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TO	Fulton Hogan **Attention**: Don Chittock
FROM	Victor Mthamo
DATE	10 March 2019
FILE	Fulton Hogan
SUBJECT	**Roydon Quarry RFI Response**

☒ **Memo RFI Response**

☐ For Information Only

☐ For Your Action

1. Introduction

Reeftide has prepared a response to one of the RFIs for the consent application CRC192410. The RFI states that:

"14 Site Rehabilitation

14.2 The activities proposed will remove topsoil over a large area (up to 40ha at a time) and remove up to 9.9 metres, of unsaturated zone above groundwater. This removes some of the natural protection for the groundwater system against microbial, heavy metal and hydrocarbon contaminants. Even after rehabilitation at the site, it is unlikely the site will be restored to its original elevation.

a) Please provide an assessment of actual and potential effects of the changes noted above (removal of large areas of topsoil and up to 9.9 metres of unsaturated zone above groundwater) on the vulnerability of groundwater to contamination. This assessment should include any increase in risk to down gradient groundwater users and the appropriateness of post-closure land uses.

b) Have conditions requiring a bond or covenant relating to site rehabilitation and land use post quarry been considered? If so, will such conditions be proposed?"

Below is an assessment of environmental effects to supply the requirements of Section 14 of the ECan/SDC RFI dated 21 December 2018.

2. Assessment of Environmental Effects

2.1. Effects of Stormwater from Buildings, Roads etc

Stormwater management within the site is described in Section 4.5.4 and an assessment of effects is provided in Section 6.2.3.4 of the consent application. In summary, stormwater from roofs on the site will be routed to storage.

The following sections provide additional assessment of the actual and potential effects of stormwater on the receiving environment.

2.1.1. Effects of Roof Stormwater

Roof water is considered to be "clean" and will be conveyed via a sealed system designed to prevent the entry of surface stormwater runoff. The normal concentrations of contaminants such as zinc and organic matter in roofing stormwater are such that there are not usually any significant adverse effects on the groundwater quality.

Therefore, the potential effects on groundwater quality arising from stormwater discharge from the roof areas will be no more than minor.

2.1.2. Effects of Hardstanding Stormwater

Hardstanding stormwater from car parking lots will be conveyed to infiltration basins to remove sediment prior to infiltration to ground.

The estimated mean contaminant loadings for urban stormwater sources based on Event Median Concentration (EMC) are summarised in Table 1 below. Given the lower traffic volumes, the limited operational hours etc the quarry contaminant levels have been conservatively been assumed to be at least 50% less than the urban concentrations.

Table 1 - Estimated Mean Contaminant Loadings

Contaminant	TSS (mg/L)	BOD (mg/L)	Zn (mg/L)	Cu (mg/L)	Pb (mg/L)	Hydrocarbons (mg/L)
Urban Areas	170[2][1]	9[3]	0.19[2]	0.023[2]	0.095[2]	2[3]
Suggested for the Quarry (at least 50% less than Urban	85	4.5	0.1	0.012	0.043	1[3]

[1] *Kingett Mitchell Ltd (2005)*
[2] *NZTA (2009)*
[3] *Williamson (1993)*

The proposed stormwater management system (detailed in the application) will ensure treatment and removal of contaminants. Further polishing of the stormwater will occur through the rehabilitated soil matrix and the >1 m of gravel above the groundwater table.

Infiltration ponds will be installed which will be lined with soils. Table 2 includes a summary of the efficiency of contaminant removal by the infiltration ponds (refer to as 'soakage pit and underlying soil treatment' in Table 2) and the expected performance. The removal efficiencies cited are taken from the Ministry for the Environment (MfE) On-Site Stormwater Management Guideline (NZWERF, 2004).

Table 2: Estimated Treatment and Water Quality Outcome

Parameter	Stormwater Concentration (mg/L)	Sumps and the Oil & Grit Interceptor (%)	Soakage Pit and underlying Soil Treatment (%)	Minimum Treatment Outcome (mg/L)	Guideline Values (mg/L)
TSS	85	40	90	5.1	50
BOD	4.5	20	90	0.36	-
Zn	0.1	N/A	85	0.015	30
Cu	0.012	N/A	85	0.0018	40
Pb	0.043	N/A	85	0.00645	0.2
Hydro-carbons	1	>75	>75	0.0625	TPH C_7-C_9 = 360 TPH C_{10}-C_{14} = 7

Given the low contaminant concentrations after treatment, it is considered that the impact on groundwater will be no more than minor.

2.1.3. Effects of Nitrates

During quarrying there will be little or no sources for nitrates as the existing landuse (animal grazing) will be discontinued within the working quarry area, which means there will be no nitrate fertiliser applications or nitrogen fixation. There will also be little or no vegetation which could potentially fix nitrogen. The concentrations of nitrates reaching groundwater is expected to be even lower as various nitrogen cycle processes (e.g. denitrification and volatilization) will also reduce the concentrations. Therefore, it is expected that the nitrogen concentrations will be negligible and is not expected to add to the baseline groundwater nitrogen concentration of 8.4 g/m^3.

It is, therefore, concluded that nitrogen discharge as a result of the activity will not be of any concern.

2.1.4. Effects of Pathogens

Table 3 contains median ranges of concentrations of common pathogenic indicator organisms in urban stormwater runoff derived from data collected in New Zealand (NZWERF (2004)), Australia Canada and the USA. There is no specific data for quarries and therefore these median values have been adopted as a proxy. It is expected that the applicant's operations will be of a lower contaminant nature.

Table 3 - Median concentrations of Faecal Coliforms and Streptococci in Stormwater[1]

Faecal Coliforms MPN/100 ml	Faecal Streptococci MPN/100 ml
4,200	11,000

The values in Table 3 are very conservative when applied to the quarry. It is expected that the concentrations in the quarry will be considerably lower (up to 90% lower) than the reported values.

According to a study by the Florida University (IFAS)[2]

"*when at least two feet of unsaturated soil exist between the infiltration system and the water table, BOD_5 removals of >90%, TSS removals of >95% and faecal coliform reductions of > 99% can be expected for a functional and properly maintained septic tank. Bacteria and viruses are effectively removed by adsorption and sorption processes in the ground water and are not transported far from the source*"

In addition to the IFAS study noted above, a number of studies also show that the passage of treated wastewater through the soil at a low rate and intermittently will enhance the natural pathogen die-off and reduce the number eventually transported into ground/surface water. The main mechanisms that operate within the soil matrix to ensure pathogen removal are filtration, adsorption and natural attrition. Results from various studies[3] [4] show virus reductions of 99.99% through 0.6 m of 0.12 mm diameter sand and bacteria reductions of 99.998% through 0.9 m of 0.15 mm diameter dune sand, with 92 to 97% reduction occurring in the top one centimetre.

NZWERF (2004) suggests a pathogen removal rate of 90% through soakage system with the removal primarily taking place in the upper soil layers. Generally, there is 1 log reduction for every 100 mm of soil.

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[1] https://www.tandfonline.com/doi/pdf/10.1080/00288330.1985.9516106
IFAS, 1984. Impact of On-Site Sewage Disposal Systems on Surface and Ground Water Quality, November 1984. Prepared by the Institute of Food and Agricultural Sciences Soil Science Department, University of Florida, Gainesville, FL for Florida Department of Health and Rehabilitative Services (HRS)
[3] *Crane S.R. and Moore J.A., (1984): Bacterial Pollution of Groundwater: A Review. Water Air & Soil Pollution 22: 67-83*
[4] *Gunn I., (1997): On-site wastewater systems and bacterial reduction in sub-soil disposal areas: A review. On-Site NewZ Special Report 97/2.*

Overall, the effects of pathogens within the stormwater discharge will be less than minor.

2.2. Effects Hazardous Substance Storage on Groundwater

Section 6.2.3.2 of the application provides a detailed discussion of the effects of the hazardous substances stored within the site on groundwater. As noted in the application there will be some fuel storage within the site. The fuel tanks will be bunded with refuelling to occur adjacent to this tank on a covered concrete refuelling pad.

A spill management plan for the site will be developed and will incorporate the management and inspection of the fuel tank (including fuel reconciliation, spill management and containment and visual inspection of the tank) as well mobile refuelling processes.

Therefore, there will be measures in place to prevent fuel and hydrocarbons from discharging onto the soil and hence movement through the unsaturated soil into the groundwater system. In the event of a spill the response plan and clean up protocol in the Spill Management Plan will be implemented. This is standard procedure across all Fulton Hogan sites.

The resulting groundwater contaminant impact will be similar to what will likely occur in case of contamination caused by the use of machinery and this is discussed in detail in Section 2.3.2. The impact on the groundwater and downstream users will be no more than minor as discussed in detail in Section 2.5.

2.3. Effects of Post Rehabilitation Landuse

A range of post quarrying land uses are discussed at Section 3.7 of the Rehabilitation Management Plan included as Appendix G of the AEE submitted with the application. Any intentions to intensify would require various consents under the Canterbury Regional Council Land and Water Plan. The plan has rules around what is and is not permissible e.g. rules around the quantities of fuel and hazardous substances that can be stored.

The highest risk rural activity would be dairying which is well known for its potential adverse effects on groundwater due to nitrate leaching. Intensive dairying is unlikely to be a feasible landuse option on this land for the following reasons:

- The stock carrying capacity will be very low based on the soil pasture yield making dairy an uneconomic option for the site as the Dry Matter yields (DM) will be low.
- If the pasture demand is 600 kg DM per year per stock unit then the carrying capacity would be 6-15 stock units/ha or a maximum of 2 dairy cows/ha. The only time the rate would be increased was if supplementary feed was provided which again makes the site unsuitable for dairying given the small number of animals that it would be able to accommodate.
- It is unlikely that dairying would comply with the Land and Water Plan rules and more specifically with the rules in the Selwyn Waihora Plan.

The most likely land use post construction based on the currently planning framework would be lifestyle blocks. These are typically accompanied by small animal (e.g. sheep, goats and pigs) rearing and possibly horticultural activities via glasshouses etc. The main risk to groundwater under the circumstances would be nitrates and pathogens depending on the farming practices. The effects of these on the soils and groundwater has been discussed above.

The likely landuses post rehabilitation will not have the kind of adverse effects on groundwater that will have significant effect on soils and the groundwater under the site. Post quarrying land uses are discussed in the draft Rehabilitation Management Plan submitted with the application.

2.4. Risk of Groundwater Contamination

2.4.1. Contamination and Groundwater Quality

The existing landuses in and around the site are described in Section 3.2. The groundwater quality reflects the current landuse above the site and upgradient of the site, groundwater flow patterns and recharge sources. As noted in Section 3.6 of the consent application groundwater flows from northwest to southeast.

Before and during quarrying, it is expected that the main source of contaminants would be hydrocarbons, copper and zinc from vehicular traffic, oil spillage and leaks. The soils will filter these contaminants, before the water infiltrates to groundwater. Furthermore, during quarrying the unsaturated zone depth will be a minimum of 1 m and it is expected that any residual contaminants from the works will be filtered out within the unsaturated zone.

When the target quarrying depth has been achieved, there will be at least 1 m of in-situ gravel between the base of the quarry and the groundwater. The main activities during this stage will be rehabilitation works, which includes restoring the soil profile to allow for the new land use. During rehabilitation the risks are similar to those of the quarry operations. After rehabilitation has been completed, the reinstated soils will provide some level of protection.

2.4.2. Effects of Machinery and Other Activities on Groundwater

The effects of machinery on groundwater during extraction are discussed in detail in Section 6.2.3.1. Below are additional considerations of the possible effects of operating machinery on the groundwater quality.

Source Control

In summary, the applicant will store fuel in bunded containers and will check for and if necessary clean up any spillages (e.g. during plant fuelling activities). The site plant will be maintained to a high level. All earthmoving machinery, pumps, generators and ancillary equipment shall be operated in a manner, which ensures spillages of fuel, oil and similar contaminants are prevented, particularly during refuelling and machinery servicing and maintenance. These mitigatory measures will reduce the possible source component of the source-pathway-receptor linkage.

Pathway

Any spillage on to the surface of the quarry either during extraction of post rehabilitation still has to travel through at least 1 m of in-situ gravel matrix before it reaches the unconfined groundwater system.

The soil and gravel matrix will likely provide some attenuation although it is likely there could be some direct pathways to groundwater or leaching will occur over time if the contaminants are not removed in time resulting in the possible contamination of the groundwater.

The soil is known to have a hydrocarbon retention capacity of 5-20 L/m^3 in gravels and 40-80 L/m^3 in silts (Pastrovich et al., 1979)[5]. Given the comprehensive spill management plan proposed and the operation and maintenance of the equipment spill and leakage volumes are expected to be small and will likely be retained in the soil. Contaminated soils resulting from spills will be removed.

Receptor

As discussed above small spills will be retained in the quarry floor gravels and the rehabilitation soil. Large spills are unlikely given the mitigation measures and the operational procedures proposed for the quarry. However, if they do occur the large spill could result in groundwater contamination.

[5] *De Pastrovich, T.L., Y. Baradat, R. Barthel, A. Chiarelli, and D.R. Fussell, 1979. Protection of ground water from oil pollution, CONCAWE, The Hague, 61 pp.*

The Canterbury Regional Council Technical Report (U02/49)[6] documents groundwater tracer experiments in Canterbury permeable gravel aquifers under different landuses including the activities simulating the release of fuel spillages. The CRC report demonstrated that the tracer concentrations which represented the behaviour of contaminants were reduced several thousand times after travel distances of a few tens of metres. Spillages entering the groundwater system beneath the site would be expected to behave in a similar manner. The concentrations of contaminants will be attenuated within short distances downgradient from the point of discharge into the groundwater.

Given the source control of spillage and the possible attenuation through the soil and gravel matrix, it is considered the impact on groundwater will be mitigated and effect on downstream users will be small.

2.5. Potential Effects on Downgradient Groundwater Users

The RFI also states that "..*assessment should include any increase in risk to down gradient groundwater users*".

Environment Canterbury has a number of reports (e.g. Hansen (2012)[7] and Hayward (2002)[8] that demonstrate the effects of contaminants discharged over the unconfined groundwater aquifer with the West Melton groundwater zone. Some of the studies discuss the old landfills e.g. the Waimairi Landfill. This is an unlined landfill and with no leachate collection system located in western Christchurch. The landfill was operational from 1962 to 1986 when refuse was used to fill the old gravel pits. The reports provide an assessment of the monitoring of groundwater quality down-gradient of several former landfills and indicate that the contaminant plume is limited in lateral extent, with no significant groundwater contamination associated with these landfill areas. The limited extent of contaminants found down hydraulic gradient of these landfills confirms that the ability of the groundwater system to dilute and disperse contaminants quickly to the point that groundwater quality is not significantly affected.

Canterbury Regional Council in 2002**Error! Bookmark not defined.**[9] also concluded that while low concentrations of chemicals were detected in close vicinity to the contamination source and there were no detections 400 m away. The study also noted that there were no incidents of contamination of the numerous shallow groundwater supplies or spring fed streams downgradient of the site.

A consideration of literature on potential assessments and actual effects from landfills indicate that the groundwater quality risks are limited to shallow groundwater within a few hundred metres of the quarry. There may be some localised changes to groundwater quality, but they are at a scale that poses only a low risk of adverse effects on nearby water supply users.

Further assessment of effects on groundwater users is covered in more detail by Golder.

It is considered that the proposed monitoring management regime will mitigate the potential effects.

2.6. Monitoring and Mitigation

Section 9 of the application discusses the monitoring that is proposed. Monitoring of groundwater levels and groundwater chemistry (detailed in Table 8 of the application), as well as overall downgradient areas of the property to detect changes in groundwater chemistry

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[6] *Canterbury Regional Council. 2002. An assessment of the potential risk of groundwater contamination from land use activities in the Christchurch / West Melton recharge zone. U02/49.*

[7] *Hansen, C. 2012: Groundwater Quality, Christchurch – West Melton Zone. Attachment 1 to Clause 8, Christchurch – West Melton Zone Committee Meeting Agenda, 27 September 2012.*

[8] *Hayward, S., 2002: Christchurch – West Melton Groundwater Quality: A review of groundwater quality monitoring data from January 1986 to March 2002. Environment Canterbury Technical Report U02/47.*

[9] *Canterbury Regional Council. 2002. An assessment of the potential risk of groundwater contamination from land use activities in the Christchurch / West Melton recharge zone. U02/49.*

and inform mitigation measures that will be implemented as per the rehabilitation plan. New monitoring wells have been installed and these will be used to check that groundwater trigger levels are not exceeded.

The measures help to ensure that the adverse effects on the groundwater is mitigated.

3. Conclusions

Based on the assessment of environmental effects, the cleanfill methodology and management proposed, the limits to the depth of excavation, management of hazardous substances, stormwater management, the restrictions of the post rehabilitation landuse and monitoring and mitigation proposed, it is considered that the any adverse effects on groundwater from removal of large areas of topsoil and up to 9.9 metres of unsaturated zone above groundwater will be less than minor.

Having regard to landfill contamination studies from with the region, the impact on other groundwater users is expected to be less than minor from the proposed quarry and cleanfill as evidence indicates that the concentrations of various contaminants dissipate within short distances of the point of discharge, even for much higher contaminant sources (i.e. a landfill) and given proposed management and mitigation measures.