ISBN 1 74043 377 7

Albany Effluent Irrigation Tree Farm

Triennial Report 2007

Great Southern Region
Customer Services Division

Albany Effluent Irrigation Tree farm
Triennial Report 2007

Date	Description	Author	Reviewers	Approved for Issue	
				Name	Signature
27 Sept 2007	Draft report	K. Eade	R. Collins D. Burkett	R. Collins	
26 Nov 2007	Issued	K.Eade	R. Collins D. Burkett	D. Burkett	

ISBN 1 74043 377 7

Albany Effluent Irrigation Tree farm, 2007 Triennial Report
Water Corporation.

Executive Summary

This Triennial Report describes environmental monitoring at the Albany Effluent Irrigated Tree Farm (AEITF) for the reporting period 2004 to 2006, inclusive. Included in the report is a Progress and Compliance Statement against the Ministerial Conditions that were developed following the Public Environmental Review process.

The AEITF at Gunn Road has been in operation since 1994. All of Albany's wastewater is treated at the Timewell Road Wastewater Treatment Plant (WWTP) and then pumped to the tree farm, 10km north-west of the city.

Growth in Albany wastewater flows has continued to increase the annual irrigation requirement at the tree farm. During 2005 there were two extreme rainfall events that resulted in the year being classified as an extreme wet year for tree farm operations. The high rainfall caused overflow of the main irrigation dam and significantly impacted operations throughout 2006 due to the residual wetness at the site.

Despite the difficult irrigation conditions experienced from mid 2005 to the end of 2006, the irrigation system remained compliant with all environmental performance targets. In particular the nitrogen and phosphorus loads discharged into Seven Mile Creek were well within the target levels of 3 tonnes of total nitrogen and 1 tonne of total phosphorus per annum.

Monitoring shows the increased nitrogen loading rate has not affected nutrient discharge levels from the site. Detailed soil monitoring is ongoing to confirm no long term adverse impacts will result from the increased application rate. Soil investigations following the first harvest rotation have validated the design life for the site as over 300 years.

Upgrade of the Timewell Road WWTP will be completed in 2007/08 and this will significantly reduce the nitrogen loads received at the tree farm site as well as change the ratio between ammonia and nitrate. The grass bays cab be decommissioned as this system relies on high ammonia concentrations to be effective.

Harvest operations over 139 hectares during 2004 to 2006 achieved an average yield in excess of 300 tonnes per hectare from both irrigated and non-irrigated areas. Coppice survival in irrigated areas has proven difficult to manage, Changes to the irrigation scheduling through summer are proposed to help overcome this by promoting deeper root establishment.

Despite challenging conditions due to the extreme weather events, the tree farm has achieved compliance in all areas of operation. The continued highly detailed levels of sample monitoring have again validated the design and environmental sustainability of the tree farm. Developments in understanding some of the forestry management aspects of an irrigated plantation are driving shifts in irrigation scheduling to allow further improvements in potential evapotranspiration rates and forestry vigour. The treatment plant and the AEITF offer a long term sustainable solution for the treatment and disposal of Albany’s wastewater.

Contents

List of Figures

List of Tables

1 Introduction

The City of Albany is situated about 400 km southeast of Perth on the southern coast of Western Australia.

Albany's wastewater is treated at the Timewell Road Wastewater Treatment Plant (WWTP) with the treated effluent being used to irrigate a Tasmanian blue gum plantation at the Gunn Road tree farm.
The Water Corporation's Effluent Irrigation Tree farm at Gunn Road was developed between 1992 and 1994 following extensive public consultation with the people of Albany. The tree farm not only manages the disposal of the treated wastewater by means of the plantation irrigation, but also reduces nitrogen through a series of overland flow bays.

This is the fourth triennial report on the operation of the tree farm. The report covers the period 2004 to 2006 and reports on the environmental monitoring at the tree farm. A Progress and Compliance Report against the Ministerial Conditions that were developed following the Public Environmental Review is also included.

1.1 Location

The tree farm is situated off Gunn Road on a 550ha parcel of land approximately 10km north of Albany, as shown in Figure 1. The site was selected for the high phosphorus retention capacity of the soils and because it is at the head of the Seven-Mile Creek catchment so has limited ground and surface water inputs. This allows for simplified hydrological management as external inputs are minimised and the site out flow is contained to the southern boundary.

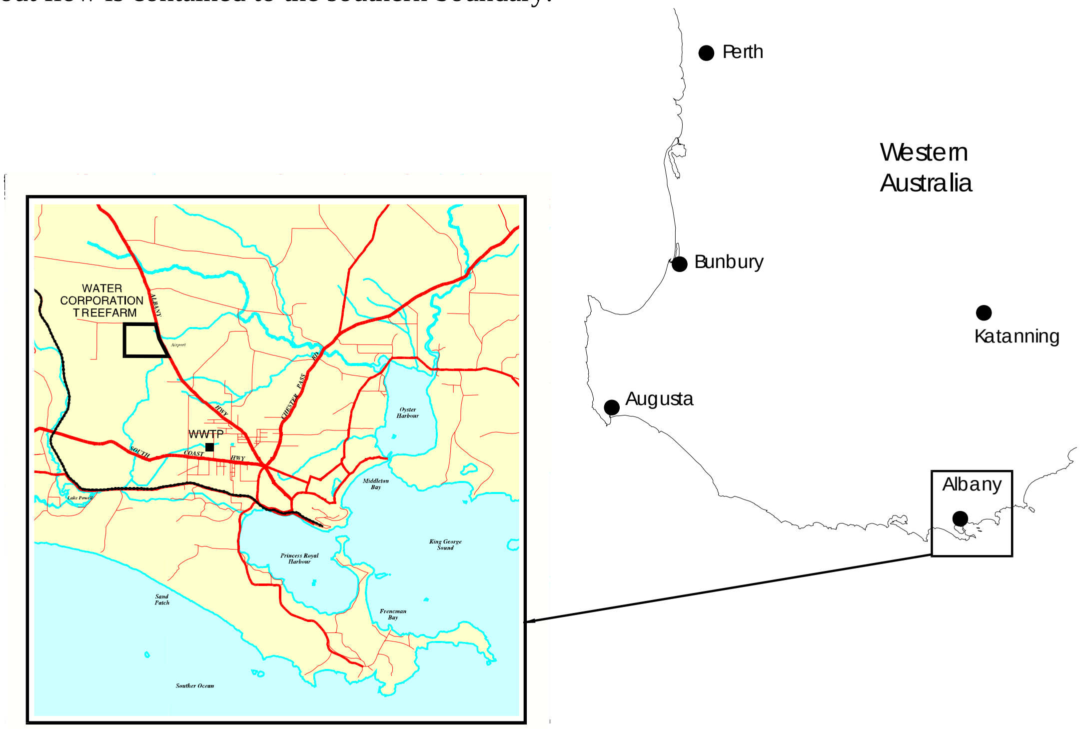


Figure 1 Location of the tree farm

2 Overview of Operations

2.1 Wastewater Treatment Plant (WWTP) and Land Disposal Site Infrastructure

The Timewell Road WWTP treats all the sewage from Albany to secondary effluent standard. The design capacity of the Timewell Road WWTP is 6 ML/day. The plant comprises influent step screens, 2 aerated ponds, 3 facultative ponds and a final effluent pump station to transfer flows to the tree farm.

An upgrade of the WWTP commenced in 2005. This upgrade introduces the use of activate sludge treatment at Albany. This will improve the quality of treatment and increase the volume of wastewater that the plant can process by approximately double. The upgrade was not complete at the end of 2006 so there was no improvement to effluent quality during the period covered by this report. However, the upgrade works has caused periods of disruption to the existing process, as each of the 2 aerated ponds were isolated for upgrade construction works.

A schematic of the tree farm process is shown in Figure 2 below. Treated wastewater is pumped from Timewell Road directly into two holding ponds at Gunn Road. These ponds supply a distribution pump station that delivers the wastewater to overland flow grass bays. There are 34 individual grass bays that give a total overland flow area of 14 hectares. The 34 bays are divided into 2 groups that are flood irrigated, each on a 6 hours ON-6 hours OFF cycle. Because the inflow to the ponds can exceed the hydraulic capacity of the grass bays, a bypass is provided that diverts excess flows to additional grass bays and then directly to the wetland area at the inlet to the irrigation storage dam.

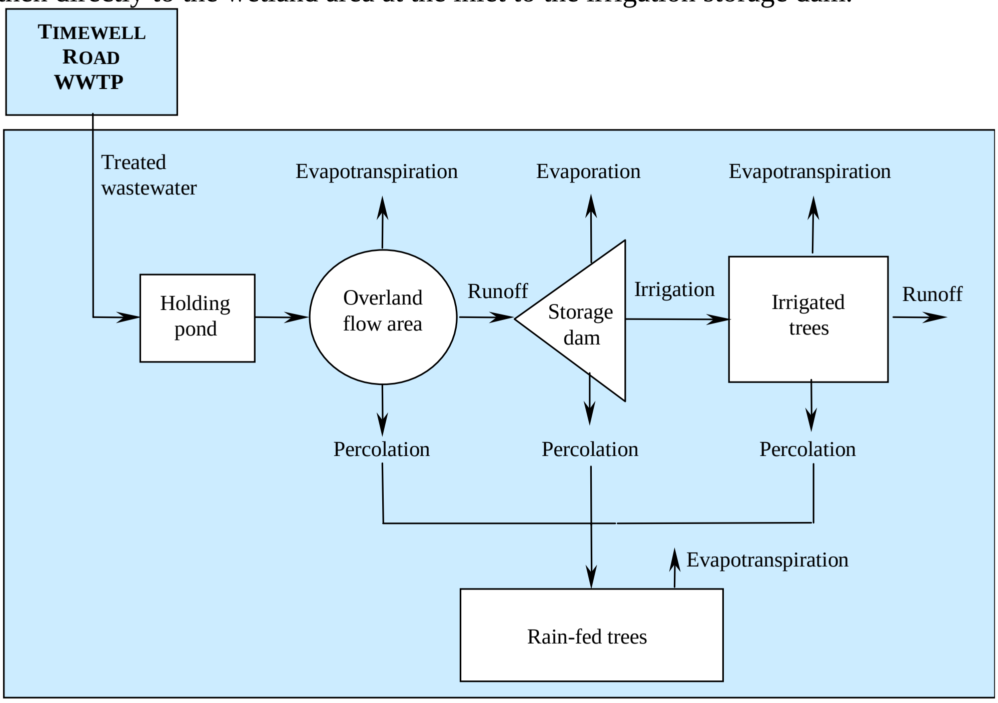


Figure 2 Land treatment flow diagram

The irrigation storage dam collects all surface runoff from the wetland and overland flow grass bays. The dam supplies the irrigation pump station through a floating off-take for distribution over the 283ha of irrigated blue gums. The pump station has facility for dosing of either sodium hypochlorite or hydrochloric acid for pH control however should it be needed.

The dam capacity is 365 ML, representing 70 days of storage at the 2006 average daily site inflow. This has reduced from 75 days reported in 2004. During peak winter flow periods the storage is reduced to about 60 days.

2.2 Overview of Wastewater Treatment Operations 2004 to 2006

2.2.1 Timewell Road Wastewater Treatment Plant

Inflows to the treatment plant have continued to increase over the reporting period, primarily in response to growth in Albany. The Water Corporation has also continued to actively promote connection to sewer from both domestic and commercial premises.

The average annual flow into the treatment plant during the 2006 year was 5.2ML/day. To provide for future growth in wastewater flows the Timewell Road WWTP is being upgraded to an activated sludge plant. The completion of the upgrade works is expected during 2007. This will increase the treatment capacity from 6ML/day to 12ML/day. Nitrogen concentration in the treated wastewater will be significantly reduced (by more than half).

2.2.1.1 BIOSOLIDS MANAGEMENT

Because of the increased load on the WWTP, aeration requirements have increased and sludge accumulation in the ponds has accelerated to a point where the ponds need to be desludged again. Desludging was last conducted during 2001 and 2002 using geotextile bags for dewatering. The dried sludge, termed biosolids, has been stored on-site in a purpose built plastic lined bund and is progressively being removed as beneficial reuse opportunities arise. All biosolids reuse is conducted in accordance with the relevant legislation and guidelines and is reported in the annual reports for the Department of Environment & Conservation License No.6786 File L174/91.

2.2.1.2 ODOUR CONTROL

The high loading on the WWTP particularly during the plants upgrade has led to occasional odour issues from the aerated ponds. This typically occurs when power failure prevents aeration, leading to loss of the aerobic layer at the pond surface. When this happens, odour problems associated with anaerobic treatment by-products such as hydrogen sulphide can result.

The upgrade of the Timewell Road wastewater treatment plant includes management of odour at the inlet works. Odour has not been an issue at the tree farm.

2.3 Overview of Land Treatment Site Operations 2001 to 2003

2.3.1 Overland Flow System

Nitrogen removal from the overland flow treatment system has been excellent. Vegetation in the grass bays has become very dense and even specialist machinery proposed for use in 2004 failed to cut through the thick mat. This led to approved burning of half of the grass bay area so as to reduce the density of kikuyu runners. This allows optimal wetting and drying cycles by improving air circulation through the grass to the soil and so promoting aerobic soil conditions. The design operational strategy for the overland flow bay of alternating between each of the two groups of flow bays for 6 hours ON-6 hours OFF was maintained throughout the 2004 to 2006 period.

2.3.2 Irrigated Blue-gum Plantation

Figure 3 to Figure 6 below show the weekly irrigation depth and the level in the main storage dam for each of the reporting years 2004 to 2006. This data provides an overview of growth in wastewater flows and the capacity of the infrastructure at the tree farm. Average irrigation depth and the nutrient loadings are calculated from weekly data, while the ‘irrigated area’ is the area before, during and after the annual harvest. The annual average site inflows during 2005 and 2006 were 5284 and 5222 kL/day respectively. This reduction in inflows reflects the extreme rainfall events experienced in 2005, and the much lower total annual rainfall 2006. These inflows are approaching 90% of the design capacity for the site.

The capacity of the irrigation system and the design hydraulic capacity of the site are within the design values of 80mm/month during summer and 50mm/month during winter. The irrigation design gives an annual average daily irrigation depth of 2.2mm compared to the 2004 to 2006 average of 1.5mm.

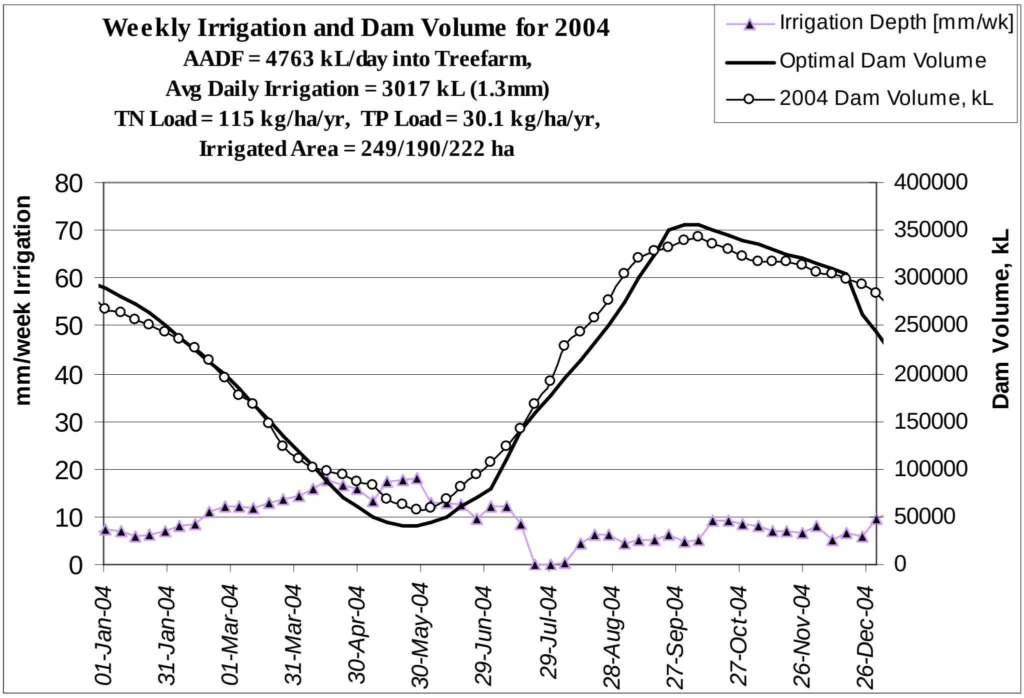


Figure 3 Dam volume and weekly irrigation summary for 2004

Whilst in 2004 the optimal storage level in the dam was maintained precisely, two extreme rainfall events in April and June 2005 grossly overloaded the hydraulic capacity of the site. Inflows to the site increased as a result of higher flows pumped for the wastewater treatment plant, as well as flooding into the storage dam from upstream catchment and neighbouring properties. The storage dam overflowed from early July for 16 weeks, with average nutrient concentrations of 24mg/L total nitrogen and 3.5mg/L total phosphorus.

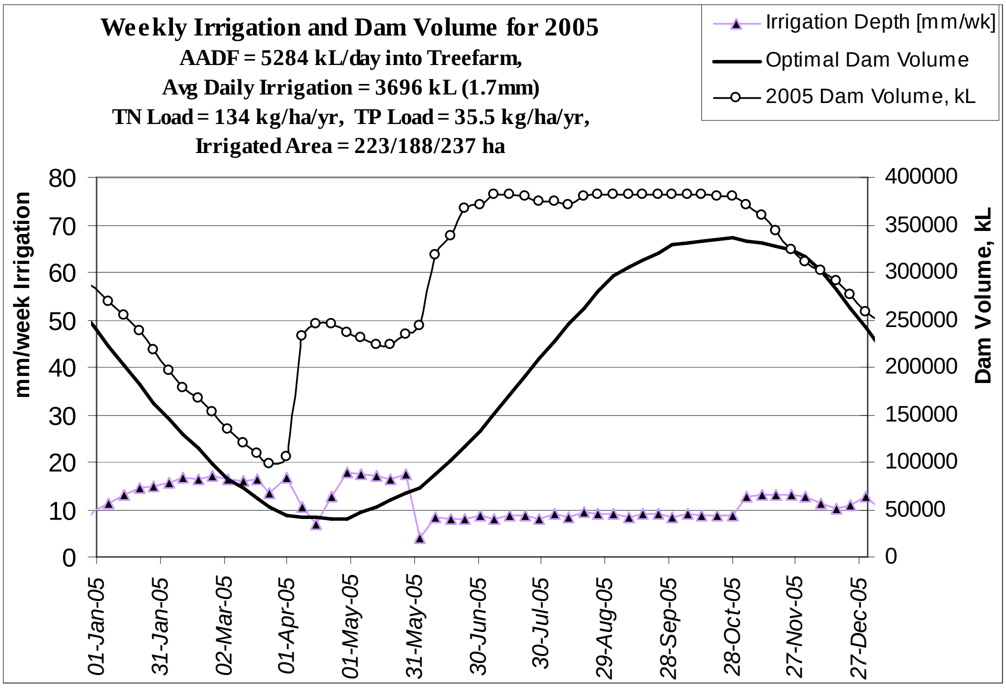


Figure 4 Dam volume and weekly irrigation summary for 2005

Figure 5 below shows two photographs of the spillway during over flow in 2005. These photos are taken from the same location and are looking upstream and downstream respectively. They clearly show the overflow was a constant trickle rather than a storm flow. This is because overflow occurred well after the storm events that filled the dam above the irrigation capacity of the site. It is estimated that the peak overflow rate reached 1ML/day intermittently over the 16 week period, with an estimated total overflow volume of 50ML. The over flow dissipated after leaving the spillway, and followed natural drainage channels for a short distance until no surface flow could be observed. The nutrient loadings in the overflow (1200kg TN and 175kg TP) are significant relative to the historic discharges from site, and elevated nutrient concentrations in groundwater and surface water along the overflow path is expected.

Figure 5 Main storage dam spillway during overflow July to October 2005.

At the commencement of 2006 the site was still extremely wet due to the higher than average rainfall in 2005. This limited the irrigation rates during 2006 so as to ensure the saturated soils were not over irrigated.

The nutrient loading rates during 2006 reflect the limitations imposed on the irrigation, with 121kg of nitrogen and 34kg of phosphorus applied per hectare during the 2006 calendar year. The loading rates applied during this reporting period are considered to be the maximum annual loadings that will ever be observed, as water quality delivered to the plantation will improve significantly following completion of the WWTP upgrade in 2007.

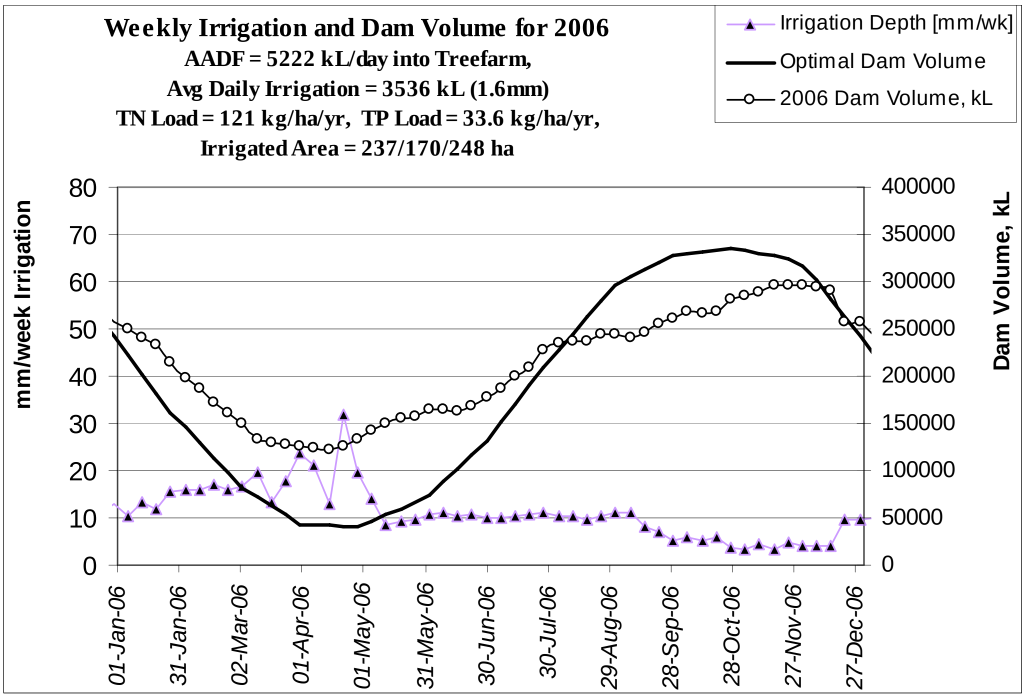


Figure 6 Dam volume and weekly irrigation summary for 2006

2.3.3 Plantation Irrigation Control System

Irrigation control is managed centrally via radio telemetry to 8 field units. Each field unit manages a group of valves and also transmits soil moisture data to the control centre. Irrigation is scheduled according to the season, recent inflow, prevalent weather and soil moisture condition. This is to ensure that excess soil saturation does not occur and also so that the trees do not become stressed due to low soil moisture.

Since 1997 there has been increased operational difficulty with the soil moisture system because of radio-telemetry problems. Upgrade work completed in 2005 has largely, but not completely, addressed these operational problems. Periods where manual intervention is required to maintain irrigation, plus managing gaps in soil moisture data are the main challenges with the sites operation.

An upgraded control interface provides improved monitoring and reporting, particularly of irrigation volumes. This system now allows the tracking of irrigation volumes to each of the nine irrigation groups at the site, rather than the total irrigation volume per day. This allows improved management of volume and nutrient loading rates around the changing structure of the plantation imposed by the harvest activity. Reliability of the control system is currently under review.

2.3.4 Soils

A detailed soil sampling program in excess to minimum requirements has been implemented since early 2004 to investigate specific areas of irrigation-nutrient-soil interactions. Soil Management Consultants (SMC) has been engaged to study the possibility of a spring flush of nitrates beneath irrigated plantation. The potential for an imbalance in nitrification and denitrification in wet soil as it warms up during spring has prompted an investigation into the relative size of soil nitrogen pools between seasons. This study was preceded by an investigation to determine suitable operational sampling methods as those developed during the research period were costly and requires specialist expertise not normally available. Further study has also been conducted by SMC into the soil properties following the cumulative effect of irrigation for the first harvest rotation. A detailed report from SMC is attached at appendix A and only summary comment is made here.

Salinity management is critical to the long term viability of any irrigation activity and is a focus of irrigation control at the tree farm through targeted annual leaching. Soil analysis shows slightly elevated salinity in irrigated plantation compared to rainfed areas, but the salinity is still classified as low.

Detailed analysis of phosphorus applications to the soil system via drip application over 10 years has shown P-saturation of the soil under a dripper will occur in 2-3 harvest rotations (about 20-30 years). The p retention capacity of the site then becomes a function of the wetted area beneath each dripper and the accuracy that the drip lines can be repositioned between harvest rotations. With a 40cm diameter wet zone beneath a dripper, 3330 drip emitters per hectare and 20 years to P-saturation beneath each dripper, the theoretical life for the site to P-saturation is about 500 years. This is consistent with the design life for the site, but the practical design life will be somewhat less owing to practical limitations in drip line repositioning.

Irrigated and rainfed (non-irrigated) areas have the same mean cation exchange capacity (CEC) but irrigated areas have higher mean exchangeable sodium percentage (ESP). The high ESP has been attributed to the precipitation or absorption of calcium and magnesium in response to the alkaline pH of the wastewater. Whilst high ESP may indicate potential for problems with soil structure and infiltration to develop, the duplex soils at the tree farm contain inactive clay minerals and these are not expected to respond to the high ESP.

Concerns expressed in earlier reporting on potassium limitation in rainfed areas are still relevant, but sampling shows this to only be the case in the poorest of soils.

2.3.5 Plantation Management & Harvest

The Forest Products Commission (FPC, formerly CALM) has undertaken the plantation management since site establishment in 1993. This work includes management of plantation health, inventory assessments, maintenance of fire breaks, weed and pest control and reporting. Since 2003 this has included the management of harvesting and post-harvest coppice regrowth including any specialist treatments required to optimise the site for its primary purpose of treated wastewater irrigation. The Triennial Report contribution from FPC is attached at Appendix B and this summarises the operations from a forestry perspective.

Management of soil moisture conditions pre and post harvest remains a challenge for the at times conflicting needs of forestry and irrigation management. Because year-round irrigation removes any impediment to growth by avoiding water stress, the irrigated plantation does not establish deep root systems. During harvest the surface soils are allowed to dry to enable harvest machinery to access the site without damaging buried irrigation pipe work. Consequently, the shallow root zone beneath irrigated trees also dries to an extent that causes water stress post harvest.

This seasonal soil drying is in line with the irrigation design and operational strategy for the site, but imposes unforseen difficulty with the coppice regrowth. Work is ongoing to determine the best time for harvest and the required irrigation strategy to ensure trees either establish roots to greater depth or they do not become stressed due to dry surface soil conditions in the first 12 months following harvest. This may require altering the irrigation strategy to encourage cycling between wet and dry soil conditions throughout summer. Currently all plots are lightly irrigated daily where a revised strategy may require less frequent and deeper irrigation.

2.3.6 Arboretums

Two arboretums were planted when the tree farm was established to enable research into species capable of replacing Tasmanian Blue Gums should they fail to survive irrigation or a market for them fail to establish. Clearly a very strong market exists for blue gums and they have proven themselves to be very effective as irrigation plantation. This success of the tree farm as established makes the arboretums arguably redundant. Because of the mixed suitability of the arboretum species for wood pulp the converse has become the case with no markets readily available for the arboretums.

3 Performance Monitoring

3.1 Flow Volumes

Flows to the tree farm are directly related to wastewater inflows at Timewell Road WWTP. The treatment plant allows some attenuation of the flows to the tree farm except during periods of very high storm flow. In these cases the pumping rate is increased to ensure adequate storage capacity is maintained in the treatment/storage ponds at Timewell Road.

Two extreme rainfall events in April and June 2005 caused extreme flows through the wastewater treatment plant and tree farm. Unlike 2003, when road drainage problems outside of the treatment plant led to the flooding of the treatment ponds, there was no overflow to the environment from the ponds. Pumping rates to the tree farm were sustained at a rate sufficient to avoid overflow.

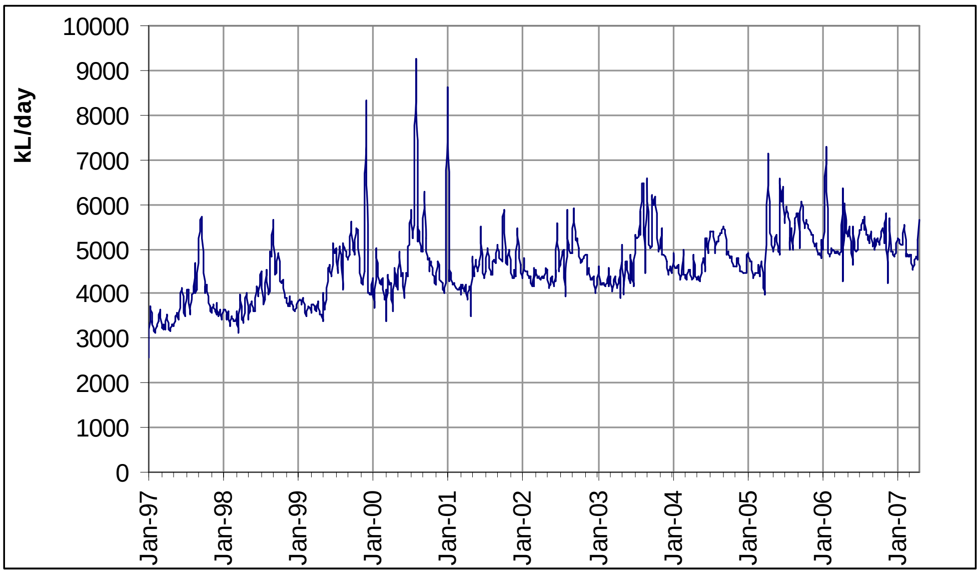


Figure 7 Daily inflow to the Albany tree farm, 1997 to 2006

The average inflow to the tree farm during 2006 was 5.22 ML/day, representing an annual growth of about 3% per annum from 2001. The inflow in 2005 was nominally higher at 5.3ML/day annual average owing to the effects of higher annual rainfall that year. These compare favourably to the licensed hydraulic capacity of 5.5ML/day for the WWTP and 6ML/day for the tree farm.

The annual volumes of flow through the overland flow distribution system and the irrigated plantation are summarised below in Table 1.

Table 1 Summary of flows at the Albany tree farm site

	Inflow to No. 1 Tree Farm ML/year		Pumped to overland flow bays	Irrigated to blue-gum plantation
	ML/year	Avg kL/day	ML/yr (% of inflow)	ML/yr (% of inflow)
1997	1354	3720	1120 (83%)	900 (66%)
1998	1426	3920	880 (61%)	960 (67%)
1999	1595	4380	950 (59%)	950 (60%)
2000	1732	4760	1250 (72%)	1250 (72%)
2001	1660	4560	1440 (87%)	1030 (62%)
2002	1689	4640	1700 (100%)[1.]	1155 (68%)
2003	1765	4850	1610 (91%)	1145 (65%)
2004	1734	4760	1550 (89%)	1100 (63%)
2005	1924	5280	1390 (72%)	1350 (70%)
2006	1901	5220	1660 (87%)	1290 (68%)

1. Unreliable data due to a calibration error with the magflow meter.

Annual irrigation volume has consistently been about 65%-70% of the site inflow. The design irrigation capacity of the site is for 1826 ML/year over 233 ha (effective) giving 784mm/yr irrigation depth. Total annual irrigation depths were 491, 610 and 581mm/year for 2004 to 2006 respectively. Importantly, the irrigation capacity is managed in terms of irrigation depth and not volume, and the harvest causes an annual variation in the area available for irrigation. So while inflow volumes have been at about 65070% of design capacity, the hydraulic loading has been higher at up to 80% of design owing to less that the design 233 hectares being available for irrigation as the harvest rotation is established.

3.1.1 Raw Wastewater and Effluent Quality at Tree Farm Inlet

Influent quality at the Timewell Road has been very consistent as would be expected for a predominantly domestic wastewater and is summarised in Table 2.

Table 2 Average influent quality at inlet to Timewell Road WWTP.

Raw Wastewater Inlet to Works	**Total Kjeldahl Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**pH**	**BOD_5 (mg/L)**	**Total Dissolved Solids (mg/L)**
1997	50.8 (8)	8.9 (8)	7.4 (8)	220 (8)	890 (8)
1998	62.9 (12)	10.1 (12)	7.4 (11)	235 (12)	940 (11)
1999	61.1 (13)	9.9 (13)	7.5 (12)	200 (13)	1000 (12)
2000	57.9 (11)	11.4 (11)	7.6 (10)	225 (10)	880 (10)
2001	52.2 (13)	8.3 (13)	7.4 (14)	180 (13)	860 (13)
2002	58.9 (11)	9.9 (11)	7.4 (11)	205 (11)	910 (11)
2003	54.4 (11)	8.8 (12)	7.4 (12)	145 (12)	970 (10)
2004	58.5 (12)	10.0 (12)	7.4 (12)	221 (12)	No data
2005	60.2 (11)	10.5 (11)	7.4 (11)	233 (10)	920 (1)
2006	65.2 (11)	11.2 (12)	7.6 (26)	210 (26)	720 (1)

(n) is number of samples used to calculate the average value and is all NATA certified analysis

The effluent quality discharged from the Timewell Road WWTP is measured at the tree farm holding ponds and is summarised in Table 3 below. This data is the combined averages from weekly operational analysis conducted on-site and monthly compliance analysis performed at a NATA certified laboratory.

The total nitrogen concentration of the treated wastewater pumped from the Timewell Road treatment plant (the tree farm inflow) has increased steadily and triggered the upgrade of the wastewater treatment plant. At the time of writing this report the WWTP upgrade was well progressed and effluent total nitrogen concentrations was considerably improved and less than 20mg/L.

Table 3 Average effluent quality at inflow to tree farm (sampled in the holding ponds)

Holding Ponds	**Total Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**	**pH**	**BOD_5 (mg/L)**	**Hardness mg /L as $CaCO_3$**
1997	32 (41)	9.0 (38)	7.6 (12)	21 (12)	*No data*
1998	40 (24)	8.6 (26)	7.6 (21)	30 (19)	229 (13)
1999	46 (51)	7.6 (49)	7.5 (49)	31 (16)	222 (47)
2000	48 (48)	8.1 (48)	7.3 (47)	26 (14)	225 (46)
2001	47 (45)	7.8 (48)	7.3 (47)	28 (16)	221 (34)
2002	51 (41)	8.9 (41)	7.6 (41)	27 (16)	238 (37)
2003	46 (48)	7.7 (48)	7.7 (48)	27 (15)	221 (44)
2004	50 (50)	8.0 (50)	7.6 (31)	29 (15)	225 (41)
2005	53 (42)	7.5 (43)	7.6 (42)	39 (12)	261 (4)
2006	56 (44)	9.0 (45)	7.5 (45)	37 (12)	256 (6)

(n) is number of samples used to calculate the average value from on-site and NATA certified analysis

3.1.2 Overland Grass Bays

Annual average nutrient removal through the grass bays is shown in Table 4 below. Whilst performance of the grass bays varies significantly between seasons due to temperature effects, this data provides a useful indication of the grass bay system performance. Typically the nitrogen and phosphorus concentrations are reduced by 30-50% and 10-20% respectively through the grass bays. The improved nutrient removal performance from 2004 to 2006 is as a result of improvements to the distribution system and control systems noted in previous reports.

Table 4 Average effluent quality at outflow from overland flow bays

Grass bay outflow	**Total Nitrogen mg/L**	**Total Phosphorus mg/L**	**pH**	**Hardness, mg /L as $CaCO_3$**
1997	21 (38)	7.2 (32)	7.6 (6)	*No data*
1998	24 (16)	6.3 (13)	7.5 (13)	235 (12)
1999	32 (47)[1]	6.0 (46)[1]	7.4 (47)	226 (46)
2000	33 (44)[1]	6.4 (45)[1]	7.3 (46)	228 (44)
2001	32 (42)	6.5 (45)	7.3 (45)	222 (34)
2002	33 (38)	6.7 (38)	7.6 (38)	237 (36)
2003	28 (46)	5.8 (46)	7.5 (46)	216 (44)
2004	26 (49)	7.1 (50)	7.4 (30)	225 (39)
2005	30 (40)	5.9 (41)	7.5 (36)	226 (8)
2006	21 (44)	6.9 (44)	7.4 (45)	266 (6)

(n) is number of samples used to calculate the average value
1. Adjustment to 99-00 data compared to previously reported following 2001 review of onsite and NATA analysis results

3.1.3 Tree Irrigation

Nutrient concentrations in the irrigation dam are lower than in the outflow from the overland flow bays due to continuing biological processes and nitrogen volatilisation in the dam. The annual average water quality in the dam is given in Table 5 below. As presented in Section 2.3.2, the nitrogen loading to the irrigated plantation was less than the Ministerial Condition limit of 150kg/ha/year. Due to the upgraded wastewater treatment plant, it is anticipated that the reported figure of 134 kg/ha/yr in 2005 was the peak nitrogen loading rate that will be experienced at the site. Whilst hydraulic loading will increase to capacity, the improved upstream treatment will allow improved (by net reduction) nitrogen loading in accordance with the original wastewater treatment and tree farm irrigation plan.

Table 5 Average effluent quality irrigated to blue-gum plantation

Main irrigation dam	**Total Nitrogen mg/L**	**NH_3-N mg/L**	**NOx-N Mg/L**	**Total Phosphorus mg/L**	**BOD_5 mg/L**	**pH**	**Hardness, mg/L as $CaCO_3$**
1997	16 (41)	*No data*	*No data*	5.9 (39)	*No data*	*No data*	*No data*
1998	22 (24)	*No data*	*No data*	5.5 (25)	*No data*	7.8 (14)	227 (13)
1999	27 (49)	*No data*	*No data*	6.7 (48)	*No data*	7.6 (48)	224 (47)
2000	29 (48)	20.7 (8)	2.3 (8)	6.3 (48)	6 (2)	7.5 (46)	220 (46)
2001	25 (44)	18.2 (13)	2.6 (13)	6.6 (48)	4 (2)	7.5 (43)	223 (37)
2002	24 (48)	17.5 (20)	2.2 (12)	6.8 (42)	*No data*	7.9 (38)	231 (38)
2003	23 (49)	18.0 (14)	1.9 (14)	6.1 (49)	4 (4)	7.9 (46)	220 (44)
2004	23 (53)	No data	3.0 (14)	5.7 (50)	4 (11)	7.9 (25)	219 (41)
2005	23 (49)	17.0 (24)	3.8 (29)	5.7 (43)	3 (20)	7.7 (29)	203 (8)
2006	20 (44)	12.4 (44)	4.1 (12)	5.9 (49)	3 (12)	7.7 (45)	242 (11)

(n) is number of samples used to calculate the average value

3.1.4 Gunn Rd Discharge

Surface discharge from the land treatment site is measured at the Gunn Road gauging station at the head of the Seven-Mile Creek. There is automatic flow logging and water quality sampling at this point. The daily discharge for the period 1997 to 2006 is shown in Figure 8 below.

Some very high storm peaks in the 2005 and 2006 discharge can be attributed to high and extreme rainfall events. Weekly rainfall in excess of 40mm was recorded on several occasions in 2005, including two consecutive weeks in April when rainfall exceeded 100mm/week. Peak rainfall in 2004 and 2006 did not exceed 50mm/week.

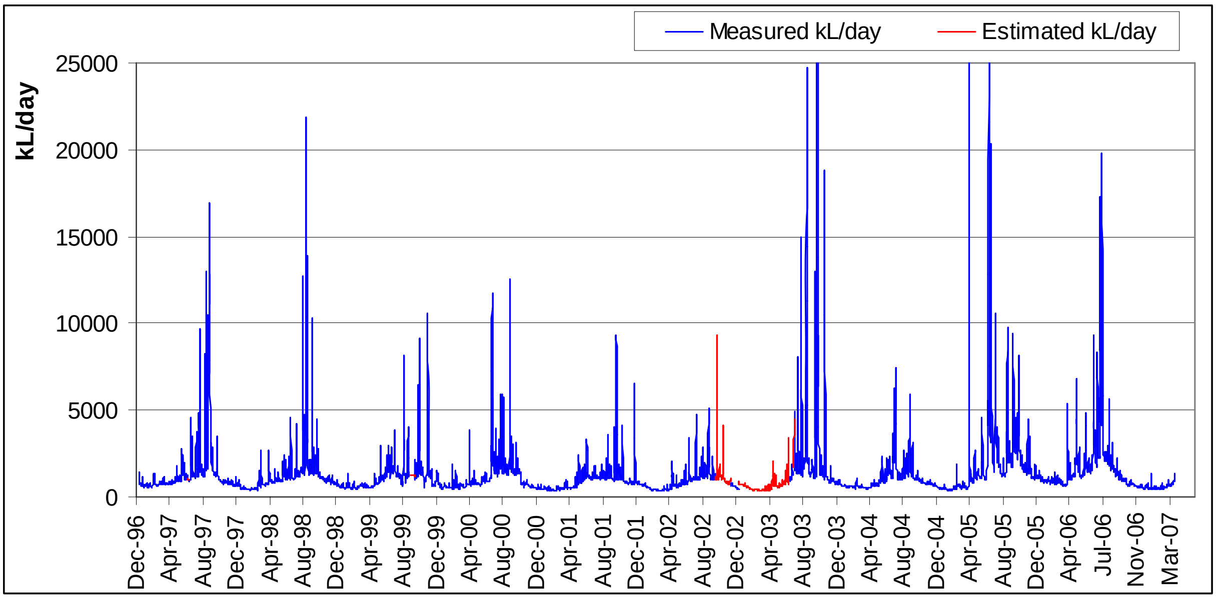


Figure 8 Streamflow at Gunn Road gauging station, 1997 to 2006

Nutrient discharge through the Gunn Road gauging station was calculated using HYDSYS hydrological software to give the nitrogen and phosphorus loads in Seven-Mile Creek. Results of daily flow logging and HYDSYS nutrient load calculations are summarised in Table 6 below. Note that these load calculations used nutrient concentration data obtained from both weekly operational analysis and testing conducted in NATA certified laboratories. Where on-site analysis varies markedly to NATA certified analysis, the data has been corrected to show the same annual average value.

Table 6 Summary of HYDSYS calculation of nutrient loads in Seven-Mile Creek

Year	Rainfall mm/year	Irrigation[1] mm/yr	Avgerage Irrigation Area, ha	Discharge ML/year	Total Nitrogen Load kg/year	Total phosphorus Load kg/year
1992[4]	931	0	-	950	1399	262
1993[4]	821	0	-	734	916	207
1994[4]	676	0	-	576	1054	169
1995[4]	720	146	230	466	514	67
1996[4]	826	264	230	593	733	95
1997	725	389	230	525	466	40
1998	773	417	230	486	456	36
1999	731	398	240	419	162[2]	21[1]
2000	748	455	275	450	459	37
2001	812	365	283	370	225	10.9
2002	667	408	283	347[3]	146[2]	8.3[2]
2003	899	449	255	648[3]	386[3]	35.9[3]
2004	621	491	229	387	427	59
2005	985	610	224	1020	1897	274
2006	655	581	238	640	637	219

1. Irrigation depth calculated over weekly irrigated area.
2. Load underestimated due to insufficient nutrient data for HYDSYS
3. Includes estimated data
4. Sourced from Albany Land Treatment System Review (Kinhill Pty Ltd, 1997)

This table includes summary data for all years since the inception of the tree farm, the commencement of planting in 1993 and the start of irrigation in March 1995. The discharge volume in Seven-Mile Creek is strongly driven by annual rainfall (R^2=0.6) rather than irrigation (R^2<0.05). The annual nutrient loads in the discharge from the site have fallen substantially since the establishment of the plantation. The improved runoff interception offered by the managed plantation compared to pasture is evident with only extreme wet years (ie 2005) showing nutrient discharge loads similar to that observed before tree farm establishment.

Nitrogen discharge is 2005 and phosphorus discharge in 2005 and 2006 are notable as they are significantly larger than observed previously. In 2005 the high nutrient export is related to the extreme rainfall events and discharge volume double normally observed. In 2006 the high phosphorus loading in surface discharge occurred primarily in July-August (88kg in July and 35kg in August). The nitrogen load in 2006 is however reduced compared to 2005. This is because the measured total nitrogen concentration was reduced from an annual average of 1.4mg/L in 2005 to <1mg/L in 2006, combined with the reduce 2006 flow.

An independent consultant (CYMOD Systems Pty Ltd) applied groundwater level data from 34 monitoring bores to a numerical model calibrated to the tree farm site, as detailed in Appendix C. This modelling enabled calculation of the groundwater component of discharge from the site. The modelling system used for these calculations has additionally been developed to estimate the groundwater export component of surface (Seven-Mile Creek) discharge and nutrient export. HYDSYS data is used in total nutrient export calibrations due to the higher frequency of in-stream water quality analysis than groundwater bore analysis. Table 7 below summarises calculated nutrient discharges using both HYDSYS and CYMOD results.

The CYMOD estimates for phosphorus are less accurate than those for nitrogen owing to the complexities in soil processes that govern phosphorus immobilisation processes, however the calibrations for nitrogen are good (Refer to Appendix C). These estimates show the groundwater nitrogen export to be comparable to previous years.

Table 7 Annual groundwater flux and nutrient loads in groundwater and surface runoff

Year	Ground-water Flux (modelled) ML/year	Estimated TN in ground-water (kg/year)	Estimated TN in Surface[4] runoff (kg/year)	Overall TN load (kg/year)	Estimated TP in Ground-water (kg/year)	Estimated TP in Surface[4] runoff (kg/year)	Overall TP load (kg/year)
1997[1]	-	191	339	530	13	30	43
1998[1]	-	221	312	533	16	26	42
1999[1]	-	205	368	573	15	26	41
2000[1]	-	305	318	623	34	14	48
2001[2]	58	148[2]	225[3]	373	18[2]	10.9[3]	28.9
2002[2]	61	156[2]	146[3]	302	18[2]	8.3[3]	26.3
2003[2]	60	162[2]	482[3]	644	18[2]	45.5[3]	63.5
2004	57	142	427	569	10	59	69
2005	55	86	1897	1983	9	274	283
2006	50	89	637	726	9	219	228

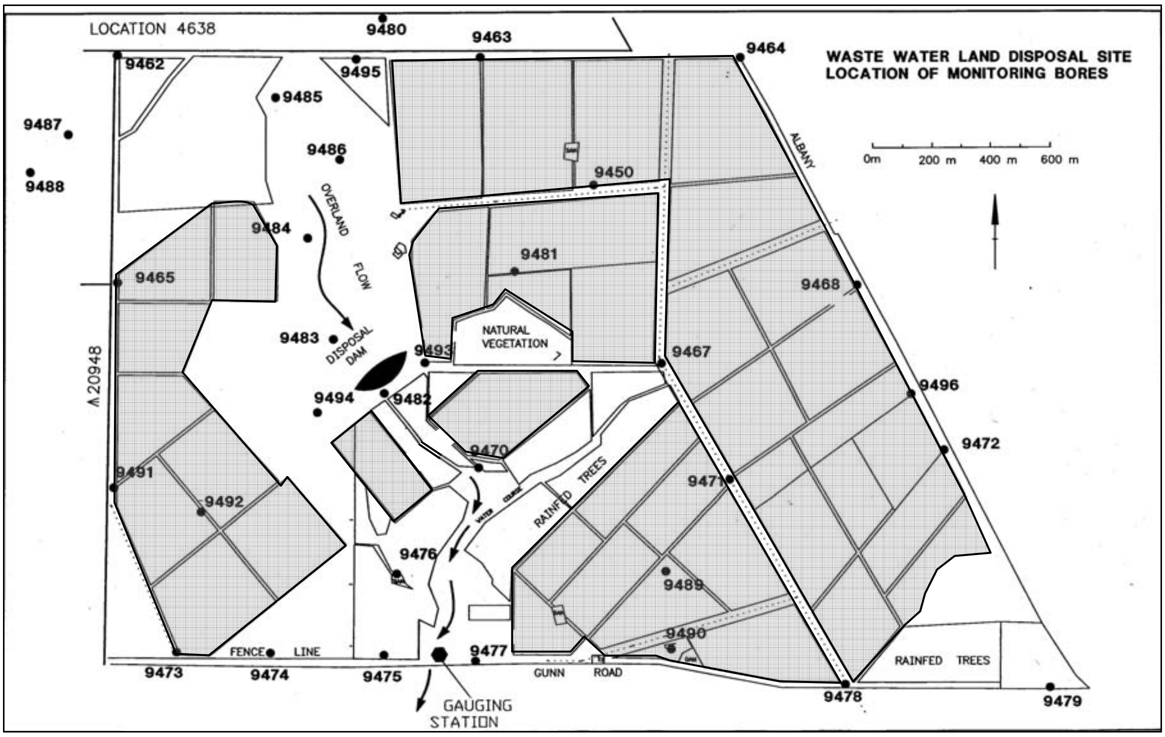
1. data from Brown & Root (2001) independent review
2. data from CYMOD (2004) independent review, TP groundwater data is estimated average over three year period.
3. Calculated from HYDSYS hydrological analysis of actual flows and weekly analysis results.
4. All surface runoff is assumed to occur through the gauging station on Seven Mile Creek

The surface runoff loads calculated for Seven Mile Creek using HYDSYS for 1997 to 2000 (Table 6) are higher than those made by the Kinhill independent review for 1997 to 2000 (Table 7). This provides some confidence that the nutrient loads presented here for 2001 to 2006 are conservative/high as these were determined using the more conservative HYDSYS methodology. Groundwater export loads are low due to generally low groundwater levels and subsequent reduced groundwater flux off site.

The total nutrient loads are well within the design estimates of three tonnes of nitrogen and one tonne of phosphorus per annum. The discharge loads have reached the levels recorded prior to the tree farm establishment in response to extreme rainfall events, and lower export rates are anticipated in the future due to the upgrade of the Timewell Road WWTP.

3.2 Groundwater Monitoring

Environmental and operational monitoring at the Albany Tree farm incorporates monthly groundwater level and quarterly analysis of 34 bores across the tree farm site. The location of the individual bores is given in Figure 9 below.



Note; Shading denotes irrigated areas.

Figure 9 Tree farm layout showing location of monitoring bores

Whilst all bores are monitored many have not been fully developed and consequently are dry in summer or unable to be pumped for sampling. In these instances grab samples are taken using a bailer. Of the total 34 bores regularly monitored, 20 are sampled by the correct pumping procedures, 12 can only hand bailed and 2 cannot be sampled at all for other than in-situ tests. Results from the bailing sampling and analysis must be considered with discretion as they may not accurately represent the groundwater condition. Detailed descriptions of bore data and sampling limitations are provided in Appendix D.

3.2.1 Groundwater Quality and Levels

Data for the monitoring bores has been summarised in the following sections to describe particular areas of the tree farm and groundwater features. Groundwater level, conductivity and nutrient concentration data is presented graphically for all bores in Appendix D and graphs are grouped by location to correspond with the following discussion.

A number of bores have shown a seasonal lowering of the water table in summer to a level that prevents sample collection. These sites therefore will only show analysis results from when sample collection was possible.

3.2.1.1 Northern, Western & Eastern Boundaries

Groundwater flow onto the site occurs to a limited extent on the northern and western boundaries. Monitoring bores along the site boundary and control bores on neighbouring properties to the north and west show groundwater variations as large as those within the irrigated areas of the tree farm. Total nitrogen and conductivity show moderate to large variations at most points in this area.

Bores 9462 and 9463 located on the sites northern boundary show a nominal increase in total nitrogen concentration over time. Bore 9462 is in a rainfed tree area and 9463 is in an irrigated tree area. Whilst the design of the tree farm anticipated that irrigation effects would not be seen in groundwater until more than 10 years after irrigation commenced, it is unclear why an increase would be seen in the rainfed area. However, the falling conductivity in bore 9463 suggests that this is not a direct leaching of treated wastewater. Irrigation ceased to the area around 9463 between March 2004 and April 2005 follow harvest. When irrigation resumed in April 2005 this was at the nominal rate of only 30% of design flows to allow for the low leaf area. The very low water level in this bore and in the site generally is clearly shown in bore 9463 even despite the removal of trees in 2004.

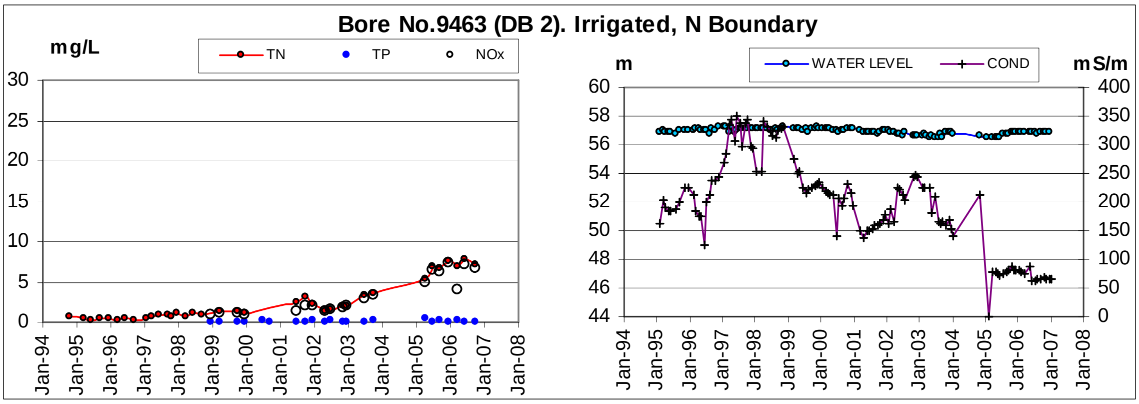


Figure 10 Bore 9463 Northern boundary – nutrients, conductivity and water level.

Bores located in farmland adjacent to the tree farm site's western boundary show elevation of nitrogen to a similar extent as those bores in rainfed and irrigated areas on the northern boundary. Variability in sampling results along the western and eastern boundaries is restricted to bores that are, or have been, sampled by bailed grab sample rather than correct pumping procedures (bores 9468, 9491 & 9496).

Most bores along the northern and western boundaries show an initial increase in groundwater elevation of between 0.5 and 1 metre since irrigation commenced in 1995 and then a progressive decline in groundwater level. In the absence of inflow to the site along these boundaries, this fall in level shows the combined impacts of lower recent rainfall and managed irrigation and uptake by the blue gum plantation.

Large and seasonal nitrogen spikes are also observed on the eastern boundary, but only to a limited extent along the northern boundary. Whilst on the eastern boundary the nitrogen spikes are likely to be related to irrigation and seasonal groundwater levels, the variations on the northern and western boundaries do not exhibit such seasonal trends. As there is some groundwater flow onto the site on the northern and western boundaries, but not the eastern, it is suggested that bores 9462, 9487 and 9488 are presenting the natural variations in groundwater quality (and sampling variability) without irrigation. These bores show low-moderate (1-8mg/L) nitrogen concentrations, and stable to slightly increasing conductivity. High nitrogen results for bore 9487 in 2001 have been attributed to the failure of bore sampling equipment preventing the correct sampling technique being used, rather than irrigation effects. Since the correct sampling method was applied this bore shows stable and low nutrient levels

The three bores along the central eastern boundary show very different profiles of total nitrogen and electrical conductivity. Total nitrogen concentration is low along this boundary except for seasonal irrigation spikes at bore 9468 (when bail sampled) and 9496 within the irrigated plantation. Recently there have been problems with sampling in these bores due to very low (or empty) water depth preventing adequate flushing prior to sampling. These bores are also adjacent to large areas where the laterite layer is very shallow, and preferential drainage pathways are suggested to have resulted from the site ripping during establishment. This could account for the high phosphorus in bore 9496, but not the elevated nitrate concentration in bore 9468, which is attributed to sampling limitations.

3.2.1.2 SOUTHERN BOUNDARY

Groundwater from the tree farm exits the site along the southern boundary. Figure 11 below shows variations in groundwater level, total nitrogen concentration and conductivity across the southern boundary from 1995 to 2006, though there is relative consistency between these sites over this time. There was an immediate reduction in the total nitrogen concentration along the western end of the southern boundary at the commencement of the tree farm operations, and a more recent reduction observed at the eastern end. The 2005 and 2006 data however show increases in nitrogen in bore 9477 which is immediately adjacent the Gunn Road gauging station on Seven Mile Creek. Bores up-slope and either side of 9477 (9475 to the west and 9490 to the east) were not able to be sampled during 2005 or 2006 due to very low levels of water. Despite the wet rainfall year of 2005, the water consumption of established trees in the valley and the low groundwater level at the end of 2003 have contributed to poor recovery to historically higher water levels during this reporting period.

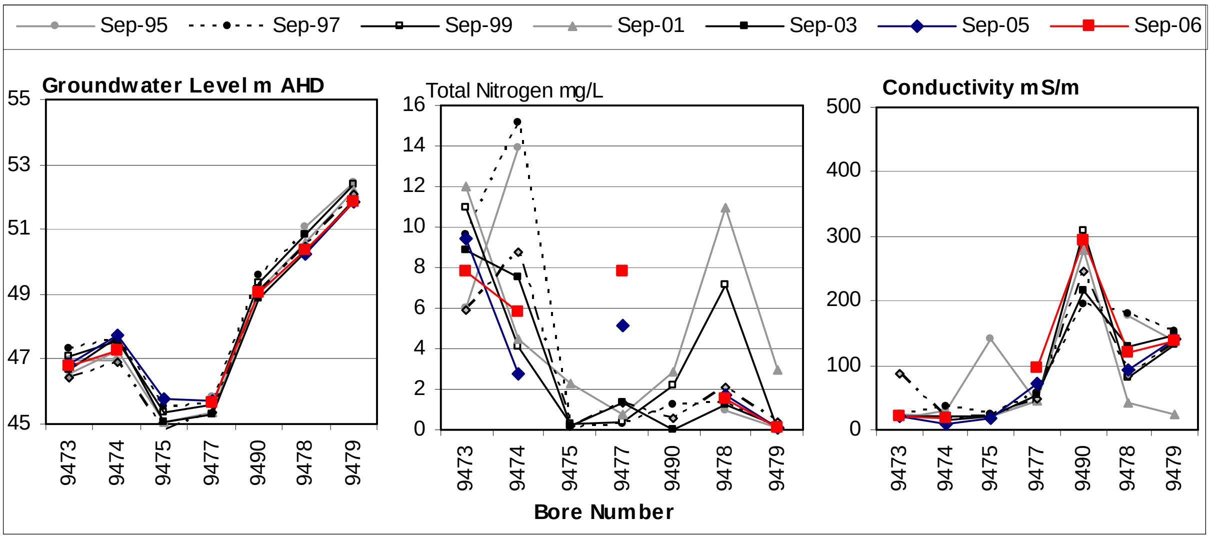


Figure 11 Cross-section of bore data along the southern boundary

Bore 9477 (Figure 12 below) is in an area of native flora adjacent to the gauging station on Seven Mile Creek and shows increasing nitrogen and conductivity levels from 2003 onwards. This bore was identified in the 2003 Triennial Report as warranting particular monitoring attention as potentially providing early detection of slightly elevated nitrate levels. Groundwater flux off-site has decreased steadily since 2002 (refer to Table 7) and this would tend to cause a concentrating effect of any nutrients from surface irrigation. Groundwater modelling has shown that low water levels have caused reduced groundwater flow off site, and consequently this high bore reading has not significantly contributed to nutrient loss to the downstream catchment. It is also possible that this bore is detecting localised wetting effects due to surface or subsurface runoff. Bore 9477 will continue to be monitored to try and better describe the cause for this localised increase in nutrient concentration relative to other monitoring bore locations.

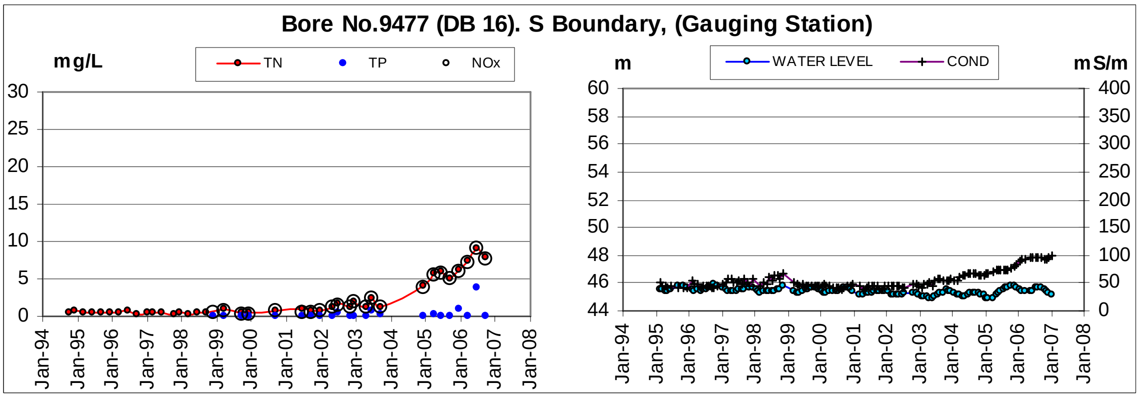


Figure 12 Bore 9477 southern boundary - nutrients, conductivity and water level.

Comparison of bores 9474, 9475 and 9479 in rainfed tree areas, and bores 9473, 9478 and 9490 in irrigated tree areas shows nitrate levels below the rainfed areas to be consistently lower than the irrigated areas. This is consistent with the irrigation of treated wastewater and the nutrient management purposes of the rainfed trees, particularly in the valley area. Bore 9479 located at the south-eastern border of the site on farmland shows background groundwater conditions, and irrigated areas on the southern boundary are comparable to this site.

3.2.1.3 RAIN-FED CENTRAL VALLEY BELOW DAM

Bores 9470 and 9476 are both below the dam wall and located in the valley area where the design expectation was that any rainfall runoff from irrigated areas would be intercepted. The nutrient concentrations in bore 9470 have shown some recent fluctuation most likely in response to wet rainfall year in 2005 and high soil moisture during 2006 from an irrigation leak in that area. The high seasonality of level in bore 9476 in particular is due to the seasonal variations in the dam storage level increasing the head on groundwater movement in that area.

3.2.1.4 OVERLAND FLOW BAYS

The four bores in the over land flow area show high seasonal change in level due to the high design and operating irrigation rates and seasonal rainfall. Bore 9484 at the northern (upstream) end of the grass bays has shown a nominal decrease in level whilst all others in the grass bays have been stable. This bore is furthest from the dam and does not exhibit large seasonal variations as observed in the bores closer to the dam.

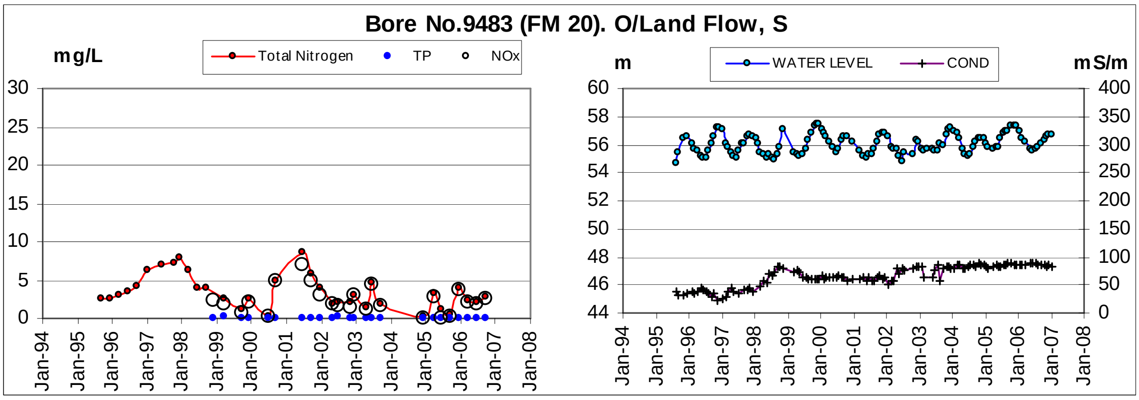


Figure 13 Bore 9483 overland flow area - nutrients, conductivity and water level.

Bores 9483 (Figure 13) and 9484 are at the lower edge of the overland flow bays and show seasonal changes in level as well as typical variations in nitrogen. Bores 9485 and 9486 have high silt levels when sampled and consequently may be less reliable as indicators of nutrient impacts in the groundwater. Despite these comments, the increases in nitrate concentration below the grass bays was expected at design, and is a function of the higher nitrogen loading that has occurred in recent years.

Consistently low total phosphorus concentrations have been measured at all bores in the overland flow area despite the very high loading rates. This is evidence that the soils are effectively retaining phosphorus in the surface layers and not allowing leaching.

3.2.1.5 STORAGE DAM AREA

Bores below and adjacent to the storage dam typically show a seasonal variation in level due to the changes in the dam storage. Bore 9482 (Figure 14 below) in rain-fed trees immediately below the dam wall, shows the largest response to the hydraulic pressures at the dam wall. The conductivity of 20-70 mS/m is representative of the groundwater at the site before the tree farm was established, although this looks to be very slightly increased in recent years. The total nitrogen concentration has fallen since 1998 as a direct result of repair to the dam lining in March 1998 and all bores in this area have total nitrogen levels within acceptable range.

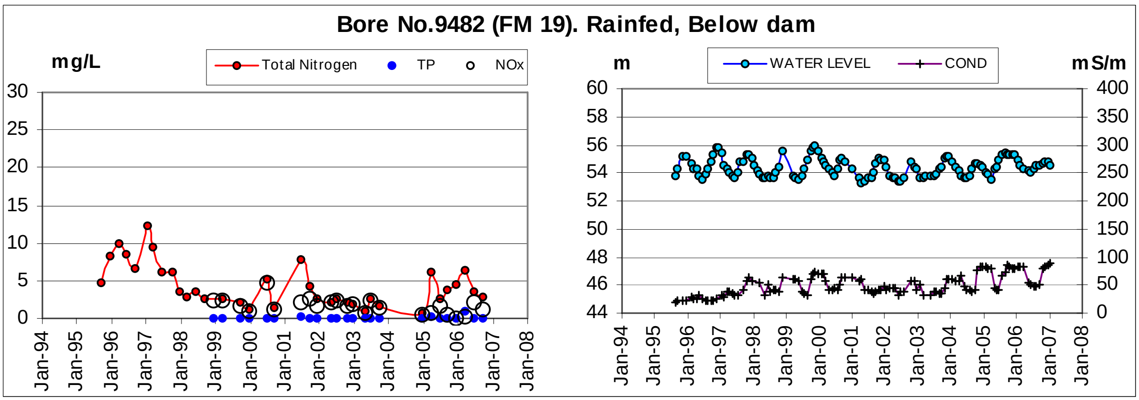


Figure 14 Bore 9482 rainfed below dam - nutrients, conductivity and water level.

3.2.1.6 IRRIGATED - CENTRAL PLATEAU

Bores 9450, 9467, 9471 and 9481 are all located at the centre area of the tree farm and above the central valley. Total nitrogen in these bores is consistently low except for bore 9467 (Figure 15 below). This bore is located at the junction of three access roads and is in a depression in the surface topography. There has been no significant increase in conductivity, and groundwater has declined steadily since the commencement of irrigation activity at the site owing to water utilisation by the trees. Some recovery in groundwater is evident possibly as a result of the commencement of harvest activities in 2003, and consequent reduced water uptake due to the removal of trees allowing greater rainfall infiltration. Given that the conductivity has remained constant in this bore, it is unclear why the nitrogen concentration should be increasing. This area becomes very wet during winter and especially following storm rainfall events, so it is possible the nitrate concentrations of greater than 10mg/L may be attributed to excessive flushing of the irrigated soils. Research has suggested the possibility of a spring flush of nitrates as nitrification rates temporarily exceed denitrification in the soil. This phenomenon is being investigated through targeted soil and soil pore water analysis undertaken by an independent specialist.

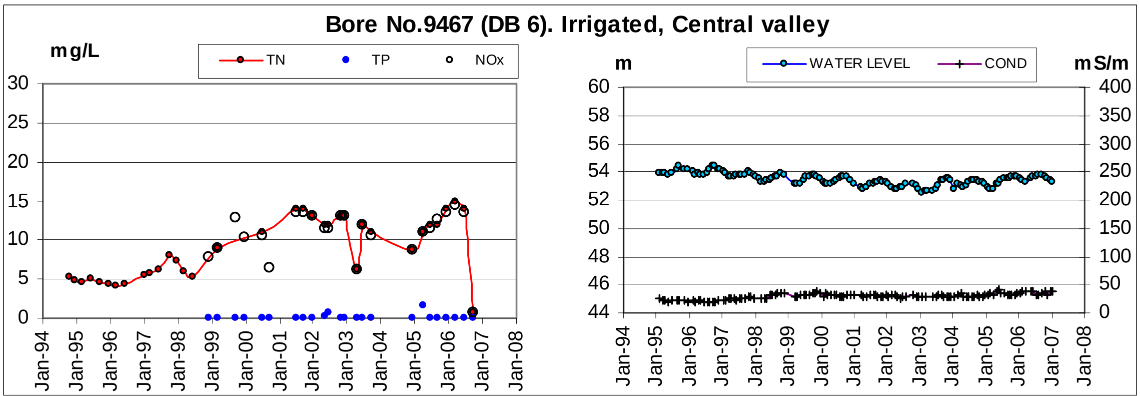


Figure 15 Bore 9467 irrigated, central valley - nutrients, conductivity and water level.

3.2.2 Groundwater Monitoring Summary

The 2004 to 2006 reporting period has seen an extreme wet year in the middle of a period of dry years whilst irrigation rates have been increasing in accordance with growth in wastewater flows. Overlayed onto this is the commencement of tree harvesting activities that is driving large spatial variability in irrigation and tree water requirements. While irrigation can be balanced to tree water requirements, rainfall to recently harvested areas is having a larger impact on soil moisture during winter, and consequently on groundwater levels, than occurs with the established plantation. This has caused some apparent localised increases in nitrogen levels in monitoring bores, though the majority of bores show no change in groundwater quality. Only three of the 34 bores being monitored at the site show a sustained increase in nitrogen concentration. Two of these are located on the northern boundary adjacent to farmland, and the third is immediately adjacent to the creek at the southern boundary. The groundwater data is therefore considered to demonstrate compliance with the design and performance expectations for the site.

3.3 Soil moisture monitoring

Soil moisture probes are installed in 16 of the 36 irrigated plots, as shown in Figure 16 below, to monitor the effects of irrigation and rainfall on soil moisture. This enables direct comparison of the system against design water balance for the site, where there are annual target wet and dry points in the soil.

The probe positioning provides soil moisture measurement at 2 locations in Groups 1-7, and at one location in Groups 8 & 9 (plots 30 & 34). Each probe is made up of 6 sensors located in what is considered to be the effective root zone, taken to be 2 metres deep. Individual sensors are placed at 10cm, 20cm, 50cm, 100cm, 150cm and 200cm depths to enable wetting of the soil profile from irrigation and rainfall events to be accurately tracked. Drainage beneath 200cm is considered for irrigation purposes to be too deep for tree uptake.

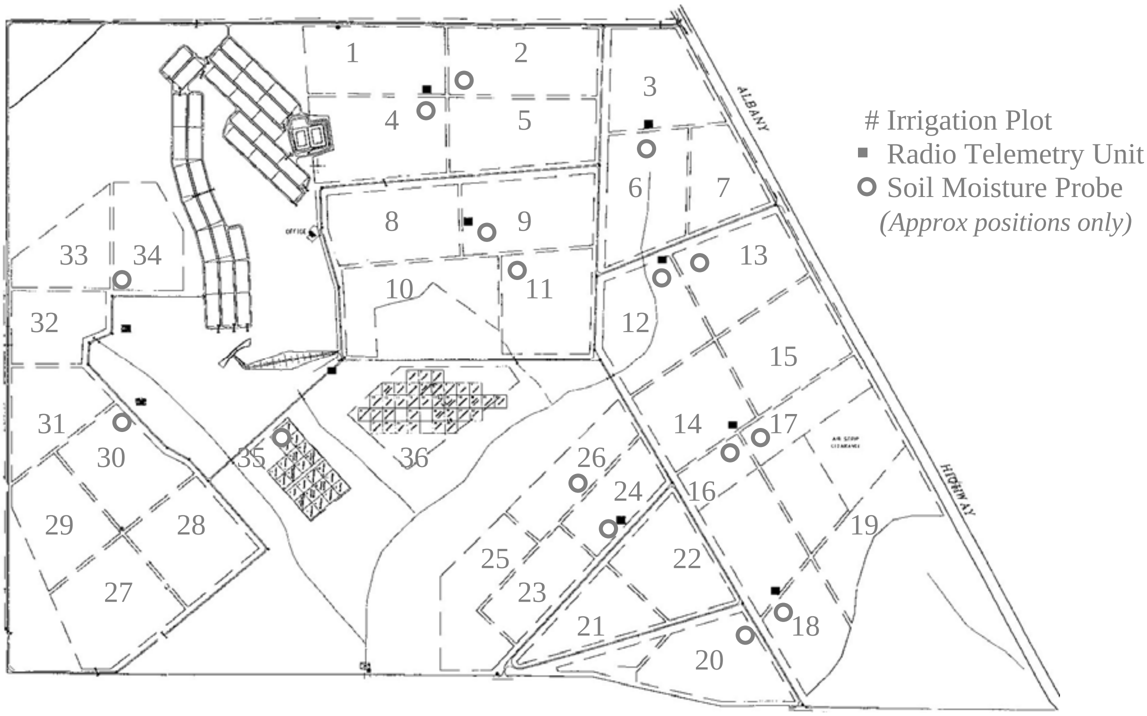


Figure 16 Tree farm layout map showing location of irrigation plots and soil moisture probes

The soil moisture records for the 14 monitoring points are given in Appendix E. This data is used for operational management of the irrigation, and as such is at very high resolution. This makes presentation of the historical data trends difficult due to the noise of seasonal rainfall and irrigation events. However, the general soil moisture condition can be assessed, and by focussing on the 10cm and 200cm deep probes the impacts of rainfall and irrigation can be assessed. Wet (saturated) and dry (wilt point) level for each soil moisture sensor is shown in these graphs. The design of the irrigation loading at the tree farm allows for annual cycling between these upper and lower soil moisture limits.

As the soil moisture probes are indicative of soil moisture and not a direct measurement (such as would be obtained gravimetrically), when reviewing this data it is important to look at relative changes rather than absolute values. The soil moisture range between dry (wilt point - tree unable to draw water from the soil) and wet (saturation - leading to direct surface runoff) conditions is denoted in the graphs by red and blue shading respectively. Soil moisture levels inside these shaded areas are not possible.

All sites show spikes associated with rain events and to a lesser extent irrigation events at the surface (10cm) and typically at 20cm and 50cm probe depths. Plot 17 clearly shows the daily and seasonal fluctuations of soil moisture at depth. Figure 17 and Figure 18 below show the individual raw soil moisture values at each depth and the total soil moisture for the zone. Other sites are less clear owing to a number of variables including soil conditions, position of probe installation relative to irrigation drippers, calibration differences and also the local topography and position on the site. The wet and subsurface monitoring environmental also leads to a high incidence of data loss due to water ingress.

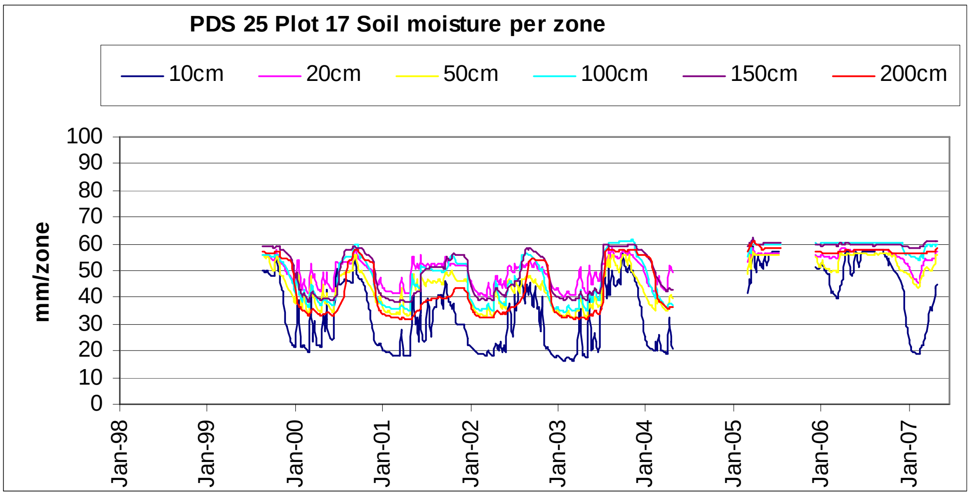


Figure 17 Raw soil moisture data for individual depths in Plot 17

Figure 17 shows the surface soil moisture is highly variable compared to progressively deeper through the soil profile. This reflects the surface applications of rainfall and irrigation being attenuated through the soil profile. The detail contained in these individual moisture readings enables the mean soil condition to be assessed. Full point for example will be indicated by a sharp response to irrigation rainfall at all sensor depths.

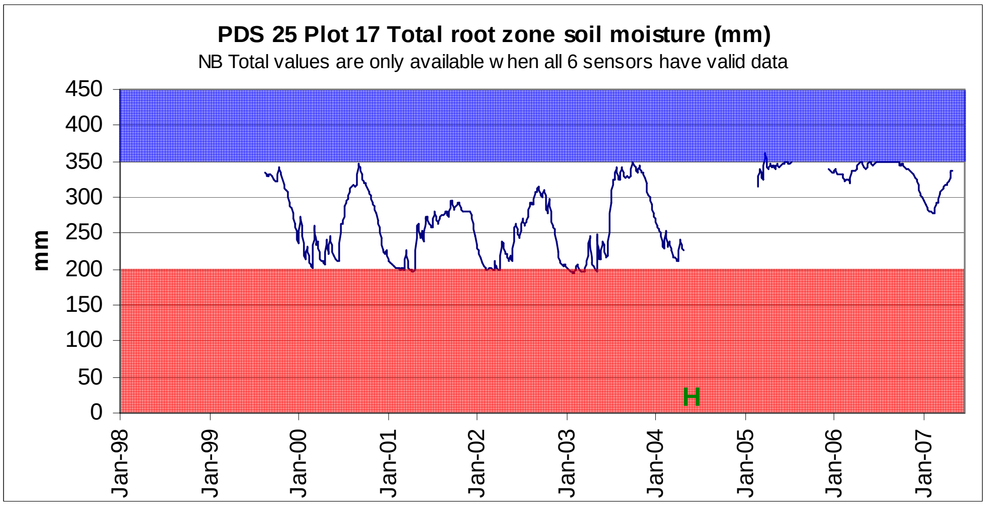


Figure 18 Total (summed) soil moisture in the 200cm root zone in Plot 17

Figure 18 shows the mean soil condition in the soil profile. In this case the soil is completely dry in terms of water availability for the trees at 200mm and is saturated at 350mm soil moisture. This represents a nominal 150mm depth of water applied over the root zone to saturate the soil from dry. Note that the 'H' in the graph denotes the point of harvest for the plot. The soil moisture sensors are removed during harvest to ensure they are not damaged.

During 2002 the combined rainfall and irrigation depth was about 1080mm and the soil content in plot 17 peaked at 300mm. Deep drainage and consequent flushing of salts from the soil profile would have been limited as a result of this low peak soil moisture (refer to section 4, page 23).

In contrast, during 2005 when rainfall and irrigation totalled nearly 1600mm the soil moisture content was maintained at or near saturation for an extended period. The lowering of the soil moisture levels through 2006 was poor as the site recovered from the extreme wet (rainfall) of 2005. The wetting of plot 17 well into 2006 from rainfall that occurred in 2005 is particularly pronounced in this data as the trees were harvested during early 2004, and consequently had a reduced water demand. Irrigation did not resume onto plot 17 until mid 2005. This scenario dominated the soil moisture across the site and consequently the large rainfall events of 2005 dominated irrigation management through 2005 and well into 2006.

3.3.1 Groundwater Monitoring Summary

Management of soil moisture is the key to operating the tree farm in a sustainable manner. It is the soil moisture level that ultimately determines the extent of runoff from the site or ensures sufficient flushing of salts from the surface soils. Additionally, if the soil is allowed to become too dry then the growth of the trees and consequently the yield from the plantation may be reduced.

The soil moisture monitoring has highlighted the influence seasonal and annual rainfall variations have on the irrigation performance of the site. However the soil moisture monitoring is not able to be used as an irrigation scheduling tool because of the temporal variability of rainfall. The soil moisture monitoring is best applied as a means of limiting extreme wet or dry conditions within the plantation.

Despite the wet conditions through 2005 and 2006 the tree farm has maintained operations within the design constraints for the site. The soil moisture monitoring data validates the sustainable operation of the site in accordance with design, particularly when considered with the water balance modelling presented in Section 4.

3.4 Metals analysis

Annual metals analysis is summarised in Table 8 below that gives the average of annual analysis from samples taken at the inlet pipe to the tree farm. Calcium, magnesium & potassium data is also provided for the main irrigation dam as this represents water irrigated to the blue-gum plantation.

Table 8 Average concentration of metals in tree the farm influent

Holding Ponds	**1998**	**2000**	**2002**	**2003**	**2004**	**2005**	**2006**	**Guideline Limit[1]**
Cadmium -Cd	0.01	0.01	0.005	0.01	0.01	0.01	0.01	0.01[3]
Chromium – Cr	0.01	0.01	0.006	0.01	0.01	0.01	0.01	0.10-1.0[3]
Copper – Cu	0.01	0.01	0.02	0.03	0.02	0.035	0.05	0.2[3]
Lead – Pb	0.03	0.05	0.0055	0.01	0.01	0.01	0.01	5.0
Iron – Fe *unfiltered*		0.28		0.26	0.24	0.24		0.2-2.0[3]
Magnesium – Mg		11	12	13	13.5	12.2	13	0.1 – 0.3
Mercury – Hg	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.002[3] -0.05[2]
Sodium – Na		130	125	125	125	130		
Zinc - Zn	0.015	0.03	0.025	0.04	0.01	0.01	0.04	2.0[3]
Main Dam	**1998**	**2000**	**2002**	**2003**	**2004**	**2005**	**2006**	**-**
Calcium - Ca		48	57	56	55	54	63	-
Magnesium – Mg		11	12	13	12	11	13	0.1 – 0.3
Potassium - K					17	17	16	-
Sodium -Na							142	-

1. Adequate range in foliage, CSIRO (1999) *Sustainable Effluent-Irrigated Plantations An Australian Guideline*
2. NWQMS (1992) *Guidelines for Sewerage Systems Acceptance of Trade Waste (Industrial Waste)* (Appendix 1)
3. CSIRO (2006) *Growing Crops With Reclaimed Wastewater;* Tables 2.7 & 8.2

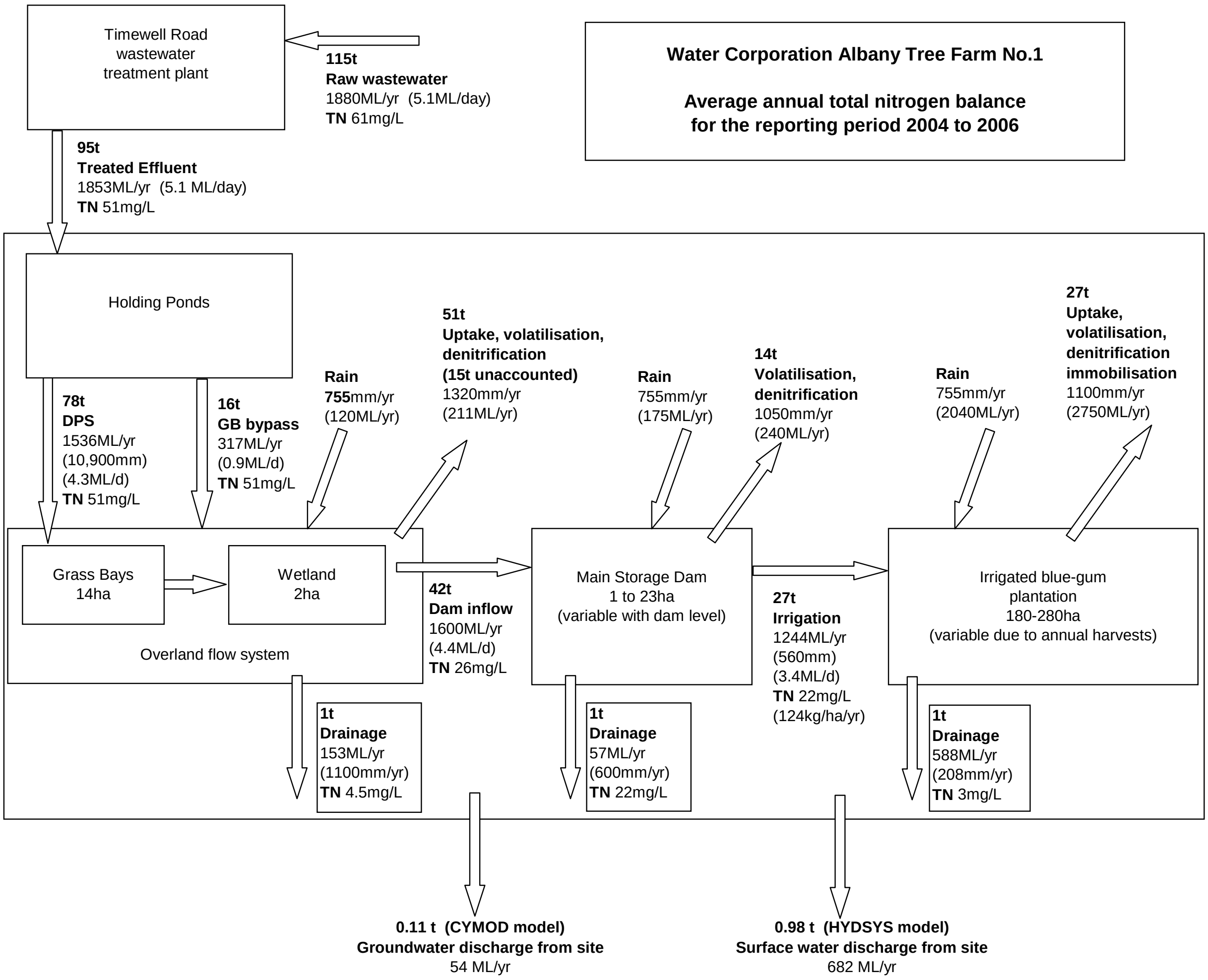
All metals analysed are within the guideline limits for sustainable irrigation. Typically, concentrations are one or two orders of magnitude smaller than the guideline limits. The only exception is cadmium which has some variability in analysis results, though never exceeding the recommended irrigation limit. The guideline limit for magnesium is recommended minimum foliar concentration required for good plantation health. The concentrations are all not only low, but are also stable, and consequently the management of metals in the irrigation water is not seen as an issue.

3.5 Actual and Design Performance

The tree farm was designed using average and wet year rainfall, and for the irrigation rate expected at a site inflow of 6 ML/day. Variable annual rainfall has impacted the tree farm operations during 2004 to 2006. In particular the wet year and extreme rainfall events during 2005 have dominated recent management at the site. Despite overflow from the main storage dam in response to multiple extreme rainfall events, the tree farm nutrient discharge has remained within design and licensed limits. This performance under extreme wet year conditions has further validated the design and environmental sustainability of the Albany Tree Farm.

4 Nutrient and Water Balance Modelling

A total nitrogen balance and water balance through the wastewater treatment scheme for 2004 to 2006 inclusive is shown in Figure 19 below. While these balances are primarily based on measured flows and nitrogen concentrations, it is not possible to directly measure many aspect of the treatment process such as denitrification and volatilisation losses, or total loss due to seepage. Consequently, the balances are completed using a combination of research measurements from previous years, estimated data, modelled data and engineering design values. Rather than adjust values to ensure 'arithmetic balance', it has been elected to present best estimates of individual component loads. Despite this the overall budget for the site has arithmetic balance to within 5%



Raw wastewater, Treated effluent, DPS, GB bypass, irrigation loads and surfacewater discharge are calculated from direct measurement of flow and nitrogen concentration
Dam inflow loads calculated from measured nitrogen concentration and modelled (water balance) flows
Nitrogen uptake, volatilisation and denitrification in the Grass bays, dam & tree areas are estimated from UWA 1998 mass balance and Kinhill design nutrient budget
Grass bay drainage load has been calculated from two total nitrogen analysis taken in November 2003
Tree uptake does not account for recycling in litterfall or immobilisation by soil microorganism populations

Figure 19 Nitrogen balance through the Albany wastewater scheme

The water balance is accurate for directly measured flows between primary process compartments (WWTP, grass bays/irrigation dam and plantation). Evaporation and infiltration/seepage losses are estimated from a combination of weather data, design expectation, research data and modelling. Surface water discharge is measured at the Gunn Road gauging station to Seven-Mile Creek, and groundwater flows determined by analysis of groundwater contours. These data combine to give an overall account of water movement through the system.

The water balance has high errors despite the direct measurement through much of the system. Errors arise from the balance being an average over three years, because rainfall and irrigation are applied to different areas and evaporation and rainfall also vary spatially relative to each other. Water losses/errors through the system are likely to be greater in drainage and evapotranspiration pathways as other pathways are able to be measured with some greater degree of accuracy. Net error through the system, when accounting total wastewater and rainfall inputs against total evaporation and drainage losses is however about 5%. This is considered a good result despite internal component flows not balancing.

Over 2004 to 2006 the average irrigation depth to the plantation was 75% of the average annual rainfall of 755mm for the period and the irrigation depth was 73% of the design irrigation capacity of 770mm per annum. These irrigation loading rates are considerably higher than in the 2001 to 2003 reporting period yet are well within the expected operating parameters for the site.

The nitrogen balance through the wastewater treatment plant and tree farm irrigation systems shows the majority of total nitrogen is lost through the grass bay system (37-52 tonnes), storage dam (15t) and tree plantation (28t). The smallest net loss of nitrogen occurred at the Timewell Road Wastewater Treatment Plant where 10t was removed. This emphasises the design and long term plan for wastewater management in Albany to require improved wastewater treatment. The upgrade of the Timewell Road WWTP commenced in 2006 will allow nominally 85 tonnes (at 2006 flows) of nitrogen to be removed before delivery to the tree farm. This will allow irrigation to the grass bays to be ceased and the area established to plantation with consequent lower environmental risk through reduced irrigation depth in the area, and lower operational cost.

4.1 Improved operational modelling of the Albany tree farm

The Water Corporation has implemented a weekly time-step spreadsheet based model to help manage irrigation at the tree farm. The model is based around design parameters for the tree farm and has been calibrated against measured water losses over the site. Since August 2003 the model has been used to guide future irrigation settings and this has helped to maintain good control of the storage level in the main dam.

More detailed daily nutrient and water balance modelling is achieved through application of the CSIRO developed ‘Soil Water Under Forests’ (SWUF) model that has been calibrated to the Albany Tree farm site by University of Western Australia researchers. This model uses detailed daily climate data to predict water stored in the canopy, litter layers, 3 surface soil layers and the deeper (800mm) root zone. This allows prediction of evaporation, surface runoff, plant uptake and drainage flows for a given set of soil and plantation parameters.

The SWUF model is applied to the tree farm as a whole, without consideration of the age structure of the plantation or spatial variability in soil parameters or irrigation. This provides a summary measure of the drainage losses beneath the irrigated plantation. The results are given below in Table 9 below. Note that irrigation depths vary slightly to data given in Table 6 due to the different method used to account for annual average irrigation area in the model.

The drainage depth is of interest as this is the critical water loss fraction that is being managed for environmental sustainability of the site. Drainage losses must occur to ensure the surface soils do not suffer increased salinity, yet these drainage losses must be controlled to ensure nutrient losses from the site are managed. The design allowed for drainage of 186mm/yr in an average rainfall year with capacity loading.

Table 9 Summary of SWUF Water Balance Modelling Output

Year	Rainfall mm/year	Irrigation mm/yr	Evaporation mm/yr	Plant water Uptake mm/yr	Surface runoff mm/yr	Drainage mm/yr	Change in Storage mm/yr	Discharge ML/year
1996	831	266	449	478	0	173	3	593
1997	724	350	378	572	0	183	60	525
1998	783	419	336	498	0	340	-17	486
1999	719	396	420	576	0	159	29	419
2000	768	436	418	638	0	131	3	450
2001	879	353	421	547	0	124	-74	370
2002	684	390	414	694	0	17	68	347
2003	847	431	459	601	0	276	5	648
2004	621	491	441	602	0	49	0	387
2005	985	610	474	716	0	353	-26	1020
2006	655	581	414	608	0	215	25	640

Typically the drainage depth is found to be similar to the design figure with variations correlated more to rainfall than irrigation. While the average annual rainfall and irrigation depths are similar these are applied quite differently. Irrigation is spread over the whole year with the largest daily application possible of 2.8mm occurring in summer when evapotranspiration is greatest. Rainfall in comparison is concentrated over 6-8 months of the year and rainfall events can give large daily applications that are more likely to result in infiltration deeper into the soil profile.

While the general trend is for increasing plant water uptake, this varies year to year due to the different effects of rainfall, temperature and age of the trees. Figure 20 below shows the modelled soil water content in the surface 800mm of the soil since 1995 as indicated by the SWUF model. This shows in 2004 that saturation did not occur for very long yet in 2005 the surface 800mm was saturated for 7 months of the year. The effective root zone of the plantation is considered to be 2 metres, so drainage losses will in practice be less that those indicated by the SWUF modelling. Note that the annual and seasonal variation in modelled soil water content shown in Figure 20 aligns well with actual data from the individual soil moisture monitoring probes, particularly with respect to the peak soil moisture content levels observed annually.

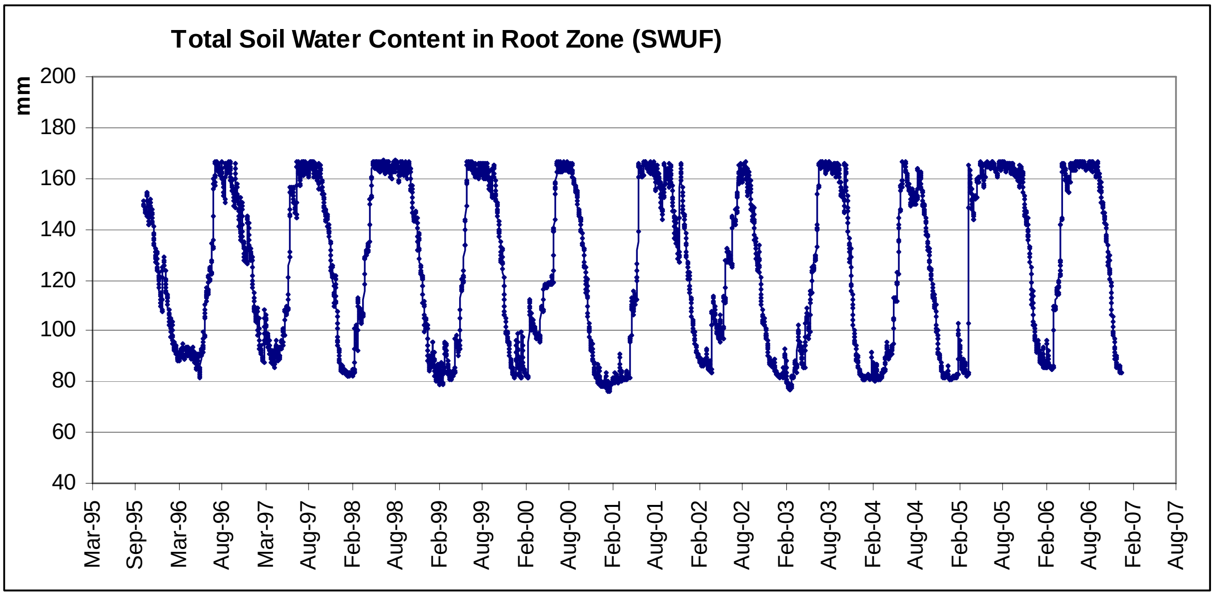


Figure 20 Modelled Total Soil Water Content in the top 800mm of the Root Zone

The SWUF model will continue to be used on an annual or triennial basis to supplement the operational monitoring and confirm the hydraulic performance of the tree farm.

5 Progress and Compliance Report

5.1 Review against Ministerial Conditions (Condition 287:M10:1)

Table 10 Statement of progress and compliance against Ministerial Conditions

Element	Requirement	Progress & Compliance
287:M1 The Proposal	Fulfill the commitments	Proposal adhered to - See detailed clauses below.
287:M2:1 Implementation	Adhere to the proposal	Proposal adhered to - See detailed clauses below.
287:M2:2 Implementation	Seek approval for modifications to the proposal	No modification to the proposal in reporting period.
287:M3:1 Land-based wastewater disposal trial planting	Commence trial planting on the land disposal site	No longer any requirement for arboretum and recommended this requirement be removed..
287:M3:2 Visual buffer	Maintain an unharvested 50 metre visual buffer consisting of plantation and ornamental native species along the southern (Gunn Rd) periphery	Recommend removal of this condition as 50m buffer strips are unstable when excised from a larger plantation and wind-throw of trees is an identified risk
287:M3:3 Irrigation	Ensure that remnant vegetation on the land disposal site is not irrigated with wastewater	19/12/1996 - Cleared
287:M3:5 Soil infiltration	Measure soil infiltration rates	Not required at this stage as soil moisture content is continuously monitored across the site
287:M3:6 Soil infiltration	Implement approved contingency measures if the values measured according to the requirements of M3:5 are sufficiently low as to threaten the retention of contaminants on the site	No contingency measures required as soil moisture content shows acceptable performance
287:M3.4:1 Rising main	Design the rising main leading into the holding ponds so that outlet is submerged at all times	19/12/1996 - Cleared
287:M3.4:2 Rising main	Manage the rising main leading into the holding ponds so that the outlet is submerged at all times	All rising main outlets at the site are submerged.
287:M4:1 Remnant vegetation	Retain remnant native vegetation at the Timewell Road (No 2) treatment plant site where practicable	19/12/1996 - Cleared
287:M5:1 Reserve 20948	Ensure that reserve 20948 (vested in the National Parks and Nature Conservation Authority) is not irrigated with wastewater	Reserve not irrigated or exposed to site runoff
287:M5:2 Alternative irrigation plan	Prepare an alternative plan for the temporary irrigation of treated wastewater in the event that insect attack, fire or a decline in soil infiltration threatens to cause either; nutrient losses from the site to exceed 3 tonne of nitrogen and 1 tonne of phosphorus per year; or surface runoff from the site to occur more frequently than 1 year in 10 (based on long term rainfall probabilities)	Nutrient discharges from the site are well within the 1t TP and 3t TN limits. Contingency plan developed and documented.
287:M5:3 Alternative irrigation plan	Implement the plan prepared under M5:2 when required by the EPA	Contingency plan not yet required to be implemented

Element	Requirement	Progress & Compliance
287:M6:1 Reports	Prepare brief annual and comprehensive triennial reports addressing but not limited to the following; 1. A water balance for the land disposal site including a comparison between measured and estimated (modelled) evapotranspiration for both rainfed and irrigated woodlots 2. results of environmental monitoring 3. results of infiltration rate measurements, trends and implications for the onsite retention of water and contaminants 4. results of trial planting of alternative species 5. compliance with the commitments, and 6. any proposed changes to management of monitoring of aspects of the system	1997 Triennial Report ISBN 0-73098-286-6 2001 Triennial Report ISBN 1-74043-073-5 2002 & 2003 Annual reports to DEP 2004 Triennial Report ISBN 1-74043-199-5 2005 & 2006 Annual reports to DoE. 2007 Triennial Report (this report) Annual reports for Timewell Rd WWTP under DEP licence 6786/3
287:M6:3 Breach of environmental commitments	Report any breach or anticipated breach of the environmental commitments immediately	Discharge of treated wastewater from Timewell Road WWTP to Five-Mile Creek due to extreme storm event (>60mm rain in 24 hours at peak of storm). DoE notified during event and reported to post event.
287:M6:4 Impacts	Modify and remedy the operations of the treatment plants and/or the land disposal site if impacts are detected which are considered to be unacceptable by the Environmental Protection Authority	No requirement to modify operations
287:M6.2:1 Reporting	Submit the reports required by M6:1	Triennial and annual reports submitted 1997-2006
287:M6.2:2 Reporting	Ensure that annual and triennial reports are publicly available	Triennial reports formally published
287:M7:1 Decommissioning	Prepare a decommissioning and rehabilitation plan for the land disposal site or for any of the treatment plants	4/4/1997 - Cleared
287:M7:2 Decommissioning and rehabilitation plan	Implement the decommissioning and rehabilitation plan	No decommissioning activity from 1997 to 2006.
287:M8:1 Transfer of proponent	Seek approval for transfer of ownership, control or management of the project	No transfer of proponent
287:M9:1 Time limit on approval	Seek approval to extend approval to implement the proposal	Proposal implemented on time
287:M10:1 Compliance auditing	Prepare periodic "Progress and Compliance Reports" to help verify the environmental performance of this project	Progress & compliance reports incorporated into Triennial reports (this table)
287:P1 Pt King WWTP	Cease discharge from the No. 1 treatment plant	19/12/1996 - Cleared
287:P2 Timewell Rd WWTP	Cease discharge from the No. 2 treatment plant into Five Mile Creek	19/12/1996 - Cleared
287:P3 Land Treatment site (9.1.3) nutrient discharge	Ensure that the nutrient discharge from the land treatment site in groundwater or surface water would not exceed 1t of phosphorus and 3t of total nitrogen per annum	Nutrient discharge at Gunn Rd is less than specified by the Ministerial limits.
287:P4 No. 2 WWTP (9.2) plant upgrade	Upgrade capacity of No. 2 aerated treatment pond treatment plant to a capacity of 3,500 kL/day	19/12/1996 - Cleared
287:P5 (9.2) Further modifications of treatment facilities	Carry out further upgrade, enlargement or replacement as necessary to meet further demand depending on performance of the treatment facilities and the land treatment facility	Extensive and detailed monitoring of the tree farm performance continues. Wastewater treatment plant upgrades and tree farm expansions are currently in progress.
287:P6:1 (9.2) Wastewater pumping	Ensure that the volume of wastewater pumped daily to the land treatment site is not less than the volume of water diverted from the No. 1 treatment plant	All treated effluent is diverted to the tree farm after treatment at No. 2 WWTP

Element	Requirement	Progress & Compliance
287:P6:2 (9.2) Wastewater pumping	Increase the volume of wastewater pumped daily to the land treatment site as the trees grow on the site until discharge into 5-Mile creek ceases	Discharge to 5 Mile Creek ceased in 1996
287:P7:1 (9.2) Noise levels	Ensure that noise levels from the aerated pond plant and any subsequent upgraded or new plant comply with the noise limits set by the EPA	Comply
287:P7:2 (9.2) Odours	Ensure that offensive odours from the aerated pond plant and any subsequent upgraded or new plant are only detectable at the nearest odour-sensitive premises on rare occasions	Comply. Instances of malodour are being addressed as part of the treatment plant upgrade.
287:P7:3 (9.2) Odours	Ensure that wastewater from the aerated pond plant and any subsequent upgraded or new plant does not create odour problems on the land treatment site	Comply
287:P7:4 (9.2) Remedial treatment for noise & odour problems	Undertake appropriate remedial action if noise or odour reach unacceptable levels	No unacceptable noise. Odour has been problematic during wastewater treatment plant upgrade works (2006/07) and odour control equipment is being installed to remediate.
287:P8 (9.2) Sludge	Dispose of sludge from the plant in accordance with the proposed 'Australian Water Council Draft Guidelines for Sewerage Systems-Sludge Management' or by a method approved by the Health Department of Western Australia	Stockpiled biosolids were beneficially reused through land application for soil amendment at Albany and Katanning, with necessary DEC approval..
287:P9 (9.2) Earthworks	Carry out earthworks for the new aerated pond and storage pond in a manner that minimises increased sediment flow into Five Mile Creek	20/12/1996 - Cleared
287:P10 (9.3.1) Woodlot	Carry out the establishment of the woodlot in an environmentally responsible manner	Woodlot fully established by 1996
287:P11:1 (9.3.1) Shatter ploughing and mounding	Avoid water courses in shatter ploughing and mounding and ensure these activities are managed to minimise increased sediment flow into Seven Mile Creek	19/12/1996 - Cleared
287:P11:2 (9.3.1) Seven Mile creek	Maintain a fifteen metre wide buffer zone on each side of Seven Mile Creek when shatter ploughing and mounding	19/12/1996 - Cleared
287:P12 (9.3.1) Herbicide	Manage herbicide for pre-emergent and post-emergent weed control	Specialist plantation managers CALM (Forest Products Commission) engaged for tree management and responsible for herbicide management
287:P13:1 (9.3.1) Earthworks	Carry out earthworks for construction of the storage dam, tracks and roads during summer	19/12/1996 - Cleared
287:P13:2 (9.3.1) Earthworks drainage discharge	Ensure that drainage discharges from areas disturbed by earthworks for the construction of the storage dam and tracks and roads on the property is diverted on to areas of established pasture	19/12/1996 - Cleared
287:P13:3 (9.3.2) Earthworks dust generation	Suppress generation of dust during earthworks by the use of water tankers	19/12/1996 - Cleared
287:P14 (9.3.2) Land treatment system	Manage and operate the land treatment system in accordance with the National Health and Medical Research Council and Australian Water Resources Council guidelines (1987) for land treatment of wastewater, or as otherwise approved by the Health department of Western Australia	Sheep grazing at the site has ceased.
287:P15 (9.3.2) Overland flow area	Operate the overland flow area so as to remove the nitrogen content in the incoming wastewater to a level that results in not more than 150 (106) kg/ha of total nitrogen per annum being applied to the area of trees irrigated	Overland flow irrigation system upgraded to improve performance. Plantation irrigation and loading rates comply. Recommend grass bays be decommissioned as upstream treatment negates their value.
287:P16 (9.3.2) Storage dam	Manage storage of wastewater in the dam so that no overflow of the dam occurs in 90 percent of years	No overflow from storage dam except in response to extreme rainfall event year (2005)
287:P17:1 (9.3.2) Irrigation system	Manage irrigation system so that no runoff is achieved in 90% of years	No runoff offsite

Element	Requirement	Progress & Compliance
287:P17:2 (9.3.2) Irrigation system	Manage irrigation system so that moisture levels in the effective root zone of the trees are achieved which are sufficient to limit downward percolation to the amount required to ensure root-zone salinity is maintained at a sustainable level	Irrigation scheduled according to design and seasonal soil moisture limits with annual flushing to manage soil salinity
287:P17:3 (9.3.2) Irrigation system	Manage irrigation system so as to achieve optimised evapotranspiration by the trees	Continual development of irrigation strategies in response to ongoing research and plantation management report outcomes
287:P18 (9.3.2) Monitoring performance	Monitor performance of the system in accordance with the program set out in appendix D of the Public Environmental Review	Monitoring program met and exceeded in areas
287:P19 (9.3.2) Insect attack	Join with CALM and other landholders with tree plantations in the Albany area to monitor insect activity	Close working relationship with CALM (now Forest Products Commission)
287:P20 (9.3.2) Insect attack	Develop and implement a plan to control insect attack in conjunction with CALM	Specialist plantation managers CALM (Forest Products Commission) engaged for tree management and responsible for insect control with close liaison with the Water Corporation
287:P21:1 (9.3.2) Firebreaks	Maintain firebreaks on the site to the satisfaction of the bush fires board	Firebreaks managed according to Bush Fire Service Guidelines (1998)
287:P21:2 (9.3.2) Fire dams	Keep all fire dams on the site full of water during summer	Dams that are accessible are maintained full during summer
287:P21:3 (9.3.2) Fire control	Provide and maintain fire control vehicles on the site to the satisfaction of the bush fires board	Fire tender sponsored and established
287:P21:4 (9.3.2) Fire incidents	Ensure that Water Authority employees are trained to handle fire incidents	Employees are trained in fire control
287:P21:5 (9.3.2) Bush Fires Act	Ensure that staff comply with the provisions of the Bush Fires Act 1954	Staff comply with the provisions of the Bush Fires Act.
287:P21:6 (9.3.2) Smoking	Prohibit smoking in the areas planted with trees	Smoking prohibited on site
287:P22:1 (9.3.3) Contingency planning	Expand the overland flow and irrigated tree areas if the land treatment system fails to perform to design	Upstream wastewater treatment plant being upgraded. Additional irrigated plantation has been approved. Recommend decommissioning of grass bays.
287:P22:2 (9.3.3) Contingency planning	Construct an additional storage dam if the land treatment system fails to perform to design	Additional dam approved and being constructed to meet expanded irrigation requirements.

5.2 Comparison of performance against commitments (Condition 287:M6:1, 5)

5.2.1 Condition 287:M3:5 Measure Infiltration rates

Measure soil infiltration rates to determine if appropriate soil water storage capacities are being achieved.

The mass balance for 2004 to 2006 and the soil moisture monitoring data shows infiltration rates are maintained at the design expectation of average 200mm/year. In 2004 the drainage was less at ~50mm in response to a low rainfall year of 621mm, and in 2005 was high at ~350mm in response to a wet rainfall year of 986mm. While 2006 started in a wet condition, the average drainage of 215mm was achieved with rainfall of 655mm.

Changes in groundwater levels beneath the site are driven by seasonal variations in rainfall rather than irrigation. The nominal fall of 0.5m in groundwater levels is attributed to the general drying climate and a lowering water table in the area.

5.2.2 Condition 287:M5:2 Prepare Contingency Plan

Prepare an alternative plan for the temporary irrigation of treated wastewater in the event that insect attack, fire or a decline in soil infiltration threatens to cause either; nutrient losses from the site to exceed 3 tonne of nitrogen and 1 tonne of phosphorus per year; or surface runoff from the site to occur more frequently than 1 year in 10 (based on long term rainfall probabilities).

The tree farm contingency plan was formally documented in August 2005. This identified only low and medium failure risks for the site. Monitoring results from the 2004 to 2006 period show the tree farm is sustainable and resistant to failure due to insects, fire infrastructure failure, extreme weather and other foreseeable events.

5.2.3 Condition 287:P3 Operation of Land Disposal Site

Ensure that the nutrient discharge from the land treatment site in groundwater or surface water does not exceed one tonne of phosphorus and three tonnes of nitrogen per annum.

Total nitrogen discharge in the Seven-Mile creek prior to the commencement of treated wastewater irrigation was approximately 980 kg. The average loads in the creek for 2004 to 2006 are 987kg TN/year for nitrogen and 184kg TP/year for phosphorus (refer to Table 7, Section 3.1.4 for summary data). These average nutrient discharges are significantly greater than in recent years owing to the driving influence of extreme rainfall events in 2005 and consequent wet conditions throughout 2006. Despite the extreme conditions experienced the total nutrient discharges have remained less than the target amounts.

5.2.4 Condition 287:P14 Manage Land Treatment System

Manage and operate the land treatment site in accordance with National Health and Medical Research Council and Australian Water Resources Guidelines (1987) or as otherwise approved by the Health Department of WA.

Sheep have not been grazed at the site during the 2004 to 2006 reporting period and there is no expectation that grazing will occur in the future. Pathogen levels have been maintained at acceptable levels and chlorination of irrigated effluent remains intermittent only and for the purposes of limiting algal growth in the drip lines. There is no chlorination performed for the purposes of pathogen reduction.

5.2.5 Condition 287:P15 Operation of Overland Flow Area

Operate the overland flow area so as to remove the nitrogen content in the incoming wastewater to a level that results in not more than 106 kg/ha of total nitrogen per annum being applied to the area of trees irrigated.

Operation of the overland flow grass bays has been in accordance with design requirements. Nitrogen reduction through the grass bay system has continued to be high. However, this system relies on the nitrogen being predominantly ammonia. The Timewell Road wastewater treatment plant has been upgraded and this has reduced both the total nitrogen concentration and the ammonia fraction. Nitrate-nitrogen now predominates in the water received at the tree farm. Irrigation depth to the grass bays is about 13m depth per annum. With a high nitrate concentration this hydraulic loading poses high risk for generating a nitrogen plume into groundwater. The grass bays are not designed to operate with high inlet nitrate concentration.

It is recommended the grass bays be decommissioned and the Ministerial Conditions altered to reflect their removal. Removal of the grass bays will additionally reduce water loss prior to flow to the main storage dam. This will reduce the site capacity by approximately 0.7ML/day annual average. The actual reduction in site capacity will be subject to validation of the water budget for the site without grass bay operation.

5.2.6 Condition 287:P16 Manage of Storage of Wastewater in the Dam

Manage storage of wastewater in the dam so that no overflow occurs in 90% of years.

The main irrigation dam overflowed intermittently through July to October during 2006. This overflow was in response to extreme rainfall events in April and June 2006 that added approximately 150ML to the main storage dam in excess of normal year inflows. It is estimated that 50ML overflowed directly to the environment between July and October. The remaining 100ML was assimilated into 2006 irrigation activity.

5.2.7 Condition 287:P17.1 and P17.2 Manage the Irrigation System

Manage irrigation system so that no runoff is achieved in 90% of years, and
Manage irrigation system so that moisture levels in the effective root zone of the trees are achieved which are sufficient to limit downward percolation to the amount required to ensure root-zone salinity is maintained at a sustainable level

Some surface runoff occurred following the extreme rainfall events in 2005. Subsequent wet conditions and excess water in the storage dam through 2006 led to increased incidence of surface flow at the site, particularly in response to localized leaks and bursts in the reticulation system. Whilst these were managed soil moisture monitoring emphasizes the impact of the extreme wet year on tree farm operations. However effective root zone flushing was maintained at design levels and soil monitoring has confirmed that salinity issues continue to be managed at the site in a sustainable manner.

5.2.8 Condition 287:P17.3 Manage the Irrigation System

Manage irrigation system so as to achieve optimised evapotranspiration by the trees

Irrigation is scheduled according to the design water balance for the site. This includes weekly storage level targets, monthly irrigation limits, seasonal soil moisture targets and harvest operation restrictions. Consideration is being given to alter the irrigation scheduling to provide less frequent irrigation to encourage wetting and hence root establishment to greater depth. Whilst this has been suggested to help with coppice survival post harvest, it is anticipated this strategy may offer improved opportunity for optimal evapotranspiration via higher peak soil moisture content during irrigation events in summer.

5.2.9 Condition 287:P18 Monitor Performance of the System

Monitor performance of the system in accordance with the program set out in appendix D of the Public Environmental Review

Considerable operational effort is imparted to ensure the highly detailed sampling and monitoring programmes are followed. Specific sampling programs are being undertaken to target areas of interest with regard to nutrient cycling and sustainability of the tree farm site. These exceed the strict requirements of the ministerial conditions and are proving valuable in identifying opportunities to reduce overall sampling effort. This Triennial review presents a summary of the information and data collated regarding the tree farm and represents a significant cost in the ongoing site management. Future sampling programs are better targeted at operational needs rather than ongoing research intensity validation of a site that has again proven to be following the anticipated design performance.

6 Management

6.1 Wastewater Flows and Hydrological Management

Discharge of flow from the wastewater treatment plant is attenuated by the transfer pumps which operate at one of two (high and low) delivery rates. As daily inflows to the wastewater treatment plant increase over time the transfer pumps are scheduled for upgrade to ensure seasonal peaks in flow can be managed without risk of overflow. Management of sedimentation in the delivery to the pipeline has become necessary and a regular program of air-scouring the main has been implemented. This ensures the friction losses in the pipeline are maintained within acceptable limits.

Future decommissioning of the grass bays at the tree farm will allow greater flexibility in delivery flow rate to the tree farm as the requirement for uniform hourly distribution to the grass bays is removed. However the design capacity of the tree farm of 6ML/day annual average inflow allows for some water loss via evaporation and drainage from the grass bay system. As the grass bays will no longer provide that water loss, and yet the tree farm irrigation capacity is not increased, this will result in a net reduction of the overall capacity of the tree farm site. It is anticipated that the new capacity will be about 5.3ML/day, however it recommended that this be validated by monitoring flows into the dam following removal of the grass bays.

6.2 Nutrient Loading and Irrigation Management

Nitrogen loading to the irrigated plantation has increased significantly in response to higher volumes and a net reduction in treatment efficiency at the Timewell Road WWTP. The upgrade to the treatment plant is well underway and this will significantly reduce the nitrogen concentration (and load) received at the tree farm. It is anticipated that the nitrogen application rates to the tree farm observed during the 2004 to 2006 period represent the peak application rate for the life of the site.

The tree farm site has not yet reached the design hydraulic capacity although this will occur much earlier than the design estimate of year 2020. This is attributable to growth in influent wastewater flows that has averaged over 5% since 1997. Irrigation scheduling during summer is under review as there are benefits to increasing the irrigation depth during this period. This would require less frequent but much larger irrigation events, most likely scheduled on a weekly rather than daily basis. This has advantages of increasing the soil moisture content and so improving the potential evaporation loss. The soil moisture at depth will also be increased and longer periods between irrigation events will encourage deeper root establishment in the irrigated plantation. This will assist in the survival rates of stumps following harvest and improve the overall efficiency of the site.

6.3 Licence and Compliance Management

The Water Corporation actively embraces sustainable environmental management and has undertaken a number of measures that exceed the minimum requirements for license compliance. As the harvest operations have become established and sampling programs outside the regulated minimum contribute to better understanding of the site processes, a number of changes to the monitoring program are recommended. Bore monitoring provides relatively less information than targeted soil analysis. Surface analysis of all flows occurs on a weekly basis and this could beneficially be reduced to monthly with only limited weekly testing without detriment to monitoring programs.

A number of Ministerial Condition in Statement 675 have become redundant (such as maintenance of arboretums) or are now recognised as unsafe (maintain a 50m buffer of plantation trees on the southern boundary) and a review of Ministerial Conditions is recommended.

.

7 Conclusions

This report has reviewed operational and environmental data for the AEITF for the period 2004 to 2006.

The tree farm has been operated in compliance with the Ministerial Conditions despite large increases in the volume of treated wastewater received at the site each year and extreme rainfall events in 2004 and 2005. Monitoring of nutrient fluxes confirm the continued low rate of nutrient export from the tree farm despite peak nutrient application rates and extreme wet conditions through 2005 and into 2006. The average total nitrogen and total phosphorus exports from the site were 1.1 and 0.19 tonnes/annum respectively, well within the Ministerial limits.

Soil investigations following the first harvest rotation have validated the design life of the tree farm with respect to phosphorus as over 300 years. Nitrogen applications are also sustainable, particularly with the upgrade of the Timewell Road WWTP. The upgrade will significantly reduce the nitrogen loads received at the tree farm and simplify operations through the removal of the grass bays.

Harvest operations over 139 hectares during 2004 to 2006 achieved an average yield in excess of 300 tonnes per hectare from both irrigated and non-irrigated areas. Greater understanding of the plantation's forestry management requirements is allowing these operations to be further optimised without compromise to irrigation requirements.

Despite some challenging operational conditions experienced during the last three years, all Ministerial Conditions and Proponent Commitments have been met. Whilst sampling requirements remain onerous, these have proven beneficial in further extending the understanding of this leading and environmentally sustainable solution for treated wastewater disposal. The expansion of the tree farm will further ensure the long term success of wastewater disposal in Albany and is testament to the Water Corporation's commitment to sustainable environmental management.

8 Appendices

Appendix A

Part A;Triennial Soil Monitoring Report, and
Part B; Soil Profile Properties and Dripper Effects
Attachment; Assessment of Methods for Measurement of Soil Inorganic Nitrogen at the Albany Effluent Irrigated Tree Farm.
(Soil Management Consultants, June 2007)

Appendix B

Triennial Forestry Report Contribution
(Neil Worrel, Forest Products Commission, September 2007)

Appendix C

Recalibration of the Flow and Solute Model of the Albany Wastewater Tree Farm
(CYMOD Systems, June 2007)

Appendix D

Groundwater bore monitoring data - graphs

Appendix E

Soil moisture data - graphs

Appendix F

Site photographs