BEFORE THE PROPOSED NATURAL RESOURCES PLAN HEARINGS PANEL

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of Water Allocation

AND

IN THE MATTER of the submissions and further submissions set out in the S42A Officer Report

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STATEMENT OF PRIMARY EVIDENCE OF DR DOUGLAS MZILA ON BEHALF OF WELLINGTON REGIONAL COUNCIL

TECHNICAL – Water Allocation – Aquifer integrity and dewatering

07 August 2017

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1. INTRODUCTION

1.1 My name is Dr Douglas Mzila. I am a groundwater Scientist with Greater Wellington Regional Council, a position I have held for 6.5 years. Prior to that I have worked for consultancy companies in New Zealand and internationally and have a total of 22 years' practical experience in groundwater resource development, research and analysis. My principal areas of expertise lie in the areas of groundwater resource management, aquifer storage and recovery, groundwater modelling and the characterisation and modelling of groundwater - surface water.

1.2 I hold the qualifications of MSc in Hydrology, MSc in Environmental Engineering specialising in surface water and groundwater interaction and PhD in Civil and Environmental Engineering specialising in groundwater science from the Nanyang Technological University in Singapore. A full copy of my qualifications and experience is available in **Attachment A** of my evidence.

1.3 Greater Wellington Regional Council has requested that I provide evidence to this hearing relating to my role in developing rules on investigation and monitoring bores, the proposed new Rule R14A, GWRC conjunctive water allocation framework for the Wellington Region and in assessing various major dewatering consents for the Wellington region.

2. CODE OF CONDUCT

2.1 I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note. I agree to comply with this code of conduct. Except where I am relying on evidence of another person, this evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express

3. SCOPE OF MY EVIDENCE

I have been asked to provide evidence in response to submissions received on the to topic Water Allocation. The specific matters of the submissions are discussed in sections 4 to 7 of this evidence and the following is a summary of specific matters/areas/schedules:

- Rule R146 Investigation and monitoring bores-permitted activity
- Proposed new Rule R146A
- Objection submission from Wellington Water on the depth of Category A in the Hutt Aquifer to be changed from 15m to 10m.

- Measures to prevent saline intrusion and is the risk increased with climate change and why we have gone with mean sea level not a datum as suggested by Wellington Water.
- Proposed dewatering for 6 months without consent under Rule R146 Investigation and monitoring bores-permitted activity

4. RULE R146 AND PROPOSED NEW RULE R146A

4.1 The scope of my evidence included assessing submissions relating to the permitted activity for investigation and monitoring bores R146 that were raised in submissions and further submissions relating to protection of the Hutt Aquifer (Waiwhetu aquifer) and also to community drinking supply protection areas in allocation provisions in the PNRP. The recommendations is to amend the permitted activity rules from Rule R146: Geotechnical investigations bores- permitted activity

4.2 The use of land and the associated diversion and discharge of water or contaminants for drilling, construction or alteration of a geotechnical investigation bore is a permitted activity, provided the following conditions are met:

a) The bore is not located within a community drinking water supply protection area shown on Map 26, Map 27a, Map 27b, or Map 27c(a) of the Proposed Natural Resources Plan (PNRP)

b) The proposed change from the draft PNRP and since the submissions is as follows: Rule R146: Investigation and monitoring bores – permitted activity

- The use of land and the associated diversion and discharge of water or contaminants for the drilling, construction or alteration of a bore for the purpose of investigating or monitoring the conditions below the ground surface is a permitted activity, provided the following conditions are met:

- Where the bore is located within a community drinking water supply protection area shown on Map 27a, or Map 27c, the depth below ground level will not exceed 5m. al for loss of aquifer pressure in artesian aquifers.

There are three main purposes for the proposed changes to Rule 146:

4.3 Purpose 1: The onshore purpose of this rule is to prevent contamination of community groundwater water supplies by limiting installation of investigation and monitoring bores to a maximum depth of 5m under the permitted activity rule (Rule R146).

a) The groundwater resources of the Wellington Region constitute a vital component of public water supply. For example Lower Hutt valley groundwater provides the Wellington four (Wellington City, Lower and Upper Hutt and Porirua) cities with 40% of the water demand and up to 70% during the summer period. Drinking water contamination could have a devastating effect on Wellington water supplies, with wider regional impacts.

b) Since around December 2016 Wellington Water Limited (WWL) have noticed changes in the water quality in the Knights Road wellfield that feeds Hutt City with drinking water through the Waterloo Water Treatment Plant. This includes increasing counts of Total Coliforms and a number of detections of E-Coli. As a result of this WWL have been chlorinating the Hutt City water supply which was up until now considered a secure supply that did not need treatment. This resource is of extreme strategic importance for the resilient supply of water to the four cities, especially during dry periods when river flows cannot sustain water demand

c) Recently, a contamination of groundwater supply in Havelock North made over 5000 people very ill and was also linked to three deaths. Such contamination in the Waiwhetu aquifer could affect approximately ten times more people than in Havelock North.

d) A suspension of groundwater take due to contamination could also result in severe water shortages for the Wellington region. Furthermore, such levels of contamination could result in the loss of "secure" water supply status for the Waiwhetu aquifer. The findings from the Havelock North incident indicated great significance regarding the issue of bore design and asset management in municipal water supplies.

4.4 My Assessment : Purpose 1

a) Micro-organisms are filtered out and die off as the water travels through the ground. Very often, because it travels slowly the water in confined aquifer has been there for many years and is free of harmful organisms.

b) These microbes are carried into the aquifer from the surface. The vulnerability of confined aquifers to microbial contamination is increased by bores that penetrate through the confining layer/aquitard. These bores are a special pollution hazard because contaminants can find their way directly into the aquifer. Because there is not a net flow of water out of the bore, any water entering the bore from above will tend to end up in the aquifer.

c) It is therefore important that any permitted activity bores are not advanced through the confining layer/aquitard in any areas identified as within the capture zone for community groundwater supplies. The selection of 5m depth throughout the region follows studies defining the minimum depth to the confining layer.

d) A detailed review and analysis of the capture zone report (Toewes and Donath, 2015) indicates that the depth to the capture zone flow path is highly variable and could be as shallow as 7m under confined conditions. This condition applies to all capture zones in the region.

e) Borelogs for the Hutt Valley aquifer indicate that the confining layer could be shallower than previously thought. Earth In Mind (2016) recognized thinning of the confining material towards the Waiwhetu stream. GWRC agrees with submitters that a more conservative approach is required for permitted activity under Rule R146 and 5m depth has been accepted.

4.5 Purpose 2: The offshore purpose of this rule is to prevent loss of artesian pressure and loss of groundwater resources of the Waiwhetu aquifer. Limiting offshore installations of investigation and monitoring bores to a maximum depth of 5m under Rule 146 A will prevent puncturing of the offshore aquitard.

4.6 Purpose 3: Another offshore purpose of this rule is to prevent loss of yield through saltwater ingress into the Waiwhetu aquifer if the aquitard is punctured by off shore installation of investigation and monitoring bores by limiting installations to a maximum depth of 5m under the permitted activity rule (Rule R146).

4.7 My Assessment :Purpose 2 and 3

a) Detailed seismic studies by NIWA (2015) and further analysis by Earth in Mind (2016) indicates that the Lambton Harbour comprises of highly uneven confining layers and widespread occurrence of springs on the seabed.

b) The enlarged bathymetry contour map shown in Figure 4.16 of Earth in Mind (2016) identifies the location of the spring vents on the harbour floor. The three main spring clusters are the Hutt River mouth with vents up to 10m deep below surrounding sea floor (bsf) indicating the depth to the

Waiwhetu aquifer is a maximum of 10m bsf at this location.

c) Bore logs from the Somes Island bore (R27/1170) show the Waiwhetu Aquifer as being at 12.5m bsf. (http://mapping.gw.govt.nz/GW/GWpublicmap/)

d) Earth in Mind (2016) identified the spring on the northern tip of Somes Island at about 5-6m deep (bsf).

e) I am of the opinion that a permitted activity rule for investigation bores to a depth of 5m bsf under R146 should be adequately conservative to limit any risks to puncturing the aquitard.

f) Through prehearing meetings and workshops, Centreport Ltd provided alternative explanations to the presence of shallow coarse sands in the Commercial Port Area (CPA). It was agreed that the aquifer does not extend into the CPA and bores to any depth within the CPA area (Map 32 in the PNRP) and the rule does not apply to the CPA.

5. CHANGING THE DEPTH OF CATEGORY A IN THE HUTT AQUIFER FROM 15M TO 10M

5.1 The submitter: WWL suggest that the policy should consider working from the top of the aquitard rather than the bottom of the aquitard and propose a depth of 10m bgl instead of 15m bgl. The current delineation of Category B is groundwater below 15m bgl throughout the Waiwhetu aquifer. WWL submits that Category A should be conservative to ensure allocation cannot draw from the Waiwhetu aquifer.

5.2 The purpose of the change proposed by WWL is to ensure the sustainability of groundwater resources from the Waiwhetu aquifer to supply the four cities under the bulk water consent. Reductions in available supply could result in water restrictions more so during the summer dry months.

5.3 The Waiwhetu aquifer under Category B allocation provides the Wellington's four cities (Wellington City, Lower and Upper Hutt and Porirua) with 40% of the water demand and up to 70% during the summer period.

5.4 The Category B groundwater is separated from Category A groundwater in the shallow subsurface by an aquitard of varying thickness.

5.5 There are currently no consented takes from Category A groundwater in the Lower Hutt Aquifer. Groundwater takes from Category A are limited by the general poor quality of water in the shallow subsurface and also saline water movements due to tidal influences.

5.6 Generally, Category A groundwater in the Lower Hutt area is accessed only for shorter periods of time such as during prolonged dewatering activities that are related to infrastructure developments.

5.7 My Assessment: The Waiwhetu aquifer allocation is assessed as Category B groundwater. An analysis of borelogs immediately north of the bore field in Knights Road indicates that the confining layer/aquitard is not uniform and could be as shallow as 7m bgl.

5.8 The depth to the Waiwhetu aquifer is variable throughout the Lower Valley deepening from north to south and lately found to be becoming shallow towards the Waiwhetu stream where the depth to the Waiwhetu aquifer could be as shallow as 10m bgl

5.9 Abstraction of groundwater below the confining layer which could be as shallow as 13m bgl will result in the depressurization of the Waiwhetu aquifer resulting in reduction of yield from this Category B aquifer.

5.10 Recent geotechnical bore monitoring at depths of 13.5m and 14m bgl (Figures 1 and 2) by Tonkin and Taylor Ltd (T&T) indicates that the installations exhibit artesian pressure conditions characteristic of the Waiwhetu aquifer as compared to shallow groundwater (Category A) shown on the same plots.

5.11 From the graphs on Figures 1 and 2 below it is evident that the Waiwhetu aquifer (Category B) at Hutt City Building is located less than 15m bgl. Taking into consideration the thickness of the aquitard it is recommended that a depth of 10m bgl should be used as a guideline in delineating between Category A and Category B groundwater.

5.12 I therefore do agree that the depth of Category A in the Hutt Valley should be changed from 15m to 10m.

5.13 The changing from 15 to 10 meters is not likely to change allocation take volumes for each of the categories in the Lower Hutt Valley. It should be noted that there are no current Category A takes.

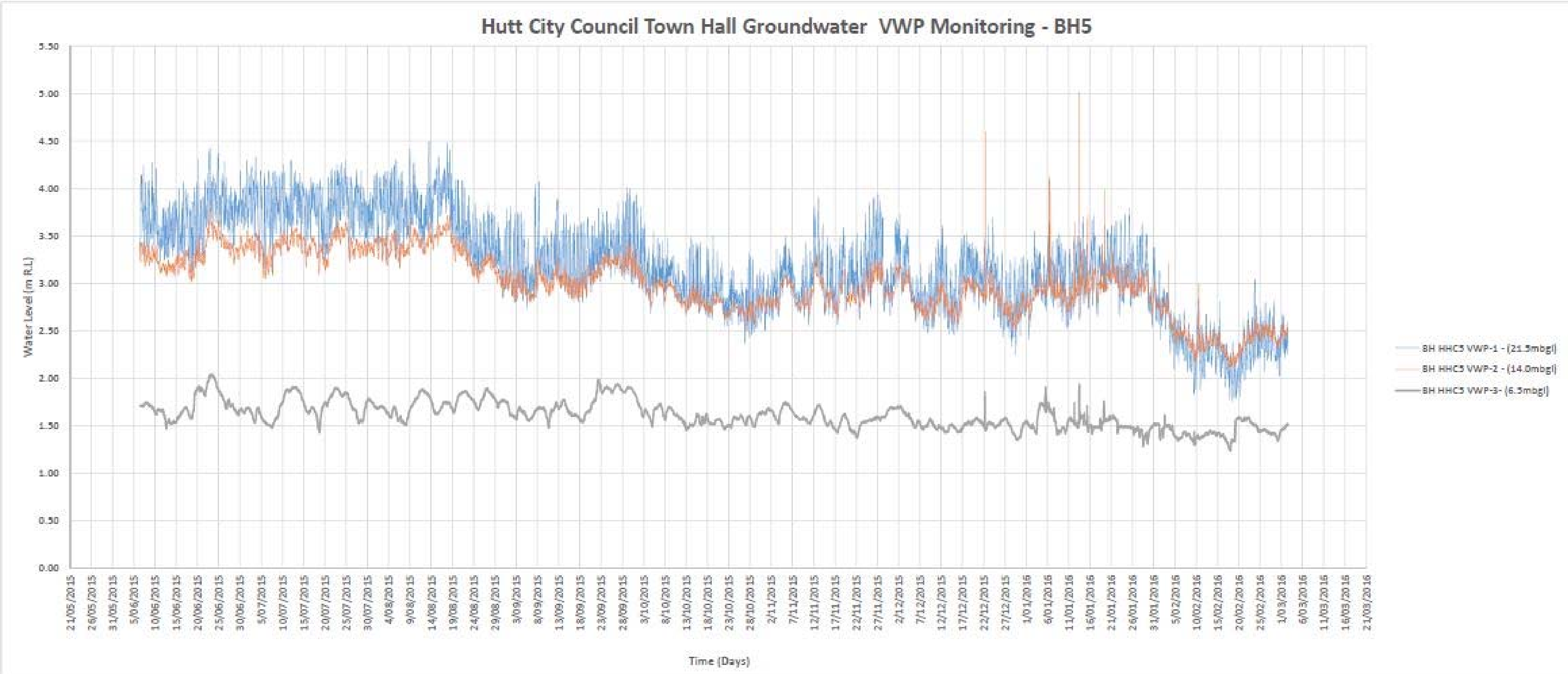

Figure 1: Hutt City Building BH5 borehole monitoring at three levels 21.5m, 14m and 6.3m below ground level. The brown graph (14m bgl) shows that the water levels are artesian and similar to the Waiwhetu aquifer (21.5m bgl, Category B) and are more than 2m higher than shallow unconfined levels (Category A)

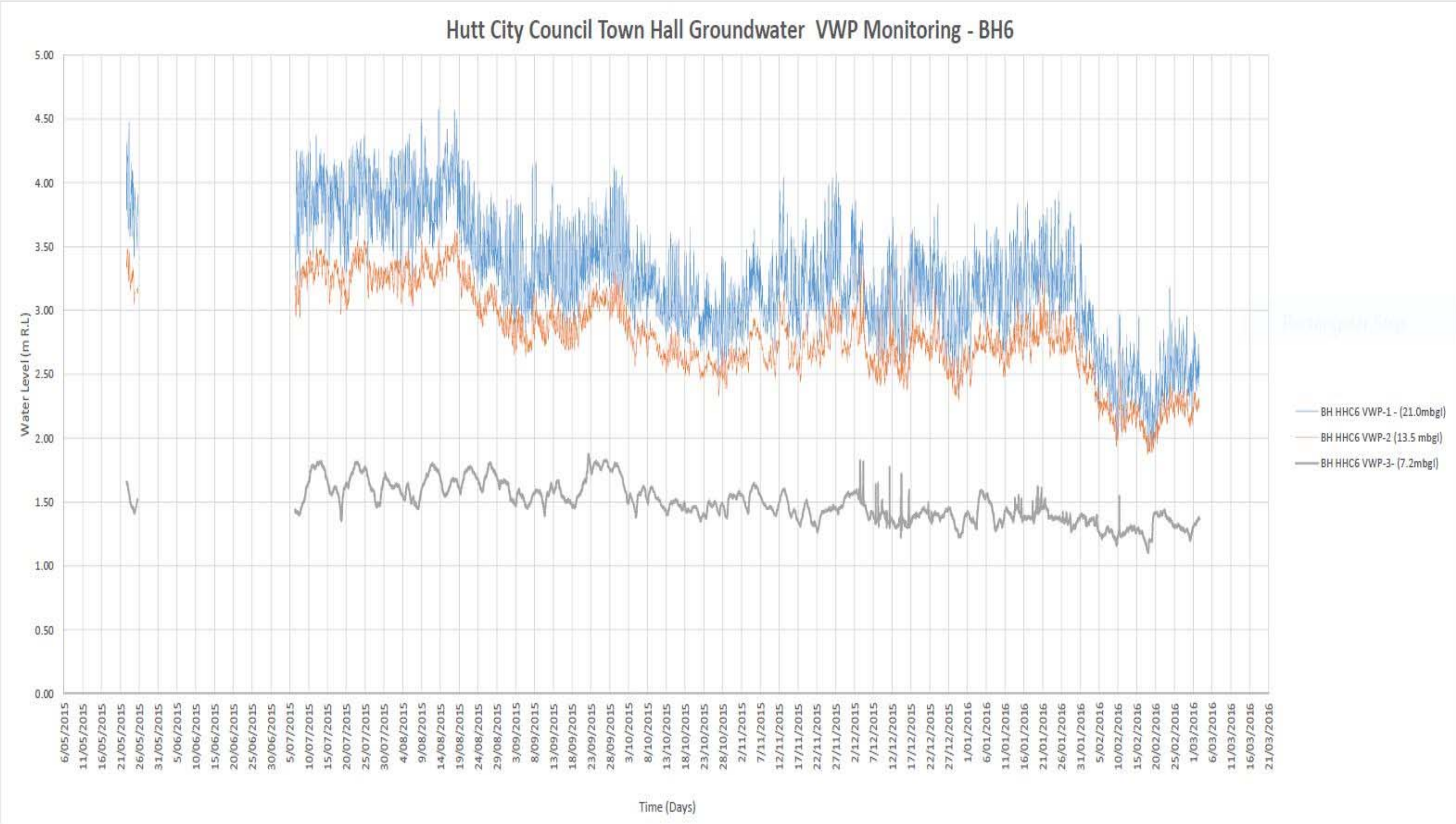

Figure 2: Hutt City Building BH6 borehole monitoring at three levels 21.0m, 13.5m and 7.2m below ground level. The brown graph (13.5m bgl) shows that the water levels are artesian and similar to the Waiwhetu aquifer (21m bgl, Category B) and are more than 2m higher than shallow unconfined levels (Category A)

6. MEASURES TO PREVENT SALINE INTRUSION AND THE RISK INCREASE WITH CLIMATE CHANGE

6.1 The submitter- WWL (s135/117) submit that it would be more appropriate to specify a datum in Policy P121 rather than just sea level. S135 suggests the datum could be Wellington vertical datum 1953.

6.2 The submitter is concerned that where fresh water aquifers interface with the coast there is a risk that significant groundwater abstraction will alter the freshwater-saltwater interface.

6.3 The purpose of Policy P121: is to prevent salt water intrusion into aquifers. Where fresh water aquifers interface with the coast there is a risk that significant groundwater abstraction will alter the freshwater-saltwater interface. Policy P121 sets management levels for aquifers on the Kāpiti Coast and the Hutt Valley to ensure the saline interface does not migrate landward and compromise the water quality in the fresh water bores. There is no connectivity of groundwater and the sea in the Wairarapa Valley hence no further analysis was undertaken for this region.

6.4 I agree and confirm that levels are based on the Wellington Vertical Datum-1953 (WVD-53). This datum is referred to as the mean sea level. Therefore we agree that the level should be based on this datum which is actually the mean sea level.

6.5 The Hutt Aquifer Model (HAM3) groundwater allocation model is based upon the groundwater level monitoring data which was reduced to the vertical survey datum WVD-53. GWRC groundwater level monitoring sites to provide elevation data for consenting trigger levels which are based on the same datum. Therefore reference should be to this datum (WVD-53). The WVD-53 datum is used in the GWRC Hilltop database.

6.6 Effects of climate change on saltwater intrusion into aquifers: Wellington Recreational Marine Fishers Association (s32/001) submit that the effects of climate change are not correctly described in the proposed Plan and we now have deeper low pressure systems that cause sea level to rise.

6.7 Furthermore the submission considers that the rising sea levels increase the head of water acting on the submarine freshwater springs in Wellington Harbour causing greater quantity of sea water to enter the aquifer base shingles. The description in Schedule P of the PNRP 'salt water intrusion shall be prevented in to the aquifers' is an inadequate description as from that there can be no management tool introduced to manage the effects of climate change. It will require a far better policy than Policy P121 and a management plan that displays a wider knowledge than what has been presented.

6.8 With reference to sea level rise and saline intrusion risk in the Wellington Harbour, I agree that management effects of climate change should be taken into account in managing abstractions to prevent saltwater intrusion into the Hutt aquifer. Below is my discussion on how climate change has been factored in the modelling of groundwater allocations for the Lower Hutt Aquifer

6.9 The groundwater allocation model (HAM3) did consider the potential effects of sea level rise due to climatic factor changes (Earth In Mind, 2016 sections 9.1 to 9.4). Sea level rise over the last 100 years are averaged at 2mm per year i.e. with a total 0.20m over this period (Wellington Vertical Datum (WVD-53). The model also considers sea level rises due to compounding factors of land subsidence caused by tectonic activities. Baseline modelling conditions use a sea level rise of 0.2m i.e. sea level rise that has occurred over the last 100years.

6.10 A combination of factors in (6.9) above is projected to result in a 0.8m rise by 2090 or 1m by 2115. The HAM3 model adopts a high sea rise scenario of 1.5m as a basis for assessing the vulnerability of the Waiwhetu aquifer. This worst case scenario will result in reduction of approximately 30% in aquifer yield.

6.11 Using the above worst case scenario it is projected that a combination of sea level rise and land subsidence will result in approximately 0.45m change in head over the duration of this PRNP. However, I recommend that saline intrusion risk management measures and minimum levels should be reviewed every 10 years.

6.12 Maintaining water levels above sea level at the foreshore of the Hutt Valley at 2m and cessation of take at 1.7m (based on groundwater levels averaged over 24 hours) should maintain adequate positive pressure head despite effects of sea level rise and land subsidence. It is anticipated that any movement of the saltwater fresh water interface will be detected by robust monitoring systems both in the Hutt Valley.

6.13 Effects of sea level rise in the Kapiti Coast are appropriately managed through cessation of take trigger levels. Cessation of takes are triggered when the foreshore falls below 1m above mean sea level (based on groundwater levels averaged over three days).

6.14 Groundwater abstraction from the Kapiti Coast is significantly less than the Wellington's Lower Hutt aquifer and offshore discharges are spread over several kilometers. A robust saltwater monitoring network that includes levels and conductivity monitoring systems at a number of sentinel wells has been installed. This network monitors the effects of abstractions from the Kapiti borefield and it contains robust trigger levels to track the movement of the saltwater/freshwater interface.

7. PROPOSED DEWATERING FOR 6 MONTHS WITHOUT CONSENT

7.1 A submitter proposed dewatering for a period of up to 6 months without resource consent. The current permitted activity rule allows for dewatering for a period of not more than one month.

7.2 It is important to recognise that dewatering and groundwater control has the potential to impact on the groundwater environment. In general terms, long duration dewatering has a greater potential to cause significant impact, compared to short term dewatering.

7.3 Conversely, it should be recognized that, say, a shallow excavation for construction of a manhole that may take only a few weeks to complete has much less potential for impact, and may only require a quick review to confirm impacts are not a significant concern.

7.4 There are a wide range of potential impacts from dewatering and groundwater lowering. These can be categorized in various ways, such as the following groups of impact types (https://www.groundwatereng.com/blog/2014/02/managing-environmental-impacts-of-dewatering) :

- *Geotechnical impacts*
- *Contamination impacts*
- *Water dependent feature impacts*
- *Water resource impacts.*

7.5 Geotechnical impacts***:*** Dewatering can cause ground settlements which, in some cases can be large enough to cause distress or damage to any structures located within the zone of drawdown.

7.6 Long term dewatering allows for shallow groundwater levels to change significantly and also allows the zone of dewatering influence to extend further from the dewatering system.

7.7 Dewatering for periods longer than one month has a potential to progressively cause settlement over a wider area.

7.8 Contamination impacts: When groundwater is pumped from wells or sumps, as occurs during some dewatering schemes, hydraulic gradients are generated, which draws the groundwater toward the well. Long term dewatering allows contaminants from other areas to move and migrate toward the dewatering system.

7.9 A site initially assessed as uncontaminated may eventually yield contaminated water without proper provisions for water treatment before that water can be discharged. It is anticipated that depending on hydraulic characteristics of the soils and dewatering rates, it could take less than one month travel times for contaminant arrival at the dewatering system.

7.10 Long term dewatering increases the exposure of shallow groundwater to surface contaminants through surface inflows.

7.11 Groundwater dependent ecosystem impacts: Natural groundwater flow plays an important role in sustaining many natural groundwater-dependent features, such as rivers, springs and wetlands. As well as their obvious function in transmitting or storing water, many of these features also form important habitats and ecosystems.

7.12 Long duration dewatering has a greater potential to cause significant impact to many natural water dependent features. Dewatering for more than one month could significantly increase stress and reduce survival of groundwater dependent ecosystems.

7.13 Shallow groundwater levels change seasonally and dewatering across seasons could limit groundwater recharge of groundwater dependent ecosystems such as wetlands and streams.

7.14 Conversely, short term dewatering allows for a relatively shorter period of time for the reestablishment of ambient equilibrium.

7.15 Water resource impacts: Where dewatering pumping is carried out in an aquifer which is used as a source for water supply by third parties (for example for drinking water or for industrial water use) there can be negative impacts on the available water resources from the aquifer.

7.16 These types of impacts are most commonly of concern where a dewatering system is to pump high flow rates for extended periods of time (more than a month). In that case the sustained dewatering pumping may have the potential to lower regional groundwater levels in the aquifer, and reduce the water resources available to third party abstractors.

7.17 This may be apparent in the short term in the form of lowered water levels in water supply wells and correspondingly reduced yields

7.18 Based on the above points and my assessment of dewatering activities that are related to infrastructure development and groundwater diversion, I recommend that the rule should not be changed i.e. the maximum dewatering without a consent should not exceed a period of one month.

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8. CONCLUSION

8.1 My evidence provides recommendations regarding submissions under Proposed Natural Resources Plan to the following topics:

(i). Investigation and monitoring bores-permitted activity

(ii). Proposed new Rule R146A

(iii). Objection submission from Wellington Water on the depth of Category A in the Hutt Aquifer to be changed from 15m to 10m.

(iv). Measures to prevent saline intrusion and is the risk increased with climate change and why we have gone with mean sea level not a datum as suggested by Wellington Water.

(v). Effects of dewatering- why we don't want to permit dewater for 6 months without consent. Rule R146 Investigation and monitoring bores-permitted activity

8.2 With respect to the proposed investigation and monitoring bores permitted activity and proposed new Rule R146A.

With respect to the submissions on the permitted activity for investigation and monitoring bores R146 focus primarily upon concerns that the rule that the

- The rule is too restrictive and results in unnecessary consenting issues

- That identified areas from CPA should be excluded from the Rule R146A.

8.3 My detailed analysis of relevant data and prehearing meetings with submitters assisted in the formation of this rule. Recent contamination of major water supply aquifers identified unconsented bores including geotechnical bores as potential pathways for groundwater contamination and hence the depth restrictions.

8.4 The proposed rule R146A is based on my thorough review of capture zones for groundwater community supplies that require special protection against surface contamination.

8.5 Borelogs and assessments of offshore spring levels all indicate that a depth of 5m is adequately conservative to prevent onshore groundwater contamination and offshore puncturing of the aquifer.

8.6 The proposed Rule 146 and Rule 146A will permit efficient use of resources as it provides permitted activity status to bores that are outside community groundwater supply capture zones. The Rules also provide protection against surface contamination of community supply aquifers through unconsented bores located within community groundwater supply capture zones. The rules also prevent offshore puncturing of the Waiwhetu aquifer.

8.7 With respect to the submission on the depth of Category A in the Hutt Aquifer to be changed from 15m to 10m below ground level. I do agree with the submission that the depth of Category A in the Hutt Aquifer to be changed from 15m to 10m. There are no affected consents from this proposed change and all available information indicates that the depth to the Waiwhetu aquifer could be much less than 15m below ground level.

8.8 With respect to the submission on the risk of seawater/saline water intrusion and effects of climate change. My conclusion is that the changes in climate and the resultant sea level changes have been adequately explained and incorporated in groundwater management calculations.

8.9 With respect to the submission why GWRC has gone with mean sea level instead of the Wellington Vertical Datum-1953, or WVD-53), I find that the mean sea level is the same as the WVD-53 datum.

8.10 With respect to the submission to permit activity for dewatering for 6 months. I find that long term dewatering can cause significant effects to natural groundwater and surface water flows. Long term dewatering has a potential to introduce contaminants through induced groundwater flows. I recommend that dewatering for more than one month should not be a permitted activity.

9. REFERENCES

1) Bore log information from WELLS database (GWRC).

2) Earth in Mind (2014). Lower Hutt Aquifer Model Revision (HAM3): Sustainable Management of the Waiwhetu Aquifer. A report prepared for Greater Wellington Regional Council.

3) Geophysical Interpretation of the Waiwhetu Gravel Aquifer in Wellington Harbour in relation to the proposed pipeline route: A report prepared by NIWA for Wellington Water Ltd (2015);

4) Earth in Mind (2014). Hydrogeological effects assessment of proposed CPL dredging in Wellington Harbour in relation to bulk water supply from the Waiwhetu Aquifer: A report prepared by for Wellington Water Ltd (2016);

5) Pre-hearing meetings

6) Proposed Natural Resources Plan (PNRP)

7) Toews, M.W.; Donath, F. 2015. Capture zone delineation of community supply wells and state of the environment monitoring wells in the Greater Wellington Region, GNS Science Report 2015/06. 69;

8) Tonkin and Taylor tables and graphs for the Hutt City Council Groundwater Monitoring consent no WGN 160007. Emails received 21/01/2017;

Attachment A
Qualifications and experience

Qualifications

PhD in Civil and Environmental Engineering, Nanyang Technological University, Singapore
MSc Civil and Environmental Engineering, University of the Witwatersrand, South Africa
MSc Hydrological Engineering, St Petersburg State University, St Petersburg

Experience:

Expertise: Groundwater Surface water interactions, Modelling and assessment of dewatering schemes, Mining Hydrogeology, Environmental Hydrogeology, Groundwater Modelling, Groundwater Resources Development, Site Characterization; Aquifer Test Design and analysis; Assessment of Environmental Effects for Resource Consent Applications and Review of Resource Consent Applications for Discharge; Environmental Expert Witness, Groundwater Numerical Modelling, Community Engagement, Multi-disciplinary and multi-project management.

Environmental Hydrogeology: Douglas is a senior hydrogeologist with more than 20 years of experience in physical and contaminant hydrogeology, groundwater modelling, geochemistry, environmental science and GIS. His experience includes working as a lead and senior hydrogeologist specializing in site hydrogeological characterization, quantitative aquifer assessment and numerical groundwater modelling. His work involved extensive work and supervision of drilling and dewatering contractors, borehole logging and adherence to health and safety standards. He also has experience in designing and carrying out groundwater tracer studies to estimate the migration of injected constituents to estimate fate and transport of pollutants. Other significant experience in water engineering include wastewater and storm water designs, pipe-network analysis with expert knowledge in using modelling software such as Visual Modflow, SEEP/W, AQTESOLV 3.5, FEMWATER, EPANET, Microsoft, PEST, MODPATH, Groundwater Vistas, Excel, WinPest and MT3D

Douglas has served as project manager for a wide variety of projects in Singapore and New Zealand, including complex site investigations for land wastewater disposal, negotiation with local and regional regulatory authorities, hydrogeologic assessments, preliminary site assessment, geophysical investigations, groundwater modelling for land conversions, aquifer testing and dewatering schemes.

Douglas has designed groundwater models for large scale civil engineering dewatering schemes related to underground railway excavation. He was also the primary groundwater investigator on the effects of dewatering for an underground rail station in Manukau, Auckland and coal mining dewatering. Douglas has undertaken extensive work to assess the effects of river diversions for hydropower generation on groundwater resources of major groundwater take valleys. The sites under investigations were highly sensitive and required unusually complex investigation strategies, representing significant liability exposure.

April 2011- Present

Greater Wellington Regional Council

Senior Groundwater Scientist/Senior Hydrogeologist

Specialist hydrogeological adviser His current role includes providing specialist hydrogeological advice and expertise to resource officers on resource consenting matters through technical assessments, critical reviews and analysis of impacts from current and proposed activities such as groundwater takes and dewatering schemes. In this role he works collaboratively with resource use applicants in complying with regulatory requirements and policies. Much of Douglas's current work is also related to reviewing resource consents for wastewater disposal projects, large scale dairy conversion nutrient transport to receiving environments and urban and rural groundwater take applications.

Douglas has developed several catchment and sub-catchment models to provide hydrogeological advice to the regional council, zone committees and other government agencies. The models were developed to assess interactions between deep and shallow groundwater with surface water systems such as to simulate surface water depletion effects from groundwater abstractions. His advice included groundwater abstraction effects on wetlands, coastal saltwater intrusion and streamflow losses and gains. This advice was used to develop groundwater management plans and also the used for development of allocation policies under the Proposed Natural Resources Plan for the Wellington Region (PNRP).

Douglas undertook complex investigations and provided technically robust solutions in contributing to the development of the PNRP and also responding to plan submissions by both opponents and proponents of the natural resources plan provisions. In his contributions to the development of policies and consenting conditions he has been recognised as always being sensitive to the needs of stakeholders such as native communities, resource users and impacts on service delivery.

Project management of Multidisciplinary teams and streams of work: Douglas engaged, managed and also worked with multi-disciplinary consultants and scientists in developing models and investigations for catchment wide groundwater and surface water quality and quantity. He worked with terrestrial ecologists to define groundwater allocation limits for protection of groundwater dependent ecosystems such as those found in groundwater fed wetlands and groundwater ecosystems such as stygofauna. He also applied complex models such as Bayesian kriging methods to develop a robust groundwater monitoring network for the Wellington Region which has been recognised as novel for New Zealand. He is currently leading work on a highly sensitive aquifer contamination and security risk assessment in ensuring sustainable groundwater supply that constitute approximately 50% of water supply for the region.

Internal and External Responsibilities: Douglas is an active committee member of the national special interest group (SIG) on groundwater. He is also a member of the Regional Science Leadership Group responsible for groundwater science. He is also involved in research and contributions to various forums such as conferences, journals and periodicals in which he has acted as a reviewer for the Hydrogeology Journal.