BEFORE THE GREATER WELLINGTON REGIONAL COUNCIL

IN THE MATTER OF	the Resource Management Act 1991
AND IN THE MATTERS OF	An application under s88 to discharge contaminants to water, land and air associated with the proposed long-term upgrade and operation of the Featherston Wastewater Treatment Plant
APPLICANT	South Wairarapa District Council

EVIDENCE IN CHIEF OF DR LEE BURBERY ON BEHALF OF WAIRARAPA REGIONAL PUBLIC HEALTH

2 May 2019

EVIDENCE IN CHIEF OF DR LEE BURBERY

INTRODUCTION

1. My full name is Lee Francis Burbery. I hold a Bachelor of Science (Honours) and a Doctorate of Philosophy, both in Environmental Science, from Lancaster University (UK). My PhD research specialised in contaminant hydrogeology.

2. I have 23 years professional experience working in the field of groundwater science, over half of which has been based in New Zealand, where I have primarily worked as a groundwater research scientist - initially with Lincoln Ventures Ltd (now Lincoln Agritech Ltd); most recently at the Institute of Environmental Science and Research (ESR).

3. I have been employed as a senior scientist in ESR's Groundwater Team, since 2012. ESR hold a contract with the Ministry of Health to provide independent scientific advice on matters relating to human health and water quality. It is through that role that I am engaged by Wairarapa Public Health.

4. Study of the fate and transport of nitrate in groundwater and characterising groundwater contaminant processes in heterogeneous, alluvial gravel aquifer systems, as can be found in the Wairarapa valley has formed a large part of my scientific research of the past 13 years. I have presented these topics at scientific conferences and published my research findings in peer-reviewed international scientific journals.

5. Between 2008 and 2010 I was employed as a Hydrogeologist (III) at Environment Canterbury (ECan) where my role was to serve as a scientific and technical advisor to the Regional Council pertaining to groundwater resource management of the Canterbury region.

6. I am a member of the New Zealand Hydrological Society.

CODE OF CONDUCT

7. I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014 and that I agree to comply with it. I have complied with it in preparing this evidence and I agree to comply with it in presenting evidence at this hearing. The evidence that I give is within my area of expertise except where I state that my evidence is given in reliance on another person's evidence. I have considered all material facts

that are known to me that might alter or detract from the opinions that I express in this evidence.

SCOPE OF EVIDENCE

8. I have been asked to provide expert evidence in relation to the following matters:

   a. Appropriateness of assessment of effects relating to pathogen and nutrient contamination of groundwater;

   b. Suitability of the site for the proposed land-based effluent disposal activity, notably the reliability of the groundwater mounding predictions.

BACKGROUND

9. In preparing this evidence I have accessed Greater Wellington Regional Council Web Map Viewer and reviewed the following documents:

   a. Assessment of Environmental Effects of Discharge of Featherston Treated Wastewater to Land, Lowe Environmental Impact (LEI), February 2017.

   b. Assessment of groundwater mounding effects and pathogen discharge made by GWS Ltd and contained in letters responding to S92 requests for further information sent to South Wairarapa District Council, 1st June 2017 and 18th October 2017.

   c. Geological and soils maps of New Zealand – GNS Qmap & Landcare S-map, respectively (accessed on-line April 2019).

   d. Wellington Regional Council Report GW/EMI-T-10/75 - Wairarapa Valley Groundwater Resource Investigation Lower Valley Catchment Hydrogeology and Modelling, November 2010.

   e. Various technical and scientific publications, referenced throughout this evidence.

PATHOGEN CONTAMINATION OF GROUNDWATER FROM THE PROPOSED ACTIVITY

10. It is proposed to irrigate with wastewater that has undergone some treatment from oxidation ponds, such that it will contain <100 cfu *E. coli* per 100 mL (or <1000 *E. coli* per litre).

11. Virus concentrations in the wastewater are less predictable, yet the AEE assumes 10^4-10^5 per litre in the untreated wastewater that will be reduced to circa. 10^1/L by the time wastewater's

undergone UV oxidation in the treatment ponds and in wastewater discharged to land. These concentrations do not seem unrealistic, provided the wastewater treatment system functions properly.

12. Attenuation of pathogens discharged to land is strongly governed by the pathogen type, soil type and aquifer material, amongst other things. In practice, attenuation can be described in terms of effective microbial removal rates that is attenuation (decrease in concentration) over a specified distance.

13. Microbial removal rates are fraught with uncertainty and the set-back distances documented in the Guidelines for Separation Distances Based on Virus Transport Between On-Site Domestic Wastewater Systems and Wells[1] represent the most relevant information for assessing health risk, since they attempt to encapsulate these uncertainties and factor in a 95% confidence limit.

14. Removal rates reported in Pang et al. (2009)[2] are another useful dataset as they represent a comprehensive review of the scientific literature for various bacterial pathogens examined under a variety of subsurface conditions. Also of viruses (which are covered by the aforementioned Separation Distance Guidelines).

15. The potential fate and transport of pathogens from the proposed land discharge and impact on the underlying groundwater resource has been assessed by GWS Ltd, using *E.Coli* and Rotavirus as reference pathogens. I consider these appropriate respective bacterial and virus reference organisms for health risk assessment.

16. The assessment made by GWS Ltd. applied a deterministic approach, in which pathogen removal rates were modelled separately for the soil and aquifer (saturated) zones, and accounting for pathogen die-off and removal separately. In addition to other parameters, a brown soil-type was assumed in the assessment and a groundwater velocity of 2.4 metres/day.

17. I gather that the brown soil type assumption must stem from the soil type identified by LEI in soil inspections made of proposal site A (April 2013) and site B (November 2015). LEI classified

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[1] ESR (2010) Guidelines for Separation Distances Based on Virus Transport Between On-Site Domestic Wastewater Systems and Wells, ESR Client Report CSC1001.

[2] Pang L (2009). Microbial Removal Rates in Subsurface Media Estimated From Published Studes of Field Experiments and Large Intact Soil Cores. Journal of Environmental Quality 38: 1531-1559.

soils at site A to be mottled orthic brown soil and describe both Tauherenikau shallow stony silt loam and Ahikouka silt loam as being distributed across site B.

18. According to Landcare's S-map soil report, Ahikouka silt loam is classified as a typic recent gley (not a brown) soil that exhibits poor drainage properties and is highly vulnerable to bypass flow effects (through macropores) of both water and contaminants.

19. The most recent S-map is provided as Figure 1, below. It shows the proposed land-based effluent disposal area spans across at least 4 different mapped soil families. The blue shaded region marks Ahikouka deep silt loam that is slowly permeable, but more significantly is recognised as being vulnerable to bypass flow, therefore high risk of facilitating microbial transport via macropores. Similarly, green shaded areas map Carterton very stony silt loam, which is also described as being vulnerable to bypass flow effects.

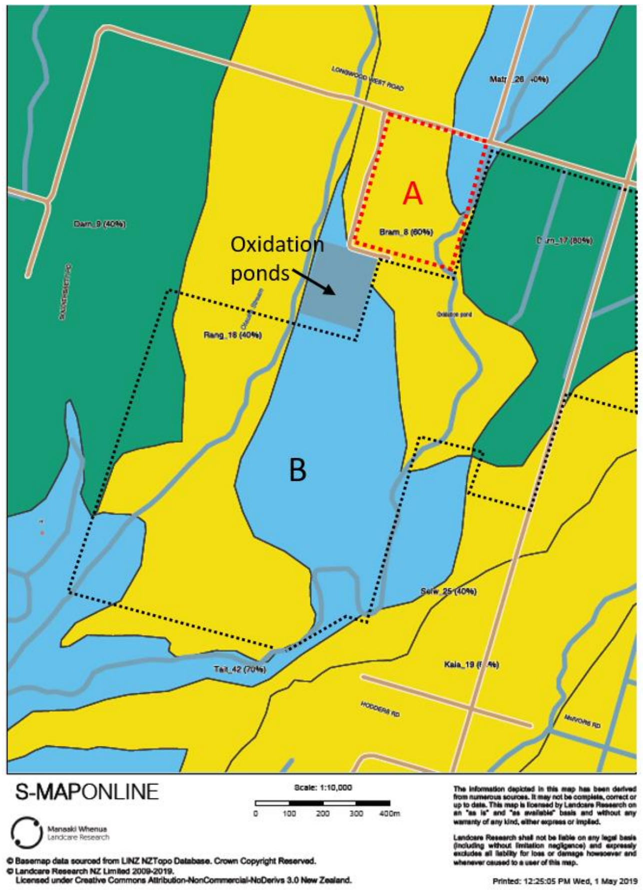

Figure 1: Most current soil map of the proposed effluent disposal area showing gley soil of the Ahikouka deep silt loam family (blue shaded area; Tait_42 label) covers the site. Note: actual site (A & B) boundaries are approximate and for illustration purposes only.

20. For the purpose of conducting a conservative pathogen risk assessment, I consider it is more appropriate to assume microbial removal rates for a gley soil cover at the effluent disposal site, not a brown soil cover.

21. ESR (2010) report a virus (pathogen) removal efficiency of 1.0 log/m for gley soils, versus 2.0 log/m for brown soils (such as assumed by GWS Ltd.). By this token, for the same 0.5 m vadose zone thickness assumed by GWS Ltd. and application of 1000 bacteria/L or 10 viruses/L, the concentration of pathogens entering the groundwater might reasonably be:

$$C_{E.Coli} = 10^{3-(1\times0.5)} = 10^{2.5} \approx 316 \text{ bacteria/L}$$
$$C_{virus} = 10^{1-(1\times0.5)} = 10^{0.5} = 3.16 \text{ virus/L}$$

22. Groundwater velocities at the site have not been directly measured. In the AEE, GWS Ltd. assumed a value of 2.4 metres/day, inferred from some broad assumptions regarding hydraulic properties of the local groundwater system.

23. A shallow aquifer composed of alluvial gravel deposits underlies the site (see para 45 below for further description).

24. In general, alluvial gravel aquifers are highly heterogeneous and susceptible to preferential flow effects attributed to highly permeable interconnected open gravel facies. I suspect such facies are present in the surficial aquifer at Featherston.

25. Based on experiences from groundwater transport studies ESR have conducted over the years in such alluvial deposits (mainly in Canterbury region), I imagine there is a high chance groundwater might in places flow faster than the bulk velocity of 2.4 metres/day assumed by GWS Ltd.

26. The separation distances in the Guidelines for Separation Distances Based on Virus Transport incorporate the risk associated with preferential flow in gravel aquifers.

27. Referring to the Separation Distances Table 1a in that report, which assumes 1 m gravel vadose zone over a gravel aquifer. A 2-log reduction in virus concentration would be achieved over a distance of 154 m.

28. In terms of contamination from bacterial contaminants, I refer to microbial removal rates listed by Pang (2009). For fast flowing (>11 metres/day) gravel aquifers (as I perceive the system at Featherston to be), Pang (2009) suggests effective microbial removal rates might conceivably be of the order 10^{-2} log/m for the uncontaminated aquifer, and 10^{-3} log/m if/when the aquifer

becomes conditioned with effluent. Note: these are significantly lower removal rates than the value of 0.32 log/m that was assumed by GWS Ltd.

29. Assuming an *E.Coli* input concentration of $10^{2.5}$ bacteria/L to the surficial aquifer (i.e. ~32 bacteria/100 mL) (refer para 21), to meet the NZ Drinking Water Standard Maximum Acceptable Value of <1 *E.Coli*/100 mL, more than a 1.5-log reduction in concentration is required.

30. Based on the effective removal rates reported by Pang (2009) this would necessitate anywhere between a 150 m and 1.5 km separation distance between the effluent disposal site and a drinking water supply well, down-gradient.

31. According to GWRC's on-line GIS database there is a private well (S27/0080; 9 m-deep) located 450 m down-gradient of the disposal site that is registered as used for domestic supply (see Figure 2, below). From what I can gather, this well is most at risk from water contamination arising from the proposed activity.

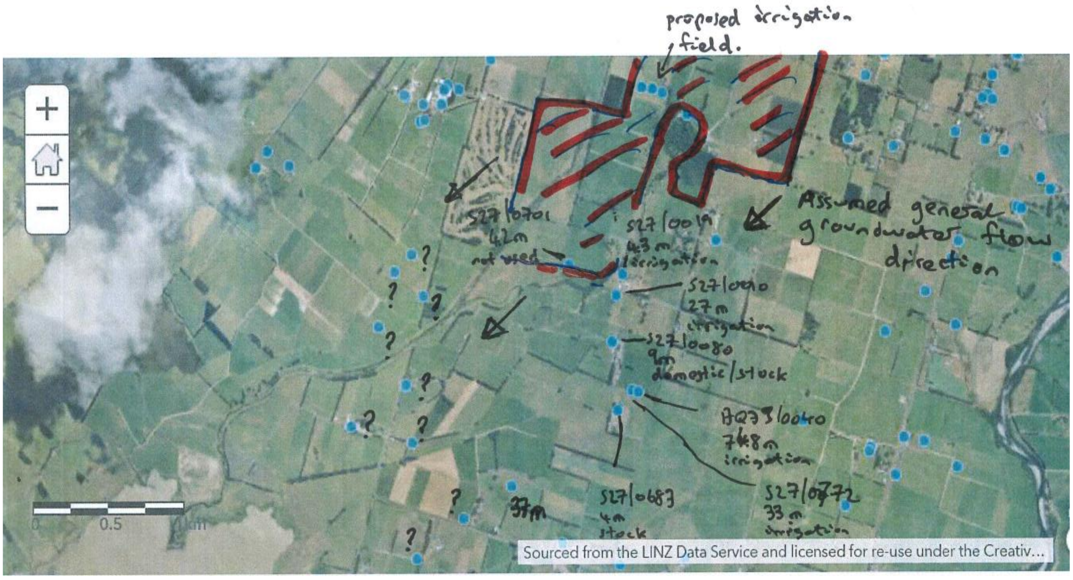

Figure 2: Screenshot from public GIS data showing location of wells in vicinity of site. Well numbers and details of select wells marked. I do not purport this to be a comprehensive assessment of the study area. Rather, the purpose of this figure is to demonstrate the sort of detail I would have expected to see the AEE for risk assessment purposes.

32. Using well S27/0080 as a reference environmental receptor then from the results of the microbial transport assessments I make above, whilst the risk is perceivably low, I would not rule out potential for the water quality of this well to be at risk of being impacted by pathogens from the proposal.

33. I make a note here that irrespective of the proposed land-based discharge activity, use of shallow groundwater in the region for untreated potable water supply is ill-advised, yet not prohibitive.

34. The issue of groundwater mounding and how this might alter the direction of natural groundwater flow is a valid concern. It is conceivable that if the hydraulic gradient were changed significantly then potentially contaminated groundwater from the site could become directed to wells that under historic, natural hydrogeological conditions are not down-gradient of the site. Perceivably supply wells located on the eastern margins of the site would be most affected by this artificial condition (as can be spotted in my Figure 1).

35. GWS Ltd. (2017) present their prediction of the water table surface (steady-state head) under the proposed condition. The contour map does not indicate significant risk to the water wells east of the site, but then this prediction is based on what I believe to be a flawed assessment due to errors in the (K_v/K_h) anisotropy ratio assumptions made by the consultant (see below for details).

NUTRIENT CONTAMINATION OF GROUNDWATER FROM THE PROPOSED ACTIVITY

36. I do not dismiss the notion that the proposed effluent irrigation is any worse in terms of nutrient loading than the existing land-use practice of dairy farming.

SUITABILITY OF THE SITE FOR THE PROPOSED ACTIVITY/GROUNDWATER MOUNDING

37. Whether the site is suitable for the proposed activity remains dubious to me, given the shallow water table condition and potential risk of surface flooding that could hinder irrigation operations. Irrespective of this technicality, when the proposal is weighed against the existing practice of discharging the same effluent directly to surface water then I consider the proposal an improvement at least, since it mitigates some risk of exposure to contaminants.

38. Hydrogeological characterisation of the site is limited. Information on groundwater levels has been obtained from a few (3) piezometers on the site. According to the AEE, the groundwater levels have been surveyed on only two occasions – once by PGES (April 2016); once by LEI (November 2015). There seems to have been no attempt to incorporate anything of the wider hydrogeological environment into the AEE or have characterised the dynamics of the groundwater system properly.

39. Details regarding the depth to groundwater and fluctuations may be uncertain, but it is apparent the water table is very shallow at the site. Whilst uncertain, the values assumed in the AEE seem reasonable to me.

40. The AEE assumes a seasonal variation in the depth to the water table of 0.5-1.5 m. I see Wellington Regional Council operate a long term groundwater monitoring station (well S27/0330) located approximately 1.8 km east of the site and closer to Tauherenikau River. The difference in historic maximum and minimum levels at that site is 1.25 m, so close to what has been assumed for the site.

41. The actual depth to the water table is reported to be as shallow as 0.88 m below ground level, based on a spot measurement, apparently made in winter. In the groundwater mounding assessment it is predicted irrigation may effect a water table rise of between 1 – 1.35 m. It is reported that whilst in summer when the water table is generally lower the aquifer will be able to accommodate this rise, in winter there is potential ponding effects (flooding with groundwater) will occur.

42. I harbour some reservations over the accuracy of the mounding assessment that stems from uncertainty in assumptions regarding the hydraulic gradient, but more importantly the hydraulic conductivities for the shallow aquifer. In the groundwater mounding assessment, GWS Ltd. assumed a hydraulic gradient of 0.003 to 0.005 - the gradient of 0.005 being the gradient of 1:180 reported by LEI (2017). A value of 0.3 was assumed for the vertical anisotropy - that is ratio of vertical permeability to horizontal permeability. Conceptually, these values will affect the ability of irrigation water to dissipate from the site.

43. Regarding the gradient, it would be better if it had been estimated from a piezometric survey of more shallow wells in the vicinity of the site. Reliance on data from two one-off surveys from wells sited in locations that do not permit good triangulation and which have demonstrated different results each time they have been surveyed seems poor practice. I have tried to source piezometric data from the Wellington Regional Council public records to correct for this.

44. From what I can assess the regional piezometric gradient in this area is I likely to be in the realm of 0.005 – 0.007. On this basis, I relax my concern and believe GWS Ltd. is close to the mark with their assumption.

45. Regarding the assumptions of the hydraulic properties of the receiving aquifer. According to GNS' Geology Qmap (see my Figure 3, below) the site is underlain by gravel alluvium associated with the Tauherenikau fan and which was deposited at the end of the last ice age (Q2).

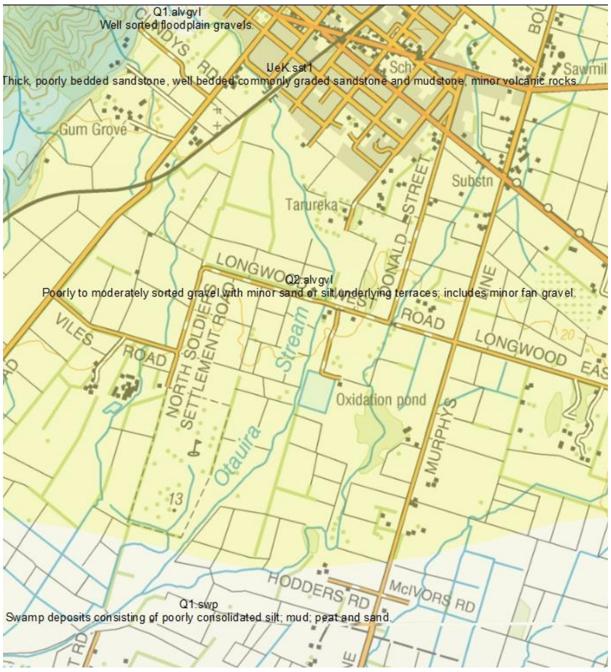

Figure 2: NZ geological map (GNS QMap) of the area of interest showing site is underlain by alluvial gravels deposited during the last ice age.

46. When calibrating a groundwater model of the Lower Waiarapa valley, WRC (2010) determined the horizontal hydraulic conductivity K_h of sediments of the Lower Tauherenikau fan to be in the range 16.4-17.3 metres/day (see Table 1 appended below). A value of 12 metres/day is assumed in the AEE. It is in the right ball park and I accept suitable for the purpose evaluating groundwater mounding effects.

47. What I disagree with however is the assumption made in the groundwater mounding assessment re: the vertical hydraulic conductivity being 30% of the value of the horizontal hydraulic conductivity. This seems unjustified, and is likely to be erroneous.

48. Considering the shallow aquifer under the site comprises alluvium, one would expect it to be more anisotropic than what GWS Ltd. suggest, owing to its hydrostratigraphic structure.

49. Normal 'text-book' values for the anisotropy ratio for $K_{vertical}/K_{horizontal}$ are 1/100 or 1%. More reasoning needs to be given for use of a value of 30% in the AEE. This reasoning ideally should include an evaluation of the predictive uncertainty associated with this modelling assumption.

50. I note that the simplified analytical groundwater mounding model of Hantush (1967) assumes isotropic conditions, consequently the water table rise is not affected by the vertical hydraulic conductivity, so errors in the assumption of K_v/K_h should not affect its prediction. Focus should be on predictions made from the more advanced physical-based models SEEP/W and MODFLOW that emulate anisotropic effects.

51. Intuitively, one would assume anisotropic effects have potential to increase the mounding potential from what has been predicted so far.

52. There are three problems I see stem from the potential for fully saturated subsurface conditions occurring. Two are human health related; the other an operational issue.

53. Firstly - and note, this is not a groundwater technical issue per se, but I raise it anyway - if the mounding does create ponded water (irrigated effluent) this is a health hazard through increasing risk of exposure to the wastewater. How the health risk from this is any different from the fact the oxidation ponds themselves are open bodies of the same quality water, I cannot comment.

54. Secondly, if, on occasion, the ground is fully saturated and there is no vadose zone then a conservative assumption would be to assume that on occasion a direct hydraulic connection of effluent with groundwater might inadvertently occur. The natural attenuation of contaminants (pathogens) in the percolating wastewater will be compromised as they will migrate downstream and increase risk of exposure to water wells.

55. The third issue associated with the groundwater mounding is the ability to irrigate. In Section 4.8 of the AEE written by LEI (2017) it is stated a criterion of the consent condition is irrigation to land will not occur if the water table is within 1 m of the ground surface. Since GWS Ltd. predict there will be periods when the water table breaks the land surface due to mounding effects, this would imply there will be periods when irrigation cannot occur. The frequency of such events is not assessed and therefore it is questionable how practicable the deferred irrigation proposal will be.

MANAGEMENT OF ANY ADVERSE EFFECTS

56. Regarding the adverse effects noted above. To me it seems prudent that the activity status of the 7 bores the AEE identifies as being sited within 2 km down-gradient of the disposal field (which includes well S27/0080 I refer to above) be formally identified. The vulnerability of and risk of contamination of these well waters can then be assessed objectively. In particular, it

should be identified whether the wells are used for potable domestic supply or not and if so, whether groundwater is treated before use, for this impacts on the level of risk.

57. The potential for groundwater mounding effects to impose on the operation of the proposed deferred deficit irrigation practice could be assessed better. Assuming the criterion of no-irrigation to be exercised if the water table is within 1 m of the ground level is accepted in the consent conditions then regulation of this rule will require some thoughtful consideration. Notably, water table depths should be monitored at locations where they are naturally shallowest (e.g. in dips) and ideally at more than one location across the disposal field.

APPENDIX

Table 1: Extract from Wellington Regional Council Report GW/EMI-T-10/75 (Wairarapa Valley Groundwater Resource Investigation Lower Valley Catchment Hydrogeology and Modelling, November 2010). Hydraulic conductivity values of alluvial deposits under Featherstone WWTP are highlighted, as calibrated in the groundwater model. Note the 'text-book' assumption vertical hydraulic conductivity is 1% of horizontal hydraulic. In the AEE groundwater mounding assessment it has been assumed K_z/K_h = 30%.

Table 11.10: Calibrated parameters for hydrostratigraphic unit A (alluvial fan deposits) of the Lower Valley transient groundwater flow model (Kx – horizontal hydraulic conductivity, Kz – vertical hydraulic conductivity, St – specific yield, Ss – specific storage, It – transfer rate in, Ot – transfer rate out)

Zone	Parameter	Location	Layers	Adjustable, fixed or tied parameter in final PEST run	Calibrated value with upper and lower 95% confidence limits for adjustable parameter
Horizontal hydraulic conductivity (Kx) unit: m/day					
1	Kx	Upper Tauherenikau fan	1–10	adjustable	9.8 (9.37 – 10.2)
2	Kx	Mid-lower Tauherenikau fan	1–7	adjustable	16.8 (16.4 – 17.3)
92	Kx	Tauherenikau fan	8–11	adjustable	15.35 (14.8 – 15.9)
93	Kx	Tauherenikau fan	12–17	adjustable	13.35 (13.0 – 13.7)
Vertical hydraulic conductivity (Kx) unit: m/day					
0	Kz	All areas	1–17	fixed	0.01 * Kx