BEFORE A HEARINGS PANEL OF THE GREATER WELLINGTON REGIONAL COUNCIL AND MASTERTON DISTRICT COUNCIL

[GWRC Ref: WAR 070077]

In the matter of	a resource consent application to Greater Wellington Regional Council pursuant to section 88 of the Resource Management Act and its Amendments.
&	
In the matter of	a Notice of Requirement to Masterton District Council pursuant to section 168 of the Resource Management Act and its Amendments.
By	Masterton District Council
For	The Proposed upgrade of the Masterton Wastewater Plant

STATEMENT OF EVIDENCE OF NEAL BORRIE
ON BEHALF OF MASTERTON DISTRICT COUNCIL

Subject Area: Land Treatment System

1. INTRODUCTION

1.1 My full name is David Neal Houston Borrie. I hold the qualifications of BE (Hons) (Agricultural Engineering) and a Post Graduate Diploma in Civil Engineering from Canterbury University. I am a member of the Institution of Professional Engineers of New Zealand, and also a member of the New Zealand Water and Wastes Association. I am currently employed as a Senior Environmental Engineer by Aqualinc Research Ltd in Christchurch, and have worked in the area of water and soil engineering for over 36 years. I have undertaken a wide range of work for central government agencies, regional and local authorities, as well as private industries and businesses.

1.2 I have had experience in the design and operation of schemes for the land treatment of wastewater for industries (such as meat processing plants, fellmongeries, vegetable processing plants and mushroom composting facilities), agricultural wastes (such as beef feedlots, piggeries and dairies) and municipal sewage treatment plants. This has included the design and commissioning of land treatment systems and the preparation of assessment of environmental effects reports, resource consent applications and waste management plans for their operation.

1.3 I was a contributing author to the *NZ Guidelines for Utilisation of Sewage Effluent onto Land*, a joint publication by NZ Land Treatment Collective and Forest Research.

1.4 In this matter, I have been engaged by Masterton District Council (MDC) to provide evidence on its behalf in relation to the design and operation of the proposed land treatment system for the discharge of treated wastewater.

1.5 I have read the Code of Conduct for Expert Witnesses issued as part of the Environment Court Practice Notes. I agree to comply with the code and am satisfied the matters I address in my evidence are within by expertise. I am not aware of any material facts that I have omitted or might alter or detract from the opinions I express in my evidence.

1.6 My evidence is structured as follows:

(a) scope of evidence;
(b) the site, soils and climate information;
(c) the proposed land treatment system;
(d) consideration of alternative irrigation methods;
(e) air discharges from the irrigation area;
(f) comments on submitters' concerns; and
(g) summary.

2. SCOPE OF EVIDENCE

2.1 My evidence will address the irrigation system proposed at the Homebush site for the land treatment of Masterton's treated wastewater. It will describe the irrigation area and the climate; the proposed irrigation method and its management including its selection and consideration of alternative irrigation methods; the proposed crop system and its management; and the effects of air discharges from the wastewater irrigation area.

2.2 The evidence of Dr Steve Green will address the soils at the site, the movement of water and nutrients through the unsaturated soils of the irrigation area and the potential effects of these contaminants on the soil. The evidence of Graeme Proffitt will address the impacts on the quality of the receiving groundwater.

3. THE SITE AND EXISTING ENVIRONMENT

Irrigation Area Overview

3.1 MDC owns two sites adjacent to the Masterton Wastewater Treatment Plant (MWTP) at Homebush. The two sites area referred to as the "91 ha site" and the "107 ha site" (gross areas). The 91 ha site is bounded to the south by the existing oxidation ponds, on the eastern side by the Ruamahanga River, on the western side by the Makoura Stream and on the northern boundary by privately owned land. The 107 ha site is bounded Makoura Stream to the east, the Martinborough Masterton Road to the west and the south and privately owned land to the north. The location of these two sites is shown on Beca Drawing No C600 in Appendix D of the AEE.

3.2 Border strip irrigation is proposed for the land treatment of wastewater at the site with the land being used to grow pasture that will be regularly harvested and carried offsite for feeding to stock (i.e. a cut-and-carry system). The irrigation layout is depicted on Beca Drawing No C601 in Appendix D of the AEE.

Soils on the 91 ha site

3.3 The soils on the 91 ha site are described in three Landcare Research Ltd reports (H Wilde and J Dando, Report No LC0304/173 July 2004, H Wilde and J Dando, Report No LC0405/090 March 2005 and H Wilde, Report No LC0506/054 March 2006).

3.4 The soils at the site have been broadly divided into three categories; well drained, moderately well drained and imperfectly to poorly drained soils (refer to Figures in H Wilde, Report No LC0506/054 March 2006). The well drained soils are located predominately in the northern and eastern areas and are well suited to receiving wastewater irrigation all year round. The moderately drained soils are located predominately through the central part of the property and are suited to receiving wastewater irrigation all year round however these soils may require a longer return interval between irrigation applications to ensure that the soil returns to an aerated state following each irrigation. The imperfectly drained and poorly drained soils are located in the south western part of the site where it is proposed to site the new oxidation ponds. These soils have a slowly permeable subsoil layer that would limit the hydraulic loading that could be applied to them however, they are not now intended to be used for irrigation of wastewater.

3.5 An irrigation drainage trial was undertaken on the poorer draining soils (i.e. the imperfectly to poorly drained soils) over two periods; February 2006 (summer trial) and June 2006 (winter trial) and is reported in Pattle Delamore Partners Ltd (2006). Two key conclusions from the field trial are that the widespread use of artificial drainage of the poorer draining soils is not necessary and that the average depth of wastewater application on the poorer draining soils could be increased from 5 mm per day to 10 mm per day during the summer months (i.e. November to April). It should be noted that these soils are not now intended to be used for wastewater irrigation as the new oxidation ponds will be sited in this area.

Soils on the 107 ha site

3.6 The soils on the 107 ha site are described in a Landcare Research Ltd report (H Wilde and J Dando, Report No LC0708/139, June 2008).

3.7 On the 107 ha site, the soils are generally finer textured than those on the 91 ha site adjacent to the river, where the coarser-textured alluvium was deposited. There is also a trend of the soils on the 107 ha site becoming finer textured from the margin towards the centre of the property.

3.8 Whereas the 91 ha site, contains predominantly well drained and moderately well drained soils, much of the 107 ha property contains poorly and imperfectly drained soils.

3.9 Further detailed information on the soils on both the 91 ha and 107 ha sites is contained in the evidence of Dr S Green.

Climatic Information

3.10 The nearest climate station to the MWTP site is at Te Ore Ore (site number D05973) which is approximately 4.5 km north of the property. At this site the mean annual rainfall for the period 1992-2007 is 936 mm. The average monthly rainfall figures at the Te Ore Ore site are shown in Table 1 and Figure 1. On average rainfall is highest in July followed by June and October and is lowest in January and February followed by March and April.

Table 1: Average monthly rainfall and PET data for Te Ore Ore (site number D05973) (Source: NIWA)

Month	Mean monthly rainfall (mm)	Mean monthly PET (mm)
January	59	125
February	61	98
March	68	77
April	66	38
May	72	21
June	97	13
July	118	13
August	81	28
September	72	51
October	93	84
November	77	103
December	69	121
Totals	936	772

3.11 The average monthly Penman potential evaporation (PET) figures for the Te Ore Ore site for the period 1992-2007 are shown in Table 1 and Figure 1. Comparing average monthly totals of rainfall and PET (Figure 1) shows that in the months of November to March PET exceeds rainfall and that during the summer months there is a substantial soil moisture deficit that produces dry summer conditions and highlights the need for irrigation. Unless irrigation water or wastewater is applied to crops this soil moisture deficit will restrict plant growth.

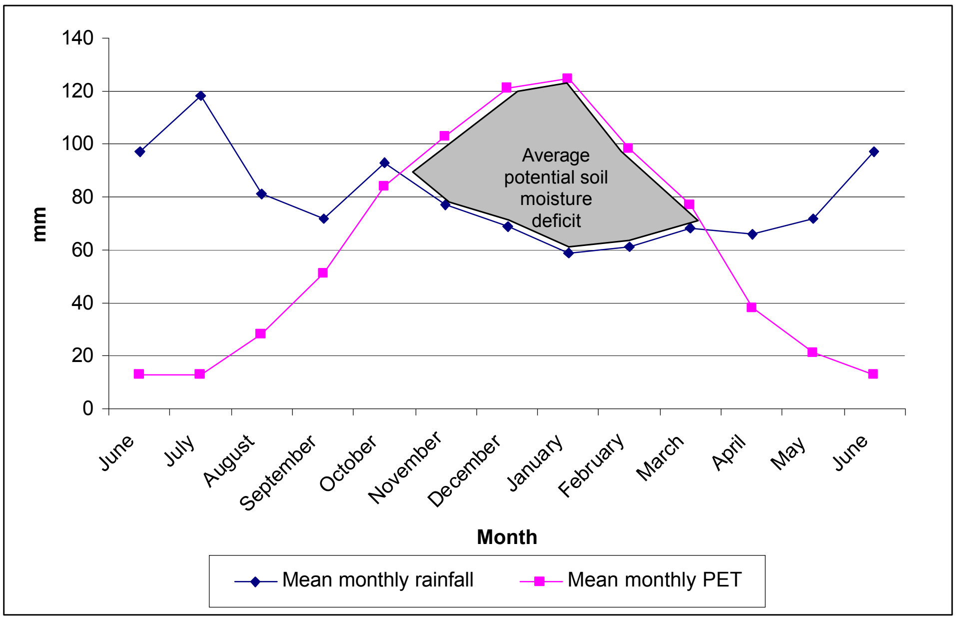

Figure 1: Mean monthly rainfall and PET for Te Ore Ore

3.12 The average number of wet days in summer is significantly less than the average number of wet winter days. The average summer rainfall is also significantly lower than winter, with autumn and spring rainfall being very similar (NIWA).

3.13 The wind rose from the East Taratahi climate station (site number D15064) shows that the prevailing wind direction is from the northeast direction (22% of the time) and typically in the range of 0 to 14.9 km/hr. West (16% of the time) and southwest (16% of the time) wind directions are the next most predominant.

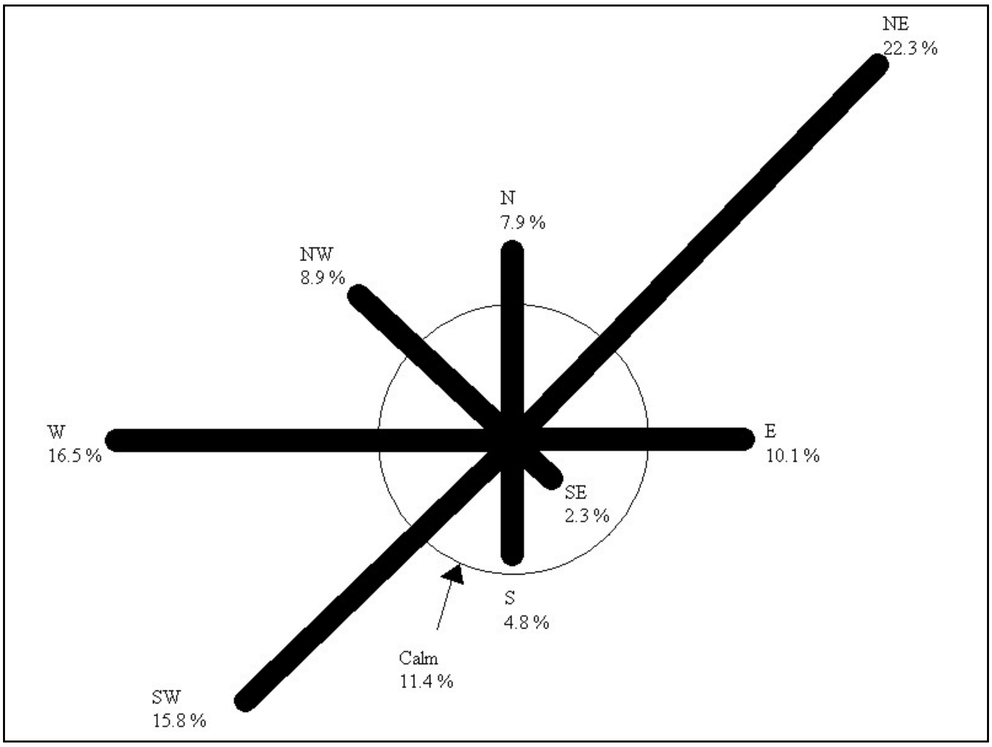

Figure 2: East Taratahi wind Rose % of total time

4. THE PROPOSED LAND TREATMENT SYSTEM

Irrigation Area

4.1 Generally, there are two different soil types at the sites, namely sandy and silty loam soils that are free draining, and silty clay soils that are less free draining. Therefore, two different irrigation rates are proposed in accordance with the different hydraulic capacities of these soils.

4.2 The net area available for border strip wastewater irrigation at the sites is approximately 75 ha after taking out the areas required for access roads, buffer areas, drains and stop banks (refer to Beca Drawing No C600 in Appendix D of the AEE). This area comprises of 49 ha of well drained and moderately well drained soils on the 91 ha site that will be irrigated all year round and 26 ha of imperfectly to poorly drained soils on the eastern side of the 107 ha site that will mainly only be irrigated during the summer months.

4.3 Following the decommissioning of the existing oxidation ponds, the area occupied by these ponds will be converted to border strip irrigation allowing the use of an additional 22 ha of free draining soils.

4.4 The 107 ha site also allows for the future expansion of the wastewater land treatment area with an additional net area of 52 ha shown on Beca Drawing No C600 in Appendix D of the AEE as 'potential future land treatment area'.

Adopted Application Depths

4.5 The adopted application depths are summarised in Table 2 where both average and maximum application depths for both summer months (i.e. November to April) and winter months (i.e. May to October) are provided.

Table 2: Proposed average application rates

Soil type	Area (ha)	Summer average/maximum (mm/day)	Winter average/maximum (mm/day)
Free draining (i.e. well drained & moderately well drained soils)	71 (49 + 22)	10/15	5/5
Clay rich (i.e. imperfectly drained & poorly drained soils)	26	10/10	0/5
Total	97		

4.6 I note that although the drainage trial (as discussed earlier in my evidence) indicated a winter application rate of 5 mm/day on the clay rich soils may be possible, there are periods when irrigation could not be undertaken due to potential increases in groundwater during winter. For this reason, and to retain an appropriate degree of conservatism, the updated storage model was based on no irrigation to the clay rich soils occurring during the winter.

4.7 The wastewater irrigation system will be designed with the ability to vary the average application depth to suit conditions. Some border strips may accept greater hydraulic loading than 10 mm/d and where possible, this should be an operational aim of the scheme in order to reduce the volume that is discharged directly to the Ruamahanga River within the constraint of avoiding excessive breakthrough of groundwater which could then enter the river. Identification of the capacity of the border strips will be ongoing and vary with season, soil moisture status, and pasture cover (depends on the pasture height).

4.8 The effects of irrigation on the groundwater are discussed in the evidence of Graeme Proffitt.

Border Strip Irrigation Method

4.9 Border strip irrigation is a surface irrigation method that utilises gravity and it is suited to free draining soils and pastoral land use systems. It is proposed to irrigate pasture rather than tree plantations because pasture is more effective in taking up the nutrients (from the applied wastewater) if a cut-and-carry system is used[1]. Border strip irrigation would not be compatible with a tree plantation land use at this site because trees as they become established would disturb ground levels within border strips and interrupt the flow path down the borders.

4.10 Border strip irrigation is a traditional irrigation method used on farms, using a series of graded strips of land (borders) with levees to contain the water. The water or wastewater is applied to the top end of the border by a headrace or pipeline and flows by gravity to the bottom end of the border, gradually soaking into the ground it flows over.

4.11 The irrigated area will be formed into a series of graded borders separated by formed levees approximately 300mm high. Generally, the borders will be approximately 150 to 200m long, with a minimum width of approximately 12m, but these dimensions may vary depending on site-specific topography. Wider borders would certainly be more convenient for operating the pasture harvesting machinery.

4.12 Wastewater will be supplied to each strip by a system of pipelines and bubble-up valves that can be operated independently. A bubble-up valve is an agricultural hydrant valve that is manually screwed open and shut. The valve discharges water radially when open. A concrete scour pad will be constructed around each bubble-up valve to manage erosion.

4.13 The proposed design flow rate is 100-150 l/s per 12 m width of border with at least one bubble-up valve per 12 m width of border. For border strips wider than 15 m two or more bubble-up valves will be required to maintain an even advance of wastewater. Factors that will affect the quantity of wastewater that

[1] The pasture is regularly cut and carried offsite for feeding to stock (i.e., no stock directly graze the irrigation site)

can be applied to an area include soil type, soil moisture status, subsoil conditions, border strip slope, climatic conditions and grass height. Any excess treated wastewater at the bottom end of the border strips will be collected by a wipe-off drain and either infiltrated into the ground or pumped back to the oxidation ponds.

4.14 The relatively high infiltration rates of the well drained and moderately well drained soils mean that, under border strip irrigation, average applications depths per irrigation strip are likely to be in the order of 70-100 mm. The irrigation return intervals will be approximately seven to ten days during the summer months, with increased return intervals used during the winter months. This will allow time for drainage and re-aeration of the soil.

4.15 To irrigate the land adjacent to the Ruamahanga River, sub-mains must cross the stopbank. The locations for these crossings are indicated on Beca Drawing No C601 in Appendix D of the AEE.

Merit of Wastewater Irrigation

4.16 As shown in Figure 1 there is a substantial soil moisture deficit that occurs over the summer months at the site highlighting the need for irrigation. Unless irrigation water or wastewater is applied to crops this soil moisture deficit will restrict plant growth. Wastewater irrigation will ensure that the pasture growth at the site is not limited by soil moisture deficit. The need for irrigation on the property was also recognised by the previous owner who had installed an irrigation system on the property.

4.17 In addition land treatment of the wastewater allows the nutrients of nitrogen and phosphorus to be recycled as these nutrients are required, together with adequate soil moisture, to optimise pasture growth.

Land Contours

4.18 The existing land area will be formed into a series of border strips that will have a uniform grade from the top (i.e. location of the bubble-up valve) to the bottom (i.e. adjacent to the wipe-off drain). To ensure that the topsoil is retained on the final surface of the paddocks it will be first stripped and stock piled before the border strips are formed after which the topsoil will be replaced. To minimise disturbance of soil the existing ground contour will be utilised as much as possible in the forming of the border strips.

4.19 Border strip irrigation systems need to be installed with good ground level control to operate efficiently and allow an even advance of the wastewater across the width of the border.

4.20 To achieve effective treatment of the wastewater by filtration through the topsoil and sub-soils, the re-contouring will be more intensive than is the case for typical farm border strip irrigation situations, so that local areas with extremes in permeability will be modified to be close to the average values for the site. This will be achieved by the following measures:

(a) Topsoil will be stripped and temporarily stored in longitudinal piles to allow the sub-base to be graded to the required fall. Uniform depths of topsoil will be placed on the re-graded sub-base, the local depth being dependent on the available topsoil in the locality. Since the topsoil provides a significant portion of the water holding capacity, the border strips will have a more uniform water absorption rate compared to the "natural" alluvial ground that would have variable topsoil depths.

(b) Where gravels protrude to the surface, these will be removed and reused for the construction of pond banks. These gravel areas will be backfilled with silty sand as a sub-base and compacted to match the density of the surrounding soils, so as not to provide a preferential flow path, and the topsoil will be reinstated.

(c) Localised areas of known existing ponding will be investigated during construction and the drainage improved with sand-filled slit drains if needed (most likely to be required where there are soils with significant depths of underlying silty clay).

(d) The earthworks will be carried out in the summer season to avoid excessive compaction of the soils. Full-time construction monitoring of the earthworks will be implemented for good quality control.

(e) Construction equipment will be fitted with laser- leveling and GPS - guided features for precise control of the re-grading work.

(f) By handling the topsoil separately, there will be minimal changes to the near surface soil characteristics. The proposed changes to sub-soils will be to improve the filtration characteristics.

Variations in Soil Permeability

4.21 To accommodate the variations in soil permeability across the site it is proposed where practicable, particularly on the 91 ha site, to locate each border on either the well drained soils or the moderately well drained soils rather than to have individual border strips containing both of these soil groupings. This will allow border strips in different soil groupings to be irrigated at different rates.

Use of Poorer Draining Soils

4.22 During the early development of the irrigation scheme, an assessment was undertaken of the appropriate application depths (wastewater plus rainfall) that would be used as the basis for proceeding with the preliminary design.

4.23 At the time of the assessment, it was considered that the heavier soils at the site might require the construction/installation of artificial drainage in order to achieve the design application rates. In order to test this, it was decided to undertake a field trial to determine the type and extent of drainage improvements. The drainage trial was undertaken over two periods, a summer trial in February 2006, and a winter trial in June 2006 (PDP, 2006a) and reported in the evidence of Mr G Proffitt.

4.24 Key outcomes from the summer trial were:

- An irrigation rate of approximately 15 mm/d is appropriate
- Drainage is adequate at all times except during rainfall events
- Periods of heavy rain caused groundwater levels to rise rapidly, but then fall rapidly following the cessation of rainfall.

4.25 With regard to the winter trial, the key outcomes were:

- An irrigation application of 5 mm/d was found to be appropriate

- Rainfall causes groundwater levels to rise rapidly, but then fall rapidly on the day following the rainfall, followed by a slower fall on the following days.

4.26 Overall conclusions from the field trial are as follows:

- The widespread use of artificial drainage over the heavier soils is not necessary.
- The current average design application depths for the heavier soils could potentially be increased from 5 mm/d in summer to 10 mm/d, and from no winter application to 5 mm/d, although winter application could not continue during prolonged rainfall or high groundwater levels, but could resume after several days of no irrigation.
- Operational experience may demonstrate that some localised areas may benefit from artificial drainage – this will be determined and implemented based on operating experience.
- The positive results from the trial provide an indication that application depths (wastewater plus rainfall) for the free draining soils could be increased above those currently used for the design of the irrigation system.

4.27 In addition a number of infiltration tests have been carried out within the 91 ha site during the course of the project to determine the hydraulic limits of the soils, which are shown in Table 3.

Table 3: Results of infiltration tests undertaken on the 91 ha site

Site	Soil type	Infiltration range mm/hr (No. tests)	Infiltration mean mm/hr	Type of test	Tested by, date
Between stopbank & Ruamahanga River	Sandy gravel	260 – 11,700 (6)	550 (median)	Uncased hole	Opus, 1998
Between stopbank & central farm track north of pond 1	Silt	10 – 30 (3)	20	Basin flooding	Beca, 2000
Between stopbank & Ruamahanga River	Fine sand	10 – 15 (2)	12	Basin flooding	Beca, 2000
Between stopbank & Ruamahanga River	Sandy gravel	100 – 150 (2)	125	Basin flooding	Beca, 2000
Between stopbank & central farm track north of pond 1	Silt	13 – 109 (10)	42	Double ring	PDP, 2000
Area between stopbank & Makoura Stream north of area of native trees	Silty clay (in most limiting layer within the profile)	50 – 244 (18)	117	Double ring	Landcare, 2004
Between stopbank & Ruamahanga River	Fine sands, silty fine sands	98 – 784 (6)	425	Double ring	Landcare, 2004
South west corner	Compacted silty clay (poorly drained soils)	3 – 4 (3)	4	Double ring	Landcare, 2004

4.28 The infiltration results in Table 3 indicate typical results for free draining soils on the 91 ha site 117 mm/hour or 2.8 m/day. USEAPA (2006) recommends taking 4 to 10% of the clean water infiltration rates for wastewater applications and the measured rates allow this to be achieved with the proposed application rates. The poorly drained soils in 91 ha site will not be used for wastewater irrigation as the new oxidation ponds will be sited on this area.

4.29 The slower subsoil drainage in the clay rich soils in the 107 ha site will limit the infiltration into these soils so they will need longer to drain and re-aerate. These soils will not ‘clog’ so long as they can re-aerate. They are still well suited to border strip irrigation. (Trevor Webb, soil scientist, Landcare Research Ltd, pers comm.).

4.30 MDC will need to vary irrigation depths, based on sound operating principles and experience so as to maximise discharge to land whilst ensuring that there are no adverse effects in terms of soil structure or run off to surface water or excessive break through of nutrients to groundwater. This management of irrigation depth is standard practice in the operation of wastewater irrigation systems. Accordingly, it would not be appropriate for the conditions of consent to specify irrigation depths. These will be detailed in a subsequent management plan.

Flooding of the Berm Areas

4.31 As shown on Beca Drawing No C601 in Appendix D of the AEE the berm area between the right bank of the Ruamahanga River and the stop bank will be used for border strip wastewater irrigation. At times of high flows in the Ruamahanga River treated wastewater will not be applied to the land but instead will be discharged directly to the river. During times of flood flows in the Ruamahanga River there may be occasions (approximately 5-year return period events) when this berm area is flooded. During flood events there will be some deposition of silt on the berm area, the effect of which will depend on the severity of the flood event. Any flood damage to the border strip system will be reinstated following the dropping of the river water levels. Flood events are not expected to cause damage to the border strip earth works due to inundation. This issue is further addressed in the evidence of Mr H Archer.

Management of border strip irrigation system

4.32 With border strip irrigation wastewater is applied to a particular land area every 7-10 days. This rest period between irrigations allows time for the soil to drain and re-aerate which is important for maintaining healthy soil conditions.

4.33 Heavy and/or unexpected rainfall during land irrigation may result in saturation of soils and increased surface runoff or leaching to groundwater.

4.34 Generally, the irrigation depths in the summer will be controlled to provide an average application of wastewater plus rainfall of 10mm/day in the summer and 5mm/day in the winter for the free draining soils. Rainfall and soil moisture will be monitored daily and the operator will make a decision on the actual depth of wastewater to be applied. An automatic rain gauge will be used to stop the irrigation pumps in the event of significant rainfall that would result in a wastewater/rainfall depth greater than an average application of 10mm/day.

4.35 It should be noted that only some areas will be irrigated on any particular day. Thus any runoff from recently irrigated areas due to unexpected heavy rainfall will be diluted by runoff from areas that have not received wastewater for about one week. In the event that wastewater or rainfall runoff reaches the end of the border strip, it will be discharged to the wipe-off drain for collection.

4.36 It is proposed to discharge wastewater collected in the wipe-off drain back to the ponds. Only excess rainfall will be discharged to the Makoura Stream. The drains will be enhanced by installing areas of sandy gravels to increase infiltration of the wastewater/stormwater to reduce runoff pumped back to the ponds or stormwater discharges to the Makoura Stream.

Excess Runoff and Stormwater Runoff Recycling System

4.37 Excess treated wastewater runoff from the border strips will be collected in a network of constructed drains, called ‘wipe-off drains’. The wipe-off drains will be flat swales, large enough to convey the runoff from the border strips. The wipe-off drain along the eastern side of Makoura Stream and from the western side of the 107 ha site will run back to a number of infiltration areas and to a recycle pump station adjacent to Pond 6 (as indicated on Beca Drawing No C602 in Appendix D of the AEE). The recycle pump station will pump the runoff back into the oxidation ponds. Wipe off drains on the Ruamahanga River berm (east of the stopbank) will extend into the sandy gravel sub-soils which are very permeable, and will therefore not need to be linked to a recycle pump station. The wipe-off drain network will also collect stormwater at times when treated wastewater irrigation is not being applied, but rainfall produces runoff from the border strips.

4.38 Operator experience will be needed to determine the depth of application required to allow the wastewater to just reach the end of the border, and no further. In the event that wastewater or rainfall runoff reaches the end of the border strip, it will be discharged to the wipe-off drain for collection. It is proposed to discharge treated wastewater collected in the wipe-off drains back to infiltration areas or to the ponds via a recycle pump station, with excess rainfall discharged to the Makoura Stream.

4.39 The infiltration areas will be enhanced by removing areas of silty clay down to the sandy gravel layer in order to expose the higher permeability material. The infiltration areas servicing the proposed irrigation area, excluding the berm area, have a total area of 5,000 m^2 and will allow for the stormwater runoff from a 2 year return period storm to be discharged. For a greater than 2 year event and up to a 5 year storm event, the runoff will flow to the recycle pump station. For storm events greater than a 5 year event the runoff will be discharged to Makoura Stream.

4.40 Recycle pump stations will operate for two hours to allow for surface runoff of wastewater to be pumped back into the oxidation ponds. Flows reaching the recycle pump station two hours after irrigation has ceased will be mainly stormwater, and hence will be suitable for direct discharge to a water body.

4.41 The two-hour period is the “time of concentration” when the flow from the extremities of the catchment reaches the pump station. At this time, the peak flow that occurs will be predominantly rainfall runoff, and contain only a very dilute concentration of treated wastewater. On most occasions, treated wastewater will not have been applied to land when heavy rainfall is predicted. In addition it should be noted that only some areas will be irrigated on any particular day. Thus, any runoff from recently irrigated areas due to unexpected heavy rainfall will be diluted by runoff from areas that have not received wastewater for about one week. Therefore, it is expected that runoff after two hours will have low concentrations of contaminants and is likely to be less than the contaminants in surface runoff from areas stocked with cows.

Proposed Cut-and-Carry Pasture System

4.42 A cut-and-carry pasture system is the proposed land use for the area that will be irrigated by border strip irrigation. A pasture land use has the ability to assimilate large quantities of nitrogen and phosphorus from the applied treated wastewater. In the proposed cut-and-carry system the pasture is harvested and carried off the property for feeding to stock, that is stock do not directly graze the irrigation area. In this way the nutrients in the pasture that are assimilated from the wastewater are removed from the property.

4.43 The nutrient uptake in pasture varies, depending on the quantities of nitrogen and phosphorus that are applied to the land and the rate at which the pasture can assimilate them. The anticipated nutrient uptake is detailed in the evidence of Dr S Green. With the proposed treated wastewater quality and quantity it is likely that pasture growth will become limited due to a deficiency of nitrogen. This deficiency will be addressed by including some nitrogen fixing species within the pasture mix. It is noted that pasture has a proven record at this site, which can have relatively high groundwater table conditions.

4.44 It is proposed that a perennial ryegrass pasture mix be used together with white and/or red clover due to the nitrogen deficiency.

4.45 A cut-and-carry system involves periodically harvesting the pasture (and hence the assimilated nutrients) in silage or balage (wrapped bales) to remove it from the growing area. The pasture dry matter yield is likely to be in the range of 9,000 – 13,000 kg per ha per year (Modelling results in Steve Green's evidence and Lincoln University, 2003).

4.46 Fonterra's May 2005 revised policy on human sewage application to dairy farms only permits very high quality treated wastewater (i.e., treated with UV disinfection) being spread onto pasture fed to dairy cows. The proposed quality of the wastewater from the oxidation ponds upgraded with maturation cells therefore would exclude the silage or balage being fed to dairy cows. However, it has been confirmed that there will be a demand in the area locally by dry stock farmers for the harvested silage or balage (David Baker, Baker & Associates Ltd, *pers comm.*).

4.47 Inherent in a cut-and-carry operation is the absence of grazing animals, although limited use of grazing animals (e.g. sheep) will be beneficial at certain times of the year to 'tidy up' those areas unable to be harvested. It is proposed that there will be limited grazing by sheep during the late autumn/winter period to tidy up those areas unable to be harvested by machinery.

Proposed Cut-and-Carry Pasture Management

4.48 Good management of the crop/water/soil system is very important to the successful operation of a cut-and-carry pasture land treatment system. The following important management issues for a cut-and-carry pasture system have been based on experience from Taupo District Council's land treatment cut-and-carry system (Mike O'Connor, AgResearch and Colin Light, Taupo District Council pers comm.) and local knowledge (David Baker & Associates pers comm.):

(a) Prior to harvesting the pasture should be spelled for a period of at least 10 days with no treated wastewater irrigation being applied.

(b) Harvesting of the pasture should occur whenever there is a yield of approximately 3,000 kg dry matter per ha. Harvesting of the pasture would generally be confined to the months of September to May.

(c) It will be important to avoid having heavy harvesting equipment on the land at times of wet soil conditions. The use of balloon tyres on harvesting equipment will reduce damage to soil structure.

(d) Weeds will need to be controlled to maintain good pasture quality.

(e) With a cut-and-carry system it is likely that potassium will become deficient and hence will need to be applied regularly to the land.

(f) It is expected that pastures will need to be regrassed every four to six years. This should be done by under drilling to avoid cultivation.

(g) Regular monitoring of the soil/plant system (i.e. soil/pasture health) is important so that potential problems can be identified and addressed before they become significant issues. Monitoring should also include preparing a regular nutrient budget.

4.49 It is important to remember that MDC's prime goal in operating the land treatment site is using and managing it for the land treatment of wastewater so as to maximise the application of wastewater whilst protecting water and soil qualities. Any income generated from the sale of silage or balage harvested from the site is a secondary benefit.

5. ALTERNATIVE IRRIGATION METHODS

5.1 The choice of border strip irrigation instead of spray irrigation was made after consideration of a range of factors as outlined in the following paragraphs of my evidence. The alternative of using centre pivot spray irrigators has been raised by some submitters and this option is also discussed. While spray irrigation has advantages in some situations, border strip irrigation of the treated wastewater is the preferred method for this scheme.

Centre Pivot Irrigation Option

5.2 The option of using centre pivot irrigation to irrigate crops to satisfy soil moisture deficits has been the subject of a separate evaluation that is reported in *Masterton Land Treatment of Wastewater*, Beca (May 2008). This report, for which I was a reviewer, concluded the following:

- The principal objective of the proposed wastewater irrigation system is to maximise the sustainable treatment of treated wastewater by the land, not to maximise the revenue earning ability from cropping the land.

- Centre pivot irrigation of treated wastewater and cash cropping is not supported because it would greatly diminish the scheme's ability to reduce wastewater and therefore nutrient discharges to the Ruamahanga River. That would be contrary to the stated MDC objective of maximising the discharge to land.

- Permanent pasture, rather than cash cropping is strongly recommended because pasture will allow the formation of stable topsoil aggregates and high infiltration capacity required for the high wastewater application rates. Also permanent pasture is more effective at assimilating the applied nutrients and being able to accept wastewater on a year round basis.

- The proposed cut-and-carry pasture harvesting will provide useful returns to MDC.

- Border strip application of the treated wastewater is recommended as the best method of achieving the land treatment objectives of the proposed wastewater treatment scheme, because relatively large volumes of treated wastewater can be applied to the land at 7 to 10 day intervals, which will allow time for the soil to drain and re-aerate.

- Extraction of groundwater from the MDC land and supplying to private farms in the vicinity (if there is a demand) is recommended as a more sustainable and safer way of increasing crop production, rather than supplying treated wastewater directly. This concept is "flagged" at this stage for future consideration and is not part of MDC's current consent applications.

5.3 I agree with these conclusions.

5.4 It would be technically feasible to apply treated wastewater to land using centre pivot irrigators at the same rate as proposed for the border strip irrigation (that is at an average summer rate of 10 mm/d) - the irrigators could be set up to apply say 10 mm with one pass of the irrigator per day. However there would be a number of issues with respect to the soil/plant system that would arise with the use of centre pivot irrigators.

5.5 To apply wastewater at rates of up to 10 mm/d the centre pivots would require a greater system capacity than those that are commonly used on farms to apply fresh water irrigation at rates of up to 5–7 mm/d.

5.6 Using centre pivot irrigators to apply 10 mm/day would result in the soil being perpetually wet, it would not be able to re-aerate and it would be prone to developing anoxic conditions with the resultant retardation of plant growth and hence nutrient renovation.

5.7 Wastewater irrigation systems require intermittent hydraulic loading to allow the soil profile to drain and to re-aerate between irrigation applications. This resting or drying period is critical to renew aerobic conditions in the soil and to allow oxidation of BOD (USEPA, 2006).

5.8 To allow the soil to drain and re-aerate after wastewater irrigation, at least 5 days would need to be allowed between irrigations. To provide at least 5 days between irrigations, would require applying 60 mm in one day every sixth day. This could be applied either with one pass or in a number of passes per day with the centre pivot travelling faster. Not only does a relatively large depth of water need to be applied in a day, the opportunity time for each sector to receive this water is limited as the wetted footprint of the irrigator is a relatively narrow strip along both sides of the centre pivot's boom.

5.9 This combination of a large application depth and a high intensity particularly from the outer sections of the centre pivot, would lead to a high potential for ponding and redistribution of the applied wastewater. The land with the greatest potential for run off to occur would be at the end of the centre pivot's circle or the outer annulus of the area irrigated. Unless the land was re-graded so that all of the ponded water could drain into collector drains, it is likely that the redistributed water would pond in lower lying areas.

5.10 While the land could be re-graded so that all of the ponded water drains to collector drains the difference with a centre pivot irrigator, due to its modus operandi, is that some of the areas where ponding and potential runoff would occur would be at the lowest point of the land surface and hence would run off immediately into the collector drains. Note that this is different to border strip irrigation where all of the water is applied to the top of the graded border and the wastewater has the whole length of the border to pass over, and hence infiltrate into, before it enters into any collector drains.

5.11 It would not be feasible to cover all of the 97 ha with centre pivot irrigators due to the shape of the irrigable area and the circular or part circular area covered by each centre pivot irrigator. To be enable the irrigation of a similar area to that covered by border strip irrigation option some other spray irrigation method, such as some form of fixed sprinklers, would be required to fill in the areas that are not able to be covered by centre pivot irrigators.

5.12 Another issue would be the potential for substantial wheel rutting caused by centre pivot wheels continually travelling on saturated soil. This is an issue that would need to be addressed to avoid having the centre pivot wheels sinking into the ground. These wheel ruts would also provide areas where wastewater would pond.

The advantages of border strip irrigation over other methods

5.13 The choice of border strip irrigation as the preferred land treatment method over other methods, such as spray irrigation, was made after consideration of a range of factors. While spray irrigation has advantages in some situations, border strip irrigation has been chosen as the most appropriate method for this wastewater irrigation scheme.

5.14 The main disadvantage with spray irrigation systems for wastewater irrigation is the potential for spray drift and the creation of aerosols. When spray irrigation of wastewater is proposed, usually there are many submissions which raise concerns about spray drift and aerosols causing effects on neighbours' health.

5.15 Typically, to mitigate such concerns, applicants for spray irrigation schemes propose additional mitigation measures such as; the use of low pressure spray nozzles that discharge close to the ground, UV lamp disinfection, larger separation distances and/or to stop spraying when the wind direction could carry aerosols onto residential properties, roads or recreational areas. (It should be noted that a UV system for pond wastewater would have an additional capital cost of $1.7 million and operating costs for power and lamp replacement of $200,000 per year.)

5.16 While technical justifications can demonstrate that the risk to public health might be minor, the perceived effect of wastewater sprays (which are visible) has been recognised elsewhere as a valid effect.

5.17 A key advantage of border strip irrigation is that the wastewater can move down the strips and percolate into the soil at the localised rate, as dictated by topsoil moisture demand and underlying drainage characteristics; this process is inherently self-correcting. Hence, it is not possible to apply more wastewater than the soil's hydraulic capacity to accept, as is possible with spray systems. This allows hydraulic loading rates to be maximised, keeping with the key objective for this scheme which seeks to divert wastewater away from the river, particularly at low river flows. Effects on groundwater in terms of nutrient breakthrough will be monitored and application rates can be adjusted for specific areas on the basis of operating experience.

5.18 Border strip systems have been criticised because of the difficulties in automating the distribution system and measuring the flows in open head race channels. In addition, headrace gates can often leak with the consequential leaking into individual border strips creating permanently wet areas with anaerobic soils. To avoid these problems, a piped distribution system will be installed with bubble-up valves to individual strips which are leak-tight when shut, and actuated valves to groups of strips which will allow the system to be largely automated, with overview inspections by an operator.

5.19 Wastewater application to land systems elsewhere in New Zealand have been designed to the site specific constraints of topography and soil infiltration rates. 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 strips have been used successfully for up to 40 years, for alluvial plain locations similar to Masterton, at Templeton, Burnham, Waimate and Leeston.

5.20 A very large system has operated at Werribee (southwest of Melbourne) for over 100 years. This system handles a flow from 1.6 million people using some 4,200 ha of the 11,000 ha total area, and uses the flood irrigation method with check borders (similar to border strip).

5.21 Drip irrigation systems have a number of advantages, such as being fully controllable, not subject to odour, aerosol or wind problems and drip irrigation avoids crop leaf wetting which can promote disease and pest problems. Drip irrigation systems are relatively expensive to install and they require high quality filtration of the wastewater to ensure that the drip outlets do not become blocked. Surface drip systems are suitable for irrigating plantation trees but they are not feasible for pasture irrigation.

5.22 While buried drip lines can be used for irrigating pasture, being buried the volume of topsoil available for the uptake of moisture and nutrients is reduced and hence they are unable to fully utilise all of the treatment capacity of the soil/plant root zone. In addition, in subsurface drip systems external root intrusion can occur.

5.23 The perimeter planted buffer areas will be irrigated with treated wastewater using surface drip irrigation, at least until the trees are established. However the irrigation of these areas will only occur during the summer months to rectify soil moisture deficits and assist the establishment of the buffer areas.

5.24 In summary, the border strip method has been chosen for this site because it is the best method of achieving MDC's objectives for this land treatment scheme of maximising the volume of wastewater applied to land so as to reduce the wastewater discharge to the Ruamahanga River. I am of the view that other methods would not be so effective in terms of this goal while protecting water and soil properties.

Review of Leeston Land Treatment Site

5.25 In January 2009 Landcare Research Ltd reported on a soils investigation that they undertook on the Leeston land treatment site to assess the impact of past treated wastewater discharges on soil structure and quality. A copy of this report is included in Appendix A of my evidence. The land treatment area at Leeston, in Selwyn District, receives treated municipal wastewater from eight oxidation ponds in series and it is irrigated by border strip irrigation. The land treatment area (total irrigation area 10.4 ha) comprises of six separate areas of which areas 1 and 2 have been used for wastewater irrigation since 1974. The treated wastewater is supplied to each border strip by a series of pipelines and bubble-up valves that are operated manually. The wastewater irrigation system at Leeston is similar to that proposed by MDC at Homebush.

5.26 The hydraulic loading at the Leeston land treatment site for the last four years is detailed in Table 4. The average hydraulic loading rates at the Leeston site range from 1.76 m to 2.73 m (refer to Table 3) which is higher than the average hydraulic loading proposed for the MDC scheme of 2.02 m.

Table 4: Treated wastewater hydraulic loading at the Leeston land treatment site for the last four years (Source: Selwyn District Council)

Location	Area (ha)	Hydraulic loading for various years (mm/year)			
		2004-05	2005-06	2006-07	2007-08
Area 1	1.85	360	2,556	3,070	2,727
Area 2	1.89	1,830	2,726	2,610	1,245
Area 3	1.92	1,713	1,687	2,111	1,492
Areas 4 & 6	3.38	2,828	2,112	3,299	4,477
Area 5	1.36	962	2,477	1,933	2,209
Total area	10.4	1,758	2,272	2,735	2,731

5.27 Landcare Research Ltd's report states that the soil condition under the wastewater irrigation border strip is very good and is similar to that under the adjacent lucerne crop that doesn't receive wastewater irrigation and the report concludes that the soil condition (soil structure and root growth in topsoils) has been maintained or improved under the current wastewater irrigation practice.

5.28 The report does highlight the poor condition of the pasture, the considerable presence of weeds and the limited harvesting of the pasture in some of the irrigation areas at Leeston. This highlights the need for a holistic approach to the management of the land treatment system that includes control of the pasture health. At the Leeston site Selwyn District Council leases the wastewater irrigation area to a neighbouring farmer and hence does not have close control over the management of the pasture. The pasture at the Leeston site is predominately grazed by sheep with only limited harvesting of the pasture occurring.

5.29 In contrast, at the Masterton site it is proposed that MDC will have direct control of the management of the wastewater irrigation system, the pasture management and the harvesting of the pasture. This will ensure that pasture and soil health is maintained and that regular harvesting of the pasture occurs. This is similar to the case at the Taupo land treatment site where the whole system is managed by the Taupo District Council and pasture growth is very good. In this context, I note that the suggestion of allowing private use of the waste water whilst feasible would need to be closely controlled and monitored.

6. AIR DISCHARGES FROM THE IRRIGATION AREA

Odour

6.1 Properties that could potentially be affected by odour emissions include an orchard and several residential properties adjacent to the northern boundary of the irrigation area, and residences to the west and southwest (on the west side of Manaia Road and on Martinborough Masterton Road adjacent to the 107 ha site). The closest dwelling is located approximately 150 m east from the proposed border strip area in the south-eastern corner of the 91 ha site. In addition, when the decommissioned ponds are converted to irrigation of pasture, the nearest properties to this area will be to the east and to the south, across the Ruamahanga River. (Refer to the plan of distances to immediate neighbours in Appendix C of the AEE.)

6.2 For odours to be released during application to land, anaerobic conditions would need to exist in the wastewater, either during the treatment process or within the conveyance pipelines.

6.3 In the proposed border strip system the treated wastewater will be piped to each border strip rather than being conveyed in an open channel (as is the case with traditional border strip systems). The piped system will prevent any potential for odour generation from treated wastewater ponding in headraces.

6.4 The ponding of treated wastewater for extended periods on the ground surface has the potential to generate odours. The border strips will be constructed with a shallow grade, falling towards wipe-off drains, thus encouraging wastewater to flow off the strip and if there is any excess, into wipe off drains. The management regime proposed for the irrigation scheme will also require that risk of ponding be minimised.

6.5 Odours can also be released from saturated soils when anaerobic conditions prevail. Border strips will be operated on a cyclic schedule, maximising the return period and re-aeration time for the soils, thus restoring aerobic conditions to the soil and avoiding odours.

6.6 The proposed automated control system will monitor the performance of the irrigation scheme, including warning the operator of problems with irrigation cycles and durations, pump pressures, valve malfunctions and excess wastewater in the wipe-off drain. This system will promote rapid response to ineffective operation of the irrigation scheme, thus mitigating the potential for odour generation.

6.7 In addition, the presence of trees as a buffer around the irrigation area is a factor that mitigates the effect of any odours by increasing the air turbulence, which in turn increases the mixing and dispersion of odours.

6.8 In summary, while there is potential for an effect for odour generation from the irrigation area, the engineering design of the scheme, operational and mitigation measures are aimed at minimising odour from the irrigation area. Existing border strip applications in New Zealand have shown that even when standing next to an operating border irrigation system (in a properly functioning wastewater treatment plant) that odour transmission is negligible. In addition a consent condition is proposed that; "The treatment, storage and wastewater irrigation activities shall not cause any noxious, offensive or objectionable odour at any dwelling or at any place more than 50 m from the boundary of the designated site." In my view this condition can readily be complied with.

Spray Drift and Aerosols

6.9 By using border strip irrigation and a drip irrigation system (for the planted buffer zones and the native tree area), the application methods proposed for the land application of treated wastewater will have no potential to create spray drift and negligible potential to create aerosols.

7. SUBMITTERS' CONCERNS

Donald J Bell (Submitter 242617)

Submitter questions why surface drip irrigation has not been considered.

Response:

7.1 The use of surface drip irrigation has been addressed earlier in my evidence under *Alternative Irrigation Methods*. Surface drip irrigation systems have a number of advantages such as being relatively easy to control the depth of application and to fully automate. d They are also not subject to issues related to odour, aerosol or wind. However while surface drip irrigation systems are suitable for irrigating row crops, such as plantation trees, they are not suitable for irrigating pasture as is proposed by MDC at Homebush.

7.2 As outlined earlier in my evidence the perimeter planted buffer areas will be irrigated with treated wastewater using surface drip irrigation, at least until the trees are established. However the irrigation of these areas will only occur during the summer months to rectify soil moisture deficits and assist the establishment of the buffer areas.

Andrew Stewart (Submitter 242620)

Submitter questions why solid set spray irrigation that is referred to in an Aqualinc report has not been adopted.

Response:

7.3 The report referred to by the submitter compares the advantages and disadvantages of using border strip and solid set spray irrigation systems for the irrigation of wastewater at the Homebush site. It concludes that with solid set spray irrigation it is possible to limit the depth of wastewater applied per application where as with border strip irrigation it is not possible to limit the application depth and hence the direct loss of applied wastewater to groundwater would be reduced with solid set spray irrigation. The report's recommendations included the following actions:

- Modelling of the land treatment area be carried out, based on historical climate data and the proposed irrigation rates, to determine the quantity and quality of the effluent leached to the groundwater and the nutrient uptake by the crop and the soils.

- Further consideration be given to the method of effluent irrigation to be used at the Homebush land treatment site (i.e. solid set sprinklers or border strip irrigation).

7.4 Both of these recommendations were subsequently carried out with the modelling being undertaken by Dr S Green and it is reported in his evidence. The second recommendation was the subject of a workshop comprising of project team members and various experts in May 2005. The outcome of this workshop was that border strip irrigation was adopted as the preferred method of wastewater irrigation on the 91 ha site at Homebush.

Riddlesworth Estate Ltd et al, Sustainable Wairarapa Incorporated, David Holmes (Submitters 242514, 242569 and 242571)

Submitters question why centre pivot irrigators have not been adopted for the irrigation of wastewater instead of border strip irrigation.

Response:

7.5 The option of using centre pivot irrigators has been addressed earlier in my evidence under *Alternative Irrigation Methods*. As outlined in my evidence there are a number of issues with respect to the soil/plant system that would arise if centre pivot irrigators were used to apply the wastewater depths proposed by MDC at the Homebush site. While the use of centre pivot irrigators has advantages in some situations, border strip irrigation has been selected for this site because it is the best method of achieving MDC's objectives of maximising the volume of wastewater applied to the land so as to reduce the discharge of wastewater to the Ruamahanga River.

Riddlesworth Estate Ltd et al, Sustainable Wairarapa Incorporated (Submitters 242514 and 242569)

Submitters question why cash crops such as maize have not been considered.

Response:

7.6 While maize for example does have the potential to produce high dry matter yields and hence high nutrient uptake it has the major disadvantage of being an annual crop. Annual crops are not as effective as pasture for assimilating the applied nutrients all year round, and at being tolerant of wet soil conditions.

7.7 The establishment of annual crops would also require lengthy periods of restricted wastewater application during the germination and young growth periods when frequent watering would cause damage to the crops. Similarly wastewater application would need to be restricted near to and following crop harvest period until a subsequent crop was established. Reduced wastewater applications to the crop would require additional applications to the remaining areas or increased discharges to the Ruamahanga River or a greater volume of wastewater storage.

7.8 In addition, the maintenance of stable topsoil structure is critical to achieving a high infiltration capacity required for wastewater application. Under well managed irrigated pasture, stable topsoil structure increases over time. However under cultivation of soils for cropping, stable topsoil aggregates are broken down to form seed beds. It takes two to three years to re-establish stable topsoil aggregation.

7.9 The optimisation of a wastewater land treatment system usually results in the selection of perennial grasses because of a longer application season, higher hydraulic loadings and greater nitrogen loadings compared to other annual agricultural crops (USEPA, 2006).

7.10 For the MDC site a perennial grass land use has been adopted because of its ability to both accept wastewater all year round and to grow and assimilate the nutrients in the wastewater all year round. A cut-and-carry pasture system has been adopted because of its ability to remove large quantities of nutrients from the site. The largest nutrient removals are generally achieved with harvested perennial grasses (Morton et al, 2000).

Rangitane O Wairarapa Iwi Authority, Kahungunu ki Wairarapa, Papawai Community Trust, Ian Gunn (Submitters 242513, 242615, 242616 and 242618)

Submitters refer to the failed example of border strip irrigation at the Waingawa Freezing Works.

Response:

7.11 My understanding, and hence my comments, on the effluent irrigation system at the former Waingawa Freezing Works are limited to the information about the effluent irrigation system contained in the New Zealand Soil Bureau Report "Effluent Disposal by Irrigation at Waingawa Freezing Works" prepared by Cook et al (1987).

7.12 The soils at the Waingawa site are mainly shallow to moderately deep with much lower water holding capacity than the soils at MDC's site. The deep soils at Waingawa are more comparable to those at the MDC site. The nitrogen content of the irrigated effluent was high (i.e. 80 g/m^3) compared to MDC's treated wastewater. The effluent from the freezing works was applied to the land by border strip irrigation that consisted of a series of open headraces to supply the effluent to the borders. (The MDC system will use buried pipelines, automated zone valves and bubble-up valves to supply the wastewater to each border strip.)

7.13 The main issue with the Waingawa border strip irrigation system was the poor state of repair of the headrace sills, the levees and the borders, leading to a very poor distribution of the applied effluent to the irrigated area. Instead of irrigating 3.4 ha per day, the actual area irrigated was estimated to be between 0.34 ha and 1.7 ha per day. As a result the effluent was only spread over a portion of the irrigation area instead of being evenly spread over the all of the irrigation area, with a resulting poor application performance and high nitrogen loadings on the limited areas receiving effluent.

7.14 The report recommended that animals should be excluded from grazing the effluent irrigation area and that the pasture should be harvested and removed from the site (i.e. a cut-and-carry system, which is what is proposed by MDC).

7.15 The report highlighted the poor performance of the Waingawa border strip effluent irrigation system but it also stated that a border strip irrigation system that spread the effluent evenly over all of the irrigation area would have similar nitrogen leaching losses to a well designed spray effluent irrigation system. (By comparison, the proposed MDC wastewater irrigation system will be appropriately constructed and maintained to ensure that the application of wastewater along total length of the borders, and between borders, is as even as possible.)

8. SUMMARY

8.1 The principal objective of the proposed wastewater irrigation system is to maximise the sustainable treatment of treated wastewater by the land, not to maximise the revenue earning ability from cropping the land.

8.2 The border strip method has been chosen for this site because it is the best method of achieving MDC's objectives for this land treatment scheme of maximising the volume of wastewater applied to land so as to reduce the discharge of wastewater and therefore nutrients to the Ruamahanga River.

8.3 With border strip application relatively large volumes of treated wastewater can be applied to the land at 7 to 10 day intervals. This rest period between irrigations allows time for the soil to drain and re-aerate which is important for maintaining healthy soil conditions. The treated wastewater will be supplied to each border strip by a system of pipelines and bubble-up valves that can be operated independently.

8.4 A permanent pasture land use is recommended because pasture will allow the formation of stable topsoil aggregates and high infiltration capacity required for the high wastewater application rates proposed. Also permanent pasture has the ability to assimilate large quantities of nitrogen and phosphorus from the applied treated wastewater and is able to accept treated wastewater on a year round basis.

8.5 A cut-and-carry pasture system where pasture is regularly harvested and carried off the property for feeding to stock is the proposed land use for the area that will be irrigated by border strip irrigation. In this way the nutrients in the pasture that are assimilated from the wastewater are removed from the property.

8.6 Good management of the crop/water/soil system is very important to the successful operation of a cut-and-carry pasture land treatment system and this will be included in the land treatment management plan.

8.7 I am satisfied that the proposed land treatment system can be sustainably operated.

DNH Borrie
13 February 2009

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Appendix A: Landcare Research Ltd's Report on Leeston Land Treatment Site