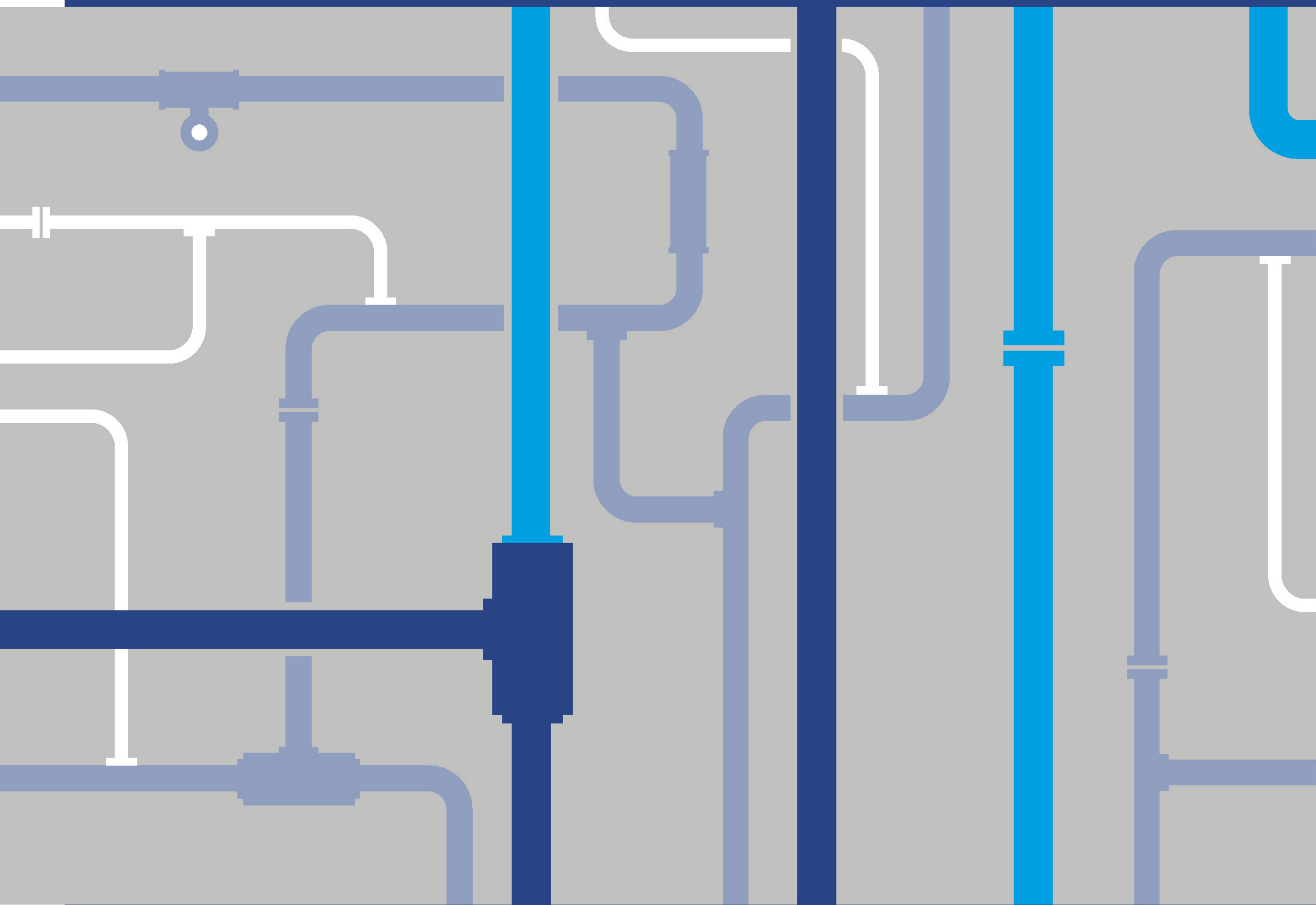
chapter 8

water (groundwater and surface water).



Environment Effects Statement | May 2021

western outer ring main

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Contents

Chapter 8

Contents (continued)

8.1 Introduction

This chapter provides an assessment of the potential impacts to surface water and groundwater associated with the construction and operation of the Western Outer Ring Main (WORM) gas pipeline project (the Project). This chapter is based on the impact assessments presented in Technical reports B *Surface water* and C *Groundwater.*

8.1.1 Surface water overview

Surface water and hydrology plays an important role in maintaining the health and sustainability of river systems, urban creeks and floodplains. The proposed Project alignment will interface with existing waterways and floodplains, which could lead to impacts on flow characteristics and water quality. The surface water report has assessed the existing conditions of the waterways and environmental values requiring protection to inform selection of construction methods to minimise or prevent impacts to waterways.

8.1.2 Groundwater overview

Groundwater is a vital resource for society and the environment, and is commonly used for irrigating crops, town water supply and power generation. It supports biodiversity and many ecological processes.

To facilitate construction of the pipeline, there is likely to be some excavations that are deeper than the groundwater table. This would require dewatering over short periods. During operation, the pipeline and trench may be below the water table which may impact groundwater flow paths. The groundwater report has investigated the potential for consequential impacts to beneficial uses of groundwater or groundwater users within the study area. This has informed the management and mitigation of groundwater impacts during construction and operation of the Project.

What is groundwater and where is it located?

Groundwater is water beneath the earth's surface. A finite resource, groundwater is sourced from rainfall or surface water from rivers, streams and other waterways, that seeps into the subsurface. Groundwater flows primarily laterally within soil and rock layers. There are two main types of layers:

Aquifers are geological materials such as unconsolidated sediments (gravel, sand or silt), permeable rock or fractured rock that act as reservoirs for groundwater. The upper surface of the zone of saturation within an aquifer is known as the **water table**.

Aquitards are soil or rock layers that could store water but are relatively impermeable, which limits the amount of groundwater flow though these layers.

8.1.3 EES scoping requirements

The EES scoping requirements set out the following evaluation objective:

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

To assess the potential effects on water and catchment values resulting from the Project, surface water and groundwater impact assessments were undertaken.

Other aspects closely related to the water and catchment values evaluation objective include biodiversity, contamination and ground movement and land stability. These are addressed in the following reports:

- Technical report A and chapter 7 *Biodiversity*
- Technical report E and chapter 10 *Contamination*
- Technical report D and chapter 9 *Land stability and ground movement*

8.2 Method – surface water

The surface water assessment involved the following key tasks:

- Review of relevant legislation and policy at a national, state and local level
- Establishment of a study area for surface water, which includes the region within the 30 metre wide construction corridor. The assessment extends upstream and downstream of each waterway crossing where possible to allow for a reach scale assessment of each waterway. The Project alignment crosses 23 waterways located within the Werribee River, Maribyrnong River and Yarra River catchments. The study area and locations of these watercourses and the broader catchment areas are shown in Figure 8-1 and the specific waterway catchment areas are shown in Figure 8-2.
- Review of relevant baseline data and reports, including water quality stream gauge data
- Characterisation of existing floodplains and waterways regarding geotechnical, flow, water quality and beneficial uses, and geomorphological conditions. Given the number of waterways intersected by the construction corridor, the baseline data review was undertaken as a two-tiered assessment.
  - A preliminary screening assessment was undertaken for all 23 waterways intersected by the Project alignment to identify the lower risk waterways where standard construction techniques and environmental controls could be applied. This involved a waterway, hydrology, floodplain and hydraulic model analysis.
  - Six waterways were identified as potentially higher risk based on the waterway status, location along the pipeline, erosion risk and flood risk, and subsequently assessed in more detail in a second phase of assessment. These include Tame Street Drain, Jacksons Creek, Deep Creek, Kalkallo Creek, Tributary to Merri Creek and Merri Creek. Further geotechnical, hydrology, flooding, and hydraulic assessment of these main waterways was carried out to enable the development of site-specific controls.

> ### What are the different 'types' of waterways?
>
> The waterways within the construction corridor are characterised based on the type of waterway as follows:
>
> - Complex waterway
> - Minor tributary
> - Main drain channel
> - Constructed drains.
>
> This is also informed by the classification of the channel type such as whether it is an:
>
> - Incised channel
> - Straightened channel
> - Intact valley fill
> - Discontinuous channel (typical of minor gully tributaries).

- As a part of the second phase assessment, of the six higher risk waterways, three were determined to be 'complex' based on the potentially higher risks associated with flooding and/or erosion (Jacksons, Deep and Merri creeks). Site inspections of the three 'complex' waterways were undertaken in January 2020 and July 2020 to understand the existing conditions of the waterways at the pipeline crossing locations. Schematic depictions of borehole log data extracted along the pipeline alignment as part of the geotechnical investigations were also used to define the distinct layers of soil profile characteristics, determine bedrock depth and inform the assessment of potential riverbed movement.
- Consultation with relevant authorities and landholders on the construction methodology, discharge water and impacts on waterways
- Risk-based review of potential impacts to prioritise the focus of the impact assessment
- Assessment of the potential surface water impacts during construction and operation based on the existing conditions of the waterways. Using the hydrological and hydraulic investigations extracted from existing Runoff Routing (RORB) and Hydraulic Engineering Centre River Analysis System (HEC-RAS) models provided by Melbourne Water Corporation (MWC), Light Detection and Ranging (LiDAR) information and a Regional Flood Frequency Estimation (RFFE) model, the assessment identified potential receptors, and quantified likely impacts to the waterways and beneficial uses downstream during construction and operation. For consistency with local planning schemes, the range of events considered included a 1% AEP design event. The potential impacts associated with the three 'complex' waterways have been assessed separately due to the greater potential for erosion and sensitivity of the floodplain to the construction activities.

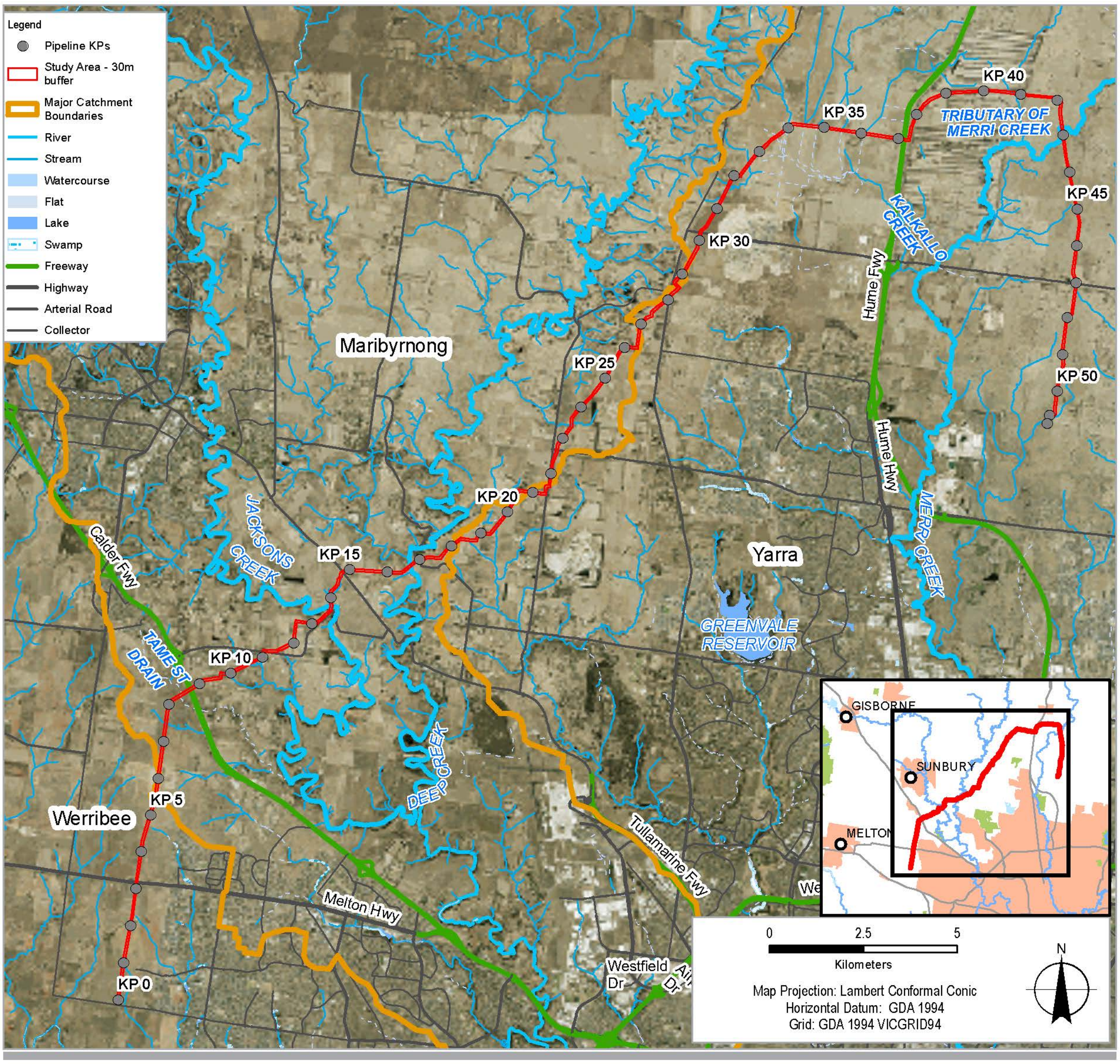
What is a 1% AEP event?

The Annual Exceedance Probability (AEP) defines the likelihood of a flood being equalled or exceeded in any given year. The most common definition is the 1% AEP or 1 in 100 Average Recurrence Interval (ARI) flood event.

This is a flood event that has a one in a hundred, or 1%, chance of being equalled or exceeded in any year.

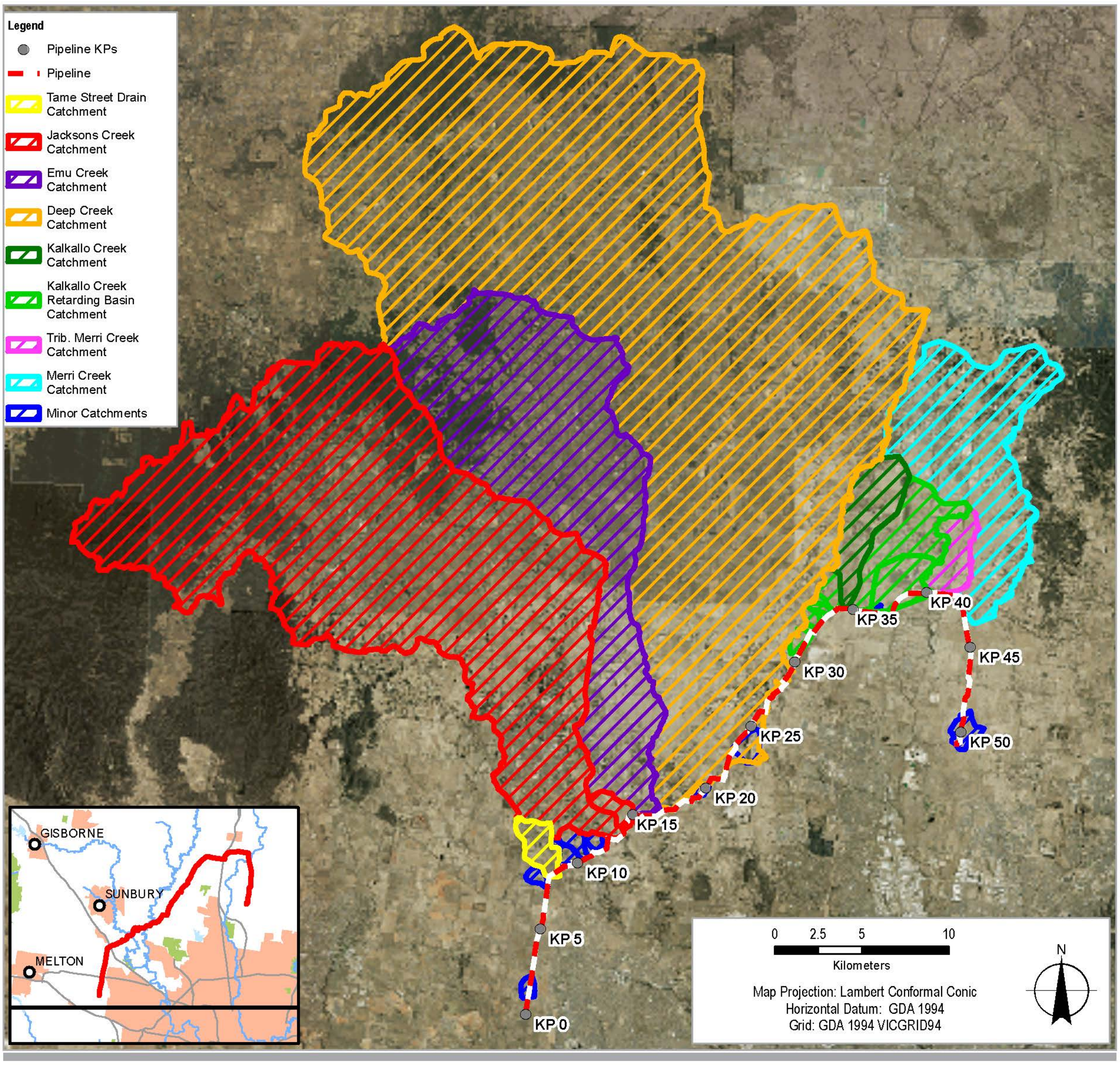
- Development of environmental management measures (EMMs) in response to the impact assessment, including additional measures for specific waterways that are subject to greater risk due to volatile existing conditions. Refer to Chapter 19 *Environmental management framework* for the full list of environmental management measures
- Assessment of the residual impacts of the Project assuming implementation of the environmental management measures
- Specifying the monitoring required to evaluate whether the Project meets the environmental management measures and detailing contingency measures as required.

Figure 8-1 Surface water study area



Data source: APA, 2020; GHD, 2020'; DELWP, Vicmap, 2020 Created by:sacevedo

Figure 8-2 Surface water overview of delineated catchments



Data source: APA, 2020; GHD, 2020'; DELWP, Vicmap, 2020 Created by:sacevedo

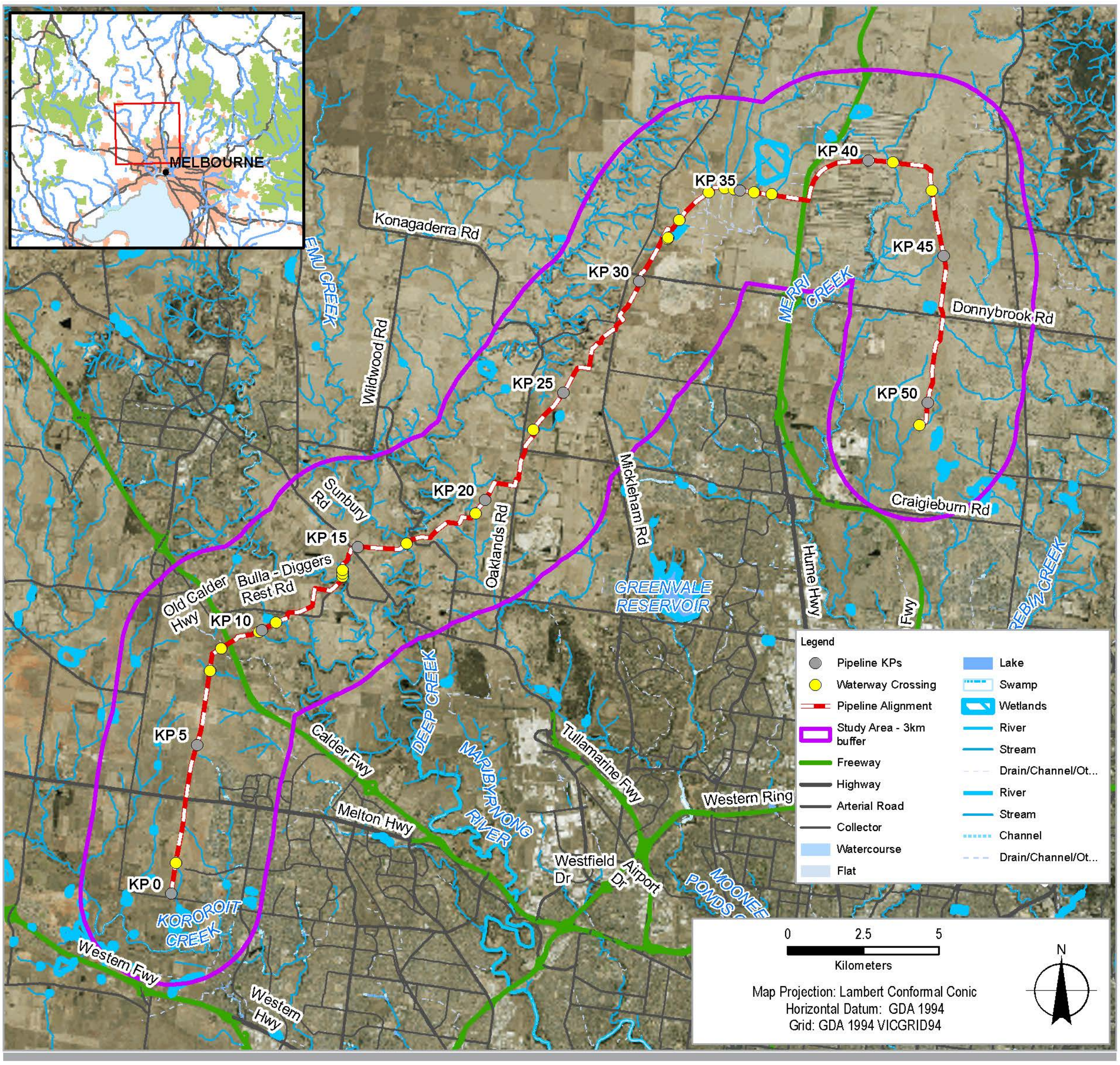
8.3 Method – groundwater

The groundwater assessment involved the following key tasks:

- Review of relevant legislation and policy at a national, state and local level
- Establishment of a study area for groundwater. While the construction corridor is a relatively narrow area (less than 100 metres wide), to aid the assessment, regional groundwater information has been presented for the area within three kilometres of the alignment, as shown in Figure 8-3.
- Desktop hydrogeological assessments and baseline data review (Stage 1 of the existing conditions methodology)
- Site visits and field investigations, completed over a number of stages in 2019 and 2020, were undertaken to assess the existing groundwater conditions along the Project alignment. The field investigations and scoping tasks broadly included:
  - Stage 2: Initial investigation program. Undertaken by Construction Science in 2019, the initial investigation program included geotechnical drilling and installation of six monitoring bores at Jacksons Creek, Deep Creek, adjacent Gunns Gully Road and Merri Creek
  - Stage 3: Further hydrogeological assessment. To inform the EES and the Project design, GHD completed a hydrogeological assessment, which relied largely on regional data sets, to identify the locations where the pipeline was likely to interact with groundwater during construction and operation. This included an initial round of monitoring completed from the six groundwater monitoring bores installed as a part of Stage 2, a preliminary risk assessment, and recommendations for further monitoring and testing
  - Stage 4: Groundwater monitoring program proposal. Based on the further hydrogeological assessment, GHD developed a groundwater monitoring program scope consisting of both initial groundwater monitoring requirements to inform the EES as well as ongoing monitoring
  - Stage 5: Datalogger deployment and monitoring bore inspection. In June 2020 GHD deployed automated dataloggers in the six historic Project monitoring bores (Stage 2). The dataloggers were deployed to capture groundwater level information at regular intervals, and to allow less frequent access to private properties along the alignment
  - Stage 6: Additional site investigation program. Based on the groundwater monitoring program prepared in Stage 4, 11 new monitoring bores were installed at selected locations along the alignment (generally where groundwater depth was expected to be less than 5 metres). This included groundwater level and quality monitoring as well as slug testing to determine field estimations of aquifer hydraulic conductivity
- Based on the desktop and field investigations, the assessment provided a characterisation of groundwater quality, depth to groundwater and hydraulic conductivity of the aquifers identified along the pipeline alignment. This has been synthesised to generate a conceptual hydrogeological model (CHM) of the Project study area. Based on this assessment, six main areas of groundwater interaction along the Project alignment were identified
- Risk-based review of potential impacts to prioritise the focus of the impact assessment
- Assessment of the potential groundwater impacts during construction and operation. Based on the investigation results, confirmation of areas where the Project is likely to interact with groundwater, identification of potential groundwater receptors and evaluation of the potential level of impact. Estimation of groundwater inflows and distance of influence during construction dewatering using analytical methods and limited slug testing of aquifer parameters

- Development of environmental management measures (EMMs) in response to the impact assessment. Refer to Chapter 19 *Environmental management framework* for the full list of environmental management measures
- Assessment of the residual impacts of the Project assuming implementation of the environmental management measures
- Specifying the monitoring required to evaluate whether the Project meets the environmental management measures and detailing contingency measures as required.

Figure 8-3 Groundwater study area



Data source: APA, 2020; GHD, 2020'; DELWP, Vicmap, 2020 Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community Created by:sacevedo

8.4 Existing conditions – surface water

The following section outlines the existing conditions of the Project study area in relation to surface water.

To assess existing conditions, the surface water assessment undertook a preliminary screening assessment of all 23 waterways intersecting the construction corridor, which led to identifying the six main waterways which were assessed in more detail. The remaining waterways were assessed as being low risk of being impacted by the Project and therefore no further assessment has been undertaken.

The existing conditions assessment for the six main waterways addressed:

- Waterways and catchment context
- Waterway condition and geomorphology
- Geotechnical interpretation
- Flooding
- Water quality and beneficial uses.

8.4.1 Waterways and catchment context

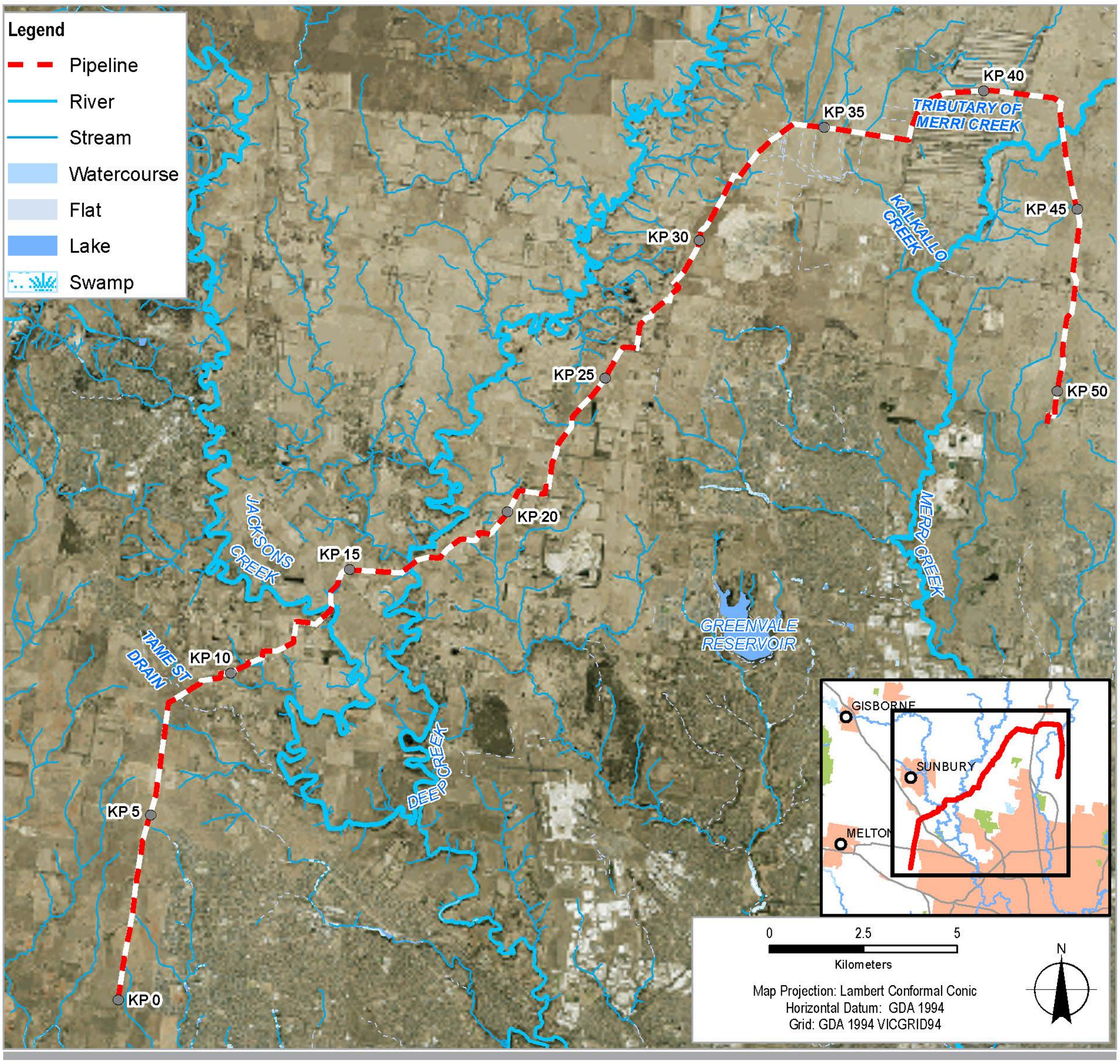
The six main waterways and associated catchments are summarised in Table 8-1, locations shown in Figure 8-4 and images of the waterways are included in Figure 8-5 to Figure 8-10.

Table 8-1 Waterways and catchments around the Project construction corridor

Waterway	Status	Location	Description	Broader catchment context
Tame Street Drain	MWC Main Drain Channel	KP 8.36	Tame Street Drain is a natural gully flow path within the Maribyrnong catchment that would be similar to surrounding undisturbed gully drainage lines but has been directly impacted by urbanisation in the upper catchment.	The Maribyrnong catchment, outside of the urban fringe with the predominant land use being agricultural.
Jacksons Creek	'Complex' waterway	KP 13.7	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 Maribyrnong catchment, outside of the urban fringe with the predominant land use being agricultural.

Waterway	Status	Location	Description	Broader catchment context
Deep Creek	'Complex' waterway	KP 16.7	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 (section of the creek) flows through agricultural land and is becoming increasingly impacted by catchment urbanisation.	The Maribyrnong catchment, outside of the urban fringe with the predominant land use being agricultural.
Kalkallo Creek	Channelised creek	KP 34.5	Kalkallo Creek north of 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. Downstream of Kalkallo Creek, the Kalkallo retarding basin plays an important role in managing flooding as each of the cut drains in this area are directed into the retarding basin. The catchment is within a Drainage Services Scheme (DSS) and will be subject to ongoing future development with various Precinct Structure Plans within the area.	The Yarra catchment consists of predominantly agricultural practices upstream from the pipeline, and urbanisation downstream.
Tributary to Merri Creek	Tributary	KP 40.8	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. The catchment is within a Drainage Services Scheme (DSS) and will be subject to ongoing future development with various Precinct Structure Plans within the area.	The Yarra catchment consists of predominantly agricultural practices upstream from the pipeline, and urbanisation downstream.
Merri Creek	'Complex' waterway	KP 42.9	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. While 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.	The Yarra catchment consists of predominantly agricultural practices upstream from the pipeline, and urbanisation downstream.

Figure 8-4 Main waterways



Data source: APA, 2020; GHD, 2020'; DELWP, Vicmap, 2020 Created by:sacevedo

Figure 8-5 Tame Street Drain looking north-west, upstream from the Calder Freeway (approximately 600 metres downstream of the pipeline crossing) Source: site photo (GHD, 2020)

Figure 8-6 Jacksons Creek looking east, immediately downstream of crossing location Source: site photo (GHD, 2020)

Figure 8-7 Deep Creek looking west at crossing location Source: site photo (GHD, 2020)

Figure 8-8 Kalkallo Creek looking south of Gunns Gully Road crossing at crossing location Source: site photo (GHD, 2020)

Figure 8-9 Tributary of Merri Creek looking north from Donavan Lane approximately 170 metres north of the pipeline crossing Source: site photo (GHD, 2020)

Figure 8-10 Merri Creek at pipeline crossing location looking north Source: site photo (GHD, 2020)

8.4.2 Waterway condition and geomorphology

The waterways assessment for the six main waterways along the Project alignment focused on the condition of the waterway in terms of hydraulic features, bed and bank condition and riparian vegetation.

A geomorphology assessment was also undertaken for the three 'complex' waterways (Jacksons, Deep and Merri creeks) that considered long term historical land and waterway formation processes to understand catchment scale and reach scale geomorphological processes. The pipeline crossing locations were assessed in more detail in the context of the reaches of waterway they are located within.

What is geomorphology?

Geomorphology relates to the study of landforms, their origin and evolution.

For the Project, the geomorphology relates to the landforms associated with the bed and banks of Jacksons Creek, Deep Creek and Merri Creek, that affect the condition and stability of waterways.

Table 8-2 provides a summary of the waterway condition and geomorphology assessment.

Table 8-2 Waterways and geomorphology assessment summary

Waterway	Waterway assessment	Geomorphology
Tame Street Drain	• The riparian vegetation on both sides of the stream is sparse with trees, limited to a dense cover of sedges and grasses along the defined channel. • The crossing location occurs 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.	• A detailed geomorphology assessment of Tame Street Drain was not undertaken as this was only assessed in more detail for the 'complex' waterways. Refer to Section 8.4.4 for an overview of the geotechnical assessment.
Jacksons Creek	• The riparian vegetation on the west bank is protected by a fence. The vegetation is intact, dense and has a healthy mix of deep-rooted trees and ground cover vegetation. The east bank is more open and exposed with limited ground storey vegetation • Within the upstream reach there is a sharp meander bend in the creek and some minor erosion of the stream banks evident. A grade rock structure providing protection to the stream bed was observed immediately upstream of the Project • The Project location is within a relative straightened reach of stream • Two sections of riffles are characterised by shallow depths with fast, turbulent water agitated by rocks and vegetation.	• Located within the easternmost part of the Western Plains geomorphic province of Victoria • At a catchment scale, the Project 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 • The reach scale geomorphology at Jacksons Creek contains alluvial terraces on both sides of the stream and is known to be sensitive and therefore some ongoing bed and bank erosion processes are expected.

Waterway	Waterway assessment	Geomorphology
Deep Creek	• Riparian vegetation of both banks is intact, dense and has a healthy mix of deep-rooted trees and ground cover vegetation. On the west side the riparian zone is protected, and the east bank is more exposed • The crossing location is within a relatively straightened section of the stream which extends from the Emu Creek confluence upstream and continues downstream • Section of riffles characterised by shallow depths with fast, turbulent water agitated by rocks and vegetation.	• Located within the easternmost part of the Western Plains geomorphic province of Victoria • At a catchment scale, upstream there is a broad convexity in the channel profile, and downstream is much steeper • The reach scale geomorphology at Deep Creek also contains alluvial terraces and is known to be sensitive and therefore some ongoing bed and bank erosion processes are expected.
Kalkallo Creek	• Kalkallo Creek is an open swale drain that runs through agricultural land and is one of many cut drainage paths of similar size that enter the Kalkallo retarding basin • The creek 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 • There is no fencing to protect the channel from animals and grazing activities which can increase bed and bank erosion.	• A detailed geomorphology assessment of Kalkallo Creek was not undertaken as this was only assessed in more detail for the 'complex' waterways. Refer to Section 8.4.4 for an overview of the geotechnical assessment, which indicates a very low potential for erosion
Tributary of Merri Creek	• 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 • 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.	• While a detailed geomorphology assessment of the tributary was not undertaken, as this was only assessed in more detail for the 'complex' waterways, the waterway condition assessment identified that there is no apparent bed incision within the natural depression overland flow path, which indicates that there is no active erosion process. Refer to Section 8.4.4 for an overview of the geotechnical assessment.

Waterway	Waterway assessment	Geomorphology
Merri Creek	• 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 • 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 on a meandering section of Merri Creek which continues downstream, with relatively quiet water flowing through a thickly vegetated stream bed • There is a section of riffles characterised by shallow depths with fast, turbulent water agitated by rocks and vegetation • 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.	• Located within the easternmost part of the Western Plains geomorphic province of Victoria • At a catchment scale, the upper 10 km of the creek has a very low gradient which increases abruptly near the location of the crossing • The reach scale geomorphology is very different to Jacksons and Deep Creek due to the large exposures of basalt in the channel walls.

8.4.3 Flooding

This section summarises the existing flooding and flow conditions for the waterways potentially affected by the Project. Flooding may be influenced by a number of factors including rainfall, season and topographic features of the landscape that may allow, prevent or direct water flow across an area.

> **What are 'perennial' and 'ephemeral' flows?**
>
> 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.
>
> Perennial and ephemeral waterways are either naturally formed or they are constructed by humans such as lakes, dams and other water storage bodies.

A range of flood events were assessed through flood modelling. A summary of the streamflow hydrology and floodplain management for each main waterway is described in Table 8-3. For further detail on the models used and the specific flood events, refer to Section 6 of Technical report B *Surface water*.

> **What is 'design flow'?**
>
> The design flow is the peak flow of the creeks or waterways for a specific event (ie 1 in 100 ARI flood event).

Table 8-3 Flooding assessment summary

Waterway	Flooding assessment
Tame Street Drain	• From observed conditions, the waterway has ephemeral flows that are generally contained within the shallow channel • As there was no gauge station along the waterway and flood models were not available, the existing hydrology and estimated flows were based on the RFFE model from ARR2019 for the 1% to 20% AEP events • 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 metres (N m^2). This indicates a relatively low potential for stream bed and bank erosion • In summary, the main channel has a less than 1 in 5 year ARI capacity, with an estimated 1 in 100 year ARI flood level of approximately 167.15 m Australian Height Datum (AHD) which would engage the floodplain to a width of approximately 65 m.
Jacksons Creek	• From observed conditions, Jacksons Creek is a fast flowing stream with some observed bed and bank instability • From streamflow data obtained at Sunbury gauge station, and a MWC flood mapping report (modelling) for the 1% to 10% AEP events, 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 • In summary, the main channel has a less than 1 in 10 year ARI capacity and the estimated 1 in 100 year flood level is approximately 124.5 AHD, and starts to spill into the floodplain terrace.
Deep Creek	• From observed conditions Deep Creek appeared to be slow moving, with no observed bed or bank instability • From streamflow data obtained at Bulla Road gauge station, and a MWC flood mapping report modelling for the 1% to 10% AEP events, the channel velocities for the range of design flows exceed 2 m/s, and the stream powers exceed 300 N m^2 in the 100 year ARI event. These velocities and stream powers indicate a relatively high potential for stream bed and bank erosion • As noted above, there is a higher erosion potential for Jacksons Creek compared to Deep Creek due to the steeper channel grade • In summary, the main channel has a less than 1 in 10 year ARI capacity and 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.

Waterway	Flooding assessment
Kalkallo Creek	• 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 Kalkallo retarding basin • While there is no gauge station along the waterway, MWC provided design flood flows for Kalkallo Creek through two HEC-RAS models which cover the multiple drains that enter the Kalkallo Creek retarding basin • The channel velocities at the Project crossing for the 1 in 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 • Based on the interpretation of the estimated flood levels, 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. This suggests a high likelihood of flooding that would need to be considered during Project construction • The flood extent at the pipeline is roughly 1 km wide as it begins to engage the floodplain across the Kalkallo retarding basin. Channel velocity and stream power are relatively low due to the flat grades as well as tailwater effects within the retarding basin. Flood waters spread-out across the retarding basin storage area as well as backwater travelling north across Gunns Gully Road and further upstream • 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.
Tributary of Merri Creek	• From observed conditions, the tributary consists of ephemeral flows 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 • While there is no gauge station along the tributary, MWC provided design flood flows for the Tributary of Merri Creek through one HEC-RAS and one RORB model • 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 • In summary, there is no defined channel and the flows spread across the natural overland flow path and surrounding floodplain, with an estimated 1 in 100 year flood level of approximately 255 m AHD, which spreads across the floodplain terrace over a width of approximately 60 m.
Merri Creek	• 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 • Using streamflow data obtained at Summerhill Road, Craigieburn gauge station, the mean annual flow is 0.04 m3/s, and the mean summer-autumn flow is 0.001 m^3/s • As flood mapping was not available, design flows were estimated using a RFFE model and hydraulic modelling was completed using HEC-RAS. The modelled channel velocities for the 1% AEP and 2% AEP exceed 2 m/s with the stream powers less than 300 N m^2. The velocities indicate a moderate potential for stream bed and bank erosion • In summary, the main channel has a less than 1 in 5 year ARI capacity and the estimated 1 in 100 year ARI flood level is approximately 257.47 m AHD at the site of interest with spilling over the floodplain expected.

8.4.4 Geotechnical investigation

This section summarises the soil profile characteristics and bedrock depth at each waterway to inform the surface water assessment of potential riverbed movement.

Table 8-4 presents a summary of the geotechnical information interpreted near the waterway locations based on a schematic depiction of borehole log data extracted along the pipeline alignment.

Table 8-4 Soil profile and bedrock depth

Waterway	Soil profile	Bedrock depth
Tame Street Drain	The soil profile consists of variations of clay for the first 1 to 2 m in all five bore holes. Basalt was reached below this point and coring continued for the remainder of the borehole.	Basalt rock occurs shallow (~2 m from natural surface) in profile relative to the natural surface. This would limit the depth of any future bed erosion.
Jacksons Creek	• The soil profile typically consists of various layers of sands, gravels and silty clays in the upper profiles (first 8–13 m), which are more erodible • The lower profiles (below depths of 8–13 m) consist of a mixture of siltstone and mudstones and continued for the remainder of the borehole.	There is no basalt indicated within the bore logs that would limit any depth of future bed erosion.
Deep Creek	• The soil profile typically consists of various layers of sands, gravels and clays in the upper profiles (first 5–10 m), which are more erodible • The lower profiles consist of siltstones and continued for the remainder of the borehole.	There is no basalt indicated within the bore logs that would limit any depth of future bed erosion.
Kalkallo Creek	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. There is clay material in the upper profiles that would be resistant to any potential erosion.	Basalt rock is relatively deep in profile at typically 10 m from surface, and coring indicated that the basalt continues for approximately a further 10 m in the profile.
Tributary of Merri Creek	The soil profile consists of a shallow clay layer (approximately 2 m deep).	Basalt rock was found at relatively shallow depths (approximately 2 m from natural surface) which would limit the depth of future bed erosion.
Merri Creek	The soil profile consists of a shallow (approximately 2 m) layer of clay before reaching basalt which continued.	Basalt rock is shallow in profile (approximately 2 m from natural surface) which would limit the depth of future bed erosion.

8.4.5 Water quality and beneficial uses

To determine the existing water quality conditions, available water quality monitoring data from gauge sites was assessed against guideline water quality parameters under the *Water Act 1989* and the State Environment Protection Policy (SEPP) (Waters). It is noted that 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.

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. While there are potential water quality impacts on these waterways from the Project, the impact assessment focused on Jacksons Creek, Deep Creek and Merri Creek as the receiving waterways.

A summary of the water quality information interpreted near the waterway locations is described in Table 8-5. For further details on the SEPP (Waters) guidelines and gauging data, refer to Section 5.5.4 and Section 6 of Technical report B *Surface water*.

Based on this data, beneficial uses downstream of the Project were identified as including water dependent ecosystems and species, agriculture and irrigation, water-based recreation (aesthetic enjoyment) and Traditional Owner cultural values.

Table 8-5 Water quality and beneficial uses summary

Waterway	Water quality assessment
Jacksons Creek	• Water quality samples from Jacksons Creek taken upstream of the Project at Sunbury exceeded the SEPP (Waters) guideline values for turbidity, nitrate, oxidised nitrogen, filtered reactive phosphate, total phosphorous, chromium, copper, lead, nickel and zinc. • Water quality samples for Jacksons Creek at Organ Pipes National Park, approximately 11 km downstream of the proposed pipeline, exceeded the guideline values for turbidity, nitrate, oxidised nitrogen, total nitrogen, filtered reactive phosphate, total phosphorous, chromium, copper, lead, nickel and zinc. • Water quality data further downstream (16 km) of the Project, from the Maribyrnong River at Keilor were also assessed. Similar to the Sunbury 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. Additional total phosphate exceeded the SEPP guideline value and pH was slightly above the guideline value. • In summary, Jacksons Creek upstream and downstream (including Maribyrnong River) exceeds the SEPP guideline values for the majority of water quality parameters. This is likely influenced by several possible sources including potential discharge and runoff from urban areas, agricultural catchments and the Sunbury Water Treatment Plant located along the Jacksons Creek alignment. The gauge data collected indicate that the frequency of exceedances varies across each water quality parameter with some parameters exceeding the guideline values more frequently than others.

Waterway	Water quality assessment
Deep Creek	• Water quality statistics from Deep Creek at Kinnear Road, Mickleham, approximately 18 km upstream of the Project, had elevated turbidity, nitrate, total nitrogen, phosphate, total phosphorus, chromium, copper, lead, nickel and zinc. • Water quality at Emu Creek at Clarkefield, approximately 20.5 km upstream of the Project, was compliant for all parameters except oxidised nitrogen, filtered reactive phosphate, total phosphorus, total nitrogen and nitrate. • Water quality downstream was measured using the Deep Creek gauge at Bulla. This had elevated concentrations of nitrate, oxidised nitrogen, total nitrogen, phosphate, chromium, copper, lead, nickel, zinc, electrical conductivity and pH. • In summary, Deep Creek upstream and downstream (including Maribyrnong River) exceeds the SEPP guideline values for the majority of water quality parameters. This is likely influenced by several possible sources including potential discharge and runoff from urban areas and agricultural catchments located along the Deep Creek alignment. The gauge data collected indicate that the frequency of exceedances varies across each water quality parameter with some parameters exceeding the guideline values more frequently than others.
Merri Creek	• There is no stream gauge site upstream of the pipeline, but water quality data downstream of the site was taken from Merri Creek at Summerhill Road, Craigieburn. • Water quality statistics identified 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 exceed the guideline values. • In summary, Merri Creek downstream exceeds the SEPP guideline values for the majority of water quality parameters. This is likely influenced by several possible sources including potential discharge and runoff from urban areas and agricultural catchments located along the Jacksons Creek alignment. The gauge data collected indicate that the frequency of exceedances varies across each water quality parameter with some parameters exceeding the guideline values more frequently than others.

8.4.6 Future development implications on waterways

The Kalkallo Creek and Tributary of Merri Creek catchments are both within Drainage Services Schemes (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. The Healthy Waterways Strategy (2018 to 2028) aims to mitigate the impacts of development in these catchments. The potential development implications on the waterways are discussed below.

Kalkallo Creek catchment DSS

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.

Interpretation of the 2013 HEC-RAS model (provided by MWC) 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 water sensitive urban design (WSUD) treatment assets proposed along the catchment.

Tributary of Merri Creek catchment DSS

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 plan proposes a formalised channel following the existing waterway alignment including a new constructed channel west of the rail tracks.

Interpretation of the 2012 HEC-RAS model (provided by MWC) 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.

8.4.7 Potential presence of gilgai formation

The mechanisms of gilgai formations are complex, vary across different sites, and 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 (Parcel ID 1PS733045 and Parcel ID 1PS733043). Preliminary site and desktop assessment of the two properties indicate small undulating topography and minor depressions, which suggests that there is potential for natural gilgai formation to be present. Both areas have been mapped as Plains Grassy Woodland (EVC 55_61) and Grassy Eucalypt Woodland of the Victorian Volcanic Plain (GEWVVP).

- Parcel ID 1PS733045 (north of Craigieburn Road): The site observations indicated that the grass across is in poor condition and the land primarily used for grazing. Gilgai and associated species were not observed or considered likely.
- Parcel ID 1PS733043 (south of Cragieburn Road): The site observations presented minor undulation in the ground surface. No gilgai specific flora features were observed within the gilgai depressions during the time of survey. This gilgai formation is likely to be supported by rainfall and wet weather conditions rather than subsurface hydrology as the groundwater monitoring bore indicated groundwater depth of 19 metres below ground level recorded at WORMBH05. The water table depth interpretated from regional data also indicate 5 to 10 metres. Therefore, the Project is not expected to encounter shallow groundwater levels in this area.

Refer to Section 6.2.4 of Technical report B *Surface water* for further detail.

8.5 Existing conditions – groundwater

The following sections outline the existing conditions of the study area in relation to groundwater, including:

- Geology and hydrogeology
- Groundwater depths
- Groundwater quality
- Hydraulic conductivity
- Groundwater dependent ecosystems
- Acid sulfate soils.

8.5.1 Geology and hydrogeology

Geological setting

The Project is located on the northern margin of the Port Phillip Basin, a sedimentary basin formed during the late Cretaceous and Tertiary periods. The basin has been progressively infilled by terrestrial sediments and marine deposits. The sediments in the Port Phillip Basin overly Silurian to Devonian basement rocks consisting of siltstones, sandstone and shales. These basement rocks outcrop around the margin of the Port Phillip Basin and within the study area. These sedimentary rocks were subsequently intruded by granites during the upper Devonian and caused local contact metamorphism, and later covered extensively by the Newer Volcanics basalts in the Project study area.

What are the Silurian, Devonian, Tertiary, and Quaternary, periods?

The Silurian is a geologic period and system spanning from 443.8 million to 416 million years ago. The Devonian period and system spans 60 million years from the end of the Silurian period.

The Tertiary period is an interval of geologic time lasting from approximately 66 million to 2.6 million years ago and is the first of two periods within the Cenozoic Era. The second period of this era is the Quaternary period, from 2.6 million years ago to the present.

Sediments of the Tertiary age were widely developed on the deep ocean floor. Sediments tend to be calcareous or siliceous (or both) in the shallower parts of the ocean (above depths of 4.5 kilometres).

Being the most recently laid geologic strata, Quaternary rocks and sediments can be found at or near the surface of Earth and the sediments can be recognised by their lack of consolidation into rock.

Geology is relevant to groundwater as the porosity and permeability of a geologic formation controls its ability to hold and transmit groundwater.

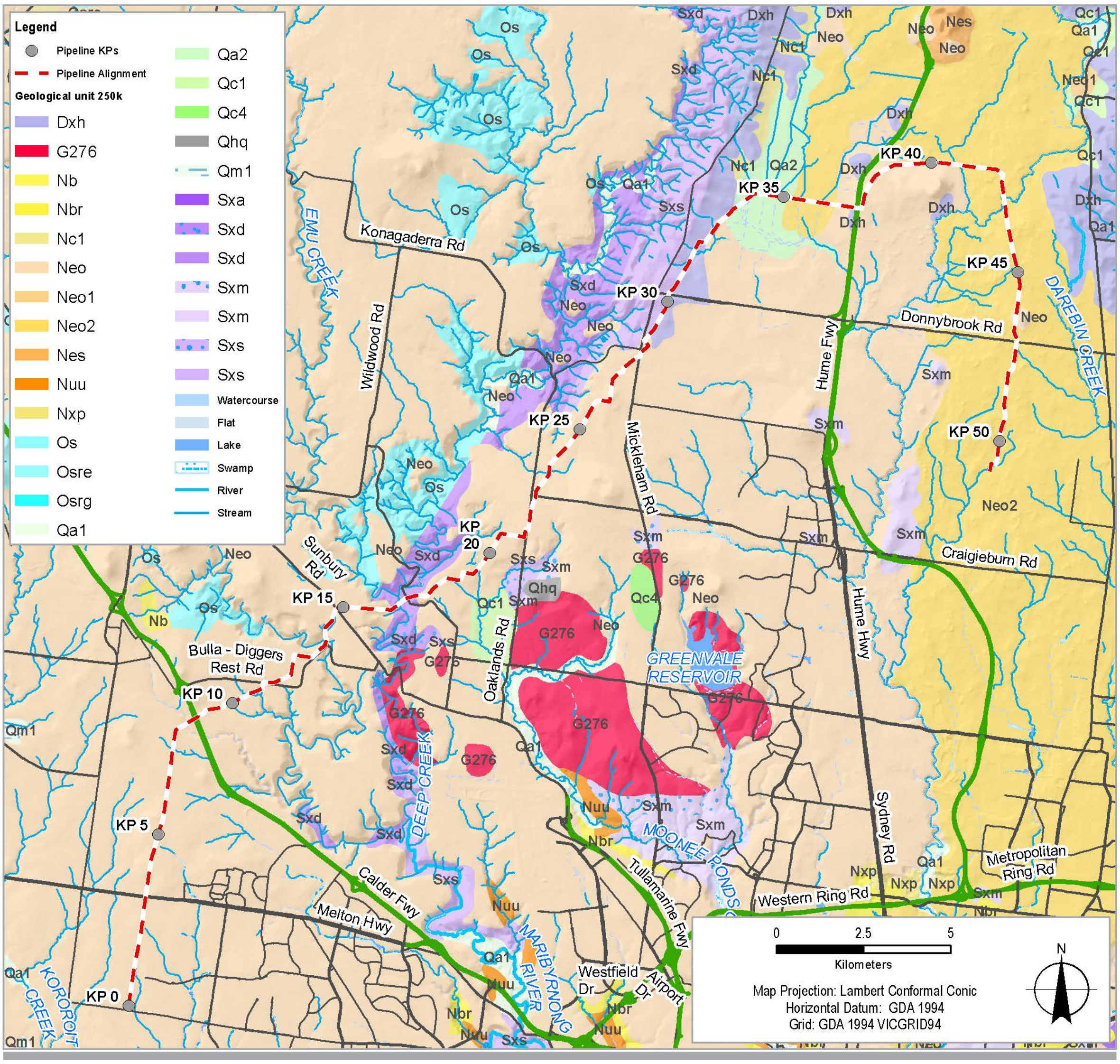
A summary of the Project geological setting includes:

- Colluvium and high level Alluvium from the Quaternary period, most significantly near Gunns Gully Road
- Newer Volcanics basalt from the Late Tertiary to Quaternary period covering the majority of the study area
- Red Bluff sands/Bullengarook gravel from the Late Tertiary period underlying the Newer Volcanic in the western portion of the study area

- Werribee Formation from the Early Tertiary period only present in the south of the study area and thin (10 metres to 20 metres)
- Bulla Granodiorite from the Late Devonian period with limited outcrop near Deep Creek and a larger outcrop east of the Bulla-Sunbury Road
- Humevale Siltstone (located outside of the study area), Deep Creek Siltstone (west of the Project crossing of Deep Creek) and Springfield Sandstone (outside the north-west edge of the study area) from the Silurian to Devonian period.

Figure 8-11 provides an overview of the geological setting around the Project.

Figure 8-11 Geological setting



Data source: APA, 2020; GHD, 2020'; DELWP, Vicmap, 2020 Created by:sacevedo

Hydrogeological setting

The outcropping geological formations described above form the water table aquifer. The shallow water table aquifer is most relevant to the Project due to the pipeline construction depth (that is, generally less than 2 metres). The water table aquifers are illustrated in Figure 8-12.

From a hydrogeological perspective, it is possible to simplify the various outcropping formations into two basic aquifer systems including:

- **Fractured rock aquifers** – groundwater mostly flows through fractures, joints and other discontinuities within the rock mass. The hydraulic properties of this type of aquifer can be highly variable, depending on the fracture properties. The fractured rock aquifers that the pipeline is anticipated to intersect include:
  - Silurian – Devonian indurated sediments such as the Humevale Siltsone and Deep Creek Siltstone
  - Late Tertiary – Quaternary Newer Volcanics basalts
- **Porous media aquifers** – groundwater is stored and flows between the interstices and pore spaces of the sedimentary grains. The porous media formations in the study area include:
  - Quaternary alluvial and colluvial sediments, a significant area of which have been mapped in the north of the study area (Kalkallo Creek area)
  - Tertiary Red Bluff sands/ Bullengarook Gravel, which comprise variable mixtures of the sands, gravels, clays and silts.

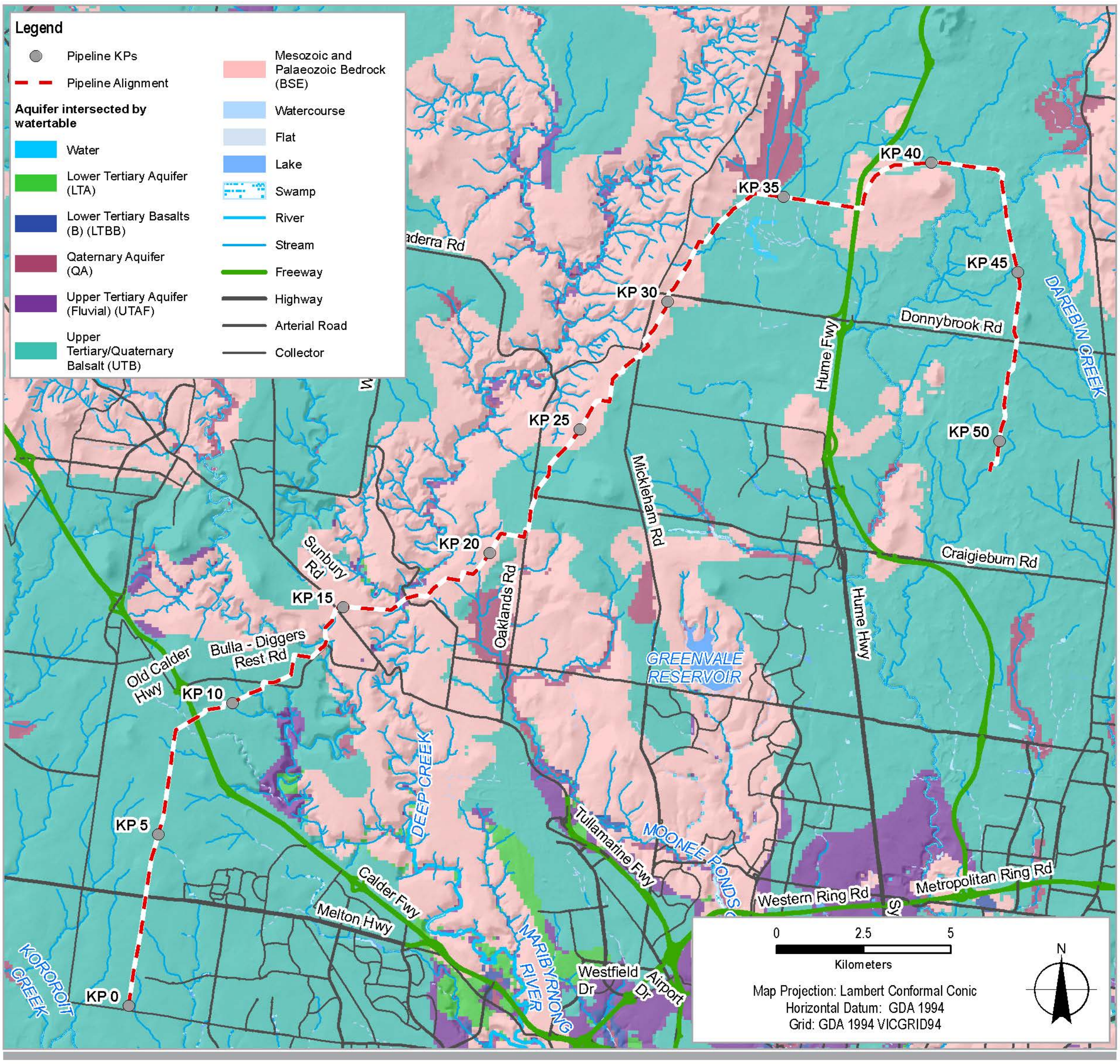
Based on this, the local groundwater flow will be influenced by the aquifer fracture orientations and permeability, as well as the local topography. As such, the groundwater flow direction is generally expected to be from the topographic highs towards local drainage lines and ultimately the major waterways, including Deep, Jacksons and Merri creeks.

Recharge and discharge

Recharge to the water table aquifers in the study area is expected to be predominately by rainfall across the outcrop area, as well as surface water recharge along creek lines, during high river flow or flood periods. In addition, there is potentially some recharge via leakage from adjacent or underlying aquifers (when multiple aquifers are present).

Groundwater discharge to some of the waterways within the study is expected, with groundwater (baseflow) components to waterways in this area contributing a proportion of the overall flow in waterways.

Figure 8-12 Water table aquifers



Data source: APA, 2020; GHD, 2020'; DELWP, Vicmap, 2020 Created by:sacevedo

8.5.2 Groundwater depths along the alignment

As a part of the regional assessment of groundwater depths, the desktop assessment using an existing regional interpretation, identified that the majority of the alignment travels through areas where the depth to groundwater has been interpreted to be greater than 5 metres.

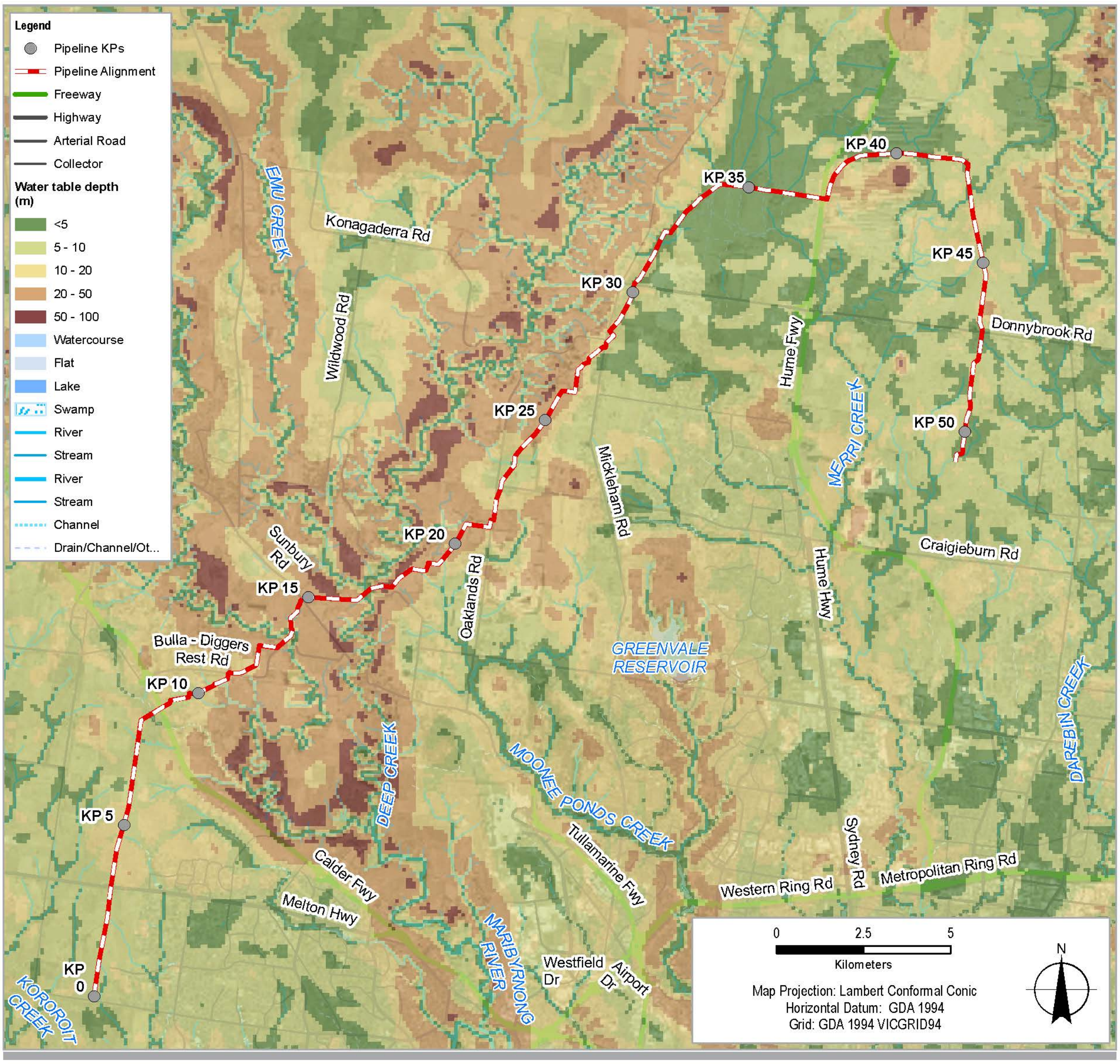
Shallower groundwater depths (less than 5 metres) had been initially identified, where the alignment crosses major waterways and a significant area in the north of the Project area near Kalkallo Creek (around eight kilometres in length from Donnybrook Rd (KP30) to the Hume Highway (KP38)). Smaller areas of shallow groundwater depths have been interpreted at the south west end and in the north east of the alignment. This was also informed by an assessment of State Groundwater Observation Network bores (SON) to provide an understanding of long-term water and seasonal water level behaviour.

A summary of areas where shallow groundwater has been interpreted, based on the SAFE dataset, across the region in the desktop assessment, is provided in Table 8-6 and illustrated in Figure 8-13

Table 8-6 Summary of potential shallow groundwater (regional data)

Approximate KP	Approximate location	Interpreted aquifer
1	Vacant land south of Beatty's Road	Newer Volcanics
7	North of Holden Road	Newer Volcanics
8	Adjacent minor creek south of Tame Street drain	Newer Volcanics
14	Jacksons Creek	Palaeozoic bedrock (siltstones)
17.5	Deep Creek	Palaeozoic bedrock (siltstones)
28	Mickleham Road	Palaeozoic bedrock/ Newer Volcanics (near boundary)
30	South of Donnybrook Road	Palaeozoic bedrock
30.5–37	Donnybrook Road – Kalkallo Creek – Gunns Gully Road	Palaeozoic bedrock and Quaternary alluvials
39–43	Donovans Lane – Merri Creek	Newer Volcanics
43	Merri Creek	Newer Volcanics
45	South of Merri Creek	Newer Volcanics
47	Donnybrook Road	Newer Volcanics
47.5–50	South of Donnybrook Road to Wollert Compressor Station	Newer Volcanics

Figure 8-13 Regional mapping depth to water table



Data source: APA, 2020; GHD, 2020'; DELWP, Vicmap, 2020 Created by:sacevedo

Areas of groundwater interaction along the Project

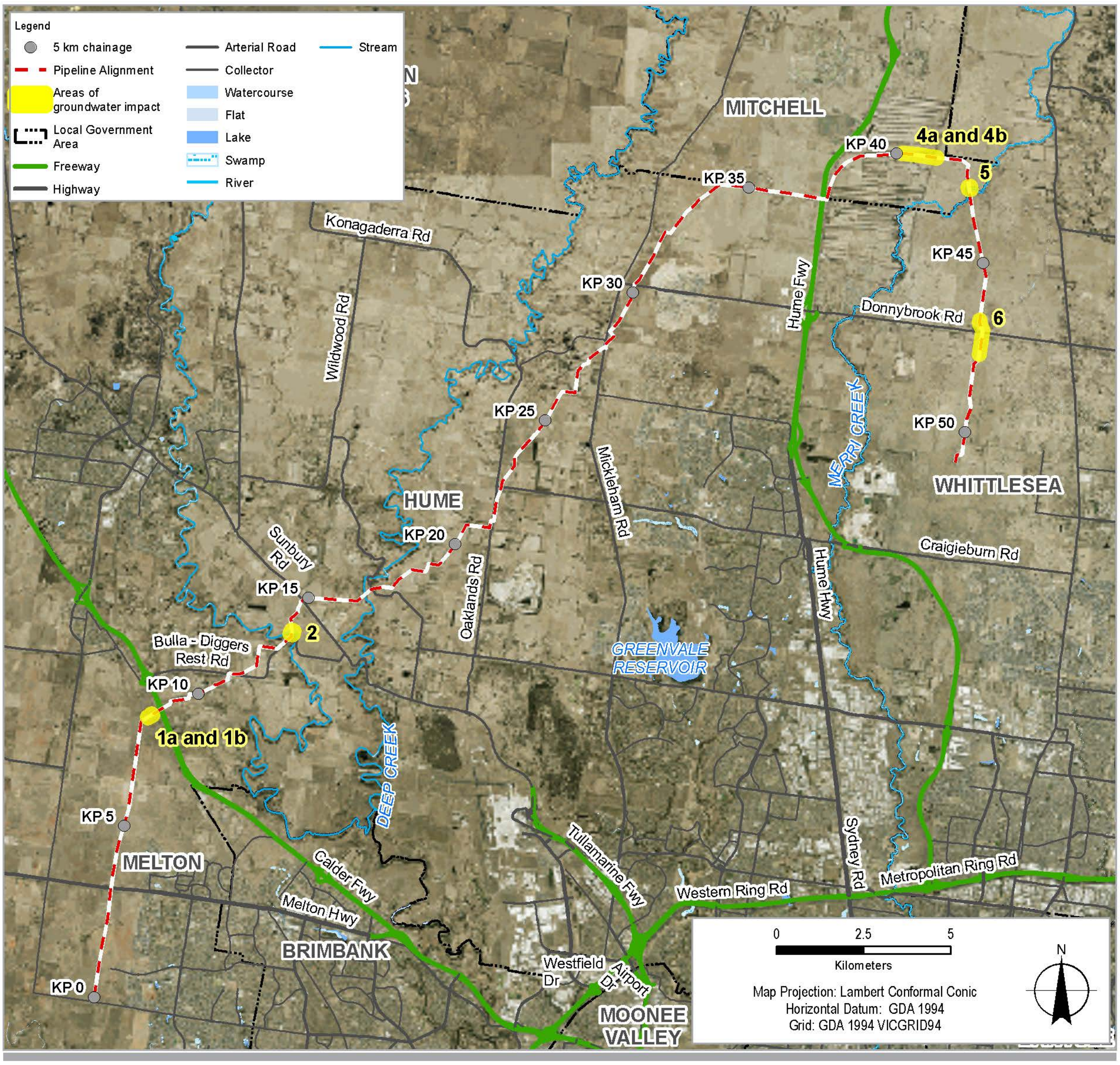
The regional assessment identified the areas which formed the focus of further investigations to confirm groundwater depth where the pipeline may interact with the water table aquifer.
The geotechnical drilling and monitoring bore installation provided further information on potential groundwater levels and depths along parts of the Project alignment. In most cases the recorded depth to water table (metres below ground level (mBGL)) was consistent with the regional interpretation.

Based on this assessment, six key areas of groundwater interaction along the Project alignment were identified. These areas are summarised in Table 8-7 and Figure 8-14. Some areas highlighted in Table 8-6, were no longer considered to be interaction zones following the field investigations and review of the pipeline design and construction method.

Table 8-7 Summary of areas of groundwater interaction along the Project alignment

Area	Approximate location	KP	Bore data depth to groundwater (mBGL) or regional
1a	Bendigo Rail	8.288–8.326	2 (assumed)
1b	Unknown creek/ Tame Street drain	8.406–8.411	2 (assumed)
2	Jacksons Creek	13.863–13.898	1.68–5
3	Deep Creek	16.828–16.85	3 – 5.7
4a	Donovans Lane	40–41	0.3
4b	North east rail reserve	40.925–40.959	4
5	Merri Creek	42.639–42.655	2 – 2.3
6	Donnybrook Road	46.5–47.5	1.24

Figure 8-14 Areas of groundwater interaction



Data source: APA, 2020; GHD, 2020'; DELWP, Vicmap, 2020 Created by:sacevedo

Groundwater level data collected at the Deep, Jacksons and Merri Creeks indicates that the groundwater levels are close to the creek bed level. This indicates that there may be groundwater discharge to the creeks during certain times of the year, as the groundwater is shallow in these locations. For further detail and sections showing the groundwater levels, refer to Section 7.2.4 of Technical report C *Groundwater*.

8.5.3 Groundwater quality

Groundwater salinity

As a part of the regional desktop assessment, the groundwater salinity along the majority of the alignment has been interpreted between 3,500 mg/L and 7,000 mg/L Total Dissolved Solids (TDS) with small areas of higher salinity groundwater mapped generally in the south west of the Project area (7,000 mg/L to 35,000 mg/L TDS) between KP0 and KP5.

A significant area of fresher groundwater has been interpreted in the north and north east of the Project area from approximately KP35 to KP50. The groundwater salinity in this area has been interpreted at between 1,000 mg/L and 3,500 mg/L TDS.

> **How are beneficial uses and groundwater quality determined?**
>
> The SEPP (Waters) forms the primary guide to determining existing impacts and risk of impacts to groundwater quality. Groundwater is categorised into segments (A to F) based on the groundwater salinity (measured as mg/L Total Dissolved Solids – TDS), with each segment having particular identified beneficial uses.
>
> For more detail on the segments and associated beneficial uses, refer to Section 4.4 of Technical report C *Groundwater*.

In regards to the SEPP (Waters), the regional interpreted groundwater salinity in the water table aquifer identifies:

- The majority of the water table groundwater (between approximately KP3 and KP33) is expected to fall within Segments C and D of the SEPP (Waters) (ie around 60 percent)
- Along approximately 35 percent of the alignment (between approximately KP33 and KP50) the interpreted groundwater salinity of 1,000 mg/L to 3,500 mg/L TDS falls within Segments A2, B and C of the SEPP (Waters)
- Along approximately 5 percent of the alignment (between approximately KP1 and KP3) the interpreted higher salinity groundwater falls within Segments E and F of the SEPP (Waters).

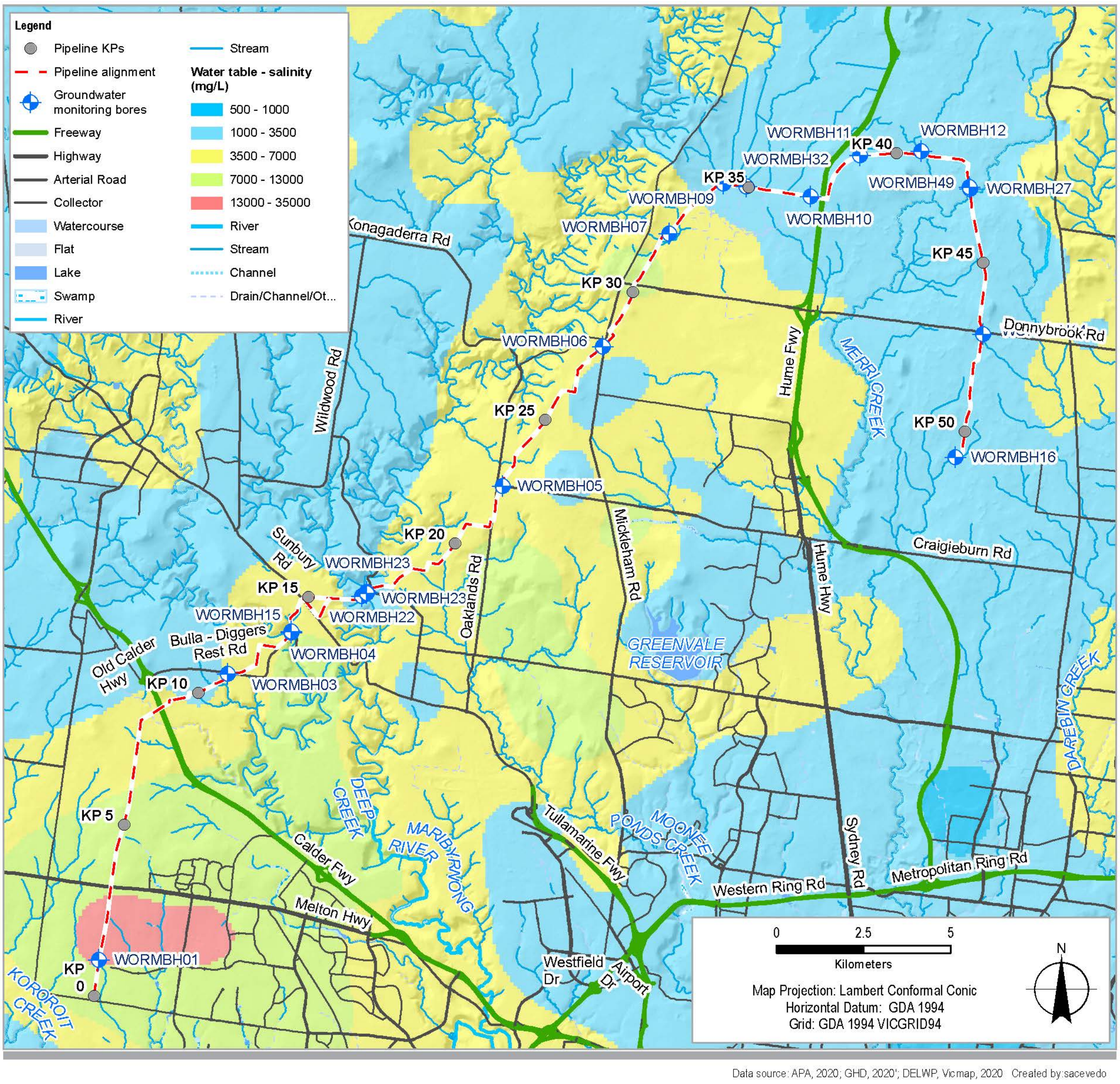
A summary of the interpreted groundwater salinity where shallow groundwater has been identified has been included in Table 8-8 and illustrated in Figure 8-15, alongside the location of the sampled groundwater bores.

Table 8-8 Summary of identified shallow groundwater and interpreted salinity

Approximate KP	Approximate location	Interpreted aquifer	Interpreted salinity (mg/L total dissolved solids)
1	Vacant land south of Beatty's Road	Newer Volcanics	3,500–7,000
7	North of Holden Road	Newer Volcanics	3,500–7,000
8	Adjacent minor creek south of Tame Street drain	Newer Volcanics	3,500–7,000
14	Jacksons Creek	Palaeozoic bedrock	3,500–7,000
17.5	Deep Creek	Palaeozoic bedrock	1,000–3,500
28	Mickleham Road	Palaeozoic bedrock/ Newer Volcanics (near boundary)	3,500–7,000
29–30	South of Donnybrook Road	Palaeozoic bedrock	3,500–7,000

Approximate KP	Approximate location	Interpreted aquifer	Interpreted salinity (mg/L total dissolved solids)
30.5–37	Donnybrook Road – Kalkallo Creek – Gunns Gully Road	Palaeozoic bedrock and Quaternary alluvials	3,500–7,000
39–43	Donovans Lane – Merri Creek	Newer Volcanics	1,000–3,500
42–43	Merri Creek	Newer Volcanics	1,000–3,500
45	South of Merri Creek	Newer Volcanics	1,000–3,500
47	Donnybrook Road	Newer Volcanics	1,000–3,500
47–50	South of Donnybrook Road to Wollert Compressor Station	Newer Volcanics	1,000–3,500

Figure 8-15 Regional mapping groundwater salinity



The groundwater field investigation also tested for groundwater salinity from the monitoring bores. The results were reasonably consistent with the regional groundwater salinity interpretation. Notable exceptions include bores WORMBH09 and WORMBH32, located adjacent Gunns Gully Road (approximately KP 35). Salinity from these bores was between approximately 5,000 mg/L and 7,300 mg/L TDS, which is higher than the regional groundwater salinity interpretation of 1,000 mg/L to 3,500 mg/L TDS.

Site specific data collected during Project investigations recorded a salinity range of 910 mg/L and 7,360 mg/L TDS. The site-specific data places the groundwater quality within Segments A2, B, C and D of the SEPP (Waters). Broadly described, the majority of the groundwater along the alignment has been classified as Segment C. As a conservative measure, groundwater to the east and south east of the Hume Freeway has been classified as Segment A2, supporting more protected beneficial uses including potable water and irrigation, and Segment B groundwater in bores identified east of the Hume Freeway.

Refer to Table 27 in Section 7.3.3 of Technical report C *Groundwater* for full suite of monitoring bore groundwater salinity data.

Beneficial uses

Protected beneficial uses of the groundwater have been identified based on the groundwater salinity assessment. These beneficial uses provide the framework for the groundwater risk assessment and impact assessment. For further detail refer to Section 4.4 of Technical Report C *Groundwater*.

Table 8-9 lists protected beneficial uses identified in the study area.

Table 8-9 Classified Project protected beneficial uses

	Segment (mg/L TDS)	
	A2	C
Use	601–1,200	3,101–5,400
Water dependent ecosystems and species	Yes	Yes
Potable water supply	Yes	No
Potable mineral water supply	Yes	No
Agriculture and irrigation (irrigation)	Yes	No
Agriculture and irrigations (stock watering)	Yes	Yes
Industrial and commercial	Yes	Yes
Water-based recreation (primary contact recreation)	Yes	Yes
Traditional Owner cultural values	Yes	Yes
Cultural and spiritual values	Yes	Yes
Buildings and structures	Yes	Yes
Geothermal properties	Yes	Yes

Source: EPA 2018.

Refer to Table 10 of Section 4.7 in Technical report C *Groundwater* for a discussion of Project groundwater beneficial uses and groundwater quality indicators.

Other groundwater quality parameters

As a part of the groundwater quality assessment, the monitoring bores were also tested for a range of other groundwater quality parameters. The laboratory analytical suites included:

- Laboratory analytical suite A: Salinity (measured as mg/L TDS), pH, EC, major ions, ammonia (as N), nitrate (as N), nitrite (as N), total nitrogen, Total Kjeldahl Nitrogen, sulfate as SO_4, total phosphorous, metals screen
- Laboratory analytical suite B, as above plus: E.Coli, Total Suspended Solids (TSS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), oil and grease, surfactants (methylene blue active substances – MBAS), Industrial Waste Resource Guidelines (IWRG) 621: Soil hazard categorisation and management, which includes TPH, OCPs, PCBs, MAH, SVOCs and VOCs, cyanide, and fluoride
- Limited per- and polyfluoroalkyl substances (PFAS) sampling and analysis from bores installed adjacent Deep and Jacksons Creeks (bores WORMBH15, WORMBH22, WORMBH23a).

This assessment found:

- The salinity from the majority of the bores exceeds the Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) irrigation requirements (long term for moderately tolerant crops), however the disposal of groundwater to land from dewatering during construction would need to be assessed on a site by site basis
- Elevated concentrations of ammonia (as N) have been reported from bores located near Deep and Jacksons Creeks
- Elevated concentrations of total nitrogen have been reported from bores located near Deep and Jacksons Creeks, as well adjacent Gunns Gully Road
- Elevated concentrations of total phosphorus have been reported from several bores along the alignment. The highest concentrations were recorded from bores located near Jacksons Creek, as well as adjacent Gunns Gully Road
- Low concentrations of arsenic were reported from all bores in March 2020. When the bores were sampled in August and September 2020, arsenic was not detected above laboratory limits of reporting
- Low concentrations of chromium, copper, nickel and zinc have been detected in all bores
- Where sampled, E.Coli has not been reported above laboratory limits of reporting
- Where sampled, concentrations of TPH, OCPs, PCBs, MAH, SVOCs and VOCs were not reported above laboratory limits of reporting (as part of the EPA Industrial Waste Resource Guidelines (IWRG) 621: Soil hazard categorisation and management)
- Where sampled, concentrations PFAS in groundwater were not reported above laboratory limits of reporting
- Sampling for PFAS was completed from bores WORMBH15, WORMBH22 and WORMHB23a. Concentrations of PFAS in these bores were not detected above laboratory limits of reporting.

Refer to Table 29 in Section 7.3.3 of Technical report C *Groundwater* for a summary of the water quality results in groundwater interaction areas.

8.5.4 Hydraulic conductivity of the water table

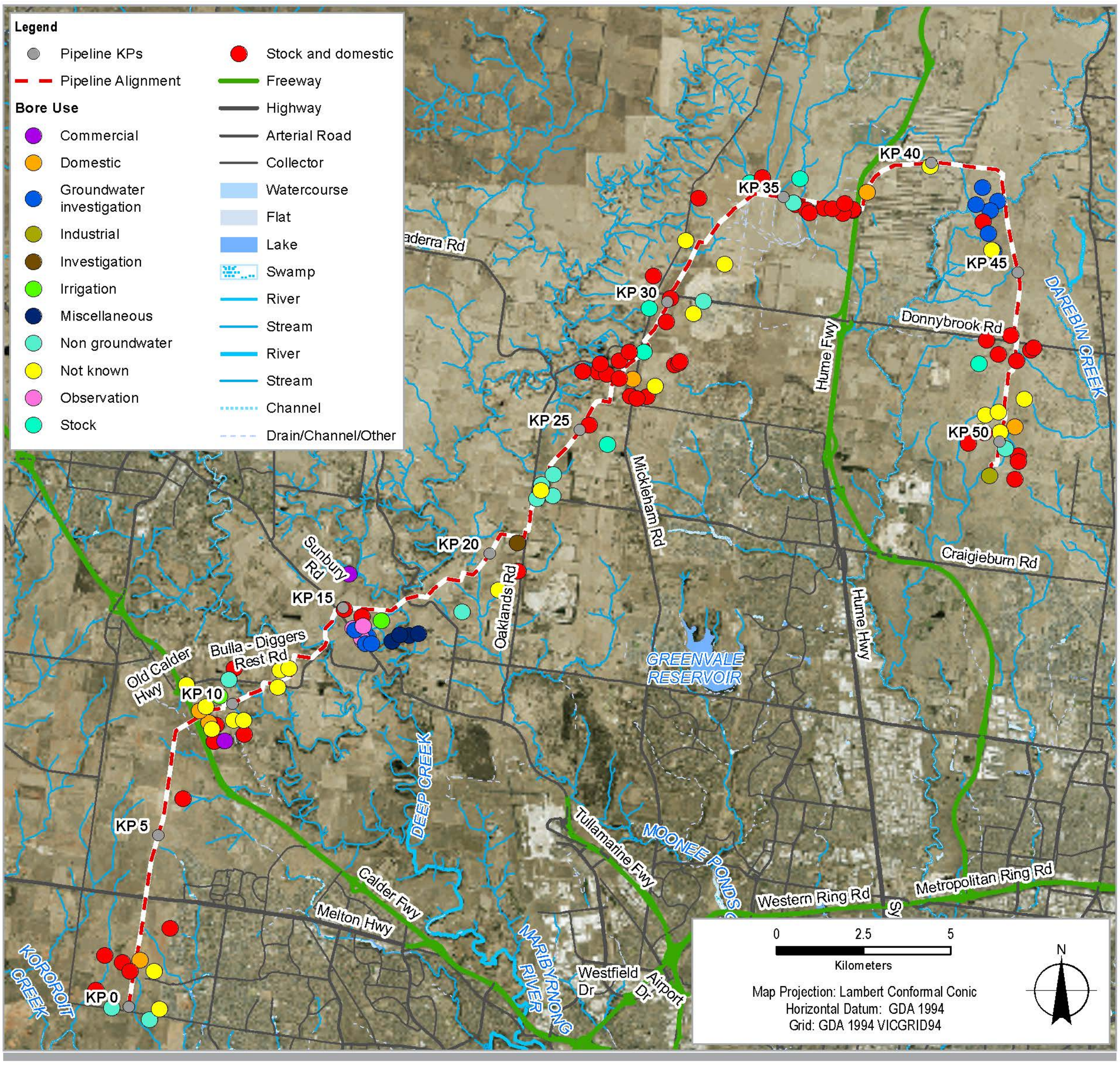
Hydraulic conductivity is a measure of how quickly groundwater can flow through the sub-surface. It is higher in a porous aquifer such as sands, and lower in fine-grained clay dominant aquifers. If conductivity is very low, the unit is often referred to as an aquitard rather than an aquifer.

Hydraulic conductivity of the water table aquifer along the alignment, based on slug testing, was 0.03 metres per day (m/day) on average, with the maximum approximately 1 m/day and the minimum of less than 0.01 m/day. These values are consistent with published literature values for the intersected aquifers, although the basalt aquifer can be highly variable and the recorded hydraulic conductivities for the basalt were in the lower end of the potential range.

Groundwater use

A search of DELWP's Water Measurement Information System (WMIS) was undertaken to identify bores within approximately one kilometre of the alignment. A total of 140 bores were identified within one kilometre of the alignment, along the entire length, consisting largely of stock and domestic use. These are identified on Figure 8-16.

Figure 8-16 Existing groundwater bores



Data source: APA, 2020; GHD, 2020'; DELWP, Vicmap, 2020 Created by:sacevedo

8.5.5 Groundwater dependent ecosystems and wetlands

Groundwater dependent ecosystems (GDEs) are natural ecosystems that require access to groundwater to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services. If the availability of groundwater to GDEs is reduced, or if the quality is allowed to deteriorate, these ecosystems are impacted.

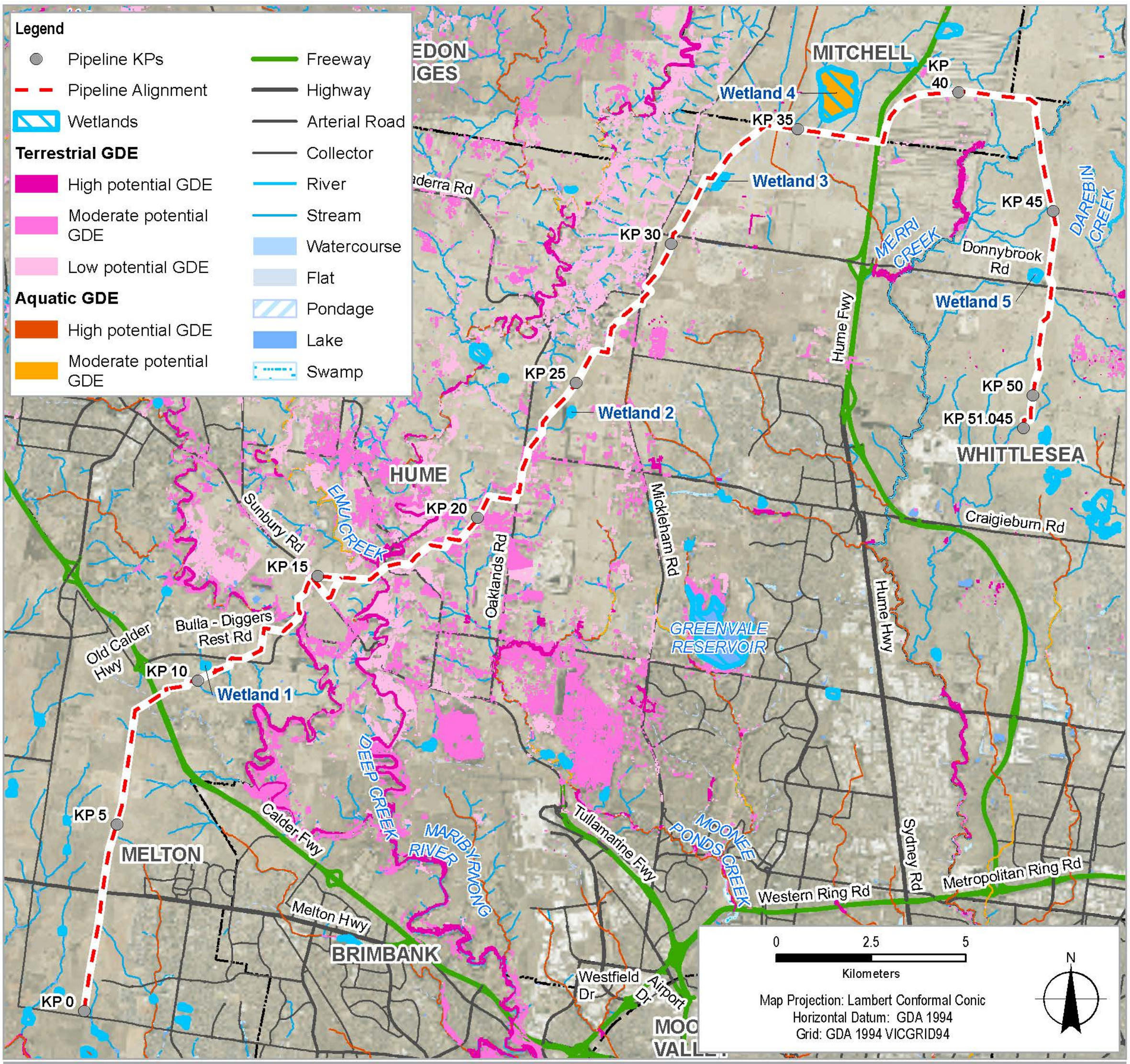
Informed by previous assessment by Biosis (2019) and through this assessment (utilising BOM Groundwater Dependant Ecosystem (GDE) Atlas), the potential GDEs identified along the alignment are illustrated in Figure 8-17. The GDEs potentially impacted by dewatering during pipeline construction are discussed in Section 8.9.1.

Although numerous potential terrestrial GDEs were originally identified along the pipeline alignment based on the regional BOM data, further site investigations have identified only one ecological vegetation class (EVC), Riparian Woodland, which could be considered a terrestrial GDE. The impact of vegetation clearing, including the Riparian Woodland, has been assessed separately in Technical report A and chapter 7 *Biodiversity and habitats*.

The DELWP Victorian Wetland Inventory (2017) was interrogated to identify the location of any wetlands along the alignment and these have been shown in Figure 8-17. Wetlands have been identified at the following locations:

1. Within the headwaters of an unnamed creek at approximately KP10. This is within approximately 0.2 kilometres of the alignment
2. Immediately south of KP25. This is within approximately 0.5 kilometres of the alignment
3. On the eastern side of the alignment between KP30 and KP32. These are within approximately 0.3 kilometres and 0.6 kilometres of the alignment
4. Immediately north of the alignment adjacent Kalkallo Creek. This wetland corresponds with the GDE mapping in the area. This is within approximately 0.5 kilometres to 1 kilometres of the alignment
5. West of the alignment, south of KP45. This is within approximately 0.5 kilometres to 1 kilometres of the alignment.

Figure 8-17 GDE areas and wetlands



\\ghdnet\ghd\AU\Melbourne\Projects\31\12529997\GIS\Maps\Working\GroundWater_EES_Rev7\12529997_006_Groundwater_dependent_ecosystems_and_wetlands_Rev7_RevB.mxd

Data source: APA, 2020; GHD, 2020'; DELWP, Vicmap, 2020 Created by:kgardner

8.5.6 Acid sulfate soils

Based on a review of CSIRO's National Acid Sulfate Soil (ASS) Atlas (ASRIS), there is a low to extremely low probability (with very low confidence rating) of ASS occurring within the construction corridor. However, the mapping is based on regional data and there may be potential to intersect unidentified ASS in soils close to features with permanent or regular inundation such as creeks, wetlands or GDEs.

Site specific testing identified that whilst there were field indicators of ASS identified by Construction Science, the SPOCAS testing completed in selected samples did not identify net acidity above the EPA assessment criteria of 0.03 % S. Limited additional ASS testing as part of more recent investigations identified one soil sample from a depth of 0.1 m at the net acidity EPA assessment criteria of 0.03 % S. This sample was taken from bore WORMBH09 adjacent Gunns Gully Road. Other soils samples collected did not report any net acidity.

Refer to Technical report E and chapter 10 *Contamination* for further information relating to acid sulfate soils.

What are acid sulfate soils and how are they affected by groundwater?

Acid sulfate soils are soils, sediments, unconsolidated geological material or disturbed consolidated rock mass that contain elevated concentrations of metal sulfides, predominantly pyrite. These soils can be rich in organics and were formed in low oxygen or anaerobic depositional environments.

The soils are stable when undisturbed or located below the water table. However, when oxygen is introduced, the sulfides oxidise, leading to potentially high concentrations of heavy metals.

Groundwater levels may fall as a result of construction dewatering activities. This can result in oxidisation of ASS material and the mobilisation of acidic groundwater and heavy metals into the environment where they can potentially impact deep-rooted vegetation, aquatic flora and fauna, and can be aggressive to reactive materials (such as concrete, steel) of foundations, underground structures (such as piles, pipes, basements) or buried services in contact with groundwater. It can also result in the discharge of acidic groundwater to receiving surface water systems

8.6 Risk assessment – surface water

The risk assessment identified the risks associated with surface water as a result of the Project's construction and operation in accordance with the method described in Chapter 5 *Evaluation and assessment framework*.

Risk ratings were applied to each identified risk pathway, assuming that initial mitigation measures were in place. Where the initial risk ratings were categorised as medium or higher, additional mitigation measures were developed to lower the residual risk where possible. Each risk 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 risk pathways and assessment presented in Table 8-10 are based on an open trench construction methodology through the waterways. Risks associated with waterway or floodplain function during operation and river bed or bank erosion during construction, have been assessed separately for each of the 'complex' waterways. This is because the other waterways are minor waterways or drains with ephemeral flows and open trench construction and restoration can be completed with minimal impact to the environment and standard mitigation measures in place. It is noted that the initial mitigation measures apply to all waterways assessed (23 waterways).

Given that Deep Creek is proposed to be crossed using HDD construction methodology (trenchless), and Merri Creek has a low potential for erosion, the waterways would be considered low risk with the appropriate mitigation measures in place. The medium to high initial risk rating for Risk ID SW4.1, SW7.1, SW9.1 are primarily associated with Jacksons Creek due to open trench construction activities that are exacerbated by the exposure to potentially erodible soil layers during construction.

Table 8-10 Surface water risk assessment

Risk ID	Works area	Risk pathway	Initial mitigation measures	Initial risk rating	Additional mitigation measures	Residual risk rating
Construction						
SW1	Pipeline	Site runoff (runoff quality)	EMM SW1 – Managing runoff from adjacent construction areas, stripped areas, discharge from dewatering activities and spills/leaks	Low	EMM SW5 – Monitoring program including contingency measures for Jacksons Creek and Merri Creek	Low
SW2	Pipeline	Waterway or floodplain function (changes to flow paths)	EMM SW2 – Waterway and floodplain function (construction)	Low	EMM SW9 – Flood Management and Response Plan	Low
SW3	Pipeline	Waterway or floodplain function (high flow or flood event)	EMM SW2 – Waterway and floodplain function (construction)	Low	EMM SW5 – Monitoring program including contingency measures for Jacksons Creek and Merri Creek	Low

Risk ID	Works area	Risk pathway	Initial mitigation measures	Initial risk rating	Additional mitigation measures	Residual risk rating
SW6	Pipeline	River bed or bank erosion – impacts to river health (all other waterways excluding 'complex' waterways)	EMM SW4 – develop appropriate control measures as part of the CEMP for open cut trench construction	Low	No additional mitigation measures	Low
SW7.1	Pipeline	River bed or bank erosion – impacts to river health (Jacksons Creek)	EMM SW4 – develop appropriate control measures as part of the CEMP for open cut trench construction	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)	Low
SW7.2	Pipeline	River bed or bank erosion – impacts to river health (Deep Creek)	EMM SW1 – Mitigation measures specific to trenchless construction method	Negligible	No additional mitigation measures	Negligible
SW7.3	Pipeline	River bed or bank erosion – impacts to river health (Merri Creek)	EMM SW4 – develop appropriate control measures as part of the CEMP for open cut trench construction	Medium	EMM SW5 – Monitoring program including contingency measures for Jacksons Creek and Merri Creek	Low
SW8	Pipeline	River bed or bank erosion – impacts to surrounding property and infrastructure (all other waterways excluding 'complex' waterways)	EMM SW4 – develop appropriate control measures as part of the CEMP for open cut trench construction	Low	No additional mitigation measures	Low

Risk ID	Works area	Risk pathway	Initial mitigation measures	Initial risk rating	Additional mitigation measures	Residual risk rating
SW9.1	Pipeline	River bed or bank erosion – impacts to surrounding property and infrastructure (Jacksons Creek)	EMM SW4 – develop appropriate control measures as part of the CEMP for open cut trench construction	Medium	EMM SW7 – Site specific construction management measures (Jacksons Creek) EMM SW8 – Site Specific rehabilitation measures (Jacksons Creek)	Low
SW9.2	Pipeline	River bed or bank erosion – impacts to surrounding property and infrastructure (Deep Creek)	EMM SW1 – Managing runoff from adjacent construction areas, discharge from dewatering activities and spills/leaks	Negligible	No additional mitigation measures	Negligible
SW9.3	Pipeline	River bed or bank erosion – impacts to surrounding property and infrastructure (Merri Creek)	EMM SW4 – develop appropriate control measures as part of the CEMP for open cut trench construction	Low	No additional mitigation measures	Low
SW10	Pipeline	Spills impacting surface water quality	EMM SW1 – Managing runoff from adjacent construction areas, discharge from dewatering activities and spills/leaks	Low	EMM SW5 – Monitoring program including contingency measures for Jacksons Creek and Merri Creek	Low
Construction and operation						
SW4.1	Pipeline	Waterway or floodplain function – Jacksons Creek	EMM SW3 – Develop appropriate Site Rehabilitation measures as part of the CEMP for disturbance caused by open cut trench construction	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	Medium

Risk ID	Works area	Risk pathway	Initial mitigation measures	Initial risk rating	Additional mitigation measures	Residual risk rating
SW4.2	Pipeline	Waterway or floodplain function – Deep Creek	EMM SW1 – Managing runoff from adjacent construction areas, discharge from dewatering activities and spills/leaks	Low	No additional mitigation measures	Low
SW4.3	Pipeline	Waterway or floodplain function – Merri Creek	EMM SW3 – Develop appropriate Site Rehabilitation measures as part of the CEMP for disturbance caused by open cut trench construction	Medium	EMM SW6 – Periodic visual monitoring for Jacksons Creek and Merri Creek EMM GM7 – Preparation and implementation of a sodic soil management measures	Low
SW5	Pipeline	Waterway or floodplain function – All other waterways	EMM SW3 – Develop appropriate Site Rehabilitation measures as part of the CEMP for disturbance caused by open cut trench construction	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 a sodic soil management measures	Low
SW11	Pipeline	Dispersive (sodic) soil behaviour	EMM SW4 – develop appropriate control measures as part of the CEMP for open cut trench construction EMM GM4 – Trench, erosion, consolidation and swelling	Medium	EMM GM7 – Preparation and implementation of a sodic soil management measures	Low

8.7 Risk assessment – groundwater

The risk assessment identified the risks associated with groundwater as a result of the Project's construction and operation in accordance with the method described in Chapter 5 *Evaluation and assessment framework*.

For groundwater, eight construction risks and three operation risks were identified and assessed. 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.

Risk ID	Works area	Risk pathway	Initial mitigation measures	Initial risk rating	Additional mitigation measures	Residual risk rating
Construction						
GW1	Pipeline	Drawdown impacts on groundwater users (registered bores)	EMM GW1 – Minimising dewatering rates and impact to groundwater levels and flows EMM GW2 – Minimise impact to groundwater bore users	Low	No additional mitigation measures	Low
GW2	Pipeline	Drawdown impacts on GDEs and receiving environments (river/ wetland base flows)	EMM GW1 – Minimising dewatering rates and impact to groundwater levels and flows	Low	No additional mitigation measures	Low
GW3	Pipeline	Drawdown activating acid sulfate soils	EMM GW1 – Minimising dewatering rates and impact to groundwater levels and flows EMM C3 – Minimise impacts from disturbance of acid sulfate soils	Low	No additional mitigation measures	Low
GW4	Pipeline	Construction dewatering impacts to groundwater levels and groundwater pressure reduction causes settlement of the ground	EMM GW1 – Minimising dewatering rates and impact to groundwater levels and flows EMM GM1– All third party services would be identified and proved prior to construction and asset owners vertical and horizontal clearance requirements will be agreed EMM GM2 – Design and construction to be informed by geotechnical and hydrogeological conditions	Negligible	No additional mitigation measures	Negligible

Risk ID	Works area	Risk pathway	Initial mitigation measures	Initial risk rating	Additional mitigation measures	Residual risk rating
GW5	Pipeline	Mobilisation of existing contaminated groundwater due to construction dewatering works, impacting groundwater quality and downgradient users	EMM GW1 – Minimising dewatering rates and impact to groundwater levels and flows EMM GW3 – Minimise impacts associated with contaminated groundwater and disposal EMM C4 – Minimise risks from contaminated groundwater/trench water	Low	No additional mitigation measures	Low
GW6	All	Leaks, spills or runoff impacting groundwater quality and downgradient users	EMM GW4 – Manage chemicals, fuels and hazardous materials EMM C6 – Manage chemicals, fuels and hazardous materials	Low	No additional mitigation measures	Low
GW7	Pipeline	Drilling fluids used for HDD impacting groundwater quality	EMM GW5 – Drilling fluids requirements	Negligible	No additional mitigation measures	Negligible
GW8	All	Disturbance and stockpiling of existing contaminated spoil impacting on groundwater quality and downgradient users	EMM GW6 – Implement spoil management procedures	Low	No additional mitigation measures	Low
Operation						
GW9	Pipeline	Pipeline infrastructure in areas of shallow groundwater may disrupt or dislocate groundwater flow paths, which may cause preferential flow paths, mounding and drawdown up gradient and downgradient	EMM GW7 – Pipeline design shall consider where groundwater interaction is expected to occur and incorporate design requirements to prevent preferential flow paths	Low	No additional mitigation measures	Low
GW10	Pipeline	Pipeline infrastructure in areas of shallow groundwater may disrupt or dislocate groundwater flow paths, which may cause preferential flow paths and movement of contaminated groundwater	EMM GW7 – Pipeline design shall consider where groundwater interaction is expected to occur and incorporate design requirements to prevent preferential flow paths	Low	No additional mitigation measures	Low
GW11	All	Leaks, spills or runoff due to maintenance work along the pipeline and associated infrastructure in areas of shallow groundwater	EMM GW4 – Manage chemicals, fuels and hazardous materials	Low	No additional mitigation measures	Low

8.8 Construction impact assessment – surface water

This section presents a discussion of the construction impacts associated with the Project in relation to surface water, which are grouped according to the following main themes:

- Runoff and spills from general construction activities
- Flooding impacts
- Erosion impacts to river health, surrounding property and infrastructure
- Dispersive soils.

The potential for impacts associated with these main themes are discussed in the following sections.

8.8.1 Runoff and spills from general construction activities

Runoff from construction areas along the Project corridor 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 can have an adverse impact on the water quality in receiving waters and beneficial uses downstream. Pollutants may include contaminated sediments, oils, solid inert waste and chemicals and nutrient inputs from silt-laden runoff (refer to Chapter 10 *Waste* for further detail on potential contamination and waste impacts). Soils introduced into waterways would also increase turbidity and sediment loads which would have an impact on aquatic fauna and flora (refer to Chapter 7 *Biodiversity*).

There is also 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 open trench construction or drilling.

What is dewatering and how does it impact surface water?

In its simplest definition, dewatering is the removal of water through a variety of different pumping or filtering processes. Dewatering on construction sites is mostly undertaken due to accumulated water in trenches.

Construction dewatering works have 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.

To minimise the impacts on beneficial use and downstream environments, standard construction controls (EMM SW1) would be implemented, including undertaking works on waterways during low flow conditions and monitoring weather forecast. Stockpiled materials would be managed, and flow diversion measures would be in place, to allow runoff to be directed away from the construction works. Water collected from open trenches after a rainfall event would require appropriate disposal in a manner that does not impact on beneficial use or human health. This includes the requirement that discharge to land should not occur within 100 metres 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:

- Waterways – such as the nearest creek
- Land – discharge to private or public land

- Stock watering – such as 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.

To monitor the performance of management measures in protecting waterway health and biodiversity values, monitoring of Jacksons and Merri creeks would be carried out where open cut trench construction is proposed (EMM SW5).

Potential water quality impacts associated with fuel or other hazardous material spills during construction would be addressed by EMM SW1 as well as the EMMs identified in Chapter 10 *Contamination and greenhouse gas*.

Application of the EMMs described above is considered to achieve 'minimisation' of the impact according to the mitigation hierarchy. Following implementation of these EMMs, the likelihood of mobilisation of site runoff, discharge from dewatering and spills impacting on water quality is unlikely and if this does occur, the impact would be expected to be short term and promptly remediated to reduce extent of impact. Therefore, the residual impact is considered to be low with the standard control measures in place as part of the final CEMP.

8.8.2 Flooding impacts

To assess potential flooding impacts during construction, the surface water assessment considered the following key issues:

- Temporary placement of construction materials, structures, or stockpiles within the floodplain, as these can impede flow and lead to change in the flood regime and floodplain function
- Potential for high flow or flood events to occur during construction which would collect and transfer construction materials and compounds into the waterway and impact the river health downstream.

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 MWC 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) would be prepared and implemented for construction works within waterways (EMM SW9). This includes Jacksons Creek, Deep Creek, Kalkallo Creek and Merri Creek where the flood extent could potentially extend beyond the construction corridor, during a flood event. As part of detailed design, flood modelling of the existing conditions for the waterways would be undertaken and need to be verified by MWC to inform the FMRP and to understand the flood response within the floodplain for the range of possible design events. 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.

Where open cut trench construction is proposed and where construction materials and pollutants could be washed downstream during high flow or flood events 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.

Application of the EMMs described above is considered to achieve minimisation' of the impact according to the mitigation hierarchy. The standard controls and approaches outlined in EMM SW2 would be applied to all waterways with an additional requirement for an FMRP to manage the four waterways that are prone to flood risk, as outlined in Table 8-10. In the event where a flood event occurs during construction, the impact on increased flood levels would be expected to be localised and short term with the appropriate mitigation measures implemented. Flooding impact on river health due to a potential flood event would also be expected to be of short duration and promptly remediated to reduce the extent of impact.

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 8-11 Standard and additional mitigation measures for identified water 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)

Overall, residual flooding impacts to river health, and surrounding properties and infrastructure are low with the appropriate standard management measures in place as well as implementation of the FMRP and water quality monitoring.

8.8.3 Erosion impacts to river health, surrounding property, and infrastructure

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.

The three 'complex' waterways (Jacksons, Deep and Merri Creek) are discussed separately to the other waterways (Kalkallo Creek, Tame Street Drain, and Tributary of Merri Creek) in the sections below. All other waterways have been assessed as a collective and these include the other 20 identified waterways crossed by the Project (excluding Jacksons, Deep and Merri Creek. Details of the 20 other waterways are described in Section 6.2.1 in Technical report B *Surface water*).

All waterways except for Jacksons, Deep and Merri Creeks

For all waterways, an open cut trench construction method is proposed. This type of construction activity within the waterways or floodplains 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 water quality.

As outlined in EMM SW4, standard controls would 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. Mitigation measures include open trench construction works to be undertaken during no or low flow conditions with reliance on timing of work and weather forecasts (eg waterway crossing works to be scheduled on days less than 1 mm rainfall). The period of construction would be limited to minimise the length of time the trench is exposed and reinstatement immediately following the installation of the pipes. Temporary measures would also be implemented to divert flow around the site and waterway reinstatement would be designed to avoid future erosion over the pipeline alignment. All waterway beds and banks shall be restored immediately 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 these standard construction management measures, the likelihood of erosion impacts to river health and surrounding infrastructure would be reduced.
If unexpected erosion was to occur, the potential impact to the waterway health and to surrounding infrastructure and property would be expected to be localised and short term with appropriate remedial actions implemented promptly to reduce extent of impact. Therefore, the residual impacts to water quality due to erosion is expected to be low.

As the majority of the waterways are small catchments and/or subject to low velocities, potential erosion impacts to the surrounding properties and infrastructure are unlikely to be significant, with the appropriate standard controls and mitigation measures of EMM SW4 implemented.

Jacksons Creek

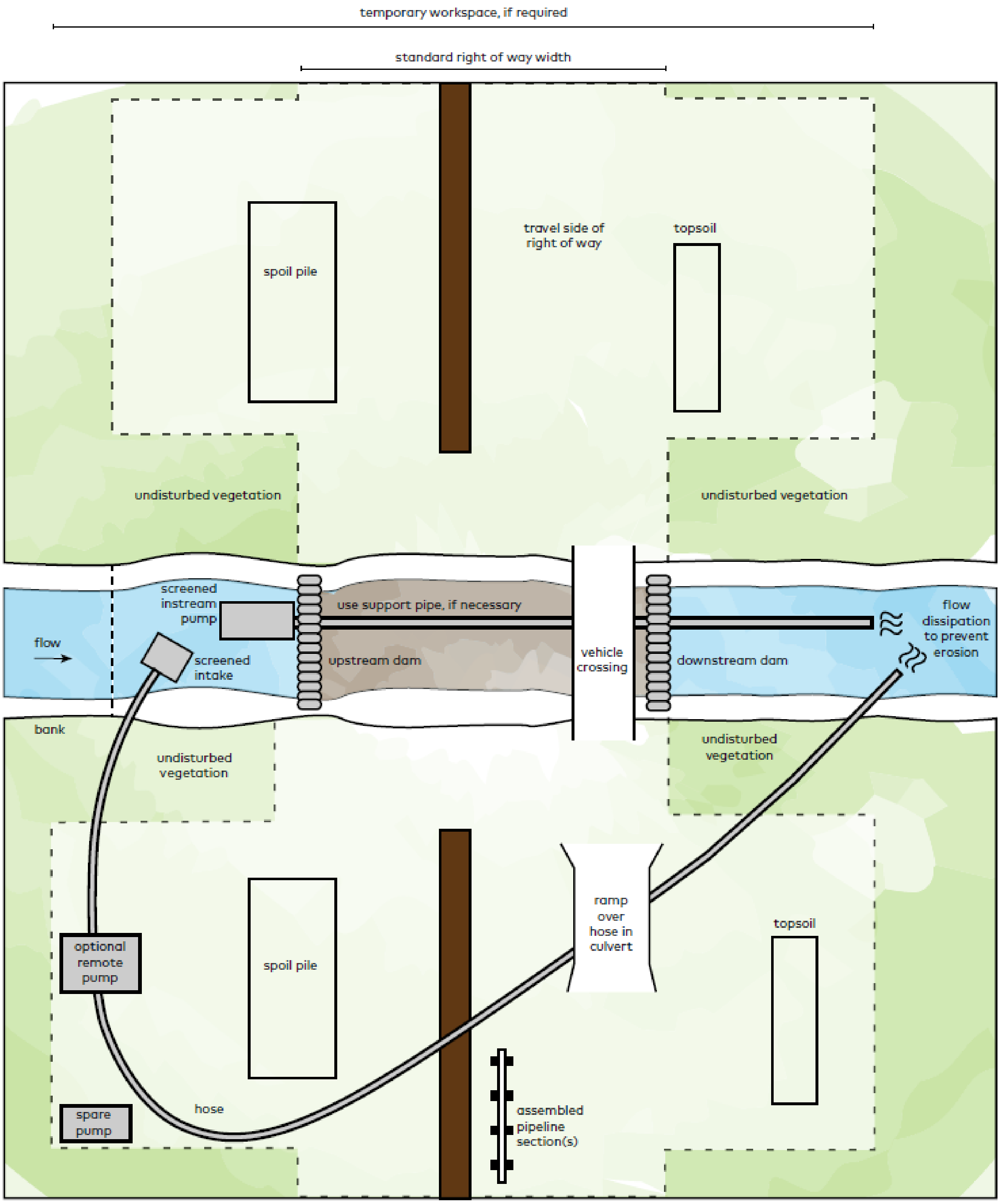
Open trench construction at Jacksons Creek is proposed as a part of the Project. Open trench construction works directly in the watercourse are expected to run for approximately two to four weeks and would include the construction of diversion dams to minimise watercourse sedimentation, such as steel plates, sandbags or inflatable dams. Where necessary, trench breakers on either side of the creek would be used to reduce sediment transport into the drain caused by water flowing along the excavated trench. Preparation of the site for construction would include the following key steps:

- Strip topsoil for construction, leaving a certain distance away from the creek bank
- Stockpile away from creek banks
- Install sediment fencing
- Install vehicle crossing point across the creek (through access is required to walk the pipe in and enable a simpler construction process, rather than bringing equipment/pipe from either side). This is not proposed for continuous access or use
- Depending on watercourse flow, start preparing the creek banks, or install diversion as per Figure 8-18, which illustrates the proposed site set up for Jacksons Creek.

Rehabilitation of the site following completion of creek open trench construction would involve:

- Backfill and prepare underlying bed and batters for rock beaching placement (where applicable)
- Place graded rock beaching to stabilise the creek bed and lower banks
- Place erosion matting protection on bed and bank areas not protected by rock beaching
- Topsoil and reseed around banks and surrounding disturbed areas as soon as possible.

Figure 8-18 Open cut construction within watercourses (higher flow water course)



Plan View
(not to scale)

At Jacksons Creek, standard management measures applied for all other waterways alone would not be adequate to minimise the risk of harm from erosion. Based on stream characteristics and erodible materials in the upper soil profile near the waterway and floodplain, Jacksons Creek has a high potential for bed and bank erosion. This risk is exacerbated by the proposed open trench construction methodology at this crossing.

Additional control measures would be implemented for Jacksons Creek to manage and reduce the likelihood of potential erosion impacts (EMM SW7). These include:

- Where possible, schedule works during summer and autumn, and align works with long-term weather forecast without significant rain
- A flow management work method statement would be required to detail reliance on pumping, cofferdams (partial or full), and temporary flume pipes
- Limit the longitudinal extent of trench exposure
- Impose limits on time for trench exposure and construction duration between bank to bank works
- Have available contingency measures such as backfill and stockpile of rock beaching to protect exposed trench to manage a potential unexpected weather event
- The contractor would be required to 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.

Open trench construction and the associated disturbance caused can lead to an ongoing impact due to complexities associated with geomorphological processes and the exposure of more highly erodible materials below the surface. HDD construction methodology was considered at Jacksons Creek but this option has been eliminated due to geological, accessibility, topographic and bore length constraints (refer to Chapter 3 *Project development* for further detail regarding the selection of construction methodology at this location). Whilst residual impact would remain during open trench construction activities, the impact would be managed through site-specific construction controls including those described above. With the site-specific requirement including limits on time of exposure for Jacksons Creek and the site-specific rehabilitation measures implemented, the likelihood and extent of potential erosion impacting on river health and surrounding property and infrastructure is expected to be unlikely. There remains residual impact to unexpected erosion associated with the works, but the potential impact to water quality would be expected to be short term and promptly remediated to reduce the downstream extent and magnitude of the impact.

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 developed and implemented as per EMM SW5. 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.

Deep Creek

The Deep Creek crossing would use the HDD construction method. The resultant risk at the Deep Creek crossing is considered negligible as HDD does not require disturbance of the ground surface at the waterway and hence minimises impact to the existing waterway and surrounding infrastructure. The mitigation measures outlined in EMM SW1 would be applied as standard controls to minimise erosion impacts due to the trenchless construction activities.

Merri Creek

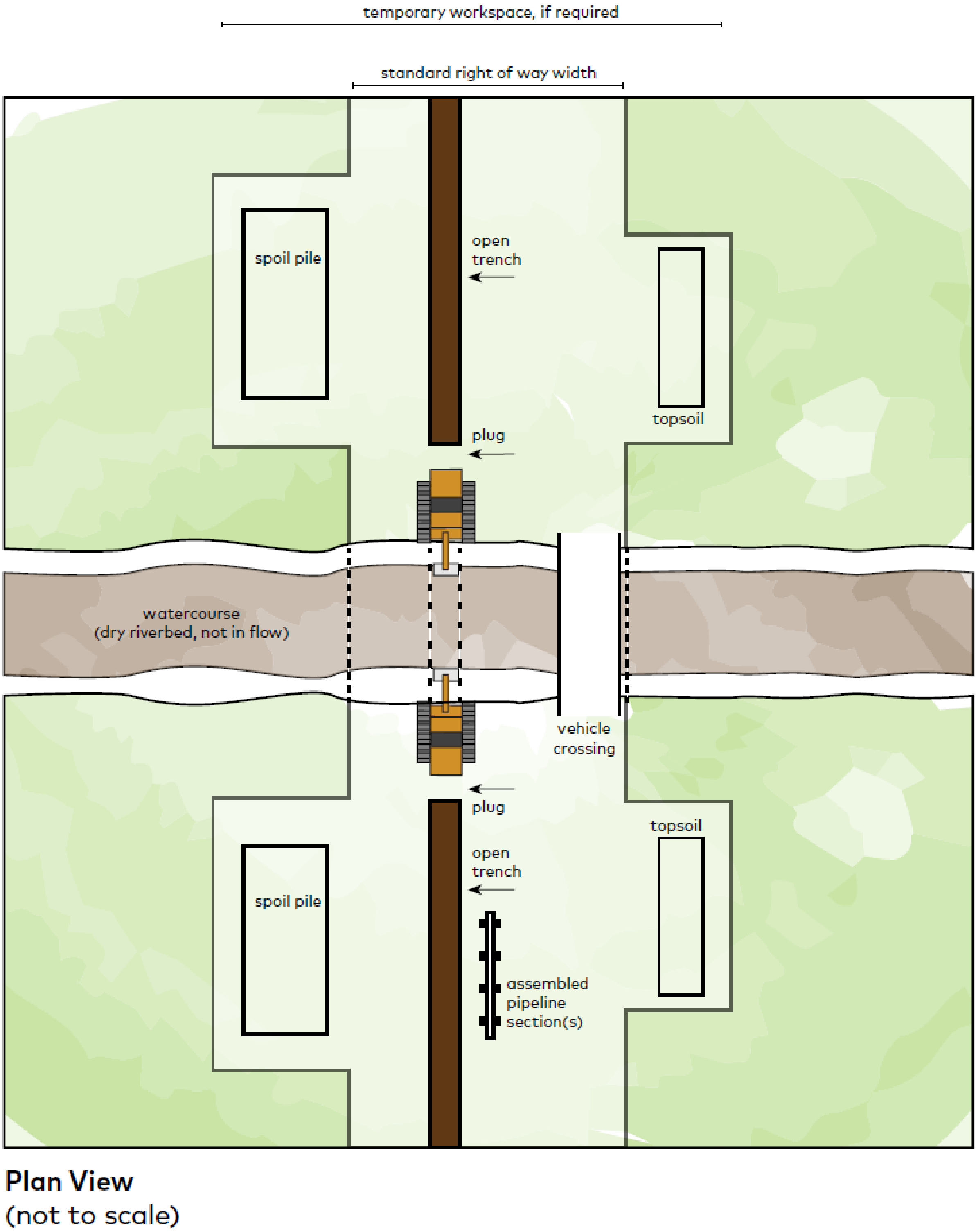
Open trench construction at Merri Creek is proposed as a part of the Project. Open trench construction works directly in the watercourse are expected to run for approximately two to four weeks and would include the construction of diversion dams to minimise watercourse sedimentation, such as steel plates, sandbags, or inflatable dams. Where necessary, trench breakers on either side of the creek would be used to reduce sediment transport into the drain caused by water flowing along the excavated trench. Preparation of the site for construction would include the following key steps:

- Strip topsoil for construction, leaving a certain distance away from the creek bank
- Stockpile away from creek banks
- Install sediment fencing
- Install vehicle crossing point across the creek (with a flume pipe) at the commencement of construction to provide ongoing access for construction traffic and plant. Access will be maintained across Merri Creek until all construction and reinstatement works are complete between KP 41 – KP 43
- Preparation for construction in the watercourse would include:
  - Depending on watercourse flow, start preparing the creek banks, or install diversion as per Figure 8-19, which illustrates the proposed site set up for Merri Creek
  - Undertake open trench construction, installation of pipe and backfill of trench in watercourse.

Rehabilitation of the site following completion of creek open trench construction would involve:

- Backfill and prepare underlying bed and batters for rock beaching placement (where applicable)
- Place graded rock beaching to stabilise the creek bed and lower banks
- Place erosion matting protection on bed and bank areas not protected by rock beaching
- Topsoil and reseed around banks and surrounding disturbed areas as soon as possible
- Remove temporary access at the completion of all construction and reinstatement works in Merri Creek.

Figure 8-19 Open cut construction methodology within watercourses (no or minimal flow watercourse)



Geotechnical investigations at Merri Creek indicated some presence of gravely clay within two metres depth, overlaying basalt. Given this underlying presence of bedrock, the risk of erosion is lower, and therefore open trenching can be readily managed with standard controls. The crossing location is within an existing APA pipeline easement that was 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. This existing APA pipeline alignment within the construction corridor 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 potential impacts on the existing pipe, the new pipe and construction work would be offset from the existing pipe alignment as much as possible within the easement. Standard control measures would be implemented as per all other waterways (EMM SW4) for the Merri Creek crossing to limit impacts to waterway stability and health. In addition, the contractor would be required to 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. Surface water quality monitoring of Merri Creek during construction would be implemented to monitor the effectiveness of control and management measures. Where monitoring identifies residual impacts to water and biodiversity values, contingency measures would be developed and implemented as per EMM SW5. The presence of basalt at shallow depths at Merri Creek would limit the depth and extent of future bed erosion. Whilst there remains low residual impact to unexpected erosion associated with the works, any potential impact to water quality would be expected to be short term and localised and promptly remediated to reduce the downstream extent and magnitude of the impact.

8.8.4 Dispersive soils

As discussed in Technical report D and chapter 9 *Land stability and ground movement*, there is potential for dispersive (sodic) soils to be present along the construction corridor, particularly in areas containing residual basaltic soils. Through localised testing, dispersive (sodic) soils have been identified at select locations along the Project alignment, including near Jacksons Creek and Kalkallo Basin.

Disturbance of dispersive soils can have adverse effects on water quality and waterway health. 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.

To manage potential impacts to waterway stability and the river health, the Project will be required to install trenching 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 (EMM SW4 and GM4). Development and implementation of sodic soil management measures would be required to manage potential impacts associated with potentially unknown presence of highly dispersive soils (EMM GM7).

Following implementation of the EMMs, if there is a potential impact to water quality due to presence of dispersive soils at an open trench waterway crossing, the duration and magnitude of the impact is expected to be short term and localised with remedial actions implemented promptly to reduce the extent of the impact. Therefore, the potential for residual impacts of dispersive soil entering the waterway and decrease water quality is considered to be ‘remote’ along the alignment. Avoidance of the potential impacts is not considered practically achievable given the anticipated extent of dispersive soils throughout the Project area and the variability inherent in geotechnical conditions.

8.8.5 Construction residual impacts summary

With the implementation of mitigation measures, residual impacts to surface water during construction include:

- Potential residual impacts to water quality due to mobilisation of site runoff, discharge from dewatering and spills is considered low and unlikely. If this does occur, the impact would be expected to be short term and promptly remediated to reduce extent of impact.
- Potential residual flooding impacts to river health, and surrounding property and infrastructure are considered low. In the event where a flood event occurs during construction, the impact on increased flood levels would be expected to be localised and short term with the appropriate mitigation measures implemented. Flooding impact on river health due to a potential flood event would also be expected to be of short duration and promptly remediated to reduce the extent of impact.
- Potential residual erosion impacts to river health and surrounding property and infrastructure are considered to be low for all trenched waterway crossings, excluding Jacksons Creek. If unexpected erosion was to occur, the potential impact to the waterway health and to surrounding infrastructure and property would be expected to be localised and short term with appropriate remedial actions implemented promptly to reduce extent of impact.
- With the site-specific requirement including limits on time of exposure for Jacksons Creek and the site-specific rehabilitation measures implemented, the likelihood and extent of potential erosion impacting on river health and surrounding property and infrastructure would be reduced to remote. There remains residual impact to unexpected erosion associated with the works, but the potential impact to water quality would be expected to be short term and promptly remediated to reduce the downstream extent and magnitude of the impact.
- Potential residual erosion impact to river health and surrounding property and infrastructure are considered low due to the presence of basalt at shallow depths at Merri Creek which would limit the depth and extent of future bed erosion. Whilst there remains low residual impact to unexpected erosion associated with the works, any potential impact to water quality would be expected to be short term and localised and promptly remediated to reduce the downstream extent and magnitude of the impact.
- The potential for residual impacts of dispersive soil entering the waterway and effecting water quality is considered to be ‘remote’ along the alignment. If there is a potential impact to water quality due to presence of dispersive soils at an open trench waterway crossing, the duration and magnitude of the impact is expected to be short term and localised with remedial actions implemented promptly to reduce the extent of the impact.

8.9 Construction impact assessment – groundwater

This section presents a discussion of the groundwater construction impacts associated with the Project and are grouped according to four main themes:

- Groundwater dewatering impacts on groundwater users, GDEs and activation of acid sulfate soils
- Ground settlement
- Mobilisation of existing contaminated groundwater
- Groundwater quality.

The potential for impacts associated with these main themes are discussed in the following sections.

8.9.1 Groundwater levels

This impact assessment relies on the steady state analytical model, which provides an estimated distance of groundwater drawdown influence and groundwater inflow rates associated with dewatering during construction. This model is informed by the construction methodology proposed (open trench construction) and the local hydrogeological conditions.
A summary of the estimated distance of drawdown during construction dewatering is listed in Table 8-12.

> **What is drawdown?**
>
> Drawdown refers to the lowering of the groundwater level caused by water extraction such as pumping from a bore or trench during dewatering works.
>
> 'Available drawdown' refers to the groundwater level above the pump.

Table 8-12 Summary of estimated inflows and distance of drawdown influence during construction dewatering along the Project alignment

Area	Approximate location	KP	Bore data depth to groundwater (mBGL) or regional	Estimated construction drawdown required (m)	Estimated distance of drawdown influence from the excavation (m)
1a	Bendigo Rail	8.288–8.326	2 (assumed)	3	25
1b	Unknown creek/Tame Street drain	8.406–8.411	2 (assumed)	2	20
2	Jacksons Creek	13.863–13.898	1.68–5	5	40
3	Deep Creek[1]	16.828–16.85	3 – 5.7	0	n/a
4a	Donovans Lane	40–41	0.3	1.5	15
4b	North east rail reserve	40.925–40.959	4	1	10
5	Merri Creek	42.639–42.655	2 – 2.3	5	40
6	Donnybrook Road	46.5–47.5	1.24	1	10

1 *Deep Creek crossing is HDD and bellholes will be above the water table so no dewatering is required.*

Groundwater users

Drawdown or lowering of the groundwater level may impact neighbouring groundwater users (extraction bores). This is dependent on the available drawdown in the existing bore, and other factors such as the current extraction rate of the bore. The predicted area of drawdown influence around the six identified areas, where dewatering will be required, is less than 50 metres (as per Table 8-12).

To assess the potential likelihood of impacts of drawdown on existing groundwater users, the estimated drawdown influence has been overlayed with the known existing groundwater bores. This demonstrates that drawdown interference with known existing users of groundwater is not anticipated during the Project's construction, and therefore the likelihood of impact to surrounding bores is considered remote.

To assess the potential consequence of impacts on existing groundwater users, the drawdown influence, hydraulic conductivity, and duration of dewatering activities have been assessed. The distance of drawdown influence predicted is generally very localised to the pipeline alignment, as the dewatering level required is between one to five metres, and the aquifer testing has recorded relatively low hydraulic conductivity in the basalt aquifer (generally less than one metre per day). Furthermore, given the anticipated short duration (less than four weeks) of dewatering activities at each location, the consequence of impact to a surrounding bore (if present) is considered moderate. In general, recovery in water levels may take a similar duration to that of the pumping. Based on this assessment, the potential for groundwater dewatering to impact neighbouring bores is low.

Construction methods will be used to minimise dewatering volumes and durations, which will minimise impacts on groundwater levels and flows (EMM GW1). These may include:

- Minimising the dewatering period. The anticipated period is expected to be four weeks at the creek crossings
- Installation of trench breakers to minimise trench inflows.

Although it is not anticipated that any neighbouring bore will be impacted by dewatering, it is possible there are unregistered bores nearby, or a slightly greater than predicted distance of drawdown influence occurs due to the variable nature of fractures rock aquifers. There is a registered bore located around 55 metres from an area of dewatering (at approximately KP 47.6), therefore neighbouring bores within 60 metres of an area of dewatering will be identified and the following management measures (EMM GW2) will be undertaken:

- The bore will be audited to check the current use, groundwater level, available drawdown, bore yield and quality (ie baseline performance)
- APA will provide alternative supply to the bore owner, if there are any impacts during dewatering encountered as required.

The application of the above management measures is considered to firstly achieve minimisation of the impact, followed by rehabilitation/restoration in the unlikely case any bore is impacted. Avoidance of impact is not considered to be practicably achievable for the open trench construction methodology. These management measures would be included within the Construction Environment Management Plan (CEMP). By applying the above management measures, the residual impacts of groundwater dewatering to neighbouring bore users is considered to be low.

Groundwater dependent ecosystems and wetlands

During construction dewatering, additional drawdown or lowering of the groundwater level near a GDE may cause a loss in groundwater availability that may impact the GDE health and function. Similarly, additional drawdown or lowering of the groundwater level near a wetland or river may impact the surface water levels or flows, which impacts local aquatic GDEs or downstream users.

Although numerous potential terrestrial GDEs were originally identified along the pipeline alignment based on the regional BOM data, further site investigations have identified only one ecological vegetation class (EVC), Riparian Woodland, which could be considered a terrestrial GDE. The impact of vegetation clearing has been assessed separately in Technical report A and chapter 7 *Biodiversity*.

To assess construction impacts on GDEs due to dewatering, the predicted area of drawdown influence area associated with groundwater extraction has been overlain with the potential GDEs, rivers and water bodies (refer to Table 8-12 for the estimated drawdown influence). As noted above, the predicted drawdown influence area is generally very localised (less than 50 metres), due to the aquifer hydraulic conductivity and the dewatering rates.

Jacksons Creek and Merri Creek are identified as potential aquatic GDEs and therefore expected to receive some groundwater baseflow in certain periods of the year. From observed conditions, Merri Creek at the crossing is ephemeral with no flow conditions expected during the drier periods of the year, while Jacksons Creek is a perennial system. Although it is ephemeral, in the upper reaches of Merri Creek, there is potential for pools that may act as drought refuges. However, during the aquatic ecology field assessment, there were no areas considered to contain refuge pools within the predicted area of drawdown influence from the crossing, with the closest potential pool estimated to be around 100 metres away. Refer to Technical report A and chapter 7 *Biodiversity and habitats* for further detail on potential aquatic values. The vegetation on the banks of Jacksons Creek is also identified as a potential terrestrial GDE based on regional data (BOM). Site investigations recorded this vegetation to be Riparian Woodland, with the dominant specifies being River Red Gum.

Recognising the groundwater and surface water interactions in these areas, the impact of construction dewatering drawdown on these GDEs, is considered minor due to:

- The drawdown extent (less than 50 metres) and level (1 to 5 metres) being localised and minor
- The duration is short (less than four weeks)
- Construction activities through the rivers would be designed to minimise the degree of groundwater and surface water interaction (ie trench breakers) and therefore minimise the dewatering requirements.

Local potential terrestrial GDEs are considered unlikely to be impacted by drawdown over this short period, unless works are carried out during a particularly dry period or drought. The River Red Gum of the Riparian Woodlands is sufficiently deep-rooted to withstand temporary and short-lived fluctuations in the water table. In addition, where possible the creek crossing works would be scheduled in early summer or late autumn when terrestrial/aquatic GDEs are less likely to be stressed. Refer to Section 3.4.4 of Technical report C *Groundwater* for further detail on the construction method summary and dewatering requirements.

Any impact on total baseflow to these river systems, due to drawdown across these small stretches for the short period of time, would be difficult to detect and are expected to be within natural climatic variations. Consequently, any impact on surface water flows would be minor and within natural flow variations and therefore impacts on potential aquatic GDEs are also considered to be insignificant to minor. Refer to Technical report A and chapter 7 *Biodiversity and habitats* for further discussion on this impact.

Overall, the potential for groundwater dewatering to impact GDE's or the receiving environments is considered low.

To manage any residual impacts, construction methods will be used to minimise dewatering volumes and durations, which will minimise impacts on groundwater levels and flows. This includes minimising the connection between the surface water and groundwater systems. Trench breakers would be installed adjacent to watercourses and wetlands (EMM GW1). Where possible, works would be scheduled in early summer or late Autumn when terrestrial/aquatic GDEs are less likely to be stressed by dry conditions. By applying the minimisation mitigation measures, the residual impacts of groundwater dewatering impacting GDEs or the receiving environments is considered to be low.

8.9.2 Ground settlement

Lowering of the water table around the trench during dewatering could result in desaturation of currently saturated unconsolidated sediments. This could result in land subsidence at the ground surface, a process that reduces ground surface elevation at affected areas. The potential for subsidence at any dewatering area will be a function of the amount of drawdown and resultant load increase on underlying soils, and the presence, thickness and compressibility of the soil strata below the water table. Damage to buildings and other infrastructure would be dependent on the amount of total and differential settlement that may occur, and the tolerance of structures to such differential movement.

The potential impacts associated with settlement were assessed separately in Technical report D and chapter 9 *Ground movement*. It was concluded that considering the limited area of the drawdown influence, the soil compressibility and infrastructure present, that the potential settlement were negligible.

To reduce the potential for ground settlement, construction methods will be used to minimise dewatering volumes and durations, which minimises residual impacts on groundwater levels and flows to negligible (EMM GW1). Other mitigation measures presented in Technical report D and chapter 9 *Ground movement* include EMM GM1 – Third party asset management and EMM GM2 – Design and construction to be informed by geotechnical and hydrogeological conditions.

8.9.3 Mobilisation of existing contaminated groundwater

Construction dewatering works have the potential to cause mobilisation of existing contaminated groundwater within the drawdown cone towards the dewatering site, which may impact groundwater quality (beneficial use) and down gradient receptors (users and/or receiving environments such as GDEs and rivers).

Potential existing contaminated groundwater from dewatering activities also requires disposal without impacting beneficial use or human health. Groundwater disposal during dewatering will likely be required at the six areas identified in Table 8-12. These areas are more than 750 metres from any potential contaminated sites, or operational landfills or quarries as identified in Technical report E and chapter 10 *Contamination*. The closest potentially contaminated site to an expected dewatering site is Jacksons Creek crossing which is 750 metres south-west of a potentially contaminated site.

What are the options for groundwater disposal?

A number of groundwater disposal options could be considered depending on volumes, groundwater quality and nearby infrastructure, including:

- Waterways: such as the nearest creek (in consultation with the relevant regulatory authorities)
- Land: irrigation of private or public land
- Stock watering: such as 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
- Aquifer recharge.

Considering the general setting of the pipeline disposal to waterways or land irrigation are likely to be considered the favoured options. The existing and future groundwater quality information, and nearby available options, will need to be considered when assessing the most appropriate disposal method at each location.

As per EMM GW3, groundwater would be disposed in accordance with the SEPP (Waters) and as per EPA Guidelines and all relevant approvals process with relevant authorities.

Based on the estimated dewatering drawdown influence zones (less than 50 metres as noted in Table 8-12), the likelihood of intersecting a significantly contaminated groundwater plume from a potential contaminated site, migrating contaminants to the dewatering area, and subsequently impacting on the existing groundwater quality and protected beneficial use around the area, is considered remote.

As noted in Section 8.5.3, the groundwater quality in potential dewatering areas exceeds the relevant ANZG (2018) and/or SEPP (Waters) criteria for ecosystem protection currently and therefore the beneficial use of the groundwater is potentially already impacted by local background conditions and/or land use. It is also noted that additional groundwater analysis should be completed at some of the dewatering areas to further assess the groundwater quality and inform the environmental management measures and disposal options.

Overall the potential for mobilisation of contaminated groundwater is considered to be low, assuming standard management measures, further establishment of baseline groundwater quality, and water disposal as per regulatory requirements.

To reduce the potential for mobilisation of any potentially contaminated groundwater, construction methods will be used to minimise dewatering volumes and durations, which will minimise residual impacts on groundwater levels and flows (EMM GW1). Extracted groundwater would be managed as follows (EMM GW3):

- Groundwater will be disposed in accordance with SEPP (Waters), as per EPA guidelines and all relevant approvals processes (approvals will be dependent on final disposal method/s)
- Groundwater from areas identified as contaminated would not be discharged to the environment (land, waterways, sewer). However, the contractor may engage with the local water authority to develop a trade waste agreement which would specify the levels of contamination to allow for sewer discharge
- Contaminated groundwater would either be treated onsite, depending on contaminants encountered (may require approval from EPA Victoria) or disposed offsite to an EPA Victoria licensed facility. Alternatively, a construction approach may be adopted where contaminated groundwater is left in-situ (ie not abstracted or disturbed).

Baseline groundwater quality conditions would be established prior to the construction phase to allow suitable disposal options to be assessed and planned. Additional groundwater quality analysis would be completed in the existing bore network to confirm baseline conditions (EMM GW3). This would include investigation of PFAS at Jacksons Creek and Deep Creek so that any dewatering or HDD in those areas can be informed about the presence of PFAS to allow for appropriate disposal of the groundwater or HDD fluids (EMM C4). By applying the above ‘avoidance’ and ‘minimisation’ management measures and undertaking some further baseline monitoring, the residual impacts of the potential mobilisation of contaminated groundwater is considered to be low.

8.9.4 Groundwater quality

Leaks or spills

Spills may occur during construction activities such as refuelling of vehicles, plant and machinery or the use of chemicals required as part of the construction. In addition, poor quality surface water runoff into trenches or bell holes could impact groundwater quality. The likelihood of these events occurring and contaminating groundwater is assessed as remote with standard management procedures in place.

To manage chemicals, fuels and hazardous materials during construction, the following requirements would be in place (EMM GW4 and EMM C6 – refer to Technical report E and chapter 10 *Contamination*):

- Minimise chemical and fuel storage on site and store hazardous materials and dangerous goods in accordance with the relevant guidelines and requirements
- Comply with the Victorian WorkCover Authority and Australian Standard AS1940 Storage Handling of Flammable and Combustible Liquids and EPA publications 1834 Civil construction, building and demolition guide (November 2020) and 1698: Liquid storage and handling guidelines
- Develop and implement management measures for dangerous substances, including:
  - Creating and maintaining a dangerous goods register
  - Disposing of any hazardous materials, including asbestos, in accordance with Industrial Waste Management Policies, regulation and relevant guidelines
  - Implementing requirements for the installation of bunds and precautions to reduce the potential for spills
- Contingency and emergency response procedures to handle fuel and chemical spills, including availability of on-site hydrocarbon spill kits
- The type and volume of liquid material (fuel, oil, lubricant) stored on-site for construction activities is to be limited to only that which is required
- Liquid material would not be stored within 50 metres of waterways
- The duration that trench sections and bell holes are open will be minimised, and surface water runoff will be diverted away from the excavations, to reduce the potential for poor quality runoff impacting groundwater.

By applying the above avoidance and minimisation management measures, the residual impacts to groundwater quality associated with potential leaks, spills or runoff is considered to be low.

Drilling fluids used for HDD

In areas where HDD will occur below the water table aquifer (such as Deep Creek), there is potential for the drilling fluids to interact with the aquifer system. These drilling fluids are designed to stabilise and seal the hole and therefore movement into the aquifer system will be very limited. In addition, the drilling fluids used are generally inert and biodegradable as they are commonly used in the groundwater bore drilling industry (EMM GW5). After use, the drilling fluids are required to be disposed as per EPA regulatory requirements. Therefore potential residual impacts associated with the drilling fluids is considered to be negligible.

Disturbance and stockpiling of existing contaminated spoil

There is a possibility that where potentially contaminated or acid sulfate soils are stockpiled, that contaminated runoff could recharge the water table aquifer, potentially impacting on groundwater quality and down gradient users/ receiving environments (GDEs/rivers). The likelihood of these events occurring is remote with standard management procedures in place.

Spoil management procedures (EMM GW6) would be included in the final CEMP including:

- Stockpiles of trench spoil would be managed in accordance with EPA publication 1834 Civil construction, building and demolition guide (November 2020) and EPA publication 1895 Managing Stockpiles (2020)
- Where it is necessary to excavate contaminated soils, they will be stockpiled separately, with containment and treatment measures appropriate to the type of contamination present, and with measures to prevent contaminated runoff from stockpiles discharging to surface or groundwater systems.

Other spoil management procedures are detailed in EMM C1 (Technical report E and chapter 10 *Contamination*). By applying the above avoidance and minimisation management measures, the residual impacts to groundwater quality associated with stockpiling of existing contaminated spoil is low.

8.9.5 Construction residual impacts summary

With the implementation of mitigation measures, residual impacts to groundwater during construction include:

- Potential residual impacts associated with groundwater levels, users and GDEs are considered to be low given the localised distance of predicted drawdown and short duration of dewatering activities (less than four weeks)
- The potential for ground settlement residual impacts on groundwater levels and flows, are considered to be negligible, as construction methods will be used to minimise dewatering volumes and durations
- The potential for mobilisation of contaminated groundwater is considered to be remote due to the estimated dewatering drawdown influence zones of less than 50 metres and the implementation of baseline groundwater monitoring and sedimentation controls
- Potential for residual impacts on groundwater quality associated with leaks or spills, drilling fluids or stockpiling during construction are considered to be low to negligible.

8.10 Operation impact assessment – surface water

This section presents a discussion of the potential impacts to surface water assets, values and uses from the operation of the Project. This includes the potential for impacts associated with permanent surface water changes.

8.10.1 Permanent surface water impacts

During operation, there is potential for erosion to continue due to the disturbance caused to the waterway and/or floodplain from the construction of the pipeline works. This is due to potential for construction-related disturbance to change waterway behaviour, particularly in response to future high flow or flood events.

Potential impacts are discussed below for all waterways, as well as in more detail for the 'complex' waterways (Jacksons, Deep and Merri creeks).

> **How might operational surface water impacts arise for the Project?**
>
> While the intent of the construction methodology is to restore the waterway and floodplain to pre-works conditions, once the waterway has been disturbed, this has the potential to trigger a future erosion response if left unmitigated.
>
> Changes to waterway or floodplain function during operation would be minimised by the implementation of the environmental management measures listed in Section 8.14 and discussed in the sections below.

All waterways

During operation, there is a low potential for permanent changes to waterways or floodplain function due to disturbance from construction and rehabilitation works, assuming the development and implementation of standard site rehabilitation measures. 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, where routine observations to monitor the effectiveness of rehabilitation works has been considered (EMM SW3). During open trench construction activities would typically be done in either low flow or no flow conditions, with controls on timing of work (preferably summer to autumn) and monitoring of weather forecasts. Construction durations would be limited and length of exposure of open trench construction would also be restricted. All waterway beds and banks would be restored as soon as practicable after pipe installation and backfilling works, and would be typically graded to stable batters (1:3, Vertical:Horizontal (V:H)), and revegetated with geofabric providing temporary protection until vegetation establishes.

Permanent works would be designed, constructed and maintained so as not to increase flood risk associated with overland flow paths or to modify flow regime of waterways. This would assist 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 and long term (for examples 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.

It is noted that the Kalkallo Creek and the Tributary to Merri Creek catchments are within the MWC DSS and would be subject to ongoing future development by Melbourne Water. 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 in the future. This would be managed through EMM SW10.

With the standard construction and site rehabilitation measures implemented for waterways, the likelihood for ongoing permanent changes to the waterways other than Jackson, Deep and Merri Creeks would be remote and result in a low residual impact on the waterway and floodplain function for all other waterways. Routine observations during post-construction would allow early detection of defective or deficient rehabilitation works to apply prompt rectification measures to limit the duration and extent of the impact to waterway health and stability.

Jacksons Creek

At Jacksons Creek there is greater potential for erosion damage to private property and infrastructure due to its high potential for bed and bank erosion. The primary impact could be potential exposure of the pipeline, in addition impacts to private property and other infrastructure could arise. The nature of these impacts is difficult to predict as there is uncertainty in the erosion response and consequence to surrounding property and infrastructure due to the complexity associated with the geomorphological processes.

Regarding the pipeline, the consequence could be reduced by providing additional protection to the pipe but the erosion response and consequence for surrounding property and infrastructure may be difficult to reduce. HDD construction methodology was considered at Jacksons Creek but this option has been eliminated due to geological, accessibility, topographic and bore length constraints (refer to Chapter 3 *Project development* for further detail regarding the selection of construction methodology at this location). A more carefully considered open trench construction method and site rehabilitation is required for Jacksons Creek as described in EMM SW6 and EMM SW7 to manage the risk. In addition to the standard measures described above for all waterways, some of the additional management measures that would be implemented at Jacksons Creek to further manage the risk include:

- Design measures including a minimum depth of 2 metres below bed, minimum length from top of left bank to top of right bank, and consideration of pipe protection (such as a concrete encasement) below the ground surface before backfilling (EMM SW7)
- Construction measures including backfilling in accordance with appropriate Melbourne Water standard drawings for pipe trenching, backfilling and compaction, as well as measures described in Section 8.8.3 Jacksons Creek (EMM SW7)
- Site rehabilitation measures including restoration of waterway bed and banks in accordance with stringent requirements (for example defined in a Work Method Statement) after pipe installation and backfilling works, bed and bank rock protection in accordance with MWC for Service Crossing Open Trench Medium Creek Crossing Guidelines, preparation of a Site Rehabilitation Plan (EMM SW8) for Jacksons Creek, and routine observations during establishment works and operation (EMM SW6).

Surface water quality monitoring of Jacksons Creek would be undertaken prior to construction, throughout the construction phase, with a final biodiversity monitoring round repeated post-construction to identify and minimise any potential impacts following rehabilitation works. In the event biodiversity monitoring identifies impacts have occurred, ongoing water quality monitoring may be recommended. During operation, periodic visual monitoring (for example annually plus following any major flood events) would be undertaken to monitor the effectiveness of rehabilitation works. Remedial action would be carried out if monitoring and inspection results indicate a potential impact from the works to the environment (EMM SW6). Emphasis on site-specific construction management measures, design interventions and site specific rehabilitation requirements for Jacksons Creek would reduce the likelihood of waterway instability and ongoing erosion to impact on water quality.
Visual monitoring of the Jacksons Creek would allow early detection of potential impacts to waterway health and stability if unexpected erosion were to occur. This would prompt remedial actions to be implemented and limiting the extent, magnitude and duration of residual impacts.

Deep Creek

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

Merri Creek

As basalt is present at relatively shallow depths at Merri Creek, the potential for operational impacts is expected to be low. This geomorphology would limit the depth and extent of any future or ongoing bed erosion. Standard control measures would be implemented as per all other waterways (EMM SW3) for Merri Creek during construction and the rehabilitation phase to limit the potential for ongoing erosion during the operation phase.

This would be followed by routine inspections (eg 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 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. Visual monitoring of the Merri Creek would allow early detection of potential impacts to waterway health and stability if unexpected erosion were to occur. This would prompt remedial actions to be implemented and limiting the extent and duration of residual impacts.

8.10.2 Operation residual impacts summary

With the implementation of mitigation measures, residual impacts on surface water during operation include:

- Potential residual impacts associated with ongoing erosion following completion of construction and during operation, are considered to be minimised. Residual impacts would remain at Jacksons Creek due to open trench construction activities occurring in an area where there is complexity associated with the geomorphological processes of the waterway. Emphasis on site-specific construction management measures, design interventions and site-specific rehabilitation requirements for Jacksons Creek would reduce the likelihood of waterway instability and ongoing erosion to impact on water quality. Visual monitoring of the Jacksons Creek would allow early detection of potential impacts to waterway health and stability if unexpected erosion were to occur. This would prompt remedial actions to be implemented and limiting the extent, magnitude and duration of residual impacts.

8.10.3 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. Given the timeframe for construction of the Project is late 2021 to 2022, there are no expected climate change impacts during construction, although short term implications of climate change may lead to increases in the 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 on the Project as the 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.

8.11 Operation impact assessment – groundwater

This section presents a discussion of the operational impacts associated with the Project in relation to groundwater and is grouped according to two main themes:

- Groundwater flow paths, levels and quality
- Leaks and spills.

The potential for impacts associated with these main themes are discussed in the following sections.

8.11.1 Groundwater flow paths, levels and quality

The pipeline and the backfilled trench in areas of shallow groundwater may disrupt or dislocate groundwater flow paths over time and potentially cause preferential flow paths within the trench or around the pipeline, which may result in localised changes in the ground water level. This may result in either mounding or drawdown of the groundwater level, up or down hydraulic gradient and subsequently has the potential to impact nearby users, GDEs, receiving waters flows/levels, or cause water logging. This may also result in localised changes to groundwater quality and beneficial use.

The areas of potential groundwater interaction along the alignment are summarised in Table 8-12, and represent approximately five percent of the entire pipeline length. Considering the limited extent of the pipeline below the water table, and the relatively small pipe diameter and trench depth below the water table compared to the aquifer thickness, it is expected that groundwater local flow paths will not be significantly altered or blocked. In addition, the potential areas where the trench is expected to be below the water table are not close to any identified potentially contaminated sites, which could cause additional consequences if a preferential flow pathway developed.

To further reduce the likelihood of the alignment becoming a preferential flow path, the pipeline design will consider where groundwater integration is expected to occur and incorporate trench breakers/pipe collars or plugs, as well as suitable backfill compaction, to prevent preferential groundwater flow paths (EMM GW7). Further establishment of baseline groundwater quality at areas where groundwater interaction is expected to occur will further inform these management measures.

Therefore, any changes in the groundwater level close to the trench are likely to be minor and management measures would minimise likelihood of the alignment becoming a preferential flow path and/or impact groundwater quality, indicating a low residual impact.

8.11.2 Leaks and spills

There is a possibility that spills or leaks may occur during the operation and maintenance of the pipeline, Wollert Compressor Station and the mainline valves. This could include fuels, oils or chemicals used in the operation phase of the Project. The likelihood of these events occurring and impacting groundwater quality is considered remote assuming standard management procedures. The VTS OEMP includes requirements for management of chemicals, fuels and hazardous materials as specified in EMM GW4. Based on this assessment, the residual impact is considered low.

8.11.3 Operation residual impacts summary

With the implementation of mitigation measures, residual impacts to groundwater during operation include:

- Any potential residual impacts to the groundwater level close to the trench are considered to be low and management measures would minimise likelihood of the alignment becoming a preferential flow path and/or impact groundwater quality
- Residual impacts associated with leaks and spills are considered to be low.

8.12 Cumulative impact assessment – surface water

The following projects adjacent to WORM have been considered as a part of the surface water cumulative impact assessment:

- Outer Metropolitan Ring Transport Corridor Project (OMR) – located alongside the Project in some locations, the cumulative impact of both projects occurring one after the other could increase effects of erosion or flooding. This could impact the water quality, stability and waterway health particularly for areas in close vicinity to waterways crossed by the Project, including Tame Street Drain, Kalkallo Creek and the tributary to Merri Creek. Potential interfaces between future drainage infrastructure along the OMR corridor, the WORM alignment and the identified waterway crossings will need to be coordinated between the relevant authorities to avoid impacts from potential clashes. Following implementation of the proposed environmental management measures and through ongoing coordination between APA and Department of Transport, this potential impact can be addressed.
- 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 are considered to arise as a result of the construction or operation of the Sunbury Road Upgrade.
- Bald Hill Yan Yean Pipeline – This project runs on a similar alignment to WORM from approximately KP 40 to KP 42. It is assumed that parts of this section of the Yan Yean pipeline trench would also require dewatering. Noting that construction timing is not confirmed, if construction is not undertaken at the same time as WORM, the potential flooding, erosion and water quality impacts are expected to be unchanged. If construction and open trench construction activities for the two projects were to occur concurrently, key cumulative effects to be considered would include increased footprint of disturbance to the waterway, additional spoil on site increasing the potential for erosion and water quality issues, and increased flood risk and changes to waterway and floodplain functions. Therefore, 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 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 Project at Merri Creek, would avoid the potential risk due to construction of both projects.
- AusNet/Mondo's Western Victoria Transmission (WVTN) project – No cumulative surface water effects are considered to arise as a result of the construction or operation of overhead power lines.

8.13 Cumulative impact assessment – groundwater

Based on a review of a number of projects adjacent to the WORM Project, the only project which is likely to interact with groundwater at a similar time, is Melbourne Water's Bald Hill Yan Yean Pipeline. 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 pipe trench would probably also require dewatering, as expected for the Project.

Assuming the Yan Yean pipe work is not carried out at the same time as the Project, the level and extent of drawdown associated with construction dewatering is expected to be unchanged from that shown in Table 8-12. If construction of the two projects occur at the same time, the drawdown area of influence would be greater than currently predicted. The distance of drawdown influence associated with the Yan Yean pipeline would depend on the depth of the pipe and the level of dewatering required.

However, assuming the distance of drawdown influence is increased to around 50 metres, there is still no registered groundwater users or GDEs in this area. Assuming the Yan Yean project has similar environmental management measures to the WORM Project in relation to groundwater disposal, the cumulative risk associated with construction dewatering would again likely remain unchanged. However, the preference is for the work to be done at different times to minimise any potential for cumulative impacts, and the timing should be confirmed with Melbourne Water

8.14 Environmental management – surface water

8.14.1 Environmental management measures

Table 8-13 lists the recommended environmental management measures for surface water.
In general, these environmental management measures 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 Sections 8.8 and 8.10 as relevant to each impact assessment.

Table 8-13 Surface water environmental management measures

EMM #	Environmental management measure	Stage	Mitigation hierarchy
SW1	**Managing runoff from adjacent construction 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 (ie 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 (eg grass filtration) if turbidity exceeds requirements in accordance with SEPP (Waters). 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 (ie grass 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* assessment (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: Ground movement and land stability (EMM GM5 and EMM GM6).	Construction	Minimisation

EMM #	Environmental management measure	Stage	Mitigation hierarchy
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 (ie 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	Minimisation
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: • 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 (eg 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.	Construction and operation	Minimisation

EMM #	Environmental management measure	Stage	Mitigation hierarchy
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 for the site with reference to 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. • 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 open trench construction 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 (eg 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*.	Construction	Minimisation

EMM #	Environmental management measure	Stage	Mitigation hierarchy
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 construction will occur. 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 (eg 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 must be developed and implemented. These remedial actions may include: • Identifying, repairing 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	Minimisation
SW6	**Periodic Visual monitoring** Carry out periodic routine observations (eg annually plus following any major flood events where damage is reported) capturing site conditions on an 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.	Operation	Minimisation

EMM #	Environmental management measure	Stage	Mitigation hierarchy
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 to be considered below the ground surface before backfilling. 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 (ie to what could be backfilled within 24 hours). • Construction duration: limit time for trench exposure and construction duration between bank to bank works to the extent reasonably practicable (eg 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.	Design, construction and operation	Avoidance and minimisation
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 (eg 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 (eg 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	Minimisation

EMM #	Environmental management measure	Stage	Mitigation hierarchy
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 the 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. • 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.	Construction	Minimisation
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	Avoidance and minimisation

8.14.2 Monitoring

Monitoring of waterways where open cut trench 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 on 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 (eg 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 (ie turbidity, temperature, dissolved oxygen, pH, salinity) and laboratory testing (ie 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.

8.15 Environmental management – groundwater

8.15.1 Environmental management measures

Table 8-14 lists the recommended environmental management measures for groundwater. In general, these EMMs have been developed in accordance with EPA Publication 1834 Civil construction, building and demolition guide (November 2020) and EPA Publication 1895 Managing Stockpiles, 2020. Application of the mitigation hierarchy is discussed in Sections 8.9 and 8.11 as relevant to each impact assessment.

Table 8-14 Groundwater environmental management measures

EMM #	Environmental management measure	Stage	Mitigation hierarchy
GW1	**Minimising dewatering rates and impact to groundwater levels and flows** Design and construct the Project to minimise changes in groundwater levels, flows and quality. Implement the following measures during construction to minimise groundwater impacts: • Where excavations require dewatering, adopt a construction method that minimises the dewatering period. The anticipated period is expected to be approximately four weeks at the creek crossings. • Install trench breakers adjacent to watercourses, wetlands and steep slopes as shown in the standard drawing (530-DWG-L7003) to minimise trench inflows.	Construction	Minimisation
GW2	**Minimise impact on groundwater bore users** Although it is not anticipated that any neighbouring bore will be impacted by dewatering, it is possible there is unregistered bores nearby, or a slightly greater than predicted distance of drawdown influence may occur. If this is the case, and any neighbouring bores are considered likely to be impacted by the Project within 60 metres of an area of dewatering (including the registered bore at approximately KP 47.6), then the location, condition and functionality of the bore must be visually confirmed and make-good arrangements must be agreed in consultation with affected landholders, if required.	Construction	Minimisation

EMM #	Environmental management measure	Stage	Mitigation hierarchy
GW3	**Minimise impacts associated with contaminated groundwater and disposal** Establish baseline groundwater level and quality conditions prior to the construction phase to assess any existing contamination or quality issues where groundwater is likely to be intercepted during construction and dewatering is expected, and also allow suitable disposal options to be assessed and planned. • Complete additional groundwater quality analysis in the existing bore network to confirm baseline conditions. • Investigate Bendigo Rail/Tame St Drain area further as regional data suggests dewatering may be necessary. • Investigate PFAS at Jacksons Creek so that any dewatering in this area can be informed about the presence of PFAS to allow for appropriate management of the groundwater, and sediments. Investigations must occur prior to construction in order to inform the CEMP and include: – Shallow groundwater and sediment sampling. Manage extracted groundwater as follows: • Dispose groundwater in accordance with the SEPP (Waters) and EPA Guidelines and all relevant approvals processes with relevant authorities. • Groundwater from areas that have been identified as contaminated must not be discharged to the environment (land, waterways). If required, engage with the local water authority to develop a trade waste agreement for sewer discharge. This agreement would specify the levels of contamination to allow for sewer discharge. • Contaminated groundwater must either be treated onsite, depending on contaminant encountered (this may require approval from the EPA Victoria) or disposed offsite to an EPA Victoria licensed facility. Alternatively, a construction approach may be adopted where contaminated groundwater is left in-situ (ie not abstracted or disturbed). Manage dewatering of excavated trenches/bellholes to minimise sedimentation, including the use of sediment control devices to remove suspended solids and dissipate flow. Sediment control devices must be listed in the site specific environmental management plans. Minimise the duration that trench sections and bell holes are open, and divert surface water runoff away from the excavations, to reduce the potential for poor quality runoff impacting groundwater.	Construction	Minimisation
GW4	**Manage chemicals, fuels and hazardous materials** Manage chemicals, fuels and hazardous materials as detailed in EMM C6.	Construction and operation	Minimisation
GW5	**Drilling Fluids Requirements** Manage drilling fluids in accordance with EMM C9.	Construction	Minimisation
GW6	**Implement Spoil Management Procedures** Implement spoil management procedures as detailed in EMM C1.	Construction	Minimisation

EMM #	Environmental management measure	Stage	Mitigation hierarchy
GW7	**Design Requirements** The pipeline design shall consider where groundwater interaction is expected to occur and incorporate trench breakers/ or plugs, as well as suitable backfill compaction, to prevent preferential flow paths. Implement trench compaction procedures as detailed in GM4 including the design of the backfill to take into account the density and permeability of the surrounding soil.	Design, construction and operation	Minimisation

8.15.2 Monitoring

Although residual impacts are low during construction, it is recommended that a groundwater monitoring plan is developed as part of the CEMP using the existing bore network set up for the Project.

The objective of groundwater monitoring is to minimise the risk of impacts to groundwater during construction. Indicators include groundwater level and quality as set out in the groundwater monitoring plan in accordance with SEPP (Waters). The groundwater monitoring plan would be implemented to:

- Assess any impacts from construction activities (ie from drawdown during construction and recovery) which includes measuring groundwater levels and quality at key groundwater interaction areas when construction works are progressing in the immediate area (locations identified in Table 8-12), particularly the open trench creek crossings (Jacksons and Merri Creek)
- Monitor groundwater quality during construction. This includes any dewatering to comply with the site-specific groundwater disposal management plan and SEPP (Waters) requirements. Monitoring to assess any site variability of the groundwater quality (eg from the baseline investigations and there is no variations that require additional management measures changing pH or salinity). When dewatering occurs at locations identified in Table 8-12, monitoring of groundwater levels and quality would be required for the duration of dewatering works as defined in the groundwater monitoring plan. Parameters to be measured include groundwater levels, salinity, pH, EC, major ions, ammonia, nitrate, nitrite, total nitrogen and total kjeldahl nitrogen.

8.16 Conclusion

This chapter has identified and assessed existing conditions, impacts and mitigation measures for surface water and groundwater for the Project.

In response to the EES evaluation objective described at the beginning of this chapter, effects of the Project on surface water and groundwater have been assessed and environmental management measures have been identified to minimise or avoid impacts associated with water.

8.16.1 Surface water

The surface water assessment identified the key assets, values and uses potentially affected by the Project. Based on a preliminary screening assessment of the 23 waterways intersected by the Project alignment, six higher risk waterways were assessed in more detail from which three main 'complex waterways' were identified (Jacksons, Deep and Merri creeks) which were the focus of the existing conditions assessment.

The key findings of the impact assessment include:

- The construction impacts assessed for the Project are generally considered to be of low residual impact following the application of both standard control measures and additional site-specific controls.
- Potential impacts of erosion during open trench construction is identified as 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 surface water and biodiversity monitoring, site specific construction management and rehabilitation measures are essential to monitor and reduce the likelihood of unexpected erosion occurring at this waterway crossing. With the site-specific requirement including limits on time of exposure for Jacksons Creek and the site-specific rehabilitation measures implemented, the likelihood and extent of potential erosion impacting on river health and surrounding property and infrastructure would be reduced. There remains residual impact to unexpected erosion associated with the works, but the potential impact to water quality would be expected to be short term and promptly remediated to reduce the downstream extent and magnitude of the impact.
- Potential impacts of erosion during open trench construction for Merri Creek are associated with identified sensitive downstream receptors. Given the ephemeral nature of the waterway in this reach and the presence of basalt at shallow depths at Merri Creek to limit the depth and extent of future bed erosion, the impacts can be more readily managed than compared to Jacksons Creek. Whilst there remains low residual impact to unexpected erosion associated with the works, any potential impact to water quality would be expected to be short term and localised and promptly remediated to reduce the downstream extent and magnitude of the impact.
- Potential impacts due to permanent changes to the waterways is also identified as significant for the Project in terms bed and bank erosion at Jacksons Creek. This can be reduced by the application of additional design, construction and rehabilitation management measures implemented for Jacksons Creek to mitigate future erosion and prevent permanent changes. Emphasis on site-specific and greater levels of construction management measures, design interventions and site-specific rehabilitation requirements for Jacksons Creek would reduce the likelihood of waterway instability and ongoing erosion to impact on water quality. Monitoring of the Jacksons Creek would allow early detection of potential impacts to waterway health and stability if unexpected erosion were to occur. This would prompt remedial actions to be implemented and limiting the extent, magnitude and duration of residual impacts.

- Potential impacts due to permanent changes to the waterways is also identified for Merri Creek are associated with identified sensitive downstream receptors. Monitoring of the Merri Creek would allow early detection of potential impacts to waterway health and stability if unexpected erosion were to occur. This would prompt remedial actions to be implemented and limiting the extent and duration of residual impacts.

Project environmental management measures would be implemented to minimise residual impacts associated with Project construction and operation that could lead to changes to surface water quality, flows and flooding, and erosion and damage to property and infrastructure. These include requirements for:

- Managing runoff from adjacent construction areas, discharge from dewatering activities and spills/leaks (EMM SW1)
- Waterway and floodplain function management during construction (EMM SW2)
- The CEMP to include site rehabilitation measures for disturbance caused by open cut trench construction (EMM SW3 and SW4)
- Implementing a monitoring program in Jacksons Creek and Merri Creek where open cut trench construction would occur (EMM SW5)
- Periodic visual monitoring during operation at Jacksons Creek and Merri Creek (EMM SW6)
- Site-specific design and construction management measures at Jacksons Creek (EMM SW7)
- Site-specific rehabilitation measures at Jacksons Creek (EMM SW8)
- Developing and implementing a Flood Management and Response Plan (FMRP) for Jacksons Creek, Deep Creek, Kalkallo Creek and Merri Creek (EMM SW9)
- Pipeline design for waterway crossings within a Drainage Services Scheme (DSS) (EMM SW10).

In response to the EES evaluation objective described at the beginning of this chapter, effects of the Project on surface water have been assessed and environmental management measures have been identified to minimise or avoid impacts and manage any residual impacts to surface water quality and flow.

With the implementation of mitigation measures, residual impacts during construction including water quality, flooding and erosion, are considered to be low. For Jacksons Creek, potential unexpected erosion impacts to water quality, river health and surrounding property would be expected to be short term and promptly remediated to reduce the downstream extent and magnitude of the impact.
For Merri Creek, residual impacts associated with unexpected erosion are considered to be low, given the presence of basalt at shallow depths. If unexpected erosion occurred, any potential impact to water quality would be expected to be short term and localised, and promptly remediated to reduce the downstream extent and magnitude of the impact. During operation, residual impacts associated with ongoing erosion are considered to be minimised.

8.16.2 Groundwater

The groundwater assessment identified the key groundwater assets, values and uses potentially affected by the Project. Based on a desktop assessment and field investigation program, existing conditions including groundwater quality, depths and presence of GDEs were assessed along the alignment.

The key findings of the impact assessment were based on the proposed construction methodology for the Project and include:

- During construction excavations are likely to be required that are deeper than the water table and will therefore require dewatering over short periods. This may impact local groundwater levels and flow paths
- During operation the pipe and the backfilled pipe trench may be below the water table which may also impact on groundwater levels and flow paths
- Six areas were identified where the pipeline may interact directly with the water table aquifer. This represents approximately five percent of the entire pipeline length
- These potential impacts on groundwater levels and flow paths may subsequently impact water availability or quality to groundwater dependent receptors, such as groundwater dependent ecosystems, surface water features receiving baseflows, groundwater users (such as existing bores), as well as activate acid sulfate soils, cause migration of any existing contaminated groundwater or cause ground subsidence.

Project environmental management measures would be implemented to minimise residual impacts associated with Project construction and operation. These include:

- Minimising dewatering rates and impact on groundwater levels and flows (EMM GW1)
- Minimising impacts on groundwater bore users (EMM GW2)
- Minimising impacts associated with contaminated groundwater and disposal (EMM GW3)
- Managing chemicals, fuels and hazardous materials during construction and operation (EMM GW4 and EMM C6)
- Drilling fluid requirements (EMM GW5)
- Implementing spoil management procedures (EMM GW6 and EMM C1)
- Pipeline design requirements to prevent preferential flow paths (EMM GW7).

In response to the EES evaluation objective described at the beginning of this chapter, effects of the Project on groundwater have been assessed and environmental management measures have been identified to minimise or avoid impacts on groundwater levels, quality and subsequent impacts on neighbouring groundwater users and GDEs, and manage any residual impacts.

With the implementation of mitigation measures, residual impacts during construction including changes to groundwater levels, users or GDEs, are considered to be low. Potential for ground settlement residual impacts on groundwater levels and flows are considered to be negligible. Potential for mobilisation of contaminated groundwater is considered to be remote and residual impacts associated with leaks or spills, drilling fluids or stockpiling are considered to be low to negligible. During operation, residual impacts associated with groundwater levels close to the trench and leaks and spills are considered to be low.