REPORT

Central Plains Water Enhancement Scheme: Assessment of Effects on the Environment for Long Tunnel

Prepared for

Central Plains Water Trust

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Contents

1 Introduction 1-1

1.1 Background 1-1

1.2 Purpose of this Report 1-1

1.3 Scope of this Report 1-1

1.4 Statutory Approvals Sought 1-2

1.5 Structure of the Assessment of Environmental Effects 1-3

2 Description of the Proposed Activity 2-1

2.1 Proposal Being Withdrawn 2-1

2.2 New Tunnel Route 2-1

2.3 Tunnel Dimensions 2-2

2.3.1 Length 2-2

2.3.2 Diameter 2-2

2.3.3 Grade 2-2

2.3.4 Depth below ground 2-2

2.4 Construction 2-2

2.4.1 Portals 2-2

2.4.2 Tunnel 2-3

2.4.3 Staging Areas 2-4

2.4.4 Water and Power Supply 2-6

2.4.5 Effluent and Waste Management and Disposal 2-6

2.4.6 Staff and Workforce 2-6

2.5 Tunnel Operation 2-7

3 Alternatives 3-1

3.1 Storage and Delivery of Water 3-1

3.2 Tunnel, Portal and Staging Area Locations 3-1

3.3 Construction Methods 3-1

4 Consultation 4-1

5 Description of the Environment 5-1

5.1 Scheme 5-1

5.2 Tunnel Route 5-1

5.2.1 Physical and Natural Values 5-1

5.2.2 Social and Cultural Values 5-3

Contents

6 Assessment of Effects 6-1

6.1 Effects no longer considered relevant 6-1

6.2 Effects at the tunnel portals 6-1

6.2.1 Physical and Natural Values 6-1

6.2.2 Social and Cultural Values 6-1

6.3 Effects along the tunnel route 6-2

6.3.1 Physical and Natural Values 6-2

6.3.2 Social and Cultural Values 6-2

7 Mitigation 7-1

7.1 Proposed Conditions 7-1

7.1.1 ECan consents 7-1

7.1.2 SDC designation 7-4

7.2 Management Plans 7-4

8 Statutory Assessment 8-1

8.1 Statutory Assessment Overview 8-1

8.2 Resource Management Act 1991 8-1

8.2.1 Part 2 – Purpose and Principles 8-1

8.3 Environment Canterbury 8-2

8.3.1 Transitional Regional Plan (TRP) 8-2

8.3.2 Proposed Natural Resources Regional Plan 8-3

8.4 Selwyn District Council 8-5

Appendix A Designation Plan

Appendix B Tunnel Plans

Appendix C Affected Landowners

Section 1 Introduction

1.1 Background

In December 2001, Central Plains Water Trust (CPWT) lodged water permit applications with Environment Canterbury (ECan) for the Central Plains Water Enhancement Scheme. This was followed in November 2005 with a suite of ancillary resource consent applications necessary to construct and operate the Scheme. In June 2006, Central Plains Water Limited (CPWL), an approved requiring authority under the Resource Management Act 1991 (RMA), lodged a Notice of Requirement with Selwyn District Council (SDC) seeking to designate aspects of the Scheme. At this time, land use resource consent applications were also lodged by CPWT to SDC. All applications have since been publicly notified, with hearings due to commence in mid-2007.

The above applications included provision for an intake drawing water from the Waimakariri River at a site ~3 km upstream of the Kowai River, referred to as the 'upper intake'. Water from the upper intake is to supply the Waianiwaniwa Reservoir. The delivery method described in the original applications was via a ~15.5 km canal along the true-right terrace of the Waimakariri River and then across the Canterbury Plains near Sheffield, followed by a ~3 km long tunnel through the Malvern Hills.

On going refinement of the Scheme concept throughout the consent process has revealed an economically viable alternative to supplying water to the Reservoir, in the form of a ~10 km long tunnel directly to the Waianiwaniwa Valley, commencing just downstream of the upper intake. This proposal will eliminate all the above-ground environmental effects of a canal cut into the river terrace and traversing the plains.

For the above reason, CPWT/CPWL has resolved to pursue the proposed ~10 km tunnel for water supply to the Reservoir. To this end, CPWT is applying for additional resource consents from ECan and CPWL is applying for an additional notice of requirement to SDC. At the same time, CPWT/CPWL is notifying ECan and SDC that the upper intake canal route and shorter tunnel no longer forms part of the scope of the ECan resource consent applications and SDC notice of requirement, and is therefore removed from further consideration.

1.2 Purpose of this Report

The purpose of this report is to assess the environmental effects of the longer tunnel and explain what changes there will be within the environment as a result of these activities. The scale and significance of these effects are reflected in the level of detail provided in this report. Measures to avoid, remedy or mitigate any potentially adverse effects are also indicated.

This report has been prepared under the Resource Management Act 1991 (RMA); Section 88, "Making an Application" and the Fourth Schedule, "Assessment of Effects on the Environment". The report aims to present clear information on the applications and the effects on the environment of the proposed activities, so that people can decide for themselves if they would like to make a submission in support of or opposition to the resource consent application and notice of requirement, and have enough information to prepare a submission.

1.3 Scope of this Report

A detailed description of the Central Plains Water Enhancement Scheme is contained in the Assessment of Effects on the Environment (AEE) lodged with the original resource consent applications and notice of requirement, and revised as a result of the provision of further information post-lodgement. These AEEs, dated June 2006, also contain detailed descriptions of the environment affected by the Scheme and discussion on the actual and potential environmental effects.

This report does not intend to repeat any of the information contained in the original reports, except where necessary to provide context for the new applications relating to the proposed longer tunnel. Therefore the reader is directed to the original AEEs for any information about the Scheme that does not relate to the proposed long tunnel.

This report deals specifically with describing the construction and operation of the proposed new tunnel, the environment affected by the tunnel, and the environmental effects of the tunnel. It technically supports both the additional resource consent applications to ECan and the new notice of requirement to SDC.

1.4 Statutory Approvals Sought

The following approvals are being sought for the proposed tunnel:

Environment Canterbury:

1) a land use consent for excavation under the Hawkins River and tributaries
2) a land use consent for excavation over unconfined or semi-confined aquifers
3) a land use consent for storage of diesel to power plant and facilities during construction;
4) a water permit for dewatering along sections of the tunnel route during construction, and
5) a discharge permit for the operation of a diesel generator during construction.
6) A discharge permit to discharge contaminants, principally sediment, and water to the Waianiwaniwa River during construction of the tunnel.

A duration of 35 years is sought on the above consents.

Full assessment of the need for the above consents is contained in Section 8 of this AEE.

Relevant to the construction and operation of a tunnel are a number of existing resource consent applications lodged with ECan for the original Scheme:

- Taking of water from the Waianiwaniwa River for concrete batching during construction is covered by CRC061930;
- Discharge of water and contaminants from the operational tunnel to land and water in the reservoir is covered by CRC061976.

Selwyn District Council:

7) a designation along the alignment of the tunnel route.

CPWL is an approved Requiring Authority under the RMA. A designation is a tool available to Requiring Authorities under Section 168 of the RMA, which allows for the provision of works and projects in District Plans, where the activity is generally not a permitted activity. In this case, construction of the tunnel is likely to be considered a discretionary or non-complying activity in the Proposed Selwyn District Plan: Rural Volume.

By identifying the proposed tunnel route in the District Plans, the wider public and future landowners would be kept informed of CPWL's intention to use the land for a designated purpose.

The designation requirement applied for with respect to the tunnel, as shown on the plan in Appendix A of this AEE, covers the entirety of the ~10 km route. The Waianiwaniwa portal and construction staging areas will be located in the requirement for designation already lodged with SDC. The Waimakariri portal will also be located in the existing designation for the canal route.

1.5 Structure of the Assessment of Environmental Effects

This Assessment of Environmental Effects (AEE) includes eight sections.

Section 1.0 Introduction

Section 2.0 A description of the construction and operation of the proposed tunnel.

Section 3.0 Describes the alternative options.

Section 4.0 Summarises the consultation process undertaken.

Section 5.0 Provides a description of the environment.

Section 6.0 Provides the assessment of environmental effects.

Section 7.0 Discusses the mitigation measures proposed.

Section 8.0 Covers the planning aspects in terms of the RMA, and Regional Policies and Plans.

The following appendices are included in support of the AEE:

Appendix A Designation Plan

Appendix B Tunnel Long Section

Appendix C Affected Landowners

Section 2 Description of the Proposed Activity

2.1 Proposal Being Withdrawn

Figure 2-1 below illustrates the canal and tunnel route submitted in the original resource consent applications to ECan and notice of requirement to SDC, and no longer being pursued by CPWT/CPWL. A larger image is contained in Appendix B.

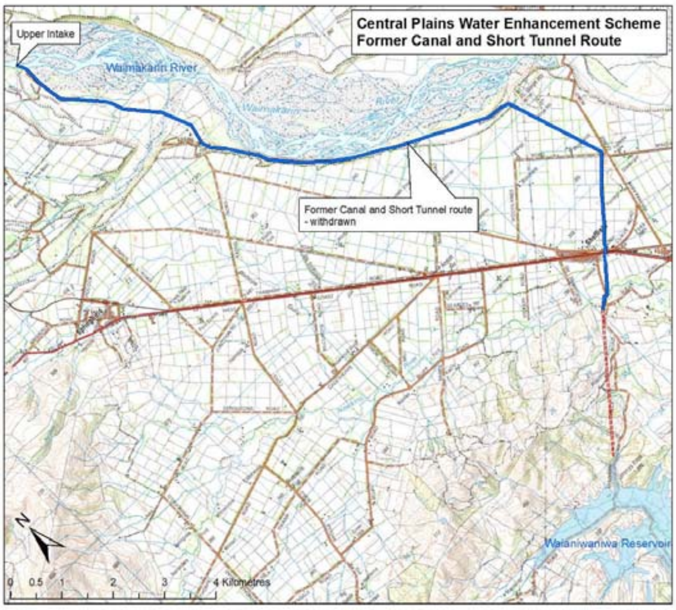

Figure 2-1 Proposal being Withdrawn

2.2 New Tunnel Route

Figure 2-2 below illustrates the canal and proposed tunnel alignment subject to the current applications and this AEE. A larger image is contained in Appendix B.

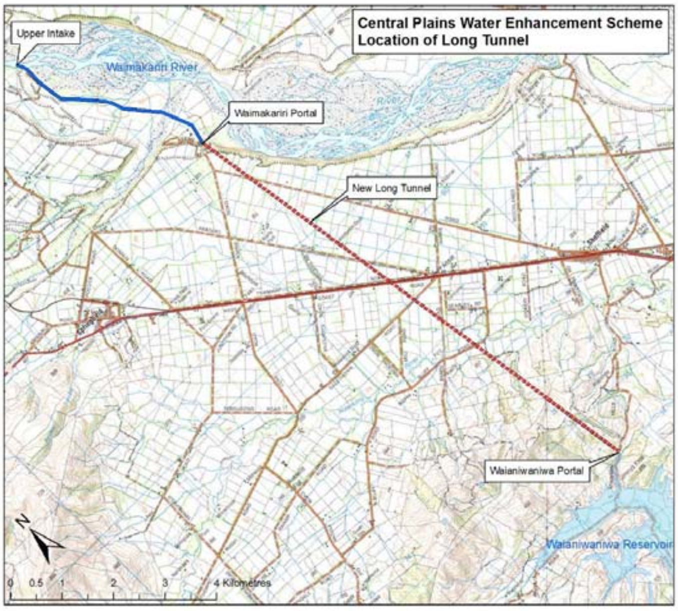

Figure 2-2 Proposed Long Tunnel

The canal will enter the proposed tunnel within 3 km of the upper intake and headworks. Note that the nature and scale of the intake and head works and initial length of canal prior to the tunnel, as described in the original AEEs, does not alter as a result of the new tunnel.

The Waimakariri tunnel portal is subject to survey and final design, but will generally be in the area approximately 1 km downstream of the Kowai River crossing, at the toe of the 80 metre high terrace running along the right bank of the Waimakariri River.

From the Waimakariri portal, the tunnel route heads due south over ~10 km and would emerge in the Waianiwaniwa Valley at a point where it would discharge into the proposed Waianiwaniwa Reservoir. The Waianiwaniwa portal location is also subject to final design and survey, but has been illustrated on Figure 2-1 above as being in the same location as the original shorter tunnel portal.

The designation corridor sought for the tunnel is 20 m wide.

2.3 Tunnel Dimensions

2.3.1 Length

The straight line length of the tunnel is approximately ~10 km. This length may require minor adjustment should subsequent investigations identify reasons to move the alignment slightly, deviate around specific geological features or relocate the tunnel portals.

2.3.2 Diameter

The finished internal diameter will be 3.5 m. The excavated diameter is likely to be in the order of 4 m, allowing for the installation of appropriate lining.

2.3.3 Grade

Water in the tunnel will flow under gravity from the Waimakariri portal to the Waianiwaniwa portal. The approximate grade is 0.1%. Final design is needed to determine the relative level of the portal in relation to surface water levels in the Reservoir.

2.3.4 Depth below ground

The tunnel will have a depth below ground of ~80 m immediately after entering the Waimakariri River terrace. Depth below ground then tapers to ~45 m under State Highway 73 and the West Coast Rail Line before reaching the tunnel's minimum depth of ~30 m under the Hawkins River. The tunnel then passes under the Malvern Hills where the maximum depth is recorded, being ~200 m below ground.

An indicative long section is included in Appendix B.

2.4 Construction

2.4.1 Portals

The Waianiwaniwa tunnel portal will be the first structure to be built in relation to the tunnel. This portal will need to be excavated and stabilised to either solid ground, or have a concrete portal structure constructed. This excavation may require drill and blast methods.

Construction of the Waimakariri portal will require a cofferdam to be constructed around the area to protect it from flooding and will comprise of a reinforced concrete box structure. This portal structure is expected to be below the bed level of the Waimakariri River and hence dewatering within the cofferdam will be required to permit construction to proceed.

2.4.2 Tunnel

Excavation Method

The tunnel will be excavated partly or in full using a tunnel boring machine (TBM). There are a number of options in terms of the type of TBM or excavation methodology to deal with the two main types of material, being rock or alluvial material. The options for this tunnel will be determined once additional geotechnical investigations have been carried out, but are likely to be one or more of the following:

- *Open Hard Rock TBM:* This could be used in the ~2 km of the tunnel under the Malvern Hills. An open hard rock TBM leaves the rock exposed behind the TBM. Rockbolts or steel set support is then installed behind the TBM to stabilise the ground and depending on the rock quality, the rock may be left unlined, or lined with shotcrete or concrete.
- *Slurry TBM with Concrete Segmental Lining:* This could be used through the alluvial section (i.e. under the Plains) of the tunnel. This type of TBM is termed a shielded TBM and is designed to go through soft ground or ground which is not self supporting. The tunnel face is pressurised with bentonite slurry to retain the ground and pre-cast concrete segments are transported into the tunnel and erected immediately behind the TBM without exposing the ground. These segments incorporate water stops to provide a watertight tunnel. An example of such a tunnel lining is included in Figure 2-2 below. The rock is crushed in the face of the TBM and transported out of the tunnel as a slurry in a closed circuit slurry system.

Figure 2-3 Example of precast concrete tunnel lining, which could be used in the alluvial section of the tunnel

- *Mixed Shield TBM*: This is a hybrid TBM which combines the slurry shield principle with the ability of the hard rock TBM to cut rock.
- *Drill and Blast techniques*: Depending on the economics of mobilising two TBMs, and if the length of tunnel through rock is relatively short (< say 2.5 km), a contractor may choose to excavate that section using traditional drill and blast techniques. This excavation could be completed in the 15 months it would take to mobilise the TBM for the remainder of the tunnel.

Examples of TBMs are illustrated in Figure 2-3 below.

Figure 2-4 Examples of tunnel boring machines

Construction of the tunnel will proceed upgrade from the Waianiwaniwa Valley portal. Excavation upgrade is always preferred to take advantage of gravity to remove any groundwater inflows and prevent the TBM from being flooded should pumps fail.

The TBMs would be expected to excavate approximately 20 metres per day on average, operating 24 hours per day, 7 days per week. (The hours of operation may vary from this depending on the shift system the contractor chooses). If only one TBM is utilised the tunnel duration would be expected to take approximately 2.5 to 3 years to complete. This time would be reduced by either using two TBM or partial drill and blast.

Tunnel Spoil

Tunnel spoil is transported from the TBM or tunnel face by a continuous tunnel conveyor attached to the wall of the tunnel, or with wagons on a rail system. A pre-cast concrete invert may be installed immediately behind the TBM on which temporary rails will be laid for the construction trains used to transport materials into the TBM.

Approximately 130,000m^3 (solid measure) of spoil will be removed from the tunnel. All material will be disposed of in the Waianiwaniwa Valley, to be used in either constructing the dam or placed in a stable contoured stockpile. Excavation of the material from the tunnel, where it lies over an unconfined or semi-confined aquifer, requires a new application and is covered by this AEE.

2.4.3 Staging Areas

Staging areas for tunnel construction are discussed in the original AEEs, with respect to the initially proposed smaller length of the tunnel. These activities and details do not change significantly as a result of the new applications, except for their duration (construction period now longer) and in the case of the Waimakariri portal, its location.

Waianiwaniwa Portal Staging Area

At the Waianiwaniwa portal, sufficient area will be required to construct the portal and associated permanent structures, assemble the TBM and accommodate tunnel services such as power supply, water supply, tunnel spoil disposal, tunnel locomotive operations, workshop, materials storage, concrete batching plant, temporary buildings, and any settling ponds and water treatment facilities required for discharge water. This staging area is likely to be less than 1 ha in area.

The spoil disposal area may be in a separate area if no suitable area is identified adjacent to the portal. Aggregate supply and concrete supply would be from the main project aggregate processing plant and concrete batching plant established for the dam works.

Section 2 Description of the Proposed Activity

A brief description of the activities and facilities in the Waianiwaniwa portal area is as follows:

- The footprint of the staging area will require initial clearance, excavation and levelling.
- A perimeter buffer zone, catch drain and fencing will be established prior to any further construction work taking place
- The TBM supply and delivery normally takes about 12 -15 months and in this period the portal structures will be constructed, a starter tunnel of about 30 m will be excavated by drill and blast, and all buildings and other construction facilities will be established.
- Diesel powered generators (if required), a substation, compressors, tunnel fans and all other temporary equipment and plant will be established for the construction work. Up to 3 MW of power will be required to power the TBM, ventilation and other services. All diesel fuelled facilities such as these or storage tanks will be bunded off to capture any accidental spillage.
- A small workshop will be built to service tunnel plant. TBM cutters need to be replaced daily and the workshop will include a cutter repair shop.
- The TBM will be assembled outside the portal on a substantial concrete pad, before it is jacked into the tunnel to commence tunnelling. Sufficient space each side of the pad is required to accommodate large cranes and the transporters bringing in components during the assembly.
- Tunnel spoil is likely to removed from the tunnel using a continuous tunnel conveyor, although this is normally the contractors choice. The rail system could be used. A stockpile area is required outside the portal to allow the TBM operation to proceed independently of any trucking operation to the spoil disposal area.
- For the slurry TBM option a slurry separation plant will be located at the portal. This plant separates the gravel and sand particles out of the bentonite slurry for removal to spoil disposal, and returns the slurry to the TBM in a closed system.
- A number of typical “Portacom” type construction buildings will be required in this area for offices, lunchroom, drying room, showers and toilets. Limited vehicle parking space will be necessary.
- Other miscellaneous buildings such as first aid and small tools will be located at the portal.
- A settling pond and water treatment plant will be required to treat dirty water from the tunnel and from the batching plant. Tunnel water would be piped into this settling pond from the portal.
- A temporary storage area for tunnel materials and plant such as rockbolts, steel sets, pipes, mesh, precast invert sections and any other materials required in the tunnel. A stockpile of materials is needed on site to ensure that no delays occur to the tunnel operation waiting on material deliveries. A small number of sheds or containers will be required to store perishable goods.
- Should drill and blast techniques be used, explosive magazines will be located in a secure position on site, in accordance with the relevant Act and Regulations.

If the tunnel portal staging area cannot accommodate all services, a secondary staging area may be required (within the designation) for:

- Aggregate processing area for concrete supply. A small aggregate screening and crushing plant would be required to produce concrete aggregates and may also be used for other works in the project.
- A mobile concrete batching plant and testing laboratory will be required to produce concrete and shotcrete for the tunnel construction.
- The disposal area for tunnel spoil. This could be temporary should the material prove suitable for dam construction. However, if permanent it will be established in the reservoir area and rehabilitated on completion. The stockpile will be contoured to be sympathetic with the surrounding landscape.

Waimakariri Portal Staging Area

A staging area will be required at the Waimakariri portal. This will be smaller than above but will be required to support construction of the temporary works and portal structure, and disassembly of the TBM when the tunnel is complete. It could be combined with a staging area for the upper intake and canal works.

2.4.4 Water and Power Supply

A modest supply of water will be required for general site operations, ablutions, tunnel operations and the concrete batching plant. This will be brought to the site and held in tanks.

The TBM will require approximately 2 MW of power and with other load sources such as ventilation fans, lights, conveyor and aggregate and batching plant, the total demand is likely to be in the order of 3 MW. Power supply could either come from the existing supply lines suitably upgraded for the increased demand, or be provided by diesel generators feeding into a local site substation for distribution. Resource consent has been applied for in the event that generators are used. The facility will be totally contained within a bunded area to contain accidental spillage of diesel.

2.4.5 Effluent and Waste Management and Disposal

With the main construction activities being undertaken from the Waianiwaniwa portal, this staging area will be the source of most of the effluent and waste from the construction activities. There will be some discharges at the Waimakariri portal from ground water pumping but this will be mainly clean water once the cofferdam construction has been completed and subsequently removed.

Potential effluent and waste can be categorised as follows:

- *Tunnel discharge water* - The tunnel will be driven upgrade from either the Waianiwaniwa portal. Ground water encountered will flow out of the Waianiwaniwa portal under gravity. It will be mixed with sediment and contaminants from the tunnel operations. This water will be collected in settling ponds, treated as necessary to achieve a stipulated standard before discharge into the Waianiwaniwa River. A discharge permit to cover this activity has been applied for, as noted in Section 1.3. Dewatering of the tunnel requires a new resource consent, which is covered by this AEE.
- *Discharge water from aggregate screening plant and concrete batching plant*. - These discharges will be discharged into settling ponds and if necessary treated to achieve a required water quality.
- *Stormwater runoff* - Runoff from surrounding farm land will be intercepted with perimeter drains and will be diverted around the staging areas. Runoff from bare ground in the staging areas will be collected in perimeter drains and diverted through silt fences and soak pits.
- *Waste water associated with the toilets, showers, washroom and lunchroom* - A waste water treatment system will be constructed at the portals to service the construction facilities.

An amount of construction waste and debris is unavoidable. This will include surplus construction materials, offcuts, packaging, office waste and household type waste from lunchrooms and ablutions. This will all be strictly controlled and will all be removed from the valley on a regular basis and disposed of in an approved disposal area.

The construction contract specifications will include a very strict Environmental Management Plan and Environmental Specification to ensure that tight controls on all effluent, waste and potential spills are maintained and all consent conditions are complied with.

2.4.6 Staff and Workforce

The portal works would be carried out by a relatively small workforce of about 12-18 people on a dayshift basis. Once tunnel excavation commences, a 24-hour, 7-day shift system is probable, with approximately

25 people per shift required, assuming one TBM is utilised, or a total shift personnel of about 75 to 80 people. These would be supported by about 15 to 20 people on dayshift including construction plant maintenance personnel and office staff. The peak workforce would be approximately 90 to 100 people. This could increase to 160 people if two TBMs are utilised.

For a large proportion of the works local subcontractors and labour will have the necessary skills and resources. The tunnelling work is specialised and a core of experienced tunnellers and supervisors will be required to come in for the project to augment the local labour. Accommodation would be in the local area or in Christchurch and it is not envisaged that a construction camp would be required.

Construction of the tunnel is expected to take approximately 3 years.

2.5 Tunnel Operation

Once construction is complete, the staging areas will be completely disestablished and rehabilitated to a state as close as practicable to existing.

Once the Scheme is operational, water will discharge via the tunnel into the Waianiwaniwa Reservoir. This discharge is principally made up of the water taken from the Waimakariri River, however, there may be a very small component of ongoing groundwater inflow along the tunnel route, although this will be minimal if gasketed concrete segments are used. Appropriate discharge structures will ensure that the bed of the Waianiwaniwa Reservoir is not affected by erosion/scour.

Section 3 Alternatives

3.1 Storage and Delivery of Water

The year-on-year reliability of the Scheme to deliver water to end users is significantly influenced by the ability to store water. As discussed in Section 4.5.3 of the original AEE submitted to ECan, a number of storage options were considered, with the Waianiwaniwa Valley being considered the best option. As the Waianiwaniwa Valley itself does not produce an adequate supply of water to serve this purpose, the Scheme concept has always involved the filling of the Reservoir using water from the Rakaia and/or Waimakariri Rivers. Alternative water sources are also discussed in the original AEEs.

With the Waianiwaniwa Valley being the best identified option for storage of water, there are then four alternatives that have been considered to deliver water to the Reservoir:

1. Gravity canal from the upper Waimakariri intake and then 3 km tunnel through Malvern Hills (as per original AEEs);
2. Pump water from the headrace canal (as per original AEEs);
3. Piped supply from upper Waimakariri intake leading to 3 km tunnel through Malvern Hills
4. The proposed longer tunnel subject to this AEE.

The original applications included both options 1 and 2, with option 2 being a backup option in the event that Option 1 did not proceed.

Option 3 has since been considered following lodgement of the AEEs and stakeholder feedback. This would involve installing a pressure pipe within the riverbed along the foot of the high terrace downstream from the Kowai River, and eliminating this part of the gravity canal. The cost would be similar to the long tunnel option if the pipe discharged after ~3 km into an open canal. Environmentally, this option would eliminate the impacts for the riverside land through that ~3 km reach but would retain the impacts of the canal for all subsequent properties. However if the pipe continued through to the Hawkins River and discharged into the short tunnel under the Malvern Hills (as in the 2005/06 applications) then for most properties along the route there would be little environmental impact after construction was finished. But the costs would be substantially higher than the long tunnel.

As noted in Section 1, CPWT has resolved to withdraw Option 1 in favour of proceeding with Option 4. This is due to Options 4's ability to avoid a number of actual and potential effects on the environment that would otherwise have been associated with Option 1. This is discussed in more detail in Section 6.1.

The ability to proceed with Option 2, as an alternative to Option 4, remains unchanged as a result of the new applications. Which of Options 2 and/or 4 proceeds will ultimately come down to funding availability and the economic situation prevailing at the time, and the subsequent decisions made on staging of the project. Option 2 has significant on-going operating costs due to the need to operate a 13.8 MW pump station, whereas Option 4 involves significantly higher capital costs.

3.2 Tunnel, Portal and Staging Area Locations

Tunnelling typically costs around $10,000 per metre. For this reason, the shortest direct underground route from the upper intake to the Waianiwaniwa Reservoir, without needing to affect the Waimakariri River terrace, has been chosen. A longer tunnel directly from the upper intake would add close to ~ 3 km (~ $30,000,000) and is economically unviable. The location of the portals and construction staging areas are a direct function of the tunnel alignment.

3.3 Construction Methods

The use of TBMs for tunnel construction is modern accepted practice over long distances, due to it being more economically efficient than traditional methods such as drill and blasting. However, short distances of the proposed tunnel may still be excavated using drill and blasting, depending on the methodology adopted by the contractor. No other methods were considered other than that described in Section 2 of this AEE.

Section 4 Consultation

CPWL/CPWT has undertaken extensive consultation with stakeholders and the community in relation to the Scheme. This is discussed in Section 5 of the original AEE lodged with ECan.

For this new application CPWL/CPWT has consulted with all farmer landowners along the tunnel route, with one exception, and has their support. The exception is a landowner who is not in New Zealand at the present time: attempts will continue to be made to contact him but it is considered the tunnel is unlikely to have a different effect on his property from the previous applications. Utility providers and statutory bodies will be consulted as soon as possible, and it is relevant that the effects on their interests will be less than with the previous applications.

Section 5 Description of the Environment

5.1 Scheme

A full description of the project area can be found in Section 6 of the original AEE lodged with ECan, covering the following matters;

- Physical Environment
- Groundwater Systems
- Soil Environment
- Climatic Environment
- Biological Environment
- Fish and Recreation
- Social Environment
- Cultural Environment
- Landscape Values

The above should be referred to for detailed descriptions of the Scheme environment. The remainder of this section deals solely with the proposed tunnel route.

5.2 Tunnel Route

5.2.1 Physical and Natural Values

Geology

Based on currently available geological information, the first ~7,700 m of the tunnel (i.e. 77% of the tunnel length) from the Waimakariri portal will encounter gravels of the Woodlands Formation and possibly also gravels of the Windwhistle Formation and/or the Hororata Formations. Cover will be between about 30 and 80 m. The gravels will comprise mainly cobble size rounded greywacke in a sandy matrix, and are at least 80 m thick at the Waimakariri portal. The gravels are thought to overlie basement greywacke with an irregular contact. The basement greywacke comprises strong, indurated, interbedded sandstone and mudstone. It is possible that basement highs will be encountered along the proposed tunnel but at this stage no geological structures are known with sufficient detail to predict locations or the likely meterage of greywacke along this reach of the tunnel.

For the next 1,700 m (~17% of the tunnel length) a basement high will be encountered based on surface outcrop. The tunnel will encounter greywacke through this interval and it is likely that significant fault zones will be encountered. The uncertainty of location of the contacts could be +/- 500 m in this location because the structure is currently poorly understood.

For the final 640 metres (about 6% of the tunnel length) the tunnel is expected to encounter a combination of gravels and tertiary age weak sedimentary rocks. The structure is poorly understood and a significant degree of faulting is expected. The gravels are greywacke cobbles in a sandy matrix but may be highly weathered in part.

Construction of tunnels in similar geology has successfully occurred in many locations around the world. Further investigations at the design phase will better determine the geological sequence, however, these investigations are not necessary to prove viability or constructability; they are purely to support the design of the TBM and tunnel.

Section 5 Description of the Environment

The plan in Appendix B illustrates expected geological conditions.

Hydrogeology

Over the last two million years glacial and interglacial outwash sediments in Waimakariri and Rakaia Rivers have built up a succession of large fans that coalesce and form the Central Plains[1]. Around the Springfield and Sheffield area, the geology is characterised by free, sandy and clay-bound gravels. Significant clay, sand- and mud-stone layers are seen in bore logs from around both Springfield and Sheffield.

A shallow aquifer is known to exist at a depth ≤ 30 metres. Recharge to this aquifer will primarily be through losses from the Waimakariri River. Short-term groundwater records from nearby Darfield wells show significant seasonal fluctuations in the shallower wells. Levels are typically ~6.5 mbgl during autumn and winter months and 18 mbgl during summer. Records from deeper wells show similar seasonal fluctuations, but with a greater drop in water levels between the seasons (4.5-24.1 mbgl). Little is known about deeper aquifers due to the limited number of deep wells within the area.

Within and around the proposed area of the proposed tunnel, 117 bores were identified using the Environment Canterbury Online GIS database. Of these, 52 have a status of 'buried', 'not used', 'casing retrieved', 'sealed up/grouted' or are proposed without having resource consent to take and use water. Of the remaining 65 'active' wells the majority of wells (85%) are less than ≤ 30 metres deep.

There are no wells within the designation corridor sought.

Flora and Fauna

With the exception of the portals, the tunnel route is located a minimum of 30 m below existing ground level and therefore there is no flora or fauna that will be directly affected by construction or operation.

The portal sites are located on farmland with no significant vegetation or terrestrial fauna. A wetland is identified in the Plains Reconnaissance PNAP survey at a distance of approximately 100 m of the Waimakariri portal – this will not be physically affected by construction works.

Waianiwaniwa River

The Waianiwaniwa Rivers is the receiving environment for water and contaminants collected from the tunnel during construction.

The Waianiwaniwa River is a 33 km long tributary of the Selwyn River. It flows through the Malvern Hills before issuing onto the inner Canterbury Plains 1.6 km northeast of Coalgate. The channel carries water through the hills, but on the plains flow is subsurface, although during floods the surface channel will carry water.

Through the Malvern Hills the river flows east-northeast before turning to flow south towards Coalgate. It is less than 10 km from the top of the catchment to its outlet past the Homebush Ridge, but the valley length is 14 km. The channel is distinctively sinuous, following a tightly meandering course of ~ 2 km for each 1 km of valley length. The channel is 2 – 5 m wide, and entrenched ~ 3m below the floodplain. There are 10 left bank tributaries draining well defined valleys 2 – 5 km long. There are only 5 right bank tributaries, although these drain the same total area as the more numerous left bank streams. The main right bank tributaries are Bush Gully (6.5 km long), an unnamed valley on the north side of Cairn Ridge (5.5 km long), and Oyster Gully (3.75 km long).

[1] North Canterbury Catchment Board and Regional Water Board, 1983, *The Groundwater Resource of the Central Plains.*

5.2.2 Social and Cultural Values

Land use above the tunnel route is based on pastoral farming. Landowners under the tunnel route are included in Appendix C. The route passes under several roads and the West Coast Rail line. The Hawkins River is classified a Waahi Taonga Management Area in the Proposed Selwyn District Plan: Rural Volume.

At the portals the areas are rural in nature with pastoral farming the predominant use.

Section 6 Assessment of Effects

6.1 Effects no longer considered relevant

Although not able to be used as an environmental baseline for this AEE, it is worth noting that the withdrawal of the canal and shorter tunnel option will eliminate a significant area of actual and potential effects on the environment that could have otherwise been anticipated, including:

- All those construction related effects (noise, dust, landscape, ecology) relating to the bulk earthworks required to grade the canal over~ 7 km up the 80 m high Waimakariri River terrace, cut through the Plains at Gorge Hill, and traverse the Canterbury Plains over 5 km.
- Social and economic impacts stemming from displacement and dissection of farms and other property.
- Social and economic impacts stemming from construction effects associated with crossings of State Highway 73, and the West Coast railway line, and several other local roads.
- Instream effects associated with establishing embankments and a siphon in the bed of the Hawkins River.

6.2 Effects at the tunnel portals

6.2.1 Physical and Natural Values

Establishment of the staging areas and portal structures will involve initial ground disturbance and vegetation clearance. Upon completion of the portal the staging areas will be removed and rehabilitated as close as practicable to their original standard. Given the lack of significant vegetation and fauna at both portals, there will be no related adverse effects.

All water collected from the tunnel at the Waianiwaniwa end will be discharged from the portal into a series of settling and treatment ponds before final discharge to the Waianiwaniwa River. This will remove any entrained sediment. Subject to this treatment, any adverse effects on the Waianiwaniwa River will be minor.

Operation of a 3 MW diesel generator to power the tunnel, should mains power not be used, will generate a discharge to air. This will meet all bar one of the conditions – relating to the generator only being used for emergency purposes - for a controlled activity under Rule AQL26 of the Proposed Natural Resources Regional Plan (refer Section 8 for further discussion). Storage of diesel over 2,500 litres also requires resource consent – such storage will be undertaken in a manner that complies with all relevant regulations and avoids adverse effects, including bunding requirements.

Dust will be controlled in portal and staging areas, and spoil disposal areas, through keeping material moist during dust conducive conditions.

The increase in excavated material removed compared to the original AEEs is relatively insignificant. There is not expected to be any substantial increase in effects over that already described. The discharge of contaminants and water will occur at the same location as described in the original AEEs, although the volumes will be greater due to the longer tunnel length. The treatment systems will be designed to cope with the expected volumes and contaminant levels for an acceptable discharge to the Waianiwaniwa River.

6.2.2 Social and Cultural Values

Both portals will have a significant buffer area between permanent residences. Some construction noise is inevitable, particularly at the Waianiwaniwa portal area from the operation of tunnel fans and compressors. Drilling and blasting activity will have an intermittent noise impact. Given the buffers involved any adverse effects are not likely to be significant. The presence of construction-related buildings at the portals will be a temporary effect only.

The increased duration of the activity (over that described in the original AEEs) will result in a longer duration of construction related traffic near the Waimakariri and Waianiwaniwa staging areas and within the Scheme area generally. However, any impact over and above that which will be occurring as part of overall construction of the Scheme is likely to be marginal. Management plans will be prepared to ensure that such impacts are minimised to the greatest extent practicable.

6.3 Effects along the tunnel route

6.3.1 Physical and Natural Values

Tunnelling in similar materials has occurred throughout the world with no above ground physical impacts, e.g. subsidence. Within the alluvial section, the tunnel will be located generally below the depth where groundwater is drawn and may in some locations be close to basement rock. The tunnel will present a minor obstruction to any groundwater flow and is unlikely to have any significant down-gradient impact. The depth of the tunnel coupled with the installation of tunnel lining will mean that any dewatering of surface waters is very unlikely.

The designation corridor has been overlaid with existing well locations in the area. There are no wells within this corridor.

Being underground, there will be no adverse effects on flora or fauna.

6.3.2 Social and Cultural Values

Noise and vibration effects

With a minimum of 30 m cover, there will be no discernible above-ground effect on people from construction or operation of the tunnel, either in the form of noise or vibrations.

Subsidence and settlement effects

In driving a tunnel, the arching effect of the ground above ensures that in normal circumstances there is no impact on ground stability beyond more than 2- 3 tunnel diameters above the tunnel. This arching height above the tunnel does depend on the type of material being excavated and in the methodology being used for tunnel excavation and ground support. In this case with the outside diameter of the tunnel being about 4 m, the arching effect would mean that settlement above the tunnel would be unlikely to extend more than 12 m above the tunnel crown and therefore there will be a large safety margin along the tunnel route.

Notwithstanding the above, in the alluvial section of the tunnel any subsidence/settlement will be avoided through the placement of concrete segmental lining immediately following the TBM. The TBM maintains a positive pressure at the cutting face to counteract the surrounding earth pressure and prevent ground failure and minimise settlement above. The TBM comprises a double shield which completely supports the ground for the length of the shield, approximately 30 m long. Pre-cast concrete segments are then erected within the tail section of the TBM so that at no time is the ground exposed or unsupported. These segments are then grouted to ensure contact with the ground so that settlement is minimised.

The above is accepted industry methodology for difficult ground conditions where ground settlement cannot be permitted, typically when driving underground tube tunnels in cities beneath city streets and multi-story buildings. Zero settlement is the normal criterion in these circumstances.

Finally there will be a tight specification for the contract that will require the contractor to submit a subsidence management plan and to monitor effects before, during and after the tunnel construction.