11. Groundwater

The Groundwater Assessment examined the potential effects of the Project on groundwater and its beneficial uses under the State Environment Protection Policy (Groundwaters of Victoria) as well as the potential for groundwater to impact on road construction and the structural integrity of the road.

The assessment found that groundwater quality in the study area is relatively poor, and that development of the resource is limited, with uses generally limited for stock and non-potable domestic purposes. Groundwater salinity in the study area is variable, ranging from 1,500 milligrams per Litre (mg/L) Total Dissolved Solids (TDS) to over 7,000mg/L TDS. Available groundwater data reveals low bore yields, generally less than one litre per second.

Available information for bores within the study area indicated standing water level ranging from 1 metre (m) to 22m below the surface. Groundwater levels are expected to be deeper in higher topographies and shallower in flatter topographies. The areas where deeper cuts are proposed are in the higher topographies.

Regional mapping by the Department of Primary Industries (DPI) has identified a number of Groundwater Dependent Ecosystems (GDEs) in the study area that potentially use groundwater to some extent, although they may not necessarily be dependent on it. Very little data is currently available to assess whether or not these GDEs are actually dependent on groundwater. However, the higher salinity groundwater in much of the study area would not be conducive to plant growth.

The key risk considered in the impact assessment was the intersection of groundwater during construction. Although it is considered that the likelihood of this occurring is low, it cannot be discounted that groundwater may be unexpectedly encountered at localised areas along the alignment. If groundwater was intersected during construction it is expected that the impact of this event would range from insignificant to moderate depending on the location in which groundwater was intersected. Adoption of a Groundwater Monitoring Plan, would assist in managing impacts to groundwater and as a consequence the overall impacts on groundwater would be negligible to low.

Shallow groundwater is not conducive to road construction and efforts to better characterise groundwater occurrence should be made during the detailed design phase of the Project.

Based on the current understanding of groundwater conditions in the study area, there is no means of conclusively differentiating the impacts on groundwater between Option 1 and Option 2.

11.1 EES Objectives

The EES objective relevant to Groundwater is:

- *To protect catchment values, surface water and groundwater quality, stream flows and floodway capacity, as well as to avoid impacts on protected beneficial uses*.

This chapter discusses the groundwater environment within the project area, including the location and quality of groundwater. The potential impacts from the Project on groundwater have been assessed and management measures have been identified to minimise these impacts. More specifically, this chapter:

- Characterises the groundwater in the project area in terms of location, behaviour and quality, including its protected beneficial uses under the State Environment Protection Policy (Groundwaters of Victoria).
- Identifies potential effects of road construction and operation activities on groundwater and any potential effects of groundwater on road construction and structural integrity.
- Identifies measures to avoid, mitigate and manage any potential effects including any relevant design features of the road or techniques for construction.
- Describes residual effects of road construction and operation activities on groundwater in the project area.

This chapter is based on a groundwater assessment completed by GHD Pty Ltd (2012d). The assessment report is included in Technical Appendix F.

11.2 Study Area

The groundwater study area encompasses a corridor extending approximately 1500m to the north and south of the edge of the existing Western Highway. In some areas this corridor has been widened to incorporate alignment options. The study area is shown in Figure 11-1. The greater regional groundwater catchment area is also relevant and has been considered.

11.3 Methodology

To assess the groundwater environment within the study area, the following tasks were completed:

- Review existing hydrogeological reports in the study area;
- Identification of beneficial uses of groundwater within the study area, in terms of State Environment Protection Policy (Groundwater) (SEPP GoV);
- Analysis of the geology of the study area and examining the relationships between aquifers at the local and regional scale;
- Interpretation of recharge and discharge processes, and interactions between surface and groundwater;
- Interpretation of groundwater quality in relation to the interpreted geology and flow systems;
- Identification of the location of users/receptors of the groundwater systems such as bore owners, streams and wetlands; and
- Provide a concise summary of the conceptual hydrogeological model for the Western Highway study area.

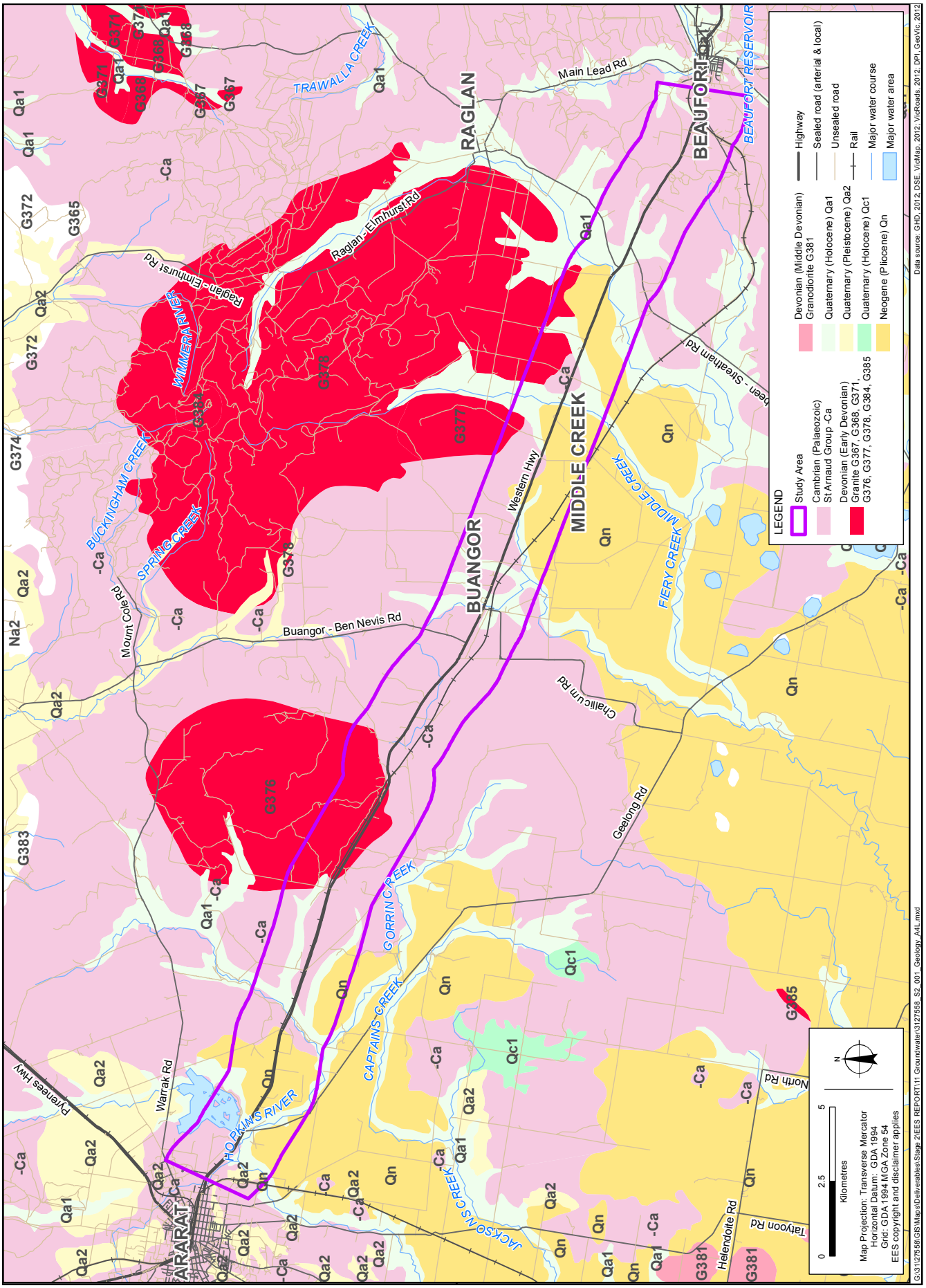

Figure 11-1 Groundwater study area

11.4 Legislation and Policy

The legislation and government policies related to groundwater are outlined in Table 11-1.

Table 11-1 Relevant legislation and policy

Legislation/Policy	Description
State	
Water Act 1989	Approval for the extraction, use or disposal of groundwater for the Project may be required under the Water Act. It is not yet known if this would be required for the Project. This would be confirmed during the detailed design phase.
Environment Protection Act 1970	The Environment Protection Act 1970 (EP Act) regulates the discharge of emissions to the groundwater environment by a system of licences and works approvals. Any discharge into groundwater during the construction of the Project must be in accordance with the requirements of the EP Act. The requirement this discharge would be confirmed by the construction contractor(s).
State Environment Protection Policy (Groundwaters of Victoria)	The State Environment Protection Policy (SEPP) (Groundwaters of Victoria (GoV)) has been developed under the provisions of the EP Act and sets out segments of the groundwater environment, based on salinity. Each segment has beneficial uses that must be protected. The EPA can determine that the beneficial uses of a segment are not applicable to groundwater where: ◗ There is insufficient yield. ◗ The background level of a water quality indicator other than total dissolved solids (TDS) precludes a beneficial use. ◗ The soil characteristics preclude a beneficial use. ◗ A groundwater quality restricted use zone has been declared.

11.5 Existing Conditions

The regional geology is relatively simple with only a limited number of formations occurring within the study area, see Figure 11-1. The identified aquifers are all unconfined, which means they are susceptible to contamination from activities on the surface. More detail on geology is provided in Chapter 10 (Soils and Geology).

Within the study area, groundwater occurs throughout the various geological formations to varying degrees. There are no Groundwater Management Units (GMUs) within 5 kilometres (km) of the study area. GMUs are designated for management of groundwater resources in the area. Lack of groundwater development in this area is circumstantial evidence of groundwater within these aquifers being considered of low value.

There are 8 licenced groundwater bores recorded within the study area, 6 for stock and domestic use, and 2 for monitoring observation. Available information from these bores suggests a water table depth range from less than 1m to 22m. Depth is expected to be greater in the higher topographies where the majority of deep road cuts are proposed. At depths where the proposed highway might potentially interact with aquifers, associated bores yields are low and generally less than 1 Litre per second (L/s).

Regional-level mapping and local bore information indicates that aquifer salinity is relatively high, ranging widely from 1,500mg/L to over 7,000mg/L TDS. Most of the study area has groundwater with salinities over 3,500mg/L TDS. High salinity means that groundwater in the area has limited extracted value, generally only suitable for stock watering and industrial use. Groundwater with lower salinity levels is suitable for irrigation, although water above 1,500mg/L to 2,000mg/L TDS may cause plant stress. The SEPP (GoV) defines beneficial uses of groundwater, based on the existing groundwater quality. A summary of the groundwater segments and corresponding beneficial uses is provided in Table 11-2.

Groundwater Dependent Ecosystems (GDEs) are ecosystems that rely on groundwater to meet all or some of their water requirements. Department of Primary Industries (DPI) regional mapping shows that in areas where the groundwater level is within 10 m of the surface, there is the potential for presence of GDEs. These consist mostly of vegetation relying on access to shallow groundwater by means of tree roots. The potential GDEs in the study area are largely associated with the granitic geology near the Langi Ghiran State Park. Figure 11-2 shows the DPI mapping of GDEs within the study area.

Table 11-2 Groundwater beneficial uses

Use	Segment				
	A1	A2	B	C	D
	Salinity (mg/L TDS)				
	0-500	501-1,000	1,001-3,500	3,501-13,000	>13,000
Maintenance of ecosystems	✓	✓	✓	✓	✓
Potable water:					
▪ Desirable	✓				
▪ Acceptable		✓			
Potable mineral water supply	✓	✓	✓		
Agriculture, parks and gardens	✓	✓	✓		
Stock watering	✓	✓	✓	✓	
Industrial water use	✓	✓	✓	✓	✓
Primary contact recreation (e.g. swimming/bathing)	✓	✓	✓	✓	
Buildings and structures	✓	✓	✓	✓	✓

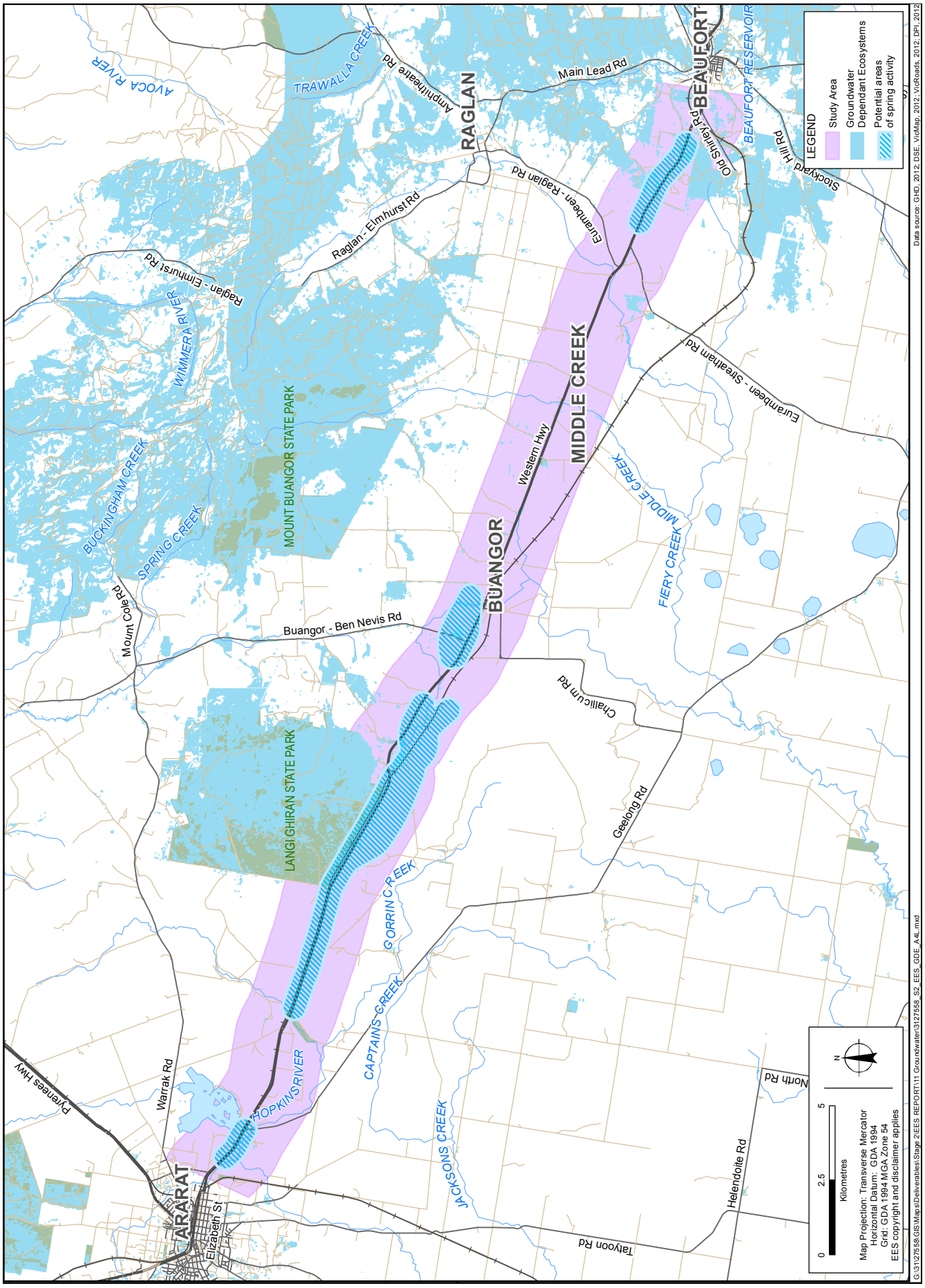

Figure 11-2 DPI identified GDEs

11.6 Impact Assessment

The impact and risk assessment presented in the following sections was conducted on the two alignment options, known as Options 1 and 2.

11.6.1 Key Issues

There is limited site groundwater information available due to the low number of bores in the locality. Nevertheless, as the two alignment options are predominately above the existing grade, and there are limited areas of deep cut, impacts of the Project on groundwater would be low.

11.6.2 Impact Pathways

Potential impacts to the groundwater environment could occur during either the construction of the Project, or during its operation. They can be simplified to those relating to groundwater availability for 'beneficial uses', and those concerning groundwater quality. In some cases there could be an overlap between these categories, for instance if construction dewatering triggered the oxidation of acid sulfate soils (ASS), affecting water quality.

11.6.2.1 Construction Dewatering

Cuts below water table along the proposed alignment could potentially cause groundwater inflows into the excavation. Not only would this impact subsurface construction, it may present issues regarding reduction in available water in neighbouring wells, dewatering of perched aquifers, loss of supply to dependant ecosystems, ground settlement, activation of ASS and mobilisation of contaminated groundwater plumes. While the water table elevation along the alignment would not be known until detailed geotechnical investigations are conducted, given that there is no evidence of salinization and water logging it is likely to be at a depth of greater than 3m. Less than 1.6km of the alignment, or about 4%, involves a cut that would exceed this depth, and is considered at greater risk of dewatering. Most of the deep cuts are located on or near the crest of hills, further reducing the likelihood of encountering groundwater. The two locations of where these cuts are most likely to occur along the alignment are the areas immediately west of both Beaufort and Buangor, see Technical Appendix F for further details.

Overall, there would be a low likelihood of encountering groundwater, however it cannot be discounted that groundwater may be unexpectedly encountered at localised areas along the proposed alignment. Geotechnical investigations would be undertaken to confirm the groundwater depth during the detailed engineering design phase. At this stage, it is expected that the impacts to groundwater would be insignificant to minor.

11.6.2.2 Neighbouring Groundwater Users

The water levels and operation of neighbouring groundwater user's wells or spring fed dams may potentially be influenced by excavations, as explained in Section 11.6.2.1, or as a result of any groundwater bores installed by the construction contractors (e.g. a water supply necessary for dust suppression).

There are few bores identified close to the proposed alignment, largely due to the poor groundwater quality. Should any bore be installed by the contractor, a licence would be required from Southern Rural Water which would include an assessment of any potential impacts. A groundwater supply bore would not be licenced by Southern Rural Water unless the risks of extraction to groundwater are acceptable.

Spring fed dams are those dams of sufficient depth to intersect the water table, or those located down slope of a spring. Figure 11-2 indicates potential areas along the alignment options where spring flow may occur. There is no evidence supporting the proposed locations of spring flow, or for the existence of spring fed dams, however these would be confirmed following geotechnical investigation of groundwater levels during the detailed engineering design phase.

Considering the limited existing development of groundwater and the processes in place to access groundwater, impacts to the groundwater environment for either of the alignment options is considered insignificant.

11.6.2.3 Compaction or Subsidence

Land subsidence is a gradual settling of the ground surface, and is potentially a result of aquifer dewatering. It may have implications for the integrity of structures where the dewatering occurs, such as buildings, roads and underground services. The speed that settlement occurs depends on the amount of depressurisation, and the aquifer material. The geological lithology most susceptible to settlement is the Tertiary and Quaternary aged sediments, which are generally restricted to present day waterways. These areas would be crossed by bridging structures and groundwater would not therefore be impacted in these localities. Most areas requiring deeper cuts are located on the Ordovician basement rock which is not considered compressible.

Overall, less than 100m of the proposed alignment, which consists of fine grained materials, is considered potentially susceptible to causing settlement. The likely impact is therefore insignificant.

11.6.2.4 Groundwater Quality

The background groundwater quality in the study area is variable. Most areas of the alignment are in Segment C with the remainder being within Segment B (see Table 11-2). This water quality is relatively poor, as outlined in Section 11.5, with salinity in

excess of that acceptable for potable use. The beneficial uses to be protected in accordance with the SEPP (GoV) are identified in Table 11-2.

It is possible that construction and operational activities could result in the contamination of groundwater, impacting on groundwater quality through:

- Spillage, improper handling, storage and application of hazardous materials during construction.
- Disposal of fluids or waste to groundwater.
- Aquifer re-injection to mitigate drawdown and related impacts (e.g. settlement).
- Exposure of ASS through dewatering. Refer to Chapter 10 (Soils and Geology) for discussion of impacts and mitigation for ASS.
- Incompatibilities with construction materials, e.g. leaching from imported backfill.
- Establishing hydraulic connection between two aquifers of differing water quality which were previously hydraulically isolated.
- Spillage and road run-off during operation of the Project.

The likelihood of these events occurring is low, as the VicRoads standard environmental management procedures address these risks. In addition, runoff generated during operation of the road would be captured in the road drainage system, largely preventing the runoff from entering the groundwater environment. The significance of impact for either of the alignment options is dependent upon the local groundwater quality. Where the groundwater salinity is at the upper end of the range, the impact to the groundwater environment is likely to be negligible. Where groundwater is at the lower end of the salinity range, the impact could be significant if the contamination adversely affects existing beneficial uses e.g. stock and/or domestic bores.

11.7 Risk Assessment

An environmental risk assessment was undertaken on the two proposed options to identify key environmental issues associated with the construction and operation of the Project. The methodology for this risk assessment has been described in Chapter 4.2 (EES Assessment Framework). A risk assessment report that explains the process in detail and contains the complete project risk register has also been included as Technical Appendix Q. The risk assessment was conducted on the shortlisted alignments only.

Table 11-3 shows a summary for groundwater of:

- The impact pathways identified.
- A description of the consequence.

Table 11-3 Groundwater Risks

Risk No.	Impact Pathway	Consequence Description
GW1	Cuts below water table along alignment, requiring dewatering	Construction dewatering results in unacceptable impact to other groundwater users, e.g. existing irrigators, stock and domestic users (construction and/or operation).
GW2	Cuts below water table along alignment, requiring dewatering	Management of the recovered groundwater – erosion or water quality degrades receiving surface waterways (construction and/or operation).
GW3	Cuts below water table along alignment, requiring dewatering	Dewatering / depressurisation consolidates compressible materials causing settlement and land instability (construction and/or operation). Few built structures are in those area that are below the grade.
GW4	Cuts below water table along alignment, requiring dewatering	Temporary construction dewatering adversely affects groundwater flow to GDEs. Cuts below grade that permanently result in change in groundwater flow regime. (construction and/or operation).
GW5	Cuts below water table along alignment, requiring dewatering	Dewatering alters hydraulic gradients resulting in existing groundwater contamination plumes potentially being dislocated / moved. Interruption of existing groundwater remediation efforts.
GW6	Cuts below water table along alignment, requiring dewatering	Potential generation of acid plumes / mobilisation of heavy metals / aggressive groundwater, leading to attack on submerged steel / concrete structures (piles, services)
GW7	Contamination of groundwater from construction activities, e.g. spillage, use of 'contaminated' fill material, construction waste management, hazardous materials handling.	Impact to groundwater quality/ breach of SEPP (GoV). Potential to breach SEPP (Waters of Victoria). Impact to worker safety during construction.
GW8	Contamination of groundwater from operational activities (road runoff, traffic accidents, stormwater, spillage)	Impact to groundwater quality/ breach of SEPP (GoV).

Risk No.	Impact Pathway	Consequence Description
GW9	Ponding and retention of water associated with highway drainage (operation)	New or increased groundwater accessions, altered groundwater flow patterns, new or exacerbated waterlogging and salinity impacts
GW10	Construction earthworks removing impervious layers (across site, floodplains, river crossings and embankments).	Site recharge enhanced increasing groundwater levels (water logging, groundwater displacement) and or introducing contaminants.
GW11	Construction works create impervious ground surface layers.	Reduced recharge to groundwater system.
GW12	Project pipelines or service conduits constructed in saturated materials alter groundwater flow.	Buried services within the alignment located below the water table may create preferential groundwater seepage paths, and alter seepage migration routes. In shallow groundwater environments the resulting impact can be significant. Furthermore groundwaters (e.g. saline groundwater) may be aggressive to buried services.
GW13	Alignment of road passes through existing groundwater bore location (or farm dam) or severs access for stock or irrigation infrastructure.	Requirement to compensate groundwater user, install replacement bore (observation, stock, irrigation etc.) or replacement dam. Temporary loss of production.
GW14	Use of groundwater for construction water supply.	Adverse impact to existing groundwater users, environment.
GW15	Shallow groundwater or rising water tables	Rising water and/or precipitation of salts can damage road pavements.

In assessing the impact to groundwater, the majority of risks associated with the Project have been assigned a negligible likelihood of occurring, as much of the Project would be constructed above the existing grade and therefore there would be limited opportunity for direct interaction with the groundwater environment. Management measures have been identified to protect and maintain groundwater availability and quality. Overall, it is concluded that the risk to the groundwater environment as a result of the construction and operation of the Project would be negligible to low.

11.8 Environmental Management Measures

VicRoads has a standard set of environmental management measures which are typically incorporated into their construction contracts for road works and bridge works. These measures have been used as the starting point for the assessment of construction related risks and are described in detail in Chapter 21 (Environmental Management Framework). In some instances, additional Project specific environmental management measures have been recommended to reduce risks.

Management measures specific to each identified groundwater risk, and the residual risk rating after environmental management measures have been applied, are outlined in Table 11-4.

Table 11-4 Groundwater Environmental Management Measures and Residual Risk

Risk No.	Environmental management measure	Residual Risk
GW1	A groundwater management plan and monitoring program would be developed and implemented to address potential impacts to groundwater if encountered. The groundwater management plan would include controls to prevent erosion and sedimentation and include water disposal options. Construction groundwater supplies would have to be from licensed bores and subject to the Southern Rural Water approvals process and/or groundwater trading rules / local management rules. An audit of landholders would be conducted to identify water supplies that may be impacted, e.g. dams or bores. Measures to mitigate groundwater draw down impacts would include: ▪ Minimise dewatering required by micro-review of gradelines. ▪ Preconstruction investigations of groundwater (occurrence and quality), particularly in proposed areas of cut, and establishment of baseline conditions. ▪ Detailed design of cuts and ground support. Alteration of the construction technique to reduce the need for dewatering. A variety of engineering options are available, e.g. use of sheet piles / contiguous piles. ▪ Careful design of the dewatering methodology, e.g. multiple closely spaced bores may create a localized cone of depression. ▪ Increased construction effort, e.g. reducing the duration over which dewatering may be required; ▪ Careful timing of the works to periods where water levels may be at their lowest. ▪ Re-injection of the pumped groundwater between the excavation site and impacted part to impart hydraulic control (aquifer recharge). ▪ Non-continuous pumping that may allow water level recovery during pumping quiescence. ▪ Supplying any affected parties with an alternate water supply, e.g. carting water, deepening the pump intake setting depth. ▪ Replacement of existing bores that are adversely impacted by construction. ▪ Implementing a groundwater monitoring program. ▪ Sufficient contingency must be incorporated into water treatment plans, monitoring programs (environmental, safety) to cope with the ingress, management, treatment and disposal of contaminated groundwater water that may be unexpectedly encountered.	Negligible
GW2	Comply with section 1200.08 Erosion and Sediment Control of the VicRoads contract specification. As per GW1.	Negligible
GW3	As per GW1. A site specific investigation would be conducted during detailed design to identify likelihood of subsidence.	Low
GW4	As per GW1. If required, an alternate water supply would be established to maintain environmental water requirements, e.g. treated stormwater / road drainage could be redirected as a replenishing or alternate water supply.	Negligible
GW5	As per GW1. Contaminated materials would be managed as follows: ▪ The discovery of contaminated material on the site during works would be managed in accordance with VicRoads and EPA Guidelines. ▪ Where putrescible waste material is encountered the Superintendent and EPA would be notified. ▪ The Contractor would undertake a visual assessment of the Site for contaminated soils and materials.	Negligible

Risk No.	Environmental management measure	Residual Risk
GW6	As per GW1. Development of an Environmental Management Plan (EMP) to establish a consistent and sustainable approach to managing PASS e.g. DSE Victorian Best Practice Guidelines for Assessing and Managing Coastal Acid Sulfate Soils Minimise the dewatering influence near PASS materials (as per GW1). Soil sampling and laboratory analysis would be conducted as part of the detailed design phase to confirm the presence of ASS. Groundwater levels and quality would be monitored in all aquifers adjoining PASS materials. Performance standards and action triggers would be established for: ▪ implementing remedial actions. Impacted or at risk areas/assets remediation can be undertaken through pH adjustment, e.g. lime dosing. ▪ considering the need for artificial recharge.	Low
GW7	Contaminated materials would be managed as follows: ▪ The discovery of contaminated material on the site during works would be managed in accordance with VicRoads and EPA Guidelines. ▪ Where putrescible waste material is encountered the Superintendent and EPA would be notified. ▪ The Contractor would undertake a visual assessment of the Site for contaminated soils and materials. The EMP could include specific procedures to minimise leakage or spillage of any fuels or chemicals. Fuel and chemical storages and equipment fill areas would be monitored at internals or not more than seven days.	Negligible
GW8	Standard procedures for State Emergency Response, Country Fire Authority and Environment Protection Authority would be implemented.	Negligible
GW9	Water Sensitive Road Design measures would be evaluated in the detailed design phase, as described in VicRoads Integrated Water Management Guidelines (August 2011).	Low
GW10	A groundwater management plan and monitoring program would be developed and implemented to address potential impacts to groundwater, if encountered. River crossings would be duplicated consistent with CMA requirements. Earthwork surface finish specifications would be specified to mitigate enhanced accessions. Site would be rehabilitated with vegetation / grasses. Grading would be conducted for erosion control. Allowance would be made for subsidence with backfilled excavations. Temporary access tracks would be removed and ground conditions rehabilitated.	Negligible
GW11	As per GW1 and GW10	Low
GW12	As per GW1. Apply pipeline construction measures (trench cut offs- or breakers) that mitigate risk process, if groundwater is encountered.	Negligible
GW13	Negotiation with asset owners would be undertaken. Confirm of bore locations (and operational status) within construction corridor and conduct landholder consultation. Construction groundwater supplies would be from licensed bores and subject to the Southern Rural Water approvals process and/or groundwater trading rules / local management rules. Audit of landholders would be conducted of identified water supplies that may be impacted, e.g. dams or bores.	Negligible
GW14	Construction groundwater supplies would be from licensed bores and subject to the Southern Rural Water approvals process and/or groundwater trading rules / local management rules.	Negligible
GW15	Adequate road (under) drainage. Understanding of conditions of existing road i.e. correlations from existing behaviour.	Negligible

11.8.1 Residual Risks

Following implementation of the proposed mitigation measures there are not expected to be any significant impacts. The overall risk to groundwater is negligible to low.

11.9 Conclusion

The alignment encompasses generally saline groundwater. Owing to its poor quality, groundwater development is limited, and therefore understanding of the water table depth is not well understood. Detailed geotechnical investigations to confirm groundwater depths would take place to inform detailed design and construction.

Two alignments have been considered within Section 2, however based on the available understanding of groundwater conditions, there is no means of conclusively differentiating either in terms the least impact. The value of the groundwater resource in the locality is low as the groundwater is generally saline, with beneficial uses only for stock and non-potable domestic purposes, and bore yields are low. Whilst potential groundwater dependent ecosystems have been identified in the locality in regional-scale mapping, it is considered that the high salinity of the groundwater in much of the study area would not be conducive to plant growth. Therefore, the project is not considered likely to impact on groundwater dependent ecosystems. However, there is uncertainty about this impact and the installation of bores should be carried out prior to detailed design to test that assumptions are correct.

The consequence of the construction of the Project intercepting groundwater is also considered to be low as there are few bores in the locality, due to the high salinity and low yields of the groundwater. Less than 1.6km (4 percent) of the alignment length is of a depth that could encounter groundwater (greater than 3m depth) and most of the deep cuts are near the crest of hills where the likelihood of encountering groundwater is further reduced. Whilst the risk is low, the consequence of any depressurisation from dewatering of an aquifer around a cut is also low due to absence of productive bores and few built structures being located in areas where a deep cut is required. Further, geotechnical investigations to be carried out during the detailed design phase of the Project will confirm groundwater depth and if groundwater is encountered, there are well developed management measures (such as groundwater re-injection and grouting) to avoid detriment to the groundwater, surface water or other assets. For these reasons, the overall impact of the Project on the groundwater environment is considered to be low.