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ASSESSMENT REPORT:

Western Outer Ring Main – Surface Water and Groundwater desktop assessment

August 2019

Document history

Revision:

Revision no.	03
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Distribution:

Revision no.	03
Issue date	5 August 2019
Issued to	Mitchell Deaves Biosis
Description:	Final

Citation:

Please cite this document as:
Alluvium (2019). Western Outer Ring Main – Surface Water and Groundwater by Alluvium Consulting Australia for Biosis, 38 Bertie St, Port Melbourne VIC 3207

Ref:
R:\Work\2019\051_APA_Gas_Pipe_Surface_Groundwater_Assess\10_Project\1_Deliverables\0119051_Western_Outer_Ring_Main_EIS_Surface_and_Groundwater_v3.0.docx

Executive summary

Purpose of this report

For the Western Outer Ring Main (WORM) gas pipeline, Alluvium undertook this desktop review of surface and groundwater hydrology/hydrogeology. The review covered the Study Area (a 100m buffer along the Preliminary Pipeline Alignment (PPA)) with a focus on water quality, water levels shallow aquifers and possible flow paths that may intersect pipeline depth. The desktop review information was used to assess the potential impacts of the PPA, including:

- The potential impacts on surface water and groundwater beneficial uses from activities associated with the APA pipeline installation.
- The potential impact on regional groundwater resources.
- The potential for extensive or major effects on the health or biodiversity of aquatic, estuarine or marine ecosystems over the long-term.

Catchment and watercourses

The Study Area spans three main catchments: The Werribee River, Maribyrnong River and Yarra River. No watercourses are crossed by the PPA in the Werribee catchment. As mapped by the Department of Environment, Land, Water and Planning (DELWP), 7 watercourses are crossed in the Maribyrnong catchment and 14 in the Yarra catchment. There are 5 named watercourse crossings (as mapped by DELWP) along the PPA.

Flooding

1 in 100 year flood extent mapping was obtained from Melbourne Water, which is the same mapping that is used as the "Land Subject to Inundation Overlay" (LSIO) in planning layers. As can be expected, there are areas of inundation mapped immediately adjacent to watercourse crossings.

Groundwater

As the pipeline excavation and construction is shallow, only shallow aquifers have the potential to be impacted by the project and not regional groundwater resources.

Surface water

Surface water quality will potentially be impacted if adequate mitigation measures are not implemented. Any such impacts are likely to be limited in extent as the footprint of disturbance is small.

Potential impacts

Hydrologic and geomorphic processes

If appropriate mitigation measures are not applied, hydrological and geomorphic processes along the PPA have the potential to cause exposure of the pipeline at watercourse crossings, active floodplains and other areas at risk of erosion during the operational phase of the Project. Any exposure of the pipeline by such processes subsequently increases the potential for pipeline damage, primarily from impact by debris. Exposure of the pipeline due to such processes could also contribute to increased turbidity and sedimentation of waterways.

It is considered that potential impacts to the pipeline caused by such hydrological and geomorphic processes can be effectively mitigated by appropriate selection of the alignment and other mitigation measures during construction.

Surface water
The risk of impacts to surface water is low and likely to be localised and temporarily associated with the construction activities. Potential risks to surface water (including the mapped wetland) include:

- Run off/erosion of spoil (turbidity and organics)
- Influx of brackish groundwater to surface water systems (salinity)
  - during excavation
  - along the pipeline/gravel pit following completion (preferential flow path)
- Disturbance of stream bed or wetland bed – changes in surface water quality (localised)
- Disturbance of stream bed wetland bed– hyporheic flow disruption (localised)
- Disturbance of stream bed wetland – brackish groundwater influx (localised)
- Disturbance of farm dams where the PPA intersects

These potential impacts are most likely to occur near or at stream crossings, and where existing farm dams may be intersected. Also where shallow water tables occur, such as the area around the PPA in the north-west of the Merri Creek catchment, including the mapped wetland in the Merri Creek catchment (KP 44 to 45).

Groundwater and wetlands
The potential for impact on groundwater is very low for the following reasons:

- The activity of installing the pipeline will only intersect the shallowest aquifer, or potentially may not intersect any aquifer at all (depending on seasonal conditions).
- The groundwater resource in the areas is generally brackish, and the activity will not result in the addition of salts to the aquifer. Consequently, the beneficial use, which is defined by the groundwater salinity, is unlikely to be at risk.
- The activity does not involve depositing or releasing any potential contaminant to shallow aquifers

The predominant risk to groundwater from the activity is the potential to create preferential flow paths that may inadvertently change groundwater flow directions. The potential for this risk is likely to be higher where the water table is shallow, such as the wetlands around the PPA in the north-west of the Merri Creek catchment (approximately KP 40 to KP 45).

Mitigation measures

Hydrology and geomorphology
For the final design, this report identifies specific locations for further assessment for pipeline alignment design with consideration of the following:

- Where practical, using existing stable crossings
- Minimising the number of channels to be crossed (where a watercourse has more than one channel or where a tributary joins)
- Crossing on straight sections of channel and not on the outside of bends
- Minimising the disturbance of bed banks and riparian vegetation
- Avoiding permanent pools where practical
- Avoiding farm dams where practical

Along the alignment there is limited risk of scour at waterway crossings but crossing points seek to minimise any risk. During construction, the pipeline should be buried in bedrock (where depth to bedrock provides a practical option) or below mobile bed material where bedrock is not present. The depth to non-mobile bed material will require a geotechnical assessment at each major crossing.

The desktop assessment considered watercourses crossing points and provides site-specific mitigation recommendations.

Residual impacts

With the application of the mitigation measures described in Section 7, all residual impacts are considered to be low or very low.

Conclusions

Based on desktop assessment only and assuming that all proposed mitigation measures are applied, overall, the PPA will not present a significant risk to regional surface water or groundwater assets or associated beneficial uses. The construction activities associated with installing the pipeline will result in localised disturbances. These risks from the PPA to beneficial use 'water-dependent ecosystems protection and species' are considered to be low and localised. Risks to other beneficial uses are likely to be very minor due to the localised disturbance from the activity.

With the application of industry standard mitigation measures there should not be any significant impacts to the geomorphic stability or condition of waterways.

With regard to potential impacts to or from flooding, as the pipeline is to be buried and the existing ground surface reinstated and rehabilitated, there will be no adverse impacts.

Contents

Figures

Tables

Abbreviations

Alluvium	Alluvium Consulting Australia Pty Ltd
EQIOs	Environmental Quality Indicators and Objectives
LMP	Longford Melbourne Pipeline
PPA	Preliminary Pipeline Alignment
SEPP	State Environment Protection Policy
SWP	South West Pipeline
VNI	Victorian Northern Interconnect
VTS	Victorian Transmission System
WORM	Western Outer Ring Main – Referred to as 'the Project'

1 Project description and this report

The project description is provided in Biosis (2019a) "*WORM Project Description*" and readers are directed to that document for details.

1.1 This report

The Project requires referral under the *Environment Effects Act 1978*. Alluvium Consulting Australia Pty Ltd (Alluvium) has undertaken a desktop assessment for surface water and groundwater to support the referral, which is presented in this report.

This report describes:

- Project description and this report. The purpose of this report (Chapter 1)
- Legislative context. For water values in the study area (Chapter 2)
- Beneficial uses and environmental and water quality objectives (Chapter 3)
- Existing baseline data. Including hydrology and geomorphology, surface water quality, groundwater context and quality and flooding (Chapter 4)
- Hydrology and hydrogeology (Chapter 5)
- Impacts. Potential effects of the Project to hydrology and geomorphology, surface water quality, groundwater and flooding (Chapter 6)
- Mitigation measures. An assessment of whether mitigation of potential effects is possible and if so, what. (Chapter 7)
- Residual impacts and conclusions. Impacts after mitigation measures, and conclusions (Chapter 9).

1.2 Objective of study

Alluvium undertook a desktop review of surface and groundwater hydrology/hydrogeology of the Study Area (a 100m buffer along the Preliminary Pipeline Alignment (PPA)) with a focus on water quality, water levels shallow aquifers and possible flow paths that may intersect pipeline depth. The desktop review information was used to assess the potential impacts of the PPA, including:

- The potential impacts on surface water and groundwater beneficial uses from activities associated with the APA pipeline installation.
- The potential impact on regional groundwater resources.
- The potential for extensive or major effects on the health or biodiversity of aquatic, estuarine or marine ecosystems over the long-term.

1.3 Assumptions

Groundwater Dependant Ecosystems (GDEs) are covered under a separate report (Biosis 2019b) "*WORM – Desktop Biodiversity Assessment*". This assessment did not assess any long-term effects on surface or groundwater beneficial uses associated with the pipeline post installation/completion such as operational activities. This assessment also assumes that APA does not intend to discharge any waste-water or groundwater to streams during the course of the pipeline installation activity.

2 Legislative context

This section details legislation for the State of Victoria that may be relevant to geomorphology, water quality and groundwater.

2.1 Environmental Protection Act 1970

The *Environmental Protection Act 1970* (EPA 1970) provides the statutory basis and framework for planning and environmental assessment in Victoria. The *EPA 1970* includes provisions to ensure the potential environmental impacts of a development are assessed and considered in the decision-making process.

The *State Environment Protection Policy (Waters)* (The SEPP (Waters)) is subordinate legislation of the EPA 1970 that provides the framework for protecting and improving Victoria's surface and groundwaters. This includes provisions for the protection of beneficial uses of surface and groundwater assets and associated environmental and water quality objectives.

2.2 Water Act 1989

Approval and/or Permits to construct (Works on Waterways License) are expected to be required from Port Philip and Westernport CMA for the crossing of all designated waterways along the PPA. The entire PPA (and Study Area) lies within this CMA.

3 Beneficial uses and environmental and water quality objectives

3.1 Introduction to beneficial uses of waters and water quality objectives

The SEPP (Waters) has identified the beneficial uses for both surface water and groundwater in Victoria and associated environmental quality indicators and objectives (EQIOs) required to be met in order to protect beneficial uses. These beneficial uses and EQIOs are specified for particular categories for surface water, and for groundwater, which the SEPP (Waters) referred to as "segments": the waters to which the beneficial uses and EQIOs of the SEPP (Waters) applies.

3.2 Surface water

With regard to assessing the impacts of the PPA on surface water and groundwater, there are four relevant segments prescribed under the SEPP (Waters):

1. The Central Foothills and Coastal Plains segment: a spatial segment pertaining to rivers and streams in a particular geographic area.
2. The Urban segment - the areas within the urban growth boundary for Metropolitan Melbourne.
3. Wetlands segment: a spatially defined segment pertaining to wetlands as defined as palustrine and lacustrine in the Victorian Wetlands Inventory.
4. Aquatic Reserve, where Aquatic Reserves are defined as rivers, streams or wetlands occurring within gazetted reserves in any geographical segment prescribed under the SEPP (Waters), and approved under various Victorian legislation, as follows:
    i. nature conservation reserves reserved or approved by Order of the Governor in Council for public purposes or the conservation of their natural values under the Crown Land (Reserves) Act 1978;
    ii. State Wildlife Reserves under the Wildlife Act 1975;
    iii. reference areas proclaimed under the Reference Areas Act 1978; areas listed in Schedules 2,4,7 and 8 to the National Parks Act 1975;
    iv. fisheries reserves declared under section 88 of the Fisheries Act 1995.

3.2.1 Beneficial uses

Beneficial uses for surface water in the Central Foothills and Coastal Plains, Urban Wetlands and Aquatic reserve segments are outlined in Table 1. For the purposes of the SEPP (Waters), water-dependent ecosystems and species of surface waters occurring in the Aquatic Reserves are considered to be largely unmodified.

Table 1. Beneficial uses for surface water segments defined under the Victorian SEPP (Waters)

Beneficial Use	Beneficial use purpose or intent (as defined in the SEPP (Water)	Central Foothills and Coastal Plains	Urban	Wetlands	Aquatic Reserves
Water dependent ecosystems and species	Water quality that is suitable to protect the integrity and biodiversity of water dependent ecosystems, including: • the protection of the integrity of riparian vegetation and bank stability; • that groundwater quality does not adversely affect surface waters; • that groundwater quality supports ecosystems that require groundwater to support all or some of their ecosystem function; • the maintenance of fish passage	Slightly to moderately unmodified	Highly modified	Slightly to moderately unmodified	Largely unmodified
Human consumption after appropriate treatment	Water quality that is suitable for use by drinking water suppliers after appropriate treatment as drinking water and for delivery to consumers. Relevant where water is sourced from a water supply catchment designated under the Catchment and Land Protection Act 1994 or the Safe Drinking Water Act 2003	The Study Area does not intersect any Declared Water Supply Catchments			
Agriculture and irrigation	Water quality that is suitable for agricultural activities such as stock watering and irrigation, as well as a range of other uses such as the irrigation of domestic gardens, commercial agriculture, parks and golf courses.	✓	✓	✓	
Human consumption of aquatic foods	Water quality that is suitable for the safe human consumption of fish and any other aquatic plant, algae or invertebrate.	✓	✓	✓	✓
Aquaculture	Water quality that is suitable for the production of fish for human consumption via aquaculture.	Where suitable water quality exists and an approval issued under Fisheries Act 1995			
Industrial and commercial	Water quality that is suitable for industrial and commercial use.	✓	✓		
Water-based recreation (primary and secondary contact, and aesthetic enjoyment)	Water quality that is suitable for primary contact recreation (e.g. swimming, diving, water skiing, caving and spas), secondary contact recreation (e.g. boating and fishing) and for aesthetic enjoyment.	✓	✓	✓	✓

Traditional Owner cultural values	Water quality that protects the cultural values of Traditional Owners, having recognised primary responsibility for protecting the values of water for cultural needs, to ensure that Traditional Owner cultural practices can continue. Values may include traditional aquaculture, fishing, harvesting, cultivation of freshwater and marine foods, fish, grasses, medicines and filtration of water holes.	✓	✓	✓	✓
Cultural and spiritual values	Water quality that is suitable for cultural and spiritual needs and that will ensure that cultural, spiritual and ceremonial practices can continue. These include the cultural values held by communities (e.g. baptisms, water-based festivals and cultural celebrations).	✓	✓	✓	✓

3.2.2 Environmental quality indicators and objectives

Under the SEPP (Waters), EQIOs are used to assess risk to the identified beneficial uses. For surface water quality, including wetlands, EQIOs are prescribed for physical and chemical water quality parameters in water as well as toxicants in sediments and water, and for biological indicators. For groundwater, the SEPP (Water) prescribes descriptive EQIOs for the protection of beneficial uses.

For surface waters, including wetlands, the SEPP (Waters) adopts the risk-based approach provided in the ANZECC Guidelines for developing and applying the EQIOs. This risk-based approach recognises that individual water quality measurements may vary in space and time. The approach moves on from previously-adopted approaches that define a single trigger value. Instead, the risk-based approach adopted by Victoria applies upper and lower limits that are derived from particular percentiles of a previously measured data set (minimum of 11 samples over 12 months). For surface water quality, the 25th and 75th percentiles are generally adopted as the EQIOs, but some exceptions occur

In the event that EQIOs are not attained, the SEPP (Waters) requires that an investigation is triggered in order to assess the risks to beneficial uses. According to the SEPP (Waters) this investigation should follow the risk-based approach outlined in the ANZECC Guidelines. The EPA Victoria has developed a guideline for assisting in designing and implementing these investigations in accordance with the ANZECC Guidelines and the SEPP (Waters): *Risk-based assessment of ecosystem protection in ambient waters*.

3.3 Groundwater

Under the SEPP (Waters) groundwater segments are defined according to the background level of total dissolved solids (TDS) in mg/L (Table 2). This classification of groundwater segments means that local knowledge is required to understand the specific segments that are relevant to a certain area/activity, and that the relevant segment may change spatially or with depth.

Table 2. Groundwater segments defined under the Victorian SEPP (Waters)

Segment	A1	A2	B	C	D	E	F
TDS range mg/L	0-600	601-1200	1,201-3,100	3,101-5,400	5,401-7,100	7,101-10,000	>10,000

3.3.1 Beneficial uses and Environmental quality indicators and objectives

Beneficial uses of groundwater under the Victorian SEPP (Waters) are identified for each of the groundwater segments (Table 3). In addition to beneficial uses for water dependent ecosystems, beneficial uses of groundwater reflect particular anthropogenic uses and values of groundwater, as well as infrastructure requirements for groundwater quality. Unlike for surface waters, the Victorian SEPP (Waters) states that there is insufficient data available in Victoria to quantify local EQIOs for the relevant beneficial uses of groundwater segments. Instead, EQIOs are descriptive and based on relevant policies and/or guidelines.

Table 3. Beneficial uses for groundwater segments defined under the Victorian SEPP (Waters)

Beneficial use	Groundwater segment							Environmental quality indicators and objectives
	A1	A2	B	C	D	E	F	
Water dependent ecosystems and species	✓	✓	✓	✓	✓	✓	✓	• Groundwater must not cause receiving waters to be affected to the extent that the level of any environmental quality indicator is greater than the level of that indicator specified for surface waters in the SEPP (Waters); and • Groundwater quality must not adversely affect the maintenance of environmental values that depend on groundwater.
Potable water supply (desirable)	✓							• Groundwater must not be affected to the extent that the level of any environmental quality indicator is greater than the health-related guideline value for that indicator as specified in the Australian Drinking Water Guidelines; and • The constituents of groundwater must not be affected in a manner or to an extent that leads to an aesthetic guideline value being exceeded, as defined in the Australian Drinking Water Guidelines.
Potable water supply (acceptable)		✓						• Groundwater must not be affected to the extent that the level of any environmental quality indicator is greater than the health-related guideline value for that indicator as specified in the Australian Drinking Water Guidelines; and • The constituents of groundwater must not be affected in a manner or to an extent that leads to an aesthetic guideline value being exceeded, as defined in the Australian Drinking Water Guidelines.
Potable mineral water supply	✓	✓	✓	✓				• Groundwater must not be affected to the extent that the level of any environmental quality indicator is greater than the level of that indicator specified in the Australia New Zealand Food Standards Code – Standard 2.6.2 – Non-alcoholic beverages and brewed soft drinks; and • The constituents of groundwater must not be affected in a manner or to an extent that leads to an aesthetic guideline value being exceeded, as defined in the Australian Drinking Water Guidelines.

<table>
<tr><th rowspan="2">Beneficial use</th><th colspan="7">Groundwater segment</th><th rowspan="2">Environmental quality indicators and objectives</th></tr>
<tr><th>A1</th><th>A2</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td>Agriculture and irrigation (irrigation)</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td><td>Groundwater must not be affected to the extent that the level of any environmental quality indicator is greater than the level of that indicator specified for irrigation in the ANZECC Guidelines.</td></tr>
<tr><td>Agriculture and irrigation (stock watering)</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td><td>Groundwater must not be affected to the extent that the level of any environmental quality indicator is greater than the level of that indicator specified for livestock in the ANZECC Guidelines.</td></tr>
<tr><td>Industrial and commercial</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td>Groundwater must not be affected to the extent that industrial or commercial water quality is impacted.</td></tr>
<tr><td>Water-based recreation (primary contact recreation)</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>• microbial water quality must not be affected to the extent that the environmental quality indicator of E. coli is greater than 10 E. coli/100 mL;
• when human faecal contamination sources have been identified no E. coli must be present; and
• any other water quality indicator must not be greater than the level of that indicator specified for water-based recreation for surface waters in this Policy.</td></tr>
<tr><td>Traditional Owner cultural values</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td rowspan="2">No EQIOs prescribed by the SEPP (Waters)
Where environmental quality indicators and objectives specified for other beneficial uses do not adequately protect cultural and spiritual values or Traditional Owner cultural values then the SEPP (Waters) states that contamination must not cause a risk to the beneficial uses, and the environmental quality objective for that indicator becomes:
a) the levels specified in the ANZECC Guidelines; or
b) the investigation level specified for groundwater in the National Environment Protection (Assessment of Site Contamination) Measure; or
c) levels derived for groundwater using a risk assessment methodology set out in the National Environment Protection (Assessment of Site Contamination) Measure.

Traditional Owners should be engaged in the development of environmental quality indicators or objectives through local management and planning processes for waterways and catchments.</td></tr>
<tr><td>Cultural and spiritual values</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Buildings and structures</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>✓</td><td>• introduced contaminants must not cause groundwater to become corrosive to structures or building materials; and
• specific indicators include pH, sulphate, chloride, redox potential, salinity or any chemical substance or waste that may have a detrimental impact on the structural integrity of buildings or other structures.</td></tr>
</table>

Beneficial use	Groundwater segment							Environmental quality indicators and objectives
	A1	A2	B	C	D	E	F	
Geothermal properties	✓	✓	✓	✓	✓	✓	✓	• introduced contaminants must not cause groundwater to become corrosive to structures or building materials; and • specific indicators include pH, sulphate, chloride, redox potential, salinity or any chemical substance or waste that may have a detrimental impact on the structural integrity of buildings or other structures.

4 Existing baseline data

4.1 Data availability

The desktop assessment was conducted via analysis of aerial imagery, geology, hydrology information and available relevant existing reports. The following table lists the GIS data and information used to inform the assessment.

Table 4. GIS data and information used in the assessment

Data/ information	Details
The PPA and Study Area	GIS shapefiles "Preliminary_pipeline_alignment" "PPA_KPs" and "Study_area" provided by Biosis
Aerial photography	Recent aerial photographs from November 2017 covering the Study Area (ARC ESRI)
Geology	Geology (DEDJTR GSV) layer provided by Geoscience Victoria and accessed through Visualising Victoria's Groundwater (http://www.vvg.org.au/)
Hydrology	GIS shapefile "hy_watercourse", part of DELWP's Vicmap Hydro contains line features delineating hydrological features, i.e. channels, rivers & streams
Flooding	GIS shapefile "Flood_Extent_100yr_Waterways", Melbourne Water flood overlay.
Catchments	GIS Shapefile "AHGFCatchment", part of the Bureau of Meteorology's Australian Hydrological Geospatial Fabric (Geofabric)
Wetlands	GIS shapefile "wetlanddir", part of Department of Environment and Primary Industries Directory of Important Wetlands in Australia (DIWA). GIS shapefile "ramsar_wetlands" http://www.environment.gov.au GIS shapefile "Wetland current", part of DELWP's Vicmap.
Geomorphology	GIS shapefile "gmu25", part of Department of Economic Development, Jobs, Transport and Resources directory of soil-landform and geomorphology assessments.

4.2 Use of data

The data has been used to assess surface and groundwater attributes that could potentially be impacted by the PPA, including:

- geomorphology of waterways
- wetlands
- surface water quality
- groundwater depth (potential interaction with the Project) and groundwater water quality

These attributes are detailed in the following sections.

4.3 Catchments and waterways

5.3.1 Catchments

The Study Area spans three main catchments: The Werribee River, Maribyrnong River and Yarra River (see Figure 1). No watercourses are crossed by the PPA in the Werribee catchment. As mapped by the Department of Environment, Land, Water and Planning (DELWP), 7 watercourses are crossed in the Maribyrnong catchment and 14 in the Yarra catchment. There are 5 named watercourse crossings (as mapped by DELWP) along the PPA.

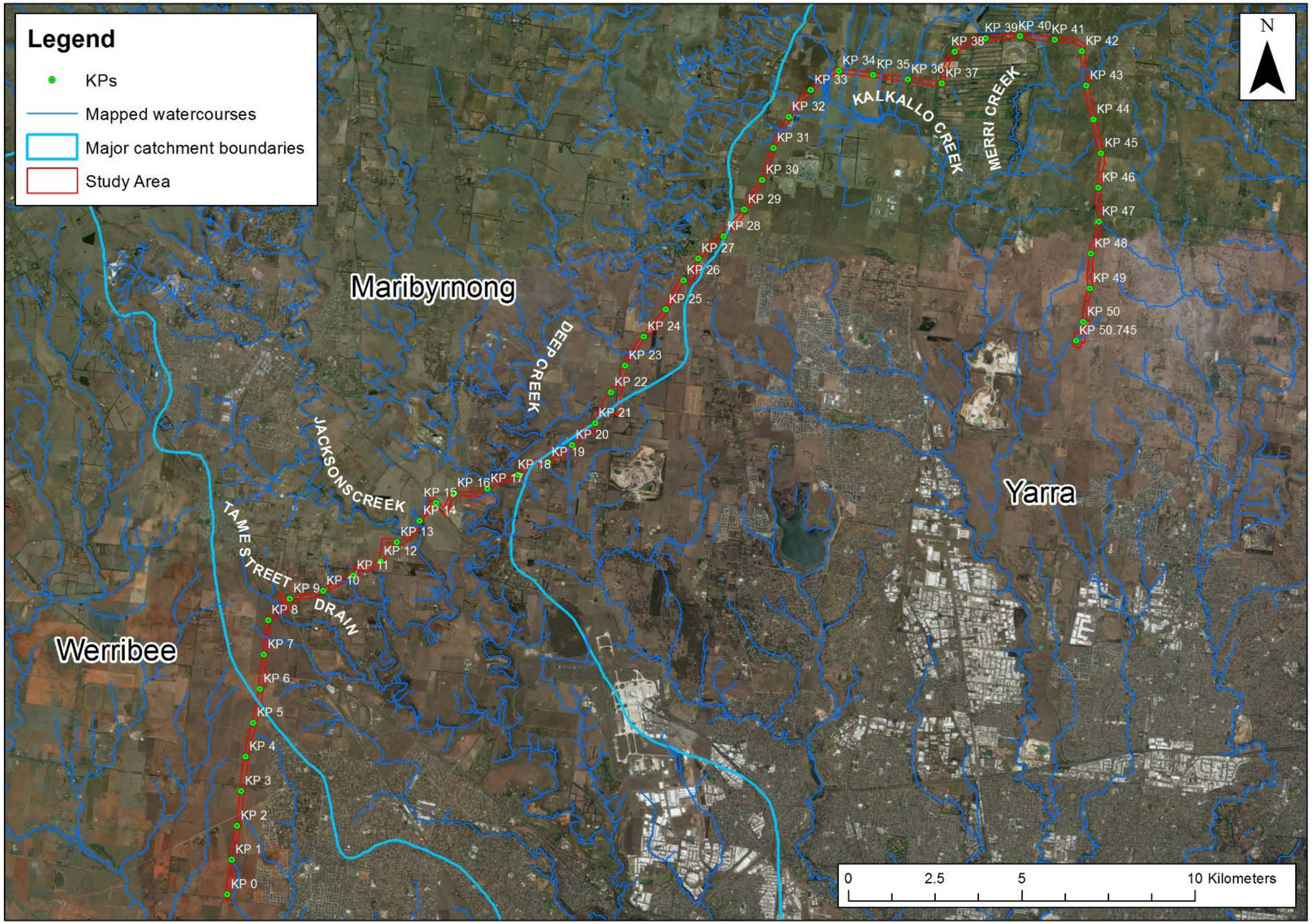

Figure 1. *Major catchments and major watercourse crossings*

5.3.2 Stream orders

Strahler's (1952) stream order system is a simple method of classifying stream segments based on the number of tributaries upstream. A stream with no tributaries (headwater stream) is considered a first order stream. A segment downstream of the confluence of two first order streams is a second order stream. Thus, a n^{th} order stream is always located downstream of the confluence of two $(n-1)^{th}$ order streams[1]. An example is shown in Figure 2. The stream order was manually assessed, for streams crossed by the Study Area, for all stream orders up to 3rd order, beyond which all watercourses are considered to require additional consideration and assessment – the category is titled 3rd order and greater. There are 13, 1st order, 3, 2nd order and 5, 3rd order and greater watercourses crossed by the Study Area.

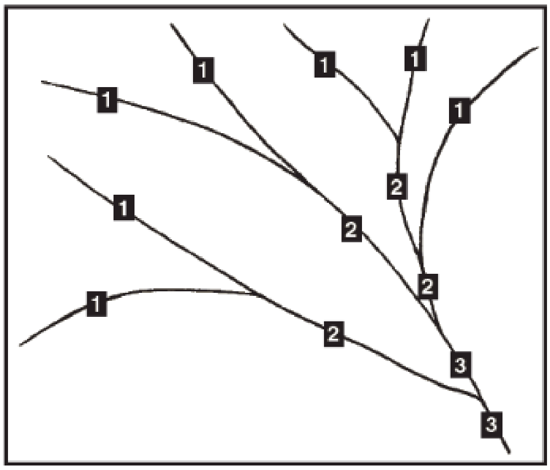

Figure 2. *Strahler stream ordering example (NSW, Office of Water, 2012a)*

Table 5. Watercourse crossing points and stream order

Watercourses and crossing points	Stream order	Catchment
KP 7.5	1st	Maribyrnong
KP 8.4 Tame Street Drain	2nd	Maribyrnong
KP 9.9	1st	Maribyrnong
KP 10.6	1st	Maribyrnong
KP 13.8: Jacksons Creek	>3rd	Maribyrnong
KP 17.1: Deep Creek	>3rd	Maribyrnong
KP 19.8	1st	Yarra
KP 23.4	1st	Maribyrnong
KP 31.5: Crosses 2 watercourses	1st	Yarra
KP 32.3	1st	Yarra
KP 33.5 to 33.7: Crosses 3 watercourses	1st	Yarra
KP 34.2: Kalkallo Creek	>3rd	Yarra
KP 34.5	2nd	Yarra
KP 35.2	2nd	Yarra
KP 35.8	3rd	Yarra
KP 40.5	1st	Yarra
KP 42.5: Merri Creek	>3rd	Yarra
50.4	1st	Yarra

[1] http://www.geog.soton.ac.uk/users/WheatonJ/Definitions/QD0109.htm - accessed 18 July 2017. Strahler, A. N. (1952). Dynamic basis of geomorphology. Geological Society of America Bulletin, 63, 923-938.

5 Hydrology and hydrogeology

5.1 Regional setting

As described in Section 4.3, the Study Area lies within three drainage basins:

1. Werribee Basin (tributaries of Kororoit Creek);
2. The Maribyrnong Basin (Jacksons and Deep Creeks); and
3. Yarra Basin (Merri Creek).

All of these drainage basins discharge to Port Phillip Bay.

5.2 Surface geology and hydrogeology overview

Surface geology in the Port Phillip Bay area, particularly in the area where the Study Area occurs, is dominated by the basalt extrusions of the Newer Volcanics. The Study Area also traverses, or passes near minor outcrops of the Paleozoic sediments of the Humevale Siltstone where the alignment crosses Deep Creek and the Deep Creek Siltstone in the northwest of the Merri Creek catchment. In the north of the Merri Creek catchment, the alignment also traverses an outcrop of Quaternary alluvium, comprising gravels and sands.

The Newer Volcanic comprises discontinuous beds of unconfined and confined aquifer layers. Hydraulic conductivity of the Newer Volcanic aquifers is highly variable, ranging from 10^{-3} m/d to 10^{2} m/d in open fractures. In some areas the basalt outcrop has weathered to form thick, clay soils, with hydraulic conductivity ranging from 10^{-6} m/d to 10^{-2} m/d. Groundwater flow in these volcanic aquifers are both locally and regionally important, although the low hydraulic gradient infers relative slow groundwater flow paths compared to steeper areas of the catchments upstream. Groundwater in these aquifers is brackish, ranging from 2000 mg/L to 10,000 mg/L. Groundwater extraction from these aquifers occurs mainly for stock and domestic use.

In some areas the brackish groundwater of the Newer Volcanic aquifers discharges to surface expressions, including depressions, swamps and streams. Conceptually, these relative shallow aquifers are considered to drain to low elevation points in streams and gullies. While regional water table elevation mapping indicates that underlying most of the Study Area the water table depth is 5m or greater in some areas, in other areas the water table is considered to be at least equal to the stream elevation and in other areas may be shallower than 2 m and, at times, be expressed at the surface or discharge to shallow drainage features. Similar elevations of the streams and shallow groundwater infer a conceptual gaining-stream scenario that is consistent across the Study Area. It infers that, in addition to the Newer Volcanics, groundwater in the Paelozoic siltstones and Quaternary alluvium are also likely be discharging to streams and other surface water expressions in some areas. There are no specific studies that identify the extent (rate and quantity, or seasonal variability) of gaining-stream scenarios across these basins. Given that that the Newer Volcanics comprise a series of discontinuous layers of basalt deposits with varying hydraulic conductivity, there is potential for shallow (< 5m) perched water tables in this outcrop that are not mapped by regional water table elevation.

5.3 Resources used to assess surface and groundwater quality

The following resources were used to assess existing surface and groundwater quality in the study area:

- Melbourne Water's water quality data sets and associated catchment resources under the river health monitoring program
- Victorian Environmental Protection Authority (EPA) water quality monitoring data sets and associated report cards
- Victoria Digital Elevation Model (DEM)
- Watercourse Network 1:25,000 - Vicmap Hydro
- Victorian Wetland Inventory
- Merri Creek Management Committee, 2009, Merri Creek and Environs Strategy 2009-2014, Merri Creek Management Committee, May 2009.

- Gippel, C,G. and Walsh C. J., 2000. *Geomorphology of the Maribyrnong River Victoria*, Report prepared by Fluvial Systems Pty Ltd for Melbourne Water Waterways and Drainage Group, East Richmond, VIC.
- Victorian governments groundwater GIS spatial layers available on https://discover.data.vic.gov.au/, including the following layers:
  - Watertable Depth to Groundwater
  - Watertable Salinity
  - State wide groundwater data set (bore locations and information)
  - Watertable Elevation Surface
  - Geological polygons (1:250,000)
- Groundwater and geology reference material including:
  - Department of Environment, Land, Water and Planning's (DEWLP) Groundwater Resource Reports for West and East Port Phillip Bay.
  - GHD, 2010, *Report for Port Phillip CMA: Groundwater Flow Modelling Report for Department of Sustainability and Environment*, May 2010.
  - Dahlhaus P.G., Heislers D.S., Brewin D., Leonard J.L., Dyson P.R. & Cherry D.P., (2004), *Port Phillip and Westernport Groundwater Flow Systems,* Port Phillip and Westernport Catchment Management Authority, Melbourne, Victoria.
  - Golder Associates, 2016, *Beveridge Central Preliminary Salinity Assessment*, Report No. 1539872-001-R-Rev1, 2 March 2016.
  - SKM, 2009, *Melbourne Groundwater Directory*: *Methods Report (Final)*, SKM, 4 September 2009.

No monitoring bores were available 200m either side of the Study Area to provide indicative groundwater levels or salinity at the local-scale. Subsequently, the GIS spatial data outlined above was used as the reference information.

5.4 Kororoit Creek catchment (Werribee Basin)

Kororoit Creek is a major waterway in the Melbourne metropolitan area and discharges directly to Port Phillip Bay in the north of the Werribee Basin. The majority of the Kororoit Creek catchment is subject to urban and/or agricultural land use pressures. Stream flow is harvested from the major channels to service urban and agricultural water demands. There are a number of palustrine and lacustrine wetlands, particularly in the mid-reaches of the catchment where Metropolitan urban fringe occurs.

Melbourne Water monitors water quality at two sites in the Kororoit Creek; the closest to the Study Area being site WBKOR0227, (~10 km downstream of the Study Area at Millbank Drive Deer Park). This site is downstream of the Study Area in an urbanised area. The most recent report card (2016-2017) classified the water quality index at this site as being poor. Monitoring records since 2000 show that the water quality index at this site has historically been very poor to fair for the majority of years, with a general trend from 2012 towards fair. Given the distance from the Study Area, the occurrence of this monitoring station in an urban area, and that the Study Area occurs in the tributaries of Kororoit Creek upstream, this monitoring site provides general background information on Kororoit Creek only and is unlikely to be informative for site assessments.

Instream macroinvertebrates, fish and amenity are considered to be in low, moderate and moderate condition, respectively. However, despite this the streams and wetland systems support a diverse range of frog and waterway-dependent bird species.

The Study Area is closest to Kororoit Creek at the southern tip, where it is approximately 1.8 km from the main channel of Kororoit Creek, near the metropolitan urban fringe. The Study Area does not intersect any tributaries of Kororoit Creek in the catchment, however there are a number of nearby wetlands, including instream lacustrine and palustrine wetlands and ephemeral freshwater meadows and marshes, in the downstream reaches of these tributaries.

The regional water table elevation mapping indicates that the water table underlying the Study Area in Kororoit Creek catchment is estimated to be greater than 5 m, with the shallowest surfaces occurring near tributaries. The groundwater salinity in this area is mapped as being brackish to saline (total dissolved solids =

13,000 – 35,000 mg/L). This indicates that the relevant groundwater segments are segments D-F, depending on local conditions.

In the Kororoit Creek catchment, the Study Area occurs within the urban growth boundary for Metropolitan Melbourne, and consequently the surface water EQIOs for the urban segment in the Werribee Basin, under the Victorian SEPP (Waters) apply (Table 6).

Table 6. Surface water environmental and water quality indicator objectives for Kororoit Creek.

Segment	Environmental quality indicator / objective									
	Total P (µg/L)	Total N (µg/L)	DO (% conc.)		Turb. (NTU)	EC µS/cm	pH		Toxicants of water	Toxicants of sediments
	75th %-ile	75th %-ile	25th %-ile	Max	75th %-ile	75th %-ile	25th %-ile	75th %-ile	% protection	
Urban (*highly modified)* – tributaries of the Werribee Basin	≤110	≤1,200	≥60	130	≤30	≤3,000	≥6.5	≤8.2	90	Low

5.5 Maribyrnong Catchment

In the Maribyrnong catchment the alignment traverses the Jacksons and Deep Creeks, which are major tributaries of the upper Maribyrnong River. The water quality of these streams are impacted by both urban and agricultural land-use pressures. Stream flow in the catchment is harvested primarily for drinking water supply for local government or Melbourne Water, although some take is also authorised for agricultural purposes.

The nearest water quality monitoring stations in Jacksons Creek (from the PPA) are MAJAC0342 (~15 km upstream of the Study Area at Sunbury) and MAJAC0398 (~15 km downstream of the PPA in Organ Pipes National Park). The most recent report card classified the water quality index at these sites as fair condition. At MAJAC0342 (upstream of the Study Area at Sunbury) there has been a general improvement in the water quality index from poor to fair. Despite pH and metals historically occurring within healthy ranges, turbidity, salinity, nutrients and dissolved oxygen parameters are typically poor, resulting in the fair classification in the recent report card. At MAJAC0398 (downstream of the Study Area in Organ Pipes National Park), salinity is often within healthy ranges, yet high turbidity and nutrient concentrations affect the overall water quality index classification. Changes in particular water quality parameters between these sites highlights spatial variability of water quality and stream health, and while overall water quality index is fair, specific water quality conditions at the site where the Study Area crosses are not available for this desktop assessment.

At Deep Creek, the nearest water quality monitoring station is MADEE0868 (~5 km downstream of the PPA). The water quality index for the most recent report card (2016-2017) is ranked as fair, with high nutrient concentrations being poor, and salinity, turbidity and dissolved oxygen being fair. The nearest upstream site is MADEE0625 in deep creek is MADEE0625; however, this site is over 20 km upstream and unlikely informative of water quality characteristics at the PPA stream crossing. In any case, data for this site is not available since 2016.

Following ongoing catchment monitoring, Melbourne Water currently classify the key values of native fish species, riparian vegetation and waterway dependent bird species as low in the Maribyrnong catchment, but the waterways support a high diversity of frog species.

With the exception of the crossings at Jacksons and Deep Creeks, the water table elevation underlying the Study Area in the Maribyrnong catchment is mapped as exceeding 10 m. At the stream crossings, water table elevation mapping indicates groundwater is likely to be shallow (< 2m) and possibly presenting as a surface expression and/or discharging to the stream. At these stream crossing, the surface geology is the New Volcanics (Jacksons Creek) and Deep Creek Siltstone (Deep Creek). At the Jacksons Creek stream crossing, the regional hydraulic gradient is mapped as low. Where the PPA crosses the neighbouring Deep Creek, the Paleozoic sediments of the Deep Creek Siltstone are exposed along the alluvial valley. The hydraulic gradient of groundwater along this stretch of the stream is low to moderate which would contribute to a gaining stream scenario in stretch of the stream where water table elevation is high. The groundwater salinity in this area is mapped as being brackish to saline (total dissolved solids = 7,000 - 13,000 mg/L). This indicates that the relevant groundwater segments are segments D-E, depending on local conditions (see Table 72).

The Study Area does not occur in the urban growth boundary for Metropolitan Melbourne. As a result, the beneficial uses and EQIOs for the lowlands (< 200 m) of Maribyrnong Basin apply to these surface waters near/at the PPA crossing (Table 7).

Table 7. Environmental and water quality indicator objectives for surface water Jacksons and Deep Creeks, relative to the position of the PPA in the catchment.

Segment	Environmental quality indicator / objective									
	Total P (µg/L)	Total N (µg/L)	DO (% conc.)		Turb. (NTU)	EC µS/cm	pH		Toxicants of water	Toxicants of sediments
	75th %-ile	75th %-ile	25th %-ile	Max	75th %-ile	75th %-ile	25th %-ile	75th %-ile	% protection	
Lowlands of Barwon, Moorabool, Werribee and Maribyrnong basins and the Curdies and Gellibrand Rivers	≤60	≤1,100	≥70	130	≤25	≤2,000	≥6.8	≤8.0	95	Low

5.6 Merri Creek Catchment (Yarra Basin)

Merri Creek is a major tributary of the Yarra River. The catchment is subjected to a number of land use pressures, predominantly urban and agriculture. Most of Merri Creek Catchment, including the area where the Study Area occurs, is situated within the urban growth boundary for Metropolitan Melbourne, and consequently beneficial uses and EQIOs for urban segments under the SEPP (Waters) apply. In addition, to urban and agricultural land-use pressures, Merri Creek is also affected by water diversions. Combined these pressures have had an impact on water quality in the catchment.

The nearest EPA monitoring station is YAMER0195 (> 15 km downstream of the Study Area crossing at Craigieburn). Since 2000, the water quality index at this site has been consistently classified as poor to very poor, with salinity, turbidity, nutrients and pH being major water quality issues. However, given this site is a considerable distance from the Study Area stream crossing, stream and water quality conditions may be different to the monitoring site YAMER0195. Melbourne Water's stream health monitoring ranked a number of key values, including native fish population (moderate), native frog biodiversity (high), macroinvertebrates and water bird populations (low).

The Study Area traverses Merri Creek in the north, and prior to the stream crossing traverses an area where a number of tributaries and wetlands occur in the east of the Merri Creek catchment. The surface geology in this area is dominated by Quaternary gravels and sands. The area was previously a swamp (Inverloch swamp), but many of these were drained during agricultural development of the area post European settlement. While the Study Area does not traverse any mapped wetlands in this area, the water table elevation is mapped as being near or at land surface elevation. In this area, the Study Area traverses a series of agricultural surface drains (earthen) as well as ephemeral minor streams for approximately 11 km, prior to the alignment heading south towards Merri Creek. Along this section the Study Area traverses ~2.5 km of the Quaternary alluvial gravels and sands, the remainder of which overlies the Newer Volcanics.

The drains are mapped as minor watercourses and discharge to the minor tributary of Kalkallo Creek. Although aerial images suggest surface flow in these drains is ephemeral, the water table elevation and vegetation surrounding some of these drains suggest groundwater discharges, at least intermittently, to these lower elevation drains. At numerous minor stream crossings, as well as Merri Creek stream crossing, the water table elevation is also high suggesting periodic discharge of groundwater to streams. A number of mapped wetlands occur in this area near the Study Area, including remnants of the Inverlochy swamp. Upper reaches of Merri Creek, north of Craigieburn, where the Study Area occurs provide drought refuges, with stream flow in some areas continuing during drought periods indicating high likelihood of a groundwater baseflow. Groundwater seeps in some areas, including the Kalkallo Creek subcatchment, are known to contribute to dryland salinity, and in some areas salt tolerant wetland vegetation species are naturally established.

Groundwater salinity in this area is mapped as ranging from ~3,500 mg/L to 7,000 mg/L where the Quaternary gravel and sands outcrop, and ~3,500 mg/L where the Newer Volcanics outcrop. This indicates that the relevant groundwater segments are segments D-F, depending on local conditions (see Table 2). The hydraulic conductivity of the sands and gravel of the Quaternary alluvial deposits can be as high as 100 m/d, indicating the potential for rapid groundwater flow, relative to other shallow aquifers, although the hydraulic gradient, in a regional context is has been categorised as low.

South of the Merri Creek stream crossing the alignment traverses a mapped wetland in the Victorian Wetland Inventory as a periodically inundated freshwater marsh or meadow (palustrine wetland). In this area the mapped water table elevation is shallow ~2-4 m and given a temporary wetland occurs in this area, groundwater-surface water connectivity is likely during wet periods (see Section 5.9).

To the south of this wetland, the alignment roughly follows the catchment boundary between Merri Creek and Darebin Creek catchment. Water table elevation at two minor stream crossings, including one minor stream in the headwaters of the Darebin catchment, are similar to the land surface elevation. The shallow groundwater in this area is likely seeping to these minor streams, particularly in wet periods. Groundwater salinity is similar for other parts of the Newer Volcanic aquifers in the Merri Creek catchment

Most of the Merri Creek catchment, including the area where the Study Area occurs, is within the urban growth boundary for Metropolitan Melbourne, and consequently the surface water EQIOs for the urban segment in the tributaries of the Yarra River apply, under the Victorian SEPP (Waters) apply (Table 8).

Table 8. Environmental and water quality indicator objectives for surface waters of Merri Creek within the urban growth boundary for Metropolitan Melbourne.

Segment	Environmental quality indicator / objective									
	Total P (µg/L)	Total N (µg/L)	DO (% conc.)		Turb. (NTU)	EC µS/cm	pH		Toxicants of water	Toxicants of sediments
	75^{th} %-ile	75^{th} %-ile	25^{th} %-ile	Max	75^{th} %-ile	75^{th} %-ile	25^{th} %-ile	75^{th} %-ile	% protection	
Urban (*highly modified)* – tributaries	≤60	≤1,100	≥70	130	≤25	≤2,000	≥6.8	≤8.0	95	Low

of the Yarra River									
Wetlands	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	95	Low

5.7 Flooding

1 in 100 year flood extent mapping was obtained from Melbourne Water, which is available for the whole alignment route. This is the same mapping that is used as the "Land Subject to Inundation Overlay" (LSIO) in planning layers. As can be expected, there are areas of inundation mapped immediately adjacent to watercourse crossings. Where this is considered of significance to the assessment, details are provided for the individual crossing points in Section 5.8.

5.8 Geomorphology

5.8.1 Bedrock

The presence of shallow bedrock can also be a mitigating factor limiting the potential for channel change. However, the desktop assessment is not able to identify the likelihood of this occurrence at, or near the waterway crossings, although there is some potential for rock in localised areas along the Study Area. No account for this is included in this assessment.

5.8.2 Geomorphic values and threats

Tame Street Drain (KP8.4)

The Tame Street Drain is a 2nd order stream at the point where the Study Area crosses, south of Diggers Rest (Figure 3). The creek then flows in a predominantly southerly direction where it joins the Maribyrnong River. The Tame Street Drain catchment upstream of the pipeline crossing is made up of basalt from the Western Volcanic Plains and the soils have a very low soil erosion susceptibility index in gullies. The relevant planning zones that the pipeline crossing sits in a Green Wedge Zone in the Melbourne Airport Environs Overlay.

The 1 in 100 year flood extent inundates approximately 80 metres of the Study Area.

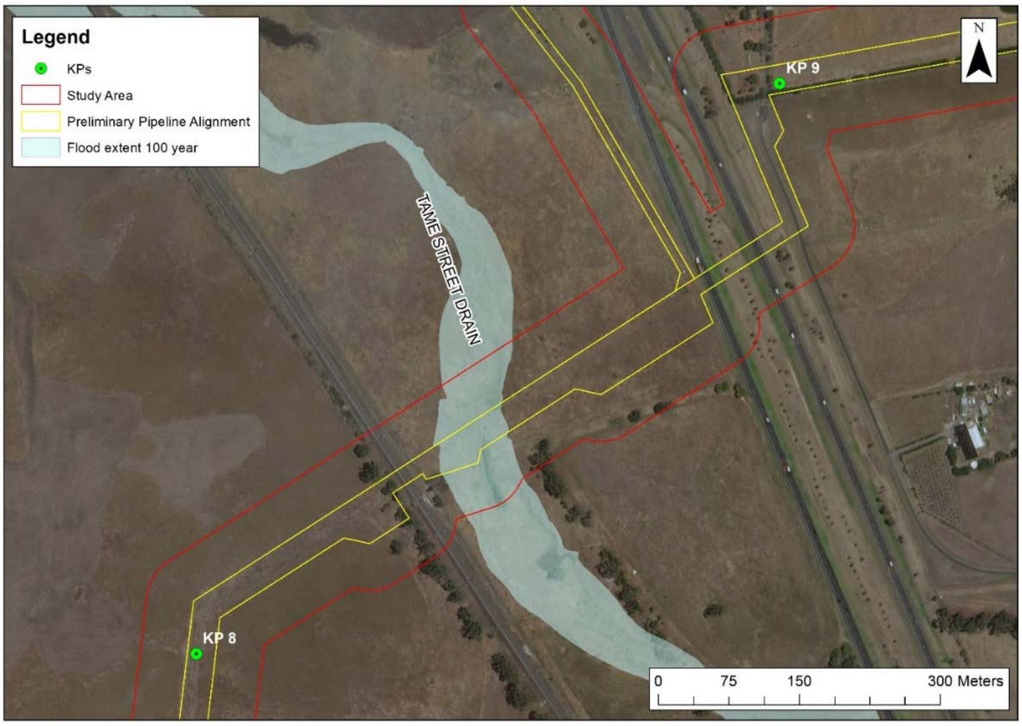

Figure 3. *Tame Street Drain crossing*

Jacksons Creek (KP 13.8)
Jacksons Creek is part of the Maribyrnong River catchment and flows in a typically southerly direction (Figure 4). Jacksons Creek is one of two major tributaries of the Maribyrnong River. The Study Area crosses Jacksons Creek east of Diggers Rest before it drains into the Maribyrnong River. The catchment is predominately urban with pastoral and grazing zones also contributing. Jacksons Creek is located in the Western Volcanic Plains with very low soil erosion susceptibility index in gullies and sits in a Green Wedge Zone in the Melbourne Airport Environs Overlay.

The 1 in 100 year flood extent inundates approximately 100 metres of the Study Area.

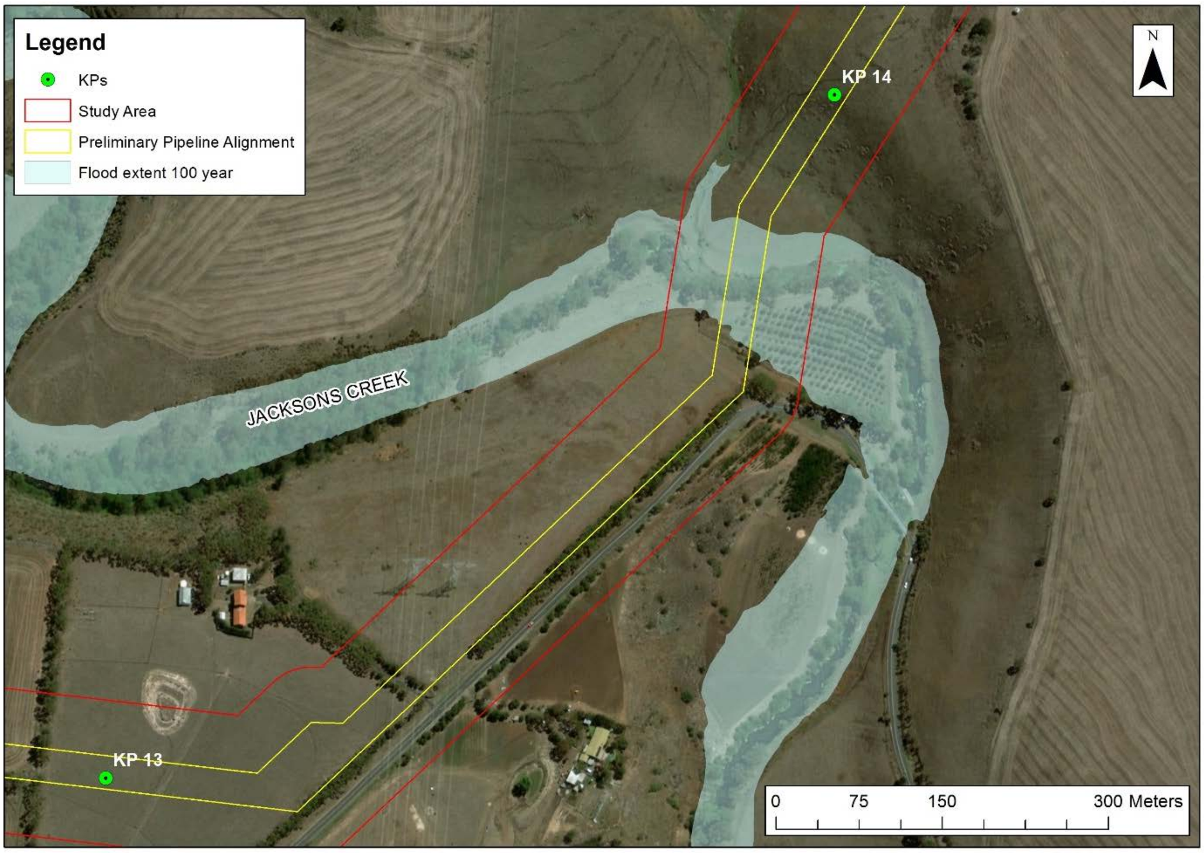

Figure 4. *Jacksons Creek crossing*

Deep Creek (KP17.1)
Deep Creek is part of the Maribyrnong River catchment and flows in a typically southerly direction where its confluence with Jacksons Creek forms the Maribyrnong River (Figure 5). The Study Area crosses Deep Creek immediately downstream of its confluence with Emu Creek in an Environmental Significance Overlay. The catchment consists of mainly farming zones and urban living land use zones in Western Volcanic Plains basalt soils. The soil has a moderate soil erosion susceptibility index in gullies.

The 1 in 100 year flood extent inundates approximately 300 metres of the Study Area.

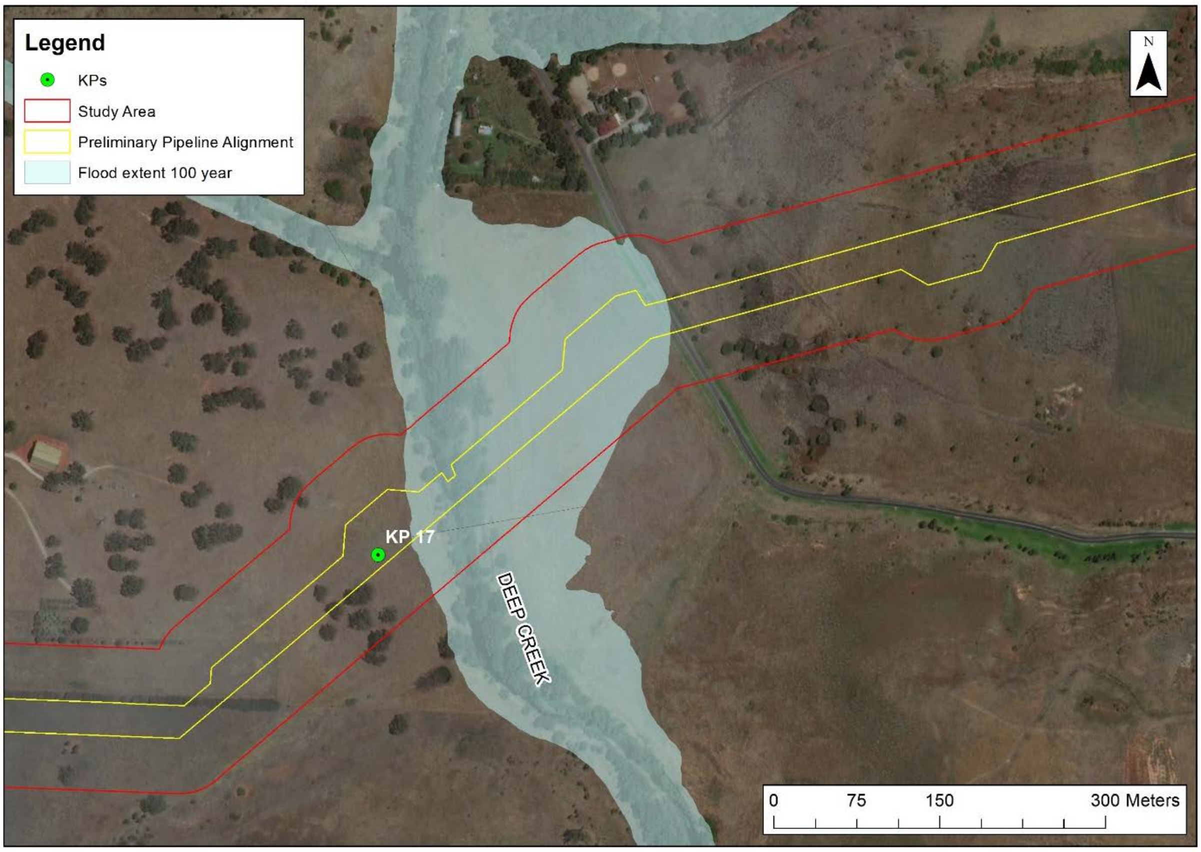

Figure 5. *Deep Creek crossing*

Kalkallo Creek (KP34.1)
Kalkallo Creek flows in a southerly direction where it joins Merri Creek as part of the Yarra River catchment (Figure 1). The Study Area crosses Kalkallo Creek at KP 34.1 and then two minor tributaries at KP34.4 and 35.1

The region is located in a Land Subject to Inundation Overlay zone (shown as the "Flood extent 100 year" in Figure 6) while the catchment upstream is predominately Urban Growth Zones and Farming Zones. The soils are sedimentary located in the Western Uplands region with a high soil erosion susceptibility index within gullies.

The 1 in 100 year flood extent inundates approximately 1,000 metres of the Study Area (Figure 6).

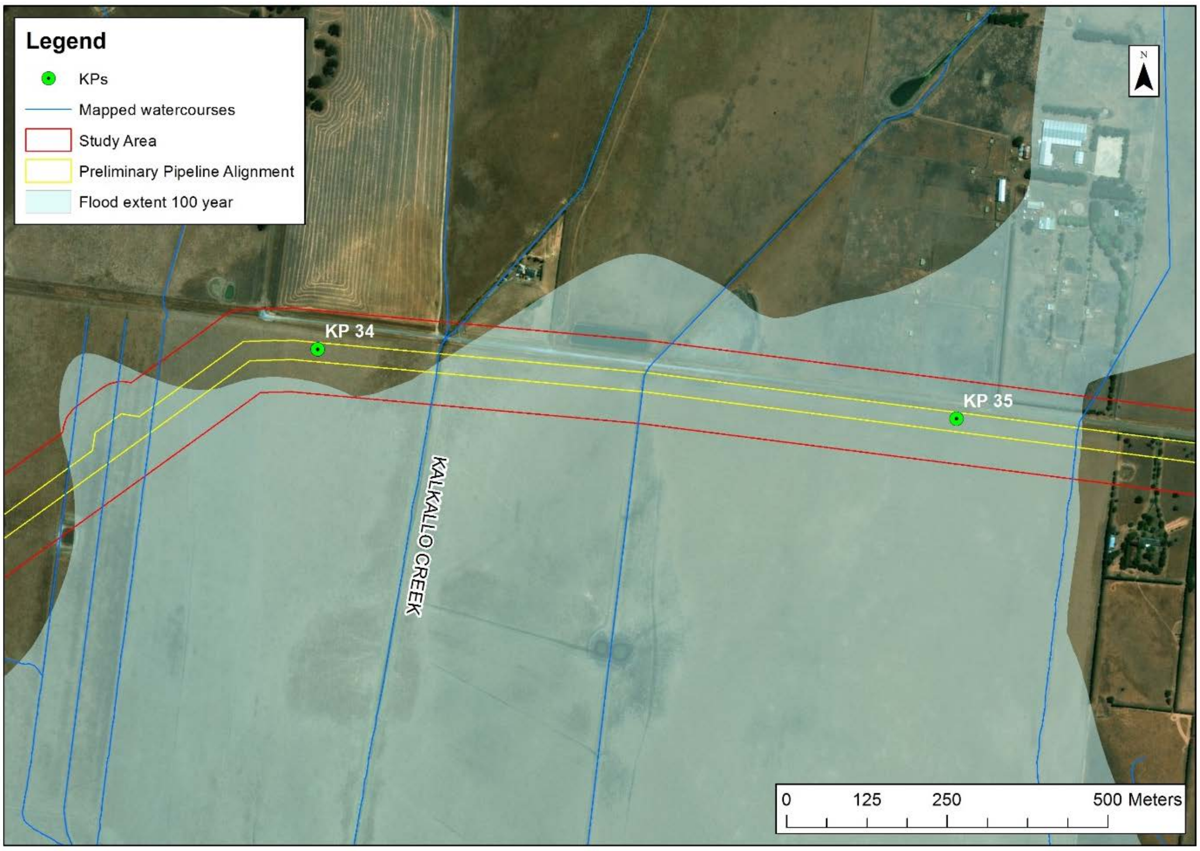

Figure 6. *Mapped 1 in 100 year ARI flood extent at KP 34-35*

Merri Creek (KP42.4)

Merri Creek flows in a southerly direction to the north of Melbourne and is part of the Yarra River catchment (Figure 7). The Study Area crosses Merri Creek with the surrounding catchment located in a Rural Conservation Zone and Environmental Significance Overlay Zone. The basaltic soils in the Volcanic Plains of the Western Plains region have a very low soil erosion susceptibility index in gullies.

The 1 in 100 year flood extent inundates approximately 65 metres of the Study Area.

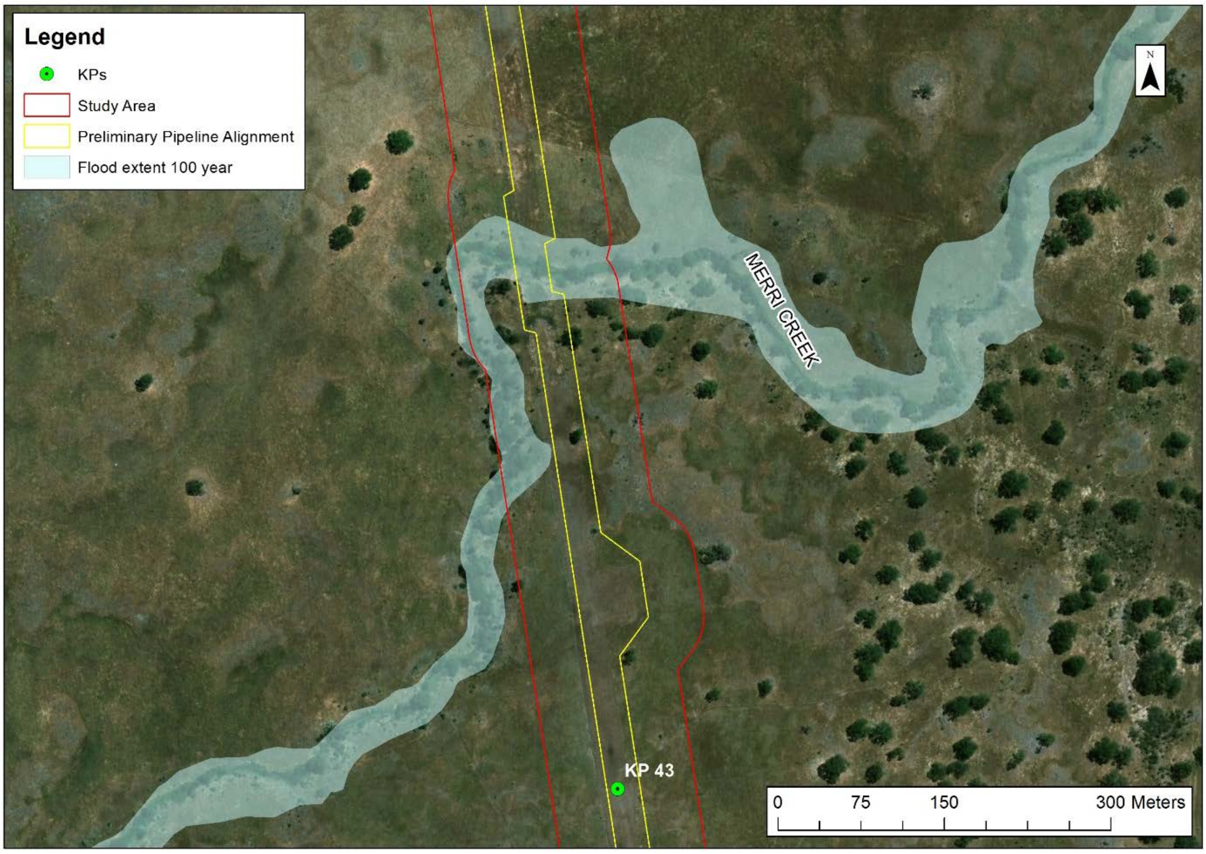

Figure 7. *Merri Creek crossing*

5.9 Wetlands

Three data sets (as listed in Table 4) were used to consider wetlands along and downstream from the Study Area. The Study Area does not cross any wetlands of International or National Importance or any watercourses that are tributaries of wetlands of International or National Importance. Some wetlands as mapped in the Victorian Wetlands Inventory do fall within the study area around KP 44 to 45 (Figure 8).

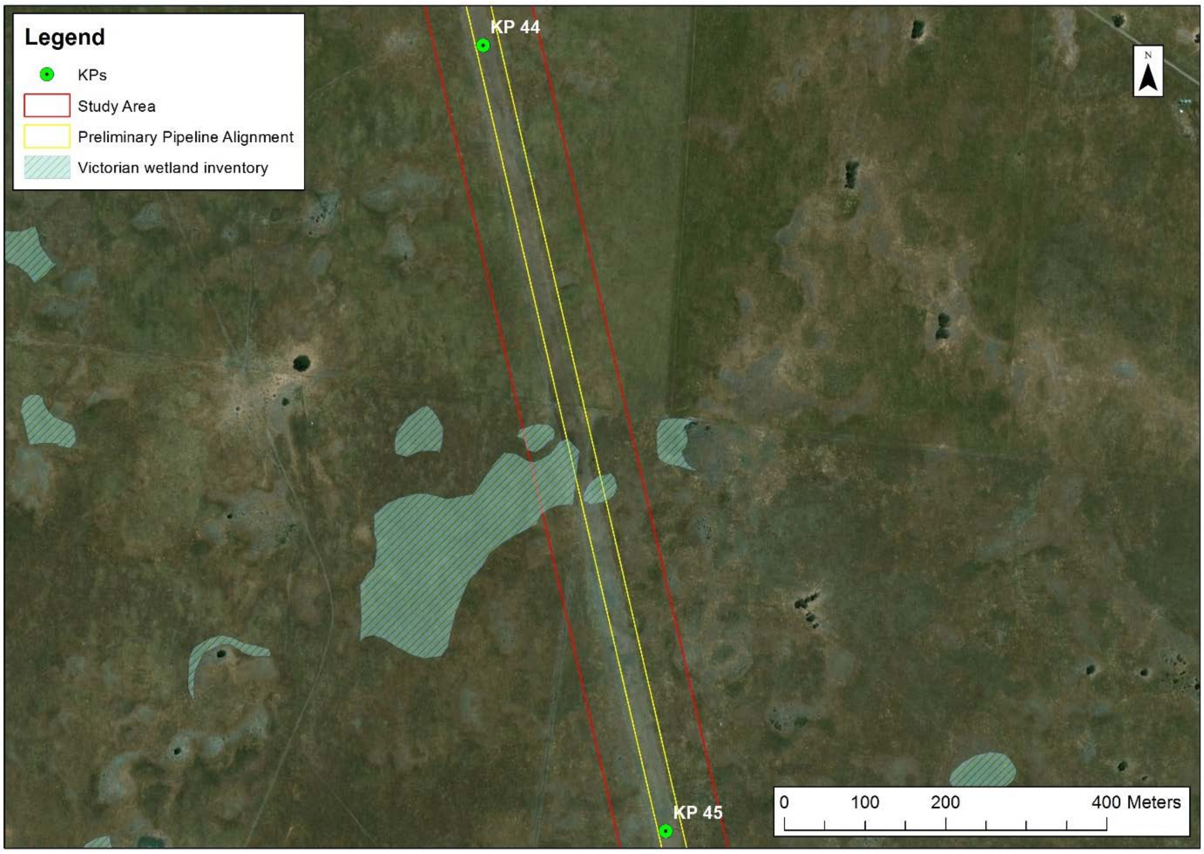

Figure 8. *Mapped wetlands in the area of KP 44 to 45 (Victorian Wetland Inventory)*

6 Impacts

Sections 1-5 used the Study Area as a basis for documenting values. This section uses the PPA to discuss potential impacts of the reference project as provided by APA.

6.1 Potential impacts

Potential impacts are expected to be limited but could include the following:

- Impacts to the project from existing hydrological conditions and processes including stream bed and bank erosion, flooding and shallow groundwater.
- Impacts from the project to water, including watercourse hydrology and geomorphology, surface water quality, shallow groundwater, water availability.

6.1.1 Groundwater

The potential for impact on groundwater is very low for the following reasons:

- The activity of installing the pipeline will only intersect the shallowest aquifer, or potentially may not intersect any aquifer at all (depending on seasonal conditions).
- The groundwater resource in the areas is generally brackish, and the activity will not result in the addition of salts to the aquifer. Consequently, the beneficial use, which is defined by the groundwater salinity, is unlikely to be at risk.
- The activity does not involve depositing or releasing any potential contaminant to shallow aquifers

The predominant risk to groundwater from the activity is the potential to create preferential flow paths that may inadvertently change groundwater flow directions. The potential for this risk is likely to be higher where the water table is shallow, such as the area around the PPA in the north-west of the Merri Creek catchment (approximately KP 40 to KP 45). Mitigation measures as described in Section 7.

6.1.2 Hydrologic and geomorphic processes

If appropriate mitigation measures are not applied, hydrological and geomorphic processes along the PPA have the potential to cause exposure of the pipeline at watercourse crossings, active floodplains and other areas at risk of erosion during the operation phase of the Project. Any exposure of the pipeline by such processes subsequently increases the potential for pipeline damage, primarily from impact by debris. Exposure of the pipeline due to such processes could also contribute to increased turbidity and sedimentation of waterways.

It is considered that potential impacts to the pipeline caused by such hydrological and geomorphic processes can be effectively mitigated by appropriate selection of the alignment and other mitigation measures as described in Section 7.

6.1.3 Surface water

The risk of impacts to surface water is low and likely to be localised and temporarily associated with the construction activities. Potential risks to surface water (including the mapped wetland) include:

- Run off/erosion of spoil (turbidity and organics)
- Influx of brackish groundwater to surface water systems (salinity)
    - during excavation
    - along the pipeline/gravel pit following completion (preferential flow path)
- Disturbance of stream bed or wetland bed – changes in surface water quality (localised)
- Disturbance of stream bed wetland bed– hyporheic flow disruption (localised)
- Disturbance of stream bed wetland – brackish groundwater influx (localised)
- Disturbance of farm dams where the PPA intersects

These potential impacts are most likely to occur near or at stream crossings, and where existing farm dams may be intersected. Also where shallow water tables occur, such as the area around the PPA in the north-west of the Merri Creek catchment, including the mapped wetland in the Merri Creek catchment (KP 44 to 45. As groundwater in the area at/near the PPA is brackish to saline, and surface water quality objectives for all streams require surface water salinity to be ≤3000 µS/cm (Kororoit catchment) or ≤2000 µS/cm (Maribyrnong and Merri Creek catchments), any influx or spill of groundwater to the stream may cause a temporary, localised impact on the beneficial use of that surface water. However, localised, temporary discharges are unlikely to present a regional risk to these surface water beneficial uses due to dilution. However, ongoing discharge, e.g. via changes in groundwater flow paths, may present an ongoing localised risk to these surface water beneficial uses.

In addition to changes in surface water salinity due to brackish or saline groundwater discharging to surface water, any groundwater discharge also has the potential to have other implications for surface water quality and subsequently impact beneficial uses, including: changes to pH, changes in the redox potential of the water (which may influence dissolved oxygen in the receiving water); changes in the concentration of nitrogen and phosphorus. The potential for these risks to beneficial uses of surface water to occur could not be assessed due to lack of sufficient groundwater quality data.

6.1.4 Wetlands in the area of KP 44 to 45

The PPA traverses a portion of a mapped wetland (See Figure 8). This is the only area where a re-alignment might be of value due to a wetland, however, there are numerous wetland bodies nearby and realignment may not be practical. The current alignment is within an existing easement and therefore likely to be a less disruptive option.

From a surface water quality perspective, if the pipeline is trenched in a wetland it means that there may be additional water quality objectives to addressed, but harder to manage if there is a trench in a wet swamp. The wetlands appear to be ephemeral, based on aerial imagery, so trenching whilst dry may not be an issue for water quality, but there will be a need to manage flow issues associated with geomorphic changes/excess spoil placement. The groundwater table is mapped as being 10-20 metres below surface in the area of the wetland, but it is likely the mapping is too coarse and that the groundwater table is shallow in this area. There is a need to avoid groundwater discharge to surface water, or to determine groundwater quality and assess the risk of discharge to surface water (the latter being a simpler option). This area is not mapped as a Groundwater Dependant Ecosystem (GDE).

6.1.5 Other areas

From the desktop assessment there are no issues identified that warrant considering realignment to address groundwater and surface water quality issues.

Groundwater is generally 10 metres or greater along the alignment, but local resolution of depth to water table is probably poor and groundwater surface water connectivity may occur at/near streams. An operations plan to manage groundwater onsite is recommended (if not already in place or planned), especially if it is discharged to surface water.

Surface water quality is managed under the State Environment Protection Policy (SEPP) according to particular spatial zones – there are a range of these with different water quality objectives, however, apart from the wetland area around KP 44 to 45, nothing else is expected to require consideration for realignment of the PPA to reduce water quality risk.

6.1.6 Flooding

Construction

If a flood event was to occur during the construction phase it could result in localised impacts to water quality due to entrainment of sediment from the construction footprint. As the duration of the construction period is short the risk is considered low. Delays to construction schedules could also occur. Measures to ensure any potential risks are minimised are discussed in Section 7.

Operation

The most important aspect with regard to potential impacts to flood behaviour during operation is that the pipeline will be buried along its entire length and the ground surface returned to its preconstruction level and rehabilitated. Although there is some potential for localised changes to existing surface water drainage / flow patterns due to the preferential flow of water along the surface of the pipeline trench this can be mitigated by standard measures descried in Section 7. As such no material changes to flood behaviour during operations are expected.

7 Mitigation measures

Potential impacts can be mitigated by application of APA's standard mitigation measures and Alluvium's recommendations for further, site specific, mitigation measures.

The standards to be followed to minimise the risk of environmental harm during construction and operation will be consistent with:

- AS/NZS ISO 14001:2004 – Environmental Management Systems – Requirements with guidance for use;
- The A*PIA Code of Environmental Practice*; and
- Compliance with all obligations relating to statutory laws, policies, licenses and industry codes of practice.

A list of relevant Standards & Industry Codes of Practice applicable to the project is provided in Table 9. The pipeline industry in Australia uses the industry-developed Australian Pipeline Industry Association (APIA) *Code of Environmental Practice* as a benchmark industry environmental standard and as such this will form the basis of the pipeline's environmental management system and *Construction Environmental Management Plan* (CEMP).

Table 9. Standards and Guidelines

AUTHORITY	TITLE
Australian Standard	• AS1940 – 2004 The storage and handling of flammable and combustible liquids • AS2436-2010 Guide to noise control on construction, maintenance and demolition sites • AS 2885.1 – 2012 Pipelines – Gas and Liquid Petroleum Part 1: Design and construction • AS 2885.2 – 2012 Pipelines – Gas and Liquid Petroleum -Welding • AS2885.3 - 2012 Pipelines - Gas and liquid petroleum – Operation and maintenance • AS2885.5 - 2012 Pipelines - Gas and liquid petroleum – Field pressure testing • AS3780 – 1994 The storage and handling of corrosive substances AS3780-2009 The storage and handling of corrosive substances • AS4970:2010 Protection of trees on development sites • AS31000-2009 Risk Management- Principles and guidelines
Industry Codes of Practice	• Australian Pipeline Industry Association (APIA). Code of Environmental Practice – Onshore Pipelines. 2013 • Australian Pipeline Industry Association & Victorian Farmers Federation. Pipeline Easement Guidelines Nov 2009
National Codes of Practice	• National Code of Practice for the Control of Workplace Hazardous Substances [NOHSC: 2007(1994)] • National Code of Practice for the Preparation of Material Safety Data Sheets [NOHSC: 2011(1994)] • National Code of Practice for the Labelling of Workplace Substances [NOHSC: 2012 (1994)]
Worksafe	• *Codes* Victorian WorkCover Authority. 2000. Dangerous Goods Storage and handling. Code of Practice No. 27 • Victorian WorkCover Authority. 2000. Code of Practice for Hazardous Substances. Code of Practice No 24
National Guidelines	• ANZECC/ ARMCANZ. 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. • National Environment Protection Council : national Environmental Protection (Ambient Air Quality)Measure • National Environment Protection Council : National Environmental Protection (Assessment of Site Contamination) Measure

7.1 Project specific mitigation measures

7.1.1 Hydrology and geomorphology

Design
Selection of the final pipeline alignment should consider the following:

- Where practical, using existing stable crossings.
- Minimising the number of channels to be crossed (where a watercourse has more than one channel or where a tributary joins).
- Crossing on straight sections of channel and not on the outside of bends.
- Minimising the disturbance of bed banks and riparian vegetation.
- Avoiding permanent pools where practical.
- Avoiding farm dams where practical.

This desktop assessment has identified that the following specific locations be assessed for further pipeline alignment design:

- KP 11 to KP 12 Three farm Dams – not a mapped watercourse but suggest possible realignment to avoid dams (Figure 9).
- KP 23.4: 1st order through farm dam. Pipeline could be realigned upstream or downstream to avoid dam wall (Figure 10).
- KP 32.8: 1st order next to dam. Pipeline could be realigned 30 metres to the west to avoid dam edge but should be a construction and operational decision (Figure 11).
- KP 36.5: Small farm dam could be avoided by minor realignment but should be a construction and operational decision (Figure 12).
- KP 39.85: Small farm dam could be avoided by minor realignment but should be a construction and operational decision (Figure 13).
- KP 40.4: 1st order stream – crosses almost parallel in channel. 25-30 m realignment north or south would provide more perpendicular crossing (Figure 14).

Construction
Along the alignment there is limited risk of scour at waterway crossings but crossing points seek to minimise any risk. During construction, the pipeline should be buried in bedrock (where depth to bedrock provides a practical option) or below mobile bed material where bedrock is not present. The depth to non-mobile bed material will require a geotechnical assessment at each major crossing.

The desktop assessment considered watercourses crossing points and provides the following site-specific mitigation recommendations.

- KP 13.8 Jacksons Creek. Stable crossing point that can be crossed with standard techniques (Figure 4). Could be moved up to 50m either side of current alignment if required.
- KP 17.1 Deep Creek. Stable, close to perpendicular, crossing point that can be crossed with standard techniques (Figure 5). Could be moved up to 50m either side of current alignment if required.
- KP 42.4: Merri Creek – Stable crossing point that can be crossed with standard techniques (Figure 7). Given that the Creek has been crossed before at this location it is a preferred location. Could be moved up to 50m either side of current alignment if required but given that the location is in an existing utilities corridor, retaining this location is recommended.
- KP 50.4: Mapped as first order, however, the mapping is no longer accurate as there is existing infrastructure where the watercourse is mapped (Figure 15). The pipeline will connect with the existing infrastructure and no new impacts on the watercourse are likely if adequate drainage is constructed.

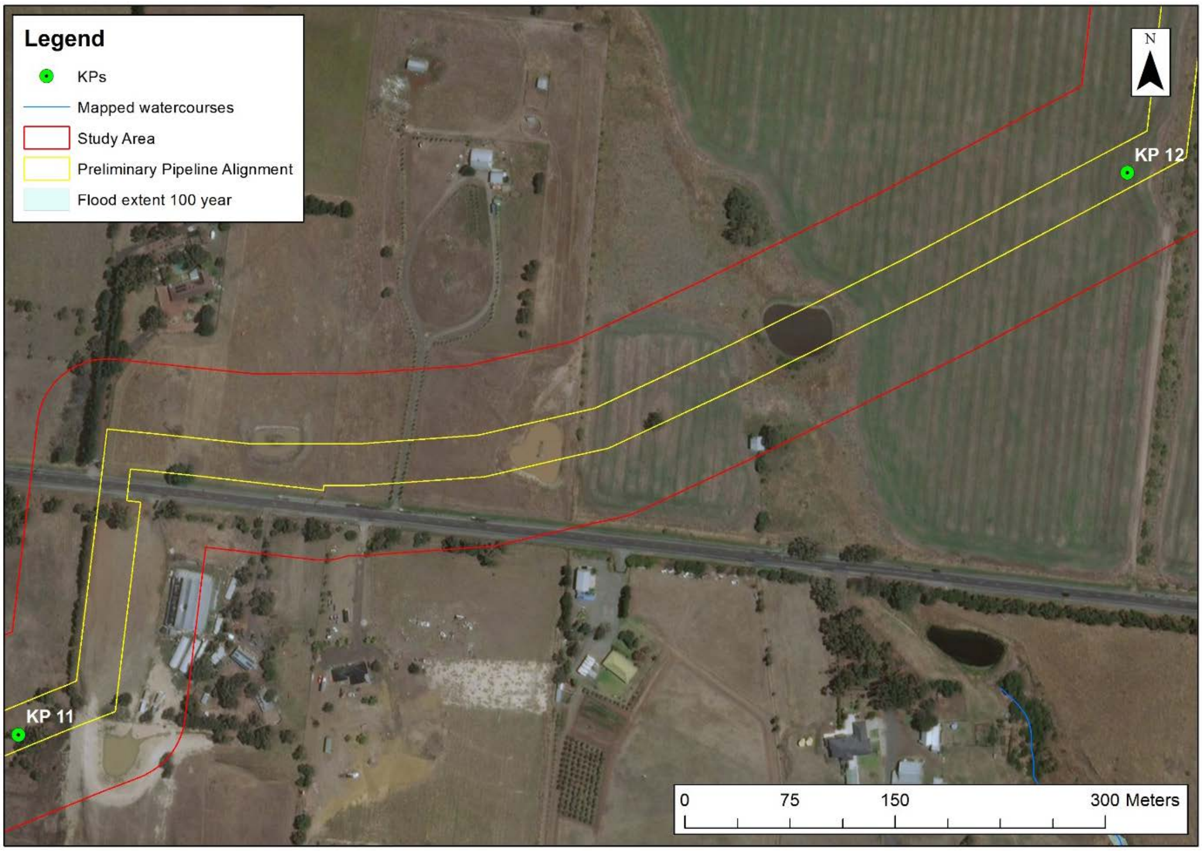

Figure 9. *KP 11 to KP 12: 3 PPA intersection with farm dams*

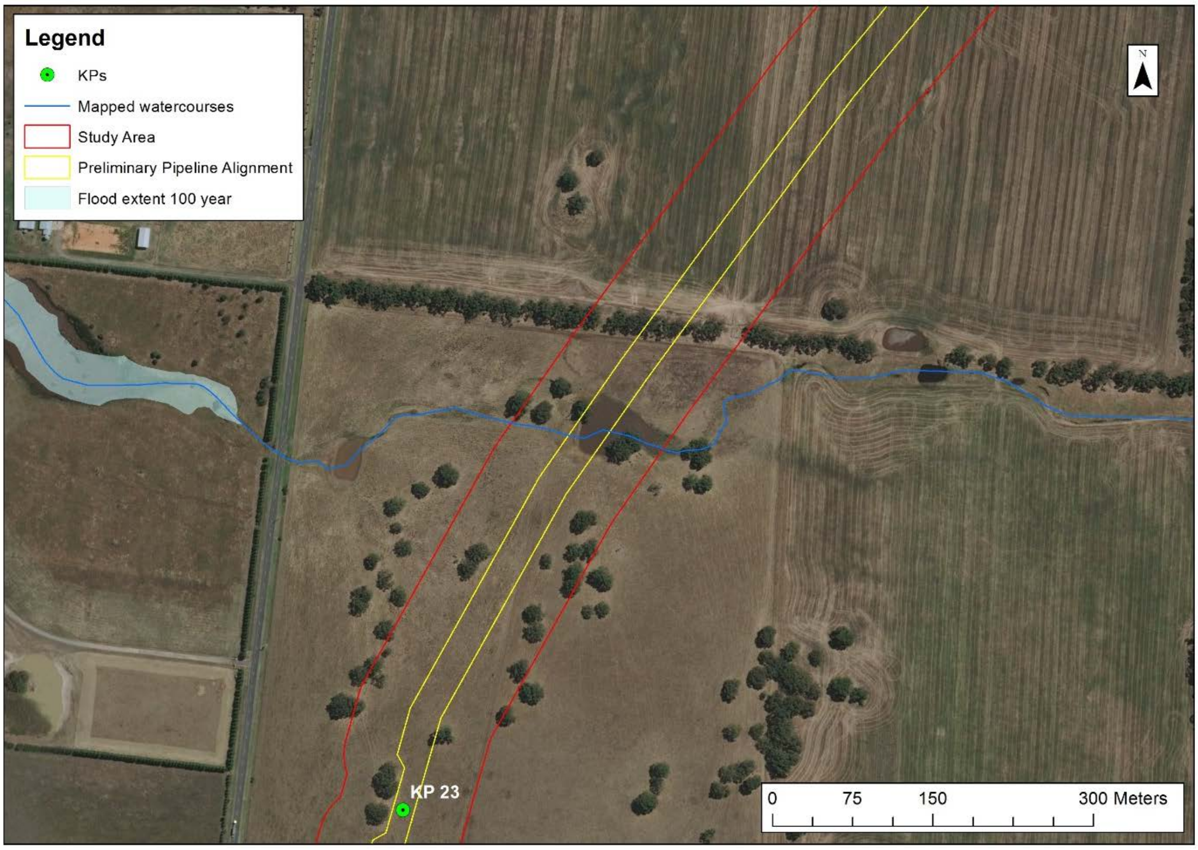

Figure 10. *KP 23.4: PPA intersection with farm dam*

Figure 11. *KP 32.8: Alignment option to avoid farm dam*

Figure 12. *KP 36.5: Alignment option to avoid dam*

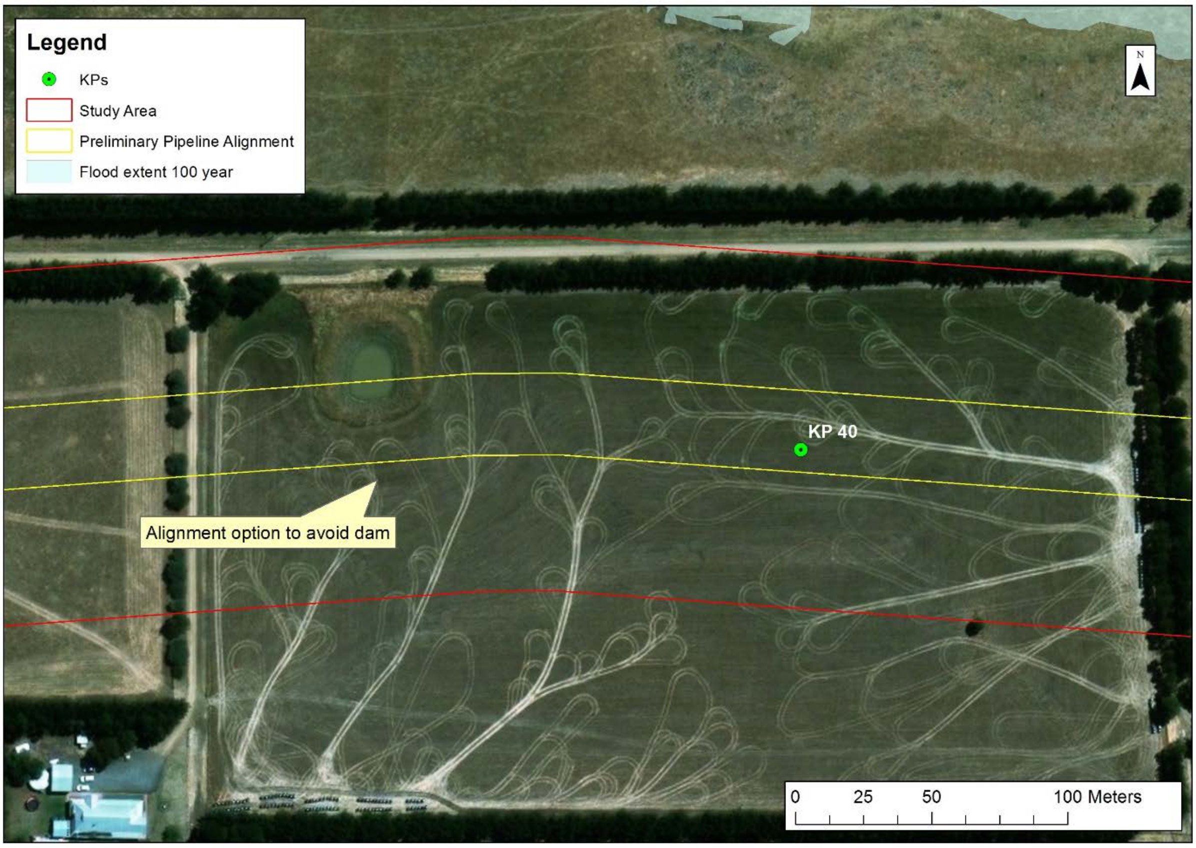

Figure 13. *KP 39.85: Alignment option to avoid dam*

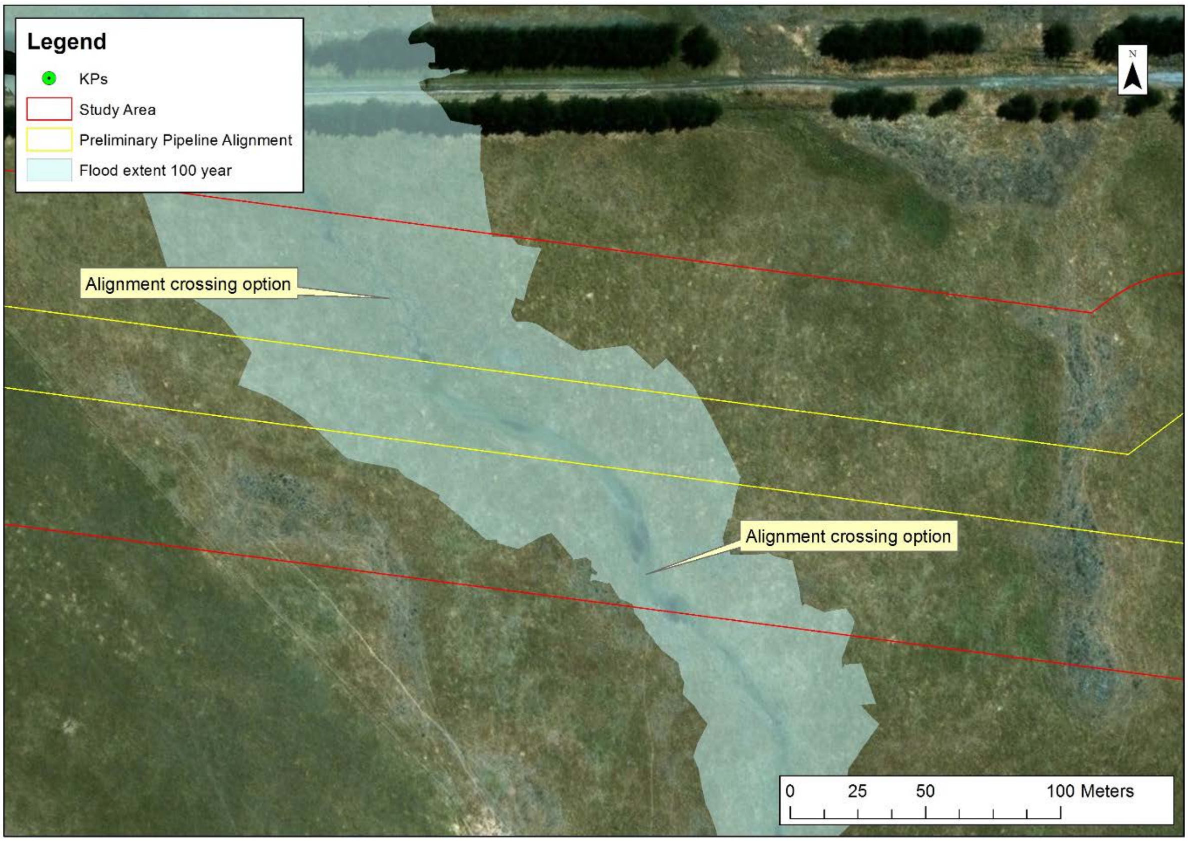

Figure 14. *KP 40.4: Alignment option to provide a perpendicular crossing*

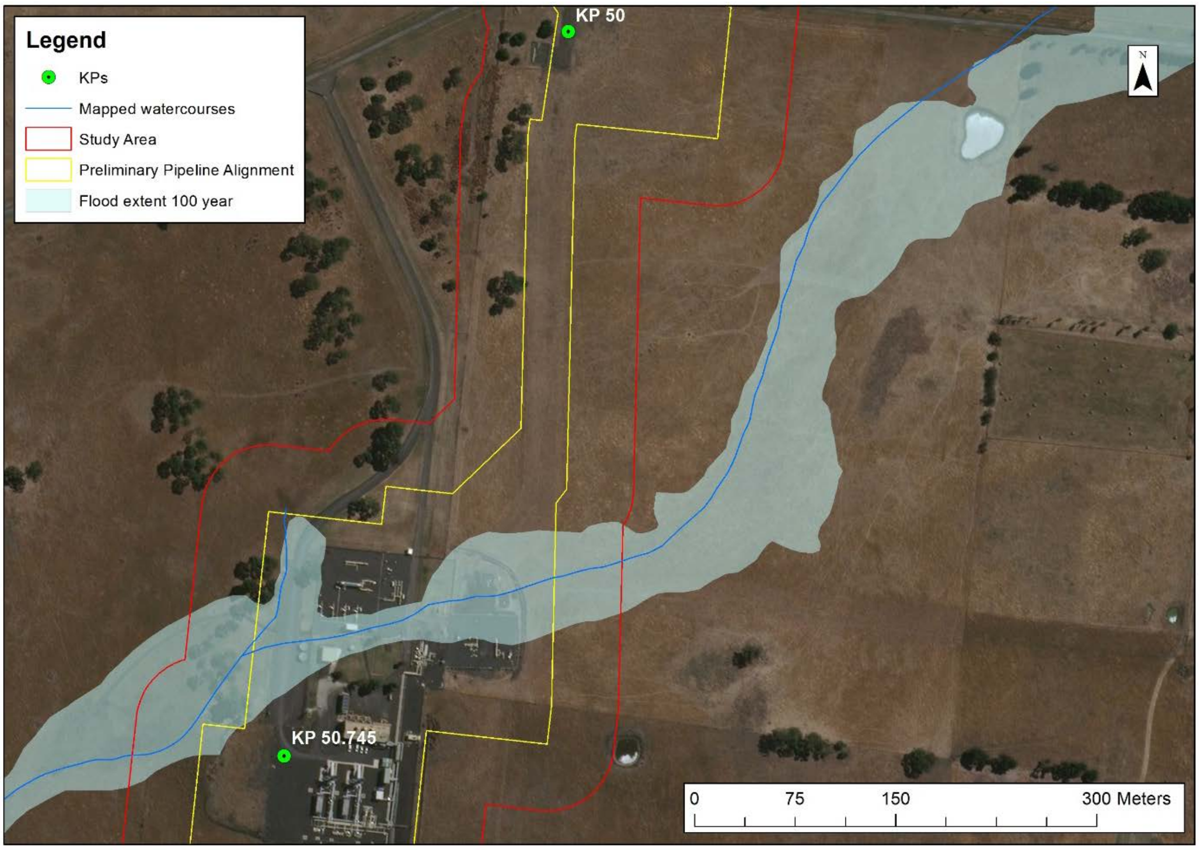

Figure 15. *KP 50.4: End of the preliminary pipeline alignment*

7.1.2 Groundwater

Design
Given that the potential for impact on groundwater has been assessed as very low (Section 6), no further design considerations are identified.

Construction
The predominant risk to groundwater from the activity is the potential to create preferential flow paths that may inadvertently change groundwater flow directions. The potential for this risk is likely to be higher where the water table is shallow, such as the area around the PPA in the north-west of the Merri Creek catchment. APA should consider implementation of appropriate subsurface barriers (trench breakers) along the pipeline in this area to prevent groundwater issues and to manage potential erosion risks.

7.1.3 Surface water

Design
Given that the potential risk of impacts to surface water is low and likely to be localised and temporarily associated with the construction activities (Section 6), no further design considerations are identified.

Construction
Overall, risks to surface water beneficial uses from the proposal pipeline installation can be mitigated by:

- Monitoring groundwater quality during excavation
- Installing groundwater flow prevention barriers along the pipeline
- Installing appropriate sediment and erosion control barriers to prevent run off/erosion of spoil
- If surface water is present in-stream, installing downstream bunds in the stream during installation activities

- Monitoring surface water quality during installation of the pipeline (in accordance with the requirements under the SEPP (Waters)

7.1.4 Wetlands

Design and construction
The only identified design mitigation measure is possible re-alignment between KP 44 and KP 45 to avoid mapped wetlands, however, there are numerous wetland bodies nearby and realignment may not be practical. The current alignment is within an existing easement and therefore likely to be a less disruptive option. No further design or construction mitigation measures are identified for wetlands.

7.1.5 Flooding

Design and construction
The pipeline alignment must cross through some areas of land subject to inundation. Design should seek to avoid such areas as much as practical and minimise construction time. Where land subject to inundation must be traversed, standard mitigation measures will be applied including weighted pipe and ensuring that the pipeline will be buried along its entire length and the ground surface returned to its preconstruction level and rehabilitated as soon as practical after construction is completed. With these measures, no material changes to flood behaviour are expected.

8 Residual impacts and conclusions

8.1 Residual impacts

With the application of the mitigation measures described in Section 7, all residual impacts are considered to be low or very low.

8.2 Conclusions

Based on desktop assessment only and assuming that all proposed mitigation measures are applied, overall, the PPA will not present a significant risk to regional surface water or groundwater assets or associated beneficial uses. The construction activities associated with installing the pipeline will result in localised disturbances. These risks from the PPA to beneficial use 'water-dependent ecosystems protection and species' are considered to be low and localised. Risks to other beneficial uses are likely to be very minor due to the localised disturbance from the activity.

With the application of industry standard mitigation measures there should not be any significant impacts to the geomorphic stability or condition of waterways.

With regard to potential impacts to or from flooding, as the pipeline is to be buried and the existing ground surface reinstated and rehabilitated, there will be no adverse impacts.

9 References

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