Duffill Watts Consulting Group

Masterton District Council
Homebush Wastewater Treatment Plant and Discharge System Upgrade

Technical Review of Discharges to Land for Greater Wellington Regional Council

February 2009

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QUALITY RECORD	Name	Date	Signature
Prepared By:	Jaye Hill Barry Lynch John Lavery Hamish Lowe	February 09	
Reviewed By:	John Lavery	February 09	
Authorised By:	Hamish Lowe	February 09	H. T. Lowe
Revised By:			

Prepared by:

Duffill Watts Consulting Group
Level 3, 89-93 Rangitikei Street
PO Box 562
PALMERSTON NORTH
Phone: (06) 354 4501

Fax: (06) 354 4516
E-mail: palmerstonnorth@duffillwatts.com

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1.0 EXECUTIVE SUMMARY

Duffill Watts Limited has been requested by Greater Wellington Regional Council (GWRC) to undertake a peer review of the current proposal, including resource consent applications, for the upgrade works for the Homebush Wastewater Treatment Plant (HWTP).

There are three aspects to the discharge to land component of the HWTP proposal, being leakage from treatment ponds, leaching from sludge management and the effects of the land application of treated wastewater. The relevant information for each of these aspects has been reviewed, including information prepared by Beca, HortResearch, Landcare and PDP. Conclusions and recommendations are provided, along with suggestions on how the system could be regulated through the adoption of resource consent conditions.

It should be highlighted up front that the proposed HWTP land application system has not been designed to maximise treatment. It will provide some treatment as a result of land passage, but the primary purpose based on the loading rates and system design is a means of discharging water to the receiving environment.

Two aspects of the proposal result in a degree of uncertainly of the effects, being:

- Limitations with the proposed design and management of the system may result in suggested design aspects and operation targets not being met; and
- The assessment of the effects using a theoretical modelling approach based on assumptions has inaccuracies which may result in errors in the predicted effects.

While it is acknowledged that border strip irrigation is a proven (and acceptable) method of effluent discharge, it can only be used efficiently if suitable environmental and management conditions are in place. Many of the recommendations in Section 8 are to provide for the sustainable operation of the border strip operation, and to ensure the predicted outcomes proposed are met.

There are inconsistencies and questions with some of the reporting. Without clarification, it is our view this may have lead to conclusions which are not entirely accurate and have a degree of error. Some of the conclusions rely heavily on parameters such as hydraulic loading, application uniformity and separation depth to groundwater. Actual site limitations, design and management may differ and this could impact on the accuracy of the predictions.

Many of the considerations and issues raised in this report relate to modelled parameters which are used to demonstrate and justify the effects of the proposed operation. In some cases the design parameters are theoretical best practice, and at best hopeful. Reality is these assumptions will not be met, and as a result it brings into question the accuracy of the modelling. For example not achieving a 100 % application uniformity will impact on the leaching potential. However, it should be noted that the modelling and approach used with the modelling is appropriate, with only the design and management assumptions giving rise to the possible inaccuracy.

In many cases the comments raised in this report are not a reflection of the technical quality of the reviewed reports or the capabilities of the team pulling the project together, but rather the evolution process of the project and changing design parameters. There have been many technical reports compiled and in some cases it is unclear if subsequent reports have accurately included the superseded information. For example technical reports (eg HortResearch, 2007) have based predicted outcomes on designs which are now superseded.

Despite the limitations noted in this report, they are not surmountable and it is the opinion of Duffill Watts that a sustainable wastewater discharge system using border strip irrigation can be developed at the HWTP site, providing appropriate design and management criteria are employed. As a result pragmatic approach has been taken to developing consent conditions to assist with ensuring that the design proposed is transferred into operational requirements and the maximum effects predicted during this consenting exercise are not exceeded in the longer term.

2.0 INTRODUCTION

2.1 Background

The Masterton District Council (MDC) has been in the process of developing an upgrade to their Homebush Road wastewater treatment plant since a long term strategy for wastewater was prepared in 1994. In November 2007 Duffill Watts was engaged by Greater Wellington Regional Council (GWRC) to undertake a peer review of the proposed land application scheme, as sought by resource consents lodged with GWRC (May 2007).

As part of the review Duffill Watts undertook a site inspection of the proposed land application area and existing ponds in late 2007. Comments on the proposed system, including comments on the initial application, were provided to the GWRC. The GWRC sought clarification on issues relating to the land application area, amongst other issues (Appendix A).

In mid 2008 the initial 2007 application was withdrawn and a new application was lodged (dated 15 August 2008). The revised application included the shifting of treatment ponds and the incorporation of additional land for irrigation. The additional land area provided the MDC with further options for treatment and land application, including the scope to relocate the treatment ponds.

The proposed upgrade has been initiated due environmental, health and amenity concerns associated with the current wastewater treatment facility and discharge method. MDC currently have resource consents for their existing operation until 2010.

2.2 Purpose and Scope

Duffill Watts have been requested by GWRC to undertake a peer review on the current proposal for the upgrade works for the Homebush Wastewater Treatment Plant (HWTP). The focus of this assessment is on the design, operation and management of discharges to land from the ponds, sludge holding areas and land application system. It is intended that this assessment will accompany the GWRC consent processing staff 42A report for the various consents sought by the MDC and other technical reports which address the impact of the current discharge, direct to the Ruamahanga River.

2.3 Consents Being Sought

The MDC has applied for a range of consents, including discharges to water and land for both the construction period and also the longer term. The assessment that follows focuses solely on the discharge to land consents, being a result of the operation of pond facilities, sludge storage facilities and the effluent land application system, and includes:

- WAR 090066 (27162) - Discharge permit to discharge treated wastewater (effluent) to land via an irrigation system;
- WAR 090066 (27163) - Discharge permit to discharge partially treated wastewater (effluent) to land and groundwater through the base of the existing oxidation ponds and new oxidation ponds;
- WAR 090066 (27164) - Discharge permit to discharge wastewater sludge and residual liquid to land from the sludge dewatering process and sludge landfill; and
- WAR 090066 (27165) - Discharge permit to discharge odours and aerosols to air from the oxidation ponds, land irrigation system, and sludge dewatering process and landfill, and other activities from the site.

2.4 Documents Reviewed

GWRC provided Duffill Watts with a number of documents in order to undertake the review process. Reports viewed as part of this review are identified in Section 9.

Given the volume of reports, and the defined scope of this review, not all reports have been reviewed.

The reports reviewed are of a high quality and technically cover most of the issues that are required. There are several omissions and discrepancies, including some technical inconsistencies. These are discussed in the Considerations below.

Several technical inconsistencies have been discussed and a number of issues have been clarified with MDC technical experts, including Steve Green (HortResearch) and Neil Borrie (Aqualinc). They have been extremely helpful and have provided an insight to the proposed operation, assessment methodology and resulting effects. We have been fortunate to discuss what is considered to be a number of technical limitations or areas which are not particularly clear. From these discussions, it is apparent that further information is being provided at the pending hearing for this project. This further information may provide answers and address issues raised in the considerations below.

2.5 Limitations

A number of valuable technical reports have been prepared. These reports are helpful in explaining the proposed operation. However, it should be noted that recommendations and conclusions in the reports are drawn from designs which have been superseded and appear to be evolving. For example short rotation forestry as discussed in the HortResearch Report (2007) is no longer being used, and the groundwater modelling in the PDP Groundwater report (2008) discusses leakage from the existing ponds. Care has been taken when writing this report to ensure the most recent text has been used, but because of the complex and evolving nature of this project (which is to be expected and is not a criticism) this may not always be the case. Further, the volume of material to be reviewed and time constraints have placed limitations on the ability to summarise all the information available.

3.0 Activity Description

The HWTP services the township of Masterton which has a population of just less than 18,000. It is currently estimated that the HWTP discharges on average 15,750 m^3/day of treated wastewater into the lower reaches of the Makoura Stream (a tributary of the Ruamahanga River) at Homebush, 5 km southeast of Masterton.

Discharge volumes vary, from 7,980 m^3/day in dry weather to over 60,000 m^3/day in peak wet weather events (maximum instantaneous discharge rate 700 L/s). The collection system within Masterton has a very high rate of stormwater infiltration. This reduces the concentration of the raw influent to the HWTP. Industrial inputs are low and estimated to make up less than 5% of the average daily flow.

An upgrade is proposed to reduce the effects of the current surface water discharge to the Makoura Stream and Ruamahanga River. The upgrade will involve the establishment of a land irrigation system combined with a partial discharge to the Ruamahanga River during higher than median river flows.

Existing leaky wastewater treatment ponds will be replaced with new clay lined ponds. A landfill will be created for the storage of sludge from the base of the existing ponds which will be remediated and incorporated into the irrigation area.

4.0 Application Overview

4.1 Ponds

4.1.1 Existing Facilities

- There are currently 3 ponds which cover an area of approximately 40 ha.
- Current ponds are built on alluvial material of variable grades with limited or no lining.
- The ponds leak, with discharge rates to groundwater varying from 890 m^3/day to a recalculated maximum of 2,400 m^3/day (AEE, Section 5.5.3).
- The ponds discharge directly to groundwater which is more than likely to discharge directly to the Ruamahanga River, due to the immediate adjacent location of the river.
- When the river is at a high water level due to flood events, groundwater can flow **into** the ponds from below.
- Leakage from the existing ponds is potentially degrading water quality in the Makoura Stream and having a general adverse effect on the quality of ground and surface waters.
- The odour at the ponds is typically described as weak to very weak and only occasionally as distinct.

4.1.2 Proposed Upgrades

- The existing ponds are to be decommissioned. Two new oxidation ponds and 5 new maturation ponds are to be constructed further from the river to replace the existing system.
- The ponds will be lined with a silty clay which is 400mm thick (2 x 200 mm compacted layers) which is believed to have a un-compacted infiltration in the order of 1×10^{-8} m/s to 5×10^{-8} m/s. Testing on re-compacted silt samples from a potential borrow area show a permeability of around 2×10^{-10} m/s. A target liner permeability of 1 to 5×10^{-9} m/s is proposed.
- 'Live' Storage of up to 275,000 m^3 will be provided in the ponds for the effluent when irrigation or discharge to the Ruamahanga River is not possible.
- The current plant receives 15,750 m^3 average daily flow.

4.2 Sludge

4.2.1 Existing Facilities

- There are currently no sludge handling facilities at the site.

4.2.2 Proposed upgrades

- The existing ponds are to be decommissioned. The sludge will be left in the base of the ponds for air drying.
- Once air dried the sludge will be stored in an on-site landfill at the existing pond site and adjacent to the new ponds.
- The initial area will be 0.7 ha, with provision for this area to be doubled.
- The land fill area will be lined with 400 mm of silty clay, presumably with a similar construction method to that used for the ponds.
- The land fill area will be capped with 300 mm of silty clay.
- From a survey carried out in 2004 it was estimated that approximately 79,793 m^3 of sludge was held in the pond system and would require storage.
- The sludge is thought to be classified as grade B for chemical contaminants and Grade b for stabilisation grade (NZWWA, 2003). This means it could be applied to land for pastoral or horticultural use with site specific controls in accordance with any conditions of a resource consent.

4.3 Land Application Area

4.3.1 Existing Conditions

- There is currently no controlled land application programme at the site.

4.3.2 Proposed upgrades

- The initial use of border strip irrigation covering a net area of 75 ha, from two areas, one being 91 ha and the other 107 ha.
- An additional 52 ha of the 107 ha area could be used if needed, but does not form part of the applications being sought.
- An additional 22 ha of site will be made available once the existing wastewater treatment ponds have been decommissioned (in one to three years time), increasing the land application area to 97 ha.
- Wipe-off drains will collect excess irrigation water and direct it to infiltration basins, of which the first flush will be collected and pumped back to the maturation ponds. During periods of high rainfall, excess flow will be directed directly to the Makoura Stream.
- Border strip irrigation of 70 to 150 mm per application.
- Some drip irrigation of effluent will occur along the western boundary and Makoura Stream.
- Irrigation will occur whenever soil conditions will allow.

5.0 Review

5.1 Review Methodology

The method of the review used in this report is to evaluate the proposed system(s) against good science and standard practice for land application of wastewater. It should be noted that in some cases standard practice is not based on good science, and in other cases good science cannot be practically achieved. Consequently it is important to ensure that the bigger picture of developing an environmentally sustainable and cost effective system is achieved, which often requires a level of pragmatism to be used.

The sections below identify a number of considerations that relate to the three components being assessed as part of this review; being discharges to land from the ponds, sludge storage area and land application area. A consequence and outcome are identified for each consideration. Finally a summary is presented as to the effects and a recommendation of how each of the components should be managed from the GWRC perspective. It should be noted that the discussion and reporting below is on an exception basis, with only issues which need to be discussed presented.

In assessing the impact of the proposed operation, consideration has been given to similar individual activities to ensure there is regional consistency. For example, the robustness of evaluation and management of contaminated sites, dairy shed ponds and wastewater discharges from new developments within the region should be no different to the individual related activities at this site.

5.2 Ponds

Consideration P1: Leakage Rate

The application places reliance on reducing pond leakage (Section 3.3.2 of AEE) using new silty clay lined oxidation ponds. In order to achieve this a practical leakage rate needs to be nominated for design purposes. The AEE (Section 6.3.6) suggests 1 to 5 x 10^{-9} m/s.

A rate should be specified in consent conditions (see condition 1 in section 6.0).

Consideration P2: Lining material

The characteristics of the lining material are critical to successful lining and being able to meet a target leakage permeability. The application alludes to but does not expressly state what material will be used for the new pond lining. If local sourced silty clay soil is used (as tested) it should be noted that there is considerable variability in soil properties and sufficient volumes may not be readily available on site.

During construction care will need to be taken to ensure sufficient appropriate material is used. A robust testing regime will need to be established and should form part of consent conditions (see condition 1 & 16 in section 6.0).

Consideration P3: Cracking of storage ponds

Earthen liners can be difficult to manage when there are varying water levels as a reduction in water levels can expose the liner leaving it prone to cracking and resulting in a loss of integrity (i.e. leakage along cracks). At the HWTP site this has the potential to result in leakage from the new ponds at a greater rate than that predicted (i.e. more than the suggested 1 to 5 x 10^{-9} m/s). Section 6.7.4 of the AEE indicates that pond leakage could be in the order of 150 m^3/d. Leakage from cracking and loss of liner integrity could increase this rate significantly.

It should be noted that the need to manage cracking is acknowledged in the AEE (Section 6.3.7) and is the rationale for transferring 40 % of the existing pond effluent to the new ponds.

It is unclear how cracking in the storage ponds, with a live storage volume of 275,000 m^3, will be managed to avoid leaking at rates greater than that nominated in the design. The consequence is pond leakage of effluent and groundwater contamination at rates greater than that predicted. Consent conditions should be developed to assess the impact of potential pond leakage and ensure excessive leakage does not occur from the storage ponds. This could be achieved by monitoring groundwater quality (see condition 21, 23, 24, 25 & 26 in section 6.0).

5.3 Sludge

Consideration S1: Details of Sludge Landfill Design

There is limited detail provided on the design of the sludge landfill operation. If this was a standalone landfill operation considerably more information is likely to have been provided. It is unclear what some of the basic land fill parameters are, including leakage rates and stormwater inflows. There is no discussion on how the land fill be managed, including settling of the land fill cap and collection and discharge of the leachate.

While many unstated design parameters are likely to be obvious, they need to be stated to ensure that they actually happen. For example, it needs to be stated how leachate will be collected and discharged. It also needs to be stated how stormwater (including rainfall) will be managed to minimise leachate production. Standard landfill consent conditions should be applied to the sludge landfill operation, including requirements for ongoing management (see condition 16, 17 & 35 in section 6.0).

Consideration S2: Ability to Dry the Sludge Insitu

It is proposed to dry the sludge from the existing ponds insitu for 3 to 4 months before it is landfilled. The success of this operation is dependent on the ability of the material to dry, which is acknowledged in the AEE. It is also noted in the AEE that during periods of high river flow water enters the existing ponds. Consequently this will impact on the ability of the sludge to be dried.

The AEE (Section 6.3.7) acknowledges the above issues and suggests a management regime. The regime includes, with some additions, the following:

- Dried sludge will have a moisture content of 35 % solids
- Remove dried sludge as quickly as possible to the landfill site
- Remove sludge from wetter areas within the base of the ponds to avoid contact with incoming groundwater
- Create sumps to dewater groundwater inflow into the base of the ponds
- Water pumped to the Makoura Stream as part of any dewatering shall have a water quality which complies with the existing interim consent
- Sludge with a solid content of less than 5 % shall be pumped to the new ponds

The above management should be reflected in consent conditions (see condition 5, 6, 7, 8 in section 6.0).

Consideration S3: Relocation of Sludge for Drying

As mentioned above, and in the AEE, sludge may have to be moved around to assist with drying. Any movement of material beyond the existing ponds, or the recipient landfill area, has the potential to have effects in addition to those assessed as part of this application. The sludge should not be moved outside the confines of the ponds when drying.

Dried or drying sludge should only be relocated within the base of the existing ponds, or the new landfill. Additional approval will have to be sought should sludge be stored or managed outside the existing ponds or the new landfill, especially as it is anticipated that the sludge will only meet a Bb biosolid grade. A consent condition is recommended to reflect this (see condition 3 in section 6.0).

Consideration S4: Effects of Sludge Drying

In general, pond leakage and the leaching of nutrients through the base of ponds can be limited by sludge layers forming anaerobic conditions which reduce the permeability and consequently the mass of nutrient/contaminants entering groundwater. As aerobic conditions are restored (i.e. during drying), permeability increases and the potential for contaminant leaching increases.

The proposed drying of sludge in the base of the existing ponds may allow for a greater rate of nutrients/contaminants to be flushed through to groundwater. While the proposed operation of insitu drying is practical, it should be completed quickly to avoid a prolonged period of additional leaching. A consent condition should be used to limit the duration of insitu drying (see condition 3 in section 6.0) . A further condition should be used to ensure that excessive leaching of the drying material does not occur (see condition 5 in section 6.0). It should be noted that it is for this very reason that the dried sludge is to be landfill in a ‘bunker’ with a low permeability base i.e. to stop the ongoing release of nutrients/contaminants to groundwater. It may be preferable to immediately transfer the more liquid sludge to the landfill, to prevent excessive leaching to the environment from ponds that are known to be compromised.

Consideration S5: Removal of all of the Sludge Prior to Re-contouring

Residual organic material has the potential to continue breaking down and release nutrients/contaminants.

The remediation proposed for the existing ponds will need to ensure all residual material is removed. A consent condition requiring an inspection prior to any back filling would be appropriate (see condition 6 in section 6.0).

Consideration S6: Beneficial Reuse

Beneficial reuse of biosolids from municipal wastewater treatment plants is being encouraged by Central Government (MfE, 2002). Landfilling, which is convenient and often more cost effective, is not seen as being a long term environmentally sustainable practice. Landfilled material will continue to breakdown and release nutrients (and contaminants) and will require ongoing management. This includes managing any accumulated leachate and maintaining an intact cap to ensure stormwater ingress is minimised.

While landfilling may be a short term solution, MDC should be encouraged to consider alternative beneficial reuse options, especially to assist with minimising the ongoing and long term management costs of the landfill (see condition 8 in section 6.0).

5.4 Land Application

Consideration LA1: The Concept of Land Disposal versus Land Treatment

Land Treatment of waste is the utilization of the biological, chemical and physical properties of the terrestrial environment to further treat solid and liquid wastes. There are numerous soil, plant, and biota processes that are capable of using, adsorbing, binding, attenuating or otherwise renovating the various chemical and biological components of wastes. The development of a land treatment system is the process of assessing the qualities and quantities of the waste product, and then assessing the potential sites, soils, crops or plants, and key processes to determine the effectiveness of the further treatment of the wastes by the land and its components. It is important to understand that all of these factors are intricately interlinked, and cannot be considered in isolation. The sustainability of the treatment and renovation of the effluent by the environment is the paramount goal of a land treatment system. This ensures the sustainability of the discharge, by ensuring the enduring and long term health of the ecosystem are addressed.

Land Treatment is philosophically and practically distinct from Land Disposal. Land Treatment seeks to utilize the environment to treat the waste, and in doing so may also seek to improve the environment through the characteristics of the waste. This can include using the waste on productive land, improving crop yields through nutrient and water addition. Land Disposal seeks primarily to dispose of the waste, using the land as a conduit to allow the waste to enter the environment. Little or no additional treatment can be expected through a Land Disposal system. The sustainability of the physical discharge (and not the ecosystem) is the paramount factor for land disposal.

Land Treatment performance or efficiency is relevant to the treatment required. Under higher loading rates the performance will potentially be compromised or require more strict management.

The term Land Treatment is independent of the rate (high rate or low rate systems), with the rate having an impact on the system's performance, along with soil type, crops management etc… Slow rate systems will typically enhance treatment efficiency. The terms of high rate and low rate should not be used interchangeably with land treatment, as some degree of land treatment will invariably result from slow and high rate systems. It should be noted that there comes a point with increasing rates where the system is primarily considered as a Land Disposal solution, when treatment efficiency (nutrient/pathogen removal) is minimal.

The AEE uses the term Land Treatment and Land Disposal interchangeably. Where the merits of the system are being claimed, including the 'minimal effect of the environment' the term Land Treatment is more frequent, and where it is acknowledged there is capacity for the soil's to receive the applied water the term Land Disposal dominates. Examples are provided in Appendix B.

In summary the AEE makes 81 text references to Land Treatment and 56 to land or effluent disposal to land. The supporting reports have similar inconsistencies, with a predominance to the use of Land Disposal.

The proposed operation will provide for some nutrient and contaminant retention. Therefore there will be some treatment as the water passes through land. However, our considered view is that the primary purpose of the site is to provide a means of discharging water and not nutrient renovation. This is evident by the method of application, rate of application, timing of application and system design. These issues are discussed in greater detail in the following sections.

The proposed operation is a Land Disposal operation, and while some treatment will be achieved, care is needed not to perceive it as an operation specifically designed to provide a high degree of Land Treatment; that would in our view be misleading.

Consideration LA2: Low Rate vs High Rate Irrigation

Land treatment is typically associated with low rate land application systems. It is well appreciated that as the rate of application increases, the efficiency of nutrient/contaminant retention decreases and there is a tendency for the system to be more of a land disposal system.

Section 3.2.1 of the AEE indicates: *"… One of the key results of these investigations was that neither the Homebush nor the Manaia Road sites were suitable for using the Rapid Infiltration (RI) option."* A foot note is provided indicating that RI is a form of high rate land disposal.

Section 6.7.8 of the AEE states: *"It is emphasised that the increased infiltration rates will remain within the range defined for "Slow Rate Irrigation" of 0.5 m to 6 m/year (refe Table 13.7 WEF Manual of Practice No 8, Design of Municipal Wastewater Treatment Plants, 1998). "Rapid Infiltration" involves much greater volumes of effluent and has application depths in the range between 6 m to 100 m/year."*

However, in Section 8.3.2 of the AEE it is stated that: *"A high-rate irrigation scenario over the complete area available to be irrigated. The high rate represents average drainage to the aquifer of 5.4 mm/d."*

Further, tables Table 46 and 47 refer to high rate irrigation.

While the proposed application rate may be within the quoted definition of a low rate system, the AEE and supporting information refer to it as a high rate system. Regardless of the definition, the proposed application (as will be discussed below) is sufficiently high to limit nutrient retention from what could be achieved if the loading rates could be optimised. Expressed differently, if the system was designed to maximise nutrient removal, the loading rate would be significantly less than that proposed.

Consideration LA3: Comparison with Other Land Application Schemes

The AEE and supporting documents provide comparisons with other land application schemes. For example Section 8.10.7 suggests *"…The aerial photograph below is of the Taupo Sewerage Land Treatment and Effluent Disposal Scheme, which is a similar irrigation system to that proposed for the subject upgrade."* And Section 10.4.2 *"…Spray systems have been used for steeper slopes (Rotorua, Levin, Whangamata and Whitianga) or where the soils are very free draining (Taupo on pumice soils). Border strip irrigation systems have been used successfully for up to 40 years, for alluvial plain locations similar to Masterton: at Templeton, Burnham, Waimate and Leeston."*

Care needs to be given when comparing other sites. The Taupo site is completely different in a number of respects. While soils are permeable, they use frequent, smaller applications, which the AEE states would not be suitable at Masterton. Further, despite the soil's being free draining, there are problems with localised blinding and runoff at Taupo. This and other factors has resulted in the area being expanded, to other free draining soils, which are being irrigated using centre-pivot irrigators. In addition, the system has had a very rigours nutrient assessment undertaken which is supported by a very structured management programme.

The table below summarises the loading rates at the sites identified in the AEE so that a comparison can be made with the HWTP proposed design. The comparison shows what is proposed to be applied at the HWTP is on the upper extreme of many other municipal land treatment sites around the country.

Table A: Comparison of Land Application Rates.

	Masterton (proposed)	Rotorua	Whiritoa	Taupo	Whangamata	Whitanga	Waimate	Tempelton	Burnham School Road Rolleston	Lincoln Road Rolleston	Waterholes Road Leeston	Beethams Road Leeston
Max Daily volume (m^3/d)	7,747 ?	30,000		15,000	5,700		4,300		7,760	1,100	58	
Average daily volume (m^3/d)		24,500					1200					
Average weekly volume (m^3/d)					3,500							
Max N Loading / ha / year (kg)	214?	570	71	550	410				150[1]	150[2]		200
Max application depth (mm)	150?		5						20	50%[2]		
Max application rate (mm/hr)		6	5	5		5.4						
Max Average weekly application (mm/wk)	100?	72	7	45	35				64[3]			
Max average daily application (mm/day)	8.0/ 10.3	72	5	15					8		7	
Land area (ha)	75/ 97	242	5. 8									4

It should be noted that the loading rates for the majority of the systems above have been developed based on specific site limitations. Therefore care needs to be taken when comparing the proposed HWTP system.

Consideration LA4: Suitable Application Rates

Section 6.4.4 of the AEE and Page 13 of the HortResearch (2007) report indicate that an application volume of 70 to 150 mm (average of 100 mm) may be used every 7 to 10 days. This is an extremely high volume given the conductivity of some of the soils are reported at 0.5 to 4 mm/hr. Reference is also made in the AEE (Section 5.2.5) that soils in both the 91 ha and 107 ha area have 'poorly drained' soils.

The AEE and HortResearch (2007) report appear to relate the suitability of the application rates to measured clean water conductance rates (e.g. saturated hydraulic conductivity). This is the maximum loading rate of fresh water that the soil can transmit. Duffill Watts however does not believe that these rates are appropriate for the regular and ongoing discharge of effluent, and believes that the loading rates should be limited. Firstly, any application rate chosen should avoid the excessive flushing through of potential nutrients/contaminants to groundwater (assuming a land treatment system is desired). Secondly, the hydraulic application rate should be sufficient to minimise the build-up of bioslimes which may lead to a reduction in the soil's ability to accept water.

There is limited empirical data available for calculating long term sustainable land application rates, however a commonly used approach is to use 10 % of the soils saturated hydraulic conductivity. A range in the order of 4 to 10 % is often used as an adjustment to allow the development of a wastewater application rate from a 'clean water' field assessment. The conversion rate implied in AS/NZS 1547:2000 ranges from 0.17 to 5 % from a field assessment of 'clean water' measurements to potential long term wastewater application rates for individual onsite wastewater

1 Difference between mass of N applied and total removed by herbage
2 of water holding capacity of soil
3 Over 5 days

systems. Examples of loading rates in USEPA (2006) typically adopt an average loading rate of 4-10 % of the published saturated hydraulic conductivity value.

Crites and Tchobanoglous (1998) in their text "*Small and Decentralized Wastewater Management Systems*" also refer to reducing the loading rate using the following calculation:

$$P(\text{daily}) = K(0.04 \text{ to } 0.10)(24 \text{ h/d})$$

Where

P = design irrigation rate (mm/d)
K = permeability of limiting soil layer (mm/hr)
0.04 to 0.10 = adjustment factor to account for the resting period between applications and the variability of the soil conditions.

Section 8.4.4 of the AEE suggests that soil saturation will not be problem. The analysis above, and in following sections casts some doubt on this conclusion. Consent conditions are considered to be appropriate to ensure anaerobic conditions do not develop (see conditions 10, 11, 14, 18 & 27 in section 6.0).

While drainage testing by PDP (2006) suggests that year round irrigation can occur on all soils, Duffill Watts believes this may not be able to be achieved over the entire site. This is also acknowledged in Section 6.4.3 of the AEE. Should year round irrigation be used (noting that there is no definite control proposed to limit year round irrigation), the consequence on the heavier soils is that the application rate will be too high for the soils to permit drainage (as drainage is essential at the proposed loading rates using border strip). This will potentially lead to the development of anaerobic conditions which will further reduce infiltration rates. While the organic content of the wastewater increases the rate (speed) of anaerobic conditions developing, clean water alone can also induce anaerobic condition. Consent conditions are recommended to limit application on to wet soils which do not have the capacity to adequately drain and to assist implement the intention in the AEE to not irrigate wet clay rich soil (see condition 10 in section 6.0). It should be noted that the concept of intermittent application, allowing for the soils to drain/reaerate, has been identified in the AEE and supporting reports and is part of the rational for utilising border strip irrigation over spray irrigation.

Should saturated conditions develop, odours may result (as is suggested in Section 8.5.2 of the AEE). A condition is required to limit odour production from that land application area (see conditions 27 & 35 in section 6.0).

Consideration LA5: Varying Loading Rates and the Use of the Wipe-off Drains

Border strip irrigation operates on the principle of applying a known volume of water to a given area of land over a set period of time, where it is distributed by gravity. The application rate is determined by the volume of water applied, slope and vegetation (The New Zealand Irrigation Manual, 2001). These factors also determine the uniformity of coverage down the borders. Typically more water is applied than is needed (wipe-off water) to ensure that the lower reaches of the border strip bay receive an application similar to the upper reaches of the bay. Typical design values for wipe-off water are in the order of 10 % of the applied water (Houlbrooke et. al., 2007, Carey, et. al., 2004, Andrew Chittick pers com. (2009)). In some cases the excess water can reach 50 % (Houlbrooke et. al 2007). This water is often recycled for reuse or reapplication to the system.

It is noted in Section 6.4.5 of the AEE that wipe-off flows are not expected as part of normal operation. If this is the case then there will be an uneven distribution of water down the bays, with the upper reaches receiving considerably more than the lower reaches (i.e. distribution efficiency will be decreased). This is likely to have an impact on the nutrient modelling undertaken, as the modelling assumes an even application over the entire area (HortResearch 2007, page 13).

Section 6.4.2 of the AEE refers to varying application depths. In an efficient border strip irrigation system, application depths can not be adjusted. Application depth is controlled by slope and soil permeability and is set when the system is established. Changing the volume of water, the time of application and vegetation coverage will only affect the evenness of distribution of the application (i.e. the upper reaches may get 100 and not 120 mm and the lower reaches may get 5 and not 80 mm). Consequently, the ability to manage application rates to match soil conditions will not be able to be achieved as is suggested in the AEE (Section 6.4.2 and elsewhere).

Further, page 13 of the HortResearch (2007) appears to indicate application depth will be variable, based on the ability of the soil to receive water (i.e. depending on the soil moisture levels the application rates will be adjusted). This will not be possible in practice. The return period may be able to be altered, but not the uniform depth as is claimed. As a result this introduces a possible error into the modelling which may have a major impact on the leaching of nutrients. The presence and nature of this error, due to the application method and uniformity of application, should be clarified with HortResearch.

Should modelling provide for lesser application volumes (i.e. less than 100 mm per application), then there is the potential for greater nutrient retention than if the proposed 100 mm is applied i.e. lower rates will have a greater residence time in the soil to allow for increased attenuation of nutrients and pathogens than at the higher rates.

It should be noted that in practice (compared to the modelled scenarios) greater leaching may be experienced than that predicted; which will predominantly apply on the sandy soils. The heavier soils may not have greater leaching, but they may have periods of greater prolonged wetness, where less water can be applied.

A consequence of the analysis above is that: 1) on the more sandy soils greater infiltration, and thus leaching of nutrients than predicted may occur; and 2) on the heavier soils less will be able to be applied requiring greater storage. If additional storage is not provided, more water than anticipated will have to be applied to the sandy areas, thus increasing leaching further.

The additional leaching as a result of a fixed application depth needs to be further quantified and compared to what was presented in the HortResearch (2007) modelling exercise. If system changes have been made, then new modelling should reflect these changes. This should include the subsequent modelling on the groundwater system and the resulting effect on the Ruamahanga River system. In the absence of this information being adequately demonstrated, an annual limit on the application depth should be included in consent conditions (see condition 10 in section 6.0) and a requirement included to avoid excessively wet soils (see conditions 10 & 11 in section 6.0).

Consideration LA6: Suitability of Seasonal Application Rates

Table 27 in the AEE presents a summary of the likely monthly discharges to land. Earlier in the AEE (Section 6.4.4) reference is made to application rates being 70 to 150 mm per application. Based on the values in Table 27, the daily application for January will be 8.0 mm/day when applied over a 97 ha area, and in the absence of the area occupied by the existing ponds, the loading rate would be 10.3 mm/day. This is a high rate and even assuming excessive drainage did not occur during or immediately after application, this daily rate will exceed plant usage and result in considerable drainage in subsequent days.

When the winter flow rate is considered, the average daily July application rate would be 2.8 mm/day over 97 ha and 3.6 mm/day over 75 ha. Despite indicating that the heavier soils can be irrigated in winter at a rate of up to 5 mm/day (AEE Section 6.4.2), in our opinion it is unrealistic that the heavier soils would be irrigated at all during winter, especially if there is a desire to operate a successful land treatment operation utilising a cut and carry system. If the heavier soils were not irrigated (as is proposed as an option in the AEE Section 6.4.3), and only 50 % (based on information provided in LandCare Research, 2008, Appendix 1c) of the soils could be irrigated year round, that would mean only 49 ha could be utilised. This would result in a winter loading rate onto the free draining soils of 5.5 mm/day based on the proposed discharge rate.

The AEE in Section 6.4.3 notes that the storage requirements were based on not allowing irrigation onto the heavier soils. Given the HortResearch (2007) report was released prior to the additional 107 ha site being incorporated, it is unclear and would seem unlikely, that the current application strategy is reflected in the modelling of nutrient leaching by HortResearch (2007). This being the case, the PDP (2008) modelling is reliant on the HortResearch modelling and if HortReasearch have not modelled the new area it is unclear how PDP would have derived leaching characteristics. This issue needs clarification and comment is needed on the accuracy of the modelling.

It is unclear as to the volumes applied to each of the irrigation areas under the currently proposed strategy. This includes consideration of the ability to maintain 100 mm applications year round, despite variable application depths being used in the modelling. Without further clarification on this issue, an annual limit on the application depth should be included in consent conditions (see condition 10 in section 6.0) and a requirement included to avoid excessively wet soils (see conditions 10 & 11 in section 6.0).

Consideration LA7: The Ability of Soils to Aerate

To avoid saturated conditions soil moisture must return to a state that allows the re-entry of air. This is ideally a moisture content less than field capacity. The prolonged duration of soil at saturated conditions for much more than 24 hours is likely to result in the onset of anaerobic conditions. The onset of these conditions can be advanced (duration reduced) with higher concentrations of readily available carbon in the wastewater and or soil.

The assessment work to date, as indicated elsewhere in this assessment, focuses on averaging the effects of individual applications i.e. the application is spread over the approximate 10 day return period. The reality is that the application will come in one off discharges, with a limited period of water dispersal immediately following application. If water can not be dispersed by evapotranspiration or drainage, the soil will be very wet when the next application is applied. The resulting soil moisture content and drainage patterns are significantly different to averaged daily applications, which have been modelled. This applies particularly to the heavier clay soils, which have indicative infiltration rates on the order of 0.5 to 4 mm/hr.

Consideration needs to be given to restricting application of effluent to wet soils where ponding may occur and last for a period of greater than 24 hours (see condition 10 & 11 in section 6.0).

Consideration LA8: Drainage Potential

Various supporting technical reports (PDP 2006/2008, HortResearch 2007, LandCare Research, 2008) suggest that the western site (107 ha site) is based on predominately silty soils, with areas of high sand/gravel or clay content. The depth of this material over the underlying more gravely strata appears to be approximately 2 m. The PDP (2008) report suggests that groundwater is encountered at 2 m. In many areas the water levels are close to the surface, with surface springs noted in the western area during a December 2007 site visit. This would suggest there is an upward hydraulic gradient, confined from above by the overlying silty soils.

The setting described above brings into question the drainage potential for the site, primarily driven by the fact that if water moves up through the profile under pressure, water may not be able to move down under gravity, due to both the confining layer, and the upward groundwater pressure gradient described above. This factor, in addition to the high hydraulic loading rate, may result in natural drainage limitations for the site caused by mounding as a result of effluent application. This has significant consequences for the management of the land application area, especially the ability to both apply effluent and harvest the grown crop. Mounding is addressed in Consideration (see condition 10 & 11 in section 6.0)

Landcare Research (2008) identifies the depth to clay enriched profile horizons and identifies soil characteristics which signal exposure to permanent or fluctuating water levels (mottling and gleyed conditions). These observations suggest that the site has drainage limitations, which occur now in the absence of irrigation. In our opinion, the addition of irrigation water, especially year round should it be used, will likely be difficult given the noted drainage limitations. While additional artificial drainage will assist, there will still be limitations to year round irrigation application. Border strip irrigation will be more problematic than other forms of irrigation. Our conclusions above appear to be consistent with the recommendations made by Landcare Research (2008) in Section 3 of their report.

As stated above, it should be noted that Section 6.4.3 of the AEE acknowledges that application onto the clay rich soils may not be used. While this is an appropriate intention, it would be prudent to ensure this important design aspect was reflected in consent conditions(see condition 10 in section 6.0) .

Experience from land application systems at other sites which have alluvial soils would suggest there may be alternating wetter and drier areas within bays, despite efforts to re-grade and generate uniform characteristics over the site. An individual irrigated border strip bay can get excessively wet if application is based on the dry, more free draining soils within that bay. Consequently care is needed with irrigation and crop management to ensure localised wet areas do not develop within individual bays. Appropriate conditions are needed to ensure a uniform application of effluent is achieved and excessively wet areas do not develop (see condition 10, 11 & 14 in section 6.0).

Consideration LA9: Suitability of Border Strip Irrigation

Border strip irrigation is a used as a low cost means of irrigation. Its efficiency in terms of distribution and utilisation efficiency can be limited, with drip and spray often being more effective. It can be used on a variety of soil types. However, its successful use will be dependent on specific site design which takes into account soil properties, flow rates and crop types.

At this site, the variability of soil properties, close proximity of groundwater to the soil surface (in some cases springs at the surface), variable length bays and use of the site for cut and carry, will significantly restrict the successful operation of border strip irrigation. While these issues will not prohibit border strip at this site, they will require special attention to detail if the system is to operate effectively. A specialist irrigation designer should be involved in the design of the system. Conditions for such are suggested (see conditions 11 & 18 in section 6.0).

Section 6.4.4 of the AEE places considerable emphasis of the system around the suitability of the sandy soils. It should be noted that the free draining soils only make up a portion of the site, and that elsewhere in the AEE (Section 6.4.9) and supporting material (HortResearch, 2007) emphasis is placed on the nutrient retention capabilities of the silty soils. Consequently varying management may have to be applied in addition to irrigation design variation to acknowledge varying site conditions. Further, the Landcare Research (2008) report in section 3 appears to suggest that a large portion of the 107 ha site is not suitable for border strip irrigation. They state in their last paragraph in the conclusions and recommendations section:

"Whereas the 91-ha Hoebush property contained predominately well drained and moderately well drained Greytown soils (Wilde 2006), much of this property contains poorly and imperfectly drained soils, neither of which are particularly suitable for border strip irrigation. Permeability

measurements made on the adjacent 91-ha block (Wilde & Dando 2004b) showed that Ahikouka soils had the slowest permeability of all the soil on that property."

Consideration LA 10: Regulation of Irrigation

Section 6.1.2 of the AEE indicates that irrigation will occur when soil conditions allow. It is unclear what these conditions are or how they will be determined. The perception that application depths can be adjusted provides greater uncertainly as to how application rates will be controlled.

Appropriate controls to regulate the start and stop of irrigation need to be identified in a Management Plan. A Management Plan is recommended as a condition (see condition 18 in section 6.0).

Consideration LA11: Groundwater Discharges via the Wipe-off Drains

The AEE suggests the wipe-off drains are to be swales and will also serve as infiltration areas. In addition, figures in Appendix D of the AEE nominate additional infiltration areas. Figure 21 in the text of the AEE indicates that the infiltration basins come after the land treatment system and before the recycling back to the maturation pond.

From the discussion presented in the AEE (Section 6.4.5) it appears that infiltration through the base of the wipe-off drains is to be encouraged; *"Wipe-off drains on the river berm area (east of stopbank) will extend into the sandy gravels subsoils (at shallow depth) which are permeable, and will therefore not need to be linked to a recycle pump station"*. It is also the reason why infiltration areas have been nominated.

This being the case, the wipe-off drains and the designated infiltration areas will be no more than a rapid infiltration system (high rate system), which will effectively provide for 'disposal' with limited treatment within the soil.

Further, as mentioned above, efficient operation of border-strip irrigation requires wipe-off flow, which based on the values presented above, could range from 10 % (good design and operation) to 50 % (poor design and operation). This effectively means that 10 to 50 % of the flows will pass directly to groundwater with very minimal land treatment.

From the information viewed it is unclear what portion of the applied flow will pass to groundwater with minimal treatment through the rapid infiltration system. It is also unclear if this issue has been considered in both the HortResearch or PDP modelling, and taken into account when assessing the impact on the Ruamahanga River.

As mentioned in the previous section, the limited ability to vary application depths may result in the sandy freer draining soils being used preferentially, resulting in higher loading rates and greater use of the sandy wipe-off infiltration areas (assuming the flow gets to the wipe-off drains).

Further clarification is needed to confirm the nutrient loading to the groundwater system, including the quantification of the wipe-off flows (at least the design target flow). The resulting impact over the site then requires reassessment, with a nutrient and pathogen mass loading value established which will enable confirmation of the effects of the discharge on the river system (this issue is to be covered by other GWRC staff).

An alternative to providing further justification as indicated above, is to nominate and set a receiving water quality target. This may include requiring groundwater samples not to exceed a specified target, and if they do, then immediate modification to the land application system is required. This is a pragmatic approach which would avoid a lot of theoretical debate about loading rates and leaching potential, by providing a maximum acceptable nutrient level in the groundwater system. This approach would also support the monitoring of leakage from the existing ponds, new ponds and landfill. Conditions for such are suggested (see conditions 22, 24, 25 &26 in section 6.0).

Consideration LA12: Wipe-off Recycling System

The collection and recycling of border strip wipe-off water is common practice. The AEE proposes that collection of the wipe-off water, via the operation of the pumping system, will occur for a period of two hours after irrigation ceases. It is unclear from the AEE how this will work, but it is envisaged that there will be a high level of automation required. This issue should be clearly spelt out in a management plan.

In addition, it should be noted that the wipe-off pump stations will be common to a number of irrigation areas, meaning that when successive areas are irrigated, the recycle pumps will have to continue operating when the next set of bays operate. Should there be groundwater infiltration into the wipe-off system, there is the potential for a large volume of groundwater to be pumped back to the treatment ponds as a result of continued pump operation. Resource consent conditions are needed to avoid the return of groundwater to the treatment ponds (see condition 13 in section 6.0).

Consideration LA13: Use of the Drainage System

Section 6.4.4 of the AEE discusses a drainage system for the western property. This will be needed to lower water levels to enable irrigation to occur over a large part of the year and minimise mounding.

Given the level of the drain discharge (into the Makoura Stream), it is unclear how effective the proposed single drain will be. The heavier soils to the east the Mokoura Stream will require a relatively steep drainage gradient (not drain, but within soil gradient) and more regular drainage channels may be required. This may limit and require modification of the design of the irrigation system if the 1 m separation depth between the surface and groundwater (which has been used to assess nutrient attenuation by HortResearch) is to be maintained.

Appropriate perimeter drainage could be used to provide a 1 m surface to groundwater separation depth. This separation depth should be reflected in consent conditions (see condition 10 in section 6.0).

It should also be noted that the wipe-off drains in the western area will run parallel to the proposed groundwater drains. It is possible that they may have similar invert levels. This may result in leakage of one to the other, resulting in wipe-off water entering the drainage system, or drainage water entering the wipe-off system. Further clarification is needed on this issue, with particular attention being given to cross contamination and the ability to pump the drainage water back to the ponds. Consent conditions are needed to restrict cross contamination (see condition 13 in section 6.0).

Consideration LA14: River Level Impact on Groundwater Levels

The AEE (Section 5.5.2) and other reports acknowledge the impact of the river on groundwater levels. It is possible that the high rate of effluent application may result in groundwater mounding, which if it coincides with high river flows may result in groundwater levels in the land application area being closer to the surface than that desirable for effective land application. This could limit the degree of nutrient attenuation which has been estimated over a 1 m depth of soil (HortResearch 2007, pages 23, 24 and 26). It may also limit management of the site, including the ability to harvest crops.

Section 8.3.2 of the AEE addresses mounding. Mounding has been modelled by PDP and it may increase water levels between 0.10 and 0.36 m (PDP, 2008). It should be noted that this is based on a daily drainage rate of 5.4 mm, which seems low given the potential to apply 150 mm in one application every 10 days (AEE Section 6.4.4). Also, it appears that mounding effects have been based on an average daily application, with a daily contribution to the groundwater system modelled. In reality, there will be a one off slug of water entering groundwater on the day of irrigation, with lesser volumes on following days. It is unclear how this would change the mounding predictions and what the consequence would be. It is also unclear if a 1 m separation depth can be maintained to provide for the nutrient attenuation as claimed.

In order to provide a sufficient depth for nutrient attenuation, as claimed in the technical reports, and to assist with site management, consideration should be given to maintaining a groundwater separation depth which includes mounding of at least 1 m (see condition 10 in section 6.0) .

Consideration LA15: Application Optimisation

The AEE (Section 6.7.4) indicates *"MDC seeks that conditions of consent provide flexibility and do not specify irrigation rates. Instead, conditions should be directed at ensuring that irrigation rates are optimised to maximise land treatment whilst avoiding surface runoff and/or water logging of the soils."*

Having consent conditions which are flexible and allow for improved management are essential for the ongoing operation of a land application system. However, the rational for requesting the flexibility in this instance is inconsistent with the proposed operation. Firstly, to *optimise irrigation rates* drainage should be minimised. An average daily application rate of 10 mm/day (100 mm/application) will generate drainage and not allow irrigation optimisation. Secondly, the induced drainage as described above, largely as a result of using border strip irrigation, will result in the flushing of nutrients through the soil profile. Increasing the application rate (if possible) as suggested will further exacerbate the flushing of nutrients. This will also not allow for the optimisation of the system.

While it is agreed that flexibility should be provided, control over the long term environmental outcomes should be maintained. A possible solution to allow for the flexibility, and also allows for the variability of the modelling as is described elsewhere in this report, is to establish a monitoring programme whereby water quality (ground and/or surface water) can not exceed a nominated concentration. This was discussed in Consideration N^{o} 25. While some flexibility in the application volume can be allowed, despite the limitations to control it, an annual limit of the application volume to any one area should be applied as this is the basis of the modelling exercise, and the resulting assessment of effects on the environment. Should monitoring, or further modelling, suggest that the impact of the system on groundwater is acceptable, then there would be justification to have the application rate(s) increased. Conditions are suggested to limit both the daily and annual hydraulic loading rate (see condition 10 in section 6.0).

Consideration LA16: Accuracy of Modelling

Modelling is a valuable tool to predict effects. It is reliant on the accuracy of the input parameters. The AEE (Section 6.4.1) indicates that the modelling undertaken has been based on nominated parameters, which may change depending on the system operation. It is also requested in the AEE that the operation of the land application system be allowed to vary from the preferred modelled scenario. This highlights that the final outcomes may not be as predicted by the modelling.

The effects predicated, especially by the HortResearch work, are based on relatively well defined parameters. Despite a range of parameters being used for differing scenarios, which effectively provides for a sensitivity analysis, changes in critical parameters may have a significant impact on the modelled result. Key considerations might be: non-uniform application, point source discharges directly to groundwater, preferential use of specific bays, the impact of vegetation and nutrient removal, drainage limitations within the soil and changes to the composition and characteristics of the effluent. If effluent characteristics change e.g. a greater concentration of nitrogen or more nitrate nitrogen being produced, then the nitrogen leaching estimates will alter. The potential for changing composition is noted in Section 8.5.1 of the AEE.

In terms of being able to validate the assessment of effects in the AEE, some form or predicted outcome is needed to enable a conclusion to be drawn about the significance of the operation. The HortResearch (2007) modelling simulates a number of scenarios. It is not clear if the various parameters that are modelled in the 2007 report are consistent with the current land application design parameters. Confirmation of the design parameters and their use in the HortResearch modelling should be sought by GWRC prior to any final recommendation being made.

Given the variability across the site, and the desire to have a flexible management structure, monitoring should be used to ensure compliance with key environmental benchmarks. For example, modelling by HortResearch and PDP suggests certain nutrient levels in groundwater. This information is then used to predict the effects on the river system. Groundwater monitoring should be used to ensure that the predicted nutrient levels are not exceeded. This is recommended in suggested consent conditions (see conditions 19 in section 6.0).

The PDP (2008) report (page 1) indicates *"The modeling is of a worst case situation of the whole of the available area being irrigated at the maximum rate throughout the design life of the project (taken to be 30 years). This is a conservative scenario because it is not feasible to irrigate continuously at high rates for the duration of the project".* This is a commendable and appropriate approach. However, from an assessment and technical review perspective, consideration needs to be given to how operators that do not have the same skills as the designers will operate the system over the life of the consent. Therefore a degree of conservatism needs to be given to the assessment, as the worst case could eventuate, and hence the need for appropriate consent conditions.

Consideration LA17: Nutrient and Pathogen Soil Attenuation

There are a range of soil properties at the site; some good for nutrient and pathogen attenuation, and other less suited. The HortResearch (2007) modelling report considers a range of scenarios and presents predicted leaching rates below 1 m depth of soil. The scenario predictions are based on input parameters, of which as discussed above, it is questionable whether they are reflective of the current design. Of particular note is the inability to vary the hydraulic application rate as proposed in the AEE, which it appears is a key parameter in the HortResearch (2007) modelling. This may not impact on nutrient and pathogen attenuation on the heavier soils, but may underestimate leaching on the heavier soils.

The HortResearch (2007) report presents average leaching profiles (page 23), indicating the concentration of nitrate nitrogen in soil water. Earlier in the report it is indicated that the applied nitrogen in wastewater will be 50 % ammonium and 50 % nitrate split. It is unclear what extent of ammonium leaching will occur, but regardless it will be more than that indicated as being leached solely as nitrate nitrogen.

The phosphorus leaching assessment in the HortResearch (2007) report is reasonable, but does not appear to take into account the impact of the high hydraulic loading. References used appear to cite the application of manure, which does not provide the same leaching potential i.e. an absence of hydraulic loading co-incident with the nutrient application. Consequently, a greater mass of phosphorus may be leach from the soil profile than has been predicted.

The Hort Research (2007) assessment of bacteria leaching does not appear to address the potential for preferential flow, which if it occurs, removes at least one of the treatment mechanisms being relied on (filtration). Given the high application rates (up to 150 mm per application) it is highly likely that preferential flow will reduce the effectiveness of the soil as a treatment media.

Clarity is required to identify exactly what the nutrient and pathogen leaching rate from the land application area may be under the current design; in particular leaching as a result of a one off application of up to 150 mm rather than daily applications of 10 mm. Further, this assessment should also include the potential for leaching from the wipe-off/infiltration areas, with special care needed to address two specific issues:

1) if no wipe-off water is collected there may not be an even coverage within the bays; and
2) if wipe-off water is collected and there is an even distribution down the bays, what will be the nutrient and pathogen loading to groundwater via the wipe-off drains/infiltration areas.

In addition to the land application area, the cumulative effect of nutrient and pathogen leaching from the HWTP site should be considered, including that from the ponds (existing and proposed) and the sludge drying operation. This should be presented as a total mass in addition to a concentration, so that a basic mass balance from the site can be completed e.g. 300 kg/yr of nutrient X discharged from the ponds, 100 kg/yr of which is discharged directly to the river, 10 kg/yr leached from the ponds, 100 kg/yr applied to land, 45 kg/yr leached under land application area and 45 kg/yr removed in crops.

In the absence of the quantification of nutrients and pathogens identified above, a monitoring regime could be developed for the site which sets a tiered trigger at a mass loading which is entering the river system. The first trigger could be the need to modify the application system, and investigate options, and an upper trigger could be used as a point of non-compliance as it will generate unacceptable groundwater and river effects.

As the quantification of the mass loading requires further clarification, to provide for constructive advancement of this application a tiered approached to groundwater monitoring is provided in possible draft conditions (see conditions 25 & 26 in section 6.0).

Consideration LA18: Nutrient Removal

The success of a land treatment operation is largely dictated by the efficiency of the nutrient removal programme, and in particular the management of material harvesting. The AEE and supporting information have used land treatment performance data which is reflective of a high performance crop yield operation. This data may be overstating the capabilities of this particular design, and consequently may influence the modelling undertaken.

Two examples include:

1) harvesting will require a rest period prior cutting. This will increase the return period and decrease the volume of water that can be applied, possibly decreasing the anticipated dry matter yield.
2) dry matter removal estimates used (AEE Section 6.4.8) of 12,000 to 16,000 kg dry matter per year are inaccurate. This would require a nitrogen input of 480 kg/y to achieve the target production (at a herbage concentration of 3 % nitrogen).

Nutrient removal is a function of crop performance and removal efficiency. While soil removal (adsorption) can play a role (especially with phosphorus) nutrients should not be allow to accumulate as this decreases the sustainability of the system. The proposed system is optimistic if an efficient land treatment operation is proposed. Should an efficient operation be desired, then a control limiting the difference between applied nutrients and removed nutrients should be imposed. As a discussion point, a condition is suggested to ensure efficiency. This would effective require the sum of the nutrients applied in wastewater and fertilisers to be no different to the sum of the nutrients removed in the crop (see condition 18 & 28 in section 6.0).

Consideration LA19: Buffer Strip and Screen Planting Irrigation

Section 6.4.7 in the AEE describes the use and irrigation of buffer area to the west of the property. No details, with the exception of drip line will be buried, are provided as to how irrigation in this are will be controlled or managed.

Resource consent conditions are required to ensure over application of effluent in this area does not occur, which may lead to odours and the killing of plantings (see condition 12 in section 6.0).

Consideration LA20: Management of the Cut and Carry Operation.

Cut and carry operations are an effective and efficient method of removing nutrients from land application systems. Their use has been well demonstrated around the world and in New Zealand. In addition to the design of the system, management is critical for the successful operation of the site. Experience suggests that management for an individual site is developed and enhanced as site specific routines are established.

A limitation at this site for the management of a successful operation will be the integration of a cut and carry system into a border strip operation, especially given the variation is soil properties, the need for a year round discharge to the entirety of the site and a fixed application depth. The heavier soils and close proximity to groundwater will likely create 'wet' areas within irrigation bays. Diligent management will be required to ensure they do not turn into larger wet areas. This will require rest periods prior to and following harvest, and where needed remediation. Cattle should not be allowed on this site, as they are likely to exacerbates problems surrounding harvesting on wet soils. Consent conditions are recommended to ensure this happens (see condition 11 in section 6.0).

The site is small and a relatively complex land application system is being proposed. This includes application onto soils with varying textures, and the resulting need to manage a range of soil moisture conditions. It also includes the use of wipe-off drains and recycle pumps. A dedicated and skilled operator will be required and it is suggested that this is a condition of consent (see condition 11 in section 6.0).

To assist this operator, and to provide GWRC with the confidence that the system will be operated in accordance with the initial intentions, including meeting water quality targets, a robust Management Plan should be provided, and is suggested that this is also a condition of consent (see condition 11 in section 6.0). It is noted that a draft Management Plan (Beca August 2008) has been prepared. This document is appropriate and covers most of the essentials, but would benefit from the inclusion of the issues raised in this report. This includes further detail on the irrigation operation, farm management, use of the wipe-off drains and recycle pumps, monitoring and correction of the ability to apply varying application rates.

Consideration LA21: Pond Storage Requirements

A number of scenarios have been considered for storage requirements. These are based on modelling of the soil water balance. Concerns expressed above about the sustainability of the hydraulic loading, year round application and the need to limit application to allow for crop management may limit the extent of irrigation initially anticipated.

If river discharges are not possible during times of restriction to land application, additional storage may be required. This may be for reasons other than abnormal conditions as indicated in Section

6.3.5 of the AEE. A particular threat for land application at this site which may require additional storage is the effects of a major flooding event. If a major flood passes over the property, then remedial works will be required, including repair to infrastructure and the reestablishment of crops/pasture, including the removal of silt. This could take some time, and while flooding is associated with high river flows, if they decline below the nominated triggers, before the land application area is ready, further storage will be required.

While a nominated storage volume has been identified, additional storage may be required if there are restrictions for irrigation. A resource consent condition should be developed to indicate that the provision of adequate storage is the responsibility of the consent holder and to ensure that the requirements of the land and water discharges are not breached (see condition 2 in section 6.0).

Consideration LA22: Area to Be Used

The initial irrigation area covers a net area of 75 ha, from two areas, one being 91 ha and the other 107 ha. An additional 22 ha of the site will be made available once the existing wastewater treatment ponds have been decommissioned (in one to three years time), increasing the land application area to 97 ha. An additional 52 ha of the 107 ha area could be used if needed, but does not form part of the applications being sought.

Section 6.7.7 of the AEE indicates that if the additional 52 ha area was to be used application rates would have to be conservative due to soil conditions. It is unclear if the soil conditions on the remaining area of the 107 ha site are equally restrictive and if so the same degree of conservatism may be required, with no irrigation on the 107 ha site. This supports the view expressed earlier that avoidance of winter application on the heavier soils may be desirable.

A resource consent condition restricting the use of the heavier soils in winter is not needed provided there are conditions which limit application on soils with free water (ponding immediately prior to irrigation) and a 1 m separation depth to groundwater. Such limitations have been recommended as consent conditions (see condition 10 in section 6.0).

To provide for flexibility and the need to have to revisit the consenting process, it would be prudent to apply for as much area as possible to be included, with its use being as a reserve area to be incorporated into the active irrigation area when and as needed. The decision as to whether or not to include this area is at the discretion of the applicant. It should be noted that modelling to date only assumes application over 97 ha, with no allowance for the additional area.

Consideration LA23: Increased Application Rates

Section 6.7.8 of the AEE suggests the use of increased application rates if possible at some stage in future. This is claimed to reduce the impact of direct discharge to the river and "*would allow a greater portion of pond effluent to have land treatment, rather than be directly discharged to the Ruamahanga River*".

While land passage may occur, it is unclear how much if any land treatment would occur. The system would simply provide and indirect means of effluent passing to groundwater and then the river system. Passage of effluent through land does not necessary mean that any land treatment is occurring. There should be a limit on the application volume and annual application rate until it can be demonstrated that the system can be operated satisfactorily with effects as predicted. Resource consent conditions limiting annual and application volumes are recommended (see condition 10 & 14 in section 6.0).

Consideration LA24: Soil Pore Blockage with Algae or Bioslimes

Section 6.7.9 of the AEE presents the option of using groundwater beneath the application area for abstraction and application to neighbouring properties as irrigation water. The section explicitly states:

…

- *There would be no algae in the groundwater, which could cause clogging of soils in hollows*
- *Soluble nutrients would be beneficial for enhanced crop growth and would not enter the river*

…

It is unclear why and how soil pore blockage would be any different to that experienced at the Homebush site, and in fact may even be worse at the HWTP site given the higher loading especially onto the heavier soils. This issue of soil pore blockage is not mentioned at all with regard to the operation of the Homebush site. Despite not mentioning this issue, consent conditions can be developed which alleviate soil pore blockage effects (see condition 10 in section 6.0).

The benefit of applying nutrients has been suggested. While this may happen, it is likely that limited benefit would be gained given the concentration and the volume applied. If anything, the Homebush site operation could be modified to retain nutrients and avoid the system entering a likely nitrogen (plus other nutrients) deficit.

Consideration LA25: Monitoring

Monitoring of a land application system should be used to asses the performance of the site and flag any issues that may develop which could limit the sustainability of the operation. Section 6.11 of the AEE indicates proposed monitoring and Section 12.1.2 presents suggested consent conditions. This focuses on soil physical and chemical parameters.

While soil monitoring is critical, there are may other aspects which should also be monitored. These will be covered in suggested consent conditions (see conditions 19 to 29 in section 6.0).

6.0 CONDITIONS AND MONITORING

Conditions and monitoring that are considered to be needed to ensure that the HWTP operation is operated as intended, and more importantly the resulting effects are as claimed, are detailed below.

There is a heavy emphasis on management in these conditions, which is intentional. This could be revised, but it is essential that the permit holder realise, undertake and operate the site as is proposed by their advisors in the application and supporting information. The resulting effects of the operation are in this case heavily reliant on sound management, and unless that management approach is transferred from the designers to operators, which may be a number of years after the consent has been granted, then the effects claimed in the applicant's AEE will be different to what will be actually observed.

Further, as highlighted in the section above, there is uncertainty regarding the assessment of effects. Consequently conditions have been included to address this uncertainty. Should further clarification be provided, then the conditions proposed below can be revised.

Number		Consideration
	Design and Operation	
1)	Pond and Landfill Lining Constructed ponds and any landfilling areas shall be lined with suitable material to ensure permeability does not exceed 1 x 10^{-9} m/s. Should an earthen liner be used, it shall be no less then 400 mm in depth.	P1
2)	Pond Capacity Wastewater ponds shall provide the capacity to store more than 275,000 m^3. This shall be 'live' storage and not be relied on for treatment purposes. The provision of sufficient storage volume to ensure compliance with the conditions of this consent is the responsibility of the consent holder.	P3 LA 21
3)	Sludge Drying The drying of sludge from the base of the existing wastewater treatment ponds shall be undertaken in accordance with the following: • Sludge shall be relocated within base of the existing ponds to facilitate drying and avoid contact with groundwater • Sumps shall be created to assist with dewatering, with 'clean' water being pumped to the Makoura Stream and contaminated water to the new wastewater ponds. • Sludge with a moisture content of more than 95 %, as measured on a wet weight basis, (i.e. less than 5 % solids) shall be pumped to the new wastewater ponds. • No sludge is to be dried or stored, including temporarily, on the property which is outside the existing wastewater ponds or the new landfill site. This includes not allowing sludge to be stored on the surface of any remediated pond area. • All sludge shall be removed from the base of the existing wastewater ponds within 24 months of wastewater discharge to the new ponds commencing. Advice note: if dried sludge is to be used as a soil conditioner, or there is a need for temporary storage outside the base of the existing pond, then additional consent may be required.	S2
4)	Clean Water De-watering During Sludge Drying Any water pumped to the Makoura Stream shall be in accordance with a resource consent	S3

	permitting such an activity.	
5)	Leaching of Sludge Contaminants Excessive leaching of contaminants below the base of the existing ponds during the dewatering/sludge drying process is not permitted. Excessive leaching shall be monitored by groundwater monitoring as required by Condition 19 and will have deemed to occurred if the water quality targets in Condition 25 have been exceeded.	S4
6)	Remediation of Existing Ponds No residual pond sludge, to within practical excavation limits, shall remain in the base of existing ponds following remediation. Prior to the backfilling of any area of the existing wastewater treatment ponds, the consent holder shall have notified the Regional Council General Manager Compliance of the intention to do so at least 5 days before filling and the area shall have been inspected and approved by a Regional Council Compliance Officer. The Compliance Officer shall ensure there is no residual sludge which will be buried. The area deemed to have been remediated, and inspected, shall be identified on a plan of the area which will be successively added to until the entire area has approved. Advice Note: For the purpose of this condition, practical excavation limits refers to not having material in clumps or layers which are greater that 25 mm in depth.	S5
7)	Landfill Operation The sludge landfill operation shall: • Only received sludge from the dewatering of the existing wastewater treatment ponds. • Only receive material that has a moisture content of no greater than 65 %, as measured on a wet weight basis (i.e. 35 % solids). • Collect and discharge leachate from the land fill to the new wastewater treatment ponds. • Stormwater from the landfill shall be collected and discharged to ground soakage. It shall not contain any sludge material or leachate.	S2
8)	Beneficial Reuse Options The consent holder shall prepare a report examining the opportunities for beneficial reuse of treatment plant solids, including the sludge being removed from the existing wastewater treatment ponds and placed in a landfill. This report shall be prepared within 6 months of the consent being granted and revised every 3 years on the anniversary of the granting of the consent. The report shall, amongst other things, identify consistency with the MfE Waste Minimisation Strategy and any relevant Regional Council policy on managing wastewater treatment plant solids and residue.	S6
9)	Wastewater Composition The discharge shall be of treated municipal wastewater with a 90 percentile concentration of analytes not exceeding: • 20 g/m^3 Biochemical Oxygen demand • 25 g/m^3 Suspended Solids • 20 g/m^3 Total nitrogen • 10 g/m^3 Nitrate nitrogen • 8 g/m^3 Total phosphorus • 5 g/m^3 Dissolved reactive phosphorus • 10,000 MPN/100 ml faecal coliforms	N/A

	Advice note: this condition is included to acknowledge that the Masterton sewer collection systems suffers from a high rate if groundwater infiltration which ultimately provides for a dilution of the wastewater, and that proposed improvements to the sewer system will reduce the inflow which will have the potential to change the composition of the wastewater being discharged from the wastewater treatment ponds. Should the wastewater composition discharged vary, then it may influence and result in effects on the receiving environment different to that which has been modelled and forming the basis of the assessment of environmental effects.	
10)	Land Application Requirements The discharge of wastewater to land shall not result in the following: • An annual application depth exceeding 2,500 mm • Any location within an irrigation bay having a single application which exceeds 150 mm • The average application depth over the length of an irrigation bay exceeding 100 mm during a single application. The average daily application rate exceeding 10 mm • The distribution efficiency being less than 75 % during any single application • The application uniformity being less than 50 % during any single application • Any significant surface water, including ponding, on the irrigation or wipeoff areas, as a result of irrigation, for a period of more than 24 hours after application • The production of offensive and objectionable odours, as determined by a Regional Council Compliance Officer, which can be detected at the property boundary • Wastewater being applied to land within 100 m of any property which exists at the time the consent is granted. No irrigation shall be applied where: • The annual nitrogen loading of wastewater will exceed 300 kg /ha/yr. • The annual nitrogen loading as a consequence of: (i) the exercise of this permit; and/or (ii) the application of nitrogen based fertiliser; and/or (iii) the application of any other material shall not exceed a maximum of 600 kilograms per hectare per year. • The mass of nitrogen and phosphorus applied annually as fertiliser and effluent exceeds 100 kg/ha and 30 kg/ha respectively of that removed in the harvested biomass. • There is surface water ponding on any irrigation area or in wipeoff drains • There is the likelihood of significant surface water ponding for a period beyond 24 hours after application • Anaerobic conditions exist at the soil surface • Prior to application a wheeled tractor can not be driven over the area to be irrigated without leaving wheel rutting • There is a likelihood of offensive and objectionable odours, as determined by a Regional Council Compliance Officer, being detected at the property boundary • Groundwater is within 1 m of the soil surface • There is bare land, including weeds, covering more that 15 % of the area to be irrigated • Pasture, or a crop, has less than 4 weeks of growth after being replanted or sown • There is a variation in application depth of more that 50 % between 10 % and 75 % of the bay run length i.e. if a bay is 100 m long, the difference in application depth at 10 m and 75 m shall be no greater than 50 %. • The wipe-off volume exceeds 20 % of the applied volume Note: A bay is defined by the wetted area between two borders and its length is from the turnout (water source) to the furthermost wetted extent in that bay. Note: Significant ponding is deemed to be surface water covering an area of more than 10 square metres or saturated soil conditions which cause an adverse effect on grass growth.	LA4
11)	Irrigation Management	

	The irrigation system shall be operated, maintained and managed by the Permit Holder in accordance with the Management Plan required by Condition 18 below. The permit holder shall appoint an Irrigation Operator who has a farming background to manage the site. This shall include 5 years farming experience and at least 6 months irrigation experience. The consent holder shall provide a 24 hour contact number to the Regional Council General Manager Compliance in case emergency contact is required. The Irrigation Operator shall: • Ensure that the land application area be used primarily as a cut and carry operation • Allow for the occasional grazing of sheep • Not allow the grazing of cattle or horses • Allow for the application of fertilisers to optimise pasture/crop growth • Allow for the growing of crops other than pasture • Provide a 2 day withholding period following application and prior to any animal grazing. Note, despite not being allowed, cattle grazing should provide for a 6 month withholding period. The consent holder shall inspect the property at monthly intervals and as soon as practicable after heavy rainfall events, to record the presence or not of seepages, developing wet areas, changes in pasture or crop growth and any other physical change to the property which may impact on the irrigation or accelerate nutrient losses or reduced system performance. Records shall be kept of those inspections	LA10 LA20 LA25
12)	Buffer area irrigation The application of wastewater to buffer areas using drip irrigation shall comply with the requirements of conditions 10 & 11 above.	LA19
13)	Management of Wipeoff Drains Wipeoff drains shall be managed to: • not intercept or collect groundwater • not allow the direct or immediate passage (through less that 10 m of soil) to surface water drainage which enters the Makoura Stream or Ruamahanga River • not allow groundwater to be returned to the treatment ponds.	LA11 LA12 LA13
14)	Increasing Application Rate After a period of 24 months operation of at least 50 ha of the land application area, the Consent Holder can increased the average daily application rate to 200 mm and the annual application to 4,000 mm, subject to being able to demonstrate to the satisfaction of the Regional Council General Manager Compliance that: • through appropriate monitoring that the application rates in conditions 10 can be complied with, • the distribution and application uniformity requirements of conditions 10 & 11 can be complied with, • anaerobic conditions and wet areas are able to be avoided as required by condition 10 • groundwater monitoring shows the nominated water quality targets in condition 25 have not been exceeded • through modelling it can be shown that the increase in application rate will not result in the exceedance of the nominated water quality targets in condition 25 • the increase in application rates is limited to application areas to the east of the Makoura Stream	LA23
15)	Increasing Nitrogen Loading Following demonstration by the Permit Holder that an average nitrogen removal rate of 300 kg N/ha/yr, with no more that 100 kg of synthetic nitrogen fertiliser being applied, can be achieved,	LA15

	the consent holder can apply to the Regional Council to have the nitrogen loading rate increased to 500 kg N/ha/yr.	
	Management and Monitoring Plans	
16)	Construction Management Plan The consent holder shall prepare and provide to the Regional Council an Earthworks Construction Management Plan which includes, but is not limited to: • The source of pond and landfilling lining material • The placing procedure for lining material • A testing and quality control regime to demonstrate the attainment of the nominated permeability • An erosion and sediment control plan • A traffic management plan should public roads be used for carting material The Construction Management Plan shall apply to all earthworks undertaken on site and include but not be limited to: • Quarrying activities • Pond construction • Landfill construction • Any irrigation works • Site remediation, including pond infilling The Construction Management Plan shall be provided to and approved by the Regional Council General Manager Compliance prior to any earthworks being undertaken.	P2
17) S	Landfill Management Plan The consent holder shall prepare and provide to the Regional Council a landfill management plan which includes, but is not limited to: • Design and installation of lining material • Design and installation of capping material • Design and management of leachate retention and handling facilities • Moisture content requirements for placed material • Management of subsidence and slumping • Management of land filling gases The Landfill Management Plan shall be provided to and approved by the Regional Council General Manager Compliance prior to any placement of material in the landfill.	S1/S2
18)	Land Application Management Plan The Permit Holder shall prepare a management plan for the land application system. In particular the plan shall include, but is not limited to: • Operational management of the irrigation system; • On-site responsibilities, including operation and maintenance of the transfer pipeline to the site; • How the system will be operated and maintained to meet the requirements of the conditions of this consent; • Contingency measures in the event of irrigation equipment or pipeline failures; • Identification of individual paddocks; • How changes in wastewater composition are to be managed; • The control and regulation of irrigation application, including application depths, return periods, and soil moisture monitoring. • The proposed harvesting regime, including recording of nitrogen removal and compliance with consent conditions • Record keeping. • Procedures to be taken in the event that the composition limits in Condition 9 are reached. The Land Application Management Plan shall be provided to and approved by the Regional	LA10 LA20 LA25

Council General Manager Compliance prior to any placement of material in the landfill.

The management plan shall be revised every two years on the anniversary of the granting of the permit.

19) Monitoring Plan — LA25

The Permit Holder shall prepare a monitoring plan covering all aspects as to demonstrate compliance with conditions of this permit. This shall include design, operation and management aspects of the ponds (new and existing), landfilling operation and land application system.

The Monitoring Plan shall be provided to and meet approval of Regional Council General Manager Compliance within 2 months of the consent being granted and prior to any discharge in accordance with this consent.

Monitoring

20) Sampling — N/A

All sample analyses shall be undertaken in accordance with the methods detailed in the "Standard Methods For The Examination Of Water And Waste Water, 2005" 21st edition by A.P.H.A. and A.W.W.A. and W.E.F., or any other method approved in advance by the Regional Council General Manager Compliance.

Sample collection, storage, and reporting of results shall be carried out to an approved standard and by a suitably qualified and experienced person. Sample results shall be forwarded to the Regional Council General Manager Compliance at quarterly intervals. Results shall be provided in an electronic format.

21) Wastewater Sampling — N/A

To the satisfaction of Regional Council General Manager Compliance the consent holder shall characterise the quality, quantity and variability of the wastewater discharge to the land application area. This shall include, but not be limited to:

Parameter*	**Frequency**	**Sample type**
Volume irrigated, rainfall	Daily	
pH Biochemical oxygen demand, Suspended solids, Total Nitrogen, Nitrate-N, Ammoniacal-N, total phosphorus, Faecal coliforms,	Weekly (only in any week there is a discharge)	Representative sample**
Sodium, calcium, chloride, potassium, conductivity, E coli,	6 monthly	Representative sample**

*The permit holder may wan to include additional parameters to assist the sale of the harvested crops
** Samples shall be representative of the effluent which is irrigated.

22) P/S/LA Location of Groundwater Monitoring — P3,S4

The consent holder shall install monitoring bores at the following locations for the purposes of monitoring groundwater quality and water levels:

Monitoring Group	Location and purpose	HB1	HB3	HB4	HB9	HB11	HB12	BB13	HB16	HB23	HB24	HB28	HB29	HB31

1a	Up gradient of land application area							x						x
1b	Down gradient of land application area	x		x		x	x		x	x				
1c	Within land application area										x	x	x	
2a	Down gradient of land fill	x		x										
2b	Down gradient of de-sludging area	x	x	x										
3	Down gradient of ponds	x		x	x									

Note: the location and suitability of the monitoring bores need to be confirmed, especially for Monitoring Group 1c.

23) Groundwater Monitoring Requirements

LA25

Groundwater samples shall be analysed for the following prameters:

Sampling tier	Parameters sampled
T1	Water level Carbonaceous Biochemical Oxygen Demand Dissolved Reactive Phosphorus (DRP) Dissolved Inorganic Nitrogen (DIN) Nitrate-N (NO_3-N) Ammoniacal-N (NH_4-N) Faecal coliforms E coli Soluble iron chloride pH conductivity
T2	Water level Phosphorus (DRP) Dissolved Inorganic Nitrogen (DIN) Nitrate-N (NO_3-N) Ammoniacal-N (NH_4-N) Faecal coliforms
T3	Water level

Groundwater sampling of the Monitoring Groups shall occur within the following months:

Monitoring Group	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1a	T1		T2		T2		T1		T2		T2	
1b	T1		T2		T2		T1		T2		T2	
1c	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3	T3
2a	T1			T2			T1			T2		
2b	T1	T2	T2	T1	T2	T2	T1	T2	T2	T1	T2	T2
3	T1			T2			T1			T2		

The Monitoring undertaken shall be for the following duration:

Monitoring Group	Start	Finish
1a	Consent granted	Consent expires
1b	Consent granted	Consent expires
1c	Consent granted	Consent expires
2a	When discharge starts to landfill	Consent expires

<table>
<tr><td></td><td>
<table>
<tr><td>2b</td><td>As ponds are dewatered</td><td>When remediation is completed</td></tr>
<tr><td>3</td><td>When discharge starts to new ponds</td><td>Consent expires</td></tr>
</table>
</td><td></td></tr>
<tr><td>24)</td><td>Groundwater Composition Limits

Ground water quality shall comply with the following:

<table>
<tr><td></td><td>Primary values</td><td>Secondary (Not to exceed) values</td><td></td></tr>
<tr><td></td><td>Any Two Samples shall not exceed:</td><td>No one sample shall exceed:</td><td></td></tr>
<tr><td>Dissolved inorganic nitrogen</td><td>0.580</td><td>0.70</td><td>g/m^3</td></tr>
<tr><td>Dissolved reactive phosphorus</td><td>0.012</td><td>0.02</td><td>g/m^3</td></tr>
<tr><td>Faecal coliforms</td><td>50</td><td>200</td><td>MPN/100ml</td></tr>
</table>
</td><td>S4</td></tr>
<tr><td>25)</td><td>Groundwater Monitoring Action

Should any monitoring undertaken in accordance with condition 19 exceed the nominated Primary Values, the consent holder shall notify the RCGMC within 14 days of the laboratory issuing the results. The notification shall identify what the exceedance is, why it was caused and steps being undertaken to ensure compliance.

Should any monitoring undertaken in accordance with condition 19 exceed the Secondary (Not to Exceed Values), the consent holder shall notify the RCGMC within 7 days of the laboratory issuing the results. The notification shall identify what the exceedance is, why it was caused and the timing of the establishment of an alternative method for the activity which resulted in the non-compliance.

Should any two samples in any 12 month period exceed the Primary Values, or if any individual sample exceeds the Secondary (Not to Exceed Values), the consent holder shall within 6 months have presented to the RCGNC an alternative method for the activity which resulted in the non-compliance. Within 12 months of the exceedance the consent holder shall have implemented the alternative method.</td><td>S4</td></tr>
<tr><td>26)</td><td>Soil monitoring

The Permit Holder shall characterise the quality and variability of the physical and chemical properties across the land application area. Unless otherwise approved in writing by the Regional Council General Manager Compliance, the Permit Holder, undertake soil monitoring during June or July of each year. In this respect a three composite soil samples shall be taken from representative locations on each of the Greytown sandy loam and Greytown silt loam soils and the following parameters reported upon:
infiltration capacity, bulk density.
soil moisture, pH, exchangeable sodium, Olsen phosphorus, total nitrogen%, organic carbon%, C:N ratio, anion storage capacity, cation exchange capacity. Analyses shall be undertaken on composite samples for each soil type at sampling depths of: 0-75 mm and 75-150mm.
prior to commencement of irrigation, then every 5 years from granting of the Permit the consent holder shall test for the elements As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni and Zn in both the irrigated and non-irrigated soils, within the 0-75 mm soil depth.
Note: the soil groupings need to be confirmed.</td><td>LA18</td></tr>
<tr><td>27)</td><td>Crop Monitoring

The Permit Holder shall record crop manage practices across the site, including:
Crop renovation areas, species used and reasons for the renovation</td><td>LA11</td></tr>
</table>

	• Dry matter content removed from the site • The nitrogen content of batches of all dry matter removed form the site • Any fertiliser application, including type and amount applied. • Records of any grazing undertaken.	
28) S	Surface Water Monitoring The Permit Holder shall monitor any discharge from the existing wastewater ponds to the Makoura Stream 15 minutes after pumping commences and 6 hourly thereafter. Compliance with water quality standards shall be in accordance with Consent WAR 090066 (27160)	S3
29)	**Reporting and Notification**	
30)	Annual report The Permit Holder shall prepare an annual report shall be provided to the Regional Council General Manager Compliance before the 1 September each year. The report shall include, but not be limited to: • A summary of compliance with conditions of this consent • A summary of monitoring results. • A summary of the complaints register • Details on any odour reports • A discussion on any trends or changes in environmental effects evident from the monitoring data, both within the annual period and compared to previous years; • A summary of nitrogen application rates for any irrigated portion of the site, in terms of kilograms nitrogen per hectare per annum, and crop yields removed from the farm, in kg N/ha/yr on a per paddock basis. • A summary of any operational improvements undertaken • Any recommendations on alterations/additions to the monitoring programmes;	LA25
31)	Notification of dewatering The consent holder shall notify Regional Council General Manager Compliance no later than 12 hours prior to any pumping of water from the existing ponds to the Makoura Stream. The consent holder shall also notify Regional Council compliance manager with in 24 hours of the discharge ceasing.	S3
32)	Breakdown/emergency notification The consent holder shall notify the Regional Council General Manager Compliance as soon as practicable and, as a minimum requirement, within 48 hours of any accidental discharge, plant breakdown or other contingency which is likely to result in an exceedance of the limits of this consent.	LA25
33)	Complaints Register The consent holder shall maintain and keep a complaints register for all aspects of all operations at the site. The register shall detail the date, time, duration and type of complaint, cause of the complaint, and action taken by the Permit Holder in response to the complaint. The register shall be available to the Regional Council General Manager Compliance at all reasonable times. The consent holder shall forward to the Regional Council General Manager Compliance a copy of all complaints received as soon as practicable but in any event within 48 hours of receipt.	N/A
34)	Odour Reporting Should an emission of odour occur that has an objectionable or offensive effect, the consent holder shall provide a written report to the Regional Council General Manager Compliance within seven days of being notified of such by the Regional Council General Manager Compliance. The report shall specify: • the cause or likely cause of the event and any factors that influenced its severity; • the nature and timing of any measures implemented by the consent holder to avoid, remedy or mitigate any adverse effects; • the steps to be taken in future to prevent recurrence of similar events.	LA4

	Note: Regional Council General Manager Compliance will consider an effect that is objectionable or offensive to have occurred if any appropriately experienced officer of the Greater Wellington Regional Council deems it so after having regard to: • the frequency, intensity, duration, offensiveness and location of the odour; and/or • receipt of complaints from neighbours or the public; or • relevant written advice or a report from an Environmental Health Officer of a territorial authority or health authority.	
35)	Signage A warning sign shall be placed on the boundaries of the site which shall be legible to a person during daylight hours, warning that partially treated wastewater may be present at the site.	N/A

7.0 Comments on Submissions

The following section highlights and provides responses to issues raised by submitters. A number of the issues have already been covered in the considerations section above. Additional comments are provided below.

Suitability of irrigation technology
Border strip irrigation is a sound and practical form of irrigation. There are limitations with its efficiency, just like any other form of irrigation. This includes managing application rates and cropping systems. However, it is still a valuable form of irrigation in the right setting. Despite this and as discussed in Consideration LA9, we believe border strip may not be suitable for the entire site under the proposed irrigation regime. There will be limitation with year round application due to the heavy soils and some areas will result in excessive drainage to groundwater.

Location of irrigation within the flood plain
The ability to operate the irrigation system in the flood plain is discussed in Consideration LA14.

Construction impact of the new ponds on the Ruamahanga River
The construction of the new pond system is likely to have limited impact on the Ruamahanga River, and in fact over time may improve the quality of water in the river. However, there is the possibility that the decommissioning of the existing ponds may have an impact, especially during the period when the sludge is being dried. This is covered in Considerations LA5.

Irrigation over application due to soil types
The impact of over application of irrigation is covered in Considerations LA8 and LA24.

Impact on drainage
The proposed drainage and application system is unlikely to impact on drainage upgradient of the site. The permeable nature of the underlying gravels will limit effects upstream of the site.

What can be done when the soils can no longer cope with the discharge
There may be the possibility that the operation may not be able to operated as intended. This is alluded to in a number of the considerations presented in the previous section. Should this be the case then alternative options need to be available. Appropriate monitoring will provide advance warning that things are not right and alternatives should be considered.

This review is solely for assessing what has been proposed. It is not intended (or appropriate) to provide alternatives. This is the responsibility of the MDC and their advisors.

Proximity to discharges
Wastewater discharges have to go somewhere. They will always end up in someone's back yard, and the question will always exist as to 'why should it be mine'. Technology is now available to allow for the recycling of treated municipal wastewater as potable drinking water. Lesser technology allows for it to be used for toilet flushing and watering of domestic garden. Treated wastewater should not be feared as it is a valuable resource. What is needed however, are appropriate controls to make sure the method of treatment matches the intended use, including receiving environment.

Despite reservations expressed in this report about the effects on the groundwater system, the application of wastewater with the proposed composition and characteristics close to houses and property boundaries is appropriate. This will be made possible by the adoption of the suggested conditions.

Alternative Options
Alternative options are available. There will always be other and possibly better ways of managing wastewater, especially as technology advances. The most suitable technology will be a balance between the cost to the community, social requirements and environmental outcomes.

This assessment of the consent applications is focused solely on the technical viability of the proposed scheme. It is not an evaluation of options, or a review of other options which have been provided.

8.0 CONCLUSION/RECOMMENDATION

There are three aspects to the discharge to land component for the HWTP (leakage from ponds, landfilling operation including pond dewatering and land application of treated wastewater). Each will be dealt with in turn presenting conclusions and recommendations on each aspect from information derived from this, and other reviewed documents.

8.1 General Comments

It should be highlighted that the proposed HWTP land application system has not been designed to maximise treatment; it is predominately a land disposal system. It will provide some treatment as a result of land passage, but the primary purpose based on the loading rates and system design is a means of discharging water to the receiving environment.

Two aspects of the proposal result in a degree of uncertainly of the effects associated with the proposed operation, being:

- Limitations with the proposed design and management of the system may result in suggested design and operation targets not being met; and
- The assessment of the effects using a theoretical modelling approach based on assumptions has inaccuracies which may result in errors in the predicted effects.

8.2 Ponds

Conclusion

At present the pond facilities are inadequate and leak with discharge rates calculated at up to an estimated maximum of 2,400 m^3/day. The discharge flows directly from the unlined ponds to groundwater which in turn discharges into the Ruamahanga River.

The proposed new ponds will be lined with a 400 mm silty clay material with an anticipated permeability of $2x10^{-10}$ m/s.

'Live' storage of up to 275,000 m^3 will be provided in the proposed new ponds for the effluent when it is not possible to irrigate or discharge to the Ruamahanga River.

Recommendations

- It is important that a specific leakage rate is nominated for design purposes and included in the consent conditions. The AEE commissioned by MDC presents a figure of 1 to $5x10^{-9}$ m/s and this should be adopted as a consent condition.

- The characteristics of the silty clay pond lining material are critical. It is alluded to but not specified in the AEE that the lining material may be sourced locally. If this is the case it should be noted that the soil in the area is extremely variable and sufficient volumes of the clay may not be available. Steps should be taken to ensure sufficient amounts of liner material are available and meets a specified standard.

- The material that is used should be rigorously checked for suitability throughout the construction period.

- Maintenance of earthen pond liners can be very difficult and exposure due to low water levels can cause cracking. Cracking will compromise the integrity of the liner and lead to leakage rates much higher than those predicted. Appropriate management of the liner is required. Monitoring of groundwater quality in the area is suggested as a consent condition to provide assurances on the integrity of the pond liner.

8.3 Sludge

Conclusion

Wastewater treatment invariably produces a solid component or sludge. This sludge has been building up in the current treatment ponds and will have to be dealt with as these ponds are decommissioned.

At present there are no sludge handling facilities on the site but a landfill is to be constructed and the sludge will be placed in this as it is removed from the existing ponds. It is proposed that following the draining of the current ponds the sludge will be left to air dry. When the sludge has dried sufficiently it will be moved to the newly constructed landfill located next to the decommissioned ponds.

The landfill will be constructed in the same way as the new ponds with a clay liner and will eventually be capped with 300 mm of silty clay. It has been estimated that the old ponds contain just under 80,000 m^3 of sludge that will need to be relocated to the landfill. There are very few details of the landfill design and management. Considerably more detail is provided.

Recommendations

- There is limited information regarding the design of the landfill contained in the current proposal. If this was a 'stand alone' project a great deal more information would be required, or alternatively the consenting authority would have rejected the application. More detailed design and management parameters should be presented such as;
    - How leachate will be collected and discharged
    - How stormwater will be managed
    - Ongoing management etc
- Standard landfill consent conditions should be stated and implemented with regard to the sludge landfill operation. This should include requirements for the management of the sludge drying process.
- Beneficial reuse of biosolids should be considered in future rather than landfilling of the sludge.

8.4 Land Application

Conclusions

It is proposed to use border strip irrigation over an area of 75 ha, increasing to 97 ha, with an application depth per application of between 70 – 150 mm. Some drip irrigation of effluent will occur along the western boundary of the Makoura Stream. While border strip irrigation is a proven method it needs to be use in the correct environment and it is debateable whether this is the correct environment under the proposed management regime.

The consequence of the suggested management regime, which may not be appropriate, is potential errors in the assessment of effects. While the modelling approach used is technically sound, assumptions used may result in deviation from the predicted effects.

Recommendations

- The AEE states that wipe-off flows are not expected as part of normal operation. If this is so it infers that effluent will be unevenly distributed in the bays of the irrigation system. This in turn will affect the nutrient modelling that has been undertaken as the modelling assumes an even effluent application over the whole system.

- Seasonal application of effluent needs to be re-examined as, in our opinion, it is unrealistic to irrigate the heavier soils at all during the winter months. This has the potential to affect other aspects of the proposed irrigation model. Further, it is unclear if the modelling undertaken by PDP (2008) uses correct input data/assumptions, as it is based on a 2007 HortResearch report which uses a design that has been superseded. Clarification and potentially remodelling may be needed.

- The natural drainage of the area should be re-examined as while the PDP report states that the ground water is at 2m there are several areas where surface springs are active indicating a higher ground water level. A high groundwater level, in some cases rising to the surface as springs, will effect drainage of applied effluent. It may impact on the accuracy of modelling, as the HortResearch report assumes a depth of unsaturated soil of 1 m.

- Border strip irrigation is a low cost means of irrigation with excellent results when used in the correct environment. The variability of the soils of the area and the high groundwater are not ideal for border strip irrigation. This is not to say it can not be done but a specialist irrigation designer should be used in the design and commissioning of the system.

- Clarity is required to identify what the nutrient and pathogen leaching rate from the land application area may be under the current design, as some reporting makes referred to earlier reports and prior system designs.

- Removal of nutrients by growing crops can work very well but the data contained in the AEE is reflective of a high performance crop operation that may not be characteristic of this particular design and therefore influence the modelling that has been undertaken. If operated as a treatment system the loading rates should be consistent with high yield crop management requirements.

- A robust management plan should be instigated for the cut and carry operation. A preliminary Management Plan has been prepared (Beca 2008) but would benefit from the inclusion of further issues raised in this report.

- Concerns expressed in this report regarding the hydraulic modelling i.e. year round application and rest periods to allow for crop harvesting etc give rise to questions regarding pond storage requirements. It may be necessary to make allowances for additional storage to cope with periods when land application rates are reduced for whatever reason.

- Monitoring of the land application system should be used to assess the performance of the site and flag any issues that may develop which could limit the sustainability of the operation.

9.0 REFERENCES

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APPENDIX A

GWRC LETTER TO MDC

File No: WP/03/06/01
Consent File: WAR070077
4 June 2008
Masterton District Council
PO Box 444
Masterton 5840

For: Kevin Montgomerie

PO Box 41
34 Chapel Street
Masterton
New Zealand
T 06 378 2484
F 06 378 2146
W www.gw.govt.nz

Dear Kevin

Notified Resource Consent Application: Masterton Wastewater Treatment Plant Upgrade – Key Issues for Consideration in Updated AEE

Applicant:	*Masterton District Council*
Proposal:	*To undertake various activities associated with the proposed long term upgrade and operation of the Masterton wastewater treatment plant*
Location:	*Homebush, approximately 5km south-east of Masterton*
District Council notice of requirement:	*Amend existing designation (42ha) to cover all land use activities and extend existing designation for an additional 89ha and 107ha for irrigation of treated wastewater to land*
Regional Council resource consents:	*Discharge permits to water, land, and air*
	Water permits to divert surface and groundwater
	Land use consents to undertake river protection works

Thank you for sending through a copy of your letter to submitters and the latest Community Report.
Prior to final drafting of your updated 'Assessment of Environmental Effects' (AEE) we thought it would be helpful to provide an overview of the key issues to date that Greater Wellington staff (including experts engaged by Greater Wellington) see with the proposed upgrade of the Masterton wastewater treatment plant. This will hopefully provide some assistance to your final drafting of the AEE. This is not intended to be an exhaustive and complete list but merely a guide as to some of the key issues we have completed some preliminary assessment on to date.

DISSOLVED REACTIVE PHOSPHORUS (DRP)

DRP concentrations in the Ruamahanga River are possibly the primary issue of importance for the discharge to water application. As the primary limiting nutrient, we believe that a DRP receiving water limit (concentration) is required. NIWA proposed a site-specific 'target' only based on an average 13-day accrual period for filamentous periphyton growth. This target is based on very limited field data, an accrual period that is not representative of river conditions during January to April (the time of greatest periphyton biomass), and does not necessarily take into account DRP contributions from contaminated groundwater beneath the land disposal area. We have analysed the hydrological record in more detail and if consents were recommended to be approved, we are likely to recommend a more stringent DRP standard based on a longer accrual period.

RECEIVING WATER LIMITS

Only 'target criteria' applied at Wardells Bridge 1.25km downstream of the point of discharge have been proposed. If consents are recommended to be approved, it is likely that we will be recommending a number of in-river limits and these are likely to apply after reasonable mixing (200-300m downstream). Note that full mixing is predicted to occur at 800m downstream.

PROPOSED MONITORING

Only existing river sampling sites upstream and downstream of the ponds (largely for comparison with historic monitoring records) are proposed as part of the monitoring regime. However additional sites are clearly needed – further upstream (the existing upstream site will probably be influenced by land irrigation) and at the boundary of reasonable mixing (200-300m downstream of the outfall).

LAND BASED WASTEWATER DISCHARGE VIA BORDER DYKE SYSTEM

The proposed border dyke system can be prone to over-application (and therefore saturation of soils) and is less than ideal on free-draining soils (with a high water table) bordering a highly valued river. Consequently there needs to be a high level of careful management of the system and site. At present there are not any limits proposed in terms of the rate(s) that effluent is applied to land. This approach promotes a 'trial and error' type of discharge scenario where potentially effluent rates are progressively increased until such point as soils appear saturated or an adverse effect is picked up in groundwater or river monitoring results. This is unlikely to be acceptable to Greater Wellington and more stringent conditions are likely to be imposed, if the consents are recommended to be approved.

Extensive earthworks are required for the establishment of the border dyke system. It was noted during our site visit in December that there is potential for a reasonable number of native trees to be cleared to make the system work effectively. If these trees were not to be removed this would greatly reduce the amount of land available for the border dyke system to work, or influence the management of the system.

The exact land area available for the border dyke system is not clear. We believe that more accurate calculations on the amount of land available needs to be undertaken, taking into consideration site constraints such as those identified above.

We have reservations about the effectiveness of treatment provided by land application via border dyke irrigation. It appears as though the system is more a land disposal system rather than a land treatment system which has implications for management of the site and ground and surface water quality away from the site. For example, the appropriateness of a cut and carry system and its effects on a border dyke irrigation system should be considered. The varying stages of crop growth on site will affect the application uniformity across the site. There are implications for crop and stock management with the proposed system which should take into account the harvesting regime, return periods, run lengths and soil types.

Overall, because the system will require careful and intensive management due to the relatively small section of land and surrounding site constraints, we believe that reconsideration of the proposed management and monitoring regime would be appropriate. This could be achieved through the preparation of a management plan to be submitted with the updated AEE. This would give Greater Wellington staff greater confidence in assessing the application and making its recommendation to a Hearings Committee, potentially supporting the application.

FINAL COMMENTS

Obviously there may be more specific comments that we could offer when you forward the draft AEE to us shortly but in the interim I hope these comments are helpful in the preparation of your updated AEE.

Regards

Stephen Thawley
Team Leader, Consents & Compliance

stephen.thawley@gw.govt.nz

Copy: Robert Schofield

Boffa Miskell
PO Box 11340
Manners Street
Wellington 6142

APPENDIX B

EXAMPLES OF LAND TREATMENT VS LAND DISCHARGE

Examples of the use of land treatment and land disposal terminology in the AEE are provided below (emphasis added):

Section 1.1
"In June 2005, the Council selected its preferred scheme, which involved upgrading the existing oxidation ponds and developing 91 hectares of land adjacent to the plant for border-strip land ***disposal of treated effluent****."*

Section 1.1
"In December 2007, following a review of options that became available after the purchase of an additional 107 hectares adjoining the Plant site, Council unanimously selected the option of constructing new clay lined ponds on part of the 91 hectare site, and using part of the 107 hectare site for border-strip ***land disposal*** *in conjunction with the remainder of the original 91 hectare site."*

Section 2.1
"Pursuant to Sections 168, 168A and section 181 of the Resource Management Act 1991, the Masterton District Council gives notice of a requirement to continue and extend the existing designation for Masterton District Council Sewage Treatment Plant purposes to include land for the proposed ***land disposal*** *scheme and flood protection works and to alter the purpose of the existing designation to be as described below:"*

Section 2.1
"The amended and extended designation is for:

> *Wastewater treatment and disposal and ancillary works and activities including:*
>
> > *The upgrade of, and ongoing use, operation and management of the whole site as a wastewater treatment plant and for* ***land disposal of effluent*** *……"*

Section 2.1
"The upgrade of the Masterton Wastewater Treatment Plant will comprise the construction of new silt-clay lined oxidation ponds and a ***land treatment*** *system for a portion of the wastewater."*

Section 2.1
"This NoR includes but is not limited to, the following activities:

- *The construction and operation of a new Wastewater Treatment Plant*
- *The construction of new clay/silt lined oxidation ponds*
- *The construction and operation of a* ***<u>land treatment scheme to dispose</u>*** *of treated wastewater (effluent)*
- *Pump stations and pipelines for the land treatment scheme"*

Section 2.1
"The following resource consents from the Regional Council are needed for the proposed activity:

- *Land use consent (erosion protection works and river diffuser)*
- *Discharge permit (discharge of wastewater and stormwater runoff to water, including stormwater runoff from earthworks during construction)*
- *Discharge to air (dust and vehicle exhaust emissions during construction, and odour and aerosols during operation)*
- *Discharge to land (irrigation scheme, sludge storage and leakage from base of the ponds)*
- *Water Permit (divert flood waters and authorize inflows to the ponds)*

- *Discharge permits for discharge to air and discharge to land on the potential future **land disposal** area (to be applied for later if required). "*

Section 2.4
*"The potential discharge of surface run off from the **land disposal** area to the Ruamahanga River and the Makoura Stream will normally be point source discharges at the downstream ends of wipe-off drains, the exception being high rainfall events where the capacity of the wipeoff drainage system may be exceeded and non-point discharges at various locations may occur."*

Section 2.7
*"The **land treatment** scheme, oxidation ponds and sludge landfill area are shown on Drawings C601 and C602 in Appendix D."*

Section 3.1
*"In early February 2004, Council negotiated an agreement for the purchase of approximately 91 ha of land at Homebush adjoining the existing Masterton Wastewater Treatment Plant site, with the view to using it for **land treatment** of the effluent."*

Section 6.4.1
*"The **land treatment** areas have been delineated into three major areas for border strip irrigation of pond effluent, as follows:"*

Section 6.7.5:
*"During summer, effluent plus rainfall will be applied by the border strip irrigation at an average rate of 10 mm/d for the purposes of **effluent disposal**"*.

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