Managing Water. Serving Communities.

ANNUAL REPORT 2010/11

Regional Environmental Improvement Plan
Werribee Irrigation District
Recycled Water Scheme

1 October 2011

Table of Figures

Table of Contents

1. Introduction

The Werribee Irrigation District (WID) is an important vegetable growing area on the western fringe of metropolitan Melbourne. Historically the district has relied on water from the Werribee River and the Deutgam Aquifer to support up to 200 growers producing predominantly lettuce, broccoli and cauliflower for local consumption and export.

The WID Recycled Water Scheme was announced on 8, January 2004 to overcome a severe water shortage due to drought and offer a secure water supply for future production. The project involved a $20 million investment comprising: an upgrade to Melbourne Water's Western Treatment Plant, building a connecting pipeline into the WID, completing an environmental investigation and developing an operational framework. The first deliveries of Class A recycled water were made in January 2005.

Recycled water is produced by Melbourne Water (MWC) at the Western Treatment Plant and supplied to participating customers by SRW through its existing irrigation channels and pipelines. The Department of Health (DHS) requires an extensive verification process to ensure that Class A quality can be guaranteed and has endorsed MWC recycled water as Class A.

During the 2010/2011 season the surface water allocation was as follows:

Date	High Reliability Water Share	Low Reliability Water Share	Stored for 2011/12 season
1-Jul-2010	6%	-	-
28-Jul-2010	8%	-	-
11-Aug-2010	16%	-	-
25-Aug-2010	30%	-	-
8-Sep-2010	60%	-	-
24-Sep-2010	63%	-	14%
7-Oct-2010	65%	-	15%
19-Oct-2010	70%	-	20%
4-Nov-2010	75%	-	25%
16-Nov-2010	85%	-	25%
1-Dec-2010	100%	10%	25%
15-Dec-2010	100%	20%	30%
31-Dec-2010	100%	25%	35%
25-Jan-2011	100%	45%	45%
23-Feb-2011	100%	50%	50%
19-Apr-2011	100%	55%	50%
7-Jun-2011	100%	55%	55%

Table 1-1 Allocation 2010-11 season

The seasonal allocation started very low but above average rainfall in the catchment completely filled the storages by December 2010 which allowed us to allocate 100% of river water entitlement, with additional water being split between low reliability water shares and storage for subsequent seasons. The catchment has continued to run strongly throughout 2011 and there is sufficient water available to supply irrigators for the next two seasons. Groundwater levels in the Deutgam Aquifer have recovered strongly and the groundwater extraction ban that was implemented in 2006 has been lifted, giving growers another source of water for irrigation.

As a result the demand for recycled water has dropped significantly with customers mainly focused on just utilising the 25% take-or-pay supply component of the contracted amount that they were obligated to pay for. There has been no recycled water delivered to the WID since February 2011.

The high salinity and nutrient levels within recycled water continues to generate dissatisfaction with WID customers following the MWC decision not to construct a salt reduction facility at the Western Treatment Plant in 2006. However, the 2011 WID Soil Report, published following the annual soil sampling program in June 2011, showed that salinity, chloride and sodicity levels in WID soils have all reduced to levels below the baseline samples of the scheme in 2004/05, due to the district experiencing above average spring and summer rainfall and reverting to river water only irrigation.

The Western Irrigation Futures (WIF) project represents the long term strategic focus for the WID and recycled water. The objective of this project has been to establish a “whole of government” plan for the future of the irrigation districts, recognising the challenges of climate change, drought, reduced water yield from traditional sources, competing land use objectives and ageing supply infrastructure. During 2009-10 the WIF Option Paper, containing information regarding future alternatives for the WID, was forwarded to the Office of the Minister for Water. Shortly after the WIF Option Paper was presented to the State Government there was an announcement to make 2,000 ML of potable water from the metropolitan system available to the WID to assist in reducing high salinity.

Melbourne Water has experienced a change in the demand profile for recycled water with more emphasis on urban uses such as residential housing developments, municipalities and industry. As such they are looking to make better use of the resource and are unable to keep providing recycled water on the basis of 25% take-or-pay. From 2012-13 irrigators in the WID will be able to sign up for long-term contracts for recycled water at the same price but with an increased commitment to pay for 50% of contracted water.

In order to reliably supply recycled water to customers with this requirement in seasons when there is a high volume of river water entitlement (>75%) SRW has needed to change the shandy rules of the REIP. These changes were approved by EPA Victoria in October 2011.

2. WID Inflows

The following table details the inflows of all water sources into the WID during 2009-2010, and includes the average weekly salinity monitored in the Main Channel as well as the system efficiency.

Week Commencing	River Into District (HR/LR)	Recycled into District	Total into District	High Reliability	Low Reliability	Recycled delivery	Outfalls	Total Deliveries	Rainfall	Efficiency	Mean EC Level (Main Channel)
5/07/2010	0.00	129.50	129.50	0.00	0.00	65.50	0.02	65.52	6.00	50.6%	1677
19/07/2010	0.00	162.80	162.80	0.00	0.00	99.60	0.34	99.94	0.00	61.4%	1762
2/08/2010	0.00	107.20	107.20	0.00	0.00	45.10	0.00	45.10	20.50	42.1%	1751
16/08/2010	0.00	23.00	23.00	0.00	0.00	14.10	0.40	14.50	0.40	63.0%	1970
30/08/2010	0.00	112.60	112.60	0.00	0.00	63.50	0.31	63.81	8.60	56.7%	850
13/09/2010	138.00	0.00	138.00	74.44	0.00	0.00	0.42	74.86	2.00	54.2%	1804
20/09/2010	77.00	71.40	148.40	23.82	0.00	60.82	0.84	85.48	0.00	57.6%	1809
27/09/2010	125.00	125.60	250.60	40.31	0.00	105.48	1.82	147.61	5.80	58.9%	1758
4/10/2010	141.20	188.00	329.20	44.45	0.00	153.50	5.27	203.22	12.50	61.7%	1790
11/10/2010	90.60	80.50	171.10	39.06	0.00	64.40	1.98	105.44	20.60	61.6%	1462
18/10/2010	59.00	21.30	80.30	25.61	0.00	17.04	0.00	42.65	0.00	53.1%	1506
25/10/2010	256.00	155.80	411.80	108.34	0.00	124.64	2.88	235.86	59.60	57.3%	882
1/11/2010	47.20	14.30	61.50	22.65	0.00	11.44	1.42	35.51	0.00	57.7%	349
8/11/2010	177.00	127.90	304.90	52.42	0.00	112.32	3.80	168.54	44.80	55.3%	891
15/11/2010	176.00	0.00	176.00	97.46	0.00	0.00	0.51	97.97	2.00	55.7%	914
22/11/2010	163.20	181.60	344.80	66.96	0.00	145.28	2.23	214.47	22.00	62.2%	690
6/12/2010	144.00	16.90	160.90	77.26	0.00	13.52	1.39	92.17	0.00	57.3%	761
13/12/2010	339.00	57.40	396.40	216.07	0.00	45.92	2.01	264.00	0.00	66.6%	967
20/12/2010	344.00	34.10	378.10	196.30	0.00	29.18	1.99	227.47	16.60	60.2%	965
27/12/2010	428.00	85.40	513.40	270.57	0.00	68.32	1.16	340.05	0.00	66.2%	714
3/01/2011	657.00	16.20	673.20	416.62	0.00	12.96	3.98	433.56	0.00	64.4%	479
10/01/2011	269.00	28.50	297.50	183.50	0.00	22.80	3.83	210.13	103.00	70.6%	614
17/01/2011	178.00	11.10	189.10	124.75	0.00	8.88	3.46	137.09	9.00	72.5%	842
24/01/2011	404.00	19.20	423.20	280.55	0.00	15.36	19.75	315.66	0.00	74.6%	489

Week Commencing	River Into District (HR/LR)	Recycled into District	Total into District	High Reliability	Low Reliability	Recycled delivery	Outfalls	Total Deliveries	Rainfall	Efficiency	Mean EC Level (Main Channel)
31/01/2011	617.00	0.00	617.00	417.03	0.00	0.00	26.27	443.30	0.00	71.8%	458
7/02/2011	64.00	0.00	64.00	19.96	0.00	0.00	1.11	21.07	114.00	32.9%	560
14/02/2011	305.00	8.60	313.60	157.07	0.00	6.88	5.93	169.88	38.00	54.2%	723
21/02/2011	244.00	0.00	244.00	150.12	0.00	0.00	4.41	154.53	0.00	63.3%	909
28/02/2011	313.00	0.00	313.00	153.84	0.00	0.00	0.18	154.02	0.00	49.2%	782
7/03/2011	394.00	0.00	394.00	247.47	0.00	0.00	4.68	252.15	0.00	64.0%	795
14/03/2011	331.00	0.00	331.00	216.37	0.00	0.00	1.24	217.61	0.00	65.7%	882
21/03/2011	416.00	0.00	416.00	238.05	0.00	0.00	11.61	249.66	0.00	60.0%	817
28/03/2011	387.00	0.00	387.00	233.90	0.00	0.00	3.55	237.45	0.00	61.4%	521
4/04/2011	424.00	0.00	424.00	248.07	0.00	0.00	3.20	251.27	0.00	59.3%	647
11/04/2011	109.00	0.00	109.00	84.54	0.00	0.00	1.50	86.04	31.30	78.9%	698
18/04/2011	253.00	0.00	253.00	114.68	0.00	0.00	12.62	127.30	9.00	50.3%	613
25/04/2011	242.00	0.00	242.00	118.60	0.00	0.00	1.78	120.38	0.00	49.7%	611
2/05/2011	113.00	0.00	113.00	58.20	0.00	0.00	0.08	58.28	11.20	51.6%	583
9/05/2011	141.00	0.00	141.00	72.96	0.00	0.00	0.90	73.86	2.00	52.4%	661
23/05/2011	172.00	0.00	172.00	100.60	0.00	0.00	5.41	106.01	18.40	61.6%	656
6/06/2011	204.00	0.00	204.00	111.49	0.00	0.00	0.18	111.67	10.20	54.7%	699
20/06/2011	234.00	0.00	234.00	130.14	0.00	0.00	0.88	131.02	7.60	56.0%	727
27/06/2011	109.00	0.00	109.00	84.90	0.00	0.00	1.57	86.47	0.00	79.3%	707
Total	**9285.20**	**1778.90**	**11064.10**	**5319.13**	**0.00**	**1306.54**	**146.91**	**6772.58**	**575.10**	**61.2%**	

3. Drain Monitoring

3.1 Drain flow and water quality monitoring

SRW's drain monitoring program for 2010/11 includes data capture from drains 1, 5, 6, and 11 where continuous stream-flow monitoring sites are in place. In accordance with the Regional Environment Improvement Plan 2009, this monitoring program surveys water quality and flow quantity in drains D1, D5, D6 and D11. The report uses flow data from each of these drains to estimate total flow from the district. As over 70 % of the district area is being monitored for flow, total district discharge is estimated by multiplying area monitored by the non monitored area on a drain wetness assessment basis.

SRW is now reporting from the two new flow monitoring sites on drain D1 to capture both total drain D1 discharge to Port Phillip Bay (Campbell's Cove site) and an upstream site to capture urban non district flows (D1 at Hoppers Lane) . The addition of these sites has increased the area monitored to 71% of total district drainage area. This will provide more certainty around total district flow discharge and consequently more accurate total nutrient discharge to the receiving waters.

The channel supply system has thirteen outfall structures that allow for unused irrigation supply to be discharged safely to the drainage system. The outfalls comprise both continuously monitored and unmonitored discharge points that vary significantly in flow discharge. Four of the outfalls are considered to be major outfalls representing over 60% of the supply system, these are also located where discharge is more likely to occur due to the configuration of the supply system. The remaining outfalls are considered minor and represent a smaller proportion of the WID and generally at the end of tightly regulated spur channels where outfalls are uncommon. These discharges are not captured by the drain monitoring sites, as they enter either downstream of drain monitoring sites or are on unmonitored drains. Total volumes discharged are added to drain discharge for overall combined discharge.

Grab sampling for nutrient analysis is undertaken at drain D5 monthly and analysed for TP, TKN and Total N. Samples were taken on 8 of the 12 dates scheduled, on 4 occasions the drain had insufficient flow for sampling. Other grab sampling was undertaken at drains D1, D6 and D11 in line with REIP requirements. Occasionally samples were not able to be taken as drains have been dry at scheduled collection times. However opportunistic sampling was undertaken at other times when sampling could be arranged at short notice.

The D5 catchment covers 21% of the total district drain catchments, D6, 17%, D11 about 11%, and the recently monitored D1 captures 22% of the districts drainage area. The drain monitoring program now captures 71% of the district's drainage catchment. These drains have differing characteristics and we have classified them accordingly.

- Drain 1 is known to be a wet drain with flows occurring on average more than 100days per annum
- Drain 5 is also considered a wet drain
- Drain 6 is considered a semi dry drain in that it flows on average less than 30 days per annum and
- Drain 11 is considered a dry drain with an average of less than 15 days recorded flows per annum.

These characteristics come about by both the types of soil and their proximity to the supply systems. Generally the wetter drains having heavier soils and being in close proximity to the supply channels.

In addition to drain monitoring, monitoring also occurs at the Werribee Diversion Weir, prior to river water entering the irrigation system. Although results of the river water monitoring are discussed elsewhere, salinity readings at the weir are discussed here, as they give some background information to interpret the readings obtained in the drainage system.
The plan below indicates the location of the current monitoring stations along with drain catchments.

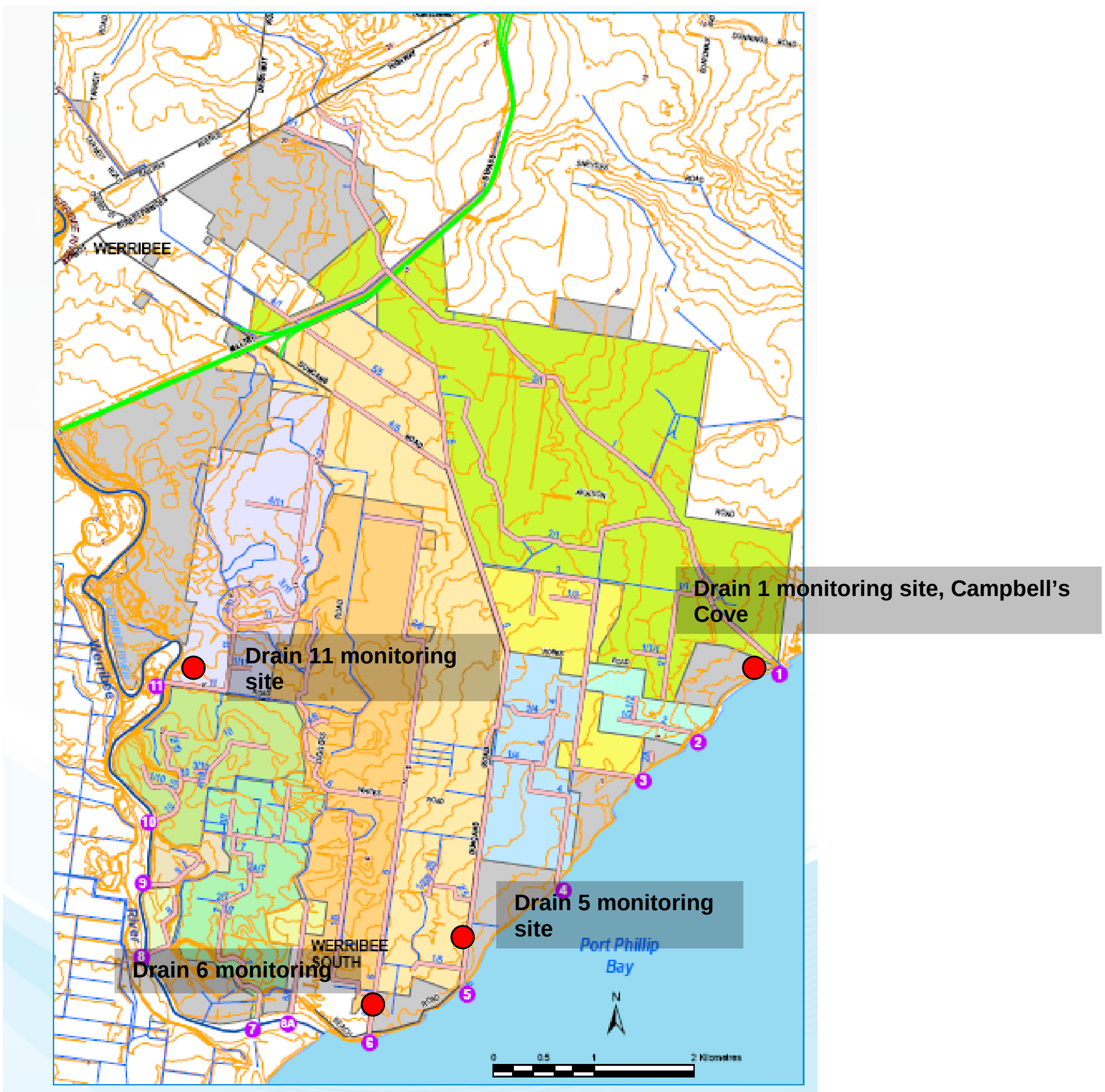

Figure 3-1 WID drainage catchments & monitoring sites

3.1.1 Drain Discharge:

Drain discharge volumes for 2010-2011 were captured at four drain sites as well as channel outfall discharges that enter receiving waters at points not monitored by the drain discharge points. The four monitored drain catchments represent 71% of the WID drainage catchments; by multiplying the monitored volume by the drainage area of the type of drain we can estimate the total discharge for the total of that type of drain e.g. drain 6 = semi dry drain classification (monitored volume) ML x semi dry drains total area 31.9/100 (total semi dry drain % of district). This is done for each of the monitored drains providing a total estimated drain discharge. The annual monitored discharge of 6,890 ML from the 4 drains includes 4,320 ML of urban discharge (this is picked up at the Drain 1 Hoppers Lane site). The extrapolated district discharge is estimated to be 5,906ML (which does not include urban monitored flow). This is roughly 11 times the value of the 525ML estimated in 2009/10.

The vast rise in drain discharge is due to a very wet year in comparison to recent years with a total of 850mm (BoM Laverton RAAF Base)recorded in 2010/2011 and less than 400mm in earlier years.

The following tables list the monitored monthly drainage and outfall discharge for 2010/2011

Month	Drain 5	Drain 6	Drain 11	Drain 1 @ freeway	Drain 1 @ Bay	Drain 1 Discharge (attributable to WID)	Drain Total
July	4.68	0.87	0.00	80.22	70.06	-10.20*	**75.6**
August	10.39	6.96	0.58	235.08	215.36	-19.70*	**233.3**
September	9.99	7.83	1.71	224.19	211.41	-12.80*	**230.9**
October	37.57	22.93	2.48	351.00	314.96	-36.00*	**377.9**
November	89.32	65.31	16.98	843.28	958.24	115.00	**1129.9**
December	31.07	11.25	0.09	150.71	339.74	189.00	**382.2**
January	127.0	130.60	11.10	636.80	879.50	242.70	**1148.2**
February	300.0	162.90	102.70	1285.20	1833.40	548.20	**2399.0**
March	48.10	19.90	0.00	62.60	133.10	70.60	**201.1**
April	43.50	26.70	5.70	211.40	234.80	23.40	**310.7**
May	23.50	13.30	0.90	142.60	191.70	49.10	**229.4**
June	32.00	7.60	1.80	98.60	130.90	32.30	**172.2**
Total	**757.19**	**476.03**	**144.00**	**4321.64**	**5513.19**	**1191.55**	**6890.4**

Table 3-1 WID drain flows 2010-11

*Negative values are result of drainage diversion between monitoring points

Month	Main outfall	Spur 4/5 outfall	Spur 5 outfall	Spur 6 outfall	All others	Outfall totals
July	0.00	0.00	0.36	0.00	0.00	**0.4**
August	0.00	2.88	0.00	0.00	0.00	**2.9**
September	0.02	0.74	0.78	0.16	0.00	**1.7**
October	0.08	2.77	8.26	0.04	0.00	**11.2**
November	0.75	1.09	5.32	1.55	0.00	**8.7**
December	0.08	3.71	3.03	1.08	0.00	**7.9**
January	0.42	6.86	18.37	5.56	0.00	**31.2**
February	5.57	12.05	10.67	9.43	0.00	**37.7**
March	1.81	6.70	8.67	3.10	0.00	**20.3**
April	3.11	3.86	11.33	1.78	0.00	**20.1**
May	1.99	0.30	3.94	0.16	0.00	**6.4**
June	0.00	0.44	1.91	0.28	0.00	**2.6**
Total	**13.83**	**41.40**	**72.64**	**23.14**	**0.00**	**151.0**

Table 3-2 WID outfalls 2010-11

Charts 1- 5 below show the monthly discharge of outfalls, drains, combined total and extrapolated with cumulative totals.

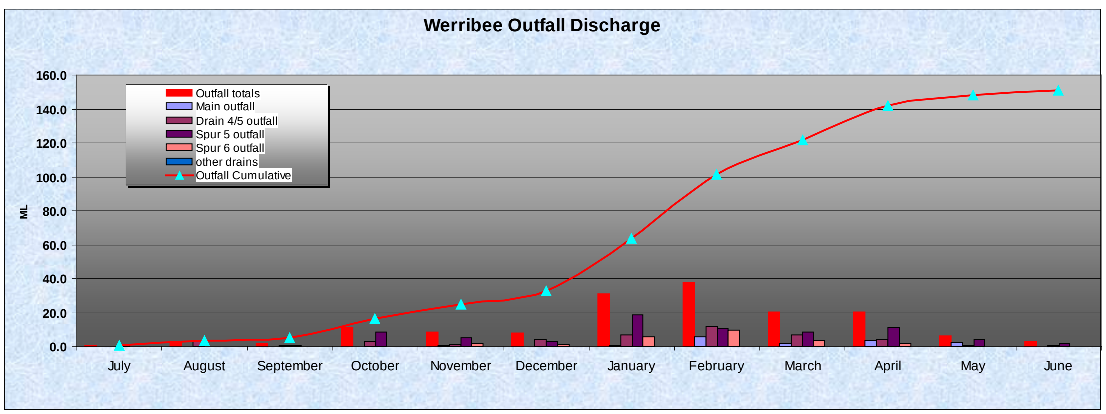

Figure 3-2 WID outfall discharges, all sites

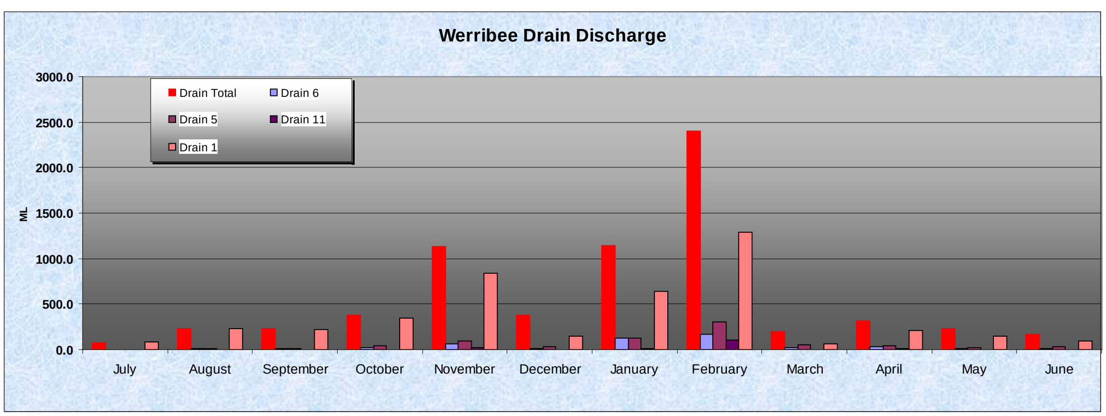

Figure 3-3 WID drain discharge, monitored sites

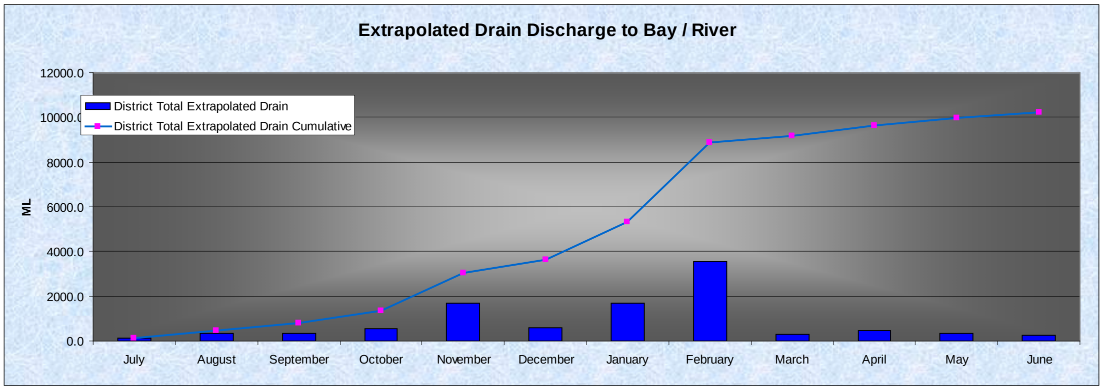

Figure 3-4 WID extrapolated drain discharge 2010-11

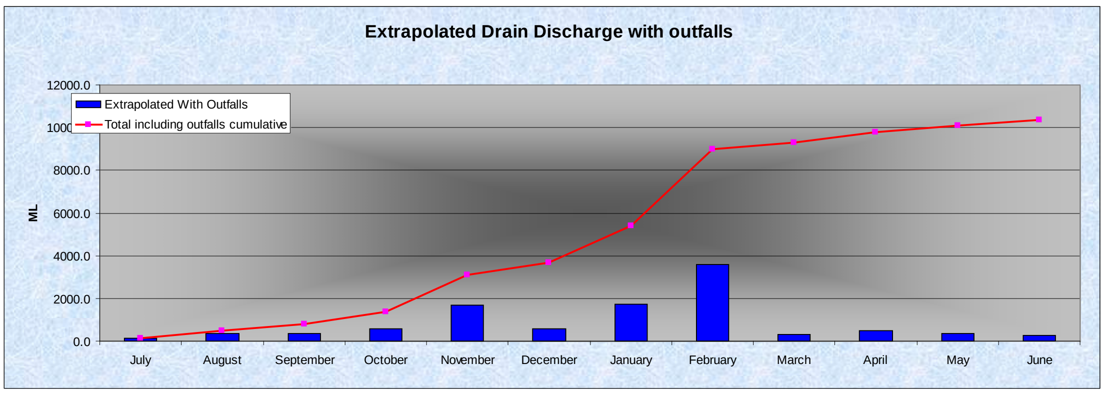

Figure 3-5 WID extrapolated drain discharge with outfalls 2010-11

Channel outfall discharge for the 12 months totalled 151ML, up on the previous years discharge of 45ML outfalled. The outfalled volume is additional to the extrapolated drain discharge of 5,906ML. Overall discharge attributable to the district to the receiving waters is estimated to be 6,057ML for the year.

3.1.2 Water Quality:

Salinity

Electrical Conductivity (EC) of drain discharge at Drain 5 for 2010/11 averaged 1,400 µS/cm which is significantly lower than the 2009/10 average of 2,030 µS/cm recorded. The Werribee River recorded an average 1,550 µS/cm in 2010/11 much lower than the preceding year which averaged 3,410 µS/cm. The Werribee River EC averaged around 2,800µS/cm during July and August 2010 and steadily decreased to around 850 for the November to March period. Towards the end of the season levels rose to around 1,300 µS/cm for both river and drain 5.

Figure 3-6 Salinity trends for drain D5 & Werribee River @ diversion weir below, shows salinity trends for both Drain 5 and the Werribee River at Diversion Weir.

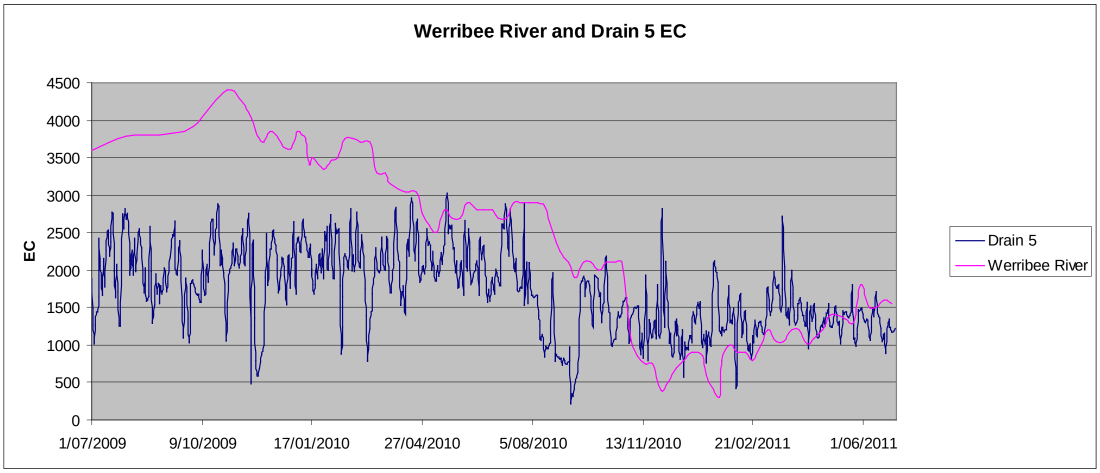

Figure 3-6 Salinity trends for drain D5 & Werribee River @ diversion weir

Nutrients

Monthly water quality data from both drain samples and Melbourne Water pre-disinfection have been used to determine overall drainage and channel outfall load volumes. Where samples were not collected due to low or no flow events at the Drain monitoring sites average values for the year have been applied. **Figure 3-7**presents the results for Total Phosphorus (TP) and Total Nitrogen (TKN+TON) in Drain 5 from the start of 2005.

For the first six months of this seasons reporting at drain D5, both Total P and Total N concentrations are lower to that of recent year's results, with an average Total P concentration of 4.0 mg/L compared to 6.5mg/L in 2009/10, and an average Total N concentration of 8.8 mg/L compared to 15.2mg/L for 2009/10. Levels for the last six months of 2010/11 returned to levels similar to that of baseline values of 2004/05 averaging 0.6mg/L for total P and 2.06mg/L for total N. The lower values are likely to be a result of the higher rainfall recorded in late 2010 and January/February 2011 and also the cessation of supply of recycled water from the end of January.

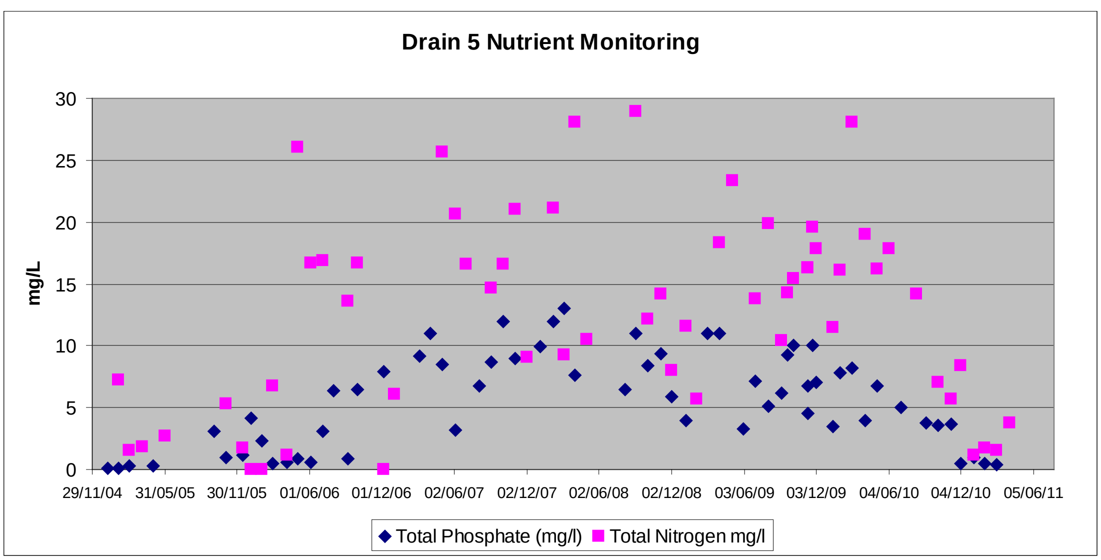

Figure 3-7 Nutrient monitoring in drain D5 2010-11

Date	Total Phosphate (mg/L)	Total Nitrogen (mg/L)
05/07/10	No Flow	No Flow
12/08/10	**5.00**	**14.20**
06/09/10	No Flow	No Flow
05/10/10	3.80	7.00
09/11/10	3.60	5.70
2/12/2010	3.70	8.40
6/01/2011	0.50	**1.12**
2/02/2011	1.00	1.75
3/03/2011	0.50	1.56
5/04/2011	**0.40**	3.80
4/05/2011	No Flow	No Flow
2/06/2011	No Flow	No Flow

Table 3-3 Monthly sampling @ drain D5 (min / max values bolded)

Loads

The method used for calculating drain discharge loads is the monthly concentration discharge method whereby, concentrations measured during a period are averaged and multiplied by the discharge over this period. Successive monthly loads are summed to produce a sum estimate for the twelve months applying the extrapolation method below. Results from drains D1, D5, D6 and D11 have been used in estimating total nutrient loads. As testing was not undertaken at channel outfalls it is not possible to provide an accurate estimate of nutrient loads discharged from channel outfalls. Previously nutrient levels from the MWC treatment plant were used in estimating outfall discharge load, this reporting was possible because recycled water made up a large percentage of total water supplied and subsequently outfalled.

L=Av Cc * (drains 1,5 Vol * 50.4/100) + (drain 6 Vol * 31.9/100) + (drain 11 Vol * 17.8/100)

An estimated TP load of 4.6 Tonnes and an estimated TN load of 32.9 tonnes were discharged from the drainage system. Recycled water made up only 34% of total water supplied in to the district up until February 2011 and then no further recycled water was supplied for the remainder of the system. Based on the percentage of recycled water supplied to the system it is estimated that the total Nitrogen discharge from outfalls is 0.37 tonnes and total Phosphorus 0.17 tonnes. By adding both drain and outfall volumes we estimate a total discharge of 4.8 tonnes of TP and 40.3 tonnes of TN.

The results show an increase in overall nutrient discharge from the drainage system with a 21% increase in TP load and nearly 4 times the volume of total N. This is due to the large increase in drain flows which were 11 times the 2009/10 volume.

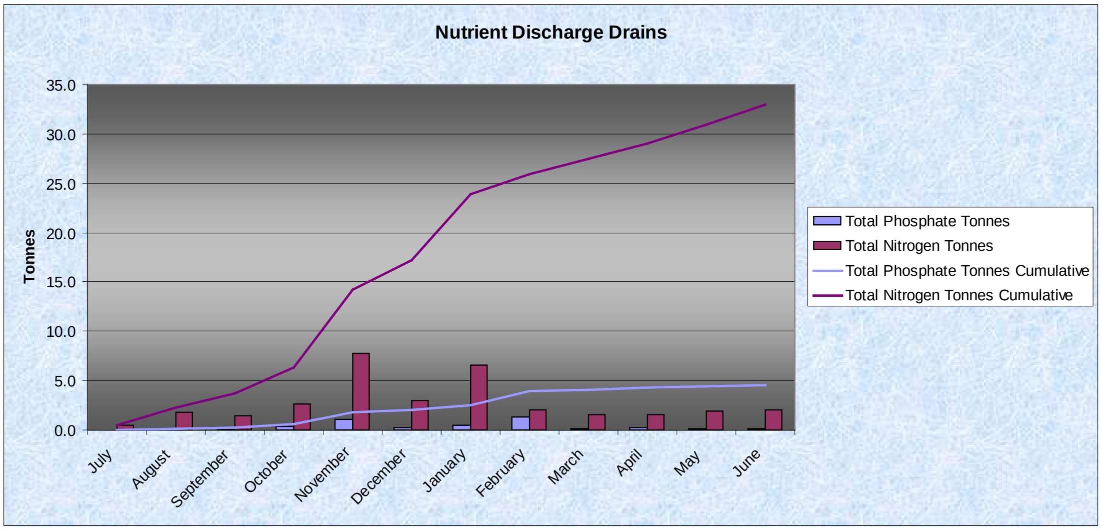

Figure 3-8 WID drain nutrient loads 2010-11

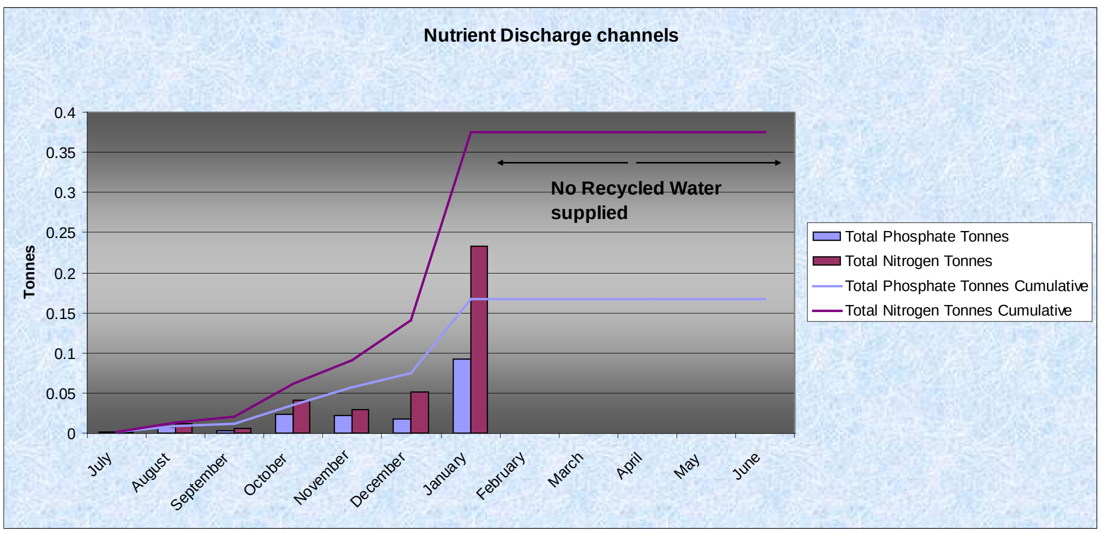

Figure 3-9 WID channel outfall nutrient loads 2010-11

Nutrient Monitoring at other sites

Samples were also collected at D1(two sites), D6 and D11 when opportunities to sample arose. Sampling on drain one commenced in February 2011with six samples taken at D1 at the upstream Hoppers Lane site, four of these were monthly routine samples and two high flow samples. This site only captures urban runoff but is required to calculate district discharge further downstream. The samples recorded here were all less than 0.25mg/L of total P and less than 2.2mg/L of total N, typical of urban catchment runoff. Samples from the high flow event recorded average values of 0.22mg/L for total P and 2.3mg/L for total N around the averages for this site.

Six samples were also collected from the D1 site at Campbell's Cove immediately upstream of where the drain enters Port Philip Bay. Routine samples recorded values averaging 0.26mg/L of total P and 10.8mg/L of total N. The high flow events provided average values of 0.3mg/L total P and 4.1mg/L total N.

Routine samples taken from D6 provided average values of 1.8mg/L for total P and 9.7mg/L for total N. It should be noted that average values for the last 6 months of the reporting year were significantly lower than the first six months.
Routine samples for drain D11 averaged 2.6mg/L total P and 9.4mg/L total N which correlate closely with drain D6 samples.

Nutrient sampling at other sites

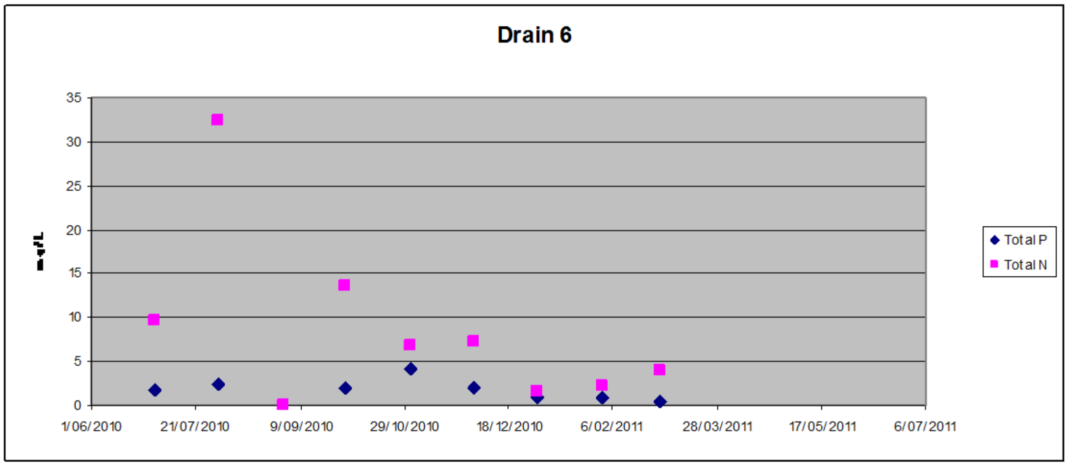

Figure 3-10 WID drain D6 nutrient monitoring

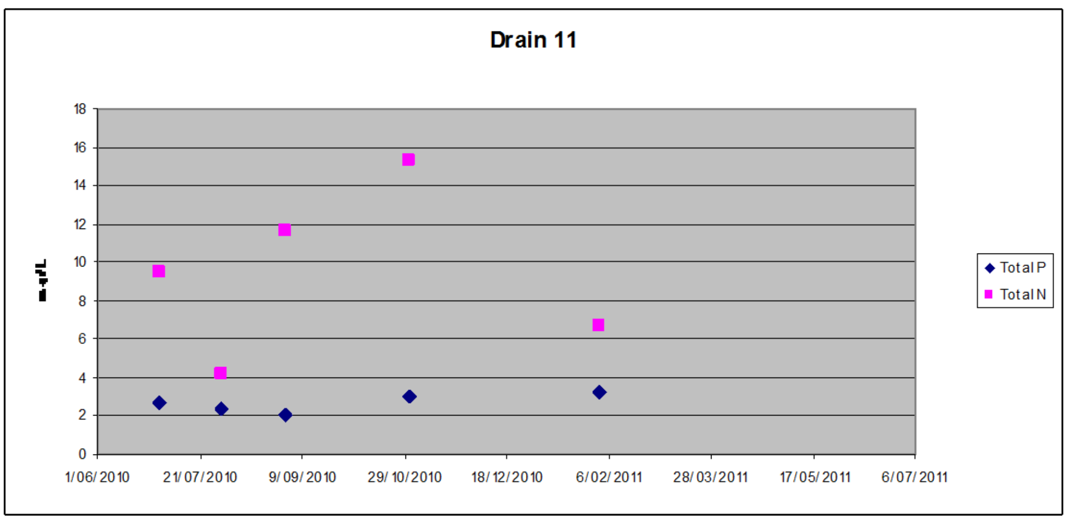

Figure 3-11 WID drain D11 nutrient monitoring

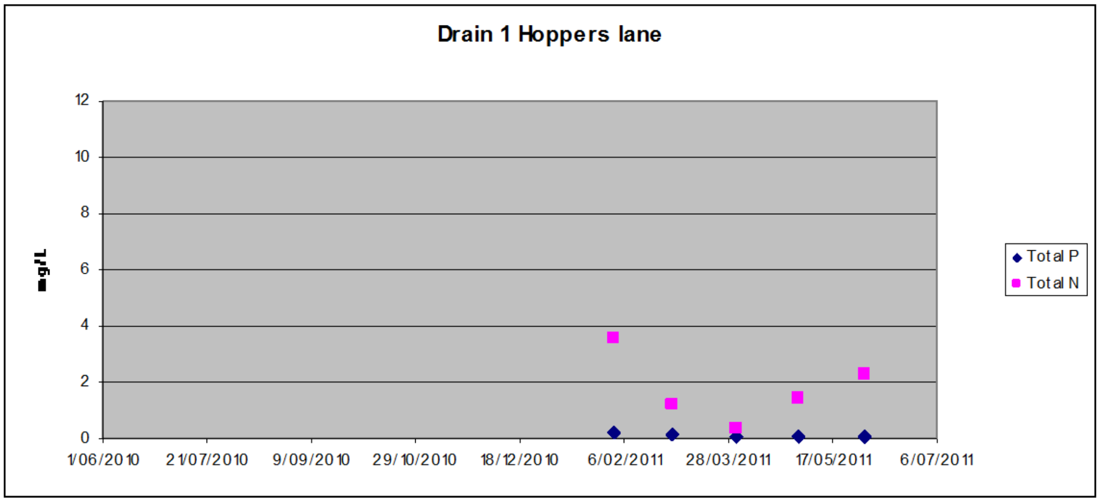

Figure 3-12 WID drain D1 monitoring @ Hoppers Lane

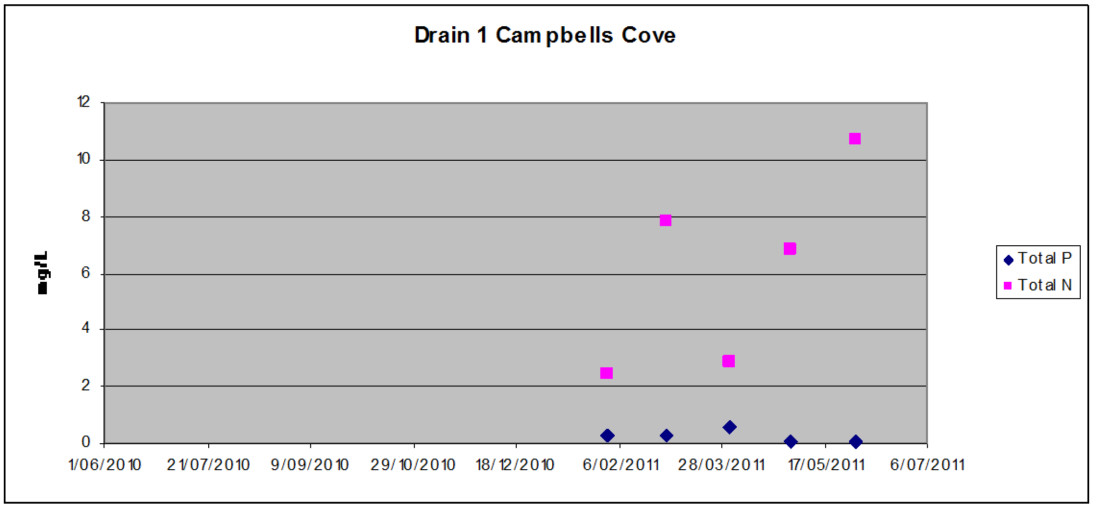

Figure 3-13 WID drain D1 monitoring @ Campbell's Cove

Grab samples at the D5 drain monitoring site were collected as per the table below:

Date	Flow at time of sample ML/d	Total P mg/L	Total N mg/L	EC@25
28/11/2010	9.1	3.7	13.7	N/A
7/2/2011	3.8	1.8	10.0	1170
12/4/2011	12.3	2.4	9.7	870
Average		2.6	11.1	
Average routine sampling		2.3	5.4	

Table 3-4 Event based sampling @ drain D5

Sampling results from the grab samples show higher average nutrient levels compared to the average for routine sampling at drain D5.

Assessment of compliance against SEPP requirements.

SEPP environmental objectives for marine and estuarine waters (estuaries and inlets) specify values of 0.3mg/L for total nitrogen (75th percentile) and 0.03mg/L for total phosphorous (75th percentile). Total nitrogen values for drain D5 were: Avg 5.4mg/L, Max 14.2mg/L, Min 1.1mg/L. Total Phosphorous values were: Avg 2.3mg/L, Max 5.0mg/L and the minimum value for the period was 0.4mg/L. The 2010/11reporting year has seen improvement in nutrient levels from the previous year although levels are still well above the SEPP objectives for marine and estuarine waters requirements.

Heavy Metals

Sampling for heavy metals was undertaken at drain 5 and drain 6 in October 2010 and again at all 5 drainage monitoring sites in February 2011, with two samples taken from drain 5.

4. Receiving Surface Waters Monitoring

With the publication of the REIP in 2009 there was a requirement to introduce a program to monitor the water quality of the receiving surface waters adjacent to the WID. This program was designed to detect whether the outfalls and drains from the WID were discharging levels of nutrients that were potentially detrimental to the environment.

4.1.1 Werribee River & Estuary Sampling Locations

- WW – Werribee Weir pool (existing SRW sampling location)
- WF – Werribee River freshwater flowing into estuary at Historic Bluestone Ford (north west of Golf Course)
- W11 – Werribee River estuary a K Road close to Drain 11 outfall (near Golf Course car park)
- W9 – Werribee River estuary near Drain 9 outfall midway between Drain 11 and river mouth (Cuttress Road)
- WM – Werribee River Mouth from end of jetty east of boat ramp (Werribee South)

The Werribee River estuary will be sampled at the turn of the outgoing tide, as water is leaving the estuary to ensure the sample is flowing past and outwards from the WID drain outlets to PPB. Samples are taken at depths up to 0.5m below the surface.

4.1.2 Port Phillip Bay – Inshore Segment Sampling Points

- PPB1 – Adjacent to Drain 1 outfall
- PPB2 – Adjacent to Drain 5 outfall
- PPB3 – Adjacent to Drain 6 outfall

4.1.3 ***Results***

Sampling was undertaken by Ecowise in January 2011 & June 2011. The full results are shown in Attachment 15.3.
The concentration of nutrients at the sampling locations is as follows:

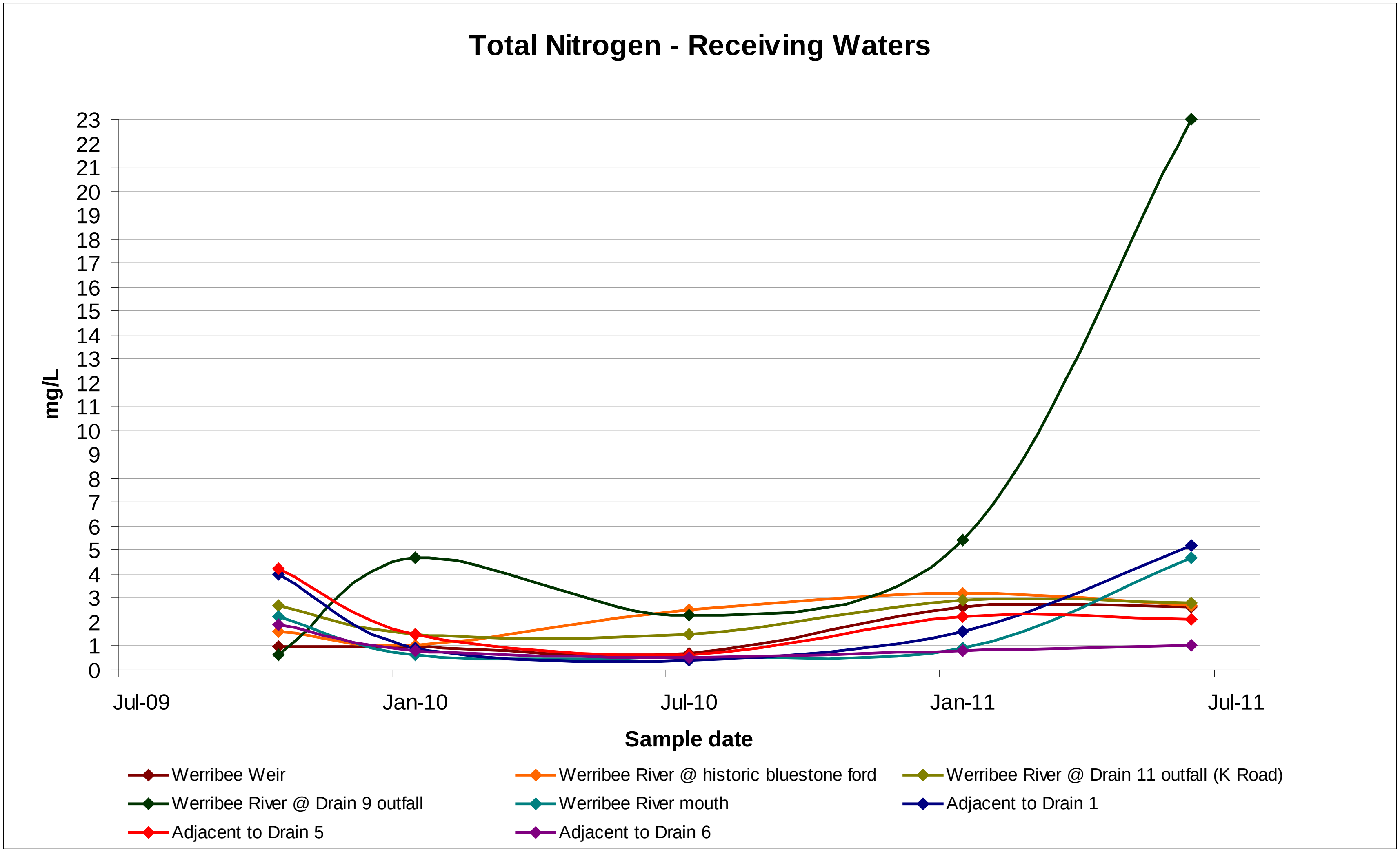

Figure 4-1 WID receiving waters nitrogen levels 2010-11

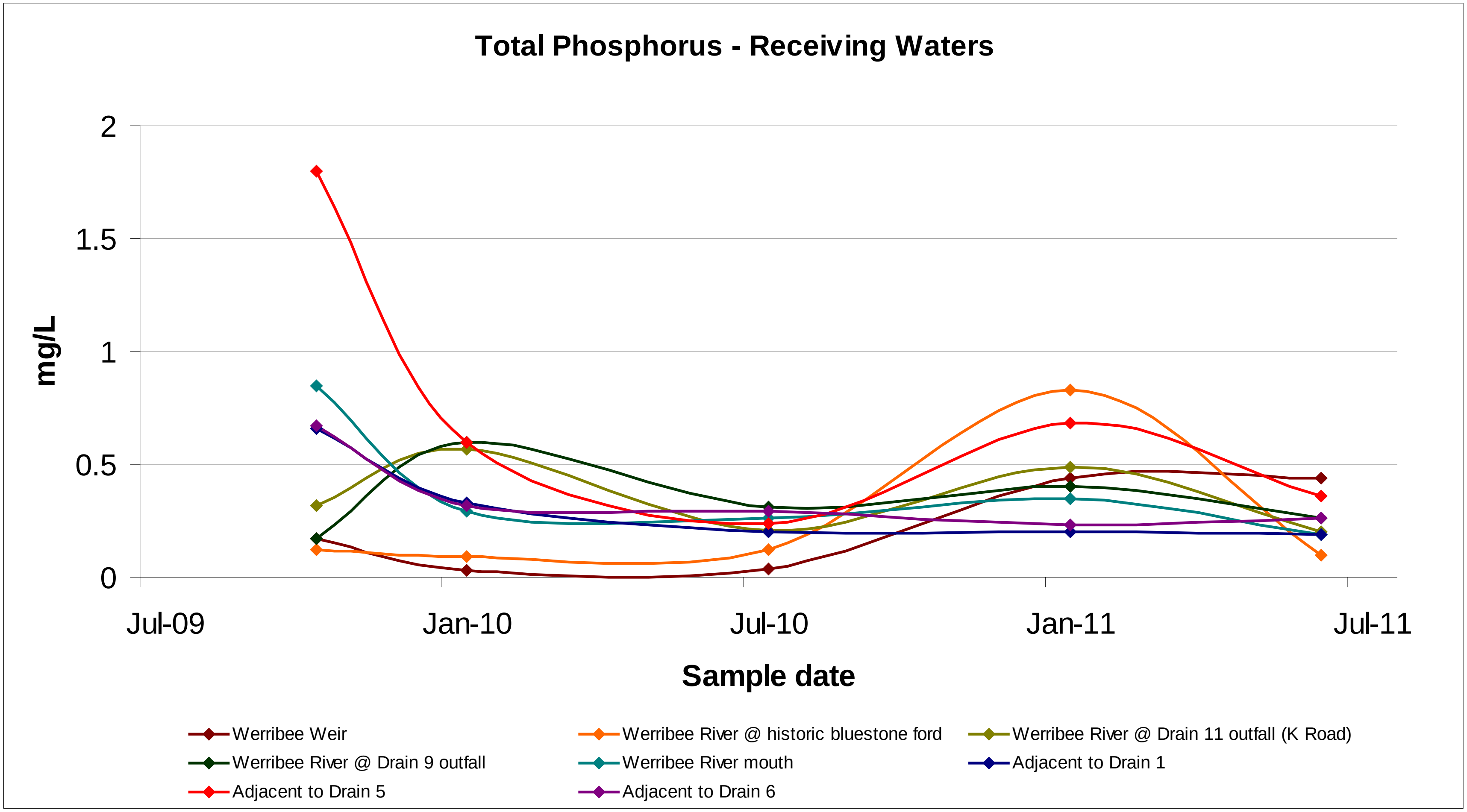

Figure 4-2 WID receiving waters phosphorus levels 2010-11

4.1.4 Assessment versus SEPP objectives

The 2010-11 irrigation season was characterised by much higher than average rainfall and very low recycled water deliveries. High flows along the Werribee River into Port Phillip Bay contained higher nutrient loads typical of storm events. As documented in the drainage section of this report the run-off from the WID was very high as compared to previous seasons. The samples that were collected this year showed that nitrogen levels remained consistent expect for a single reading at the W9 site. Phosphorus levels peaked at the beginning of the year and have subsequently fallen back.

4.1.4.1 Nitrogen

In January 2011 nitrogen levels in the river were at or below SEPP objectives (300 mg/l @ 75th percentile) for estuaries and inlets. Results from the coastal waters were at similar levels but the lower objectives (120 mg/l @ 75th percentile) meant that all samples remained above SEPP objective levels.

In July 2011, at which point recycled water had not been delivered to the WID in six months, there were some higher nitrogen results recorded in the receiving waters at drains PPB1, W9 & WM. These levels are consistent with the higher nutrient loads (albeit at lower concentrations) observed in the drains and outfalls.

The result of 2300 mg/l recorded at W9 was inconsistent with upstream and downstream samples and a retest was requested from the laboratory which had unfortunately not stored a second sample. This has been documented in the non-compliance section.

4.1.4.2 Phosphorus

The January 2011 samples reflected higher levels of phosphorus at the Werribee Weir and river sampling points, consistent with the rainfall events that occurred during that time.

In July 2011 phosphorus levels were below SEPP objectives for all sampling sites except the Werribee Weir and drain D5.

5. Groundwater

5.1 Groundwater overview

The Werribee Irrigation District (WID) overlies a groundwater management area known as the Deutgam Water Supply Protection Area (WSPA). The WSPA covers an alluvial gravel aquifer to a depth of 40 metres, known as the Werribee Delta. A groundwater extraction ban to mitigate the threat of saline intrusion resulting from over-extraction of the resource was lifted during 2011 following significant rainfall and aquifer recovery.

Currently, groundwater monitoring is undertaken in accordance with the REIP requirements, as well as additional monitoring undertaken to assess the threat of saline intrusion to the aquifer from the Werribee River estuary, Port Phillip Bay and underlying, saltier aquifers. Saline intrusion monitoring is conducted on a monthly basis but only information relevant to the operation of the recycled water scheme has been reported here. Monitoring infrastructure comprises 25 State Observation Bores (SOB) and a number of private groundwater bores (**Figure 5-1 WID groundwater monitoring locations**).

In general, groundwater flows from north to south across the WSPA and is recharged via a combination of rainfall, river flows, delivery channel leakage and irrigation leaching.

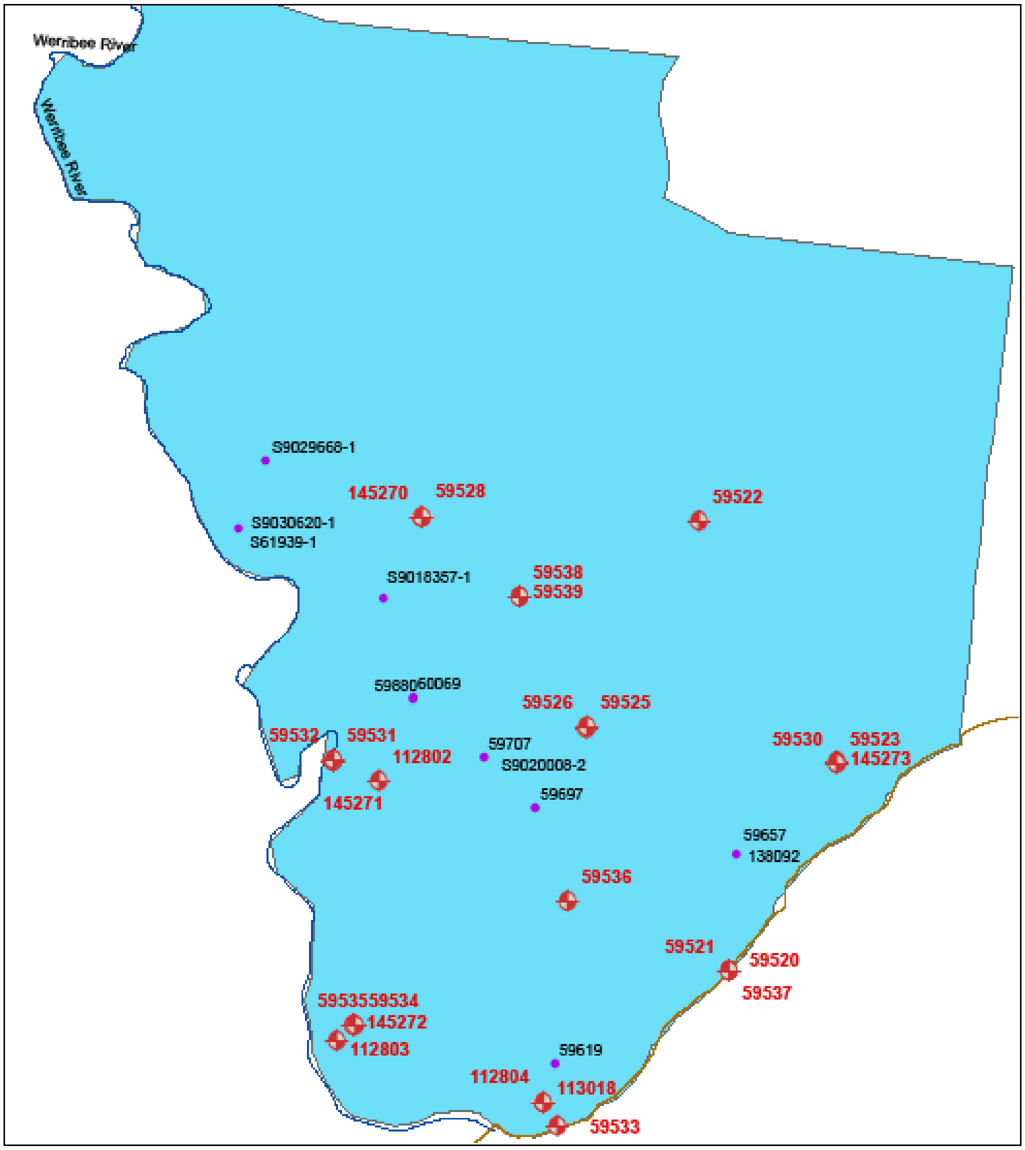

Figure 5-1 WID groundwater monitoring locations

SOB network shown in red, private bores are indicated in purple.

5.2 Groundwater Level Monitoring

Groundwater level is monitored across all 25 SOB on a monthly basis as part of SRW's saline intrusion monitoring program. The graph below illustrates the average drawdown across the entire alluvial aquifer over time. In general, groundwater levels declined during the low rainfall period commencing in 1997. There was a significant period of decline between 2005 and 2007, with some recovery observed over the following 3 years (attributed to increased compliance with the groundwater extraction ban). Significant recovery has since occurred in the past 12 months due to replenishment from rainfall, resulting in groundwater levels that are at a lower risk of saline intrusion from both the estuary and the Bay. Groundwater level contour maps are not regularly updated and have not been provided.

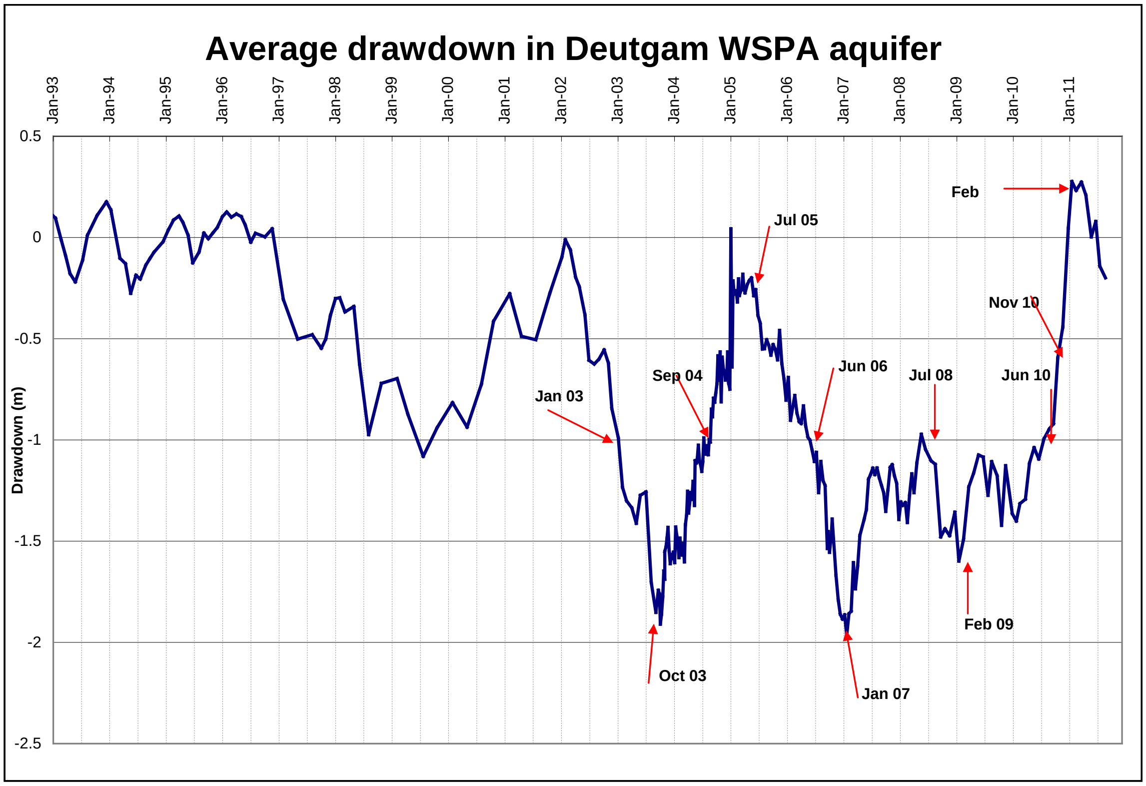

Figure 5-2 Average drawdown in Deutgam WSPA aquifer

5.3 *Groundwater Salinity Monitoring*

Groundwater salinity monitoring is conducted in 9 out of the total 25 State observation bores on a rotating monthly basis as part of SRW's saline intrusion monitoring program. Data is also collected from several private bores. Only information relevant to the recycled water scheme operation is presented in this report.

Private bore monitoring data collected to date indicates that salinity may be increasing in two of the private bores, in the central and northern WID. The reason behind the apparent increases is not clear.

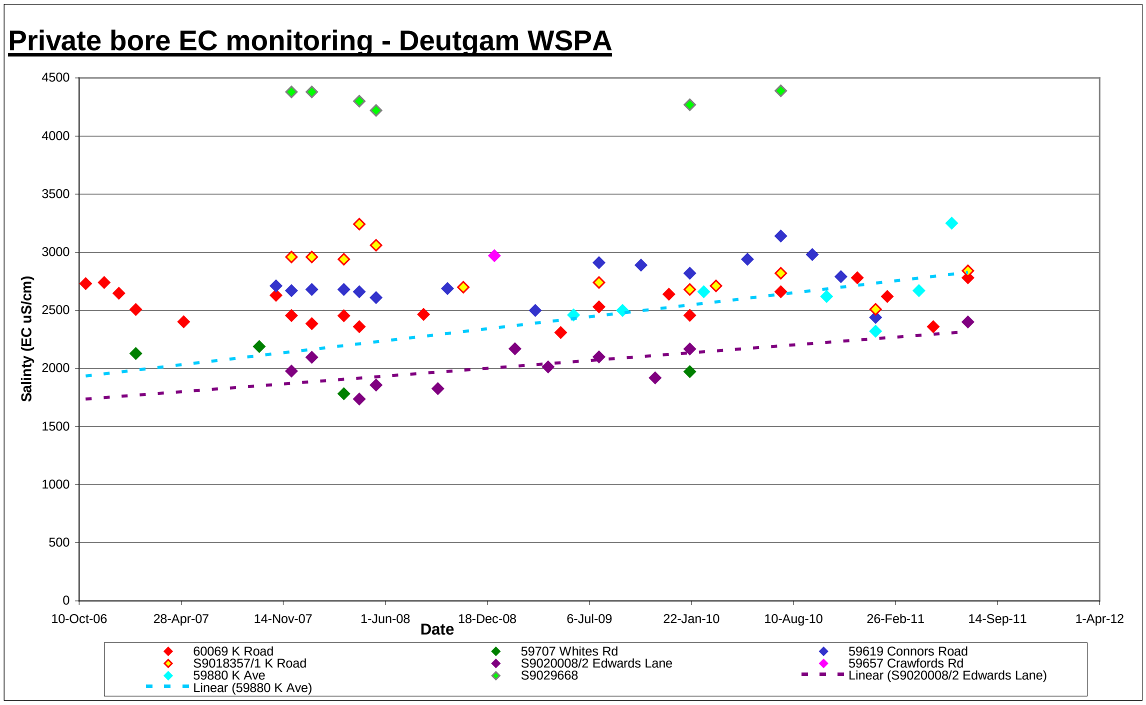

Figure 5-3 Private bore monitoring - Deutgam WSPA

Salinity data collected from alluvial aquifer bores in the northern and mid portions of the WID (see graphs below), adjacent to delivery channels, indicates no significant overall increase in groundwater salinity since recycled water delivery commenced in December 2004. Some increase was experienced in low rainfall years, attributed primarily to reduced freshwater recharge, however with increased rainfall in the past 12 months salinity has generally declined. This indicates that there is little contribution to salinity from recycled water infiltration.

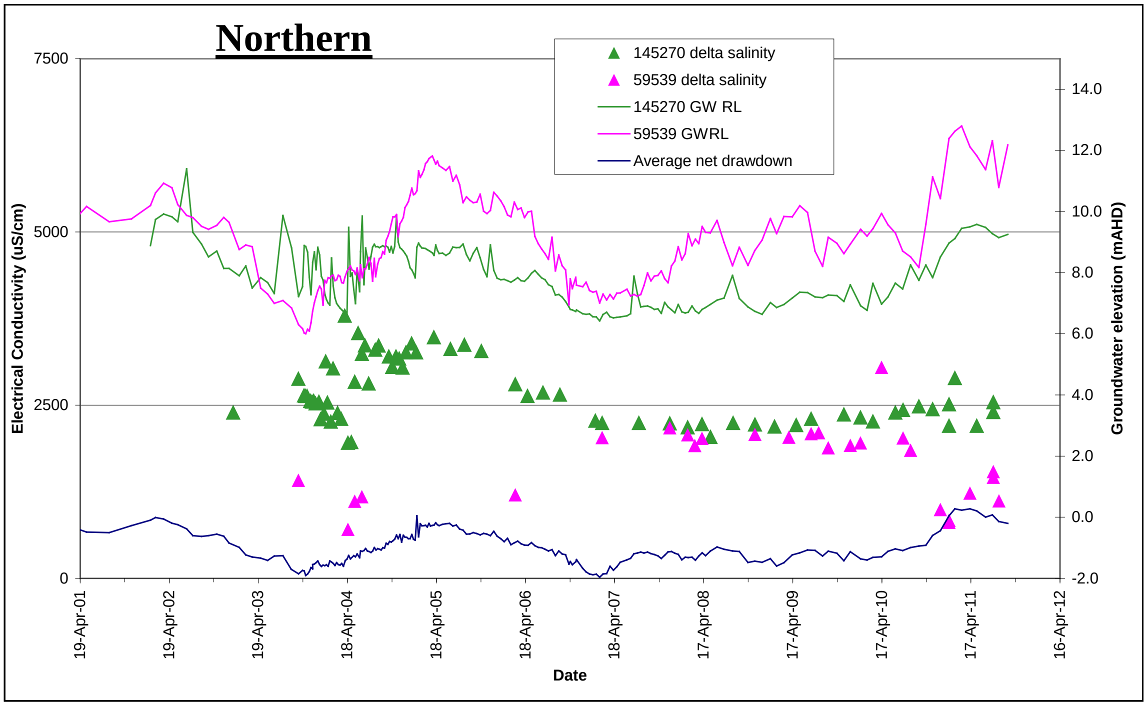

Figure 5-4 Salinity data from bores in northern section of WID

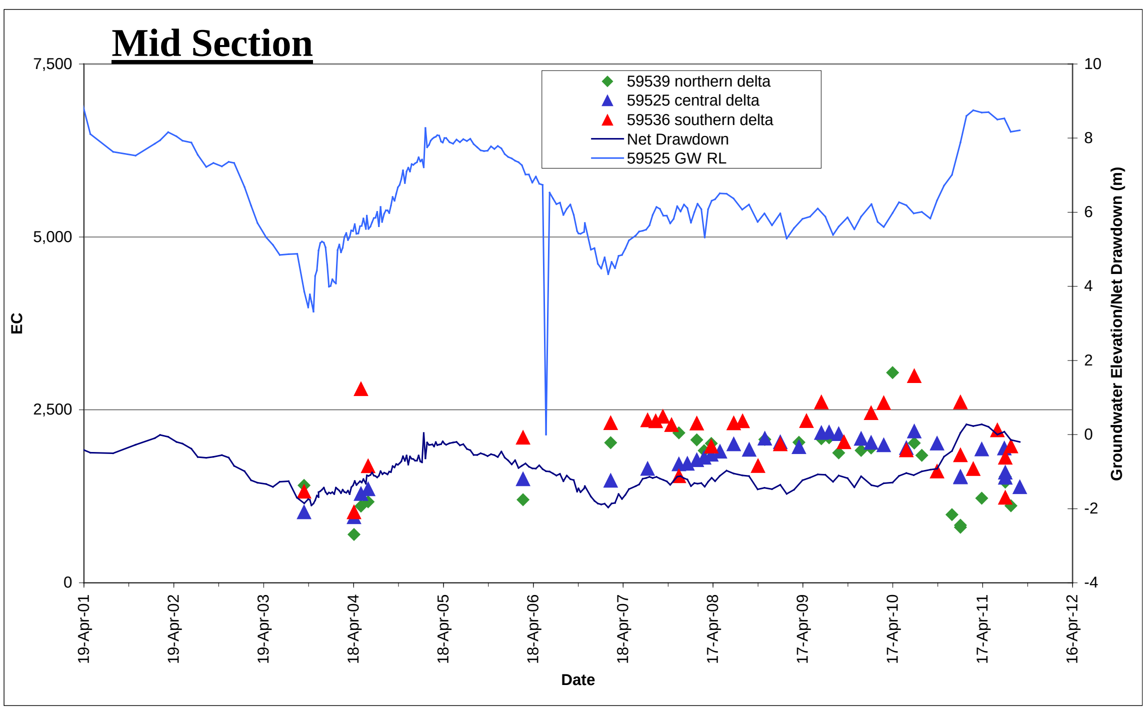

Figure 5-5 Salinity data from bores in central section of WID

In contrast, salinity data collected from coastal and riverside monitoring bores clearly indicates significant increases in salinity at depth, although this has decreased over the past 12 months in correlation with freshwater replenishment of the aquifer from higher rainfall. There is little change in the salinity of shallow bores. Increases in salinity in deeper bores are attributed to saline intrusion from the estuary and the Bay and not to recycled water. If recycled water was the primary cause of salinity changes in the alluvial aquifer, we would expect to see more uniform changes to salinity with depth and across the WID, with a slightly higher rate of change in bores adjacent to delivery channels, such as 59539.

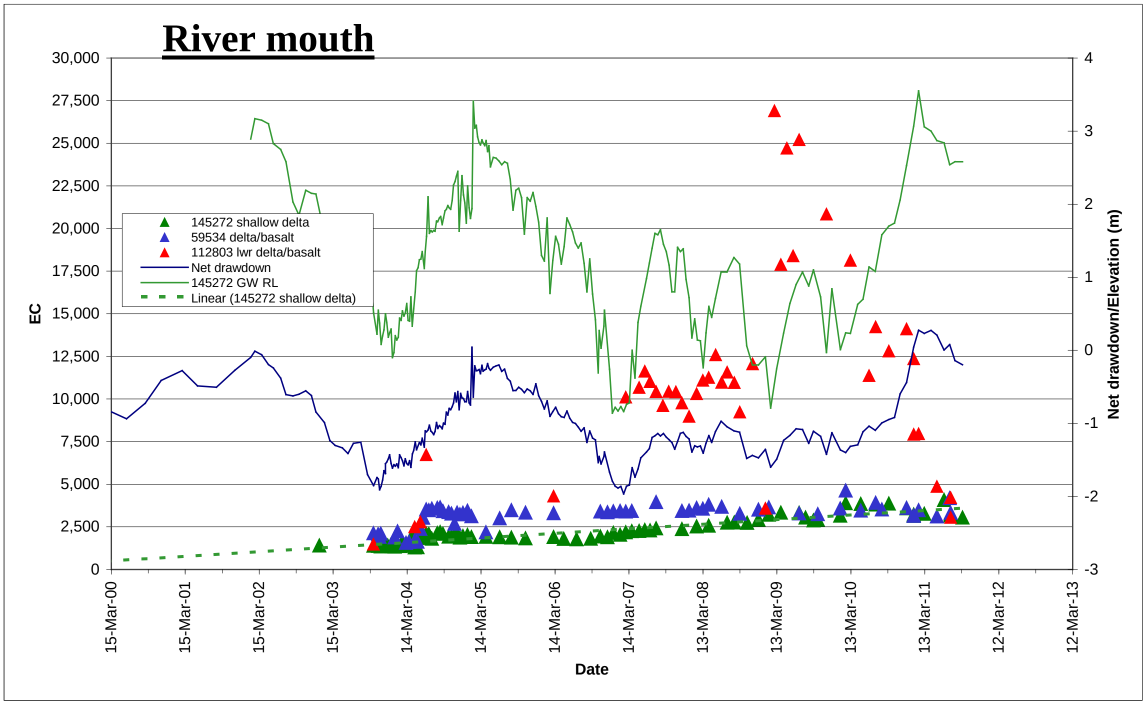

Figure 5-6 Salinity data from bores adjacent to Werribee River mouth

5.4 Groundwater Contaminant Monitoring

REIP groundwater sampling event was conducted twice during the reporting period (July 2010 and January 2011) in accordance with REIP requirements. A complete REIP sampling round was also completed in July 2011 and summary results are included, but this data will be further documented in the next reporting period. Groundwater analytical results from the REIP sampling program are summarised in Attachment 15.1 and compared to relevant ANZECC criteria for irrigation and marine ecosystem protection (for slightly to heavily modified systems). The application of these guideline figures was reviewed, and it was decided to continue comparison with guidelines for T90 – 95% levels of ecosystem protection. As the area is highly modified, the T99% level of protection was considered inappropriate. Additional SEPP criteria for estuaries and inlets were also compared to sampling results. Laboratory analytical certificates are available on request.

Relevant contaminant concentration guidelines for some metals have been exceeded in several bores on one or more occasions. While in some cases lab detection limits were similar to or higher than some guideline values, these were as low as reasonably practical with consideration to cost. Additionally, exceedances of ecosystem protection guidelines by metals are common even in systems which have not been heavily modified and these results are considered unlikely to be directly related to operation of the recycled water scheme. There are no indications of increasing concentrations or spatial trends to the results.

Total nitrogen results are summarised in the graphs below. Nutrient concentrations exceeded the guidelines for protection of slightly modified marine ecosystems in most bores and across the majority of sampling events conducted to date. Many bores also exceed the recommended ANZECC long term trigger value for the application of irrigation water.

Total nitrogen concentrations from the majority of SOB in the delta aquifer showed no increasing trends. Some sites experienced decreases in samples taken in July 2011, particularly 59537 (central eastern coast), 145272 (SW river on coast) and 59536 (lower mid central). SOBs drawing from multiple aquifers also showed no overall increases in TN concentrations. Most SOBs in the deeper aquifers experienced no upward trend, with the exceptions of 112804 (Brighton Formation, central coast) and 59535 (Volcanics/Brighton formation at the river mouth). These sites showed increasing total nitrogen concentration over the past 6 - 12 months. Similar results have been recorded at 59535 in the past so the most recent results are within the historical range for this bore. Total nitrogen concentration in private bores showed no overall increase except 9018537/1 (northern central). Not all private bores could be sampled for all events due to localised flooding.

There is no evidence to suggest that recycled water use is leading to decreases in groundwater quality. The few sites that show increases in total nitrogen concentrations are located near the coast rather than near irrigation channels. It would be expected that if upward trends were due to the application of recycled water, sites closer to irrigation channels and irrigation areas would experience the highest rises in concentrations. As peaks in nutrient concentration are not reflected in boron concentrations (see **Figure 5-11 Boron in groundwater - Delta aquifer** and **Figure 5-12 Boron in groundwater - Multiple aquifers**), it is likely that these trends are due to fertiliser use, rather than recycled water impacts.

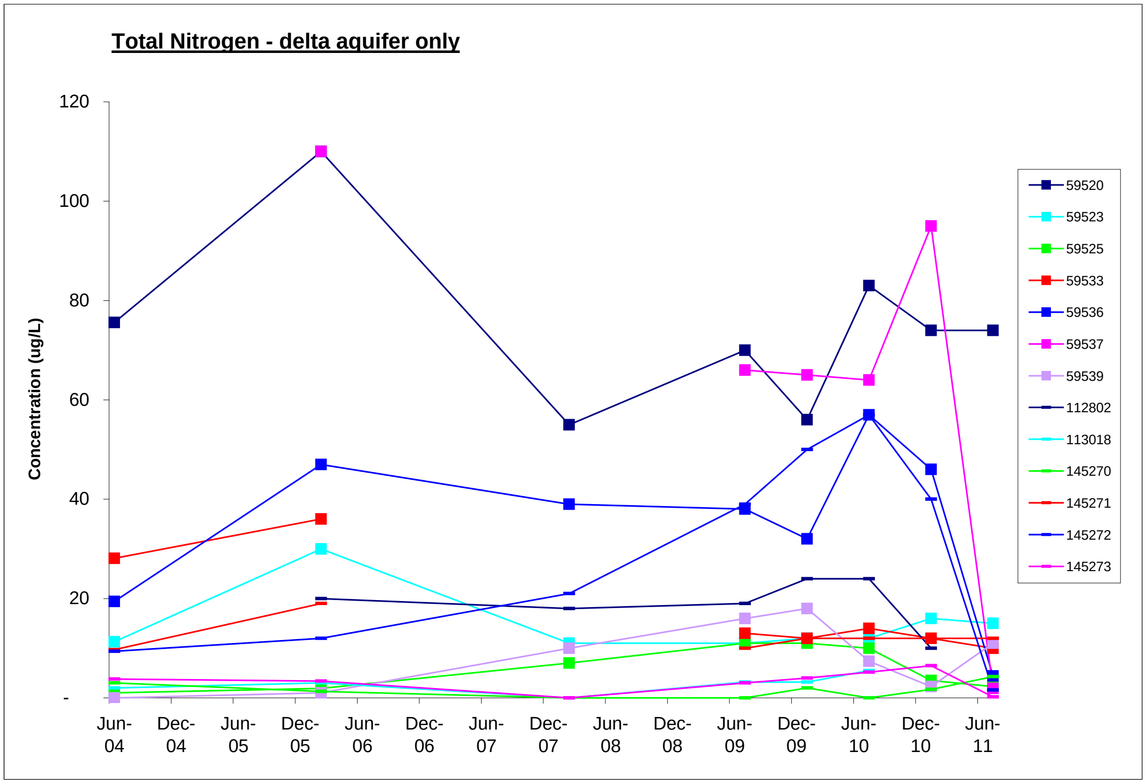

Figure 5-7 Total nitrogen in groundwater - Delta aquifer

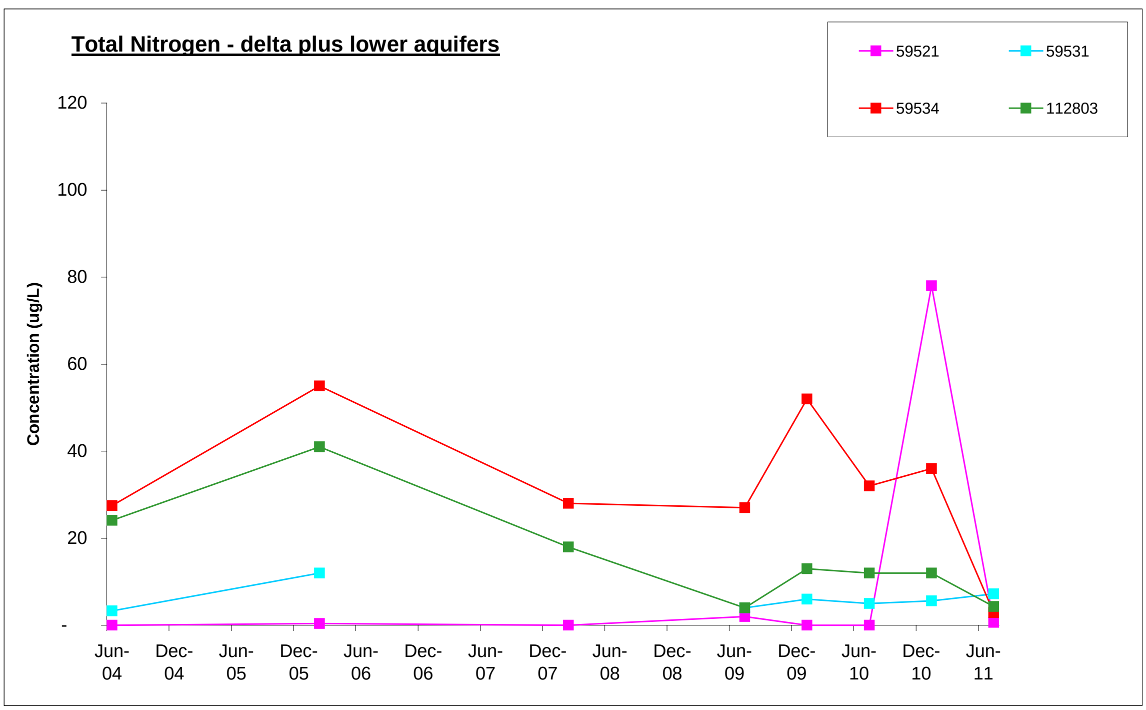

Figure 5-8 Total nitrogen in groundwater - Multiple aquifers

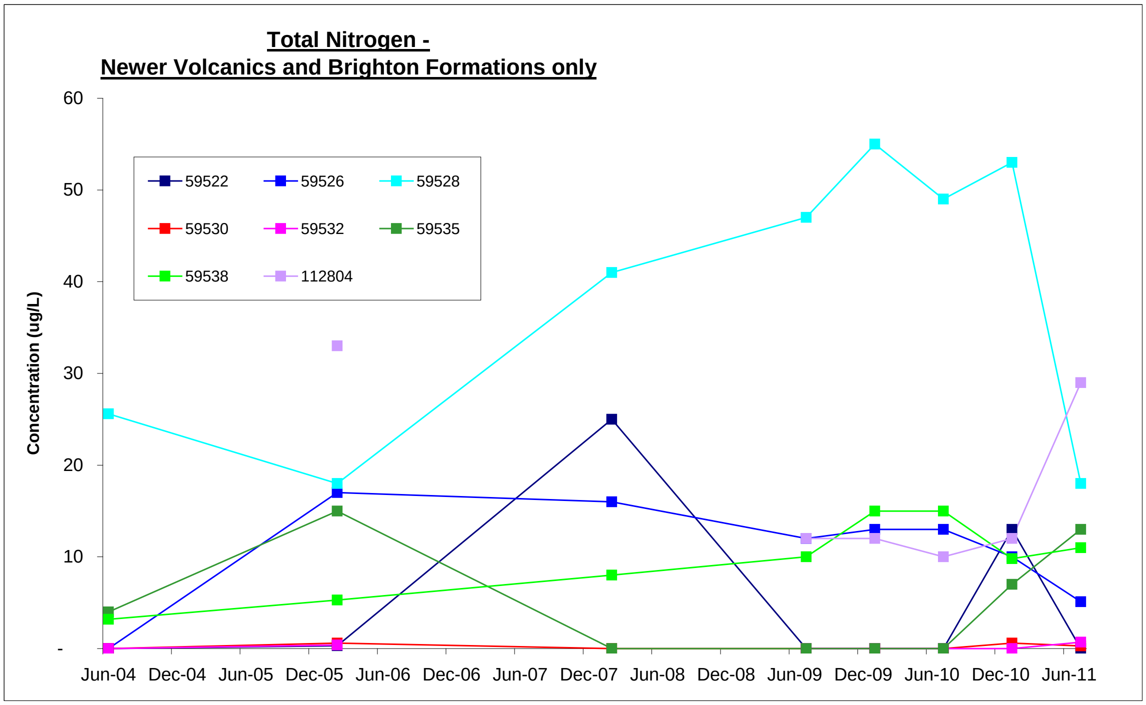

Figure 5-9 Total nitrogen in groundwater - Lower aquifers

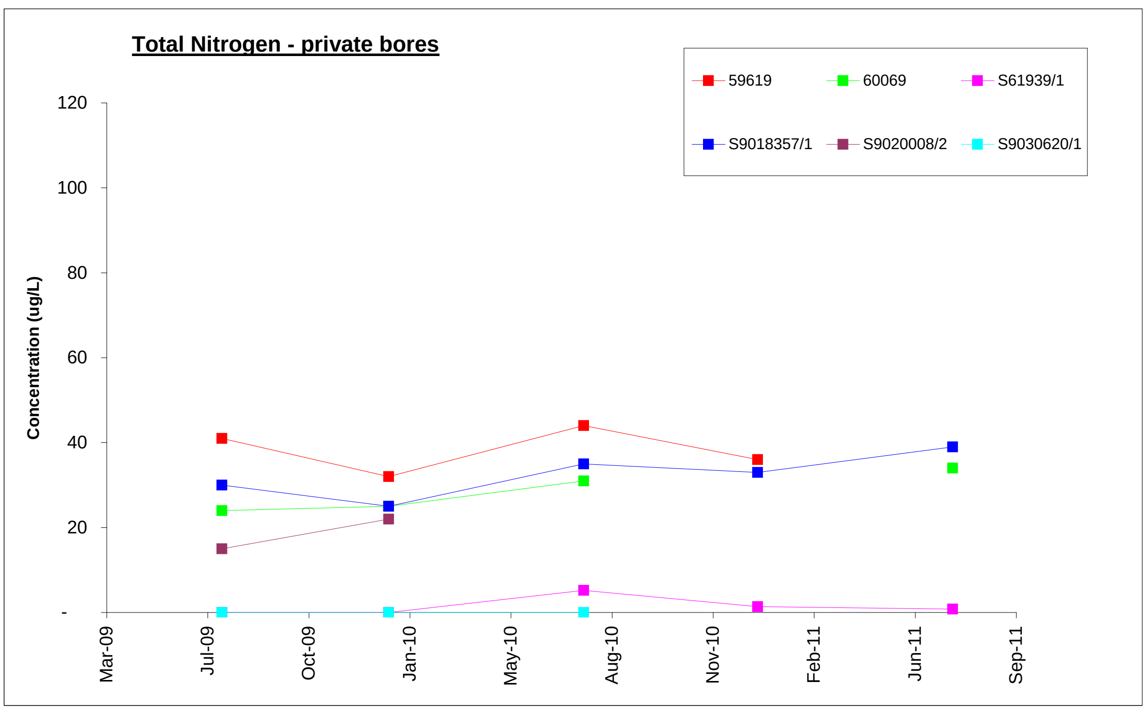

Figure 5-10 Total nitrogen in groundwater - Private bores

Boron concentrations also exceeded SEPP guidelines for rivers and streams at most bore sites for the majority of sampling events. The graphs below show a summary of recorded boron concentrations. High boron levels are typically associated with the use of recycled water however there is no indication of increasing concentrations since the beginning of the recycled water scheme. The majority of boron concentrations recorded from SOBs in both the delta aquifers and multiple aquifers showed no overall increasing trend. The exception to this is bore 145272 (delta aquifer, river mouth) which experienced a slight upward trend

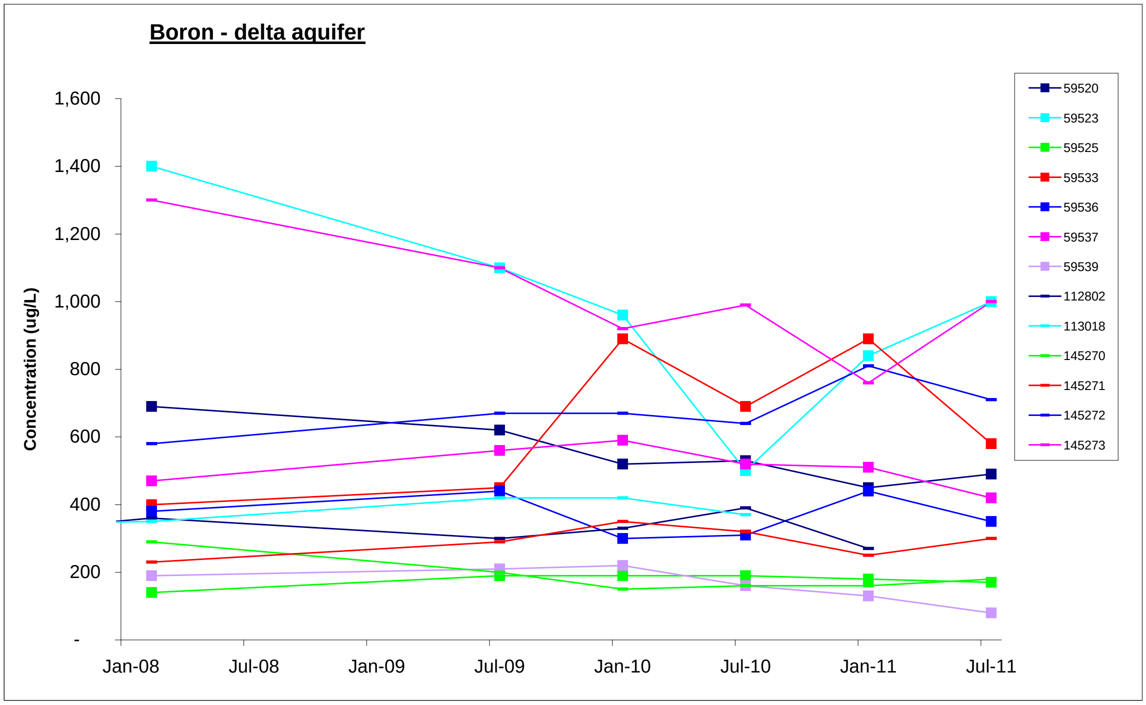

Figure 5-11 Boron in groundwater - Delta aquifer

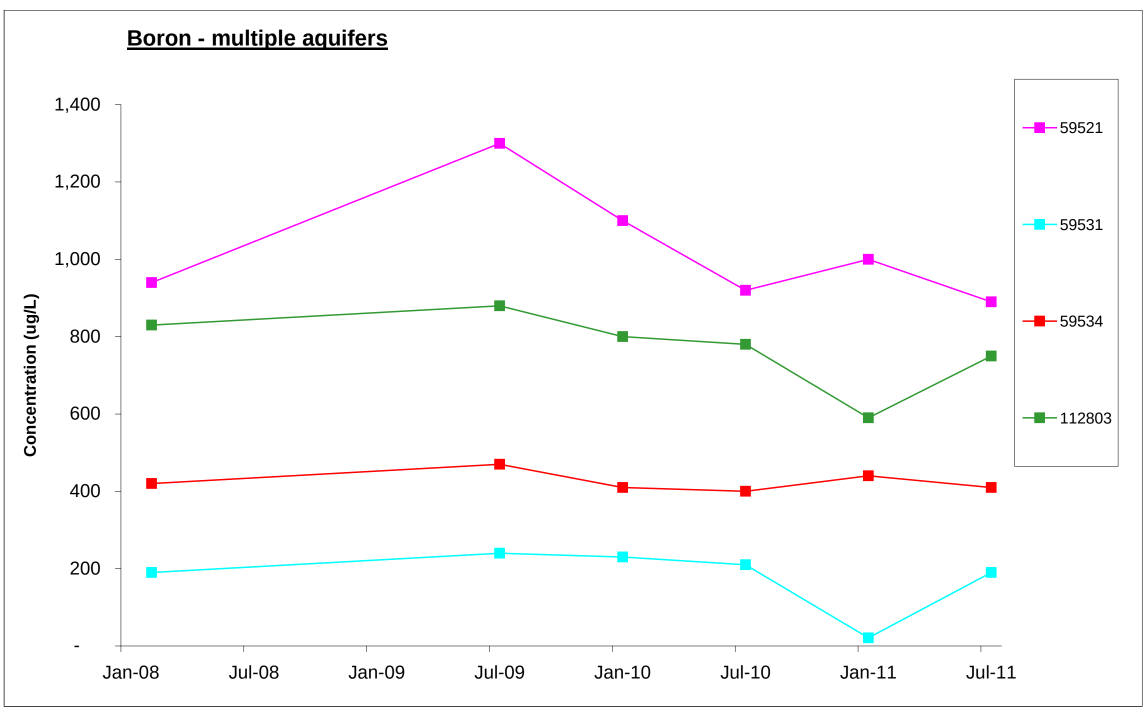

Figure 5-12 Boron in groundwater - Multiple aquifers

6. Soil Monitoring

6.1 Introduction

This is the seventh annual soil monitoring report for the Werribee Recycled Water Scheme. For the first time in five years, only minor use of recycled water has occurred in Werribee South, due to well above average rainfall and the recommencement of river and bore water for irrigation use.

The 2011 annual soils monitoring for the recycled water use in the Werribee Irrigation District (WID) has been undertaken with reference to 2009 REIP. The 2009 REIP contains prescriptive actions and responses required when soil results indicate levels of some soil parameters above or below certain values. The 2009 REIP defines a number of trigger points whereby action is required. The sampling plan and sampling procedures have been determined by a combination of the 2004 and 2009 REIPs, along with interpretation, identification of target and trigger points and follow up action required as a consequence of the 2011 soil sampling.

For the first time in many years, the irrigation of crops in Werribee South was primarily from river and bore water. Total recycled water use in the district for 2010/11 was 1,700 ML, down from 8,600 ML in 2009/10. Growers had access to 155 % of their river water entitlement and 100 % of their bore water entitlement. When recycled water was supplied it typically comprised 25 % of a shandy with river water.

The 2010/11 season has been particularly wet, with annual rainfall 57 % above the long-term average at Laverton (850 mm compared to the long term mean of 540 mm). The months of October and November in 2010 and January and February 2011 were the wettest months with rainfall exceeding the long term average by over around 100 % in each of these four months. These impacts are presented graphically in **Figure 6-1**. There have also been a number of intensive rainfall events, which have provided significant leaching of salts from soils that were already moist at the time of the rainfall. These rainfall events over the past 12 months are likely to have had a positive effect on the soils in the district.

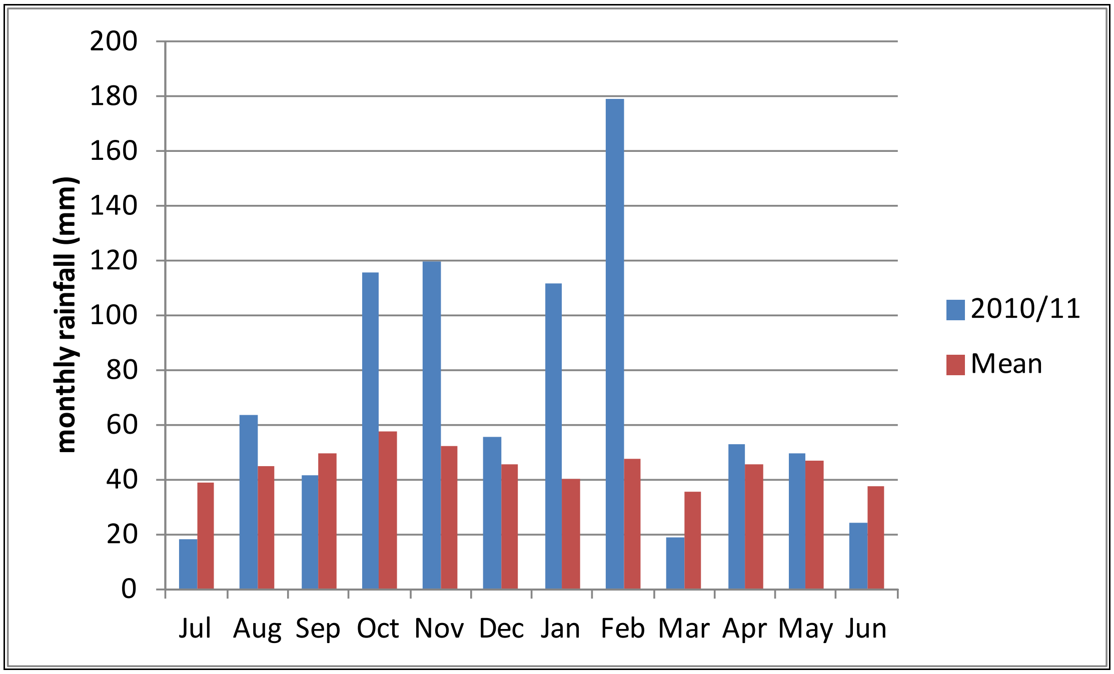

Figure 6-1 Monthly rainfall recorded @ Laverton 2010-11 & the long term mean

Soil monitoring has occurred on 12 individual sites as part of the winter 2011 annual soil monitoring. This is a substantial decrease on the 143 sites monitored in 2010 and can be attributed to the low recycled water use across the district. These farms have used more than 1.5 ML per hectare of recycled water, or have used more than 2.0 ML/ha over the previous 2 seasons.

A total of 32 sites were monitored in January 2011 as part of the six monthly soil health alert monitoring program. These sites were selected as they exceeded at least one soil health trigger in the 2010 winter monitoring. This is the first time the results of the January soil monitoring have been included in the annual soil monitoring report and are discussed in Section 6.1.1 relating to soil health.

6.2 Soil Monitoring Site Selection Procedure

The 2009 REIP describes the annual soils monitoring procedure for the scheme, and has been the reference document for deciding upon the annual sampling plan. Each property that is part of the scheme is required to be tested annually for a range of critical soil parameters, and the owner and operator (they may be different) as well Southern Rural Water are to be advised of the outcome. The soil depth at which tests are to be completed are different for each property depending on how many years they have been actively involved in the scheme. Surface sampling only (0 to 30 cm) is required after the first season at the end of the third season of recycled water use, and at the end of the fifth season of recycled water use. Surface sampling and subsoil sampling (0 to 30 cm and 30 to 45 cm) are required after two seasons and six seasons of recycled water use. Full profile sampling (0 to 30 cm, 30 to 45 cm, 85 to 100 cm) is required after four seasons and at the end of eight seasons of recycled water use.

These requirements are presented in **Table 6-1 Soil sampling depth & frequency**.

As there has been a progressive signing on to the scheme over a number of years, there are properties at all different stages through this cycle. The 2011 sampling plan has been prepared by reviewing each property individually to decide on how the soils are to be sampled for analytical testing.

Irrigation with Class A recycled water at Werribee South commenced in January 2005 under licence from the Environmental Protection Authority (EPA). The operational framework of the recycled water scheme was initially described in the November 2004 Regional Environmental Improvement Plan (2004 REIP). The licence was approved until June 2009, beyond which continuation of the scheme was to depend upon the outcome of a review and audit of the scheme that was undertaken in 2008. The scheme has now been approved by the EPA for continuation until 2012. The original REIP has been updated and replaced by a new REIP that was released in July 2009 (2009 REIP). The procedure followed for site selection, site visit and soil sampling in 2011 is that outlined in the 2009 REIP.

Schedule for soil sampling	Soil Sampling Depth		
	0 to 30 cm	30 to 45 cm	85 to 100 cm
Baseline – prior to use of recycle water	✷	✷	✷
In May/June after 1 irrigation season	✷		
In May/June after 2 irrigation seasons	✷	✷ *	
In May/June after 3 irrigation seasons	✷		
In May/June after 4 irrigation seasons	✷	✷	✷
In May/June after 5 irrigation seasons	✷		
In May/June after 6 irrigation seasons	✷	✷	
In May/June after 7 irrigation seasons	✷		
In May/June after 8 irrigation seasons	✷	✷	✷

Table 6-1 Soil sampling depth & frequency

[*] The requirement for a subsoil test after 2 years recycled water use is specified in the 2004 REIP but not in 2009 REIP. The 2011 sampling plan has followed the 2004 REIP.

Not all farms have been tested each year. The protocol that has been adopted has been to collate data on water use for each farm and only those farms that have received recycled water of 1.5 ML/ha or greater are scheduled for soils monitoring. This has now become part of the 2009 REIP. Where a property was bypassed for monitoring last season but there has been collectively more than 2.0 ML/ha of recycled water use over the past 2 years, then this property has been included for soils monitoring in 2011. Where a property has registered for recycled water use but has not been tested for the two previous seasons due to low recycled water use, such properties are also included after three years.

One farm met all the criteria for potential exemption from the soil sampling plan for 2011. This farm had the key soil parameters of salinity, sodicity, chloride and pH all within target values from the 2010 monitoring. Thus these soils were in excellent health prior to the commencement of the 2010/11 irrigation season. The 2009 REIP specifies that such properties should be bypassed for monitoring for one season.

The remaining circa 200 farms that were bypassed for soil monitoring in winter 2011 had used insufficient volume of recycled water in 2010/11 for the sampling to be required.

A list of the farms that were part of the 2011 soil monitoring program is provided in **Table 6-2 Properties included in the sampling plan for 2011**.

Outlet	2010/11 Recycled Water Use (ML/ha)	Years of Recycled Water Use	Notes
WE 205	2.4	7th	Surface
WE 234	1.5	7th	Surface
WE 149	1.8	4th	Full Profile
WE 375	1.9	5th	Surface
WE 379	0.7	4th	Surface
WE 102	1.7	2nd	Surface
WE 278	2.1	6th	Surface & subsoil
WE 401	0.3	4th	Surface
WE 122	2.7	7th	Surface
WE 157	3.1	2nd	Surface
WE 349	0.3	4th	Full Profile
WE 354		3rd	Surface

Table 6-2 Properties included in the sampling plan for 2011

In the review of the soil analytical data in Section 6.6, averages across all monitoring sites have been used. As far as possible, soil monitoring sites have been selected to be representative of the soil and irrigation management for that property, and normally the cropping, irrigation and fertiliser management should be reflected in the chemical parameters obtained from the soil analyses. For each individual property however it is not possible to determine whether the irrigation water and cropping intensity has been applied evenly to the whole property, or whether some parts of the farm have had a lesser or greater amount of cropping activity. District averages are used to even out the variability involved in interpreting individual sites. At a farm level the individual sites have been interpreted for the key soil parameters, but in this report averages have been used unless otherwise stated.

6.3 Recycled Water Quality

The treatment processes for the recycled water at the Western Treatment Plant include conventional anaerobic and aerobic treatment, activated sludge treatment maturation for pathogen reduction, ultraviolet light treatment and chlorination. The effectiveness of these processes is subject to internal review by Melbourne Water and is beyond the scope of this report. As part of this internal review, Melbourne Water regular monitor the recycled water for a range of parameters, and the data from these analyses provides valuable information on the suitability of the water for various crops, and the potential cumulative effects of the water on the soils, the crop productivity, and the environment. **Table 6-3 Western Treatment Plant water quality for recycled water (post disinfection)** has been compiled from Melbourne Water data which is available on the SRW website[1].

The median recycled water value for total dissolved solids (TDS) was 980 mg/litre, down from 1050 mg/litre in 2009/10. Inorganic total dissolved solids (TDS inorganic) have a seasonal median of 860 mg/litre. The salinity of the water is determined by inorganic dissolved solids and is also measured through electrical conductivity, which has a seasonal mean value of 1800 µS/cm. The dominant cation was sodium and the dominant anion was chloride and combined they account for 75 % of the measured inorganic fraction of total dissolved solids. That is, measured sodium chloride accounts for 75 % of the measured salinity. The balance of the measured salinity was then comprised of roughly equal quantities of potassium, calcium and magnesium for cations. Total phosphorus in the recycled water has decreased from 9.8 in 2009/10 to 8 mg/L. This is still quite a high value and crops would be able to extract much of their phosphorus needs from the recycled water.

Apart from the cations sodium, magnesium calcium and potassium, the metal ions which registered consistently in the recycled water were boron, copper, iron, manganese, arsenic and aluminium. The first four of these metal ions (boron, copper, iron and manganese) are all plant nutrients and were present at levels that are below the potential for nutrient removal in a vegetable cropping system. Traces of zinc and nickel were also detected, but at low levels. Cadmium and mercury levels are below the detectable limits.

The salinity hazard of irrigation waters is both immediate and cumulative. The immediate hazard relates to tissue damage, particularly cuticle damage, as a consequence of the osmotic gradient induced by applying high salinity water to foliage. On sunny and warm days, the salinity may rapidly concentrate to toxic levels on the leaf surface as the water is evaporated away, leaving salt residues behind.

Chloride is a particular hazard because it has a high charge density, and is thus potentially more lethal than other ions with low charge density. The chloride concentration in the recycled water has decreased slightly since last year, but is still at a level whereby it could cause cuticle damage to the foliage of particularly sensitive crops such as lettuce, celery, onion and capsicum. Whether or not damage occurs depends upon the weather, soil conditions and irrigation method. If the water is applied under very hot and windy conditions, or is applied with a poor uniformity across the crop, damage is

[1] Southern Rural Water (SRW) website **http://www.srw.com.au/Page/Page.asp?Page_Id=323&h=0** Accessed 24 October 2011

more likely to occur. Irrigation systems which produce more misting also induce a higher risk of foliar damage.

The cumulative effect from salinity hazard relates to the progressive accumulation of salts in the root zone. Each irrigation applies another quantity of salts to the soil surface, some of which are plant nutrients but others have no useful function in plant growth. They all contribute to establishing an osmotic gradient from the plant roots to the soil, so that as the salts accumulate, the plant roots have progressively more difficulty in extracting moisture to maintain cell turgidity and maintain plant growth. Plants growing on salinised soils will tend to wilt under just mild conditions of moisture stress or heat stress. Until the salts are washed from the root zone, they will continue to accumulate and make plant growth progressively more difficult.

Parameter	**Units**	**Median 2010/11**	**Median 2009/10**	**Median 2008/09**
pH		**7.4**	7.5	7.6
BOD	mg/L	**4.0**	3.0	
Suspended Solids	mg/L	**3.0**	4.3	
E. Coli	orgs/100 mL	**0.00**	0	
Total Nitrogen	mg/L	**18.00**	18	17
Nitrite	mg/L	**<0.01**	0.034	
Nitrate	mg/L	**17.0**	17	
Total Phosphorus	mg/L	**8.0**	9.8	9.8
Sodium	mg/L	**270**	275	300
Potassium	mg/L	**28**	30	31
Calcium	mg/L	**41**	39	40
Magnesium	mg/L	**27**	27	28
SAR		**8.1**	8.3	8.9
Chloride	mg/L	**405**	425	450
Total Dissolved Solids (TDS)	mg/L	**980**	1050	1100
TDS (inorganic)	mg/L	**860**	920	990
TDS (organic)	mg/L	**125**	115	
Electrical Conductivity (EC)	µS/cm	**1800**	1900	2100
Metals of Interest				
Arsenic	mg/L	**0.002**	0.002	0.002
Boron	mg/L	**0.18**	0.18	0.24
Cadmium	mg/L	**<0.0002**	<0.0002	0.0002
Copper	mg/L	**0.01**	0.006	0.006
Iron	mg/L	**0.03**	0.0625	0.06
Manganese	mg/L	**0.02**	0.0335	0.038
Mercury	mg/L	**<0.0001**	<0.0001	0.0001
Nickel	mg/L	**0.01**	0.012	0.015
Zinc	mg/L	**0.03**	0.0265	0.023

Table 6-3 Western Treatment Plant water quality for recycled water (post disinfection)

The following will limit the hazards associated with using high salinity water:

- Avoid irrigation during mornings when temperature and evaporative losses are rapidly rising.
- Intentionally apply excess water as part of irrigation. An additional 20 % irrigation above crop requirements every third or fourth irrigation cycle should provide adequate leaching on permeable soils.
- Maintain enough operating pressure to ensure good irrigation application uniformity (Distribution Uniformity > 85%) in the applied water, without overdoing it and creating too much mist.
- Use soil management techniques to ensure that the soil profile maintains good vertical permeability. This includes measures such as regular use of gypsum, deep ripping, laser grading and artificial drainage.
- Modify fertiliser applications to match crop needs. Werribee South soils have high nutrient levels and there is considerable scope to reduce fertiliser rates.

The average salinity (TDS inorganic from **Table 6-3**) of the recycled water is 860 mg per litre, which means that for every 1000 litres, 860 grams or just less than 1 kg of salt is being applied to the soil. For every irrigated Megalitre of recycled water around 0.86 tonnes of salts are being applied. While some components of these salts are plant nutrients, around 75 % is sodium chloride which has no role in plant nutrition. The total salt load is substantial and these salts need to be removed from the soil profile on a regular basis to avoid accumulation to toxic levels. Most cropping cycles also add salts to the soil and between 500 kg and 1000 kg of fertiliser salt would commonly be applied in a single cropping cycle. Thus the total salt in the recycled water is similar to and approximately double the salt load received from fertiliser application.

For the six years prior to 2010/11, recycled water comprised the major source of irrigation water throughout the WID. In depth analysis of the constituents within the recycled water was appropriate given that recycled water was the main supply of salts along with fertiliser. Assessing the individual chemical parameters of the recycled water applied in the 2010/11 is not considered necessary given the low use of recycled water and that most of the irrigation water applied was from other sources such as bore and river water. The maximum use of recycled water by any one grower was 3.1 ML/ha which is well below last year's district average of 4.2 ML/ha.

6.4 Sample Collection and Processing

6.4.1 Procedures on Farms

For each property that has become part of the recycled water scheme, a reference site of approximately six metres in diameter has been created for the collection and analysis of soils. Where the farm operator has indicated significant soil variation on the property, more than one reference site has been created with each site being representative of a particular soil type. Baseline soil samples have been collected as bulked samples from four separate hand drilled auger holes from within the soil reference site. Soil samples are collected from the standard depths of:

0 to 30 cm: (regular cultivation zone for these soils) referred to as surface soils;

30 to 45 cm: the B horizon of most soils (immediately below the cultivation zone); and

85 to 100 cm: the C horizon (below the root zone).

Each reference site is identified with latitude and longitude coordinates taken from a hand held GPS receiver using the ADG 66 datum. The GPS coordinates are used to locate each reference site, and each location is normally cross checked against written notes and sketch maps of each property.

The soil depth at which tests are to be conducted on each property are different for each year of the scheme. The tests for the first four years of recycled water irrigation are specified in the November 2004 REIP and have been expanded out to the eighth year of irrigation in the 2009 REIP. Surface sampling only (0 to 30 cm) is required after the first, third, fifth and seventh season of recycled water use. Surface sampling and subsoil sampling (0 to 30 cm and 30 to 45 cm) are required after 2 years and 6 years of recycled water use. Full profile sampling (0 to 30 cm, 30 to 45 cm, 85 to 100 cm) is required in the fourth and eighth seasons of recycled water use. As there has been a progressive signing on to the scheme over a number of years, there are properties at all different stages through this cycle, and the sampling plan has to be reviewed on a farm by farm basis to determine how the soils are to be sampled for testing. The 2011 sampling plan identified 9 properties that required surface soil sampling only, 1 property that required surface sampling and subsoil sampling, and 2 properties for full profile sampling. This is well below the 143 properties sampled in winter 2010.

At all monitoring sites, soil samples were collected and bulked together from 4 separate hand augured sampling holes at each reference site. Where more than 1 reference site had been created on a property due to soil type or other variation, the farm operator was given the option as to whether to sample just one site or multiple sites, and if the former, to nominate which site was monitored. The soil samples were stored in cool boxes in the field and in a coolroom until transferred to Farmright Technical Services for processing.

6.4.2 Laboratory Procedures

Approximately 700 g of soil was forwarded to Farmright Technical Services in Kyabram, Victoria. Each bulked soil sample was then thoroughly mixed and dried prior to sub-sampling of approximately 100 g of soil, which was forwarded to MGT Environmental Laboratories in Oakleigh for cadmium residue analysis. Farmright conducted the following analyses on the remaining 600 g:

Soil pH (in water)	Phosphorus Buffer Index	Chloride
Soil pH (in Calcium chloride)	Nitrate	Slaking
Electrical conductivity	Exchangeable cations	Dispersion index
Available phosphorus & potassium (Colwell method)		

6.4.3 Soil Health

The 2009 REIP includes a procedure for formally assessing soil health via a set of soil targets and trigger levels for a designated set of soil parameters (salinity, chloride, sodicity, phosphorus and nitrate). A list of the soil trigger points and targets has been included in Table 6-4 Soil targets & trigger points (REIP 2009) for each of these soil parameters.

The REIP trigger points for each soil parameter identifies when a critical threshold for one of these parameters is exceeded. The farm operator is to be informed and advised as to the nature of the problem and the soil reference site is scheduled for further testing in 6 months.

The REIP target values identify the level of salinity and sodicity below which no soil management problems should occur in the immediate future. Sites where targets are met have soils that are in particularly good condition with no immediate threats or risks from any soil problems. At sites where all targets are met, the farm operator is informed that the property will be bypassed for soil monitoring for one year, and not scheduled for further soil sampling until 24 months time.

Soil Parameter	Sampling Depth (cm)	Target Value	Trigger Value
Soil Salinity	0 – 30	ECe < 3.5 dS/m	ECe > 6.0 dS/m
Soil Chloride	0 – 30	Chloride < 200 mg/kg	Chloride > 600 mg/kg
Soil Sodicity	0 – 30	ESP < 10 %	ESP > 15 %
Soil pH (1:5 water)	0 – 30	pH < 8.0	pH < 5 or pH > 8.0
Phosphorus (Colwell)	0 – 30		> 800 mg/kg
Phosphorus (Colwell)	30 – 45		> 200 mg/kg increase above baseline levels
Phosphorus (Colwell)	85 – 100		> 50 mg/kg increase above baseline levels
Nitrate	30 – 45		> 100 mg/kg increase above baseline levels
Nitrate	85 – 100		> 100 mg/kg increase above baseline levels

Table 6-4 Soil targets & trigger points (REIP 2009)

These soil health procedures have been followed for the 2011 soil results. The soil analytical data has been used to identify properties where one or more of the critical soil health parameters are beyond these trigger points. The data has also been used to identify properties that will be bypassed for sampling in 2012. The properties with soil health alerts are to be revisited for soil sampling in January 2012.

6.5 Reporting

Soil monitoring reports have been prepared for each site and forwarded to farm operators and owners where they are not the same.

The annual tabular report comes with customized comments and interpretation of the significant soil parameters along with a generic interpretation guide.

6.6 Soils Results for 2011

The analytical data for each monitoring site is kept in Excel spreadsheet format, with one copy held by the Senior Project Officer of Southern Rural Water and the other copy under password access at Ag-Challenge Consulting Pty Ltd. The analytical data for each monitoring site in winter 2010 is provided in Appendix 2 and January 2011 results are included in Appendix 3 of the Soil Monitoring Report in Attachment 15.2.

6.6.1 Soil Health

6.6.1.1 January 2011

As part of the 2009 REIP, sites which triggered a soil health alert in Winter 2010 were retested after six months (January 2011). There were 32 sites sampled as part of the follow-up monitoring as a consequence of soil health alerts from the Winter 2010 sampling.

This is the first time that the results of the six monthly soil health program have been included in the annual soil monitoring report. The complete set of results has been included in Appendix 3 of the report. A summary of the changes in sodicity (ESP) and salinity (E.C.e) relative to the 2010 winter results have been included in Table 5, along with the soil parameter that was triggered in winter 2010.

Wheel No.	ESP 2010	ESP 2011	Decrease in ESP	E.C.e 2010	E.C.e 2011	Decrease in E.C.e	2010 Trigger
134	19.4	11.9	7.5	5.7	3.0	2.7	ESP
234	16.5	8.2	8.3	4.6	3.0	1.6	ESP
380	18.8	9.5	9.3	3.6	3.1	0.5	ESP
71 B	17.9	10.4	7.5	4.4	2.6	1.8	ESP
190	15.5	13.3	2.2	3.7	2.6	1.1	ESP
222B	17.4	8.0	9.4	6.4	3.4	3.0	E.C.e & ESP
56	10.5	4.8	5.7	6.5	4.2	2.3	E.C.e
288	12.9	5.0	7.9	7.6	2.9	4.7	E.C.e
248	20.7	14.6	6.1	4.7	4.2	0.5	ESP
324	15.5	8.8	6.7	3.3	1.9	1.5	ESP
303	16.9	10.2	6.7	2.8	1.5	1.3	ESP
34	16.5	9.6	6.9	2.9	1.8	1.1	ESP
273	16.6	7.6	9.0	3.3	1.7	1.6	ESP
280	16.7	5.7	11.0	4.6	1.7	2.1	ESP
282	17.0	8.8	10.5	4.5	1.9	2.3	ESP
241	18.4	5.5	11.2	5.0	1.9	2.8	ESP
283	17.6	8.9	8.1	4.4	1.9	2.6	ESP
200A	16.7	8.6	9.8	3.8	2.2	2.8	ESP
307A	19.3	8.6	9.0	4.2	2.2	2.2	ESP
117	15.7	13.4	2.3	3.0	2.3	0.7	ESP
202	17.8	10.6	7.2	3.3	2.6	0.7	ESP
200	16.3	14.1	2.2	3.3	4.0	+0.7	ESP

Wheel No.	ESP 2010	ESP 2011	Decrease in ESP	E.C.e 2010	E.C.e 2011	Decrease in E.C.e	2010 Trigger
403	15.7	6.3	9.4	3.2	3.6	+0.4	ESP
225B	14.6	6.2	8.3	6.7	2.8	3.7	E.C.e
197	13.1	4.7	9.9	6.5	3.1	3.6	E.C.e
199B	14.5	10.8	2.3	6.5	2.4	4.1	E.C.e
369	15.7	9.3	6.4	3.0	2.2	0.8	ESP
401	19.1	17.5	1.6	2.7	3.3	+0.6	ESP
62	7.9	3.8	4.1	6.6	4.8	1.8	E.C.e
212A	10.1	4.2	5.9	6.4	2.8	3.6	E.C.e
126	11.1	4.9	6.2	6.2	2.8	3.4	E.C.e
376	17.9	13.0	4.9	3.1	2.2	0.9	ESP

Table 6-5 January 2011 monitoring sites & results for sodicity (ESP) & salinity (E.C.e) in comparison with Winter 2010
highlighted site remains the only one above the critical soil health level.

From Table 6-6 January 2011 monitoring sites & results for sodicity (ESP) & salinity (E.C.e) in comparison with Winter 2010 it can be observed that every site retested in January 2011 recorded a decrease in ESP and all but three sites recorded a decrease E.C.e. The decreases in sodicity and salinity were so significant that of the 32 sites which had triggered soil health alerts in Winter 2010, only one remained above the critical trigger level by January 2011. Also of particular note were the following statistics:

- 26 of the 32 sites moved below the target ECe value of 3.5 dS/m;
- 30 of the 32 sites moved below the target chloride value of 200 mg/kg and;
- 25 of the 32 sites became equal to or below the target ESP value of 10.

These were all very encouraging results and were mostly attributed to the average to above average rainfall in Werribee since the completion of the Winter 2010 sampling. The results and trends shown in these 32 sites monitored in January 2011 are reflective of the Winter 2011 results and demonstrate that the soils in the WID were showing improvement by January 2011. These positive results from 32 of the worst sites in the district assist in the verification of the results obtained from only 12 sites sampled as part of the annual soil monitoring program.

6.6.1.2 Winter 2011

A soil health alert was triggered for just 1 site from the 12 tested sites, which is less than 10 % of the properties tested. In 2010, 36 % of the properties exceeded at least one soil trigger. While the total number of properties monitored is small compared to 2010, the decline in the incidence of sites exceeding trigger levels is dramatic and demonstrates how well the soils have responded to the leaching rains. This point is further reiterated by the fact that 10 of the 12 properties tested now meet the REIP target levels for salinity, sodicity, chloride and phosphorus. This is a very positive result as only one property in 2010 reached the target level for all four soil health parameters. These 10 sites will not need to be monitored until 2013. It is recommended that an information sheet be sent to each of these farm operators, congratulating them upon the fine outcome of the results and that these sites will not need to be monitored in 2012 regardless of the amount of recycled water irrigated.

None of the properties exceeded the trigger levels for salinity, chloride and ESP. The one property that exceeded trigger values had a soil phosphorus level greater than the trigger level of 800 mg/kg in the surface soil (Highlights in red in Appendix 2 of the soil report). This site (outlet 315) exceeded the trigger level for salinity and ESP as part of the 2010 soil monitoring and was the only site of 30 to remain above the trigger levels when monitored in January 2010. Excess phosphorus in the surface soil is managed under the Nutrient Management Process of the Soil Improvement Plan (2009 REIP) and as such an information sheet will be sent to this farm operator. The information sheet outlines the nature of the soil health problem and provides some guidelines as to how to improve the soil. Follow up sampling for this site will occur in January 2012.

Of the three properties where subsoil was monitored, all were below the threshold for nutrient increases in nitrogen and phosphorus relative to baseline.

The number of sites monitored in 2011 is significantly lower than has occurred in recent years, but the number of sites exceeding the target levels provides a strong indication that soil health has improved markedly over the whole district in the past year. The improvement in soil salinity has can be attributed to the leaching rainfall, and the improvement in sodicity may be a result of gypsum applications in recent years starting to have an effect.

6.7 Trends in Surface Soils

The 2011 surface soils district average data for the significant soil parameters for sustainable irrigation with recycled water are shown in **Table 6-6 Comparison of surface soil parameters with baseline values** and in graphical format in **Figure 6-2, Figure 6-3 & Figure 6-4**. **Table 6-6** includes the data for the past four years and the baseline soil chemistry that has been collected from each property before irrigation with recycled water commenced. The following can be stated from a consideration of the data in **Table 6-6**:

- Total salinity (represented by E.C. and E.C.e) have decreased significantly in 2011 and are now well below baseline levels prior to the commencement of irrigation with recycled water. The 2011 district average for E.C. is 0.36 dS/m and represents a decrease of 0.12 dS/m (25 % lower value) compared with the 2010 mean value. This continues the downward trend in EC that was reported on in 2010 when EC decreased from 0.63 dS/m to 0.48 dS/m. The large decrease in surface soil salinity can be attributed to the above average rainfall over the past year and intensive leaching rains during this time. The fact that soil salinity is now well below the baseline level prior to the commencement of recycled water irrigation demonstrates the inherent resilience of these soils which enables them to be so responsive and so suitable for recycled water irrigation and intensive cultivation. The decrease in surface soil E.C. may also be in part attributed to the use of better quality irrigation water supplied from the Werribee River.
- District average exchangeable sodium percentage (ESP) has shown a genuine decrease for the first time since the commencement of irrigation with recycled water. The soil ESP was steadily increasing up until 2009, but remained essentially unchanged from 2009 to 2010 at around 13. The decline in the district mean ESP value from 13.3 to 8.6 in 2011 presents a vast improvement in likelihood of maintaining soil structure under regular and intensive cultivation. The improvement in soil ESP is unlikely to be directly attributed to the leaching rainfall, as rainfall alone will not change the ratio of cations on the clay lattice. Anecdotal evidence suggests that gypsum use throughout the district has been on the rise for some

years. Gypsum does not readily dissolve and can therefore take years to react upon the soil ESP, particularly on alkaline soils as are present across the WID. The more widespread use of gypsum now appears to be having a positive impact upon soil sodicity.

- The soils of the WID now appear to be in very good condition to receive further recycled water. In 2010 there was no corresponding decline in soil sodicity to much the sharp decline in salinity and as such soil structural stability was still at risk. While the soils are now still slightly sodic, the soils are in better shape than they have been since irrigation with recycled water commenced. The soils of Werribee South are unique and have responded well to the leaching rains of the past year. There is still a strong need to continue with the application of gypsum on the soils of Werribee South, to ensure soil structure is maintained.
- The mean district value for soil chloride in surface soils was 218 mg/kg in 2010 and has now decreased to 107 mg/kg, which is a decrease of 111 mg/kg. The current district mean chloride value is now around half the baseline value. The downward trend in soil chloride is clearly depicted in Figure 4, which also highlights that the district mean for soil chloride is well below the critical level of 400 mg/kg at which plant toxicity may start to occur.
- Soil phosphorus has increased from 475 mg/kg in 2010 to now be 612 mg/kg. This is the largest increase in soil phosphorus since soil monitoring commenced and is difficult to explain, given that is has remained steady for the past 5 years. The amount of phosphorus applied in the recycled water cannot account for this large increase and it must have come from another source. These levels of soil phosphorus are very high and well above that required for maximum plant growth. There is a genuine risk that this phosphorus will be mobilised from the surface soil to the subsoil and groundwater in the future. Soil phosphorus levels do not need to be this high and more work is required to educate growers if a decline in phosphate fertiliser use across the district is to be achieved.

- Soil nitrate levels are now below that recorded in baseline sampling. Measurement of soil nitrate can vary with soil moisture, temperature and other seasonal variations. Current nitrate levels are of no concern.

- The other parameters in **Table 6-6** show no definite changes.

Parameter	Units	**Mean Value**	**Mean Value**	**Mean Value**	**Mean Value**	**Mean Value**	**Mean Value**
		Baseline sampling	2007	2008	2009	2010	**2011**
Electrical conductivity	dS/m	0.47	0.6	0.59	0.63	0.48	**0.36**
E.C.e.	dS/m	3.5	4.5	4.5	4.6	3.6	**2.7**
Chloride	mg/kg	192	320	270	341	219	**107**
Exchangeable Sodium Percentage	%	9.5	12.4	12	13.6	13.3	**8.6**

Parameter	Units	Mean Value	Mean Value	Mean Value	Mean Value	Mean Value	Mean Value
		Baseline sampling	2007	2008	2009	2010	**2011**
pH (in water)	pH	8.1	8.2	8.2	8.2	8.1	**7.9**
Available phosphorus	mg/kg	430	446	474	464	475	**612**
Nitrate	mg/kg	40	59	47	55	35	**28**

Table 6-6 Comparison of surface soil parameters with baseline values

The positive soil results from the 12 farms monitored Winter 2011 as part of the annual soil monitoring program are reflective of the trends shown from the 32 sites monitored in January 2011 as part of the six monthly soil health program.

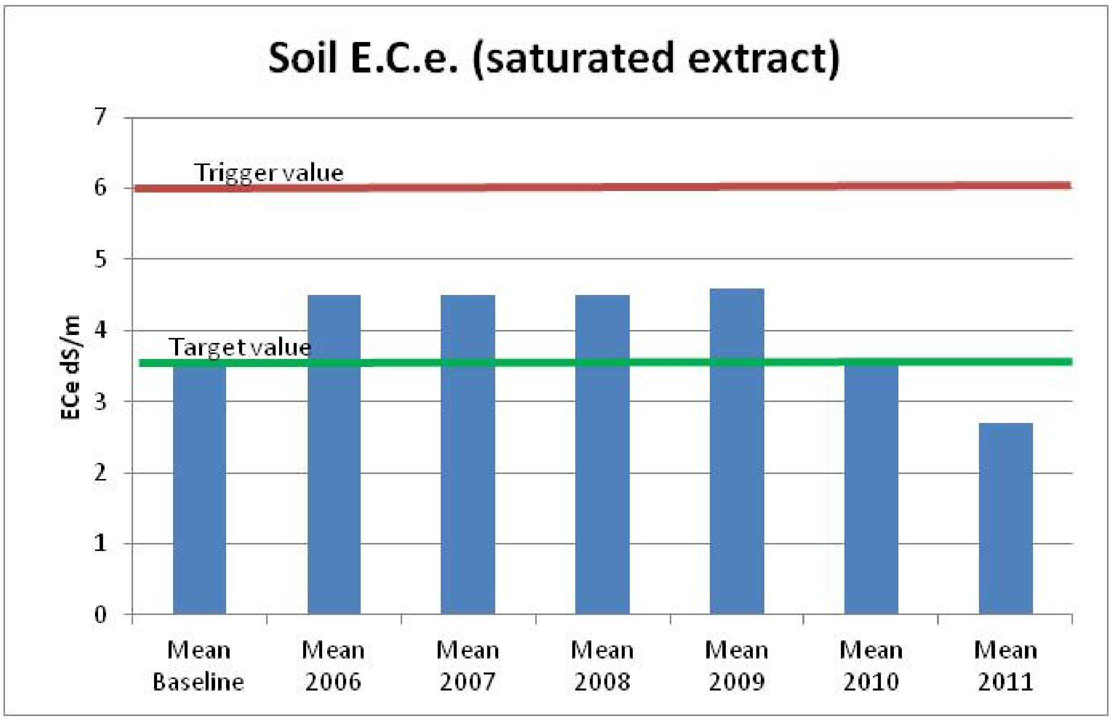

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Figure 6-2 Soil salinity (E.C.e) for surface soils (0-30cm) from baseline to 2011

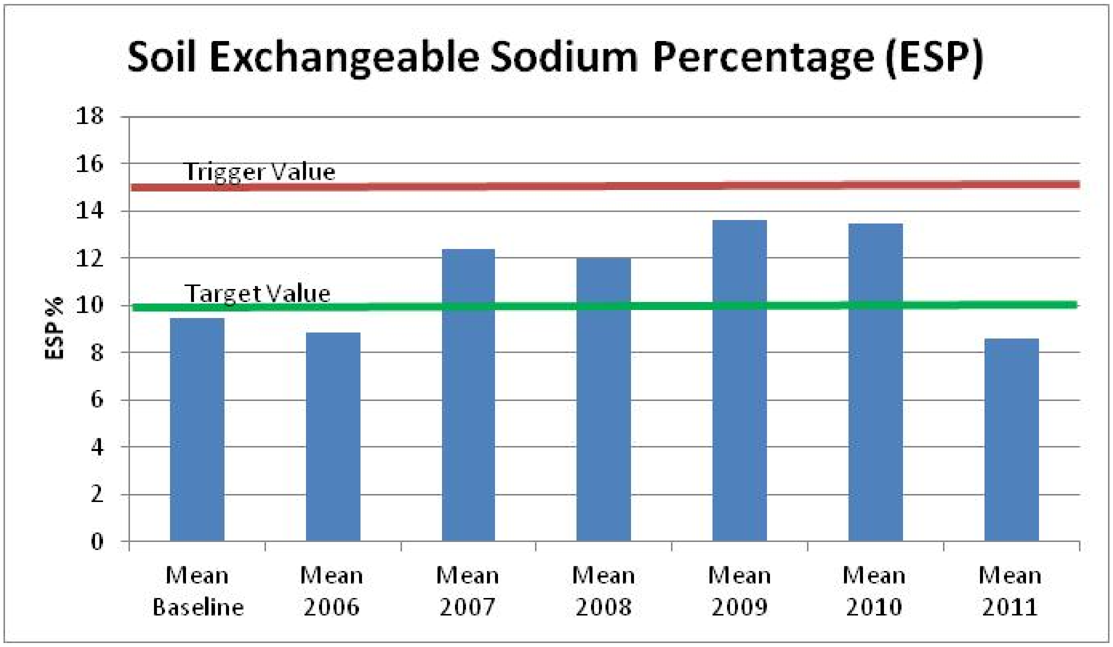

Figure 6-3 Soil sodicity (ESP) for surface soils (0-30cm) from baseline to 2011

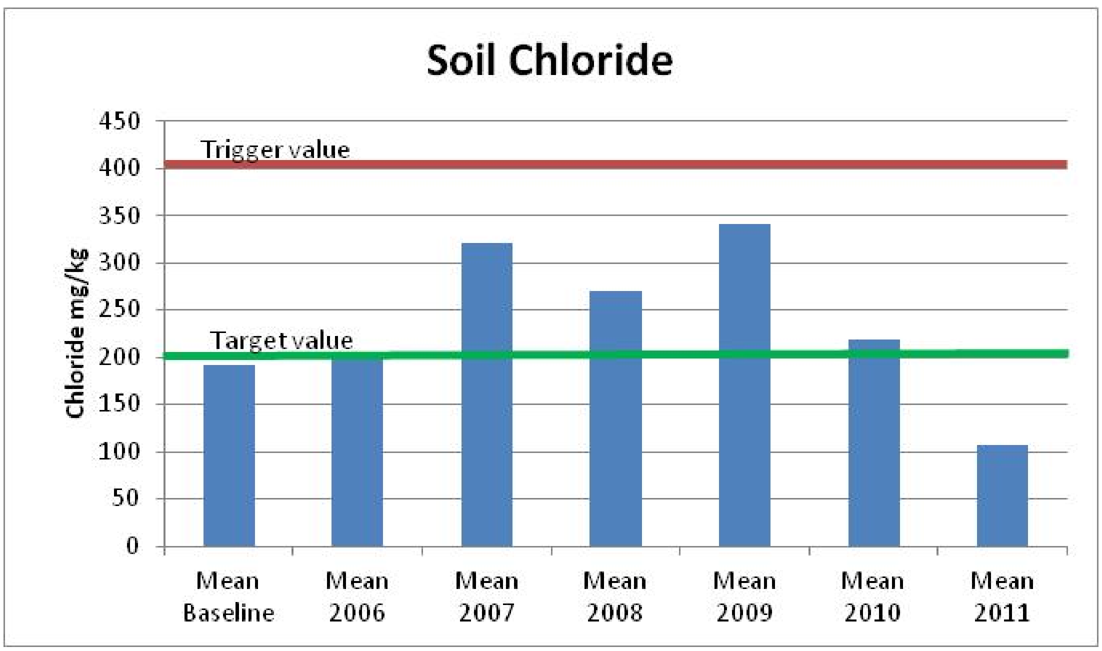

Figure 6-4 Soil chloride for surface soils (0-30cm) from baseline to 2011

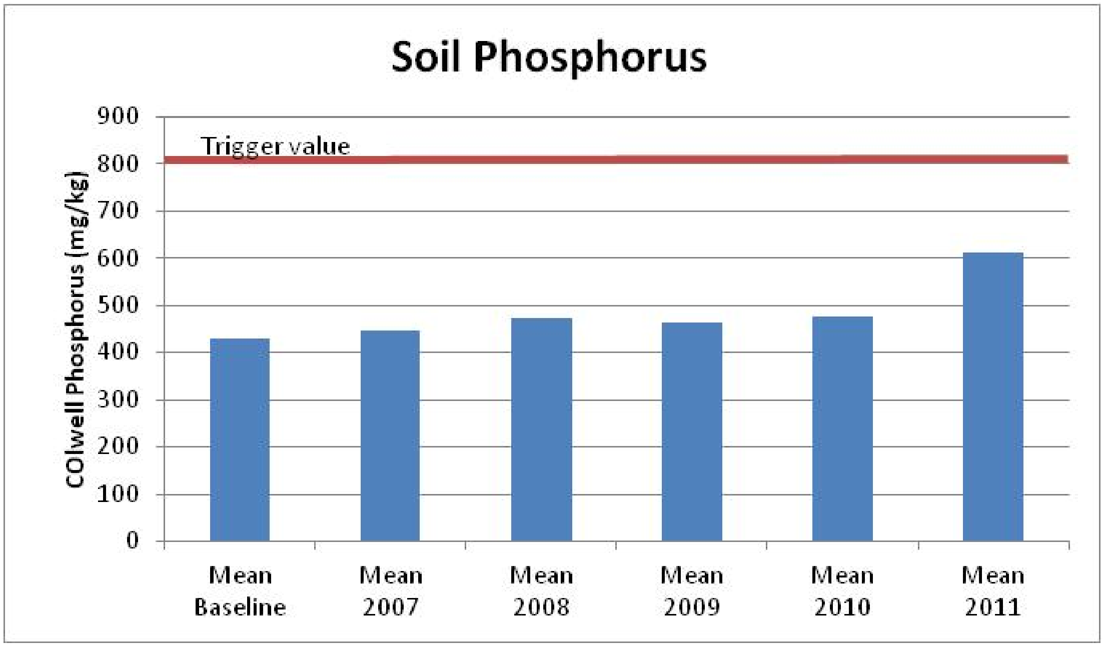

Figure 6-5 Colwell phosphorus for surface soils (0-30cm) from baseline to 2011

6.8 Trends within the Subsoil

There has been insufficient sampling of the subsoils at depths of 30 – 45 cm and 85 – 100 cm to warrant comparison with past years.

6.9 Individual Soil Parameters

6.9.1 Salinity

There has been a steady decline in the district mean soil salinity (E.C.e) since 2009 from 4.5 dS/m to the current 2.7 dS/m (**Figure 6-2**). Soil salinity is now well below both the soil health target and baseline level of 3.5 dS/m. This is a very positive result. The sharp decrease in salinity over the past year also implies that the soils remain permeable and responsive to leaching volumes of water, which is essential for the long-term viability of recycled water irrigation. The large decrease in surface soil salinity is most likely a result of well above average rainfall over the past 12 months and reiterates the need for substantial leaching irrigation rates, when rainfall is below the long-term mean.

The large decrease in E.C.e means that the previous district problem of high soil salinity is now well under control. The district mean surface soil salinity of 2.7 dS/m is below the critical E.C.e value for a 25 % reduction for all crops listed in **Table 6-7**, including lettuce. It is likely that a greater range of crops can now confidently be grown in the WID without a reduction in yield due to salinity.

Vegetable	Critical E.C.e Value for 10 % Yield Reduction	Critical E.C.e Value for 25 % Yield Reduction
Broccoli	3.9	5.5
Cabbage	2.8	4.4
Celery	3.4	5.8
Lettuce	2.1	3.2

Table 6-7 Critical E.C.e values - Source: Ayers & Westcott 1991, Landon 1984

6.9.2 Chloride

Chloride can damage the leaf cuticle if the concentration becomes high enough on the leaf surface, the result being a necrotic burn to the leaf margins of the younger and softer leaves. This is a specific hazard for the chloride concentration in the irrigation water, although there is some interaction with soil chloride. It is also highly soluble and is among the most mobile ions in soil water. Soil chloride values above 400 mg/kg indicate that a toxicity problem may be occurring, and values of 600 mg/kg would be of concern. Irrigation management plays a very important role in determining whether or not chloride accumulates in the surface soil.

The mean chloride values for the 2011 soils monitoring have decreased substantially from the 2010 values. The mean surface soil chloride is currently 107 mg/kg, down from 318 mg/kg in 2010 and is now well below the baseline mean of 192 mg/kg.

There were no soil health alerts for elevated soil chloride.

6.9.3 Sodicity

A soil is deemed to be sodic if more than 6 % of the exchangeable cations are sodium ions, and strongly sodic if the sodium ions comprise more than 15 % of the total exchange capacity. Surface sealing, reduced aeration, reduced permeability, tendency to disperse, and difficulty in getting the right moisture content for cultivation are all negative properties of Werribee soils that are a direct consequence of sodicity. During the baseline sampling of these soils, approximately 80 % of the district soils were sodic at the soil surface and there were 13 sites where the soil was strongly sodic in the soil surface.

Soil sodicity has declined for the first time since soil monitoring commenced and the district mean ESP of 8.6 is now below the soil health target and baseline ESP levels of 10 and 9.5 respectively. Four of the 12 soil monitoring sites now have ESP values of 6 or less and are no longer considered sodic. The mean value for ESP across the 12 monitoring sites of 8.6, presents a substantial decrease from the district mean 13.3 in 2010. The risk of soil structure loss and reduced soil permeability has significantly declined as a result of this decrease in soil sodicity. The soils are now in a much better condition to receive recycled water than they were prior to the commencement of the recycled water use in the WID.

There are a number of possible explanations for the sudden seemingly district wide decline in soil sodicity. Gypsum has been applied to soils across the district for some years now but until this year has been relatively ineffective in reducing soil sodicity on a district wide basis. Some potential explanations for the sudden decline in ESP include:

- Gypsum application rates have increased to a level that is sufficient to off-set the amount of sodium applied from all sources such as recycled water, inorganic fertiliser, chook manure, irrigation water from other sources, eg bore and river water.
- Gypsum is being used by more growers such that the district wide application rate has increased.
- Responses in ESP are normally slow (eg in the order of years) compared to responses in soil salinity (eg in the order of weeks or months). The increased use of gypsum over the years across the district may now be starting to have an impact on sodicity.
- The soils meet some of the criteria of “Self reclaiming” soils as defined by the FAO. Strictly speaking Self reclaiming soils contain natural gypsum, which is slowly released with sufficient leaching rates of irrigation. While gypsum is not naturally present in these soils, the soils are naturally calcareous and alkaline and as such applied gypsum will be slow to dissolve and react on the clay lattice to displace sodium. On properties where gypsum has been applied in recent years, there may have been insufficient leaching with irrigation water for this gypsum to fully dissolve and react on the soil lattice. The leaching rains over the past year may have been adequate to enhance the reaction rate of gypsum in the soil, prompting the sudden decline in soil sodicity. The minor decrease in pH will also have assisted in the natural remediation of these soils.

Regardless of the cause, the substantial drop in soil sodicity is a very positive outcome, and bodes well for soil structure, permeability and workability across the entire WID. Despite the small number of monitoring sites assessed this year, the downwards trends in sodicity and salinity are steep and have been consistent across all sites. It is therefore fair to predict that these positive trends are likely to be indicative of the WID as a whole.

6.9.4 Soil pH

The main issue with soil pH is the impact of very high values (above 8.5) on the solubility of calcium, and thus the effectiveness of gypsum. At pH values above 8.5, free carbonate ions in the soil can potentially bind with the soluble calcium ions from the gypsum and form the relatively insoluble salt of calcium carbonate. Calcium carbonate would then precipitate out of solution within the soil water, rendering the calcium unavailable for cation exchange with sodium on the clay lattice. Farm operators should avoid liming their soils to a pH level above 8.5.

There is also an issue of reduced availability of a number of plant nutrients at soil pH values above 8.5. Zinc and manganese are affected by pH values at this level and above.

The soil pH throughout the profile has remained relatively unchanged since the commencement of irrigation with recycled water, but the mean district soil pH of 7.9 has dropped below 8 for the first time. This decrease in soil pH is not surprising given the pH of the recycled water and leaching rains which may have removed some of the carbonate. As per 2010, no farms exceeded the soil health trigger for soil pH, which is a good result. A minor decline in soil pH has the potential benefit of increasing the rate at which gypsums reacts in the soil and may also increase the availability of some nutrients.

Traditionally lime has been applied to suppress soil borne diseases. Anecdotal observations suggest that applying lime in narrow bands along transplant rows is now becoming more common rather apply the lime to the whole of the cultivated area. This change in management practice may be resulting in less total lime use, which may be contributing to the decline in the district wide mean soil pH.

The slight decline in soil pH is of no concern and may be beneficial in increasing the reactivity of gypsum.

6.9.5 Soil Nitrogen

Nitrate tests are an imperfect assessment of soil nitrogen. Nevertheless low values for nitrate are normally around 15 mg/kg or less, and a high value is greater than 50 mg/kg. Outside these extremes the soil could be either in need of additional nitrogen, or have excess nitrogen.

The mean surface soil nitrate value of 28 mg/kg is lower now than it was during baseline sampling of 40 mg/kg. No farms in 2011 exceeded the soil health trigger for elevated nitrate in the subsoil.

Soil nitrate levels are currently of no concern.

6.9.6 Soil Available Phosphorus

Soil available phosphorus across the WID was extremely high in baseline samples analysed prior the commencement of irrigation with recycled water. The district has a long history of vegetable growing, and common fertiliser practice has been to use more phosphorus fertiliser than the crop requires to ensure there is no limitation to growth. Unused fertiliser can accumulate in the soil and may be available for future crops to use.

The district average soil available phosphorus (Colwell test) at baseline sampling was 430 mg/kg. In 2011 the district mean for soil available phosphorus is 612 mg/kg. For the past five years soil phosphorus has remained relatively unchanged, and where a change has occurred the change was minor and statistically significant. The increase in soil phosphorus of 137 mg/kg in the past year has been significant and cannot be attributed to recycled water use alone. Phosphorus in the recycled water is present at a concentration of 8 mg/L. The mean recycled water hydraulic loading rate of the 12 monitored sites was 1.6 ML/ha, which equates to a mean phosphorus application rate of 12.8 kg/ha. This is the equivalent of around 100 kg/ha of single super fertiliser, which would be expected to increase the Colwell phosphorus value to a depth of 30 cm in WID soils by 1 to 2 mg/kg of Colwell phosphorus. The increase in soil phosphorus of 137 must therefore be a result of other sources such as fertiliser, chook manure, river or bore water.

The only soil health alert triggered in 2011 was for elevated soil phosphorus in the surface soil at one site. However given the district wide increase it appears as if most growers are applying phosphorus over and above plant nutrient requirements, be it intentionally in fertiliser and soil ameliorants or else inadvertently in irrigation waters. It is likely that the number of phosphorus binding sites in these surface soils has been exceeded and phosphorus has begun to migrate vertically down through the soil profile. Considerable opportunity appears to exist for reducing phosphorus in the applied fertiliser. The level of phosphorus removal in most vegetable crops ranges from 13 kg/ha to 79 kg/ha depending on the crop being grown. The annual quantity of phosphorus being applied in the recycled water averages 12.8 kg/ha at the mean hydraulic loading for the district of 1.6 ML/ha. Fertiliser phosphorus may be unnecessary for some cropping cycles, or is only required at minimal levels.

The Smart Water project in Werribee included a number of trial plantings where phosphorus was removed from the planting fertiliser completely. Lettuce and cauliflower crops were sown with a planting fertiliser that applied nitrogen and potassium only. The crops were observed to see if there were any differences in yield, crop maturity, or product quality as a consequence of removing phosphorus from the planting mix. Samples of crop tissue were analysed to see if there were any measurable differences in chemical composition as a consequence of the different fertiliser. All the trial plantings had normal fertiliser practice alongside for comparison. Some farms were followed through multiple crop cycles to see if there were any long term effects.

What was found:

- The crops with no phosphorus at planting had **no measurable differences** in leaf phosphorus levels or for any other nutrient.
- **The marketable yields were generally no different.** For one lettuce crop the grower thought that there may have been a very minor delay in maturity but the following crop on the same area showed no observable differences.
- **There was no effect on product quality** as a consequence of removing phosphorus from the fertiliser program.
- Comparative soil tests are not able to show any decline in soil phosphorus as a consequence of removing phosphorus from the fertiliser program.
- There is a potential cost saving in fertiliser of around $100 per hectare from taking phosphorus out of the base fertiliser mix.
- This saving can be fairly easily captured by using Rustica Gold fertiliser at planting instead of Rustica Plus. To get the financial benefit the Rustica Gold is applied at 400 kg/ha instead of the more commonly used rate of 500 kg/ha. The Rustica Gold is higher in nitrogen and potassium than Rustica Plus and only needs to be used at this reduced rate to apply the same quantity of nitrogen and potassium.

Despite the potential saving offered by the use of this product, anecdotally there has been no significant shift in the district towards the use of Rustica Gold as a replacement for Rustica Plus at planting. It is likely that the potential saving in fertiliser is not deemed significant compared to the perceived potential reduction in crop yield and its associated cost.

6.9.7 Cadmium

Regular soil cadmium tests were specified in the November 2004 REIP, and regular tests have been undertaken each year since the commencement of recycled water irrigation in the district. However their inclusion in the testing program has been a matter for debate because the levels of cadmium in the recycled water are extremely low and unlikely to constitute a human health hazard. Soil cadmium values at or above 1.0 mg/kg are considered to pose some potential risk of uptake of cadmium into the harvested product presented for sale to the consumer. As well as soil levels, the uptake is determined by many other additional factors including crop type, cultivar, soil pH and salinity. Soil cadmium tests are subject to cyclic and sampling variability.

The 2009 REIP modified the cadmium testing regime to a two year interval, pending the outcome of the 2009 soils monitoring report. For the third year in a row the 2011 soil monitoring results have had no monitoring sites return a soil cadmium level in excess of 1.0 mg/kg.

It is recommended that further cadmium tests be deferred until 2013 soil monitoring.

6.10 Storage and Retrieval

A full set of the 2011 monitoring data has been added to the Excel spreadsheet *werribeedatacurrent.xls* and two copies of this spreadsheet exist – one is held on computer file by Ag-Challenge Consulting with password access only and the other is under the control of the Senior Project Officer, Southern Rural Water. Access to the version held by Southern Rural Water is under the authority of the Senior Project Officer.

An abridged version of the data is provided in Appendix 2 of this report. The identification of property owners, crown allotment numbers, latitude and longitude coordinates and other identification has been removed from the abridged version.

6.11 Recommendations and Conclusions

Werribee South has received well above average rainfall over the 2010/2011 season and this has resulted in the significant improvement of most soil parameters monitored. The above average rainfall has meant that the demand for recycled water has also declined, such that only 12 sites used more than 1.5 ML/ha and these are the only sites upon which the findings in this report are based.

Surface soil salinity has decreased dramatically in the past year from 3.6 dS/m, to now be 2.7 dS/m, which is also well below the baseline level of 3.5 dS/m measured prior to the commencement of irrigation with recycled water. This is a very positive result and suggests that a large amount of salt has been leached from the soil profile, and will enable a broader range of crops to be grown in the WID going forward.

For the first time since the commencement of irrigation with recycled water, soil sodicity has also decreased. The decrease in the mean ESP across the district has been substantial, from 13.5 to 8.6. Four of the 12 sites monitored no longer have sodic surface soils. This decrease in soil sodicity will have a positive impact upon soil structure, further enhancing the soils ability to mobilise salts from the soil profile. The sudden decline in soil sodicity may be attributed to a number of factors but it is likely that increased use of gypsum across the district is a contributing factor.

These substantial improvements in both soil salinity and sodicity, further exemplifies the quality of the soils in the WID and the speed by which they are able to recover. With salinity and sodicity currently lower than when recycled water irrigation commenced, the soils are now in a better condition to receive recycled water than they were prior to the commencement of irrigation with recycled water. This demonstrates the potential sustainability of recycled water irrigation in the WID given adequate leaching rates are applied.

A total of 10 of the 12 sites monitored in 2011 achieved the soil health targets for all four soil health parameters; salinity, sodicity, chloride and pH. According to the 2009 REIP, having achieved the target level for each of these four soil parameters, these 10 farms will not be included in the annual soil monitoring program in 2013. Only one of the 143 sites achieved the soil health target for all four soil parameters in 2010.

Only one farm exceeded a soil health trigger in 2011. This farm exceeded the surface soil phosphorus threshold of 800 mg/kg. This is the second time this site has exceeded a soil health trigger. Last year this site exceeded the triggers for both salinity and sodicity.

Despite only one farm exceeding the soil health trigger for elevated phosphorus in the surface soil, the district mean phosphorus level at this depth has increased from 475 mg/kg in 2010 to now be 612 mg/kg. This is a substantial and unnecessary increase in soil phosphorus. Trials conducted as part of the Smart Water Project in Werribee have found no detrimental effect to crop yield or quality from removing phosphorus from the fertiliser at planting. This message needs to be more widely disseminated throughout the WID grower community.

For the third year in a row, the 2011 soil cadmium tests have returned no sites with values above 1.0 mg/kg in the surface soil. **It is recommended that further soil cadmium tests be deferred until soil sampling in June 2014.**

7. Reporting Triggers

Table 6.0 – REIP 2009 reporting triggers

Trigger Value		Outcome
Recycled Water		
Concentrations exceed recycled water defined in MW RWQMP and “Guidelines for Environmental Management: Dual Pipe Water Recycling Schemes” (EPA Pub. No. 1015, Oct 2005)		Refer 2010-2011 Melbourne Water Annual Report
Conditions are such that undesirable levels of chloramines maybe produced		No chloramine was produced during the 2010-2011 season
If known extreme levels of toxicants are identified in recycled water that exceed relevant guideline levels in ANZECC / ARMCANZ 2000.		Refer 2010-2011 Melbourne Water Annual Report
WID Water Distribution System Inflows and Outflows		
Water management system identifies less than 60% efficiency on an annual flow basis.		This trigger was not exceeded; refer Section 2 for summary data.
Customer Site Soil Triggers		
Salinity > 6.0 ECe	Sodicity > 15% ESP	For sites that exceeded these triggers the criteria outlined in the Soil Improvement Plan were followed. Customers have been notified and all exceeded triggers have been recorded. Please refer Section 6 (Soils) for more information regarding soil sampling results.
pH <5.0 or >8.8	Chloride > 600mg/kg	
Phosphorus (Cowell):	Increase above baseline levels	
Depth	85-100cm	
Trigger	> 50mg/kg	
Nitrate:	Increase above baseline levels	
Depth	85-100cm	
Trigger	> 100 mg/kg	
Groundwater		
Concentrations of parameters monitored as per Table 6-4 of the REIP increase significantly (> 20%) from pre-recycled water (January 2005) baseline levels		Some triggers have been exceeded, refer to Section 5.4
Concentrations of parameters monitored as per Table 6-4 of the REIP exceed SEPP or ANZECC / ARMCANZ 2000 water quality objectives for defined Beneficial Use Criteria		
Surface Drains		
Concentrations of parameters monitored as per Table 6-5 of the REIP exceed SEPP or ANZECC / ARMCANZ 2000 water quality objectives for defined Beneficial Use Criteria		These triggers have been exceeded, refer to Section 3.1.2
Receiving Waters: Werribee River Estuary & Port Phillip Bay		
Concentrations of monitored parameters as per Table 6-6 in the REIP exceed SEPP or ANZECC / ARMCANZ 2000 water quality objectives for defined Beneficial Use Criteria		These triggers have been exceeded, refer to Section 4.1.4

8. Asset Inspection & Maintenance

8.1 Melbourne Water asset handover for WID

Melbourne Water are currently responsible for all scheduled and unscheduled maintenance from the Western Treatment Plant to downstream of the supply valves on the main and the 4/1 channels.

Negotiations are currently underway for SRW to take over the maintenance responsibilities for the valves, meters, automatic actuation and infrastructure at both these supply points. The outstanding issues to be resolved are the SCADA automation, automatic shut-off for the main valve and the 4/1 sensor. The main valve issue has been rectified by Melbourne Water and the SCADA system and 4/1 sensor issues require further testing to ensure that they are now operating correctly.
The currently plan is to complete testing after the supply of recycled water to the WID resumes in March 2012. SRW will continue to engage Transfield for the maintenance of the assets when the transfer is complete.

8.2 SRW Assets

During 2010-2011 SRW started asset life and asset condition inspections in the WID and currently 60% of these reviews have been completed. The reviews consist of rating the condition of the asset and scheduling any urgent maintenance.

Table 7.0 – SRW asset maintenance overview

Asset	SRW (or Contractor)	2010 Performance
Asset Life Inspection		
	Ongoing - 5 year cycle	60%
Channels		
Maintenance and Repairs	Ongoing	Completed
Inspection	Ongoing	Completed
De-silting	June – Sept	Completed
Weed Control	Quarterly	Completed
Drains - WID		
Maintenance and Repairs	Ongoing	Completed
Weed Control	Quarterly	Completed
Inspection	Ongoing	Completed
Flow Monitoring	Ongoing(now data log capable)	Completed
Monitoring Equipment	Monthly	Completed
Drain 1 - WID		

Maintenance and Repairs	When required	Completed
Inspection	Quarterly	Completed
Weed Control	Quarterly	Completed
Pipeline		
Maintenance and Repairs	Ongoing	Completed
Equipment – Valves / Meters / Wheels		
Maintenance and Repairs	When required	Completed
Inspection	Ongoing	Completed
Interface Point - Downstream		
Maintenance and Repairs	Quarterly and as Required	Completed
SCADA System	When required	Completed
Interface Point - Upstream		
Maintenance and Repairs	Subject to SRW Acquiring Asset	Asset handover pending due to repairs
SCADA System	Subject to SRW Acquiring Asset	Asset handover pending due to repairs
Outfalls		
Maintenance and Repairs	Ongoing	Completed
Monitoring	Ongoing(now data log capable)	Completed

9. Incident & Non-conformance Reporting

9.1 Receiving Waters Sampling June 2011

During the receiving waters sampling program the June 2011 sample gave a very high reading of nitrogen at the W9 sampling point. On reviewing the data we requested that the laboratory retest the sample to confirm the result.

Unfortunately the laboratory had disposed of the original sample and not retained a second sample for retesting, as stipulated in the 2009 REIP.

The procedures at the testing laboratory have now been updated to hold a second sample, which is frozen, in the eventuality that retesting maybe required.

10. Complaints & Enquiries

There was very little operational interaction with recycled water customers during 2010-11. The main reason was the availability of river water due to above average rainfall in the catchment filling the storages at Pykes Creek & Melton. Additionally the groundwater extraction ban was also lifted during the season as aquifer levels recovered.

The structure of the shandy rules in the REIP also made it difficult to deliver recycled water to customers in seasons when river water allocations are above 50% and SRW struggled to even meet the 25% take-or-pay component of the supply contract.

SRW drafted a proposal to EPA, with assistance from URS, to request an amendment to the shandy rules that would enable consistent delivery of recycled water every year in line with the 50% take-or-pay requirement stipulated by Melbourne Water.

After consultation with EPA agreement was reached to change the recycled water shandy rules in the 2009 REIP. A copy of the proposal to EPA is attached to this document.

11. Audits & Verification of Information

In reviewing the Customer Site Management Plans the Operations Supervisor WID decides which properties should be targeted for an audit of the CSMP, based on the contents of the CSMP, recycled water delivery history and customer knowledge.

In addition to these customer sites SRW will also conduct CSMP audits at sites where the soil results have consistently exceeded the trigger values in the REIP and Customer Supply Agreements.

> In 2011, there were 20 sites audited in the WID, managed by 20 farm operators. SRW staff visited these locations between 16th May and 18th May 2011.

Issues

1. At WE294, the CSMP did not reflect the most up to date details for the property.
2. At WE228, taps carrying recycled water required painting lilac.
3. At WE112, recycled water signage was required.
4. At WE375, recycled water taps required repainting lilac.
5. At WE188, an updated map needed to be generated.
6. At WE257, an updated map needed to be generated.

12. Improvement Programs

In 2010 / 2011, due to the higher allocation of river water and very low supply of recycled water there was very little focus on programs associated with recycled water delivery.
The Werribee Irrigation Futures project is progressing with a business case due for publication in the 2011/2012 season.

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13. Data Quality Statement

Data Source:	Annual Soil Sampling Program Receiving Waters Monitoring Program WID Groundwater Monitoring Program WID Drainage Monitoring Program
Institutional Environment:	SRW collects this data gathered by private contractors, including Ag-Challenge Pty Ltd, Ecowise Australia Pty Ltd, Theiss & SKM The data was collected under the guidelines set forth by the 2009 Regional Environmental Improvement Plan for the Werribee Irrigation District Recycled Water Scheme. The data was compiled by the organisation responsible for collection.
Relevance:	Werribee Irrigation District during the 2010-2011 financial year. WID Water Supply data includes volumes of water from all sources, into and out of the district. WID Groundwater data includes levels and sample analysis for major cations, heavy metals and nutrients. WID Drainage data includes volumes, major event logging and water quality. WID Receiving Waters data includes water quality. WID Annual Soil Sampling Program data includes standard agronomic tests, cation balances and soil texture. The data has been collected to ensure that SRW are able to comply with the monitoring requirements of the WID Recycled Water Scheme REIP 2009.
Timeliness:	All data was collected in accordance with the guidelines set forth in Section 6 of the WID Recycled Water Scheme REIP, any exceptions have been clearly identified. The reference period for this data is the 2010-2011 financial year.
Accuracy:	All samples were taken in accordance with the requirements in Section 6 of the WID Recycled Water Scheme REIP, each of the organisations collecting the samples have provided relevant QA statements. Privacy legislation requires that soil samples taken from landholders cannot be individually identified from any published use of the data. All data has been compiled by fully accredited organisations with the relevant QA checks in place to minimise processing errors. The data has also been verified by SRW staff to ensure that the reporting requirements have been met. When data collection has not occurred according to the schedules set out in the WID Recycled Water Scheme REIP, this has been recorded and noted in the Annual Report.
Coherence:	The data from 2010-2011 is directly comparable to the previous year and more detailed than samples taken in earlier years. However, valid comparisons can still be made between results from different years. There is a consistent time series for this data.

	In 2010-2011 the impact of recycled water in the WID would have been mitigated by the increase in rainfall over previous monitoring years. This is reflected in the subsequent results. The data is collected and recorded in a way that enables direct comparison with SEPP water quality objectives for Victoria.
Interpretability:	Other Supporting information: For additional information please refer to the WID Recycled Water Scheme REIP, available for download from the SRW website.
Accessibility:	The data is available in the 2010-2011 REIP Annual Report, which provides summary information for each reporting category as well as copies of the raw data in the appendices.

For further information please contact:

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14. Other Information

MWC Liaison Meetings

Liaison meetings with Melbourne Water were held quarterly to discuss ongoing operations and maintenance of the recycled water supply. Separate meetings were also held to discuss,

- The transfer of Melbourne Water assets located in the Werribee Tourist Precinct to SRW,

Demonstration Sites

The final report of the Smart Water On-farm Demonstration Sites project was completed and submitted to the scheme steering committee, detailing the findings from on-farm trials conducted in the following areas:

- Soil Permeability
- Water Usage & Sprinkler Distribution Uniformity.
- Zero Phosphorus Fertiliser Trial.
- Organic Matter Soil Injection.
- Gypsum analysis
- Fowl manure analysis

WID register of recycled water customers & 2010-11 usage

Customers Reference	Recycled Water Usage ML
ABA044977	10.67
ABA044978	4.05
ABA044980	8.92
ABA044981	12.02
ABA044986	16.05
ABA044987	33.07
ABA044989	5.86
ABA044991	4.05
ABA044992	11.84
ABA044993	31.73
ABA044994	2.44
ABA044995	1.05
ABA044997	8.65
ABA044998	12.07
ABA044999	19.24
ABA045000	14.69
ABA045003	1.12
ABA045006	12.23
ABA045007	1.85
ABA045009	12.37
ABA045010	4.11
ABA045012	1.58
ABA045013	8.16
ABA045015	14.29
ABA045016	0.43
ABA045020	7.76
ABA045021	3.73
ABA045022	7.95
ABA045023	36.08
ABA045024	3.54
ABA045025	2.36
ABA045028	4.63
ABA045030	0.69
ABA045031	3.88
ABA045033	7.2
ABA045034	9.69
ABA045037	1.74
ABA045039	12.4
ABA045040	0.55
ABA045044	1.54
ABA045045	2.26
ABA045046	0.81

Customers Reference	Recycled Water Usage ML
ABA045047	7.1
ABA045050	4.99
ABA045051	5.68
ABA045052	11.65
ABA045054	9.72
ABA045055	90.94
ABA045056	10.78
ABA045057	9.56
ABA045059	1.86
ABA045060	19.92
ABA045062	7.83
ABA045063	2.18
ABA045064	42.7
ABA045067	2.58
ABA045070	8
ABA045071	3.73
ABA045075	14.26
ABA045076	17.19
ABA045077	0.4
ABA045079	4.51
ABA045083	19.53
ABA045084	1.53
ABA045085	19.76
ABA045087	3.54
ABA045088	4.65
ABA045090	18.78
ABA045093	0.48
ABA045094	3.34
ABA045095	4.97
ABA045096	87
ABA045098	0.36
ABA045100	1.09
ABA045101	0.92
ABA045103	3.68
ABA045105	6.42
ABA045106	5.29
ABA045107	2.91
ABA045108	11.15
ABA045109	20.56
ABA045112	4.86
ABA045114	3.14
ABA045115	8.76
ABA045123	4.78
ABA045124	7.23
ABA045126	32.12

Customers Reference	Recycled Water Usage ML
ABA045128	4.51
ABA045129	12.05
ABA045130	5.19
ABA045132	3.64
ABA045135	3.28
ABA045136	11.4
ABA045137	2.96
ABA045139	0.03
ABA045142	7.51
ABA045143	2.05
ABA045144	0.67
ABA045145	0.26
ABA045148	0.71
ABA045151	1.1
ABA045152	1.02
ABA045153	1.68
ABA045158	4.56
ABA045159	0.31
ABA045161	5.34
ABA045162	1.4
ABA045163	7.95
ABA045164	16.04
ABA045167	2.16
ABA045168	1.46
ABA045169	4.1
ABA045170	5.01
ABA045171	0.82
ABA045172	4.13
ABA045173	8.76
ABA045174	10.1
ABA045175	1.03
ABA045176	19.95
ABA045177	5.03
ABA045178	1.47
ABA045179	3.02
ABA045180	2.96
ABA045181	4.36
ABA045182	66.6
ABA045183	9.55
ABA045184	1.42
ABA045186	0.78
ABA045187	18.37
ABA045188	2.26
ABA045189	3.77
ABA045191	3.27

Customers Reference	Recycled Water Usage ML
ABA045192	3.43
ABA045193	6.67
ABA045194	2.86
ABA045195	1.74
ABA045196	17.21
ABA045197	4.64
ABA045198	6.83
ABA045199	1.6
ABA045200	10.52
ABA045201	6.18
ABA045202	7.1
ABA045203	0.75
ABA045205	7.59
ABA063625	4.8
ABA064158	17.43
ABA064268	12.45
ABA064385	8.42
ABA065473	0.48
Total	1306.54

15. Attachments

15.1 Groundwater Monitoring Results 2011

Groundwater monitoring results for

Guidelines gw results 2010-2011.xls

15.2 Soil Monitoring Results 2011

2011 soil monitoring report.pdf

January 2011 Triggers.pdf

15.3 WID Receiving Waters Data 2011

WID REIP Receiving Waters Monitoring Sc

15.4 CSMP Audit Reports 2011

2011 CSMP Audit Reports.pdf