APPENDIX F

SEMP 006 Accidental Aquifer Interception Management Plan

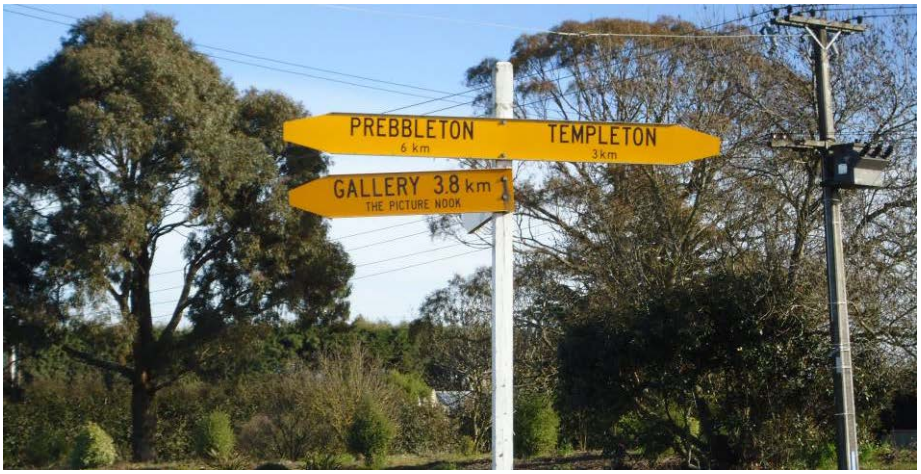
NZ TRANSPORT AGENCY
WAKA KOTAHI

CEMP Appendix F SEMP006

Christchurch Southern Motorway Stage 2 and Main South Road Four Laning

Draft Accidental Aquifer Interception Management Plan

November 2012



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Contents

Glossary of Terms

Aquifer	A formation, group of formations or part of a formation that contains sufficient saturated permeable material to yield viable quantities of water to wells and springs
Artesian Aquifer	A confined aquifer containing groundwater under positive pressure
CEMP	Construction Environmental Management Plan
Confined Aquifer	A formation in which the groundwater is isolated from the atmosphere at the point of discharge by low permeability geological formations
CSM2	Stage 2 of the Christchurch Southern Motorway, between Halswell Junction Road and Main South Road
MSRFL	Four-laning of Main South Road between CSM2 and Rolleston
NoR	Notice of Requirement
NZTA	The New Zealand Transport Agency
RMA	Resource Management Act 1991
Piezometer	A device used to measure static groundwater pressure by measuring the height to which a column of the water rises against gravity, or the pressure (the piezometric head) of groundwater at a specific point
Unconfined Aquifer	An aquifer where the water table is exposed to the atmosphere through pore spaces in the overlying materials

1. Introduction

The NZ Transport Agency (NZTA) seeks to improve access for people and freight to and from the south of Christchurch via State highway 1 (SH1) to the Christchurch City centre and Lyttelton Port by constructing, operating and maintaining the Christchurch Southern Corridor. The Government has identified the Christchurch motorway projects, including the Christchurch Southern Corridor, as a road of national significance (RoNS).

The proposal forms part of the Christchurch Southern Corridor and is made up of two sections: Main South Road Four Laning (MSRFL) involves the widening and upgrading of Main South Road (MSR), also referred to as SH1, to provide for a four-lane median separated expressway; and the construction of the Christchurch Southern Motorway Stage 2 (CSM2) as a four-lane median separated motorway. The proposed construction, operation and maintenance of MSRFL and CSM2, together with ancillary local road improvements, are referred to hereafter as 'the Project'.

A draft Construction Environmental Management Plan (CEMP) has been prepared to provide the framework, methods and tools for avoiding, remedying or mitigating environmental effects of the construction phase of the Project. The CEMP is supported by six SEMP including this document relating to accidental aquifer interception management during construction.

1.1 Proposal description

1.1.1 MSRFL

Main South Road will be increased in width to four lanes from its intersection with Park Lane north of Rolleston, for approximately 4.5 km to the connection with CSM2 at Robinsons Road. MSRFL will be an expressway consisting of two lanes in each direction, a median with barrier separating oncoming traffic, and sealed shoulders. An interchange at Weedons Road will provide full access on and off the expressway. MSFRL will connect with CSM2 via an interchange near Robinsons Road, and SH1 will continue on its current alignment towards Templeton.

Rear access for properties fronting the western side of MSRFL will be provided via a new road running parallel to the immediate east of the Main Trunk rail corridor from Weedons Ross Road to just north of Curraghs Road. For properties fronting the eastern side of MSRFL, rear access is to be provided via an extension of Berketts Drive and private rights of way.

The full length of MSRFL is located within the Selwyn District.

1.1.2 CSM2

CSM2 will extend from its link with SH1 / MSRFL at Robinsons Road for approximately 8.4 km to link with Christchurch Southern Motorway Stage 1(CSM1, currently under construction) at Halswell Junction Road. The road will be constructed to a motorway standard comprising four lanes, with two lanes in

each direction, with a median and barrier to separate oncoming traffic and provide for safety.1 Access to CSM2 will be limited to an interchange at Shands Road, and a half-interchange with eastward facing ramps at Halswell Junction Road. At four places along the motorway, underpasses (local road over the motorway) will be used to enable connectivity for local roads, and at Robinsons / Curraghs Roads, an overpass (local road under the motorway) will be provided. CSM2 will largely be constructed at grade, with a number of underpasses where elevated structures provide for intersecting roads to pass above the proposed alignment.

CSM2 crosses the Selwyn District and Christchurch City Council boundary at Marshs Road, with approximately 6 km of the CSM2 section within the Selwyn District and the remaining 2.4 km within the Christchurch City limits.

1.2 Purpose and Scope

SEMP 006, this draft Accidental Aquifer Interception Management Plan (AAIMP or the Plan) forms part of a comprehensive suite of environmental controls within the Construction Environmental Management Plan (CEMP, Volume 4) for the construction phase of the Project. The AAIMP addresses the potential impacts on aquifers that might be encountered during construction activities for the Project.

Interception of artesian aquifers in piling might result in floating of piles, loss of pressure in the artesian aquifer or mixing of water between aquifers if depressurisation of the aquifer occurs. Interception of artesian aquifers in excavations that is uncontrolled might result in piping of sands into the excavation or heave of silts; require excessive pumping, drawdown and potential ground settlement beyond the excavation.

While it is anticipated that some groundwater will be intercepted during the normal course of earthworks and consents and compliant procedures are in place to address this, the purpose of this AAIMP is to set out the activities that would need to be carried out to mitigate and remediate:

- Accidental artesian aquifer interception in an excavation
- Accidental artesian aquifer interception during pile installation
- Unexpected interception of large non-artesian groundwater inflow to an excavation.

The AAIMP provides an overall framework for the control of accidentally intercepted groundwater.

[1] CSM2 will not become a motorway until the Governor-General declares it to be a motorway upon request from the NZTA under section 71 of the Government Roading Powers Act 1989 (GRPA). However, for the purposes of this report, the term "motorway" may be used to describe the CSM2 section of the Project.

2. Context

2.1 Hydrogeology

Springston Formation (fine grained alluvial sands and silts up to about 15 to 17 m thick) covers the eastern side of the project (the Halswell junction side) where groundwater is encountered at depths of 4 m to 7 m below ground surface (median depth to groundwater of 6 m). The Springston Formation may act as a confining layer to the underlying Riccarton Gravel Aquifer. On the western (Robinson Road) side of the project, gravelly soils occur up to the surface and groundwater levels are quite variable (5 m to 14 m below ground surface; median depth of 11.5 m), but are expected to be generally unconfined.

The Riccarton Gravels (Aquifer 1 of the Canterbury Aquifer system) are typically a few metres to some 30 m thick (encountered at a depth of 15 m to 40 m in the vicinity of the project) and comprise gravel and clayey/silty/sandy gravel. Piles driven or bored as part of the project will need to penetrate and be founded within the Riccarton Gravels.

The nearest wells abstracting water from the Riccarton Gravels aquifer with associated current consents to take and use groundwater are:

- South: M36/7502 (500 m S), M36/7671 (1 km S), M36/4458 (1 Km S),
- North: M36/8502 (400 m N), M36/10126 (750 m N), M36/8870 (1 km N).

In addition piezometers have been installed in investigation boreholes drilled as part of the Project to depths of 12 m to 20 m. Water level monitoring in piezometers should be carried out in accordance with the Groundwater monitoring conditions.

2.2 Construction Methods

The following subsurface construction techniques will be utilized that might result in accidental interception of aquifers:

- Driven steel H piles penetrating the Riccarton Gravels Aquifer at 20 m to 30 m below ground level (along the eastern side as proposed at Shands, Marshs, Springs and Halswell Junction Roads);
- Shallow footings founded on sandy gravels (at Trents and further westwards)
- Earthworks excavations to a maximum depth of 7.5 m below ground surface at Robinsons (in the west) and 3.5 m at Halswell Road in the east.

3. Operation

3.1 Operating/management procedures

- Locate a local supplier of construction material. Maintain adequate supplies of Portland cement, grout additives, sand bags, bentonite and geotextile. If an artesian flow is sediment laden, time is crucial.
- Understand grout mix design calculation procedure. By measuring the artesian head and knowing the depth at which the flow was encountered, a grout mix can be designed with a sufficient unit weight to arrest the flow. An underweight grout mix will not only be unsuccessful but may hinder further attempts to stop the flow.
- Emergency phone contact list. Establish an emergency phone contact list. Include phone numbers for ECan, the Engineer, the piling company, local suppliers, and any supporting or stand-by contractors that may be of assistance.

3.2 Observer Equipment

- Cellular phone, camera. Be prepared to communicate the artesian situation with ECan and the Engineer and effectively document the situation.
- Water level indicator (dip meter) and tape measure. Determine the height of artesian flow. A water level indicator should be used to determine the height (additional casing stickup may need to be added).
- 1000 ml graduated cylinder or measuring cup. Allows a qualitative estimate of the turbidity of the flow or used with a timer, determination of the rate of flow.
- Grout mix design property sheets. Typical mix design details to readily establish the cement content based on the artesian head and depth encountered. Include use of additives to increase grout unit weight.

3.3 Remedial Equipment

- Non-coated bentonite chips. For sealing the annular space of bored piles to confine the flow to within the casing so a head and flow rate can be measured.
- Packers, riser pipe, pressure gauges and appropriate fittings. Artesian flow may be cut off with use of a packer system at depth within the pile hole. Pressure gauges may be used to determine the artesian head and flow meters to determine rate of flow. This equipment is needed high flow/ high volume artesian situations.
- Portland cement and necessary amendments. Portland cement is the key component of any grout mixture should the pile hole or excavation need to be immediately abandoned. Bentonite addition can be used in low flow conditions, calcium chloride additives can be used

to accelerate the set time of the grout and thixotropic modifiers can be used to increase grout viscosity and limit fluid mobility.

- Portable grout plant with moyno pump. Necessary to achieve the desired grout consistency, especially if a heavier grout is needed to arrest the artesian flow.
- Geotextile and sandbags. These items can be used after grouting to filter any additional artesian flow while the grout sets and provide a normal force at the top of the hole.
- Polymer Drilling Mud. Use of a drilling mud will create a head differential to offset and suppress low artesian flows during pile advancement.

4. Implementation

This section outlines steps to be taken to control, stop, and seal groundwater flow during construction.

4.1 Piling

Avoidance of interception of artesian aquifers in piling is desirable to:

- Avoid floating of piles
- Avoid depressurisation of the aquifer
- Avoid the potential for mixing of water from the Springston Formation with the Riccarton Gravels (and possible spread of contaminants into that aquifer) if depressurisation of the aquifer occurs.

4.1.1 Driven Piles

It is anticipated that most piles will be driven through the Springston Formation to the top of the Riccarton Gravels. Because the artesian pressure in the Riccarton Gravels is generally 2 m to 5 m below the ground surface, water might rise around the pile for a time, but as it cannot flow out, the pressure will be transferred to more permeable layers within the Springston Formation and no remedial action would be needed. Minor temporary depressurisation of the aquifer may occur.

4.1.2 Bored Piles

In the event that bored piles are required, the following steps shall be taken: precast tremie down centre; pot hole; redesign foundation to fit

- Install a temporary casing around the pile to 8 m below ground surface
- Complete the drilling of each pile hole (using a high viscosity, dense polymer if required; however as the groundwater level is not expected to rise above the ground level polymer fluids should not be needed)
- Once full depth is reached, complete the pile with concrete tremied from the base up
- Recover and re-use the displaced polymer which will be pumped from the hole as the tremie proceeds
- Have any remaining neutralized polymer trucked away by Envirowaste.

The polymer to be used should be a 1:1 mix of SC mud P System (produced by ECP Ltd, Environmental Control Products) or similar, and soda ash.

The density of the polymer must be sufficient to exceed the artesian pressure of the Riccarton Gravels aquifer. The viscosity of the polymer will allow the hole to remain open until the tremie is complete. However, if polymer is used all polymer must be cleaned out of the pile before concrete can be added to avoid the development of a gel-concrete annulus that will not set. The concrete will seal against the formation.

4.1.3 Artesian Pressures above the Ground Surface

In the unlikely event that artesian ground water is encountered above the ground surface, the following procedures will apply:

- Stop work
- Contact the Engineer
- Instigate mitigation works as agreed between the Engineer, the Contractor and ECan which are likely to include the following:
    - Attach a vertical pipe to the pile hole (bored pile) or insert into the side of the pile (driven pile); a seal will need to be made secure against the pile or casing or standpipe. The water up-flow will be allowed to stabilise within the pipe and its level above ground measured
    - If the level inside the standpipe exceeds 2 m above ground, provision will be made to hold the standpipe in place by added weight
    - The hole should be grouted using 1:1 (by volume) water: cement ratio grout. Grout will be injected at the base of the hole at pressures controlled to be 2 m to 3 m above the static water level. Grouting can be done either through the extended standpipe or injected through a pipe inserted into the base of the hole. Grouting can only be effective if the situation is sealed and no exit flow from the aquifer occurs, otherwise the exit flow, even if minor, will wash the cement out.
    - Grouting will be discontinued at refusal
    - After the grout has set, an alternate method of piling will be used.

4.2 Excavations

Avoidance of artesian aquifer interception and large groundwater inflows to excavations is desirable to:

- Avoid piping of sands into the excavation or heave of silts;
- Avoid excessive pumping, drawdown and potential ground settlement;
- Avoid the need to discharge large volumes of sediment laden water.

4.2.1 Larger Earthworks Excavations

In the case of uncontrolled aquifer inflows to larger excavations bound by sheetpiles or similar, the following steps shall be taken:

- **Assess the situation**. Determine if the flow is constant or increasing. Determine if the turbidity is constant or increasing. Determine if the flow is confined to the pile hole or excavation, and if not, take measures to confine flow.
- **Notify project engineer and/or project manager**. Be able to describe in detail the conditions and events prior to encountering artesian flow.
- **Email photographs and/or video, in real-time if possible**. Consult with the Engineer and determine primary strategy and contingency plan should the primary strategy be insufficient to arrest the artesian flow.
- **Notify ECan and NZTA**. Inform ECan and NZTA representative of the situation and planned action items.

Actions are likely to include:

- Tremie mass concrete into the excavation until the mass of the concrete is sufficiently heavy to stem the flow; a thickness of 1.5 m to 2 m is likely to be needed;
- Install a vibrating wire piezometer in the grout in a suitable location to allow monitoring of water pressure and record water levels in project piezometers in proximity;
- Control any discharge of water by established site erosion and sediment control measures;
- Pump out excess water to the sediment control basin;
- Leave overnight for the concrete to harden;
- Design will need to be altered to allow a casing to be "spun" into the "green" concrete to allow control of the artesian pressures;
- Excavate with balancing pressure;
- Place a thickness of graded crushed aggregate to act as a controlled filtered exit. Design the thickness of the aggregate to avoid piping or heaving depending on the difference in height between the aquifer level and the depth to be excavated;
- Pump out gradually, allowing water to flow out from the aquifer without sand piping or silt heaving.

4.2.2 Shallow Footings or Pipe Laying

In the case of excavation of sumps or piles or the laying of pipes, the method described for larger excavations could be used or the use of concrete could be substituted with the placement of filtered gravels which will allow water to continue to flow but avoid piping.

5. Roles and responsibilities

All Site Staff

- Attending inductions, tool box talks and training to manage accidental artesian aquifer interception
- Responsible for reporting all incidents involving accidental artesian aquifer interception
- Ensuring processes for managing accidental artesian aquifer interception are adhered to.

Environmental or Project Manager

- Prepares, reviews and updates AAIMP
- Monitors and reports performance against the AAIMP
- Ensures sufficient resources are provided to manage accidental artesian aquifer interception in accordance with the AAIMP
- Provides leadership to the Project team in this area.

6. Monitoring

Monitoring of water levels in piezometers should be carried out monthly prior to commencement of construction, increasing in frequency to twice weekly in piezometers that are located within 100 m of active construction. This gives warning of changing or elevated groundwater levels and also allows confirmation that groundwater conditions have stabilised following completion of works, in particular where accidental artesian or large unconfined inflows have been encountered.

Appendix A
Relevant Project Conditions

[To be added when confirmed]