Appendix I of the CEMP

Groundwater (Level) Management Plan

NZ TRANSPORT AGENCY
WAKA KOTAHI

1 MacKays to Peka Peka Expressway

Revision History

Revision Nº	Prepared By	Description	Date
A	Sian France Paul Goff	First draft for review	4 October 2011
1	Mark Utting	Second Draft Revision	16 November 2011
2	Sian France Mark Utting	Updated for initial EPA comments	22 February 2012

Document Acceptance

Action	Name	Signed	Date
Prepared by	Sian France Mark Utting		16 November 2011
Reviewed by	Ann Williams		22 February 2012
Approved by	Ann Williams		22 February 2012
on behalf of	Beca Infrastructure Ltd		

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Appendices

1 Introduction

1.1 Scope and Purpose of Groundwater Management Plan

This Groundwater (Level) Management Plan (GWMP) (the Plan) forms part of a comprehensive suite of environmental controls within the Construction Environmental Management Plan (CEMP, Volume 4) for the MacKays to Peka Peka Expressway Project ("the Project").

The GWMP addresses the potential effects on groundwater levels associated with both the construction and long term operation of the Project, and identifies the minimum standards that must be complied with as well as best practicable options for groundwater management for the Project. It is intended as a framework for the development of groundwater level management practices and procedures to minimise impact on the environment.

The potential for effects on the environment to occur can be measured by recording changes in groundwater levels in piezometers installed in proximity to the works and responding by implementation of suitable mitigation measures if action levels are reached.

The GWMP will be updated, with the necessary approval, throughout the course of the Project to reflect material changes associated with construction techniques or to the natural environment. Approval from the Greater Wellington Regional Council (GWRC) will be required for any relevant revisions of a material nature to the GWMP.

It should be noted that this GWMP does not consider changes to groundwater quality that could be caused by the Project. Groundwater quality changes and associated monitoring requirements are addressed in the Contaminated Soils and Groundwater Management Plan (Appendix K of the CEMP, Volume 4) and also included within the CEMP, Volume 4.

1.2 Project description

For a description of the Project, refer to the Project Description (Construction and Operation) within Part D, Chapters 7 and 8, Volume 2.

1.3 Performance standards

The CEMP, Volume 4 identifies general legislative standards and other requirements relevant to the management of groundwater for the Project.

1.4 Environmental plans and maps

The table below summarises the location of relevant environmental plans and maps within the CEMP, Volume 4.

Plan/ Map	Relevance	Location
Settlement Effects Management Plan (SEMP)	Management of potential impact on buildings and services from settlement related to Expressway construction.	Appendix J of the CEMP, Volume 4
Contaminated Soils and Groundwater Management Plan (CSGMP)	Management and monitoring of potential environmental and health risks arising from changes to soil and groundwater contamination as a result of Expressway construction.	Appendix K of the CEMP, Volume 4
Ecological Management Plan (EMP)	Management and monitoring of potential impacts on freshwater ecology caused by a reduction of groundwater flow or level in wetlands or surface water bodies.	Appendix M of the CEMP, Volume 4
Erosion and Sediment Control Plan (ESCP)	Management of sediment discharges contributed by the Project (eg surface water run-off at earthworks).	Appendix H of the CEMP, Volume 4
Environmental Maps	Project alignment and receiving environments.	Appendix C of the CEMP, Volume 4

2 Environmental aspect

Assessments of the existing groundwater regime and changes that might occur as a result of the Expressway have been made from groundwater modelling that has been calibrated to in-situ investigation data and both in-situ and laboratory testing. The groundwater models developed for the assessment serve to define the locations and ranges of groundwater changes that are expected to result from construction of the Expressway. They also serve to guide the development and implementation of this monitoring programme (GWMP) to verify these changes, and to trigger any mitigation or corrective actions that are needed to protect the environment. Because models are always limited by the available data used in their construction and calibration, the modelled effects are not, and can never be, exact. Actual effects may be larger or smaller than those predicted at some locations, especially those locations away from the areas of focus of the model. In spite of

these limitations, the models do serve as the most reliable assessment of future effects that are likely to be caused by the Expressway.

It is important to check that actual changes in groundwater levels during and following construction are similar to those modelled. This can be done by:

- Recording water levels in selected piezometers adjacent to and at distance from the Expressway; and
- Monitoring water levels and base flows in wetlands and other surface water bodies.

The monitoring plan set out in Section 5 of this GWMP is designed to confirm current baseline conditions (including seasonal variations), verify the validity of the modelling and to give warning of changing groundwater level conditions resulting from construction of the Expressway. The use of modelling and monitoring together provides a greater level of understanding than reliance on either modelling or monitoring alone.

Because changes to groundwater levels occur some time before settlement is experienced, mitigation measures can be carried out to limit groundwater drawdown if monitoring indicates potentially deleterious effects due to higher than anticipated drawdown; monitoring acts as a warning system for settlement effects. In the same way, recorded changes in water levels as compared with those anticipated, can be used as an indicator of potential effects on wetlands and other surface water bodies and mitigation measures can be applied if necessary.

This GWMP describes how these potential effects will be addressed.

2.1 Changes in groundwater level

Lowering of the groundwater level (drawdown) might occur as a result of:

- Drainage associated with the Expressway cuts;
- Excavation and replacement of peat with more permeable sand to construct the Expressway embankments;
- Permanent storm water measures (i.e. lowering of the ground and groundwater levels for flood attenuation);
- Pumping of wells for construction water supply; and/or
- Reduced infiltration due to increasing the amount and coverage of paved surfaces.

Drawdown will result in a depression of the groundwater level that will extend outwards and decline in magnitude with distance from the activity.

A rise in the groundwater level could occur as a result of:

- Preloading or surcharging the peat resulting in reduced permeability and through flow of groundwater;
- Infiltration of run-off from (unlined) storm water devices; and / or
- Replacement of excavated sand with compacted peat (in these areas the peat may have a lower permeability than the surrounding ground and may locally act as an impediment to groundwater flow, resulting in a rise in groundwater level).

Technical Report 21, Volume 3 (Assessment of Groundwater Effects) found that assessed changes in groundwater level were generally of limited extent with effects of less than 0.3 m predicted at distances of 50 m to 70 m from the Expressway. This Plan sets out monitoring of water level changes in the area up to 200 m from the Expressway, being approximately double the distance of anticipated drawdown or mounding effects in most locations and the greatest extent of calculated ground settlement effects at any location along the route.

2.2 Drawdown induced settlement

The drawdown of groundwater below its normal seasonal variation can cause settlement of the ground, which in turn may result in settlement of structures founded on or in the ground. This movement can result in damage to structures depending on the amount of settlement that is induced and how this changes beneath the structure, and the nature of the structure and its foundations.

The settlement associated with groundwater drawdown is predicted to extend for the most part in the order of 90 m to 200 m from the Expressway embankment, though noticeable effects are likely to be limited to less than 90 m (refer to Technical Report 35, Volume 3 and Appendix J of the CEMP, Volume 4).

2.3 Effects on wetlands and surface water bodies

Drawdown and damming of groundwater levels in the vicinity of wetlands or surface water bodies may alter the contribution of groundwater that naturally flows towards these areas; it may also increase the volume of water that naturally discharges through the bed of such areas to recharge the underlying groundwater system.

Technical Report 21, Volume 3 (Assessment of Groundwater Effects) found that in general, assessed changes in groundwater level or flows to wetlands were expected to be negligible (when considering the lining of storage areas that might have otherwise resulted in larger changes in water level).

2.3.1 Wharemauku Stream

Lowering the groundwater level around flood storage areas 2, 3A and wetland 3 reduces the amount of groundwater which naturally discharges to the Wharemauku Stream (a reduction of about 17 %) and drain 7 (a reduction of about 13 %) over a length of some 600 m. The groundwater that would have naturally discharged to the stream instead discharges to the flood offset area, and is then redirected to the stream further down gradient such that down gradient flows are not affected. Flow gauges will be established on the Wharemauku Stream and Drain 5 to monitor stream flows.

3 Roles and responsibilities

Roles and responsibilities for the Project are described in the CEMP, Volume 4. Specific roles and responsibilities relating to managing groundwater are described below.

The Project team[1] will manage and monitor the effects associated with groundwater level changes including:

- Extent of settlement and the resulting effects on buildings, services, and retaining walls (refer Appendix J of the CEMP, Volume 4);
- Reduction of flows or levels in surface water bodies and wetlands; and
- Reporting to the Consent Authority (Greater Wellington Regional Council).

The Project team will monitor the effects on the groundwater and surface water regime by comparing the results of monitoring with modelled values.

If groundwater effects beyond those estimated occur then the Project team will pass on the findings and coordinate any discussions with the affected party. The Project team will implement measures to limit groundwater drawdown, effects on surface water bodies and ground settlement, and carry out remedial actions on affected buildings and services. This will include consideration of actual geology encountered as compared with modelled geology and updating the relevant model if necessary.

All personnel working on the Project including Project team employees and subcontractors have the responsibility for following the requirements of this GWMP.

[1] This Plan refers to the Project team as carrying out works on behalf of and as contracted by the NZTA. The NZTA is the requiring authority and the consent holder.

4 Training

Environmental training for all relevant staff will be undertaken as part of the site induction programme as described in the CEMP, Volume 4.

The Environmental Induction will include information on the following aspects of this Plan:

- Information about the activities and stages of construction that may cause impacts on groundwater within the construction area;
- Consent requirements;
- Complaints management procedures;
- Groundwater monitoring and management procedures; and
- Roles and responsibilities for management of groundwater on the Project.

5 Monitoring requirements

This section details the monitoring programme for the measurement of groundwater levels during and after the construction period.

Changes in groundwater level give an indication of the potential for drawdown-induced settlements and interactions with surface water bodies. Differences between modelled and actual changes in groundwater level can be expected, and will need to be considered in terms of the actual geological sequence encountered compared with that modelled and the impact this might have (if any) on potential effects.

5.1 Monitoring of groundwater levels

Groundwater levels will be recorded in monitoring bores that will include piezometers already installed along the alignment, as well as bores drilled subsequently to supplement the current distribution (Appendix I.A).

5.1.1 Location of groundwater monitoring bores

Monitoring bore sets will be established (where they do not exist already) along the alignment with a particular focus on sensitive areas such as where natural wetlands occur, where significant man made ponds / wetlands are proposed or in areas already susceptible to high groundwater levels / surface flooding.

Each monitoring bore set will comprise a suite of one, two or three separate bores (according to the geological profile at that location), each monitoring a separate geological horizon.

Groundwater level monitoring will be carried out in the existing and proposed boreholes shown approximately on drawings GT-GW-100 to 111 in Appendix I.A of this Plan and on drawings GT-GW-100 to 111, Management Plan Appendices, Appendix I, Volume 5 (subject to access, services location and consenting in progress). Monitoring boreholes will be installed at least 12 months ahead of commencement of construction, where permissible to collect data on seasonal variations in groundwater level.

5.1.2 Construction of groundwater monitoring bores

Piezometers will be installed so that the screened interval of each piezometer targets a separate geological unit. Piezometers will be developed immediately following construction. Typical installation details are attached in Appendix I.B.

5.1.3 Monitoring records

Monitoring will consist of the recording of:

- Piezometer name, screened geological unit, date and time of monitoring;
- Depth to groundwater (as both a depth below ground surface and as a reduced level); and
- Any damage to the piezometer or ponding of water or other change at the bore head.

An example field recording sheet is attached in Appendix I.C.

5.1.4 Monitoring frequency

Groundwater monitoring bores will be monitored for at least twelve (12) months prior to commencement of the construction works (where permissible), during construction, and for at least twelve (12) months, but up to three (3) years, after construction is complete. In cases where post-construction mitigation is implemented, monitoring specific to such mitigation may be continued for a longer period if the collected data do not indicate a return to pre-construction groundwater levels or establishment of a new equilibrium. The frequency and type of monitoring will vary depending on the stage of construction.

a. Prior to construction

In the 12 months prior to construction, groundwater level monitoring will be undertaken at monthly intervals. For the final month before construction, the frequency of groundwater level monitoring will be increased to weekly intervals.

b. During construction

As the active construction stage starts to affect the relevant section, the frequency of groundwater level monitoring will be increased to twice weekly. Active construction is defined as beginning when

the advancing construction face comes within 200 m of the section and ending when earthworks are complete and / or no dewatering is occurring within 200 m of the section.

Groundwater levels in boreholes more than 200 m from the active construction zone will be monitored twice monthly.

c. Post construction

Monitoring will continue on a monthly basis for a period of twelve (12) months after construction of the Expressway is complete. Following this twelve month period and provided that records indicate that changes in groundwater level have stabilized, or reversed approximately in accordance with predictions, then monitoring shall cease.

Where monitoring bore sets indicate changes in groundwater level that have not yet stabilized, or where groundwater level monitoring bore sets are located within 100 m of an unlined stormwater wetland or storage device, monitoring will continue for a further period of up to two years at a frequency of quarter-yearly (once every three months).

If groundwater levels in any particular bore within this period show equilibrium in the groundwater level (allowing for the seasonal variation), the monitoring may cease on written approval from the GWRC representative.

5.1.5 Monitoring methodology

Monitoring will be undertaken by a specifically identified and trained team. Review and reporting of collected monitoring data will be undertaken by a suitably experienced person (eg specialist hydrogeologist).

5.1.6 Reporting

A Groundwater Monitoring Report recording the groundwater monitoring data and interpretation of the data will be prepared by the Project team's Environmental Manager and forwarded to the Consenting Authority (Greater Wellington Regional Council) at quarter-yearly (once every three months) intervals.

The Groundwater Monitoring Report presenting the monitoring results will be submitted to the Greater Wellington Regional Council within one (1) week of the final monitoring round within any 3 month period.

An outline report structure for the Groundwater Monitoring Report is provided in Appendix I.C.

5.1.7 Groundwater level alert and action levels

The variability of groundwater levels at each bore will be established using all data collected from that bore over the 12 month pre-construction period (or greater period if available). This data will be

used to establish seasonal groundwater level variations and groundwater monitoring trigger levels will be calculated based on these monitoring results.

The purpose of the Alert level is to check that changes in water level are comparable with modelled levels and if exceeded, increase the frequency of data collection.

The purpose of the Action level is to avoid the occurrence of adverse effects that might result from groundwater drawdown (or mounding) in excess of modelled levels.

Trigger levels for each individual piezometer shall be set as a reduction below the lowest recorded naturally occurring low level or above the highest recorded naturally occurring high level for the piezometer as set out in the schedule below (or as modified in agreement with the Project team's Environmental Manager and Consenting Authority (Greater Wellington Regional Council)).

A buffer distance of 200 m has been selected for monitoring of water level changes near the Expressway. This distance is approximately double the distance of anticipated drawdown or mounding effects in most locations and the greatest extent of calculated ground settlement effects at any location along the route. Monitoring Alert and Action Levels are defined as follows:

Shallow bores - Within 200 m of the Expressway, until active excavation or dewatering is more than 200 m away:

Alert Level	0.75 m variation outside the naturally occurring range[2] for the piezometer
Action level	1.0 m variation outside the naturally occurring range for the piezometer
Shallow bores are screened through the Holocene Peat or Holocene Sand.	

Shallow Bores - More than 200 m from the Expressway or any active excavation or dewatering:

Alert Level	0.5 m variation outside the naturally occurring range for the piezometer
Action level	To be set when the alert level is reached, relative to the potential for effects at that location
Shallow bores are screened through the Holocene Peat or Holocene Sand.	

Deep Bores – Within 200 m of the Expressway, until active excavation or dewatering is greater than 100 m away:

Alert Level	0.75 m variation outside the naturally occurring range for the piezometer

[2] Either reduction below naturally occurring lowest level, or rise above naturally occurring highest level.

Action level	1.0 m reduction below the lowest naturally occurring level for the piezometer
Deep bores are screened in the Pleistocene Sands (upper and lower) or deeper gravel aquifers.	

Deep Bores – More than 200 m from the Expressway or any active excavation or dewatering:

Alert Level	0.5 m variation outside the naturally occurring range for the piezometer
Action level	To be set when the alert level is reached, relative to the potential for effects at that location
Deep bores are screened in the Pleistocene Sands (upper and lower) or deeper gravel aquifers.	

5.1.8 Alert trigger response management

Where an alert trigger level is exceeded, the Project team's Project Manager and the Consenting Authority (Greater Wellington Regional Council) will be notified by the Environmental Management Team, in writing, within 3 working days with details of actions to be undertaken.

Potential actions are outlined below:

- Increase frequency of groundwater level monitoring to daily for all bores within 200 m radius of the affected monitoring bore;
- Survey all ground and building settlement monitoring marks within a 200 m radius of the affected monitoring bore within five (5) days of the trigger exceedance. The survey levels will be compared with the surface level triggers set by the consent. Surveys will be carried out every seven (7) days, with results submitted to the Project team's Project Manager and the Consenting Authority (Greater Wellington Regional Council) within seven (7) days of completion, until the affected monitoring bore shows either:
  - Recovery of the groundwater level at that monitoring bore to above the trigger level; OR
  - A trend of increasing groundwater level over at least three (3) consecutive weeks; OR
  - Ground surface settlement monitoring mark levels over at least three (3) consecutive weeks indicate that ground surface settlement around the bore is within seasonal range; OR
  - Analysis of the data indicates that adverse effects are not anticipated, in which case revised trigger levels would be set with approval of the Project Manager, Environmental Management Team and Greater Wellington Regional Council.

5.1.9 Action trigger response management

Where an Action trigger level for a monitoring bore is exceeded, activities that have the potential to cause adverse effects (such as increasing drawdown) will be ceased or mitigated (such as by reinjection of abstracted water). The following people will be notified:

- The Project and Site Managers;
- The Consenting Authority (Greater Wellington Regional Council); and
- The Environmental Management Team.

Works may recommence ore recommence without mitigation once groundwater levels return to sub-Action levels. Alternatively, works may recommence if written notice is received from the Consenting Authority (Greater Wellington Regional Council) indicating that they are satisfied that damage to buildings, structures and services, or impacts on wetlands are unlikely.

5.2 Monitoring of water levels in wetlands

Groundwater drawdown due to construction of the Expressway and storm water devices is expected to result in a negligible reduction in the volume of groundwater discharging to surface water bodies and/or potentially a negligible increase in the amount of water in surface water bodies that is lost through their beds to the groundwater system. Monitoring of potential changes to water levels in wetlands will be accomplished by monitoring groundwater levels between the Expressway and the wetlands. By monitoring groundwater levels the potential for effects on water levels in wetlands can be identified. If groundwater level changes reach Alert or Action levels, then potential effects on wetlands can be avoided by mitigating groundwater level changes before the wetland is deleteriously affected (they are accustomed to lower water levels in mid-late summer and short term elevations following heavy winter rains when the ground is already saturated).

Where natural wetlands or surface water bodies are within 100 m of the Expressway, specific groundwater level monitoring wells will be installed between the Expressway and the wetlands, as set out in drawings GT-GW-100 to 111 in Appendix I.A of this Plan and drawings GT-GW-100 to 111, Management Plan Appendices, Appendix I, Volume 5. The following wetlands are specifically monitored:

- Raumati Manuka Wetlands, CH3700 to CH4100 – 3 piezometers;
- Crown Hill and other small wetlands, CH7400 to CH7700 – 1 piezometer;
- Wetland(s) down gradient of the Otaihanga landfill, CH8700 to CH9100 – 3 piezometers;
- El Rancho Wetland, CH10900 to CH11600 – 4 piezometers;
- Te Harakiki/ Kawakahia wetland, CH12400 to CH13200 – 2 piezometers; and
- Te Harakiki Regen Wetland / Nga Manu Sanctuary, CH13700 to CH14700 – 4 piezometers.

Because the monitoring of potential water level changes to wetlands will be accomplished by monitoring changes in groundwater levels, the methodology, reporting, and response management are as outlined in Section 5.1.

Trigger levels for standpipe piezometers in wetlands are:

Alert Level	0.2 m variation outside the naturally occurring range for the piezometer
Action level	To be set when the alert level is reached, relative to the potential for effects at that location

An example of responses triggered is given in Appendix I.D.

5.3 Monitoring of Stream Flows

Gauges will be established at the following locations (marked on drawing GT-GW-104 in Appendix I.A of this Plan and drawing GT-GW-104, Management Plans Appendices, Appendix I, Volume 5):

- Up-stream of the Wharemauku Stream crossing;
- Down-stream of the Wharemauku Stream crossing; and
- Drain 5.

The actual location of gauges will be dependent on stream bed conditions. Where possible, gauges will be placed in locations such that they are able to record the full range of flows (very low to very high) and be in proximity to groundwater level monitoring wells.

Baseline surveys will be required a year in advance of construction (where feasible) in order to establish seasonal flow ranges (i.e. lowest naturally and highest naturally occurring flows due to seasonal influences).

Where surface water is ephemeral, shallow standpipes should be installed in the place of permanent gauging stations.

5.3.1 Monitoring Records

The flow gauging (continuous if feasible) will provide a raw data record of in-stream flow and its variations over time. The raw data will be separated into base flow (that derived from storage within surface water bodies) and quick flow (that resulting from rainfall, storm water runoff etc).

5.3.2 Monitoring Frequency

Where continuous monitoring gauges are able to be established, monitoring will be recorded at 15 minute intervals for one (1) year prior to commencement of construction (if feasible), continuing through the construction period and for one (1) year following construction, or for a shorter period if no effect on flows has been recorded. Prior to construction, these records will be downloaded for processing every 3 months. During and for a period of 12 months following construction, the data will be downloaded monthly.

If it is not feasible to install continuous flow gauges, spot gauging will be carried out at monthly intervals for one (1) year prior to commencement of construction, continuing through the

construction period and for one (1) year following construction, or for a shorter period if no effect on flows has been recorded.

5.3.3 Reporting

Results of surface water flow monitoring will be downloaded and analysed monthly. The data and assessment of the data will be presented three (3) monthly as an appendix to the groundwater (level) monitoring reports issued at the same time.

5.4 Monitoring of inflows to excavations

Actual groundwater inflow to the excavations shall be monitored where practical and compared with modelled inflows.

Where groundwater inflows are sufficient to warrant pumping and removal, discharged volumes shall be monitored and recorded on a daily basis. This flow monitoring will be carried out in conjunction with monitoring as described in the monitoring section of the Erosion and Sediment Control Plan (Appendix H of the CEMP, Volume 4) and/or the Contaminated Soils and Groundwater Management Plan (Appendix K of the CEMP, Volume 4).

5.5 Monitoring of ground conditions

Actual ground conditions encountered in excavation of stormwater storage areas and wetlands will be recorded by a geologist or geotechnical engineer. Where these differ noticeably from modelled ground conditions, the relevant model will be updated to reflect actual conditions and the effects checked against those anticipated to determine whether any further mitigative action by design is needed.

6 Mitigation measures

This section describes potential mitigation measures available; a variety of measures are available and the most appropriate measure will be determined by the Project team's Engineer for each specific case should it be required. Measures shall be implemented in accordance with the Conditions and in agreement with the Consenting Authority (GWRC).

The procedures for regular monitoring of groundwater levels during the construction phase are given in Section 5 and Appendix I.C of this GWMP. The Alert and Action Levels used to trigger any of the mitigation measures listed below are specified in Section 5 of this GWMP.

6.1 Groundwater drawdown contingency measures

A small amount of drawdown is expected within the designation resulting from temporary excavations, peat replacement and groundwater lowering for flood management. In the event of groundwater drawdown exceeding the anticipated levels away from the immediate works, the following actions will be considered:

- Changes to construction methodology i.e.:
  - Alternative peat treatment (surcharge);
  - Lining (temporary and / or permanent) of cuts below the groundwater level; or
  - Limit the length and drained duration of temporary excavations.
- Local cut off (clay bund or slurry wall);
- Recharge water through trenches or well; or
- Redirection of treated surface water to affected areas (i.e. wetlands).

Where drawdown is found to affect private well use, water from the construction supply wells could be provided via tanker truck to affected users (short term) or it might be necessary to deepen the private pump or well. Should monitoring indicate that excessive groundwater drawdown begins after the completion of the Expressway, any of the mitigation options listed above (except for changes to construction methodology) could be implemented. However, the predicted drawdowns in the aquifers supplying water to most wells in the areas away from the Expressway and associated construction are small, 0.2 to 0.5 m in the most-affected wells and less than 0.2 m in most others. These relatively small changes are unlikely to be noticed by well water users away from the Expressway Designation.

6.2 Groundwater damming and mounding contingency measures

A small amount of groundwater damming is expected within the designation resulting from surcharging and compression of the peat. Groundwater mounding is also likely in the short term from infiltration at the base of swales and unlined stormwater devices. In the event that groundwater damming or mounding exceeds the anticipated levels the following actions could be taken:

- Changes to construction methodology i.e.:
  - Alternative peat treatment (excavate and replace);
  - Increase permeability of starter drainage layer in embankment (to act as drainage blanket) to transfer groundwater from outside of the Project;
- Introduce active drainage measures (e.g. sub-soil drains beneath embankment).

7 Transition phase

At the end of construction, all monitoring data will be handed over to the NZTA to allow monitoring to continue through the post-construction stage. As far as possible, continuity of personnel should be maintained through this phase of the monitoring, at least for the up to 3-year period following Project completion.

8 GWMP review

This section describes how the Plan will be reviewed, including considering the environmental controls and procedures to make sure that they are still applicable to the activities being carried out.

The GWMP will be reviewed by the Project team after confirmation of the resource consent and designation conditions and will be revised in accordance with these conditions. The GWMP will be updated, with the necessary approval, throughout the course of the Project to reflect material changes associated with changes to construction techniques or the natural environment. Approval from GWRC will be required for any relevant revisions of a material nature to the GWMP.

A management review of the GWMP will be undertaken at least annually by the Project team Project Management team. The management review will be organised by the Environmental Manager and the Project team will be informed of any changes to this Plan through the regular Project communications processes. The review will take into consideration:

- Significant changes to construction activities or methods;
- Significant change in the volume or nature of groundwater encountered;
- Key changes to roles and responsibilities within the Project;
- Changes in industry best practice standards or recommended pollution controls ;
- Changes in legal or other requirements (social and environmental legal requirements, the NZTA objectives and relevant policies, plans, standards, specifications and guidelines);
- Results of monitoring, inspection and maintenance programmes, logs of incidents, corrective actions, internal or external assessments; and
- Public complaints.

Reasons for making changes to the GWMP will be documented. A copy of the original GWMP document and subsequent versions will be kept for the Project records, and marked as obsolete. Each new/updated version of the GWMP documentation will be issued with a version number and date to eliminate obsolete GWMP documentation being used.

9 References

Coe, L. Assessment of Ground Settlement Effects: Technical Report 35, Volume 3 of the MacKays to Peka Peka Expressway Project AEE.

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France, S. and Michaelsen, J. Assessment of Groundwater Effects: Technical Report 21, Volume 3 of the MacKays to Peka Peka Expressway Project AEE.

Park, M. Ecological Impact Assessment: Technical Report 26, Volume 3 of the MacKays to Peka Peka Expressway Project AEE.

Ridley, G. Erosion and Sediment Control Plan: Appendix H of the CEMP, Volume 4 of the MacKays to Peka Peka Expressway Project AEE.

Smith, G. Contaminated Soils and Groundwater Management Plan: Appendix K of the CEMP, Volume 4 of the MacKays to Peka Peka Expressway Project AEE.

Appendix I.A

Monitoring Location Plan

Water levels will be monitored at the piezometers listed in Table A-1 at the approximate locations shown in the Plans following. A total of 72 piezometers have already been installed and have been used to collect water level data since as far back as 2007. The completion depths for the as-yet-to-be-installed piezometers (designated as the 2012 series) will be determined in the field. One shallow (screen completion in peat) and one deep (screen completion in sand) piezometer will be installed at each location following the general design shown in Appendix B.

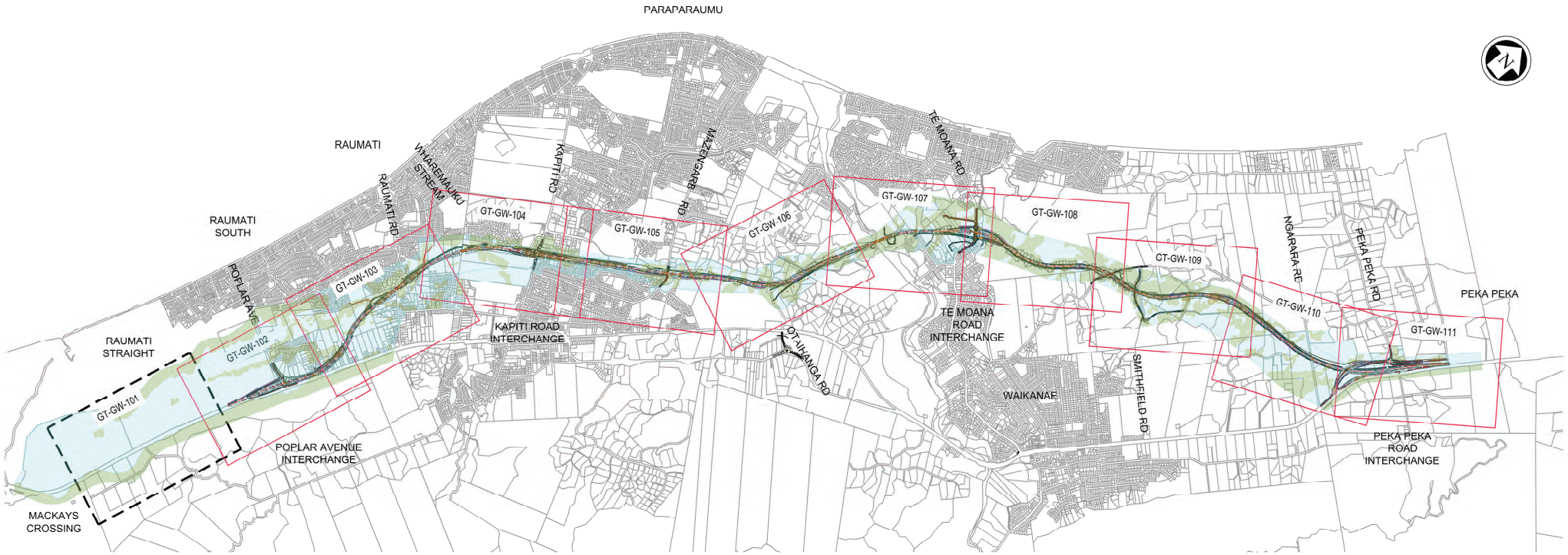
Table A-1. Monitoring Bores/ Piezometers

Borehole/ Piezometer	Designation	Ground Surface (mRL)	Screened Material	Screen			
				Depth (m)		Elevation (mRL)	
				Top	Bottom	Top	Bottom
2007/BH-A		21.8	Sand	26	29	-4.2	-7.2
2007/BH-B		5.1	Gravel	10	13	-4.9	-7.9
2007/BH-C		4.8	Sand	12	15	-7.2	-10.2
2007/BH-D		3.3	Sand	7	10	-3.7	-6.7
2007/BH-E		11.1	Sand /Silt	7	10	4.1	1.1
2007/BH-I		9.7	Sand/ Gravel	6	9	3.7	0.7
2007/BH-J		6.3	Sand	4	7	2.3	-0.7
2007/BH-K		6.2	Sand	7	10	-0.8	-3.8
2007/BH-L		3.7	Sand	10	13	-6.3	-9.3
2007/BH-M		3.6	Gravel	1.5	4.5	2.1	-0.9
2007/BH-N		10.0	Sand	5	8	5.0	2.0
2007/BH-N(A)		3.4	Sand	6	9	-2.6	-5.6
2007/BH-O		2.9	Sand	10	13	-7.1	-10.1
2007/BH-Q		25.7	Sand	27	30	-1.3	-4.3
2007/BH-R		4.1	Sand	7	10	-2.9	-5.9
2007/BH-S		4.6	Sand	7	10	-2.4	-5.4
2007/BH-T		8.0	Sand	7	10	1.0	-2.0
2007/BH-U		6.1	Sand	7	10	-0.9	-3.9
2007/BH-V		7.3	Sand	6	9	1.3	-1.7
2008/BH202		13.5	Sand	9.5	12.5	4.0	1.0
2008/BH204		13.0	Sand	18.8	21.8	-5.8	-8.8
2008/BH205		3.3	Sand	6.4	9.4	-3.1	-6.1
2010/BH04		8.2	Gravel/ Sand	5	16	3.2	-7.8
2010/BH05		7.8	Gravel/ Sand	3	12	4.8	-4.2
2010/BH07		3.6	Gravel/ Sand	2.5	15	1.1	-11.4
2010/BH12		8.6	Sand	1.5	16	7.1	-7.4
2010/BH13 S	deep	7.2	Sand	3.5	15	3.7	-7.8
2010/BH13 N	shallow	7.2	Organics	0.2	1.5	7.0	5.7
2010/BH16		11.3	Sand	5.5	15	5.8	-3.7
2010/CPT14		6.0	Peat	0	3	6.0	3.0
2011/BH204 E	deep	5.8	Gravel	5.5	9	0.3	-3.2
2011/BH204 W	shallow	5.8	Peat	1	2.5	4.8	3.3
2011/BH205		8.5	Peat	2.4	5.4	6.1	3.1
2011/BH206 NE	deep	6.1	Gravel	5.5	9	0.6	-2.9
2011/BH206 SW	shallow	6.1	Peat	1	2.5	5.1	3.6
2011/BH207 E	shallow	5.1	Gravel	19.5	23	-14.4	-17.9
2011/BH207 W	deep	5.1	Gravel/ Sand	5	8	0.1	-2.9
2011/BH208		21.7	Sand	18.5	21	3.2	0.6
2011/BH209		12.5	Sand	16.5	20	-4.0	-7.5
2011/BH210		8.6	Sand	16.5	20	-7.9	-11.4
2011/BH211		7.5	Sand	14.5	18	-7.0	-10.5

Borehole/ Piezometer	Designation	Ground Surface (mRL)	Screened Material	Screen			
				Depth (m)		Elevation (mRL)	
				Top	Bottom	Top	Bottom
2011/BH211A		9.2	Sand	13.5	20	-4.3	-10.8
2011/BH213 S	shallow	4.8	Sand, tr. wood	9	10	-4.2	-5.2
2011/BH213 N	deep	4.8	Gravels	4.5	6	0.3	-1.2
2011/BH214		7.1	Sand	9.5	10.5	-2.4	-3.4
2011/BH215		3.8	Sand	9	10	-5.2	-6.2
2011/BH216		10.3	Gravel	15.5	17.5	-5.2	-7.2
2011/BH301 E	shallow	8.4	Peat	2.5	3.5	5.9	4.9
2011/BH301 W	deep	8.4	Sand/ Gravel	5	8	3.4	0.4
2011/BH302 N	shallow	6.3	Peat	1	2.8	5.3	3.5
2011/BH302 S	deep	6.3	Sand	4	7.7	2.3	-1.4
2011/BH303 N	deep	3.9	Sand	2	5	1.9	-1.1
2011/BH303 S	shallow	3.9	Sand	7	10	-3.1	-6.1
2011/BH305 S	deep	9.3	Sand	7.5	10.5	1.8	-1.2
2011/BH305 N	shallow	9.3	Sand	2.5	4	6.8	5.3
2011/BH306 S	deep	8.25	Sand	7	10.5	1.3	-2.3
2011/BH306 N	shallow	8.25	Peat	0.7	2.2	7.6	6.1
2011/BH307 S	shallow	8.4	Sand	7.5	10.5	0.9	-2.1
2011/BH307 N	deep	8.4	Fill	1	2	7.4	6.4
2011/BH308 N	deep	8	Peat	0.5	2.5	7.5	5.5
2011/BH308 S	shallow	8	Sand	8	10	0.0	-2.0
2011/BH309 N	shallow	8.4	Peat	0.5	3.5	7.9	4.9
2011/BH309 S	deep	8.4	Sand	9	12	-0.6	-3.6
2011/BH3010 E	shallow	8.8	Peat	0.5	3.5	8.3	5.3
2011/BH3010 W	deep	8.8	Sand/ Gravel	7	10	1.8	-1.2
2011/ HA WM02		7.2	Peat	0.0	2.1	7.2	5.1
2011/HA WM04		2.6	Sand	1.0	1.25	1.6	1.4
2011/HA WM05		2.9	Sand	0.6	0.9	2.3	2.0
2011/HA WM08 N	shallow	5	Peat	0.2	0.5	4.8	4.5
2011/HA WM08 S	deep	5	Peat	0.3	0.9	4.7	4.1
2011/HA WM09		5	Peat	0.3	0.6	4.7	4.4
2011/HA WM10		5	Peat	0.3	0.6	4.7	4.4
2012/BH01	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH02	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH03	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH04	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH05	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH06	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH07	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH08	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH09	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH010	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH011	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH012	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH013	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD

Borehole/ Piezometer	Designation	Ground Surface (mRL)	Screened Material	Screen			
				Depth (m)		Elevation (mRL)	
				Top	Bottom	Top	Bottom
2012/BH014	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH015	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH016	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH017	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH018	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH019	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH020	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH021	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH022	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH023	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH024	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD
2012/BH025	Shallow & deep?	TBD	TBD	TBD	TBD	TBD	TBD

Note: TBD indicates values are “To Be Determined.”



NOTES:

GROUNDWATER MONITORING LOCATIONS TO GENERAL BE IN ACCORDANCE WITH THESE DRAWINGS.

Original Scale (A3)

Revision.	Amendment.	Approved.	Date.
1	AEE LODGEMENT	NRN	15.03.12

NZ TRANSPORT AGENCY
WAKA KOTAHI

Project: MACKAYS TO PEKA PEKA EXPRESSWAY

Title: GROUND WATER INVESTIGATION LOCATIONS SHEET INDEX

Status: - FOR CONSENTING

Document ID: M2PP-AEE-DWG

Rev. 1

Drawing No: GT-GW-100

Document No.: M2PP-AEE-DWG-GT-GW-100.DWG

Drawing Plotted: 08 Mar 2012 05:20 p.m.

2010/BH04

2010/CPT14

WHAREROA STREAM / TRIBUTARY

Poplar Avenue

Sydney Cres

Leinster Avenue

DRAIN NO.7

2011/BH204

2011/BH206

SH 1

2010/BH05

LEGEND: GROUNDWATER MONITORING

- STORMWATER WETLAND
- OFFSET FLOOD STORAGE AREA
- EXISTING WETLANDS
- PROPOSED WELL (TO BE INSTALLED) FOR MONITORING
- EXISTING WELL FOR MONITORING
- PROPOSED STREAM GAUAGING

NOTES:

Original Scale (A3)

1:5000

Revision.	Amendment.	Approved.	Date.
1	AEE LODGEMENT	NRN	15.03.12

NZ TRANSPORT AGENCY
WAKA KOTAHI

Project: MACKAYS TO PEKA PEKA EXPRESSWAY

Title: GROUND WATER MONITORING LOCATIONS SHEET 2 OF 11

Status: - FOR CONSENTING

Document ID: M2PP-AEE-DWG

Drawing No: GT-GW-102

Rev. 1

Document No.: M2PP-AEE-DWG-GT-GW-102.DWG

Document created for NZTA by M2PP Alliance, Level 2, 17-21 Whitmore St, WELLINGTON

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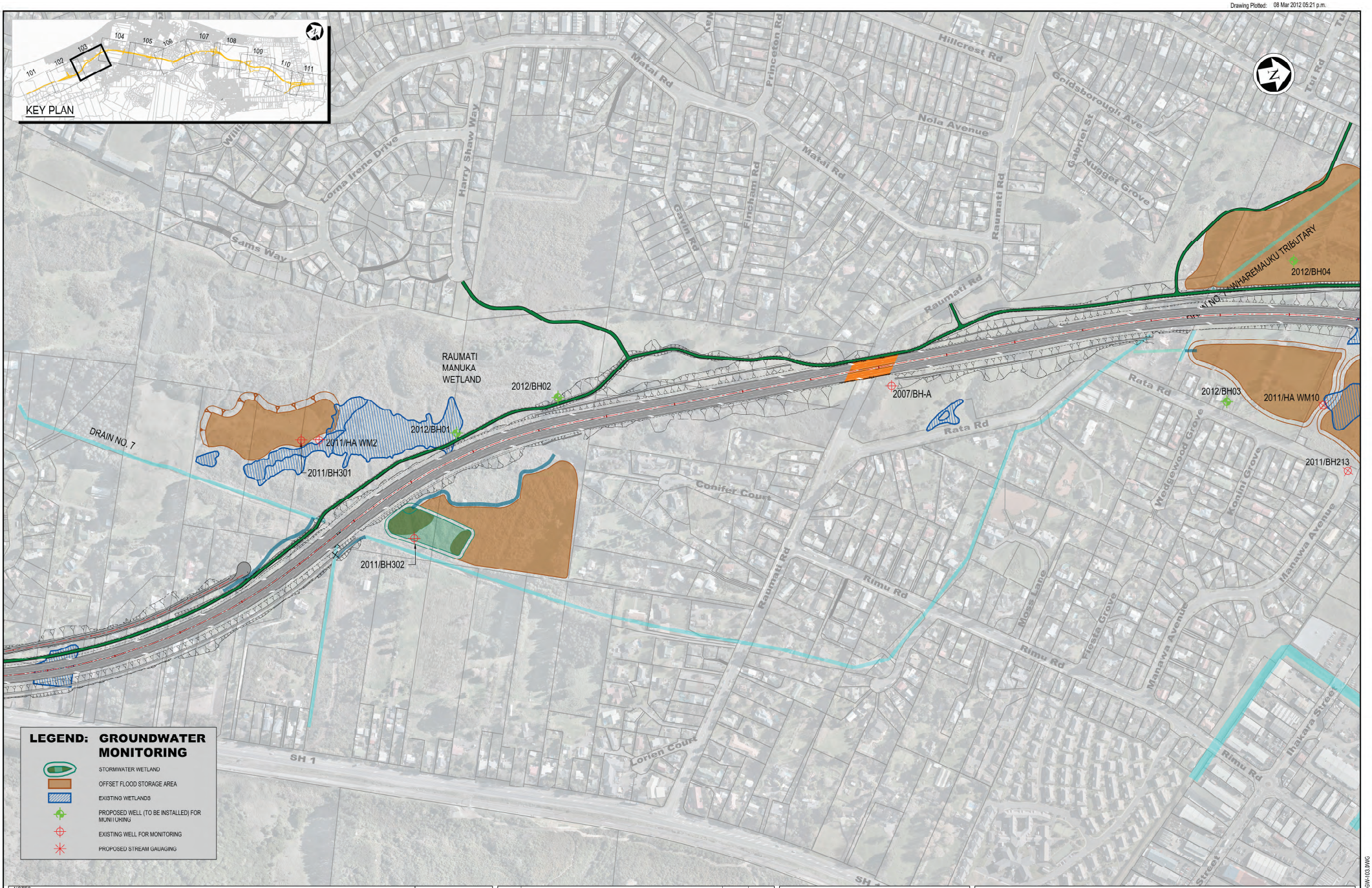

NOTES:

Original Scale (A3)

1:5000

Revision.	Amendment.	Approved.	Date.
1	AEE LODGEMENT	NRN	15.03.12

NZ TRANSPORT AGENCY
WAKA KOTAHI

Project:

MACKAYS TO PEKA PEKA EXPRESSWAY

Title:

GROUND WATER
MONITORING LOCATIONS
SHEET 3 OF 11

Status:	FOR CONSENTING	
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Drawing No:	GT-GW-103	1

Document No. - M2PP-AEE-DWG-GT-GW-103.DWG

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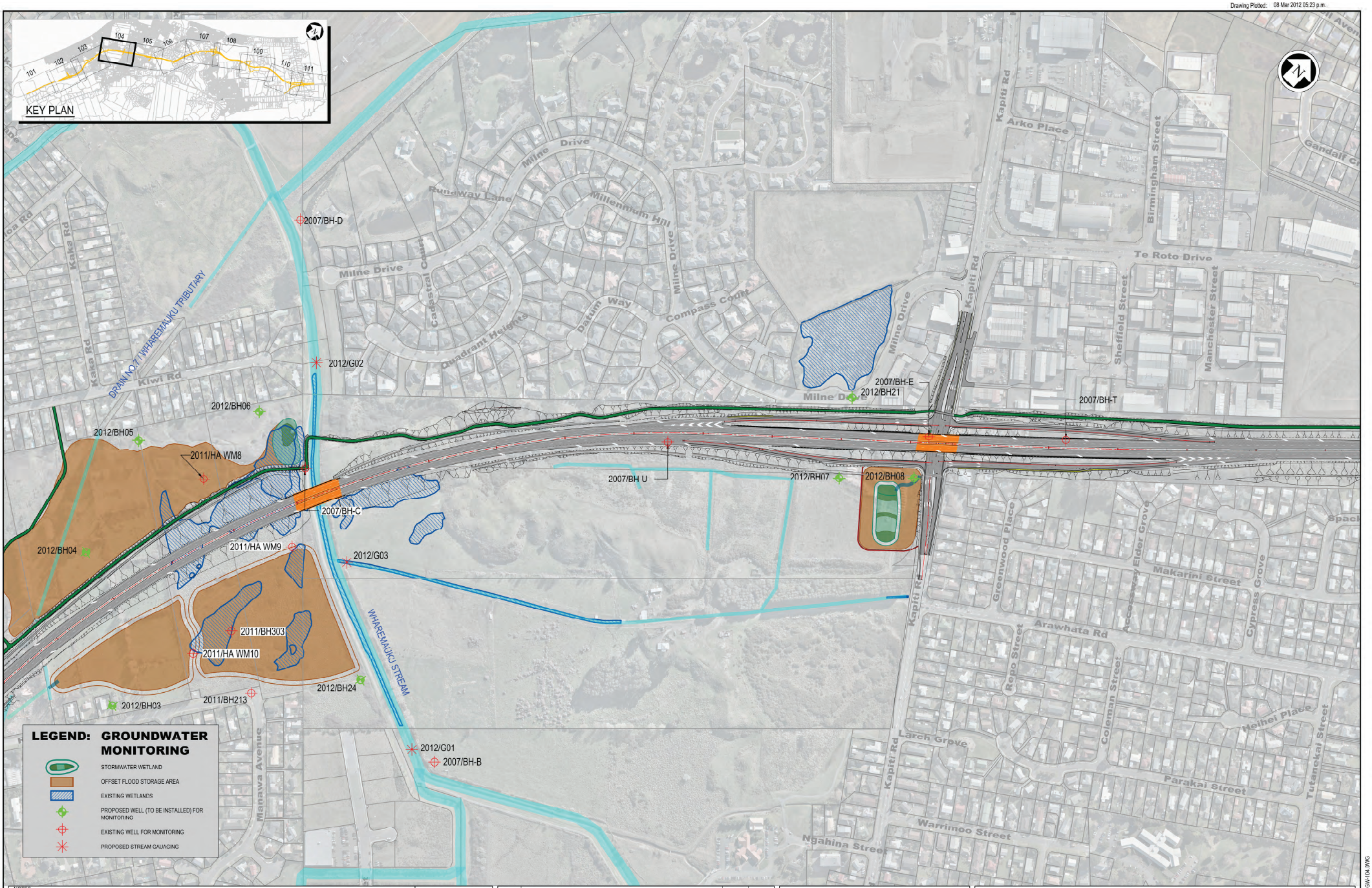

NOTES:

Original Scale (A3)

1:5000

Revision.	Amendment.	Approved.	Date.
1	AEE LODGEMENT	NRN	15.03.12

NZ TRANSPORT AGENCY
WAKA KOTAHI

Project: MACKAYS TO PEKA PEKA EXPRESSWAY

Title: GROUND WATER MONITORING LOCATIONS SHEET 4 OF 11

Status: - FOR CONSENTING

Document ID: M2PP-SAR-DWG

Drawing No: GT-GW-104

Rev. 1

Document No.: M2PP-AEE-DWG-GT-GW-104.DWG

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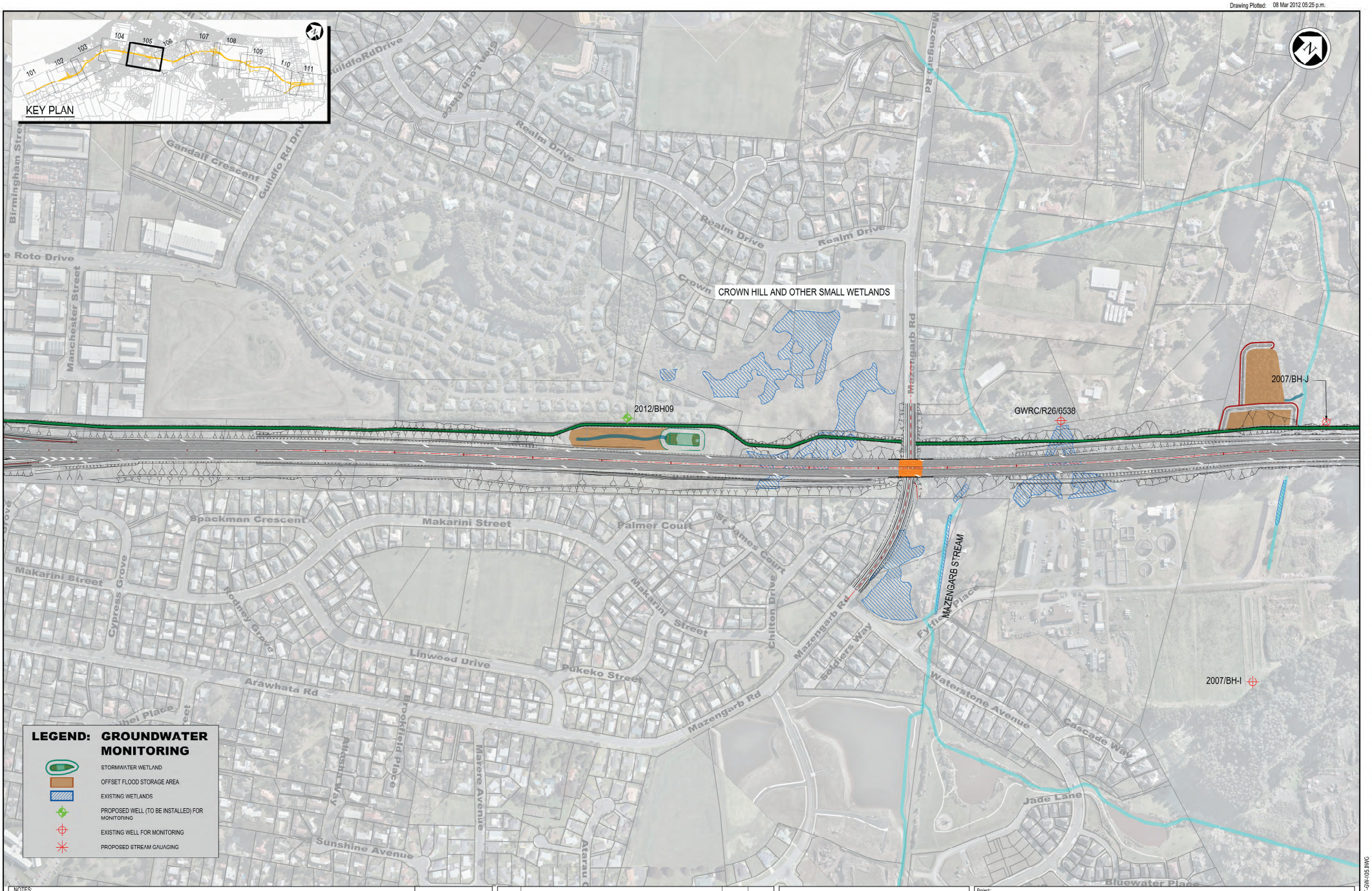

LEGEND: GROUNDWATER MONITORING

- STORMWATER WETLAND
- OFFSET FLOOD STORAGE AREA
- EXISTING WETLANDS
- PROPOSED WELL (TO BE INSTALLED) FOR MONITORING
- EXISTING WELL FOR MONITORING
- PROPOSED STREAM GAUGING

NOTES:

Original Scale (A3)

1:5000

Revision.	Amendment.	Approved.	Date.
1	AEE LODGEMENT	NRN	15.03.12

NZ TRANSPORT AGENCY
WAKA KOTAHI

Project: MACKAYS TO PEKA PEKA EXPRESSWAY

Title: GROUND WATER MONITORING LOCATIONS SHEET 5 OF 11

Status: - FOR CONSENTING

Document ID: M2PP-AEE-DWG

Drawing No: GT-GW-105

Rev. 1

Document No.: M2PP-AEE-DWG-GT-GW-105.DWG