BEFORE THE HEARINGS PANEL APPOINTED BY CANTERBURY REGIONAL COUNCIL

UNDER	the Resource Management Act 1991 (RMA)
AND	
IN THE MATTER	of an application by Canterbury Regional Council for resouce consents CRC222040, CRC222041 and CRC222043 to discharge agrichemicals to rivers and their connected waterbodies, air and the coastal marine area, and the clearance of vegetation, for the purposes of weed management to provide flood, erosion, drainage and river enhancement works.

STATEMENT OF EVIDENCE OF MARTA SCOTT ON BEHALF OF CANTERBURY REGIONAL COUNCIL (APPLICANT)

7 March 2024

SUMMARY STATEMENT

There is some evidence that glyphosate and to a lesser degree triclopyr are able to migrate through soil and enter groundwater. Their transport within highly permeable gravel aquifers encountered in Canterbury is uncertain. Some of the uncertainty could be addressed through targeted sampling. The drinking water limits applied to glyphosate and triclopyr vary internationally. Maintaining separation distances between herbicide application and drinking-water wells and timing of applications during dry weather when there is no groundwater recharge would reduce the risk to drinking water supplies.

Introduction

1 My name is Marta Scott. I am employed as a Senior Scientist – Groundwater at the Canterbury Regional Council (**Regional Council**).

Qualifications and Experience

2 I hold a Master of Environmental Engineering from The University of Melbourne. I also have a Bachelor of Science degree with majors in Organic Chemistry and Biochemistry from The University of Adelaide and a PhD in Organic Chemistry from The Australian National University.

3 I have been within the groundwater team at the Regional Council since May 2011.

4 My work at Canterbury Regional Council includes investigating, monitoring, data analysis and reporting on the chemical and microbiological quality of groundwater in the region. I also provide technical advice for a variety of consents where discharges may lead to contaminants entering groundwater.

Code of Conduct

5 I can confirm that I have read and am familiar with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023. I have complied with the Code of Conduct in preparing this evidence and I agree to comply with it while giving any oral evidence during this hearing. Except where I state that I am relying on the evidence of another person, my 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.

6 Although I am employed by the Regional Council, I am conscious that in giving evidence in an expert capacity that my overriding duty is to the Hearings Panel.

Scope of evidence

7 I have been asked to provide evidence on behalf of the applicant to inform resource consent applications to discharge agrichemicals and clear vegetation.

8 My evidence addresses matters under the following headings:

(a) Application summary

(b) Receptors

(c) Drinking water guidelines

(d) Herbicide movement through soil

(e) Herbicide movement in groundwater

(f) Timing of herbicide application

(g) Proposed consent conditions, as relevant to my field of expertise.

9 Such evidence is within my area of expertise.

10 In preparing my evidence I have reviewed the relevant sections of following documents:

(a) The application and assessment of environmental effects submitted by the applicant;

(b) Three requests for further information and their responses.

(c) Evidence of Duncan Peter Gray

(d) Evidence of Neil Malcolm Thomas

(e) Publications from scientific journals or national and international agencies as cited in my evidence.

Application Summary

11 My understanding is that the Regional Council is seeking to renew a comprehensive consent to spray agrichemicals within and adjacent to watercourses including rivers, small waterways and drains within the Canterbury Region. This proposal seeks a consent to discharge two listed agrichemicals (glyphosate and triclopyr) and **any others** later deemed fit for purpose with improved outcomes. The Regional Council is not seeking to renew the use of diquat, I have therefore not considered this herbicide.

12 The consent is proposed to cover any river, stream or waterbody within Canterbury and includes spraying of water, dry riverbeds, tracks, stopbanks and berms. This consent also seeks to allow agrichemical spraying within community drinking water protection zones.

Receptors

13 Potential contaminants applied into or onto land or waterbodies may infiltrate with water that recharges to groundwater. Once contaminants enter groundwater, they may be transported some distance away from their source, depending on aquifer characteristics, mobility of the contaminants and how readily they degrade. Possible receptors of groundwater contaminants are Stygofauna, biota in springs and any people who rely on the groundwater as their drinking-water supply. Duncan Gray has provided comments on potential impacts on Stygofauna and spring biota, and I have only considered drinking water use.

14 As well as community supply wells, which have protection zones mapped, private wells which supply drinking water should also be considered.

Drinking water guidelines

Glyphosate

15 Worldwide there is considerable controversy around the use and safety of glyphosate. The European Commission recently renewed glyphosate approval, despite its member states failing to reach an agreement for its continued use. Some countries have restricted or banned the use of glyphosate.

16 The WHO Recommended Classification of Pesticides by Hazard (2019) lists glyphosate as Class III pesticide which is slightly hazardous. It lists an LD_{50} value of 4,230 mg/kg.

17 The International Agency for Research on Cancer (World Health Organisation's cancer research group) has classified glyphosate as probably carcinogenic (Group 2A).

18 Although WHO has derived a health-based value for glyphosate of 0.9 mg/L, they have not set a drinking water standard because glyphosate concentrations in drinking water are typically orders of magnitude lower than 0.9 mg/L.

19 In the European Union, the Drinking Water Directive (Council Directive 2020/2184) specifies a parametric value for any pesticide (which includes herbicides, and their metabolites), at 0.1 μg/L (i.e. 0.0001 mg/L) and a total concentration for all pesticides at 0.5 μg/L (i.e. 0.0005 mg/L).

20 US EPA, set a maximum contaminant level (enforceable limit) of glyphosate in drinking water at 0.7 mg/L because of potential kidney problems and reproductive difficulties.

21 Canada set a maximum acceptable concentration for glyphosate in drinking water at 0.28 mg/L whereas Australia has set it at 1.0 mg/L.

22 New Zealand does not currently have a drinking water limit for glyphosate.

23 Canterbury Land and Water Regional Plan has set standards for glyphosate in receiving water of 0.37 mg/L, 1.2 mg/L and 2.0 mg/L for 99%, 95% and 90% species level of protection. There is no specific limit set for drinking water in the plan.

Triclopyr

24 The WHO Recommended Classification of Pesticides by Hazard (2019) lists triclopyr as Class II pesticide which is moderately hazardous. It lists an LD_{50} value of 710 mg/kg.

25 WHO has not set a drinking water standard for triclopyr.

26 US EPA has not set a maximum contaminant level for triclopyr in drinking water.

27 Canada set not set a maximum acceptable concentration for triclopyr in drinking water but in Australia it was set at 0.02 mg/L.

28 As above, in the European Union, the Drinking Water Directive (Council Directive 2020/2184) specifies a parametric value for any pesticide (and

their metabolites), at 0.0001 mg/L and a total concentration for all pesticides at 0.0005 mg/L.

29 In New Zealand the health-based maximum acceptable value (MAV) for triclopyr in drinking water is 0.1 mg/L.

30 Schedule 8 of the Canterbury Land and Water Regional Plan sets a regional groundwater limit of <50% MAV for 'other contaminants', and as such a limit for triclopyr is 0.05 mg/L.

Other chemicals

31 No specific new chemicals have been provided by the applicant so these will need to be assessed by a prescribed process.

32 I am comfortable that the proposed process which includes obtaining subject matter expert opinion, including engagement with Regional Councils groundwater team (via Science Manager), and acceptance of only EPA approved agrichemicals, provides confidence that any new agrichemical would be adequately reviewed prior to use.

Herbicide movement through soil

Glyphosate

33 Glyphosate isopropylamine and glyphosate monoammonium appear to be the two most commonly used forms of glyphosate.

34 According to US EPA CompTox Chemicals Dashboard (accessed online 2023), the water solubility of glyphosate isopropylamine is 2.98 mol/L, which is equivalent to about 678 g/L. US EPA CompTox (accessed online 2023) indicates glyphosate monoammonium has water solubility of about 6.93 mol/L, which is about 1,290 g/L. Another online source (National Pesticide Information Centre, accessed online 2023) indicates that solubility for glyphosate isopropylamine salt (at pH 4.06) is 786 g/L and for glyphosate ammonium salt is 144 g/L (at pH 3.2). These values indicate that glyphosate solubility in water is high.

35 Soil adsorption coefficient (organic carbon-water partitioning coefficient, K_{oc}) is a ratio of mass of a chemical that is adsorbed in the soil per unit mass of organic carbon to its concentration in dilute aqueous solution, at equilibrium. US EPA CompTox lists K_{oc} of glyphosate in its two common forms as having a high K_{oc} of $2.09e^{+3}$ L/kg, which means that they bind

strongly to soils. It is this property of binding strongly to soil that generally limits glyphosate leaching to groundwater, despite its high water solubility.

36 Strong sorption to soil particles reduces the risk of leaching but on the other hand it often retards the degradation of the herbicide and can lead to its accumulation in soil (Laitinen, 2009). Glyphosate is initially degraded to AMPA (aminomethylphosphonic acid), which has similar toxicity.

37 US EPA CompTox lists K_{oc} of AMPA at 4.17 L/kg, which is lower than for glyphosate and indicates it may be more prone to leaching.

38 Scientific publications refer to a concept of 'aged' glyphosate, which means that glyphosate becomes bound to the soil. Some aged glyphosate can become irreversibly bound (Laitinen, 2009). It is not clear what fraction can be irreversibly bound and this is likely to depend on soil types and climatic conditions.

39 Herbicides can be transported in water as solutes (dissolved form) or bonded to soil colloids (very small particles that are carried by the water). Both forms can be transported through the soil to the subsurface and into groundwater (Laitinen, 2009).

40 The US National Pesticide Information Centre[1] (accessed online 2023) report that in soils the half-life of glyphosate in various studies was 2 to 197 days with a typical value of 47 days. In water the half-life varied from a few days to 91 days. A review by Suwardji and Sudantha (2021) indicated a highly variable half-life of glyphosate in soils. In one study the half-life of the soluble phase was only about one week but the soil sorbed phase ranged from 7 months to 6 years. The authors concluded that considerable differences between studies are likely to be due to the strength of sorption that renders glyphosate unavailable for decomposition in some soils.

41 Bento (2018) studied the persistence of glyphosate and AMPA in loess soils under different combinations of temperature, soil moisture and sunlight. For glyphosate they reported dissipation time DT_{50} of between 1.5 and 53.5 days and DT_{90} of between 8.0 and 280 days. For AMPA they reported DT_{50} of between 26.4 and 44.5 days and DT_{90} of between 87.8 and 148 days. Given the high prevalence of silty soils in Canterbury, these

[1] A collaboration between experts from the US EPA and Oregon State University.

results may be used to design groundwater monitoring for glyphosate and AMPA.

42 Suwardji and Sudantha (2021) summarises what is known about glyphosate binding to soils. At low glyphosate concentrations adsorption occurs through interaction with iron (and/or aluminium), in a process similar to binding of phosphate fertiliser. At high glyphosate concentrations, hydrogen bonding can occur with glyphosate molecules already adsorbed onto iron and/or aluminium. Glyphosate competes with phosphate fertiliser for the same sorption sites so high concentrations of soil phosphate could result in more glyphosate leaching.

43 I have found some studies that could be relevant to the expected behaviour of glyphosate in alluvial gravel environments and variable rainfall conditions that are common across Canterbury. Barrett and McBride (2007) showed that glyphosate may leach to a limited degree from coarse-textured soils and can be exchanged for phosphate. Strange-Hansen *et al.* (2004) looked at glyphosate leaching upon application to different gravel columns. They noted lower binding in gravels compared with soils, but the lower degree of binding allowed higher degradation rates. The authors noted highest dissolved glyphosate concentrations moving through rounded gravels after the first rain event.

44 Milan *et al.* (2022) also concluded that leaching of glyphosate and AMPA is effectively event-driven especially in the first rainfall event after application. They detected glyphosate even if leaching occurred 30 days after glyphosate application. They noted that rainfall shortly after application may result in glyphosate leaching, particularly if the soils were initially dry. If there is a delay in initial rainfall, then AMPA may form, and this may be leached during subsequent rainfall events. This is consistent with our general understanding of contaminant transport in Canterbury, where rainfall is often the driver for higher contaminant concentrations in groundwater. In a field site study in Denmark, glyphosate, was found to transport deep into the soil and leach out with drainage water (Kjaer *et al.*, 2003).

45 While I agree with Mr Thomas that in theory glyphosate and is strongly sorbed to soils, there is sufficient evidence to suggest that some leaching of glyphosate and AMPA occurs. Certain soil types and environmental conditions may provide more favourable conditions for leaching.

46 With the assumption that glyphosate binding to soil is similar to that of phosphate fertiliser, a GIS layer that we have available (Phosphorus Leaching Vulnerability) could be utilised when preparing annual plans for agrichemical spraying. Some areas may also be prone to bypass flow even if they have low vulnerability of leaching phosphorus. A GIS layer (Vulnerability to bypass flow) for bypass flow is also available. Areas near private drinking-water wells and community supply wells that have high phosphorus leaching risks or high bypass flow risks should be carefully managed during spraying with glyphosate.

Triclopyr

47 The two most commonly used forms of triclopyr used are triethylamine (TEA) salt and butoxyethyl ester (BEE). Currently, only triclopyr BEE is used by the Regional Council as there is limited availability of triclopyr TEA in New Zealand.

48 According to US EPA CompTox the water solubility of triclopyr TEA is $3.13e^{-3}$ mol/L, which is equivalent to about 1.1 g/L. US EPA CompTox report water solubility of triclopyr BEE at $3.1e^{-5}$ mol/L which is equivalent to 0.011 g/L. I note that Montague *et al.* (2019) state very different solubility for triclopyr TEA of 412 g/L. For triclopyr BEE solubility of 0.0074 g/L is similar to the CompTox value. There isn't much consistency in values reported by various online sources, and I do not have original references to check for any obvious differences (e.g. pH) in different studies.

49 According to US EPA CompTox, triclopyr BEE soil adsorption coefficient (Koc of $1.62e^{+3}$ L/kg) is similar to that of glyphosate, while triclopyr TEA (Koc of 46.8 L/kg) has a lower adsorption coefficient. Binding of triclopyr to soils increases if they are 'aged' (Compliance services international, 2001). Freshly applied triclopyr is therefore more likely to leach, particularly if rainfall occurs shortly after application.

50 Microbial degradation is the main pathway for reduction of triclopyr and is reported to be quite rapid in aerobic soils due to its low adsorption (Compliance services international, 2001). Reported half-life in soils are variable and may depend on temperature, soil pH, organic matter content, microbial numbers and aeration of soil. Compliance services international (2001) report half-lives of less than 1 day to about 1 year. Higher temperature and lower water content lowered the half-life in one study.

This study also indicated a lag of 14 to 28 days before rapid dissipation occurred. Triclopyr is readily degraded by sunlight, while glyphosate is not.

51 While the mechanism of binding to soils is not specifically described by Compliance services international (2001), they hypothesised that hydrogen bonding is involved.

52 Mr Thomas highlighted that a New Zealand study noted some leaching of triclopyr through allophanic soils. Allophanic soils are not common throughout Canterbury, so I am uncertain if any triclopyr spraying occurs on such soils within Canterbury. However, there is uncertainty around triclopyr leaching on more typical Canterbury soils particularly in areas with very thin soils.

53 Mr Thomas identified that areas away from rivers, for example stopbanks, access tracks and berms are likely to present the greatest risk to groundwater due to lower dilution from rivers. I partly agree with this assessment as areas near large, braided rivers may provide additional dilution to groundwater. However, near smaller spring-fed streams or drains the groundwater flow direction would be towards those water bodies and hence dilution of nearby groundwater may not occur. The areas near large rivers may also have very thin soils that may be more prone to herbicide leaching.

Herbicide movement through groundwater

54 There is a large body of literature on herbicides in the freshwater environment and I haven’t conducted a detailed review of these publications. But I have looked for some examples where glyphosate and triclopyr were detected in groundwater, to show that this is a possibility.

Glyphosate

55 Cederlund (2022) reported a study that monitored groundwater for glyphosate under Swedish railways. Glyphosate was detected in 16% of samples, and 6% exceeded the EU groundwater standard of 0.1 μg/L. AMPA was detected in 14% of samples and 4% exceeded the EU groundwater standard. The authors reported limited horizonal spreading. They noted that detections in groundwater often occurred 3-4 months after application rather than a few days after and concluded that later conditions

were more conductive to leaching. This agrees with our understanding of contaminant transport into groundwater, which is often driven by rainfall events that result in recharge. The geology at the sites studied had a higher dominance of silts, clays and sand compared with Canterbury gravel. It is possible that, as with other contaminants, glyphosate could potentially travel faster and further in Canterbury aquifers, especially via open framework gravel channels.

56 Campanale *et al.* (2022) reviewed a study by Van Stempvoort *et al.* (2016) from Canada where the authors investigated the occurrence of glyphosate and AMPA in shallow groundwater. The presence of the herbicides was detected in 5 to 10.5% of samples, depending on the season. The maximum concentration of about 0.7 µg/L (or 0.0007 mg/L) was below the Canadian drinking water guidelines. The authors also detected glyphosate in precipitation samples, indicating atmospheric transport is possible. They concluded that glyphosate and AMPA are persistent enough to allow groundwater to store and transmit glyphosate residues to surface waters.

57 These studies indicate that there is a possibility of contaminating groundwater with glyphosate and our understanding of Canterbury gravel aquifers is that they are prone to contamination and can transmit contaminants over long distances. If glyphosate enters groundwater, the presence of finer sediments in the gravel matrix could allow for glyphosate to bind, however there is considerable heterogeneity within our aquifers and more permeable channels can transport groundwater and contaminants rapidly over distances of tens to hundreds of metres.

58 There has been very little testing for glyphosate in Canterbury groundwater and to my knowledge only 6 wells have been tested for glyphosate and AMPA. The 6 wells were part of a 2018 New Zealand wide survey of groundwater in which one well from 135 sampled had a glyphosate detection (Close and Humphries, 2019). None of the Canterbury wells had any glyphosate present above the laboratory detection level. Because the soils and geology vary throughout New Zealand, the national detection rate cannot necessarily be extrapolated to Canterbury. Furthermore, the sampling was not targeted at sites where glyphosate was necessarily used nearby.

59 We carried out a pesticide survey in Canterbury in 2018-2019 (Scott, 2019), where 77 wells were sampled. Unfortunately, due to high analytical

costs, glyphosate was not part of this survey, but 34% (26 out of 77) wells had measurable detections of various pesticides. The national detection rate was 24.4%. This highlights the vulnerability of Canterbury groundwater to contamination.

Triclopyr

60 Detections of triclopyr in groundwater are rare. EFSA (2005) report that in a study in Germany, triclopyr was not detected in over 500 groundwater samples. EFSA (2005) report that it was detected in 11 sites from 1683 groundwater samples in a UK study. Only one of the detections was above 0.1 µg/L.

61 In the US (Emmett and Morgan, 2004), there were 5 detections from 379 wells which were sampled with the highest concentration being 0.58 µg/L.

62 The Regional Council tested for triclopyr in the 2018-2019 regional survey of pesticides in Canterbury groundwater and there were no detections in any of the 77 samples. However, it is uncertain whether this herbicide was used near any of the sampling sites. It was also not detected in the New Zealand wide surveys in 2018 or in 2022.

Timing of herbicide application

63 I note that the spraying for braided rivers typically occurs in March or April and for drainage networks between October and March. However, stopbank, berm and track maintenance occur throughout the year. Contaminant entry to groundwater is typically driven by recharge events. These typically occur through winter when soil moisture levels are high but may also occur at other times of the year, following significant rainfall.

64 I recommend that spraying areas in close proximity to any community or private water supplies is avoided in winter and at other times of the year when high rainfall events are predicted. Small amounts of rainfall may not necessarily result in the herbicide entering groundwater.

Proposed consent conditions, as relevant to my field of expertise

65 I note that one proposed condition states: “Agrichemical discharge shall only be carried out where there are no practical alternatives to vegetation management (as identified in the Agrichemical Strategic Management Plan).” However, other parts of the application suggest that many of the

non-chemical methods are cost-prohibitive and therefore agrichemical spraying is likely to continue into the foreseeable future.

66 The conditions focus on surface water intakes for community supplies. These are high risk sites, but there are also groundwater galleries, community wells and private wells that need to be considered in the assessment carried out prior to spraying. Assistance from the groundwater science team could be requested as part of the annual plan of works.

67 There is a proposed condition to monitor surface water for glyphosate and triclopyr after reasonable mixing. It was indicated in the AEE that the previous 2 years of monitoring had not detected these herbicides above their detection limits.

68 There is no proposal to monitor groundwater. Groundwater may offer less mixing than surface water over the same distance. I agree with PDP that there is potential for groundwater monitoring to detect effects from other sources such as from application of these herbicides on farms or as other permitted activities. However, any herbicide detection, could improve our understanding of herbicide travel to and within Canterbury groundwater. Without additional sampling, there will continue to be significant uncertainty.

69 I recommend that the Regional Council undertakes some targeted monitoring near the herbicide application sites to inform our general understanding. If the monitoring is designed with the expertise of groundwater scientists and the herbicides are not detected, then the monitoring could cease. Sampling should focus on shallow wells downgradient from herbicide application. Ideally, the sampling would occur shortly after application and following first significant rainfall.

70 Mr Thomas carried out some modelling and based on this, he recommended to use a separation distance of 50 m for spraying of herbicides near shallow wells (less than 20 m deep). I agree with this suggested buffer distance to drinking water wells. This is also consistent with the separation distances used for other discharges in the Canterbury Land and Water Regional Plan. However, I think that this should only apply to drinking water wells and not to wells used for other purposes. For other wells, a 5 m buffer that protects from contamination around the well

could be sufficient. Additionally, public supply wells of any depth should have a 50 m buffer applied as a precaution.

71 Targeted sampling could further improve our understanding of herbicide movement in Canterbury groundwater and would allow us to set better informed separation distances in the future.

72 There is no Maximum Acceptable Value for Glyphosate in drinking water in New Zealand. Selected countries that I considered have set limits of between 0.0001 mg/L and 1 mg/L.

73 New Zealand has set a Maximum Acceptable Value for triclopyr in drinking water of 0.1 mg/L. Selected countries that I considered have set limits of 0.0001 mg/L and 0.02 mg/L whilst others have not set any limits.

74 The limits proposed by the applicant for receiving waters after resonable mixing are 0.1 mg/L for glyphosate and 0.01 mg/L for triclopyr. The applicant has not proposed any groundwater sampling but if it is carried out then I recommend adopting the same limits for groundwater.

75 Spraying of chemicals onto gravely areas, without topsoil should be avoided in close proximity to drinking water wells.

Conclusion

76 I am not aware of any reported detection of glyphosate or triclopyr from groundwater samples collected in Canterbury, however there is uncertainty around the transport of glyphosate and triclopyr into and within Canterbury groundwater. Some of this uncertainty could be addressed through targeted sampling. A precautionary approach to drinking water limits may need to be applied due to significant differences in established international limits.

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Dated 7 March 2024

Marta Scott