

Preferential Flowpath Land Treatment System Pilot plant trial, Report June 2011



Sustainable Wairarapa Incorporated



**THE AGRICULTURAL AND MARKETING
RESEARCH AND DEVELOPMENT TRUST**

This study was undertaken by Sustainable Wairarapa Incorporated, with funding from the AGMARDT, Carterton District Council, Greater Wellington Regional Council, South Wairarapa District Council, and Masterton District Council, and would not have been possible without voluntary work from the following people:

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A handwritten signature in black ink that reads 'AGD'.

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Sustainable Wairarapa Incorporated /Carterton District Council

Land treatment trial

1. Background

New Zealand produces around a billion litres of municipal wastewater per day. (inf-facts-issues-Sep09.pdf, 2009) Currently very little of this effluent is used for farm irrigation, despite declining water resources in many areas. A key obstacle to uptake of treated wastewater for farm irrigation is perception. Thus whilst technology is sufficiently advanced to ensure that public health risks are acceptable in a scientific sense, there is a knowledge gap in achieving cultural acceptability.

Sustainable Wairarapa Incorporated received funding from AGMARDT, Greater Wellington Regional Council, Carterton District Council, Masterton District Council, and South Wairarapa District Council to carry out a land treatment trial based on the Preferential Flowpath Land Treatment System concept.

The trial was carried out in partnership with Carterton District Council, on Council land at the wastewater treatment plant in Dalefield road, Carterton.

The primary purpose of the investigation was to scope the feasibility of contaminant removal from treated municipal wastewater, namely the 'human elements' that compromise the use of recycled water by a perception taint. Whilst mechanical removal is relatively straightforward, there is a perceptual difference when 'natural' or biological processes are used to effect this removal.

There are many examples of how recycled water perceptually loses its stigma and is viewed as fresh or natural water. Septic tanks, for example, discharge into ground, and the wastewater in its passage through soil into the groundwater and in its passage through land as groundwater, is transformed into water. Whilst the physical and chemical changes to the water are sometimes less reliable than man-made treatment processes, public perception favours this natural process.

This trial therefore attempts bio-mimicry by introducing land treatment as a mechanism for recycled water polishing in a controlled manner.

In other related matters, the storage of treated wastewater for farm irrigation during the summer months is jeopardised by the possibility of algal growth, caused by high nutrient levels. Thus, nutrient removal is also of benefit for farm irrigation when storage is considered.

2. Location

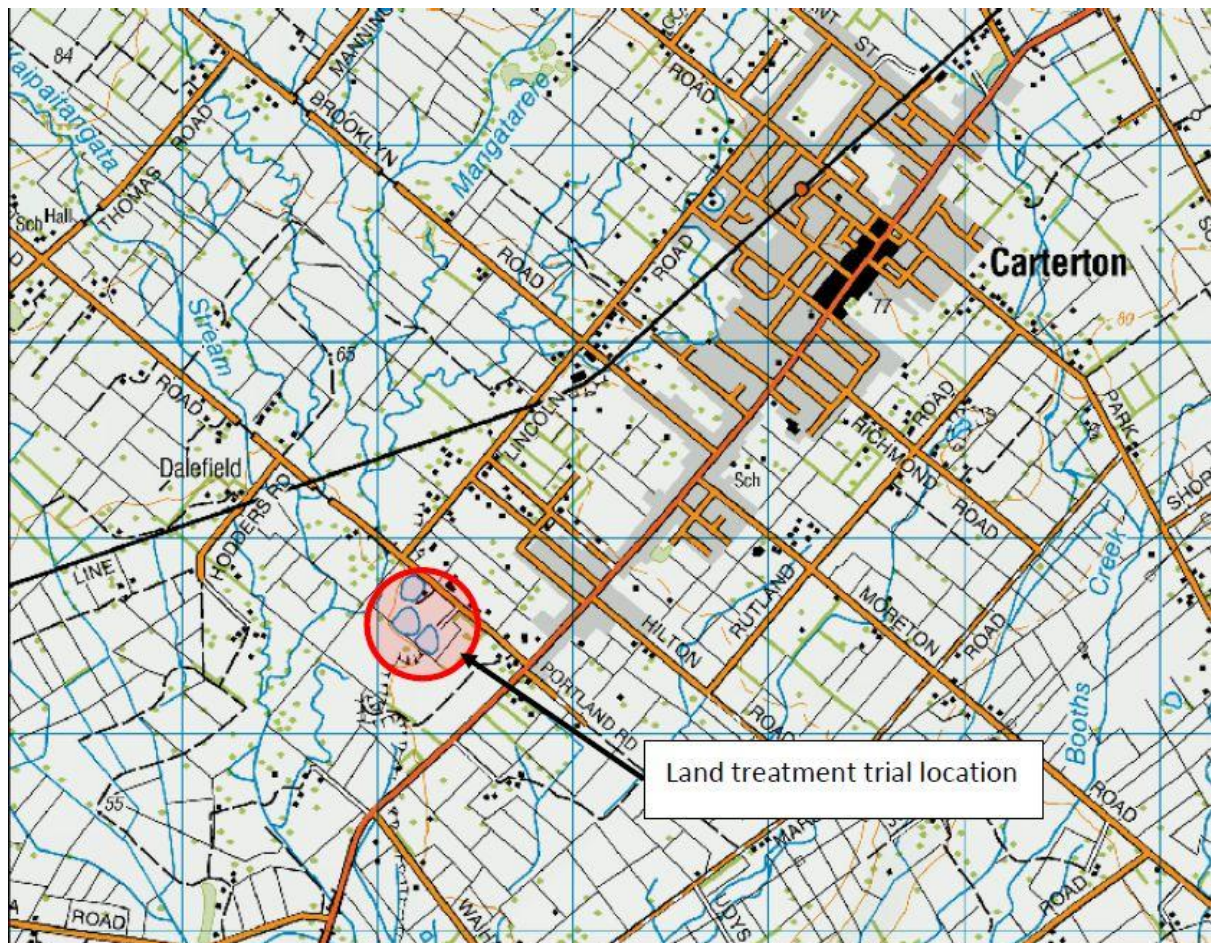


Figure 1 Site Location Plan

The site provided not only a physical space in which to construct the trial trench, but also treated and partially treated municipal wastewater with which to test the efficacy of treatment.

The trial trench is located at the eastern end of the site adjacent to the oxidation pond (fig. 2).

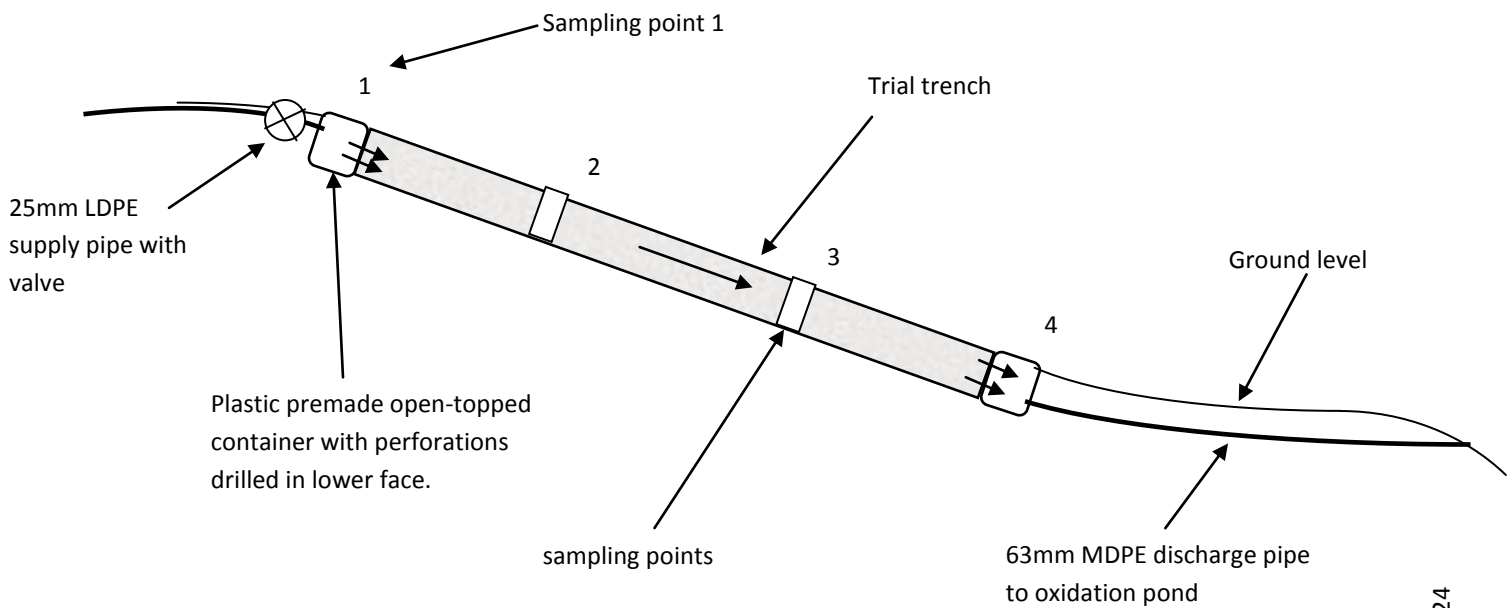


Figure 2 trial trench location

The trench was located to receive effluent from the feed pipe for an effluent dripline area, and from a submersible pump in the primary oxidation pond adjacent.

The outlet from the trench returns to the oxidation pond.

3. Schematic



4. Trench details

Trench length:	15m
Trench width:	1.35m
Trench depth:	0.25m imported filter material, 0.15m topsoil
Trench lining:	Polythene (trench located over existing landfill so infiltration to soil not desirable in this case)
Sample points at:	0m,5m,10m,15m,
Slope:	1:3

5. Soil characteristics

In order to make a realistic end product for full scale use, relatively high permeability soils are needed (permeability of around 10m/d and upwards). This requires a sand material. In order to increase the treatment efficacy Environmental Science & Research investigations suggest that incorporation of volcanic soils is beneficial (these have the opposite ionic charge to pathogens) (Pang, Volume 38, July–August 2009). Pumice sand was therefore imported from Taupo as a mixer.

The capacity of soils for effluent renovation is commonly limited by depth to groundwater. In addition, the upper, oxygenated soil layers provide habitat for biological activity not present in deeper soil strata. Research by Environmental Science & Research (Pang, Volume 38, July–August 2009) recorded microbial removal rates through different types of soil, which varied from around 0.3 to 16 log/m (mean), most soils displaying mean removal rates of between 1 and 4 log/m. Typically sandy soils out-performed clayey soils. There are a number of mechanisms that remove pathogens in sand filter systems (Bomo, Stevik, Hovi, & Hanssen, 2004) (Garabedian, 1991).

It is clear that in terms of microbial removal, the longer passage through soil, the better the removal rate, and the greater the proportion of biologically active soil, the better the removal rate.

The desire to re-use recycled water for irrigation requires that water be recaptured after land treatment, and this is not always possible or practicable in naturally occurring soil strata. In-situ soils can also exhibit non homogeneous conditions or macro-pore flowpaths, reducing the efficacy and predictability of treatment.

The above limitations led to the generation of the Preferential Flowpath Land treatment System (PFLTS) (patent pending). This concept utilises an imported high permeability soil confined within a trench in a low-permeability naturally occurring site soil. The water is (relatively) unable to escape through the surrounding impermeable soil, and follows a preferential flowpath through the high permeability soil.

6. Construction

The trial trench was constructed in early May 2011.



Figure 3 Commencing construction



Figure 4 mixing sand and pumice



Figure 5 Filling the trench

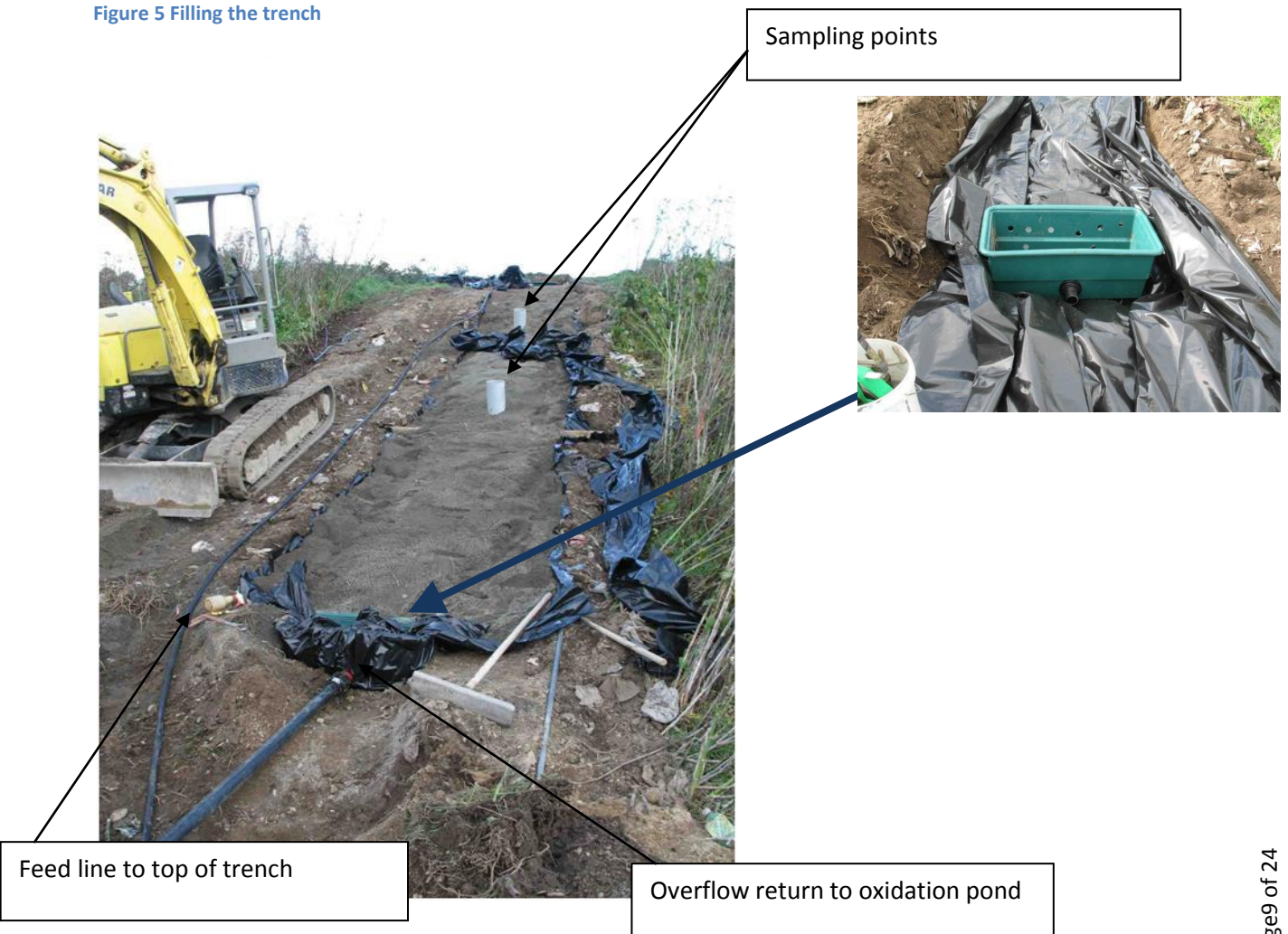


Figure 6 trench nearing completion



Figure 7 Completed trench

7. Trial Details

A three week trial period was run from 16th May to 2nd June

7.1. Sampling.

Timing: Given the soil transmissivity, it was anticipated that there would be a delay between effluent entering the trench and it appearing at the sampling points. An initial timing trial suggested that there was a 2 hour time lag for each 5m so 6 hours overall. This time lag was progressively applied between effluent application and sampling for each sampling point.

Aggregate samples were taken where possible to increase the probability of samples being representative. Sampling was carried out by Vanessa Vermeulen, Environmental Health Officer for Carterton District Council. Before sampling, each container was labelled with the date and time of sampling, site name, and sampler identification. Nutrient samples were collected in sterile plastic nutrient containers provided by the ELS. Samples were collected by completely submersing the open container in the effluent until the bottle was entirely filled. Bacteria and MS2 phage sampling was conducted using aseptic technique. Each sample was collected in sterile 500ml tinfoil covered

glass jars. The samples were sealed leaving an air gap of 20ml, and stored upright a chilly bin containing ice packs. All the samples from the day were refrigerated overnight and sent on the express courier to ELS or Environmental Science & Research the following morning. A completed Chain of Custody document accompanied each set of samples to ELS/ESR.

7.2. Influent quality

Different influent qualities were trialled (and hence contaminant concentrations). The experiment had three distinct phases:

- a) Current best (final) wastewater treatment plant effluent quality (disk filtration and UV)
- b) Water taken directly from the primary oxidation pond.
- c) Spiking the final effluent with MS2 phage concentrate to measure the removal efficiency.

The existing effluent quality was trialled first, as that is the most likely scenario for actual full scale use. E-coli concentrations were low in the influent, and did not adequately test the trench in terms of pathogens; however nutrient and physical parameters were also modelled.

The effluent in all cases is viewed as mediocre quality in terms of that envisaged for a full-scale system, where it is anticipated that further removal of gross solids would be necessary to ensure a suitable trench life expectancy. A passive screening or sand filter may be suitable.

Whilst physical contaminant testing was continued past the first week, the effluent quality on the second week was so poor that it was expected to overload the trench in terms of physical loading. In fact, the results indicate that although there would undoubtedly be long-term implications of applying low quality effluent, in the short-term high contaminant removals are still possible, particularly for Phosphorus.

The physical testing in week 3 was contaminated by soil entering the bottom chamber (washed off from above), and the results have been ignored.

7.3. Contaminants tested

Constituent	Number of days per sampling round	Location	Total number of samples	Timing /sampling rounds	Testing by
Total N	4	1,4	24	Week 1,2,&3	ESL
Total P	4	1,4	24	Week 1,2,&3	ESL
Suspended Solids	4	1,4	24	Week 1,2,&3	ESL
Dissolved Oxygen	4	1,4	24	Week 1,2,&3	ESL
BOD₅	4	1,4	24	Week 1,2,&3	ESL
MS2 phage	4	1, 2, 3, 4	16	Week 3	ESR
E-Coli	3	1, 2, 3, 4	21 overall	Week 1&2	ESR

Table 1 sampling details

7.4. Commissioning

The trial trench was commissioned using final Carterton District Council effluent; however, it became apparent on the first day of sampling that this had not been sufficient, as fines and protein type foam were apparent in the sampling ports. It is thought that this is due to the 'settling down' of the particles in the trench fill, finding their physical equilibrium. During this period, finer material is released.

The test results for some parameters were therefore compromised on the first day of sampling.

8. Results

The results are separated into three categories: physical, biological, and appearance.

8.1. Physical testing

For all physical parameters except Dissolved Oxygen, a reduction in the parameter is of environmental benefit. For these parameters a percentage reduction is cited, for Dissolved Oxygen (DO) a percentage increase is cited (i.e. for all parameters a negative percentage indicates degradation).

Dissolved Oxygen

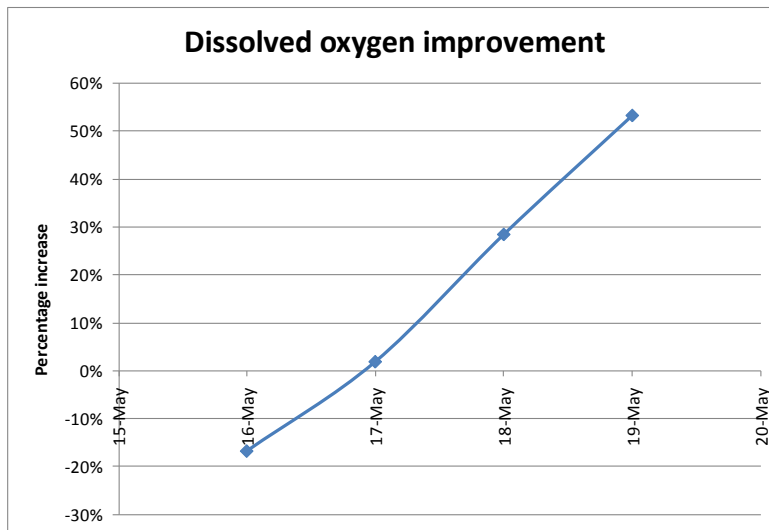


Figure 8 Improvement in dissolved oxygen in passage through the trench. Week 1

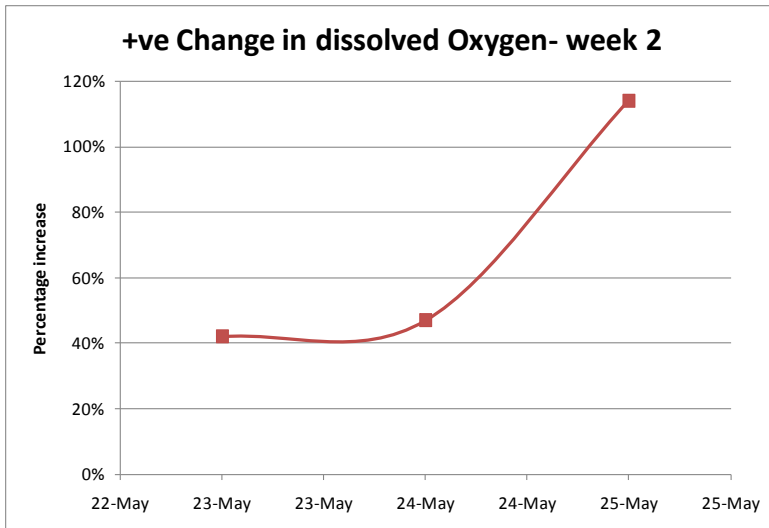


Figure 9 Improvement in dissolved oxygen in passage through the trench. Week 2

It can be seen that an improvement in dissolved oxygen was achieved in passage through the trench.

Suspended Solids and Nitrogen:

The suspended solids removal was good under the normal Carterton District Council effluent, and decreased with the poor quality oxidation pond water. The nitrogen removal rate is clearly dependent on a number of factors (as per the nitrogen cycle) and is a complex issue (fig. 10). Given experience in land application systems elsewhere, cut and carry crops could be used to remove nitrogen. In addition, NIWA has trialled trenches using sawdust as a medium to absorb Nitrogen from effluent, and this is a possibility here.

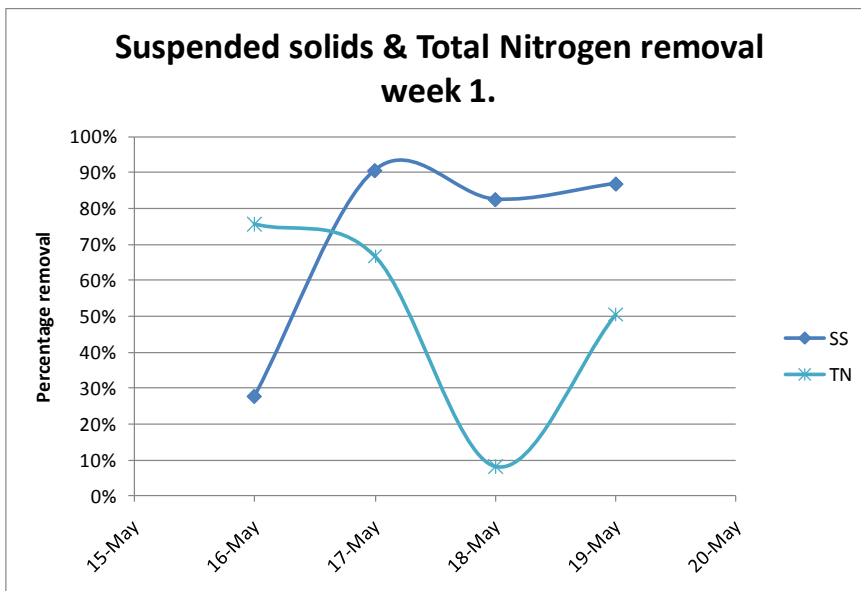


Figure 10 Suspended solids and Nitrogen removal rates week 1

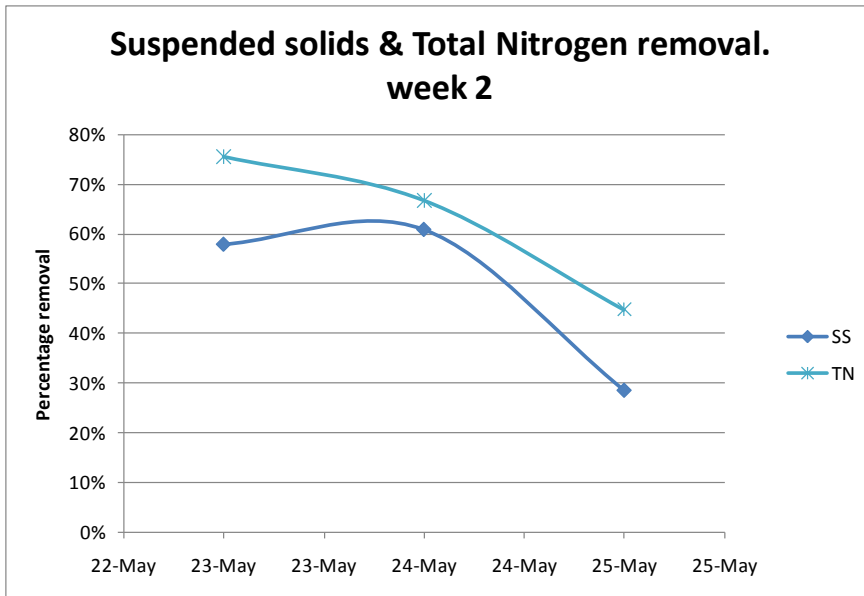


Figure 11 Suspended solids and Nitrogen removal rates week 2

Phosphorus and Biochemical Oxygen Demand:

The Phosphorus removal was significantly higher than anticipated, and remained high for the duration of the trial. Biochemical Oxygen Demand removal appears related to the influent quality, but was also relatively high.

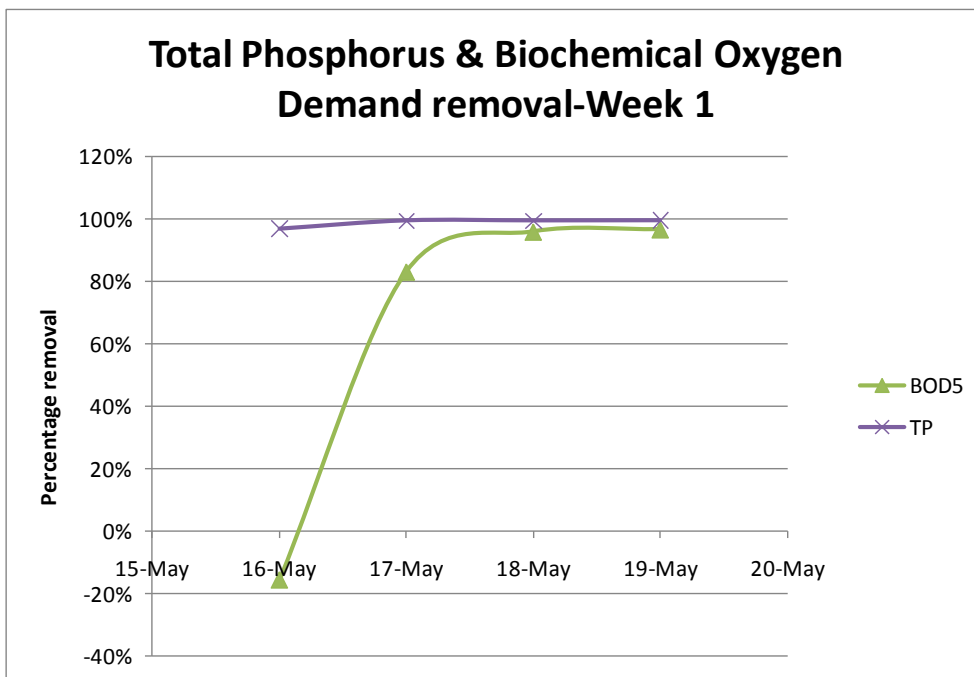


Figure 12 Total Phosphorus and Biochemical Oxygen Demand removal. Week 1

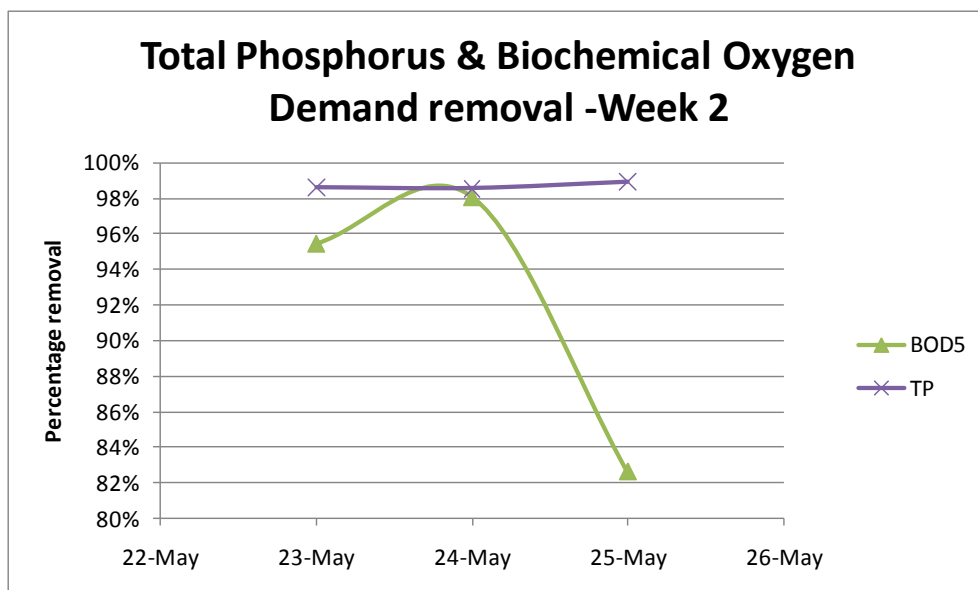


Figure 13 Total Phosphorus and Biochemical Oxygen Demand removal. Week 2

8.2. Pathogen testing

The trial in terms of pathogen investigated e-coli removal (week 1) and virus removal (week 2). Suitable e-coli concentrations were obtained by using primary oxidation pond effluent. An MS2 phage was propagated by Environmental Science & Research in Christchurch, and mixed into a dosing tank at the head of the trench (fig. 14).



Figure 14 Header tank for dose loading of viruses

This allowed a known volume and hence the virus concentration could be established such that it was at an appropriate level for testing. Virus concentrations were at a level 20-250 times that that could be expected in raw sewage from a contaminated community (Metcalf & Eddy, 2003).

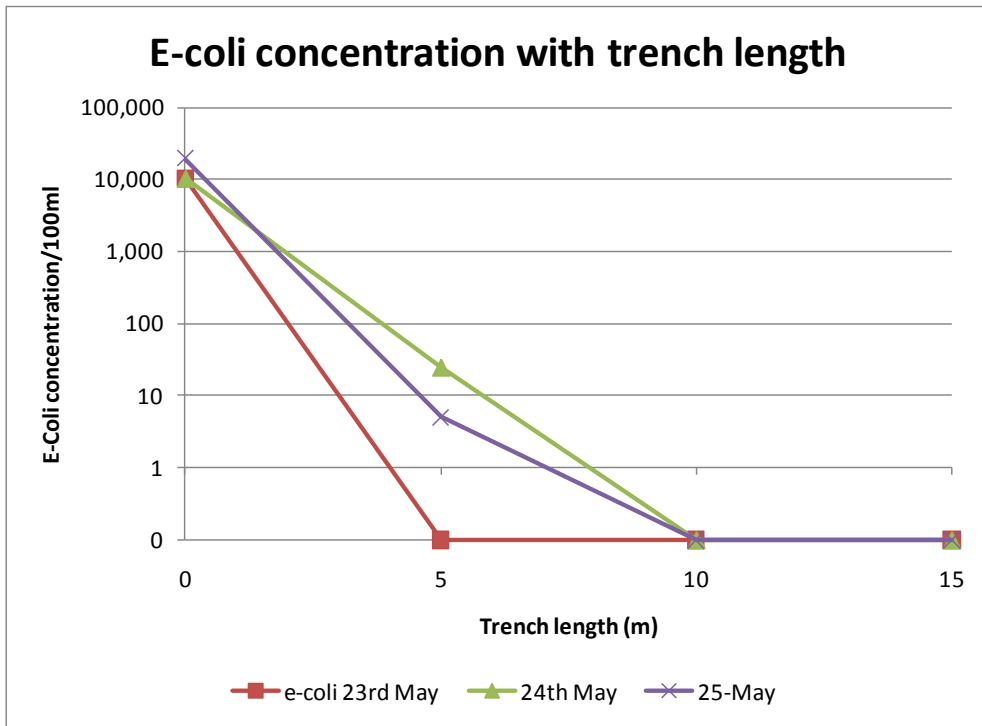


Figure 15 E-coli Concentration with trench length (oxidation pond effluent)

Note: The e-coli test results should strictly be recorded as Most Probable Number <1, but for ease of presentation have been shown as zero.

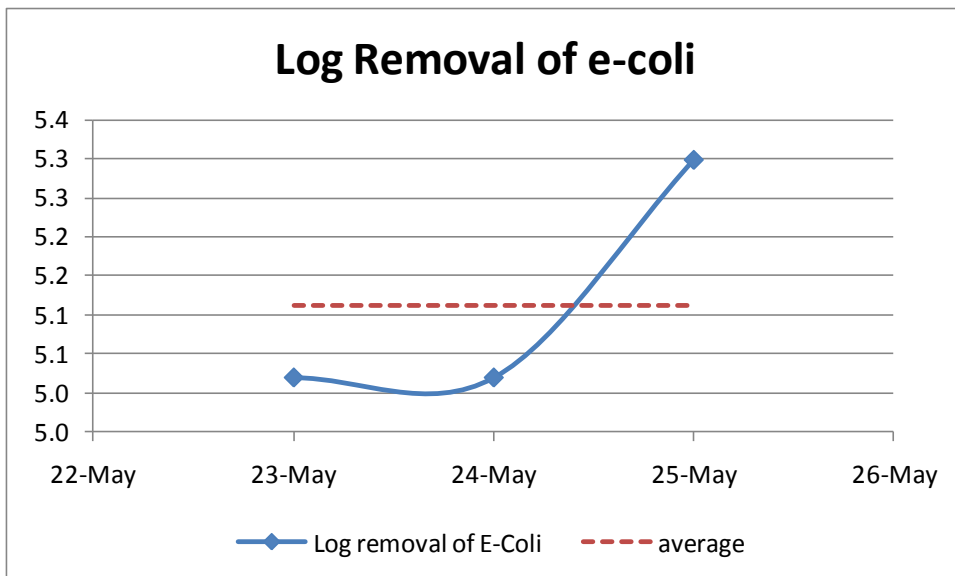


Figure 16 log removal of e-coli

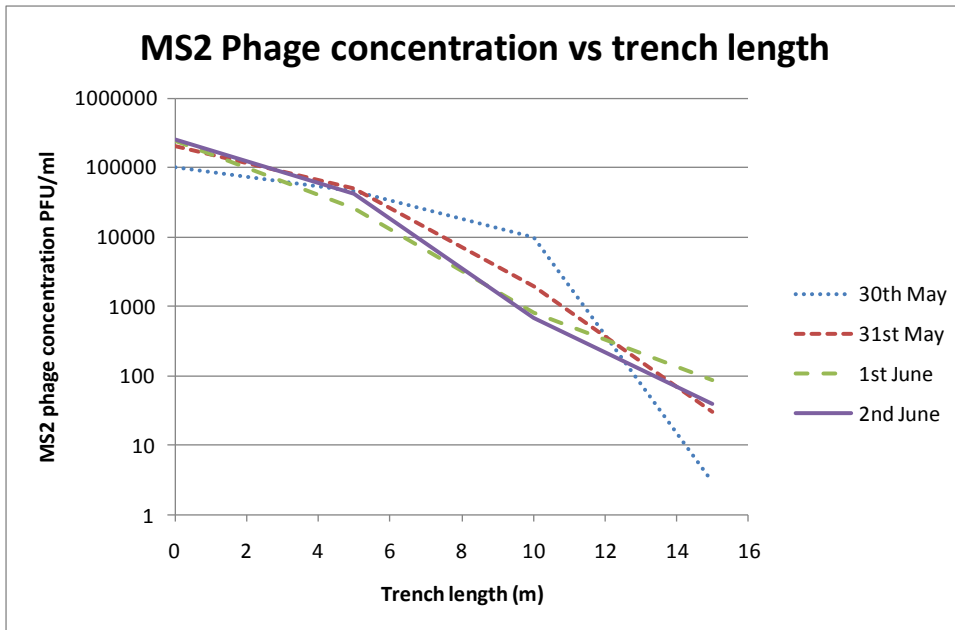


Figure 17 Virus (MS2 phage) removal

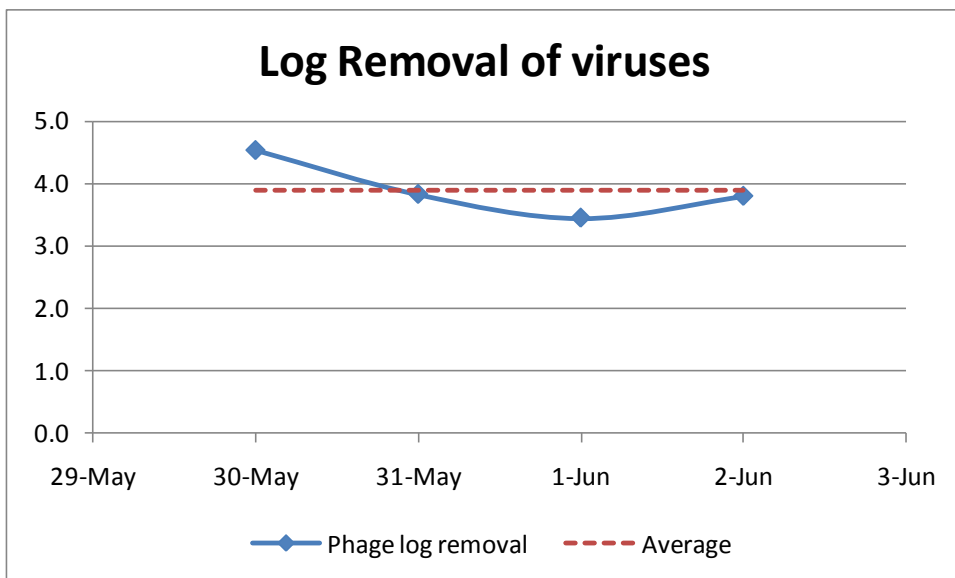


Figure 18 Log removal of viruses

8.3. Appearance

The resultant recycled water was a clear, colourless, devoid of any visible solids, and had no odour (fig. 19).



Figure 19 Recycled water (left) and influent (right) samples

9. Discussion

The trial objective was to provide a proof-of-concept and engage the community in terms of the perception of land treatment as a method of providing socially acceptable recycled water.

Ra Smith of Ngati Kahungunu ki Wairarapa was commissioned to provide an Iwi perspective on the perception of wastewater treatment and how the Preferential Flowpath Land Treatment System performed in this role (Appendix A). The results are encouraging, and tend to support the hypothesis that if contaminants in the water are removed to such an extent that the origin of the water cannot be deduced, a new classification of 'recycled water' is formed, as distinguishable from 'treated wastewater'. This creates significantly more opportunities for water reuse.

The trial was for a relatively short duration, and it is still unknown how the system would perform on a long-term basis. Following the trial results, Carterton District Council has agreed to take over the monitoring to assess whether the system could be used as part of its long-term treatment solution. This monitoring will provide greater certainty on the longevity and efficacy of the system, and take it from proof-of-concept to full-scale implementation stage.

It has been agreed with Carterton District Council that the trenches remain (i.e. do not get decommissioned), and that they are available for further testing in terms of other contaminants. Of particular interest is the performance in terms of emerging contaminants such as hormones. Environmental Science & Research have expressed interest in involvement in this, and there may be

significant Public good in carrying out such studies. The current study therefore has flow-on benefits outside of the results of the study.

In wastewater treatment terms, a 4-log reduction in pathogens is a significant goal. Because of the likely influent concentrations, it generally reduces pathogen counts to acceptable risk levels for human contact. The reductions indicated in this trial suggest that as a polishing treatment (i.e. there are a number of treatment mechanisms beforehand that are likely to reduce contaminant levels), both bacterial and viral pathogens could be completely removed from the water. Once again, the consistent removal over time needs to be proven, however the removal mechanisms believed to occur suggest that removal efficacy should continue unabated.

Although the study was focussed on the removal of human elements, physical parameters were also measured, and indicated some significant improvement in water quality. Of particular interest was the removal of Phosphorus which, at around 98%-99%, is considerably higher than might be expected. The main benefits of this are:

- Recycled water stored for future farm irrigation is significantly less at risk of toxic algal blooms if the nutrient levels are reduced in the magnitude observed in the trial.
- There is a possibility of adapting the system for use in the treatment of dairy shed effluent.
- It increases the possibility of treating municipal wastewater to a standard at which discharges to water may be considered satisfactory.

This research features as a significant addition to the Sustainable Wairarapa Incorporated Recycled Water Farm Irrigation Feasibility Study (Sustainable Wairarapa Incorporated, 2011)

Soils have a finite capacity for adsorption of Phosphorus, and following the trial results Landcare Research have been engaged to carry out Phosphate Sorption Curves – laboratory tests that give an indication of the capacity of the soil to retain Phosphates. Armed with this information, it should be possible to predict the longevity of the trenches (the point at which trench fill material would need to be replaced). This is the primary factor in the operational cost of the trenches, and hence the system viability when Phosphorus removal is required. Results are pending and will form part of the ongoing body of knowledge that will be collected by the Carterton sampling.

It also appears feasible that when the trench fill reaches Phosphorus holding capacity, it could be removed, air dried, and sold as a fertiliser product. It would be high in Phosphorus and Nitrogen, and in an easy form for incorporation in soils. It is envisaged that as world Phosphorus supplies decline and prices increase, this will become more attractive.

10. Conclusions

The trial established that the land treatment system has significant potential as a polishing treatment for municipal wastewater.

The system has the capacity for total removal of human pathogens from traditionally treated municipal wastewater.

Phosphorus removal rates are of the same magnitude as those that could be expected from specialised nutrient removal plants, and indeed exceeded those from coagulant dosing trials run at Carterton during the same period.

Initial indications are that there is a perceptual difference between the recycled water produced by the trench and that produced by the wastewater treatment works.

The seed funding provided by AGAMRDT has allowed this research to take place. In securing a Carterton District Council agreement to ongoing testing and establishing a working relationship with Environmental Science & Research in this field, the funding has been successful in kick-starting further investment.

Further research is required to validate the results of the trial and to establish parameters for the potential treatment of dairy shed effluent and similar.

11. Further research

The following items are required to further this work:

- Long-term (6-month to 1 year) sampling of water to confirm treatment efficacy.
- Phosphate sorption curve analysis and prediction of trench longevity in terms of Phosphorus removal.
- Investigation of potential to treat dairy shed effluent.
- Sociological assessment of the system in terms of the perception improvements offered by the system.

The first two elements of the above are in hand.

12. Where to from here?

Some partnerships have been formed for ongoing work on the Preferential Flowpath Land Treatment System, however further funding and partnerships would be of benefit:

- A joint venture with Environmental Science & Research would require funding from agencies such as the Envirolink Fund, the Waste Minimisation fund, or the Freshwater Fund. Typically, most funding agencies are narrow in applicability, and are over-allocated.
- There could be interest from companies like DairyNZ to form a partnership in terms of the dairy sector application.
- There may also be applications for water treatment in developing countries, and hence interest from bodies such as New Zealand Aid, Water Aid, etc.

All of the above could benefit from introductions to third parties or recommendations from the AGMARDT board.

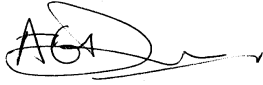
13. Acknowledgment

Sustainable Wairarapa Incorporated would like to acknowledge the assistance from AGMARDT, Carterton District Council, Greater Wellington Regional Council, Masterton District Council, and South Wairarapa District Council in contributing to the study.

Special thanks goes out to the many staff at Carterton District Council who by their physical help and unwavering support have made a challenging undertaking easy.

In addition, the input of Environmental Science & Research staff, notably Jacqui Horswell, Liping Pang, and Louise Weaver has been invaluable.

Last, but not least, the project team that have given guidance, direction, and impetus to take this study on in addition to their commitments for the Farm Irrigation Feasibility Study.



Andrew Duncan

B.Eng(Hons) M.Eng CPEng

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World Phosphate Institute, 3, Rue Abdelkader Al Mazini, 20001 Casablanca, Morocco

HOW CAN WE ENHANCE PHOSPHORUS REMOVAL IN CONSTRUCTED FARM WETLANDS?

Deborah J. Ballantine and Chris C. Tanner NIWA, PO BOX 11115, Hillcrest, Hamilton

Farm dairy effluent treatment Steve Couper^{A,C}, Michael Tan^A, Robert Leib

AWT New Zealand Ltd, PO Box 109-601, Auckland B Scion, Private Bag 3020, Rotorua

Corresponding author. Email: steve.couper@awtwater.com

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Design, Set-Up, and Operation of a Pilot Scale Intermittent Sand Filter -Septic Tank System

to Evaluate the Effects of Sand Dep'th and Infiltration Rate on Filter Treatment Efficiency

A Thesis Presented in Partial Fulfillment of the Requirements for the Degree of Master of Science in the Graduate School of The ui.io State University By James Albert Peebles, B.S.

Appendix A – A Maori framework for assessing wastewater issues.

Appendix B Pathogen sampling results

Samples: Week 1

Report no.: 01

Sampled by: Andy Duncan

<u>Lab ID</u>	<u>Sample ID</u>	<u>Date/Time sampled</u>		<u>Parameter</u>	<u>Result</u>	<u>Units</u>	<u>Detection limit</u>
Site 1	Site 1	16.05.11	08:55, 10:05, 13:35	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	4 7,270	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 2	Site 2	16.05.11	10:06, 13:33	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	2 >24,192	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 3	Site 3	16.05.11	13:40, 16:35	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 4,106	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 4	Site 4	16.05.11	16:45	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	1 754	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 1	Site 1	17.05.11	09:05, 11:25	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	4 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 2	Site 2	17.05.11	11:30, 16:47	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 3	Site 3	17.05.11	14:30	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 4	Site 4	17.05.11	14:35, 16:45	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 1	Site 1	18.05.11	11:37, 14:28	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	2 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 2	Site 2	18.05.11	11:35, 14:30	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 3	Site 3	18.05.11	14:31, 16:32	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 4	Site 4	18.05.11	14:32, 16:36	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 1	Site 1	19.05.11	09:13, 11:42, 14:37	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	2 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 2	Site 2	19.05.11	11:45, 14:40	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 3	Site 3	19.05.11	14:45, 16:37	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 4	Site 4	19.05.11	14:46, 16:30	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL

Samples: Week 2

Report no.: 02

Sampled by: Andy Duncan

<u>Lab ID</u>	<u>Sample ID</u>	<u>Date/Time sampled</u>		<u>Parameter</u>	<u>Result</u>	<u>Units</u>	<u>Detection limit</u>
Site 1	Site 1	23.05.11	09:45, 11:52, 15:21	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	10,462 >24,192	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 2	Site 2	23.05.11	15:22, 19:00	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 7,701	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 3	Site 3	23.05.11	19:01, 21:12	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 24,192	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 4	Site 4	23.05.11	21:15	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 1	Site 1	24.05.11	09:32, 13:25, 20:05	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	10,462 >24,192	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 2	Site 2	24.05.11	13:25, 20:07	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	25 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 3	Site 3	24.05.11	20:10	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 4	Site 4	24.05.11	21:20	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 1	Site 1	25.05.11	11:30, 15:35, 20:18	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	19,863 >24,192	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 2	Site 2	25.05.11	15:37, 20:16	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	5 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 3	Site 3	25.05.11	20:15, 21:40	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 4	Site 4	25.05.11	21:36	<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN	<1 >2,419.2	MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 1	Site 1	Not received		<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN		MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 2	Site 2	Not received		<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN		MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 3	Site 3	Not received		<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN		MPN/100mL MPN/100mL	<1/100mL <1/100mL
Site 4	Site 4	Not received		<i>E.coli</i> Colilert MPN Faecal coliform Colilert MPN		MPN/100mL MPN/100mL	<1/100mL <1/100mL

Samples: Week 3

Report no.: 03

Sampled by: Andy Duncan

<u>Lab ID</u>	<u>Sample ID</u>	<u>Date/Time sampled</u>	<u>Parameter</u>	<u>Result</u>	<u>Units</u>	<u>Detection limit</u>
INJ	Injection spike	30.06.11	MS2 bacteriophage	98,000	PFU/mL	<1/mL
Site 1	Site 1	30.06.11 10:00, 12:40, 14:42	MS2 bacteriophage	101,000	PFU/mL	<1/mL
Site 2	Site 2	12:42	MS2 bacteriophage	46,000	PFU/mL	<1/mL
Site 3	Site 3	14:45	MS2 bacteriophage	9,900	PFU/mL	<1/mL
Site 4	Site 4	14:50, 17:15	MS2 bacteriophage	3	PFU/mL	<1/mL
INJ	Injection spike	31.05.11	MS2 bacteriophage	107,000	PFU/mL	<1/mL
Site 1	Site 1	31.05.11 09:45, 12:50, 15:10	MS2 bacteriophage	207,000	PFU/mL	<1/mL
Site 2	Site 2	12:55	MS2 bacteriophage	51,000	PFU/mL	<1/mL
Site 3	Site 3	15:07	MS2 bacteriophage	1,970	PFU/mL	<1/mL
Site 4	Site 4	15:05, 16:47	MS2 bacteriophage	31	PFU/mL	<1/mL
INJ	Injection spike	01.06.11	MS2 bacteriophage	232,000	PFU/mL	<1/mL
Site 1	Site 1	01.06.11 09:40, 12:54, 15:33	MS2 bacteriophage	240,000	PFU/mL	<1/mL
Site 2	Site 2	12:56, 15:35	MS2 bacteriophage	25,600	PFU/mL	<1/mL
Site 3	Site 3	15:32, 17:16	MS2 bacteriophage	800	PFU/mL	<1/mL
Site 4	Site 4	15:31, 17:04	MS2 bacteriophage	86	PFU/mL	<1/mL
INJ	Injection spike	02.06.11	MS2 bacteriophage	221,500	PFU/mL	<1/mL
Site 1	Site 1	02.06.11 12:35, 15:00, 16:05	MS2 bacteriophage	249,000	PFU/mL	<1/mL
Site 2	Site 2	15:05	MS2 bacteriophage	42,000	PFU/mL	<1/mL
Site 3	Site 3	16:24, 17:54	MS2 bacteriophage	670	PFU/mL	<1/mL
Site 4	Site 4	16:27	MS2 bacteriophage	40	PFU/mL	<1/mL