7	13.7	Jacksons Creek	Additional Construction requirements (EMM SW7)	Monitoring program (EMM SW5)
9	16.7	Deep Creek (HDD construction)	Standard Control (EMM SW1 – HDD)	N/A
16	34.5	Kalkallo Creek	Standard Control (EMM SW4)	N/A
20	40.8	Tributary of Merri Creek	Standard Control (EMM SW4)	N/A
21	42.9	Merri Creek	Standard Control (EMM SW4)	Monitoring program (EMM SW5)

For the risks associated with erosion affecting river health (SW6) and surrounding property and infrastructure, the construction mitigation measures would be implemented to reduce the risk of uncontrolled erosion occurring from exposure during trenching activities for all waterways. Based on the existing conditions assessment Jacksons Creek (and to a lessor extent Merri Creek) exhibit a higher potential for erosion compared to all other waterways that are proposed to be trenched. As such, there is a higher potential for erosion to impact on the river health and beneficial uses in the area which would be continuously monitored through the surface water and biodiversity monitoring program in order for work practices to be modified where continuous or post-construction monitoring shows degraded water quality.

8.1.4 Open trench construction activities within and near waterways that have potential for dispersive (sodic) soil behaviour (Risk No. SW11)

As identified in the EES Technical Report D Land stability and ground movement, dispersive (sodic) soils are known to be present at Jacksons Creek, Deep Creek, Kalkallo Basin and Merri Creek where localised testing was undertaken. Further testing will be undertaken to confirm the likely presence of dispersive soils in the project alignment, particularly for areas containing residual basaltic soils. Dispersive soils when disturbed and exposed to fresh water are highly prone to erosion. Disturbance of dispersive soil can have significant land degradation effects and have an adverse effect on the water quality and waterway health.

Dispersive soils are difficult to detect as they usually occur in the subsoil. Construction activities and events such as excavation, removal of topsoil and ponding of rainwater will increase the risk of dispersivity of the soil. Runoff from areas with presence of dispersive soils are likely to contain large amounts of clay and form into dissolved slurry when exposed to rain water. If runoff containing dispersive soil enters the waterway, this can lead to an increase in turbidity and decrease the water quality. As such, appropriate management measures would be implemented to protect the water quality and beneficial uses downstream.

Available testing results have identified presence of dispersive soils at the locations listed in Table 6.2 of the EES Technical Report D Land stability and ground movement. Further testing or sampling along the alignment will be undertaken to confirm presence of dispersive soils, particularly in areas containing residual basaltic soils. Without the appropriate mitigation measures applied during construction, there is potential for ongoing degradation of natural landforms, impact on the water quality and subsequently affecting the local flora and fauna within the waterways.

Initial management measures including EMM SW4 and EMM GM4, would be implemented for all waterway crossings to limit the impact to the waterway stability and the river health. The application of EMM GM4 includes installing trench breakers at regular intervals along the trench excavation, compaction of trench backfill, as well as routine inspection and monitoring of the construction area to be undertaken throughout operation. These initial mitigation measures are considered effective in managing the impact under most circumstances, however, it may not effectively account for the presence of highly dispersive soils.

As such, additional site investigations are to be completed as part of EMM GM7 to further identify areas of higher dispersive risk along the alignment. This investigation will inform the development of sodic soil management measures which may be made proportional to the level of risk identified by the additional site investigations along the alignment including waterway crossings. Following implementation of sodic soil management measures, the residual impact can be appropriately assessed and management measures will be captured in the contractors CEMP. Successful application of the EMMs are considered to reduce the likelihood of dispersive soil entering the waterway and decreasing water quality to ‘remote’ along the alignment.

Summary

The following EMM is applicable to all waterways where open cut trench construction occurs across waterways and floodplains:

- EMM GM4 – Trench, erosion, consolidation and swelling
- EMM GM7 – Preparation and implementation of Sodic Soil Management Measures

Application of these EMMs is considered to achieve ‘minimisation’ of the impact from the mitigation hierarchy. ‘Avoidance’ is not considered practically achievable given the anticipated extent of dispersive soils throughout the project area and the variability inherent in geotechnical conditions.

In summary, ongoing surface or tunnel erosion effects exacerbated by the presence of dispersive (sodic) soils would be managed by EMM GM4 and EMM GM7 for all waterways crossings where trench excavations are to occur. This includes standard erosion mitigation measures such as the installation of trench breakers as well as preparation and development of sodic soil management measures to minimise the potential impact to waterway health and stability during operation.

8.2 Operation impacts

This section describes the impacts that have the potential to result in impacts to surface water assets, values and uses from the operation of the Project.

8.2.1 Permanent changes due to pipeline works (Risk No. SW4, SW5)

The risk during construction and operation is associated with the potential for ongoing erosion due to the disturbance caused to the waterway and/or floodplain from the construction of the pipeline works. It is more related to the risk of future change in waterway behaviour given the fact that some disturbance has been caused, particularly in response to future high flow or flood events. These risks are further exacerbated by the potential presence of sodic (dispersive) soils in the area’s surrounding the creek crossings, which may increase the rate of ongoing erosion.

Whilst the intent would be to restore the waterway and floodplain to pre-works conditions, once the waterway has been disturbed this in itself has the potential to trigger a future erosion response if left unmitigated. The “complex” waterways and all other waterways have been assessed as separate risk items under SW4.1, SW4.2, SW4.3 and SW5.

Risk due to permanent changes for Jacksons Creek (risk ID SW4.1)

For the identified higher risk waterways, there is potential consequence regarding potential damage to private property and infrastructure, as well as the risk of exposure of the pipeline itself due to any erosion. Changes to waterway or floodplain function during operation could be as a result of inadequate construction in terms of pipe foundation, backfilling and in particular the surface restoration works as part of site rehabilitation. Regarding the pipeline, the consequence could be reduced by providing additional protection to the pipe (e.g. concrete encasement) but the erosion response and consequence for surrounding property and infrastructure may be difficult to reduce.

Open trenching of waterways can lead to various impacts during construction as outlined in Section 8.1. Open trenching and the associated disturbance caused can lead to an ongoing risk due to complexities associated with geomorphological processes and the exposure of more highly erodible materials below the surface. The inception of any erosion could occur at any “weak point” within the surface rehabilitation. Possible use of HDD technique at Jacksons Creek crossing was considered not feasible due to a number of contributing factors described in Section 7.

As discussed in Section 8.1.3, the impact associated with trenching of Jacksons Creek is significant due to its high potential for bed and bank erosion. Additional controls are recommended specifically to manage the potential for ongoing erosion and permanent changes to the waterway which focus on site-specific and greater levels of construction management, design interventions and site rehabilitation requirements. The specific construction management measures to be implemented for Jacksons Creek as part of the CEMP are detailed in EMM SW7 (design and construction requirements) and EMM SW8 (site rehabilitation requirements).

These site specific EMMs are to be applied to Jacksons Creek crossing. Application of these EMMs is considered to achieve ‘minimisation’ and ‘rehabilitation/restoration’ of the impact according to the mitigation hierarchy. ‘Avoidance’ is not considered practically achievable given the anticipated extent of dispersive soils throughout the Project are and the variability inherent in geotechnical conditions.

The comparison of the standard controls and additional limitations, requirements and controls for Jacksons Creek is summarised in Table 8-4. These additional controls for Jacksons Creek would need to be managed and implemented accordingly to reduce the likelihood of ongoing erosion to the waterway. Surface water quality monitoring of Jacksons Creek would be undertaken throughout the construction phase, with a final biodiversity monitoring repeated post-construction to identify any potential impacts following rehabilitation works. Where monitoring identifies residual impacts to water and biodiversity values, contingency measures would be implemented as outlined in EMM SW5. During operation, periodic visual monitoring (EMM SW6) would be undertaken to monitor the effectiveness of rehabilitation works to prompt remedial action when monitoring and inspection results indicate a potential problem to the environment.

Table 8-4 Open Trenching – Standard verses Additional Controls for Jacksons Creek

Management or Mitigation	Standard Controls	Additional Controls (Jacksons Creek)
Design	**Minimum depth**: 1.2 m below bed IL **Length of flat graded pipe below channel base**: To extend to a minimum length to channel base width **Pipe protection**: n/a	**Minimum depth**: 2m below bed IL **Length of flat grade pipe below channel:** To extend to a minimum length from top of left bank to top of right bank **Pipe protection**: Concrete encasement, concrete coated pipe or slab protection be considered below the ground surface before backfilling
Construction	**Standard construction management measures may consist of:** **Timing of works**: Preferably summer-autumn but could be managed at other times subject to conditions	**Additional Construction management measures (e.g. defined in Work Method Statements) specific for Jacksons Creek (EMM SW7) may consist of:** **Timing of works**: Summer-autumn only
	Flow management: Open trenching to be undertaken in no flow conditions	**Flow management**: Prepare a flow management work method statement to detail reliance on pumping, cofferdams (partial or full), temporary flume pipes
	Weather Forecast: Monitor to avoid having open trenches when high rainfall events are expected	**Weather Forecast**: Align timing of works with long term weather forecast without significant rain
	Trench exposure: Limit the longitudinal extent of trench exposure	**Trench exposure:** Limit the longitudinal extent of trench exposure (i.e. to what could be backfilled within 24 hours)

Management or Mitigation	Standard Controls	Additional Controls (Jacksons Creek)
	Construction duration: Minimise time for trench exposure and construction duration	**Construction duration**: Impose limits on time for trench exposure and construction duration between bank to bank works (e.g. pre-prepare the pipe works to allow for quicker construction)
	Backfilling works: Backfilling in accordance with APA standard drawing	**Backfilling works**: Backfilling in accordance with appropriate MWC standard drawings for pipe trenching and backfilling and compaction testing requirements
	Contingency works: Have available backfill and temporary erosion protection for exposed trench	**Contingency works**: Have available backfill and stockpile of rock beaching to protect exposed trench in lieu of a late change or unexpected forecast weather event
Site Rehabilitation	**Timing**: Waterway bed and banks shall be restored as soon as practicable after pipe installation and backfilling works**.**	**Timing**: Waterway bed and banks shall be restored in accordance with site-specific requirements for Jacksons Creek (e.g. defined in a Work Method Statement) after pipe installation and backfilling works
	Bank restoration: Banks shall be restored by grading (nominally 1:3 grade and revegetation), and smoothly transitioned to the undisturbed banks (refer to APA standard drawing no. 530-DWG-L-5008). **Bed restoration:** Waterway bed shall be restored to preconstruction profile, and smoothly transitioned to the upstream and downstream undisturbed bed condition **Temporary protection:** Geofabric or erosion matting should be provided on bed and banks to prevent erosion until vegetation has established	**Bed & Bank restoration**: Bed and bank rock protection in accordance with MWC for *Service Crossing Open Trench Medium Creek Crossing - guidelines*. This may be a combination of lower bank rock beaching and upper bank and floodplain revegetation. The works will need to smoothly transition to upstream and downstream undisturbed conditions. A Site Rehabilitation Plan (EMM SW8) for the waterway and floodplain will need to be prepared as a part of a site specific design for Jacksons Creek.
	Monitor civil establishment works: Carry out routine inspections (e.g. minimum every six months plus potentially following any significant flood event) to monitor effectiveness of civil rehabilitation works (earthworks and rock beaching works) during the first	**Monitor civil establishment works:** Carry out routine inspections (e.g. minimum every two months or following any significant flood event) to monitor effectiveness of civil rehabilitation works (earthworks and rock beaching works) during the first 12 months

Management or Mitigation	Standard Controls	Additional Controls (Jacksons Creek)
	12 months post-construction. Where monitoring identifies defects or deficiency in civil rehabilitation works, appropriate rectification measures will need to be implemented. **Monitor vegetation establishment:** Establishment of vegetation cover within the first three months post construction. Following establishment of vegetation/ground cover, routine maintenance to be undertaken for a period between 12 – 24 months to monitor and manage successful reinstatement.	post-construction. Where monitoring identifies defects or deficiency in civil rehabilitation works, appropriate rectification measures will need to be implemented. **Monitor vegetation establishment:** Establishment of planting and vegetation for the first three months post construction. Following planting and vegetation establishment period, routine maintenance (e.g. monthly during Autumn and Spring) to be undertaken for a period between 12 – 24 months to monitor and manage successful vegetation establishment.
	Operation: Routine observations during operation phase is optional	**Operation:** Periodic routine observations should remain ongoing during operation (EMM SW6)

Risk due to permanent changes for Deep Creek (risk ID 4.2)

As Deep Creek is expected to be crossed using the HDD construction method, the impact due to potential permanent changes to the Deep Creek crossing would be expected to be low as HDD does not require disturbance of ground surface at the waterway and minimises impact to the existing waterway and surrounding infrastructure. This would require HDD specific mitigation measures, as outlined in EMM SW1, to be applied as standard controls to prevent ongoing erosion during operation phase due to the trenchless construction activities.

Risk due to permanent changes for Merri Creek (risk ID 4.3)

The impact due to ongoing erosion associated with the Merri Creek crossing would also be low due to basalt being present at relatively shallow depths which would limit the depth and extent of any future or ongoing bed erosion. Given the low potential for ongoing bed erosion, standard control measures would be implemented (EMM SW3) for Merri Creek during construction and rehabilitation phase to limit any ongoing erosion during operation phase. This would be followed by routine inspections (e.g. minimum every six months plus potentially following any significant flood events) to monitor the effectiveness of civil rehabilitation works during the first 12 months post-construction. Where monitoring identifies defects or deficiency in the civil rehabilitation works, appropriate rectification measures would need to be implemented accordingly. Vegetation and ground cover would be established within the first three months post construction followed by routine maintenance to be undertaken for a period between 12 to 24 months to monitor and manage successful reinstatement.

Surface water quality monitoring of Merri Creek would be undertaken throughout the construction phase, with a final biodiversity monitoring repeated post-construction to identify any potential impacts following rehabilitation works. Where monitoring identifies residual impacts to water and biodiversity values, contingency measures would be implemented as outlined in EMM SW5. During operation, periodic visual monitoring (EMM SW6) would be undertaken to capture site conditions on an ongoing basis for Merri Creek and implement remedial actions when monitoring and inspection indicate a potential problem to the environment.

Risk due to permanent changes for all other waterways (risk ID SW5)

The potential impact associated for all other waterways is attributed to Kalkallo Creek and the Tributary to Merri Creek as the two catchments are within the Drainage Services Scheme (DSS) and would be subject to ongoing future development. The design requirements for pipe design invert levels at Kalkallo Creek and the Tributary to Merri Creek would need to allow for ongoing future development as part of the MWC DSS. As such, the design of the pipe depth would need to take into consideration future re-construction or formalisation of existing channels which the pipeline crosses. This would involve further consultation with MWC and the relevant authorities when designing the pipe vertical alignment to account for future development that may potentially expose the pipeline or to avoid the need to relocate the pipeline later on. This would be managed through EMM SW10.

The operation impact associated with the potential for permanent changes to the waterways or floodplain function due to disturbance from construction and rehabilitation works is considered low for all other waterways. This is with the assumption that standard site rehabilitation measures are developed and implemented as part of the CEMP for distance caused by open cut trenching for all other waterways. The standard controls and approaches for the majority of waterways would include standard design approaches for depth of pipe below invert, standard construction approaches and site rehabilitation as outlined in Table 8-7 (EMM-SW3). During open trenching construction activities would typically be done in either no flow or low flow conditions, and reliance on timing of work and weather forecasts. Construction durations would be limited and length of exposure of trenching would also be restricted. All waterway bed and banks shall be restored as soon as practicable after pipe installation and backfilling works, and would be typically graded to stable batters (1:3, V:H), and revegetated with geofabric providing temporary protection until vegetation establishes.

Permanent works to be designed, constructed and maintained as not to increase flood risk associated with overland flow paths or to modify flow regime of waterways to minimise risk from changes to flood levels, flows and velocities. To maintain the waterway and floodplain function, the Project would compact soil, scarify and re-profile the land to original geometry, and incorporate short term and long term (e.g. vegetation re-establishment) surface protection in the site rehabilitation. This includes site specific application of rock beaching protection. Any operational works would be restricted to the easement only, with landholder requirements determined prior to commencement of works.

With the standard construction and site rehabilitation measures implemented for all other waterways, the likelihood for ongoing permanent changes to the waterways would be remote and result in low impact to the waterway and floodplain function for all other waterways.

Summary

The following EMMs are applicable to all waterways where open cut trench construction occurs across waterways:

- EMM SW3 - Develop appropriate Site Rehabilitation measures as part of the CEMP for disturbance caused by open cut trench construction
- EMM SW10 - Managing pipeline design solution for waterway crossings within a Drainage Services Scheme (Kalkallo Creek and Tributary of Merri Creek)
- EMM GM7 – Preparation and implementation of sodic soil management measures. EES Technical Report D Land Stability and ground movement), which recommends further testing and analysis of soil dispersivity at several locations along the alignment. The CEMP will include minimum requirements for sodic soil management measures, which may be proportional to the level of risk identified through further testing.

The following site specific EMMs are required as additional mitigation measures to manage the construction works and rehabilitation at Jacksons Creek and Merri Creek:

- EMM SW7 – Site specific construction management measures for Jacksons Creek
- EMM SW8 – Site Specific rehabilitation measures for Jacksons Creek
- EMM SW6 – Periodic visual monitoring for Jacksons Creek and Merri Creek

The application of the above management measures is considered to achieve 'minimisation' and 'rehabilitation/restoration' of the impact according to the mitigation hierarchy. 'Avoidance' of the impact is not considered to be practicably achievable given the uncertainty and variability inherent in geotechnical conditions. See Section 9 for more detail on the above EMMs.

Successful application of the site-specific EMMs at Jacksons Creek crossing is considered to minimise the likelihood of ongoing erosion following the completion of the construction and during operation, although the residual impacts would remain due to trenching activities occurring in an area where there is complexity associated with the geomorphological processes of the waterway.

The key mitigation measures based on the individual waterway crossings are outlined in Table 8-5 highlighting where additional measures are required for waterways that are at higher risk.

Table 8-5 Standard and additional control measures for identified waterway crossings

Crossing No.	Pipeline Ch (KP)	Waterway Crossing	Construction	Site Rehabilitation	Monitoring
All other waterways			Standard Control (EMM SW3) Additional Control (EMM GM7)	Standard	N/A
3	8.36	Tame Street Drain	Standard Control (EMM SW3) Additional Control (EMM GM7)	Standard	N/A
7	13.7	Jacksons Creek	Additional Construction requirements (EMM SW7) Additional Control (EMM GM7)	Site Specific Rehabilitation requirements (EMM SW8)	Periodic visual monitoring (EMM SW6)
9	16.7	Deep Creek (HDD construction)	Standard Control (EMM SW1 – HDD) Additional control (EMM GM7)	n/a	N/A
16	34.5	Kalkallo Creek	Standard Control (EMM SW3) Additional Control: (EMM SW10) (EMM GM7)	Standard	N/A
20	40.8	Tributary of Merri Creek	Standard Control (EMM SW3) Additional Control: (EMM SW10) (EMM GM7)	Standard	N/A
21	42.9	Merri Creek	Standard Control (EMM SW3) Additional Control (EMM GM7)	Standard	Periodic visual monitoring (EMM SW6)

8.3 Climate change

Climate change has not been explicitly assessed within the impact assessment, however it is considered that climate change may lead to increases in frequency and peak flows in the waterways. During the construction, if there are short term implications of climate change then this may lead to increase in frequency and magnitude of peak flow events. Subject to the site being re-established, the implications of climate change will not change the impact assessment.

There are no long-term flooding impacts to the project as the Project pipeline is buried. As there are no long-term impacts, the potential for climate change to effect Project outcomes is limited. Even assuming the RCP (Representative Concentration Pathway) 8.5 projection, no significant changes are expected in rainfall during the expected construction period.

This situation may need to be reconsidered if Project construction was significantly delayed. If the Project is significantly delayed, the relevant climate change scenario would need to be considered in detailed flood modelling. This could be used for setting limitations on construction and infrastructure.

8.4 Cumulative impacts

The following planned future projects have been considered for any cumulative impact on surface water risks:

Project	Cumulative risk potential	Cumulative impact
Outer Metropolitan Ring (OMR) Transport Corridor Project (E6).	There is potential for surface water-related cumulative impacts associated with the WORM Project, where future works for the Outer Metropolitan (OMR) Transport Corridor project intersect with the APA pipeline alignment. Generally, these effects are unlikely to overlap with the WORM Project, unless there is significant intersection of the two projects. Where there are any changes to the waterways or floodplain function as part of the OMR project, any existing or ongoing effects caused by the WORM project would need to be considered. Key cumulative effects to be considered would include: • Cumulative risk of erosion due to potential ongoing effects caused by the WORM Project and where excavation activities are required in and around the waterway for the construction of the OMR project. This could impact the water quality, stability and waterway health particularly for areas in close vicinity to waterways crossed by the WORM Project, including Tame Street Drain, Kalkallo Creek and Tributary to Merri Creek. This risk is considered minimised through appropriate mitigation measures applied during the construction and operation of both projects. • Potential interfaces between future drainage infrastructure along the OMR corridor, the WORM pipeline alignment and the identified waterway crossings increasing the risk of the gas pipeline and future drainage infrastructure to potential clashes. The Revision 7 alignment for the Project takes into account the interactions with the OMR, however, coordination between APA and Department of Transport	Minor to negligible

Project	Cumulative risk potential	Cumulative impact
	(DoT) should be ongoing throughout the subsequent design stages to allow for adequate cover and clearances to account for potential future waterway conditions. • No cumulative impacts to flood risk or runoff effecting water quality from construction works have been identified assuming both projects would be designed to meet the relevant environmental management measures during construction and operation.	
Sunbury Road Upgrade	The construction period of the proposed Sunbury Road upgrade is likely to overlap with the WORM project, however, where the road upgrade intersects with APA pipeline, the WORM is proposed to be installed using trenchless HDD method. The Sunbury Road upgrade is generally within the existing road corridor and a sufficient distance from the waterways crossed by the WORM project (in particular Jacksons Creek and Deep Creek). As part of the road upgrade, a new bridge will be constructed over Jacksons Creek to replace the existing bridge along Sunbury Road. Assuming both projects would be designed to meet relevant environmental management measures during construction and operation, this is unlikely to have a significant cumulative surface water impact as the proposed upgrade over Jacksons Creek is a considerable distance upstream of where the WORM crosses the creek. No significant cumulative surface water effects considered to arise as a result of the construction or operation of the Sunbury Road Upgrade.	None

Project	Cumulative risk potential	Cumulative impact
Bald Hill to Yan Yean Pipeline	The proposed Bald Hill to Yan Yean pipeline works is likely to overlap with the WORM Project. This pipeline runs on a similar alignment from approximately KP40 to KP42, including crossing under the North Eastern rail reserve. It is assumed that parts of this section of the Yan Yean pipeline trench would also require dewatering; similar to the APA pipeline works. This would require trenching through section of the Merri Creek. Assuming construction is not undertaken at the same time, the risks associated with flooding, erosion and water quality effects are expected to be unchanged. If construction and trenching activities for the two projects were to occur concurrently, key cumulative effects to be considered would include: • Increased footprint of disturbance to the waterway • Cumulated effects due to additional spoil on site • Increased potential for erosion and water quality issues • Increased flood risk and changes to waterway and floodplain functions It is preferential for the timing of works to not overlap to minimise the cumulative impacts at the site where the two projects intersect. Assuming the Bald Hill to Yan Yean Pipeline project implements similar environmental management measures adequately, the cumulative risk would be negligible. Coordination of design alignments and management of construction timing for this future project to avoid intersection of the WORM project at Merri Creek and to avoid the potential risk due to construction of both projects.	Minor to negligible
AusNet / Mondo's Western Victoria Transmission (WVTN) project	No significant cumulative surface water effects are considered to arise as a result of the construction or operation of overhead power lines.	None

The Project has the potential to interface with a number of local future developments within the Precinct Structure Plans (PSPs) and the MWC Drainage Services Scheme (DSS). This will need to take into consideration future developments involving water related infrastructure such as Retarding Basins, wetlands and swales adjacent or crossing the Project alignment. The individual PSPs interfacing the WORM alignment have been assessed and addressed in the EES Technical Report K Land use. Table 8-6 summarises the potential waterway interfaces between the Project and the proposed PSPs and DSS.

Table 8-6 Potential PSP and DSS interfacing the WORM pipeline

Future developments	Description of the interface and implications with WORM pipeline
Plumpton PSP	• Pipeline unlikely to have significant impact on existing or new waterways • This PSP has been addressed in EES Technical Report K - Land use • The Land Use report indicates that the existing gas pipeline easement is accounted for in the PSP and the pipeline location was considered in terms of land uses provided for within the PSPs Pipeline design depth will need to be confirmed and coordination of future works between council and APA. The design of the APA pipeline needs to be at a sufficient depth below existing levels to meet the minimum cover requirement of any future condition with the proposed swales.
Donnybrook/Woodstock	• Pipeline in close proximity to a future waterway and drainage reserve. • This PSP has been addressed in EES Technical Report K Land use • The Land Use in the PSP has been accounted for when designing the alignment as the pipeline is unlikely to directly intersect with the waterway/drainage reserve, however it is in close proximity to the site Pipeline design depth will need to be confirmed and coordination of future works between council and APA.
Kalkallo Creek (DSS)	• The Kalkallo Creek catchment is within a Drainage Services Scheme (DSS) and will be subject to ongoing future development with various Precinct Structure Plans within the area • Currently a significant amount of urban development occurring in the upper catchment regions • The DSS also presents indicative locations of future drainage assets which includes a number of wetlands, retarding basins and diverted formalised channels located throughout the catchment This is discussed further in Section 6.6.7. Pipeline detailed design and alignment to be developed in consultation with Melbourne Water Corporation (MWC).
Beveridge East (DSS)	• The Tributary of Merri Creek catchment is within a Drainage Services Scheme (DSS) and will be subject to ongoing future development with various Precinct Structure Plans within the area • As shown in the latest MWC DSS for Beveridge East (6513), there is a significant amount of proposed urban development across the entire catchment area of the Tributary • The MWC DSS plan for Beveridge East proposes a formalised channel following the existing waterway alignment including a new constructed channel west of the rail tracks This is discussed further in Section 6.7.6. Pipeline detailed design and alignment to be developed in consultation with Melbourne Water Corporation (MWC).

9. Environmental management measures

Table 9-1 lists the recommended environmental management measures (EMMs) relevant to the surface water assessment. In general, these EMMs have been developed in accordance with EPA Publication 1834 Civil construction, building and demolition guide (November 2020), International Erosion Control Association Best Practice Erosion and Sediment Control, Appendix P – Land Based Pipeline Construction (IECA, 2008) and SEPP (Waters). Application of the mitigation hierarchy is discussed in Section 8 as relevant to each impact assessment.

Table 9-1 Recommended environmental management measures

EMM #	Environmental Management Measure	Stage
EMM-SW1	**Managing runoff from adjacent construction areas, stripped areas, discharge from dewatering activities and spills / leaks.** Implement measures to minimise impacts on downstream environments due to construction activities and potential runoff, including: • Where practicable, construct all trenched crossings of ephemeral watercourses during no or low flow conditions and reinstated as soon as reasonably practicable • Form discrete stockpile segments (i.e. rather than a continuous row of stockpile materials) to prevent causing water to pond on the upstream side • Where drainage lines intersect the construction corridor, place flow diversion measures upstream of soil stockpiles • Direct surface water runoff from external catchments through regular gaps in soil stockpiles where erosion and sediment controls are installed to allow runoff to pass over the construction corridor at a controlled location without causing erosion. • Implement erosion and sediment controls for the site with reference to International Erosion Control Association Best Practice Erosion and Sediment Control, Appendix P – Land Based Pipeline Construction (IECA, 2008). • Monitor weather forecasts to manage the pipeline works with the intent of avoiding open trench works at each individual waterway crossing when high rainfall events are expected. • Collect and treat water from dewatering of trenches due to rainfall prior to discharge into the waterways (e.g. grass filtration) if turbidity exceeds requirements in accordance with SEPP (Waters) as part of the Construction Environment Management Plan (CEMP). Manage non- contaminated groundwater and surface water run-off that enters the open trenches and bell holes in accordance with SEPP (Waters). Discharge to land (i.e. grass	Construction

EMM #	Environmental Management Measure	Stage
	filtration) must not occur within 100 metres of watercourses. • Manage any spills and / or leaks during construction in accordance with mitigation measures described in EES Technical Report E Contamination (EMM C6). Implement measures to minimise impacts due to discharge from Trenchless construction sites including, where reasonably practicable: • Install a combination of earth bunds and drainage channels around the upper edges of trenchless drilling sites to divert runoff away from the site and prevent it from mixing with material used during drilling operations • Install sump pits at the bottom of trenchless drilling sites to capture any runoff from drilling compound and construct earth bunds around the sump pits to prevent spillage from entering the waterway • Construct bunds around all facilities that are involved in the HDD activities including around slurry operations and pumping of drilling mud. • Manage trenchless bores and drilling fluids in accordance with mitigation measures described in EES Technical Report E Contamination (EMM C9) and EES Technical Report D Land stability and ground movement (EMM GM5 and EMM GM6).	
EMM-SW2	**Waterway and floodplain function (construction)** Implement measures to minimise impacts to the function of waterways and floodplains during construction and allow flow to be conveyed across the construction area, including: • Form discrete stockpile segments (i.e. rather than a continuous row of stockpile materials) to prevent causing water to pond on the upstream side • Provide regular gaps in stockpiles to allow flood water to pass through. • Avoid stockpiling material near waterways. Material must be located away from the top of banks so that there is no restriction to the flow conveyance area. • To maintain the waterway and floodplain function, the Project must compact soil, scarify and re-profile the land to original contours as far as reasonably practicable.	Construction
EMM-SW3	**Site Rehabilitation measures for disturbance caused by open cut trench construction** This will include all standard construction management measures and site rehabilitation measures outlined in Table 8-7 of EES Technical Report B Surface water. Implement site rehabilitation measures including:	Construction and Operation

EMM #	Environmental Management Measure	Stage
	• Compact soil, scarify and re-profile the land to original contours to maintain the waterway and floodplain function, • Restrict any operational works to the easement only, with landholder requirements determined prior to commencement of works • Restore waterway bed and banks as soon as reasonably practicable after pipe installation and backfilling works • Restore banks by grading (nominally 1:3 grade and revegetation), and smoothly transition to the undisturbed banks (refer to APA standard drawing no. 530-DWG-L-5008). • Restore waterway bed to preconstruction profile, and smoothly transition to the upstream and downstream undisturbed bed condition • Provide temporary protection such as geofabric or erosion matting on bed and banks to prevent erosion until vegetation has established • Carry out routine inspections (e.g. minimum every six months plus potentially following any significant flood event) to monitor effectiveness of civil rehabilitation works (earthworks and rock beaching works) during the first 12 months post-construction. Where monitoring identifies defects or deficiency in civil rehabilitation works, appropriate rectification measures will need to be implemented. • Establishment of vegetation cover within the first three months post construction. Following establishment of vegetation/ground cover, routine maintenance to be undertaken for a period between 12- 24 months to monitor and manage successful reinstatement • Include site specific application of rock beaching protection as part of site rehabilitation where required.	
EMM-SW4	**Control measures for open cut trench construction and watercourse management** Where open cut trench construction is required for a watercourse implement the following mitigation measures: • Implement erosion and sediment controls (ESC) for the site will be implemented with reference to the International Erosion Control Association Best Practice Erosion and Sediment Control, Appendix P – Land Based Pipeline Construction (IECA, 2008) • Construct trenched crossings of ephemeral watercourses during no or low flow conditions, where reasonably practicable	Construction

EMM #	Environmental Management Measure	Stage
	• Monitor weather forecasts to minimise the likelihood of having open trenches at the waterway when high rainfall events are expected • Remove all obstructions to flow after the pipe has been laid and backfilled • Assemble and prepare the pipeline so that it can be installed as soon as reasonably practicable once the trenching over the watercourse has been undertaken • Reinstate the exposed trench within the watercourse and riparian zones as soon as reasonably practicable following the installation of the pipeline • Design waterway reinstatement to avoid future erosion over the pipeline alignment and to provide bank stability at the crossing location as the same or better than prior to construction. • Provide temporary erosion and sediment control as needed to prevent erosion and scour until the vegetation has established throughout the post-construction period (e.g. up to 12 months depending on establishment of vegetation) • Undertake visual monitoring downstream of the trench during flow events if the trench has not been reinstated • Provide temporary flow diversions if there is permanent flow in the waterway. Flow diversion measures may include pumps to ensure that water can be moved from one side of trench to the other, screened inlets (or other appropriate equipment) to minimise the entrapment of aquatic fauna and outlet structures that are designed to avoid scouring of the channel. Measures must be in accordance with International Erosion Control Association Best Practice Erosion and Sediment Control, Appendix P – Land Based Pipeline Construction (IECA, 2008). • Restore waterway bed and banks as soon as reasonably practicable after pipe installation and backfilling works • Carry out bed and bank restoration, temporary protection and monitoring of establishment works as part of the site rehabilitation • Prepare a construction management plan for Merri Creek works including site works methodology, construction timeframes and durations, and water quality monitoring frequency and parameters for APA approval • Groundwater levels and flows will be managed in accordance with EMM GW1 described in EES Technical Report C Groundwater.	

EMM #	Environmental Management Measure	Stage
EMM-SW5	**Implement a Monitoring Program** Develop and implement a monitoring program for the main waterways to determine if there are any construction related impacts. This must occur in Merri Creek and Jacksons Creek where open cut trench construction will occur. Construction work practices will be modified where continuous monitoring reveals degraded water quality. The monitoring program must adopt a control/impact approach with water quality monitored at a suitable distance of 20 - 200 metres from the Project Area both upstream and downstream of the works to establish background conditions. The monitoring program must be developed and undertaken in accordance with SEPP (Waters) and ANZG Australia Guidelines for Water Quality Monitoring and Reporting (2018). Water quality monitoring must occur immediately prior to construction to establish background conditions upstream and downstream of the Project Area. Monitoring must then occur on a continual basis during construction (e.g. at appropriate intervals) with comparisons of upstream and downstream conditions used to infer if there is a downstream impact such as increased turbidity. The biodiversity monitoring must occur at the two sites upstream and downstream of the Project Area prior to construction to establish background conditions. A final biodiversity and water quality monitoring must be repeated post-construction to identify any potential impacts from the construction and rehabilitation works. Should the monitoring determine adverse residual impacts on surface water and biodiversity values, contingency measures will need to be developed and implemented. These remedial actions may include: • Identify, repair and redesign failed management measures aimed at reducing impacts due to erosion and sedimentation • Further stabilise banks and beds at waterway crossing to reduce erosion potential and sedimentation • Inspect pumping of water from coffer dams and / or other areas if water quality exceeds background conditions and implement further management measures.	Design, Construction
EMM-SW6	**Periodic Visual monitoring** Carry out periodic routine observations (e.g. at least annually plus potentially following significant flood events where damage is reported) capturing site conditions on an	Operation

EMM #	Environmental Management Measure	Stage
	ongoing basis during operation for Jacksons Creek and Merri Creek. Incorporate specific details of the visual monitoring into the OEMP including triggers for remedial action when monitoring and inspection results indicate a potential problem to the environment.	
EMM-SW7	**Design and Construction Management (Jacksons Creek)** The detailed design must include the following measures: • Minimum depth: 2m below bed invert level • Length of flat grade pipe (extend from top bank to top of bank) • Pipe protection: concrete encasement, concrete coated pipe or slab protection be considered below the ground surface before backfilling	Design, Construction and Operation
	Develop site specific construction management measures for Jacksons Creek: • Timing of works: Summer-autumn only • Flow management: Prepare a flow management work method statement to detail reliance on pumping, cofferdams (partial or full), temporary flume pipes • Weather Forecast: align timing of works with long term weather forecast without significant rain • Trench exposure: Limit the longitudinal extent of trench exposure to the extent reasonably practicable (i.e. to what could be backfilled within 24 hours) • Construction duration: limits on time for trench exposure and construction duration between bank to bank works to the extent reasonably practicable (e.g. pre-prepare the pipe works • Backfilling works: Backfilling in accordance with appropriate MWC standard drawings for pipe trenching and backfilling and compaction requirements • Contingency works: Have available backfill and stockpile of rock beaching to protect exposed trench in lieu of a late change or unexpected forecast weather event • Prepare a construction management plan for Jacksons Creek works including site works methodology, construction timeframes and durations, and water quality monitoring frequency and parameters for APA approval.	

EMM #	Environmental Management Measure	Stage
EMM-SW8	**Site Rehabilitation (Jacksons Creek)** Develop and implement site specific rehabilitation for Jacksons Creek including: • Timing: Restore waterway bed and banks in accordance with site-specific requirements after pipe installation and backfilling works • Bed & Bank restoration: bed and bank rock protection in accordance with MWC Service Crossing Open Trench Medium Creek Crossing - guidelines. This may be a combination of lower bank rock beaching and upper bank and floodplain revegetation. The works must smoothly transition to upstream and downstream undisturbed conditions. • Rehabilitate and reinstate Jacksons Creek in accordance with EMM B7 described in EES Technical Report A: Biodiversity and habitats • Carry out routine inspections (e.g. minimum every two months or following any significant flood event) to monitor effectiveness of civil rehabilitation works (earthworks and rock beaching works) during the first 12 months post-construction. Where monitoring identifies defects or deficiency in civil rehabilitation works, appropriate rectification measures will need to be implemented. • Establishment of planting and vegetation for the first three months post construction. Following planting and vegetation establishment period, routine maintenance (e.g. monthly during autumn and spring) to be undertaken for a period between 12-24 months to monitor and manage successful vegetation establishment.	Construction and Operation
EMM-SW9	**Develop and implement a Flood Management and Response Plan (FMRP) for Jacksons Creek, Deep Creek, Kalkallo Creek and Merri Creek** Develop and implement a Flood Management and Response Plan during construction for Jacksons Creek, Deep Creek, Kalkallo Creek and Merri Creek. The FMRP must include but not limited to: • Measures to manage flood risk during construction including end of day requirements to limit flood risk exposure overnight • Limiting footprint of disturbance of works within waterways and floodplains to limit flood risk exposure at any point in time to the extent reasonably practicable • Placement of construction equipment and stockpile materials above threshold flood levels	Construction

EMM #	Environmental Management Measure	Stage
	• Flood warning communication protocols and emergency response procedures. As part of the detailed design, flood modelling of the existing conditions for the waterways must be undertaken and verified by MWC to inform the FMRP and to understand the flood response within the floodplain for the range of possible design events The plan could identify restrictions on construction activities within threshold flood extents, as well as contingency planning if a flood were to occur. A specific FMRP must be prepared for Kalkallo Retarding Basin and the various waterways and drainage lines that enter the Kalkallo Retarding Basin to consider the flood response within the basin and incoming waterways during construction.	
EMM-SW10	**Managing pipeline design solution for waterway crossings within a Drainage Services Scheme (DSS)** To minimise potential impacts to the pipeline and to account for ongoing future development within the DSS, develop the pipeline detailed design and alignment in consultation with Melbourne Water Corporation (MWC) to inform the design requirements at waterway crossings that are within a DSS. This is relevant for the crossings at Kalkallo Creek and the Tributary to Merri Creek.	Design

9.1 Performance criteria

9.1.1 Monitoring program

Monitoring of waterways where open cut trenching construction is planned are recommended as part of EMM SW5 to monitor the performance of management measures with the objective to minimise risk of impact to beneficial uses. As such, a monitoring program would need to be prepared for Jacksons Creek and Merri Creek as the two identified complex waterways where the construction impact to the creek can have an adverse effect on waterway health, biodiversity and beneficial uses downstream. In general, this requires:

- The monitoring program (EMM SW5) to be developed in accordance with SEPP (Waters) and Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality (2018). Specific details of the monitoring will be incorporated into the CEMP. This will require monitoring to be undertaken before, during and after construction up to approximately 200 metres both upstream and downstream of the Project Area. Water quality monitoring should consider potential variability within the upstream and downstream locations to ensure results are representative of the overall waterway condition.

Water quality monitoring

- Water quality indicators to be monitored will include physical and chemical stressors (PC) and toxicants as per ANZG (2018). Specific parameters for these water quality indicators will need to be selected appropriately with consideration of site conditions and potential impacts due to the works (e.g. turbidity, nutrients, dissolved oxygen, pH, temperature, toxicants water and toxicant sediments).
- Water quality monitoring will occur immediately prior to construction to establish background conditions. Monitoring will be repeated post-construction to identify any potential impacts from the construction and rehabilitation works. This will include both *in-situ* monitoring (i.e. turbidity, temperature, dissolved oxygen, pH, salinity) and laboratory testing (i.e. nutrients and heavy metals).
- During construction activities directly in the watercourse, daily *in-situ* monitoring will occur for indicators such as turbidity, temperature, dissolved oxygen, pH, and salinity upstream and downstream from works. Comparisons of upstream and downstream conditions will be used to infer if there are downstream impacts.

Biodiversity monitoring

- Biodiversity response indicator to be monitored will include macroinvertebrate communities as per ANZG (2018)
- The biodiversity monitoring will occur immediately prior to construction to establish background conditions, subject to available flows (Merri Creek). Monitoring will be repeated post-construction to identify any potential impacts from the construction and rehabilitation works.

Contingency measures

Should the monitoring determine adverse residual impacts on surface water and biodiversity values, contingency measures will be implemented. These remedial actions may include:

- Identifying, repairing and redesigning management measures such as those aimed at reducing impacts due to erosion and sedimentation to improve water quality and biodiversity values
- Inspecting water pumped from coffer dams and / or other areas if water quality exceeds background conditions and implement further management measures
- Further stabilising banks and beds at waterway crossing to reduce erosion potential and sedimentation

10. Conclusion

The purpose of this report is to provide a surface water impact assessment to inform the preparation of the EES required for the Project.

A summary of the key assets, values or uses potentially affected by the Project, and the associated impact assessment are summarised below.

10.1 Existing conditions

From the detailed assessments the following summary in Table 10-1 has been compiled of the assessment of the existing conditions for the higher risk waterways applicable to the Project.

Table 10-1 Detailed Assessment - Summary Table.

Waterway	Geotechnical Interpretation	Hydrology & Flooding	Channel & Floodplain Hydraulics
Tame Street Drain	Shallow basalt (2 m depth)	Ephemeral, standard flood risk	Velocities < 1.5 m/s Stream Powers < 300 Nm2 Stable channel condition
Jacksons Creek (including Crossing 8)	Erosive soils in upper profile, and no depth to basalt was encountered	Perennially flowing, preferred timing summer-autumn	Velocities > 1.5 m/s Stream Powers > 300 Nm2 Active erosion evident, and expected over geomorphic trajectories Crossing 8 – Velocities > 3 m/s
Deep Creek	Erosive soils in upper profile, and no depth to basalt was encountered	Perennially flowing, preferred timing summer-autumn	Velocities > 1.5 m/s Stream Powers > 300 Nm2 Active erosion evident, and expected over geomorphic trajectories
Kalkallo Creek (including Crossing 15, 17, 18)	Presence of clays within first 10 m from surface, to where basalt is encountered	Ephemeral, higher apparent flood risk being within RB – the periphery flood risk could be managed	Velocities < 1.5 m/s Stream Powers < 300 Nm2 Stable channel condition
Tributary to Merri Creek	Shallow basalt (2 m depth)	Ephemeral, standard flood risk	Velocities - < 1.5 m/s Stream Powers < 100 Nm2 Stable channel condition, no sign of incision
Merri Creek	Shallow basalt (2 m depth)	Ephemeral, standard flood risk	Velocities < 1.5 m/s Stream Powers expected to be low Stable rehabilitated channel condition

Further detailed assessments including additional site inspections, interpretation of geotechnical information, further hydraulic modelling, geomorphology and water quality assessment of the main waterways of Jacksons Creek, Deep Creek and Merri Creek were undertaken. A summary of this additional assessment is provided in Table 10-2 below.

Table 10-2 Further Detailed Assessment of Key Waterways

Waterway	Summary of Findings
Jacksons Creek	**Geotechnical** - Erosive soils (sands/gravels) in upper profile, and no depth to basalt was encountered. **Waterway** – Ford crossing on basalt outcrop providing d/s control. High velocities & stream powers at site. **Water Quality and beneficial uses -** Water quality samples from Jacksons Creek at Sunbury exceeded the guideline values for turbidity, nitrate, oxidised nitrogen, filtered reactive phosphate, total phosphorous, chromium, copper, lead, nickel and zinc. The gauge data downstream at Keilor presented similar results to the upstream gauge with total nitrogen also exceeding the guideline values. It should be noted that the results are likely influenced by the Sunbury Water Treatment Plant which is located between the upstream gauge and pipeline crossing location. Beneficial Uses downstream may include water dependent ecosystems and species, agriculture and irrigation, water-based recreation (aesthetic enjoyment) and Traditional Owner cultural values **Geomorphology** - Lateral erosion evident, but no significant change in stream morphology in the last 50 years. Whilst long term expected average rates of bed incision is low, and the downstream ford control may offer "protection" to the site of interest, the presence of the alluvial sediments in both channel and floodplain indicate potential future erosion, particularly if disturbed.
Deep Creek	**Geotechnical** – Erosive soils (gravels) in upper profile, and no depth to basalt was encountered. **Waterway** - Perennially flowing, generally passive flow conditions with minor riffle sequences along the reach defined by a rock outcrop control ~200m downstream. **Water Quality and beneficial uses –**Water quality samples collected form the upstream gauges had elevated concentrations of turbidity, nitrate, total nitrogen, phosphate, total phosphorus, chromium, copper, lead, nickel and zinc. The upstream gauges are located within an agricultural catchment where elevated levels of nitrogen and phosphorus may be present. The downstream gauge provided similar results to the upstream gauges but with noncompliant electrical conductivity and pH. Beneficial Uses downstream may include water dependent ecosystems and species, agriculture and irrigation, water-based recreation (aesthetic enjoyment) and Traditional Owner cultural values **Geomorphology** – Stable configuration of stream, with some minor lateral widening, but no significant change in stream morphology in 50 years. Slightly meandering low flow with stable bar configuration and ephemeral parallel secondary channel occupied in moderate floods. Deep scour common in secondary channels and if disturbed could trigger a permanent change in the main flow path.
Merri Creek	**Geotechnical** – Basalt within 2m depth, with weathered to fresh basalt exposed at the surface along downstream reach. **Waterway** - Ephemeral waterway, tightly meandering channel, and stable banks with the notable steepening of the gradient downstream of the pipe location. Low velocities near site although increasing downstream, and presence of shallow bed rock and exposed boulders suggest low potential for erosion. Easement area has recovered from previous pipe trenching works well. **Water Quality and beneficial uses –** There is limited water quality data available for Merri Creek and there is no stream gauge site upstream of the pipeline. Water quality data from the downstream gauge indicated elevated pH, dissolved oxygen, electrical conductivity, turbidity, ammonia, nitrate, total nitrogen, phosphate, total phosphorus, chromium, copper and zinc. Results from this gauge may be influenced by a housing estate located proposed pipe line and the gauge.

Waterway	Summary of Findings
	Beneficial Uses downstream may include water dependent ecosystems and species, agriculture and irrigation, water-based recreation (aesthetic enjoyment) and Traditional Owner cultural values **Geomorphology** - No significant change in stream morphology evident, and little potential for incision or lateral erosion given shallow/exposed underlying rock.

10.2 Impact assessment

The impact assessment considered the following key issues:

- Runoff from general construction activities and dewatering impacting on the waterway health and beneficial uses downstream
- Construction activities causing the flood regime and floodplain function to change leading to potential flood impacts to surrounding properties and infrastructure
- Construction works causing riverbed or bank erosion that could affect river health and potentially impact surrounding properties and infrastructure
- Open trench construction activities within and near waterways that have potential for dispersive (sodic) soil behaviour leading to long-term erosion of dispersive soils
- Potential for ongoing erosion due to the disturbance caused to the waterway and/or floodplain from the construction of the pipeline works

The construction impacts assessed for the Project are generally low with the application of both standard control measures and additional site specific controls. The residual impacts associated with erosion due to open trench construction in operation is potentially more significant for Jacksons Creek due to complexities of the geomorphological processes and the exposure to more highly erodible materials below the surface. Additional controls relating to site specific construction management (EMM SW7) and rehabilitation measures (EMM SW8), as well as development and implementation of a monitoring program (EMM SW5 and EMM SW6) for Jacksons Creek, are considered to minimise the impact and reduce the likelihood of unexpected erosion occurring at this waterway crossing during operation.

The additional controls and management measures discussed in Section 8.2.1 would protect property and infrastructure, and mitigate potential future erosion and prevent permanent changes to Jacksons Creek. This will involve greater protection of the pipes through design interventions, increased restrictions and requirements in the construction management plan and site-specific rehabilitation plan developed for Jacksons Creek. In addition, periodic visual monitoring during operation of the disturbed and rehabilitated Jacksons Creek waterway and floodplain will be important to achieve sustained stability, Appropriate implementation of design, construction and rehabilitation measures specific to Jacksons Creek will reduce the potential for operational risk. The successful application of the above management measures at Jacksons Creek crossing is considered to minimise the likelihood of ongoing erosion following the completion of the construction and during operation

In addition, the presence of dispersive soils through the Project area may increase the potential for ongoing erosion during operation of the Project. To minimise the impact, preparation and implementation of sodic soil management measures is recommended to effectively identify and assess the risk through the Project area. These would include management measures to be applied during construction and operation that would be appropriate for the levels of dispersion risk identified for each section of the alignment.

Cumulative impact was considered for future planned projects, developments and schemes, such as the Outer Metropolitan Transport Corridor, Precinct Structure Plans (PSPs) and the Drainage Services Scheme (DSS), that are likely to intersect with the WORM pipeline. Generally, the Project is unlikely to overlap with the construction of the future planned projects discussed in Section 8.4 with the exception of Bald Hill to Yan Yean pipeline works. This pipeline runs on a similar alignment to the Project from approximately KP40 to KP42. As such, if any construction and trenching activities for the two projects were to occur concurrently, this could potentially increase the footprint of disturbance to the waterway, cumulated effects due to additional spoil on site leading to increased potential for erosion, water quality issues and flood risk. It is preferential for the timing of works to not overlap to minimise the cumulative impacts where the two projects intersect.

Key environmental management measures to minimise the impact associated with the construction and operation of the Project include:

- Manage runoff from adjacent construction areas, discharge from dewatering activities and spills/leaks to minimise impact on downstream environments due to construction activities and potential runoff
- Manage placement and storage of stockpiled materials on site and re-establish the land to pre-work conditions to allow flow to be conveyed across the construction area and minimise the impacts to the function of waterways and floodplains during construction
- Develop and implement an appropriate site rehabilitation plan as part of the CEMP that takes into consideration the waterway and floodplain functions during post-construction phase and operation to minimise the potential for permanent changes to the waterways and floodplain functions
- Develop and implement an appropriate CEMP) and site rehabilitation plan which includes erosion sediment controls for the construction sites, measures to control timing and duration of construction activities and appropriate rehabilitation of the waterway to minimise the impacts associated with bed or bank erosion
- Develop and implement a monitoring program for Jacksons Creek and Merri Creek to establish background conditions prior to construction and undertake ongoing water quality monitoring during construction to monitor potential impacts to water quality and beneficial uses downstream
- Develop and implement periodic routine observations to monitor site conditions during operation for Jacksons Creek and Merri Creek
- Develop and implement site specific design, construction management measures for Jacksons Creek to manage and mitigate the potential high risk associated with construction activities at this site
- Develop and implement site specific rehabilitation measures for Jacksons Creek to minimise the potential for permanent changes or ongoing erosion during construction, post-construction and operation
- Develop and implement a Flood Management and Response Plan (FMRP) for Jacksons Creek, Deep Creek, Kalkallo Creek and Merri Creek that considers the flood response within the floodplain and basin during construction to manage and respond appropriately during flood events
- Manage pipeline design solution for waterway crossings that are within a Drainage Services Scheme (DSS), such as the crossings at Kalkallo Creek and Tributary to Merri Creek, to minimise potential impacts to the pipeline and any future development that may have an effect on the waterway

Overall, with the appropriate implementation of the key environmental management measures outlined above, the residual impact of the Surface Water risks is not considered to result in any significant adverse environmental effects and the evaluation objective for the Project in terms of maintaining surface water and floodplain environments and minimising impacts on water quality and beneficial uses can be achieved.

11. References

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Appendices

Appendix A – Risk assessment

The scoping requirements require a risk-based approach to be adopted during the design of EES studies, so that a greater level of effort is directed at investigating and managing those matters that pose relatively higher risk of adverse effects.

The risk assessment as part of the assessment framework for the EES, is described in Chapter 5 Evaluation and assessment framework.

The risk pathways define the cause and effect topics relevant to surface water based on an understanding of the existing conditions and the Project activities. The risk pathways are provided in Table A4. Each pathway shows the initial risk rating based on standard management measures, and a residual risk rating based on additional management measures (if required) recommended through the impact assessment process.

The consequence of the risk occurring were assigned using a consequence guide specific for each technical discipline. The consequence guide is provided in Table A1.

The likelihood was assigned using a likelihood guide applied to all technical disciplines. The likelihood guide is provided in Table A2.

The risk rating was determined using the risk matrix developed for this EES. The risk matrix is shown in Table A3.

Table A1 Consequence approach

Level	Qualitative and/or quantitative description
Insignificant	Applicable water quality standards met across the region. Negligible or very minor change to waterway and flow regime.
Minor	Isolated and temporary exceedance of applicable water quality standards. Some change to waterway or flow regime with minor implications.
Moderate	Localised exceedance of applicable water quality standards. Changes to waterway or floodplain function with moderate implications
Major	Major exceedance of water quality standards in a local area. Waterway, floodplain levels where river health is significantly compromised.
Severe	Regional and prolonged exceedance of applicable water quality standards. Extensive impact to waterway, floodplain function or flow regime with irreversible distance to river health or flood levels.

Table A2 Likelihood approach

Level		Description
1	Rare	The event is conceivable and may occur only in exceptional circumstances
2	Remote	The event could occur but is not anticipated and may occur if certain abnormal circumstances prevail
3	Unlikely	The event is unlikely but could occur if certain circumstances prevail
4	Likely	The event will probably occur in most circumstances
5	Almost certain	The event is expected to occur in most circumstances or is planned to occur

Table A3 Risk rating approach

		Consequence rating				
		Insignificant	Minor	Moderate	Major	Severe
Likelihood rating	Almost certain	Low	Medium	High	Very high	Very high
	Likely	Low	Low	Medium	High	Very high
	Unlikely	Negligible	Low	Medium	High	High
	Remote	Negligible	Negligible	Low	Medium	High
	Rare	Negligible	Negligible	Negligible	Low	Medium

Table A4 Risk pathways

Risk ID	Description	Pipeline/ MLV/ Compressor	Initial mitigation measure	Initial risk			Additional mitigation measure	Residual Risk		
				C	L	Risk		C	L	Risk
Construction										
SW1	**Site runoff (runoff quality)** Construction works within or near the watercourse impacting on downstream environments including due to runoff from adjacent construction areas and discharge from dewatering activities.	Pipeline	**EMM SW1 -** Managing runoff from adjacent construction areas, discharge from dewatering activities and spills / leaks.	Minor	Unlikely	Low	**EMM SW5 -** Monitoring program including contingency measures for Jacksons Creek and Merri Creek	Minor	Unlikely	Low
SW2	**Waterway or floodplain function** Construction works including works at waterways, ground disturbance and stockpiling changing flooding or surface water flow paths impacting property or infrastructure.	Pipeline	**EMM SW2 -** Waterway and floodplain function (construction)	Minor	Unlikely	Low	**EMM SW9** – Flood Management and Response Plan	Minor	Unlikely	Low

Risk ID	Description	Pipeline/ MLV/ Compressor	Initial mitigation measure	Initial risk			Additional mitigation measure	Residual Risk		
				C	L	Risk		C	L	Risk
SW3	**Waterway or floodplain function** High flow or flood event occurring during construction works including disturbed areas associated with waterways and floodplains impacting river health downstream.	Pipeline	**EMM SW2 -** Waterway and floodplain function (construction)	Minor	Unlikely	Low	**EMM SW5 -** Monitoring program including contingency measures for Jacksons Creek and Merri Creek	Minor	Unlikely	Low
SW6	**River bed or bank erosion (all other waterways excluding the "complex" waterways)** Construction works causing river bed or bank erosion that could affect river health.	Pipeline	**EMM SW4 -** Develop appropriate control measures as part of the Construction Environment Management and Site Rehabilitation (CEMP) for open cut trench construction	Minor	Unlikely	Low	No additional mitigation measures identified.	Minor	Unlikely	Low

Risk ID	Description	Pipeline/ MLV/ Compressor	Initial mitigation measure	Initial risk			Additional mitigation measure	Residual Risk		
				C	L	Risk		C	L	Risk
SW7.1	**River bed or bank erosion - Jacksons Creek** Construction works causing river bed or bank erosion that could affect river health.	Pipeline	**EMM SW4 -** Develop appropriate control measures as part of the Construction Environment Management and Site Rehabilitation (CEMP) for open cut trench construction	Moderate	Likely	Medium	**EMM SW5** – Monitoring program including contingency measures for Jacksons Creek and Merri Creek **EMM SW7** – Site specific construction management measures (Jacksons Creek) **EMM SW8** – Site Specific rehabilitation measures (Jacksons Creek)	Minor	Unlikely	Low
SW7.2	**River bed or bank erosion - Deep Creek** Construction works causing river bed or bank erosion that could affect river health.	Pipeline	**EMM SW1** –Mitigations measures specific to trenchless construction method	Minor	Rare	Negligible	No additional mitigation measures identified.	Minor	Rare	Negligible
SW7.3	**River bed or bank erosion - Merri Creek** Construction works causing river bed or bank erosion that could affect river health.	Pipeline	**EMM SW4 -** Develop appropriate control measures as part of the Construction Environment Management and Site Rehabilitation (CEMP) for open cut trench construction	Moderate	Unlikely	Medium	**EMM SW5** – Monitoring program including contingency measures for Jacksons Creek and Merri Creek	Minor	Unlikely	Low

Risk ID	Description	Pipeline/ MLV/ Compressor	Initial mitigation measure	Initial risk			Additional mitigation measure	Residual Risk		
				C	L	Risk		C	L	Risk
SW8	**River bed or bank erosion (All other waterways excluding "complex" waterways)** Construction works causing river bed or bank erosion that could impact surrounding property and infrastructure.	Pipeline	**EMM SW4 -** Develop appropriate control measures as part of the Construction Environment Management and Site Rehabilitation (CEMP) for open cut trench construction	Minor	Remote	Low	No additional mitigation measures identified.	Minor	Remote	Low
SW9.1	**River bed or bank erosion - Jacksons Creek** Construction works causing river bed or bank erosion that could impact surrounding property and infrastructure.	Pipeline	**EMM SW4 -** Develop appropriate control measures as part of the Construction Environment Management and Site Rehabilitation (CEMP) for open cut trench construction	Moderate	Unlikely	Medium	**EMM SW7** – Site specific construction management measures (Jacksons Creek) **EMM SW8** – Site Specific rehabilitation measures (Jacksons Creek)	Moderate	Remote	Low

Risk ID	Description	Pipeline/ MLV/ Compressor	Initial mitigation measure	Initial risk			Additional mitigation measure	Residual Risk		
				C	L	Risk		C	L	Risk
SW9.2	**River bed or bank erosion - Deep Creek** Construction works causing river bed or bank erosion that could impact surrounding property and infrastructure.	Pipeline	**EMM SW1** –Mitigations measures specific to trenchless construction method	Minor	Rare	Negligible	No additional mitigation measures identified.	Minor	Rare	Negligible
SW9.3	**River bed or bank erosion - Merri Creek** Construction works causing river bed or bank erosion that could impact surrounding property and infrastructure.	Pipeline	**EMM SW4 -** Develop appropriate control measures as part of the Construction Environment Management and Site Rehabilitation (CEMP) for open cut trench construction	Moderate	Remote	Low	No additional mitigation measures identified.	Moderate	Remote	Low
SW10	**Spills (surface water)** Construction activities such as an oil spill resulting to contaminated discharge, impacting on water quality at local waterway.	All	**EMM SW1 -** Managing runoff from adjacent construction areas, discharge from dewatering activities and spills / leaks.	Moderate	Remote	Low	**EMM SW5 -** Monitoring program including contingency measures for Jacksons Creek and Merri Creek	Moderate	Remote	Low

Risk ID	Description	Pipeline/ MLV/ Compressor	Initial mitigation measure	Initial risk			Additional mitigation measure	Residual Risk		
				C	L	Risk		C	L	Risk
SW11	**Dispersive (sodic) soil behaviour** Open trench construction works within or near waterways that are subject to dispersive soil behaviour increasing the potential for erosion that could affect river health	Pipeline	**EMM SW4 -** Develop appropriate control measures as part of the Construction Environment Management and Site Rehabilitation (CEMP) for open cut trench construction **EMM GM4 -** Trench; erosion, consolidation and swelling	Moderate	Unlikely	Medium	**EMM GM7** – Preparation and implementation of sodic soil management measures	Moderate	Remote	Low

Risk ID	Description	Pipeline/ MLV/ Compressor	Initial mitigation measure	Initial risk			Additional mitigation measure	Residual Risk		
				C	L	Risk		C	L	Risk
Construction and Operation										
SW4.1	**Waterway or floodplain function – Jacksons Creek** Disturbance caused to the waterway or floodplain from construction and rehabilitation works resulting in permanent changes to the waterway or floodplain function, that could potentially impact the pipeline itself and/or surrounding property/infrastructure	Pipeline	**EMM SW3 -** Develop appropriate Site Rehabilitation measures as part of the Construction Environment Management Plan (CEMP) for disturbance caused by open cut trench construction	Major	Unlikely	High	**EMM SW6** – Periodic visual monitoring for Jacksons Creek and Merri Creek **EMM SW7** – Site specific construction management measures (Jacksons Creek) **EMM SW8** – Site Specific rehabilitation measures (Jacksons Creek) **EMM GM7** – Preparation and implementation of sodic soil management measures	Major	Remote	Medium

Risk ID	Description	Pipeline/ MLV/ Compressor	Initial mitigation measure	Initial risk			Additional mitigation measure	Residual Risk		
				C	L	Risk		C	L	Risk
SW4.2	**Waterway or floodplain function – Deep Creek** Disturbance caused to the waterway or floodplain from construction and rehabilitation works resulting in permanent changes to the waterway or floodplain function, that could potentially impact the pipeline itself and/or surrounding property/infrastructure	Pipeline	**EMM SW1 -** Mitigations measures specific to trenchless construction method	Moderate	Rare	Negligible	**EMM GM7** – Preparation and implementation of sodic soil management measures	Moderate	Rare	Negligible
SW4.3	**Waterway or floodplain function – Merri Creek** Disturbance caused to the waterway or floodplain from construction and rehabilitation works resulting in permanent changes to the waterway or floodplain function, that could potentially impact the pipeline itself and/or surrounding property/infrastructure	Pipeline	**EMM SW3 -** Develop appropriate Site Rehabilitation measures as part of the Construction Environment Management Plan (CEMP) for disturbance caused by open cut trench construction	Moderate	Unlikely	Medium	**EMM SW6** – Periodic visual monitoring for Jacksons Creek and Merri Creek **EMM GM7** – Preparation and implementation of sodic soil management measures	Moderate	Remote	Low

Risk ID	Description	Pipeline/ MLV/ Compressor	Initial mitigation measure	Initial risk			Additional mitigation measure	Residual Risk		
				C	L	Risk		C	L	Risk
SW5	**Waterway or floodplain function (all other waterways)** Disturbance caused to the waterway or floodplain from construction and rehabilitation works resulting in permanent changes to the waterway or floodplain function, that could potentially impact the pipeline itself and/or surrounding property/infrastructure	Pipeline	**EMM SW3 –** Develop appropriate Site Rehabilitation measures as part of the Construction Environment Management Plan (CEMP) for disturbance caused by open cut trench construction	Moderate	Unlikely	Medium	**EMM SW10 -** Managing pipeline design solution for waterway crossings within a Drainage Services Scheme (Kalkallo Creek and Tributary of Merri Creek) **EMM GM7** – Preparation and implementation of sodic soil management measures	Moderate	Remote	Low

Appendix B – Preliminary Desktop Hydrological Assessment

	Name	Location	Catchment Area (km^2)	Flow 100 ARI (m^3/s)	Flow 10 ARI (m^3/s)	LSIO/mapping	Description
01	Unnamed	1	1.41	4.18	1.99	Unavailable	Typical ephemeral gully depression
02	Unnamed Tributary	7.5	1.33	4.04	1.92	Unavailable	Typical ephemeral gully
03	Tame Street Drain	8.36	8.27	16.9	8.08	Available	Urbanized upstream, ephemeral with occasional pools of water
04	Unnamed	9.9	2.00	5.47	2.61	Available	Typical ephemeral depression, interrupted by small farm dams
05	Unnamed	10.6	2.77	7.14	3.41	Unavailable	Typical ephemeral gully interrupted by small farm dams
06	Unnamed	11.7	1.32	3.89	1.86	Unavailable	Typical ephemeral gully interrupted by small farm dams
07	Jacksons Creek	13.8	580.30	459	219	Available	Perennially flowing, well-defined stream channel set into steep terrain
08	Unnamed	14	4.36	10.2	4.86	Unavailable	Typical ephemeral gully
09	Deep Creek	17.1	1,356.51	717	342	Available	Perennially flowing, well-defined stream channel set into steep terrain
10	Unnamed	19.8	0.68	3.22	1.53	Unavailable	Typical ephemeral depression interrupted by small farm dams
11	Unnamed	23.4	3.16	7.93	3.79	Unavailable	Typical ephemeral gully interrupted by small farm dams
12	Unnamed	31.9	1.80	5.34	2.55	Unavailable	Ephemeral depression interrupted by small dams
13	Unnamed	32.6	1.31	3.74	1.78	Unavailable	Ephemeral depression interrupted by small dams
14	Unnamed	33.7	0.88	3.47	1.66	Unavailable	Typical ephemeral gully interrupted by small dams
15	Unnamed	33.9-34.1	3.18	8.54	4.07	Unavailable	Agricultural shallow drain with ephemeral flows

	Name	Location	Catchment Area (km^2)	Flow 100 ARI (m^3/s)	Flow 10 ARI (m^3/s)	LSIO/mapping	Description
16	Kalkallo Creek	34.5	25.43	43.4	20.7	Available	Agricultural drain with ephemeral flows through a series of dams
17	Unnamed	34.9	11.8	23.0	11.0	Unavailable	Agricultural shallow drain with ephemeral flows
18	Unnamed	35.5	11.8	22.9	10.9	Unavailable	Agricultural shallow drain with ephemeral flows
19	Unnamed	36.2	12.58	24.5	11.7	Unavailable	Agricultural shallow drain with ephemeral flows
20	Tributary of Merri Creek	40.8	4.36	10.6	5.07	Available	Typical ephemeral gully
21	Merri Creek	42.9	127.73	141	67.2	Available	Perennially flowing, well-defined stream channel set into steep terrain
22	Seasonal Wetlands	44.8	0.62	NA	NA	Unavailable	Ephemeral freshwater marsh or meadow that periodically inundate during wet periods
23	Unnamed	51	0.55	3.18	1.52	Unavailable	Ephemeral depression interrupted by small dams

Appendix C – Preliminary Desktop Hydraulics Assessment

	Name	Location	Slope	Velocity (m/s)
01	Unnamed	1	1 in 85	0.46
02	Unnamed Tributary	7.5	1 in 60	0.92
03	Tame Street Drain	8.36	1 in 150	0.87
04	Unnamed	9.9	1 in 100	0.59
05	Unnamed	10.6	1 in 60	1.90
06	Unnamed	11.7	1 in 40	0.79
07	Jacksons Creek	13.8	1 in 100	4.53
08	Unnamed	14	1 in 10	3.29
09	Deep Creek	17.1	1 in 300	1.85
10	Unnamed	19.8	1 in 35	1.37
11	Unnamed	23.4	1 in 110	1.10
12	Unnamed	31.9	1 in 60	0.48
13	Unnamed	32.6	1 in 50	1.80
14	Unnamed	33.7	1 in 65	0.64
15	Unnamed	33.9-34.1	1 in 1200	0.25
16	Kalkallo Creek	34.5	1 in 600	0.24
17	Unnamed	34.9	1 in 360	0.21
18	Unnamed	35.5	1 in 320	0.19
19	Unnamed	36.2	1 in 180	0.21
20	Tributary of Merri Creek	40.8	1 in 1100	1.08
21	Merri Creek	42.9	1 in 285	0.97
22	Seasonal Wetlands	44.8	1 in 330	NA
23	Unnamed	51	1 in 200	0.52

Appendix D – 1 Page Waterway Preliminary Assessment

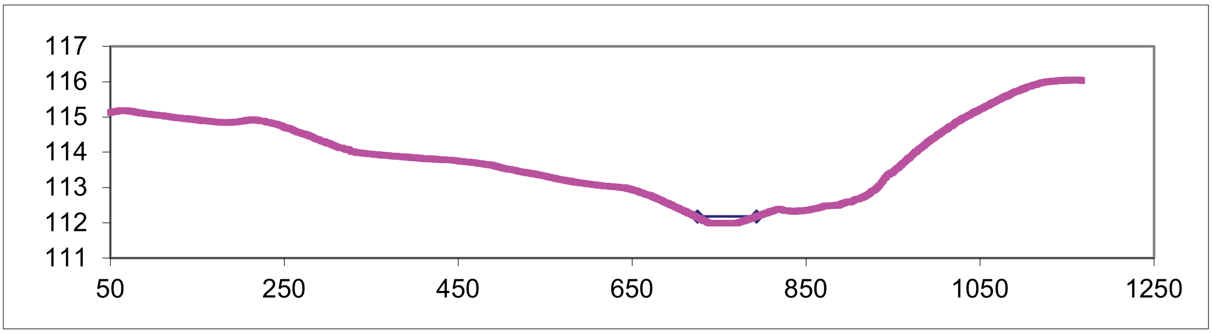
Crossing 1 - Unnamed tributary

The waterway for Crossing 1 runs relatively straight and discharges into Kororoit Creek to the south-east past Taylors Road. The the APA pipeline does not actually intersect the channel that flows parallel within the works zone near KP 1. The waterway is an underfined channel within a defined valley, with occassional areas of ponding from man made features. The waterway is surrounded by agricultural land, with no discerning vegetation present within the riparian zone. Near the crossing location, the tributary has an averaged grade of 1 in 85. The catchment area upstream of the pipeline crossing is roughly 1.41 km2, consisting primarily of agricultural land and scattered rural residential properties.

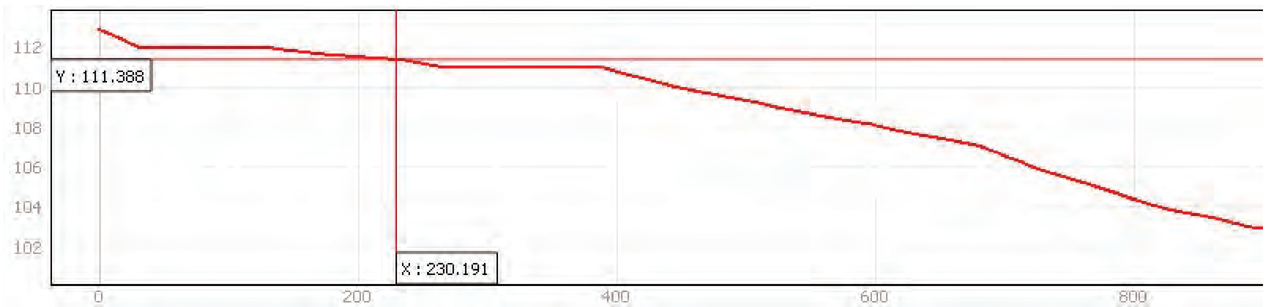
Pipe alignment & waterway location

Location (KP Chainage)	1
Waterway status	Minor gully tributary
Stream Order	1st
Stream type classification	Intact valley fill
Approx. Crossing Length (m)	n/a
Catchment Area (km^2)	1.41
1 in 100 year Flow (m3/s)	4.18
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	1 in 85
Stream Velocity (m/s)	0.47
Erosion Hazard	Low
Flood Hazard	Low

Representative Cross Section



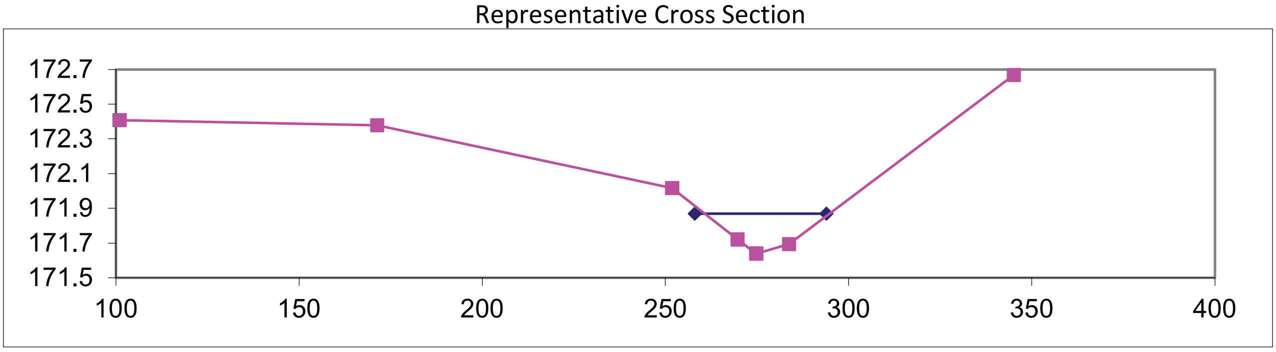
Interpreted Longitudinal Profile



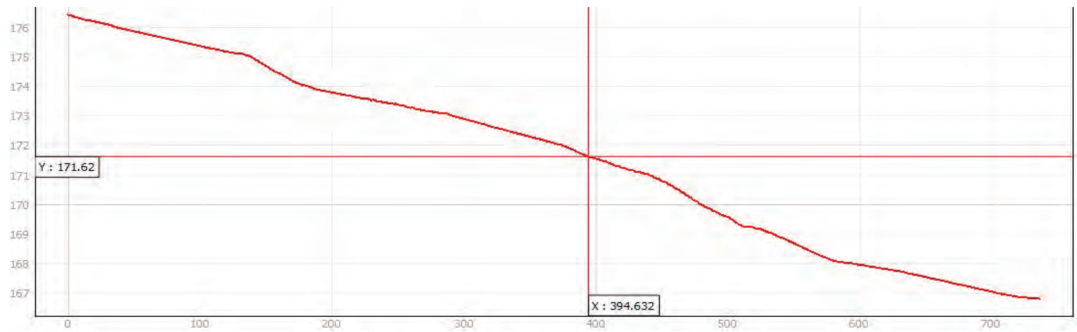
Outcome: Standard design, construction methodology and site controls.

Crossing 2 - Unnamed Tributary		
The waterway for Crossing 2 runs relatively straight from a series of agricultural ponds, then flowing into a secondary stream before discharging into Jacksons Creek. The stream intersects perpendicular with the APA pipeline at KP 7.5. The stream's width at the point of crossing is less than 5m, with occasional ponding of water. The stream is an undefined channel with grass coverage and no discernible vegetation has been identified within the riparian zone. Located close to the highest point in the catchment, the stream has an average grade of 1 in 60. The catchment area upstream of the pipeline is 1.33 km2, consisting prmarily of unpaved, pervious agricultural land.		
Pipe alignment & waterway location	Location (KP Chainage)	7.5
	Waterway status	Minor gully tributary
	Stream Order	1st
	Stream type classification	Confined discontinuous
	Approx. Crossing Length (m)	30
	Catchment Area (km^2)	1.33
	1 in 100 year Flow (m3/s)	4.04
	LSIO Impact (1 in 100yr) (m wide)	n/a
	River Grade (averaged)	1 in 60
	Stream Velocity (m/s)	0.92
	Erosion Hazard	Low
	Flood Hazard	Low

Representative Cross Section



Interpreted Longitudinal Profile



Outcome: Standard design, construction methodology and site controls.

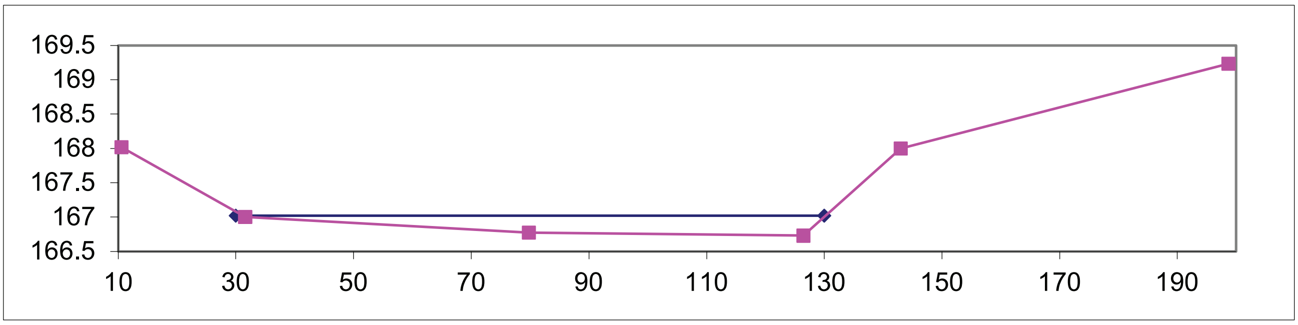
Crossing 3 - Tame Street Drain

The waterway for Crossing 3, Tame Street Drain, runs relatively straight from Diggers Rest, discharging into Jacksons Creek to the southeast. The drain intersects perpendicular with the APA pipeline at KP 8.36. The drains width at the crossing is around 20 meters and is defined channel with occasional ponding of water. Covered by grass, the drain has no discernible vegetation within the confines of the riparian zone. Near the crossing, the drain has an average grade of 1 in 150. The catchment area upstream of the pipeline crossing is roughly 8.72 km2 and is 50% residential and 50% agricultural. The residential area of Diggers Rest and the Calder Fwy are located within Tame Street Drain catchment.

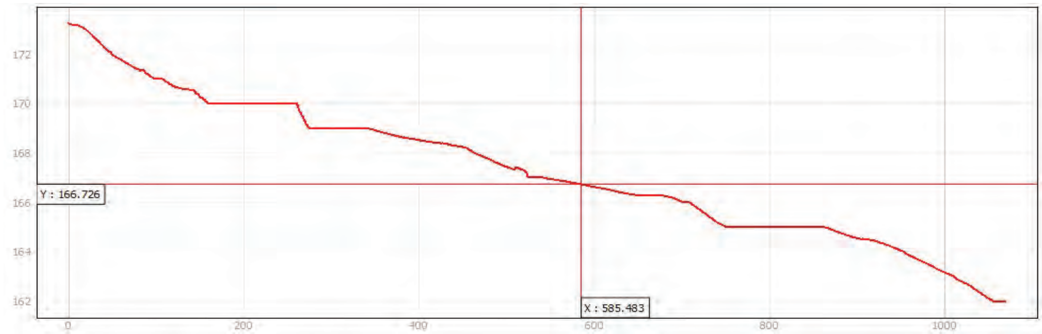
Pipe alignment & waterway location

Location (KP Chainage)	8.36
Waterway status	Main Drain channel
Stream Order	2nd
Stream type classification	Confined discontinuous
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	8.27
1 in 100 year Flow (m3/s)	16.9
LSIO Impact (1 in 100yr) (m wide)	80
River Grade (averaged)	1 in 150
Stream Velocity (m/s)	0.87
Erosion Hazard	Potential
Flood Hazard	Potential

Representative Cross Section



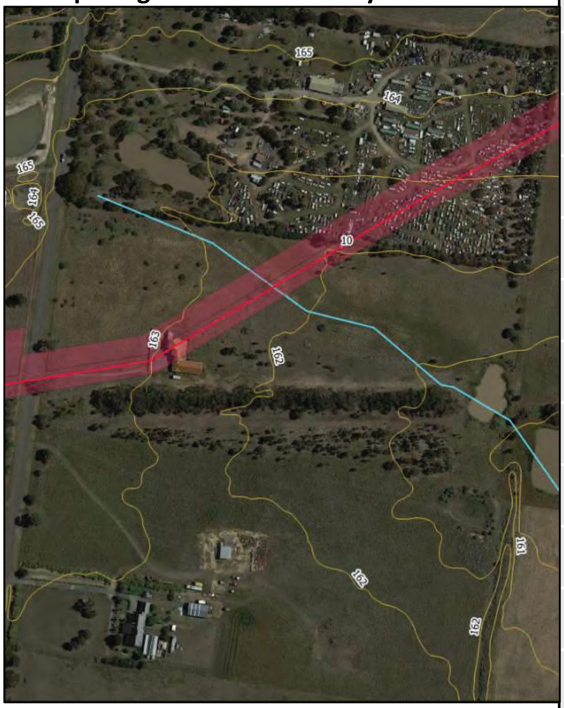
Interpreted Longitudinal Profile



Outcome: Potential hazard to pipe asset, further assessment required.

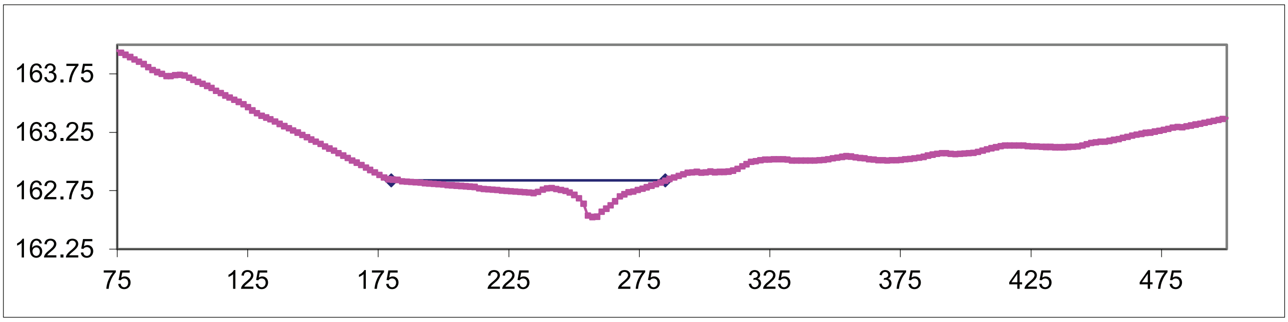
Crossing 4 - Unnamed tributary
The waterway for Crossing 4 runs relatively straight, east from the Calder Fwy and discharges into Jacksons Creek to the southeast. The tributary intersects perpendicular with the APA pipeline at KP 9.9. The tributaries width at the crossing is approximately 5m, with a minor defined streambed and occasional ponding of flow. Covered by grass, the drain has no discernible vegetation within the confines of the riparian zone. Near the crossing, the drain has a grade of 1 in 100. The catchment area upstream of the pipeline crossing is roughly 2km2 and is covered predominantly with agricultural land. Minor residencies are present within the catchment area though they appear largely unpaved.

Pipe alignment & waterway location

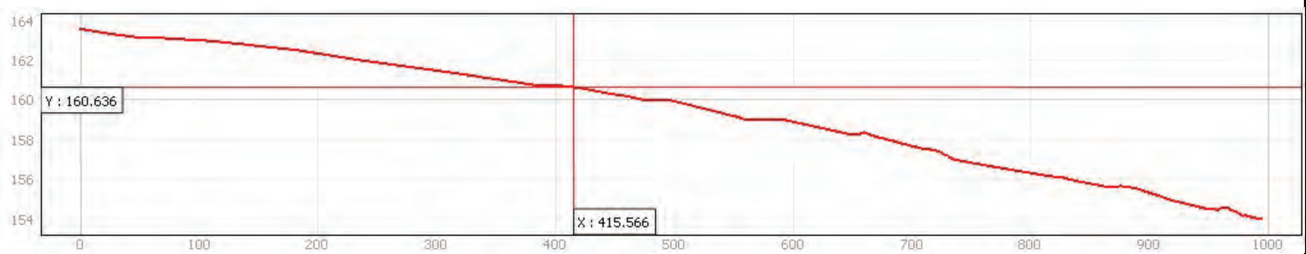


Location (KP Chainage)	9.9
Waterway status	Minor gully tributary
Stream Order	1st
Stream type classification	Intact valley fill
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	2.00
1 in 100 year Flow (m3/s)	5.48
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	1 in 100
Stream Velocity (m/s)	0.59
Erosion Hazard	Low
Flood Hazard	Low

Representative Cross Section



Interpreted Longitudinal Profile

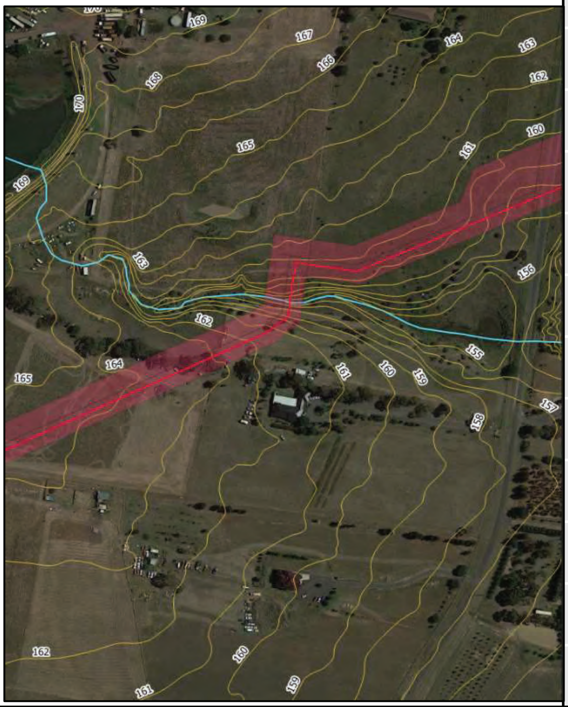


Outcome: Standard design, construction methodology and site controls.

Crossing 5 - Unnamed tributary

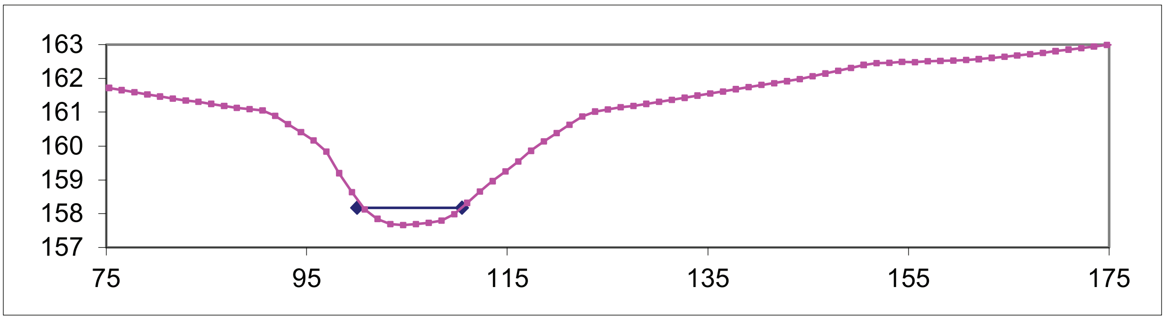
The waterway for Crossing 5 runs south-east, relatively straight from Bulla-Diggers Rest Rd, flowing through a series of ponds into a secondary stream before discharging into Jacksons Creek. The tributary intersects perpendicular with the APA pipeline at KP 10.6. The tributary is an underfined channel within a defined valley, with occasional ponding of water. The estimated velocity does not take into account the water storage (i.e. ponds, dams). A stream velocity is expected to be much less than 2.02 m/s due to the attenuation of flows along the tributary. The flow path is covered in grass with intermittent vegetation identified within the riparian zone, found primarily around the perimeter of the ponds. Near the crossing, the tributary has an average grade of 1 in 45. The catchment area upstream of the crossing is roughly 2.77 km2 and is covered predominantly with agricultural land. Minor residencies are present within the catchment area though they appear largely unpaved.

Pipe alignment & waterway location

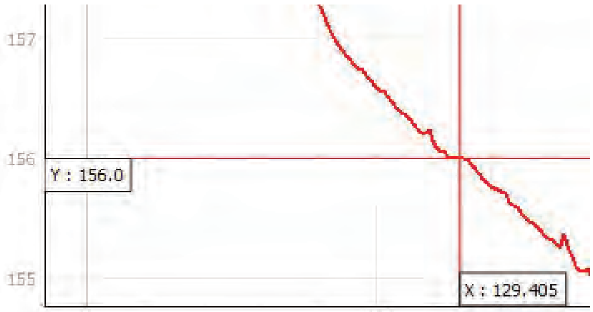


Location (KP Chainage)	10.6
Waterway status	Minor gully tributary
Stream Order	1st
Stream type classification	Confined discontinuous
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	2.77
1 in 100 year Flow (m3/s)	7.14
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	1 in 45
Stream Velocity (m/s)	2.02
Erosion Hazard	High
Flood Hazard	Low

Representative Cross Section



Interpreted Longitudinal Profile

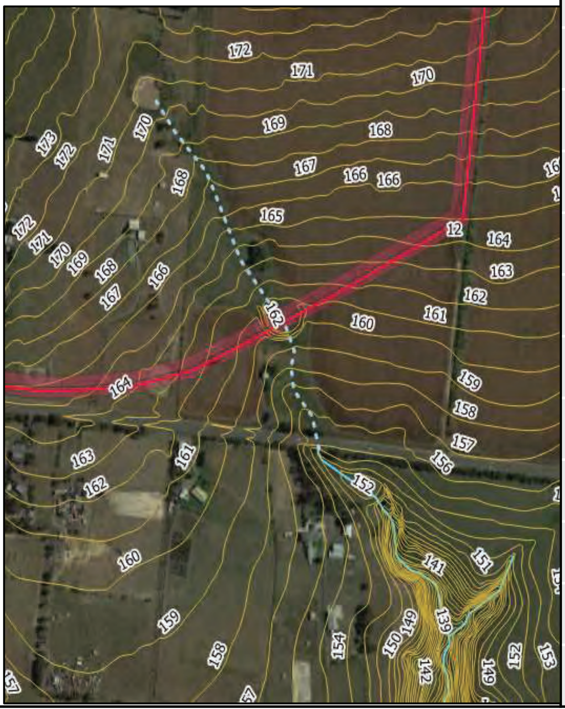


Outcome: Standard design, construction methodology and site controls.

Crossing 6 - Unnamed dam crossing

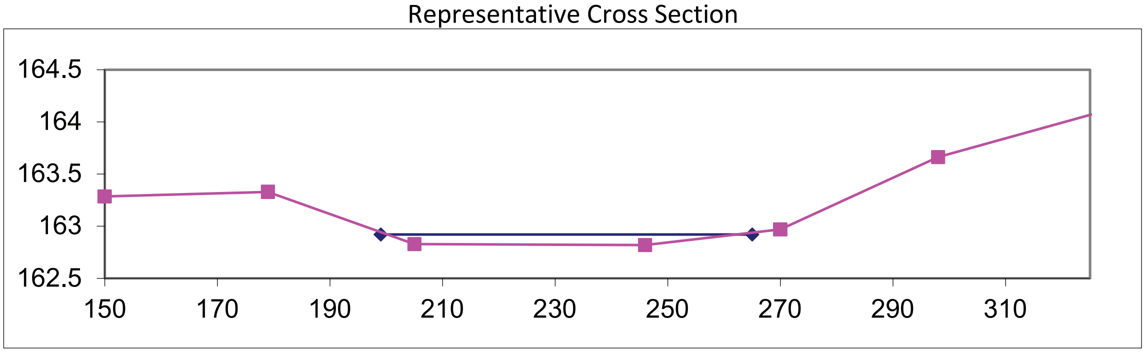
The waterway for Crossing 6 runs south, relatively straight from Bulla-Diggers Rest Rd, flowing through a series of minor dams before discharging into Jacksons Creek. The dam crossing intersects perpendicular with the APA pipeline at KP 11.7. The dam crossing has an approximate width at the intersection of 40m with no defined flow path north of Bulla-Diggers Rest Rd. Definition of flow path increases on the southern side of Bulla-Diggers Rest Rd as the gully increase in steepness. Flow path is covered with grass, with minor vegetation identified within the riparian zone. Near the crossing, the tributary has an average grade of 1 in 40. The catchment area upstream of the crossing is roughly 1.32 km2 and is covered predominantly with agricultural land.

Pipe alignment & waterway location



Location (KP Chainage)	11.7
Waterway status	Minor gully tributary (farm dam)
Stream Order	1st
Stream type classification	Intact valley fill
Approx. Crossing Length (m)	40
Catchment Area (km^2)	1.32
1 in 100 year Flow (m3/s)	3.9
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	1 in 40
Stream Velocity (m/s)	0.79
Erosion Hazard	Low
Flood Hazard	Low

Representative Cross Section



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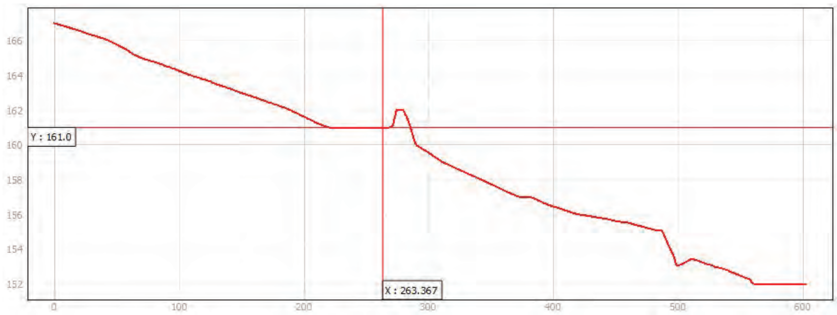
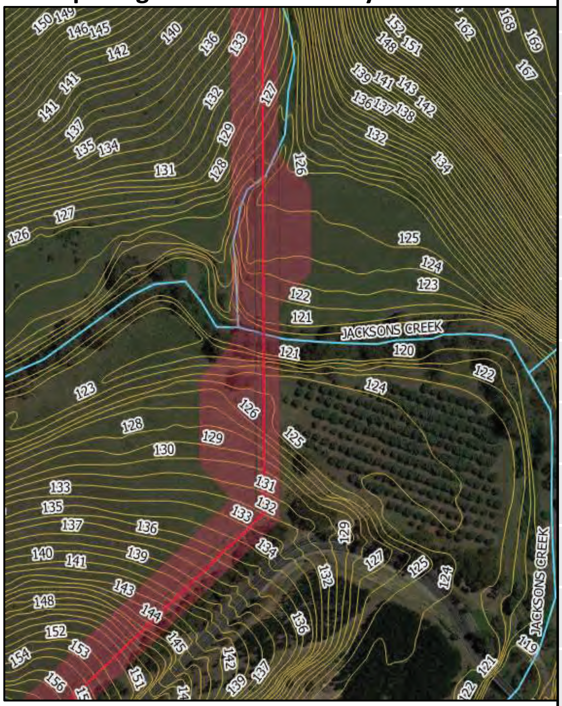


Outcome: Standard design, construction methodology and site controls.

Crossing 7 - Jacksons Creek

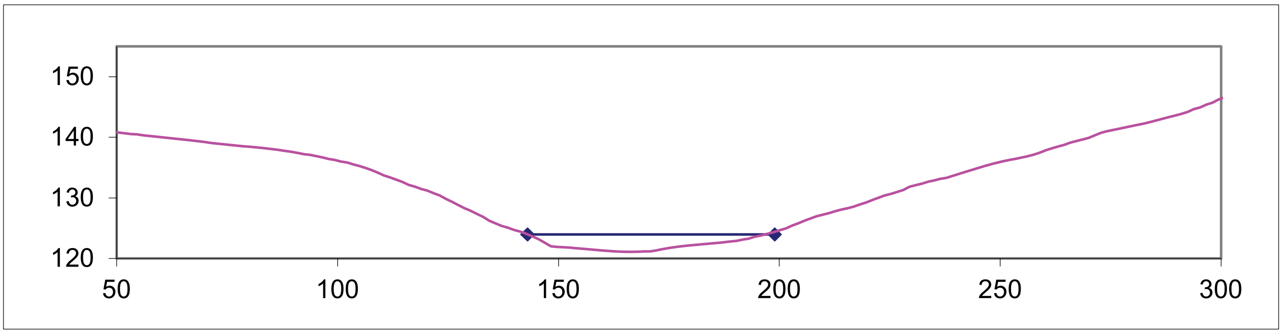
The waterway for Crossing 7, Jacksons Creek, runs south-east, meandering roughly parallel with Sunbury road, discharging into the Maribyrnong River. The crossing intersects perpendicular with the APA pipeline at KP 13.8. The creek has an approximate width at the intersection of 22.8m with a well-defined channel set into steep embankments. The flow path is covered with grass and significant vegetation within the riparian zone. Near the crossing has an average grade of 1 in 75. The catchment area upstream of the crossing is roughly 580 km2 and is a mix of agricultural land, state park land whilst also capturing some major residential zones such as Sunbury, Gisborne and Macedon.

Pipe alignment & waterway location

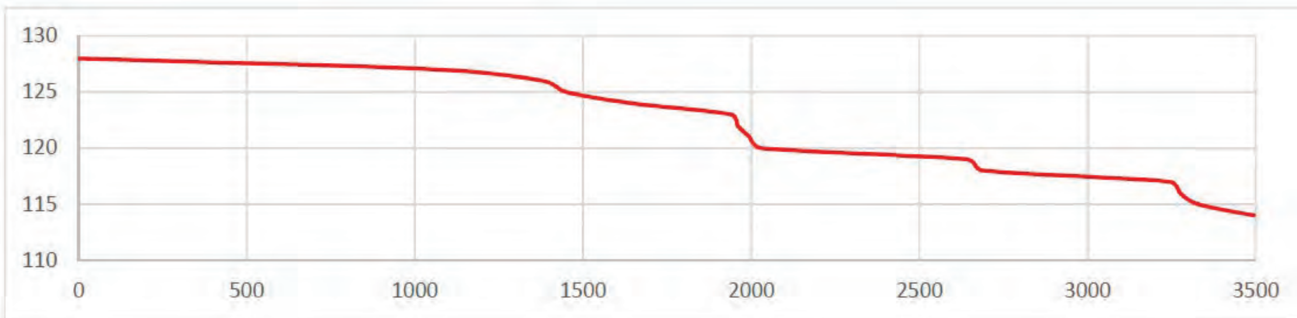


Location (KP Chainage)	13.8
Waterway status	Major waterway
Stream Order	3rd
Stream type classification	Incised channel
Approx. Crossing Length (m)	22.8
Catchment Area (km^2)	580.30
1 in 100 year Flow (m3/s)	387.93
LSIO Impact (1 in 100yr) (m wide)	100
River Grade (averaged)	1 in 75
Stream Velocity (m/s)	4.53
Erosion Hazard	High
Flood Hazard	High

Representative Cross Section



Interpreted Longitudinal Profile

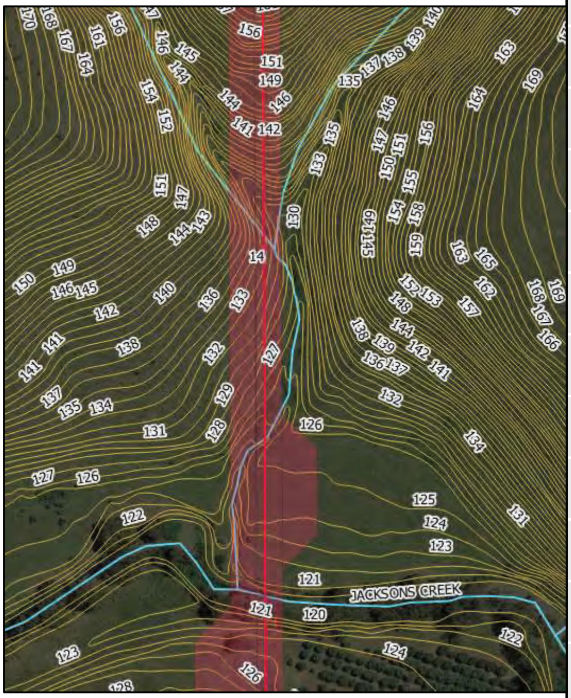


Outcome: Expected hazard to asset, further assessment required

Crossing 8 - Unnamed Tributary

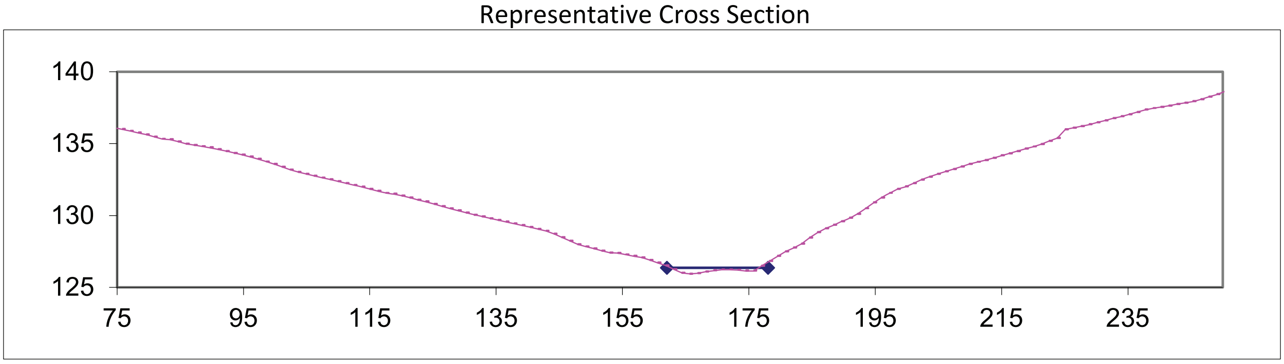
The waterway for Crossing 8 runs south from Sunbury road, relatively straight. The intersection incorporates 2 unnamed 1st order streams which flow into a 2nd order stream before discharging into Jacksons Creek. The tributary intersects with the APA pipeline at KP 13.9 and 14 and runs parallel to the works zone between these 2 points over a distance of 230m. The tributary has an approximate width at the intersection of 15m with minor defined streambed. The stream is grass covered and no discernible vegetation has been identified within the riparian zone. Near the crossing, the tributary has an average grade of 1 in 10. The catchment area upstream of the crossing is roughly 4.36 km2 and is covered predominantly with agricultural land but also includes a section of Sunbury Rd.

Pipe alignment & waterway location

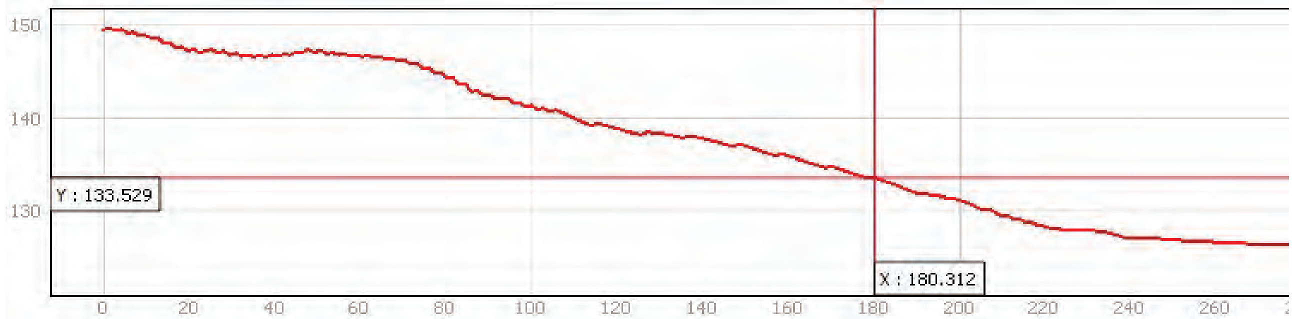


Location (KP Chainage)	14
Waterway status	Gully tributary
Stream Order	2nd
Stream type classification	Confined discontinuous
Approx. Crossing Length (m)	230
Catchment Area (km^2)	4.36
1 in 100 year Flow (m3/s)	10.20
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	1 in 10
Stream Velocity (m/s)	3.29
Erosion Hazard	High
Flood Hazard	Low

Representative Cross Section



Interpreted Longitudinal Profile



Outcome: Expected hazard to asset, further assessment required which will be included within the Jacksons Creek assessment

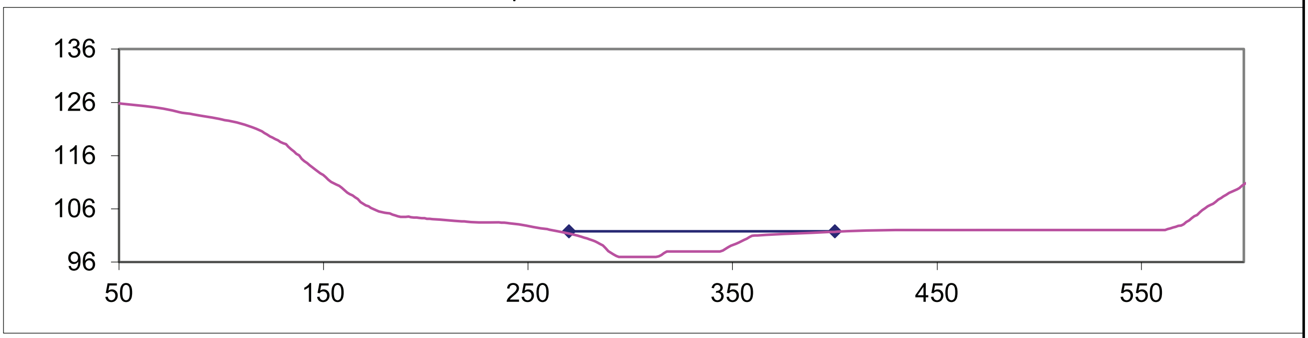
Crossing 9 - Deep Creek

The waterway for Crossing 9, Deep Creek, meanders south from Wildwood Rd towards Sunbury Rd, discharging into the Maribyrnong River. The crossing intersects diagonally with the APA pipeline at KP 17.1. The creek has an approximate width at the intersection of 13.2m with a well-defined channel and a relatively wide flood plain. There is significant vegetation throughout the riparian zone. Near the crossing, the creek has an average grade of 1 in 300. The catchment area upstream of the crossing is roughly 1,356 km2 and is a mix of agricultural land, state park land whilst also capturing some residential zones such as Romsey and Lancefield.

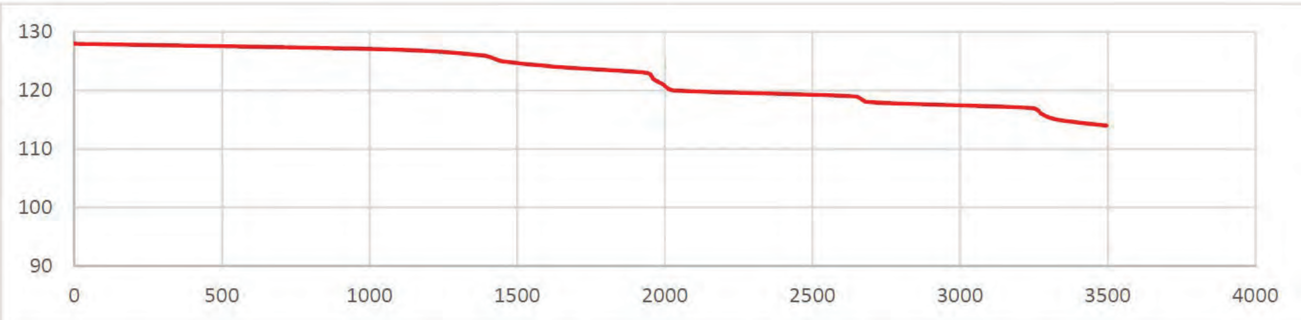
Pipe alignment & waterway location

Location (KP Chainage)	17.1
Waterway status	Major waterway
Stream Order	5th
Stream type classification	Incised Channel
Approx. Crossing Length (m)	13.2
Catchment Area (km^2)	1356.00
1 in 100 year Flow (m3/s)	570.00
LSIO Impact (1 in 100yr) (m wide)	300
River Grade (averaged)	1 in 300
Stream Velocity (m/s)	1.80
Erosion Hazard	High
Flood Hazard	High

Representative Cross Section



Interpreted Longitudinal Profile

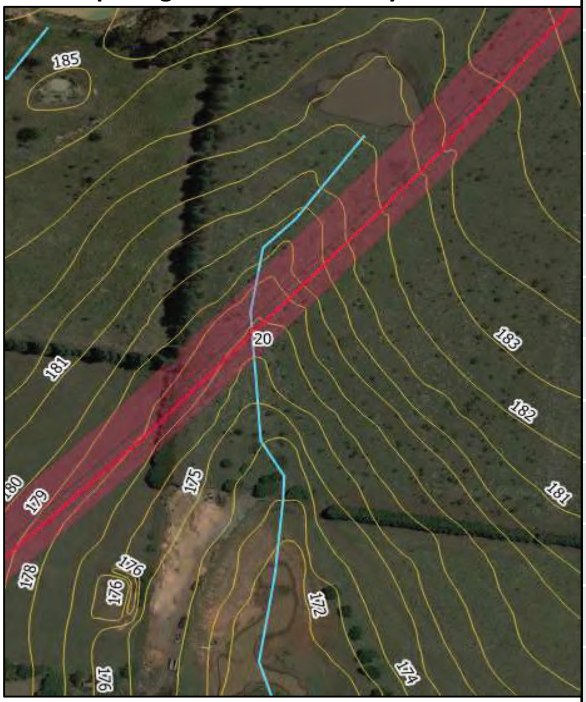


Outcome: Potential hazard to asset, furher assessment required.

Crossing 10 - Unnamed Tributary

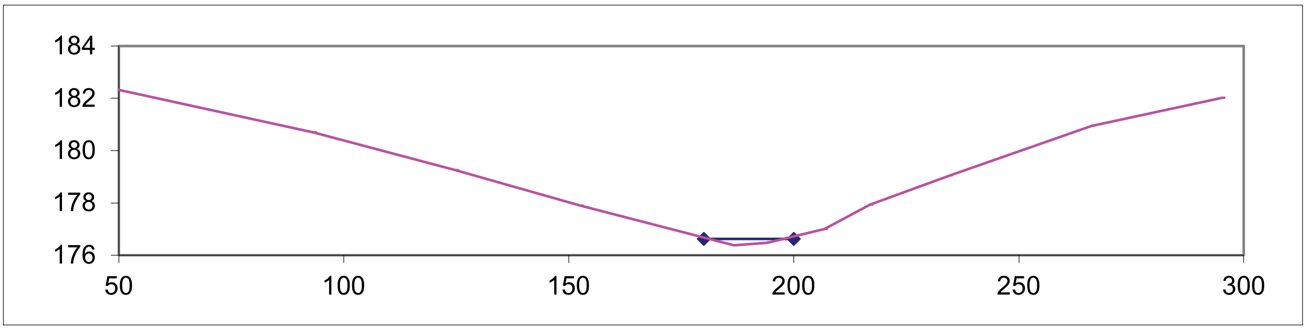
The waterway for Crossing 10 runs south, relatively straight between Wildwood Rd and Oaklands, flowing through a series of ponds before discharging into Moonee Ponds Creek. The tributary intersects diagonally with the APA pipeline at KP 19.5. The tributary is an undefined channel within a defined valley with occasional ponding of water. Flow path is covered with grass with no discernible vegetation within the confines of the riparian zone. Near the crossing, the tributary has an average grade of 1 in 35. The catchment area upstream of the crossing is roughly 0.68 km2 and is covered predominantly with agricultural land.

Pipe alignment & waterway location

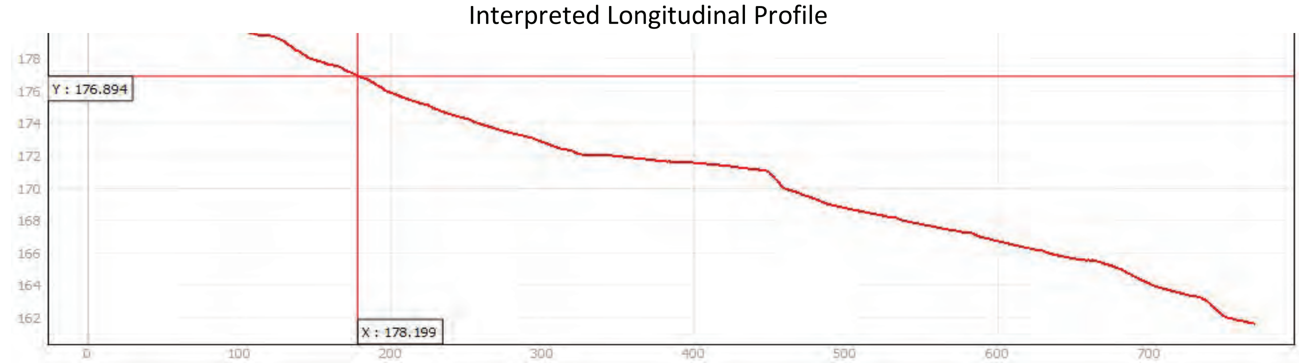


Location (KP Chainage)	19.5
Waterway status	Minor gully tributary
Stream Order	1st
Stream type classification	Confined discontinuous
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	0.68
1 in 100 year Flow (m3/s)	3.22
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	1 in 35
Stream Velocity (m/s)	1.37
Erosion Hazard	Potential
Flood Hazard	Low

Representative Cross Section



Interpreted Longitudinal Profile



Outcome: Standard design, construction methodology and site controls.

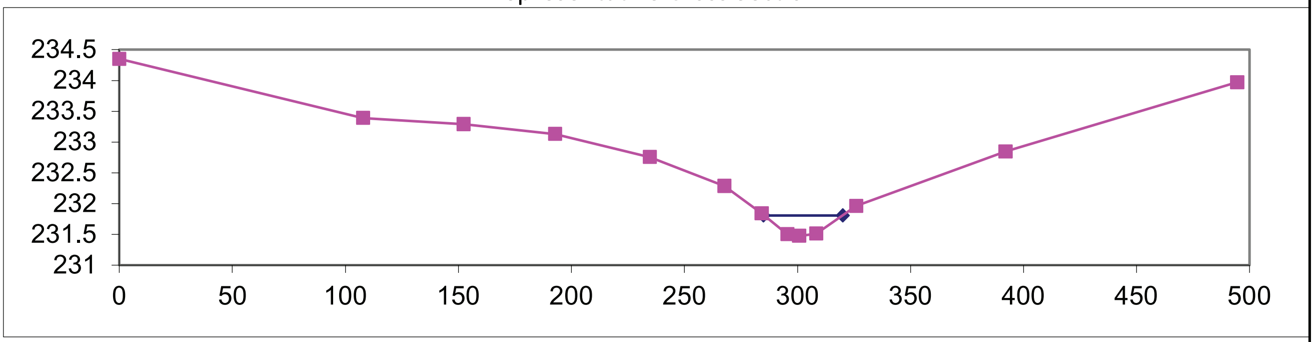
Crossing 11 - Unnamed Dam Crossing

The waterway for Crossing 11 runs north-west, relatively straight from Mickleham Rd towards Konagaderra Rd, flowing through a series of ponds before discharging into Deep Creek. This intersection sees the pipeline run through a pond of width 55m at KP 23.4. The waterway is covered with grass and minor vegetation is found within the confines of the riparian zone. Near the crossing, the tributary has an average grade of 1 in 110. The catchment area upstream of the crossing is roughly 3.16 km2 and is covered predominantly with agricultural land.

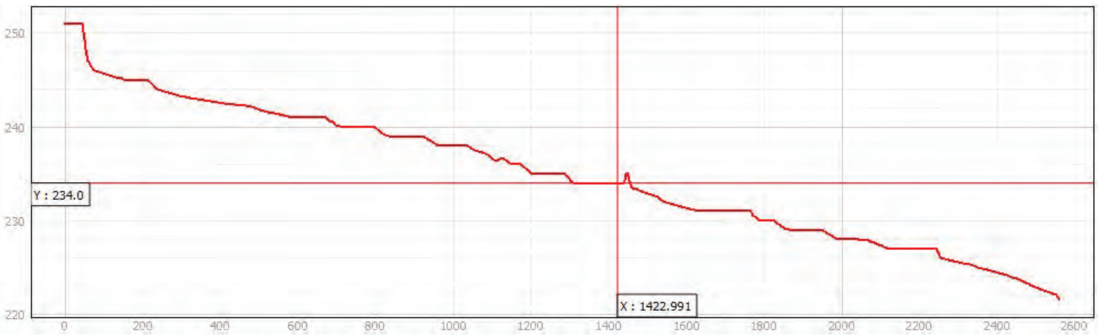
Pipe alignment & waterway location

Location (KP Chainage)	23.4
Waterway status	Minor gully tributary (farm dam)
Stream Order	1st
Stream type classification	Confined discontinuous
Approx. Crossing Length (m)	55
Catchment Area (km^2)	3.16
1 in 100 year Flow (m3/s)	7.93
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	1 in 110
Stream Velocity (m/s)	1.10
Erosion Hazard	Potential
Flood Hazard	Low

Representative Cross Section



Interpreted Longitudinal Profile



Outcome: Standard design, construction methodology and site controls.

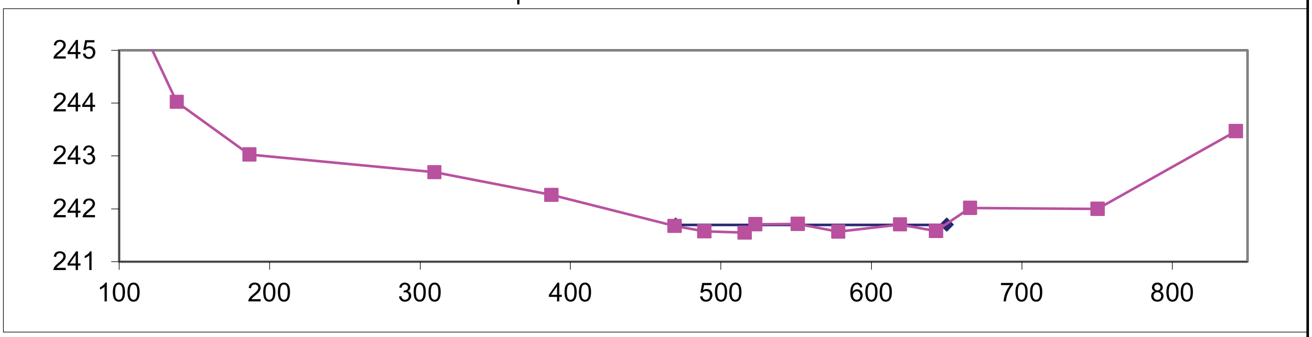
Crossing 12 - Unnamed Tributaries

The waterway for Crossing 12 runs north-east, relatively straight from Old Sydney Rd, flowing through a series of ponds before discharging into a reservoir. There are 2, 1st order tributaries intersecting with the APA pipeline at KP 31.9. Both tributaries have an approximate width at the intersection of 5m and is either an undefined channel or is obstructed by a newly developed residential area. The stream is grass covered and no discernible vegetation has been identified. Near the crossing, the tributary has an average grade of 1 in 60. The catchment area upstream of the crossing is roughly 1.80 km2 and is covered predominantly with agricultural land. Merrifield development is situated southeast of the intersection on the border of this catchment and possibly affects the flow at this intersection.

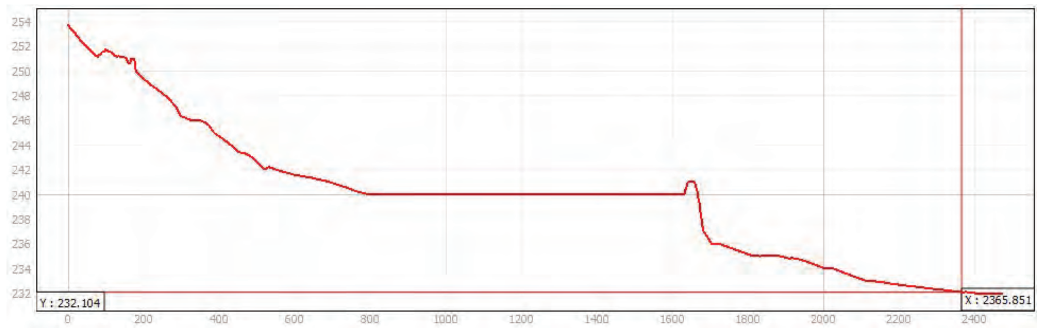
Pipe alignment & waterway location

Location (KP Chainage)	31.9
Waterway status	minor tributary
Stream Order	1st
Stream type classification	Confined discontinuous
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	1.80
1 in 100 year Flow (m3/s)	5.43
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	1 in 60
Stream Velocity (m/s)	0.48
Erosion Hazard	Low
Flood Hazard	Low

Representative Cross Section



Interpreted Longitudinal Profile

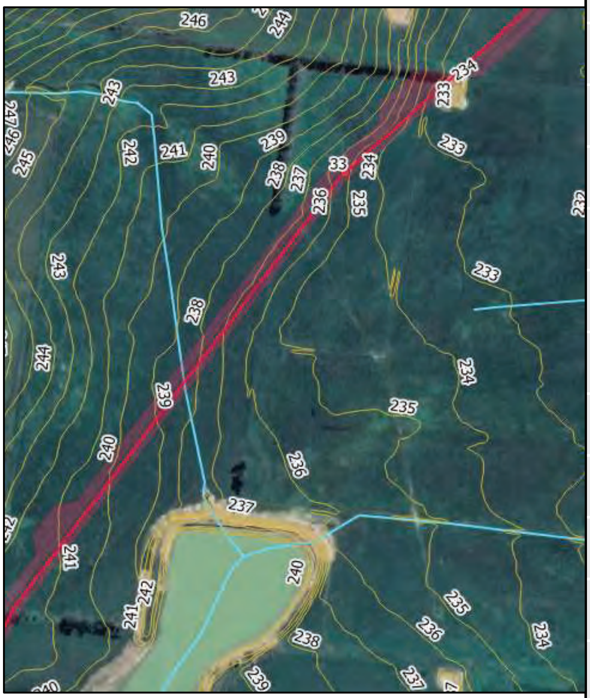


Outcome: Standard design, construction methodology and site controls.

Crossing 13 - Unnamed Tributary

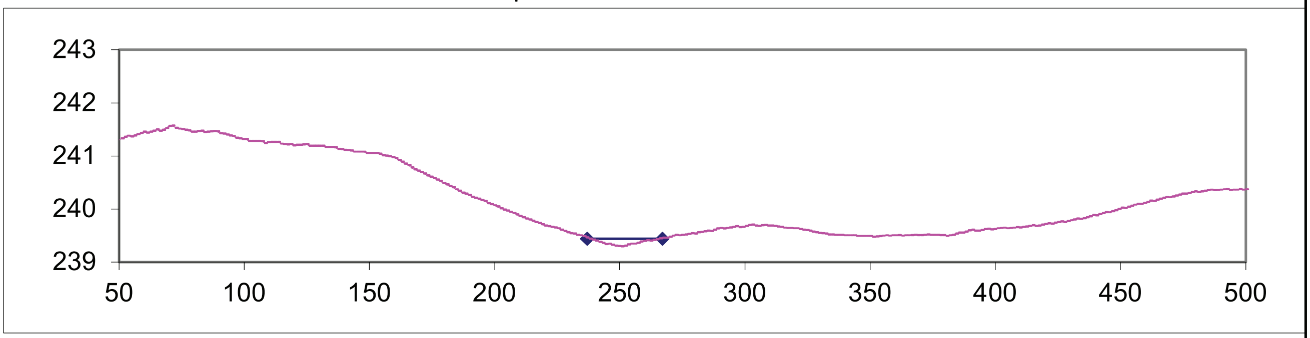
The waterway for Crossing 13 runs southeast, relatively straight from Old Sydney Rd, flowing through a series of dams before discharging into a reservoir. The tributary intersects perpendicularly with the with the APA pipeline at KP 32.6. The tributary is an underfined channel which has an approximate width at the intersection of 5m. The stream is grass covered and no discernible vegetation. Near the crossing, the tributary has an average grade of 1 in 50. The catchment area upstream of the crossing is roughly 1.31 km2 and is covered predominantly with agricultural land.

Pipe alignment & waterway location

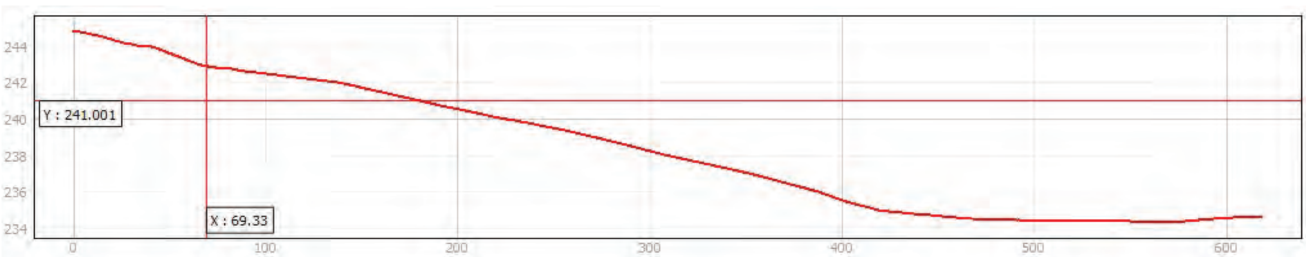


Location (KP Chainage)	32.6
Waterway status	minor tributary
Stream Order	1st
Stream type classification	Confined discontinuous
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	1.31
1 in 100 year Flow (m3/s)	3.74
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	1 in 50
Stream Velocity (m/s)	1.80
Erosion Hazard	Potential
Flood Hazard	Low

Representative Cross Section



Interpreted Longitudinal Profile



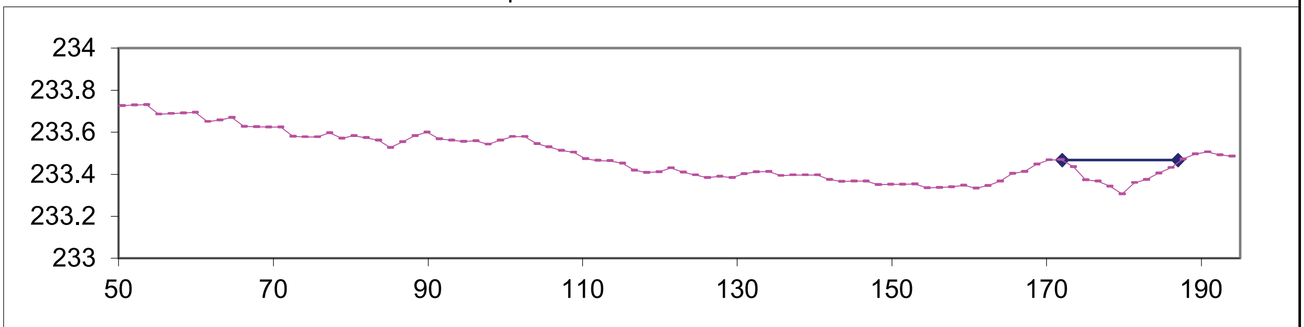
Outcome: Standard design, construction methodology and site controls.

Crossing 14 - Unnamed Tributary
The waterway for Crossing 14 runs south-east, relatively straight from Old Sydney Rd, flowing through a series of ponds then connecting to a series of irrigation channels before discharging into the Kalkallo Creek. The tributary intersects perpendicularly with the APA pipeline at KP 33.7. The tributary is an undefined channel with a width at the intersection of less than 5m. The stream is grass covered and no discernible vegetation has been identified near the tributary. Near the crossing, the tributary has an average grade of 1 in 65. The catchment area upstream of the crossing is roughly 0.88 km2 and is covered predominantly with agricultural land.

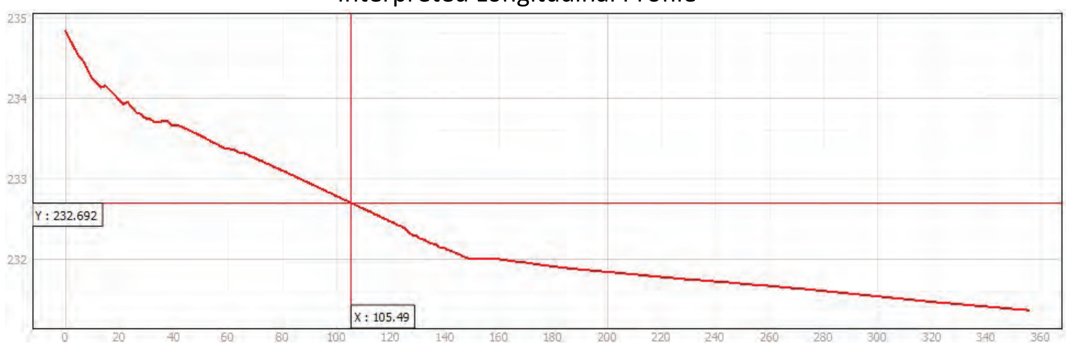
Pipe alignment & waterway location

Location (KP Chainage)	33.7
Waterway status	Gully stream
Stream Order	1st
Stream type classification	Confined discontinuous
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	0.88
1 in 100 year Flow (m3/s)	3.74
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	1 in 65
Stream Velocity (m/s)	0.64
Erosion Hazard	Low
Flood Hazard	Low

Representative Cross Section



Interpreted Longitudinal Profile



Outcome: Standard design, construction methodology and site controls.

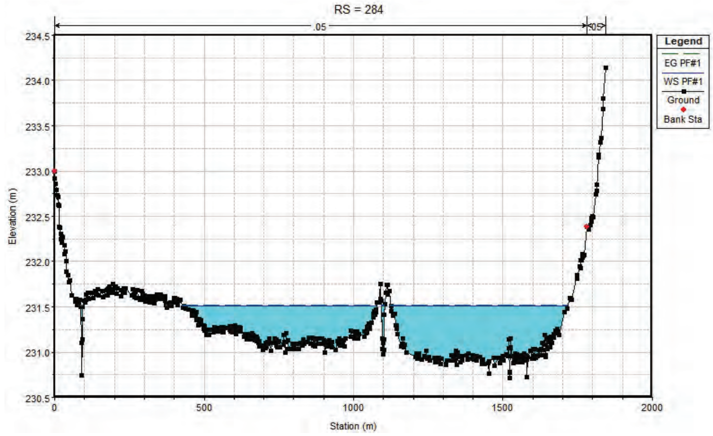
Crossing 15 - 3 Unnamed Agricultural Drains

The waterway for Crossing 15 contains 3 agricultural drains and runs south, straight from Gunns Gully Rd towards Donnybrook Rd. Two 1st order drains (KP 33.9 and KP 34) flow into a 2nd order drain (KP 34.1), which discharges into Kalkallo Creek. The drains intersect diagonally with the with the APA pipeline at KP 33.9-34.1. The drains are defined channels which have an approximate width at the intersection of 5m. The drains are used for conveying water across a large retarding basin which is inundated with flood waters up to 231.5 mAHD in a 1 in 100 year ARI flood event. Therefore, the depth of water is at least 1m at the crossing. The retarding basin has an embankment wall further to the south of the crossing. The two 1st order drains are grass covered and no discernible vegetation has been identified within flood plain. The 2nd order drain is grass covered with intermittent vegetation identified upstream of the intersection within the riparian zone. Near the crossing, the tributary has an average grade of 1 in 1200. The catchment area upstream of the crossing is roughly 3.18 km2 and is covered predominantly with agricultural land.

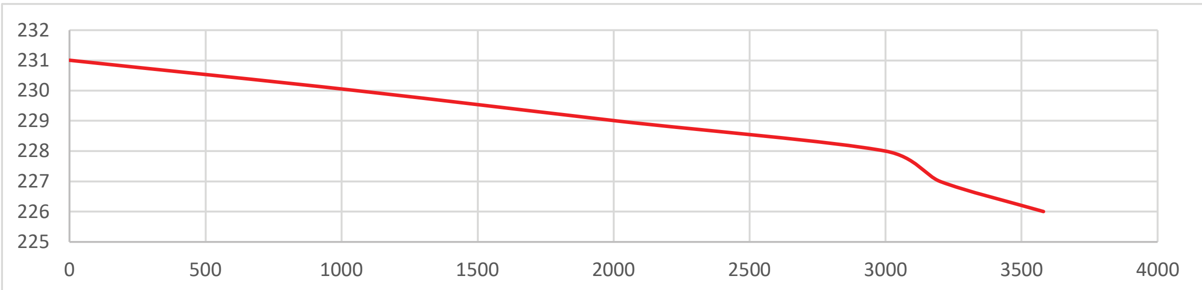
Pipe alignment & waterway location

Location (KP Chainage)	33.9 - 34.1
Waterway status	Constructed drains
Stream Order	1st & 2nd
Stream type classification	straightened channelised
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	3.18
1 in 100 year Flow (m3/s)	8.54
LSIO Impact (1 in 100yr) (m wide)	1000
River Grade (averaged)	1 in 1200
Stream Velocity (m/s)	0.25
Erosion Hazard	Low
Flood Hazard	High

Representative Cross Section



Interpreted Longitudinal Profile



Outcome: Potential hazard to asset, further assessment required which will be included within the Kalkallo Creek assessment.

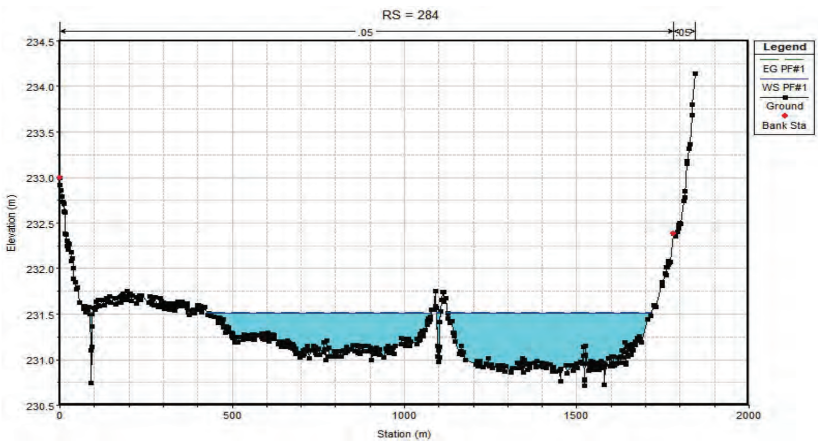
Crossing 16 - Kalkallo Creek

The waterway for Crossing 16, Kalkallo Creek, runs south, relatively straight from Old Sydney Rd, parallel to the Hume Hwy, flowing through a series of dams and discharging into Merri Creek. The creek intersects perpendicular with the APA pipeline at KP 34.5. The creek is an defined channel which has an approximate width at the intersection of 10m. The drains are used for conveying water across a large retarding basin which is inundated with flood waters up to 231.5 mAHD in a 1 in 100 year ARI flood event. Therefore, the depth of water is at least 1m at the crossing. The retarding basin has an embankment wall further to the south of the crossing. The creek is grass covered and vegetation has been identified within the riparian zone upstream and downstream of the intersection. Near the crossing location, the creek has an average grade of 1 in 600. The catchment area upstream of the crossing is roughly 25.4 km2 and is covered predominantly with agricultural land.

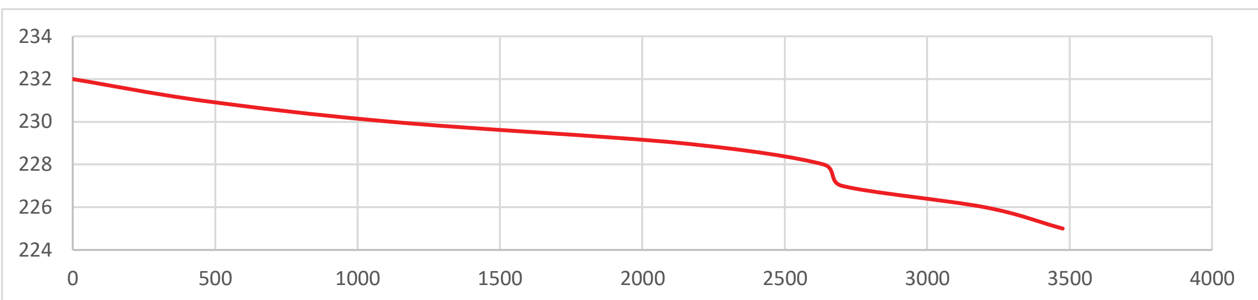
Pipe alignment & waterway location

Location (KP Chainage)	34.5
Waterway status	Constructed Drain
Stream Order	3rd
Stream type classification	straightened channelised
Approx. Crossing Length (m)	10
Catchment Area (km^2)	25.40
1 in 100 year Flow (m3/s)	71.80
LSIO Impact (1 in 100yr) (m wide)	1000
River Grade (averaged)	1 in 600
Stream Velocity (m/s)	0.29
Erosion Hazard	Potential
Flood Hazard	High

Representative Cross Section



Interpreted Longitudinal Profile

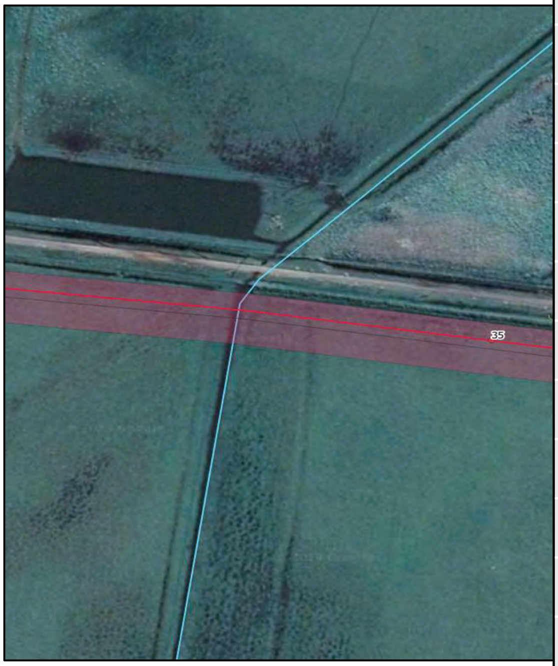


Outcome: Potential hazard to asset, further assessment required.

Crossing 17 - Unnamed Agricultural Drain

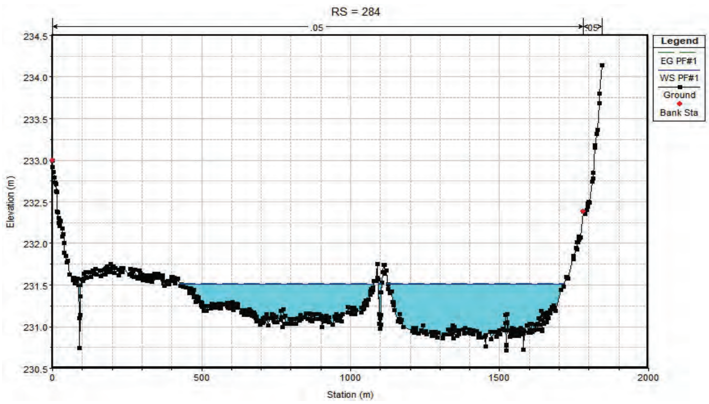
The waterway for Crossing 17 runs south, relatively straight between Old Sydney Rd and the Hume Hwy. Flowing through a series of dams and a small residential development, this drain discharges into Kalkallo Creek, which discharges into Merri Creek. The drain intersects perpendicularly with the APA pipeline at KP 34.9. The drain has a defined channel with an an approximate width at the intersection of 5m. The drains are used for conveying water across a large retarding basin which is inundated with flood waters up to 231.5 mAHD in a 1 in 100 year ARI flood event. Therefore, the depth of water is at least 1m at the crossing. The retarding basin has an embankment wall further to the south of the crossing. The drain is grass covered with no significant vegetation identified within the riparian zone. Near the crossing location, the drain has an average grade of 1 in 360. The catchment area upstream of the crossing is roughly 11.8 km2 and covered predominantly with agricultural land but also contains a minor residential development.

Pipe alignment & waterway location

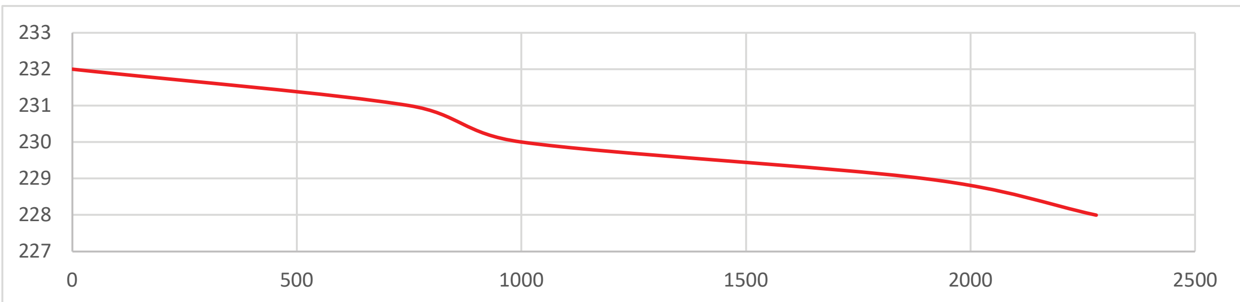


Location (KP Chainage)	34.9
Waterway status	Constructed Drain
Stream Order	3rd
Stream type classification	straightened channelised
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	11.80
1 in 100 year Flow (m3/s)	23.00
LSIO Impact (1 in 100yr) (m wide)	1000
River Grade (averaged)	1 in 360
Stream Velocity (m/s)	0.21
Erosion Hazard	Low
Flood Hazard	High

Representative Cross Section



Interpreted Longitudinal Profile



Outcome: Potential hazard to asset, further assessment required which will be included within the Kalkallo Creek assessment.

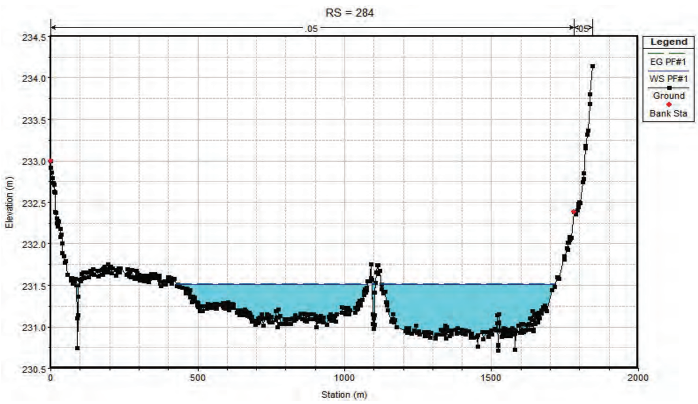
Crossing 18 - Unnamed Agricultural Drain

The waterway for Crossing 18 runs south, relatively straight between Old Sydney Rd and the Hume Hwy. Flowing through a series of dams and a small residential development, this drain discharges into the Kalkallo Creek, which discharges into Merri Creek. The drain intersects perpendicularly with the with the APA pipeline at KP 35.5. The drain has a defined channel with an an approximate width at the intersection of 5m. The drains are used for conveying water across a large retarding basin which is inundated with flood waters up to 231.5 mAHD in a 1 in 100 year ARI flood event. Therefore, the depth of water is at least 1m at the crossing. The retarding basin has an embankment wall further to the south of the crossing. The drain is grass covered with no significant vegetation identified within the riparian zone. Near the crossing location, the drain has an average grade of 1 in 320. The catchment area upstream of the crossing is roughly 11.8 km2 and covered predominantly with agricultural land but also contains a minor residential development.

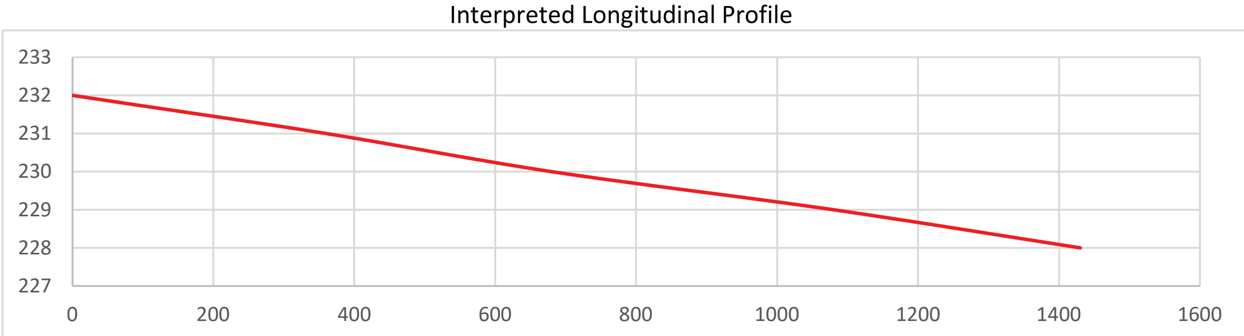
Pipe alignment & waterway location

Location (KP Chainage)	35.5
Waterway status	Constructed Drain
Stream Order	2nd
Stream type classification	straightened channelised
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	11.80
1 in 100 year Flow (m3/s)	22.90
LSIO Impact (1 in 100yr) (m wide)	1000
River Grade (averaged)	1 in 320
Stream Velocity (m/s)	0.20
Erosion Hazard	Low
Flood Hazard	High

Representative Cross Section



Interpreted Longitudinal Profile



Outcome: Potential hazard to asset, further assessment required which will be included within the Kalkallo Creek assessment.

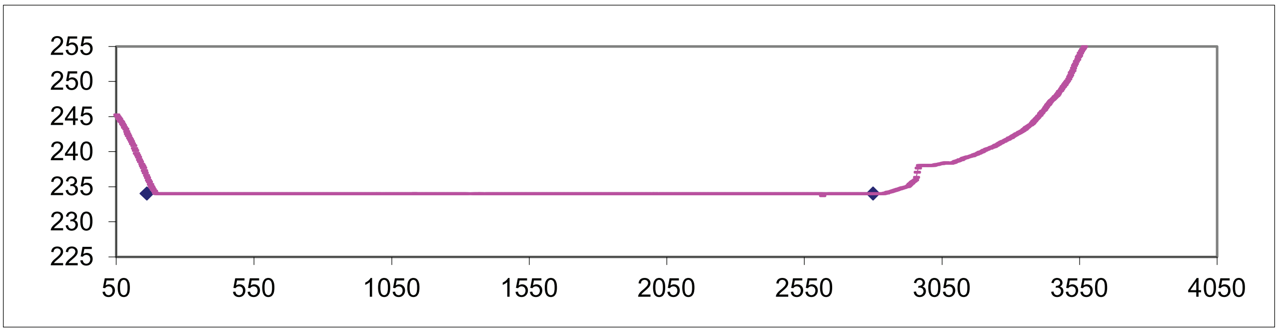
Crossing 19 - Unnamed Agricultural Drain

The waterway for Crossing 19 runs south from Whiteside St, relatively straight between Old Sydney Rd and the Hume Hwy. This drain flows through a series of ponds and collects water from numerous agricultural drains west of the Hume Hwy. The drain intersects perpendicularly with the with the APA pipeline at KP 36.2. The unnamed agricultural drain discharges to Kalkallo Creek downstream of the retarding basin, after which it flows for 3 km's before discharging into Merri Creek. The drain has a defined channel with an an approximate width at the intersection of 5m. The creek is grass covered with no discernible vegetation identified within the riparian zone. Near the crossing location, the drain has an average grade of 1 in 180. The catchment area upstream of the crossing is roughly 11.8 km2 and is covered predominantly with agricultural land as well as a section of the Hume Hwy.

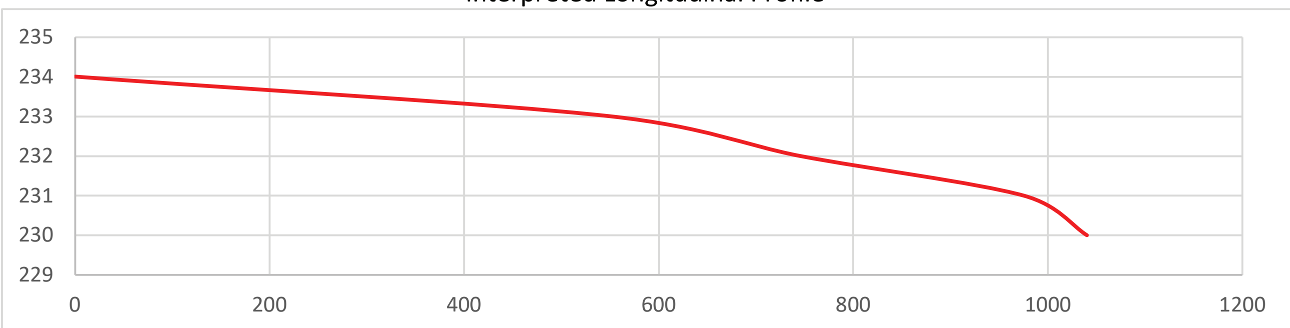
Pipe alignment & waterway location

Location (KP Chainage)	36.2
Waterway status	Constructed Drain
Stream Order	2nd
Stream type classification	straightened channelised
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	12.60
1 in 100 year Flow (m3/s)	24.50
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	1 in 180
Stream Velocity (m/s)	0.27
Erosion Hazard	Low
Flood Hazard	Low

Representative Cross Section



Interpreted Longitudinal Profile



Outcome: Standard design, construction methodology and site controls.

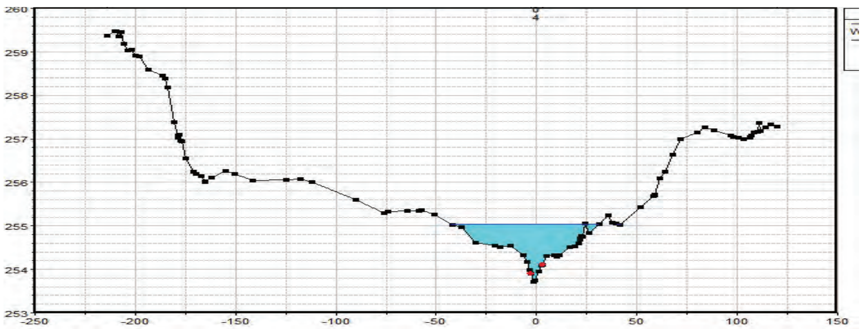
Crossing 20 - Tributary of Merri Creek

The waterway for Crossing 20 runs south, relatively straight from Beveridge Rd between the Hume Hwy and Merriang Rd. Flowing through a series of dams, the tributary crosses Donovan's Lane before discharging into Merri Creek. The tributary intersects diagonally with the APA pipeline at KP 40.8. At the crossing, the stream has an undefined channel with an approximate width at the crossing is 60m. The stream is covered with grass and minor vegetation. Near the crossing, the tributary has an average grade of 1 in 1100. The catchment area upstream of the crossing is roughly 4.36 km2 and is covered predominantly with agricultural land as well as capturing a small section of a residential development.

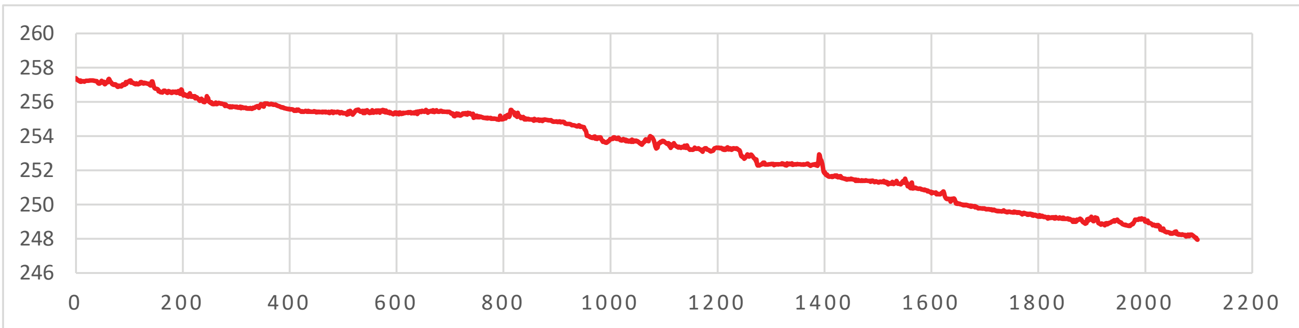
Pipe alignment & waterway location

Location (KP Chainage)	40.8
Waterway status	Tributary creek
Stream Order	2nd
Stream type classification	intact valley fill
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	60.00
1 in 100 year Flow (m3/s)	26.12
LSIO Impact (1 in 100yr) (m wide)	180
River Grade (averaged)	1 in 1100
Stream Velocity (m/s)	1.08
Erosion Hazard	Potential
Flood Hazard	Low

Representative Cross Section



Interpreted Longitudinal Profile



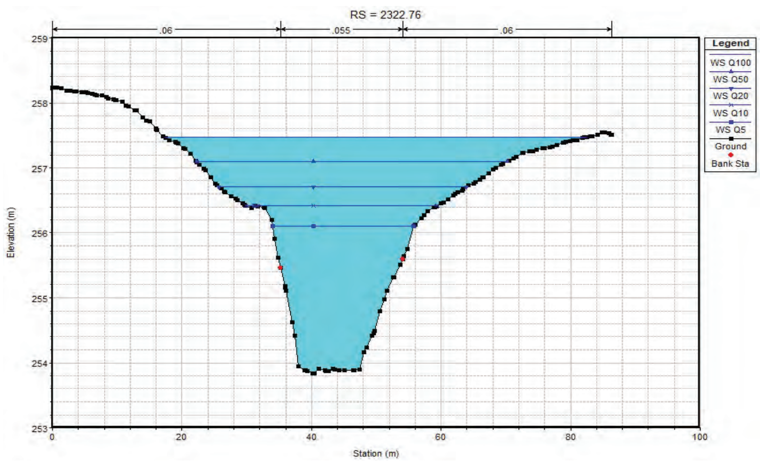
Outcome: Potential hazard to asset, further assessmet requried.

Crossing 21 - Merri Creek
The waterway for Crossing 21, Merri Creek, is one of Melbourne's major waterways. The creek meanders south towards Donnybrook Rd, between the Hume Hwy and Merriang Rd, discharging into the Yarra River. The crossing intersects perpendicularly with the APA pipeline at KP 42.9. The creek has an approximate width at the intersection of 40m with a well-defined channel. The creek is covered with grass and significant vegetation has been identified within the riparian zone. Near the crossing, the tributary has an average grade of 1 in 285. The catchment area upstream of the crossing is roughly 127.7 km2 and is approximately 60% agricultural land, 10% state park and 30% paved residential zone, namely Wallan.

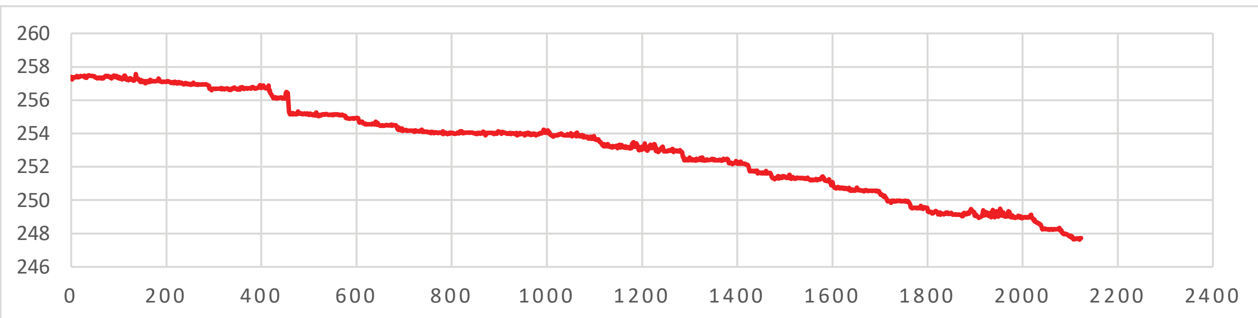
Pipe alignment & waterway location

Location (KP Chainage)	42.9
Waterway status	major waterway
Stream Order	4th
Stream type classification	Incised meander channel
Approx. Crossing Length (m)	40
Catchment Area (km^2)	127.70
1 in 100 year Flow (m3/s)	141.00
LSIO Impact (1 in 100yr) (m wide)	65
River Grade (averaged)	1 in 285
Stream Velocity (m/s)	2.18
Erosion Hazard	High
Flood Hazard	High

Representative Cross Section



Interpreted Longitudinal Profile

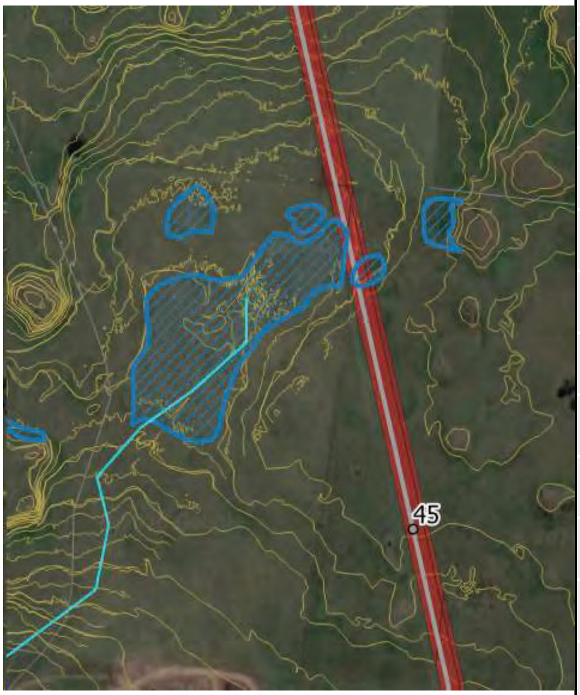


Outcome: Potential hazard to asset, further assessmet requried.

Crossing 22 - Seasonal Wetlands

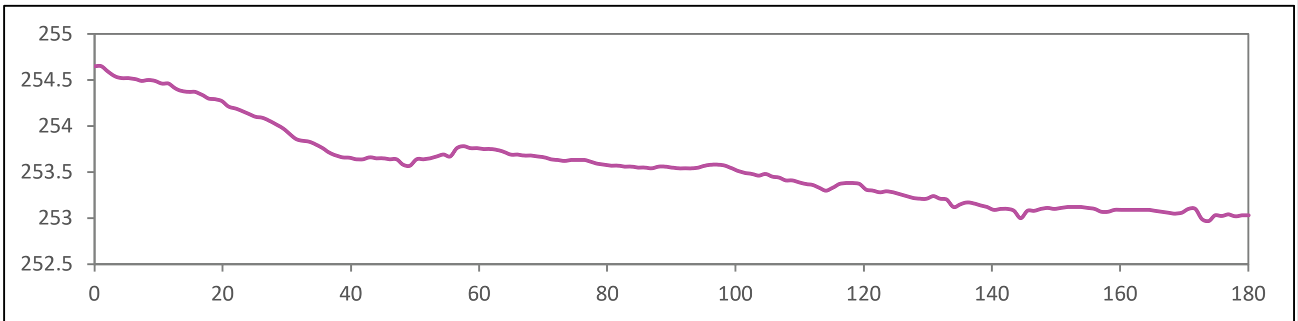
The waterway for Crossing 22 includes two of the mapped wetlands that are partially intersected by the Project. These natural wetland bodies are mapped in the Victorian Wetlands Inventory and there are a number of these small wetlands scattered across the land north of Donnybrook Road and east of Merri Creek. The two mapped palustrine wetlands periodically inundate when there is a significant rainfall event. The larger wetland that is partially crossed by the Project flows through a minor tributary into a secondary stream before discharging into the Merri Creek. From aerial imagery, the wetlands appear to be mostly dry and ephemeral with no discernible vegetation. The catchment area upstream of the crossing is roughly 0.62 km2 and is covered predominantly with agricultural land.

Pipe alignment & waterway location



Location (KP Chainage)	44.7
Waterway status	minor tributary
Stream Order	1st
Stream type classification	Wetland
Approx. Crossing Length (m)	n/a
Catchment Area (km^2)	0.62
1 in 100 year Flow (m3/s)	n/a
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	n/a
Stream Velocity (m/s)	n/a
Erosion Hazard	Low
Flood Hazard	Low

Representative Cross Section



Outcome: Standard design, construction methodology and site controls.

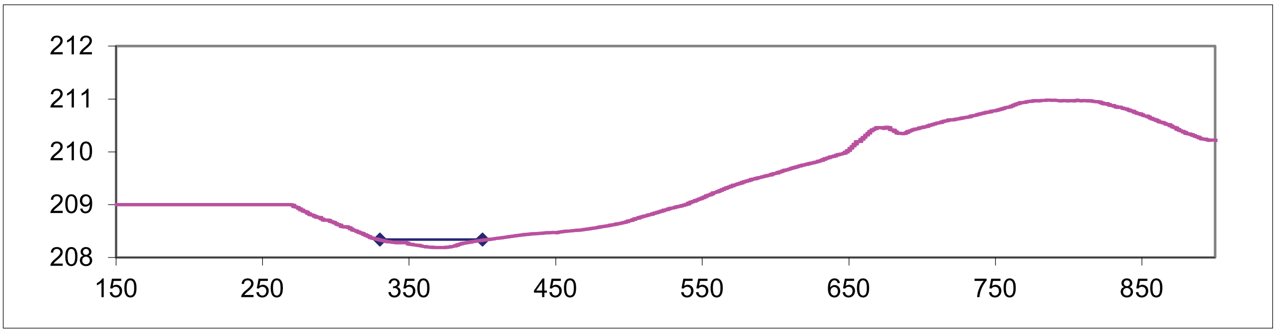
Crossing 23 - Unnamed Tributaries

The waterway for Crossing 23 runs south-west, relatively straight from Summerhill Rd towards Craigieburn Rd before discharging into the Merri Creek. This section considers 2 tributaries, the first intersects the pipeline longitudinally and the second perpendicularly KP 51. The power station has had a significant impact on the tributary flow path. Both tributaries have an underfined channel with an approximate width at the intersection of 5m. The streams are covered with grass with no discernible vegetation within its confines. Near the crossing, the tributary has an average grade of 1 in 200. The catchment area upstream of the crossing is roughly 0.55 km2 and is covered predominantly with agricultural land, with a paved section at the point of intersection.

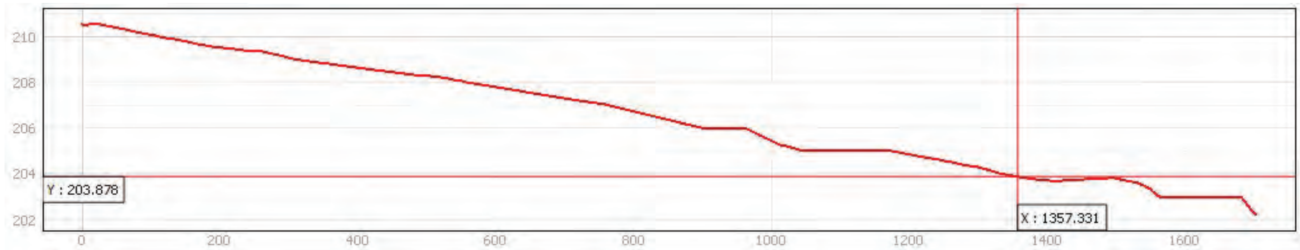
Pipe alignment & waterway location

Location (KP Chainage)	51
Waterway status	minor tributary
Stream Order	1st
Stream type classification	intact valley fill
Approx. Crossing Length (m)	< 5
Catchment Area (km^2)	0.55
1 in 100 year Flow (m3/s)	3.18
LSIO Impact (1 in 100yr) (m wide)	n/a
River Grade (averaged)	1 in 200
Stream Velocity (m/s)	0.52
Erosion Hazard	Low
Flood Hazard	Low

Representative Cross Section



Interpreted Longitudinal Profile



Outcome: Standard design, construction methodology and site controls.

Appendix E – HEC –RAS Flow Profiles

Appendix E

Tame Street Drain – Long section profiles

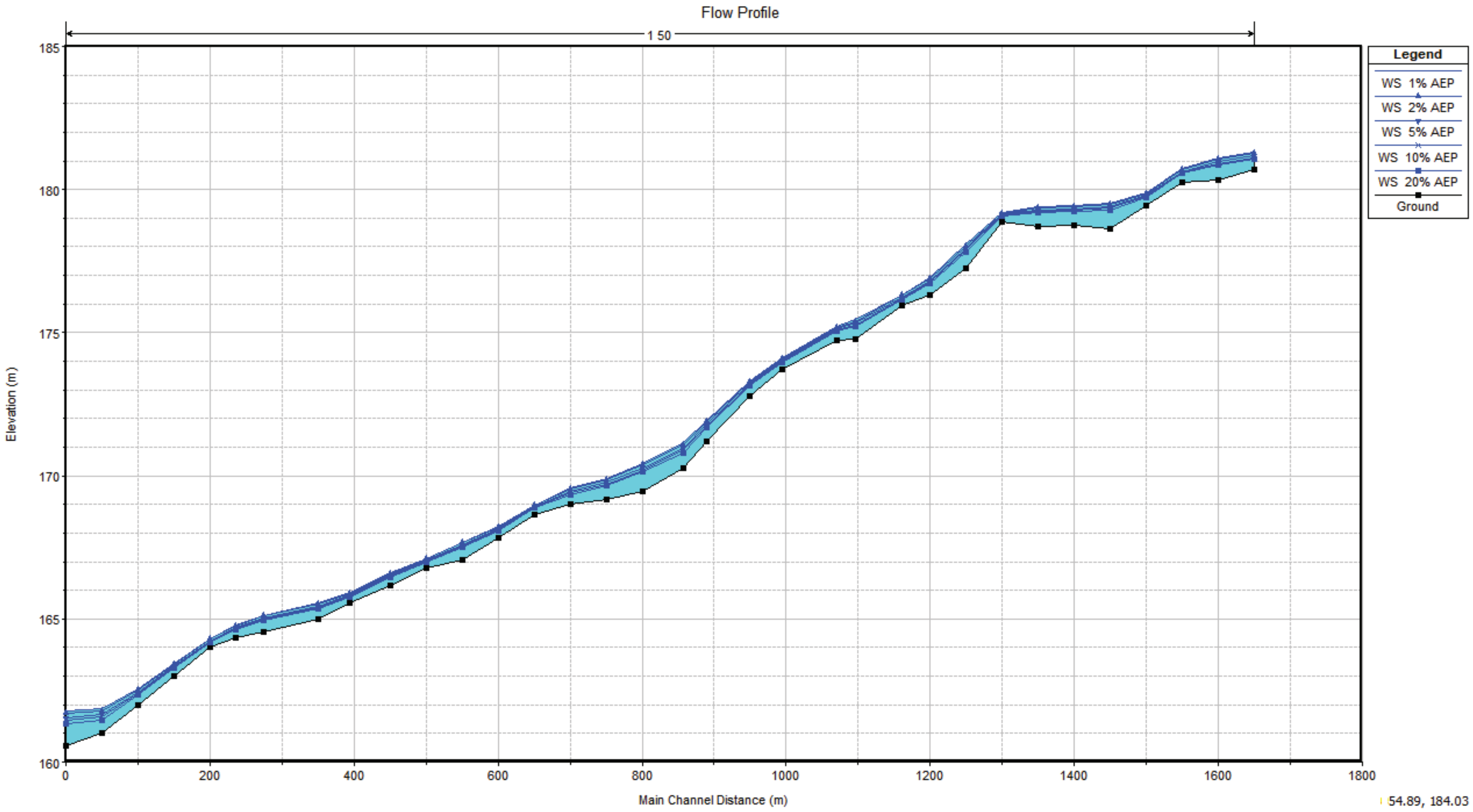


Figure 1: Tame Street Drain flood level profile (5, 10, 20, 50 and 100yr ARI).

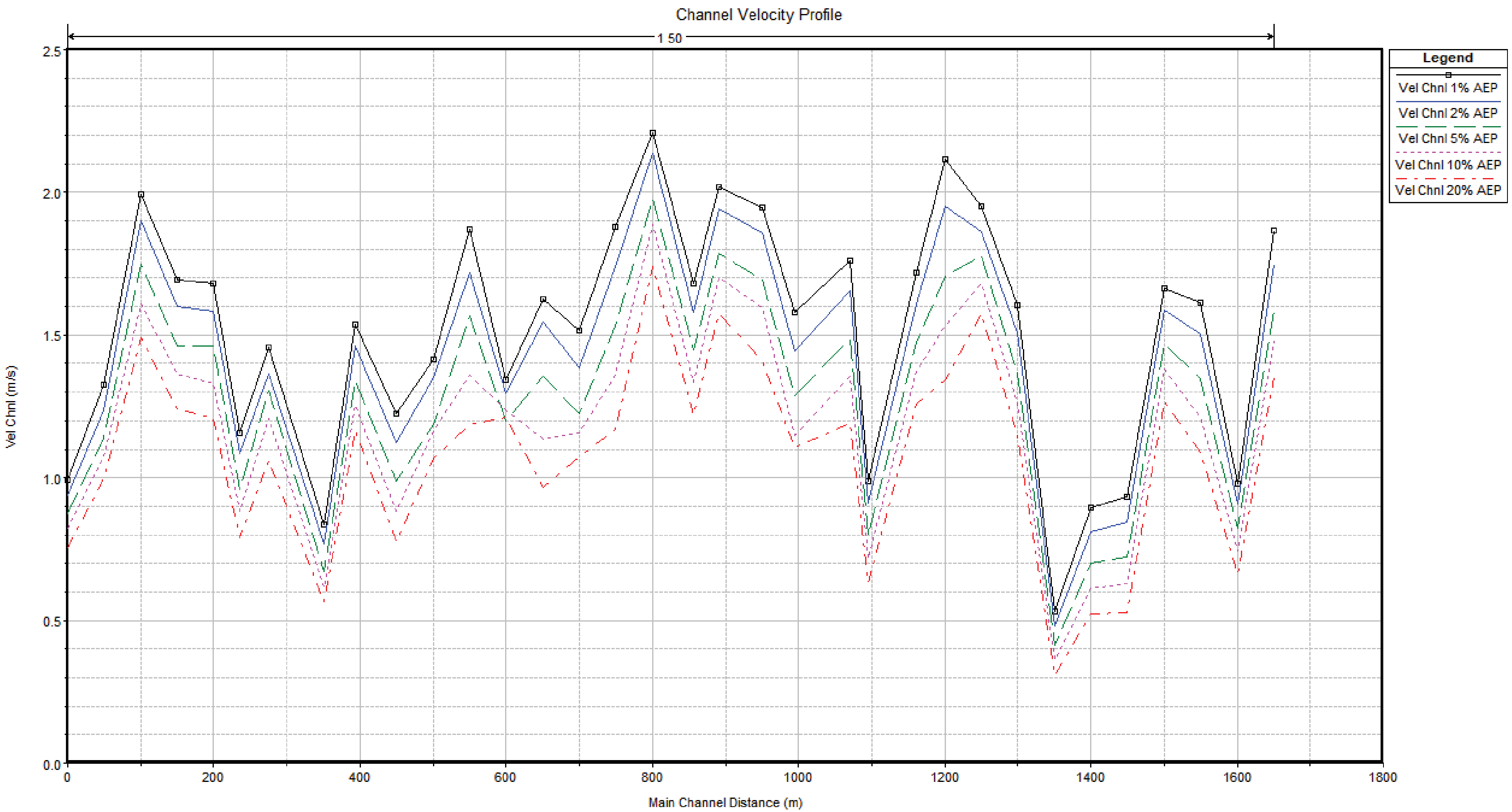


Figure 2: Tame Street Drain channel velocity profile (5, 10, 20, 50 and 100yr ARI).

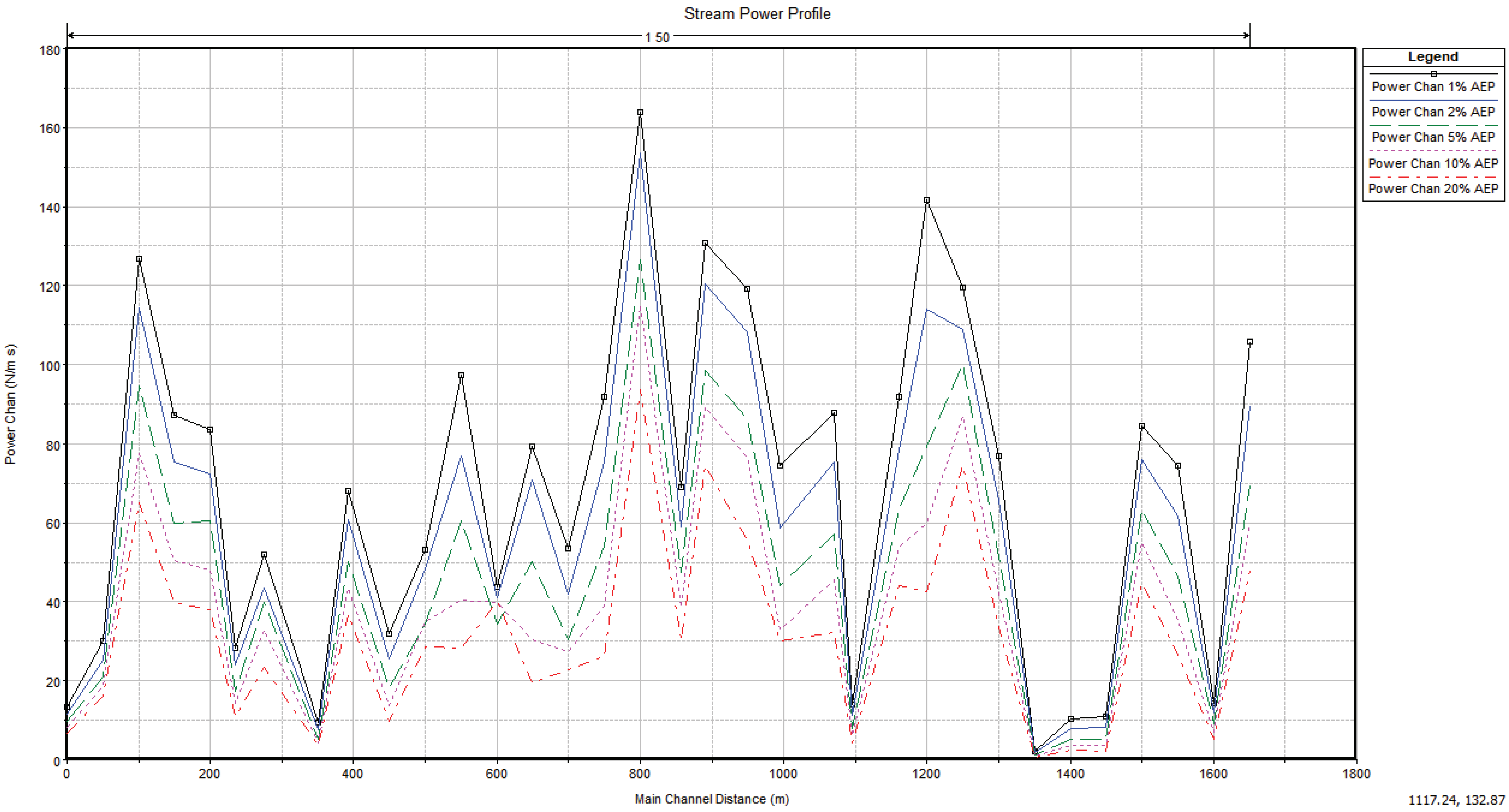


Figure 3: Tame Street Drain channel stream power profile (5, 10, 20, 50 and 100yr ARI).

Jacksons Creek - Long section profiles

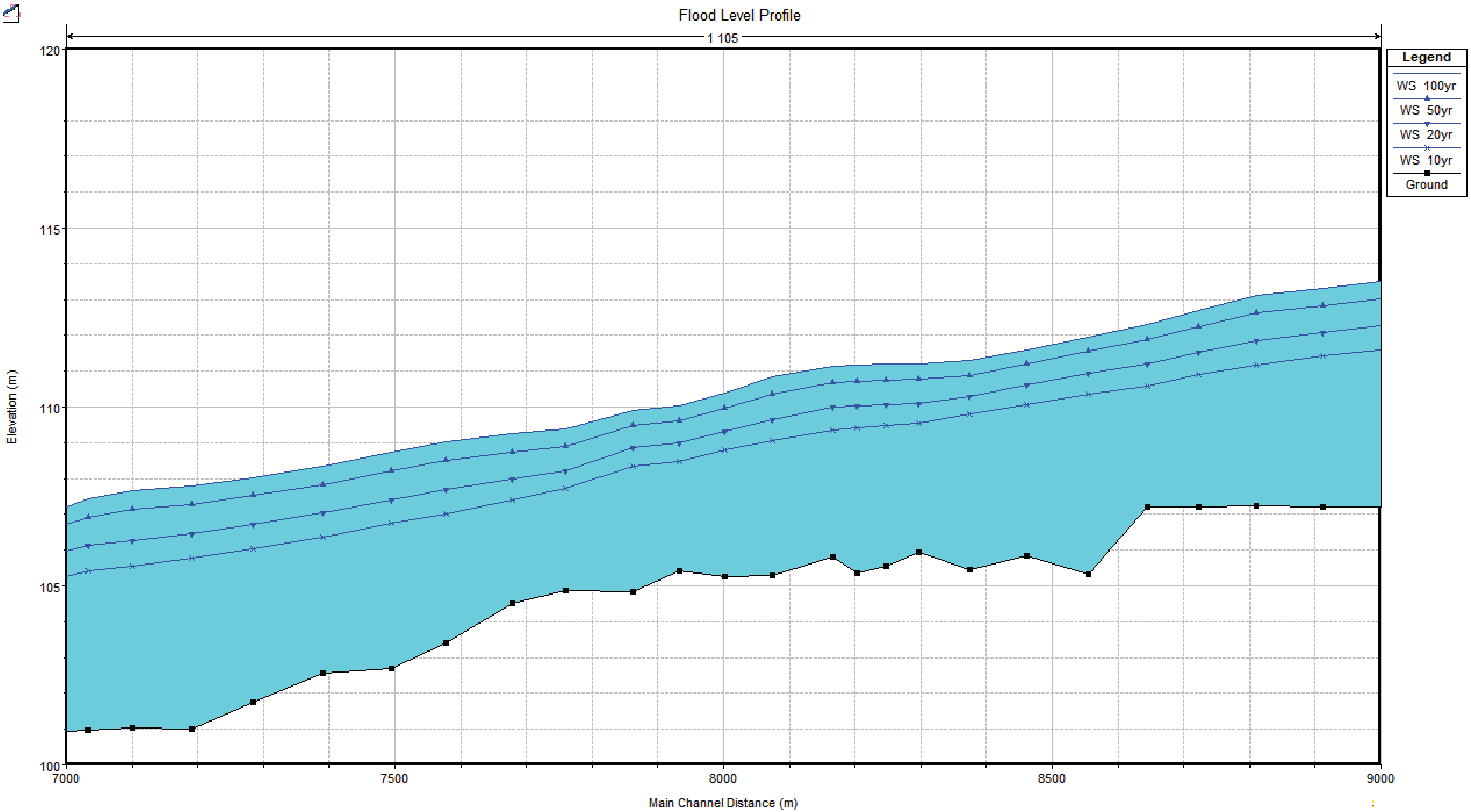


Figure 4: Jacksons Creek flood level profile (10, 20, 50 and 100yr ARI).

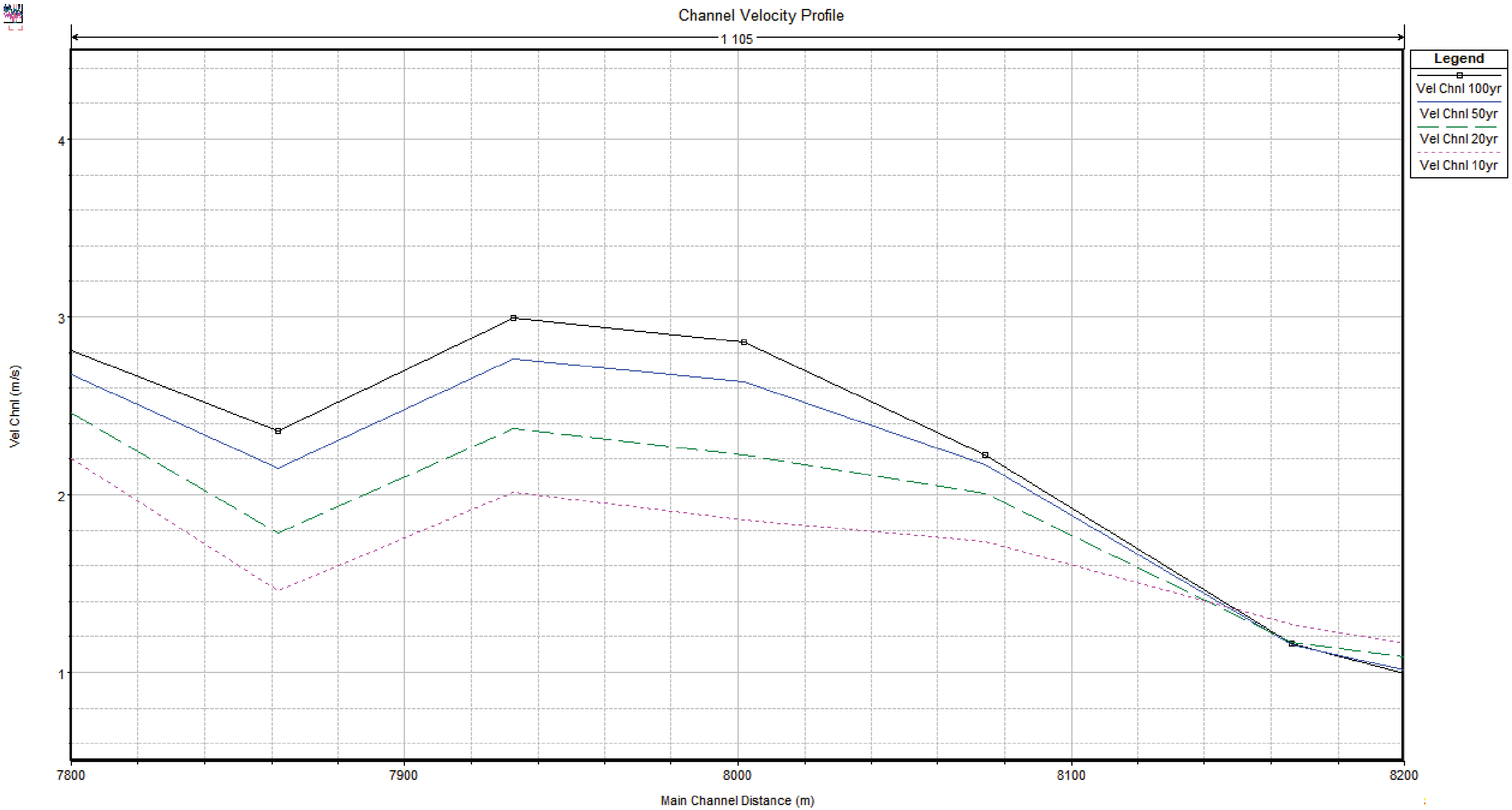


Figure 5: Jacksons Creek channel velocity profile (10, 20, 50 and 100yr ARI).

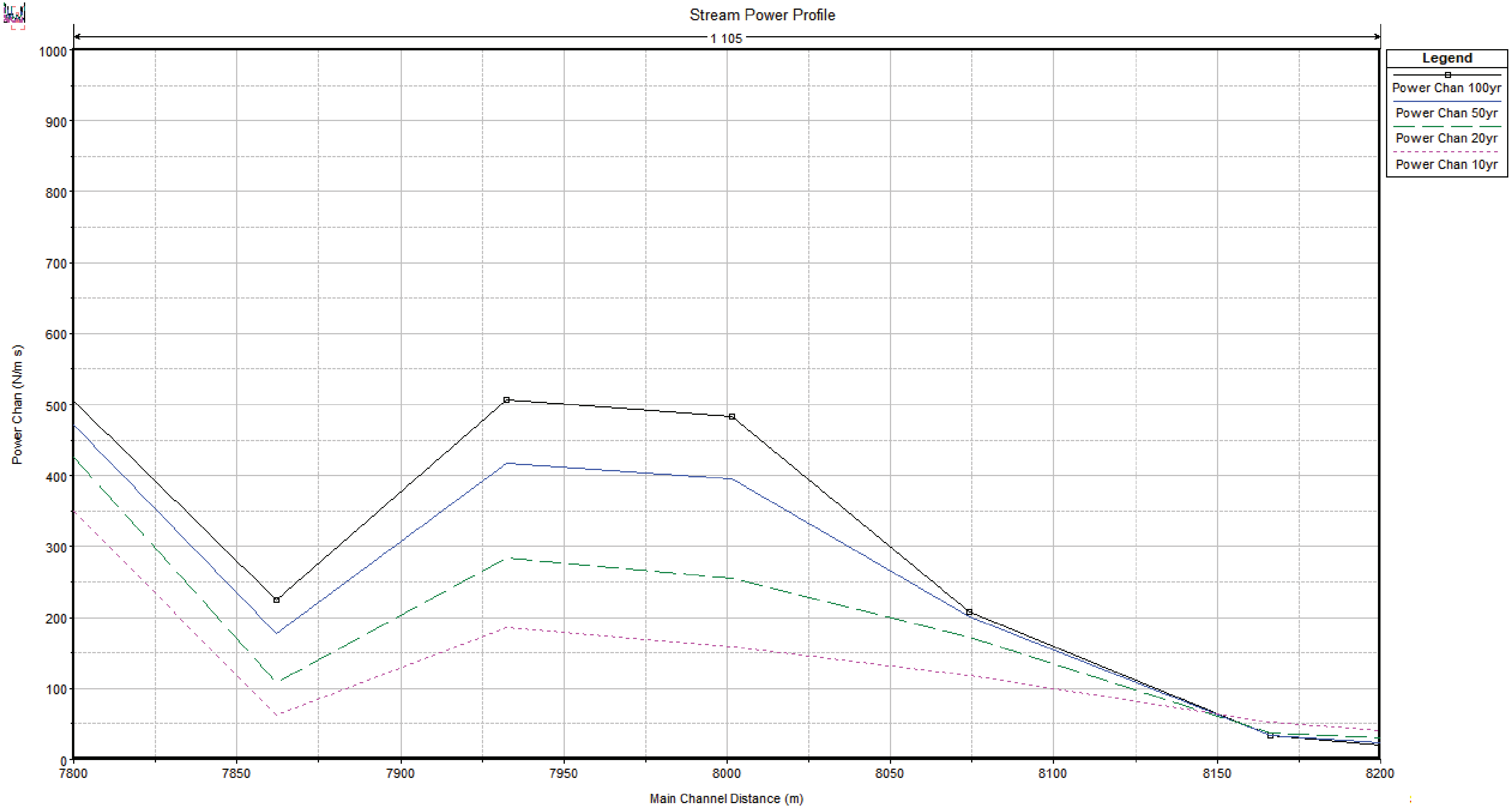


Figure 6: Jacksons Creek channel stream power profile (10, 20, 50 and 100yr ARI).

Deep Creek - Long section profiles

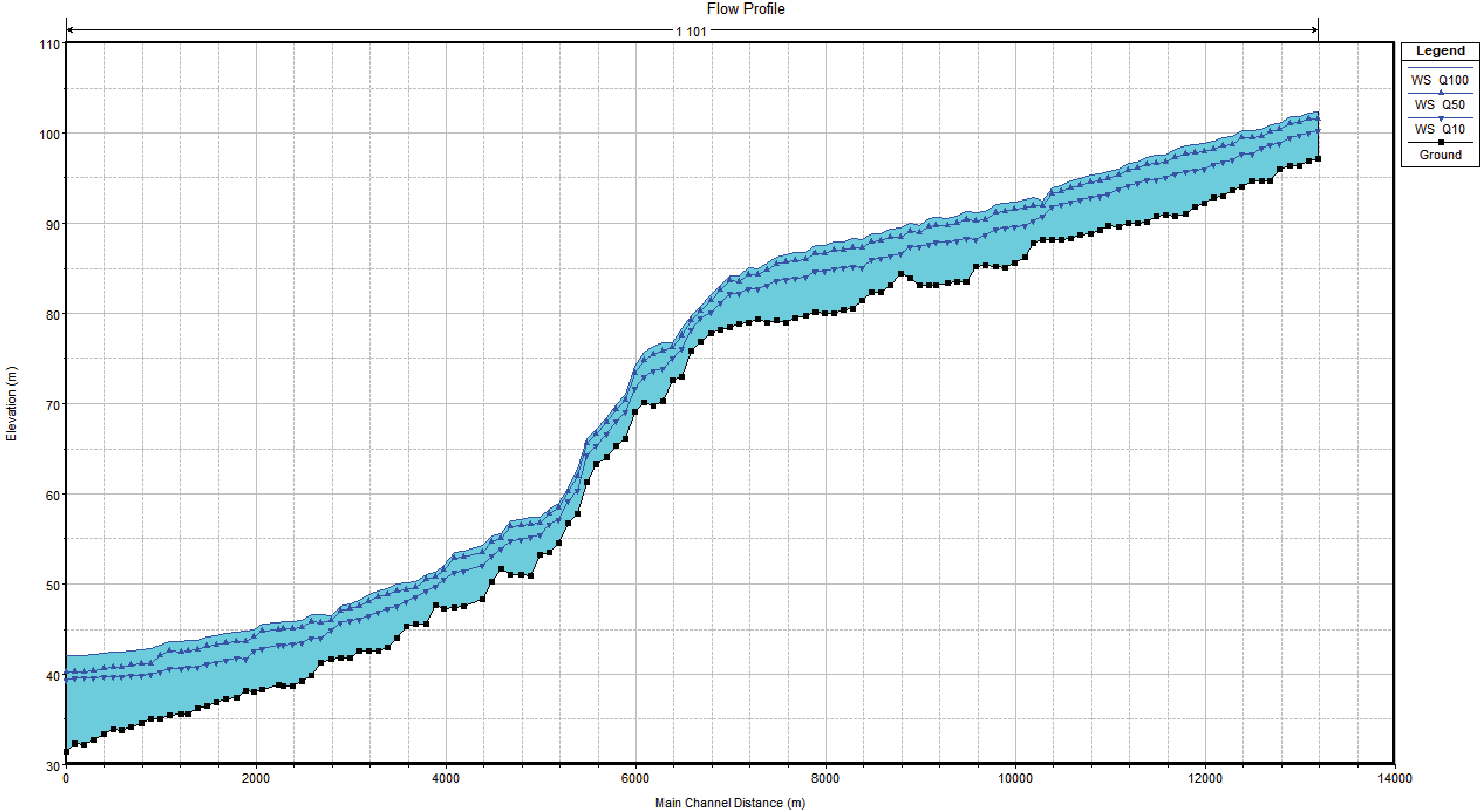


Figure 7: Deep Creek flood level profile (10, 50 and 100yr ARI).

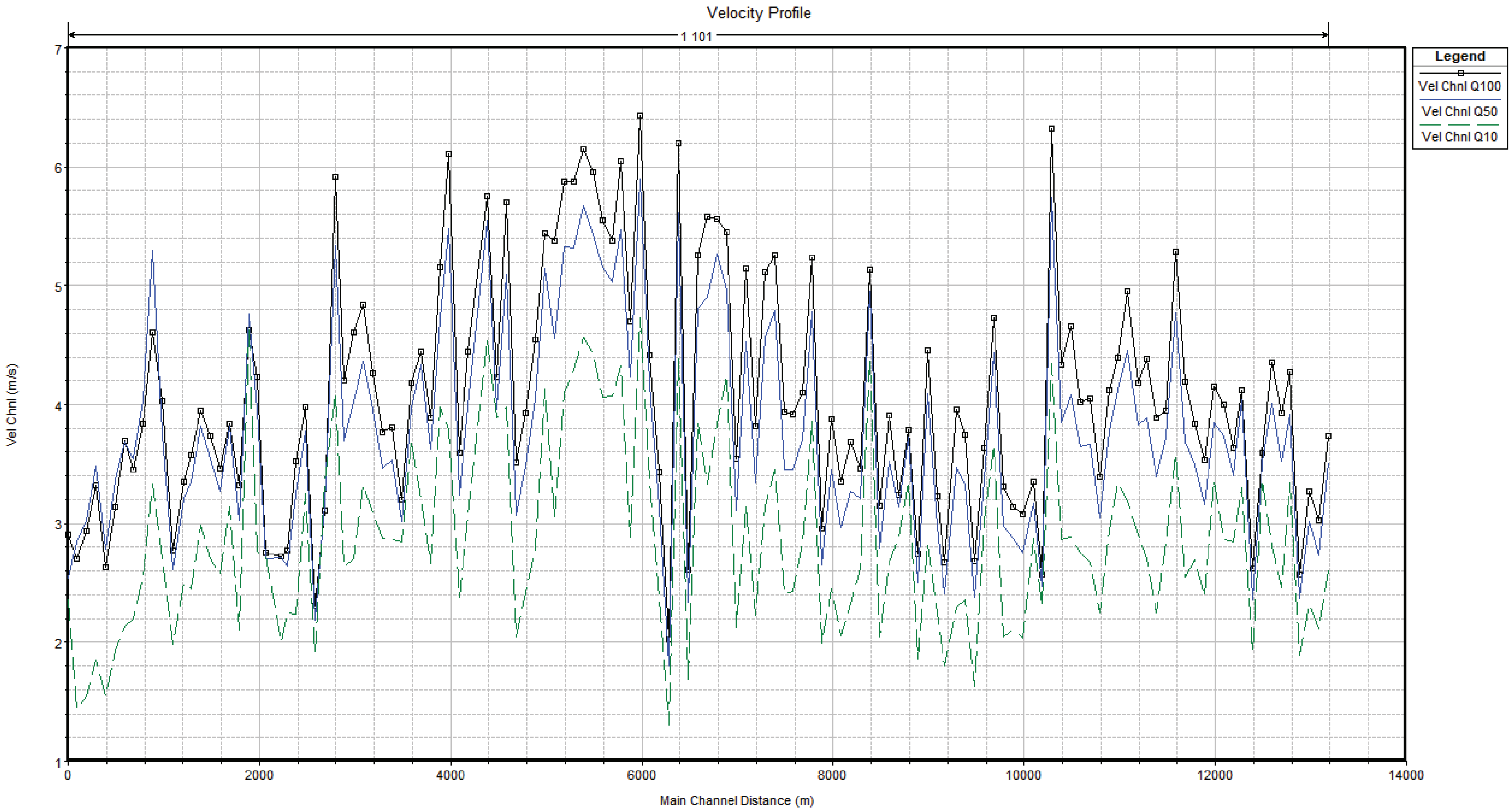


Figure 8: Deep Creek channel velocity profile (10, 50 and 100yr ARI).

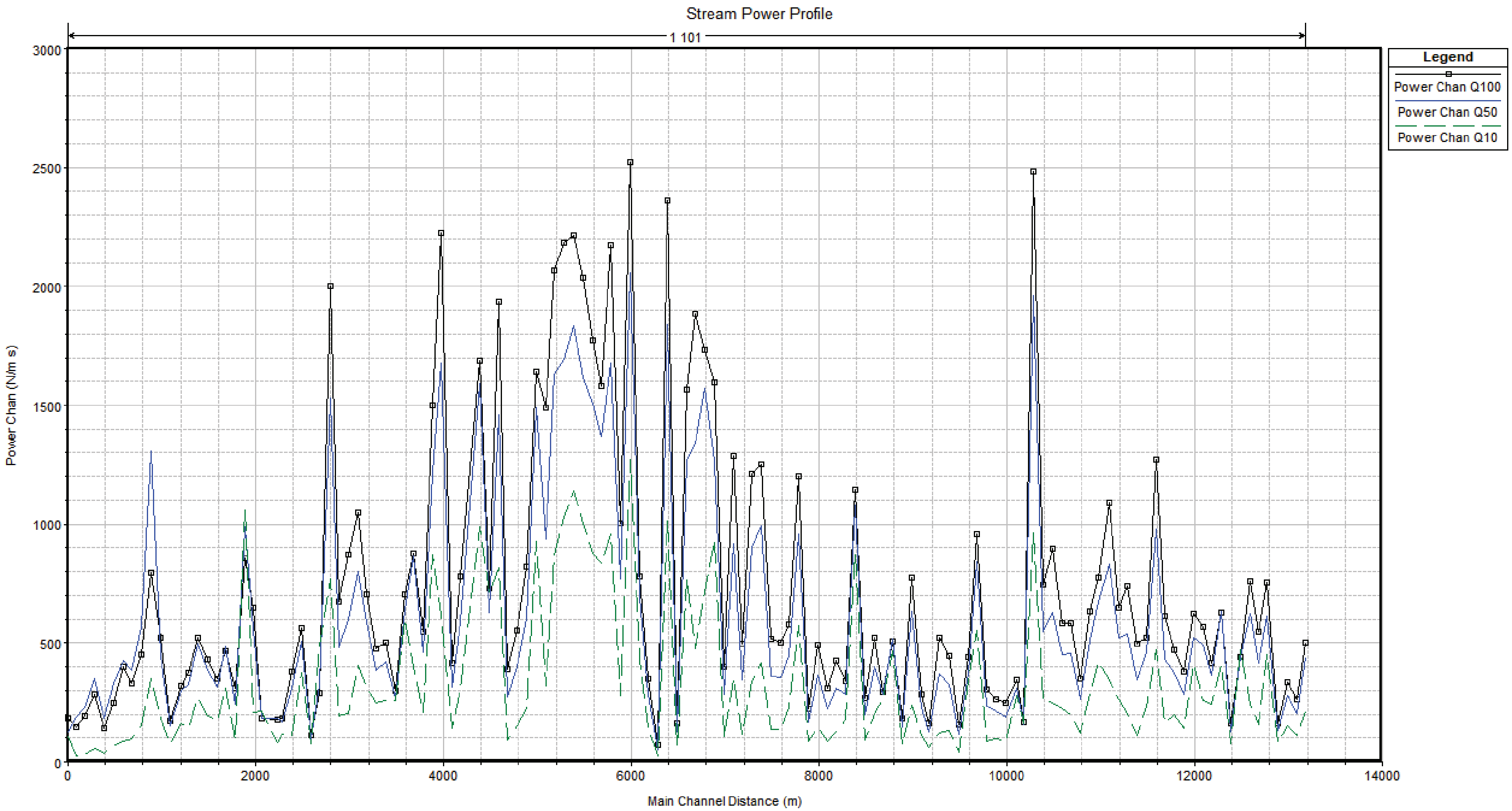


Figure 9: Deep Creek channel stream power profile (10, 50 and 100yr ARI).

Kalkallo Creek East Drain – Long section profiles

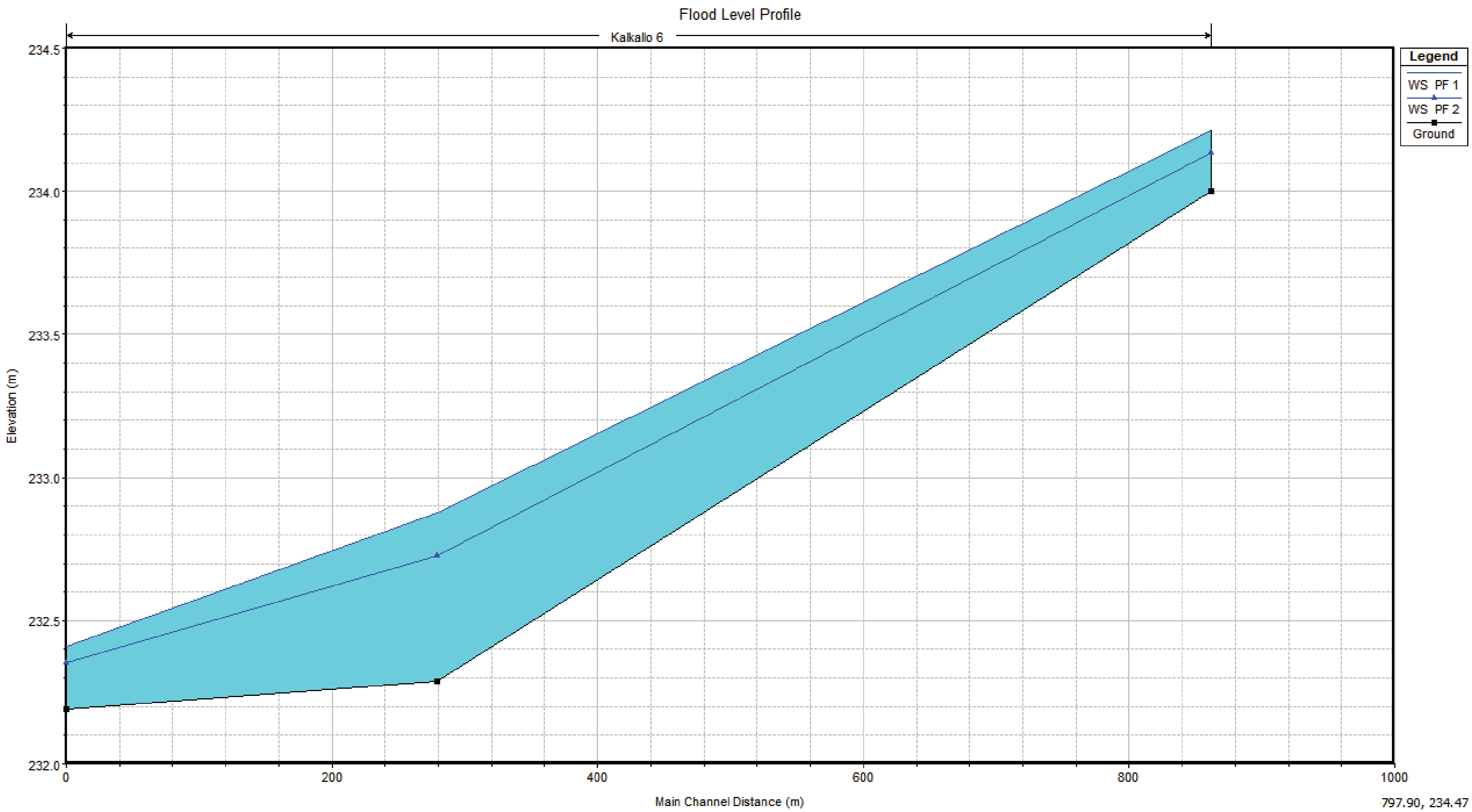


Figure 10: Kalkallo Creek East Drain flood level profile (10 and 100yr ARI).

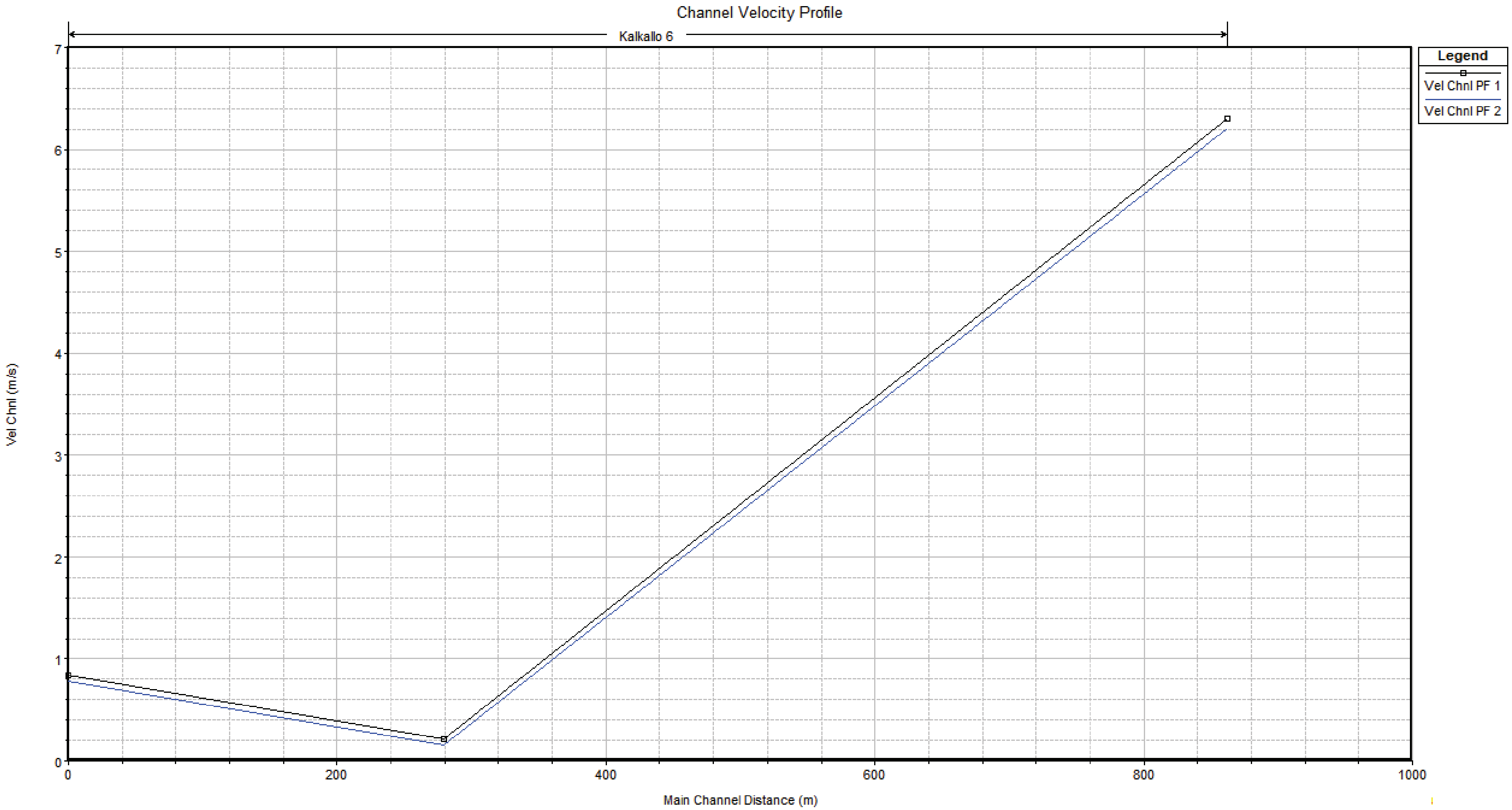


Figure 11: Kalkallo Creek East Drain channel velocity profile (10 and 100yr ARI).

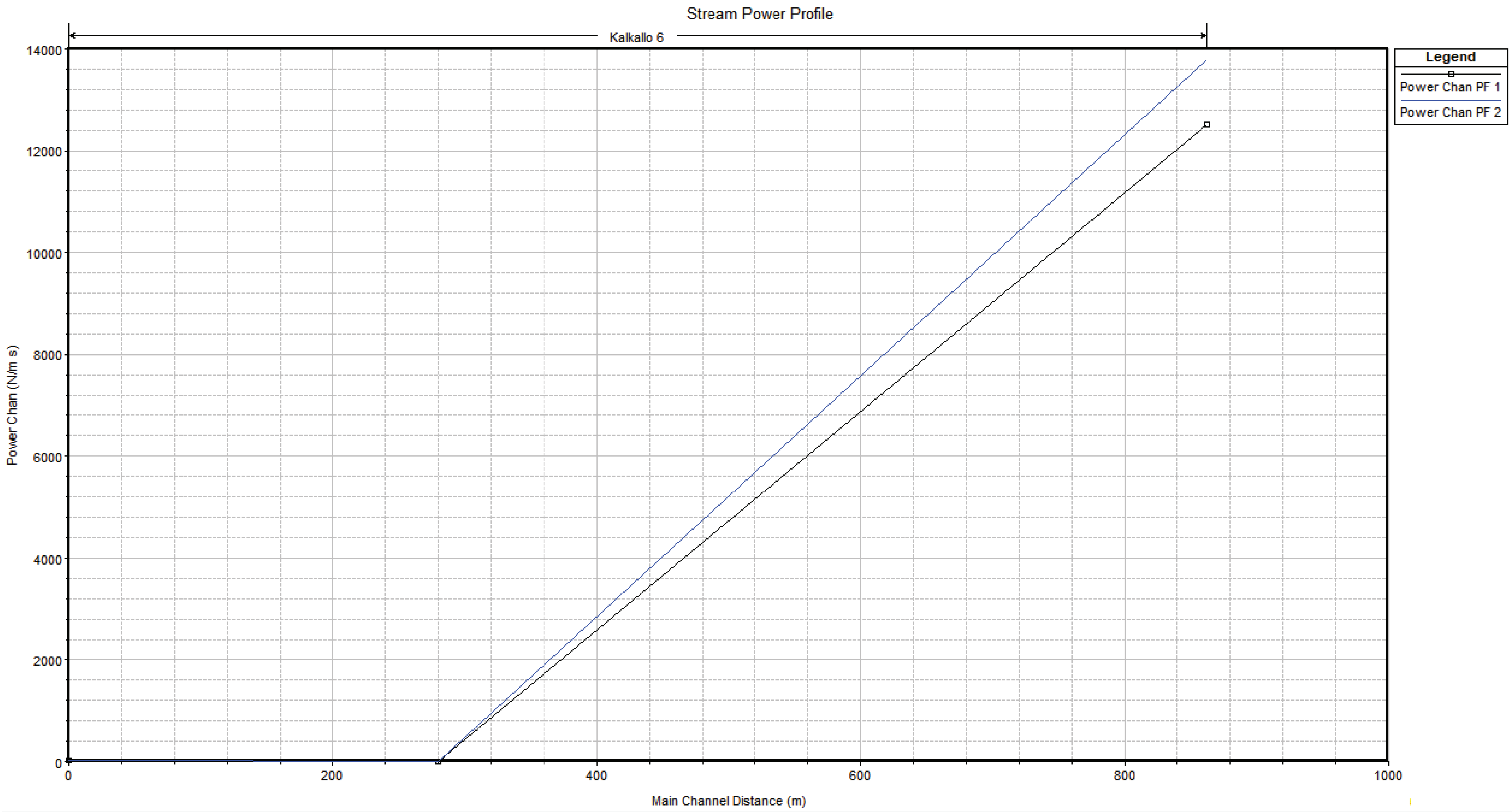


Figure 12: Kalkallo Creek East Drain channel stream power profile (10 and 100yr ARI).

Kalkallo Creek West Drain – Long section profiles

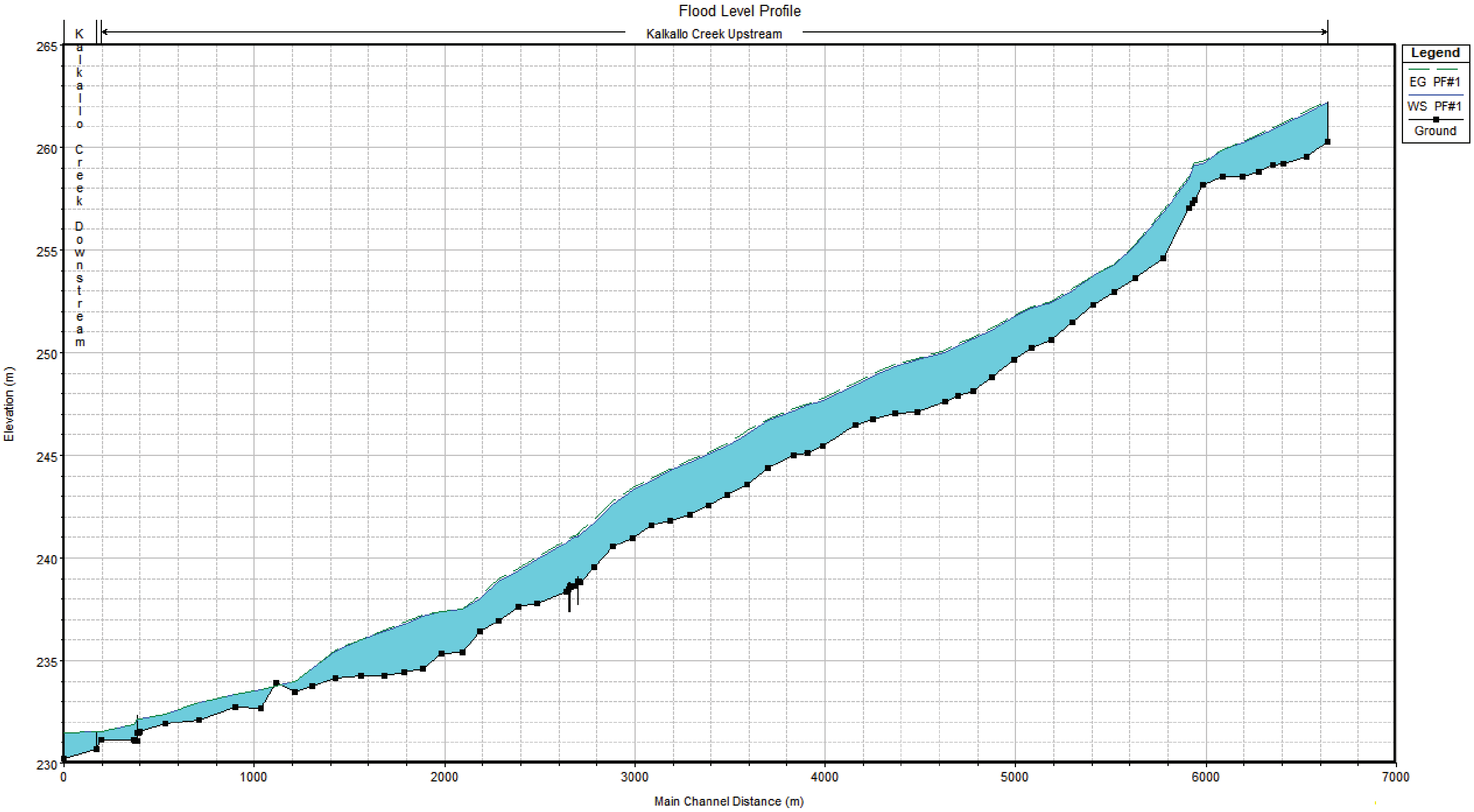


Figure 13: Kalkallo Creek West Drain flood level profile (100yr ARI).

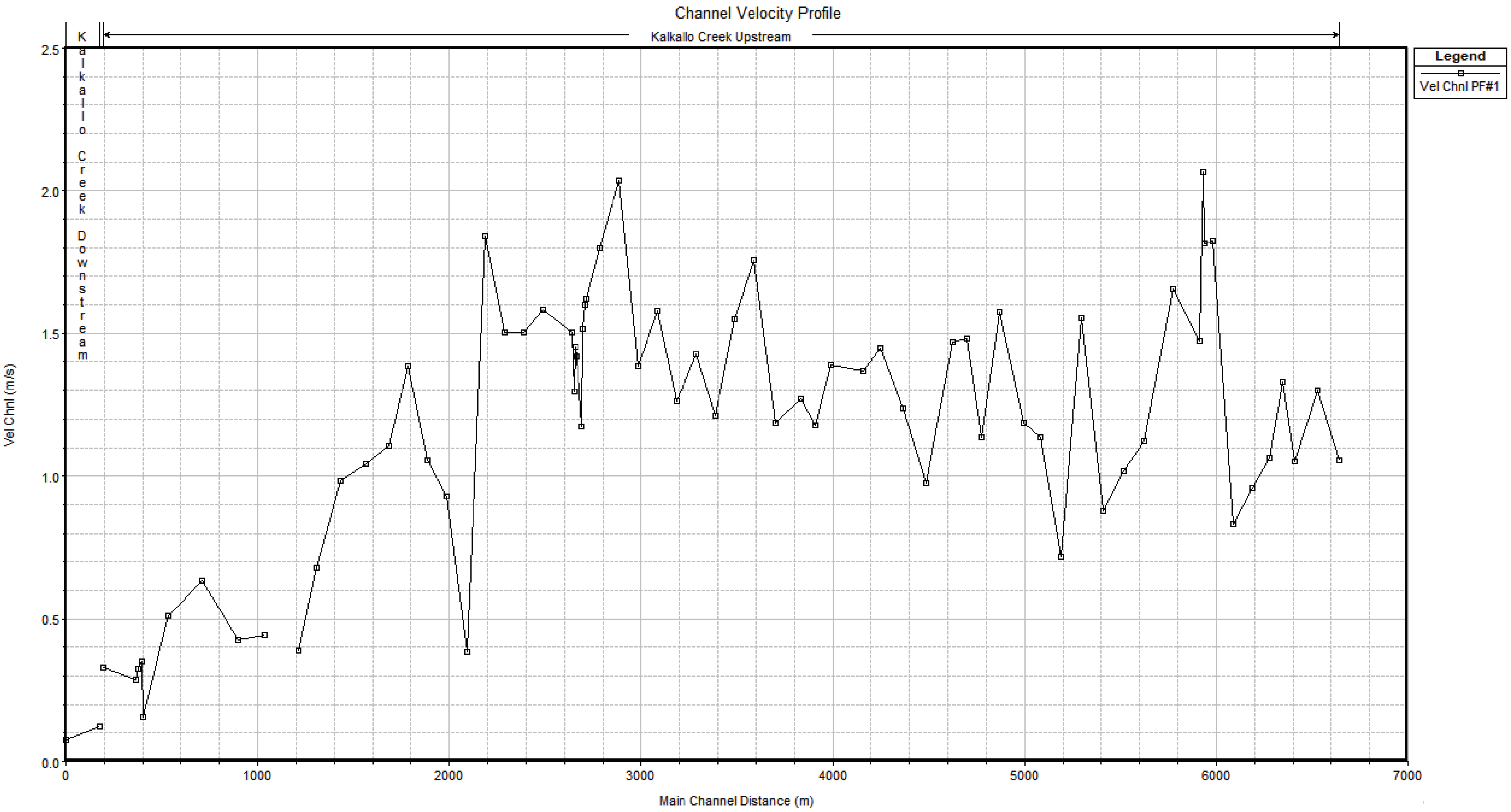


Figure 14: Kalkallo Creek West Drain velocity profile (100yr ARI).

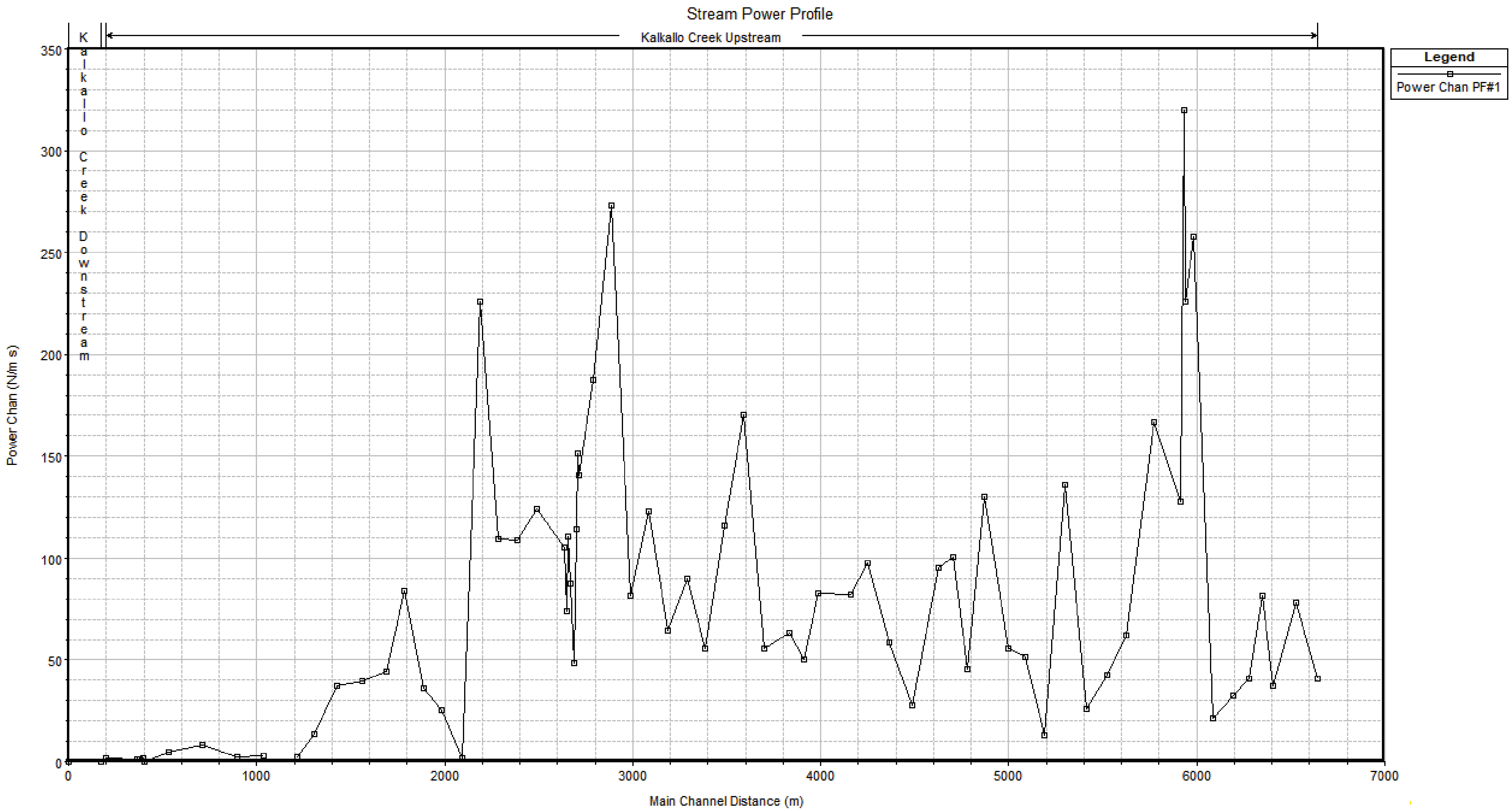


Figure 15: Kalkallo Creek West Drain stream power profile (100yr ARI).

Merri Creek Tributary - Long section profiles

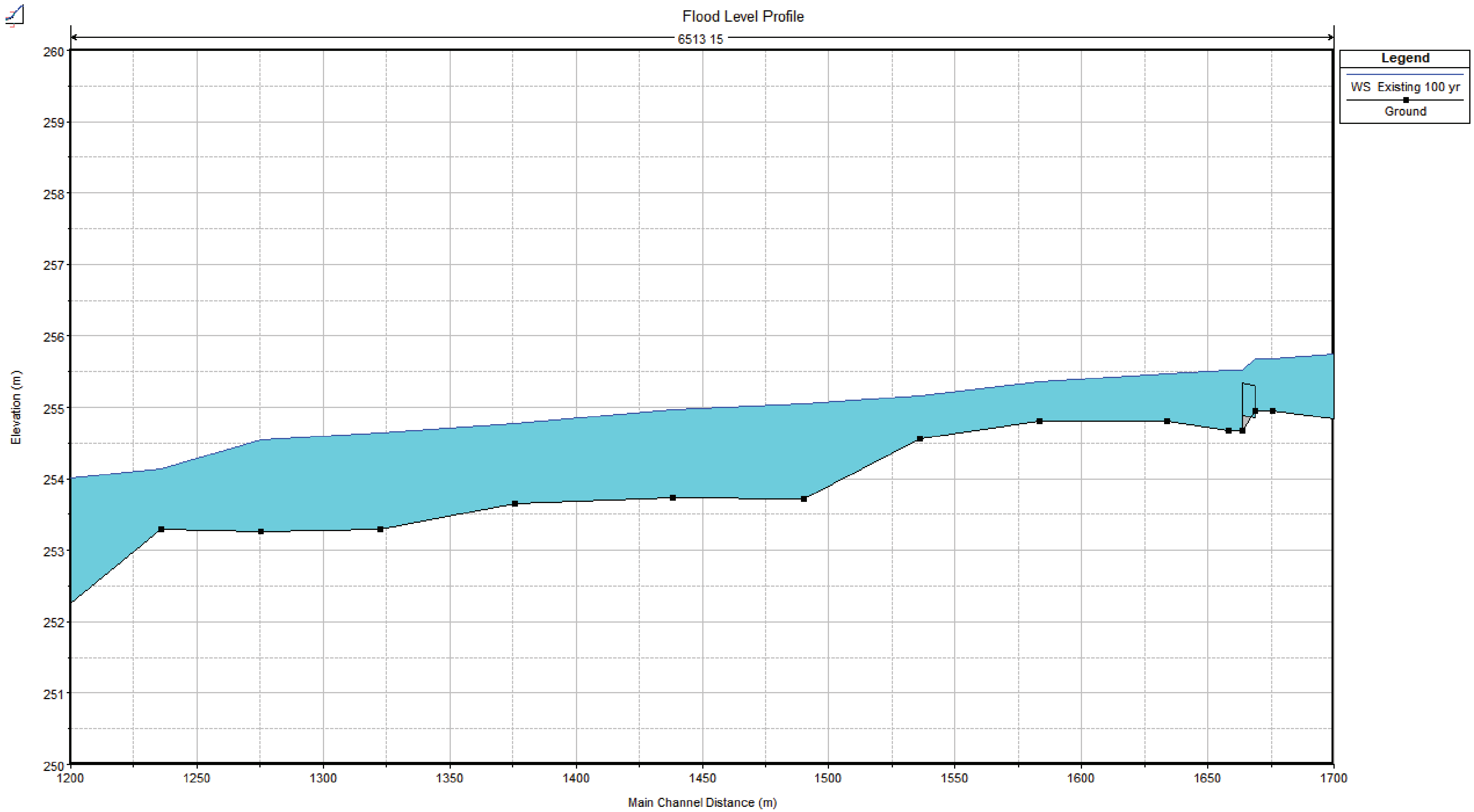


Figure 16: Tributary of Merri Creek flood level profile (100yr ARI).

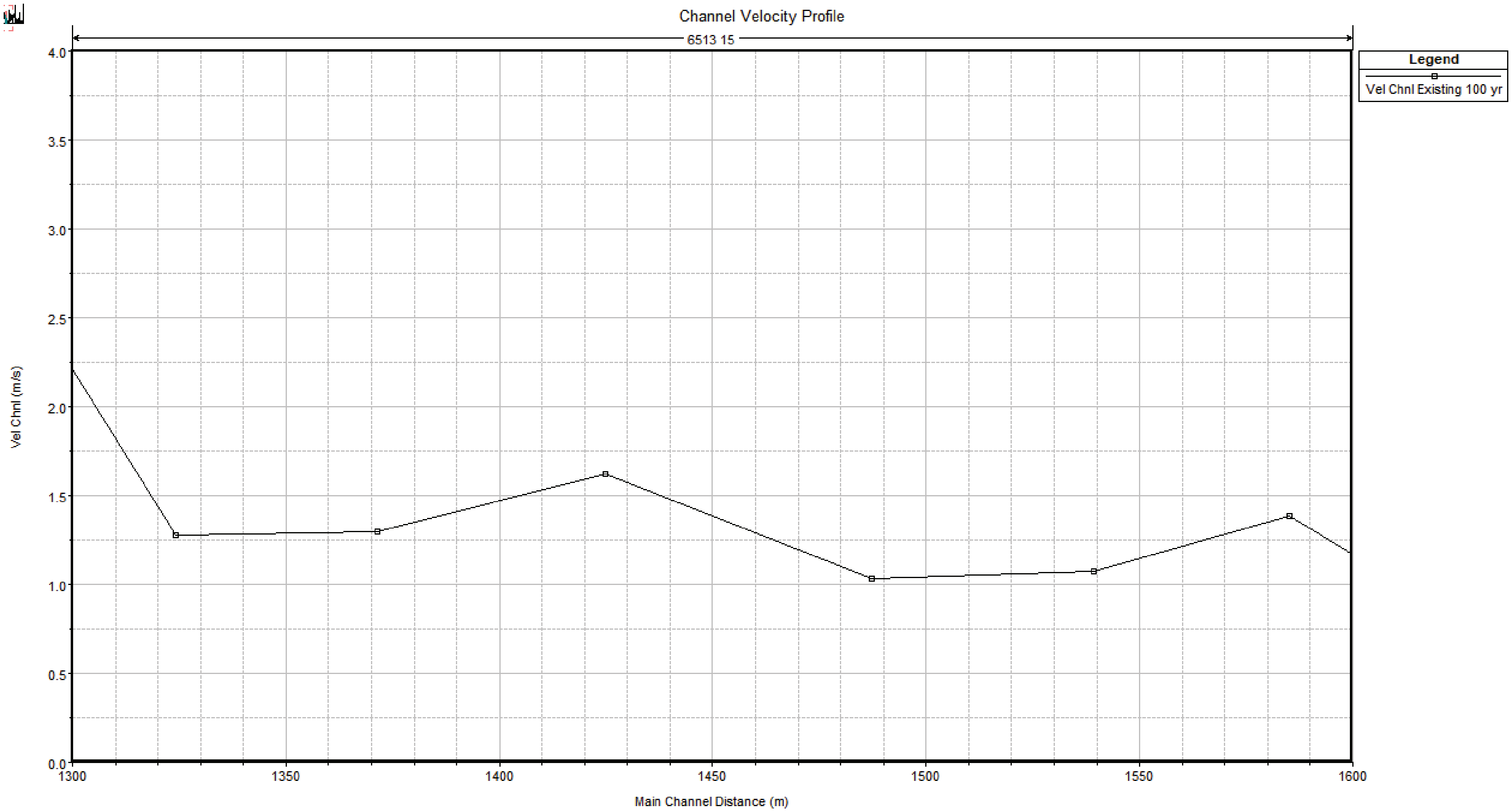


Figure 17: Tributary of Merri Creek channel velocity profile (100yr ARI).

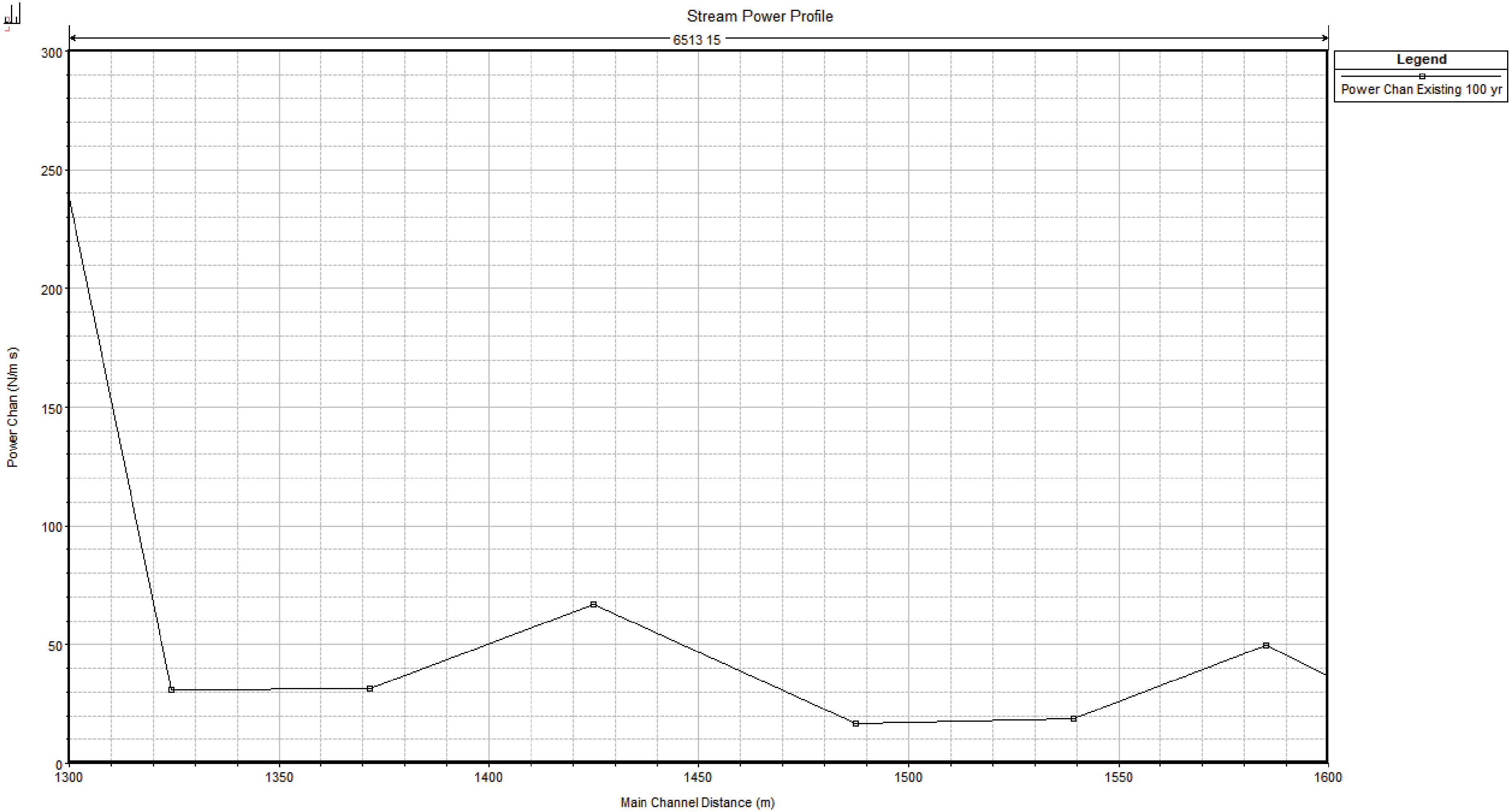


Figure 18: Tributary of Merri Creek channel stream power profile (100yr ARI).

Merri Creek - Long section profiles

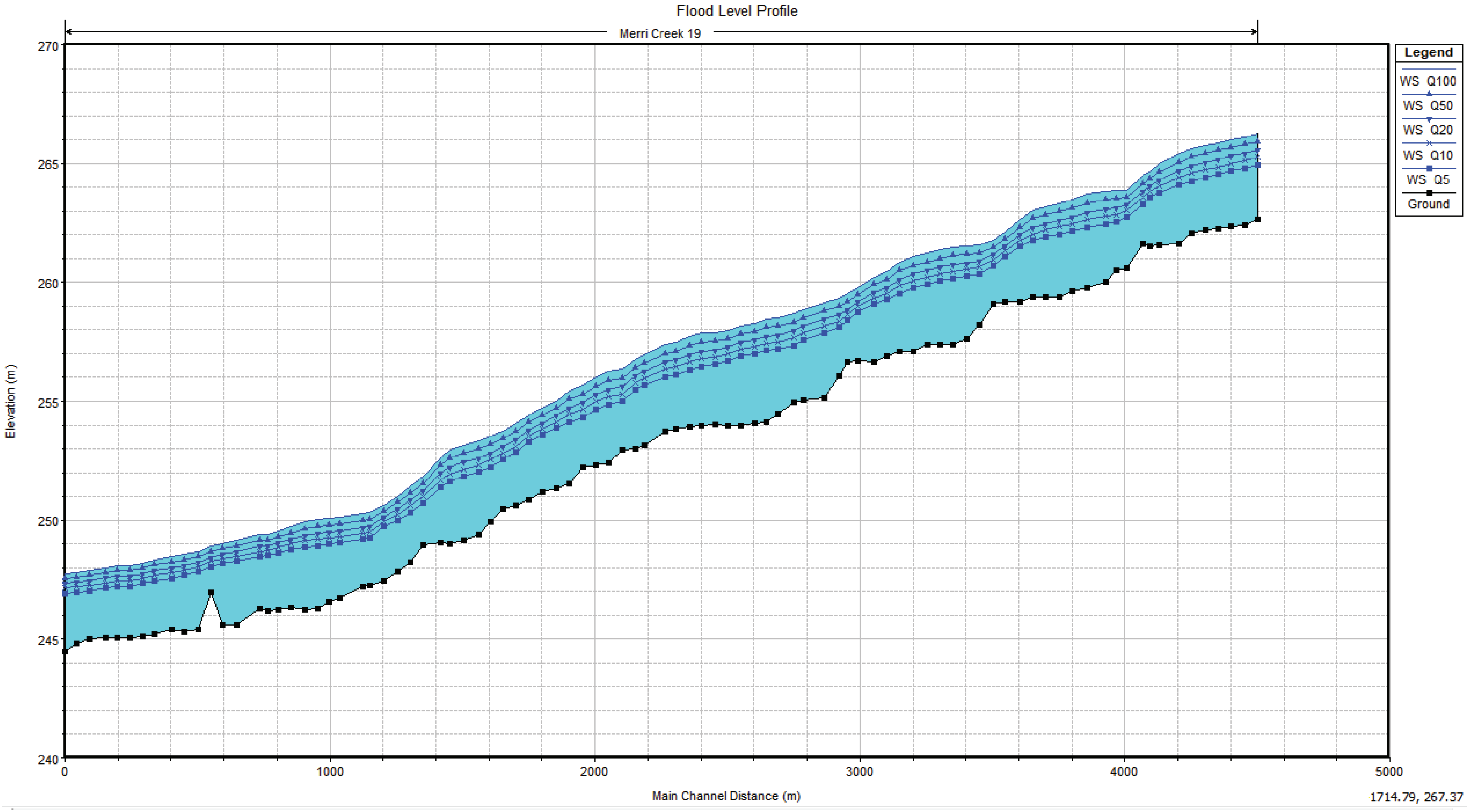


Figure 19: Merri Creek flood level profile (5, 10, 20, 50 and 100yr ARI).

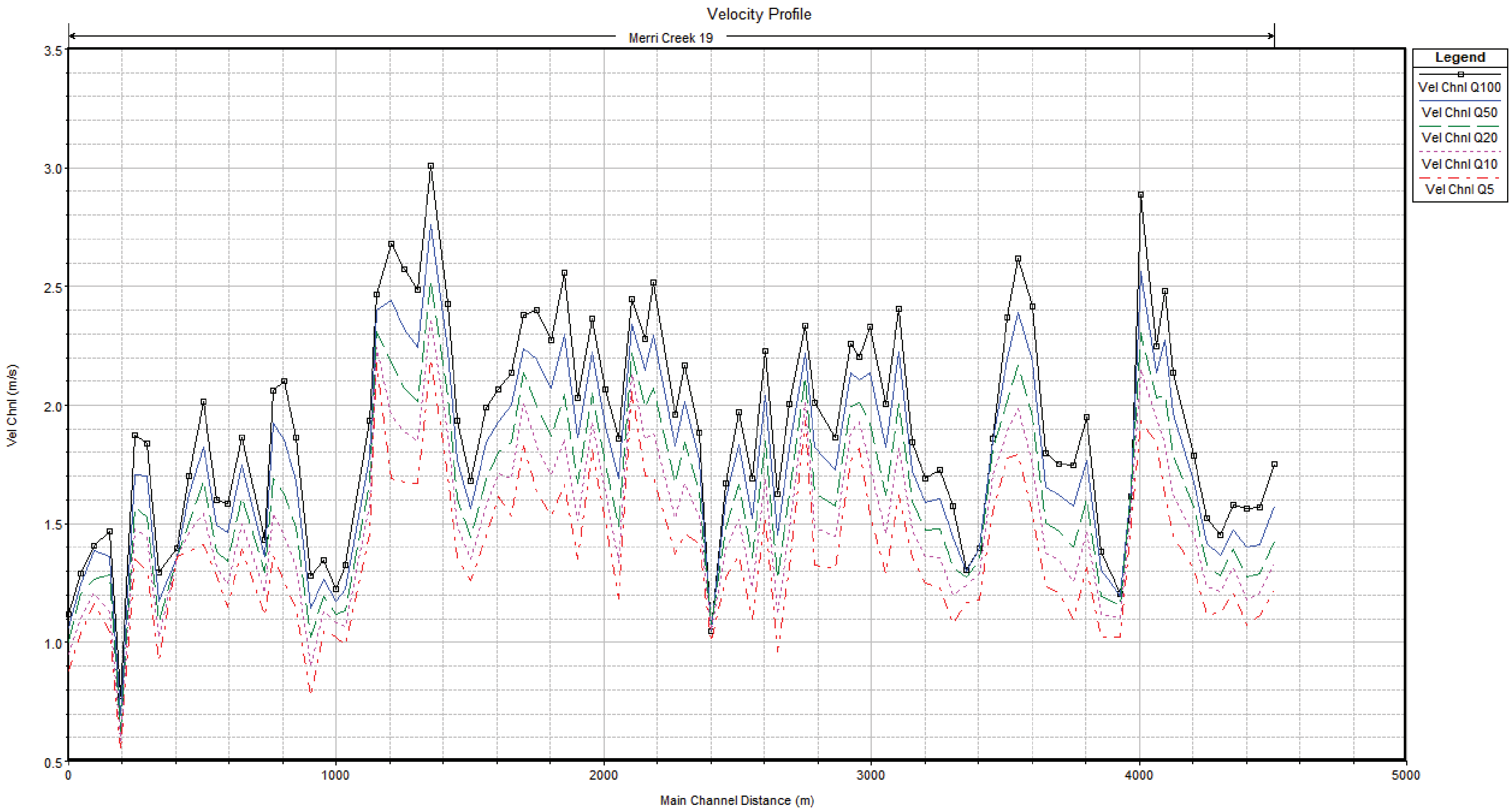


Figure 20: Merri Creek velocity profile (5, 10, 20, 50 and 100yr ARI).

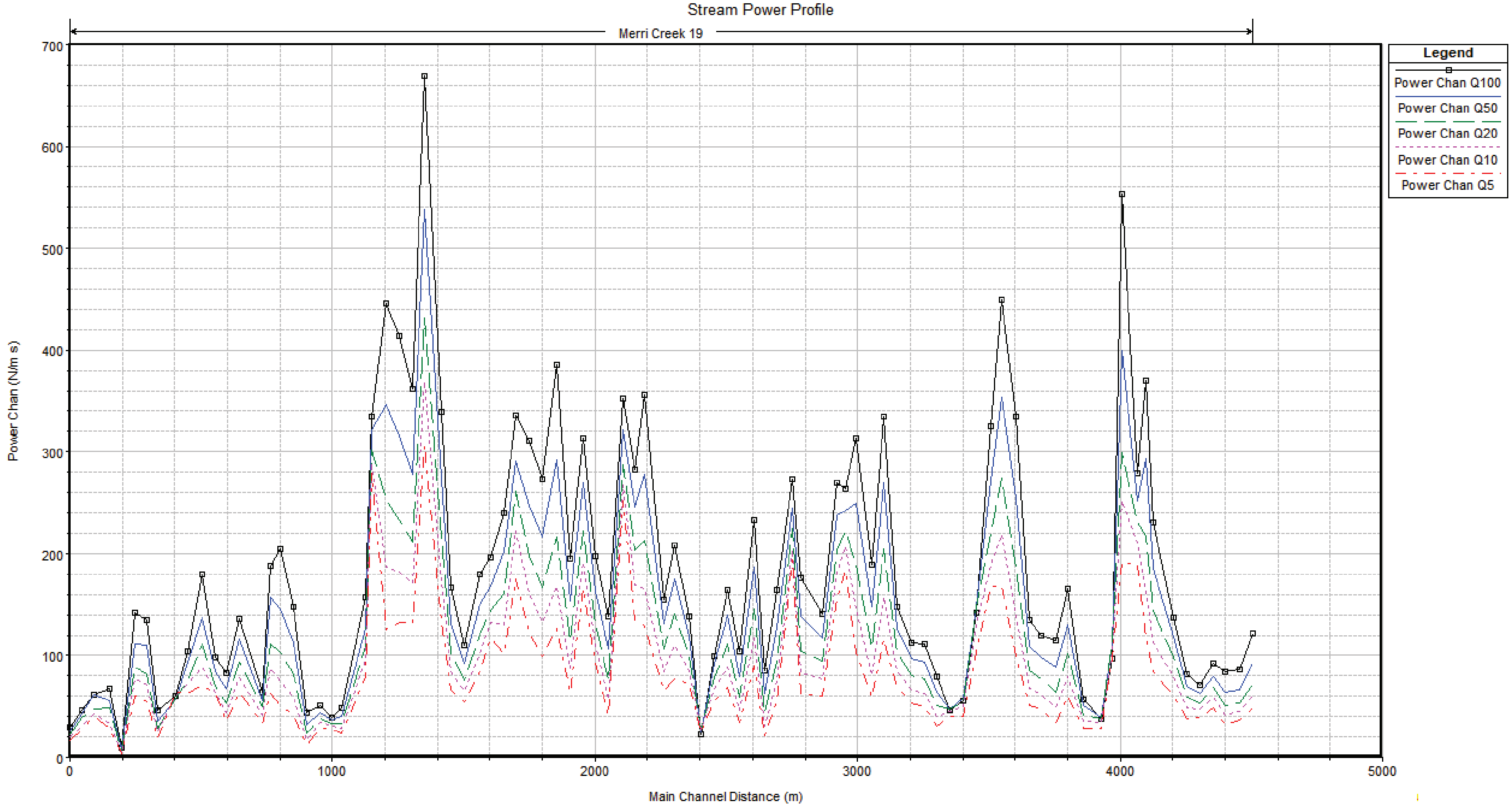


Figure 21: Merri Creek stream power profile (5, 10, 20, 50 and 100yr ARI).

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