BIODIVERSITY AND CONSERVATION SCIENCE

ECOSYSTEM SCIENCE PROGRAM

A REVIEW OF HYDROCHEMISTRY MONITORING DATA: LAKE WARDEN WETLAND SYSTEM

Prepared for DBCA Parks and Wildlife Service's South Coast Region

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Wetlands Conservation Program

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Cover image reference

Mullet Lake (photographed by Jen Higbid)

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Executive summary

The Department of Biodiversity, Conservation and Attractions has undertaken regular hydrological monitoring of the Lake Warden Wetland System (LWWS) since the late 1970's, with major data collection through the South West Wetland Monitoring Programme (SWWMP) and Lake Warden Recovery Catchment Programme (LWRCP). A baseline hydrochemical study in the early 2000's reported that major ion hydrochemical data were important to help separate and quantify different water sources and flow rates, which prompted the LWRCP monitoring program to include the collection of these data to understand the LWWS lake water and salt balances.

Between 2000 and 2013 over 700 surface water and groundwater samples were collected and their major ion hydrochemistry analysed. These data are compiled, quality assured and reviewed in this report. Results advise that data collected are fit for purpose to interpret and understand hydrological (surface water and groundwater) interactions in the LWWS. Hydrochemical data collected over this period focused on sampling and understanding shallow groundwater and surface water in Lake Warden and to a lesser extent Pink Lake and Bandy Creek.

Important findings are:

- *Lake Warden is a groundwater 'discharge lake' and aquifers discharge generally low salinity groundwater into the lake and contribute to its water and salt balance,*
- *Lake Warden lake water salinity and lake water depth generally exhibits a relatively simple relationship (e.g. salinity increases as lake levels (metres) decrease due to evaporation),*
- *Lake Warden lake water hydrochemistry (e.g. Na/Cl and Br/Cl) provides an independent measurement/ fingerprint for precipitation and dissolution and is capable of resolving more complex interactions than salinity (e.g. intra-seasonal climate driven patterns),*
- *Hydrochemical data and modelling combined with groundwater level data can be used in the LWWS to develop local scale conceptual hydrological models that increase our understanding of seasonal hydrological processes (e.g. conceptual model of Lake Warden informs on surface water and groundwater interactions, as well as potential hydrological connections with Pink Lake),*
- *Ramsar published water quality trigger exceedances in Lake Warden lake water (between 2000 and 2013) appear to be caused through the recycling of solutes in near surface sediments,*
- *Increasing compliance in the collection, handling and management of hydrochemical samples and data will improve the value and confidence in future data collected and*
- *Monitoring programs using hydrochemical data obtained from laboratory analyses need to be underpinned by a robust conceptual hydrological model as they can be an expensive option for regular monitoring, if the changes they are measuring are small (not resolvable) or the results are ambiguous.*

1 Introduction

The Department of Biodiversity, Conservation and Attractions (the Department) has been undertaking regular hydrological monitoring of the Lake Warden Wetland System (LWWS) since the late 1970's. Biannual (September and November) lake water depth and water quality (e.g. pH, EC derived salinity, nitrogen and phosphorus) collected as part of the South West Wetland Monitoring Programme (SWWMP) (Lane et. al. 2004).

In the early 2000's the Department established the Lake Warden Recovery Catchment Programme (LWRCP) in order to expand hydrological monitoring and management of the LWWS. These improvements to the monitoring program were carried out due to observations that deleterious lake water quality and level trends could jeopardise the biodiversity and Ramsar status of the LWWS (DEC 2009). The full range of work undertaken is outlined in detail in Drew et. al. (2015), with studies relevant to this review referred to here, which includes;

- Increasing the spatial extent and frequency of lake, ephemeral drainage and groundwater monitoring,
- Extending water quality parameters analysed (e.g. measurements of field temperature and redox potential and laboratory major ion analyses),
- Establishing a comprehensive shallow groundwater monitoring network and
- Constructing a surface water diversion structure to help manage lake water levels.

The updated monitoring program was designed to understand the lake water and salt balances and in particular which areas (e.g. shallow regolith and aquifers) contained higher concentrations of solutes and if, where and how fast, they were moving (e.g. vertically or horizontally via rainfall or ephemeral surface water flows and at what rates). This type of hydrological investigation is generally described as a groundwater and surface water interaction study.

In the LWWS initial baseline data were collected, interpreted and reported in Marimuthu et. al. (2005), which concludes that major ion hydrochemical data were important to help separate and quantify different water sources and the flow rates. Results from this study form the basis of the current conceptual hydrological model of the LWWS.

This report uses data collected to 2013, after which the LWWS ceased to be managed as a Recovery Catchment (Wallace et. al. 2010). After 2013 monitoring was reduced to a minimal 'care and maintenance' program, which focuses on the collection and interpretation of lake water levels and lake water quality (e.g. electrical conductivity, pH and nutrient concentrations (predominantly total nitrogen and phosphorus).

1.1 Objective

The main objective of the work undertaken here is to compile and review the hydrochemistry data collected in the LWWS between 2000 and 2013, and report on its value to improve understanding of the lake and water solute balances.

1.2 Scope

The main tasks undertaken are to:

1. Source and summarise the frequency and range of water quality data collected, including spatial and temporal sampling and analytes selected for analysis,
2. Provide details of workflow protocols undertaken; sample collection and handling (e.g. chain of custody (COC) procedures), data quality assurance (QA) and quality control (QC) assessments, and review if best practice methods are compatible with available regional laboratory services and,
3. Determine if hydrochemical data, in particular major ion analyses, collected are suitable to;
    a. Provide input to assess published LWWS Ramsar management guidelines and triggers (DEC 2009),
    b. Resolve hydrochemical fingerprints for different water types (e.g. rainwater, surface water and surficial aquifer groundwater) and develop a water and solute balance and iterate the existing conceptual model (e.g. Mariumuthu et. al. 2005) and
    c. Increase knowledge of hydrological processes to improve management outcomes.

2 Location

The LWWS is a wetland system of international significance and is located to the north of Esperance on the south coast of Western Australia (DEC 2009). The major lakes within the LWWS are shown in Figure 1 and their location in relation to the broader surface water catchments that sustains them is shown in Figure 2.

The wetlands provide habitat for endangered vegetation communities and feeding and breeding grounds for a variety of bird life and are therefore of high conservation value (DEC 2009). Land use changes in the catchment for the wetland systems, namely the clearing of native vegetation for cropping and other agricultural activities, has changed the water balance. This has increased surface water runoff and groundwater recharge (Drew et. al. 2015).

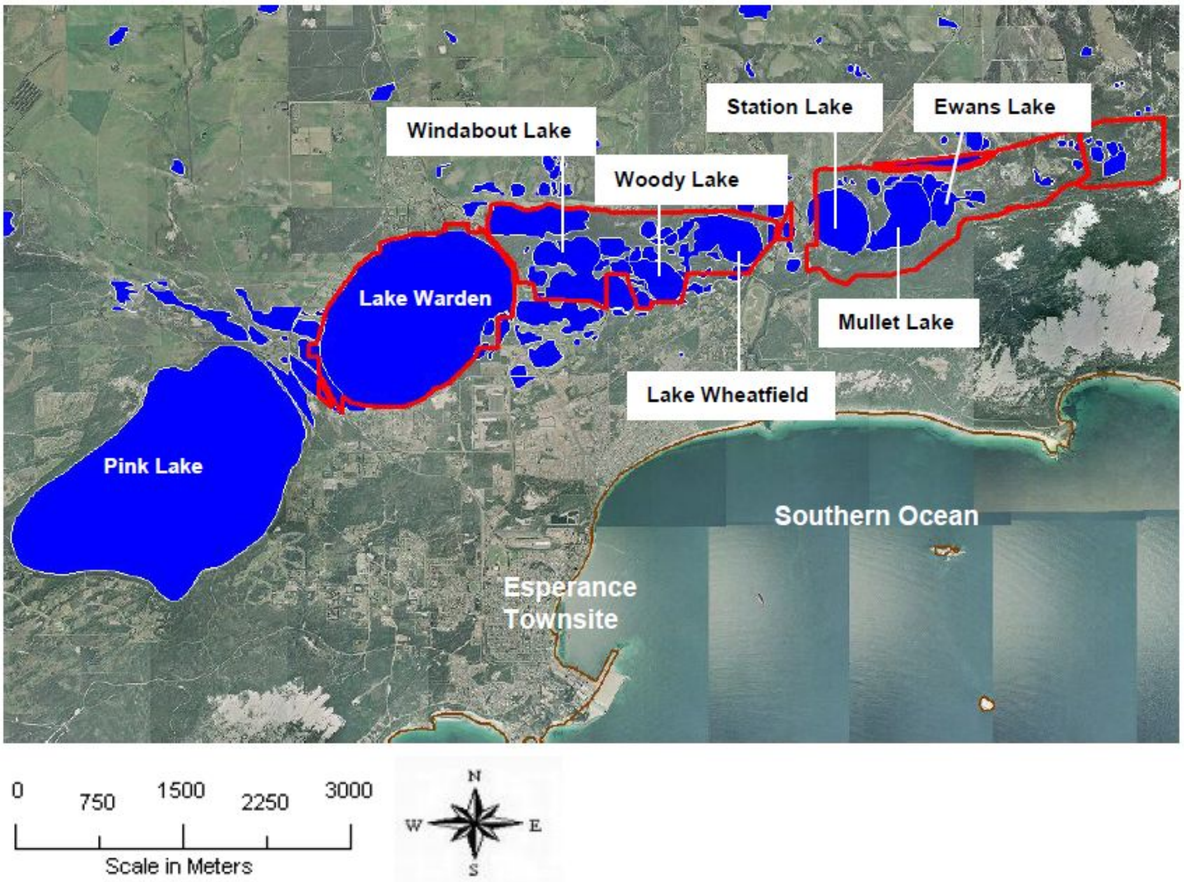

Figure 1. Location of the Lake Warden Wetland system (LWWS) in relation to the town of Esperance; Ramsar boundary is shown as a red outline and shows three sections; an Eastern Suite of lakes including Ewans, Mullet and Station Lakes, a Central Suite with Wheatfield, Woody and Windabout Lakes and the Western Suite of Lakes comprised of Lake Warden and outside the Ramsar boundary, Pink Lake, (from DEC 2009)

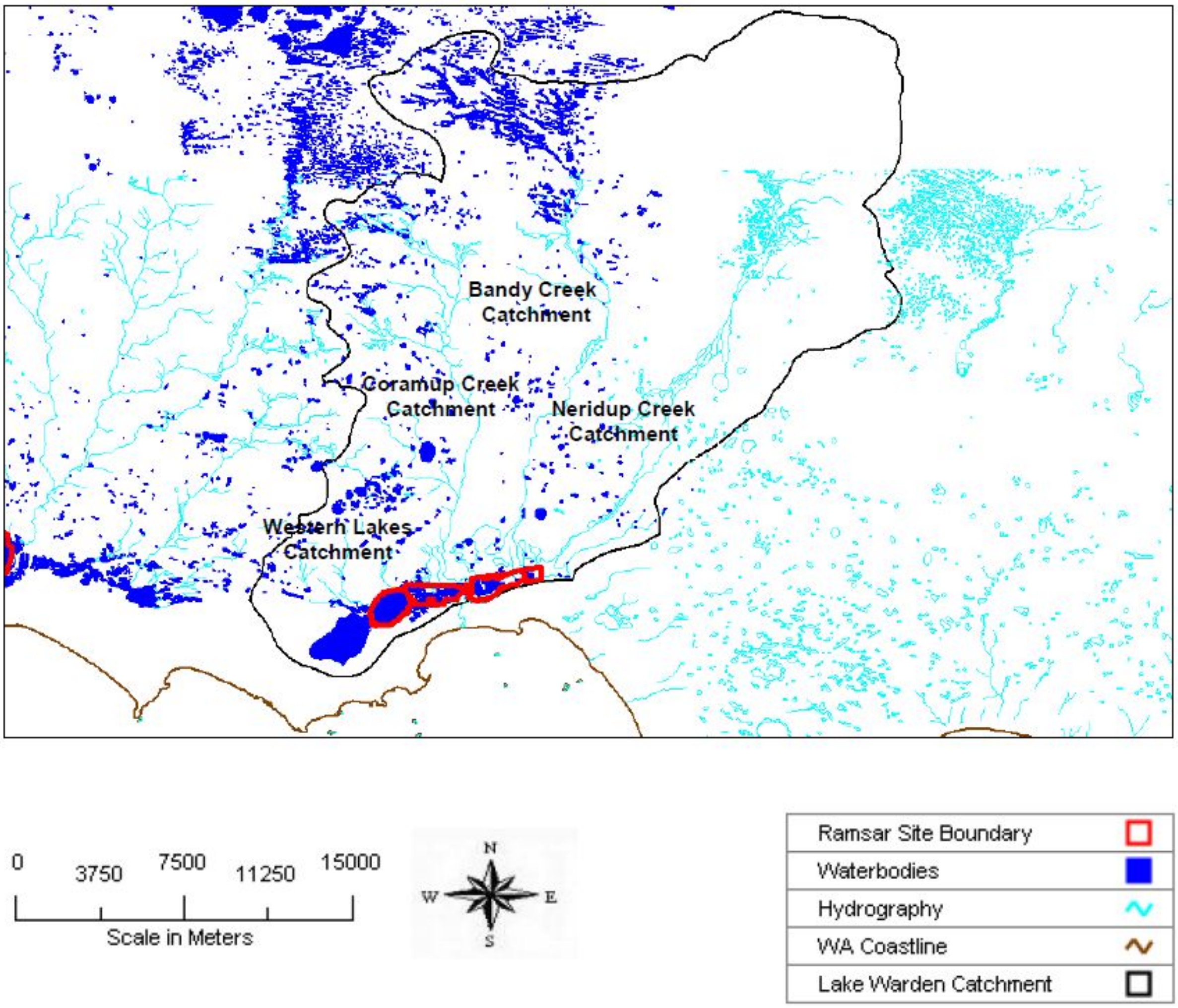

Figure 2 The Lake Warden Catchment, showing the four main sub catchment ephemeral surface water drainages; Neridup Creek, Bandy Creek, Coramup Creek and Western lakes (from DEC 2009)

Higher water levels in the lakes within the LWWS result in a decrease in the area of the wading zone, an important depth interval for feeding birds, as well as the water logging and subsequent death of fringing vegetation communities. Changes in the water balance will also alter the salt balance, which can contribute to ecological decline when enhanced salt loads reach the root zone of sensitive vegetation communities. The Departments Wetlands Conservation Program aims to restore and preserve these threatened and important ecological communities. In the LWWS, this has led to the development of water level and quality triggers for the major lakes (DEC 2009).

3 Data sourcing, compilation and quality assurance

In December 2013 to January 2014 hydrochemistry data (major ions, nutrients and physical chemistry (pH, electrical conductivity (EC) and temperature)) and available supporting documentation on data collection and handling were sourced from the DBCA South Coast Region LWWS conservation officer. Rainfall major ion data collected in 2002 to 2003 were provided by Marimuthu et. al. (2005) and rainfall (amount) and climatic data (wind, humidity, temperature etc.) were sourced from the Australian Bureau of Meteorology (2014) (BOM site 9789).

A total of 725 hydrochemical analyses (60% surface water, 38% groundwater and 2% rainwater) were sourced and compiled in a spreadsheet database. A consistent format was developed to capture different information, collected over time by different officers (e.g. development of a consistent naming convention and measurement units). The resultant database contains the information below for each sample location; (a subset of information for each site and sample is shown in Appendix 1);

1. Site Identification (ID),
2. Dates (field sampling, laboratory analysis and holding times),
3. Field and laboratory methods (instrument used, limits of detection and reporting),
4. Measured parameter units (converted to common milliequivalent (meq) units),
5. Charge balance error (CBE); sample ionic balance/common cation/anion relationship (indirect indicator of veracity of sampling and laboratory analyses).

Best practice methods for the collection, handling, laboratory quality assurance and interpretation of hydrochemical data are outlined in Appendix 2.

Chain of Custody documentation detailing processes followed in the collection and post-sampling of surface and groundwater samples was found to be variable and sometimes missing. Information provided indicated samples collected to analyse nutrient concentrations generally exceeded recommended holding times, and therefore these data are not interpreted here. It was also noted that the stability of groundwater field parameters (pH, EC and temperature) during pumping/purging, prior to sampling, was not routinely checked prior to 2010. Lower confidence being attributed to these data (Appendix 1).

Hydrochemical (major ion) data were quality assurance following protocols outlined in Appendix 2. All 725 samples were found to have a charge balance error (CBE) of less than 5%, confirming confidence in laboratory analyses and suitability for interpretation in this study.

Hydrochemical data discussed in the following sections refers to major ion analyses and they are examined in relation to field and laboratory physical chemistry measurements (e.g. pH, electrical conductivity (EC) and EC derived salinity) and derived modelled parameters (Appendix 2).

3.1 Major ion sampling program – spatial distribution and frequency of data collection

A subset of 468 (65%) of the 725 samples were selected for interpretation based on the;

- Number of samples collected per site (greater than 3 samples),
- Period of data collection (e.g. spread over sufficient time to determine trends) and
- Value of the site location to provide information on the report scope aims (e.g. surface water and groundwater flows into the LWWS and groundwater flow down gradient of the LWWS; sites and data interpreted are highlighted in yellow in Tables 1 and 2).

Bores where groundwater was sampled for hydrochemical (major ion) analysis (and data collected are interpreted in this report) are shown in Figure 3. Most data collection focuses on bores bordering Lake Warden and Pink Lake (Figure 3, Table 1, and Appendix 1).

Figure 3 Location of groundwater sample points (red) and other monitoring bores (yellow) in the Lake Warden Wetland System (LWWS)

Table 2 provides information on rainwater and surface water hydrochemical data (lake and ephemeral drainage) sampling sites. Around 10% of data collected is focused on inflows to the Eastern Suite of wetlands (16 samples; 7%) and 50% of surface water data analysed here is focused on Bandy Creek (15 samples; 7%) and the flow of surface water into the central suite of wetlands via lake Wheatfield (97 samples; 43%).

Most of the remaining data are collected in and around Lake Warden (93 samples; 41%).

Table 1. Number and location of groundwater hydrochemical measurements (2000-2013) (sites and data analysed in this report are highlighted in yellow)

Type	Grouping	ID	Number of samples
	Eastern suite		
		LW18D	4
		LW18DB	3
	Central suite		
		LW13D	3
		LW14D	3
		LW16D	3
		LW17DB	3
		LW8D	3
		LW8DW	3
		LWds01D	1
		LWds01-OB	5
		LWds02D	1
		LWds02-OB	14
		WLds01D	1
		WLds01-OB	5
	Western suite		
		EWD4A	6
		LW10D	3
		LW10DB	3
		LW10-OB	34
		LW11-OB	36
		LW15D	2
		LW15DB	2
		LW15-OB	34
		LW19D	3
		LW20D	3
		LW20-OB	35
		LW21-OB	9
		LW22-OB	20
		LWst-OB	11
		LWus01-OB	4
		PL N-OB	4
		PL W-OB	3
		PLds01-OB	3
		PLds02-OB	8
Groundwater		***Analysed 225 samples (82%)***	**275**

Table 2. Number and location of surface water (lake and ephemeral drainage) hydrochemical measurements in the LWWS and adjoining catchments (2000-2013) (sites and data analysed in this report are highlighted in yellow)

Type	Grouping	ID	Number of samples
		BOM 9789	16
Rainfall		***Analysed 16 samples (100%)***	**16**
	Coramup creek		
		Coramup creek (Gibson Road)	3
		Coramup creek (wetlands)	3
		Coramup creek- Myrup rd	6
	Bandy creek		
		Bandy creek (Flowmanns Road)	3
		Bandy creek- Fisheries rd	15
		Bandy creek harbour	35
		Bandy creek- pipeline	76
		Bandy creek- weir at Bandy harbour	47
	Central suite		
		Lake Wheatfield GP	10
		Lake Wheatfield- South at pipeline	77
		Lake Windabout East GP	20
		Woody Lake	3
	Eastern suite		
		Lake Ewans- West GP	10
		Lake Station GP	6
		Mullet Lake- North West GP	6
	Western suite		
		Lake Warden- Bukenerup inflow	10
		Lake Warden East GP	78
		Lake Warden- Lake Windabout inflow	12
		Lake Warden Satellite lake East	6
		Lake Warden West	3
		Pink Lake	5
Surface water		***Analysed 227 samples (52%)***	**434**

The location of the surface water sampling sites are not shown as geographic locations as there have been some changes of the location of sites between 2000 and 2013 (see Drew et. al. 2015). This is not uncommon when sampling surface water in dynamic environments where water bodies change in extent and near surface processes (e.g. erosion and sedimentation) and stream energy can change the location of suitable sampling sites, particularly within ephemeral stream channels.

Based on this information the LWWS hydrochemical sampling program is best suited to understand surface water and groundwater interactions within and between Lake Warden and Pink Lake, and possibly surface water moving through the central and Western wetland suites, as sampled at Lake Wheatfield. The latter dependent on where and when sampling has taken place.

4 Results: Data analysis

4.1 Existing conceptual model

The conceptual hydrological model of Marimuthu et. al. (2005) proposes that lakes in the LWWS behave as separate hydrogeochemical entities that are superimposed on an easterly flow dominated groundwater through-flow system. Lateral groundwater movement in the deep aquifers is slow, but where upward hydraulic heads exist minor amounts of deeper groundwater discharges to the shallow aquifer. Deep groundwater discharge mixes with groundwater in the shallow (surficial) aquifer.

As a result, groundwater in shallow (surficial) aquifers, which is critical to the environmental health of the LWWS biodiversity, is a mixture of;

- Recent incident rainfall,
- Surface water runoff/overland flow,
- Minor amounts of deeper aquifer (e.g. sedimentary and saprolite aquifers; see Mariumuthu et. al. 2005) groundwater discharge, where upward hydraulic heads exist,
- Groundwater through-flow (and interflow) from laterally extensive shallow aquifers, and
- Evaporated lake water when lake levels are below the water table.

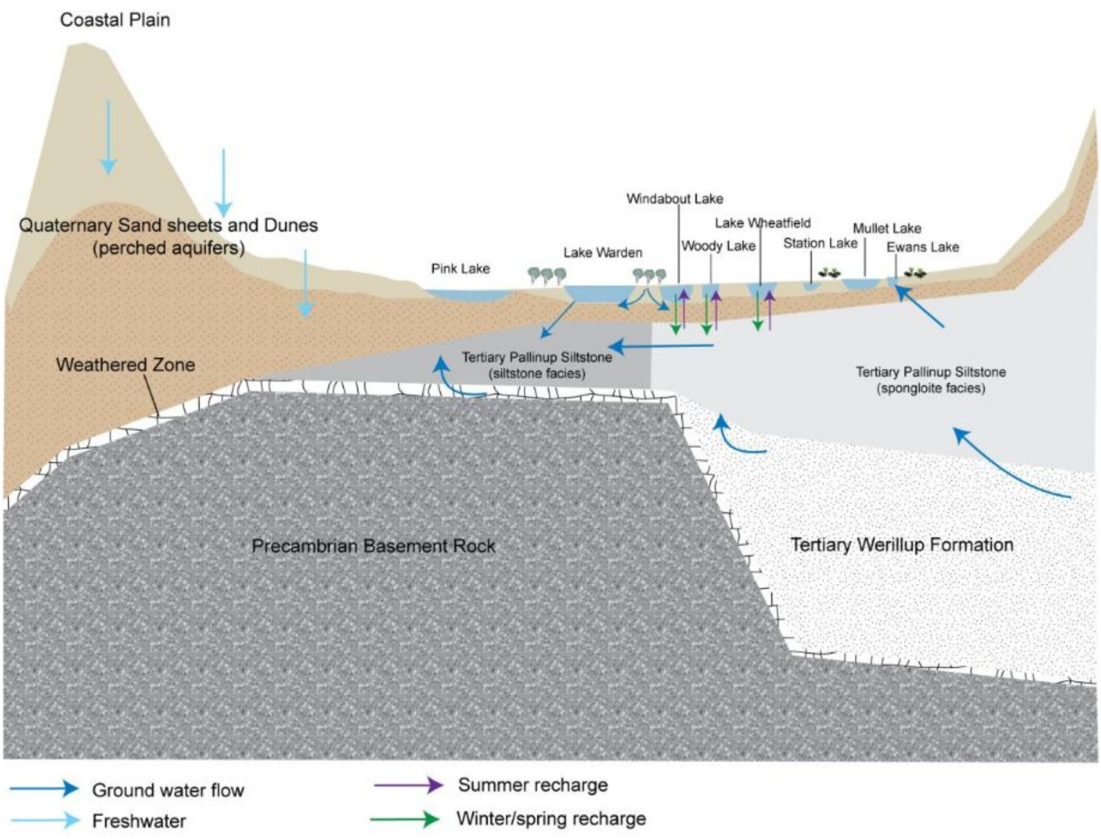

Figure 4 Conceptual groundwater model within the Lake Warden System Ramsar Site, Esperance, Western Australia (adapted from Marimuthu et. al., 2005) (from DEC 2009)

The coarse scale groundwater flow direction is inland to the coast (north to south) (Figure 4). Surface water flow is generally east to west (Figure 5) within the valley floor but varies according to the amount of surface water moving through the system. For example, gradients can reverse when more surface water is present and lakes near capacity (Figure 5) and in drier periods vertical processes may become more dominant (see seasonal responses to lakes in Figure 4).

Figure 5 Conceptual surface water flows within the Lake Warden System Ramsar Site, Esperance, Western Australia (from DEC 2009)

4.2 Weather and climate trends

The climate of the Esperance area is typified by cool, with wet winters and warm-hot, dry summers (see data for Bureau of Meteorology (BOM) Station No 9789 in Figure 6). On average, nearly 80% of the annual rainfall falls between the months of April to October. For the purposes of this report, this wet period will be referred to as the “winter” season, while November through March will be referred to as the “summer” season.

During summer season, wind speeds tend to increase significantly, in conjunction with lower rainfall and higher temperatures. The result is that the potential for evaporation during the summer season would be much higher than during the winter season. Therefore, most rainfall received during summer is more likely to be evaporated, be taken up by vegetation and replenish soil water storages. Intense summer rainfall events generating higher runoff/overland flow due to the water repellence of dry soils.

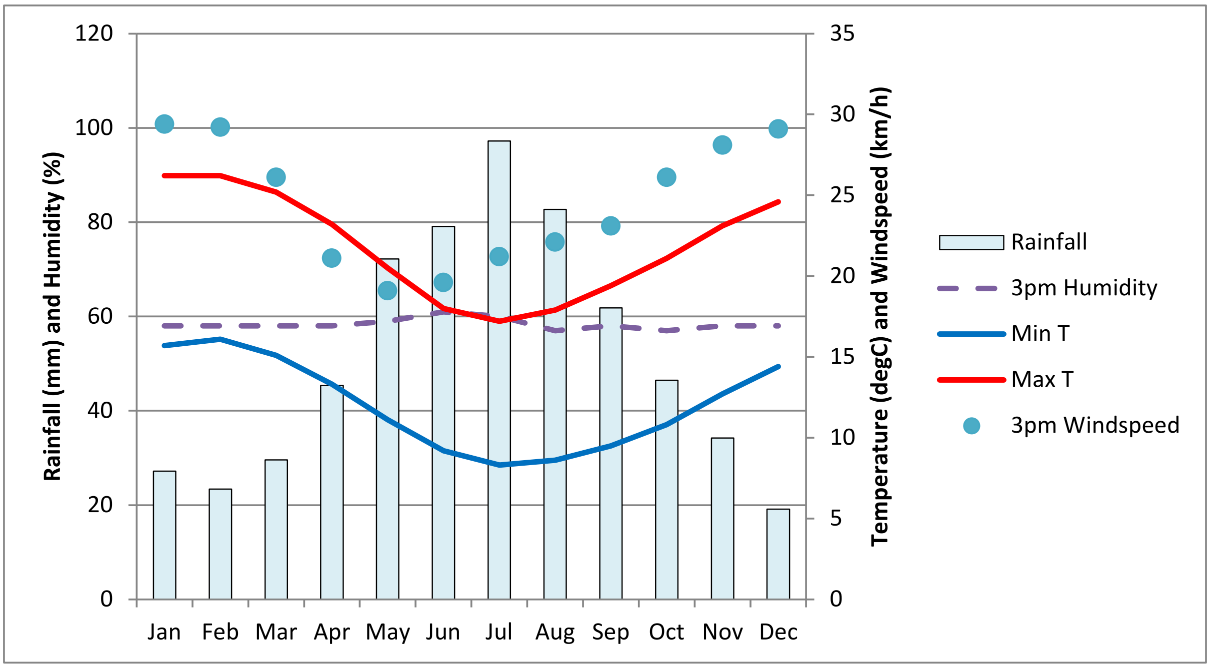

Figure 6. Average monthly climate details for Esperance (Bureau of Meteorology station 9789) for the period 1969 to 2014.

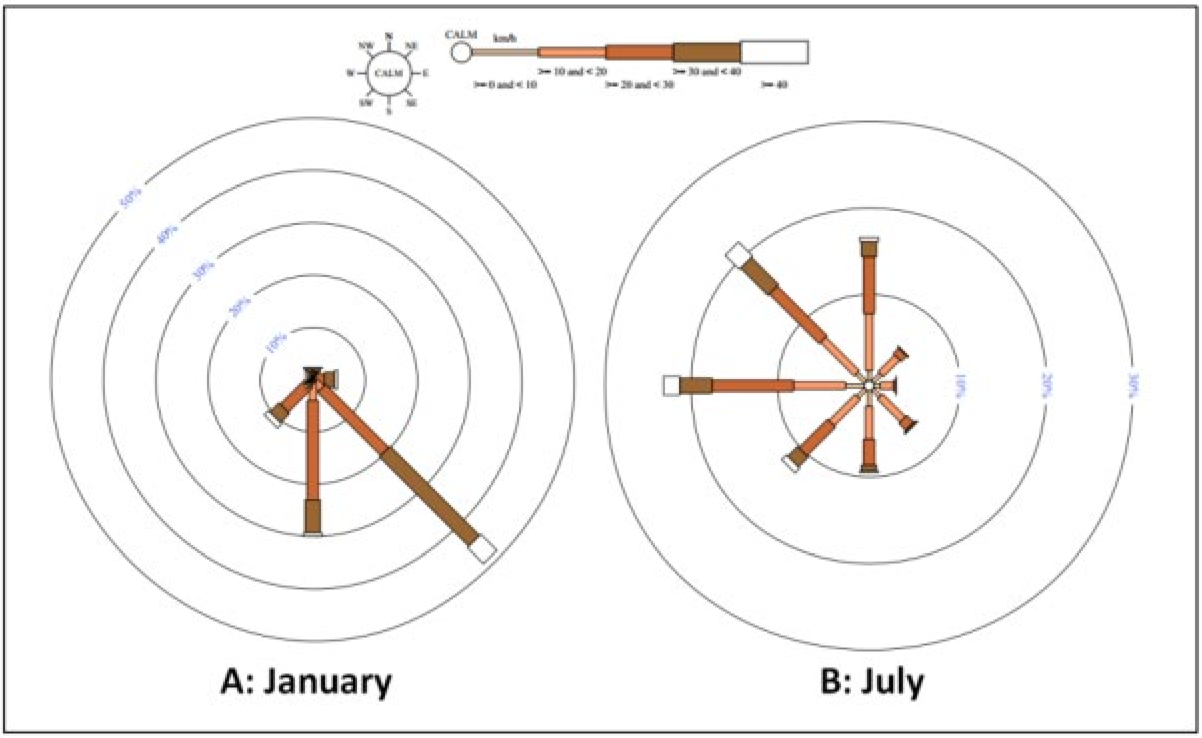

Figure 7. Wind rose plots showing wind speed and direction for Esperance in January (summer) and July (winter) (Bureau of Meteorology station 9789).

Figure 7 shows wind rose plots typical of winter (A) and summer (B) conditions, showing that during summer windy conditions are dominated by the south easterly sea breeze, while during winter periods, wind speeds are generally lower, and the dominant wind direction is inland, from the west-northwest. Given the proximity of the wetlands to the ocean, summer winds are likely to carry a significant salt load derived from evaporated sea spray, which is liable to deposit as a dry aerosol. During autumn and winter rains these dry aerosol derived salts move laterally, with overland flow, into drainage lines and once soil field capacities are reached, they move vertically into groundwater.

4.2.1 Average rainfall patterns

Southwest of Western Australia has been experiencing a drying period since the late 1970's. In the south coastal regions, the drying trend is less pronounced and is better described as a shift toward drier winters and wetter summers (see Figure 8 and Table 3). Table 3 shows the seasonal rainfall at Esperance relative to long term seasonal averages, while Figure 8 shows monthly rainfall (2004 to 2014) and the cumulative deviation from mean (CDFM) monthly rainfall record for Esperance Bureau of Meteorology Station No 9789. The CDFM represents a simple way to view rainfall trends over time; with decreasing and rising graphical trends representing drying and wetting trends in average rainfall.

Table 3. Seasonal rainfall data (mm) from summer 2009 to winter 2013, red shading indicates drying and blue wetting trends (sourced from Bureau of Meteorology Esperance station 9789)

Season	Rainfall (mm)	Deviation from long term mean (%)
Average Summer rainfall	133.5	
Average Winter Rainfall	484.9	
Summer 2009-2010	75.6	-43%
Winter 2010	403.4	-17%
Summer 2010-2011	137.6	3%
Winter 2011	431.6	-11%
Summer 2011-2012	222.4	67%
Winter 2012	425.4	-12%
Summer 2012-2013	251.2	88%
Winter 2013	571.4	18%

Rainfall CDFM data graphed in Figure 8 illustrates a short-lived drying trend between 2010 and 2013, followed by a recent wetting trend, while monthly rainfall patterns show intense rainfall events occur in summer.

In response to these rainfall changes the overall groundwater budget is likely to be either static or in deficit as summer rainfall is less likely to recharge groundwater.

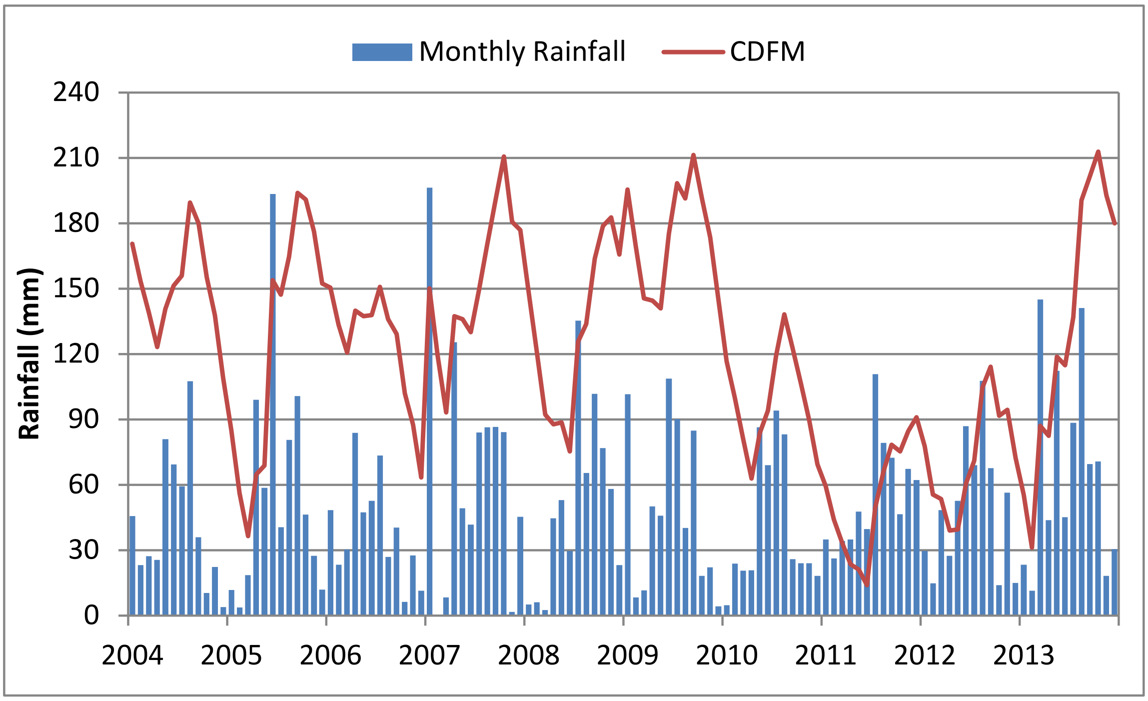

Figure 8. Monthly rainfall (mm) and CDFM for Esperance (Bureau of Meteorology station 9789) for the period 2004 to 2017

4.3 Rainfall chemistry

The ionic composition of rainfall samples collected, analysed and reported in Marimuthu et. al. (2005) are summarised in Appendix 1 and bivariate plots in Appendix 3. Marimuthu et. al. (2005) collected and analysed rainfall major ion chemistry from BOM station 9789 and changing concentrations of individual ions are shown in milliequivalents per Litre (meq/L) on bivariate plots, in relation to the conservative ion chloride. Two additional bivariate plots show changes in calcium concentration with respect of SO_4 and alkalinity. All graphs also depict the average Esperance rainfall tend line (derived from data collected at BOM station 9789), as well as the *global* seawater ionic composition tend line determined from data in Hem (1985).

Data presented in Appendix 3 indicates lake rainfall composition is quite variable, which is common in low TDS analyses (e.g. TDS generally less than 10mg/L; see Appendix 1). Ions showing increases along the seawater line being evaporated prior to analysis and those elevated above the rainwater and seawater trend lines indicating reactions may have taken place, pre or post sampling and analysis. This is most evident in Ca and HCO_3/alkalinity, which may occur if atmospheric or anthropogenic dust bearing calcite was mixing and interacting to the rainfall. Given that rainfall is largely delivered from the west to north-west (see Section 4), a region dominated by semi-arid terrain and varied land uses, there could be interactions with terrestrially derived evaporite minerals (such as calcite), or anthropogenic sources (e.g. fertilizer). This enrichment needs to be considered in relation to trends observed in other analytes, and this is discussed in the following sections of this report.

4.4 Catchment surface water (ephemeral) chemistry

The salinity of ephemeral surface water flows in Bandy Creek and Coramup Creek are generally brackish to saline (DEC 2009). Limited sampling of these systems (up-gradient of the harbour) shows that except for HCO_3/alkalinity, other ions fall on the seawater ionic composition line (Appendix 1 and 4). Alkalinity is elevated compared with seawater, probably due to the interactions with atmospheric carbon dioxide, soil pedogenic carbonates and/or surficial evaporites during runoff/overland flow. The elevated salinity and seawater ionic composition of the sub-catchment drainage surface water suggests interaction of runoff/overland flow with surficial salt stores.

4.5 Shallow (surficial aquifer) groundwater chemistry

At a coarse scale, groundwater flow in surficial aquifers in the LWWS tends to be north to south following topography, which overall decreases inland to coastal areas (Marimuthu et. al. 2005). Bores located near lakes may interact with lake surface water and show more variation in groundwater levels and possibly groundwater chemistry (HydroConcept 2014).

For the purpose of this study groundwater hydrochemical data are grouped in relation to the position of bores being upgradient or downgradient of the LWWS and those close to lakes are discussed along the surface water flow path, which is roughly east to west (Sections 4.5.1 to 4.5.6; Appendices 1 and 5 to 11).

Important to note that there has been little sampling of groundwater from deeper aquifers since the early 2000's (see bores labelled with D in Table 1), probably due to the conceptualisation advising they play a minor role in the water and solute balance (see Section 4.1). Therefore, due to the lack of temporal hydrochemical data from deeper aquifers they are not discussed in this study.

4.5.1 Up-gradient of lakes - groundwater

There is limited hydrochemical sampling of shallow groundwater upgradient of the lakes. Bivariate plots of available sample (Appendix 1 and 5) resolve two main water types, NaCl and Na-Ca-Cl-HCO_3. Lake Warden is characterised by NaCl water (e.g. LWSt & LWUS01), which may indicate less rainfall recharge, longer equilibration time with soil water and/or mixing with deeper groundwater. Groundwater up-gradient of Pink Lake (the current terminal lake) shows elevated Ca and HCO_3 compared with Lake Warden (e.g. Na-Ca-Cl-HCO_3 type water) and this could be due to this lake receiving increased recent recharge (see Section 4.3) or there is local water rock interaction with evaporite minerals (carbonate dissolution e.g. calcite).

4.5.2 Eastern lakes – surface water

The chemistry of the eastern lakes shows that these wetlands are similar in hydrochemical composition (Appendix 6). The dominant water type is NaCl, with some comparative depletion in Ca, minor enrichment in Na and Cl (relative to Br) and enrichment in alkalinity / HCO_3.

Bromine (Br), as the Bromide ion (Br^-), is present in sufficient concentrations in seawater and rainwater to make it an important constituent. In a chloride brine evaporation may continue to concentrate Br after the brine reaches saturation with respect to NaCl, which makes Br a useful analyte in understanding the evolution of brines (Hem 1985).

Therefore the observations made here indicate the evapo-concentration of surface water takes place and it may include the recycling of evaporite minerals, which include the precipitation of calcite and halite.

4.5.3 Lake Windabout and adjacent groundwater

Lake Windabout is adjacent and east of Lake Warden (Figure 1). Hydrochemical data have been collected from two bores located to the north, and between these two lakes. The chemistry of groundwater from this location is shown in bivariate plots in Appendix 7 and results are generally similar to the eastern lakes (Section 4.5.2), with the exception of variation in Ca concentration being apparent between the two bores sampled. Groundwater from bore LW11 is similar to Lake Windabout, but generally has higher salinity indicative of evapo-concentration and recharge of lake water. Bore LW10 has elevated Ca and alkalinity/HCO_3, which could be due to receiving increased recent recharge (see Section 4.3) or there is local water rock interaction with evaporite minerals (carbonate dissolution e.g. calcite).

4.5.4 Lake Warden – surface water

The composition of Lake Warden surface water is shown in Appendix 8**Error! Reference source not found.**. It should be noted that Lake Warden salinity and ionic concentrations are variable, with high salinity water being several times higher than those from Lake Windabout or groundwater data sampled upgradient and to the east. Lake water is NaCl in type and depleted in Ca and alkalinity/HCO_3, probably due to the precipitation of evaporite minerals such as calcite. A few of the higher salinity samples show enrichment in Mg and SO_4 and lower Cl/Br ratio. These trends can be explained by the precipitation of halite at these higher concentrations (e.g. Br continuing to concentrate following the saturation and precipitation of halite). This is discussed in more detail in Section 4.6.

4.5.5 Between Lake Warden and Pink Lake

The chemical composition of groundwater from the surficial aquifer between Lake Warden and Pink Lake is shown in Appendix 9. Bivariate plots indicate salinities are lower than that of Lake Warden, with higher salinity groundwater sampled from bore LW15, located between the two lakes.

Groundwater is generally NaCl in type, with depletion in Ca evident in bore LW15. Alkalinity/HCO_3 concentrations are low, which complicates assessing the variation within the sites sampled and prohibits drawing conclusions on mixing and water rock interactions that may be occurring.

The uniformity of the alkalinity results appears erroneous and requires resampling, with the collection of field alkalinity data and analysis of duplicate samples at different NATA accredited laboratories (Appendix 2).

4.5.6 Down-gradient of Lakes

As mentioned above, coarse scale groundwater flow in the surficial aquifer is north to south, so it is anticipated that shallow groundwater sampled down gradient of the lakes will have a hydrochemical fingerprint that reflects evaporative processes occurring within the LWWS.

Alternatively, the down-gradient bores may reflect local gradients and hydrochemical processes (e.g. water-rock interactions with calcareous materials that are more common towards the coast). Insufficient information exists on aquifer water levels and lithology to identify if coarse or local scale influences play the major role.

Data discussed in this section indicates that evaporative processes are likely to be identified by depleted Ca and alkalinity/HCO_3 where evaporite minerals such as calcite are precipitating. Higher Ca and alkalinity/HCO_3 is observed where evaporite (calcite) dissolution is taking place, or where there is recent groundwater recharge (see Section 4.3).

Bivariate plots in Appendix 10 display data for groundwater sampled down-gradient of Lake Windabout (WLDS01) and Lake Warden (LWDS01 and LWDS02), as well as the bore up gradient of Lake Warden (LWUS01). The salinity and ionic compositions of all groundwater sampled down-gradient of the lakes are too low to confidently resolve trends, make comparisons and determine processes.

Shallow groundwater sampled at bore LWDS02 is relatively enriched in Na and SO_4, but concentrations are low, and more sampling is required to assess causation. The groundwater composition down-gradient of Pink Lake is plotted in Appendix 11. Down-gradient bores (PLDS01 and PLDS02) are plotted with up gradient groundwater compositions (PLN). Water type is Na-Ca-Cl-HCO3 and similar to data presented in Appendix 10, salinity and ionic concentrations are too low to confidently resolve trends and make comparisons.

As with Section 4.5.5, the uniformity of the alkalinity results in Appendix 10 and 11 looks erroneous and requires resampling, with the collection of field alkalinity data and analysis of duplicate samples at different NATA accredited laboratories (Appendix 2).

4.5.7 Piper trilinear diagram – all data

A Piper trilinear diagram showing all data in Appendix 12 removes ionic concentration information but shows the dominance of NaCl water type across all data analysed in this section.

Increases in Ca and alkalinity/HCO_3 to develop a Na-Ca-Cl-HCO_3 water type is shown to be respectively dominant in groundwater down-gradient of the LWWS, followed by rainfall and groundwater up-gradient of the LWWS. Rainfall showing an improved relationship with anions in up-gradient groundwater (lower alkalinity/HCO_3) and cations in down-gradient and a subset of Lake Warden groundwater (increased Ca). This confirms that up gradient surficial aquifers receive and are characterised by recent rainfall recharge. These aquifers contrast with groundwater downgradient that indicates mixing with shallow groundwater beneath and marginal to the lakes occurs.

4.6 Lake Warden lake surface water and groundwater interactions: salinity dynamics

As discussed in Section 3 (e.g. Tables 1 and 2) the majority of hydrochemical sampling (lake surface water and groundwater) takes place at Lake Warden. This section reviews hydrochemical data in relation to physical data (lake water levels) collected at Lake Warden to assess the lakes current and predicted function.

4.6.1 Salinity, pH and depth

The depth of lake water in Lake Warden is related to seasonal rainfall, the lake accession occurring over the winter months and peaking around September and the recession occurring in summer when temperature and evaporation increases (Figure 9) (Lane 2008).

Recharge to the lake is a mix of direct rainfall, overland flow and surface water flow received from the wetland system to the east (Figure 5), which drains several surface water tributaries and discharge from the local shallow groundwater.

There appears to be a lag in lake level response to seasonal rainfall (Figure 9), which suggests that surface water delivery from the Eastern wetland suite is the major source of recharge.

Discharge from Lake Warden is a mix of evaporation (open water body), transpiration from the fringing vegetation, discharge to shallow, or leakage to deeper, groundwater systems. In the past discharge also included surface water drainage to Pink Lake, as prior to the construction of the south coast highway and rail road, Lake Warden would historically have drained into Pink Lake during flooding events. The absence of a storm water culvert within this feature (pers. com. John Lizamore), means that the surface water connection between Lake Warden and Pink Lake has been removed, except during extreme floods which overtop the road. This significance of this change means that in the absence of surface water connection to Pink Lake, its terminal lake status may be transferred to Lake Warden.

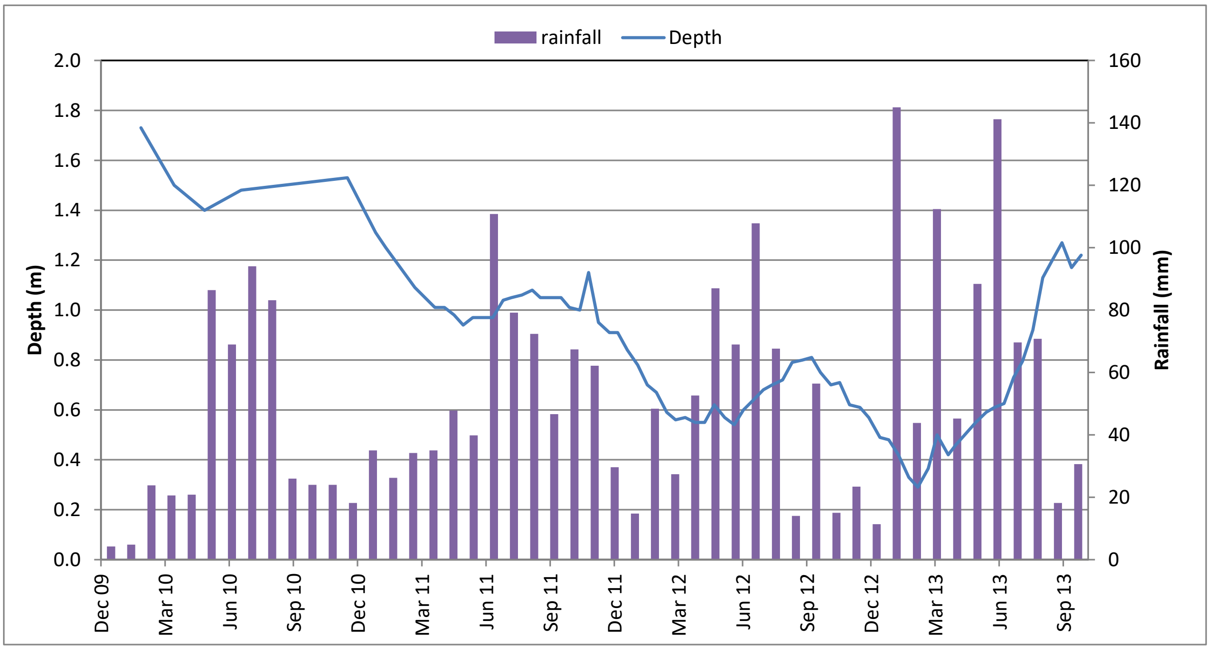

Figure 9 Monthly rainfall totals for Esperance (Bureau of Meteorology station 9789) and lake water levels at Lake Warden

The risk of Lake Warden becoming a terminal lake is interpreted in lake salinity and depth data presented in Figures 10 and 11.

These figures show an inverse relationship exists between salinity and lake water depth at Lake Warden (e.g. during the 2012-13 summer (indicated on Figures 8 and 9) there was a fall in lake depth from 0.8 to 0.4 m, while salinity rose from about 150 g/L to around 300 g/L).

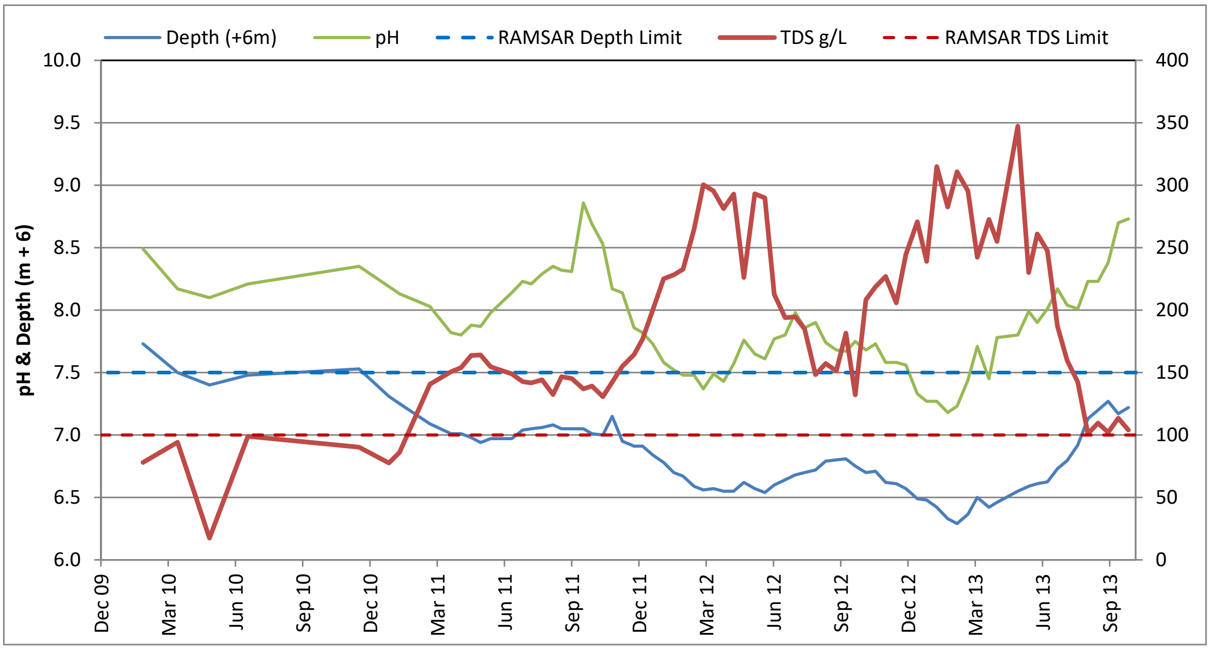

Figure 10. Salinity, pH and water levels of Lake Warden. Depth is offset by six metres (+6 m) for graphing purposes.

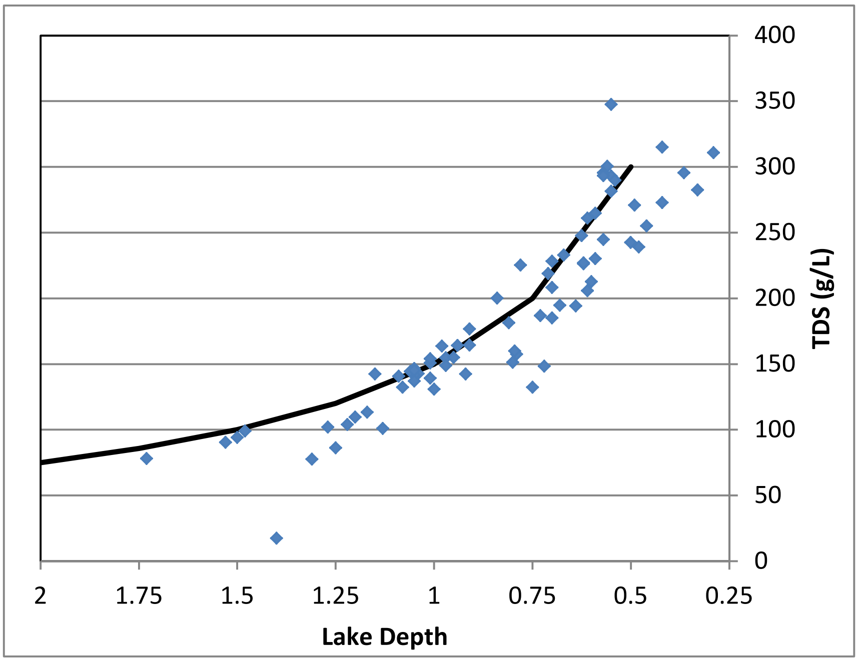

Figure 11. Lake Warden lake water level (metres) vs lake water Total Dissolved Solids (TDS), showing a hand drawn trend line representing an idealised volume: concentration relationship for a closed system

Figure 11 shows a hand drawn trend line that represents a relationship between volume and TDS that would be expected (base on the assumption of a cylindrical lake geometry, depth = volume) where evaporation is the major process concentrating solutes. Most data fall on, or close to this trend line.

The maximum salinity of the lake is likely not to exceed the observed maximum values of around 300 g/L however, owing to the precipitation of halite at these concentrations. The pH of Lake Warden has a direct correlation with lake depth and is likely at least in part associated with carbonate equilibrium. Salinity and pH dynamics are discussed in more detail below.

Figure 10 also shows the published Ramsar median summer salinity threshold of 100 g/L and maximum lake depth threshold of 1.5 m, and demonstrates that, while compliance with the depth threshold was maintained, the salinity limit was exceeded for a continuous period from 2011 till late 2013. Also, of note is that lake salinity returns to the same level for periods where the lake was the same depth. For example, salinity was around 140 g/L in June 2011 when the lake was approximately 1 meter deep. A period of 'drying' and associated evaporation and salinization occurred and was followed by 'wetting' and filling of the lake in mid-August 2013, which returned the lake to the pre-drying levels and salinity.

This supports the hypothesis that there is no significant salt loss from the lake at low water levels, indicating that the development of dense brines has not resulted in the vertical removal of salt from the lake, through the development of density driven flow to deeper aquifers.

Together these data suggest that under the current regime, Lake Warden groundwater may not move/flow to Pink Lake as the current salinity and depth threshold values are incompatible (e.g. physical chemistry and gradients). Groundwater movement from Lake Warden to Pink Lake can therefore only be achieved if significant lake substrate salt stores were removed from Lake Warden.

4.6.2 Evaporite mineral dissolution and precipitation in Lake Warden

Geochemical modelling of mineral saturation indices (SI) was undertaken in PHREEQC software (Appelo and Postma, 2006) using the WATEQ4F themodynamic database. This forms part of the hydrochemical data quality assurance and interpretation process outlined in Appendix 2. Results of the modelling are tabled in Appendix 13 and data for halite, calcite and gypsum are graphed in Figure 12.

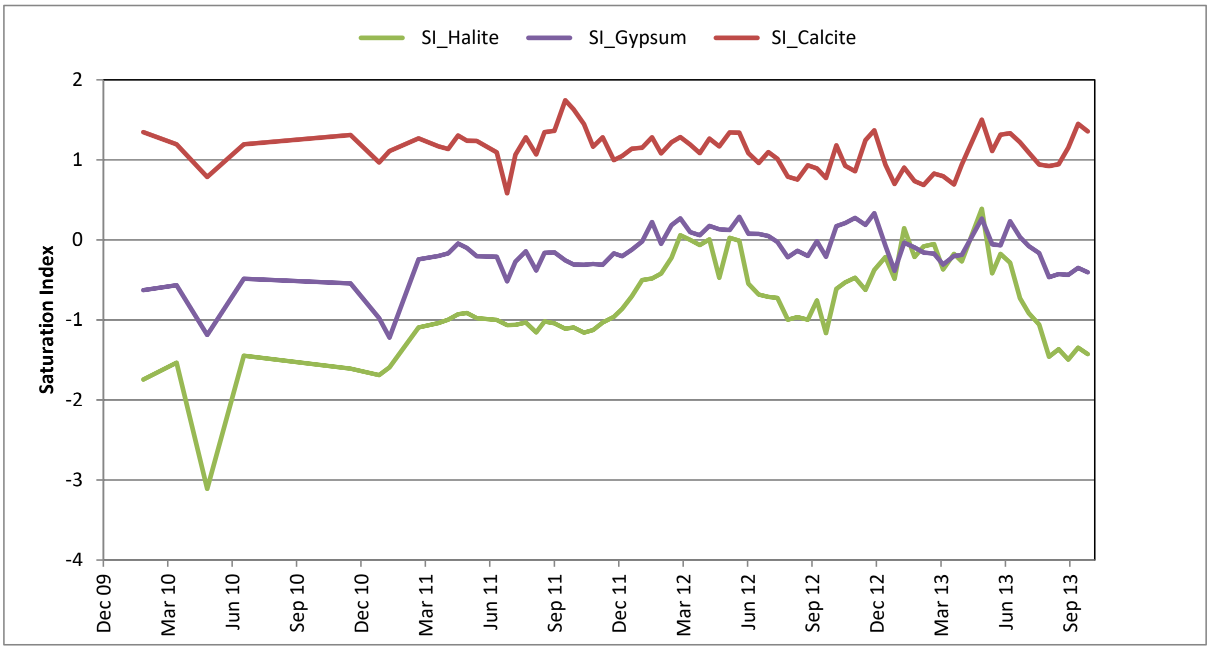

Figure 12. Saturation index (SI) values for halite, calcite and gypsum for Lake Warden

Figure 12 shows that SI values for the likely major mineral phases that may precipitate from the evaporating lake water. The model predicts consistent over-saturation and therefore preference of calcite not to dissolve (and to a higher degree, it's polymorph, aragonite, not shown here). It is likely however, that the solubility constant used here for calcite is not applicable to brines of this ionic strength (higher degrees of ionic shielding and complexation with other ions) and applies more to fresher waters. Lake waters are instead more likely to remain at approximate equilibrium with respect to calcite.

Geochemical modelling also predicts that the lake becomes saturated with respect to gypsum at higher salinities. This is supported by plotting the ratio of calcium against TDS for the same dataset (Figure 13). This figure demonstrates that the relative abundance of calcium declines as evaporative concentration increases, which infers two simple processes control precipitation (with evaporation) or dissolution (with freshening/lowering of salinity/TDS during recharge) of calcite and/or gypsum.

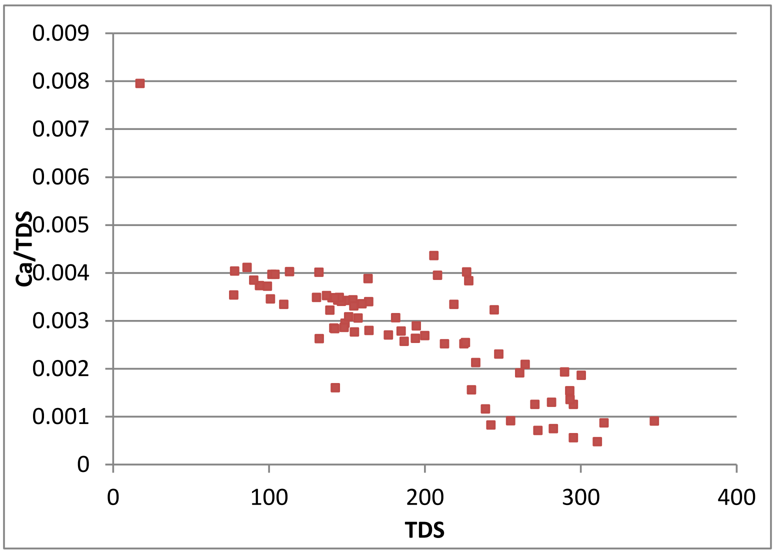

Figure 13. Plot of calcium versus total dissolved solids for Lake Warden

The precipitation and dissolution of calcite has important implications for the pH of lake water. As calcite ($CaCO_3$) is precipitated, removing carbonate from solution:

$$Ca^{2+} + CO_3^{2-} \rightarrow CaCO_3$$

With the removal of carbonate, the aqueous carbon species are in disequilibrium, and bicarbonate (and carbonic acid) must deprotonate to restore equilibrium (toward the right in the equation below):

$$H_2CO_3 \quad \leftrightarrow \quad HCO_3^- + H^+ \quad \leftrightarrow \quad CO_3^{2-} + 2H^+$$

Because the dominant aqueous carbon species at environmentally relevant pH conditions is HCO^{3-}, the precipitation/dissolution of calcite can effectively be described by the following reaction, which clearly demonstrates how these processes can influence pH:

$$Ca^{2+} + HCO_3^- \rightarrow CaCO_3 + H^+$$

4.6.2.1 Halite dissolution and precipitation and "storage" of salinity

The saturation index (SI) of halite (NaCl), has been shown to vary from under saturated to equilibrium/slightly oversaturated at during more saline conditions in the lake (Figure 14 Appendix 13).

Saturation with respect to halite occurred at the end of summer in 2012 and 2013, commensurate with lower lake water levels and higher TDS. Figure 14 below shows that the Cl/Br ratio declined during these periods, indicating that active halite precipitation was occurring (see Appendix 1 for Cl and Br data).

Data presented in this figure also shows that, following the return to wetter conditions and a rise in lake level in March of 2013 (see Figure 9), the Cl/Br ratio increased markedly, indicative of halite dissolution. During this period, high salinities and equilibrium with respect to halite were maintained until June, by which point the lake had received winter recharge (e.g. lake levels rose by 0.5 m).

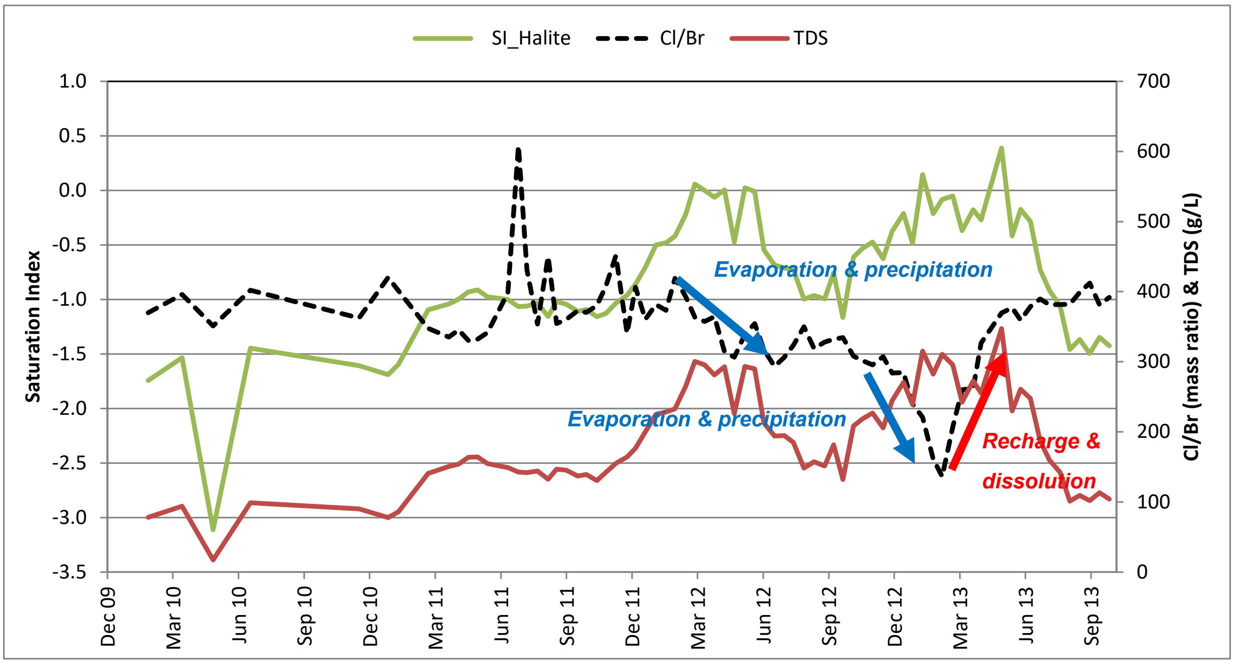

Figure 14. Plot of the saturation index (SI) of halite, the Cl/Br ratio, and the TDS of Lake Warden. Arrows show periods of precipitation and dissolution of Halite within the lake.

This hydrochemical behaviour can be explained by the mobilisation of salt from the lake bed during recharge/lake filling. While recharge waters received are less saline, high salinities are maintained through the dissolution of the stored salt precipitate (salt/evaporite recycling), which serves as a salinity “buffer”. This salt storage prevents an immediate freshening of the lake when recharge is received in early winter months.

This salt recycling process will continue to maintain high salinity levels until something changes the solute balance of the lake (e.g. removal of salt stores from the lake substrate). The conceptual model of Lake Warden salt dynamics is shown in Figure 15 below.

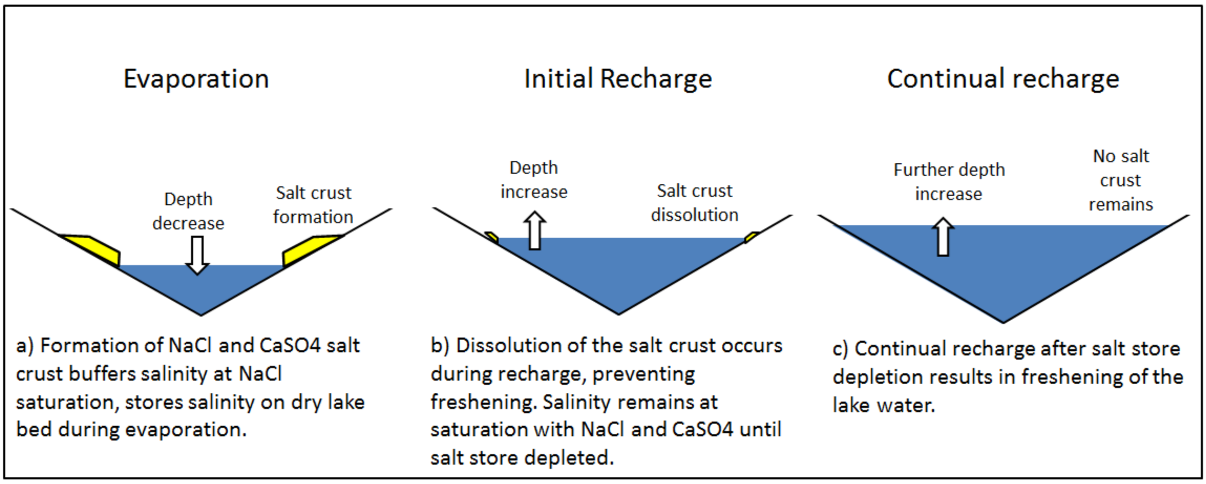

Figure 15. Conceptual model of salt crust salinity storage dynamics

4.6.3 Standing water levels and hydraulic gradients

Lake Warden lake water levels and groundwater levels within the surficial aquifer show strong seasonal and longer-term climatic controls and trends, which suggests they are hydraulically connected (Figures 16 and 17). In particular groundwater to the west of Lake Warden (bore LW15) appears to be in hydraulic equilibrium with that lake, while to the east (bore LW10) shows similar trends to Windabout Lake.

Data presented in Figure 16 are in mAHD and show the changes in groundwater hydraulic gradients (in relation to Lake Warden and Windabout Lake) over time. The data show increasing groundwater levels and gradients in shallow aquifers (e.g. bores LW10-OB and LW11-OB) to the east, north (LW22-OB) and south (LW15-OB) of Lake Warden. Groundwater levels are elevated in relation to Lake Warden lake levels confirming the lake can be considered to function as a discharge lake (e.g. groundwater discharges into the lake and contributes to the lake water balance).

Figure 17 shows the spatial and seasonal variation in shallow aquifer groundwater discharging to Lake Warden. Elevated salinity in aquifers to the north east (LW11-OB) and particularly the west (LW15-OB), where aquifer gradients into the lake are lower. Data indicate that following a lake fill event groundwater provides lower salinity discharge to Lake Warden and therefore the observed increases in lake water salinity are the result of saline surface water inflows and subsequent evaporation. In the event of flooding gradients between the lakes and shallow groundwater may change, and depending on the significance of the event shallow aquifers may be recharged with lower or higher salinity surface water, with potentially a different chemistry.

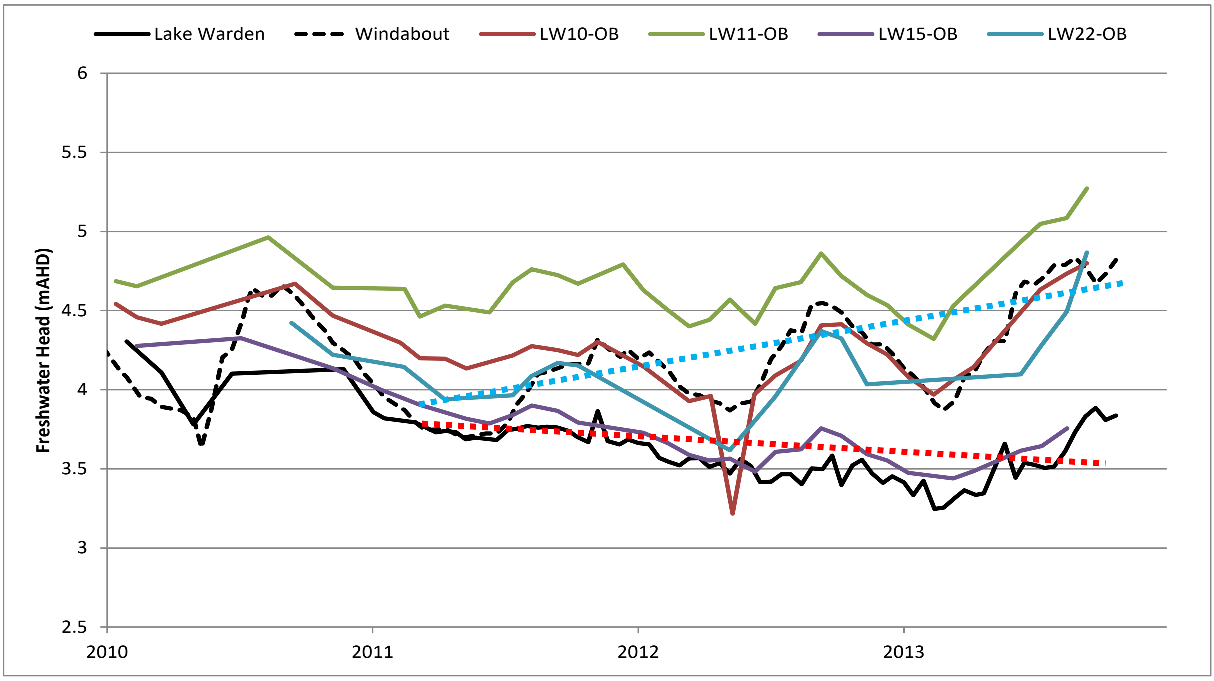

Figure 16 Freshwater (density correction applied) heads of Lake Warden, Windabout Lake and surrounding groundwater monitoring bores (NB uncleaned data; errors for LW10-OB have not been removed).

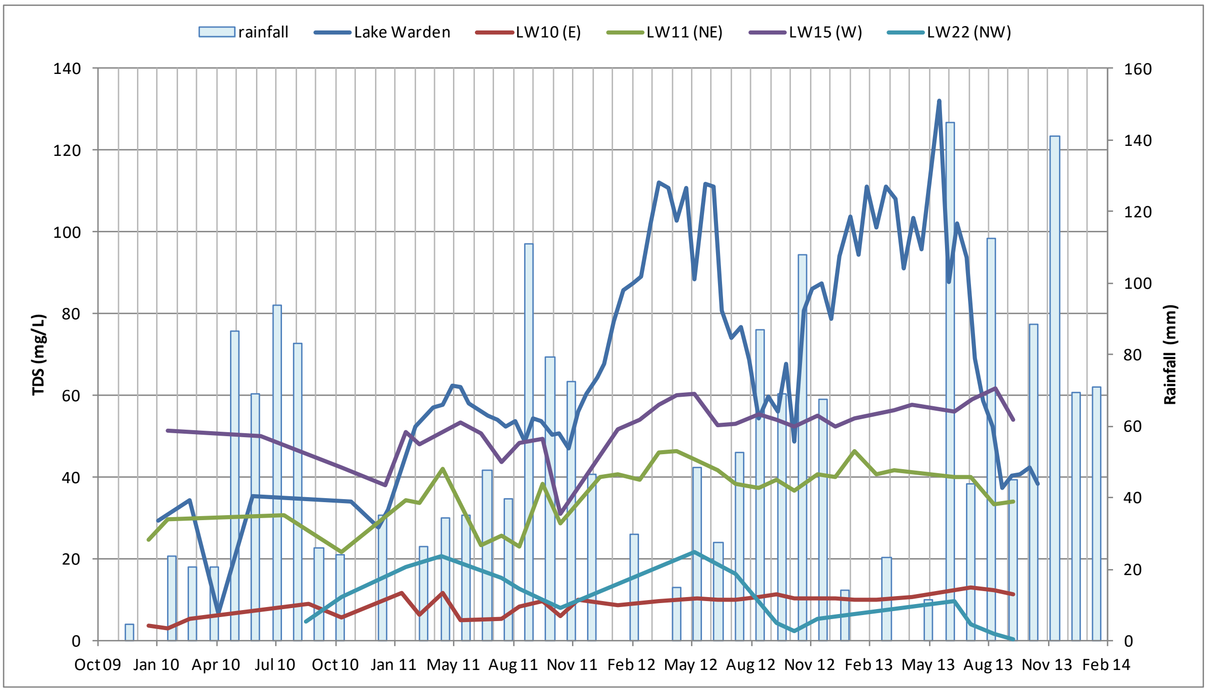

Figure 17. Plot of Esperance monthly rainfall (Bureau of Meteorology station 9789) and TDS (meq/L) of lake surface water in Lake Warden and groundwater for nearby bores.

5 Discussion

5.1 Hydrochemical data collection

Between 2000 and 2013 over 700 surface water and groundwater samples were collected and their hydrochemistry analysed. In this study laboratory results (major ions) were compiled and quality assured, with all data found to be fit for purpose to interpret and understand hydrological (surface water and groundwater) interactions in the LWWS. Spatially hydrochemical data collected were observed to be optimally distributed to monitor change in shallow groundwater and surface water in Lake Warden and to a lesser extent Pink Lake and Bandy Creek.

5.2 Using hydrochemical data to review published Ramsar water quality triggers

Modelling of the hydrochemical data (e.g. mineral saturation indices and ionic ratios Cl/Br) collected support physical chemistry data and indicate that elevated lake water salinity in Lake Warden may be produced through the recycling of solutes in near surface lake sediments. Undertaking the work reported here has allowed for this to be interpreted and a local scale conceptual model developed.

This recycled salt load, rather than groundwater or surface water inflows, could be the main cause for published Ramsar water quality trigger exceedances, which sees the lake being compliant with the salinity threshold when it fills (due to dissolution and dilution of solutes) but exceeding the water level threshold. When the lake dries the salinity and water level exceedances reverse.

5.3 Hydrochemical fingerprints and conceptual models

The hydrochemical fingerprint of rainwater, surface water and shallow groundwater is variable, which complicates using hydrochemical data in isolation to quantify coarse scale recharge, throughflow and discharge. In particular the variation in rainfall chemistry, with elevated Ca and alkalinity, does not lend itself to quantifying lake water and shallow aquifer interactions. The shallow groundwater system around Pink Lake was identified as being compositionally distinct relative to that of the rest of the LWWS, displaying higher concentrations of Mg, Ca and alkalinity, suggesting they are recharged by water interacting with evaporites within Pink Lake.

The hydrochemical monitoring program analysed in this report lacks sufficient spatial data collection to use as input to review the current coarse scale conceptual hydrological model (e.g. that the lakes act as a superimposed “flow through” system).

Marimuthu et. al. (2005) collected and analysed environmental tracers (stable water isotopes δO18 and δH2) in conjunction with hydrochemical data to help reduce the equivalence problems and quantify processes. This is discussed further in Section 6.

5.4 Increasing understanding of hydrological processes for management

A correlation between Lake Warden water quality and lake water levels exists. Salinity data alone indicate the process is uniform but when interpreted with hydrochemical data seasonal patterns emerge. Hydrochemical data and modelling have demonstrated they have value in feeding into the development of a local scale conceptual hydrological model to explain water quality in Lake Warden. This increases our understanding of seasonal unsaturated zone processes and their linkages with shallow aquifers at Lake Warden and potentially Pink Lake. Important to note that there is less hydrological information available for Pink Lake and its unlikely the Lake Warden salinity and hydrochemical data relationship is directly transferable.

Hydrochemical data suggest that there may be a groundwater connection between Lake Warden and Pink Lake, but how this connection would affect lake water and salt balances is unknown (e.g. extent and magnitude of groundwater salt export from the Lake Warden). Apart from during major flood events there is no surface mechanism for Lake Warden to export salt via westerly surface water flows elevated lake salinities and lower lake water levels are likely to persist under the current climatic conditions.

6 Recommendations

6.1 Hydrochemical data collection

Increasing compliance in the collection, handling and management of hydrochemical samples and data will improve the value and confidence in future data collected.

This should include the development of standard operating procedures (SOPs) that cover methodologies and procedures and the creation of supporting metadata, as outlined in Appendix 2. Sampling schedules need to be developed in line with holding times and laboratory services available, particularly with respect to the collection of sensitive analytes such as nutrients.

The rationale underpinning the frequency of collecting hydrochemical data must be developed in relation to changes in system dynamics under investigation being resolvable. Results presented here indicate that periodic (e.g. decadal for coarse scales) sampling of groundwater and surface water may be sufficient to measure changes relating to most emerging threats.

6.2 Ramsar triggers

Consideration should be given to reviewing published Ramsar hydrology management triggers in relation to the work presented here. If the current climatic conditions continue it is recommended that either the salinity or water level threshold is raised.

This should be undertaken in conjunction with a review of hydrological management options for the LWWS to ensure that management actions that have potential to change the water and solute balance are assisting, rather than exacerbating, the lakes salinity problem.

6.3 Hydrochemical fingerprints, conceptual models and increasing understanding of hydrological processes for management

The review of hydrochemical data in this study indicates there is limited, but sufficient variation, in fingerprints to use them in conjunction with other data (e.g. environmental tracers and aquifer groundwater levels) to assess water and solute balances in the LWWS. Data collected at different spatial and monitoring frequency scales need to be tailored to suit either a coarse or fine scale investigation, as both have different requirements.

The review of the current conceptual hydrological model requires a coarse scale study to assess the interactions of the LWWS with the movement of groundwater from north to south and surface water from east to west (Section 4.1). This study would enable salt storages in shallow and deep aquifers and lakes to be reviewed against baseline data collected in the early 2000's and the contribution of deeper aquifers to shallow aquifer and lake water balances to be better understood. The investigation requires infrequent (approximately decadal) high spatial and temporal scale, campaign style data collection. There is existing robust hydrological infrastructure (e.g. bores, lake depth gauges, etc) and as the last coarse scale (baseline) dataset was acquired in the early 2000's it is recommended that this study is undertaken when funds become available.

Similarly, hydrochemical data and supporting environmental tracers are likely to be useful in understanding the degree of mixing and solute export following episodic flood events. Results advising on the dynamics of the system and allowing for the reassessment of hydrological threats.

Finer scale hydrochemical investigations (such as understanding the connectivity between Lake Warden and Pink Lake) require more planning to ensure they are designed to answer the questions being asked. To succeed they may require the installation of appropriate local scale infrastructure and the development of a seasonal monitoring program (e.g. collection of groundwater level and quality minimum (March/April) and maximum (September/October) data). Hydrochemcial data collected together with environmental tracers to assess recharge and mixing (e.g. lakes bearing an enriched/evaporated stable water isotopic signature compared to rainfall) is of value to manage individual lakes and potentially understanding the connection between lakes, where sufficient supporting data exists. Data needs to be quality assured and reviewed annually to ensure the analytes, tracers and frequency of data collection are providing useful information.

Hydrochemical data are an expensive option for regular monitoring if the changes they are measuring are small or not resolvable. It is therefore recommended that an understanding is established of the hydrological processes hydrochemcial data advise on, and following this, relationships with other data that are regularly collected (e.g. physical chemistry pH, EC and Temperature) are developed and periodically reassessed.

7 References

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Appendices

Appendix 1 Major ion Database

No	Station ID	Sample type	Spatial grouping	Sample_Date	Alternative ID	Watertype	Temp (°C)	pH (field)	EC (Field) (uS/cm)	ORP (field) (mV)	pH (lab) (uS/cm)	EC (lab) (uS/cm)	18O	2H	CBE (%)	TDS (calc) (mg/L)	Ca (meq)	Mg (meq)	Na (meq)	K (meq)	Br (meq)	Cl_meq	SO4_meq	CO3_meq	HCO3_meq
1	Bandy creek (Flowmanns Road)	Surface water	Bandy creek	1/09/2002	E11	Na-Cl	21.1	7.4					-2.97	-11.64	-1.4	34188	8.21	70.21	495.57	3.92		548.85	42.66		1.96
2	Bandy creek (Flowmanns Road)	Surface water	Bandy creek	1/12/2002	E11	Na-Cl	27.3	8.2					-1.96	-8.70	3.3	34455	8.38	95.53	506.58	4.57		514.31	59.36		3.60
3	Bandy creek (Flowmanns Road)	Surface water	Bandy creek	1/03/2003	E11	Na-Cl	21.8	8					-2.11	-7.22	0.1	35740	11.00	99.94	500.44	5.27		553.59	59.84		1.58
4	Bandy creek- Fisheries rd	Surface water	Bandy creek	1/09/2002	Bandy 2	Na-Mg-Cl	17.1	7.5					-4.80	-21.70	2.7	7412	5.39	37.44	89.78	2.35		117.78	8.45		1.84
5	Bandy creek- Fisheries rd	Surface water	Bandy creek	1/12/2002	Bandy 2	Na-Cl	22.8	7.9					-4.33	-21.28	-3.3	6580	2.26	14.53	89.89	0.97		102.63	9.96		2.24
6	Bandy creek- Fisheries rd	Surface water	Bandy creek	1/03/2003	Bandy 2	Na-Cl	18.2	7.8					-4.42	-18.25	1.1	14980	5.76	41.85	210.97	2.48		228.51	25.52		1.36
7	Bandy creek- Fisheries rd	Surface water	Bandy creek	7/01/2010	Bandy 2	Na-Cl	22.1				8.12	12690			-0.1	5603	2.79	13.29	77.34	0.89	0.09	79.55	11.54	0.07	3.10
8	Bandy creek- Fisheries rd	Surface water	Bandy creek	7/07/2010	Bandy 2	Na-Cl	9.9				7.74	38100			2.5	22207	8.61	61.13	317.03	4.13	0.34	328.09	37.25	0.12	6.43
9	Bandy creek- Fisheries rd	Surface water	Bandy creek	13/04/2011	Bandy 2	Na-Cl	18.1				8.09	18790			2.1	39425	21.39	116.11	547.51	10.79	0.90	604.49	60.79	0.03	2.56
10	Bandy creek- Fisheries rd	Surface water	Bandy creek	14/10/2011	Bandy 2	Na-Cl	10.2				8.48	20900			1.3	7184	2.64	17.23	103.01	1.20	0.12	107.25	9.99	0.11	3.47
11	Bandy creek- Fisheries rd	Surface water	Bandy creek	26/10/2011	Bandy 2	Na-Cl	17				8.32	26600			0.1	9993	3.78	24.20	140.85	1.81	0.14	151.88	14.30	0.08	3.77
12	Bandy creek- Fisheries rd	Surface water	Bandy creek	20/11/2013	Bandy 2	Na-Cl	19	8.61	14820						1.0	8958	3.98	25.18	124.37	1.60	0.03	135.35	13.39	0.14	3.32
13	Bandy creek- Fisheries rd	Surface water	Bandy creek	4/12/2013	Bandy 2	Na-Cl	22	8.54	14860						0.5	8896	3.76	24.85	122.84	1.61	0.01	134.82	13.26	0.12	3.46
14	Bandy creek- Fisheries rd	Surface water	Bandy creek	18/12/2013	Bandy 2	Na-Cl	23.2	8.41	15590						1.2	9473	4.29	26.50	131.59	1.74	0.17	141.90	14.18	0.10	4.00
15	Bandy creek- Fisheries rd	Surface water	Bandy creek	31/12/2013	Bandy 2	Na-Cl	24.3	8.55	16720						3.3	10261	3.97	28.80	147.77	1.84	0.18	151.80	15.01	0.14	3.93
16	Bandy creek- Fisheries rd	Surface water	Bandy creek	15/01/2014	Bandy 2	Na-Cl	22.9	8.59	18900						4.2	11694	5.49	32.18	170.30	2.07	0.20	171.77	16.84	0.18	4.52
17	Bandy creek- Fisheries rd	Surface water	Bandy creek	28/01/2014	Bandy 2	Na-Cl	21.4	8.67	18790						-0.3	12505	5.19	34.31	171.39	2.21	0.22	191.01	18.05	0.23	4.80
18	Bandy creek- Fisheries rd	Surface water	Bandy creek	12/02/2014	Bandy 2	Na-Cl	21.8	8.71	22400						-0.6	13831	6.04	38.10	187.96	2.47	0.25	210.59	20.72	0.29	5.58
19	Bandy creek harbour	Surface water	Bandy creek	1/09/2002	Bandy 3	Na-Cl	20.8	8.6					-1.89	-6.20	-2.7	13075	4.79	41.23	171.04	1.89		210.42	17.36		2.94
20	Bandy creek harbour	Surface water	Bandy creek	1/12/2002	Bandy 3	Na-Cl	25.8	8.2					0.60	9.60	-2.9	14887	6.00	36.26	201.68	2.05		234.20	22.55		3.68
21	Bandy creek harbour	Surface water	Bandy creek	1/03/2003	Bandy 3	Na-Cl	22	8.6					0.22	2.65	1.3	16901	9.01	46.25	235.87	3.05		255.03	27.59		4.12
22	Bandy creek harbour	Surface water	Bandy creek	21/12/2009	Bandy 3	Na-Cl									-3.1	37449	20.25	107.06	484.19	10.15	0.79	600.18	56.48	0.02	2.66
23	Bandy creek harbour	Surface water	Bandy creek	16/02/2010	Bandy 3	Na-Cl									2.2	30014	17.07	88.46	414.16	8.57	0.68	446.28	57.13	0.01	2.00
24	Bandy creek harbour	Surface water	Bandy creek	3/03/2010	Bandy 3	Na-Cl									1.0	26290	14.43	76.79	356.13	7.19	0.58	385.05	58.32	0.01	1.67
25	Bandy creek harbour	Surface water	Bandy creek	1/05/2010	Bandy 3	Na-Cl									-0.5	36290	21.69	107.64	481.33	10.86	0.84	568.91	55.42	0.01	2.64
26	Bandy creek harbour	Surface water	Bandy creek	6/05/2010	Bandy 3	Na-Cl									1.7	36145	20.15	111.59	493.73	10.28	0.79	552.71	59.13	0.01	2.25
27	Bandy creek harbour	Surface water	Bandy creek	1/07/2010	Bandy 3	Na-Cl									0.4	29907	16.77	87.47	405.46	8.36	0.66	465.66	44.99	0.02	2.28
28	Bandy creek harbour	Surface water	Bandy creek	20/07/2010	Bandy 3	Na-Cl	16				7.81	47600			-1.1	20339	9.85	54.81	271.74	4.97	0.38	298.08	48.61	0.01	1.67
29	Bandy creek harbour	Surface water	Bandy creek	8/11/2010	Bandy 3	Na-Cl	21				8.39	53200			1.8	28660	15.62	85.99	393.68	8.16	0.68	435.25	48.45	0.06	1.98
30	Bandy creek harbour	Surface water	Bandy creek	23/11/2010	Bandy 3	Na-Cl	20.3				8.08	54800			1.3	27327	14.73	82.62	370.32	7.83	0.59	404.46	56.44	0.05	1.83
31	Bandy creek harbour	Surface water	Bandy creek	8/12/2010	Bandy 3	Na-Cl	20.7				8.58	54700			1.0	37523	20.30	112.74	510.09	10.46	0.88	577.20	61.11	0.03	2.37
32	Bandy creek harbour	Surface water	Bandy creek	18/01/2011	Bandy 3	Na-Cl	22.2				8.14	55700			1.6	36578	20.70	111.17	499.11	10.51	0.88	558.39	60.61	0.03	2.47
33	Bandy creek harbour	Surface water	Bandy creek	2/02/2011	Bandy 3	Na-Cl	22.2				8.14	55200			0.7	31295	16.67	87.89	427.56	8.44	0.71	469.54	60.52	0.03	2.05
34	Bandy creek harbour	Surface water	Bandy creek	1/03/2011	Bandy 3	Na-Cl	21.1				8.17	55200			0.3	37467	21.24	112.74	503.02	10.74	0.90	580.53	59.94	0.02	2.58
35	Bandy creek harbour	Surface water	Bandy creek	30/03/2011	Bandy 3	Na-Cl	22.2				7.94	55200			0.4	38816	21.59	115.21	524.35	10.94	0.92	602.13	60.79	0.02	2.67
36	Bandy creek harbour	Surface water	Bandy creek	13/04/2011	Bandy 3	Na-Cl	19.4				8.08	35400			0.1	39531	21.44	129.94	519.93	10.86	0.85	604.49	72.60	0.03	2.64
37	Bandy creek harbour	Surface water	Bandy creek	27/04/2011	Bandy 3	Na-Cl	20.3				7.89	55300			1.6	31873	17.86	95.29	435.27	9.03	0.69	479.89	58.19	0.02	2.23
38	Bandy creek harbour	Surface water	Bandy creek	10/05/2011	Bandy 3	Na-Cl	18.9				8.05	55500			-0.1	36383	20.35	108.95	486.40	10.38	0.80	564.13	59.32	0.03	2.51
39	Bandy creek harbour	Surface water	Bandy creek	24/05/2011	Bandy 3	Na-Cl	18.6				8.08	55000			0.5	26247	14.68	77.95	353.48	7.40	0.55	397.90	48.47	0.02	1.85
40	Bandy creek harbour	Surface water	Bandy creek	22/06/2011	Bandy 3	Na-Cl	17.1				8.07	54700			-0.5	24364	13.03	68.51	328.77	7.88	0.57	390.20	29.71	0.02	1.62
41	Bandy creek harbour	Surface water	Bandy creek	7/07/2011	Bandy 3	Na-Cl	15.2				8.2	51000			2.2	18687	9.95	51.60	263.44	5.69	0.43	290.01	24.63	0.02	1.38
42	Bandy creek harbour	Surface water	Bandy creek	19/07/2011	Bandy 3	Na-Cl	16.2				7.88	54400			1.1	29821	15.92	84.26	412.03	9.39	0.69	472.02	36.23	0.01	1.83
43	Bandy creek harbour	Surface water	Bandy creek	3/08/2011	Bandy 3	Na-Cl	14.8				8.12	54800			-0.1	18498	9.90	52.67	252.30	5.69	0.42	302.53	16.90	0.01	1.11
44	Bandy creek harbour	Surface water	Bandy creek	18/08/2011	Bandy 3	Na-Cl	15.6				8.23	53800			-0.1	18111	8.76	51.04	246.08	5.58	0.42	284.07	26.36	0.02	1.15
45	Bandy creek harbour	Surface water	Bandy creek	30/08/2011	Bandy 3	Na-Cl	15.8				7.85	54500			-0.4	29156	14.97	77.29	398.55	9.26	0.66	465.18	36.35	0.02	1.70
46	Bandy creek harbour	Surface water	Bandy creek	13/09/2011	Bandy 3	Na-Cl	16.4				8.18	54800			4.4	30494	16.87	86.40	440.00	10.28	0.72	466.61	39.12	0.02	1.83
47	Bandy creek harbour	Surface water	Bandy creek	29/09/2011	Bandy 3	Na-Cl	16.9				8.75	54600			0.3	21887	12.68	66.21	293.97	6.20	0.47	342.72	32.38	0.08	1.39
48	Bandy creek harbour	Surface water	Bandy creek	11/10/2011	Bandy 3	Na-Cl	18.5				8.35	54600			-2.9	25332	14.73	68.84	329.69	7.65	0.58	406.14	36.52	#N/A	2.05
49	Bandy creek harbour	Surface water	Bandy creek	20/11/2013	Bandy 3	Na-Mg-Cl	20.5	8.21	41600						-1.1	27723	17.81	102.12	348.26	7.29	0.01	439.34	43.12	0.05	3.05
50	Bandy creek harbour	Surface water	Bandy creek	4/12/2013	Bandy 3	Na-Cl	21.5	8.16	37500						-0.5	24752	14.37	72.91	329.90	6.34	0.01	385.91	38.79	0.05	3.27
51	Bandy creek harbour	Surface water	Bandy creek	18/12/2013	Bandy 3	Na-Cl	22.4	7.88	43800						3.0	25811	15.47	79.66	358.14	6.91	0.59	390.31	40.45	0.02	3.29
52	Bandy creek harbour	Surface water	Bandy creek	31/12/2013	Bandy 3	Na-Cl	24.3	8.07	39500						1.9	22500	12.67	68.71	308.55	5.91	0.50	342.02	35.46	0.04	3.54
53	Bandy creek harbour	Surface water	Bandy creek	12/02/2014	Bandy 3	Na-Cl	21.3	7.99	46500						-3.2	29184	16.82	83.28	375.10	7.55	0.68	461.66	47.14	0.04	3.78
54	Bandy creek- pipeline	Surface water	Bandy creek	15/04/2010		Na-Cl									2.9	21655	10.41	57.02	311.11	3.55	0.31	317.30	35.02	0.12	8.27
55	Bandy creek- pipeline	Surface water	Bandy creek	1/05/2010		Na-Cl									3.2	9123	4.36	24.87	130.11	1.72	0.16	132.02	14.32	0.07	4.80
56	Bandy creek- pipeline	Surface water	Bandy creek	5/05/2010		Na-Cl									0.2	6640	3.05	18.05	91.09	1.28	0.12	99.21	10.85	0.01	2.75
57	Bandy creek- pipeline	Surface water	Bandy creek	9/06/2010		Na-Cl	12.7				8.33	22300			-2.0	14071	6.03	37.64	188.88	2.47	0.20	217.10	22.94	0.03	3.91
58	Bandy creek- pipeline	Surface water	Bandy creek	20/07/2010		Na-Cl	12.5				8.31	20700			3.2	12926	5.02	35.79	186.96	2.14	0.18	192.25	20.10	0.03	3.50
59	Bandy creek- pipeline	Surface water	Bandy creek	8/11/2010		Na-Cl	22.8				8.37	16470			0.9	8096	3.35	22.37	112.58	1.49	0.14	119.72	14.58	0.33	2.38
60	Bandy creek- pipeline	Surface water	Bandy creek	8/12/2010		Na-Cl	22.4				8.3	18330			4.7	5176	1.40	12.19	77.30	0.84	0.07	67.14	14.65	0.17	1.56
61	Bandy creek- pipeline	Surface water	Bandy creek	3/01/2011		Na-Cl	24.6				8.01	30000			-3.8	10606	3.96	25.63	139.68	1.75	0.21	154.03	26.98	0.03	2.66
62	Bandy creek- pipeline	Surface water	Bandy creek	18/01/2011		Na-Cl	25.8				7.95	38800			-3.0	17481	6.15	51.03	227.33	3.62	0.31	263.76	38.83	0.02	2.13
63	Bandy creek- pipeline	Surface water	Bandy creek	2/02/2011		Na-Cl	27.2				8.01	37600			-2.1	11935	4.12	26.57	161.78	2.03	0.18	161.05	38.73	0.08	2.39
64	Bandy creek- pipeline	Surface water	Bandy creek	15/02/2011		Na-Cl	24				7.91	35300			0.8	19871	8.73	51.79	277.44	3.60	0.30	292.29	37.31	0.07	6.05
65	Bandy creek- pipeline	Surface water	Bandy creek	1/03/2011		Na-Cl	23.8				7.94	37900			4.5	25066	12.27	70.70	363.66	5.12	0.42	365.35	41.16	0.10	7.15
66	Bandy creek- pipeline	Surface water	Bandy creek	30/03/2011		Na-Cl	23.3				7.77	37300			4.3	23990	12.36	66.89	346.61	4.88	0.40	348.46	39.79	0.05	7.77
67	Bandy creek- pipeline	Surface water	Bandy creek	13/04/2011		Na-Cl	20.1				7.6	40600			2.4	27683	15.03	78.78	387.67	6.25	0.53	414.05	44.43	0.06	6.76
68	Bandy creek- pipeline	Surface water	Bandy creek	27/04/2011		Na-Cl	20.5				7.47	41800			2.6	23215	12.65	64.18	326.16	5.47	0.46	339.28	43.47	0.04	5.18
69	Bandy creek- pipeline	Surface water	Bandy creek	10/05/2011		Na-Cl	18.4				7.61	41600			1.0	22428	12.44	60.80	308.55	5.19	0.43	330.95	42.68	0.05	5.36

No	Station ID	Sample type	Spatial grouping	Sample_Date	Alternative ID	Watertype	Temp (°C)	pH (field)	EC (Field) (uS/cm)	ORP (field) (mV)	pH (lab) (uS/cm)	EC (lab) (uS/cm)	18O	2H	CBE (%)	TDS (calc) (mg/L)	Ca (meq)	Mg (meq)	Na (meq)	K (meq)	Br (meq)	Cl_meq	SO4_meq	CO3_meq	HCO3_meq
70	Bandy creek- pipeline	Surface water	Bandy creek	24/05/2011		Na-Cl	17.2				7.74	29400			2.9	10350	5.31	26.13	146.68	2.11	0.19	140.15	26.98	0.02	3.15
71	Bandy creek- pipeline	Surface water	Bandy creek	22/06/2011		Na-Cl	15.2				8.62	13290			-2.2	7946	2.65	19.89	108.27	1.74	0.15	126.13	9.63	0.10	2.38
72	Bandy creek- pipeline	Surface water	Bandy creek	7/07/2011		Na-Cl	12.3				8.46	32600			0.3	9767	2.86	22.23	140.24	1.72	0.14	147.20	16.81	0.05	1.79
73	Bandy creek- pipeline	Surface water	Bandy creek	19/07/2011		Na-Cl	12.2				8.02	25200			1.3	12160	3.77	27.07	178.00	2.34	0.19	187.06	16.00	0.03	2.57
74	Bandy creek- pipeline	Surface water	Bandy creek	3/08/2011		Na-Cl	14.5				8.35	22000			-0.6	8158	2.65	17.59	116.75	1.44	0.12	128.13	9.63	0.05	2.22
75	Bandy creek- pipeline	Surface water	Bandy creek	18/08/2011		Na-Cl	11.6				8.68	20600			-0.6	7084	2.25	15.50	101.22	1.38	0.11	111.71	8.16	0.08	1.74
76	Bandy creek- pipeline	Surface water	Bandy creek	30/08/2011		Na-Cl	15.3				8.7	18600			-1.3	7613	2.35	14.69	109.40	1.59	0.12	121.42	7.85	0.09	1.92
77	Bandy creek- pipeline	Surface water	Bandy creek	13/09/2011		Na-Cl	17.1				8.28	19020			2.7	5520	1.75	10.05	83.87	1.15	0.10	82.12	8.05	0.06	1.34
78	Bandy creek- pipeline	Surface water	Bandy creek	29/09/2011		Na-Cl	16.8				9.76	26700			-3.2	30452	8.80	77.93	413.42	4.69	0.42	485.61	45.45	1.52	2.69
79	Bandy creek- pipeline	Surface water	Bandy creek	11/10/2011		Na-Cl	18.6				8.89	17990			-2.0	6876	2.75	16.49	93.79	1.10	0.09	103.45	13.06	0.15	1.88
80	Bandy creek- pipeline	Surface water	Bandy creek	26/10/2011		Na-Cl	19.5				8.51	16590			-3.1	8479	3.66	20.72	113.27	1.46	0.13	130.22	14.08	0.10	3.08
81	Bandy creek- pipeline	Surface water	Bandy creek	8/11/2011		Na-Cl	20.8			321.6	8.59	19440			-0.6	11599	4.82	29.54	160.95	1.90	0.16	178.65	18.03	0.10	2.53
82	Bandy creek- pipeline	Surface water	Bandy creek	22/11/2011		Na-Cl	24.2			369.5	8.39	17720			-1.7	11067	5.01	29.29	149.55	1.90	0.16	171.71	17.27	0.07	2.74
83	Bandy creek- pipeline	Surface water	Bandy creek	9/12/2011		Na-Cl-SO4	21				7.86	18130			2.2	4420	1.75	9.63	64.73	0.61	0.05	53.77	15.89	0.01	1.35
84	Bandy creek- pipeline	Surface water	Bandy creek	18/01/2012		Na-Mg-Cl	24.9			312.8	8.37	39400			4.1	29296	7.57	110.60	410.25	3.62	0.28	436.68	50.01	0.12	5.23
85	Bandy creek- pipeline	Surface water	Bandy creek	15/02/2012		Na-Cl	22.9			296.3	7.97	25500			-0.9	16151	8.51	43.42	218.20	2.81	0.20	246.47	25.59	0.05	5.62
86	Bandy creek- pipeline	Surface water	Bandy creek	29/02/2012		Na-Cl	22.4			397	7.72	38000			1.8	24828	14.24	73.36	342.13	5.14	0.38	374.11	39.62	0.03	6.38
87	Bandy creek- pipeline	Surface water	Bandy creek	13/03/2012		Na-Cl	24.5			279.6	7.88	42600			-0.8	33373	17.53	98.34	449.03	7.29	0.55	524.25	50.03	0.02	3.08
88	Bandy creek- pipeline	Surface water	Bandy creek	27/03/2012		Na-Cl	22.6			327.1	7.92	34200			0.2	22947	14.02	67.42	307.50	5.16	0.40	348.66	38.02	0.05	5.85
89	Bandy creek- pipeline	Surface water	Bandy creek	10/04/2012		Na-Cl	20.4			363.2	7.86	37500			-0.1	24869	15.45	74.03	330.21	6.70	0.44	380.28	40.74	0.04	5.46
90	Bandy creek- pipeline	Surface water	Bandy creek	24/04/2012		Na-Cl	22.1			319.7	7.89	38000			-1.2	26248	13.08	65.74	359.44	5.12	0.54	410.01	38.08	0.04	5.18
91	Bandy creek- pipeline	Surface water	Bandy creek	8/05/2012		Na-Cl	17.5			293.4	7.91	44900			2.8	27486	15.89	82.21	383.58	6.95	0.60	415.33	42.39	0.04	4.44
92	Bandy creek- pipeline	Surface water	Bandy creek	22/05/2012		Na-Cl	15.3			52.2	8.16	24300			0.9	18133	10.54	51.88	248.43	3.23	0.34	274.62	28.44	0.08	5.30
93	Bandy creek- pipeline	Surface water	Bandy creek	6/06/2012		Na-Cl	16.5			331.8	7.83	40100			1.3	23204	13.06	68.69	317.33	5.50	0.61	352.07	35.94	0.04	5.60
94	Bandy creek- pipeline	Surface water	Bandy creek	20/06/2012		Na-Cl	13.5			307.1	8.68	41600			0.4	22795	7.24	61.66	319.07	3.84	0.33	345.53	38.23	0.23	4.87
95	Bandy creek- pipeline	Surface water	Bandy creek	4/07/2012		Na-Cl	13.9			243.3	8.81	43400			1.1	22268	6.98	60.30	315.64	3.58	0.34	336.71	36.56	0.28	4.45
96	Bandy creek- pipeline	Surface water	Bandy creek	18/07/2012		Na-Cl	13.9			328.9	8.96	31700			2.1	17269	6.30	48.44	245.95	2.89	0.28	258.74	28.40	0.32	3.59
97	Bandy creek- pipeline	Surface water	Bandy creek	31/07/2012		Na-Cl	13			300.7	8.97	35100			0.3	18304	6.62	50.12	255.21	2.92	0.30	278.46	29.81	0.37	3.98
98	Bandy creek- pipeline	Surface water	Bandy creek	15/08/2012		Na-Cl	14.3			318.5	8.71	22200			-1.7	13861	4.57	35.98	189.53	2.14	0.21	214.37	22.11	0.17	3.41
99	Bandy creek- pipeline	Surface water	Bandy creek	29/08/2012		Na-Cl	16.9			329.1	8.91	31800			1.1	19378	6.36	51.93	274.96	2.92	0.30	292.81	31.88	0.32	3.93
100	Bandy creek- pipeline	Surface water	Bandy creek	13/09/2012		Na-Cl	15.7			261.4	9.26	32700			0.7	20338	6.82	55.30	286.32	3.13	0.34	308.95	33.42	0.65	3.63
101	Bandy creek- pipeline	Surface water	Bandy creek	26/09/2012		Na-Cl	18.2			305.6	8.87	28600			1.1	17478	6.80	47.29	246.82	2.74	0.28	265.99	28.00	0.22	3.01
102	Bandy creek- pipeline	Surface water	Bandy creek	9/10/2012		Na-Cl	20.4				8.55	18660			0.3	11905	5.12	34.27	163.47	2.08	0.21	181.62	18.37	0.12	3.38
103	Bandy creek- pipeline	Surface water	Bandy creek	24/10/2012		Na-Cl	20.8			485.6	8.24	15860			0.9	9924	4.71	29.02	136.24	1.80	0.17	149.60	15.14	0.06	3.75
104	Bandy creek- pipeline	Surface water	Bandy creek	6/11/2012		Na-Cl	20.2			328.2	8.43	15760			1.7	9818	4.71	28.84	136.42	1.82	0.17	147.57	15.05	0.09	3.21
105	Bandy creek- pipeline	Surface water	Bandy creek	20/11/2012		Na-Cl	24			359.2	8	23800			-0.4	14023	7.44	38.64	189.83	2.60	0.25	211.35	25.59	0.03	3.23
106	Bandy creek- pipeline	Surface water	Bandy creek	5/12/2012		Na-Cl	22.3			368.8	8.12	19020			-0.6	11353	6.72	34.83	149.42	2.37	0.23	173.77	17.15	0.06	4.33
107	Bandy creek- pipeline	Surface water	Bandy creek	18/12/2012		Na-Cl	26.2			322.9	7.89	26200			0.9	16622	9.92	52.33	222.63	3.25	0.33	249.09	27.90	0.04	5.65
108	Bandy creek- pipeline	Surface water	Bandy creek	3/01/2013		Na-Cl	30.6				8.02	35600			4.6	23692	14.78	75.22	331.95	6.88	0.46	346.73	38.75	0.07	6.42
109	Bandy creek- pipeline	Surface water	Bandy creek	16/01/2013		Na-Cl	24			344.2	7.77	36000			3.9	23236	15.43	74.11	321.55	5.53	0.49	339.26	40.39	0.04	6.73
110	Bandy creek- pipeline	Surface water	Bandy creek	30/01/2013		Na-Cl	23.5			322.6	7.75	37400			2.5	17347	9.32	45.46	246.04	3.41	0.30	255.84	26.82	0.04	7.15
111	Bandy creek- pipeline	Surface water	Bandy creek	14/02/2013		Na-Cl									2.3	26272	13.90	69.17	373.01	5.07	0.45	390.38	41.10	0.05	8.69
112	Bandy creek- pipeline	Surface water	Bandy creek	27/02/2013		Na-Cl	24.2			319.3	7.77	38200			0.2	24388	14.08	67.40	332.17	5.35	0.48	368.35	39.75	0.06	7.12
113	Bandy creek- pipeline	Surface water	Bandy creek	14/03/2013		Na-Cl	23.8			295	7.87	28200			-0.2	17123	10.63	48.44	228.85	3.72	0.34	258.74	27.54	0.05	6.41
114	Bandy creek- pipeline	Surface water	Bandy creek	27/03/2013		Na-Cl	19.9			273.9	8.08	30400			1.4	18697	8.17	50.66	264.22	3.13	0.27	283.94	29.77	0.02	3.33
115	Bandy creek- pipeline	Surface water	Bandy creek	11/04/2013		Na-Cl	22.6			200.1	8.32	29700			2.5	18354	8.02	49.15	263.83	2.97	0.26	276.43	28.73	0.07	3.48
116	Bandy creek- pipeline	Surface water	Bandy creek	24/04/2013		Na-Cl	21				8.58	28400			1.2	17324	7.81	47.38	243.60	2.88	0.24	264.10	27.21	0.12	3.07
117	Bandy creek- pipeline	Surface water	Bandy creek	8/05/2013		Na-Cl	18.7			244.2	8.8	32600			4.5	20824	8.98	56.58	307.50	3.26	0.28	308.09	33.10	0.22	3.60
118	Bandy creek- pipeline	Surface water	Bandy creek	22/05/2013		Na-Cl	15.9			233.5	9.15	39700			0.8	18604	8.74	50.25	260.35	2.88	0.27	283.06	30.13	0.47	3.34
119	Bandy creek- pipeline	Surface water	Bandy creek	6/06/2013		Na-Cl	16.3			169.7	8.51	25700			-0.4	15993	6.72	43.18	219.94	2.43	0.22	243.93	25.13	0.16	5.02
120	Bandy creek- pipeline	Surface water	Bandy creek	18/06/2013		Na-Cl	13.4			102.9	8.93	28500			1.6	17622	7.96	51.87	246.78	2.70	0.24	268.93	27.71	0.23	2.68
121	Bandy creek- pipeline	Surface water	Bandy creek	2/07/2013		Na-Cl	12.5			116.6	9.26	27900			0.5	17519	7.35	47.98	244.86	2.67	0.25	268.64	27.52	0.52	2.87
122	Bandy creek- pipeline	Surface water	Bandy creek	16/07/2013		Na-Cl	14.5			337.6	8.86	27100			1.5	16675	6.68	47.42	235.07	2.54	0.23	253.92	26.07	0.22	3.01
123	Bandy creek- pipeline	Surface water	Bandy creek	29/07/2013		Na-Cl	14			345.3	9.08	30800			3.3	18376	6.85	55.38	263.52	2.96	0.28	274.71	30.90	0.27	2.28
124	Bandy creek- pipeline	Surface water	Bandy creek	13/08/2013		Na-Cl	15.1			175	9.11	26500			-0.5	16504	6.32	47.84	225.59	2.57	0.26	255.41	25.78	0.39	3.04
125	Bandy creek- pipeline	Surface water	Bandy creek	27/08/2013		Na-Cl	19.2			291.5	8.51	18430			-0.5	11267	3.96	31.20	155.08	1.76	0.15	173.63	17.06	0.10	3.04
126	Bandy creek- pipeline	Surface water	Bandy creek	10/09/2013		Na-Cl	17.3			278.6	9.03	22000			0.1	13851	5.84	40.03	190.18	2.11	0.20	212.96	21.03	0.36	3.40
127	Bandy creek- pipeline	Surface water	Bandy creek	25/09/2013		Na-Cl	17.9			173.7	9.11	25000			3.5	15691	5.80	42.40	230.38	2.32	0.19	236.60	21.76	0.44	3.47
128	Bandy creek- pipeline	Surface water	Bandy creek	8/10/2013		Na-Cl	22.4			14.9	8.7	22000			2.2	14048	5.79	38.12	201.23	2.19	0.21	212.68	21.28	0.14	2.87
129	Bandy creek- pipeline	Surface water	Bandy creek	22/10/2013		Na-Cl	14.9			234.9	8.75	19180			1.7	11631	4.33	30.55	166.87	1.84	0.17	176.90	17.47	0.13	2.27
130	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	26/10/2011		Na-Cl	19.7				8.37	43500			-5.0	20011	10.99	52.18	254.91	5.38	0.43	324.46	29.11	0.06	2.46
131	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	8/11/2011		Na-Cl	20.6			354.5	8.29	47600			4.6	30615	17.02	91.18	440.09	8.01	0.61	459.05	47.07	0.05	2.50
132	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	22/11/2011		Na-Cl	24.2			400.8	8.2	48300			2.3	25983	14.28	80.57	357.31	6.66	0.52	389.38	47.49	0.03	1.92
133	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	9/12/2011		Na-Cl	20.7				8.03	50900			2.7	31625	17.61	98.50	438.35	8.49	0.64	481.35	49.91	0.03	2.53
134	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	20/12/2011		Na-Cl	25.2			313.2	8.12	48700			3.0	31473	18.21	101.22	434.70	8.31	0.63	477.33	50.36	0.04	2.76
135	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	3/01/2012		Na-Mg-Cl	22.9			356.2	8.12	48200			3.2	31243	14.08	120.06	422.34	6.89	0.42	476.60	50.01	0.04	3.15
136	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	18/01/2012		Na-Mg-Cl	24.2			322.4	8.23	50200			2.7	35123	13.68	135.61	474.08	7.01	0.55	538.42	56.30	0.05	3.16
137	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	1/02/2012		Na-Cl	17.7			363.6	7.98	52100			4.2	36453	17.61	104.01	529.77	8.03	0.66	551.25	52.07	0.04	4.06
138	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	29/02/2012		Na-Cl	20.3			407.2	7.85	55600			0.7	37049	21.24	110.35	502.97	9.49	0.69	572.85	58.69	0.02	2.75

No	Station ID	Sample type	Spatial grouping	Sample_Date	Alternative ID	Watertype	Temp (°C)	pH (field)	EC (Field) (uS/cm)	ORP (field) (mV)	pH (lab) (uS/cm)	EC (lab) (uS/cm)	18O	2H	CBE (%)	TDS (calc) (mg/L)	Ca (meq)	Mg (meq)	Na (meq)	K (meq)	Br (meq)	Cl_meq	SO4_meq	CO3_meq	HCO3_meq
139	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	13/03/2012		Na-Cl	22.6			291.1	8.13	56100			-0.7	35079	17.47	97.68	471.05	8.16	0.60	541.12	57.67	0.09	6.41
140	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	27/03/2012		Na-Cl	20.3			345.2	7.98	56000			-0.9	37750	20.90	115.45	498.55	10.00	0.61	594.17	58.50	0.02	2.53
141	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	24/04/2012		Na-Cl	19			379.3	8.09	57700			-3.4	38583	19.55	115.70	494.43	9.95	0.93	624.40	55.42	0.03	2.60
142	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	8/05/2012		Na-Cl	17.9			305.6	8.07	59000			-0.8	37876	20.65	114.05	503.10	9.33	0.92	596.27	57.92	0.03	2.50
143	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	22/05/2012		Na-Cl	15.3			21.2	7.95	60900			1.3	37352	21.59	112.41	512.69	8.49	0.87	579.31	55.76	0.02	2.49
144	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	6/06/2012		Na-Cl	16.5			323.7	7.86	59300			-1.5	35849	20.60	114.14	463.29	9.95	0.87	565.11	57.26	0.02	2.59
145	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	20/06/2012		Na-Cl	15.5			315.2	8.18	58100			0.7	35297	19.30	110.10	474.82	9.44	0.81	543.82	56.90	0.05	3.46
146	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	4/07/2012		Na-Cl	16.1			300.7	8.42	47800			-3.9	28393	13.88	78.36	367.66	6.40	0.61	456.09	42.33	0.09	3.42
147	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	18/07/2012		Na-Cl	15.4			341.9	8.48	53900			0.2	31159	18.51	92.00	418.25	8.65	0.71	481.30	50.68	0.08	2.67
148	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	31/07/2012		Na-Cl	14.9			284.9	8.5	44700			-1.5	23968	12.04	68.42	318.55	5.48	0.51	373.74	38.58	0.11	3.48
149	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	15/08/2012		Na-Cl	15.4			299.2	8.35	39900			1.0	23839	13.18	70.07	325.16	5.92	0.53	362.88	39.79	0.07	3.24
150	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	29/08/2012		Na-Cl	15.4			318.2	8.87	30600			0.7	18568	6.37	49.56	261.57	3.03	0.29	281.37	30.73	0.24	3.71
151	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	13/09/2012		Na-Cl	17.9			261.7	8.94	30800			0.6	18984	7.96	52.34	263.91	3.65	0.31	288.27	31.02	0.34	3.85
152	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	26/09/2012		Na-Cl	18.6			298.3	8.36	43300			1.5	26842	15.27	80.65	367.79	6.96	0.62	410.84	43.37	0.05	2.14
153	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	9/10/2012		Na-Cl	19.2				8.34	34300			3.6	21208	12.39	67.03	296.71	5.38	0.46	320.53	32.15	0.06	2.77
154	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	24/10/2012		Na-Cl	19.8			356.8	8.18	41200			1.4	27103	16.87	85.01	365.79	7.63	0.64	415.65	43.06	0.04	2.79
155	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	6/11/2012		Na-Cl	20.7			368.4	8.16	45400			4.6	28300	18.36	95.21	389.37	11.02	0.72	416.32	49.74	0.04	3.06
156	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	20/11/2012		Na-Cl	22.9			338.3	8.28	50900			-2.5	32136	20.30	104.43	403.77	9.62	0.88	505.01	56.42	0.04	1.96
157	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	5/12/2012		Na-Cl	19.8			360.9	8.02	47500			-0.2	32182	22.73	109.12	412.77	9.74	0.81	499.49	52.42	0.04	3.95
158	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	18/12/2012		Na-Cl	23.7			343.9	8.06	53500			3.4	34729	24.83	112.33	470.01	13.95	0.94	518.51	59.61	0.04	3.23
159	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	30/01/2013		Na-Cl	20.8			299.1	7.8	51600			-1.2	20682	12.58	59.40	272.96	5.69	0.49	324.46	31.38	0.02	2.66
160	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	27/02/2013		Na-Cl	24.7			310.7	8.15	54300			4.8	35290	22.09	109.03	502.36	9.92	0.87	526.89	55.49	0.04	2.83
161	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	14/03/2013		Na-Cl	21.6			251.2	8.13	53400			-3.3	34834	22.54	103.36	440.69	9.95	0.87	555.10	55.53	0.04	3.15
162	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	27/03/2013		Na-Cl	18.7			338.2	8.06	30800			0.5	18984	8.66	52.43	263.74	3.37	0.29	291.87	30.29	0.03	2.52
163	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	11/04/2013		Na-Cl	24.3			206.4	8.09	43900			2.7	28090	16.42	83.20	390.89	7.07	0.61	426.22	44.74	0.04	2.95
164	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	24/04/2013		Na-Cl	19.2				8.34	31900			0.3	16927	8.21	46.36	232.90	3.23	0.25	254.40	30.98	0.07	3.12
165	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	8/05/2013		Na-Cl	19.5			276.7	8.12	47400			2.7	30894	18.88	94.30	429.39	8.19	0.67	471.65	49.68	0.00	0.32
166	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	22/05/2013		Na-Cl	17.1			234.2	8.7	38000			2.2	24079	14.23	69.15	336.39	5.19	0.44	364.18	38.91	0.16	3.25
167	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	6/06/2013		Na-Cl	15			174.9	8.27	25800			0.1	15413	7.00	43.07	212.58	2.51	0.22	236.99	24.63	0.05	2.65
168	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	18/06/2013		Na-Cl	15.5			169.2	8.58	35600			2.7	22032	13.20	68.05	305.54	5.08	0.47	333.75	35.23	0.10	2.54
169	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	2/07/2013		Na-Cl	16.4			186.8	8.6	40000			2.2	25083	15.10	77.05	344.87	6.34	0.55	381.92	39.93	0.11	2.69
170	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	16/07/2013		Na-Cl	17			331.1	8.51	39000			3.0	24433	14.03	73.01	342.61	5.92	0.52	368.71	39.47	0.08	2.40
171	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	29/07/2013		Na-Cl	15.2			366.1	8.85	30100			1.8	18182	7.76	54.05	254.52	3.08	0.29	274.77	29.96	0.22	3.11
172	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	13/08/2013		Na-Cl	15.6			227.1	8.87	33000			2.9	20507	10.30	61.97	288.10	4.25	0.38	306.88	33.85	0.26	3.54
173	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	27/08/2013		Na-Cl	18.5			371	8.14	18140			-0.2	11066	4.70	31.19	151.51	1.82	0.17	169.94	16.91	0.04	3.07
174	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	10/09/2013		Na-Cl	21.5			279.1	8.6	24600			0.2	15245	7.80	43.89	207.63	3.02	0.25	233.18	24.17	0.14	3.49
175	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	8/10/2013		Na-Cl	24			56.1	8.45	34100			2.3	21611	11.98	63.77	300.93	5.08	0.45	327.56	34.29	0.08	2.99
176	Bandy creek- weir at Bandy harbour	Surface water	Bandy creek	22/10/2013		Na-Cl	15.9			220.5	8.92	25300			-0.1	15310	5.58	41.82	212.89	2.40	0.22	236.96	23.55	0.20	2.42
177	BOM 9789	Rainfall	Rainfall	30/04/2002		Ca-Na-HCO3-Cl							-3.41	-6.70	0.6	25	0.23	0.04	0.10	0.00		0.17	0.02		0.18
178	BOM 9789	Rainfall	Rainfall	21/06/2002		Na-Cl							-2.81	-4.99	-4.7	91	0.12	0.24	1.06	0.02		1.33	0.13		0.12
179	BOM 9789	Rainfall	Rainfall	4/07/2002		Na-Ca-Cl-HCO3									3.9	83	0.45	0.24	0.67	0.01		0.85	0.09		0.34
180	BOM 9789	Rainfall	Rainfall	5/07/2002		Na-Ca-Cl-HCO3							-6.24	-26.09	-1.2	61	0.24	0.17	0.54	0.01		0.68	0.09		0.22
181	BOM 9789	Rainfall	Rainfall	13/07/2002		Na-Cl							-7.71	-31.60	-4.8	44	0.05	0.11	0.50	0.01		0.56	0.07		0.10
182	BOM 9789	Rainfall	Rainfall	24/07/2002		Na-Cl-HCO3							-4.16	-13.15	0.2	27	0.05	0.04	0.31	0.00		0.25	0.03		0.12
183	BOM 9789	Rainfall	Rainfall	28/07/2002		Na-Ca-Cl							-4.66	-7.75	-0.4	45	0.15	0.11	0.45	0.01		0.54	0.07		0.12
184	BOM 9789	Rainfall	Rainfall	15/09/2002		Na-Cl							-9.74	-54.02	-4.2	72	0.09	0.19	0.84	0.02		1.04	0.10		0.10
185	BOM 9789	Rainfall	Rainfall	16/09/2002		Na-Cl							-5.97	-15.17	-4.4	93	0.09	0.25	1.11	0.02		1.35	0.13		0.12
186	BOM 9789	Rainfall	Rainfall	24/11/2002		Na-Ca-Cl							-2.58	1.91	0.9	65	0.22	0.17	0.68	0.02		0.85	0.11		0.12
187	BOM 9789	Rainfall	Rainfall	2/12/2002		Na-Cl							-2.49	1.80	-3.1	120	0.23	0.31	1.38	0.03		1.78	0.18		0.12
188	BOM 9789	Rainfall	Rainfall	22/12/2002		Na-Ca-Cl							-2.39	1.70	1.4	92	0.43	0.22	0.85	0.04		1.10	0.25		0.14
189	BOM 9789	Rainfall	Rainfall	27/02/2003		Na-Mg-Cl-HCO3							-2.88	4.03	-4.4	46	0.05	0.15	0.48	0.01		0.51	0.10		0.15
190	BOM 9789	Rainfall	Rainfall	12/04/2003		Na-Ca-Cl							-9.34	-37.13	3.9	54	0.18	0.14	0.57	0.03		0.65	0.08		0.12
191	BOM 9789	Rainfall	Rainfall	15/04/2003		Na-Ca-Cl									2.5	36	0.14	0.10	0.36	0.01		0.42	0.06		0.10
192	BOM 9789	Rainfall	Rainfall	26/04/2003		Na-Ca-Cl							-4.13	-9.08	0.7	35	0.12	0.08	0.34	0.01		0.37	0.08		0.10
193	Coramup creek (Gibson Road)	Surface water	Coramup creek	1/09/2002	E12	Na-Cl	25.3	8.6					-3.88	-18.50	-4.3	14597	5.84	44.44	187.40	1.97		237.98	20.67		2.06
194	Coramup creek (Gibson Road)	Surface water	Coramup creek	1/12/2002	E12	Na-Cl	29.9	8.8					-3.91	-18.11	-5.0	5898	2.43	14.19	77.41	0.96		94.90	7.89		1.92
195	Coramup creek (Gibson Road)	Surface water	Coramup creek	1/03/2003	E12	Na-Cl	23.9	8.9					-4.40	-21.18	1.2	11197	5.29	32.31	155.55	2.18		172.01	16.79		2.18
196	Coramup creek (wetlands)	Surface water	Coramup creek	1/09/2002	E39	Na-Cl	23	8.2					-4.76	-19.64	-4.5	8761	3.84	21.81	116.41	1.23		146.44	8.37		1.68
197	Coramup creek (wetlands)	Surface water	Coramup creek	1/12/2002	E39	Na-Cl	27.2	9					-2.69	-9.60	-1.7	4473	2.32	11.17	60.56	0.78		69.30	6.50		1.62
198	Coramup creek (wetlands)	Surface water	Coramup creek	1/03/2003	E39	Na-Cl	21.7	8.6					-4.84	-19.81	-4.6	5903	3.02	15.20	76.29	1.21		94.34	8.99		1.32
199	Coramup creek- Myrup rd	Surface water	Coramup creek	1/09/2002	Coramup Creek (CC)	Na-Cl	15.3	7.3					-5.27	-23.39	3.5	3981	1.95	10.37	57.86	0.69		58.76	5.95		1.48
200	Coramup creek- Myrup rd	Surface water	Coramup creek	1/12/2002	Coramup Creek (CC)	Na-Cl	25.8	8.3					-3.66	-18.05	-3.2	3959	1.96	9.96	52.38	0.70		61.93	5.76		1.56
201	Coramup creek- Myrup rd	Surface water	Coramup creek	1/03/2003	Coramup Creek (CC)	Na-Cl	22.6	8					-5.06	-20.08	-4.4	5493	2.73	14.58	70.89	1.14		88.01	8.04		1.32
202	Coramup creek- Myrup rd	Surface water	Coramup creek	6/06/2013	Coramup Creek (CC)	Na-Cl	15.2			287.1	7.79	18610			-0.5	11020	5.82	32.43	148.16	1.86	0.19	169.88	17.12	0.02	2.80
203	Coramup creek- Myrup rd	Surface water	Coramup creek	18/06/2013	Coramup Creek (CC)	Na-Cl	12.5			309.5	8.02	16110			2.3	9814	4.59	28.27	138.24	1.64	0.16	146.66	14.57	0.04	3.66
204	Coramup creek- Myrup rd	Surface water	Coramup creek	15/01/2014	Coramup Creek (CC)	Na-Cl	23.2	8.19	6010						1.7	2955	1.59	7.83	40.72	0.62	0.06	42.09	4.08	0.04	2.85
205	EWD4A	Groundwater	Western suite	9/10/2012	OB EWD 4A	Na-Cl	17.2				6.13	2360			4.9	1833	2.74	4.92	21.73	2.81	0.03	24.78	3.18	0.00	1.24
206	EWD4A	Groundwater	Western suite	11/12/2012	OB EWD 4A	Na-Cl	19			256.3	5.98	2120			2.5	1121	1.69	2.79	11.49	2.30	0.02	13.08	2.14	0.00	2.15
207	EWD4A	Groundwater	Western suite	9/01/2013	OB EWD 4A	Na-Cl	19.4			201.6	6.1	1760			3.4	937	1.64	2.22	10.37	1.50	0.02	11.39	2.01		1.28

No	Station ID	Sample type	Spatial grouping	Sample_Date	Alternative ID	Watertype	Temp (°C)	pH (field)	EC (Field) (uS/cm)	ORP (field) (mV)	pH (lab) (uS/cm)	EC (lab) (uS/cm)	18O	2H	CBE (%)	TDS (calc) (mg/L)	Ca (meq)	Mg (meq)	Na (meq)	K (meq)	Br (meq)	Cl_meq	SO4_meq	CO3_meq	HCO3_meq
208	EWD4A	Groundwater	Western suite	13/02/2013	OB EWD 4A	Na-Cl	19.8			283.8	6.38	1570			-3.7	849	1.29	1.64	8.93	1.33	0.01	10.52	1.66	0.00	1.51
209	EWD4A	Groundwater	Western suite	12/03/2013	OB EWD 4A	Na-Cl	19.6			226.7	6.64	1590			-2.5	922	1.34	2.05	9.67	1.17	0.02	11.31	1.64	0.00	1.99
210	EWD4A	Groundwater	Western suite	7/10/2013	OB EWD 4A	Na-Cl									4.0	1117	3.08	3.23	11.33	1.75	0.01	14.16	3.49		0.28
211	Lake Ewans- West GP	Surface water	Eastern suite	1/09/2002	E26	Na-Cl	22.4	8.4					-2.82	-10.01	1.0	10695	4.05	27.01	153.61	0.82		163.08	16.65		2.32
212	Lake Ewans- West GP	Surface water	Eastern suite	1/12/2002	E26	Na-Cl	25.1	8.6					0.95	10.21	2.1	14332	5.58	35.37	207.98	2.02		213.47	24.41		3.12
213	Lake Ewans- West GP	Surface water	Eastern suite	1/03/2003	E26	Na-Cl	19.7	8.1					-3.26	-11.58	1.5	12615	6.02	35.17	176.86	2.40		190.64	21.88		1.62
214	Lake Ewans- West GP	Surface water	Eastern suite	30/03/2010	E26	Na-Cl									1.5	27299	5.22	65.63	397.98	4.49	0.40	404.77	46.20	0.28	7.61
215	Lake Ewans- West GP	Surface water	Eastern suite	13/04/2010	E26	Na-Cl-SO4					8.57	26400			0.1	8462	2.29	16.08	120.45	1.25	0.11	106.80	29.77	0.06	2.89
216	Lake Ewans- West GP	Surface water	Eastern suite	25/05/2010	E26	Na-Cl					8.21	19250			-0.1	10180	3.83	23.30	143.33	1.71	0.15	149.48	18.72	0.03	4.05
217	Lake Ewans- West GP	Surface water	Eastern suite	20/07/2010	E26	Na-Cl					7.71	24900			-0.4	8608	2.64	21.33	119.84	1.30	0.13	123.73	20.61	0.00	1.71
218	Lake Ewans- West GP	Surface water	Eastern suite	14/10/2011	E26	Na-Cl					9.9	22300			-2.5	6210	1.99	13.21	87.35	1.12	0.10	99.67	7.72	0.43	0.54
219	Lake Ewans- West GP	Surface water	Eastern suite	26/10/2011	E26	Na-Cl					8.85	20100			-4.0	5580	1.69	11.98	75.43	0.94	0.08	85.08	10.30		1.84
220	Lake Ewans- West GP	Surface water	Eastern suite	8/11/2011	E26	Na-Cl					8.66	32000			4.6	21220	7.22	62.27	312.94	3.42	0.25	316.81	31.90	0.15	3.34
221	Lake Station GP	Surface water	Eastern suite	1/09/2002	Station	Na-Cl	25.7	8.9					-1.95	-6.34	-0.8	13528	4.39	27.81	196.14	1.61	#N/A	216.85	14.26	#N/A	2.60
222	Lake Station GP	Surface water	Eastern suite	1/12/2002	Station	Na-Cl	26.3	8.1					3.42	27.70	5.0	24690	8.83	68.92	366.21	3.95	#N/A	359.09	43.26	#N/A	4.84
223	Lake Station GP	Surface water	Eastern suite	1/03/2003	Station	Na-Cl	21.3	8.6					-2.26	-2.86	0.5	20293	6.72	51.89	287.06	3.98	#N/A	309.30	34.68	#N/A	2.34
224	Lake Station GP	Surface water	Eastern suite	17/01/2014	Station	Na-Cl	24.9	8.16	92500						3.9	72431	17.56	212.14	1061.40	12.18	1.03	1084.51	110.78	0.18	12.53
225	Lake Station GP	Surface water	Eastern suite	28/01/2014	Station	Na-Cl	25.3	8.03	132900						0.9	115893	21.51	353.85	1623.07	18.65	1.69	1774.83	193.33	0.14	12.78
226	Lake Station GP	Surface water	Eastern suite	11/02/2014	Station	Na-Mg-Cl	20.5	7.51	198900						4.7	228931	23.20	798.62	3300.00	31.64	3.04	3305.65	486.71	0.05	14.09
227	Lake Warden- Bukenerup inflow	Surface water	Western suite	29/08/2012		Na-Cl	17.8			360.6	8.62	16110			-1.1	9688	4.33	23.06	133.76	1.94	0.16	148.89	13.78	0.15	3.48
228	Lake Warden- Bukenerup inflow	Surface water	Western suite	6/06/2013		Na-Cl	13.8			175.2	8.38	18350			0.5	10883	6.72	28.04	150.08	2.55	0.20	166.75	16.16	0.06	2.51
229	Lake Warden- Bukenerup inflow	Surface water	Western suite	18/06/2013		Na-Cl	15.7			266.4	9.03	20800			1.0	12659	6.78	31.64	177.74	2.99	0.22	193.66	17.89	0.32	3.02
230	Lake Warden- Bukenerup inflow	Surface water	Western suite	16/07/2013		Na-Cl	13.8			468.2	8.21	8760			3.0	5062	3.74	13.26	70.47	1.18	0.09	72.30	6.69	0.07	4.37
231	Lake Warden- Bukenerup inflow	Surface water	Western suite	29/07/2013		Na-Cl	12.6			439.4	8.4	11140			-0.1	6595	4.21	16.24	88.96	1.44	0.12	95.91	8.80	0.15	6.16
232	Lake Warden- Bukenerup inflow	Surface water	Western suite	13/08/2013		Na-Cl	12.7			341.6	8.3	66900			1.7	3728	2.97	9.63	50.46	0.87	0.07	52.98	4.68	0.08	4.04
233	Lake Warden- Bukenerup inflow	Surface water	Western suite	27/08/2013		Na-Cl	16.7			362	8	125700			0.5	104452	17.80	270.65	1497.57	20.59	1.84	1632.96	149.57	0.06	5.83
234	Lake Warden- Bukenerup inflow	Surface water	Western suite	10/09/2013		Na-Cl	15.2			268.1	8.24	118300			1.4	102461	16.40	323.81	1436.67	19.08	1.71	1566.20	176.10	0.09	5.05
235	Lake Warden- Bukenerup inflow	Surface water	Western suite	24/09/2013		Na-Cl	16.8			244.1	8.32	115800			2.5	95194	19.51	239.88	1406.25	18.86	1.68	1463.24	134.85	0.12	5.55
236	Lake Warden- Bukenerup inflow	Surface water	Western suite	8/10/2013		Na-Cl	19.3			72.6	8.78	120100			1.1	102611	21.58	261.35	1484.06	20.59	1.84	1595.76	146.64	0.31	5.17
237	Lake Warden East GP	Surface water	Western suite	1/09/2002	Lake Warden	Na-Cl	22	7.9					0.70	16.93	-4.7	73859	14.83	172.03	1003.28	12.48		1223.58	90.06		3.60
238	Lake Warden East GP	Surface water	Western suite	1/12/2002	Lake Warden	Na-Cl	26.9	8.4					1.91	29.82	-0.7	72839	15.32	178.07	1037.98	13.01		1162.76	95.56		3.12
239	Lake Warden East GP	Surface water	Western suite	1/03/2003	Lake Warden	Na-Cl	20.3	7.6					3.75	27.50	-3.5	92625	20.16	216.04	1270.75	20.76		1506.82	123.52		3.68
240	Lake Warden East GP	Surface water	Western suite	28/01/2010	Lake Warden	Na-Cl	21.3				8.49	98700			0.9	78089	15.72	197.33	1125.17	16.83	1.45	1211.26	110.72	0.07	7.84
241	Lake Warden East GP	Surface water	Western suite	17/03/2010	Lake Warden	Na-Cl	23.6				8.17	112000			-1.7	94080	17.51	221.44	1325.37	19.08	1.68	1500.56	124.38	0.07	8.54
242	Lake Warden East GP	Surface water	Western suite	22/06/2010	Lake Warden	Na-Cl	16.5				8.21	121800			-3.4	99038	18.36	233.37	1361.06	20.12	1.76	1598.50	133.35	0.08	8.94
243	Lake Warden East GP	Surface water	Western suite	23/11/2010	Lake Warden	Na-Cl	22.6				8.35	118600			1.2	90257	17.32	231.73	1301.86	20.22	1.71	1393.12	132.12	0.13	8.29
244	Lake Warden East GP	Surface water	Western suite	3/01/2011	Lake Warden	Na-Cl	25				8.19	135200			-4.1	77547	13.68	185.98	1058.99	17.55	1.39	1319.77	56.86	0.09	5.79
245	Lake Warden East GP	Surface water	Western suite	18/01/2011	Lake Warden	Na-Cl	25.2				8.13	142600			-1.1	86096	17.66	224.73	1219.54	19.41	1.63	1477.81	26.46	0.09	6.99
246	Lake Warden East GP	Surface water	Western suite	1/03/2011	Lake Warden	Na-Cl	20.1				8.03	158500			0.0	140613	24.38	356.56	2006.90	30.59	2.82	2209.43	194.38	0.05	9.45
247	Lake Warden East GP	Surface water	Western suite	30/03/2011	Lake Warden	Na-Cl	24.3				7.82	167200			1.6	150674	25.72	399.02	2180.77	33.23	3.08	2331.41	216.51	0.06	9.59
248	Lake Warden East GP	Surface water	Western suite	13/04/2011	Lake Warden	Na-Cl	22.2				7.8	167300			0.8	153964	26.37	401.33	2209.22	34.25	3.08	2401.22	218.44	0.05	9.40
249	Lake Warden East GP	Surface water	Western suite	27/04/2011	Lake Warden	Na-Cl	20.9				7.88	176000			2.1	163675	31.64	434.82	2381.62	36.30	3.39	2520.56	236.75	0.06	9.75
250	Lake Warden East GP	Surface water	Western suite	10/05/2011	Lake Warden	Na-Cl	19.6				7.87	177500			1.2	164046	27.81	423.38	2373.64	36.27	3.41	2550.18	230.62	0.06	9.98
251	Lake Warden East GP	Surface water	Western suite	24/05/2011	Lake Warden	Na-Cl	19.6				7.98	171500			0.8	154624	25.52	400.42	2227.91	33.69	3.17	2435.96	199.21	0.06	8.84
252	Lake Warden East GP	Surface water	Western suite	22/06/2011	Lake Warden	Na-Cl	14.2				8.14	173500			-0.3	148908	21.89	375.82	2123.13	29.65	2.62	2347.81	210.65	0.05	6.25
253	Lake Warden East GP	Surface water	Western suite	7/07/2011	Lake Warden	Na-Cl	14.9				8.23	158400			1.5	142705	11.39	367.92	2102.57	19.71	1.62	2225.09	202.04	0.05	3.09
254	Lake Warden East GP	Surface water	Western suite	19/07/2011	Lake Warden	Na-Cl	15				8.21	165600			-0.5	141730	20.10	351.46	2027.59	24.51	2.30	2235.42	202.39	0.09	5.53
255	Lake Warden East GP	Surface water	Western suite	3/08/2011	Lake Warden	Na-Cl	11				8.29	164900			0.0	144234	24.68	355.49	2065.28	30.47	2.83	2259.35	208.20	0.14	7.04
256	Lake Warden East GP	Surface water	Western suite	18/08/2011	Lake Warden	Na-Cl	18.9				8.35	156600			-0.5	132378	17.32	331.88	1889.54	23.08	2.05	2085.95	192.96	0.10	4.57
257	Lake Warden East GP	Surface water	Western suite	30/08/2011	Lake Warden	Na-Cl	13.5				8.32	164700			-0.1	146668	24.88	371.62	2092.25	30.13	2.89	2307.65	206.35	0.10	7.05
258	Lake Warden East GP	Surface water	Western suite	13/09/2011	Lake Warden	Na-Cl	17.1				8.31	165000			-0.6	145212	25.22	361.01	2058.81	30.90	2.80	2275.86	217.92	0.10	6.77
259	Lake Warden East GP	Surface water	Western suite	29/09/2011	Lake Warden	Na-Cl	18.9				8.86	159300			-1.0	137011	24.08	348.00	1928.27	28.98	2.59	2179.05	186.90	0.47	6.49
260	Lake Warden East GP	Surface water	Western suite	11/10/2011	Lake Warden	Na-Cl	21.5				8.69	165700			-1.5	139236	22.34	361.17	1942.71	29.11	2.67	2229.90	185.82	0.33	6.65
261	Lake Warden East GP	Surface water	Western suite	26/10/2011	Lake Warden	Na-Cl	21.8				8.53	167400			-3.0	130693	22.73	327.76	1791.17	27.98	2.46	2109.47	180.30	0.19	5.65
262	Lake Warden East GP	Surface water	Western suite	22/11/2011	Lake Warden	Na-Cl	26.5			287.8	8.14	174600			4.3	154772	21.34	438.03	2314.88	33.54		2368.18	210.20	0.10	7.33
263	Lake Warden East GP	Surface water	Western suite	20/12/2011	Lake Warden	Na-Cl	24.7			337.6	7.82	179500			3.7	176728	23.83	611.99	2533.21	35.12	2.98	2728.89	245.44	0.05	7.25
264	Lake Warden East GP	Surface water	Western suite	3/01/2012	Lake Warden	Na-Cl	27.8			281.2	7.73	183400			5.1	200109	26.82	686.30	2933.86	39.85	3.78	3067.36	264.77	0.04	7.79
265	Lake Warden East GP	Surface water	Western suite	18/01/2012	Lake Warden	Na-Mg-Cl	26.8			364.8	7.58	192800			3.1	225135	28.26	789.33	3196.13	42.49	4.08	3512.77	300.54	0.03	9.14
266	Lake Warden East GP	Surface water	Western suite	1/02/2012	Lake Warden	Na-Cl	27			258.6	7.52	204000			3.1	228204	43.63	697.90	3305.16	44.87	4.19	3522.70	319.97	0.03	8.79
267	Lake Warden East GP	Surface water	Western suite	14/02/2012	Lake Warden	Na-Cl	25.6			294.4	7.48	212000			2.2	232765	24.68	642.68	3411.46	49.55	3.88	3662.48	278.06	0.03	9.90
268	Lake Warden East GP	Surface water	Western suite	29/02/2012	Lake Warden	Na-Cl	24.1			273.3	7.48	222000			3.5	264537	27.51	734.69	3930.26	50.52	4.56	4041.82	384.19	0.03	10.46
269	Lake Warden East GP	Surface water	Western suite	13/03/2012	Lake Warden	Na-Cl	25			238.9	7.37	223000			0.6	300495	27.91	846.63	4285.55	60.57	5.78	4734.57	412.75	0.02	10.50
270	Lake Warden East GP	Surface water	Western suite	27/03/2012	Lake Warden	Na-Cl	27.2			285.6	7.49	218000			1.1	295410	18.41	830.54	4243.27	61.21	5.70	4593.66	439.93	0.03	9.58
271	Lake Warden East GP	Surface water	Western suite	10/04/2012	Lake Warden	Na-Cl	26.6			273.2	7.43	221000			-1.3	281354	18.16	769.91	3924.93	57.71	5.44	4462.14	415.43	0.03	9.58
272	Lake Warden East GP	Surface water	Western suite	24/04/2012	Lake Warden	Na-Cl	24.3			264.4	7.57	225000			1.4	293055	22.44	762.17	4302.38	44.64	6.47	4584.58	398.56	0.03	8.46
273	Lake Warden East GP	Surface water	Western suite	8/05/2012	Lake Warden	Na-Cl	17.1			236.2	7.76	221000			4.3	226106	28.71	610.43	3413.28	40.29	4.96	3431.41	323.83	0.05	7.89
274	Lake Warden East GP	Surface water	Western suite	23/05/2012	Lake Warden	Na-Cl	18			318.8	7.65	225000			2.0	293282	19.80	782.25	4329.75	49.57	6.02	4598.15	368.73	0.05	11.75
275	Lake Warden East GP	Surface water	Western suite	6/06/2012	Lake Warden	Na-Cl	17			253.4	7.61	247000			2.7	289839	27.91	801.09	4265.26	60.70	5.64	4502.88	383.96	0.04	9.93
276	Lake Warden East GP	Surface water	Western suite	19/06/2012	Lake Warden	Na-Cl	16.6			267	7.77	241000			2.0	212645	26.72	571.50	3097.20	46.56	4.58	3277.04	315.55	0.04	7.45

No	Station ID	Sample type	Spatial grouping	Sample_Date	Alternative ID	Watertype	Temp (°C)	pH (field)	EC (Field) (uS/cm)	ORP (field) (mV)	pH (lab) (uS/cm)	EC (lab) (uS/cm)	18O	2H	CBE (%)	TDS (calc) (mg/L)	Ca (meq)	Mg (meq)	Na (meq)	K (meq)	Br (meq)	Cl_meq	SO4_meq	CO3_meq	HCO3_meq
277	Lake Warden East GP	Surface water	Western suite	4/07/2012	Lake Warden	Na-Cl	12.3			311.3	7.8	256000			2.6	194060	25.47	518.43	2846.51	40.90	4.43	2931.81	322.50	0.05	7.21
278	Lake Warden East GP	Surface water	Western suite	18/07/2012	Lake Warden	Na-Cl	15.9			315.4	7.98	219000			5.1	194688	28.06	545.58	2937.73	42.18	4.22	2917.73	295.85	0.05	5.49
279	Lake Warden East GP	Surface water	Western suite	31/07/2012	Lake Warden	Na-Cl	16.3			350.7	7.86	227000			-0.2	184908	25.67	475.64	2631.44	38.68	3.98	2903.82	270.00	0.05	6.29
280	Lake Warden East GP	Surface water	Western suite	15/08/2012	Lake Warden	Na-Cl	13.9			297.3	7.9	182000			-1.2	148299	21.14	374.91	2086.53	30.47	2.98	2351.64	213.00	0.04	5.42
281	Lake Warden East GP	Surface water	Western suite	29/08/2012	Lake Warden	Na-Cl	16.4			304.7	7.74	182500			1.8	157322	23.98	412.36	2290.28	33.25	3.37	2420.52	238.55	0.03	5.71
282	Lake Warden East GP	Surface water	Western suite	13/09/2012	Lake Warden	Na-Cl	17.8			238.7	7.68	184500			-0.4	151208	23.23	390.96	2142.09	31.90	3.21	2376.50	216.41	0.05	9.92
283	Lake Warden East GP	Surface water	Western suite	26/09/2012	Lake Warden	Na-Cl	16.2			303.5	7.67	185600			0.5	181451	27.71	476.29	2600.61	37.83	3.79	2841.45	258.00	0.03	6.94
284	Lake Warden East GP	Surface water	Western suite	9/10/2012	Lake Warden	Na-Cl	18.3				7.75	194300			-0.2	132234	26.47	366.44	1851.47	28.88	2.76	2082.87	190.75	0.03	5.59
285	Lake Warden East GP	Surface water	Western suite	24/10/2012	Lake Warden	Na-Cl	22.1			279.8	7.68	198800			3.7	208287	41.00	591.75	3069.94	47.17	4.61	3197.80	285.74	0.03	6.67
286	Lake Warden East GP	Surface water	Western suite	6/11/2012	Lake Warden	Na-Cl	15.8			281.5	7.73	206000			5.0	218707	36.42	621.95	3287.66	49.09	4.87	3313.72	308.32	0.02	4.20
287	Lake Warden East GP	Surface water	Western suite	20/11/2012	Lake Warden	Na-Cl	22			259.5	7.58	213000			3.2	226906	45.42	670.33	3301.02	53.03	5.26	3506.87	311.58	0.01	3.14
288	Lake Warden East GP	Surface water	Western suite	5/12/2012	Lake Warden	Na-Cl	22.1			241.7	7.58	215000			2.9	205825	44.73	631.58	2954.38	48.68	4.60	3183.72	284.14	0.03	9.18
289	Lake Warden East GP	Surface water	Western suite	18/12/2012	Lake Warden	Na-Cl	26.5			241.4	7.56	219000			2.9	244710	39.40	620.38	3613.41	57.35	5.76	3684.37	404.43	0.03	9.53
290	Lake Warden East GP	Surface water	Western suite	3/01/2013	Lake Warden	Na-Cl	31.1				7.33	223000			3.1	270705	16.87	860.91	3878.83	82.34	6.46	4146.36	404.27	0.02	9.85
291	Lake Warden East GP	Surface water	Western suite	30/01/2013	Lake Warden	Na-Mg-Cl	29				7.27	214000			-2.4	315040	13.58	1275.24	3944.50	97.49	10.10	5025.64	525.91	0.02	9.23
292	Lake Warden East GP	Surface water	Western suite	14/02/2013	Lake Warden	Na-Mg-Cl	27.4			227.9	7.18	201000			1.2	282501	10.55	1418.49	3414.46	108.15	11.16	4057.70	760.06	0.03	17.91
293	Lake Warden East GP	Surface water	Western suite	27/02/2013	Lake Warden	Na-Mg-Cl	23.7			309.9	7.23	191900			3.2	310722	7.32	1880.49	3566.26	132.12	14.02	4304.06	949.54	0.04	20.90
294	Lake Warden East GP	Surface water	Western suite	14/03/2013	Lake Warden	Na-Mg-Cl	23.9			270	7.44	210000			1.0	295502	8.21	1179.73	3885.25	87.87	9.44	4409.59	631.90	0.04	13.62
295	Lake Warden East GP	Surface water	Western suite	27/03/2013	Lake Warden	Na-Cl	21.8			216.4	7.71	216000			2.0	242428	9.90	832.11	3391.78	59.27	6.36	3728.83	387.49	0.04	8.63
296	Lake Warden East GP	Surface water	Western suite	12/04/2013	Lake Warden	Na-Cl	23.1			156.5	7.45	219000			2.6	272723	9.65	880.51	3886.16	64.08	7.00	4136.18	463.10	0.03	9.24
297	Lake Warden East GP	Surface water	Western suite	23/04/2013	Lake Warden	Na-Cl	21.4				7.78	213000			1.6	255097	11.58	807.51	3607.67	60.19	5.35	3939.78	399.60	0.05	7.92
298	Lake Warden East GP	Surface water	Western suite	22/05/2013	Lake Warden	Na-Cl	15.6			287.4	7.8	224000			2.2	347417	15.71	974.17	5074.32	69.73	6.44	5368.19	509.20	0.06	10.14
299	Lake Warden East GP	Surface water	Western suite	6/06/2013	Lake Warden	Na-Cl	16.4			40.8	7.99	201000			2.2	230054	17.87	613.39	3387.81	46.53	4.19	3562.95	322.98	0.06	6.41
300	Lake Warden East GP	Surface water	Western suite	18/06/2013	Lake Warden	Na-Cl	15			222	7.9	212000			3.7	260971	24.87	747.52	3909.94	55.38	5.18	4201.06	199.02	0.06	7.28
301	Lake Warden East GP	Surface water	Western suite	2/07/2013	Lake Warden	Na-Cl	13.6			235.2	8.01	206000			1.8	247558	28.41	668.77	3603.94	49.55	4.50	3841.30	357.32	0.06	6.28
302	Lake Warden East GP	Surface water	Western suite	16/07/2013	Lake Warden	Na-Cl	15.6			316.3	8.17	178900			0.1	186871	23.91	479.17	2664.10	36.04	3.26	2857.14	333.39	0.09	5.89
303	Lake Warden East GP	Surface water	Western suite	29/07/2013	Lake Warden	Na-Cl	15			328.9	8.04	170200			-0.6	159819	26.73	425.85	2247.38	32.44	2.93	2515.52	237.51	0.07	5.92
304	Lake Warden East GP	Surface water	Western suite	13/08/2013	Lake Warden	Na-Cl	14.1			247.5	8.01	156200			-0.6	142348	24.70	382.07	1998.38	28.88	2.61	2241.19	211.40	0.06	5.43
305	Lake Warden East GP	Surface water	Western suite	27/08/2013	Lake Warden	Na-Cl	16.9			294.1	8.23	122000			-0.2	101069	17.40	263.82	1432.91	20.30	1.84	1582.47	150.74	0.08	4.84
306	Lake Warden East GP	Surface water	Western suite	10/09/2013	Lake Warden	Na-Cl	16.8			234.1	8.23	128300			-0.4	109561	18.24	278.14	1557.80	21.56	1.92	1723.21	158.86	0.08	4.76
307	Lake Warden East GP	Surface water	Western suite	8/10/2013	Lake Warden	Na-Cl	20.7			-44.4	8.7	130100			0.4	113379	22.75	288.67	1625.03	22.94	2.07	1775.69	161.65	0.23	4.60
308	Lake Warden East GP	Surface water	Western suite	22/10/2013	Lake Warden	Na-Cl	17.8			145.7	8.73	124500			-0.4	103980	20.58	261.44	1477.03	21.04	1.85	1637.85	148.78	0.22	4.15
309	Lake Warden East GP	Surface water	Western suite	18/12/2013	Lake Warden	Na-Cl	22	8.31	154600						3.2	137663	28.54	350.80	2049.42	27.68	2.49	2105.93	194.38	0.15	7.19
310	Lake Warden East GP	Surface water	Western suite	31/12/2013	Lake Warden	Na-Cl	27	8.2	162800						0.3	144973	28.29	378.45	2067.38	29.78	2.65	2276.32	202.45	0.12	7.83
311	Lake Warden East GP	Surface water	Western suite	15/01/2014	Lake Warden	Na-Cl	24.9	8.16	177200						1.6	165445	32.44	427.00	2405.81	33.71	3.04	2557.10	241.26	0.12	8.03
312	Lake Warden East GP	Surface water	Western suite	17/01/2014	Lake Warden	Na-Cl	23.2	8.13	180700						2.9	172095	36.18	448.89	2538.49	35.30	3.14	2635.89	249.34	0.11	8.17
313	Lake Warden East GP	Surface water	Western suite	28/01/2014	Lake Warden	Na-Cl	24.3	7.97	189800						1.7	183441	36.98	488.56	2661.59	38.01	3.39	2874.43	238.04	0.07	8.01
314	Lake Warden East GP	Surface water	Western suite	11/02/2014	Lake Warden	Na-Cl	21.9	7.67	199600						-0.1	207407	36.73	545.01	2938.03	42.49	3.83	3250.30	308.61	0.04	8.14
315	Lake Warden- Lake Windabout inflo	Surface water	Western suite	26/09/2012		Na-Cl				294.6	8.83				0.9	20339	7.91	54.89	285.62	3.75	0.38	309.33	31.75	0.30	4.44
316	Lake Warden- Lake Windabout inflo	Surface water	Western suite	6/06/2013		Na-Cl	17.1			7.3	8.42	37000			2.1	22995	10.12	64.59	324.68	4.41	0.43	345.33	36.50	0.15	5.53
317	Lake Warden- Lake Windabout inflo	Surface water	Western suite	18/06/2013		Na-Cl	14.1			225.4	8.58	32800			1.7	21212	8.79	57.59	300.54	3.99	0.41	321.78	32.08	0.18	4.68
318	Lake Warden- Lake Windabout inflo	Surface water	Western suite	2/07/2013		Na-Cl	11.3			184.8	8.77	32400			1.8	20239	8.38	57.30	284.93	3.91	0.37	305.96	31.29	0.28	4.66
319	Lake Warden- Lake Windabout inflo	Surface water	Western suite	16/07/2013		Na-Cl	14.6			252.7	8.86	30500			2.8	18992	7.77	53.41	272.05	3.59	0.36	284.70	29.25	0.31	4.22
320	Lake Warden- Lake Windabout inflo	Surface water	Western suite	29/07/2013		Na-Cl	13.9			97.3	8.96	28300			0.3	17390	7.36	48.29	240.21	3.28	0.32	265.71	27.09	0.37	4.07
321	Lake Warden- Lake Windabout inflo	Surface water	Western suite	13/08/2013		Na-Cl	14.3			138.5	9.12	26800			1.3	16742	7.05	45.44	235.94	3.10	0.31	253.81	25.63	0.51	3.85
322	Lake Warden- Lake Windabout inflo	Surface water	Western suite	27/08/2013		Na-Cl	17			262.2	9.05	23100			1.4	14218	6.23	40.71	198.40	2.60	0.27	215.41	21.76	0.41	3.62
323	Lake Warden- Lake Windabout inflo	Surface water	Western suite	10/09/2013		Na-Cl	17.1			149.2	9.09	20900			1.8	13067	5.42	36.37	184.57	2.35	0.23	197.30	19.49	0.44	3.58
324	Lake Warden- Lake Windabout inflo	Surface water	Western suite	24/09/2013		Na-Cl	18.5			128	9.35	22300			1.9	14043	5.83	38.13	199.84	2.56	0.25	211.86	21.15	0.74	3.29
325	Lake Warden- Lake Windabout inflo	Surface water	Western suite	8/10/2013		Na-Cl	20.2			-212.9	9.58	22800			3.2	14092	5.88	37.56	204.75	2.56	0.23	210.02	21.84	1.05	2.74
326	Lake Warden- Lake Windabout inflo	Surface water	Western suite	22/10/2013		Na-Cl	20.6			-115.4	9.55	33400			1.1	20675	6.72	55.56	293.32	4.09	0.37	316.83	31.38	0.97	2.72
327	Lake Warden Satellite lake East	Surface water	Western suite	25/09/2013	Warden Satelite Lake	Na-Cl	15			189.8	8.58	36200			2.6	22503	11.89	50.13	329.12	4.72	0.39	339.58	30.15	0.24	6.25
328	Lake Warden Satellite lake East	Surface water	Western suite	8/10/2013	Warden Satelite Lake	Na-Cl	21.4			-55	9.99	26800			1.5	16726	6.20	43.36	239.73	3.23	0.30	255.61	23.11	2.64	2.69
329	Lake Warden Satellite lake East	Surface water	Western suite	23/10/2013	Warden Satelite Lake	Na-Cl	20.8			82.4	9.18	35800			1.8	22729	10.07	50.64	331.95	4.80	0.39	349.16	29.92	0.57	3.78
330	Lake Warden Satellite lake East	Surface water	Western suite	4/12/2013	Warden Satelite Lake	Na-Cl	18.4	8.63	63000						0.7	44512	15.32	100.06	645.50	9.03	0.01	695.07	59.88	0.19	4.49
331	Lake Warden Satellite lake East	Surface water	Western suite	18/12/2013	Warden Satelite Lake	Na-Cl	22.1	8.12	80300						1.3	56726	19.36	134.54	821.24	11.87	1.00	878.06	76.43	0.10	7.85
332	Lake Warden Satellite lake East	Surface water	Western suite	15/01/2014	Warden Satelite Lake	Na-Cl	32.9	7.32	202000						2.1	223946	60.53	581.63	3257.28	43.64	3.85	3426.08	343.84	0.03	13.01
333	Lake Warden West	Surface water	Western suite	19/06/2012	Warden (Wa)	Na-Cl									1.0	264595	30.10	697.57	3823.35	55.76	5.66	4115.05	388.53	0.04	7.45
334	Lake Warden West	Surface water	Western suite	20/11/2013	Warden (Wa)	Na-Cl	17.8	8.44	138600						1.0	112739	23.20	297.48	1620.38	23.02	0.15	1759.71	161.83	0.15	5.55
335	Lake Warden West	Surface water	Western suite	4/12/2013	Warden (Wa)	Na-Cl	19.5	8.37	147800						3.3	125814	26.00	310.81	1886.68	25.15	2.28	1936.53	165.21	0.15	6.39
336	Lake Wheatfield GP	Surface water	Central suite	1/09/2002	Wheatfield	Na-Cl	21.5	8.7					-3.03	-8.83	5.0	5581	2.98	16.42	81.25	0.42		79.35	10.33		2.10
337	Lake Wheatfield GP	Surface water	Central suite	1/12/2002	Wheatfield	Na-Cl	25.8	8.6					-0.59	5.94	-2.7	7150	3.63	18.39	95.21	1.29		112.44	10.52		2.02
338	Lake Wheatfield GP	Surface water	Central suite	1/03/2003	Wheatfield	Na-Cl	20.4	8.2					1.04	13.84	1.2	9207	5.19	24.51	128.23	2.02		139.63	13.70		2.80
339	Lake Wheatfield GP	Surface water	Central suite	20/11/2013	Wheatfield	Na-Cl	18.7	13.5	13390						3.2	7487	3.52	22.30	107.23	1.48	0.26	111.46	11.58	3.14	0.00
340	Lake Wheatfield GP	Surface water	Central suite	4/12/2013	Wheatfield	Na-Cl	21.9	8.63	14130						0.6	8275	3.68	23.21	114.01	1.54	0.15	124.97	12.30	0.14	3.28
341	Lake Wheatfield GP	Surface water	Central suite	18/12/2013	Wheatfield	Na-Cl	22.9	8.55	14390						1.9	8671	3.70	24.36	121.89	1.60	0.16	129.51	12.70	0.13	3.57
342	Lake Wheatfield GP	Surface water	Central suite	31/12/2013	Wheatfield	Na-Cl	24.2	8.69	15480						0.7	9252	3.34	27.07	127.54	1.72	0.17	139.78	13.68	0.18	3.69
343	Lake Wheatfield GP	Surface water	Central suite	15/01/2014	Wheatfield	Na-Cl	23.9	8.69	17600						2.4	7692	3.44	21.89	108.53	1.40	0.14	114.34	11.33	0.16	3.16
344	Lake Wheatfield GP	Surface water	Central suite	28/01/2014	Wheatfield	Na-Cl	22.4	8.84	19280						2.1	12002	4.75	33.99	169.69	2.18	0.21	180.01	17.24	0.31	4.44
345	Lake Wheatfield GP	Surface water	Central suite	12/02/2014	Wheatfield	Na-Cl	21	8.96	20500						1.3	12490	5.49	37.77	171.69	2.40	0.23	188.44	18.03	0.45	4.94

No	Station ID	Sample type	Spatial grouping	Sample_Date	Alternative ID	Watertype	Temp (°C)	pH (field)	EC (Field) (uS/cm)	ORP (field) (mV)	pH (lab) (uS/cm)	EC (lab) (uS/cm)	18O	2H	CBE (%)	TDS (calc) (mg/L)	Ca (meq)	Mg (meq)	Na (meq)	K (meq)	Br (meq)	Cl_meq	SO4_meq	CO3_meq	HCO3_meq
346	Lake Wheatfield- South at pipeline	Surface water	Central suite	18/01/2010		Na-Cl-SO4					9.03	18900			3.6	4080	2.14	8.94	58.59	0.64	0.07	48.75	13.99	0.26	2.35
347	Lake Wheatfield- South at pipeline	Surface water	Central suite	28/01/2010		Na-Cl					9.13	18400			-0.4	7731	3.73	20.02	105.05	1.43	0.14	112.33	14.36	0.05	4.22
348	Lake Wheatfield- South at pipeline	Surface water	Central suite	16/02/2010		Na-Cl					9.05	20000			0.0	6315	3.28	17.89	86.65	0.64	0.13	97.07	9.78	0.00	1.54
349	Lake Wheatfield- South at pipeline	Surface water	Central suite	17/03/2010		Na-Cl					8.54	23400			2.2	7420	3.43	19.53	104.57	1.30	0.13	104.97	14.55	0.03	3.74
350	Lake Wheatfield- South at pipeline	Surface water	Central suite	30/03/2010		Na-Cl									2.8	7512	3.78	18.29	106.84	1.28	0.12	100.94	18.37	0.02	3.90
351	Lake Wheatfield- South at pipeline	Surface water	Central suite	1/05/2010		Na-Cl					8.78	19010			3.1	8004	3.83	21.41	114.49	1.53	0.14	116.20	12.73	0.02	3.83
352	Lake Wheatfield- South at pipeline	Surface water	Central suite	25/05/2010		Na-Cl	16.5				8.31	11200			4.1	3723	1.79	10.17	53.20	0.79	0.08	50.52	8.99	0.00	1.33
353	Lake Wheatfield- South at pipeline	Surface water	Central suite	7/07/2010		Na-Cl	12				8.35	14800			4.0	3988	2.09	9.52	57.12	0.69	0.07	49.93	11.87	0.01	2.37
354	Lake Wheatfield- South at pipeline	Surface water	Central suite	8/11/2010		Na-Cl-SO4	23.1				9.16	16010			2.9	3326	1.14	7.47	47.72	0.54	0.06	39.38	13.26	0.08	0.88
355	Lake Wheatfield- South at pipeline	Surface water	Central suite	23/11/2010		Na-Cl	21.7				8.62	16350			0.1	7032	2.59	19.86	97.05	1.28	0.12	106.15	11.46	0.33	2.05
356	Lake Wheatfield- South at pipeline	Surface water	Central suite	8/12/2010		Na-Cl	23.5				8.73	17030			-0.5	6024	1.94	12.88	84.74	1.05	0.08	84.94	14.76	0.02	1.86
357	Lake Wheatfield- South at pipeline	Surface water	Central suite	3/01/2011		Na-Cl	23.4				8.65	19870			-2.8	8373	2.89	21.58	112.10	1.48	0.13	127.48	15.55	0.10	2.28
358	Lake Wheatfield- South at pipeline	Surface water	Central suite	15/01/2011		Na-Cl	24.7				9	21700			-1.8	26176	6.67	72.37	356.48	4.36	0.41	407.44	40.81	0.57	5.64
359	Lake Wheatfield- South at pipeline	Surface water	Central suite	2/02/2011		Na-Cl	27.6				8.9	22800			-2.9	11887	4.28	29.29	159.69	2.07	0.17	180.40	21.17	0.38	4.20
360	Lake Wheatfield- South at pipeline	Surface water	Central suite	15/02/2011		Na-Cl	25.3				8.79	22000			1.6	7120	2.84	18.62	99.75	1.25	0.13	98.09	17.17	0.26	2.88
361	Lake Wheatfield- South at pipeline	Surface water	Central suite	1/03/2011		Na-Cl	25.2				8.7	23200			-2.9	15079	5.42	40.20	200.84	2.60	0.26	235.58	20.86	0.30	6.25
362	Lake Wheatfield- South at pipeline	Surface water	Central suite	30/03/2011		Na-Cl	22.2				8.64	21800			2.2	13422	5.07	37.90	189.83	2.45	0.23	198.77	19.35	0.28	6.53
363	Lake Wheatfield- South at pipeline	Surface water	Central suite	13/04/2011		Na-Cl	20.6				8.62	35000			0.4	12754	4.58	34.78	177.05	2.32	0.22	192.17	18.06	0.26	6.12
364	Lake Wheatfield- South at pipeline	Surface water	Central suite	27/04/2011		Na-Cl	19.5				8.74	18390			4.9	7219	2.69	19.20	105.97	1.30	0.12	98.34	15.03	0.21	3.63
365	Lake Wheatfield- South at pipeline	Surface water	Central suite	10/05/2011		Na-Cl	17.5				9.03	16960			0.8	7231	2.94	18.21	101.18	1.28	0.12	103.87	13.14	0.36	3.95
366	Lake Wheatfield- South at pipeline	Surface water	Central suite	24/05/2011		Na-Cl	17.2				8.73	12200			4.3	2440	1.00	6.15	35.48	0.61	0.04	33.43	4.71	0.06	1.47
367	Lake Wheatfield- South at pipeline	Surface water	Central suite	22/06/2011		Na-Cl	14.8				8.66	13000			2.2	5666	1.59	13.04	83.48	1.25	0.11	85.90	6.81	0.11	2.02
368	Lake Wheatfield- South at pipeline	Surface water	Central suite	7/07/2011		Na-Cl	16.1				8.83	12390			-1.0	1878	0.60	5.66	24.98	0.48	0.05	28.44	2.82	0.06	0.90
369	Lake Wheatfield- South at pipeline	Surface water	Central suite	19/07/2011		Na-Cl	13.7				8.52	10260			-0.9	3240	1.14	6.24	46.24	0.82	0.07	50.27	3.42	0.05	1.52
370	Lake Wheatfield- South at pipeline	Surface water	Central suite	3/08/2011		Na-Cl	14.8				8.21	11110			2.1	2794	1.00	6.89	40.25	0.56	0.06	41.10	4.21	0.02	1.27
371	Lake Wheatfield- South at pipeline	Surface water	Central suite	18/08/2011		Na-Cl	18.4				8.62	11710			3.1	3131	1.09	7.55	46.20	0.66	0.06	46.86	4.05	0.05	1.11
372	Lake Wheatfield- South at pipeline	Surface water	Central suite	30/08/2011		Na-Cl	14.7				8.33	12310			0.5	4909	1.44	9.76	71.91	1.17	0.10	76.48	5.33	0.03	1.42
373	Lake Wheatfield- South at pipeline	Surface water	Central suite	13/09/2011		Na-Cl	16.7				7.75	12010			1.1	7378	3.53	20.68	102.31	1.40	0.17	110.87	12.45	0.02	1.76
374	Lake Wheatfield- South at pipeline	Surface water	Central suite	29/09/2011		Na-Cl	17.2				8.7	10930			-3.1	7610	3.38	19.94	100.44	1.38	0.13	117.64	11.79	0.15	3.04
375	Lake Wheatfield- South at pipeline	Surface water	Central suite	11/10/2011		Na-Cl	21				8.68	10990			-2.6	1453	0.60	3.53	19.52	0.31	0.03	22.19	2.35	0.03	0.58
376	Lake Wheatfield- South at pipeline	Surface water	Central suite	26/10/2011		Na-Cl	19.7				8.67	10770			-3.5	2928	1.19	6.97	39.25	0.59	0.05	46.63	3.65	0.05	0.98
377	Lake Wheatfield- South at pipeline	Surface water	Central suite	8/11/2011		Na-Cl	21.6			354.3	7.96	12030			2.4	5838	2.64	16.57	82.22	1.15	0.10	85.36	10.57	0.02	1.76
378	Lake Wheatfield- South at pipeline	Surface water	Central suite	22/11/2011		Na-Cl	24			380.2	8.23	12810			2.2	4848	2.44	13.45	67.73	0.92	0.08	69.37	9.96	0.03	1.60
379	Lake Wheatfield- South at pipeline	Surface water	Central suite	8/12/2011		Na-Cl	19.3			337.6	8.32	14460			0.2	8179	3.68	22.81	112.01	1.53	0.12	123.25	13.54	0.06	2.66
380	Lake Wheatfield- South at pipeline	Surface water	Central suite	20/12/2011		Na-Cl	24.8			299.8	8.63	12980			1.1	3168	1.29	10.09	41.55	0.48	0.04	39.66	10.19	0.10	2.35
381	Lake Wheatfield- South at pipeline	Surface water	Central suite	1/02/2012		Na-Cl	21.8			318.4	8.62	14830			1.7	9418	4.68	25.35	132.59	1.71	0.13	141.47	14.20	0.13	3.12
382	Lake Wheatfield- South at pipeline	Surface water	Central suite	14/02/2012		Na-Cl	24.1			274.2	8.55	15180			-0.9	8053	4.33	22.48	107.40	1.50	0.14	120.37	14.22	0.12	3.29
383	Lake Wheatfield- South at pipeline	Surface water	Central suite	29/02/2012		Na-Cl	22.4			280.9	8.65	16790			0.2	21156	7.27	56.53	296.06	3.93	0.29	326.57	31.48	0.18	4.05
384	Lake Wheatfield- South at pipeline	Surface water	Central suite	13/03/2012		Na-Cl	24			226.2	8.73	17710			0.5	12002	5.87	31.99	166.21	2.17	0.16	180.80	18.52	0.24	4.45
385	Lake Wheatfield- South at pipeline	Surface water	Central suite	28/03/2012		Na-Cl	23.6			292.8	8.95	15600			2.5	9646	5.22	28.64	133.85	1.91	0.15	141.36	15.38	0.10	4.54
386	Lake Wheatfield- South at pipeline	Surface water	Central suite	10/04/2012		Na-Cl	21.4			286	8.96	16510			1.4	10269	5.77	30.03	141.03	1.91	0.16	153.80	15.36	0.39	4.22
387	Lake Wheatfield- South at pipeline	Surface water	Central suite	26/04/2012		Na-Cl	20.2			287.1	9.07	16220			4.2	10058	1.99	26.66	148.77	1.61	0.17	146.55	13.70	0.63	5.33
388	Lake Wheatfield- South at pipeline	Surface water	Central suite	8/05/2012		Na-Cl	16.4			276.8	8.74	14830			2.9	9782	4.53	26.25	140.51	1.68	0.17	145.70	13.24	0.23	4.18
389	Lake Wheatfield- South at pipeline	Surface water	Central suite	23/05/2012		Na-Cl	14.5			316.8	8.93	13360			3.1	7938	5.37	20.19	113.10	1.33	0.12	114.36	13.04	0.33	3.82
390	Lake Wheatfield- South at pipeline	Surface water	Central suite	6/06/2012		Na-Cl	13.7			369	8.96	15180			1.4	7976	3.83	21.41	111.58	1.48	0.13	119.02	11.25	0.35	3.87
391	Lake Wheatfield- South at pipeline	Surface water	Central suite	19/06/2012		Na-Cl	13.9			359.3	8.62	13240			2.4	7027	3.48	19.28	99.09	1.33	0.13	103.02	10.65	0.15	3.52
392	Lake Wheatfield- South at pipeline	Surface water	Central suite	4/07/2012		Na-Cl	13.7			311.3	8.59	16030			0.2	7966	3.73	22.48	108.05	1.45	0.16	117.04	13.78	0.16	4.07
393	Lake Wheatfield- South at pipeline	Surface water	Central suite	31/07/2012		Na-Cl	13.5			348	8.09	17970			2.7	9478	4.28	27.90	133.89	1.73	0.18	141.76	14.61	0.03	2.70
394	Lake Wheatfield- South at pipeline	Surface water	Central suite	15/08/2012		Na-Cl	14.5			247.6	8.28	15520			-1.4	8866	3.78	24.78	119.15	1.53	0.16	136.28	14.05	0.05	2.78
395	Lake Wheatfield- South at pipeline	Surface water	Central suite	29/08/2012		Na-Cl	16.6			385.9	8.05	13420			-0.5	7754	3.38	22.15	104.84	1.43	0.14	117.83	12.45	0.03	2.68
396	Lake Wheatfield- South at pipeline	Surface water	Central suite	13/09/2012		Na-Cl	19.7			231.8	8.74	13370			2.5	7643	3.28	22.07	107.97	1.38	0.15	113.60	11.94	0.14	2.57
397	Lake Wheatfield- South at pipeline	Surface water	Central suite	26/09/2012		Na-Cl	18.2			322.8	8.35	13860			0.1	8101	3.48	22.81	111.23	1.43	0.16	123.79	12.66	0.05	2.15
398	Lake Wheatfield- South at pipeline	Surface water	Central suite	9/10/2012		Na-Cl	21.4				8.37	14050			-0.3	8165	3.63	24.28	110.23	1.50	0.16	124.97	12.81	0.06	2.38
399	Lake Wheatfield- South at pipeline	Surface water	Central suite	24/10/2012		Na-Cl	20			388.9	8.33	14520			-0.3	8807	4.03	26.09	118.28	1.63	0.17	132.78	13.66	0.09	4.06
400	Lake Wheatfield- South at pipeline	Surface water	Central suite	6/11/2012		Na-Cl	19.7			344.8	8.62	14400			-3.9	8964	3.63	24.28	116.67	1.66	0.17	140.54	13.70	0.13	3.14
401	Lake Wheatfield- South at pipeline	Surface water	Central suite	20/11/2012		Na-Cl	23.5			354.6	8.53	15140			-1.7	11056	4.83	30.77	147.94	2.09	0.22	171.09	17.67	0.09	2.78
402	Lake Wheatfield- South at pipeline	Surface water	Central suite	5/12/2012		Na-Cl	20.8			359.6	8.65	14330			-2.4	8215	3.48	22.23	108.84	1.61	0.16	126.01	13.08	0.15	3.24
403	Lake Wheatfield- South at pipeline	Surface water	Central suite	18/12/2012		Na-Cl	27.2			318.8	8.74	14850			0.3	8393	3.83	24.78	113.75	1.58	0.17	125.34	13.68	0.20	3.59
404	Lake Wheatfield- South at pipeline	Surface water	Central suite	16/01/2013		Na-Cl	23.2			350.5	8.61	17460			0.6	10743	5.32	32.41	145.46	2.04	0.22	161.45	16.54	0.19	4.56
405	Lake Wheatfield- South at pipeline	Surface water	Central suite	30/01/2013		Na-Cl	24.3			306.8	8.94	19320			-3.7	12270	5.47	32.32	160.73	2.19	0.24	193.29	17.64	0.37	4.22
406	Lake Wheatfield- South at pipeline	Surface water	Central suite	14/02/2013		Na-Cl	29.4			39.4	8.78	22000			-1.6	13271	6.02	36.27	177.48	2.45	0.25	203.00	19.70	0.36	5.92
407	Lake Wheatfield- South at pipeline	Surface water	Central suite	27/02/2013		Na-Cl	23.7			298	8.73	23700			0.2	14274	6.12	39.14	196.71	2.58	0.27	216.23	20.65	0.32	5.98
408	Lake Wheatfield- South at pipeline	Surface water	Central suite	14/03/2013		Na-Cl	22.7			162.2	8.61	15530			-0.8	8997	4.63	25.19	120.23	1.79	0.17	135.58	14.10	0.18	4.31
409	Lake Wheatfield- South at pipeline	Surface water	Central suite	27/03/2013		Na-Cl	19.5			263.6	8.33	14920			2.5	8978	4.43	24.94	126.89	1.66	0.17	132.50	13.91	0.08	3.67
410	Lake Wheatfield- South at pipeline	Surface water	Central suite	11/04/2013		Na-Cl	24.5			232.6	8.63	14910			-0.4	8529	4.48	24.12	114.97	1.63	0.15	129.48	13.62	0.13	2.94
411	Lake Wheatfield- South at pipeline	Surface water	Central suite	8/05/2013		Na-Cl	19.2			247.5	8.49	11720			3.2	7123	3.89	19.13	101.79	1.39	0.14	104.41	11.14	0.09	2.76
412	Lake Wheatfield- South at pipeline	Surface water	Central suite	22/05/2013		Na-Cl	15.8			288.4	8.82	11480			0.0	6809	3.52	18.39	92.83	1.34	0.12	101.92	10.70	0.20	3.05
413	Lake Wheatfield- South at pipeline	Surface water	Central suite	6/06/2013		Na-Cl	15.4			187.2	8.37	10060			1.1	5799	3.01	15.99	80.17	1.19	0.11	86.75	9.28	0.05	2.03
414	Lake Wheatfield- South at pipeline	Surface water	Central suite	18/06/2013		Na-Cl	14.6			157.8	8.33	12540			1.3	7343	4.40	22.40	99.75	1.38	0.13	110.39	11.40	0.06	2.67

No	Station ID	Sample type	Spatial grouping	Sample_Date	Alternative ID	Watertype	Temp (°C)	pH (field)	EC (Field) (uS/cm)	ORP (field) (mV)	pH (lab) (uS/cm)	EC (lab) (uS/cm)	18O	2H	CBE (%)	TDS (calc) (mg/L)	Ca (meq)	Mg (meq)	Na (meq)	K (meq)	Br (meq)	Cl_meq	SO4_meq	CO3_meq	HCO3_meq
415	Lake Wheatfield- South at pipeline	Surface water	Central suite	2/07/2013		Na-Cl	15.8			219.6	8.5	14410			2.7	8729	4.51	24.94	123.41	1.52	0.15	130.61	13.23	0.08	2.61
416	Lake Wheatfield- South at pipeline	Surface water	Central suite	16/07/2013		Na-Cl	15.4			353.2	8.48	13610			0.3	7866	4.05	23.44	106.53	1.42	0.14	119.98	12.28	0.07	2.30
417	Lake Wheatfield- South at pipeline	Surface water	Central suite	13/08/2013		Na-Cl	15.1			236.1	8.28	16550			0.6	9721	4.81	29.50	132.07	1.74	0.18	147.71	15.24	0.06	2.92
418	Lake Wheatfield- South at pipeline	Surface water	Central suite	27/08/2013		Na-Cl	17.4			365.4	7.74	13110			-0.1	7651	3.41	22.03	104.14	1.32	0.15	117.16	11.48	0.01	2.49
419	Lake Wheatfield- South at pipeline	Surface water	Central suite	10/09/2013		Na-Cl	19.1			322.3	8.41	14350			0.6	8619	4.04	24.85	118.45	1.48	0.15	131.26	13.06	0.07	2.64
420	Lake Wheatfield- South at pipeline	Surface water	Central suite	25/09/2013		Na-Cl	18.7			156.2	8.01	14860			2.0	8501	3.84	25.26	118.71	1.53	0.14	128.30	12.47	0.03	2.78
421	Lake Wheatfield- South at pipeline	Surface water	Central suite	8/10/2013		Na-Cl	22.6			114.1	8.23	14670			1.0	8736	3.81	24.86	121.32	1.52	0.15	132.59	13.14	0.05	2.68
422	Lake Wheatfield- South at pipeline	Surface water	Central suite	22/10/2013		Na-Cl	16			228.5	7.78	7910			-4.7	4203	2.00	11.93	52.98	0.90	0.08	65.95	6.54	0.01	1.75
423	Lake Windabout East GP	Surface water	Central suite	1/09/2002	Windabout flowthroug	Na-Cl	17.49	8.3					0.50	11.98	-4.3	14209	5.52	37.58	187.18	1.50		228.25	20.35		3.46
424	Lake Windabout East GP	Surface water	Central suite	1/12/2002	Windabout flowthroug	Na-Cl	26.4	8.5					3.25	29.15	-3.4	14347	5.39	39.44	189.23	2.40		227.98	20.57		4.04
425	Lake Windabout East GP	Surface water	Central suite	1/03/2003	Windabout flowthroug	Na-Cl	21.1	8.9					3.73	28.32	1.3	25861	9.49	73.46	361.69	5.74		393.92	39.12		6.50
426	Lake Windabout East GP	Surface water	Central suite	30/03/2010	Windabout flowthroug	Na-Cl	21.7					43100			1.3	26513	13.03	77.86	365.97	3.62	0.40	385.86	60.36	0.00	2.31
427	Lake Windabout East GP	Surface water	Central suite	30/04/2010	Windabout flowthroug	Na-Cl	18.3				8.5	48200			3.5	18708	6.32	49.06	270.31	3.80	0.31	260.72	40.70	0.02	6.56
428	Lake Windabout East GP	Surface water	Central suite	11/05/2010	Windabout flowthroug	Na-Cl					8.4				-1.0	29163	7.42	76.22	402.72	5.89	0.52	445.44	46.93	0.10	8.39
429	Lake Windabout East GP	Surface water	Central suite	3/01/2011	Windabout flowthroug	Na-Cl	24.6				8.64	34900			0.3	4035	1.19	7.71	57.68	0.77	0.06	52.92	12.95	0.04	0.94
430	Lake Windabout East GP	Surface water	Central suite	15/01/2011	Windabout flowthroug	Na-Cl	23.6				8.6	38600			-1.5	10914	3.48	26.18	150.55	2.47	0.17	167.29	18.00	0.10	2.57
431	Lake Windabout East GP	Surface water	Central suite	2/02/2011	Windabout flowthroug	Na-Cl	25.5				8.5	42500			-3.6	19647	5.02	53.17	260.00	3.95	0.33	306.89	33.58	0.13	4.05
432	Lake Windabout East GP	Surface water	Central suite	15/02/2011	Windabout flowthroug	Na-Cl	24.3				8.43	44100			1.5	13441	2.69	32.73	195.84	2.78	0.23	204.97	19.95	0.06	2.20
433	Lake Windabout East GP	Surface water	Central suite	1/03/2011	Windabout flowthroug	Na-Cl	23.8				8.48	48700			-2.6	21868	5.27	56.85	297.45	4.28	0.38	348.51	29.36	0.13	4.38
434	Lake Windabout East GP	Surface water	Central suite	30/03/2011	Windabout flowthroug	Na-Cl	23.8				8.35	56300			-0.2	30090	6.92	77.95	424.21	6.33	0.54	471.28	39.91	0.12	5.48
435	Lake Windabout East GP	Surface water	Central suite	13/04/2011	Windabout flowthroug	Na-Cl	23.7				8.38	58700			-2.3	28143	6.42	73.19	385.06	6.02	0.50	450.05	36.06	0.12	5.05
436	Lake Windabout East GP	Surface water	Central suite	10/05/2011	Windabout flowthroug	Na-Cl	18.2				8.41	63500			-2.1	32358	6.47	83.69	447.20	6.81	0.60	526.05	34.56	0.13	5.01
437	Lake Windabout East GP	Surface water	Central suite	24/05/2011	Windabout flowthroug	Na-Cl	19.1				8.35	60600			0.3	10151	1.84	22.98	145.81	2.12	0.19	148.53	21.22	0.04	1.63
438	Lake Windabout East GP	Surface water	Central suite	29/09/2011	Windabout flowthroug	Na-Cl	18.3				9.1	36500			-2.8	10088	2.69	26.50	136.50	2.07	0.19	162.12	12.14	0.29	2.29
439	Lake Windabout East GP	Surface water	Central suite	18/06/2013	Windabout flowthroug	Na-Cl	14.4			292.6	8.6	32900			3.5	20516	8.84	58.31	294.97	4.04	0.38	304.17	32.92	0.19	4.79
440	Lake Windabout East GP	Surface water	Central suite	20/11/2013	Windabout flowthroug	Na-Cl	18.2	9.87	24100						2.6	15222	6.29	40.32	218.76	2.76	2.28	226.02	23.36	1.36	1.82
441	Lake Windabout East GP	Surface water	Central suite	20/11/2013	Windabout flowthroug	Na-Cl	18.6	10.09	24000						3.3	14848	6.34	40.32	216.06	2.74	0.26	222.75	22.74	1.86	1.50
442	Lake Windabout East GP	Surface water	Central suite	4/12/2013	Windabout flowthroug	Na-Cl	18.7	9.61	25900						0.5	16163	6.74	43.28	226.16	3.02	0.24	247.82	25.42	0.89	2.17
443	LW10D	Groundwater	Western suite	1/09/2002	E35b	Na-Cl	21.6	6.4					-2.37	-13.60	-4.3	192956	37.93	551.07	2558.93	19.64		3107.08	323.82		3.46
444	LW10D	Groundwater	Western suite	1/12/2002	E35b	Na-Cl	19.2	6.1					-2.31	-12.75	4.8	158014	31.47	447.03	2378.59	20.79		2358.36	263.99		2.92
445	LW10D	Groundwater	Western suite	1/03/2003	E35b	Na-Cl	24.3	6.4					-2.02	-9.70	-4.0	149458	32.30	460.60	1949.95	20.62		2386.04	266.56		3.22
446	LW10DB	Groundwater	Western suite	1/09/2002	E35c	Na-Cl	20.8	6.6					-2.32	-12.42	-4.5	143618	33.26	418.43	1888.85	16.98		2366.40	201.81		3.34
447	LW10DB	Groundwater	Western suite	1/12/2002	E35c	Na-Cl	19.8	6.2					-2.31	-12.37	-0.4	146748	32.42	460.30	2020.59	16.68		2311.75	234.26		3.32
448	LW10DB	Groundwater	Western suite	1/03/2003	E35c	Na-Cl	21.3	6.6					-2.60	-11.54	-3.4	140518	32.99	434.93	1849.63	19.48		2262.54	226.64		3.28
449	LW10OB	Groundwater	Western suite	13/01/2010	LW10ob	Na-Cl	18.7				7.37	21000			-0.5	3812	2.54	10.01	50.46	0.36	0.06	50.30	11.60	0.01	1.98
450	LW10OB	Groundwater	Western suite	11/02/2010	LW10ob	Na-Cl	19.3				7.4	19640			-1.2	2941	1.94	8.29	38.08	0.23	0.04	38.65	9.49	0.00	1.45
451	LW10OB	Groundwater	Western suite	17/03/2010	LW10ob	Na-Cl	19.3				7.26	19990			-2.0	5487	3.78	16.90	70.21	0.66	0.09	82.51	10.03	0.01	2.49
452	LW10OB	Groundwater	Western suite	17/09/2010	LW10ob	Na-Cl	15.1				7.68	19650			-0.2	9103	5.87	26.66	121.41	1.15	0.14	134.84	16.67	0.08	3.80
453	LW10OB	Groundwater	Western suite	8/11/2010	LW10ob	Na-Cl	16.3				7.73	18900			2.0	5652	3.38	16.98	77.21	0.69	0.08	78.76	13.51	0.09	2.06
454	LW10OB	Groundwater	Western suite	9/02/2011	LW10ob	Na-Cl	20.7				7.27	18260			3.7	11573	8.36	38.81	160.78	1.66	0.18	178.26	13.33	0.07	3.23
455	LW10OB	Groundwater	Western suite	8/03/2011	LW10ob	Na-Cl	18.9				7.18	17010			-2.5	6369	4.93	16.57	84.04	1.02	0.11	103.70	5.56	0.11	2.32
456	LW10OB	Groundwater	Western suite	11/05/2011	LW10ob	Na-Cl	17.9				7.17	17110			2.3	4907	5.22	16.49	64.34	0.64	0.08	72.98	7.18	0.01	2.62
457	LW10OB	Groundwater	Western suite	14/07/2011	LW10ob	Na-Cl	16.4				7.38	19670			0.6	5327	4.38	15.75	71.47	0.89	0.10	83.61	5.75	0.00	1.99
458	LW10OB	Groundwater	Western suite	9/08/2011	LW10ob	Na-Cl	15.8				7.33	21100			0.0	8233	6.72	26.50	108.05	1.25	0.15	130.39	8.80	0.01	3.06
459	LW10OB	Groundwater	Western suite	14/09/2011	LW10ob	Na-Cl	15.7				7.31	19360			-1.9	9582	8.46	27.24	124.58	1.38	0.16	155.24	8.51	0.01	3.90
460	LW10OB	Groundwater	Western suite	12/10/2011	LW10ob	Na-Cl	15.9				7.44	19860			-1.3	6160	5.72	20.02	76.69	0.84	0.10	92.30	7.10	0.02	6.30
461	LW10OB	Groundwater	Western suite	8/11/2011	LW10ob	Na-Mg-Cl	16.7			-103	7.34	22900			1.5	9901	9.11	35.52	129.93	1.25	0.14	155.78	14.95		
462	LW10OB	Groundwater	Western suite	10/01/2012	LW10ob	Na-Mg-Cl	19.2			28.5	7.29	19340			2.5	8816	8.96	32.90	113.80	1.10	0.13	132.95	10.55	0.01	5.69
463	LW10OB	Groundwater	Western suite	13/03/2012	LW10ob	Na-Cl	19.3			68.6	7.19	17140			-1.0	9666	11.99	32.90	119.23	1.20	0.14	153.69	9.88	0.01	4.98
464	LW10OB	Groundwater	Western suite	12/04/2012	LW10ob	Na-Mg-Cl	20.4			69.2	7.18	16940			0.4	10119	13.68	36.84	127.37	1.28	0.16	158.31	10.27	0.01	4.94
465	LW10OB	Groundwater	Western suite	12/05/2012	LW10ob	Na-Cl	18.5			12	7.29	17890			-1.1	10335	12.58	34.30	128.80	1.10	0.19	165.93	9.76	0.01	4.85
466	LW10OB	Groundwater	Western suite	11/06/2012	LW10ob	Na-Cl	17.6			36.4	7.31	18890			-0.7	10040	12.88	34.38	124.02	1.22	0.17	159.95	9.59	0.01	5.25
467	LW10OB	Groundwater	Western suite	10/07/2012	LW10ob	Na-Mg-Cl	19.6			35.2	7.13	19900			4.5	9975	12.93	34.87	129.80	1.20	0.20	150.05	11.08	0.01	6.45
468	LW10OB	Groundwater	Western suite	14/08/2012	LW10ob	Na-Cl	15.5			-18.8	7.3	17730			-1.3	10559	12.63	35.77	130.50	1.25	0.18	168.05	11.64	0.01	4.78
469	LW10OB	Groundwater	Western suite	11/09/2012	LW10ob	Na-Cl	16.1			-26.4	7.31	19500			-1.9	11250	11.14	37.90	139.81	1.33	0.19	177.33	15.44	0.01	4.22
470	LW10OB	Groundwater	Western suite	9/10/2012	LW10ob	Na-Mg-Cl	17.7				7.33	19200			1.4	10410	12.49	38.48	131.20	1.38	0.19	160.88	12.50	0.01	4.97
471	LW10OB	Groundwater	Western suite	13/11/2012	LW10ob	Na-Mg-Cl	17.5			-87.6	7.16	16710			-1.4	10325	14.03	37.33	122.63	1.30	0.19	162.01	10.67	0.01	7.37
472	LW10OB	Groundwater	Western suite	11/12/2012	LW10ob	Na-Mg-Cl	18.6			-67.8	7.15	16640			0.5	10527	15.37	41.76	125.58	1.53	0.21	165.20	10.94	0.01	6.01
473	LW10OB	Groundwater	Western suite	9/01/2013	LW10ob	Na-Mg-Cl	18.8			-209.8	7.2	16820			2.8	10051	14.97	39.88	123.41	1.73	0.23	152.76	9.84	0.01	7.46
474	LW10OB	Groundwater	Western suite	13/02/2013	LW10ob	Na-Cl	19.4			45.6	7.14	17420			-3.5	9891	14.93	32.98	114.93	1.25	0.17	159.89	9.20	0.01	6.17
475	LW10OB	Groundwater	Western suite	12/03/2013	LW10ob	Na-Mg-Cl	18.8			60.3	7.06	17890			1.2	10397	14.88	36.84	129.72	1.30	0.19	162.07	9.63	0.01	6.47
476	LW10OB	Groundwater	Western suite	9/04/2013	LW10ob	Na-Mg-Cl	19.2			-38.5	7.15	18900			1.2	10859	14.97	38.40	136.16	1.25	0.21	168.84	10.25	0.01	6.87
477	LW10OB	Groundwater	Western suite	10/07/2013	LW10ob	Na-Cl	17.2			51.3	6.6	17320			-1.5	12949	16.02	44.07	155.73	1.49	0.22	196.99	13.77	0.01	12.98
478	LW10OB	Groundwater	Western suite	15/08/2013	LW10ob	Na-Cl	15.6			-93.7	7.33	20100			-0.8	12399	17.43	42.31	151.34	1.47	0.22	195.72	13.30	0.01	6.63
479	LW10OB	Groundwater	Western suite	12/09/2013	LW10ob	Na-Mg-Cl	15.3			-22.8	7.33	18740			-0.2	11275	15.35	40.12	138.03	1.38	0.21	177.36	11.39	0.01	6.58
480	LW10OB	Groundwater	Western suite	9/10/2013	LW10ob	Na-Cl									2.0	11004	15.20	37.47	141.51	1.31	0.19	171.91	10.02	0.01	5.72
481	LW10OB	Groundwater	Western suite	11/12/2013	LW10ob	Na-Mg-Cl	18	7.21	22300						1.1	13890	17.47	49.46	174.91	1.61	0.24	214.45	16.55	0.01	7.13
482	LW10OB	Groundwater	Western suite	14/01/2014	LW10ob	Na-Mg-Cl	18.6	7.24	24600						1.9	15167	17.17	53.49	195.40	1.76	0.26	231.04	18.80	0.01	8.10
483	LW11OB	Groundwater	Western suite	13/01/2010	Lw11ob	Na-Cl	21.2				6.74	57300			0.8	24714	11.34	59.16	347.61	4.67	0.44	355.54	55.07	0.03	5.08

No	Station ID	Sample type	Spatial grouping	Sample_Date	Alternative ID	Watertype	Temp (°C)	pH (field)	EC (Field) (uS/cm)	ORP (field) (mV)	pH (lab) (uS/cm)	EC (lab) (uS/cm)	18O	2H	CBE (%)	TDS (calc) (mg/L)	Ca (meq)	Mg (meq)	Na (meq)	K (meq)	Br (meq)	Cl_meq	SO4_meq	CO3_meq	HCO3_meq
484	LW11OB	Groundwater	Western suite	11/02/2010	Lw11ob	Na-Cl	21				6.9	57500			-2.3	29853	13.13	68.75	406.38	5.25	0.50	452.19	56.36	0.06	7.02
485	LW11OB	Groundwater	Western suite	11/08/2010	Lw11ob	Na-Cl	15.2				6.91	57000			2.1	30746	13.43	73.51	444.38	5.79	0.52	454.24	54.76	0.17	5.94
486	LW11OB	Groundwater	Western suite	8/11/2010	Lw11ob	Na-Cl	19.4				7.89	48400			2.0	21673	8.61	45.37	316.64	4.11	0.33	310.20	41.37	0.10	8.14
487	LW11OB	Groundwater	Western suite	15/02/2011	Lw11ob	Na-Cl	19.9				6.99	58400			4.0	34237	16.77	88.96	502.06	6.35	0.60	506.16	56.15	0.13	5.55
488	LW11OB	Groundwater	Western suite	8/03/2011	Lw11ob	Na-Cl	20.9				6.82	60500			3.1	33852	15.82	80.65	497.12	7.40	0.63	516.96	39.16	0.04	9.51
489	LW11OB	Groundwater	Western suite	12/04/2011	Lw11ob	Na-Cl	20				6.77	59000			1.9	42180	21.14	106.89	601.34	8.24	0.72	640.27	56.92	0.04	13.49
490	LW11OB	Groundwater	Western suite	12/06/2011	Lw11ob	Na-Cl	17.1				6.97	58400			0.9	23404	10.99	43.32	337.65	4.16	0.39	325.42	56.38	0.01	7.50
491	LW11OB	Groundwater	Western suite	14/07/2011	Lw11ob	Na-Cl	16.2				6.83	52500			1.8	25764	12.09	58.83	374.40	5.48	0.47	402.35	23.11	0.01	9.43
492	LW11OB	Groundwater	Western suite	9/08/2011	Lw11ob	Na-Cl	15.1				6.94	51100			-0.4	22974	9.95	47.75	327.34	5.20	0.41	360.80	23.67	0.01	8.29
493	LW11OB	Groundwater	Western suite	14/09/2011	Lw11ob	Na-Cl	15.7				7.06	61700			-0.9	38434	18.36	94.30	530.25	7.55	0.67	597.71	50.86	0.06	12.27
494	LW11OB	Groundwater	Western suite	12/10/2011	Lw11ob	Na-Cl	16.7				6.73	61500			0.6	28850	13.48	67.36	408.07	5.97	0.50	440.46	33.75	0.01	14.30
495	LW11OB	Groundwater	Western suite	13/12/2011	Lw11ob	Na-Cl	18.5			-41	6.9	61200			3.2	40007	22.98	122.78	559.14	8.29	0.66	607.44	48.47	0.01	15.78
496	LW11OB	Groundwater	Western suite	10/01/2012	Lw11ob	Na-Cl	21.2			-7.1	6.88	59800			3.1	40678	17.91	131.50	570.89	7.14	0.65	617.51	51.57	0.01	14.74
497	LW11OB	Groundwater	Western suite	13/02/2012	Lw11ob	Na-Cl	20.7			6.6	6.84	63600			1.3	39518	20.00	101.46	559.70	6.76	0.54	602.91	52.03	0.01	13.75
498	LW11OB	Groundwater	Western suite	13/03/2012	Lw11ob	Na-Cl	21			65.6	6.79	64100			2.7	46213	22.98	124.50	663.79	7.96	0.67	704.39	61.07	0.01	11.67
499	LW11OB	Groundwater	Western suite	10/04/2012	Lw11ob	Na-Cl	21.1			25.8	6.84	64300			1.3	46300	24.23	112.16	657.15	9.41	0.74	703.83	65.19	0.01	13.71
500	LW11OB	Groundwater	Western suite	8/05/2012	Lw11ob	Na-Cl	18.6			18.1	6.77	66900			-0.5	44444	20.30	108.29	620.20	7.30	0.86	689.09	60.82	0.01	12.47
501	LW11OB	Groundwater	Western suite	12/06/2012	Lw11ob	Na-Cl	17.1			71.3	6.94	69400			-0.8	41804	19.95	110.93	571.59	7.70	0.73	653.34	52.76	0.01	14.14
502	LW11OB	Groundwater	Western suite	10/07/2012	Lw11ob	Na-Cl	15.2			-14.9	6.84	65300			1.9	38461	19.50	92.16	550.55	7.37	0.78	572.96	58.94	0.01	13.15
503	LW11OB	Groundwater	Western suite	14/08/2012	Lw11ob	Na-Cl	14.9			-20.1	6.93	55300			2.0	37350	18.41	87.56	538.93	7.12	0.71	562.83	50.82	0.01	13.11
504	LW11OB	Groundwater	Western suite	11/09/2012	Lw11ob	Na-Cl	16.4			20.3	6.93	60100			2.8	39497	18.46	93.48	577.53	7.70	0.77	597.40	49.34	0.01	13.19
505	LW11OB	Groundwater	Western suite	9/10/2012	Lw11ob	Na-Cl	17.1				6.9	56700			4.0	36713	18.66	92.49	535.41	8.21	0.75	536.53	54.57	0.01	14.50
506	LW11OB	Groundwater	Western suite	13/11/2012	Lw11ob	Na-Cl	17.7			-124.4	6.92	63900			-0.8	40735	22.78	104.01	554.36	8.14	0.81	627.61	59.07	0.01	13.15
507	LW11OB	Groundwater	Western suite	11/12/2012	Lw11ob	Na-Cl	20.6			-103.5	6.81	61200			-0.5	40105	22.98	109.86	539.58	8.62	0.82	612.73	56.21	0.01	17.73
508	LW11OB	Groundwater	Western suite	9/01/2013	Lw11ob	Na-Cl	20			-57.1	6.89	65400			3.9	46483	28.06	126.97	663.79	12.27	0.94	687.46	67.31	0.01	15.74
509	LW11OB	Groundwater	Western suite	13/02/2013	Lw11ob	Na-Cl	20.9			-34.3	6.74	64500			-2.2	40789	23.68	100.72	547.43	8.09	0.80	635.60	59.15	0.01	12.35
510	LW11OB	Groundwater	Western suite	12/03/2013	Lw11ob	Na-Cl	19.9			-132.1	6.86	62600			4.2	41635	22.34	102.04	614.00	7.98	0.79	614.95	58.69	0.01	13.75
511	LW11OB	Groundwater	Western suite	9/04/2013	Lw11ob	Na-Cl									4.7	37446	18.76	86.08	561.65	7.32	0.71	550.18	50.55	0.01	13.74
512	LW11OB	Groundwater	Western suite	13/06/2013	Lw11ob	Na-Cl	17.3			-109.7	6.86	62000			1.2	39919	20.89	92.16	568.88	8.48	0.72	607.37	54.03	0.01	12.92
513	LW11OB	Groundwater	Western suite	10/07/2013	Lw11ob	Na-Cl	15.4			-104.8	7.05	56000			1.4	39960	19.46	91.01	583.77	8.32	0.74	598.09	56.63	0.01	12.09
514	LW11OB	Groundwater	Western suite	15/08/2013	Lw11ob	Na-Cl	15.3			-75.9	7.01	55500			1.4	33474	14.99	68.85	484.46	7.95	0.62	500.09	46.51	0.01	14.39
515	LW11OB	Groundwater	Western suite	12/09/2013	Lw11ob	Na-Cl	14.7			96.8	7.13	48100			0.7	34019	15.04	69.81	489.44	7.61	0.58	512.25	47.12	0.02	13.96
516	LW11OB	Groundwater	Western suite	9/10/2013	Lw11ob	Na-Cl									1.8	42972	20.68	105.50	614.97	9.00	0.78	651.40	57.50	0.01	14.28
517	LW11OB	Groundwater	Western suite	11/12/2013	Lw11ob	Na-Cl	19.9	6.82	59600						1.3	41522	19.01	96.36	594.47	9.03	0.75	630.07	56.67	0.01	13.64
518	LW11OB	Groundwater	Western suite	14/01/2014	Lw11ob	Na-Cl	20.6	6.91	66500						2.6	41862	19.16	99.49	609.57	8.65	0.78	629.25	56.82	0.01	13.41
519	LW13D	Groundwater	Central suite	1/09/2002	E40	Na-Cl	24.5	6.3					-4.41	-22.81	-3.1	48584	19.22	114.93	668.82	4.76		797.24	59.47		2.02
520	LW13D	Groundwater	Central suite	1/12/2002	E40	Na-Cl	21.6	6					-3.86	-18.87	-3.2	48979	19.24	117.96	672.81	4.16		800.67	63.18		1.86
521	LW13D	Groundwater	Central suite	1/03/2003	E40	Na-Cl	20.8	6					-4.13	-21.43	1.2	40349	21.87	126.99	552.68	6.22		622.09	67.82		1.80
522	LW14D	Groundwater	Central suite	1/09/2002	E52	Na-Cl	19.9	6.1					-6.24	-29.62	-3.6	8569	2.04	8.94	126.55	1.30		136.87	10.71		1.52
523	LW14D	Groundwater	Central suite	1/12/2002	E52	Na-Cl	19.9	6.1					-5.75	-23.33	-3.7	5553	1.43	8.94	78.71	0.97		87.10	8.41		1.26
524	LW14D	Groundwater	Central suite	1/03/2003	E52	Na-Cl	20.1	5.8					-6.82	-26.93	-4.8	5509	1.77	9.00	75.85	1.25		86.55	8.61		1.48
525	LW15D	Groundwater	Western suite	1/09/2002	E49A	Na-Cl	18.9	6.1					-2.60	-8.18	-5.3	243968	24.88	809.03	3102.90	33.45		3936.23	444.67		1.78
526	LW15D	Groundwater	Western suite	1/12/2002	E49A	Na-Mg-Cl	19.6	5.8					-1.76	1.40	-0.7	280571	26.40	1252.12	3562.22	38.14		4449.34	492.56		1.06
527	LW15DB	Groundwater	Western suite	1/12/2002	E49B	Na-Mg-Cl	19.5	5.8					-1.97	-4.90	-0.3	154541	39.94	666.88	1993.82	19.49		2579.95	155.94		1.54
528	LW15DB	Groundwater	Western suite	1/03/2003	E49B	Na-Mg-Cl	20	5.8					-0.13	-2.64	-4.1	243850	24.21	843.14	3113.56	45.97		3890.64	452.90		1.24
529	LW15OB	Groundwater	Western suite	11/02/2010	LW15ob	Na-Cl	19				7	74200			-1.7	51276	9.35	128.54	712.84	9.67	0.91	798.56	86.88	0.01	3.40
530	LW15OB	Groundwater	Western suite	5/07/2010	LW15ob	Na-Cl	17.2				7.09	75400			2.5	50191	9.35	133.31	738.04	9.72	0.84	775.41	66.67	0.02	4.59
531	LW15OB	Groundwater	Western suite	8/11/2010	LW15ob	Na-Cl	16.9				6.61	76500			1.6	42441	8.86	93.23	626.80	8.67	0.73	638.61	70.83	0.01	4.66
532	LW15OB	Groundwater	Western suite	14/01/2011	LW15ob	Na-Cl	18.6				7.04	78800			2.6	38076	8.16	94.55	560.83	7.88	0.68	568.77	65.90	0.19	2.88
533	LW15OB	Groundwater	Western suite	14/02/2011	LW15ob	Na-Cl	20.6				7.13	77600			1.3	51122	11.14	113.31	753.35	10.81	0.91	788.18	70.68	0.01	6.11
534	LW15OB	Groundwater	Western suite	8/03/2011	LW15ob	Na-Cl	17.8				7.04	78000			0.6	48212	9.75	112.00	703.26	11.09	0.87	775.55	45.03	0.01	5.42
535	LW15OB	Groundwater	Western suite	11/05/2011	LW15ob	Na-Cl	17.5				7.01	78500			1.2	53280	11.64	118.99	782.93	11.30	0.95	824.46	72.66	0.01	6.03
536	LW15OB	Groundwater	Western suite	12/06/2011	LW15ob	Na-Cl	17.5				7	79300			0.9	50647	10.70	111.34	743.20	10.48	0.87	779.55	74.02	0.00	5.34
537	LW15OB	Groundwater	Western suite	14/07/2011	LW15ob	Na-Cl	17.1				7.04	81200			1.2	43689	9.06	100.48	643.23	10.05	0.82	697.25	42.14	0.01	4.92
538	LW15OB	Groundwater	Western suite	9/08/2011	LW15ob	Na-Cl	17				7.05	82100			1.1	48326	9.75	106.57	714.19	11.07	0.91	766.86	50.32	0.01	5.10
539	LW15OB	Groundwater	Western suite	14/09/2011	LW15ob	Na-Cl	16.9				7.13	78800			2.8	49244	10.05	114.79	739.00	11.09	0.91	765.03	56.59	0.01	5.17
540	LW15OB	Groundwater	Western suite	12/10/2011	LW15ob	Na-Cl	16.7				7.3	78300			2.9	30956	7.02	79.25	456.61	7.04	0.55	477.98	33.48	0.02	7.94
541	LW15OB	Groundwater	Western suite	10/01/2012	LW15ob	Na-Cl	17.6			-103.5	7.16	85400			2.3	51878	6.52	154.38	753.74	7.40	0.60	812.20	61.90	0.01	7.25
542	LW15OB	Groundwater	Western suite	13/02/2012	LW15ob	Na-Cl	18			-107.3	7.17	83600			0.9	54208	10.60	136.03	785.23	11.12	0.85	850.48	66.67	0.01	7.19
543	LW15OB	Groundwater	Western suite	13/03/2012	LW15ob	Na-Cl	18.4			-95.1	7.13	83600			-1.0	57737	10.80	140.14	817.71	11.68	0.87	917.93	71.89	0.01	8.20
544	LW15OB	Groundwater	Western suite	10/04/2012	LW15ob	Na-Cl	18.9			-107.7	7.12	83100			-0.3	59977	11.29	137.42	866.16	11.04	0.91	952.83	71.43	0.01	7.49
545	LW15OB	Groundwater	Western suite	8/05/2012	LW15ob	Na-Cl	17.6			-117.5	7.04	88900			-0.8	60466	12.24	145.24	863.08	10.89	1.21	970.35	71.00	0.00	4.66
546	LW15OB	Groundwater	Western suite	12/06/2012	LW15ob	Na-Cl	14.9			-57	7.23	90800			1.6	52717	11.39	134.21	769.66	10.64	0.93	831.86	57.42	0.01	7.00
547	LW15OB	Groundwater	Western suite	10/07/2012	LW15ob	Na-Cl	17			-101.7	6.94	89900			0.5	53133	12.44	125.82	766.36	10.86	1.11	823.45	74.26	0.01	7.65
548	LW15OB	Groundwater	Western suite	14/08/2012	LW15ob	Na-Cl	17.5			-130.6	6.93	80300			0.9	55301	12.04	129.85	806.74	10.81	1.07	864.18	69.41	0.01	7.53
549	LW15OB	Groundwater	Western suite	11/09/2012	LW15ob	Na-Cl	17.6			-116.5	6.95	80100			5.0	54016	11.89	134.05	828.64	11.07	1.10	828.68	57.42	0.01	7.29
550	LW15OB	Groundwater	Western suite	9/10/2012	LW15ob	Na-Cl	17.4				6.95	77300			3.5	52461	13.23	141.05	772.52	11.76	1.09	794.71	73.31	0.01	7.93
551	LW15OB	Groundwater	Western suite	13/11/2012	LW15ob	Na-Cl	17.4			-127.6	6.97	78600			-1.6	55194	14.08	139.48	765.32	11.63	1.13	879.45	72.14	0.01	7.17
552	LW15OB	Groundwater	Western suite	11/12/2012	LW15ob	Na-Cl	18.9			-117.6	7.08	77000			-1.3	52326	14.58	146.06	713.62	12.22	1.08	831.10	68.08	0.01	9.16

No	Station ID	Sample type	Spatial grouping	Sample_Date	Alternative ID	Watertype	Temp (°C)	pH (field)	EC (Field) (uS/cm)	ORP (field) (mV)	pH (lab) (uS/cm)	EC (lab) (uS/cm)	18O	2H	CBE (%)	TDS (calc) (mg/L)	Ca (meq)	Mg (meq)	Na (meq)	K (meq)	Br (meq)	Cl_meq	SO4_meq	CO3_meq	HCO3_meq
553	LW15OB	Groundwater	Western suite	9/01/2013	LW15ob	Na-Cl	18.7			-142.8	7.08	77100			0.3	54296	13.03	146.31	761.46	15.10	1.07	851.47	70.29	0.01	8.46
554	LW15OB	Groundwater	Western suite	12/03/2013	LW15ob	Na-Cl	18.5			-198.9	6.99	81000			2.1	56361	14.13	138.91	828.12	11.40	1.12	872.90	70.54	0.01	7.97
555	LW15OB	Groundwater	Western suite	9/04/2013	LW15ob	Na-Cl	19			-287.6	6.66	84400			1.4	57845	14.23	151.33	833.72	11.73	1.16	897.90	76.01	0.00	8.57
556	LW15OB	Groundwater	Western suite	13/06/2013	LW15ob	Na-Cl	17.1			-124.6	7.08	79400			1.8	55978	15.69	137.26	816.88	11.87	1.08	869.62	70.48	0.01	7.46
557	LW15OB	Groundwater	Western suite	12/07/2013	LW15ob	Na-Cl	16.7			-74	7.25	80400			2.4	59070	15.05	148.62	867.72	12.18	1.14	913.88	73.68	0.01	8.41
558	LW15OB	Groundwater	Western suite	16/08/2013	LW15ob	Na-Cl	16.1			-122.5	6.89	84400			1.6	61598	15.59	139.65	909.86	12.42	1.18	963.85	73.39	0.01	6.56
559	LW15OB	Groundwater	Western suite	12/09/2013	LW15ob	Na-Cl	16.8			-111	7.08	77400			0.2	54006	14.84	134.05	769.70	11.16	0.97	848.95	68.50	0.01	7.99
560	LW15OB	Groundwater	Western suite	9/10/2013	LW15ob	Na-Cl									-0.7	54699	12.73	135.28	772.19	11.40	1.03	864.45	69.14	0.01	9.11
561	LW15OB	Groundwater	Western suite	13/12/2013	LW15ob	Na-Cl	18	7.04	77500						1.3	53844	13.17	136.19	779.17	11.20	1.03	841.36	67.69	0.01	6.77
562	LW15OB	Groundwater	Western suite	14/01/2014	LW15ob	Na-Cl	18.6	7.09	76400						0.3	53767	12.43	135.04	769.12	11.00	1.00	845.79	67.87	0.01	7.17
563	LW16D	Groundwater	Central suite	1/09/2002	E48	Na-Cl	22.4	6.4					-5.94	-27.22	1.8	3777	1.29	6.57	55.98	0.85		53.51	7.13		1.84
564	LW16D	Groundwater	Central suite	1/12/2002	E48	Na-Cl	21.2	6.4					-5.73	-22.10	-2.8	3558	1.25	6.57	49.28	0.71		52.79	6.46		1.82
565	LW16D	Groundwater	Central suite	1/03/2003	E48	Na-Cl	21.1	6.5					-6.81	-24.54	-4.8	3633	1.38	7.14	48.13	0.95		54.65	6.78		1.84
566	LW17DB	Groundwater	Central suite	1/09/2002	E50	Na-Cl	20.6	5.7					-2.47	-12.37	-1.9	86977	39.32	256.97	1168.98	11.10		1411.52	118.20		0.76
567	LW17DB	Groundwater	Central suite	1/12/2002	E50	Na-Cl	19.9	5.7					-2.37	-2.80	-4.3	105923	41.83	288.10	1404.20	12.11		1774.83	121.83		1.04
568	LW17DB	Groundwater	Central suite	1/03/2003	E50	Na-Cl	19.3	5.7					-1.28	-3.13	-1.1	98775	43.25	299.15	1334.04	15.68		1593.87	132.88		1.80
569	LW18D	Groundwater	Eastern suite	1/09/2002	E45A	Na-Cl	6.6	6.1					-6.23	-28.93	-4.8	12299	6.39	32.70	159.23	2.02		203.34	14.97		1.76
570	LW18D	Groundwater	Eastern suite	1/12/2002	E45A	Na-Cl	20.7	6					-5.67	-24.90	-3.2	10571	5.16	28.02	140.36	1.51		168.53	16.06		1.58
571	LW18D	Groundwater	Eastern suite	1/03/2003	E45A	Na-Cl	19.2	6					-5.83	-28.23	1.3	10092	6.59	28.24	138.90	2.03		152.14	17.15		2.10
572	LW18D	Groundwater	Eastern suite	1/09/2003	E45A	Na-Cl									-4.5	9792	6.93	26.23	124.10	1.78		155.01	16.85		1.74
573	LW18DB	Groundwater	Eastern suite	1/09/2002	E45B	Na-Cl	18.7	6.6					-5.80	-29.34	-1.8	31069	13.46	77.67	428.48	3.94		495.34	43.60		3.24
574	LW18DB	Groundwater	Eastern suite	1/12/2002	E45B	Na-Cl	21.2	6.5					-5.23	-23.58	-1.7	28280	12.86	74.29	386.02	3.33		445.67	43.69		3.58
575	LW18DB	Groundwater	Eastern suite	1/03/2003	E45B	Na-Cl	19.7	6.4					-5.72	-28.02	0.9	26150	14.27	77.04	358.67	4.58		396.91	46.16		3.54
576	LW19D	Groundwater	Western suite	1/09/2002	E53	Na-Cl	21.7	6.2					-5.79	-27.93	-3.7	30861	34.08	86.82	391.54	2.61		524.96	26.82		2.02
577	LW19D	Groundwater	Western suite	1/12/2002	E53	Na-Cl	18.6	6.4					-5.60	-24.44	-3.7	27988	32.72	89.36	343.26	2.93		474.78	26.82		2.00
578	LW19D	Groundwater	Western suite	1/03/2003	E53	Na-Cl	19.6	6.2					-5.51	-26.07	-0.3	28333	36.29	93.59	360.55	3.73		464.56	30.15		1.94
579	LW20D	Groundwater	Western suite	1/09/2002	E55	Na-Mg-Cl	17.8	6.4					-3.56	-16.62	-3.2	35229	25.82	130.48	430.79	3.87		568.21	57.32		2.88
580	LW20D	Groundwater	Western suite	1/12/2002	E55	Na-Mg-Cl	21.2	6.4					-3.24	-11.45	-4.3	35612	26.42	136.15	424.12	3.02		574.67	62.82		2.82
581	LW20D	Groundwater	Western suite	1/03/2003	E55	Na-Mg-Cl	21.2	6.4					-3.37	-11.29	-0.2	35177	27.04	130.12	449.38	4.44		551.83	59.41		2.20
582	LW20OB	Groundwater	Western suite	11/03/2010	LW20ob	Na-Cl	22				7.07	12370			0.4	2198	2.29	5.33	29.06	0.54	0.05	31.43	3.88	0.00	1.54
583	LW20OB	Groundwater	Western suite	15/07/2010	LW20ob	Na-Cl	18.6				6.86	11850			3.1	20413	8.76	56.04	298.76	2.27	0.35	314.45	29.67		
584	LW20OB	Groundwater	Western suite	11/08/2010	LW20ob	Na-Cl	17.4				7.02	12080			-0.7	3386	5.07	10.83	41.89	0.54	0.08	53.82	3.11	0.24	1.61
585	LW20OB	Groundwater	Western suite	8/11/2010	LW20ob	Na-Cl	19.1				7.37	12390			3.0	3174	4.68	9.76	40.77	0.48	0.06	44.57	3.88	0.07	3.80
586	LW20OB	Groundwater	Western suite	14/01/2011	LW20ob	Na-Cl	24				6.83	9430			1.2	3971	5.22	12.96	50.42	0.59	0.07	60.06	4.59	0.00	2.82
587	LW20OB	Groundwater	Western suite	14/02/2011	LW20ob	Na-Cl	22.4				6.86	14120			1.6	8665	9.65	29.86	112.58	1.40	0.15	136.17	9.53	0.12	2.71
588	LW20OB	Groundwater	Western suite	8/03/2011	LW20ob	Na-Cl	21.8				6.88	14140			0.7	4480	6.12	12.39	58.25	0.66	0.09	68.35	4.88	0.10	2.85
589	LW20OB	Groundwater	Western suite	11/04/2011	LW20ob	Na-Cl	21.5				6.75	14560			1.7	7868	14.48	25.27	96.00	0.99	0.13	114.67	9.22	0.07	8.27
590	LW20OB	Groundwater	Western suite	12/06/2011	LW20ob	Na-Cl	19.6				6.86	15420			0.3	8697	15.67	28.72	104.27	1.05	0.14	131.52	9.05	0.01	7.99
591	LW20OB	Groundwater	Western suite	14/07/2011	LW20ob	Na-Cl	18.6				6.83	15400			1.3	5166	6.92	14.52	67.90	0.82	0.11	80.23	4.51	0.00	3.11
592	LW20OB	Groundwater	Western suite	9/08/2011	LW20ob	Na-Cl	17.9				6.92	14410			1.4	6559	8.91	19.12	85.83	0.94	0.12	101.81	5.65	0.00	4.07
593	LW20OB	Groundwater	Western suite	14/09/2011	LW20ob	Na-Cl	19.1				6.79	16730			-2.8	10238	15.37	31.76	120.54	2.12	0.17	160.29	11.25	0.04	7.42
594	LW20OB	Groundwater	Western suite	12/10/2011	LW20ob	Na-Cl	18.2				7.06	14140			0.8	4722	7.47	13.04	59.20	0.69	0.08	68.66	3.82	0.01	6.59
595	LW20OB	Groundwater	Western suite	8/11/2011	LW20ob	Na-Cl	18.2			126.9	7.09	14620			-1.0	9310	11.34	27.65	117.89	1.20	0.15	145.42	9.94	0.01	5.66
596	LW20OB	Groundwater	Western suite	10/01/2012	LW20ob	Na-Mg-Cl	21.2			76.9	6.85	14880			4.5	6859	9.55	27.57	85.83	0.61	0.08	96.76	7.68	0.01	8.69
597	LW20OB	Groundwater	Western suite	13/02/2012	LW20ob	Na-Cl	21.5			139.1	6.99	15030			-1.5	7744	12.19	23.14	92.74	1.02	0.11	115.55	8.78	0.01	8.52
598	LW20OB	Groundwater	Western suite	13/03/2012	LW20ob	Na-Cl	21.5			111.1	7.11	14480			-0.6	10097	14.88	30.52	124.98	1.35	0.15	154.96	11.15	0.01	7.57
599	LW20OB	Groundwater	Western suite	10/04/2012	LW20ob	Na-Cl	22			130.5	6.96	14090			3.3	9936	16.52	32.41	126.76	1.30	0.15	146.64	10.75	0.01	8.52
600	LW20OB	Groundwater	Western suite	8/05/2012	LW20ob	Na-Cl	20.1			153.6	7.07	14650			-0.7	9158	15.32	28.06	110.58	0.99	0.22	137.81	9.84	0.00	9.09
601	LW20OB	Groundwater	Western suite	12/06/2012	LW20ob	Na-Cl	18.9			152.3	7.15	14860			-1.5	8029	14.38	25.85	93.53	0.92	0.15	121.39	8.70	0.01	8.32
602	LW20OB	Groundwater	Western suite	10/07/2012	LW20ob	Na-Cl	17.9			159.7	6.98	11340			1.0	7863	11.89	23.06	99.40	1.05	0.16	116.23	9.07	0.01	7.37
603	LW20OB	Groundwater	Western suite	14/08/2012	LW20ob	Na-Cl	17.5			165.4	7.03	10220			1.3	6286	10.35	18.05	79.17	0.77	0.11	92.27	6.08	0.01	7.17
604	LW20OB	Groundwater	Western suite	11/09/2012	LW20ob	Na-Cl	19.3			24.5	6.9	8190			4.3	5616	8.56	15.42	75.78	0.77	0.13	81.61	5.38	0.00	5.30
605	LW20OB	Groundwater	Western suite	9/10/2012	LW20ob	Na-Cl	19.7				7.12	7670			4.4	4379	7.81	12.71	56.72	0.64	0.08	61.27	4.28	0.01	5.81
606	LW20OB	Groundwater	Western suite	13/11/2012	LW20ob	Na-Cl	19.7			143.7	7.11	7610			-0.9	4198	6.52	11.16	51.63	0.61	0.08	61.44	3.59	0.01	5.97
607	LW20OB	Groundwater	Western suite	11/12/2012	LW20ob	Na-Cl	20.4			160.2	7.08	9770			-0.4	5407	9.11	17.56	64.25	0.71	0.11	80.45	5.40	0.01	6.33
608	LW20OB	Groundwater	Western suite	9/01/2013	LW20ob	Na-Cl	21.2			70.9	7.03	10350			0.9	5882	11.09	17.48	71.43	0.82	0.12	85.76	6.08	0.01	7.07
609	LW20OB	Groundwater	Western suite	13/02/2013	LW20ob	Na-Cl	21.2			154	6.97	9940			-2.6	5923	10.55	16.41	69.34	0.84	0.11	89.06	6.12	0.01	6.97
610	LW20OB	Groundwater	Western suite	12/03/2013	LW20ob	Na-Cl	21.4			0	7.04	10210			2.7	5999	10.40	17.40	76.52	0.82	0.11	86.77	5.92	0.01	6.87
611	LW20OB	Groundwater	Western suite	12/06/2013	LW20ob	Na-Cl	18.9			127.3	6.88	8500			1.2	4784	8.49	13.67	59.46	0.69	0.08	70.02	4.75	0.00	5.52
612	LW20OB	Groundwater	Western suite	9/07/2013	LW20ob	Na-Cl	18.2			94.9	7	7340			2.5	4675	7.64	13.17	60.12	0.66	0.09	67.76	4.58	0.01	5.32
613	LW20OB	Groundwater	Western suite	11/09/2013	LW20ob	Na-Cl	18.3			-55.1	6.91	5640			0.6	3216	5.43	8.63	40.26	0.47	0.07	47.20	3.00	0.00	3.87
614	LW20OB	Groundwater	Western suite	7/10/2013	LW20ob	Na-Cl									-0.3	1512	3.19	3.79	18.19	0.30	0.03	22.55	1.22	0.00	1.83
615	LW20OB	Groundwater	Western suite	13/12/2013	LW20ob	Na-Cl	22.5	6.59	5780						4.3	3225	5.09	8.39	43.20	0.52	0.06	45.56	2.89	0.00	4.08
616	LW20OB	Groundwater	Western suite	16/01/2014	LW20ob	Na-Cl	22.2	6.63	6050						1.5	3348	5.34	9.13	42.59	0.54	0.06	48.69	3.14	0.00	4.06
617	LW21OB	Groundwater	Western suite	1/12/2002	OB LW-21	Na-Cl	18.6	7					-1.82	3.60	-4.3	44791	21.06	130.65	573.72	9.28		727.51	68.91		2.14
618	LW21OB	Groundwater	Western suite	1/03/2003	OB LW-21	Na-Cl	18.6	7					-1.50	-0.21	1.1	41171	21.84	124.59	562.50	10.94		635.15	66.61		2.40
619	LW21OB	Groundwater	Western suite	14/02/2011	OB LW-21	Na-Cl	21.2				7.3	1230			4.5	398	0.45	1.07	5.33	0.13	0.01	5.18	0.64	0.00	0.54
620	LW21OB	Groundwater	Western suite	8/11/2011	OB LW-21	Na-Cl	16.2			504.7	6.55	710			3.2	3288	1.79	7.22	48.11	0.77	0.05	48.44	3.86	0.00	2.00
621	LW21OB	Groundwater	Western suite	9/10/2012	OB LW-21	Na-Cl	16.3				7.47	1140			2.0	626	0.80	1.64	8.03	0.13	0.01	8.24	0.68	0.00	1.23

No	Station ID	Sample type	Spatial grouping	Sample_Date	Alternative ID	Watertype	Temp (°C)	pH (field)	EC (Field) (uS/cm)	ORP (field) (mV)	pH (lab) (uS/cm)	EC (lab) (uS/cm)	18O	2H	CBE (%)	TDS (calc) (mg/L)	Ca (meq)	Mg (meq)	Na (meq)	K (meq)	Br (meq)	Cl_meq	SO4_meq	CO3_meq	HCO3_meq
622	LW21OB	Groundwater	Western suite	13/06/2013	OB LW-21	Na-Cl	16.4			100.8	6.52	900			1.4	9800	6.01	27.27	136.11	0.88	0.18	150.22	14.81	0.00	2.21
623	LW21OB	Groundwater	Western suite	15/08/2013	OB LW-21	Na-Cl	14.6			339.7	6.54	710			0.1	369	0.53	0.88	4.38	0.15	0.00	4.50	0.42	0.00	1.00
624	LW21OB	Groundwater	Western suite	12/09/2013	OB LW-21	Na-Cl	15			149.9	6.72	850			1.8	483	0.58	1.26	6.12	0.13	0.01	6.16	0.63	0.00	1.00
625	LW21OB	Groundwater	Western suite	9/10/2013	OB LW-21	Na-Cl									0.3	528	0.58	1.24	6.73	0.14	0.01	6.89	0.69	0.00	1.04
626	LW22OB	Groundwater	Western suite	1/12/2002	LW22ob	Na-Cl	18.5	7					-2.51	-0.21	-1.5	35003	15.80	86.56	486.16	4.61		563.66	43.94		3.06
627	LW22OB	Groundwater	Western suite	1/03/2003	LW22ob	Na-Cl	18.6	7					-1.71	-3.47	1.0	33691	20.20	103.83	456.47	7.85		520.89	53.61		3.02
628	LW22OB	Groundwater	Western suite	12/09/2010	LW22ob	Na-Cl	15.6				6.87	5890			1.6	4823	1.89	13.54	67.08	1.43	0.10	72.16	7.78	0.00	1.36
629	LW22OB	Groundwater	Western suite	8/11/2010	LW22ob	Na-Cl	17.6				6.96	32400			-0.4	10604	3.63	34.13	142.59	1.25	0.21	161.50	18.58	0.00	2.55
630	LW22OB	Groundwater	Western suite	14/02/2011	LW22ob	Na-Cl	21.3				6.75	29100			2.9	18081	7.61	55.79	258.96	1.66	0.33	281.71	19.78	0.14	4.37
631	LW22OB	Groundwater	Western suite	11/04/2011	LW22ob	Na-Cl	19.5				5.77	32000			3.0	20806	13.23	69.58	286.45	2.04	0.37	303.73	46.51		
632	LW22OB	Groundwater	Western suite	14/07/2011	LW22ob	Na-Cl	17				6.34	35200			1.0	15373	9.40	49.97	208.28	1.45	0.29	235.98	25.59	0.00	1.89
633	LW22OB	Groundwater	Western suite	9/08/2011	LW22ob	Na-Cl	16.1				5.94	27700			0.2	12741	7.02	35.69	176.35	1.76	0.22	201.19	17.73		0.69
634	LW22OB	Groundwater	Western suite	14/09/2011	LW22ob	Na-Cl	17.7				6.17	22700			-4.3	10168	15.37	30.69	117.10	2.19	0.16	161.19	10.96	0.03	7.45
635	LW22OB	Groundwater	Western suite	12/10/2011	LW22ob	Na-Cl	17.7				6.97	20200			0.3	8056	4.43	21.25	112.71	0.92	0.14	126.63	10.25	0.00	1.47
636	LW22OB	Groundwater	Western suite	8/05/2012	LW22ob	Na-Mg-Cl	19.5			224.8	6.62	36100			1.2	21562	15.47	77.29	286.67	1.48	0.44	340.33	28.02	0.00	3.59
637	LW22OB	Groundwater	Western suite	10/07/2012	LW22ob	Na-Cl	15.9			137.5	6.36	30700			0.9	16512	10.15	49.72	223.46	3.01	0.33	247.94	28.59	0.00	4.29
638	LW22OB	Groundwater	Western suite	11/09/2012	LW22ob	Na-Cl	16.8			115.1	6.5	8250			3.3	4412	1.99	9.52	66.64	0.38	0.08	66.94	5.35	0.00	1.20
639	LW22OB	Groundwater	Western suite	9/10/2012	LW22ob	Na-Cl	17.8				6.49	5040			3.8	2387	1.09	4.51	35.91	0.31	0.03	33.68	2.66	0.00	2.43
640	LW22OB	Groundwater	Western suite	13/11/2012	LW22ob	Na-Cl	18.7			132.3	6.75	9860			-1.1	5355	2.49	11.16	74.39	0.79	0.11	81.75	1.37	0.00	7.47
641	LW22OB	Groundwater	Western suite	13/06/2013	LW22ob	Na-Cl	17.5			112.3	6.27	18000			0.9	9800	6.01	27.27	136.11	0.88	0.18	150.22	14.81	0.00	2.21
642	LW22OB	Groundwater	Western suite	10/07/2013	LW22ob	Na-Cl	17.1			31.2	6.18	7450			-0.9	4201	1.94	8.64	58.12	0.41	0.08	59.38	5.64	0.00	5.30
643	LW22OB	Groundwater	Western suite	15/08/2013	LW22ob	Na-Cl	16.2			72.7	6.42	3780			-0.3	1856	0.62	2.56	27.54	0.22	0.03	27.43	2.05	0.00	1.60
644	LW22OB	Groundwater	Western suite	12/09/2013	LW22ob	Na-Cl	16.2			91.7	5.56	720			4.3	460	0.23	0.69	6.99	0.13	0.01	6.39	0.46		0.52
645	LW22OB	Groundwater	Western suite	14/01/2014	LW22ob	Na-Cl	20.2	6.68	8120						0.6	4792	2.22	12.34	66.47	0.63	0.11	73.06	1.06	0.00	6.46
646	LW8D	Groundwater	Central suite	1/09/2002	E54A	Na-Cl	19.6	6.6					0.73	12.39	-4.0	24248	8.02	64.32	319.27	5.08		393.44	24.75		10.36
647	LW8D	Groundwater	Central suite	1/12/2002	E54A	Na-Cl	19.8	6.7					0.03	16.05	-4.4	23188	8.17	60.87	303.38	4.91		377.74	24.15		9.32
648	LW8D	Groundwater	Central suite	1/03/2003	E54A	Na-Cl	19.7	6.7					-2.94	-13.38	-0.3	20644	6.53	56.16	284.25	4.99		321.78	20.30		11.80
649	LW8DB	Groundwater	Central suite	1/09/2002	E54B	Na-Cl	20.3	6.2					-4.85	-16.80	-3.9	88010	41.12	272.38	1141.18	10.83		1496.63	81.10		4.44
650	LW8DB	Groundwater	Central suite	1/12/2002	E54B	Na-Cl	20.6	6.3					-3.29	-10.01	-1.1	88760	42.40	272.42	1199.15	11.16		1447.11	105.98		3.42
651	LW8DB	Groundwater	Central suite	1/03/2003	E54B	Na-Cl	20.3	6.6					1.23	14.93	-2.4	79910	39.73	249.01	1047.81	13.13		1313.58	98.00		3.54
652	LWds01D	Groundwater	Central suite	14/01/2014	LWDS01D	Na-Ca-Cl	19.7	7.08	3890						0.6	1827	12.48	6.21	13.05	0.10	0.03	28.04	0.54	0.00	2.85
653	LWds01OB	Groundwater	Central suite	13/11/2012	LWDS01ob	Na-Ca-Cl-HCO3	18.4			431.9	7.53	1260			-3.8	792	3.18	2.05	5.77	0.10	0.01	6.10	0.46	0.02	5.36
654	LWds01OB	Groundwater	Central suite	11/12/2012	LWDS01ob	Na-Ca-Cl-HCO3	18.9			294.5	7.47	1350			-4.4	876	4.53	1.97	5.77	0.05	0.01	7.23	0.52	0.02	5.64
655	LWds01OB	Groundwater	Central suite	12/03/2013	LWDS01ob	Na-Ca-Cl-HCO3	18.6			176.7	7.46	1260			-2.9	779	3.58	1.97	5.64	0.05	0.01	6.58	0.42	0.01	4.87
656	LWds01OB	Groundwater	Central suite	15/08/2013	LWDS01ob	Na-Ca-Cl-HCO3	18.5			165.2	7.38	1250			-4.3	699	2.55	1.83	5.69	0.04	0.01	6.78	0.32	0.01	3.88
657	LWds01OB	Groundwater	Central suite	13/12/2013	LWDS01ob	Na-Ca-Mg-Cl-HCO3	18.5	7.33	1267						0.7	605	2.30	1.93	5.44	0.03	0.01	6.69	0.27	0.01	2.59
658	LWds02D	Groundwater	Central suite	14/01/2014	LWDS02D	Na-Cl	20.7	7.38	28700						0.6	16369	6.99	28.72	241.38	3.48	0.31	257.42	12.47	0.02	7.30
659	LWds02OB	Groundwater	Central suite	11/09/2012	LWDS02ob	Na-Cl-HCO3	18.2			300.9	7.61	3400			0.0	1488	1.39	2.38	19.08	0.28	0.02	15.41	2.84	0.02	4.84
660	LWds02OB	Groundwater	Central suite	13/11/2012	LWDS02ob	Na-Cl-HCO3	19.1			355.5	7.45	3070			-0.2	1914	1.79	2.95	23.12	0.33	0.03	14.74	3.96	0.03	9.54
661	LWds02OB	Groundwater	Central suite	11/12/2012	LWDS02ob	Na-Cl-HCO3	19.6			295.8	7.56	3120			-3.2	2054	2.89	2.87	23.03	0.36	0.03	16.48	3.90	0.04	10.53
662	LWds02OB	Groundwater	Central suite	9/01/2013	LWDS02ob	Na-Cl-HCO3	19.6			162.8	7.57	3100			-4.9	2071	1.49	3.12	23.46	0.43	0.03	16.09	4.05	0.04	11.12
663	LWds02OB	Groundwater	Central suite	14/02/2013	LWDS02ob	Na-Cl-HCO3	19.5			221.7	7.65	3220			-3.6	2111	2.09	3.20	24.76	0.48	0.03	17.72	4.01	0.05	10.12
664	LWds02OB	Groundwater	Central suite	12/03/2013	LWDS02ob	Na-Cl-HCO3	18.8			278.2	7.3	3050			-3.3	2022	2.49	2.87	22.68	0.38	0.03	15.58	3.70	0.02	10.94
665	LWds02OB	Groundwater	Central suite	9/04/2013	LWDS02ob	Na-Cl-HCO3	21.2			118.1	7.4	3030			-3.5	2112	2.14	2.87	23.59	1.05	0.03	16.88	3.92	0.03	10.84
666	LWds02OB	Groundwater	Central suite	13/06/2013	LWDS02ob	Na-Cl-HCO3	18.3			182.9	7.41	3070			-4.3	1884	1.48	2.65	21.58	0.33	0.02	14.34	3.55	0.03	10.36
667	LWds02OB	Groundwater	Central suite	11/07/2013	LWDS02ob	Na-Cl-HCO3	18.5			265.1	7.62	3050			-4.5	2103	1.44	2.79	24.28	0.38	0.03	15.80	3.91	0.05	11.73
668	LWds02OB	Groundwater	Central suite	16/08/2013	LWDS02ob	Na-Cl-HCO3	18.6			244.2	7.2	3000			2.3	1930	1.49	2.93	24.93	0.35	0.03	15.66	4.10	0.01	8.57
669	LWds02OB	Groundwater	Central suite	12/09/2013	LWDS02ob	Na-Cl-HCO3	18.5			349	7.54	3130			-4.7	2175	1.37	3.06	25.24	0.33	0.03	17.02	3.99	0.04	11.78
670	LWds02OB	Groundwater	Central suite	9/10/2013	LWDS02ob	Na-Mg-Cl-HCO3									4.9	2205	1.67	9.04	24.55	0.32	0.03	17.13	3.91	0.04	11.24
671	LWds02OB	Groundwater	Central suite	11/12/2013	LWDS02ob	Na-Cl-HCO3	19.9	7.45	3120						1.4	1919	1.62	3.04	24.84	0.32	0.03	17.86	3.77	0.02	7.36
672	LWds02OB	Groundwater	Central suite	14/01/2014	LWDS02ob	Na-Cl-HCO3	19.7	7.45	3140						0.0	1818	1.83	2.78	22.32	0.36	0.03	15.68	3.39	0.02	8.17
673	LWstOB	Groundwater	Western suite	11/09/2012	OB LW-St	Na-Cl	16.4			193.8	6.35	1060			1.3	754	0.65	0.74	10.84	0.13	0.02	9.37	1.39	0.00	1.28
674	LWstOB	Groundwater	Western suite	9/10/2012	OB LW-St	Na-Cl	16.4				6.14	940			-2.5	1037	0.40	1.64	14.14	0.23	0.02	13.92	1.66	0.00	1.63
675	LWstOB	Groundwater	Western suite	13/11/2012	OB LW-St	Na-Cl	16.8			-16	6.27	1230			3.0	555	0.20	0.49	8.24	0.10	0.01	6.02	1.08	0.00	1.40
676	LWstOB	Groundwater	Western suite	11/12/2012	OB LW-St	Na-Cl	18			168.3	6.29	1000			-7.4	521	0.25	0.41	7.16	0.10	0.01	6.10	0.93	0.00	1.32
677	LWstOB	Groundwater	Western suite	9/01/2013	OB LW-St	Na-Cl-HCO3	18.9			171.3	6.42	960			-3.8	565	0.20	0.33	7.68	0.10	0.01	6.13	1.02	0.00	1.79
678	LWstOB	Groundwater	Western suite	12/03/2013	OB LW-St	Na-Cl	18.8			34.3	6.38	900			-0.7	481	0.15	0.33	6.89	0.10	0.01	5.46	0.91	0.00	1.20
679	LWstOB	Groundwater	Western suite	9/04/2013	OB LW-St	Na-Cl	18.8			84.2	6.61	900			-0.5	500	0.20	0.25	7.24	0.10	0.01	5.71	0.91	0.00	1.24
680	LWstOB	Groundwater	Western suite	13/06/2013	OB LW-St	Na-Cl-HCO3	17.2			216.3	5.93	910			-2.4	542	0.12	0.26	7.60	0.09	0.01	5.74	0.92		1.79
681	LWstOB	Groundwater	Western suite	10/07/2013	OB LW-St	Na-Cl-HCO3	15.5			204.2	6.14	920			-1.0	536	0.12	0.28	7.63	0.08	0.01	5.57	0.90		1.79
682	LWstOB	Groundwater	Western suite	15/08/2013	OB LW-St	Na-Cl-HCO3	14.7			179.8	6.27	890			2.4	521	0.43	0.43	7.29	0.09	0.02	5.20	0.84	0.00	1.79
683	LWstOB	Groundwater	Western suite	12/09/2013	OB LW-St	Na-Cl	16.7			62	6.09	900			2.0	467	0.11	0.25	7.12	0.08	0.01	5.40	0.82		1.04
684	LWus01OB	Groundwater	Western suite	11/09/2012	LWUS01ob	Na-Cl	20.2				7.2	8720			3.7	4592	2.69	10.50	67.08	1.17	0.09	67.22	6.12	0.00	2.27
685	LWus01OB	Groundwater	Western suite	15/08/2013	LWUS01ob	Na-Cl	16.2			154.6	6.29	1510			2.0	769	0.52	0.91	11.41	0.10	0.01	10.33	1.11	0.00	1.00
686	LWus01OB	Groundwater	Western suite	13/12/2013	LWUS01ob	Na-Cl	17.3	6.57	995						0.5	551	0.30	0.55	7.74	0.12	0.01	6.35	0.70	0.00	1.57
687	LWus01OB	Groundwater	Western suite	14/01/2014	LWUS01ob	Na-Cl	20.8	6.26	1906						0.5	1053	0.37	2.00	14.83	0.14	0.02	13.85	1.49	0.00	1.81
688	Mullet Lake- North West GP	Surface water	Eastern suite	1/09/2002	E25	Na-Cl	26.3	8.2					-1.16	2.26	-1.5	21903	6.96	55.65	304.55	2.45		345.09	32.64		3.12
689	Mullet Lake- North West GP	Surface water	Eastern suite	1/12/2002	E25	Na-Cl	23.7	8.3					3.36	26.77	-1.4	27213	8.54	68.66	378.03	3.75		423.01	44.32		4.04
690	Mullet Lake- North West GP	Surface water	Eastern suite	1/03/2003	E25	Na-Cl	20.4	8.4					-0.13	3.09	-1.8	45492	10.16	117.96	627.73	8.09		709.31	78.32		3.32

No	Station ID	Sample type	Spatial grouping	Sample_Date	Alternative ID	Watertype	Temp (°C)	pH (field)	EC (Field) (uS/cm)	ORP (field) (mV)	pH (lab) (uS/cm)	EC (lab) (uS/cm)	18O	2H	CBE (%)	TDS (calc) (mg/L)	Ca (meq)	Mg (meq)	Na (meq)	K (meq)	Br (meq)	Cl_meq	SO4_meq	CO3_meq	HCO3_meq
691	Mullet Lake- North West GP	Surface water	Eastern suite	30/03/2010	E25	Na-Cl									-0.1	170029	31.64	510.36	2347.49	25.43	2.57	2558.14	342.70	0.02	14.53
692	Mullet Lake- North West GP	Surface water	Eastern suite	22/06/2010	E25	Na-Cl	15.2				8.98	28900			-0.7	18596	6.32	48.40	258.26	3.24	0.26	288.24	28.23	0.10	3.61
693	Mullet Lake- North West GP	Surface water	Eastern suite	20/07/2010	E25	Na-Cl	14.1				8.72	27300			2.1	6440	1.89	14.94	92.96	0.94	0.09	85.62	19.28	0.01	1.29
694	Pink Lake	Surface water	Western suite	1/09/2002	Pink Lake	Na-Cl	24.3	7.8					-1.06	-2.41	1.2	240830	6.67	681.66	3501.46	39.53		3820.76	306.30		3.64
695	Pink Lake	Surface water	Western suite	1/03/2003	Pink Lake	Na-Mg-Cl	25.4	7.1					-2.26	-12.97	-2.3	280004	7.98	1034.05	3627.88	72.80		4500.42	442.03		4.39
696	Pink Lake	Surface water	Western suite	1/09/2003	Pink Lake	Na-Cl									-3.2	80859	5.14	190.83	1135.93	12.76		1342.73	84.71		2.58
697	Pink Lake	Surface water	Western suite	24/01/2014	Pink Lake	Na-Cl	29.5	7.89	200000						2.3	198973	5.89	595.45	2912.02	38.09	3.50	3206.04	176.93	0.10	12.39
698	Pink Lake	Surface water	Western suite	11/02/2014	Pink Lake	Na-Cl	21.4	7.83	205000						-1.8	217444	4.88	633.96	3006.11	41.16	3.79	3550.37	252.50	0.07	10.47
699	PL N OB	Groundwater	Western suite	11/09/2012	PLNob	Na-Mg-Cl	18.3			14.9	7.2	3220			-0.6	1737	4.03	6.48	17.74	0.20	0.03	21.94	2.66	0.01	4.15
700	PL N OB	Groundwater	Western suite	9/10/2012	PLNob	Na-Mg-Cl-HCO3	17.4				7.29	3860			-4.4	2358	4.93	7.96	22.64	0.26	0.04	27.37	3.30	0.02	8.20
701	PL N OB	Groundwater	Western suite	13/11/2012	PLNob	Na-Mg-Cl-HCO3	18			-124.1	7.16	3650			-1.4	2250	6.12	7.71	21.60	0.26	0.04	26.10	3.11	0.01	7.37
702	PL N OB	Groundwater	Western suite	16/01/2014	PLNob	Na-Cl	19.4	7.21	4020						1.3	2262	6.49	7.16	23.58	0.27	0.04	27.36	3.19	0.01	5.98
703	PL W OB	Groundwater	Western suite	11/09/2012	PLWob	Na-Ca-Mg-Cl-HCO3	19.1			7.5	7.35	1020			0.8	522	2.29	2.13	3.47		0.01	3.68	0.71	0.01	3.36
704	PL W OB	Groundwater	Western suite	13/11/2012	PLWob	Na-Ca-Mg-HCO3-Cl	18.8			-116.8	7.32	1010			-1.4	627	3.18	2.22	3.30	0.05	0.01	3.18	0.60	0.01	5.17
705	PL W OB	Groundwater	Western suite	15/01/2014	PLWob	Na-Ca-Mg-HCO3-Cl	18.5	7.35	990						0.6	607	2.85	2.26	3.75	0.05	0.01	3.72	0.64	0.01	4.43
706	PLds01OB	Groundwater	Western suite	11/09/2012	PLDS01ob	Na-Ca-Cl-HCO3	19			328.4	7.6	1080			1.4	523	1.99	1.39	4.77	0.10	0.01	4.95	0.77	0.01	2.28
707	PLds01OB	Groundwater	Western suite	13/11/2012	PLDS01ob	Na-Ca-HCO3-Cl	19.9			431.9	7.62	920			-1.7	608	3.28	1.72	3.60	0.05	0.00	3.99	0.56	0.01	4.37
708	PLds01OB	Groundwater	Western suite	15/01/2014	PLDS01ob	Na-Ca-Cl-HCO3	20.1	7.41	1119						2.2	690	3.32	1.69	5.61	0.05	0.01	5.70	0.45	0.01	4.05
709	PLds02OB	Groundwater	Western suite	11/09/2012	PLDS02ob	Na-Mg-Ca-Cl-HCO3	19.3			195.5	7.21	2030			0.8	958	3.43	3.45	8.67	0.18	0.02	11.48	0.87	0.00	3.13
710	PLds02OB	Groundwater	Western suite	13/11/2012	PLDS02ob	Na-Ca-Mg-Cl-HCO3	19.6			-31.2	7.16	1970			-1.6	1145	4.98	3.86	8.15	0.18	0.01	10.32	0.87	0.01	6.47
711	PLds02OB	Groundwater	Western suite	12/03/2013	PLDS02ob	Na-Ca-Mg-Cl-HCO3	19.4			23.6	7.23	2010			-3.1	1206	5.17	3.86	8.80	0.18	0.02	12.07	0.85	0.01	6.17
712	PLds02OB	Groundwater	Western suite	9/07/2013	PLDS02ob	Na-Mg-Ca-Cl-HCO3	18.4			113	7.11	2000			-58.3	1154	3.93	3.97	8.86	0.18	0.01	12.33	0.78	0.01	5.58
713	PLds02OB	Groundwater	Western suite	11/09/2013	PLDS02ob	Na-Ca-Cl-HCO3	19.6			187.7	7.13	2020			1.6	1288	4.46	3.88	11.68	0.18	0.01	11.97	0.74	0.01	6.81
714	PLds02OB	Groundwater	Western suite	11/10/2013	PLDS02ob	Mg-Na-Cl-HCO3									1.1	1541	4.67	10.76	8.68	0.17	0.01	12.90	0.78	0.01	10.07
715	PLds02OB	Groundwater	Western suite	12/12/2013	PLDS02ob	Na-Ca-Mg-Cl	19.8	7.09	2050						1.6	1051	4.26	4.03	9.09	0.17	0.01	12.84	0.80	0.00	3.38
716	PLds02OB	Groundwater	Western suite	16/01/2014	PLDS02ob	Na-Ca-Mg-Cl-HCO3	19.8	7.13	2070						-1.8	1148	4.77	4.09	8.96	0.17	0.02	13.20	0.84	0.01	4.58
717	WLds01D	Groundwater	Central suite	16/01/2014	WLDS01D	Na-Cl	20	6.96	122300						0.3	96282	20.51	255.26	1367.90	17.70	1.69	1502.41	137.75	0.01	10.08
718	WLds01OB	Groundwater	Central suite	11/09/2012	WLDS01ob	Na-Ca-Cl-HCO3	15.8			227.5	7.34	1010			1.2	630	2.59	1.64	5.72	0.08	0.01	6.36	0.83	0.01	2.59
719	WLds01OB	Groundwater	Central suite	11/12/2012	WLDS01ob	Ca-Na-HCO3-Cl	18.2			47.9	7.3	870			-2.5	707	5.47	1.15	2.65	0.13	0.00	2.90	0.73	0.01	6.21
720	WLds01OB	Groundwater	Central suite	11/10/2013	WLDS01ob	Mg-Ca-Na-HCO3-Cl									-3.4	807	3.05	5.24	2.37	0.10	0.00	2.69	0.48	0.01	8.28
721	WLds01OB	Groundwater	Central suite	12/12/2013	WLDS01ob	Ca-Na-Mg-HCO3-Cl	19	7.26	911						2.2	452	2.96	1.41	2.22	0.10	0.01	2.55	0.44	0.01	3.41
722	WLds01OB	Groundwater	Central suite	16/01/2014	WLDS01ob	Ca-Na-HCO3-Cl	20	7.34	956						-2.1	617	4.22	1.35	2.71	0.11	0.01	3.02	0.53	0.01	5.18
723	Woody Lake	Surface water	Central suite	1/09/2002	E28	Na-Cl	22.1	8.9					-1.59	-2.43	-1.7	5913	3.09	13.58	81.26	0.95		91.88	8.16		2.16
724	Woody Lake	Surface water	Central suite	1/12/2002	E28	Na-Cl	25.6	8					1.56	15.94	4.1	7975	4.11	22.86	115.44	1.34		118.58	11.61		2.42
725	Woody Lake	Surface water	Central suite	1/03/2003	E28	Na-Cl	21.8	8.9					2.75	18.67	4.0	11912	5.27	30.18	175.32	2.48		176.12	17.77		3.54

Appendix 2 Hydrochemical data: data collection & interpretation quality assurance and background information

The quality of a hydrochemical dataset is determined by the veracity of sample collection, handling, processing and reporting. Record keeping is important throughout the workflow, from the point of sample collection through to the reporting of measured parameters. Chain of custody documentation is important document that demonstrates appropriate procedures have been established and maintained.

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000) are the industry standard benchmark and provide information on developing and operating a monitoring program for water quality. Information important for the collection of hydrochemical data are detailed below.

Record keeping and data management

Thorough record keeping and data management techniques that allow samples and records thereof to be tracked from the point of collection through to entry of analysis into a master database. Including the development of:

- Clear and concise naming convention for samples and measurements, to allow traceability of samples and objective interpretation of data by other operatives;
- Compilation of COC and other metadata information (such as sampling/field measurement records and hand-over records) and retention of this data within the broader database, to provide confidence in the methodology and QA/QC measures undertaken; and
- Centralised data storage, preventing fragmentation of the database.

Furthermore, the robustness of future sample collection and analysis should be improved by the incorporation of:

- sampling duplicates
- field and trip blanks
- spiked samples

The results of which should be clearly identified, periodically reviewed and reported on, and stored within the broader database.

Trip blanks

It is recommended in the Australian and New Zealand Guidelines for field guide to sampling groundwater from Geoscience Australia (Sundaram et al, 2009) that trip blanks be incorporated into geochemical investigation programs to quantify any potential contamination of samples introduced during sampling, storage or transport of samples. Trip blanks involve the creation of a blank sample (e.g. deionised water) that is subjected to the same storage and transport conditions as samples collected and stored in the same way (e.g.: within the same type of sample bottle and carried within the same esky and/or refrigerator during transport/storage. The blank is then shipped to the laboratory on ice and analysed with the samples to quantify any contamination resulting from the procedures employed.

It is not apparent that blanks have been utilised in collection of samples for the current study, which means that error introduced during storage and transport has not been assessed.

Sampling and spiked duplicates

Sampling duplicates consist of collecting two distinct samples (i.e. in separate bottles, labelled accordingly) from the same sampling event and they are used to assess error introduced due to degradation during sampling, transport and storage. The preparation of spiked duplicates is useful for determining sample degradation/alteration that may occur during transport and storage of samples prior to analysis and involve the addition of a known quantity of an analyte (or analytes) of interest to a duplicate of a sample, which is then stored, transported, analysed and compared with the un-spiked duplicate.

Nutrients

In environmental hydrogeochemical investigations, nutrient concentrations (such as nitrogen and phosphorous) are known to alter radically through post sampling redox and biological activity. As this potentially introduces large errors often preservation of samples is required, and all guidelines require strict sampling and storage protocols and prescribe short holding times before analysis. To understand the how significant degradation may be in a study area it is recommended that spiked duplicates for phosphate/nitrate are incorporated into the investigation design.

Sampling duplicates or spiked duplicates were not used in the LWWS sampling program. Samples were not preserved and a review of the holding times (the time between sampling and analysis) shows they exceed recommendations with holding times of 6 months being routine and greater than 9 months common.

As a result, nutrient data were not included in this geochemical data review and data need to be interpreted with caution as they may not be accurate or be representative of sample sites.

Analytical suite and charge balance error (CBE)

The analytical geochemical suite selected includes all major ions and a range of nutrients and minor ions relevant to environmental water quality.

Sampling for a full suite of major ions allows for the calculation of the solution charge balance and determining charge balance error (CBE). CBE can be a useful way to determine the level of accuracy in analytical procedures. CBE, expressed as a percentage of total charge, is the calculated imbalance between the milliequivalents (total charge) of the measured cations versus that of the anions, and is calculated by the following formula:

$$CBE = \frac{Cations - Anions}{Cations + Anions} \times 100$$

Because a solution must have equal cationic to anionic charge (charge balanced), a CBE indicates a level of uncertainty in measurement results. A CBE of 5% or less is considered acceptable. Samples with a CBE greater than 5% are considered problematic, as this level of error indicates either major flaws in analytical technique, a failure to account for a major component, or the presence of particulate material (e.g. in an unfiltered sample) that may have been dissolved by the addition of acid during analysis.

Interpretation

Analysis was undertaken by graphing geochemical and hydrological data, examining ionic ratios and geochemical modelling. These are routine methods used to resolve trends in the geochemical evolution of groundwater.

Major ions include the cations; sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}) and the anions chloride (Cl^-), alkalinity, including carbonic acid, bicarbonate and carbonate proper (H_2CO_3, HCO_3^- and CO_3^{2-}) and sulphate (SO_4^{2-}). Bromide (Br^-) is also occasionally considered as a major ion, particularly in solutions that have undergone significant halite (NaCl) precipitation, and hence relative enrichment in Br. Sodium and Chloride usually constitute the bulk of the total dissolved solids (TDS) in natural waters.

Chloride is considered conservative in natural waters as it is not commonly released by the weathering of rocks or sediments, surface complexes on the surface of minerals do not form and it does not readily precipitate to form halite until high concentrations are reached. Chloride is therefore used as the dependent variable in bivariate scatterplot graphs to observe the change in concentration of chloride relative to other ions. Linear increases indicating evapotranspiration is the dominant process and departure from linear trends indicating other hydrological processes are occurring.

A common metric incorporated into these scatterplots is the *seawater line,* which allows data to be compared to the relative abundance of ions within an average composition of seawater that is concentrated or diluted; assuming no precipitation or chemical reactions.

Departure from the seawater line occurs when ions are not conservative. For example, the precipitation of calcite will result in the removal of calcium but not chloride, resulting in calcium having a lower relative concentration and departing from the seawater line linear relationship.

Piper diagrams can also be useful in depicting water end member *type* waters and mixing of water from different sources where water type end members are distinct. In this study Piper diagrams are generated using the United States Geological Survey (USGS) open source software *GW_Chart* (http://water.usgs.gov/nrp/gwsoftware/GW_Chart/GW_Chart.html).

Geochemical modelling

Geochemical modelling provides a useful tool for analysing the redox and ionic states of hydrogeochemical data. The PHREEQC geochemical modelling code (Parkhurst and Apple, 1999) is an open source code developed and maintained by the USGS (http://wwwbrr.cr.usgs.gov/projects/GWC_coupled/phreeqc/).

If hydrogeochemical data is characterised by high salinity (high ionic strength) the interaction of ions may effectively lower the aqueous activity of some components and potentially influence calculated mineral saturation states and aqueous speciation. These effects are accounted for in PHREEQC version 3 (which incorporates a PITZER database). In this study simulations were conducted using PHREEQC version 2 (via PHREEQC for Windows) and PHREEQC version 3, with no significant differences being observed in the results.

Mineral Saturation

Speciation of an ion is an important aspect to consider computing mineral saturation states, activities of ionic complexes in solution, equilibrium of a solution with gases etc. The default PHREEQC database was used in this study to calculate speciation and subsequently calculate saturation state of minerals within a solution.

Saturation Ratios (SR) are commonly used to depict whether a solution is super saturated (able to precipitate) or under saturated (able to dissolve) with respect to a given mineral. A saturation ratio is calculated as the ratio of the ionic activity product (IAP) to the stability constant (K) for a mineral.

$$SR = \frac{IAP}{K}$$

Where, for the reaction:

$$aA + bB \rightarrow cC + dD$$

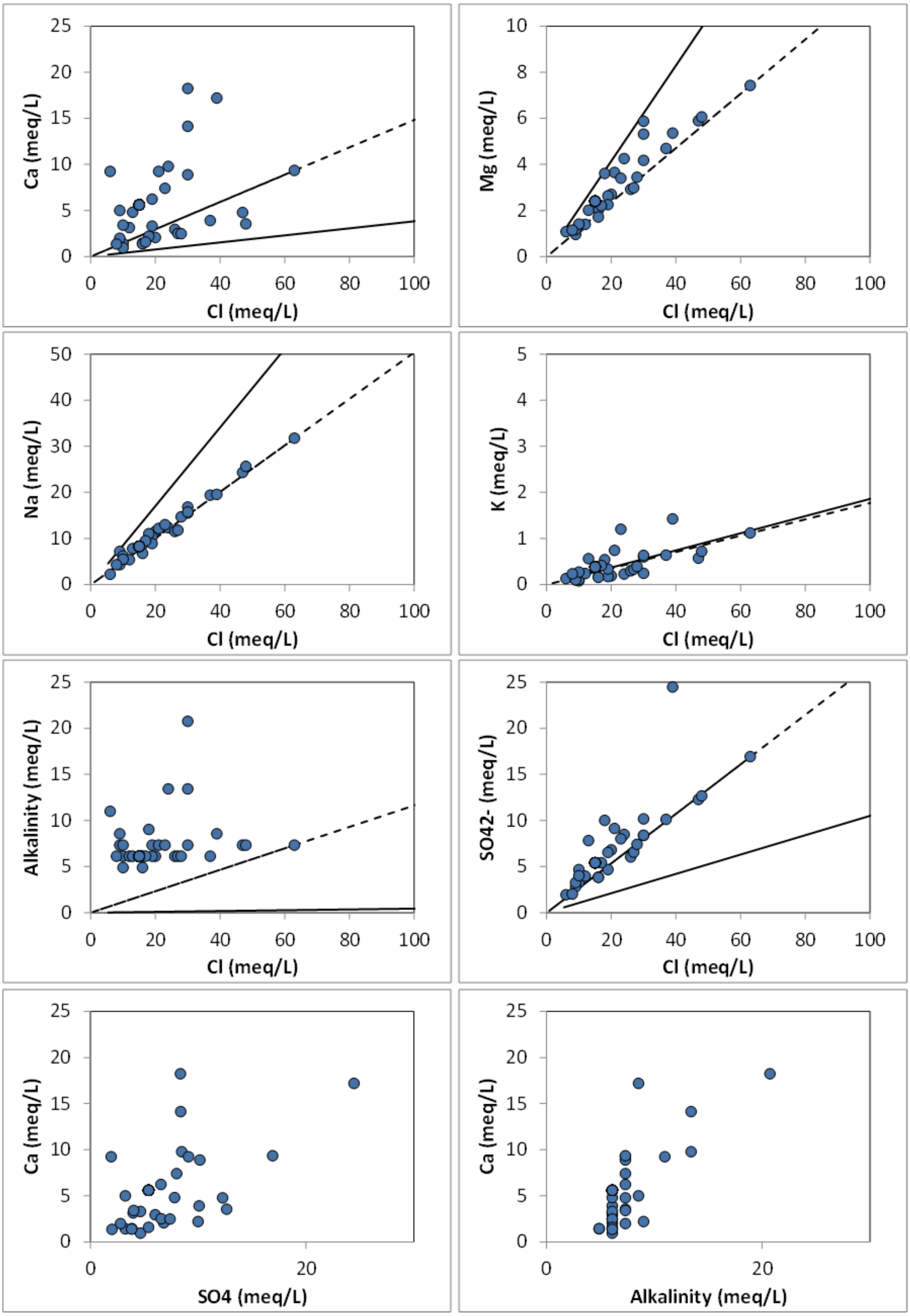
IAP can be calculated by the equation:

$$IAP = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

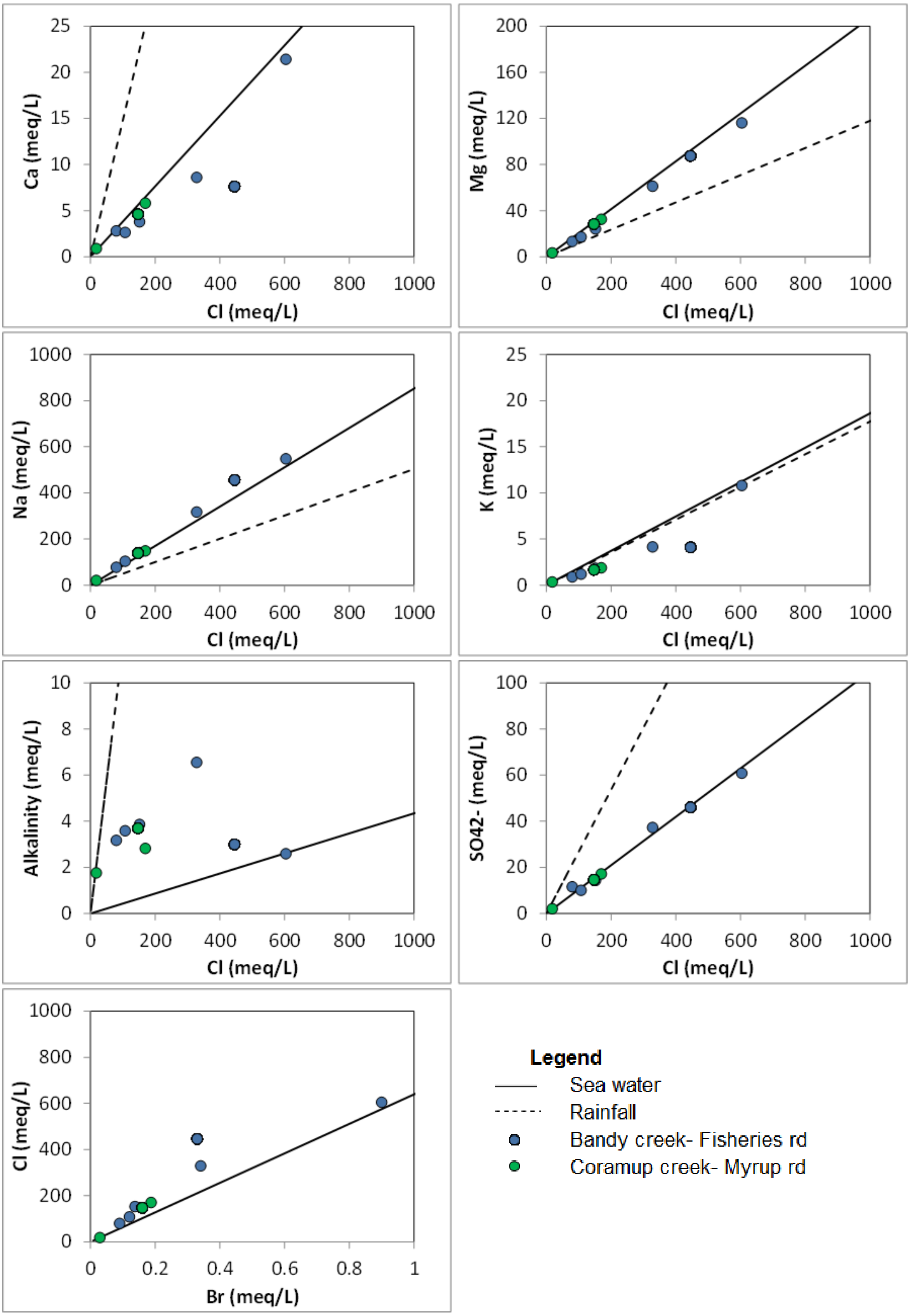
Note that in the formulation for IAP, solid phases and water are excluded.

By definition for mineral phases, IAP = K at equilibrium (SR=1), IAP < K when under saturated (SR<1) and IAP > K when supersaturated (SR>1). Saturation Index is equal to log (SR), and therefore SI is negative when under saturated, positive when supersaturated and equal to zero at equilibrium. By convention, this report will refer to mineral saturation states by their SI.

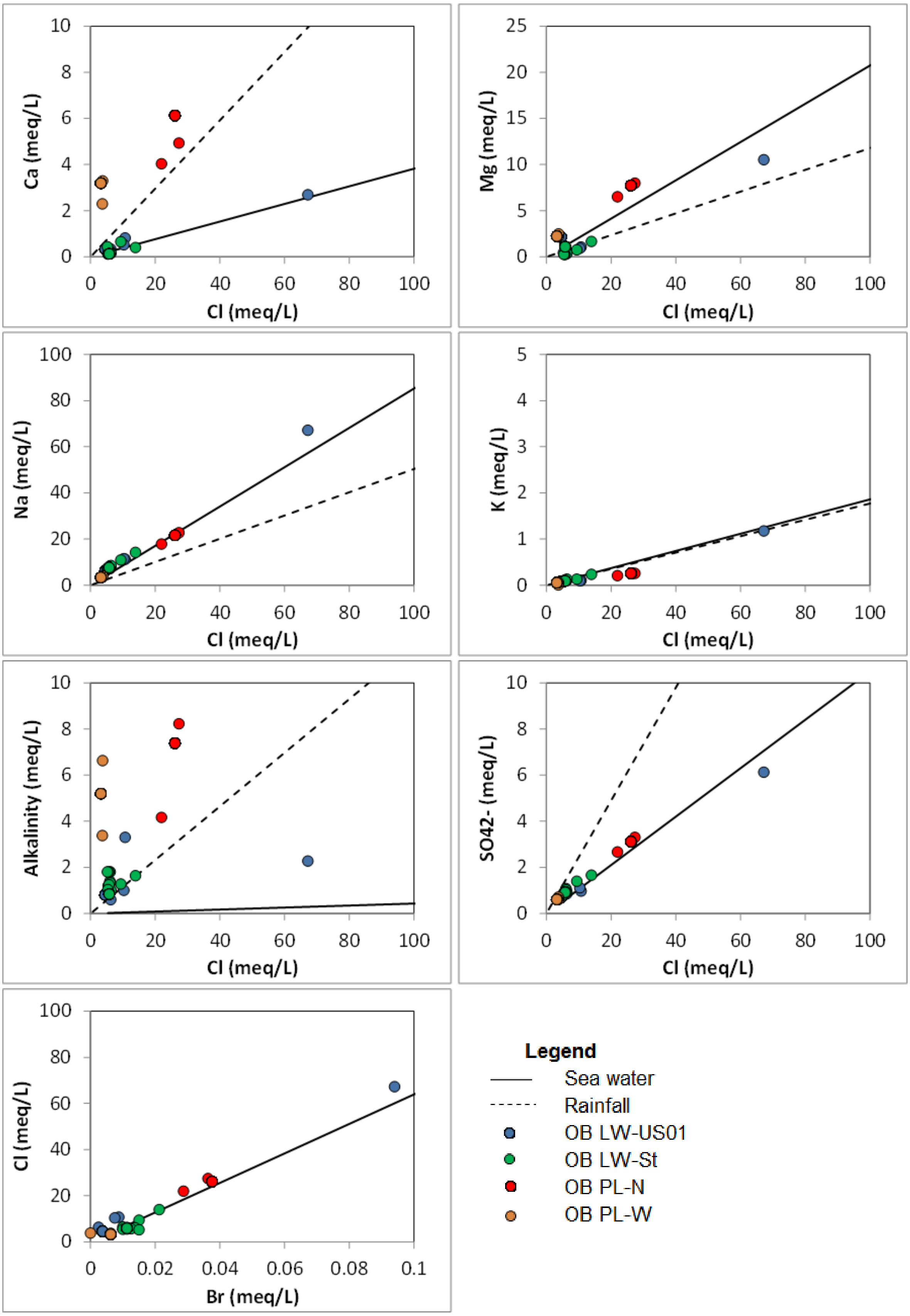
Appendix 3 Rainfall compositions, after Marimuthu et. al. (2005)



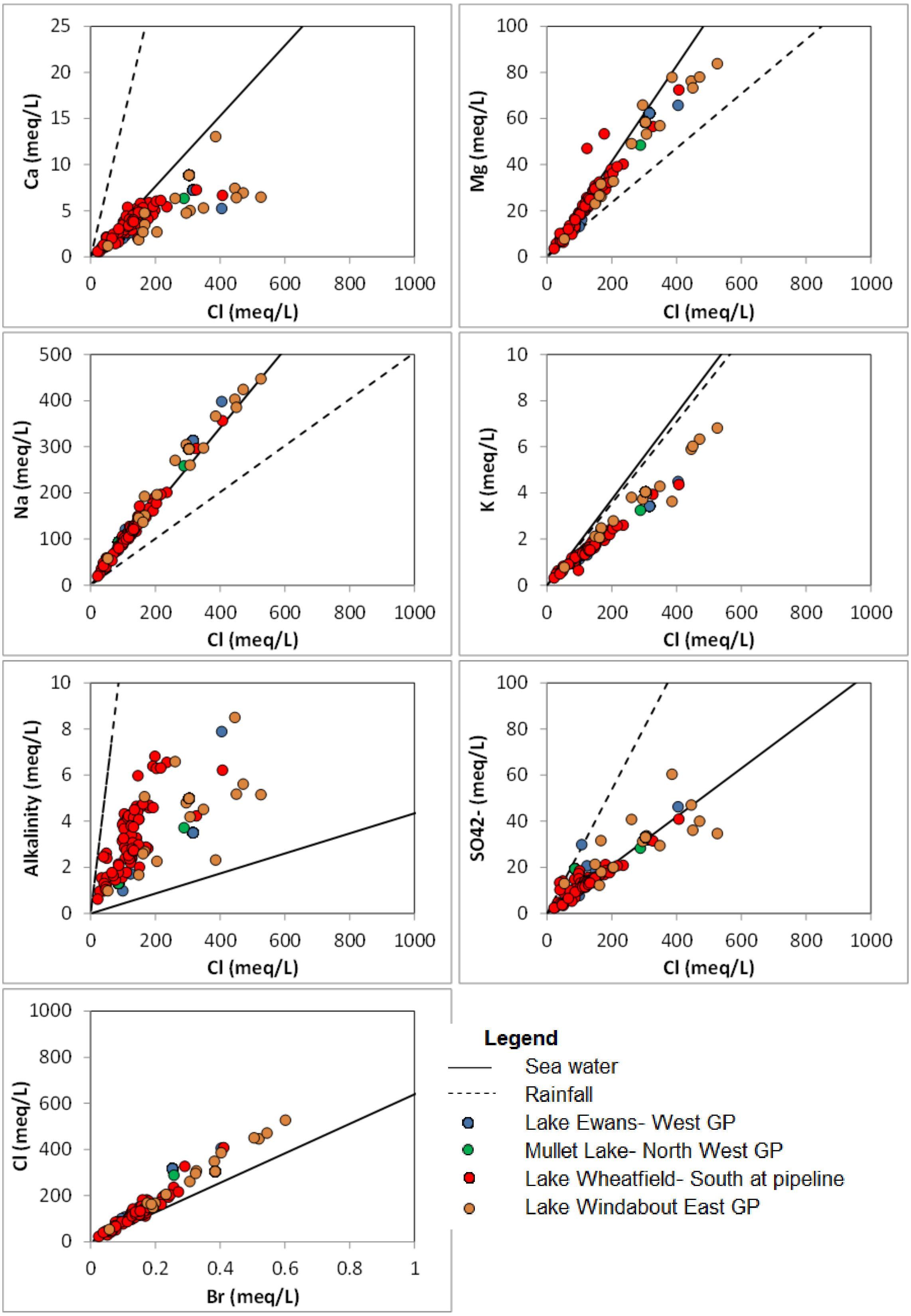
Appendix 4 Catchment surface water (ephemeral) chemistry



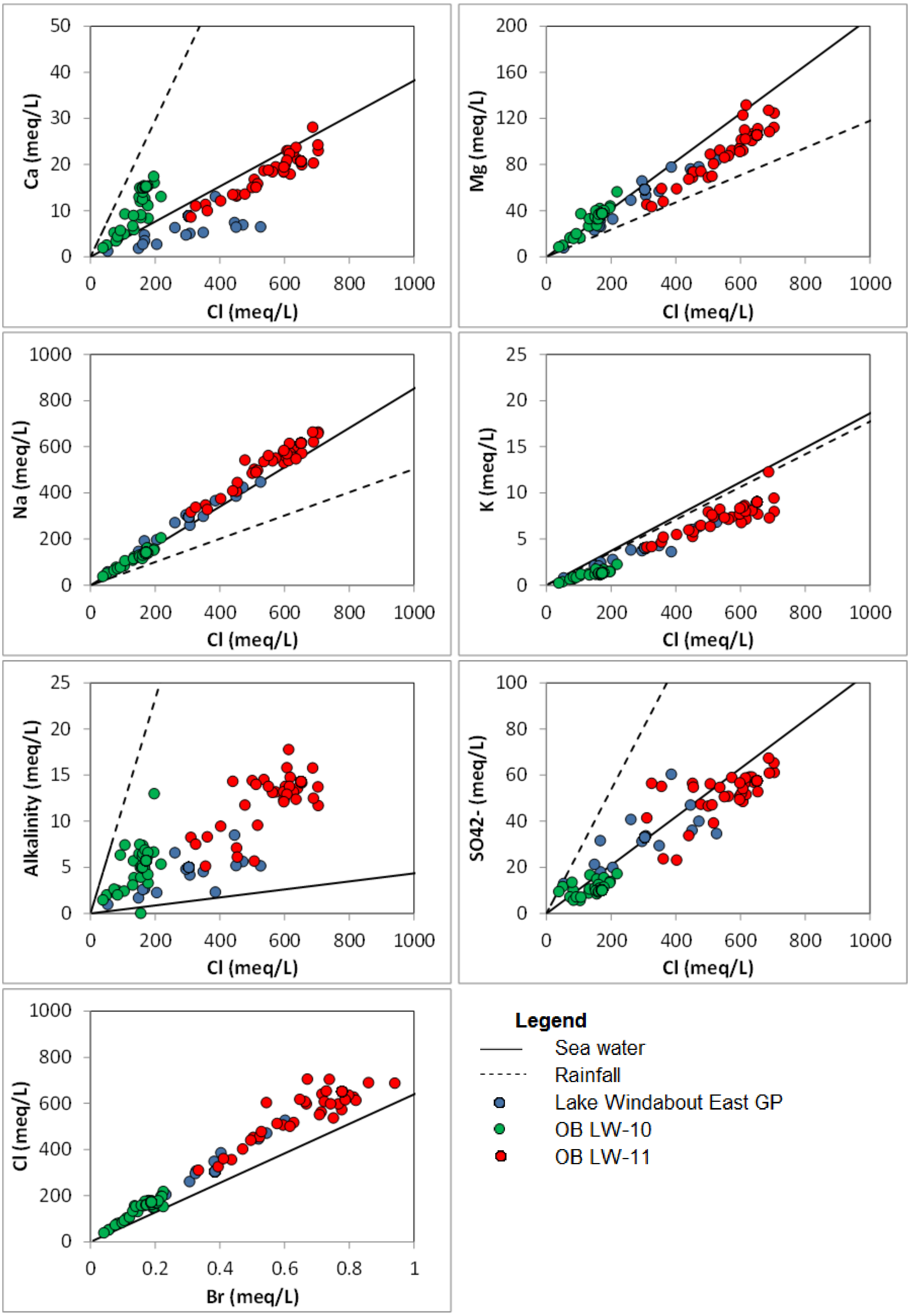
Appendix 5 Groundwater Chemistry: Up-gradient of Lakes



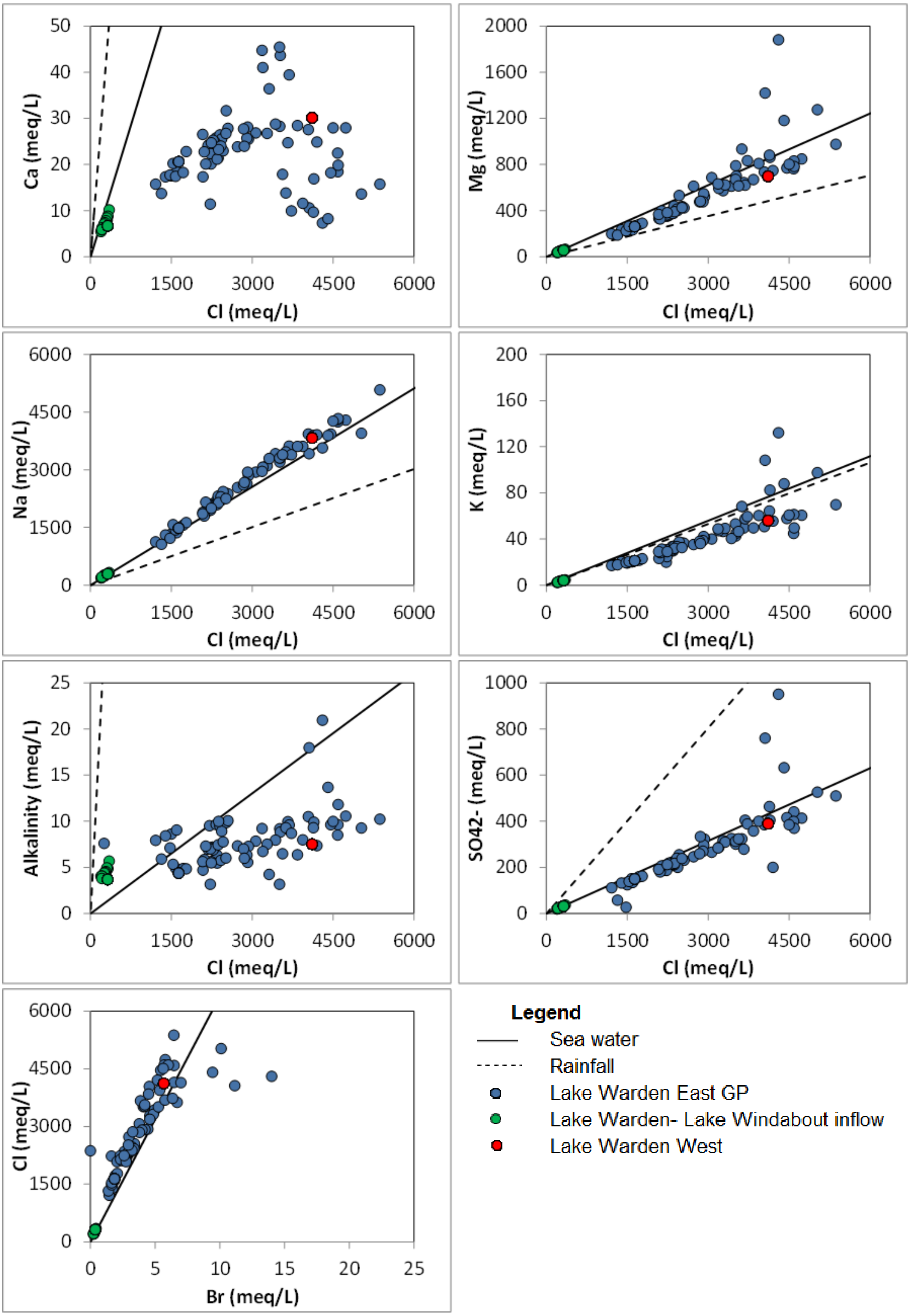
Appendix 6 Chemistry of Eastern Lakes



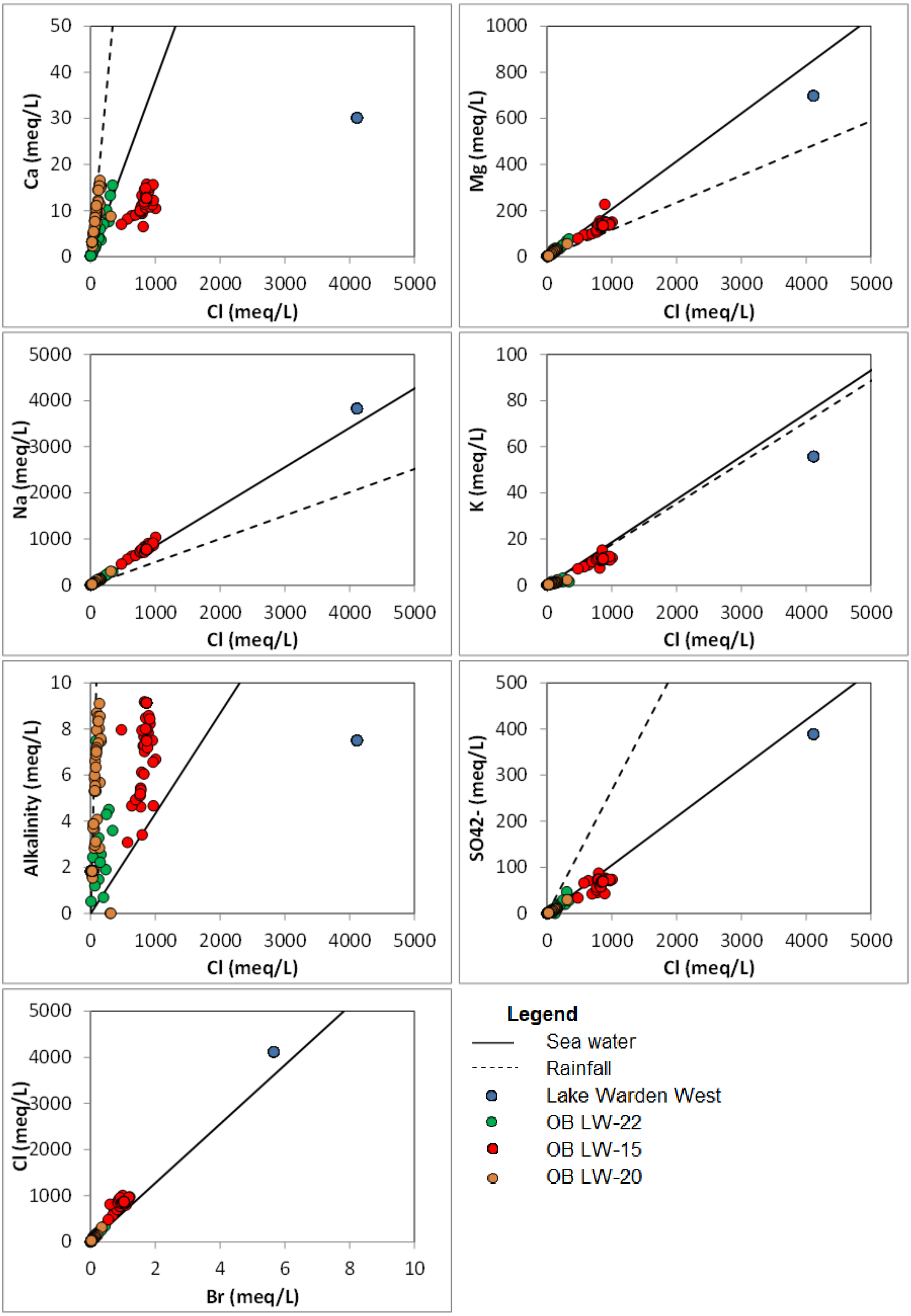
Appendix 7 Chemistry of Lake Windabout and adjacent groundwater



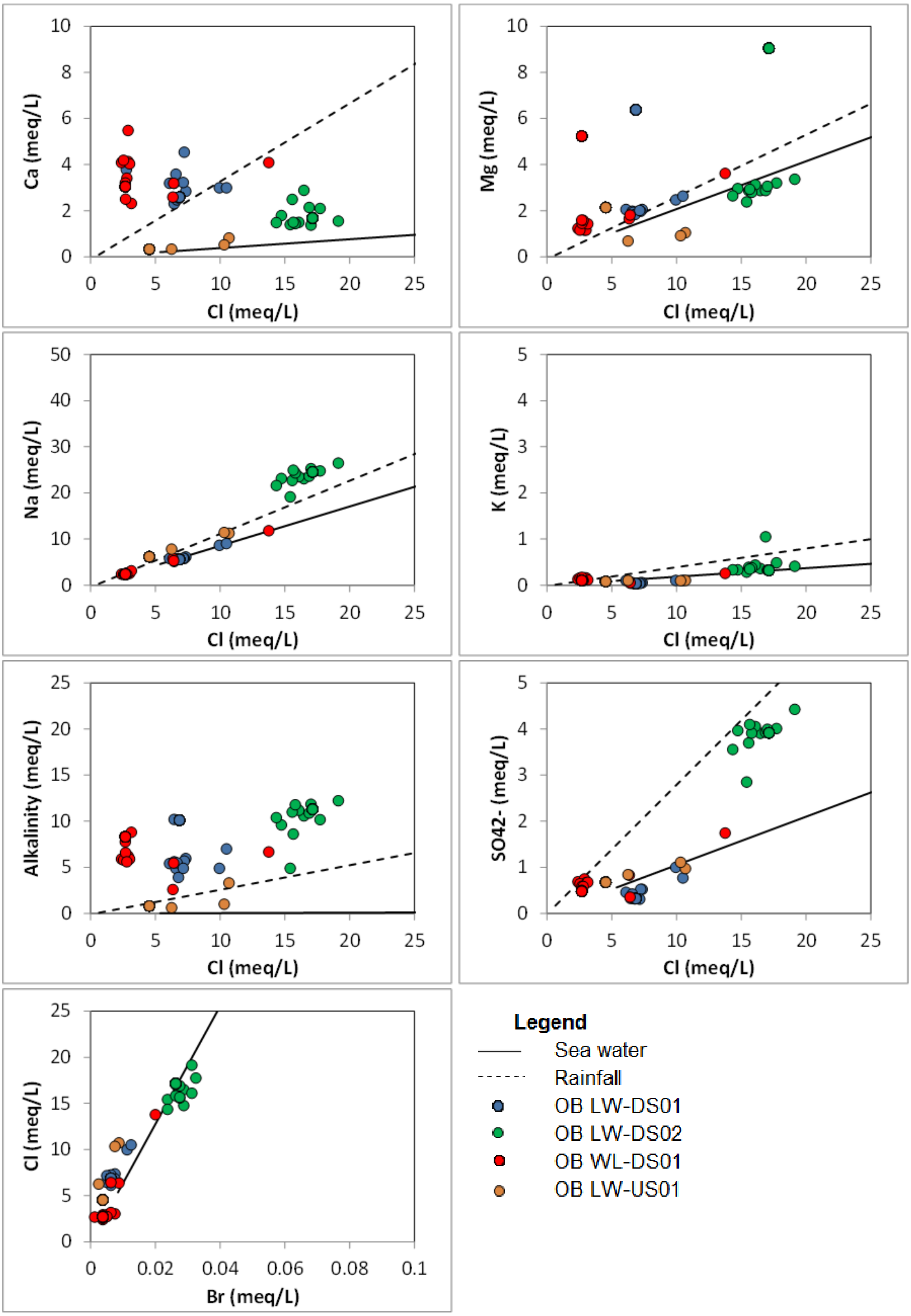
Appendix 8 Chemistry of Lake Warden



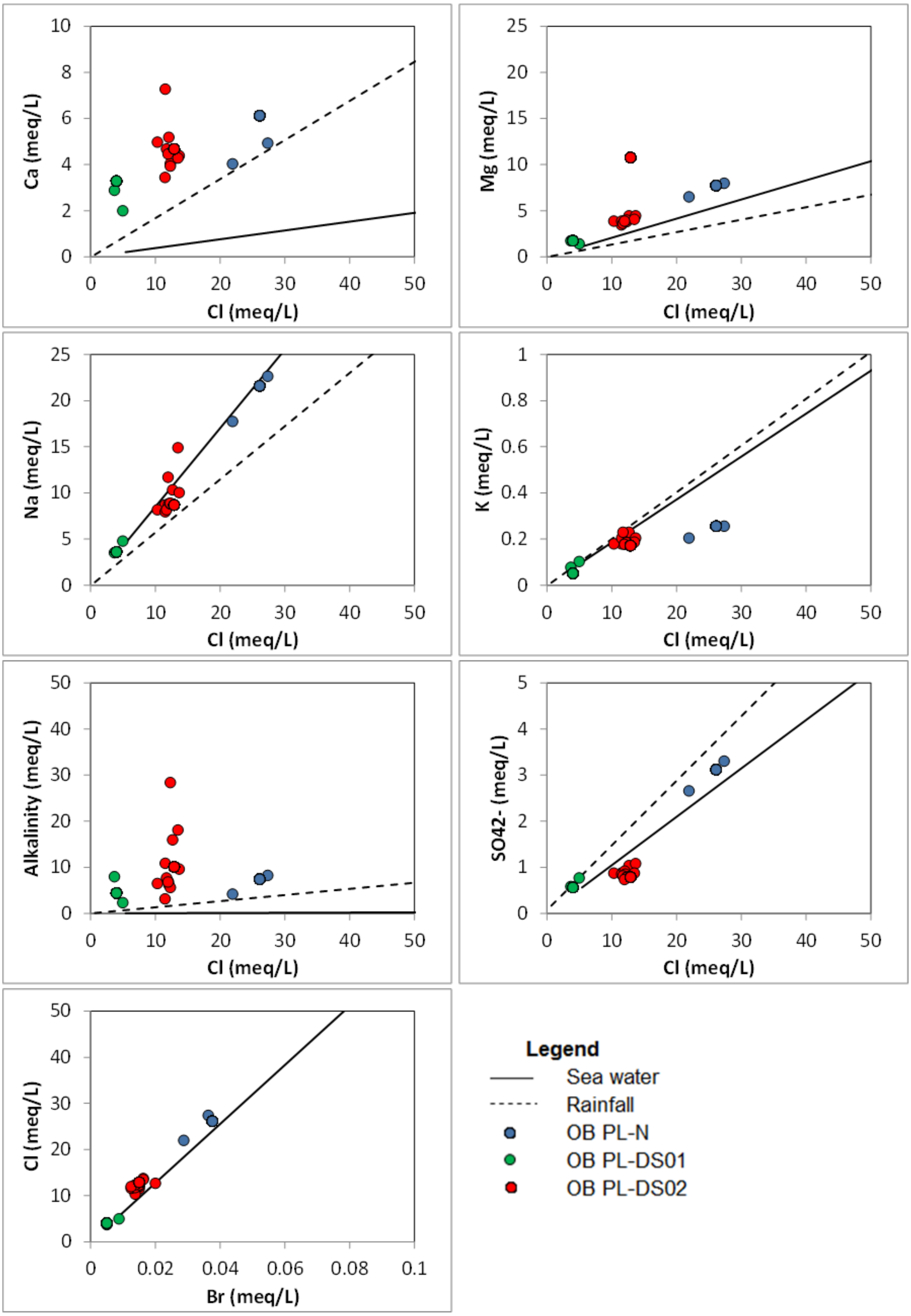
Appendix 9 Chemistry of groundwater between Lake Warden and Pink Lake



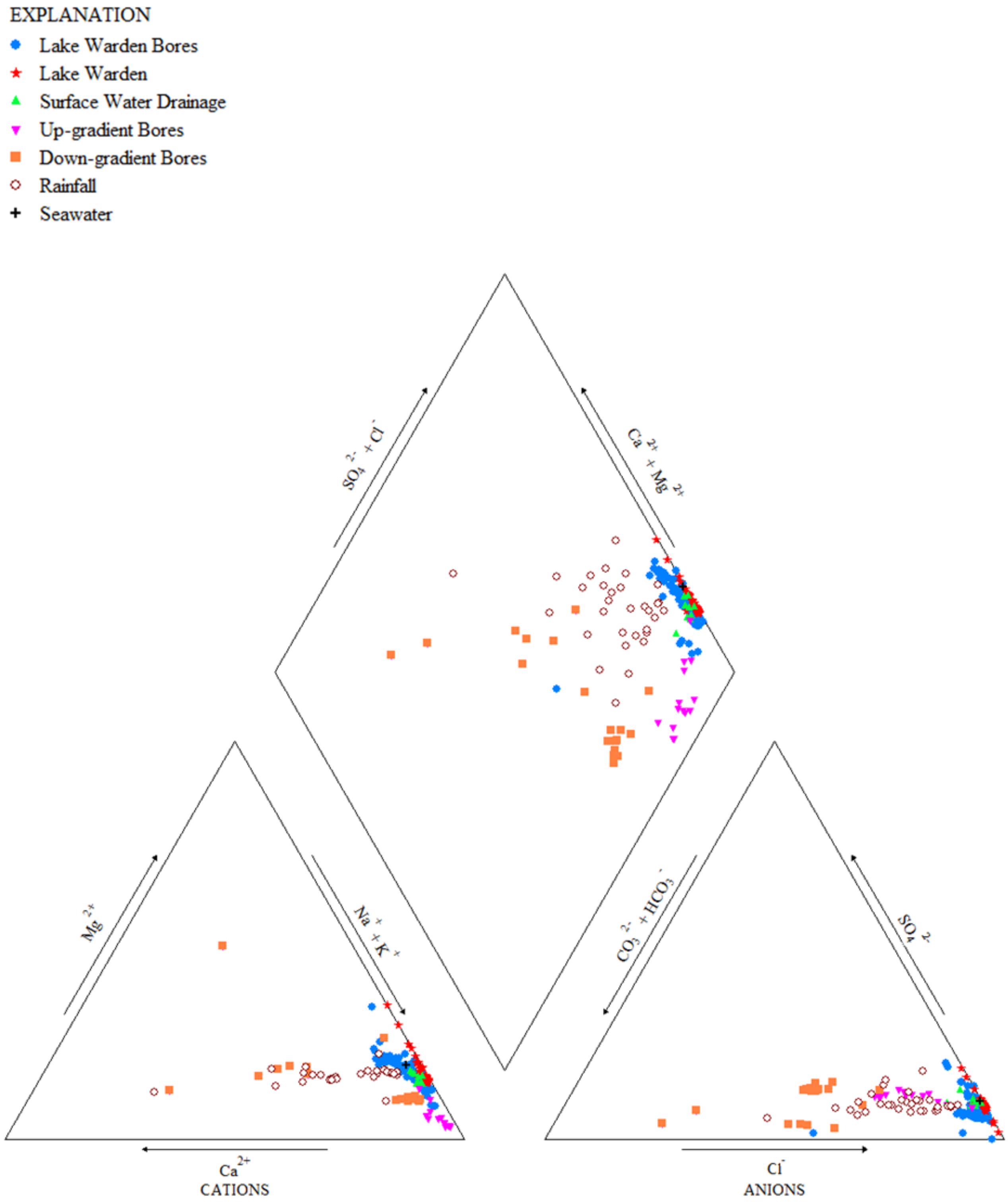
Appendix 10 Chemistry of groundwater down-gradient of Lake Warden - compared with up-gradient bore LWUS01



Appendix 11 Groundwater chemistry down gradient of Pink Lake, compared with up-gradient bore PL-N



Appendix 12 Piper diagram showing the composition of shallow groundwater (up-gradient of, proximal to and down-gradient of Lake Warden), Lake Warden water, surface water drainage into the LWWS (Coramup Creek and Bandy Creek), rainfall and seawater



Appendix 13 Table of modelled saturation indices for a selection of minerals for Lake Warden water samples, calculated in PHREEQC

Date	SI_Calcite	SI_Halite	SI_Gypsum	SI_Aragonite	SI_Dolomite
28/01/2010	1.3E+00	-1.7E+00	-6.3E-01	1.2E+00	4.0E+00
17/03/2010	1.2E+00	-1.5E+00	-5.7E-01	1.1E+00	3.7E+00
30/04/2010	7.9E-01	-3.1E+00	-1.2E+00	6.4E-01	2.5E+00
22/06/2010	1.2E+00	-1.4E+00	-4.9E-01	1.0E+00	3.6E+00
23/11/2010	1.3E+00	-1.6E+00	-5.4E-01	1.2E+00	3.9E+00
3/01/2011	9.7E-01	-1.7E+00	-9.8E-01	8.2E-01	3.3E+00
18/01/2011	1.1E+00	-1.6E+00	-1.2E+00	9.7E-01	3.6E+00
1/03/2011	1.3E+00	-1.1E+00	-2.4E-01	1.1E+00	3.9E+00
30/03/2011	1.2E+00	-1.0E+00	-2.0E-01	1.0E+00	3.8E+00
13/04/2011	1.1E+00	-1.0E+00	-1.7E-01	9.9E-01	3.7E+00
27/04/2011	1.3E+00	-9.3E-01	-4.7E-02	1.2E+00	4.0E+00
10/05/2011	1.2E+00	-9.1E-01	-1.0E-01	1.1E+00	3.9E+00
24/05/2011	1.2E+00	-9.8E-01	-2.0E-01	1.1E+00	3.9E+00
22/06/2011	1.1E+00	-1.0E+00	-2.1E-01	9.4E-01	3.5E+00
7/07/2011	5.8E-01	-1.1E+00	-5.2E-01	4.3E-01	2.8E+00
19/07/2011	1.1E+00	-1.1E+00	-2.7E-01	9.1E-01	3.5E+00
3/08/2011	1.3E+00	-1.0E+00	-1.4E-01	1.1E+00	3.8E+00
18/08/2011	1.1E+00	-1.2E+00	-3.8E-01	9.2E-01	3.6E+00
30/08/2011	1.3E+00	-1.0E+00	-1.6E-01	1.2E+00	4.0E+00
13/09/2011	1.4E+00	-1.0E+00	-1.6E-01	1.2E+00	4.0E+00
29/09/2011	1.7E+00	-1.1E+00	-2.6E-01	1.6E+00	4.8E+00

Date	SI_Calcite	SI_Halite	SI_Gypsum	SI_Aragonite	SI_Dolomite
11/10/2011	1.6E+00	-1.1E+00	-3.1E-01	1.5E+00	4.7E+00
26/10/2011	1.4E+00	-1.2E+00	-3.1E-01	1.3E+00	4.3E+00
8/11/2011	1.2E+00	-1.1E+00	-3.0E-01	1.0E+00	3.8E+00
22/11/2011	1.3E+00	-1.0E+00	-3.1E-01	1.1E+00	4.2E+00
8/12/2011	9.9E-01	-9.6E-01	-1.7E-01	8.5E-01	3.6E+00
20/12/2011	1.0E+00	-8.6E-01	-2.0E-01	9.1E-01	3.8E+00
3/01/2012	1.1E+00	-7.1E-01	-1.2E-01	1.0E+00	4.0E+00
18/01/2012	1.2E+00	-5.0E-01	-2.1E-02	1.0E+00	4.1E+00
1/02/2012	1.3E+00	-4.8E-01	2.2E-01	1.1E+00	4.1E+00
14/02/2012	1.1E+00	-4.2E-01	-4.9E-02	9.4E-01	3.9E+00
29/02/2012	1.2E+00	-2.2E-01	1.8E-01	1.1E+00	4.2E+00
13/03/2012	1.3E+00	5.7E-02	2.7E-01	1.1E+00	4.4E+00
27/03/2012	1.2E+00	6.0E-04	9.5E-02	1.0E+00	4.4E+00
10/04/2012	1.1E+00	-6.4E-02	5.9E-02	9.4E-01	4.2E+00
24/04/2012	1.3E+00	4.3E-03	1.8E-01	1.1E+00	4.4E+00
8/05/2012	1.2E+00	-4.7E-01	1.3E-01	1.0E+00	3.9E+00
23/05/2012	1.3E+00	2.5E-02	1.2E-01	1.2E+00	4.6E+00
6/06/2012	1.3E+00	-9.9E-03	2.9E-01	1.2E+00	4.4E+00
19/06/2012	1.1E+00	-5.5E-01	7.9E-02	9.3E-01	3.7E+00
4/07/2012	9.6E-01	-6.8E-01	7.2E-02	8.1E-01	3.3E+00
18/07/2012	1.1E+00	-7.1E-01	4.8E-02	9.5E-01	3.7E+00
31/07/2012	1.0E+00	-7.3E-01	-2.5E-02	8.6E-01	3.5E+00
15/08/2012	7.9E-01	-1.0E+00	-2.2E-01	6.4E-01	2.9E+00
29/08/2012	7.5E-01	-9.6E-01	-1.3E-01	6.0E-01	2.9E+00

Date	SI_Calcite	SI_Halite	SI_Gypsum	SI_Aragonite	SI_Dolomite
13/09/2012	9.3E-01	-1.0E+00	-2.0E-01	7.8E-01	3.3E+00
26/09/2012	8.9E-01	-7.6E-01	-1.7E-02	7.4E-01	3.2E+00
9/10/2012	7.7E-01	-1.2E+00	-2.1E-01	6.2E-01	2.9E+00
24/10/2012	1.2E+00	-6.1E-01	1.7E-01	1.0E+00	3.8E+00
6/11/2012	9.2E-01	-5.3E-01	2.1E-01	7.7E-01	3.3E+00
20/11/2012	8.6E-01	-4.7E-01	2.7E-01	7.1E-01	3.2E+00
5/12/2012	1.2E+00	-6.3E-01	1.9E-01	1.1E+00	3.9E+00
18/12/2012	1.4E+00	-3.8E-01	3.3E-01	1.2E+00	4.3E+00
3/01/2013	9.4E-01	-2.1E-01	-7.4E-02	8.0E-01	4.0E+00
16/01/2013	7.0E-01	-4.9E-01	-3.9E-01	5.6E-01	3.7E+00
30/01/2013	9.0E-01	1.5E-01	-3.6E-02	7.6E-01	4.2E+00
14/02/2013	7.4E-01	-2.1E-01	-9.5E-02	5.9E-01	4.0E+00
27/02/2013	6.9E-01	-8.3E-02	-1.6E-01	5.4E-01	4.1E+00
14/03/2013	8.3E-01	-5.2E-02	-1.7E-01	6.8E-01	4.2E+00
27/03/2013	8.0E-01	-3.7E-01	-3.1E-01	6.5E-01	3.8E+00
12/04/2013	6.9E-01	-1.8E-01	-2.0E-01	5.5E-01	3.7E+00
23/04/2013	9.4E-01	-2.7E-01	-1.9E-01	8.0E-01	4.0E+00
22/05/2013	1.5E+00	3.9E-01	2.6E-01	1.3E+00	5.1E+00
6/06/2013	1.1E+00	-4.2E-01	-5.6E-02	9.6E-01	4.0E+00
18/06/2013	1.3E+00	-1.8E-01	-6.9E-02	1.2E+00	4.4E+00
2/07/2013	1.3E+00	-2.8E-01	2.3E-01	1.2E+00	4.2E+00
16/07/2013	1.2E+00	-7.3E-01	3.4E-02	1.1E+00	3.9E+00
29/07/2013	1.1E+00	-9.2E-01	-7.9E-02	9.4E-01	3.5E+00
13/08/2013	9.4E-01	-1.1E+00	-1.7E-01	7.9E-01	3.2E+00

Date	SI_Calcite	SI_Halite	SI_Gypsum	SI_Aragonite	SI_Dolomite
27/08/2013	9.2E-01	-1.5E+00	-4.7E-01	7.7E-01	3.2E+00
10/09/2013	9.5E-01	-1.4E+00	-4.3E-01	8.0E-01	3.2E+00
24/09/2013	1.2E+00	-1.5E+00	-4.4E-01	1.0E+00	3.6E+00
8/10/2013	1.4E+00	-1.3E+00	-3.5E-01	1.3E+00	4.2E+00
22/10/2013	1.4E+00	-1.4E+00	-4.0E-01	1.2E+00	4.0E+00