

# Chapter 9

# Groundwater



This chapter discusses the potential impacts on groundwater associated with the construction and operation of the Gas Import Jetty and Pipeline Project (the Project). This chapter is based on the impact assessment presented in EES Technical Report D: Groundwater impact assessment.

## 9.1 Overview

Groundwater is considered a vital resource for society and the environment. In Victoria, groundwater is primarily used for irrigating crops and dairy farm pastures as well as for town water supply and power generation. Approximately 70 towns across Victoria rely on groundwater as a supplementary or primary water supply. In addition to being an important part of Victoria's water supply, groundwater supports biodiversity and many ecological processes. Groundwater dependent ecosystems (GDEs) rely on access to groundwater to maintain the communities of plants and animals and ecological processes they support and the ecosystem services they provide.

Shallow groundwater is anticipated to be intersected along some sections of the Project during construction activities for the installation of the pipeline, and piling associated with the Gas Import Jetty Works. Construction has the potential to impact groundwater levels, flow and quality. It is important to assess whether these activities could impact the beneficial uses of groundwater, or groundwater users that pump water from existing bores within the study area. This would subsequently inform the management and mitigation of groundwater impacts during construction and operation of the Project.



### Groundwater and aquifers

Groundwater is water located below the Earth's surface. It is found in vast quantities, usually occurring through the filling of pores and fractures between grains of soil or rock and slowly flows through permeable aquifers.

Groundwater is sourced from water that originates above ground from rain that has seeped into the soil or from surface water sources such as rivers and waterways. Groundwater is a finite resource and is increasingly more vulnerable as water becomes scarcer.

**Aquifers** are geological materials such as unconsolidated sediments (gravel or sand), permeable rock or fractured rock that act as reservoirs for groundwater. Wells drilled into aquifers extract groundwater for a variety of uses.

Groundwater provides several beneficial uses protected under the State Environment Protection Policy (SEPP) (Waters). The aim of the SEPP is to protect the quality of groundwater as to not impact on the beneficial uses provided. Beneficial uses are considered to be environmental values and human activities that require safeguarding for the community.

## 9.2 EES evaluation objective

The scoping requirements for the EES set out the following relevant draft evaluation objective:

*Water and catchment values – To minimise adverse effects on water (including groundwater, waterway, wetland, estuarine, intertidal and marine) quality and movement particularly as they might affect the ecological character of the Western Port Ramsar site.*

To assess the potential impact of the Project on groundwater levels, flow and quality, a groundwater impact assessment was undertaken.

## 9.3 Methodology

The approach adopted for the groundwater impact assessment involved the following key tasks:

- a review of relevant legislation and policy at Commonwealth, state and local level
- a review of relevant baseline data and reports, including publicly available information and data on groundwater and hydrogeology
- consultation with Southern Rural Water, as well as review and consideration of relevant stakeholder input collected as part of engagement activities carried out by AGL and APA
- a field program to determine if any shallow aquifers were present along the proposed pipeline alignment – 26 shallow groundwater monitoring bores were installed along the proposed pipeline alignment in December 2018 and February 2019, with all bores gauged to measure the depth of groundwater. Wells with sufficient water column for sampling and aquifer testing were selected to provide spatial coverage along the alignment, as well as coverage of differing rock types (such as clay, silty clay and sand). The monitoring network was based on:
  - targeted bores:
    - in low-lying parts of the landscape, typically near surface water courses, where shallow groundwater associated with alluvial sediments might be expected to be encountered
    - at sites with the potential to contaminated groundwater (discussed in EES Technical Report E: Contamination and acid sulfate soils and **Chapter 10** Contamination and acid sulfate soils)
    - based on the various mapped surface geology
  - infill bores:
    - located along the proposed pipeline alignment between targeted bores above to provide coverage along the length of the pipeline
- characterisation of groundwater quality, depth to groundwater and hydraulic conductivity (permeability) of the aquifers identified along the pipeline alignment
- a risk assessment as described in **Chapter 5** Key approvals and assessment framework to inform the impact assessment and development of additional mitigation measures
- assessment of groundwater impacts during construction and operation of the Project
- development of mitigation measures in response to the groundwater impact assessment.

## 9.4 Study area

This groundwater impact assessment focused on proposed intrusive works in the Project Area that may intersect groundwater as well as surrounding areas where groundwater levels or groundwater quality could be impacted.

The groundwater study area included the pipeline alignment, other options and a buffer area of 200 metres either side of the pipeline. The groundwater study area also included the Gas Import Jetty Works in relation to potential piling activities. The study area is shown in **Figure 9-1**.



◀ **Figure 9-1:**  
Groundwater study area

Pipeline installation method    Alignment and options 200 m buffer  
 Trench    KooWeeRup Water Supply Protection Area  
 Horizontal Bore  
 Thrust bore  
 Pipeline Options

## 9.5 Existing conditions

The existing conditions of relevance to understanding groundwater in the study area included:

- topography and surface water
- geology and hydrogeology
- hydraulic conductivity
- groundwater management
- groundwater quality and beneficial uses
- groundwater users including groundwater dependent ecosystems (GDEs).

### 9.5.1 Topography and surface water

The study area for the groundwater impact assessment is located in the Western Port catchment which covers approximately 3,700 square kilometres and contains 2,200 kilometres of rivers and creeks.

A number of major rivers and creeks enter Western Port including the Bunyip, Tarago, Cardinia, Yallock, Lang Lang and Bass River networks which all discharge directly into the area of Western Port listed under the Ramsar Convention on Wetlands of International Importance. The catchment varies from hilly regions near the Bunyip State Park and Strzelecki Ranges to the low lying, flat to undulating terrain of the former Koo Wee Rup swamp.

Within the study area, coastal floodplains are located in the lower reaches of the catchment where the relief is mostly low lying and generally flat to gently undulating. The ground surface elevation is one to two metres Australian Height Datum (AHD) above sea level in the southern part of the study area and gently rises to 10 to 25 metres AHD above sea level in the northern part.

### 9.5.2 Geology

The Project site is located within the Western Port Basin which is a relatively shallow, structurally controlled sedimentary basin consisting of sediments and volcanic flow. These sediments and volcanic flows of the basin form a multi-layered aquifer system dominated by a Tertiary Age sedimentary sequence that thickens out to approximately 200 metres in the Koo Wee Rup area and then tapers out along the margins of the Western Port Basin.

The Tertiary Age sediments are overlaid by a relatively thin layer of Quaternary sediments, including coastal and inland dune deposits, swamp and lake deposits and alluvial deposits. However, these sediments thicken to between 10 and 50 metres in the Koo Wee Rup area.

The Crib Point Receiving Facility is mapped as being underlain by the Tertiary Age ferruginous sandstones of the Baxter Sandstone formation.



#### Tertiary and Quaternary periods

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 can be recognised by their lack of consolidation into rock.

The depth of excavation required to install most of the pipeline would typically be two metres (trenched sections). During site investigations, the geology encountered to a depth of three metres was found to be all unconsolidated loose material including clay, silt and sand with occasional gravels.

Deeper excavations up to four metres (known as bell holes) would also be required for non-trenched sections. In addition, excavation works involved for the End of Line Scraper System (EOLSS), where the pipeline would connect to the Victorian Transmission System (VTS) may exceed three metres and reach up to 5.5 metres.

Beneath the nitrogen tank at the Crib Point Receiving Facility (Gas Import Jetty Works) up to 100 piles are proposed, which would reach a depth of 20 metres below the ground surface in competent rock (bedrock).



### 9.5.3 Hydrogeology

The water table in the study area is generally shallow, less than four metres below ground surface, and lies mostly within Quaternary sediments and tertiary Red Bluff Sandstone. Quaternary sediments are predominant in the outcropping geology of the southern portion of the Pipeline Works and Crib Point Receiving Facility (Gas Import Jetty Works) area. Within these sediments, groundwater would likely be limited in lateral and vertical extent. Where the Quaternary sediments become thinner, the water table aquifer is then formed by the Red Bluff sandstone.

As the pipeline alignment turns inland towards Pakenham in the northern section of the Pipeline Works, the area becomes underlain with a thicker sequence of Quaternary swamp and lake sediments which are associated with the Koo Wee Rup floodplains. Where these sediments are saturated, they are likely to be low yielding and the groundwater would have a higher level of salinity. The final two kilometres of the pipeline alignment is underlain by outcropping basalts of the Older Volcanic Lower Tertiary Basalts aquifer. Groundwater levels are inferred to be from 10 to greater than 20 metres below ground surface in this area. As a result, no monitoring wells were installed in the basalt as the maximum trench depth of the pipeline construction works would be four metres and so would not intersect this aquifer.

Previous environmental investigations carried out at the proposed site of the Crib Point Receiving Facility (Gas Import Jetty Works area) in 1997 encountered groundwater levels at 6.7 and 7.5 metres below ground surface (mbgs). Further gauging was undertaken in March 2017 at five monitoring bores at the proposed site, with groundwater encountered between 6.11 and 8.35 metres below top of casing (mbtoc)<sup>1</sup> in the western portion of the proposed site. The ground surface in this area is approximately seven to eight metres Australian Height Datum (AHD) metres above sea level and groundwater levels are expected to be in the order of one to two metres above sea level.

The depth to water was measured in January 2019 at all 26 monitoring wells installed for the EES groundwater investigation. Most of the water levels were recorded as deeper than the depth of the pipeline trench, which would typically be two metres and a maximum of three metres. However, some wells recorded water levels at a depth shallower than the depth of thrust bore bell holes, which are typically up to four metres in depth. Four of the wells had water levels below the base of the well and were recorded as dry, seven of the wells had water levels shallower than two metres below ground, and five wells had water levels between two and three metres below ground. The geology, groundwater wells and water levels are shown in **Figure 9-2**.

<sup>1</sup> mbtoc – refers to metres below top of casing reference point. Where top of casing is above ground surface, the depth to groundwater below ground surface(mbgs) will be less than the mbtoc measurement.

### 9.5.4 Hydraulic conductivity

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. The geology along the pipeline alignment is mostly fine-grained clay or silty clay so the hydraulic conductivity measured in shallow monitoring wells is generally low.

### 9.5.5 Groundwater management

The central and northern portion of the proposed pipeline alignment falls within the Koo Wee Rup Water Supply Protection Area (KWR WSPA) and the remainder is located within the general Unincorporated Area (see **Figure 9-1**). The KWR WSPA is managed by a Groundwater Management Plan which documents all local management rules including trade, groundwater monitoring and licenses. A Permissible Consumptive Volume of 12,915 megalitres per year currently applies to the KWR WSPA. If water required for construction is sourced from groundwater within the KWR WSPA, a temporary entitlement may need to be purchased from an existing licence holder as the KWR WSPA is fully allocated.

### 9.5.6 Groundwater quality and beneficial uses

The aquifer yield and salinity of groundwater in the Quaternary sediments of the Upper Aquifer is known to be highly variable, which reflects the diversity of the soil type (clay, clayey silts/sands), aquifer thickness, and depth to groundwater.



#### What does aquifer yield and salinity mean?

**Yield** is a measure of how much and how quickly groundwater can be extracted from an aquifer. Yield tends to be higher in large aquifers that have greater storage capacity, well-connected spaces within the aquifer material and where the pressure is high. Yield is highly dependent on the aquifer material, with more permeable materials such as gravel, sand and clay producing higher yields.

**Salinity** refers to the concentrations of salts in water or soils. Small amounts of dissolved salts in natural waters are vital for the life of aquatic plants and animals. Salinity is usually measured as total dissolved solids in milligrams per litre.

Groundwater salinity was measured in 14 monitoring wells along the pipeline alignment. Measured as total dissolved solids (TDS), salinity ranged from 1,253 milligrams per litre to 16,414 milligrams per litre, with an average of 6,334 milligrams per litre. Typically, groundwater is not considered suitable as potable supply when TDS is above 500 milligrams per litre and is not suitable for stock use or irrigation when TDS is above 3,500 milligrams per litre. The sampled groundwater wells and measured salinity are shown in **Figure 9-3**.

Under the State Environment Protection Policy (SEPP) (Waters), groundwater segments are classified based on background total dissolved solids. Protected beneficial uses are provided for each segment under the SEPP (Waters). Groundwater quality indicators and objectives, such as salinity, are established to protect each beneficial use. The term 'beneficial use' refers to the values and uses of water environments the SEPP (Waters) aim to protect.



◀ **Figure 9-2:**  
Geology,  
groundwater wells  
and water levels

Across the Pipeline Works and Gas Import Jetty Works areas, groundwater has been assumed as Segment B (1,201-3,100 milligrams per litre) based on monitoring well salinity data and regional mapping of TDS. The Segment B beneficial uses to be protected include:

- water dependent ecosystems and species
- agriculture and irrigation (irrigation)
- agriculture and irrigation (stock watering)
- industrial and commercial
- water-based recreation (primary contact recreation)
- Traditional Owner cultural values
- cultural and spiritual values
- buildings and structures
- geothermal properties.

These beneficial uses provide the framework for the groundwater risk assessment and impact assessment.



### 9.5.7 Groundwater use

There are 69 registered groundwater bores located within the study area (not including the 26 monitoring wells drilled as part of the EES groundwater study). Of these 69 bores, 48 have consumptive uses which include domestic, stock and irrigation, and eight are designated a status of 'not used'. The total depth of the 69 registered bores ranges from 5.4 metres below ground to 114.3 metres below ground. The number of bores and their respective uses are summarised in **Table 9-1**.

Potential impacts on bores with consumptive uses are discussed in **Section 9.5** of this chapter.

### 9.5.8 Groundwater dependent ecosystems

Groundwater plays an important role in sustaining aquatic and terrestrial ecosystems. Understanding groundwater dependent ecosystems (GDEs) helps to inform groundwater planning and management. The Groundwater Dependent Ecosystem Atlas (GDE Atlas) was developed as a national dataset of Australian GDEs. Watercourses and waterbodies can be categorised as either a 'gaining' or 'losing' water resource. A gaining waterbody receives groundwater discharge, whereas a losing waterbody acts as a recharge source to groundwater. Watercourses identified as potential GDEs means they are also potentially gaining watercourses—that is, relying on groundwater.

**Figure 9-4** shows the location of GDE types within the study area. The pipeline alignment would intersect 11 watercourses designated as high potential aquatic GDEs: Warringine Creek, Olivers Creek, Kings Creek, Watson Creek, Langwarrin Creek, Rutherford Creek, Western Outfall Creek, Cardinia Creek, Lower Gum Scrub Creek, Deep Creek and Toomuc Creek.

Within the southern end of the study area between Crib Point and the Pearcedale area, there are several moderate to high potential terrestrial GDEs within the Pipeline Works area, or which are located adjacent to the Crib Point Receiving Facility. These include woodland, coastal saltmarsh, swamp scrub and salt meadows. Potential impacts on these GDEs are discussed in **Section 9.7.2** of this chapter.



#### Potential groundwater dependent ecosystems

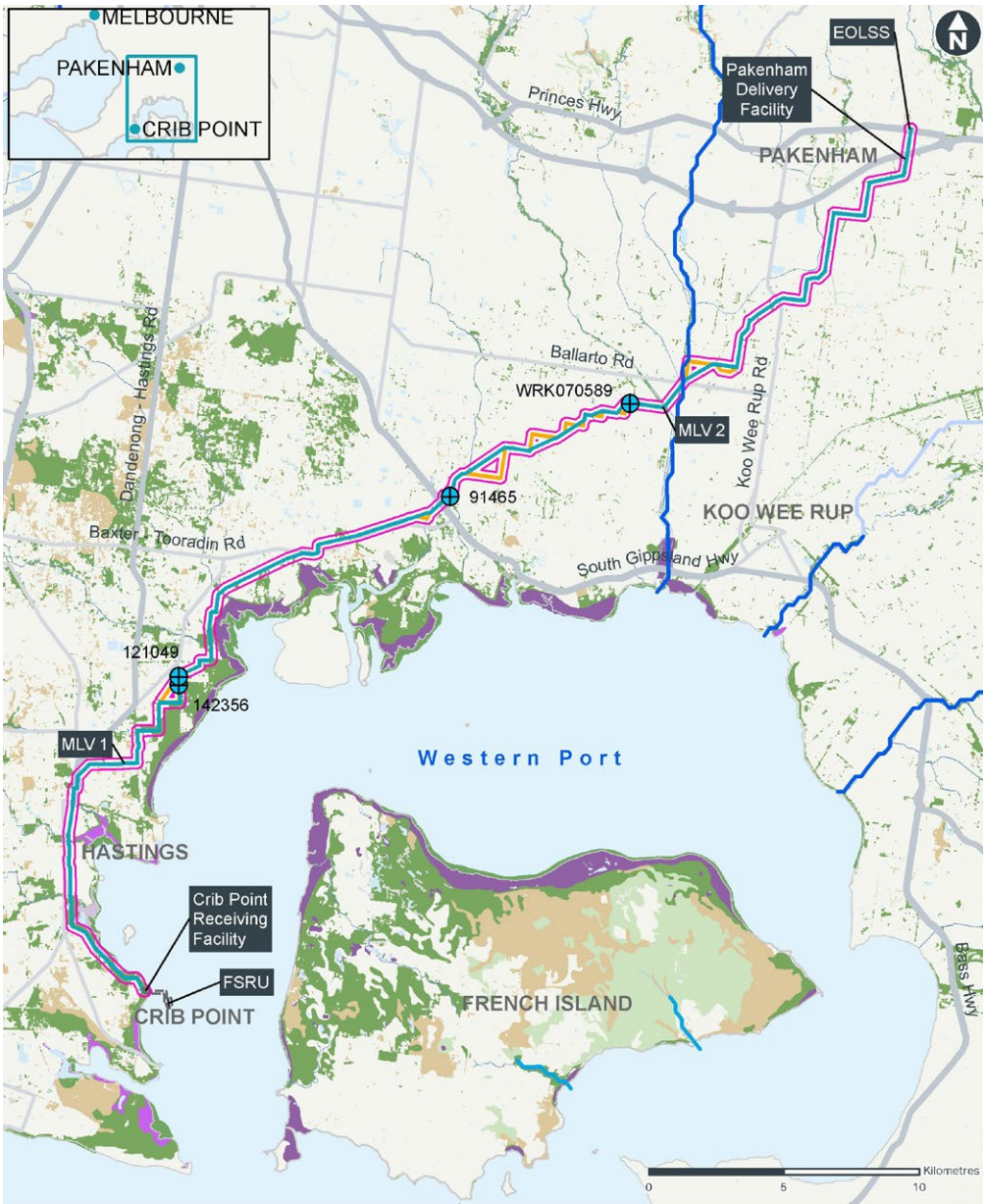
Potential groundwater dependent ecosystems (GDEs) are ecosystems, whether terrestrial or aquatic, that have been identified as likely to be at least partly dependent on groundwater. The term 'potential' is used to reflect the uncertainty in using desktop methods to identify ecosystems as being groundwater dependent. Field work is often required to confirm this analysis.

Therefore, GDEs identified as high potential are considered to have a high likelihood of interacting with groundwater.

**Table 9-1:** Registered groundwater bores in the study area

Mitigation measure ID	Mitigation measure
<b>Monitoring/observation uses</b>	
Observation	5
Observation, groundwater investigation	1
Observation, State Observation Network	2
Groundwater investigation	10
Observation, State Observation Network, groundwater investigation	3
<b>Total – monitoring/observation uses</b>	<b>21</b>
<b>Consumptive uses</b>	
Domestic (including one bore with a status of 'not used')	3
Stock and domestic	18
Irrigation (including one bore with a status of 'not used')	3
Stock	15
Stock, domestic irrigation	1
Unknown (including one bore with a status of 'not used')	8
<b>Total – consumptive uses</b>	<b>48</b>





◀ **Figure 9-4:**  
Groundwater users

- ⊕ Consumptive use bores with 30m
- Pipeline
- Pipeline Options
- Alignment and options 200 m buffer
- Groundwater - surface water interactions**
  - Gaining
  - Neutral/Losing
  - Unclassified
- Aquatic GDEs**
  - Known GDE (regional studies)
- High potential GDE (regional studies)
- Moderate potential GDE (regional studies)
- Unclassified potential GDE (regional studies)
- High potential GDE (national assessment)
- Moderate potential GDE (national assessment)
- Terrestrial GDEs**
  - High potential GDE (national assessment)
  - Moderate potential GDE (national assessment)
  - Low potential GDE (national assessment)

## 9.6 Risk assessment

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** Key approvals and assessment framework.

The assessment included consideration of the environmental, social, economic and health and safety consequences of each risk and their likelihood of occurring.

**Table 9-2** summarises the groundwater risks identified. A complete risk register, including the likelihood and consequence of each risk pathway, is located in EES Attachment III *Environmental risk report*.

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.

Only one risk was initially identified as medium (Risk ID HG7), where there is potential for registered bores to be damaged or lost during construction of the Project. With additional mitigation measures, this risk is reduced to very low. All other initial groundwater risks identified during construction of the pipeline were rated as low or very low. Five of the risks initially rated as low were reduced to very low with additional mitigation measures.

Two initial risks to groundwater related to the operation of the Project were identified. These relate to changes to groundwater flow patterns and groundwater quality and are rated as low (Risk IDs HG9 and HG10).

The construction and operation impacts are discussed in **Section 9.7** (Construction impacts) and **Section 9.8** (Operation impacts) of this chapter.

**Section 9.9** (Mitigation measures) of this chapter and **Chapter 25** *Environmental Management Framework* set out the mitigation measures.

## 9.7 Construction impacts

The potential groundwater impacts during the construction and installation of the Pipeline Works and the land side portion of the Gas Import Jetty Works include:

- reduction of groundwater levels (drawdown) from dewatering activities
- change in groundwater quality from use of horizontal directional drilling (HDD) drilling fluids
- overland flow impacting groundwater quality, via trenches that are open
- water supply for dust suppression and hydrostatic (pressure) testing of the pipeline
- loss, damage or inaccessibility of registered bores during construction
- interconnection of aquifers with different groundwater quality and protected beneficial uses during piling installation at the Crib Point Receiving Facility.



### Drawdown and dewatering

**Dewatering** refers to the removal of groundwater or surface water from a construction site. Dewatering on construction sites is mostly undertaken due to accumulated water in trenches. Water should be removed during construction projects to ensure a safe workplace and to keep working as scheduled.

**Drawdown** refers to the lowering of the groundwater level caused by water extraction such as pumping from a bore or trench during dewatering.

**Table 9-2:** Risks – Groundwater

Risk ID	Works area	Risk pathway	Initial mitigation measures	Initial risk rating	Additional mitigation measures	Residual risk rating
<b>Construction</b>						
HG1	Pipeline Works	Dewatering reduces groundwater levels at registered groundwater bores.	No initial measures identified	Low	<b>MM-HG01</b> Dewatering activities will be limited in duration	Very low
HG2	Pipeline Works	Dewatering reduces groundwater levels at potential GDEs and/or watercourses.	No initial measures identified	Low	<b>MM-HG01</b> Dewatering activities will be limited in duration	Low

Risk ID	Works area	Risk pathway	Initial mitigation measures	Initial risk rating	Additional mitigation measures	Residual risk rating
HG3	Pipeline Works	Dewatering reduces groundwater levels causing saline intrusion.	No initial measures identified	Low	<b>MM-HG01</b> Dewatering activities will be limited in duration	Very Low
HG4	Pipeline Works	Uncontrolled loss of drilling muds during trenchless installation, which affects groundwater quality.	<b>MM-HG03</b> Use suitably qualified and experienced contractors	Low	<b>MM-HG02</b> Drilling muds used in horizontal directional drilling should be biodegradable and non-toxic, where geotechnical conditions allow	Very low
HG5	Pipeline Works	Poor quality overland flow entering groundwater via trench or bell holes.	No initial measures identified	Low	Trenched water course crossings during low/ no flow conditions as per mitigation measures described in <b>Chapter 8</b> Surface water (MM-SW05) <b>MM-HG04</b> Minimise the time trench sections and bell holes are open	Very low
HG6	Pipeline Works	If groundwater used for construction phase - drawdown from water supply reduces groundwater levels at groundwater users (incl. potential GDEs and registered bores).	<b>MM-HG05</b> Sourcing of water for construction supply will be in accordance with relevant legislation.	Very low	No additional measures identified	Very low
HG7	Pipeline Works	Registered bores become damaged, lost (destroyed) or inaccessible thereby impacting bore user.	No initial measures identified	Medium	<b>MM-HG06</b> Landowner liaison and agreements	Very low
HG8	Gas Import Jetty Works	Aquifers interconnected during augering for piling installation that adversely impacts groundwater quality in one or more aquifers.	<b>MM-HG03</b> Use suitably qualified and experienced contractors	Low	No additional measures identified	Low
<b>Operation</b>						
HG9	Pipeline Works	Trenched sections of pipeline create a preferential flow path resulting in changed groundwater flow patterns and/or levels and contaminant migration.	<b>MM-HG07</b> Compaction of backfill using excavated material <b>MM-HG08</b> Use of trench breaker adjacent to watercourses, wetlands and steep slopes	Low	No additional measures identified	Low
HG10	Gas Import Jetty Works	Installed piles beneath nitrogen tank impeding groundwater flow that adversely effects groundwater users.	No initial measures identified	Very low	No additional measures identified	Very low

9.7.1 Drawdown estimates from dewatering (Risk IDs HG1, HG2, HG3)

This impact assessment is based on the maximum estimated groundwater drawdown that may occur as a result of construction dewatering if shallow groundwater was encountered during construction. The drawdown estimates are summarised in **Table 9-3**.

The drawdown due to dewatering would only extend laterally up to approximately 30 metres from the trenched pipeline sections and up to around 60 metres from the thrust bore bell holes and HDD tie-in bell holes under the 'reasonable worst case' scenario. The method used to reach this estimate is described in Appendix H of EES Technical Report D: *Groundwater impact assessment* and impacts associated with these drawdown estimates are described below.

The potential implications of these drawdown estimates on registered bore users, potential GDEs and saline intrusion are discussed in the following sections on impacts to groundwater levels and groundwater quality.

9.7.2 Impacts on groundwater levels

Registered groundwater bore users (Risk ID HG1)

Dewatering of trenches and bell holes (thrust bore and HDD tie-in locations) has the potential to temporarily reduce groundwater levels and subsequently reduce the amount of groundwater available for extraction in nearby groundwater bores. If a trench or thrust bore pit (an excavation at the launching point of trenchless drilling) intersects groundwater, water can then accumulate. The trench/bore pit would then require dewatering to remove the accumulated groundwater for construction works to continue.

Typically, dewatering of excavations is avoided or minimised as much as practicable to reduce the risk of destabilising the trench and bell holes, and to reduce the volume of discharged water to be managed. Impacts to groundwater levels and flow would therefore likely be temporary and limited in magnitude and extent; based on the predominantly low permeability soils (silts and clays), shallow depth of excavations and short-term dewatering activities.

A reasonable worst case scenario of a high watertable, with dewatering limited to two days (for trenching) and ten days (thrust bore and HDD bell holes) provided an estimate for the extent and magnitude of water level reduction away from the excavation (sometimes called the cone of depression). Limiting the dewatering duration where practicable to do so (see mitigation measure MM-HG01), seeks to limit the cone of depression and the potential for effects on groundwater to significantly impact on groundwater users (including at groundwater bores).

Registered irrigation bores 121049 and 142356 are mapped as being within six metres of the proposed trench for the pipeline alignment. Groundwater investigation bore 10673 is mapped as being two metres from the alignment.

Table 9-3: Summary of drawdown estimates

Scenario	Maximum drawdown (m)		
	at 10 m from excavation	at 25 m from excavation	at 60 m from excavation
Open trench intersecting two metres of water	0.79	0.09	-
Thrust bore bell hole intersecting 3.5 metres of water	1.81	0.78	0.10



Registered bores WRK070589 and 91465 are more than 30 metres from trenched sections of the proposed pipeline alignment, but within 30 metres of the alternative options; WRK070589 is mapped as 20 metres and 91465 as 23 metres from trenched sections. These four bores are registered for stock and domestic or irrigation consumptive use. There are no bores registered for consumptive use within 60 metres of thrust bore bell holes or HDD tie-in boreholes.

The closest monitoring wells to bore WRK070589 are MW17 (965 metres south-west of the bore), which was installed to a depth of four metres below ground and was dry during gauging, and MW18 (1.8 kilometres north-east of the bore) which recorded water at a depth of 3.92 metres below ground surface (mbgs). The trench would therefore unlikely intersect groundwater near bore WRK070589, with no requirement to conduct dewatering during construction.

The closest monitoring well to bore 91465 is MW15 (300 metres north-east of the bore) which recorded a water level of 2.24 mbgs. On the basis the pipeline trench would be excavated to a depth of two metres, it is assumed the trench would not intersect groundwater or require dewatering. Further, trenching would only be within 30 metres of the bore if the alternative alignment options are chosen. In this case the bore would be approximately 23 metres from the trench and, even if open trenching intersected groundwater due to higher water levels, the potential impact on this groundwater user is considered negligible (see estimated drawdown of 0.09 metres drawdown at 25 metres in **Table 9-3**).

Bore 121049 (at 47.8 metres deep) and bore 142356 (at 42.6 metres deep) are both relatively deep bores and would unlikely be impacted by dewatering of shallow trench sections (if it were required). The closest monitoring well to these bores is MW08 (135 metres north-east of bore 121049 and 430 metres north-east of bore 142356). The depth to water at MW08 was measured at 3.5 mbgs. Ground elevations at bores 121049 and 142356 are approximately 2.5 metres higher than at MW08, and so groundwater levels at these locations are anticipated to be several metres below the base of trench – generally assumed to be two mbgs. The potential need for dewatering is unlikely and the potential for impact on these groundwater users is considered negligible. The potential for loss, damage or lack of access to these bores during construction is discussed below.

In summary, dewatering of trenched sections, thrust bore bell holes and HDD tie-in bell holes during construction of the pipeline are not anticipated to impact on the availability of groundwater in the registered bores along the pipeline alignment (that is, the overall risk is considered to be very low).

Depth to groundwater beneath the End of Line Scraper System (EOLSS) facility is anticipated to be greater than 10 metres and would not likely be intersected. Further, the nearest groundwater users (registered bore 84052 and potential terrestrial GDEs) are approximately 200 metres from the EOLSS facility where the ground surface elevation is below the base of EOLSS excavation. Any reduction in groundwater levels from dewatering of the EOLSS (if required) would therefore not impact these groundwater users.

### Groundwater dependent ecosystems and watercourses (Risk ID HG2)

There is potential for dewatering of trenches, HDD tie-in bell-holes and thrust bore pits to temporarily reduce water levels beneath terrestrial GDEs that rely on groundwater for survival, or to temporarily reduce groundwater inflows into gaining streams.

The pipeline alignment would intersect 11 watercourses identified as high potential GDEs. Of these potentially gaining streams, trenching is proposed at only two: Olivers Creek and Western Outfall Creek. HDD would be used for installing pipeline sections at the remaining nine watercourses. HDD is a trenchless construction method that avoids surface disturbance and dewatering is only required for a short duration during tying-in of HDD section with the adjacent trenched section of pipeline.

Typically, dewatering of excavations is avoided or minimised as much as practicable to reduce the risk of destabilising the trench and bell holes, and to reduce the volume of discharged water to be managed. Impacts to groundwater levels and flow would therefore likely be temporary and limited in magnitude and extent; based on the predominantly low permeability soils (silts and clays), shallow depth of excavations and short-term dewatering activities.

A reasonable worst case scenario of a high watertable, with dewatering limited to two days (for trenching) and ten days (thrust bore and HDD bell holes) provided an estimate for the extent and magnitude of water level reduction away from the excavation (sometimes called the cone of depression). Limiting the dewatering duration where practicable to do so (see mitigation measure MM-HG01), seeks to limit the cone of depression and the potential for effects on groundwater to significantly impact on groundwater users (including GDEs).

It is noted that the potential aquatic and terrestrial GDEs that fall within the Western Port Ramsar site, between the Crib Point Receiving Facility and Hastings, are beyond the potential dewatering impact zone estimated in **Section 9.7.1**.

### Saline intrusion (Risk ID HG3)

In coastal regions, fresher groundwater (the freshwater lens) sits on top of the denser (that is, heavier) saline groundwater (the salt wedge) which is in connection with seawater. Extracting or pumping significant volumes of groundwater in coastal regions can produce long-term reductions in fresher groundwater levels, leading to upward flow of the underlying salt wedge. This potential increase in salinity within the fresher groundwater may impact groundwater bores and GDEs.

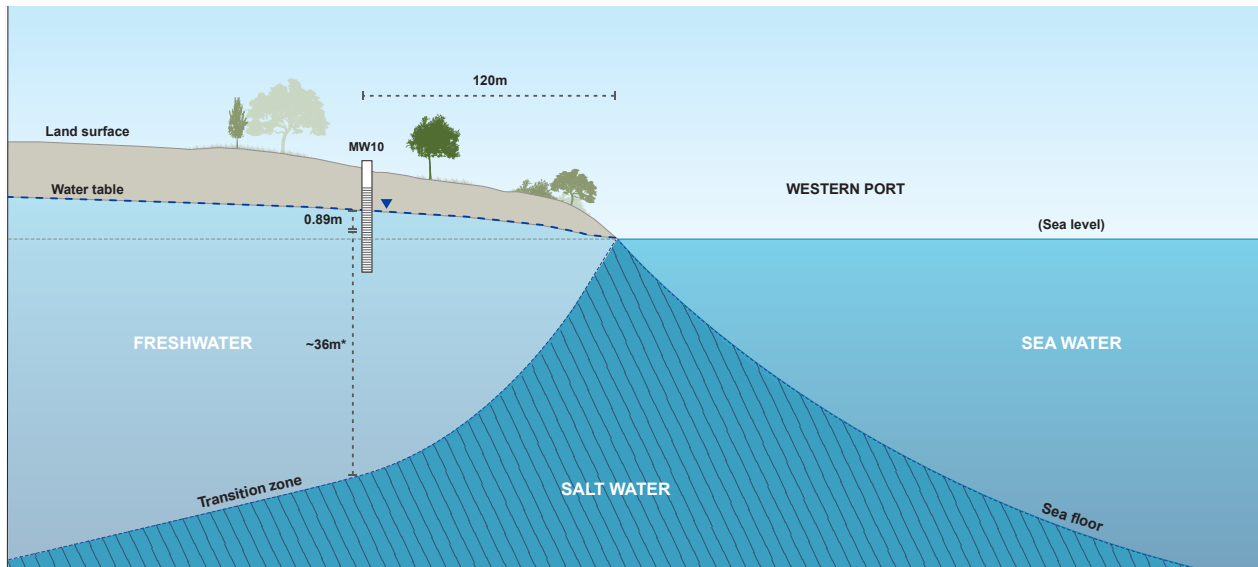
As the pipeline alignment is located within 150 metres of Western Port, the potential for saline intrusions to occur has been considered. As a general rule, for every metre of freshwater lens thickness above sea level, the freshwater extends 40 metres below sea level as shown in **Figure 9-5**. Based on groundwater elevations along the pipeline alignment closest to the coast, the freshwater lens would equate to 30 metres thick. As construction dewatering activities would lead to localised, small scale and temporary reductions in groundwater, generally less than two metres at the excavation, the potential to induce lateral flow from the coast, or upward flow from the salt wedge is considered very low. The duration of any site dewatering near the coast would be limited where practicable to do so (see mitigation measure MM-HG01) to limit the cone of depression and further reduce the potential for saline intrusion effects to significantly impact on groundwater users.

## 9.7.3 Impacts on groundwater quality

### Drilling muds (Risk ID HG4)

Drilling muds would be used where HDD is proposed for the pipeline construction. Drilling muds aid the drilling of boreholes by providing stability and support to the bored hole, reducing drilling torque, and mixing with the drill cuttings which are then removed.

If drilling muds contain contaminants, it has the potential to impact groundwater quality and beneficial uses through the uncontrolled migration of drilling muds away from the drill path, which could enter the groundwater table via an existing fracture or formation opening in the soil or rock substrate. The uncontrolled loss of drilling muds is considered unlikely and any impacts would be managed and localised where a suitably qualified and experienced HDD contractor is used (see mitigation measure MM-HG03). The potential effects on groundwater quality would be further reduced if non-toxic and biodegradable drilling muds are used where geotechnical conditions allow (see mitigation measure MM-HG02). The primary clay used for drilling mud is bentonite (sodium montmorillonite), a non-toxic, naturally occurring mineral clay, which is added to fresh water to produce a 'mud'. As such, the residual risk of drilling muds impacting groundwater quality is very low.



#### NOTES

Not to scale

\*Approximate depth of freshwater beneath sea level - based on Ghyben - Herzberg relation.

m = Metres.

▲ **Figure 9-5:** Saltwater wedge



#### Overland flow to groundwater (Risk ID HG5)

Significant rainfall while trench sections or bell holes are open during construction activities could lead to runoff of low-quality water to flow into the excavation and potentially infiltrate into groundwater via the excavation. The highest potential for this to occur is at or near trench crossings of waterways. Trenching of water crossings would be undertaken during no or low flow conditions where possible, when there is typically less overland flow anticipated (see mitigation measures described in EES **Chapter 8** Surface water). If runoff did enter the trench, impacts on groundwater quality would be limited as the ability for the runoff to move laterally would be restricted in the predominantly clay dominant soils of the Pipeline Works area. The potential to impact groundwater quality from this already low risk event would be further reduced by minimising the duration for which excavations remain open.

#### What is piling?

Piling is a technique that sets deep foundations for construction work such as buildings. Piling involves inserting large amounts of wood, steel or concrete into the soil of the ground. The deep insertion ensures a sturdier base for construction works.

#### Interconnection of aquifers during piling (Risk ID HG8)

During augering of the piling hole and before the placement of concrete slurry for piling as part of the Gas Import Jetty Works, there is potential to intersect aquifers of different water quality. If these aquifers became connected, the differing quality in water could lead to the loss of beneficial uses or affect groundwater users in one or more aquifers.

The Crib Point Receiving Facility is underlain by Baxter Sandstone of the upper tertiary aquifer, which is typically greater than 20 metres thick. The potential for multiple aquifers being intersected across the 20-metre depth of piling is considered unlikely, and the variability of groundwater quality in terms of beneficial uses is not anticipated to be substantial. Furthermore, if the interconnection of aquifers did occur, it would be of short duration.

#### 9.7.4 Water supply (Risk ID HG6)

It is likely that water would be required during the construction of the pipeline for dust suppression and hydrostatic (pressure) testing of the pipeline. Hydrostatic testing involves using water to test pressure vessels such as pipelines for strength and potential leaks. If the water is sourced from groundwater within the KWR WSPA, a temporary entitlement may need to be purchased from an existing licence holder as the WSPA is fully allocated. All relevant legislation and policy requirements regarding water sourcing would be adhered to (see mitigation measure MM-HG05). The risk of the Project adversely impacting water supply is considered very low.

#### 9.7.5 Loss of registered bores (Risk ID HG7)

There is a potential for registered bores within, or near, the construction footprint of the proposed pipeline alignment or alignment alternatives to be damaged, lost (that is, destroyed), or become inaccessible during construction. Following the completion of detailed design, the location and condition of registered bores relative to the Pipeline Works area could be visually confirmed on site before construction started by liaising with landowners and/or bore owners potentially affected. In instances where a landholder bore was deemed to be impacted by the Project, consultation can facilitate agreement between AGL and APA and landholder (see mitigation measure MM HG06).

### 9.8 Operation impacts

Two risks to groundwater related to the operation of the Project were identified. These relate to changes to groundwater flow patterns and groundwater quality and are rated as low.

#### 9.8.1 Preferential flow paths (Risk ID HG9)

If the trench backfill material surrounding the pipeline has a higher hydraulic conductivity than the surrounding undisturbed soils, there is a potential to create a preferential flow path (where groundwater flows faster through the backfill material than in surrounding material). There is a risk this could create a drainage-like feature that may result in a permanent change in groundwater flow along the pipeline alignment. This could potentially impact GDEs close to the pipeline alignment and/or reduce groundwater discharge to gaining streams that cross the pipeline.

A preferential flow path becomes more significant where the trench backfill is coarse grained, as water is able to move more readily through this medium. It may also become more significant if the fall of the trench is steep and there is a point of discharge from the trench. To mitigate this risk of creating a preferential flow path, the pipeline trench would be backfilled with the native excavated material in most locations along the alignment (see mitigation measure MM-HG07). This is the preferred construction methodology to minimise the amount of residual materials to be managed, with imported packing sands only used along short sections where required such as beneath roads. Backfill, whether excavated or imported, would be placed and compacted such that the permeability is similar to the unexcavated material (as per AS/NZS 2885.1<sup>2</sup>). Trench breakers (lower permeability material backfilled around the pipeline) would also be installed in sections of the trench where the pipe has a steeper fall to reduce preferential flow paths (see mitigation measure MM HG08).



### 9.8.2 Impeded groundwater flow paths due to piles (Risk ID HG10)

There is potential for groundwater flow to be impeded by the presence of piles for the Crib Point Receiving Facility in the Gas Import Jetty Works area which could lead to changes in groundwater levels and groundwater flow direction. This could result in potential impacts such as reduced groundwater flow to GDEs, exposure of acid sulfate soils down the hydraulic gradient of piles (due to groundwater level decreases) and raising saline/brackish groundwater into the soil zone.

The degree of change to groundwater flow depends on several factors, including the extent to which the aquifer perpendicular to groundwater flow has been impeded by piles. If a conservative estimate of 100 piles are required beneath the nitrogen tank, the piles would block the equivalent of 9 per cent of the aquifer through which groundwater flow is occurring (from west to east) beneath the Crib Point Receiving Facility. It is anticipated that groundwater would flow around the piled section and/or through spacing with negligible effect on groundwater levels and flow. Potential impacts would be mitigated with the use of contractors that are suitably qualified in piling installation (see mitigation measure MM HG03).

## 9.9 Mitigation measures

The mitigation measures developed for groundwater impacts are summarised in **Table 9-4**.

In addition to the groundwater mitigation measures recommended in **Table 9-4**, mitigation measures to avoid, minimise and mitigate impacts to groundwater are also recommended in:

- **Chapter 8** Surface water.

## 9.10 Conclusion

The groundwater impact assessment has identified the risks and potential impacts of the construction and operation of the Project on groundwater levels, flow and quality. The Gas Import Jetty Works were assessed in the context of potential risks posed by piling beneath the proposed nitrogen storage tank.

Several of the potential groundwater impacts associated with the construction of the Pipeline Works are related to the reduction of groundwater levels if dewatering activities are required. This has the potential to affect registered bore users, GDEs and induce saline intrusion. Other potential impacts identified are related to groundwater quality impacts from HDD drilling muds, poor quality runoff entering open trenches and interconnection of aquifers during auger drilling for piling. The possibility of registered bores becoming damaged or inaccessible has also been identified as a potential risk.

Construction impacts identified have been assigned a risk rating of low or very low with the implementation of additional mitigation measures. These potential impacts would be managed through implementation of the recommended mitigation measures including limiting the duration of dewatering activities, using non-toxic and biodegradable HDD drilling muds, conducting works in low or no flow conditions and minimising the time trench sections are open.

The impact assessment found limited potential for the operation of the Project to impact groundwater levels and flow. The risk of permanently reducing groundwater levels by creating a preferential flow path within the trench was considered, together with potential changes in groundwater levels and flow due to the installation of piles at the Crib Point Receiving Facility.

The risk of potential impacts on groundwater levels, quality and flow from construction and operational activities have been identified as low or very low, with the recommended mitigation measures in place. As such, the potential for groundwater quality and movement to affect the ecological character of the Western Port Ramsar site during construction and operation of the Project is considered to be low.

In response to the water and catchment values draft evaluation objective, impacts of the Project on groundwater have been assessed and mitigation measures have been identified to reduce or minimise these impacts.

Table 9-4: Groundwater mitigation measures

Mitigation measure ID	Mitigation measures	Works area	Stage
MM-HG01	<b>Dewatering activities</b> Where groundwater is entering an excavation, dewatering activities will be limited to two days or less in trenched sections and HDD tie-in bell holes, and 10 days or less at thrust bore sections and thrust bore bell holes, wherever practicable.	Pipeline Works	Construction
MM-HG02	<b>Drilling muds</b> Horizontal directional drilling muds will preferentially use non-toxic (e.g. bentonite) biodegradable drilling muds where geotechnical conditions allow.	Pipeline Works	Construction
MM-HG03	<b>Suitably qualified contractors</b> Contractor(s) that are suitably qualified and experienced in trenchless installation techniques and piling installation will be used.	Gas Import Jetty Works and Pipeline Works	Construction
MM-HG04	<b>Minimise the duration of open trench and bell holes</b> The duration that trench sections and bell holes are open will be minimised, to reduce the potential for poor quality runoff impacting groundwater.	Pipeline Works	Construction
MM-HG05	<b>Sourcing of groundwater</b> Sourcing of groundwater for construction supply (if required) will be in accordance with Section 50 Licence to take and use water of the Water Act 1989.	Pipeline Works	Construction
MM-HG06	<b>Condition of groundwater bores</b> Through liaison with landholders, the location, condition and functionality of potentially affected bores (due to damage, destruction or loss of access) will be visually confirmed prior to construction commencing and make-good arrangements will be agreed if required.	Pipeline Works	Construction
MM-HG07	<b>Compaction of trench backfill</b> Compaction of backfill using excavated material, where practicable, will be carried out to reduce the potential for preferential lateral flow along the trench.	Pipeline Works	Construction
MM-HG08	<b>Trench breakers</b> Trench breakers will be installed adjacent to watercourses, wetlands and steep slopes as shown in the standard drawing (CPT.2373-DWG-L-0106).	Pipeline Works	Construction