25 Groundwater

Overview

Construction and operation of the proposed Expressway will require formation of embankments with localised surcharge/preload or excavation/replacement of peat (peat treatment) that in places requires cuts below the groundwater table, construction of stormwater devices for treatment, conveyance and attenuation of run-off, and short term groundwater take for construction water supply. These activities have the potential to cause a change (lowering or rise) in groundwater levels.

Two and three-dimensional groundwater modelling has been undertaken to assess the effects of the construction (short term) and operation (long term) of the proposed Expressway on regional and local groundwater flows.

The modelling suggests that the construction groundwater take is likely to result in small changes to groundwater levels, flow directions and aquifer through-flow, but that such changes will be limited to the period of proposed Expressway construction. In the longer term the proposed Expressway embankment (and associated peat treatment) will result in very small long term changes to groundwater levels and flow directions, with no discernible changes in aquifer through-flow. Where stormwater devices are constructed at the approximate groundwater level there will be no discernible changes to the existing groundwater regime. However, where such devices are constructed above or below the existing groundwater level, and modelling indicates that without mitigation a change in groundwater level might result that would be deleterious to the existing environment, it is proposed that they are lined to reduce groundwater interactions.

The results of numerical modelling indicate maximum changes in water level of up to 0.2 m within six existing private groundwater take wells, and this level of drawdown is unlikely to have an adverse impact on existing users. However, in the event that these are very shallow, low volume wells there could be a corresponding affect on their yield and a temporary replacement supply or longer term solution may be required.

To ensure that appropriate mitigation measures are triggered in the event that actual effects differ from those predicted, a monitoring programme will be implemented prior to construction to record natural variations in groundwater levels and surface water flows. This will establish a benchmark against which actual changes recorded during and following construction can be assessed.

25.1 Introduction

This Chapter provides an assessment of the potential changes that could occur to the existing groundwater regime as a result of the construction and operation of the proposed Expressway, and comprises a summary of the more detailed assessment contained in Technical Report 21 Assessment of Groundwater Effects, Volume 3 of this AEE.

Inter-related information and assessments are also contained in the following Technical Reports in Volume 3:

- Technical Report 22 – Assessment of Hydrology and Stormwater Effects;
- Technical Report 23 - Assessment of Land and Groundwater Contamination Effects;
- Technical Report 26 – Ecological Impact Assessment;
- Technical Report 27 – Ecological Technical Report 1: Terrestrial Vegetation and Habitats (including Wetlands);
- Technical Report 35 – Assessment of Ground Settlement Effects; and
- Technical Report 36 – Geotechnical Interpretive Report.

25.2 Existing environment

The existing groundwater environment in the Project area is characterised by the following matters which are discussed in further detail below:

- Hydrogeology;
- Groundwater levels, gradients and flow;
- Groundwater use; and
- Groundwater/surface water interaction.

25.2.1 Hydrogeology

There are eight primary hydrogeological units[196] in the vicinity of the proposed Expressway. These are as follows:

Hydrogeological Unit	Description	Thickness (m)	Depth (mRL)[197]
Holocene Alluvium	Alluvial gravel deposits in and around the present course of the Waikanae River and debris deposits (alluvium/colluvium) from the adjacent greywacke hills	0 to 20 (thickest at foothills and River bed).	Surface or beneath cover of peat/sand
Holocene Peat	Fibrous woody material to amorphous, silty peat, organic silt, organic clay, organic sand	0 to 8	Surface

[196] These are broad geological types that exhibit similar hydrogeological properties and behaviours.

[197] Refers to 'metres relative level' and relates to the elevation in metres above (if positive) or below (if negative) sea level.

Hydrogeological Unit	Description	Thickness (m)	Depth (mRL)[197]
Holocene Sand	Fine to medium dune sand; coastal and inland sand dunes	5 to 30	Surface to 8
Pleistocene Sand	Sand deposits that lie below the Holocene sand boundary and include reworked dune sands, beach and estuarine sands	5 to 40	10 to -105
Pleistocene Silt/Clay	Silt and clay at depth often packed with carbonaceous leaves and wood	0 to 30	0 to -60
Parata Aquifer	Pleistocene sand/gravel and clay-bound gravel; thinning to the south and surfacing at the foothills in the north	10 to 40	-10 to -20
Waimea Aquifer	Terrestrial sand/gravel and clay-bound gravels.	5 to 40[198]	-20 to -100
Greywacke		Basement rock	0 - > -100 m

The proposed Expressway alignment passes through the Waikanae Groundwater Zone (WGZ), one of six broad groundwater management zones on the Kāpiti Coast. The key aquifers within the WGZ are the deep Waimea and Parata Aquifers. Water from both of these aquifers is abstracted by KCDC for public water supply purposes. Domestic wells generally abstract water from the shallow Pleistocene and Holocene Sands.

The construction of the proposed Expressway has the greatest potential to affect the shallow groundwater system (i.e. the Holocene Sand, Peat and Alluvium) as associated works will be largely carried out within these materials.

The Holocene Peat is variable in nature, ranging from amorphous organic silt and clay through to fibrous woody peat. Generally, the peat is more fibrous towards the northern end of the alignment, with amorphous peat dominant at the southern end of the alignment.

25.2.2 Groundwater levels, gradients and flow

Hydrographic data indicates that there is a seasonal variation in groundwater levels on the Kāpiti Coast, with the lowest water levels typically recorded in April (end of summer) and the highest levels in October (end of winter). Recorded water levels in the deeper bores in the region appear to be rising slightly, while in the shallow bores the water level trend remains generally constant from year to year.

Comparison of recorded rainfall data collected at the Waikanae Treatment Plant indicates that there is a strong correlation between changes in water level in the shallow unconfined aquifers and rainfall events, suggesting that the shallow aquifers respond rapidly to rainfall recharge.

[198] Base of layer not encountered in all boreholes (therefore may be thicker in some areas).

25.2.3 Groundwater use

Approximately 3000 domestic garden irrigation wells are estimated to be spread across the populated area included in the groundwater flow modelling undertaken for the Project. The pumping schedules, as-built details and abstraction rates for these wells are presently unknown, but they are generally thought to be between 3 - 5 m deep with each abstracting between 1 – 5 m3/day. Although the volume of each individual take is relatively small, the cumulative volume is significant (i.e. 3,000 m^3/day to15,000 m^3/day).

25.2.4 Groundwater/surface water interaction

There are a large number of surface water features within the WGZ that interact with the shallow and deeper groundwater system:

- Waikanae River – the river has a direct connection with the underlying gravel aquifer with large losses and gains to and from groundwater;[199]
- Waimeha and Wharemauku Streams – these streams have a direct connection to groundwater, being almost entirely spring-fed through shallow gravels and sands with flows of 100 - 300 l/s, and 20 - 50 l/s respectively;
- Wetlands – wetlands and lagoons have typically formed in the low lying areas between dunes where peat has been deposited and the groundwater level is very close to the surface. Wetlands are generally thought to be points of groundwater "discharge" with flows largely sustained by shallow groundwater. However, there is also evidence to suggest that many of the wetlands within the Kāpiti Coast are "recharge" wetlands fed by rainfall and run-off that has settled on the low permeability peat. Data collection and modelling carried out as part of the Project confirms that both types of wetland occur depending on the particular site conditions; and
- Drains - there are several large drains that were historically constructed to lower the water table in the area,[200] the largest being the Mazengarb Drain which is thought to discharge approximately 50 l/s of shallow groundwater into the surrounding environs.

25.3 Potential groundwater issues

The construction of the proposed Expressway has potential implications for groundwater on the Kāpiti Coast. These are outlined in further detail below.

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[199] For example, a flow loss of up to 300 l/s from the river to groundwater has been calculated between SH1 and Jim Cooke Memorial Park.

[200] These are described in more detail in Technical Report 22, Volume 3.

25.3.1 Construction issues

There are a number of elements associated with constructing the proposed Expressway that have the potential to affect groundwater:

- Embankment construction:
    - Cuts below the groundwater table, some requiring short term dewatering[201];
    - Excavating and replacing peat with sand; and
    - Potentially surcharging[202] peat to accelerate ground settlement.
- Stormwater attenuation:
    - Constructing stormwater attenuation ponds;
    - Constructing swales for conveying surface run-off from the proposed Expressway; and
    - Earthworks to provide flood storage areas (cuts resulting in permanent lowering of the groundwater level and/or bunds).
- Installation and pumping of water supply wells to provide a short-term source of water for construction.

Construction of the embankments and stormwater devices, cuts and at-grade activities will be limited to the upper, unconfined groundwater system (upper marine sands, alluvium, dune sands and peat), but may result in changes (lowering or rise) in groundwater levels that could potentially result in:

- Consolidation settlement in the peat;[203]
- Reduced groundwater through flow, and groundwater levels in surface water bodies that may change ecological habitats;[204]
- Changes to direction and flow of groundwater, potentially altering contaminant migration paths;[205] and
- Reduced water levels in existing wells.

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[201] Allowing water to seep into an open face, be collected in a sump and pumped out of an excavation for disposal.

[202] The controlled placement of fill materials that will later be removed (or partially removed) to induce settlement before a structure is constructed.

[203] This issue is discussed in Technical Report 35, Volume 3. Consolidation settlement is the lowering of original ground level resulting from the weight of a structure or additional materials applied at the surface.

[204] The significance of wetlands and potential changes to ecological habitats are discussed in Technical Report 26, Volume 3.

[205] This issue is addressed in Technical Report 23, Volume 3.

25.3.2 Geotechnical issues

25.3.2.1 Excavations in peat (construction phase):

- Dewatering of the peat over a few days may be required to allow the optimal placement and compaction of sand, but any related drawdown will be transient in nature and unlikely to extend beyond the designation.
- In areas where an upward groundwater gradient is present and the full thickness of peat is removed, 'boiling'[206] may occur in the base of an excavation potentially resulting in increased groundwater flow and instability in the excavation cut.
- Dewatering/groundwater inflow into the peat is unlikely to be uniform, with greater volumes in areas of more fibrous/woody peat and lesser volumes in areas of amorphous peat/organic silt.

25.3.2.2 Embankments on peat (construction and operation phase):

- Localised dewatering for excavation or surcharging of the peat might result in consolidation settlement.
- As the peat is not uniform in nature, vertical thickness or lateral extent it may experience differential effects in some areas; some local discharge of water may also occur due to its very high natural water content.

25.3.2.3 Deep cuts (construction phase):

- There is a possibility that perched aquifers[207] may be encountered and that local discharge may occur resulting in drainage of small volumes of groundwater.

25.3.2.4 Consolidation of peat and sand:

- Where peat is surcharged its hydraulic conductivity[208] could be reduced by a factor 1:10 to 1:1000 and result in a decrease in groundwater through-flow.
- In areas where peat is excavated and replaced with sand, the sand will have a higher hydraulic conductivity than the in-situ peat it replaces thereby increasing the rate of groundwater through-flow.

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[206] Upward discharge of groundwater in the base of an excavation that resembles boiling water.

[207] A zone capable of supplying water to a well (an aquifer) that overlies a zone of dry sands and/or gravels.

[208] A measure to determine the ability of soil or rock to transmit a specific fluid.

25.3.3 Sector specific issues[209]

25.3.3.1 Sector 1 – Raumati South

The proposed Expressway passes in close proximity to the Raumati Manuka Wetland and over a significant surface drain (Drain No. 7). Key groundwater issues identified in this sector are:

- The interaction between the constructed stormwater Wetland OA and the Raumati Manuka Wetland on the opposite side of the proposed Expressway; and
- The potential for peat surcharge to reduce groundwater through-flow to the Raumati Manuka Wetland.

25.3.3.2 Sector 2 – Raumati/Paraparaumu

The proposed Expressway will pass through the Kiwi Wetland, Wharemauku and Mazengarb Streams (and their tributaries) and close to several other small wetland areas. Key groundwater issues identified in this sector are:

- The interaction between storage areas 2 and 3 and the Wharemauku Stream and the possibility that groundwater lowering may reduce the groundwater flow to the stream over a 600 m length before being re-introduced from the storage areas to the stream;
- The effect of potential groundwater lowering on aquifer systems and yield from existing wells;
- The potential for groundwater lowering to result in consolidation settlement for neighbouring residential areas; and
- The potential effects of peat treatment methodologies (for example, damming or lowering of the local water table).

25.3.3.3 Sector 3 – Otaihanga/Waikanae

The proposed Expressway alignment passes close to several wetlands of significant ecological and cultural value, most notably the El Rancho Wetlands.[210] It also crosses two significant surface water bodies, the Waikanae River and the Waimeha Stream. Key groundwater issues identified in this sector are:

- Potential interactions with the El Rancho wetland - while groundwater lowering may address surface flooding in the area, it could also potentially reduce the water level in the El Rancho wetlands and induce ground settlement; and

[209] A diagram and detailed description of each of these Sectors is included in Chapter 6 of Volume 2.

[210] Information regarding the ecological and cultural significance of these wetlands is included in Technical Report 26, Volume 3.

- The potential effects of peat treatment methodologies (for example, damming or lowering of the local water table).

25.3.3.4 Sector 4 – Waikanae North

The proposed Expressway alignment passes through the Te Kouka Wetland and between the ecologically significant Nga Manu Nature Reserve and Te Harakeke/Kawakahia Wetland. Key groundwater issues identified in this sector are:

- Peat treatment methodologies and their affect on natural wetlands (for example, the damming or lowering of these wetlands); and
- The potential effects of groundwater lowering if this is required to facilitate flood offset storage.

25.4 Investigations and groundwater modelling

In order to understand and assess the groundwater regime in the vicinity of the proposed Expressway fieldwork was undertaken that comprised:

- Ground investigations;[211]
- Groundwater level monitoring; and
- Peat excavation trials.

The data derived from these investigations was used to develop a conceptual hydrogeological model. It was also used to inform the development of two and three dimensional groundwater flow models, including their calibration. A site specific model was also developed to consider the interactions of the Otaihanga Landfill and adjacent wetlands with the proposed Expressway construction.

The three dimensional modelling was employed to evaluate the aquifer budget[212] and to assess the likely local and regional effects of the proposed Expressway construction on groundwater, wetland and river levels. The two dimensional modelling was used to assess the potential effects of embankment construction on aquifer through-flows and groundwater levels, particularly those effects associated with peat excavation and replacement or peat surcharge.

A detailed description of the groundwater investigations and subsequent modelling is contained in Technical Report 21 (Volume 3).

[211] These consisted of site investigations comprising boreholes, test pits, hand augers, cone penetration tests and standpipe piezometers.

[212] This refers to the volume of water flowing into and out of the model.

25.5 Assessment of potential construction and operational effects on groundwater

25.5.1 Groundwater levels and flow directions

Construction of the embankments, stormwater devices and cuts associated with the proposed Expressway is likely to affect the existing groundwater levels. The results of numerical modelling suggest overall that:

- Abstraction of water from construction water supply wells is likely to result in changes in groundwater level of less than 0.7 m in the shallow groundwater system within a couple of hundred metres of any wells that are used on a continuous basis. It is also likely that there will be very small associated changes in flow directions and aquifer through-flow in the vicinity of these wells. However, such changes will be limited to the construction period and recovery will occur rapidly following cessation of use;
- The embankments (and associated peat treatment) will result in small (generally 0.3 m but up to 0.5 m) long-term changes to groundwater levels and flow direction immediately adjacent to the proposed Expressway, with no discernable change in groundwater levels, flow direction or aquifer through-flow at a distance of 50 m to 70 m from the proposed Expressway;
- Where storm water devices are constructed at the approximate existing groundwater level there will be no discernible changes to groundwater levels, flow direction or aquifer through-flow;
- Where the water level maintained in stormwater devices is more than 0.5 m above or below the existing groundwater level, and modelling indicates that without mitigation a change in groundwater level might result that would be deleterious to the existing environment, the devices will be lined to avoid lowering of the groundwater level beneath and adjacent to the them; and
- Where storm water devices are constructed less than 0.5 m below or above the existing groundwater level, they are likely to result in a small (< 0.5 m) change to groundwater levels and flow direction immediately adjacent to the devices, reducing to no discernable change in groundwater levels, flow direction or aquifer through-flow beyond a distance of 200 to 300 m from the device in the worst case (upgradient of storm water storage areas 2 and 3), but typically less than 50 m.

Given the relatively small scale, magnitude and extent of these changes, it is unlikely that adverse effects on groundwater levels and flows will occur as a result of constructing the proposed Expressway. The exception is in the area upgradient of storage areas 2 and 3, where some ground settlement is expected to occur.[213]

[213] This is discussed in further detail in Technical Report 35, Volume 3.

25.5.2 Wetlands and surface waters

The results of numerical modelling suggest that overall changes to the groundwater budget are unlikely to be discernible.

Modelling undertaken suggests there will be no discernible long term effect on groundwater contributions to rivers and streams or to water levels in natural wetlands. This is due to the relatively limited extent of construction drawdown, along with stormwater ponds being lined in areas where effects might otherwise arise.

However, during construction the groundwater contribution to rivers and streams may reduce by up to 1.5% (peak) as a result of the water take. Also, groundwater that would have directly discharged to the Wharemauku Stream will instead be discharged to flood offset areas 2 and 3 before being directed to the stream. Although this is a non-consumptive take, it will result in a 17% reduction in the groundwater base flow over a 600 m length of the Stream adjacent to the pond during the construction period, and stream gauging is proposed as a mitigation measure.[214]

25.5.3 Contaminant migration

As changes in groundwater levels, gradients and flow are expected to be very small; the potential for changes in contaminant migration as a result of the Project is also very small.

Both regional and site-specific 3D groundwater modelling of the proposed Expressway in the vicinity of the Otaihanga Landfill indicate no noticeable change in groundwater levels, gradients and flow as a result of proposed Expressway construction (refer Appendix F, Technical Report 21, Volume 3). Consequently, changes in contaminant migration from the landfill as a result of proposed Expressway construction are considered to be negligible.

25.5.4 Groundwater users

The results of numerical modelling indicate maximum changes in water level of up to 0.2 m within six existing wells, and this level of drawdown is unlikely to have an adverse impact on existing users. However, in the event that these are very shallow, low volume wells there could be a corresponding affect on their yield and a temporary replacement supply or longer term solution may be required.

25.5.5 Sector specific effects

25.5.5.1 Sector 1 – Raumati South

Assuming that Wetland OA is lined, the construction of the proposed Expressway and associated stormwater devices may draw down the water table by up to 0.5 m immediately adjacent to this wetland and the Raumati Manuka Wetland. However, as the numerical modelling undertaken indicates that this

[214] Further detail is contained in Appendix I of the CEMP in Volume 4.

effect is unlikely to extend beyond a range of 20 m to 40 m from the devices, a drawdown of the water level in the Raumati Manuka Wetland is not anticipated. Monitoring will be undertaken during construction to confirm that effects are within the range modelled.

Some minor, localised seepage out of the base of Wetland OA is likely. This will raise the water level immediately below the wetland (by up to 0.5 m), but no effects are expected beyond the boundary of the wetland.

Lowering of the groundwater level around Wetland OA will also reduce the amount of surface flooding west of the alignment, therefore reducing the volume of groundwater that will discharge to Drain No. 7 in this area.

25.5.5.2 Sector 2 – Raumati/Paraparaumu

Lowering of the groundwater level associated with flood offset storage areas 2 and 3 will result in up to 0.5 m of drawdown immediately adjacent to the wetlands within this sector, with drawdown extending radially outwards for a distance of 200 m to 300 m from these storage areas. While this may help alleviate surface flooding experienced in the area, there is potential for consolidation settlement[215] of ground beneath the neighbouring residential properties to occur.[216]

Because of the upward groundwater gradient in this area (as indicated by the spring fed Wharemauku Stream and artesian water levels in deep piezometers[217]), some drawdown will also occur in the upper Marine Sand layer (up to 0.5 m directly beneath the pond) when peat is excavated from the pond footprint and the confining head is removed. In deeper layers drawdown of less than 0.2 m is predicted.

Lowering of the groundwater level around storage areas 2 and 3 will reduce the amount of groundwater which naturally discharges to the Wharemauku Stream and Drain No. 7 over a length of some 600 metres.[218] However, as the groundwater that would have naturally discharged to the stream will instead discharge to the flood offset area and be redirected to the stream further down gradient, overall down gradient flows will be unaffected (i.e. the take is non-consumptive).

Monitoring will be undertaken during construction to confirm that effects are within the range modelled.

25.5.5.3 Sector 3 – Otaihanga/Waikanae

The construction of the proposed Expressway (peat excavated and replaced with sand) may draw down the water table by up to 0.4 m immediately adjacent to the proposed Expressway, with measurable

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[215] Gradual subsidence of the ground or structure due to compression of the soil.

[216] Refer to Technical Report 35, Volume 3, for a detailed assessment of ground settlement effects and associated mitigation.

[217] Instruments used to measure or monitor fluid pressure.

[218] These reductions will be in the order of 17% and 13% respectively.

drawdown (0.1 m) typically extending for a distance of less than 50 m (but up to 100 m). Drawdown of the water table beneath the adjacent natural wetlands is not expected.

Although Wetland 9 will be constructed with a low permeability liner in order to limit interactions between the wetland and groundwater level, some very small changes in groundwater level are expected. Immediately adjacent to constructed Wetland 9 a maximum drawdown of 0.3 m is likely, reducing to less than 0.1 m at a distance of 20 m to 30 m.

As changes in groundwater level are of limited magnitude and extent, there is no measureable change to the volume of groundwater that naturally discharges to the Waikanae River in this area.

Monitoring will be undertaken during construction to confirm that effects are within the range modelled.

25.5.5.4 Sector 4 – Waikanae North

As the alignment in this sector is largely above the groundwater level, the effects on water levels in the adjacent Te Kouka Wetland, Nga Manu Nature Reserve and Te Harakeke/Kawakahia Wetland are expected to be negligible.

Large flood offset storage areas are proposed near Kakariki Stream, but these are planned to be at or above groundwater level and will therefore have little effect on the groundwater system. A system of drains proposed north of Ngarara Road will also result in local lowering of the groundwater level, which may result in consolidation settlement affecting existing SH1 and the railway embankment. The final design solution for this area is yet to be determined.[219]

25.6 Measures to avoid, remedy or mitigate actual or potential adverse effects on groundwater

Measures to address the groundwater effects identified in Section 25.5 comprise monitoring in addition to a range of mitigation strategies. While a detailed outline of these measures is included in the CEMP Appendix I, Volume 4, they are summarised below.

25.6.1 Monitoring

Monitoring of groundwater levels, ground surface elevations (settlement) and surface water flow is proposed for a period of 1 year prior to and 3 years following construction. The purpose of undertaking this monitoring is to confirm the results of predictive modelling and to refine models if early monitoring indicates that actual behaviour differs from that predicted.

Monitoring will also serve as a trigger to initiate more comprehensive monitoring and / or implementation of mitigation measures if required.

[219] Refer to Technical Report 22, Volume 3, for further discussion on hydrological and stormwater effects and associated mitigation.

To facilitate this process a groundwater monitoring programme (GWMP) has been prepared as part of the CEMP (in Volume 4) comprising:

- Standpipe piezometers (single and paired) in proximity and at distance from the proposed Expressway to monitor changes in groundwater levels as set out in Appendix A of the GWMP;
- Baseline monitoring data taken in advance of works to obtain information on seasonal and annual variations (this has been underway since November 2010);
- Flow meters or continuous flow monitoring of key surface water features to provide additional data for groundwater model calibration at detailed design;
- Monitoring of key indicators of mobile contaminants in selected bores down gradient and below landfills (as detailed in Appendix K – Contaminated Soils and Groundwater Management Plan, CEMP, Volume 4);
- Monitoring groundwater elevation;
- Monitoring of spring flows at Te Puna o Rongomai;
- Establishing various trigger levels (Alert and Action) with appropriate remedial action plans if those trigger levels are reached; and
- A system of review to determine at what stage monitoring can be reduced or cease post-construction.

25.6.2 Mitigation

In the detailed design of the proposed Expressway the following strategies will be applied to mitigate potential effects on groundwater:

- Lining and other refinements to the design of large stormwater devices where they involve excavations below the water table and modelling indicates that, without mitigation, a change in groundwater level might be detrimental to the existing environment; and
- Optimising construction activities, including where practicable:
  - Drilling a larger number of construction water take wells spread out along the prosed Expressway alignment, with each taking a small volume at different times depending on the construction programme rather than relying on fewer wells pumping continuously at higher rates;
  - Limiting the open length of excavation to reduce the area and period of any dewatering; and
  - Using the starter layer in embankment construction as a drainage blanket to minimise damming effects up-gradient of surcharged peat.

In addition, the following strategies commonly used during the construction phase of works will be considered to reduce the amount of drawdown and associated effects should acceptable levels of drawdown be exceeded:

- Responding appropriately to any information obtained from monitoring groundwater elevation, flow and quality;
- Altering the excavation methodology to reduce the period of time that excavations are drained;
- Altering the peat treatment methodology to balance drawdown / damming effects;
- Using active drainage measures beneath embankments (e.g. pipe) to facilitate flow through the embankment;
- Redirecting treated surface water to wetlands or surface water bodies;
- Where private water supply wells are affected, tankering water from construction wells to users or deepening wells to increase the available drawdown; and
- Controlling the recharge of groundwater to limit the amount of drawdown.

Appropriate mitigation method(s) will be selected by NZTA at the time that the need for further mitigation is identified, with the method selected dependent on the nature, extent and location of the exceedance.[220]

[220] Refer to Appendix I of the CEMP in Volume 3 for further detail regarding proposed mitigation.