Peer Review of Soakage System for Proposed Wallaceville Residential Development

Prepared for

Wellington Water

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Limitations:

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Executive Summary

Pattle Delamore Partners Ltd (PDP) has been requested by Wellington Water to review the stormwater management proposed for the development of the former Wallaceville Research Centre into a residential subdivision.

PDP was provided with the information lodged by the applicant describing the stormwater management system. This system consists of:-

- On-site soakage pits and infiltration trenches, with associated pre-treatment devices;
- Grassed, planted swales located along roadways, including infiltration trenches;
- Wetland(s) with forebays for stormwater treatment & first flush contaminant removal;
- An upgraded existing soakage basin and proposed new soakage basin.

PDP has reviewed the testing that has determined the viability of the soakage basins and infiltration trenches. The methods used are inconsistent between tests, the tests have not been run long enough, and there are insufficient numbers of tests to adequately characterise the soakage rate of the in-situ strata. Despite this the photographs of the strata and borelogs indicate that soakage to ground is feasible. More detailed testing is needed to more accurately determine the soakage rate for design purposes.

Groundwater level seems to respond rapidly to rainfall inputs over part of the site, indicating the possible presence of lower permeability material. Concentrating discharges at some locations may result in mounding. This would need to be further characterised with more observations of groundwater levels and analytical calculations.

PDP has concerns over the viability of the stormwater management system proposed and the risk to groundwater that it may generate. The system is quite complicated and could be simplified by using infiltration trenches and infiltration basins. These provide treatment through the media in the base of the basins. The soakholes proposed after the planted swales and the soakage basins could allow more contaminants, particularly bacteria, reaching the groundwater than by using alternative designs.

In conclusion, PDP considers the use of infiltration and soakage systems at this site will be feasible. Further work will be needed to characterise the soakage rates and mounding. Consideration should be given to altering the design to provide better treatment with a simplified design.

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Appendices

1.0 Introduction

Wallaceville Developments Ltd is proposing a residential development encompassing the former Wallaceville Research Centre in Upper Hutt.

It is proposed to manage stormwater runoff from the development by soakage to ground.

Wellington Water (WW) has engaged Pattle Delamore Partners Limited (PDP) to review the feasibility of the stormwater management that is proposed for the development along with providing information for some other matters as described in Section 2.

2.0 Scope

The scope of the review and provision of additional information is:-

- Review of the stormwater management for the proposed development including:-
  - Is any essential information missing
  - General review of completed fieldwork and proposed design
  - Capacity of system for design events
  - Comment on the hydrogeology including whether groundwater levels are likely to impact on the proposed system
- Advice on how councils in other areas enforce maintenance or upgrade of infiltration systems, particularly individual domestic soakpits
- Management of infiltration basins and cost for on-going maintenance.

3.0 Documents Reviewed

To complete the review of the Wallaceville Soakage System PDP was provided with seven PDF documents by WW. These documents were prepared by Harrison Grierson Limited. The documents reviewed are as follows:

- Infrastructure Assessment Report - provides a basic overview of existing and proposed infrastructure, including wastewater, stormwater, water supply, power, gas and telecommunication networks.

- Infrastructure Report Appendix 1 of 4 - Rev A – contains figures of the proposed road layout, proposed road cross sections, road detail drawings (swale, pavement, nib, kerb), layout overview, proposed stormwater drainage.

- Infrastructure Report Appendix 2 of 4 - Rev A - contains figures of the proposed wastewater drainage layout.
- Infrastructure Report Appendix 3 of 4 - Rev A – contains figures showing the proposed overland flow paths, post-development.
- Infrastructure Report Appendix 4 of 4 - Rev A – contains figures of swale catchpits, trench and soakage hole detail, and water supply layout.
- Wallaceville Stormwater Management Plan – provides an overview of stormwater effects assessment, ecological values, design principles and criteria, assumptions, constraints and opportunities, and stormwater management options for water quality and quantity. This report also states the purpose of the plan, the framework, general drainage solutions, water quantity solutions, and the implementation and maintenance concepts.
- Wallaceville Stormwater Management Plan Appendices – existing drainage plan, existing overland flow paths, initial soakage basin sizing calculations and soakage test results, proposed drainage plan (stormwater, overland flow paths, swale catchpits and soak hole details), and Auckland Council sourced Standard Drawings for Operation and Maintenance Plans for On-site Stormwater Measures on Individual Lots.

In addition to these initial review documents, PDP requested further information from the Applicant. This information was provided in a letter prepared by the Applicant's consultant (ENGEO Limited). This additional information included groundwater monitoring well locations, driller's logs and groundwater level records for the installed piezometers.

PDP also requested the following information from the Applicant which was not available:

- Analytical groundwater mounding calculations;
- Evidence of retardation of pollutants before impacting the water table;
- Expected attenuation (dispersion, dilution, absorption) below the water table;
- Results from hydraulic testing; and,
- An assessment of effects on neighbouring bores including a contaminant transport model or similar.

The Applicant's consultant advised that this information would be assembled as part of the design phase.

4.0 Review of Stormwater Management

4.1 Proposed Stormwater Management System

The proposal includes a stormwater management system which differs from what PDP staff would normally expect to see for residential runoff. The system is summarised in the Stormwater Management Plan Section 3.3 as follows:-

- On-site soakage pits and infiltration trenches, with associated pre-treatment devices;
- Wetland(s) with forebays (for stormwater treatment and first flush contaminant removal). One such device is indicatively proposed adjacent to the Neighbourhood Park to be located on the western part of the Grant's Bush covenant area. This is intended to be designed, along with an additional attenuation storage and soakage area, at the detailed design phase;
- An existing soakage basin, proposed to be upgraded and enhanced, located within the eastern part of the Grant's Bush covenant area;
- Grassed, planted swales located along roadways. The swales are proposed to also incorporate infiltration trenches below. The infiltration trenches will be filled with free draining drainage media and will extend to a depth of 1.5 to 2.5 m, varying in order to penetrate the underlying free draining gravel layers;
- Raingardens;
- Dry/Temporary Storage Areas;
- The protection and enhancement of existing ponding areas.

The onsite soakage systems and roadway swales and infiltration trenches will be sized for the 10% Annual Exceedance Probability (AEP) Event. Local soakage areas will be sized for the 4% AEP event. The large soakage basins are sized to handle the runoff in excess of the capacity of the onsite and roadway systems up to the 1% AEP event.

The calculations include a 16% increase in runoff to allow for climate change effects.

4.2 Suitability of Information

The information presented in the application includes:-

- A preliminary stormwater layout showing the locations of swales and the large soakage basins;
- A preliminary design of the swale/infiltration trench systems

- a description of the field work and limited calculation of soakage rates at four locations
- a calculation of the runoff and sizing of the soakage systems based on the results of the field work
- commentary on the depth to groundwater.

Additional information that PDP considers is required to assist with assessing the feasibility of the proposal includes:-

- Discussion on the range of soakage rates measured and how this may impact on the feasibility of infiltration across the site.
- Commentary on the range of groundwater levels likely to occur, the response of these groundwater levels to rainfall, and hence possible groundwater level response (mounding) to discharge of stormwater by soakage.

Further more detailed commentary is provided below, reviewing the information provided.

4.2.1 Review of Completed Field Work

Four soakage tests were undertaken. The soakage test methodology is inconsistent across the tests. Two have been tested as trenches, one as a bore hole without wetting, and one as a borehole which was pre-wetted. Average results for soakage were reported and varied considerably from 0.98 L/min to 266.5 L/min.

It is not possible to compare the results from the different test methods as the trenches will be dominated by vertical infiltration while the borehole tests will be dominated by horizontal infiltration out the sides of the boreholes.

Borehole/test pit dimensions are provided in the documents along with the average soakage rates for the soakage tests. However, this does not provide adequate information for PDP to determine how the soakage rate used in the basin sizing was determined. Additionally, PDP considers the average soakage rate to be inadequate for determining the long-term rate of soakage from the soakage basin and soak holes. Stormwater discharge by soakage will occur either continuously throughout an event (for the onsite and roadway soakage systems) or to the soakage basin once the upstream systems reach capacity. Both discharges may occur for hours if not days and will saturate the soil profile.

The tests carried out and the reported soakage rates are insufficient to determine the rate to be used for design. Plotting the soakage rate over the duration of the test and running the test for longer is required to determine the likely rates to be used (along with the application of a safety factor). While a factor of safety of three is often used (as used in the application) it needs to be adjusted based on the accuracy and duration of the tests.

Soakage rates are reported as $L/m^2/s$. It is normal to report soakage rates as flow rate (L/s) per unit area (m^2) i.e. $L/s/m^2$.

The field work reported for the application relates to five test pits located in the first stage of the proposed development. There is no information presented to demonstrate the soakage capacity of the area to the southwest (adjacent to the Trentham Racecourse).

The proposed development of Stage 1 shows two relatively central soakage basins. However no testing has been carried out to demonstrate the feasibility of soakage at those locations. Given the variability reported in the test results it is important that soakage tests be undertaken at the location of the proposed soakage basins to determine the appropriateness of these locations and the rate of soakage to be used for the design.

4.2.2 Review Methodology to Size Infiltration Basins and Soakpits

The design method for the Wallaceville subdivision's soakage basins is based on the Christchurch City Council "Waterways, Wetlands and Drainage Guide" (2003). The onsite soakage pits for each household, roadway soakage holes and road swales have not been designed yet but will be sized for a 10 percent AEP event. It is not clear whether the on-site soakpits are sized for all the runoff from individual sites or just the roof water. This should be clarified.

In the Canterbury area it is normal for the roofwater to be discharged to ground on the site and any runoff from hardstand areas that can contribute to network stormwater (e.g. the driveway at the front of a property) to be included in the network design. Any hardstand at the back of a residential property (e.g. a patio) is considered to be a non-connected impervious area and is not included as runoff. It is assumed to be lost to the surrounding grass or landscaping.

The basin sizing presented in the Stormwater Management Plan (SMP) appendix is for one basin taking the entire catchment area (206.3 ha), however, the SMP indicates one or more soakage basins will be designed during the detailed design phase. The method to size the basin is provided although detailed information is absent and therefore we are unable to determine whether the method is correct.

The basin sizing has used the rainfall intensity for a 100 year and 10 year storm event for six storm durations and includes a 16% increase factor to account for climate change. The volume of runoff has been found for each storm duration, for both return periods. It would appear that the volume is based on the area multiplied by a C Factor, and the rainfall depth.

The C Factor appears to be the same for each event regardless of duration and also appears to be very low for a volumetric approach. Normally a higher C

Factor would be used for the longer durations because, during longer duration events, the percentage of rainfall that runs off increases with duration as the only losses are initial loss and depression storage, which are much the same regardless of duration.

The volume of infiltration into the basin over the storm duration was calculated using a soakage rate of 10.9 m/hr (182 L/min). It is unclear how this soakage rate was derived from the results of the tests.

Finally, the live basin storage was found as the difference between the runoff volume entering the basin and the volume infiltrating to ground. The largest volume out of the six storm durations was then considered the minimum live storage required and basin dimensions were determined for this size. This is reasonable.

4.3 Hydrogeology

4.3.1 Review of investigations to date

Five monitoring wells were installed at depths of 10 to 11 m as part of the investigations. The locations of these are shown in Figure 1. The Applicant's consultant has provided groundwater levels and borehole logs, but no other hydrogeological information.

Groundwater levels were recorded on ten occasions over five months between 12 August 2014 and 22 December 2014. Groundwater levels in monitoring wells MW1 and MW2, located to the east and south of the site, respectively, are relatively consistent throughout this period at around 10 to 10.2 m bgl (below ground level). However, groundwater levels in MW3, MW4 and MW5 are more variable. Levels declined by approximately 1 m in these bores over approximately a one month period from August to September, before rising by up to 0.75 m (in MW5) over a seven-day period in September 2014.

This rapid rise in groundwater level correlates with a 39.7 mm rainfall event on 19 September 2014. Rainfall occurred on each of the previous six days and the event was followed by three more days of rainfall. Between the two monitoring dates on 15 September and 22 September a total of 79.7 mm of rainfall occurred. The groundwater levels and rainfall are shown on Figure 2.

The rapid response time suggests that rainfall recharge could be as important as recharge from the Hutt River at this location. In the conceptual model, the Applicant's consultant has stated that only 5 % of recharge to the unconfined aquifer will be from rainfall. However, this value is likely to be only valid close to the Hutt River. Away from the river, a much greater proportion of rainfall recharge should be expected.

Such a large fluctuation of groundwater level could be indicative of a relatively low permeability formation. Borehole logs indicate that all of the bores are installed within an unconfined alluvial gravel unit containing some silt. The presence of interstitial silt within a gravel aquifer can lower the permeability, and compromise groundwater flow.

Recent pumping test analysis in the region suggests that the unconfined gravels have a relatively high transmissivity of around 2,100 m^2/day (Gyopari, 2015). However, this value should be treated with caution, as the pumping test was conducted to the east of the site in a 20 m deep bore. The proportion of silt, and by extension the hydraulic properties within the aquifer, will likely vary both laterally and vertically owing to the heterogeneous nature of alluvial deposits. There may also be preferential pathways for groundwater flow along palaeo-channels.

The northernmost basin is proposed to be installed to the south of monitoring well MW5. Although depth to groundwater is quite large (≥ 8.5 m during the period of measurement), if the permeability is sufficiently low groundwater mounding could occur. Analysis of rainfall events recorded at Trentham Racecourse over the past 35 years indicates that daily rainfall events of > 40 mm occur 5 to 6 times per year, on average. It is feasible that during a particularly wet period, groundwater levels could rise significantly. It is therefore recommended that hydraulic testing and analytical mounding calculations are undertaken to verify that mounding will not occur to a level that would impact on the operation of the soakage basin.

Concentrating flows in a few large basins creates a greater risk of groundwater mounding impacting on the operation of an infiltration basin than distributing the discharge to a larger number of basins. PDP recommends that the applicant considers a system with more soakage basins. This would distribute the discharge of stormwater and reduce the risk of mounding.

Relative levels for the bores were not supplied with the borehole logs, and therefore a groundwater flow direction cannot be definitively derived. PDP has used ground level contours to estimate groundwater RLs, and the derived groundwater flow direction appears to be approximately north-west. The Applicant's consultant has not interpreted groundwater levels to derive a flow direction, however, it does state that groundwater will generally flow down the topographical gradient.

Whilst PDP agrees with this conclusion, cross section A – A' of Figure 2 in ENGEO's response to PDP's request for further information (attached) shows groundwater flowing in the opposite direction to the topographical gradient. This is misleading and should be amended accordingly.

4.3.2 Further investigations required

Since groundwater levels have only been recorded intermittently, it is difficult to appreciate the full range of groundwater level variability, and to correlate changes with recharge events, such as periods of high rainfall or high river flows. PDP recommends either increasing the frequency of manual monitoring or ideally installing pressure transducers in one or more of the boreholes. Surveying the collars of each of the monitoring wells should also be undertaken, as this will allow the groundwater flow direction at the site to be determined.

In order to estimate the hydraulic properties, and the likelihood of groundwater mounding, hydraulic testing of the formation, for example slug testing, is essential. This information can then be used in analytical groundwater modelling calculations.

Given the current design and potential for partially treated stormwater to reach the ground through the soakholes located at the end of the swales, consideration should be given to undertaking contaminant transport modelling to determine the distance and direction any contaminants would travel within the groundwater and whether any neighbouring bores would be affected.

The main contaminant of concern would be bacteria due to the potentially high concentrations possible in residential areas from dogs and birds (in particular). These would not be adequately removed by swales. In fact swales could be a contaminant source as they present an environment which might be conducive to birds. Heavy metals in residential stormwater are generally below drinking water guidelines and with partial treatment through swales the risk to the groundwater from heavy metals is minimal.

4.4 Review of Proposed Stormwater Management System

The proposed stormwater management system is described in Section 4.1 and the design is presented in the application documents.

The design differs from what PDP staff might normally expect to see although the overall concept is feasible.

The areas of concern PDP have with the proposed design is:-

- It is not clear whether the on-site systems are for roofwater or roofwater plus hardstand.
- The conceptual design for the roadside swales and soakage system shows water discharging from the swales through a catch pit to a soak hole followed by discharge to an infiltration trench. It is unclear why this complexity is required.
- The soakage basins appear to be open to the underlying gravels.

As noted above, it is normal practice in Canterbury for the on-site system to manage the roofwater discharge. It is designed to handle the runoff from the 1hr duration 10% AEP event as set out in the *New Zealand Building Code Clause E1 Surface Water*. Any roofwater in excess of the capacity of this soakpit (only occurs for a relatively short duration between 30 minutes and two hours) adds flow to the roading network. This roof water is discharged untreated. Hardstand runoff discharges to the reticulated network and is treated in the treatment system used to handle that flow.

In respect of the design of the road side swale and infiltration trenches, this appears to be an unnecessarily complicated system. In addition, it includes a soakhole which partially treated stormwater could discharge to, risking contamination of groundwater. The infiltration trench that is shown will only take stormwater after the rate of discharge exceeds the capacity of the soakhole. We have trouble making sense of this concept.

It would make more sense if the infiltration trench took the flow first and any excess then discharged into the soakhole. This would allow the water that is partially treated through the swale to be filtered further through the media proposed for the infiltration trench.

Finally, the soakage basins proposed to take the flow in excess of the on-site soakpits and road side swale systems appears to be open to (free to directly discharge to) the underlying gravels. This presents the risk of contamination occurring directly to the groundwater through contamination of the ponded water in the soakage basin (e.g. from birds settling on the ponded water), or illegal discharges into these basins by residents. In addition the open soakage devices are potentially subject to clogging from debris from stormwater accumulating on the surface. It would be much better if these soakage basins are enclosed soakage pits similar in configuration to the infiltration trench that is proposed, but with larger aggregate. A larger number would be required but, as commented on in the hydrogeology section, this would enable distribution of the discharge and reduction in groundwater mounding.

4.4.1 Compliance with Upper Hutt City Council Requirements

It is understood that Upper Hutt City Council (UHCC) requires that new primary stormwater systems (including soakage) are designed for the 4% AEP (1 in 25 year) events.

The proposal to size on-site soakage areas for the 10% AEP events does not comply with the above requirement.

The primary stormwater management system within the subdivision along with the localised soakage areas are sized to cater for the 4% AEP event (pg 5 of the Stormwater Management Plan in the application).

4.4.2 Secondary Flow Paths

The Stormwater Management Plan discusses the management of secondary flow paths within the development (i.e. those which carry flow in excess of the primary stormwater management system). However, while the direction of overland flow paths from the site is shown in the appendices there is no discussion about secondary overflow from the development in the event of the failure of the soakage systems. Certainly within Canterbury an applicant would be expected to identify what happens to water in the event that there is runoff in excess of the design capacity of the stormwater system (including infiltration basins) or in the event of partial failure of the systems to ensure that the flood hazard is not exacerbated either on the site or on downstream land. This information has been required at the Plan Change stage of a development as it is required to demonstrate that the proposal meets the Policies and Objectives of Environment Canterbury's Regional Policy Statement.

4.4.3 Freeboard on Soakage Basins

The proposal includes soakage basins where water would be stored when runoff exceeds the rate of discharge to ground allowed for in the design of the soakage basins. It would be expected that this design, as with any ponded water, would include a freeboard above the design level to account for wave action, uncertainty in calculations, and rainfall on the basin. This would typically be 300 mm. In circumstances where the freeboard also fills up, as described above, it is expected that there will be secondary flow paths that direct the excess water off the development in a manner that does not exacerbate downstream flood hazard.

4.4.4 Alternative Designs

The stormwater system proposed is not a true infiltration system and could be modified to simplify it and improve its treatment performance to reduce the risk to groundwater. The main changes suggested, while retaining the overall concept, are:-

- Modify the swales so that these are designed to infiltrate through the base, relying on filtration through infiltration media to the underlying gravels. These could be sized for a first flush volume (e.g. the runoff from the first 25 mm of rainfall). Localised infiltration trenches could be used for the overflow from these, sized for remaining storm flows up to the 1% AEP event. If not practical, then retain larger soakpits to take these flows.
- If using the larger soakpits ensure that these are covered to minimise illicit and natural contamination that may occur.

An alternative design would be to use the swales as conveyance to infiltration basins. The infiltration basins are sized to treat the first flush of stormwater by infiltrating through the infiltration media placed in the bottom of the basin. Typically the infiltration media will be a sand/soil/compost mix which is planted in grass species. When the first flush capacity is reached the remaining runoff bypasses the infiltration basin and discharges directly to soakpits. Roofwater on individual properties would still discharge to ground on site via individual soakpits.

5.0 Management of Individual Soakpits

Wellington Water requested information on how councils throughout New Zealand manage stormwater infiltration

5.1 Regional and District Council Planning Rules

Five regional council plans were reviewed to identify regional rules relating to stormwater discharge. Apart from Greater Wellington Regional Council, the councils were selected on the basis of having geology conducive to stormwater infiltration and, in some cases, known widespread use of such (e.g. Southland and Canterbury). These councils were:

- Greater Wellington Regional Council
- Hawkes Bay Regional Council
- Horizons Regional Council
- Environment Southland, and
- Environment Canterbury.

5.1.1 Greater Wellington

Discharges to land in the Greater Wellington Region are regulated by the Regional Plan for Discharge to Land. Rule 3 (Stormwater) of this plan specifies discharge of stormwater contaminants into or onto land. It is a permitted activity provided the conditions are met. The only condition of interest to a soakage system would be condition (b) which states the requirement for discharge not to enter any other property.

5.1.2 Hawkes Bay Regional Council

Rule 43, Diversion and discharge of stormwater, of the Hawkes Bay Regional Resource Management Plan would apply to soakage systems. This is a controlled activity and has conditions relating to the production of conspicuous oil or grease films, scums etc., changes in colour or clarity, objectionable odour, effects on consumption of water and effects on aquatic life.

5.1.3 Horizons Regional Council

The Horizons Region Council's One Plan has Rule 14-18 which allows discharge of stormwater to surface water and land as a permitted activity provided the conditions are met. The conditions relate to erosion, industrial stormwater discharges, the rate of discharge so as to prevent flooding outside the soakage area and effect of flood flow conveyance.

5.1.4 Environment Southland

Rule 12 of the Regional Water Plan for Southland, Discharge of stormwater into or onto land, applies to discharges of stormwater through soakage systems. It is a permitted activity provided the conditions are met. The conditions relate to industrial or trade stormwater origins, contamination of the stormwater, flooding of neighbouring properties and discharge to Natural State Waters. Rule 3 of the Regional Water Plan for Southland covers "other discharges to water" including to groundwater, and may apply to soakage systems. It would be a discretionary activity.

5.1.5 Environment Canterbury

Until recently the operative Plan in Canterbury was the Natural Resources Regional Plan. However, with respect to stormwater, the appeals have been resolved for the proposed Land and Water Regional Plan (PLWRP) and Environment Canterbury (ECan) have informed PDP that the rules in this Plan are considered to be operative.

For management of soakpits on individual properties Rule 5.96 of the PLWRP is the relevant rule:-

5.96 The discharge of stormwater onto or into land where contaminants may enter groundwater is a permitted activity provided the following conditions are met:

1. *The discharge is into a reticulated stormwater system and the discharger has obtained written permission from the system owner to discharge into the system; or*
2. *The discharge is not into a reticulated stormwater system, and*

    (a). The discharge is not from, into or onto contaminated or potentially contaminated land;

    (b). The discharge:

    (i) does not cause stormwater from up to and including a 24 hour duration 2% Annual Exceedance Probability rainfall event to enter any other property; and
    (ii) does not result in the ponding of stormwater on the ground for more than 48 hours, unless part of the stormwater treatment system; and
    (iii) is located at least 1 m above the seasonal high water table that can be reasonably inferred for the site at the time the discharge system is constructed; and

(iv) is only from residentially zoned land.

Condition 2 of the Rule is the relevant provision setting out the requirements for the performance of a soakpit.

The regional rules are summarised in Table 1 below.

5.1.6 District Plan Bylaws

In addition to reviewing the regional plans, the bylaws for the district councils within the previous regional jurisdictions were also reviewed to identify any council rules relating to domestic soakage systems. Only five of the district councils within the regions investigated had bylaws which regulated the use of private drainage systems. These councils were:

- Central Hawkes Bay
- Rangitikei
- Gore
- Southland, and
- Christchurch.

Table 2 provides a summary of the content of these bylaws.

Only two of the council bylaws discuss maintenance of privately owned stormwater systems these are the Rangitikei District Council (RDC) and the Christchurch City Council (CCC).

The RDC bylaw does not specifically mention soakage systems but does require owners/occupies of private drainage systems to immediately clear any blockage. If this is not done the council will serve a notice requiring the blockage to be cleared within 24 hours. When an owner/occupier fails to comply with the notice the Council may clear the blocked private drainage system and may recover the cost of the work. The owner/occupier can also be fined for breaching the bylaw.

The Christchurch City Council sets out maintenance responsibilities for privately owned stormwater systems in which the owner is responsible for maintaining the system and must ensure free flow of water. As part of this bylaw there is an over-arching rule that every person who breaches the bylaw is committing an offence and is liable on summary conviction to a fine not exceeding $20,000. This is set out in the Local Government Act 2002. The council is therefore able to fine an owner who does not maintain their stormwater systems.

Table 1: Comparison of Regional Council Rules Relating to Discharge of Stormwater to Land

Region	Plan name	Relevant Rule	Flooding of other properties considered	Discharge depth to groundwater considered	Consideration of groundwater quality	Consideration of water supplies nearby	Considers ponding duration
Wellington	Regional Plan for Discharges to land	Rule 3	Yes	No	No	No	No
Hawkes Bay	Regional Resource Management Plan	Rule 43	No	No	No	Yes	No
Horizons	One Plan	Rule 14-18	Yes	No	No	No	No
Environment Southland	Regional Water Plan for Southland	Rule 12	Yes	No		No	No
	Regional Water Plan for Southland	Rule 3	No	No	No	No	No
Environment Canterbury	Proposed Land and Water Regional Plan	Rule 5.96	Yes	Yes	No	No	Yes – no longer than 48 hrs

Table 2: Comparison of District Council Bylaws Relating to Privately Owned Stormwater Systems

Council	Specific mention of soakage/detention devices	Requires evidence that the system will work (pre-construction)	Specifies storm return period to which device must be maintained	Repercussions for not maintaining	Considers proximity to groundwater
Central Hawkes Bay District Council	Yes	No	Yes (10% AEP)	Yes – can be fined.	No
Rangitikei District Council	No	No	No	Yes – charged if council has to fix it. Also, liable to a fine.	No
Gore District Council	Yes	Yes - permeability tests.	No	No	No
Southland District Council	Yes	Yes – require soakage test to be undertaken.	No – but states storm device must be designed to.	No	Yes
Christchurch City Council	No	No	No	Yes – can be fined.	No –considered in regional rules.

The Central Hawkes Bay District Council does not discuss maintenance directly but does requires owners of private soakage systems to ensure that their systems are functioning in order to prevent a nuisance in up to a 10 % AEP storm. The Council can request that an owner provide information to demonstrate that it is functioning to this level and, if not, require work to be undertaken to remedy the situation. As with the Christchurch City Council, every person who fails to comply with the bylaw may be fined up to $20,000.

Gore District Council does not make specific mention of maintenance of soakage systems post-construction but does state that due allowance must be made during design for long-term pore clogging of the receiving ground. The council also requires that the system demonstrate that soakage disposal is suitable through permeability tests, that it is a viable long-term solution, that silt entry will be minimised, that the cost is better than a piped system, future utility extensions will not be limited, secondary flow paths are identified and protected, and tests are carried out at each soakage facility and certified by an Engineer.

Southland District Council's bylaw relates to soakage systems in general, not specifically privately owned infrastructure. It specifies matters to be considered in designing a soakage system including the requirement to consider maintenance of the system.

In addition to these council bylaws, the Hastings District Council provides a document "Subdivision and Infrastructure Development – Best practice Design Guide". This document discusses using consent notices to provide for ongoing maintenance of on-site infrastructure and covenants to cover obligations including standards and guidelines for the development of on-site stormwater detention and its continued maintenance.

None of the council bylaws include the ability to enforce an upgrade of a private drainage system.

5.2 Advice on Maintenance and Upgrade

Based on the review of the various rules and bylaws there are mechanisms to enforce the operation of onsite stormwater soakpits. For instance while Christchurch City Council has a bylaw to prosecute it is not absolutely necessary as any non-compliance with the ECan rule can lead to an abatement notice and (in the event of continual non-compliance) a prosecution and fines.

The life of roofwater soakpits and the sizing methodology vary from location to location. Using the Verification Method in *New Zealand Building Code Clause E1 Surface Water,* the onsite strata require testing and the soakpit is designed using the base area only. Where the soakpit intercepts gravels (as would be the situation at Wallaceville) there can be significant infiltration through the side walls. This generally provides a factor of safety that allows for clogging up of the soakpit over many years.

PDP's experience is that older soakpits using less rigorous design have often blocked up in periods of less than 10 years. Soakpits can be further protected from debris build-up by using devices such as a sump prior to the soakpit, leaf slides on down pipes, or other such filter/settling devices.

In summary there are mechanisms that can be put in place and enforced to require owners to maintain and replace soakpits if these do become blocked. With good soakage testing and appropriate design there is no reason why soakpits should not continue operating successfully for periods in excess of 25 years.

6.0 Management of Infiltration Basin

PDP is unfamiliar with the use of open soakage basins proposed for residential runoff. Our alternative design incorporates infiltration trenches or infiltration basins. These would be managed in a similar manner to the way infiltration basins are managed in Canterbury. The following sections describe the management and estimated costs for management of these systems.

6.1 Basin Management

The day to day management of infiltration basins in the Canterbury environment is minimal. It is largely restricted to mowing the basins, maintaining any landscaping, and removal of litter and other debris that might reach the basin during a rainfall event. In some circumstances, grass may need to be re-sown on slopes that have eroded, or around inlets to the basins. This work is generally only required during the initial one to two year maintenance period.

In most circumstances the discharge from the infiltration basins is covered by a resource consent from ECan. Most of the consents include a condition to monitor the level of contaminants that are in the infiltration media in the basins. The reason for this is that, if the concentrations are too high, contaminants might be washed from the media to the underlying groundwater by subsequent rainfall events, or the elevated high concentrations risk causing die off of vegetation.

Consent conditions usually stipulate monitoring every 5 or 10 years. PDP suspects that ECan is not vigorously enforcing this monitoring requirement as PDP has only been engaged once to carry out this monitoring despite having been involved in the installation of infiltration basins for some 19 years.

Monitoring conditions are also generally included to require testing and removal of contaminated soil in the event of a spill of contaminants entering the stormwater network, which in turn reach the infiltration basin. As specialists in contamination and mitigating the effects of spills, PDP has never been approached to address spills that have contaminated infiltration basins (but see further below).

It is not known how long the infiltration media will last before it needs to be replaced. The main reasons for replacement are associated with reduced infiltration rates (due to build-up of sediments on the basin surface) and levels of contaminants within the infiltration media exceeding the concentrations specified in the consents.

When infiltration basins were first being considered by Christchurch City Council, the expectation was the media would last around 20 years before it needed to be replaced. PDP is not aware of any media needing to be replaced at this time. However, we are aware for some sites of media being re-laid during the initial maintenance period, generally as a result of the media being over-compacted during installation, with the infiltration rate being too low to allow the infiltration basin to drain out sufficiently quickly.

PDP was also involved in assisting the replacement of media at one site where thousands of litres of milk and alcohol had spilled, and was allowed to flow into the infiltration basin, as a result of the failure of racking in a warehouse during the September 2010 earthquake.

6.2 On-going Maintenance Costs

Discussions with Christchurch City Council have identified the following operation and maintenance costs for infiltration basins:-

- Routine landscape maintenance (removing litter, mowing, weeding)
- Routine drainage maintenance (removing sediment, clearing inlets and outlets)
- Asset audit (to assess the condition of the infiltration basin and soakage chamber)
- Minor repairs and replanting
- Infiltration testing (often required by consent conditions)
- Sampling for contaminants (usually every five years in Environment Canterbury consents)
- Replacement of infiltration media (as a result of a spill of contaminants or build-up of contaminants to unacceptable levels)

Table 3 provides indicative costs based on information received from Christchurch City Council and PDP’s own experience in carrying out some of the tasks.

Table 3: Indicative Costs for Maintaining Infiltration Basins (2015 Costs Excl. GST)			
TASK	**Frequency**	**Rate**	**Unit**
Routine Landscape Maintenance	22/year	$0.02	m^2
Routine Drainage Maintenance	8/year	$500	per pond
Asset audit	1/year	$500	per pond
Minor repairs & replanting	1/year	$1,000	per pond
Infiltration test	1/10yr	$2,000	per pond
Contaminant Sampling	1/5yr	$1,000	per pond

Assuming a basin is 1,000 m^2 in area, then the typical annualised operation and maintenance cost (at 2015 costs) is $6,340 (excl. GST). It would seem that this is the direct cost per basin and does not included overhead and administration costs.

The cost for replacing media has not been included in the table as it is not expected to be replaced with normal stormwater runoff during the 35-year life of a consent. The actual costs will also depend on the reasons for replacing the media, and where the removed media can be discarded to.

As an indicative cost the replacement of the media for the basin after the September earthquake, referred to above, was about $10,000 (Excl. GST) for labour, materials, and construction supervision. The basin has an area of approximately 220 m^2. We were not provided the cost for dumping the contaminated soil.

7.0 References

Christchurch City Council, (2003), Waterways, Wetlands and Drainage Guide.

Environment Canterbury, (2014), *Land and Water Regional Plan*.

Environment Southland, (2010), *Regional Water Plan for Southland*.

Greater Wellington Regional Council (2014), *Regional Plan for Discharges to Land for the Wellington Region.*

Hastings District Council, (2011), Subdivision and Infrastructure Development in Hastings District.

Horizons, (2014), *One Plan.*

Hawkes Bay Regional Council, (2014), *Hawke' Bay Regional Resource Management Plan*.

New Zealand Department of Building and Housing, Compliance Document for New Zealand Building Code Clause E1 Surface Water.

Appendix A

Figures

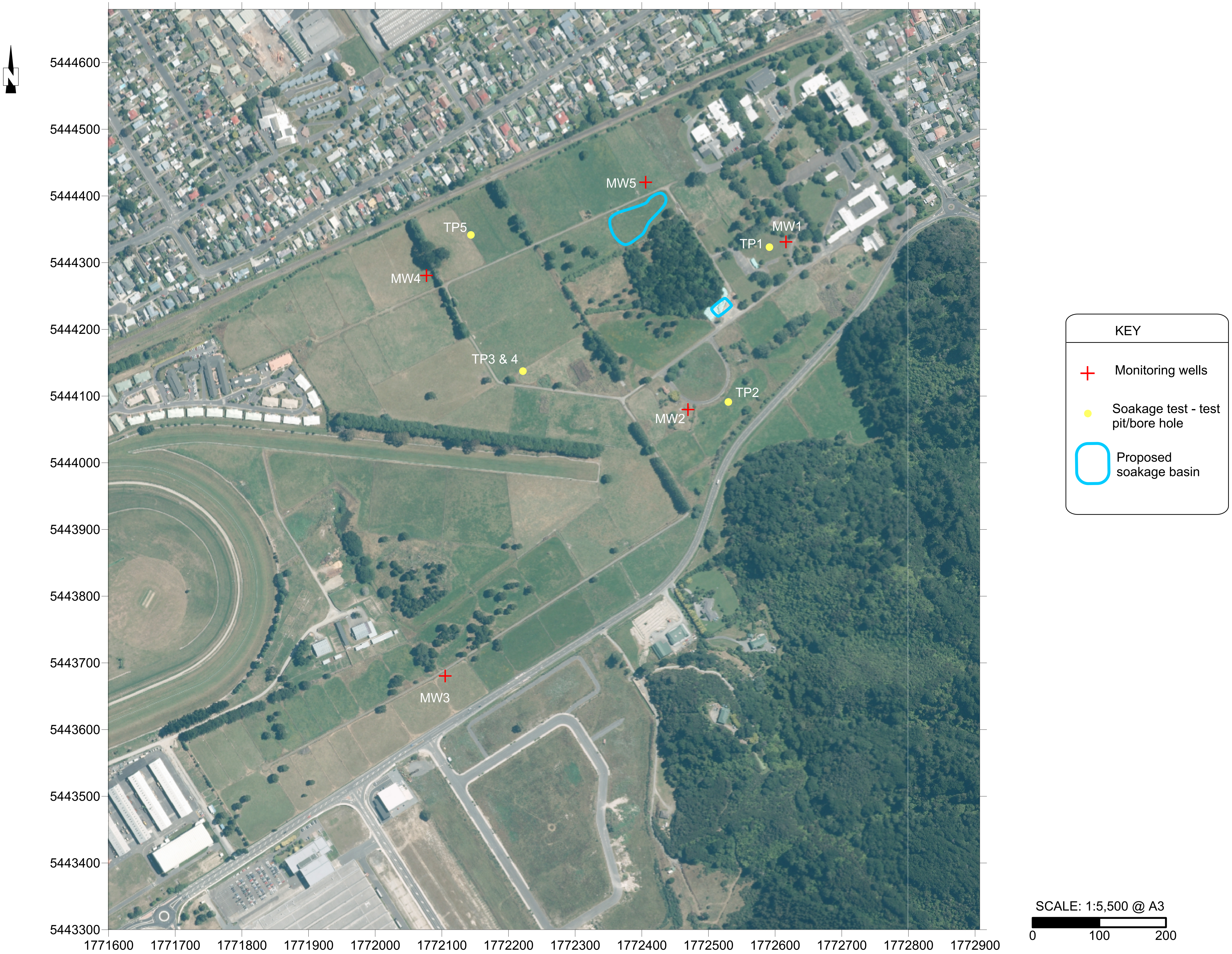

FIGURE 1: MONITORING WELL, TEST PITS AND PROPOSED SOAKAGE BASINS

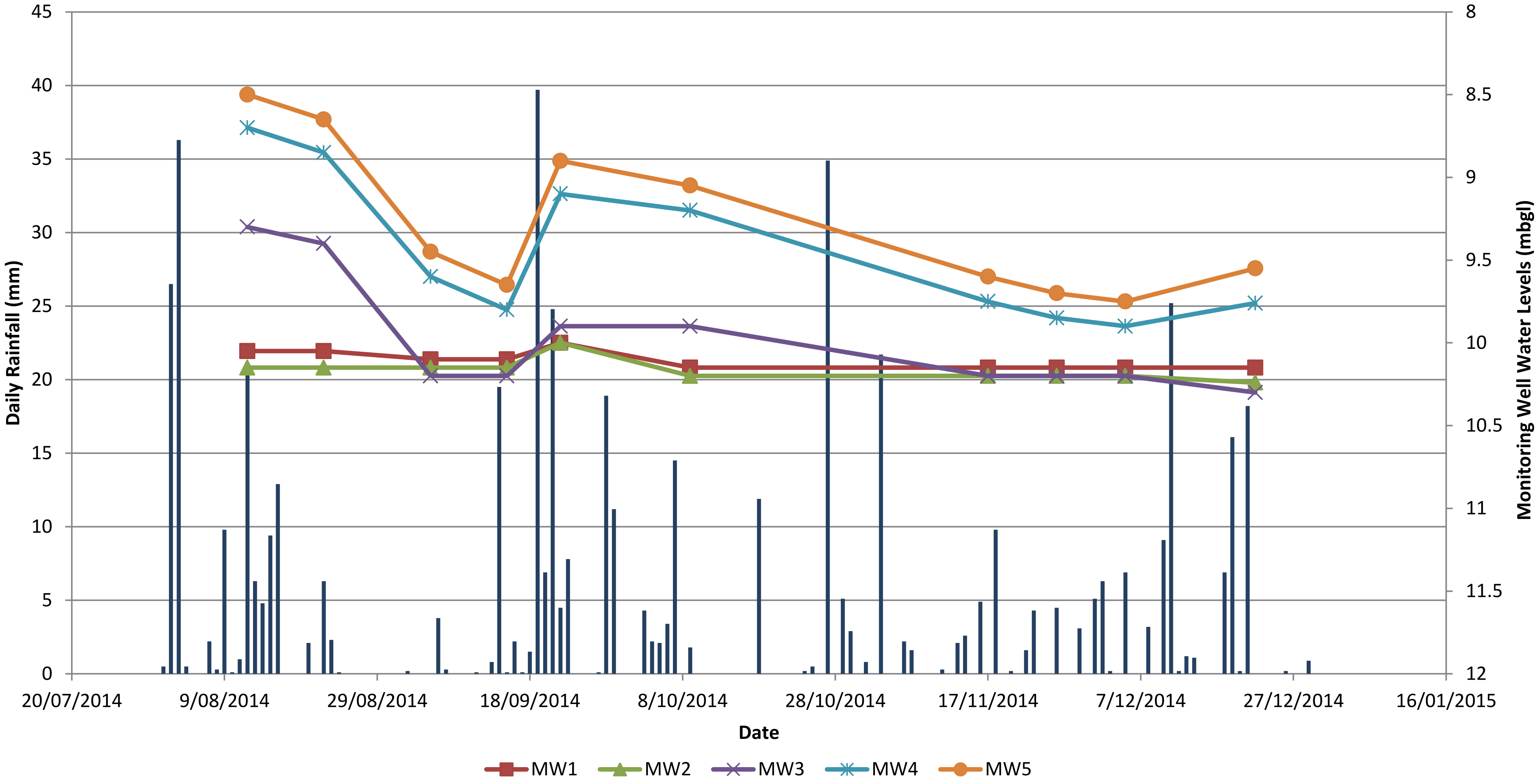

Figure 2: Rainfall data (at Trenham Racecourse) and groundwater levels in five monitoring wells.

Appendix B

ENGEO Letter

5 June 2015

Mr. Malcolm Gillies
Wallaceville Developments Limited
Via email

Dear Mr. Gillies

RE: RESPONSE TO REQUEST FOR FURTHER INFORMATION;
WALLACEVILLE SOAKAGE SYSTEM
Our Reference: 11307.000.000

1 Introduction

Wallaceville Developments Limited have requested that ENGEO Ltd (ENGEO) respond to the request for further information regarding the design of the proposed Wallaceville soakage system submitted as part of the plan change application.

ENGEO have provided this response on the soakage system, based on our previous investigations at the site, our understanding of the application and request for information, provided by Pattle Delamore Partners (PDP), acting on behalf of Wellington Water and supplied via email on Wednesday, 27 May 2015.

2 Summary of Available Information

Further hydrogeological information is appended to this letter and is based on the currently available site investigation data.

Information referred to in the Stormwater Management Plan (SMP) includes:

- Groundwater Monitoring Bore Locations;
- Drillers borehole logs for each of the installed piezometers; and
- Groundwater level records for these piezometers.

The above information is appended to this letter (Appendix A).

There are a number of bores in the wider area, with the closest water being approximately 200 m from the site boundary (see Figure 1 on attachment to this letter).

2.1 Indicative Proposed Soakage Solutions

A summary of the proposed soakage devices is provided. This is indicative only at this stage, but should be noted that stormwater management will be handled in a dispersed manner across the site, to diffuse any potential point source impacts and take full advantage of the available storage capacity and transmissivity of the deep unsaturated zone and alluvial aquifer directly beneath the site.

For the residential portion of the site, stormwater management will include:

- Individual on-site soakage pits for each lot; and
- Each pit to be approximately 1.5 m deep to maximize pit storage capacity (to attenuate peak discharge rates) whilst retaining a significant unsaturated zone beneath each pit.

For roadways, stormwater management will include:

- Swale drains with infiltration trenches below;
- Periodic collection pits or storage basins; and
- An optimised mix of treatments ponds with swales, possibly wetlands or rain gardens.

For both residential and roadways, it should be noted that all stormwater will be treated to meet or where possible exceed TP10 guidelines. This should provide a significant degree of treatment of stormwater at the surface prior to infiltration.

The above measures are considered to provide two significant outcomes in relation to groundwater impacts:

1. The distributed soakage systems that include storage capacity are likely to result in a localised impact only on groundwater levels. Therefore it is unlikely that groundwater mounding from adjacent systems will significantly overlap, due to the attenuation of peak flows and the high transmissivity of the alluvial gravel. Groundwater mounding within the site and beyond the site boundary is likely to be insignificant; and

2. Surface treatment combined with the proposed distributed soakage system will maximise the potential for the removal of contaminants, both via the treatment devices and natural attenuation in the ground. The unsaturated zone will be maintained to a greater degree with a distributed system, further maximising the potential for natural attenuation.

Given the above two factors along with the highly transmissive nature of the aquifer and rapid throughflow of groundwater (groundwater dating at the foreshore indicated groundwater residence times of as little as 6 to 40 years[1]) the dilution and dispersion potential of the Hutt Valley aquifer system is considered extremely high.

2.2 Summary of Geology, Groundwater Flow and Occurrence

The published geological map and associated text[2] of the area indicates that the site is underlain by alluvium comprising alternating units of gravel and silt/clay deposited by the Hutt River. A deep bore in Trentham Memorial Park (located towards the centre of the Hutt Valley and therefore likely to have a greater thicknes of alluvium) indicated that the alluvium is underlain at an approximate depth of 200 m by Triassic age Torlesse Complex grey Sandstone (“Greywacke”) and Siltstone/Mudstone (Argillite) sequences. This Greywacke rock outcrops to the southeast of the site.

The shallow fluvial sequence from published mapping was corroborated at the site by driller’s logs (Appendix A). These suggested medium to large cobbles with silt occur to a depth of approximately 6 metres below ground level (mbgl), overlying rounded to sub-rounded gravels, proven to a depth of approximately 10.4 mbgl.

Regionally, groundwater follows the topography and will flow along the Hutt Valley to the discharge zone in Wellington Harbour. The regional hydraulic gradient is shallow due to the relatively flat topography of the aquifer in the Hutt Valley and the high transmissivity of the alluvial sequence[1].

Groundwater levels at the site were monitored across the site between August to December 2014 (Appendix A). Generally groundwater was observed to be between 8.5 to 10.2 mbgl and within the alluvial gravel layer. An unsaturated zone of at least 2.5 m was maintained within the gravel layer (and below the overlying unsaturated shallow soils) throughout the monitoring period. This represents a significant zone for groundwater storage and potential additional transmissivity solely within the gravel layer that underlies the unsaturated less permeable shallow soils.

There was minimal observed hydraulic gradient across the site, corroborating the regionally observed conditions with regard to the fairly flat topography of the site along with the highly transmissive alluvial gravels of the Upper Hutt Valley.

2.3 Conceptual Hydrogeological Model

Figure 2 (see attachment to this letter) gives indicative cross sections showing the likely groundwater occurrence across the site.

Groundwater levels in the recharge zone of the Hutt Valley aquifer system are controlled by the aerial recharge from rainfall and infiltration from the Hutt River. It has been estimated that as little as 5% of recharge to the unconfined aquifer system comes from rainfall, the remainder from direct bed infiltration from the Hutt River[2].

Groundwater was therefore considered to flow through the site boundary, with minimal rainfall recharge, generally flowing down topographical gradient, likely to be bounded to the southeast by the relatively impermeable Upper Hutt Foothills and an approximate groundwater divide created along the Hutt River.

3 Additional Analysis

Further hydrogeological study will be undertaken at the detailed design stage. The detailed analysis will include the following, as previously requested:

- Analytical groundwater mounding calculations;
- Evidence of retardation of pollutants before impacting the water table;
- Expected attenuation (dispersion, dilution, absorption) below the water table;
- Results from hydraulic testing undertaken as part of subsequent Resource Consent application; and
- An assessment of effects on neighboring bores.

No list of pollutants of concern were provided by PDP (May 2015) and it is unclear if this should concentrate on pollutants from the proposed development or from previous land usage.

Furthermore, due to the uncertainty in the location, sizing and wider methodology for post-development handling of stormwater at the Wallaceville site at this early stage, it is considered unnecessary for this level of analysis to be undertaken for a plan change application.

4 Conclusions

ENGEO agree that additional analysis will be required and we look forward to submitting this with a subsequent Resource Consent application, subject to the outcome of the plan change. It is noted that there are a number of options for stormwater management at this site, the most suitable of which will be selected as part of the detailed design process.

Given the highly favourable conditions for soakage at the site, along with the nature of the development (e.g. standard residential lots with minimal sources of contamination), the detail to which the Stormwater Management Plan has been undertaken is considered reasonable for the application for a plan change.

Prepared by

Huw Williams

Senior Hydrogeologist

Reviewed by

Guy Cassidy, MIPENZ, PEngGeol

Principal Engineering Geologist

5 References

1. Morgan M. and Hughes B. 2001: Wellington. In Groundwaters of New Zealand, M.R. Rosen and P.A. White (eds). New Zealand Hydrological Society Inc. Wellington. P397-410.

2. Begg, J.G., Mazengarb, C., 1996. Geology of the Wellington Area, scale 1:50,000. Institute of Geological and Nuclear Sciences geological map 22. 1 sheet + 28p. Lower Hutt, New Zealand: Institute of Geological and Nuclear Sciences Limited

Attached to this letter:

- Figure 1. Known Local Wells;
- Figure 2. Conceptual Hydrogeological Model; and
- Appendix A.

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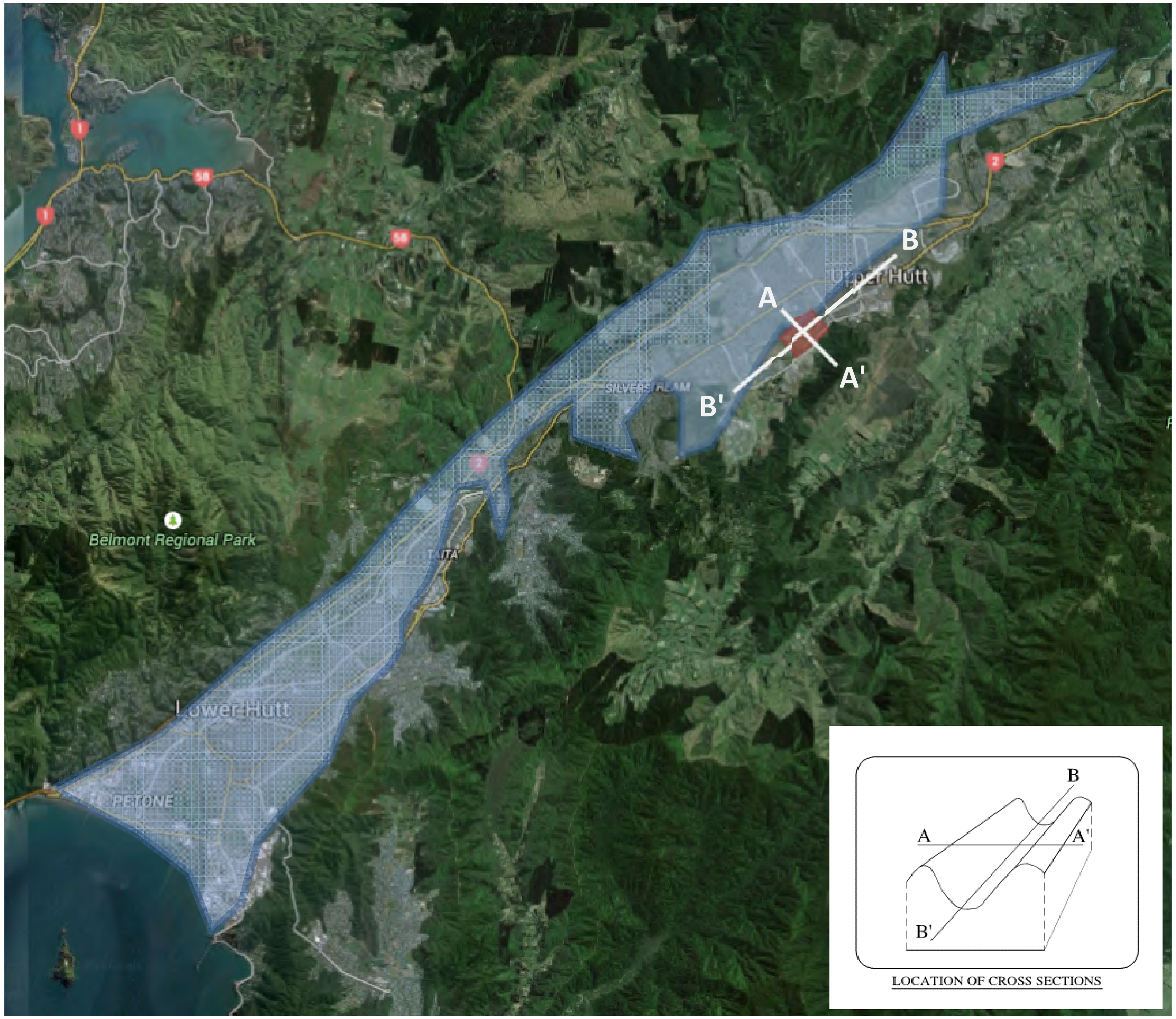
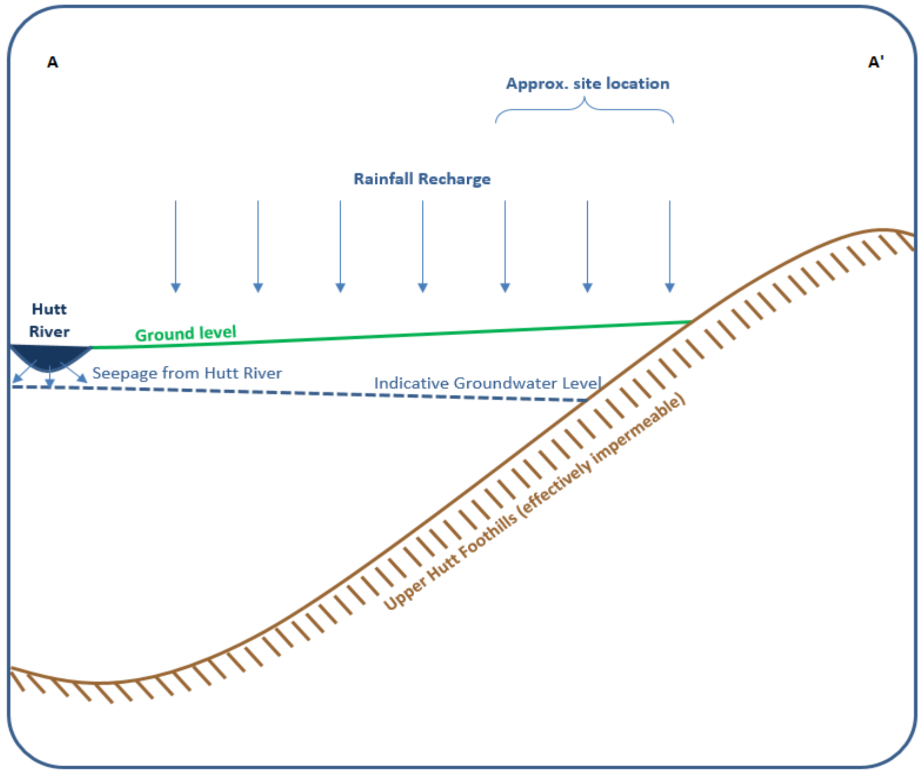
Approximate Site Location

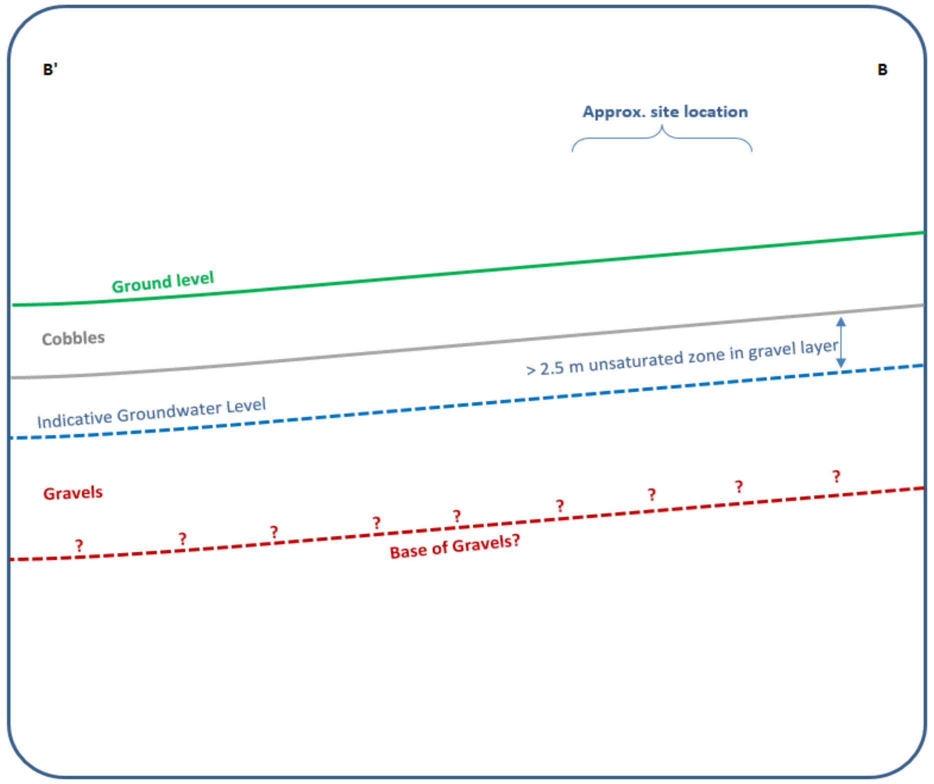
Known Well Location and Well Reference

NOTES Figure sourced from Wellington Regional Council GIS Viewer (accessed 05/06/2015)

Date	04/06/15	**Client**	**Wallaceville Development**		
Drawn by	HW	**Project**	**Response to Request for Further Information; Wallaceville Soakage System**		
Approved by	GC	**Description**	**Known Local Wells**		
Scale	NTS	**Figure Number**	1	**Project Number**	11307







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- Approximate Site Location
- Hutt Valley Aquifer System

Date	04/06/15	**Client**	**Wallaceville Development**		
Drawn by	HW	**Project**	**Response to Request for Further Information; Wallaceville Soakage System**		
Approved by	GC	**Description**	**Conceptual Hydrogeological Model**		
Scale	NTS	**Figure Number**	2	**Project Number**	11307

Note: Location map sourced from Google. Aerial photograph sourced from Greater Wellington Regional Council WebMap

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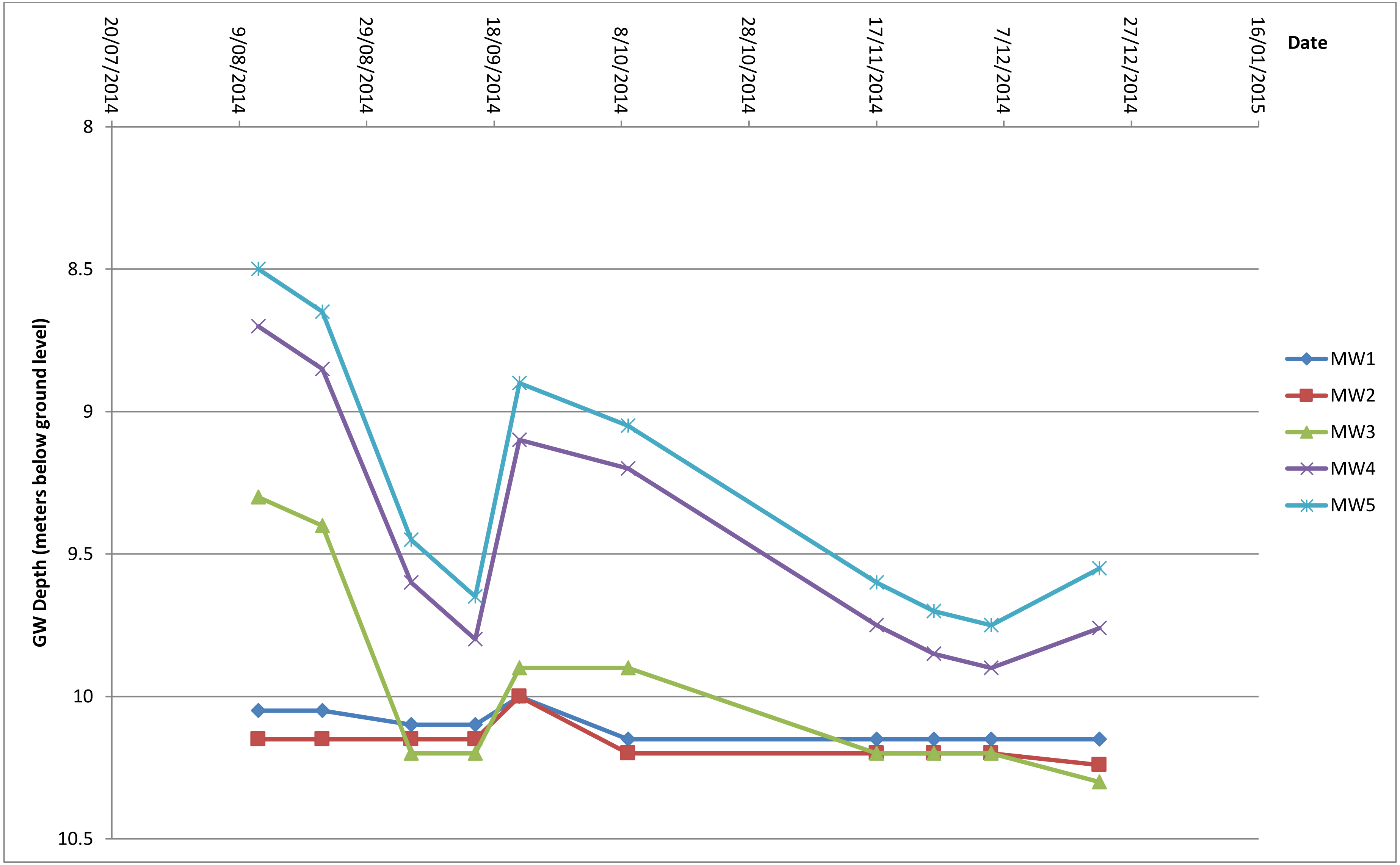
Date	Dec-14	**Client**	**Wallaceville Developments Ltd**		
Drawn by	CG	**Project**	**Groundwater Monitoring Wells Locations**		
Approved by		**Description**	**Site Location Plan**		
Scale	NTS	**Figure Number**	1	**Project Number**	11307

APPENDIX A

Figure 2: Wallaceville Groundwater Depths



APPENDIX A

Appendix 1: Wallaceville Groundwater Monitoring Raw Data

Monitoring Well	Date of Measurement	Weather Conditions	Depth of Well (mbgl)	Depth to Groundwater (mbgl)
MW1	12/08/2014	Rain in morning, becoming fine	10.4	10.05
MW2			10.3	10.15
MW3			10.2	9.3
MW4			10.3	8.7
MW5			10.35	8.5
MW1	22/08/2014	Fine	-	10.05
MW2			-	10.15
MW3			-	9.4
MW4			-	8.85
MW5			-	8.65
MW1	5/09/2014	Overcast, light drizzle – much of the surface water observed during previous visits had dried up	-	10.1
MW2			-	10.15
MW3			-	10.2
MW4			-	9.6
MW5			-	9.45
MW1	15/09/2014	Fine – visited site after two days of rain	-	10.1
MW2			-	10.15
MW3			-	10.2
MW4			-	9.8
MW5			-	9.65
MW1	22/09/2014	Heavy showers – previously rained on and off for three days	-	10.0
MW2			-	10.0
MW3			-	9.9
MW4			-	9.1
MW5			-	8.9

MW1	09/10/2014	Fine – previously rained on and off for two days (MSD BH Whakatiki Street measured 5.5 m depth)	-	10.15
MW2			-	10.2
MW3			-	9.9
MW4			-	9.2
MW5			-	9.05
MW1	17/11/2014	Fine – rained previous day, variable weather recently	-	10.15
MW2			-	10.2
MW3			-	10.2
MW4			-	9.75
MW5			-	9.6
MW1	26/11/2014	Light showers on day of measuring and fine on previous days	-	10.15
MW2			-	10.2
MW3			-	10.2
MW4			-	9.85
MW5			-	9.7
MW1	5/12/2014	Light showers on day of measuring and previous day	-	10.15
MW2			-	10.2
MW3			-	10.2
MW4			-	9.9
MW5			-	9.75
MW1	22/12/2014	Fine	10.33	10.15
MW2			10.31	10.24
MW3			10.34	10.3
MW4			10.33	9.76
MW5			10.32	9.55

WEBSTER DRILLING

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Site : **Wallaceville**
Client : **Geoscience**
Job : **40708**
Driller : **Ian Glassford**

Borehole	***Date***				***Borelog***
BH # 1	1-Aug-14	GL	to	1.50	JET VAC
		1.50	to	4.90	Medium to large COBBLES with brown silty clay
	4-Aug-14	4.90	to	6.70	Large COBBLES with hard brown silt
		6.70	to	8.30	Hard medium grey subrounded GRAVEL
		8.30	to	10.20	Small to medium rounded grey GRAVEL with hard damp brown silt
					COMPLETION
		10.20	to	1.00	50mm slotted PVC
		1.00	to	0.50	50mm blank above ground
		10.20	to	0.70	2mm sand
		0.70	to	0.40	Bentonite
		0.40	to	GL	Concrete with stand pipe installed
BH # 2	4-Aug-14	GL	to	1.50	JET VAC
		1.50	to	5.70	Large COBBLES with hard brown silt
		5.70	to	7.80	Hard grey medium to large GRAVEL
		7.80	to	10.10	Grey small to large rounded GRAVEL with some brown silt
					COMPLETION
		10.10	to	1.00	50mm slotted PVC
		1.00	to	0.50	50mm blank PVC above ground level
		10.10	to	0.70	2mm sand
		0.70	to	0.40	Bentonite
		0.40	to	GL	Concrete with stand pipe installed

BH # 3	4-Aug-14	GL	to	1.50	JET VAC
		1.50	to	5.90	Large COBBLES with hard brown silt
		5.90	to	8.30	Hard grey medium to large GRAVEL
		8.30	to	10.10	Small to medium rounded GRAVEL with some silts
					COMPLETION
		10.10	to	1.00	50mm slotted PVC
		1.00	to	0.50	50mm blank PVC above ground level
		10.10	to	0.70	2mm sand
		0.70	to	0.40	Bentonite
		0.40	to	GL	Concrete with stand pipe installed
BH # 4	5-Aug-14	GL	to	1.50	JET VAC
		1.50	to	5.80	Large COBBLES with brown silts
		5.80	to	7.60	Medium to large grey GRAVEL
		7.60	to	10.20	Small to medium subrounded GRAVEL with brown silt
					water at 8.7m
					COMPLETION
		10.20	to	1.20	50mm slotted PVC threaded
		1.20	to	0.50	50mm blank PVC threaded above ground level
		10.20	to	0.70	2mm sand
		0.70	to	0.50	Bentonite
		0.50	to	GL	Concrete with stand pipe installed
BH # 5	5-Aug-14	GL	to	1.50	JET VAC
		1.50	to	4.20	Large COBBLES with brown silts
		4.20	to	7.20	Medium to large grey GRAVEL
		7.20	to	10.20	Small to medium subrounded GRAVEL with brown silt
					water at 8.3m
					COMPLETION
		10.20	to	1.20	50mm slotted PVC threaded
		1.20	to	0.50	50mm blank PVC threaded above ground level
		10.20	to	0.70	2mm sand
		0.70	to	0.50	Bentonite
		0.50	to	GL	Concrete with stand pipe installed