Appendix Ten – Infiltration Trench Trial 2012

Silver Fern Farms Limited Pareora

SILVER FERN FARM PAREORA

Infiltration Trench Trial 2012 14

FINAL May 2014

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Executive Summary

This trial is the culmination of a series of investigations spanning a number of years. The aim has been to investigate the feasibility of using sub-surface infiltration as an alternative to the sea outfall to augment wastewater disposal when land capacity is reduced.

There were several facets to the trial:

- freshwater discharge - to ascertain whether the infiltration trench and surrounding media had recovered from blockages and loss of porosity / infiltration potential, that occurred during previous trials;
- wastewater treatment - with polyelectrolyte and a baleen filter to reduce those contaminants that contributed to the loss of porosity / infiltration potential and;
- wastewater discharge to establish whether discharge of the further treated wastewater was sustainable at the determined optimal discharge rate through the infiltration trench.

Previous trials had identified that the optimal discharge rate was 15L/s. This was achieved and sustained utilising freshwater, however a series of failures (surface eruptions and weeping) of the infiltration trench when using wastewater, even when treated, has led to the conclusion that the system is not viable for wastewater discharge.

It would appear that even when treated, the wastewater quality, specifically Suspended Solids and Total Grease, is not conducive to subsurface infiltration. The system is too sensitive to provide a reliable and sustainable discharge route due to the tendency of the filtration media (naturally occurring beach gravels) to blind with the solid and grease fraction of the wastewater.

Further treatment of the wastewater to increase removal of the solid fraction to a point where it is unlikely to cause blinding is considered not to be practicable.

The concept of the infiltration trench for wastewater treatment and disposal has been discounted as a viable alternative for the ocean out fall and as a means to augment disposal of wastewater when land capacity is reduced.

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1 Introduction

1.1 Background

1.1.1 Preface

The Silver Fern Farms Pareora site encompasses a modern multi species meat processing facility. To maintain the high standard of hygiene expected in export food processing facilities, a high volume of water is used throughout the operation. For this reason, large volumes of wastewater are generated and require managing. This is currently achieved following treatment via land-based irrigation and ocean discharge.

Historically wastewater was solely discharged to sea, in recent times to minimise that volume, Silver Fern Farms Pareora has progressively been developing a land-based irrigation network, Table 1.1.1 show the implementation timeline. Land based irrigation uses available nutrients and moisture from the wastewater discharged, via centre-pivots, to grow crops on a cut-and-carry basis; crops are grown, harvested, and taken off-site, therefore removing nutrients.

Year	**Development**
2008	Pivot 1 & 2
2009	Pivot 3
2010	Pivot 4
2013	Pivot 5

Table 1.1.1: Land-based Irrigation Network Implementation Summary

The key objective of moving to land-based irrigation is to minimise the volume of wastewater being discharged to sea. However, before deciding on land-based irrigation, Silver Fern Farms also investigated several other options:

- *Connection to a local council treatment network* - there is no local council network available at, or near, Silver Fern Farms Pareora operation to connect to; the local Pareora village utilises residential septic tank systems.

- *Deep ocean outfall* - due to significant engineering difficulties in placing a pipeline on, or under, the highly mobile gravel sea floor which undergoes extremely strong wave forces means this option is quickly discounted and potentially impossible to achieve.

- *Rapid infiltration trench into subsoil to intercept sub-surface groundwater flows* – given the free-draining nature of the sub-soil at Pareora this option showed merit to intercept the sub-surface groundwater flows going under coast and allow the slow percolation of wastewater with groundwater through the seafloor to the ocean. Contaminant removal is achieved through filtration of the wastewater through the sub-soil aggregate as well as biological and chemical activity within the sub-soil aggregate. This option would also require pre-treatment of wastewater to remove as much of the suspended solids as possible before it reaches the trench in order to avoid blinding the sub-soil aggregate profile.

The feasibility of land-based irrigation compared to all other options identified this as the best available option, and was therefore progressed. However, sub-surface infiltration showed merit.

1.1.2 Key driver

Avoiding a direct sea-water discharge via ocean outfall was seen as being highly beneficial in removing the visual environmental aspect of the sea discharge operation, a key concern of the general public. This is the key driver to developing alternative options to 100% direct ocean outfall discharge.

During the development of the land-based irrigation network it has become apparent that due to the nature of soils on the irrigation areas, and rain patterns across the district, land irrigation will not always be possible due to soil moisture levels, even when all the proposed land irrigation areas are developed.

Silver Fern Farms therefore decided that land application via sub-surface infiltration warranted investigation as an alternative discharge route to help avoid increasing the percentage of wastewater being sent to the ocean outfall during these periods.

A scheme that uses land-based irrigation and sub-surface infiltration to ocean was seen as potentially offering a more visually aesthetic sustainable alternative to an approach that includes an ocean outfall discharge.

1.1.3 Proof-of-concept investigation

In 2005 Silver Fern Farms began investigating the possibility of using subsurface infiltration as an alternative to a direct point source discharge to sea when land-based irrigation is not possible, or is constrained, (e.g., during periods of wet weather).

In 2011, Silver Fern Farms compiled a report of all investigations carried out up to that date, attached as Appendix One. In summary, the report highlighted that trials had confirmed sub-surface injection of water to an infiltration trench was feasible, but there was a high sensitivity of the receiving sub-soils to blinding from wastewater.

Following on from those trials, this report outlines the further work that was undertaken to lower the solid and grease content of the wastewater. This was carried out to minimise potential for sub-surface gravels to blinding, and determine whether long-term infiltration could be sustained; trial steps shown below in Figure 1.1.3.

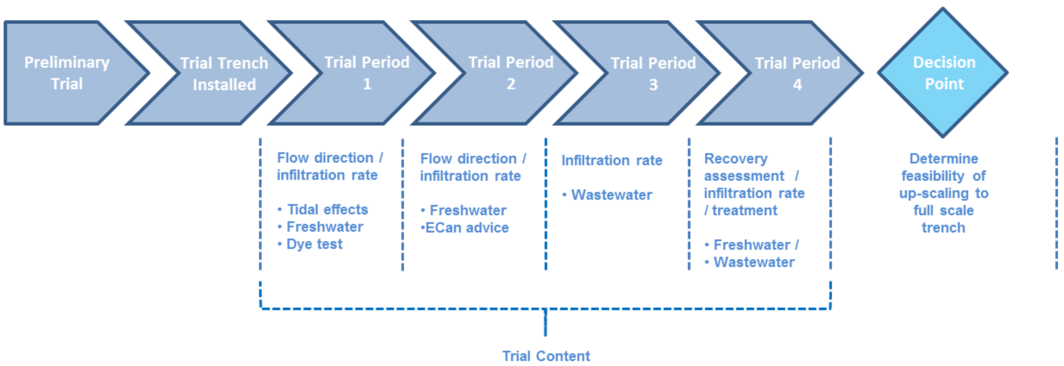


Figure 1.1.3: Summary of Trial Steps

In this report of the final stage of the trial (Trial Period 4), the information gathered up to this point is reviewed and a decision made as to whether discharging wastewater to an infiltration trench is a feasible and a viable option for up-scaling to handle full production wastewater throughputs; this decision is covered in the recommendations section of this report (s.5).

2 Trial Period Four

2.1 Recap – Previous Investigative Trial Findings

Preliminary analysis was performed to determine infiltration rates across different site-soil profiles, in order to identify a suitable location for a trial infiltration trench. A suitable site was identified between the stock-yards and the foreshore, shown in Figure 2. A twenty five metre trench, lined with filter fabric and filled with stone around a sub-surface pipe network was constructed. Monitoring bores were installed to supplement existing ones to monitor sub-surface water flows.

Figure 2.1: Location of Infiltration Trench and Monitoring Bores

2.1.1 Trial Period One and Two

During Trial Period One and Two, freshwater injection confirmed that sub-surface infiltration is free flowing under the beach toward the sea, and provided the basis to determine an optimal rate of sub-surface injection (15 L/s). Higher flow rates resulted in surface eruptions of water in the immediate vicinity of the trench and on the beach due to overloading the drainage capacity of the soils.

The structure of the sub-surface beach gravels across the Pareora site meant it was not possible to determine the dilution rate of the sub-surface injection due to the potential for preferential flows.

2.1.2 Trial Period Three

Initial wastewater trials (Trial Period Three) at the optimal rate identified no issues of back-flow, emergence of water on the beach or by the trench, or soil-pore blinding. However, later in the trial blinding and surface eruption of wastewater above the infiltration trench did occur.

A portion of the trench was excavated and a thin layer of fatty grease was observed coating gravels within the trench. Investigation identified the likely source to be from rendering activities; due to the colour of the fat indicating it had undergone heating which could only have happened in rendering activities.

Before progressing with any further trials, the trench was reinstated and rested to provide for natural attenuation of the fatty grease coating.

Overall, Trial Period Three highlighted the sensitivity of the porosity of the material in and around the trench to blinding and the importance of any future trials / development to take a precautionary approach to mitigate against blinding potential.

2.2 Trial Period Four

Trial Period Four included:

- Re-commissioning the trial infiltration trench with freshwater to establish if sustainable sub-surface discharge could be achieved. This step would confirm whether assumed natural attenuation did occur, flush any remaining particulates, and fill up the soil pores in preparation for wastewater flows.
- Increasing removal of solids and grease from the wastewater stream by the addition of a polyelectrolyte to the wastewater stream to improve volume of solids removal at the Baleen Filter.
- Ensure rendering was not operational during the wastewater portion of the trial. The rationale behind this was to eliminate a blinding potential variable highlighted during previous trials.
- Commence discharge of polyelectrolyte treated wastewater incrementally to see if sustainable sub-surface discharge could be achieved.

- Monitoring baseline water quality before the trial began, weekly during the trial, and post-trial until water quality levels returned to baseline levels. Samples were analysed for BOD, Nitrate Nitrogen, pH and total grease.

3 Findings

3.1 Natural Attenuation

Natural attenuation relies on natural biodegradation processes from microbes that live in soil, groundwater, and the wastewater itself, to digest the organic grease material observed during Trial Period Three that lead to the blinding of the trench.

At the beginning of the Trial Period Four freshwater discharge was started at a reduced rate (5L/s) and increased gradually to the optimal rate (15L/s) to establish whether permeability in the trench had recovered, and to what extent.

The observed water level in the monitoring bores (Appendix One) reflected observations made in previous trials:

- Trench bore slightly elevated during discharge - the Trench Bore is approximately one to two metres from the infiltration trench itself, an increase in water level would be expected, as water infiltrating from the trench will fill the surrounding pore spaces, locally raising the water level.
- Water levels in the Stockyards bore were relatively consistent - the baseline water level measured indicated some tidal influence on the water level as measured pre-discharge. In previous trials an influence on the bore from the infiltration trench was discounted, this conclusion is reinforced.

Monitoring bore water quality indicated a short-lived increase which may indicate degraded material from natural attenuation flushing through the sub-soil profile with the injected freshwater. There were no other variables which may indicate reasoning for such a temporary deviation.

Back pressure is a measure of resistance of the water discharging from the Infiltration Trench. As the water discharges from the trench and starts to fill the pore space of the surrounding material the back pressure increases. The more resistance the water faces to flow through the pore space the higher the back pressure.

Blinding of the pore spaces with solid material makes it harder for the water to infiltrate away from the trench and therefore increases the back pressure.

As expected back pressure increased and decreased with flow, but maintained a similar constant level at optimal flow rates (Appendix Two) as in previous trials indicating natural attenuation was successful in clearing restricted sub-soil pores.

Based on this evaluation of findings and that sustained discharge of freshwater was maintained would indicate natural attenuation was successful. Remediation appears to have been achieved, allowing the trench and sub-soils to be free-draining and suitable for wastewater discharge trials.

3.2 Wastewater Infiltration

Polyelectrolyte was added to the wastewater stream to enhance aggregation of suspended particles which would otherwise be difficult to remove by filtration alone. Polyelectrolyte promotes flocculation of small particles by causing colloids and other suspended particles in liquids to aggregate, forming a floc allowing for easier removal.

Wastewater was dosed with polyelectrolyte (Figure 3.2 below) and passed through the baleen filter before being discharged into the trench. For monitoring purposes, wastewater quality was sampled pre-polyelectrolyte treatment and post-baleen filtering in order to characterise the incoming wastewater quality and assess the efficiency of treatment. Preliminary trials showed dosing at 20ppm polyelectrolyte would have around 80% efficiency.

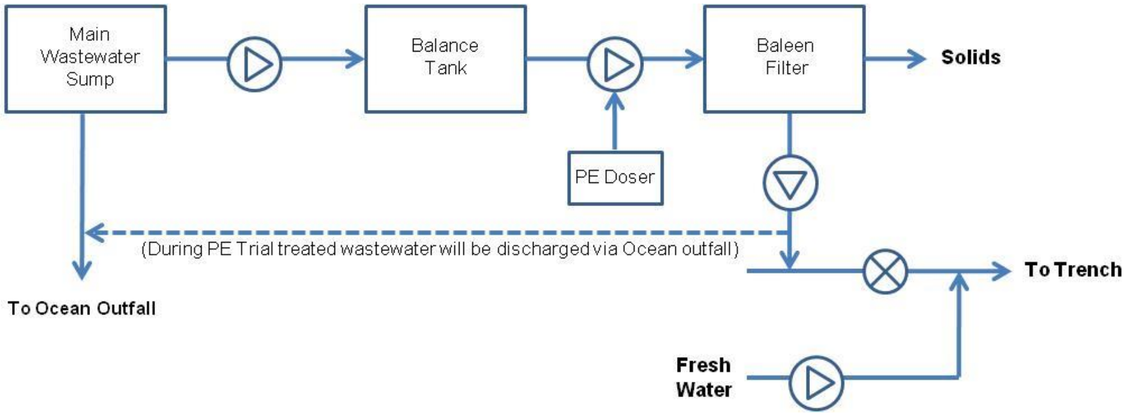


Figure 3.2: Infiltration trench injection process flow

Water quality in the monitoring bores was tested during freshwater discharge, during wastewater discharge, and post-wastewater discharge to compare baseline with previous trials, determine flow patterns of wastewater, and to determine time of recovery. Samples were analysed for biological oxygen demand (BOD), nitrate nitrogen, pH and total grease; results shown in Appendix Three.

Wastewater was injected into the infiltration trench at between 5L/s and 15L/s, and equates to ~ 432 m^3 per day (limited by dosing system and baleen).Table 3.2 below provides a summary of the wastewater trial that was conducted 17th October to 21st November 2013.

Date	Actions / Observation
17th Oct 2012	Pre- discharge Groundwater Monitoring Samples (high/low tide) Start Fresh Water @ 5L/s
24th Oct 2012	Groundwater Monitoring Samples Start Wastewater @5L/s – problems with poly-dosing gear
25th Oct 2012	Water Level Monitoring Poly-dosing working, discharging @ 7.5L/s
26th Oct 2012	Wastewater Samples Water Level Monitoring
29th Oct 2012	Groundwater Monitoring Samples Surface eruption / blow-out @ 12.3L/s
30th Oct 2012	Wastewater Samples Water Level Monitoring 5L/s ok 7.5L/s ok but BP high
31st Oct 2012	Groundwater Monitoring Samples Started 08:30 @ 10L/s – immediate surface eruption / blow-out Resumed @ 7.4L/s – ran for 1 hour (until ~09:30) before blow-out Resumed @ 5L/s
1st Nov 2012	Wastewater Samples 5L/s surface eruption / weeping Decision made to cease trial
6th Nov 2012	Post-discharge Groundwater Monitoring Samples
12th Nov 2012	Post-discharge Groundwater Monitoring Samples
21st Nov 2012	Post-discharge Groundwater Monitoring Samples

Table 3.2: Infiltration trench injection process flow

Surface eruptions of wastewater became evident as flow rates were increased upward toward the optimal. However, this did not appear to be accompanied by an elevation in observed back pressure or water level in the Trench Monitoring Bore. It is thought that this may be due to the wastewater quickly finding alternative pathways to the surface when the soil pores once again became blocked.

Following those eruptions, several further flow rate trials were carried out to determine if a sustainable lesser flow rate could be maintained. However, no such success was forthcoming. It appeared once the sub-soil pores were blocked the only alternative pathways being available were those that breached the surface.

4 Discussion and Conclusions

4.1 Freshwater Trial

On re-commissioning the Infiltration Trench, the blinding of the trench material that ceased the previous trial appeared to have naturally attenuated. Injected fresh water flowed freely, with no surface eruptions or springs being observed.

During the Freshwater trial the Infiltration Trench performed well at the optimal flow rate of 15L/sec. The flow rate was sustained over an extended period of approximately eight weeks. Back pressure increased with increasing flow rate but remained relatively consistent throughout the trial indicating no issues. Similarly, there were no observable eruptions of freshwater over the surface.

It was concluded from the initially high then decreasing levels of BOD observed in the Trench monitoring bore that over the duration of the trial, freshwater had to some extent flushed residual natural attenuation material from the trench.

On the basis that the sustained injection of fresh water was successful, with the trench functioning well, the decision to proceed with the wastewater injection phase of the trial was sound.

4.2 Wastewater

4.2.1 Treatment

The parameters of most interest were Suspended Solids and Grease, as these were thought to be responsible for the blinding of the trench in the previous trial.

Grease levels in the pre-treatment samples were significantly lower than previous trials; this was attributed to different processing occurring at the time of the trial including the absence of a rendering waste stream as renderable material was being processed off-site at the time of the trial.

The shortened trial due to the surface eruptions only allowed for a small data set of five samples to be analysed pre and post treatment. Results between samples were variable, however the combined polyelectrolyte and baleen treatment yielded an average reduction in grease of 55%.

A decrease was also observed in Suspended solids, the average being 42%.

The decrease in both solids and grease observed showed the combined polyelectrolyte and baleen treatment was highly successful and greater than the reduction seen in previous trials that utilised only the baleen filter.

4.2.2 Sub-surface Infiltration

Despite the apparent success of the treatment of the wastewater in removing grease and suspended solids, the discharge of wastewater through the Infiltration Trench was not successful.

Discharge of treated wastewater was started at a reduced rate and increased toward the optimal rate of 15L/s. Surface eruptions of wastewater occurred before the optimal flow rate was achieved. Subsequent attempts to discharge the wastewater resulted in numerous surface eruptions at lower flow rates. The decision to cease the trial was made on the seventh day of the wastewater portion of the trial.

There was no warning of potential surface eruptions when looking at the water level or backpressure data. It was assumed these would indicate before preferential pathways were found. However, it appears alternate preferential flow paths happened almost concurrently as pathways blocked, keeping levels and backpressure consistent.

It was surmised that despite the additional, and relatively efficient, treatment of the wastewater with polyelectrolyte and the baleen filter that the remaining solids and grease were still at a level to fill and block the pore space of the sub-soil aggregates in and surrounding the trench, blinding and reducing infiltration potential causing failure.

Due to the unsuccessful sustained injection and surface eruptions with wastewater, it was decided that there was no value in using tracer dye as in previous trials.

5 Recommendations

Based on these, and previous trial findings, the only recommendation that can be made is to cease the pursuit of using an Infiltration Trench as an alternative discharge option to an approach that includes an ocean outfall discharge and land-based irrigation.

Despite the use of polyelectrolyte and the baleen filter to remove suspended solids, and the Infiltration Trench functioning successfully with freshwater at the optimal discharge rate of 15L/s, the sub-soil aggregates are too sensitive and vulnerable to blinding when discharging wastewater.

6 Appendix One: Previous Trial Summary Report

7 Appendix Two: Freshwater Trial

7.1 Summary

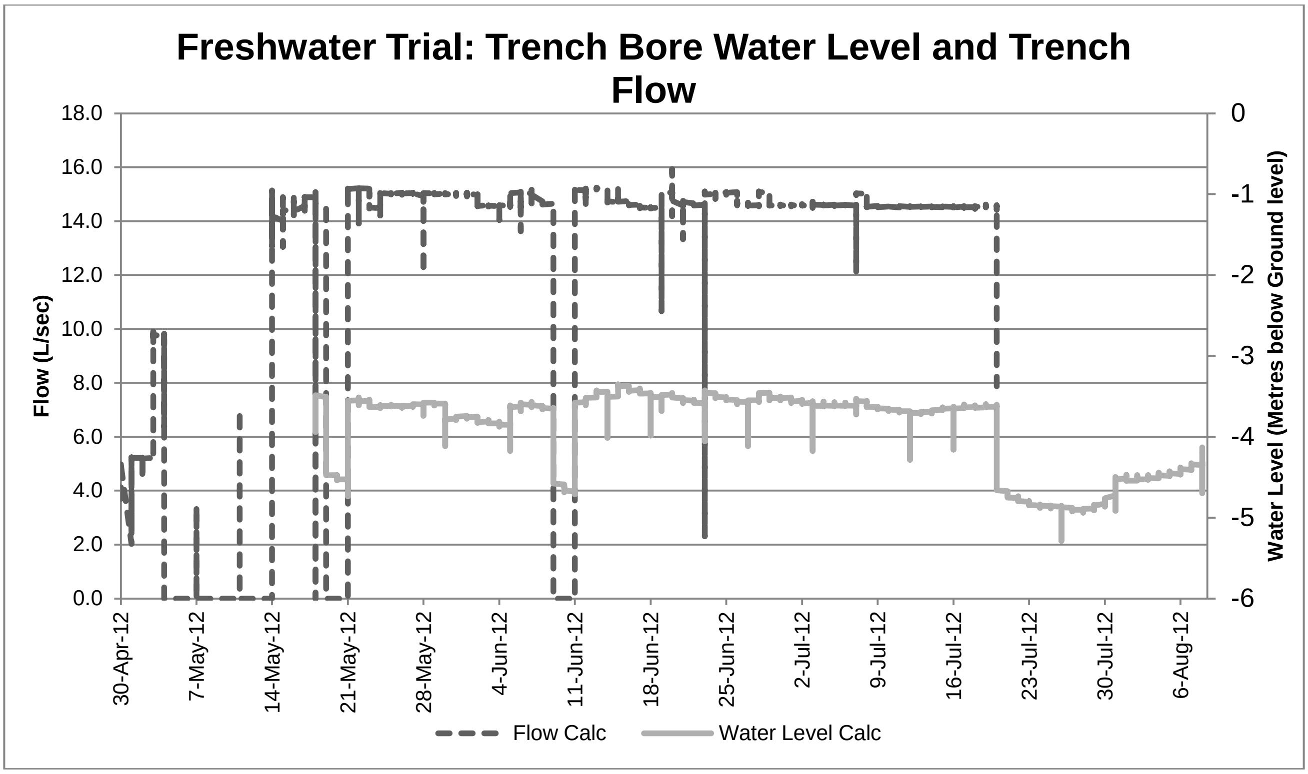
The freshwater trial was conducted between the 23rd April 2012 and 8th August 2012. Table 7.1 below contains a brief chronological summary.

Table 7.1 Freshwater Trial Summary

Week Beginning	Flow (L/sec)	Comments
30 Apr 2013	5, 10	30 Apr - fresh water started at 5 L/sec 3 May - flow increased to 10 L/sec 3 May - water level and quality sampling
7 May 2013	15	7 May - pump issues resulted in no discharge 8 May - water level and quality sampling
14 May 2013	15	14 May - flow increased to 15L/sec Night flow not consistent Back pressure up to 200 kpa – no surface eruptions or springs observed 17 May - water level and quality sampling
21 May 2013	15	21 May - water level and quality sampling
28 May 2013	15	30 May - water level and quality sampling
4 Jun 2013	15	5 Jun - water level and quality sampling
11 Jun 2013	15	14 Jun - water level and quality sampling
18 Jun 2013	15	18 Jun - water level and quality sampling
25 Jun 2013	15	27 Jun - water level and quality sampling
2 Jul 2013	15	3 Jul - water level and quality sampling
9 Jul 2013	15	12 Jul - water level and quality sampling
16 Jul 2013	15	16 Jul - water level and quality sampling 20 Jul - discharge to trench ceased
23 Jul 2013	0	26 Jul - post discharge water level and quality
30 Jul 2013	0	31 Jul - post discharge water level and quality
All samples and levels taken at high tide unless otherwise specified.		

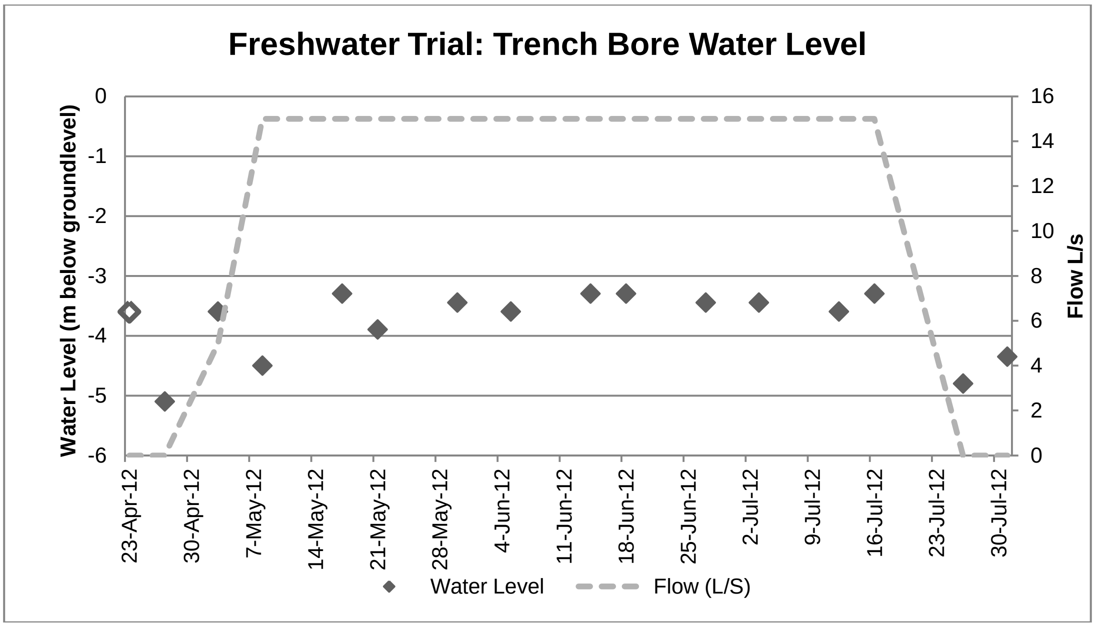
7.2 Water Levels

The Figures below show the continuously monitored Trench Bore water level and corresponding flow Appendix One, Figure (a) and the manually taken water levels in each bore with corresponding flow Appendix One, Figure (b) to (d).



Appendix One, Figure (a): Freshwater Trial: Continuously Monitored Trench Water Level and Trench Flow

The graph shows elevations in water level caused by the discharge from the Infiltration Trench are temporary.

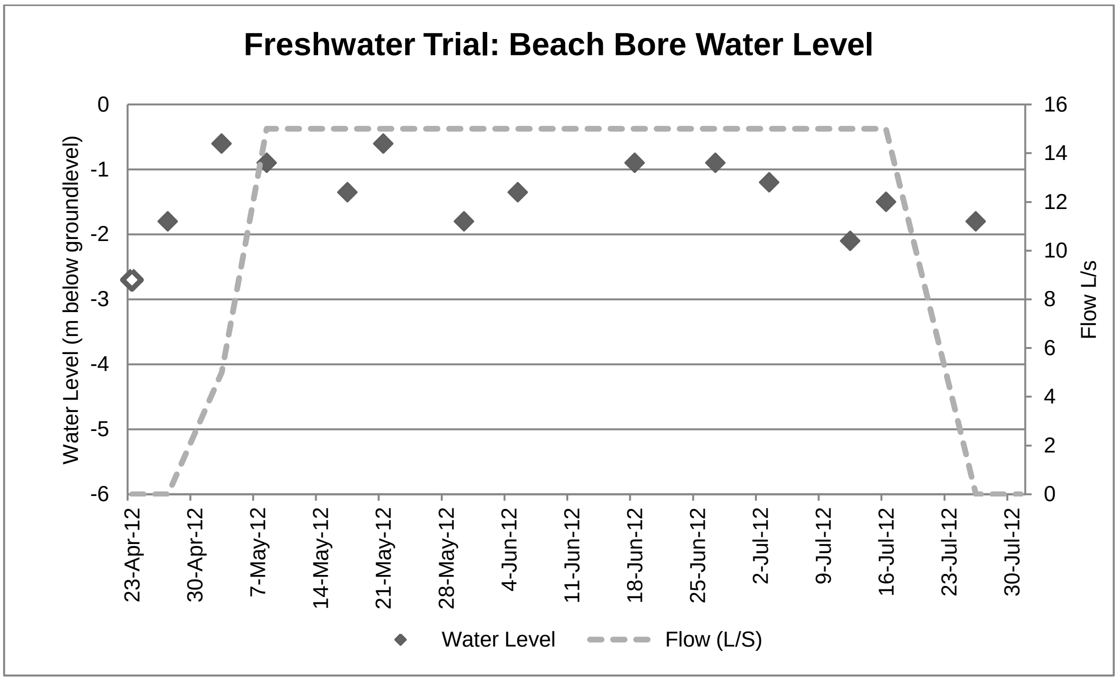


◊ Low Tide (potential erroneous measurement)

Appendix One, Figure (b): Freshwater Trial Trench Bore Water Level

During freshwater discharge, the water level displayed a sustained elevation of approximately 0.9 metres in the Trench Bore.

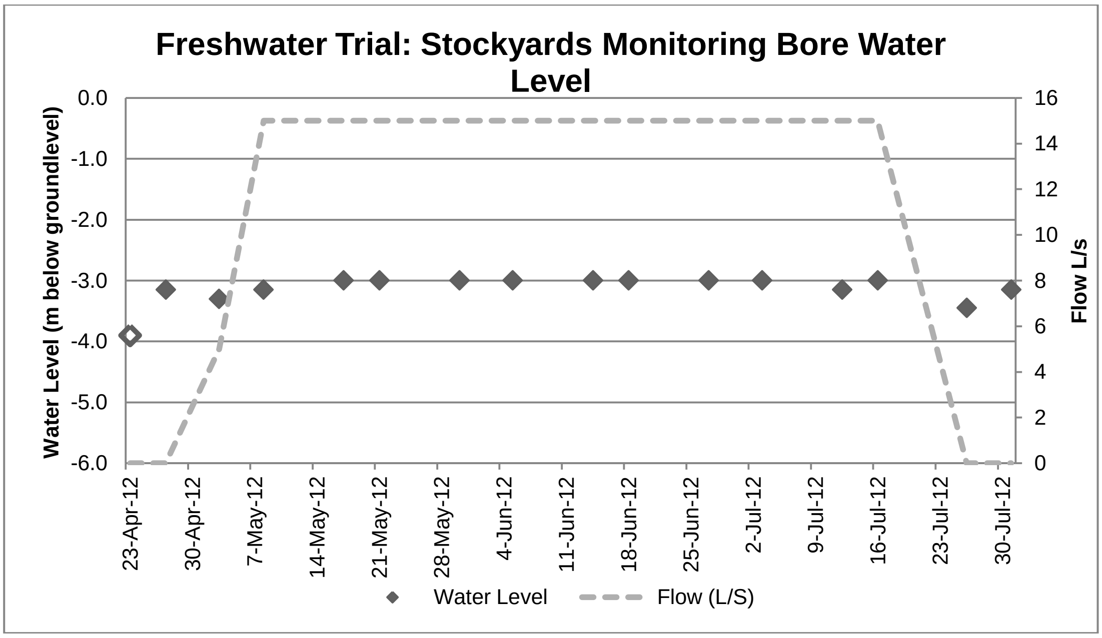
The observed elevation is to be expected given the proximity to the Infiltration Trench and is consistent, although greater than, observations made in previous trials.



◊ Low Tide

Appendix one, Figure (c): Freshwater Trial Beach Bore Water Level

The average level during discharge was 1.2 metres below ground level. It is assumed that given all the measurements were taken at high tide this 0.6 metre difference is due to elevation of the water table from the discharge from the Infiltration Trench.



Appendix One, Figure (d) Freshwater Trial Stock Yard Water Level

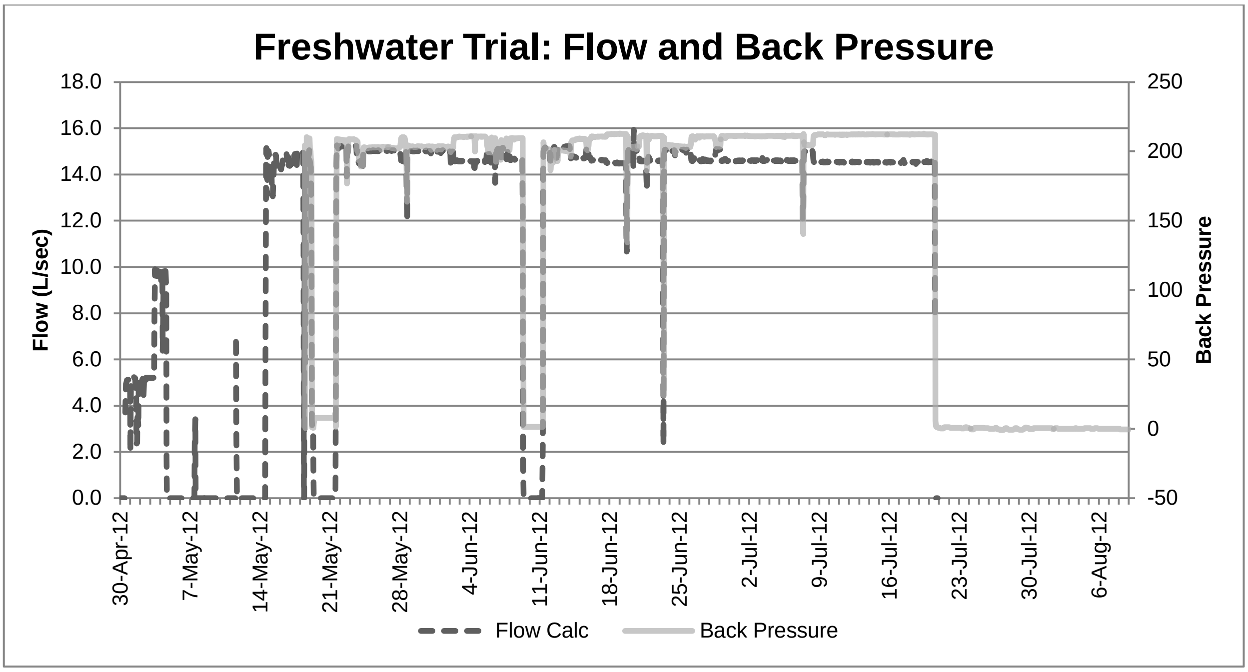
◊ Low Tide

It is clear there is some tidal influence on the water level in the bore but it is not as clear if the 20mm difference during discharge is significant to conclude difference that the variation in water level is attributable to discharge.

In previous trials an influence on the bore from the Infiltration Trench was discounted.

7.3 Back Pressure

Back Pressure was continuously electronically monitored in the Trench Bore.



Appendix One, Figure (e) Fresh water trial: Back Pressure

Figure (e) shows the flow to the trench and the corresponding back pressure. Due to recording issues there is no data from 23rd April 2012 to 17th May 2012. As would be expected back pressure increases and decreases with increasing and decreasing flow.

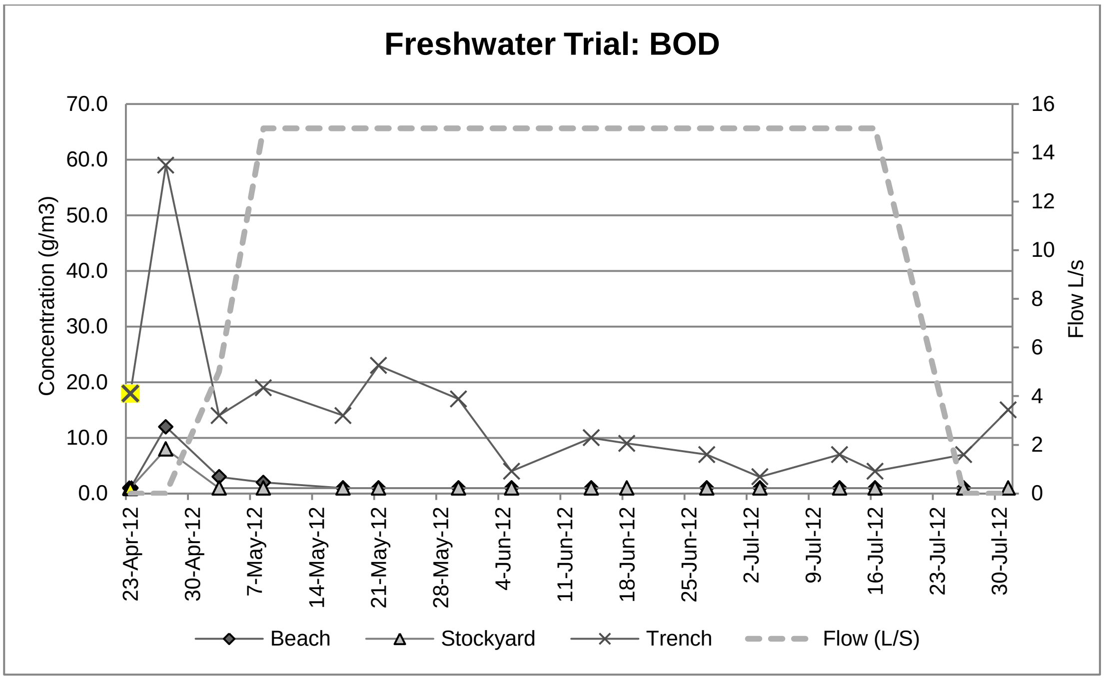
At a flow of approximately 15L/s the average backpressure was 208kpa. Due to recording issues there was limited data for other flow rates.

7.4 Groundwater Monitoring

Water quality in the bores was tested weekly during freshwater discharge to the Infiltration Trench. Samples were analysed for biological oxygen demand (BOD), nitrate nitrogen, pH and total grease.

Baseline samples were taken at low and high tide, to compare against samples during discharge. As with the water level monitoring measurements for consistency all samples during discharge were taken at high tide so any tidal influence will be the same in all samples. The low tide samples are the first results on each graph and are for reference only.

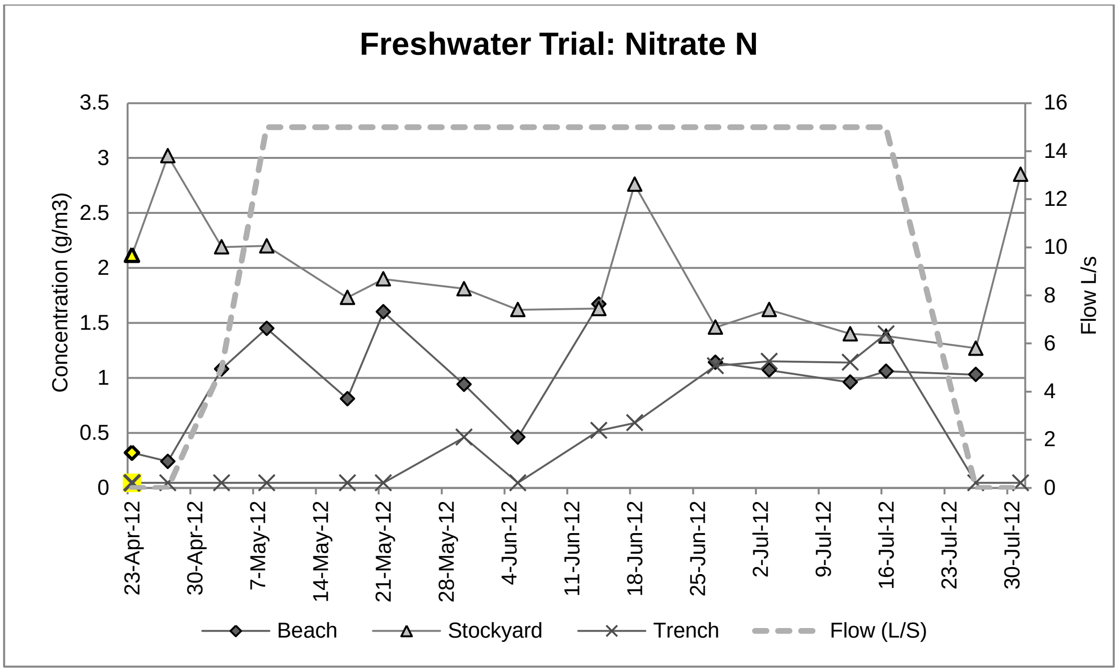
Figure (f) below shows BOD analysis for the three monitoring bores.



Appendix One, Figure (f) Fresh water trial Bore Water Quality BOD

A facet of the Freshwater trial was to flush the trench in an attempt to remove any residual material from the last round of trials, which lead to the blinding of the trench media and loss of function. Elevated BOD in the Trench Bore would indicate that residual wastewater material was present and it could be inferred that decreasing BOD levels are a result of a reduction in residues from the flushing. Otherwise with Freshwater only being injected it would not be expected to see a large BOD load or an elevation in BOD.

Figure (g) shows Nitrate N levels in the three monitoring bores.

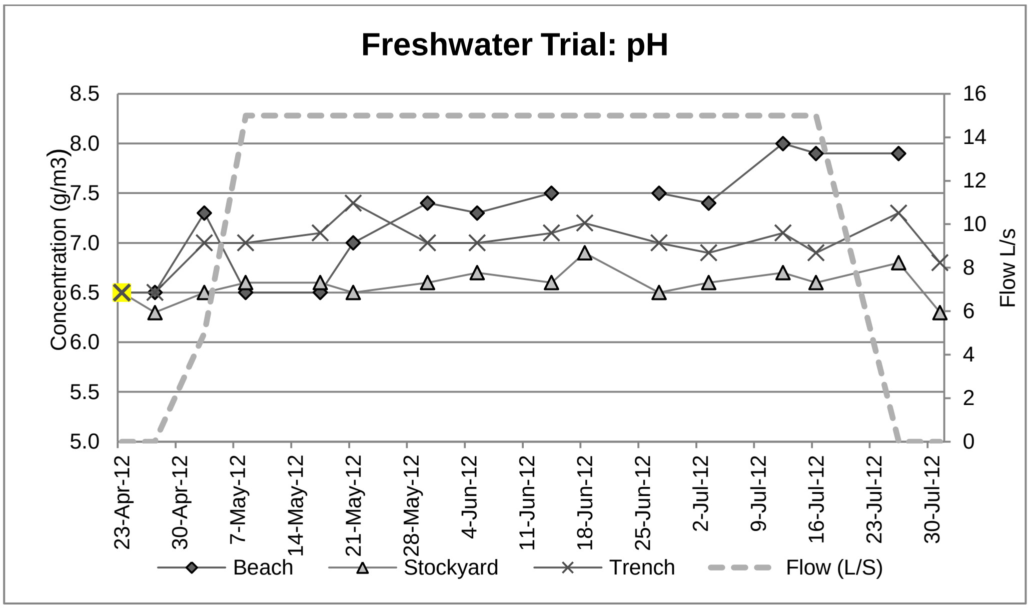


Appendix One, Figure (g) Fresh water trial Bore Water Quality Nitrate-N

Nitrate nitrogen levels in all three bores were within, and did not deviate outside typical groundwater levels. Nitrate nitrogen concentrations were approximately less than half of those observed during previous trials.

Nitrate nitrogen levels fluctuated in all three monitoring bores but the fluctuations were within levels typically seen in the area.

Figure (h) shows pH levels pre / post and during discharge.

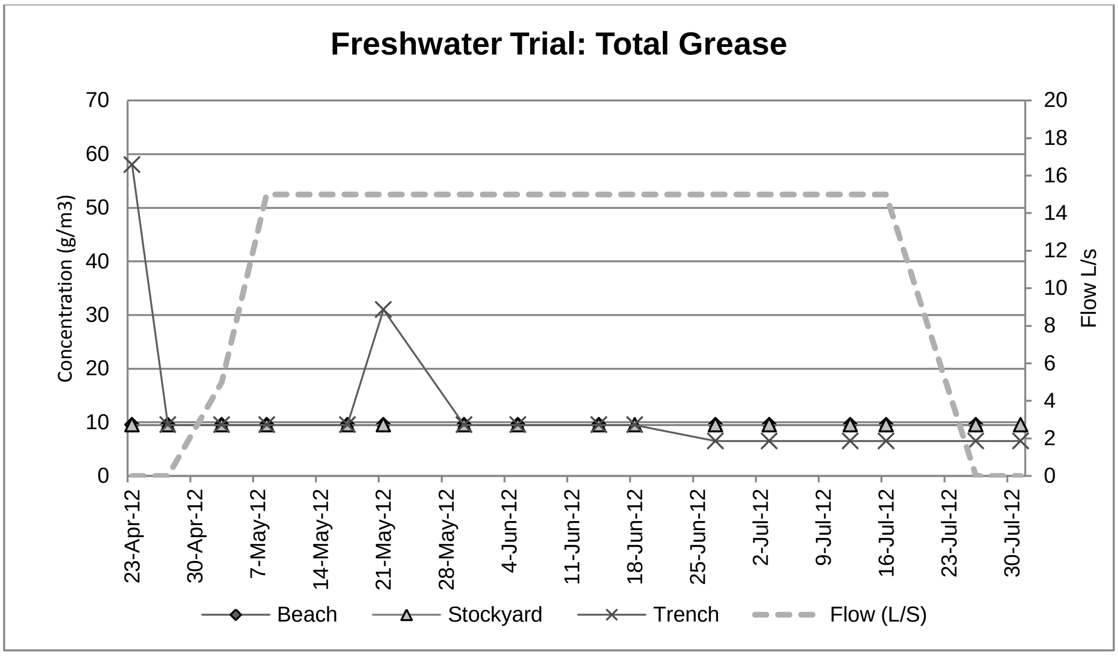


Appendix One, Figure (h) Fresh water trial Bore Water Quality pH

A trend of increasing pH was observed in all three bores during freshwater discharge, most obviously in the Beach bore, where levels rose from 6.5 to 8. Increases were smaller in the Stockyard and Trench Bores, with levels returning towards pre discharge levels the week following cease of discharge.

The reason for the rise in pH is not clear. The pH of sea water is approximately 8 and fresh water 6.5 to 7; observed pH was within this range.

Figure (i) shows



Appendix One, Figure (1) Fresh water trial Bore Water Quality Total Grease

Grease levels in the Beach and Stockyard bores remained unchanged throughout the trial, not varying from the observed baseline trial level of <19 g/m³ (graphed as 9.5g/m³).

It is unclear whether the two elevated results in the trench bore were due to possible flushing of residual material from the material surrounding the infiltration trench from the previous trials or if they were erroneous results.

8 Appendix Three: Wastewater Trial

8.1 Summary

The wastewater trial was conducted between the 17th October and 21st November, Table 8.1 a brief chronological summary of the trial.

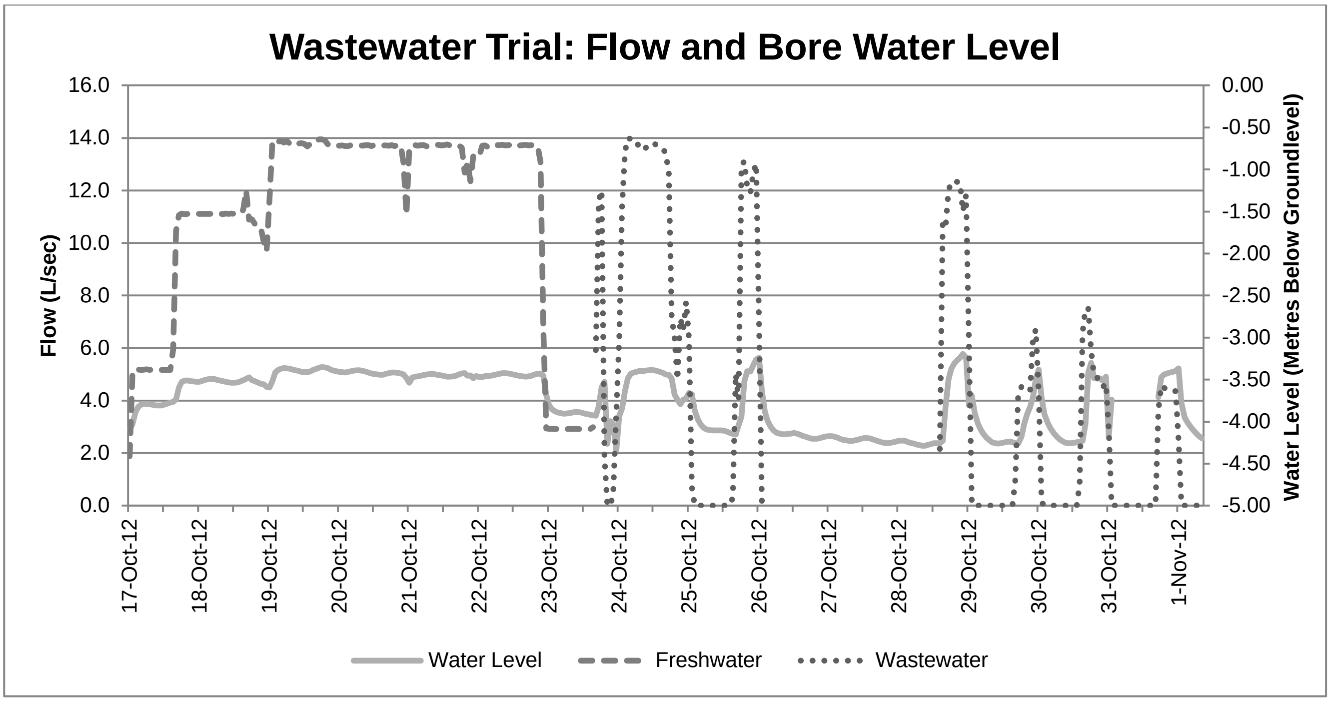
Table 8.1 Wastewater Trial Summary

17th Oct 2012	Pre- discharge Groundwater Monitoring Samples (high/low tide) Start Fresh Water @ 5L/s
24th Oct 2012	Groundwater Monitoring Samples Start Wastewater @5L/s – problems with poly-dosing gear
25th Oct 2012	Water Level Monitoring Poly-dosing working, discharging @ 7.5L/s
26th Oct 2012	Wastewater Samples Water Level Monitoring
29th Oct 2012	Groundwater Monitoring Samples Surface eruption / blow-out @ 12.3L/s
30th Oct 2012	Wastewater Samples Water Level Monitoring 5L/s ok 7.5L/s ok but BP high
31st Oct 2012	Groundwater Monitoring Samples Started 08:30 @ 10L/s – immediate surface eruption / blow-out Resumed @ 7.4L/s – ran for 1 hour (until ~09:30) before blow-out Resumed @ 5L/s
1st Nov 2012	Wastewater Samples 5L/s surface eruption / weeping Decision made to cease trial
6th Nov 2012	Post-discharge Groundwater Monitoring Samples
12th Nov 2012	Post-discharge Groundwater Monitoring Samples
21st Nov 2012	Post-discharge Groundwater Monitoring Samples

8.2 Water Levels

The same monitoring as the fresh water trial was employed for the wastewater trial, with three monitoring bores (Trench, Beach and Stockyards). Manual levels were taken weekly at high tide and continuous electronic monitoring occurring within the Trench Bore.

The four figures below show water level and flow for the period of the trial.



Appendix Three, Figure (a) Trench Bore Wastewater Trial Continuously Recorded Data: Flow and Water Level

The wastewater started with an initial discharge of freshwater (17th to 23rd October). Flows were started at 5L/s and increased to approximately 14L/sec. Table 3.4.1 below summarises average water levels for flow during fresh water discharge.

Flow (L/sec)	Water level (mbgl)
Baseline	4.18
1-5	3.89
5-7.5	3.79
7.5 - 10	3.59
10-12.5	3.53
12.5-15	3.43

There is a clear relationship between flow and water level in the Trench Bore, as flow increases the water level in the bore rises.

Wastewater discharge commenced on 24th October 2012, flow was variable initially whilst the polyelectrolyte dosing was fine tuned. Water levels during wastewater injection were comparable to those during freshwater discharge.

8.3 Backpressure

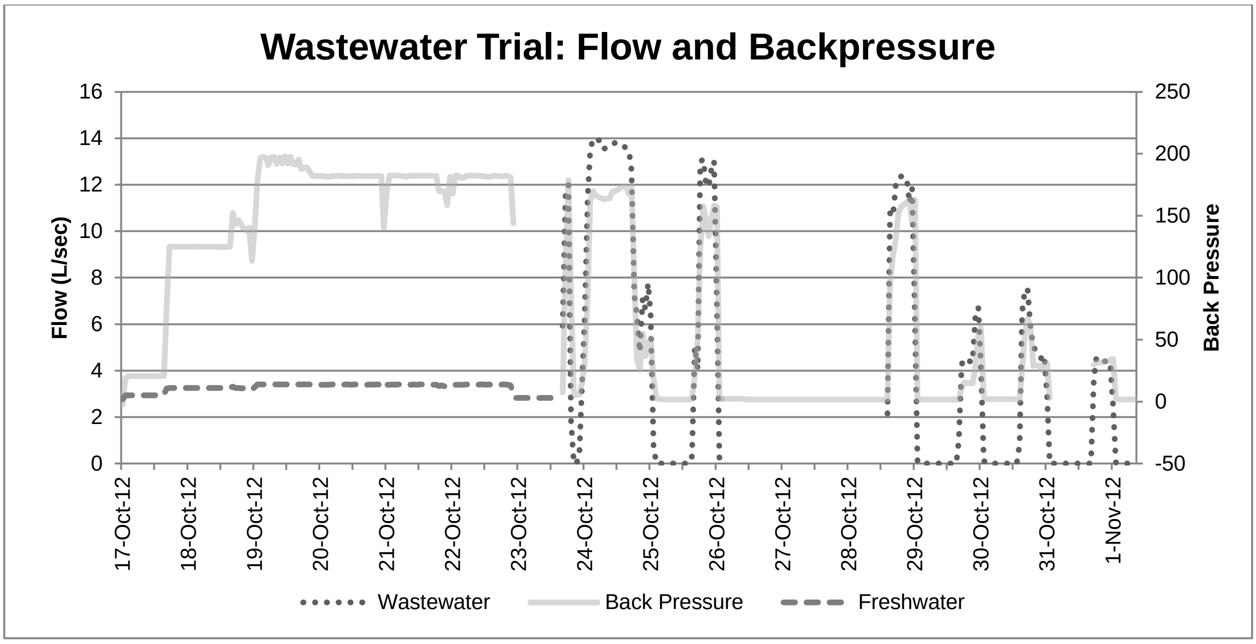


Figure 3.2.2 Wastewater Trial: Flow and Backpressure

The graph shows that Backpressure increases with increasing flow, and when flow ceases back pressure returns to baseline levels almost immediately.

The surface eruptions of wastewater that were observed and noted during the trial (29th and 31st October 2012 and 1st November 2012) did not appear to be accompanied by an elevation in observed back pressure or water level in the Trench Monitoring Bore. It is thought that this may be due to the wastewater quickly finding alternative pathways.

8.4 Particle Distribution

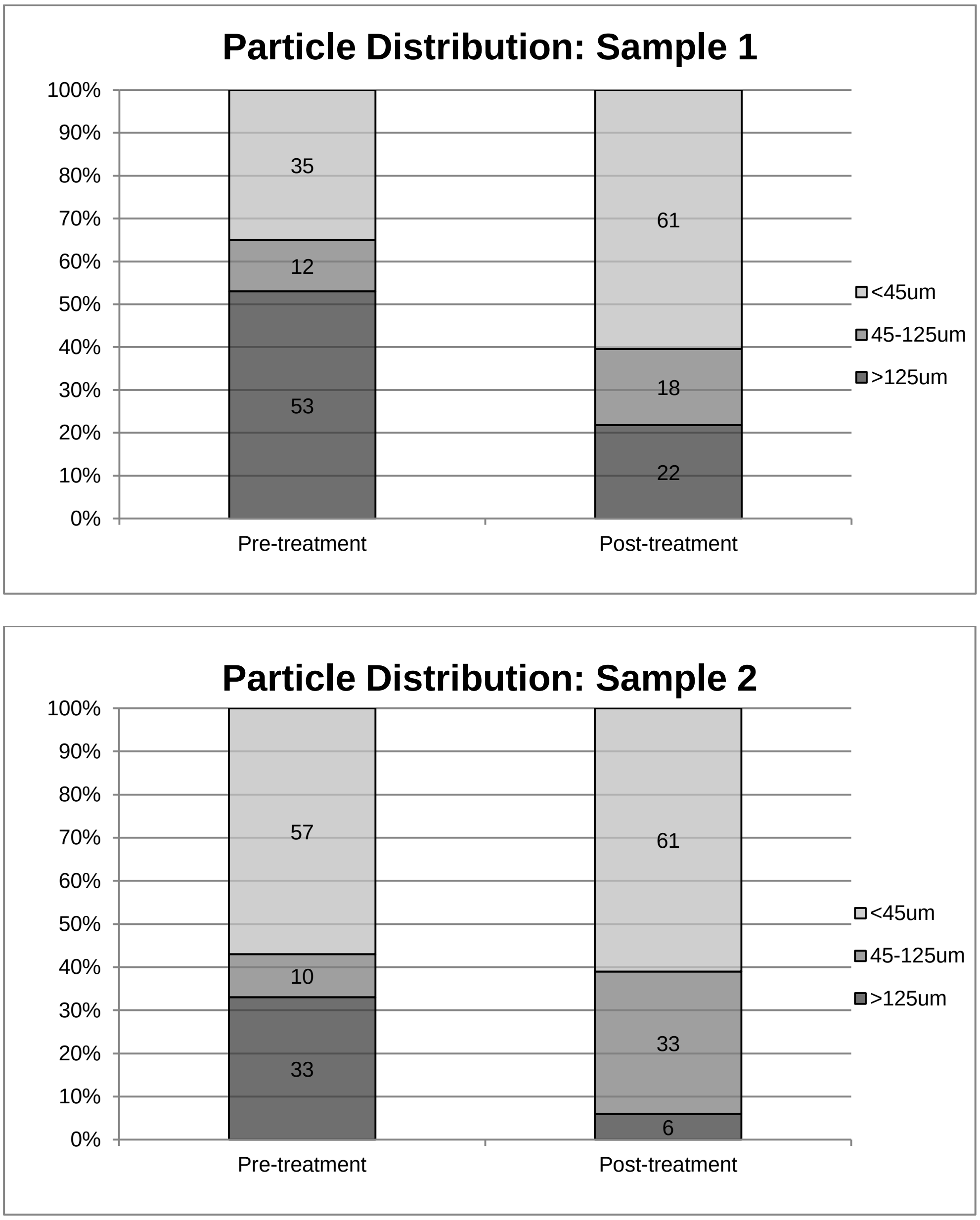
Two samples were analysed for particle size Pre and Post treatment. The baleen filter is 140µm and it was expected that the majority of solids removal would be from the coarser sediment portion, with the remaining solids being finer in nature.

Table 3.2.3.3 Pre and Post Treatment Particle Distribution

	Sample 1		Sample 2	
Particle Size	Pre	Post	Pre	Post
>125µm	420	221	422	380
45-125µm	197	173	284	357
<45µm	146	134	241	232

Units = g/m³

Particle size proportions varied between and within the two samples. The largest proportion of particles, and subsequently the biggest reduction, occurred in the >125 µm size range, as would be expected with a 140 µm Baleen filter.



Appendix Three, Figure (e) Suspended Solid Particle Distribution

The charts support the observation for the removal of solids from the coarser >125 µm fraction, reduction in the finer portion was less pronounced.

8.5 Wastewater Quality

Wastewater was sampled before and after treatment. Treatment consisted of the addition of polyelectrolyte and screening through a 140µm baleen filter. The wastewater was sampled to assess the quality of the incoming wastewater, the effectiveness of the treatment and the quality of the wastewater discharged into the Infiltration Trench.

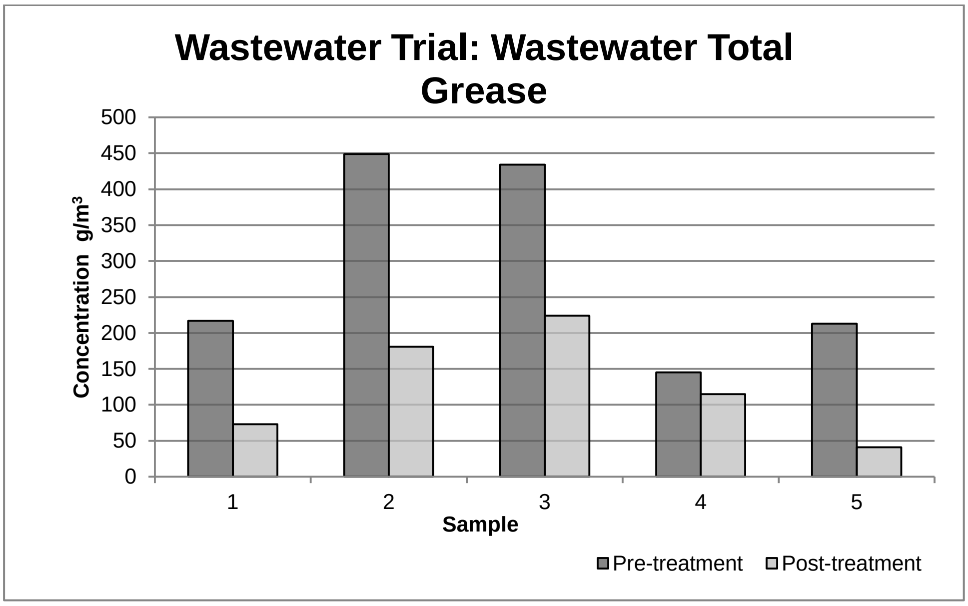
Waste water was analysed for pH, BOD, Ammonia-Nitrogen, Nitrate-Nitrogen, Total Kjeldahl Nitrogen, Suspended solids, Grease and Faecal coliforms. Particle distribution was also looked at.

Statistical analysis was conducted on the data for each parameter, including a two sample mean *t-test*. The *t-test* in this context was used to help establish whether there was a statistically significant difference between pre and post treatment samples.

The *P-value* from the *t-test* was calculated using a hypothesised mean difference of zero and a confidence level (α) of 95%.

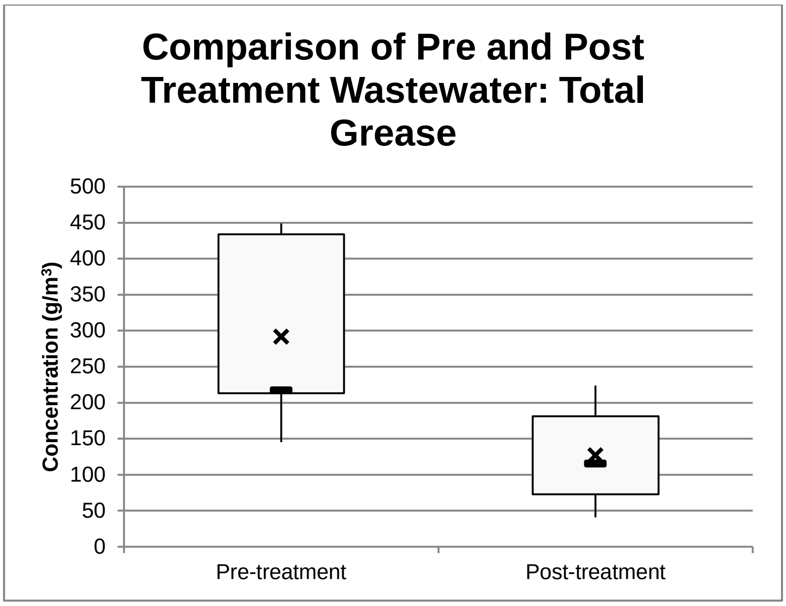
For the purposes of defining statistical significance, a *P-value* as small as or smaller than *α* (0.05) has been considered to be statistically significant.

Figure (a) shows Total Grease levels in the wastewater pre and post treatment.



Appendix Three, Figure (a) Wastewater Trial: Wastewater Analysis Pre and Post Baleen – Total Grease

Total Grease levels were variable between the five samples however pre-treatment levels were observed to be higher than post-treatment in all five samples. This would indicate that the polyelectrolyte and baleen filter were effective at removing Total Grease from the wastewater.



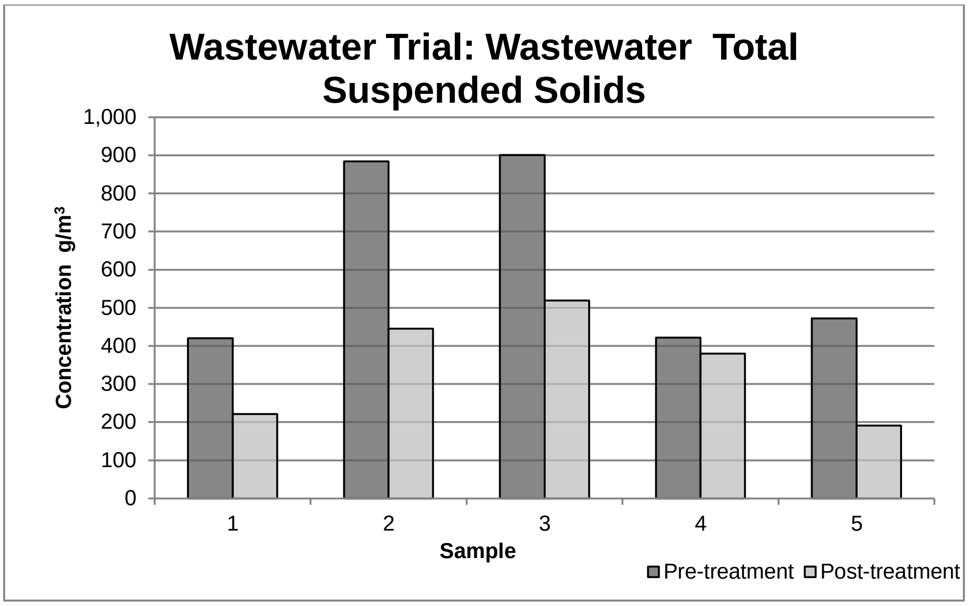
Statistical Summary

	Pre	Post
Q1	213	73
Min	145	41
Median	217	115
Average	292	127
Max	449	224

P = 0.012 , α = 0.05

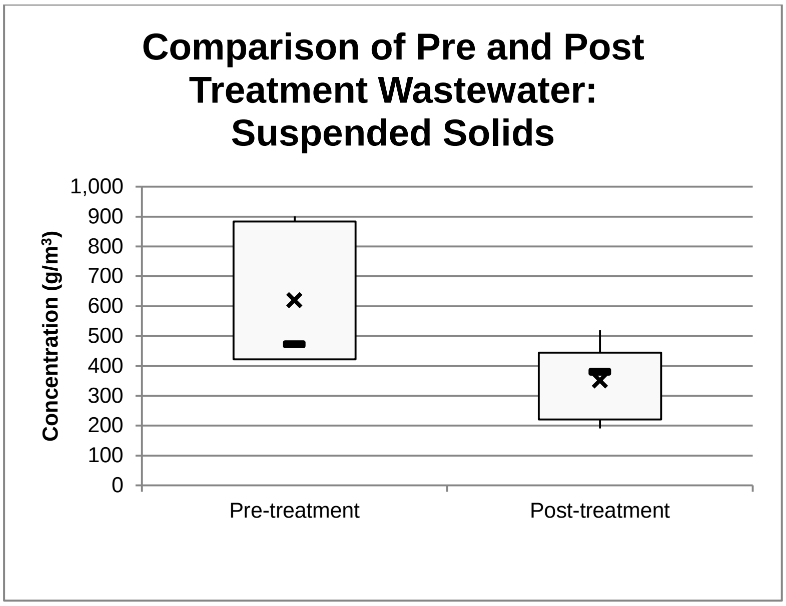
Appendix Three, Figure (b) Wastewater Trial: Comparison of Pre and Post Treatment Total Grease

The *t-test* returned a *P-value* of 0.012. *P*-0.012 is less than *α*-0.05 and therefore it can be concluded that there is a statistically significant difference between the Pre and Post treatment samples. In this case, supporting the other observations, that treatment lead to a significant reduction in Total Grease levels.



Appendix Three, Figure (c) Wastewater Trial Pre and Post Baleen Comparison of Total Suspended Solids

Results again were variable over the small data set, and observed levels were less than previous trials. Pre-treatment suspended solids levels were between 420 g/m³ to 901 g/m³ with an average of 620 g/m³ (average of 2636g/m³ in previous trial). Post treatment levels ranged from 191 g/m³ to 519 g/m³ with an average of 445 g/m³.



Statistical Summary

	Pre	Post
Q1	422	221
Min	420	191
Median	472	380
Average	619	351
Max	901	519

P = 0.037 , α = 0.05

Appendix Three, Figure (d) Wastewater Trial: Comparison of Pre and Post Baleen Total Grease

The average difference (a reduction) in suspended solids between Pre and Post treatment was 269 g/m³ or 42% (previous trial 34%).

The *t-test* returned a *P-value* of 0.037. *P* 0.037 is less than *α 0.05* and therefore it can be concluded that there is a statistically significant difference between the Pre and Post treatment samples. In this case, supporting the other observations, that treatment lead to a significant reduction in Suspended Solids levels.

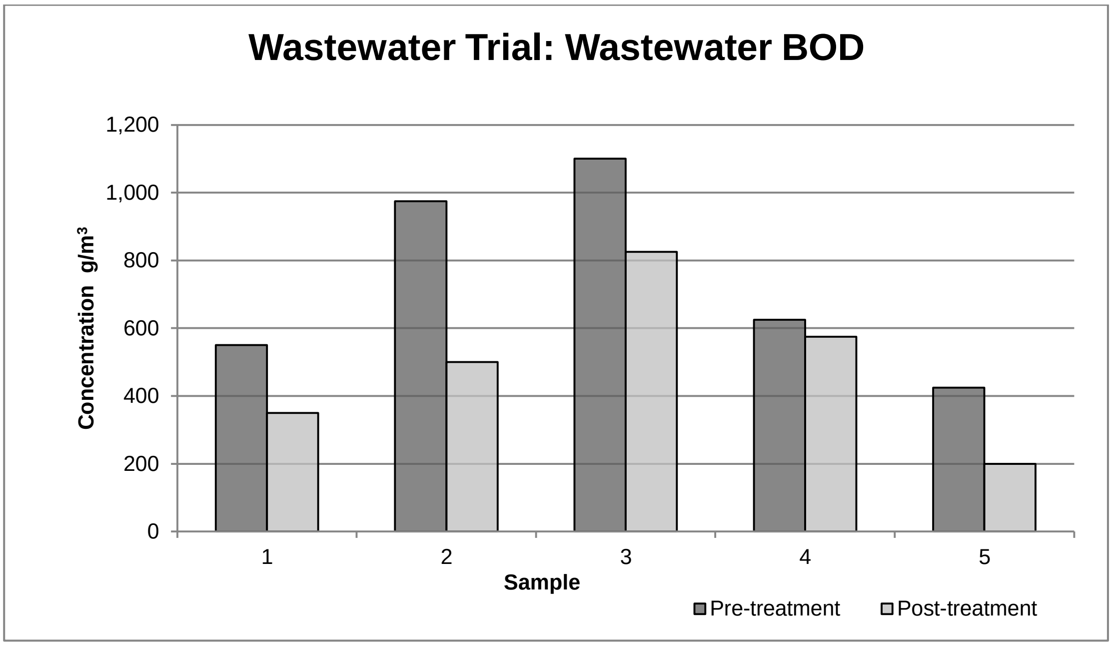
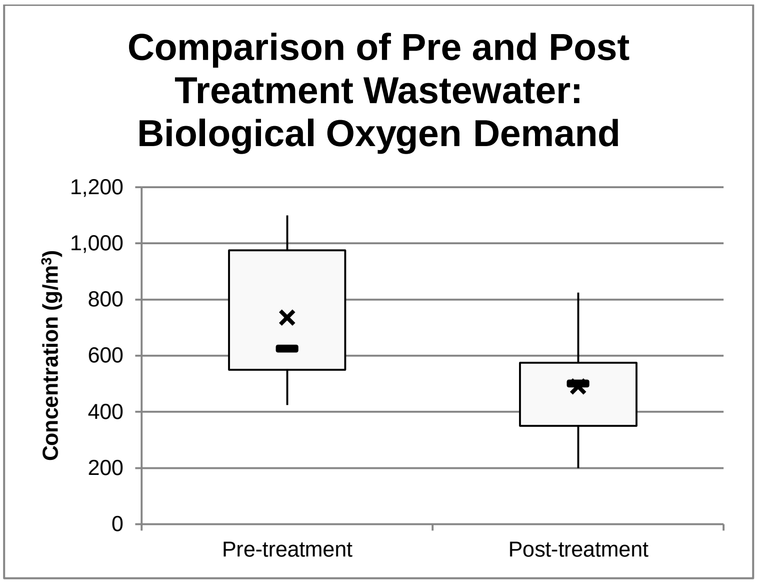


Figure 5.1(a) Wastewater Trial: BOD

BOD levels were variable between the five samples, however all post-treatment samples were lower than their respective pre-treatment counterparts.

Pre-treatment levels ranged from 425g/m³ to 1100g/m³ with an average of 735g/m³ and post-treatment levels ranged from 200g/m³ to 825g/m³ with an average of 490g/m³.



Statistical Summary

	Pre	Post
Q1	550	350
Min	425	200
Median	625	500
Average	735	490
Max	1100	825
Q3	975	575

$P = 0.127$, $\alpha = 0.05$

Figure 5.1(b) Wastewater Trial: BOD Pre / Post comparison

Due to the variability within the relatively small data set, statistically the difference between Pre and Post sample means cannot be described as significant, but the data does show a clear reduction between Pre and Post samples. The average reduction of BOD after polyelectrolyte dosing and screening was 245 g/m³ or 34%.

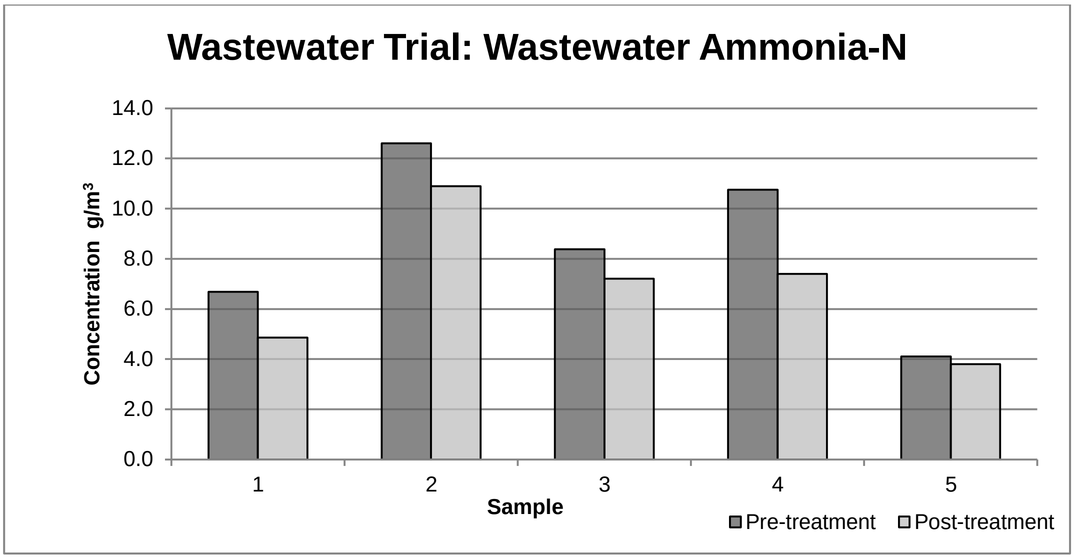
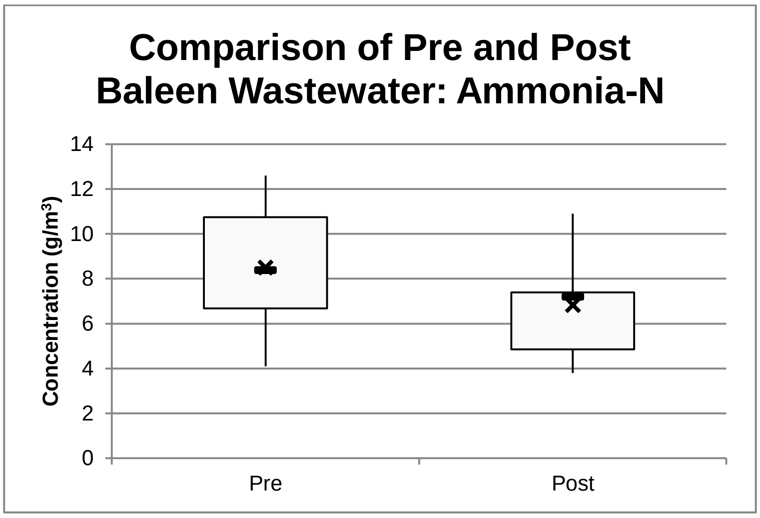


Figure 5.2(a) Wastewater Trial: Ammonia Nitrogen

Ammonia N levels were variable over the small data set. The average pre-treatment level was 9 g/m³, post-treatment 7 g/m³. All post-treatment levels were lower than their pre-treatment counterparts.



Statistical Summary

	Pre	Post
Q1	6.68	4.86
Min	4.1	3.8
Median	8.38	7.2
Average	8.50	6.83
Max	12.6	10.9
Q3	10.75	7.4

P = 0.176 , α = 0.05

Figure 5.2(b) Wastewater Trial: BOD Pre / Post comparison

The average difference (reduction) between Pre and Post samples was 1.67 g/m³ or 18%.

Due to the small data set and the variability between the samples, whilst a reduction of Ammonia-N between the pre and post treatment samples was observed it was not statistically significant.

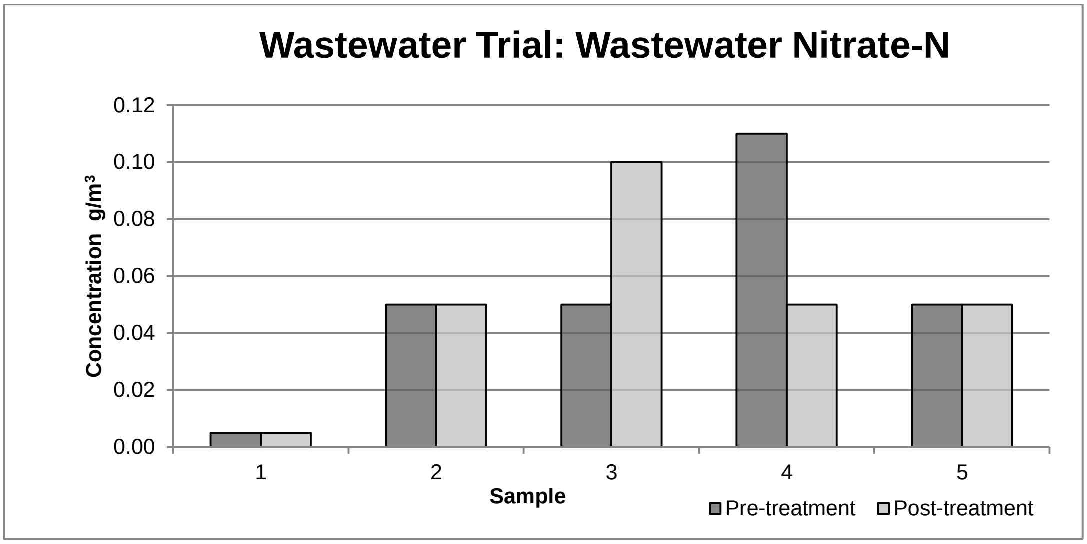


Figure 5.3(a) Wastewater Trial: Wastewater Nitrate Nitrogen

Due to its low contaminant loadings Nitrate N was not one of the target parameters for treatment and as such levels were not significantly affected by the treatment.

Nitrate Nitrogen wastewater concentrations were minimal, with an average of 0.053g/m³ pre-treatment and 0.005g/m³ post-treatment with no difference observed between three of the Pre and Post-treatment samples.

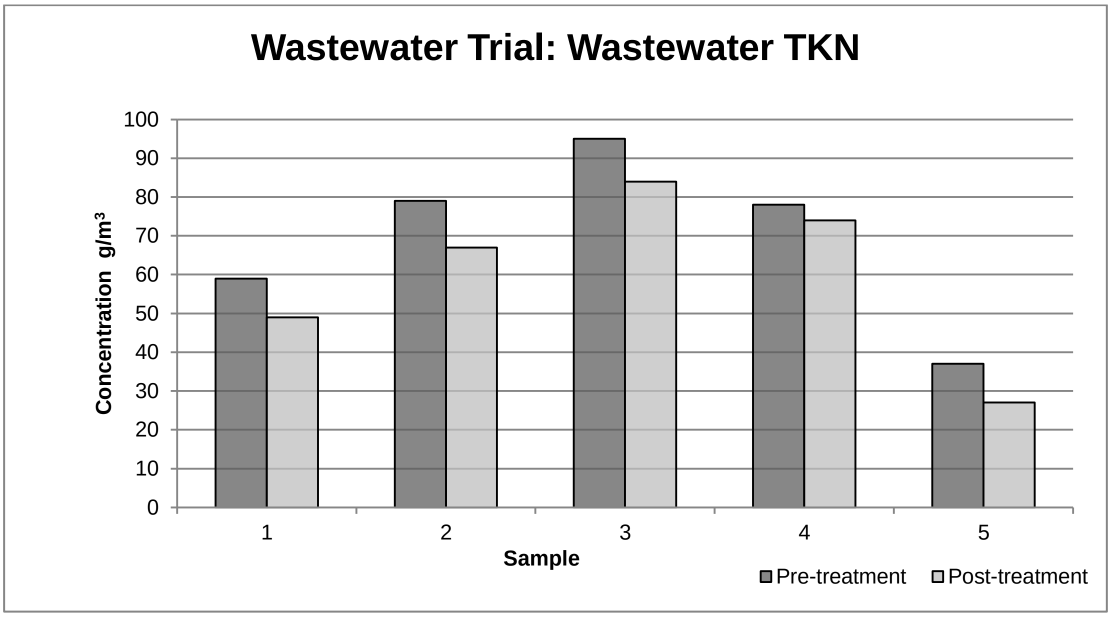


Figure 5.4(a) Wastewater Trial: Wastewater Total Kjeldahl Nitrogen

TKN varied over the small data set with pre-treatment levels ranging from 37 g/m³ to 97 g/m³ with an average of 69.6 g/m³ and Post baleen from 27 g/m³ to 84 g/m³ with an average of 60.2 g/m³. The average difference between pre and post treatment samples was 9.4g/m³ or 15%.

TKN was not one of the target parameters for treatment and as such levels were not significantly affected by the treatment.

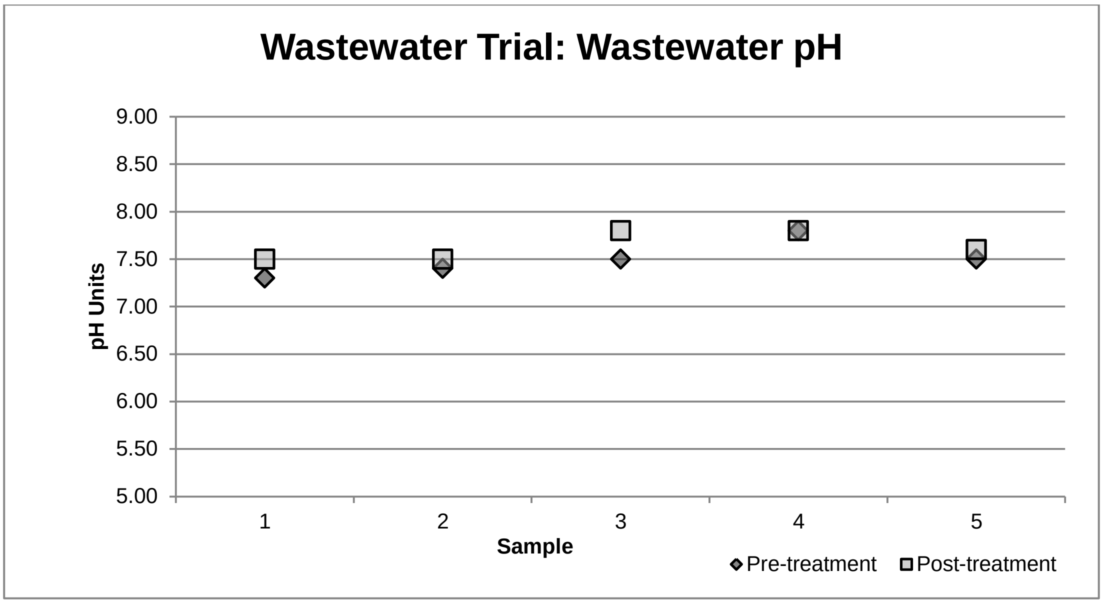


Figure 5.5(a) Wastewater Trial: Wastewater pH

pH was reasonably consistent between samples ranging between 7and 8 pH units for both pre and post treatment samples. The pH of the wastewater was consistent with expected and previously observed levels.

Post treatment pH was observed to be minimally higher than pre-treatment samples, although the difference in pre and post treatment means was not deemed to be statistically significant.

pH was not one of the target parameters for treatment and as such levels were not significantly affected by the treatment.

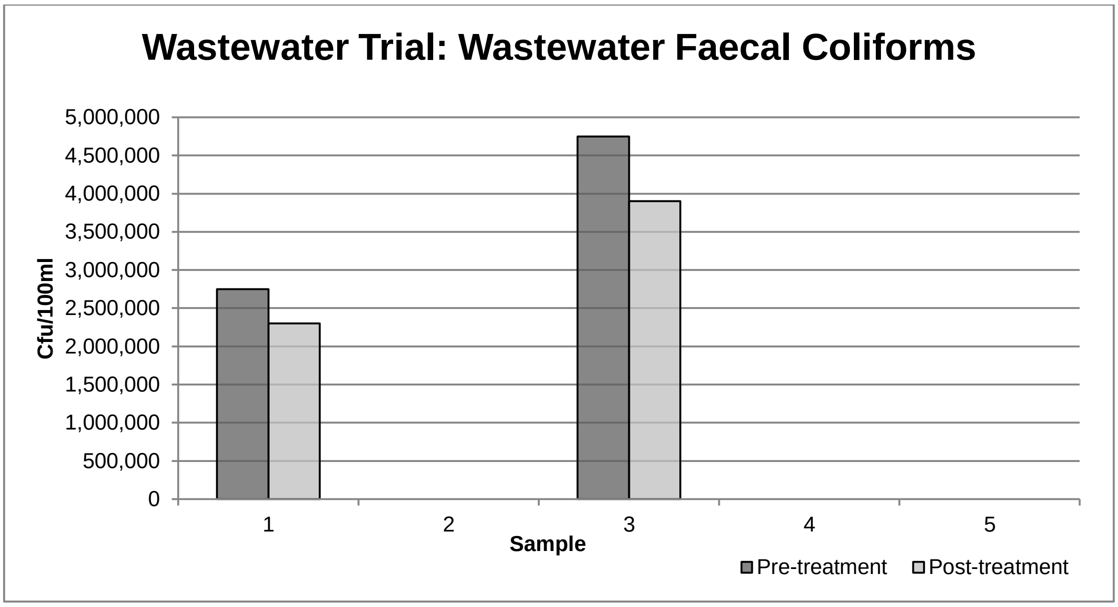


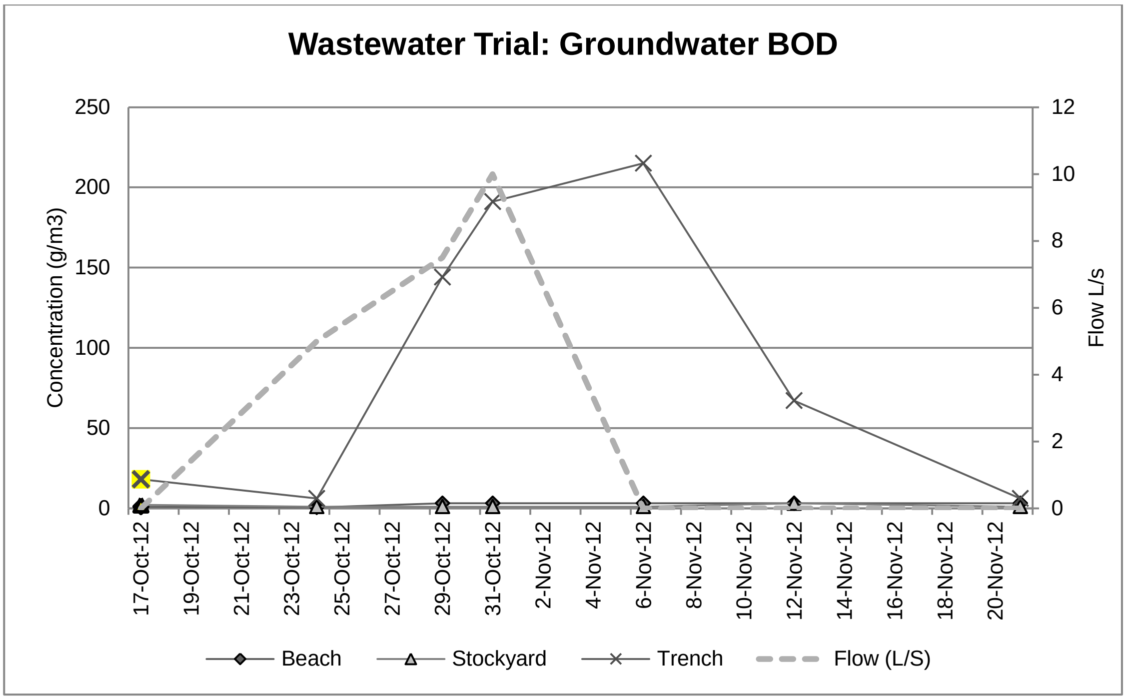
Figure 5.6(a) Wastewater Trial: Wastewater Faecal Coliforms

Faecal coliforms were only analysed in two of the samples taken. The levels of faecal coliforms present in the pre and post-treatment samples were within the previously observed and expected range.

Faecal coliforms were not a target of the treatment and as such a significant decrease in faecal coliform loading was not expected post treatment, although both post-treatment samples were lower than their pre-treatment counterparts the difference was not considered statistically significant.

8.6 Groundwater Monitoring

Figure (f) below shows BOD analysis for the three monitoring bores.

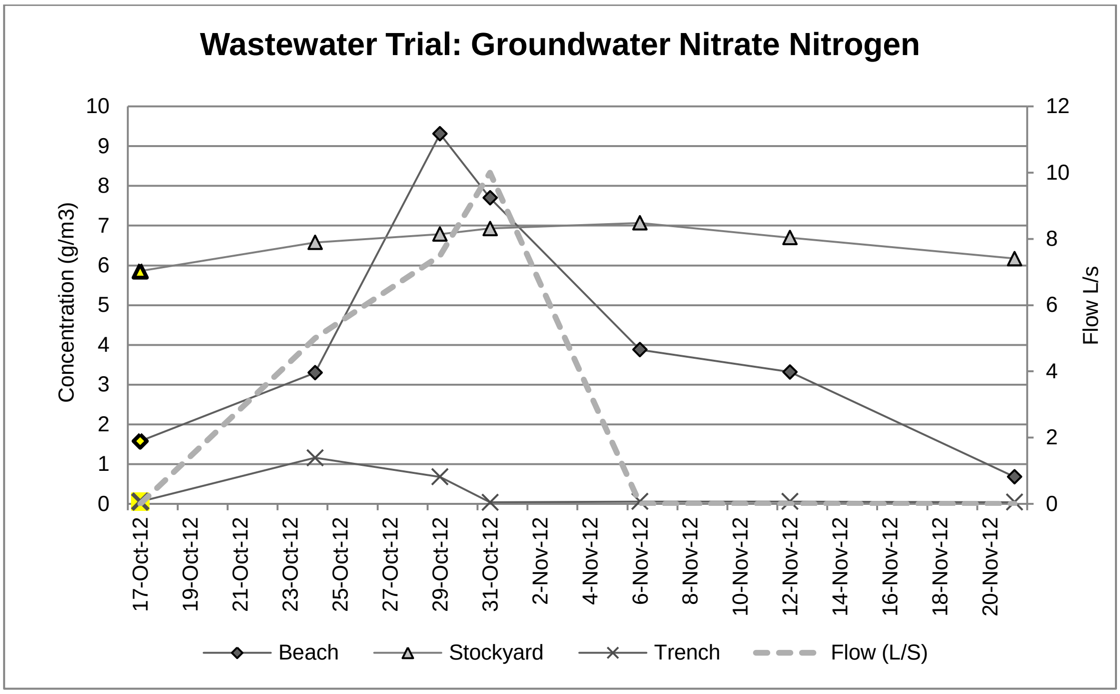


Appendix Three, Figure (f) Waste water trial Bore Water Quality BOD

The biological oxygen demand (BOD) of the wastewater was between 200g/m³ and 800g/m³.

BOD in the Trench Bore increased in conjunction with the discharge of wastewater to the infiltration trench, which would be expected given its proximity. The maximum level recorded was 215g/m³. Levels decreased back to baseline pre discharge levels within two weeks of cessation of the discharge of waste to the infiltration trench.

Figure (g) shows Nitrate-N levels in the three monitoring bores.

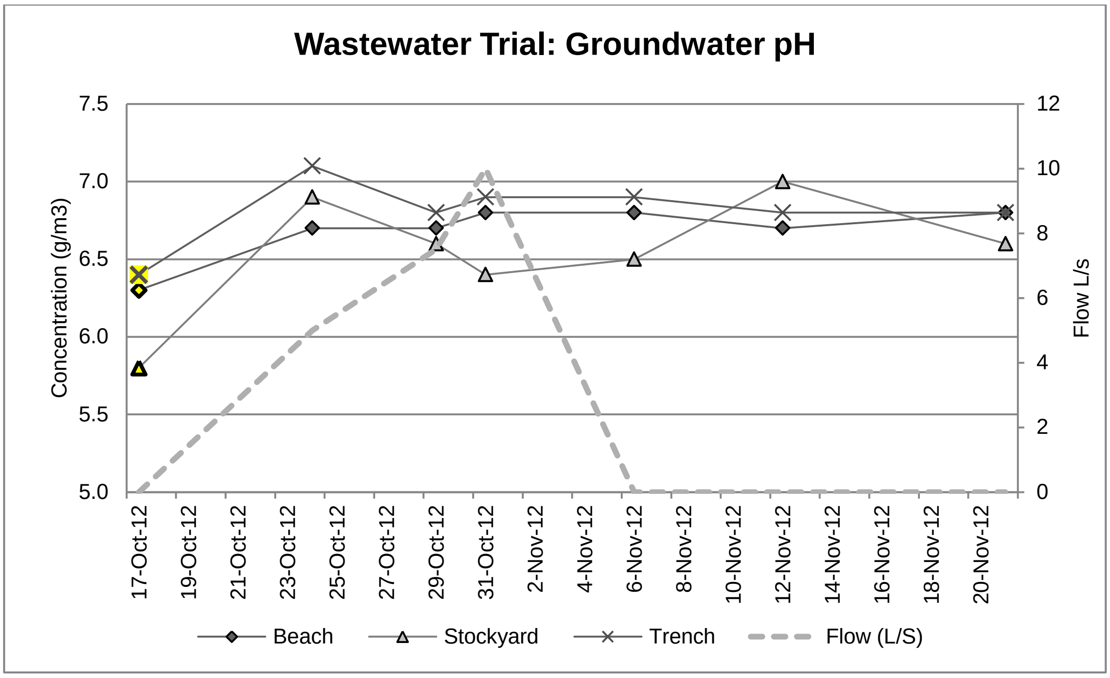


Appendix Three, Figure (g) Waste water trial Bore Water Quality Nitrate-N

Nitrate nitrogen levels in the wastewater were minimal (average 0.05g/m^3) and therefore an increase of nitrate nitrogen was not expected.

There was no clear reason for the elevation of Nitrate-Nitrogen in the Stockyards bore given wastewater has a minimal contaminant load and the bore is upstream of the influence from the Infiltration Trench. Levels were also higher than average observed nitrate nitrogen levels in the groundwater and surface water of the surrounding area. It was surmised that the rise in nitrate nitrogen levels in the Stockyards bore was due to an unknown outside influence rather than the discharge from the infiltration trench.

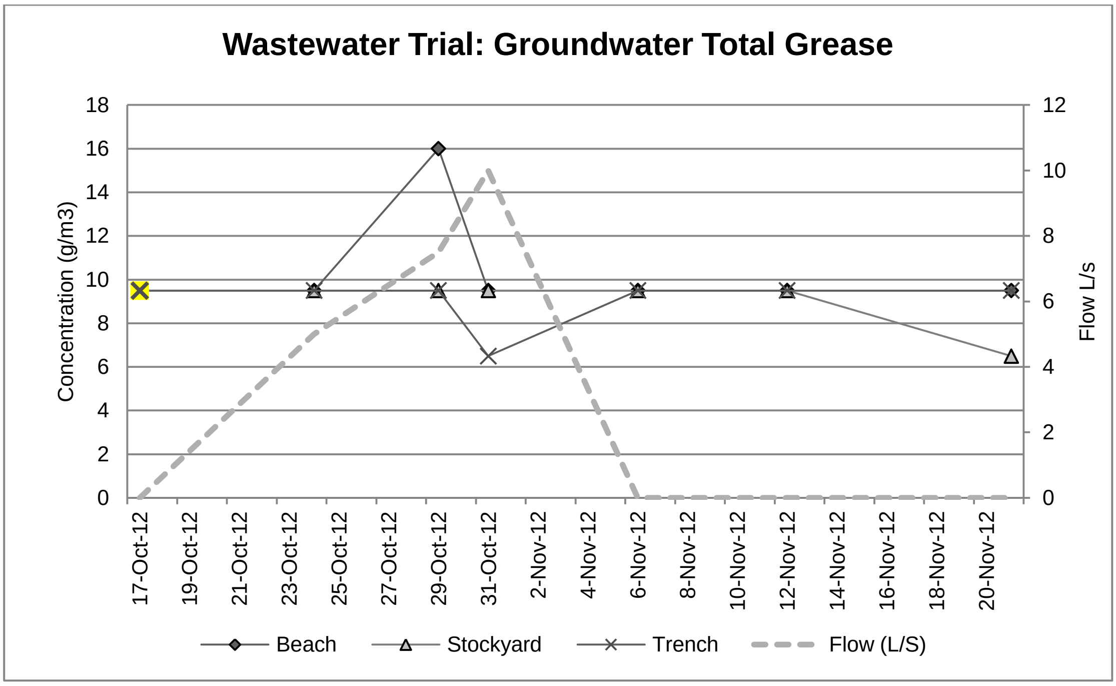
Figure (h) shows pH levels pre / post and during discharge.



Appendix Three, Figure (h) Wastewater trial Bore Water Quality pH

The average pH of the wastewater during the trial was 7.64. With the exception of the results at low tide, pH was relatively consistent Pre, Post and during wastewater injection, with no significant changes.

Figure (i) shows Total Grease



Appendix Three, Figure (j) Fresh water trial Bore Water Quality Total Grease

Baseline Total Grease levels in all three bores were reported as being <20 g/m^3 and remained consistent throughout the trial.

Due to the low concentrations and minimal changes observed, it could be inferred that either the injected wastewater had a negligible effect on groundwater quality or that flows did not intercept monitoring points.