Appendix 6

Investigation of Prospective Case Studies

Burdekin River Irrigation Area (Qld)

Key Issues:

Inadequate surface water storage, ecological sensitivity, saline intrusion

Key Management Initiatives

Groundwater recharge

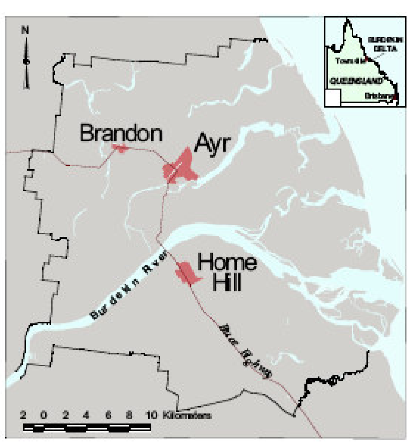
Piped delivery system from river

Improved on-farm water use efficiency

Artificial recharge schemes

The Burdekin River Irrigation Area (BRIA) is located in the dry tropics of North Queensland within the Burdekin River delta and associated flood plains. The region is located approximately 100km south of Townsville and encompasses about 40,000ha of irrigated land, mostly sugarcane (Figure 1).

The area has been irrigated for more than 100 years. Initially, irrigation was from naturally replenished groundwater supplies sourced from the river floodplain sediments of gravels and sands. After the Second World War, surface water irrigation from weirs began to be developed. Over the last 20 years, the need for additional water has outstripped supply and additional management measures have been adopted to sustain irrigation in the area. Following severe droughts in 1935 and 1964, serious concerns over groundwater level decline and seawater intrusion led to the establishment of the North and South Burdekin Water Boards in 1965-66 and the establishment of enhanced recharge schemes in the Burdekin Delta.



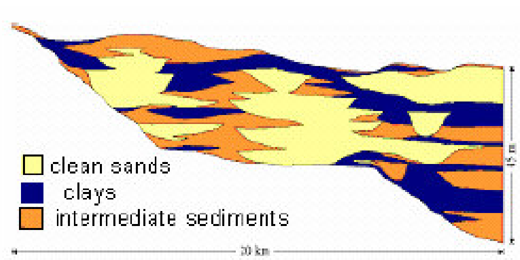
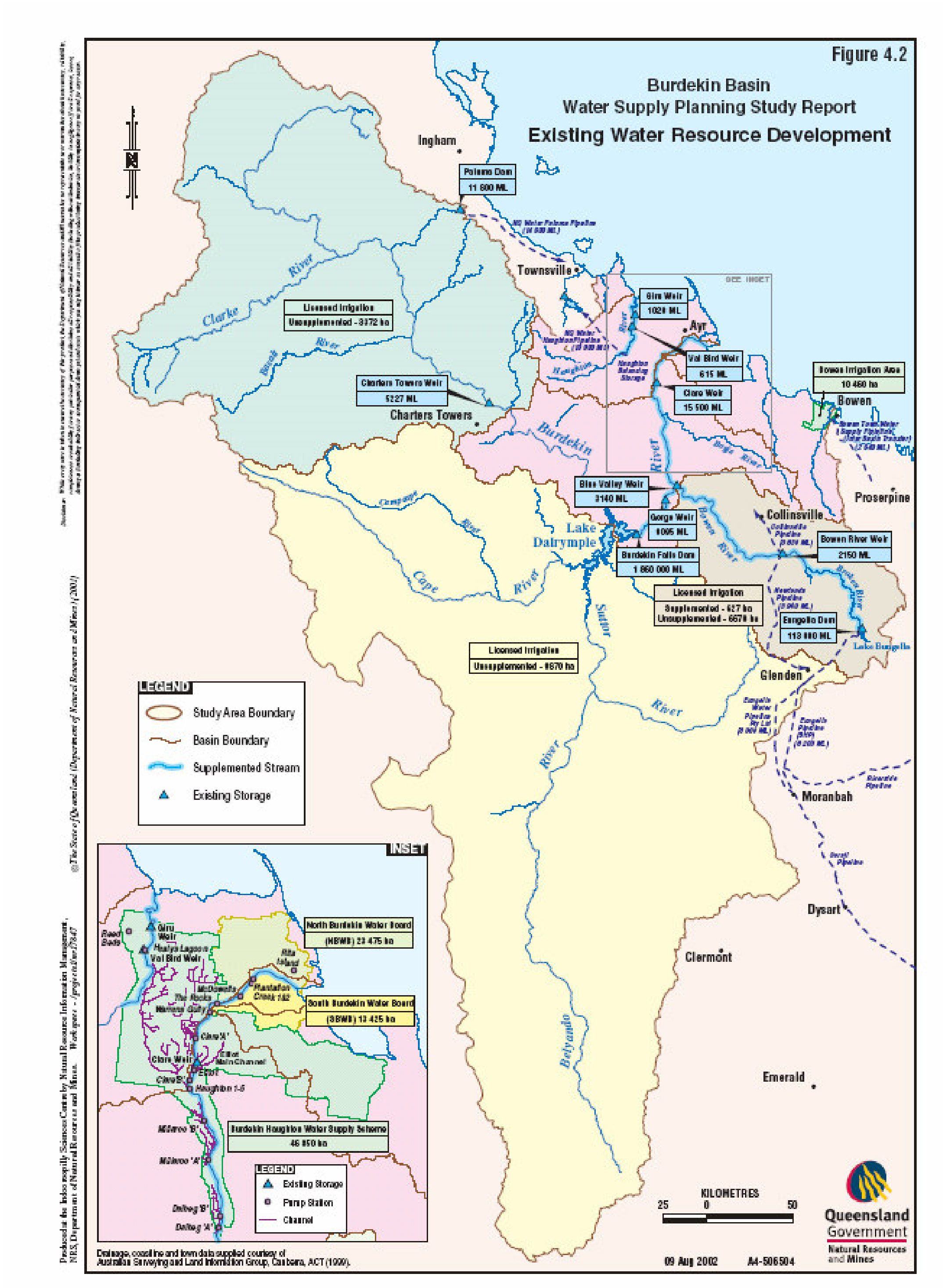


Figure 1: Map of Burdekin Delta.



Management Issues

This BRIA overlies major groundwater supplies and it is close to environmentally sensitive wetlands, waterways, estuaries and the Great Barrier Reef. A key issue is the whether the ongoing use of groundwater is sustainable in the long term. Of particular concern is interaction between current water management practices and farm activities and groundwater quality / quantity and other offsite impacts. The potential for groundwater quality degradation with nutrients, salt and chemicals is recognised (Figure 2). From a long-term sustainability point of view, these are likely to be the most critical issues affecting the natural system.

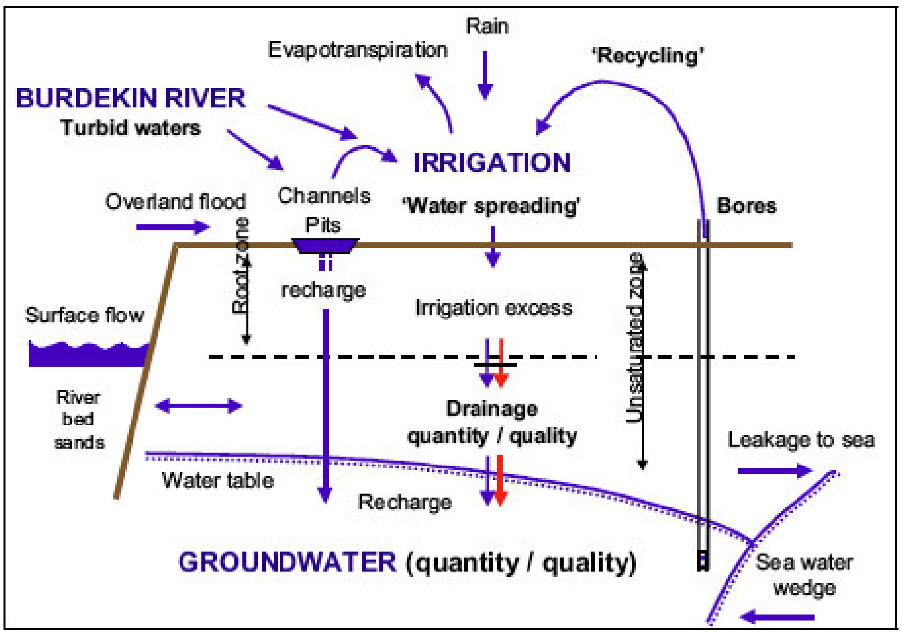


Figure 2: Schematic showing key factors of importance in the Burdekin delta irrigation area

Description

The topography of the Burdekin River Delta is flat to slightly undulating with the general gradient sloping slightly towards the coast. The delta plain is characterized by floodplains, levee banks, coastal sand dunes and mud flats with outcrops of bedrock around the fringes of the delta in the south and southwest. Surface water within the delta comprises the main Burdekin River, a number of natural distributaries, and a network of artificial diversion/distribution channels and recharge facilities. Near the coastal areas, natural lagoons and tidal marshes exist but are mostly beyond the extent of the irrigated area.

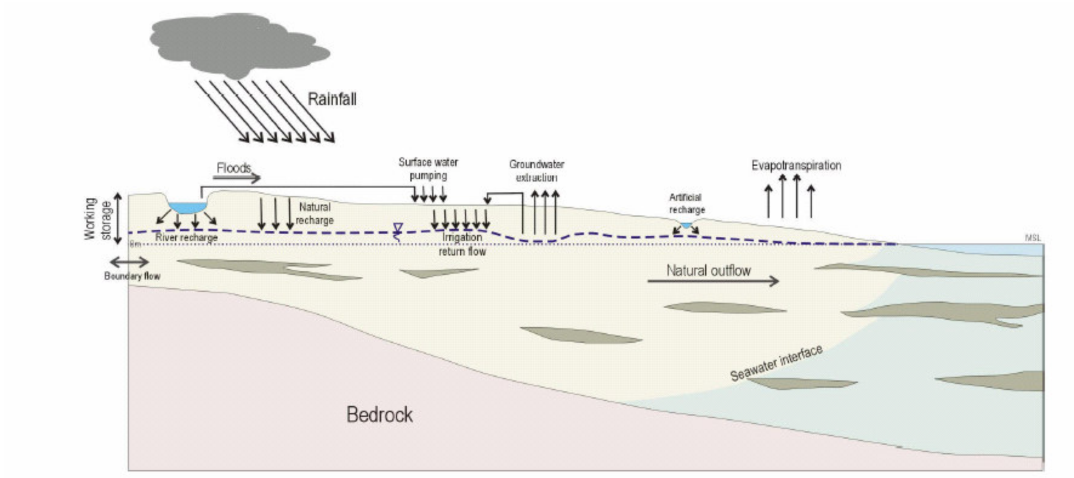
The sediments overlie a basement of granite. The aquifers comprise a complex distribution of clean sands, gravels, silt, clay and organic muds deposited from the Burdekin River. The sediments can be up to 100m thick near the coast. The sediments occur as discontinuous lenses however due to the absence of significant clays are all considered to be part of one heterogeneous aquifer. The aquifer is recharged by leakage from the Burdekin River's bed and banks.

It is estimated that there are approximately 2000 groundwater pumps in the delta area of which at least 1400 are currently in use. Existing water resource development is shown below.

Management Actions

The Water Boards operate a network of artificial recharge facilities comprising pits and channels fed by water from the Burdekin River. This scheme commenced in 1965 and has been expanded to include a series of river pumping stations feeding a network of artificial recharge pits, distribution channels, and natural distributaries. Sand dams have been continuously maintained on the river bed to ensure that water levels remain high enough to maintain pumping throughout dry periods.

Water management practices have evolved over the last few decades in response to local needs. These practices include the use of riverbed sand dams, extraction of river water to distribution channels, natural waterways and large recharge pits to assist with artificial replenishment of the groundwater systems. At this stage the average artificial recharge rate in the Burdekin delta has been estimated as 96,000 ML/yr. Farm water practices such as ‘recycling’, 'water spreading', and direct pumping from recharge channels have also evolved to play an integral role in the management of the groundwater systems.



Rainfall
Floods
Surface water pumping
Groundwater extraction
Evapotranspiration
Working storage
Natural recharge
River recharge
Irrigation return flow
Artificial recharge
MSL
Boundary flow
Natural outflow
Seawater interface
Bedrock

Ord River Irrigation Area Case Study

The ORIA straddles the border between the WA and NT portions of the Kimberley Region, and is situated on black soil plains associated with the Ord and Keep Rivers. The Ord River Dam impounds Lake Argyle, which supplies the water for the irrigation area. The town of Kununurra is the commercial and administrative centre for the area.

Hydrogeological Typology: Unconsolidated Sediments

Hydrogeological Setting: The Ord River Irrigation Area is characterised by complex topography and geology, resulting in highly variable and localised groundwater conditions.

Groundwater
occurs in the alluvial sediments, bedrock, and weathering profiles beneath the plains. The most important hydrogeological formation is the highly transmissive gravels which directly underlie the irrigation areas. Salinity is also highly variable, ranging from fresh through to saline.

Irrigation Development
In 1963, the completion of the Diversion Dam impounded the Ord River to create Lake Kununurra from which channelled water has supplied irrigated agriculture on the Ivanhoe Plain. In 1972, the formation of Lake Argyle made possible the release for irrigation of up to 13 000 ha of land on the Ivanhoe Plain and 2500 ha on the Packsaddle Plain.

Since 1994 various studies have been undertaken to determine the feasibility of expanding the irrigation area to accommodate an increased demand. There are six main areas promoted for the

Stage 2 development – West Bank of the Ord, Carlton Plain, Mantinea Flats, the Weaber Plain, Keep River Plain and the Knox Creek Plain. The proposed Stage 2 development would cover approximately 46 500 ha, bringing the total amount of irrigable land in the Ord River Irrigation Area to around 62 000 ha.

Management Issues

One of the main concerns, with respect the extension of the irrigation scheme is rising groundwater levels, which has already occurred on the Ivanhoe and Packsaddle Plains. Rising groundwater levels could lead to increased groundwater discharge to the rivers as well as land degradation and could alter groundwater ecosystems within the subsurface environment. Investigations, that are the basis of this Report, enable an assessment to be made of the environmental consequences of changes in the groundwater system.

Management Actions

Since the 1960s, Government agencies from WA and the NT have conducted a series of groundwater drilling investigations, installed piezometers, and constructed test production bores for pumping tests in the ORIA (Table 1). The agencies recognised that an understanding of the geology, groundwater level fluctuations, chemistry, and aquifer hydraulics is required to define the hydrogeology in sufficient detail to plan management for sustainable agriculture. Knowledge of the sub-surface conditions has permitted the modelling of the groundwater regime response to irrigation and has provided the basis to objectively plan and manage irrigation, and assess groundwater management options.

Early investigations included the construction of piezometers to monitor groundwater levels and salinity on the Ivanhoe Plain and Carlton Plain in 1964.65. There was some re-drilling on the Ivanhoe Plain in 1968 and Carlton Plain in 1978. The Weaber Plain saw an extensive piezometer construction program in 1968 with some redrilling in 1970. In 1983, the GSWA supervised a large piezometer installation program on the Ivanhoe Plain and Weaber Plain including Cave Spring Gap (Laws, 1983a,b; McGowan, 1983). The Keep River Plain had a modest spread of piezometers installed in 1966 and 1972. Little documentation is available for early drilling on the Mantinea Flats.

From 1994 to 1996, the government agencies of WA and the NT undertook a drilling program across the entire ORIA. It included expanding the monitoring network, constructing production bores with monitoring bores and undertaking pumping tests. The GSWA and the Power and Water Authority (PAWA) of the Northern Territory started the program in 1994. The Water and Rivers Commission (WRC) of Western Australia and Department of Lands Planning and Environment (DLPE) of the Northern Territory completed the program in 1996. Details of borehole completions for the 1994.96 program are presented in Humphreys *et al.,* 1995; Nixon (1997a,b,c,d,e,f,g,h), and O.Boy Agriculture Western Australia (AgWA) has also undertaken extensive shallow drilling for irrigation infiltration studies. These studies are at irrigation-bay scale, and piezometers are monitored with continuous data loggers. Bores drilled in WA have generally been numbered with a prefix letter, which in latter years has denoted location (e.g. PS . Packsaddle, KC . Knox Creek). The year of drilling and a sequential number identify piezometers installed by AgWA (e.g. 91/1 is the first bore drilled in 1991). Bores in the NT are identified by a Registered Number (RN) which is sequential in order of drilling (Table 1).

References

HUMPHREYS G., TICKELL S., YIN FOO D., and JOLLY P., 1995, Sub-surface hydrology of the Keep River Plains: Northern Territory Power and Water Authority, Water Resources Division (unpublished).

LAWS, A. T., 1983a, Proposed drilling and hydraulic testing program, Ivanhoe Plain, Kununurra, WA: Western Australia Geological Survey, Hydrogeology Report 2491 (unpublished).

LAWS A. T., 1983b, Groundwater conditions in the Ord Irrigation Project Area, Kununurra, WA, (Weaber Plain): Western Australia Geological Survey, Hydrogeology Report 2519 (unpublished).

McGOWAN, R. J., 1983, Ord River Irrigation Area analysis and interpretation of drilling and hydraulic testing program, Ivanhoe Plain, 1983: Western Australia Geological Survey, Hydrogeology Report 2513 (unpublished).

NIXON, R. D., 1997a, Ord River Irrigation Area drilling project, bore completion report on the Knox Creek Plain: Western Australia Water and Rivers Commission, Hydrogeology Report No. 65 (unpublished).

NIXON, R. D., 1997b, Ord River Irrigation Area drilling project, bore completion report on the Weaber Plain: Western Australia Water and Rivers Commission, Hydrogeology Report No. 66 (unpublished).

NIXON, R. D., 1997c, Ord River Irrigation Area drilling project, bore completion report on the Carlton Plain: Western Australia Water and Rivers Commission, Hydrogeology Report No. 67 (unpublished).

NIXON, R. D., 1997d, Ord River Irrigation Area drilling project, bore completion report on the Mantinea Plain: Western Australia Water and Rivers Commission, Hydrogeology Report No. 68 (unpublished).

NIXON, R. D., 1997e, Ord River Irrigation Area drilling project, bore completion report on the Packsaddle Plain: Western Australia Water and Rivers Commission, Hydrogeology Report No. 69 (unpublished).

NIXON, R. D., 1997f, Ord River Irrigation Area drilling project, bore completion report on the Ivanhoe Plain: Western Australia Water and Rivers Commission, Hydrogeology Report No. 70 (unpublished).

NIXON, R. D., 1997g, Ord River Irrigation Area drilling project, bore completion report on the Cave Spring Gap: Western Australia Water and Rivers Commission, Hydrogeology Report No. 71 (unpublished).

NIXON, R. D., 1997h, Ord River Irrigation Area miscellaneous data report on the Weaber and Knox Creek Plains: Western Australia Water and Rivers Commission, Hydrogeology Report No. 72 (unpublished).

O'BOY, C. A., TICKELL, S. J., YESERTENER, C., COMMANDER, D. P., JOLLY, P., and LAWS, A. T., 2001, Hydrogeology of the Ord River Irrigation Area, Western Australian and Northern Territory, Water and Rivers Commision, Hydrogeological Record Series, Report HG 7.

Shepparton Irrigation Region

The Shepparton Irrigation Region covers more than 500,000 ha in north central Victoria and has a population of about 110,000. Of this 317,000 ha was irrigated in 2000-2001 using 1.5M ML/a. The main primary industries are horticulture, dairying, cropping, viticulture, wool, forestry and grazing. The Shepparton Irrigation Region contributes 25 % of Victoria's export earnings with production in 2000-2001 totalling about $6 billion.

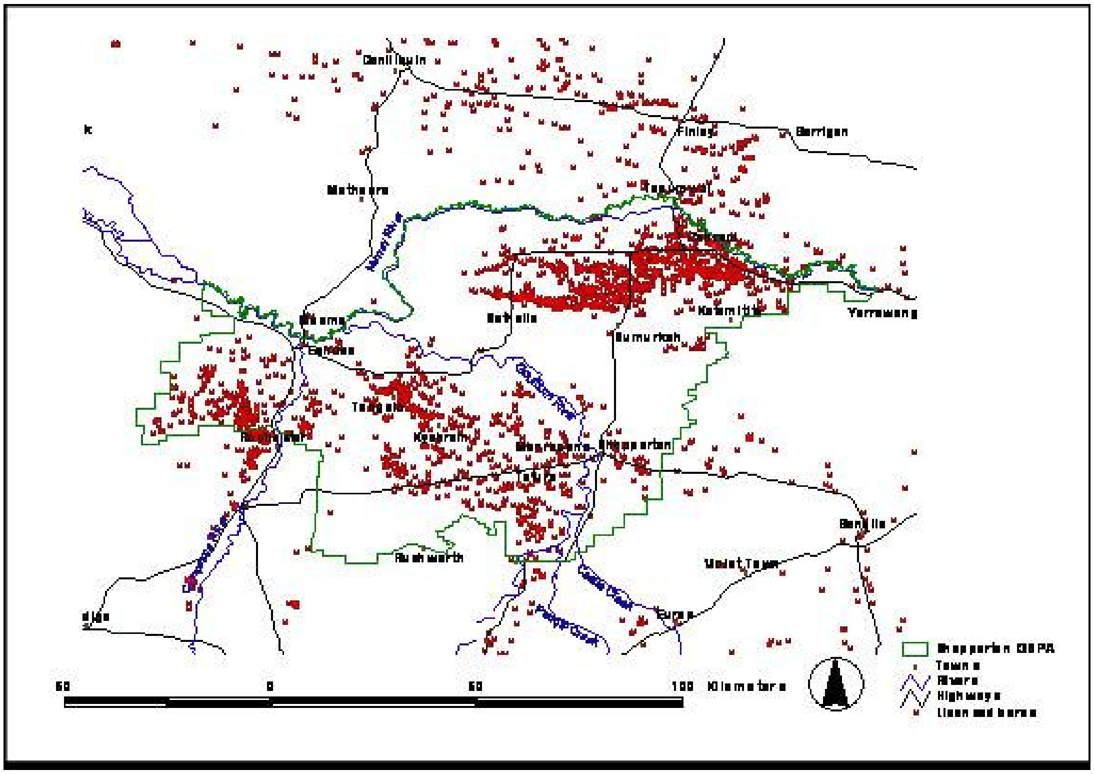
This community is dependent on the sustainable development of its water resources for irrigation. Management of water resources is undertaken by a number of agencies. Irrigation water is extracted from both rivers and water-bearing horizons in the ground (aquifers). Each has different impacts on the natural environment.

The Shepparton Groundwater Supply Protection Area applies to water supply bores in the Shepparton Formation excluding those used solely for stock and domestic purposes.

Hydrogeological Setting

Shepparton lies in a regionally extensive multi-layered sedimentary basin. There are three major aquifer systems in this area but only two are used for irrigation. The uppermost aquifer system is the Shepparton Formation aquifer. This unit has lenses of silt, sand and gravel in clay. Irrigation supplies are extracted from the lenses of sand and gravel. Water enters this aquifer (it is recharged) from the infiltration of rainfall and surface water. If there is a pathway to the surface through interconnected sand lenses then the water in the lens is likely to be fresh, otherwise it will be saline. Better quality supplies are commonly found close to creeks and lakes. To obtain enough water for an irrigation supply a number of shallow bores are connected and pumped together. This is known as a spear point system.

The deeper parts of the Shepparton Formation gradually become sandier until there are lenses of clay in an aquifer that is mainly sand. The unit that lies under the Shepparton Formation is the Calivil Formation. This unit comprises sand and gravel. The unit below this is the Upper Renmark Formation. This unit also comprises sand. These three units together form one aquifer. Because of the high sand and gravel content very large supplies of good quality water are available. The map below shows the location of licensed irrigation bores in this area.

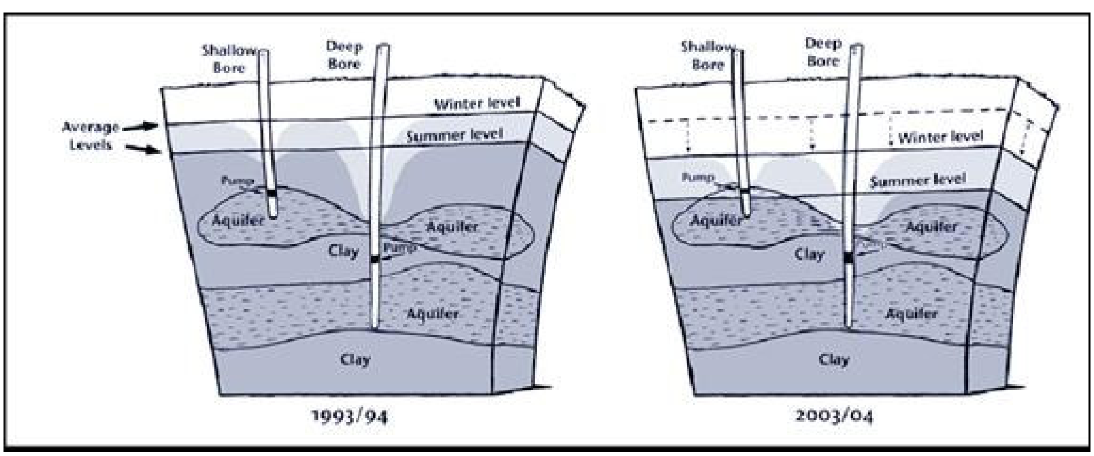


Surface Water Supplies

Surface water supplies are distributed through a network of channels and drains that criss-cross the irrigation region. Irrigators are licensed for a certain volume of water however in dry years when the total amount of water available for irrigation is lower the allocation may be significantly reduced.

Management Issues

1. In many areas, water levels in major aquifers have been declining and over the last ten years non-sustainable extraction has resulted in many bores going dry. This results partly from increasing extraction by irrigators and partly due to a decrease in rainfall and surface water flows which recharge the aquifers.



Source: Goulburn-Murray Water, Newsletter No 5 May 2004

2. Mounding of the watertable beneath irrigation areas irrigated by surface water occurs particularly where the Shepparton Formation is clayey. This has not been as significant an

issue since the start of the drought but it is expected that when the current drought is over that this will become a significant issue once more.

3. Water loss in open channels occurs through evaporation and also due to the water soaking through the base of the channel. Where the channel crosses a sandy lens of the Shepparton Formation these losses can be as high as 59-68%.
4. Salinity in adjacent highland areas has resulted from a change in land use from tree covered slopes to cleared land. This means that less water is being used by vegetation leaving more to soak into the ground increasing aquifer recharge. Consequently water levels have risen bringing the watertable closer to the surface. Where the groundwater is salty this causes dryland salinity. It is estimated that 260,000 tonnes of salt flows to the Murray River each year.
5. Surface water quality and river health is impacted by contaminants including salt, nutrients from irrigation drainage, sewerage treatment plants, sediment mobilisation, urban stormwater and intensive animal industries. Flow patterns in waterways have been altered impacting aquatic biodiversity, water quality and the waterway environment.

Management Initiatives

1. Groundwater management areas have been established to monitor groundwater usage in irrigation areas and to cap usage in areas where the extractions exceed current estimates of recharge. In some cases minimum groundwater levels are specified in Groundwater Management Plans
2. An extensive network of monitoring bores and a regular monitoring program have been in place since the 1980's to monitor the status of groundwater mounds.
3. Water authorities are closing inefficient channels and moves are underway to pipe other channels where losses are high. The introduction of water trading has allowed water managers to effectively move water usage to more appropriate locations.
4. The dryland salinity issue is being addressed by research and development, together with on-ground works undertaken by the Farm, Sub-surface Drainage and Community Surface Water Management programs.
5. A wide range of programs and partnerships have been established to address the various components of the surface water quality and rive health issues.

Loxton Irrigation District (SA)

Location: The town of Loxton is located on the River Murray in South Australias Riverland region. It comprises the irrigation sub-districts of Loxton, Media, Rilli and Sherwood.

Hydrogeological Typology: Sedimentary Basin.

Hydrogeological Setting: Regionally extensive multi-layered sedimentary basin, highly saline groundwater, irrigation with imported surface water (River Murray). Three major aquifer systems have been identified in the Loxton irrigation area; the unconfined Upper Loxton Sands below the irrigated highlands, the confined Murray Group Limestone system and the Alluvial Monoman Formation (or floodplain sands).

The hydrogeology of the Loxton area is documented in detail in AWE (2002).

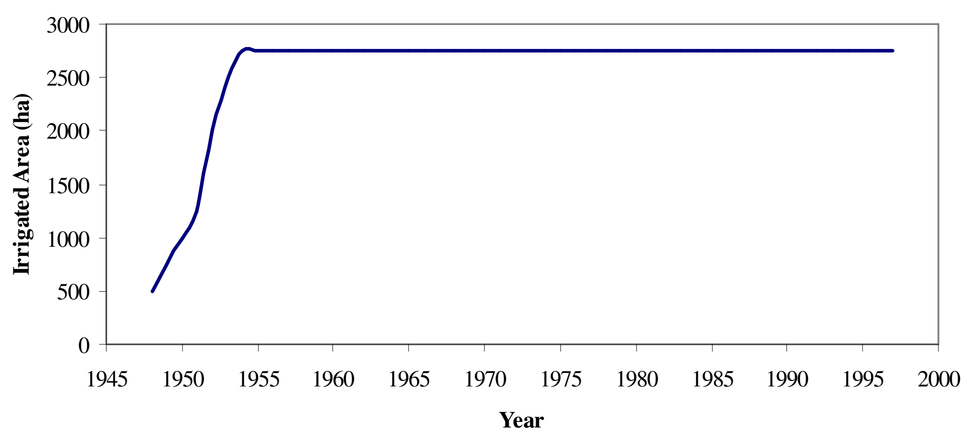
Irrigation Development

The Commonwealth Government established the Loxton Irrigation Area in the 1940's as a War Service Land Settlement Scheme. A brief chronological history of events related to irrigation and drainage developments in the Loxton Irrigation Area are presented in Table 1.

Table 1: Chronology of Irrigation and Drainage Developments at Loxton (PPK, 1997)

Year	Event
1945	Land Surveys for the Loxton Irrigation Area commence
1946	Construction of the irrigation scheme commences
1948	First 50 properties settled – irrigation commences
1952	Perched water tables result in waterlogging and salinisation of root zones Seepage shafts sunk – tile drain systems installed with connection to shafts
1955	Irrigation headworks completed – final settlement of 260 properties Drilling of drainage bores reaching to deeper aquifers commences
1964	Construction of comprehensive drainage scheme delivering to Katarapko Island Disposal Basin supersedes seepage shafts and drainage bores
1983	Media Irrigation Area landholding connected to CDS under agreement with SA Water – additional landholding included in 1989

The estimated growth in irrigated area for Loxton is shown in Figure 1 below.



Currently more than 32 GL/yr of River Murray water is allocated for diversion for the irrigation of over 3,000 ha of horticulture within the Loxton, Media, Rilli and Sherwood irrigation areas.

Management Issues

Accessions of irrigation drainage water below the root zone have resulted in the formation of a large groundwater mound below the irrigated areas, which extends to more than 15 m above the adjacent Murray River pool level. Historically, these accessions have comprised drainage water that was not intercepted by the Comprehensive Drainage Scheme (CDS), leakage from the open channels that delivered irrigation water to individual properties and overflow of unused water from the channels. The CSDS delivers water to a series of ancient ox-bow lake depression on Katarapko Island, across the river from Loxton (Figure 2, from AWE 2003). The interactions between irrigation, drainage and the hydrogeology at Loxton are shown on the salt and water balance block diagram (Figure 3, from AWE 2002).

As the groundwater mound grew, problems arose including waterlogging of irrigable land, seepage and salinisation of the adjacent river floodplain (including Rilli, Thiele and Loxton floodplains) and increasing River Murray salinity levels in the Loxton reach due to the displacement of high salinity native groundwater in the underlying aquifers. The disposal of drainage water to Katarapko Island may also be contributing to the increased river salinity levels.

River salinity surveys have indicated the salt load increase in the Loxton reach (approximately 20 km) can exceed 130 tonnes/day.

Management Actions

Management of the off-site issues of irrigation at Loxton need to focus on minimising drainage water accessions and the interception of the flow of saline groundwater to the river and floodplain environment.

The recent completion of the rehabilitation of the water delivery system from open channels to a pressurised pipe system was recently completed, and it is expected that this will result in a significant decrease in the overall volume of drainage water recharge to the aquifers. It is estimated that the drainage water volumes could decline by around 25% as a result of rehabilitation (Smith 1997).

The South Australian Department for Water Land and biodiversity Conservation are currently investigating and designing a groundwater pumping scheme (Salt Interception scheme) to address the measured high salt load discharges to the River Murray. The Murray-Darling Basin Commission requires an approval submission prior to funding the investigation, design and construction of SISs, and this is documented in MDBC (2003).

References

Australian Water Environments (2002). *Loxton LWMP Investigations Preliminary Salt and Water Balance for the 1999 / 2000 Year*. Loxton to Bookpurnong LAP, September 2002.

Australian Water Environments (2003). *Loxton, Media, Rilli and Sherwood Preliminary land and Water Management Plan – Summary Document*. Loxton to Bookpurnong LAP.

PPK (1997). *Assessment of the Impact of the Loxton Irrigation District on Floodplain Health and Implications for Future Options*. Loxton Irrigation Advisory Board, September 1997.

Smith, K. (1997). *Drainage Report Loxton Irrigation District for the Loxton Irrigation Advisory Board and South Australian Water Corporation.* Ken Smith Technical Services, 1997.

Murray-Darling Basin Commission (2003). *Approval Submission for the Loxton and Bookpurnong Salt Interception Schemes.* MDBC, 2003.

Figure 2: Irrigation Network and CDS

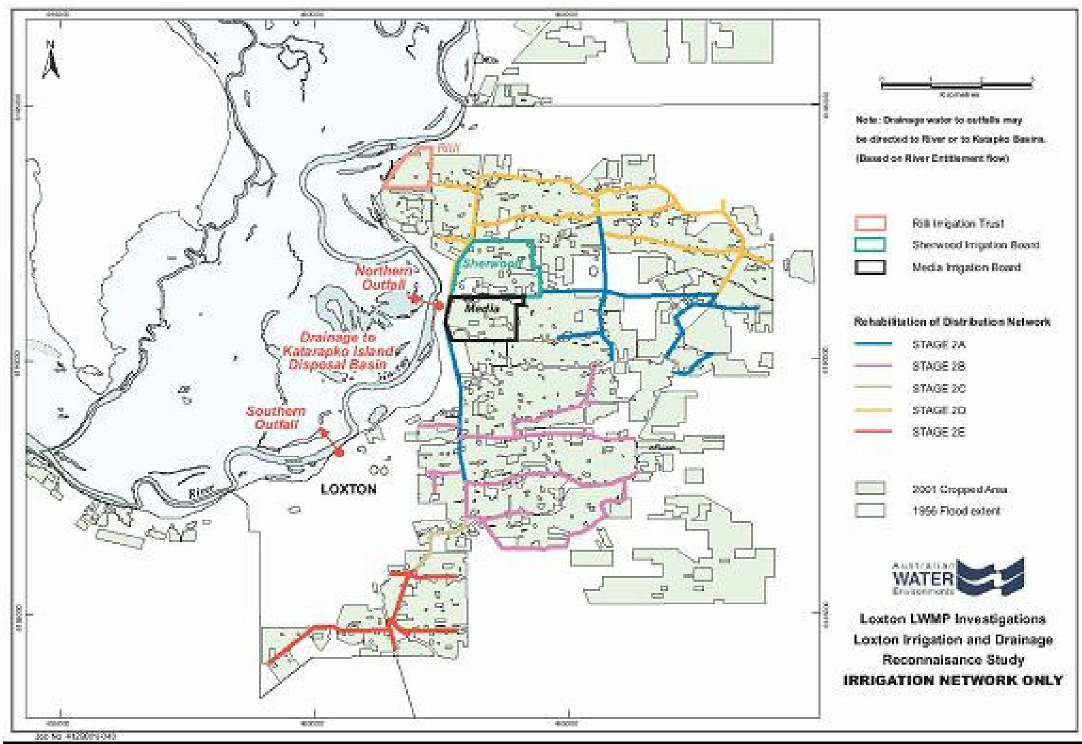
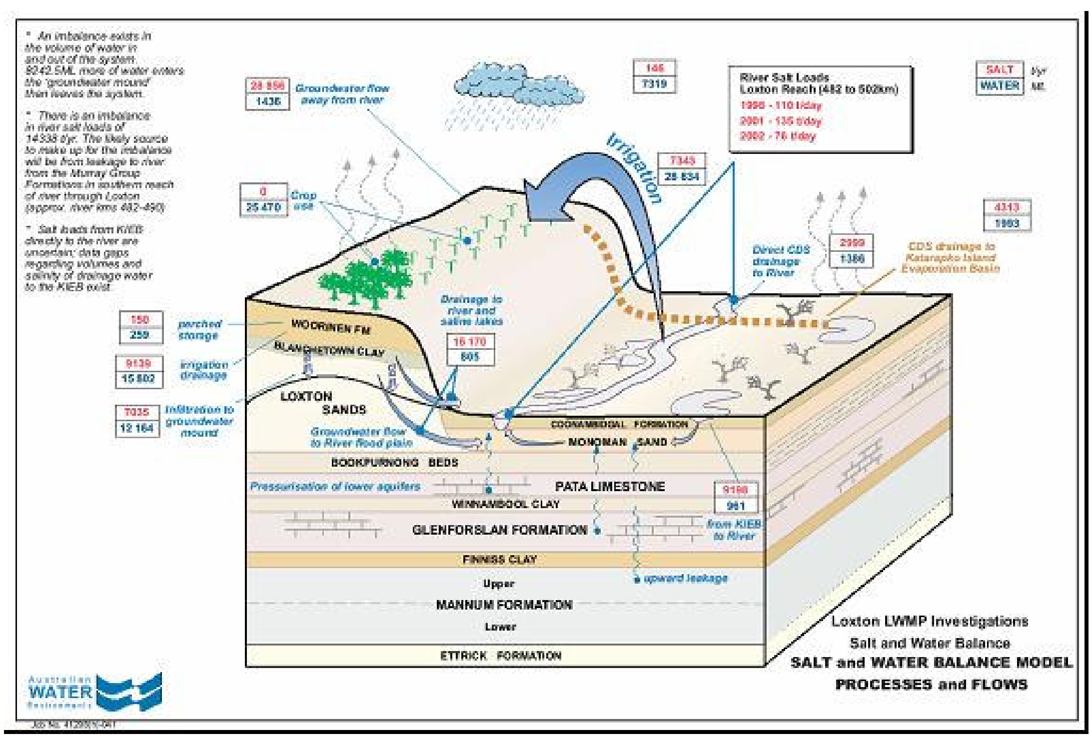
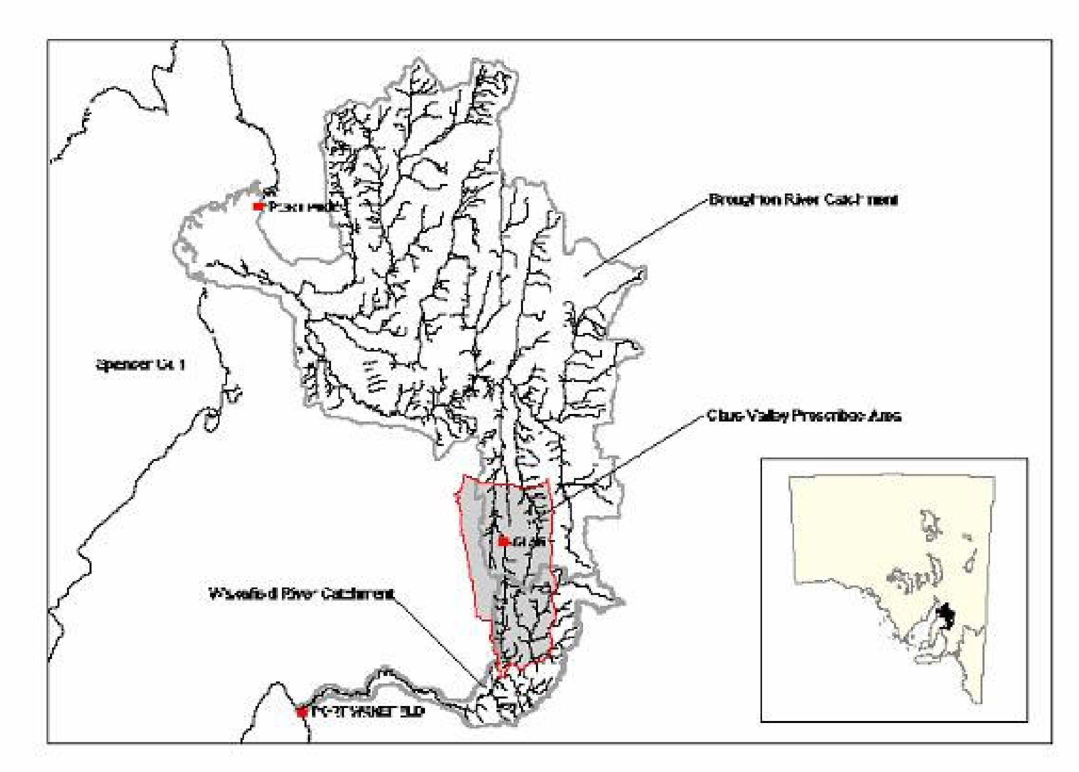


Figure 3: Block Diagram of Salt and Water Balance



Clare Valley Prescribed Wells Area (SA)

Location: The Clare Valley is located some 100 km to the north of Adelaide within the Mt Lofty Ranges (Figure 1).



Hydrogeological Typology: Fractured Rock.

Hydrogeological Setting: This description of the hydrogeological setting in the Clare Valley is transcribed from the Clare Valley prescribed Water Resources Area Water Allocation Plan. There are two water bearing aquifers in the Clare Valley

1. A fractured rock aquifer which is a consolidated rock with the voids provided by cracks or fractures (figure 5). Groundwater flows within the fractures while the majority of water is stored in the low porosity matrix. A variety of different materials including slate, shale, dolomite and quartzite form the fractured rock aquifers. The majority of the ground water resources used in the Clare Valley are sourced from fractured rock aquifers. The aquifers have a low capacity to store water due to their low percentage of pore spaces in the rock matrix, and therefore the available resource is significantly affected by seasonal conditions. Recharge to underground water occurs regionally throughout the Clare Valley and occurs when the soil moisture increases to such levels that the water infiltrates into the ground. In some cases, underground water recharge can occur directly where the fractured rock is exposed. Some recharge, particularly to alluvial aquifers, occurs through the bed of a watercourse.

2. Sedimentary aquifers in the Clare Valley have been formed through the deposition of unconsolidated gravel, sand and silt particles by rivers. Water is stored and travels through

interconnected voids in these unconsolidated sediments with relatively high porosities Geographically these aquifers form in the middle of the valley and interact closely with the surface watercourses that pass over them. Sedimentary aquifers are not extensive in the Clare Valley area, and provide only a small portion of the underground water resource.

Figure 1: Schematic of Fractured Rock Aquifer

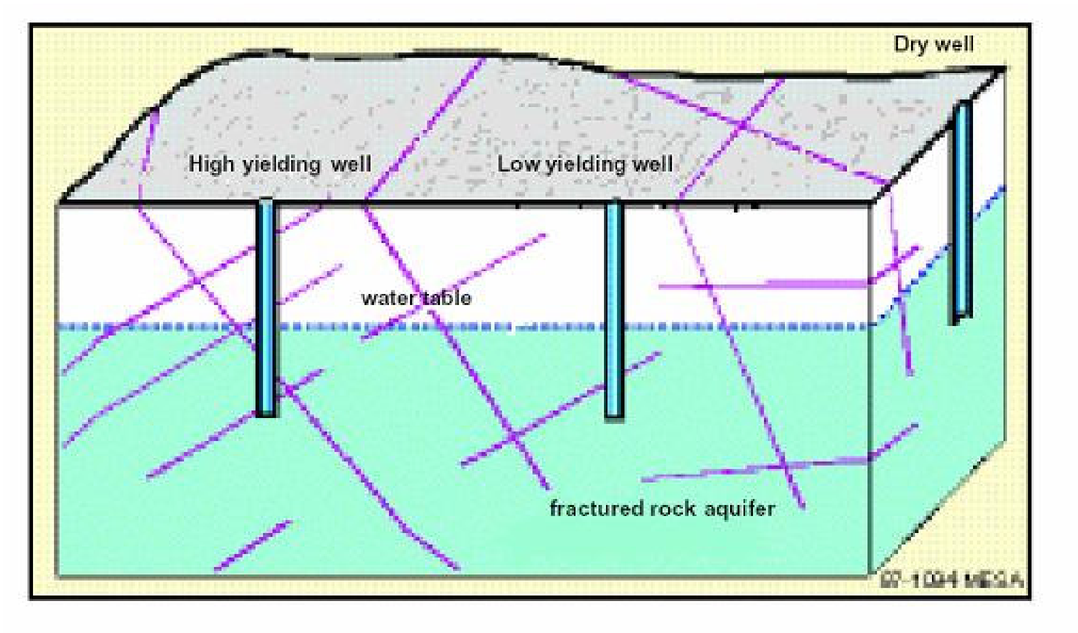
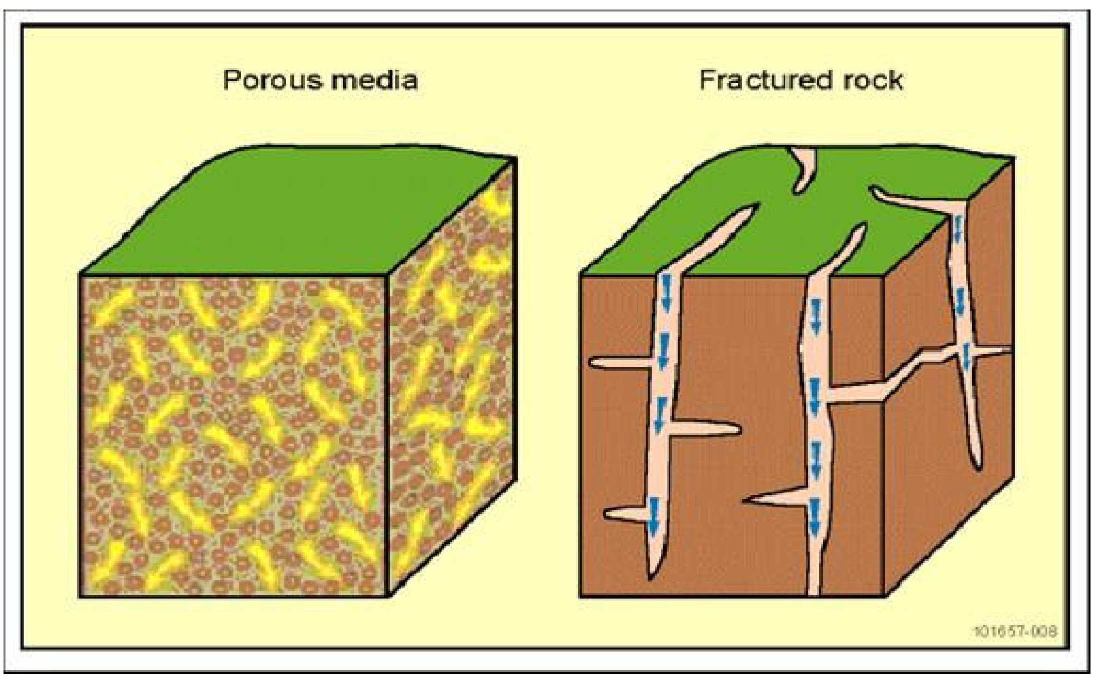


Figure 2: Comparison of Porous Media and Fractured Rock Aquifer Texture



Irrigation Development

There are 4 200 ha of vines in the Clare Valley, a large increase compared to the 2 000 ha of vines existing in 1995. Not all vines are irrigated and some are only partly irrigated. Approximately 1 500 ML of surface water and water from watercourses and 2 700 ML of underground water is allocated (or the equivalent in hectares and maximum irrigation rates).

Management Issues

Due to the nature of the fractured rock aquifers, the volume of good quality underground water is unknown and it is difficult to predict the long-term sustainability of the underground water resource. An extensive groundwater monitoring program has been undertaken in the Clare Valley since 1987/88 to monitor the depth and salinity of the underground water. The results to date indicate that:

- large drawdowns in water table levels during the summer are recorded but these have been shown to recover during an average rainfall winter.
- some wells show a large seasonal variation in salinity. When water levels drop, some wells show an increase in salinity.

Although there are large seasonal variations in the depth of the water table and salinity, the monitoring does not show any clear deterioration in the quality or volume of the groundwater resource.

The Clare Valley groundwater resource has a limited capacity for further development, given its nature and size and the requirements for ecosystems and downstream users.

There are localised problems with demand approaching and/or exceeding the capacity of the resource, particularly after a series of below average rainfall years.

Management Actions

Water Allocation Planning policy in the Clare Valley recognises that a workable limit to the capacity of the resource can be determined in terms of a zone of influence around each licensed well or group of wells. New licensed wells can not be established within an existing zone of influence, because this would exceed the local capacity of the groundwater resource.

Imported water, brought in via the SA Water pipelines from the River Murray, can provide extra capacity in the Clare Valley Prescribed Water Resources Area. The amount of water and the locations where it will be used depend on the effect of the use of imported water on the receiving prescribed water resources and the productive capacity of the land.

Further development can also be accommodated if the efficiency of water use is increased. For example, the evaporation losses from dams are considerable and cause efficiency losses.

References

Department for Water Resources (2000). *Water Allocation Plan for the Clare Valley Prescribed Wells Area*. Department for Water Resources, December 2000.

Northern Adelaide Plains Prescribed Wells Area (SA)

Location: The Northern Adelaide Plains extend over an area of approximately 800 km2 and centred 30 km to the North of Adelaide. It extends from the Mt Lofty Ranges in the east to Gulf St Vincent in the west.

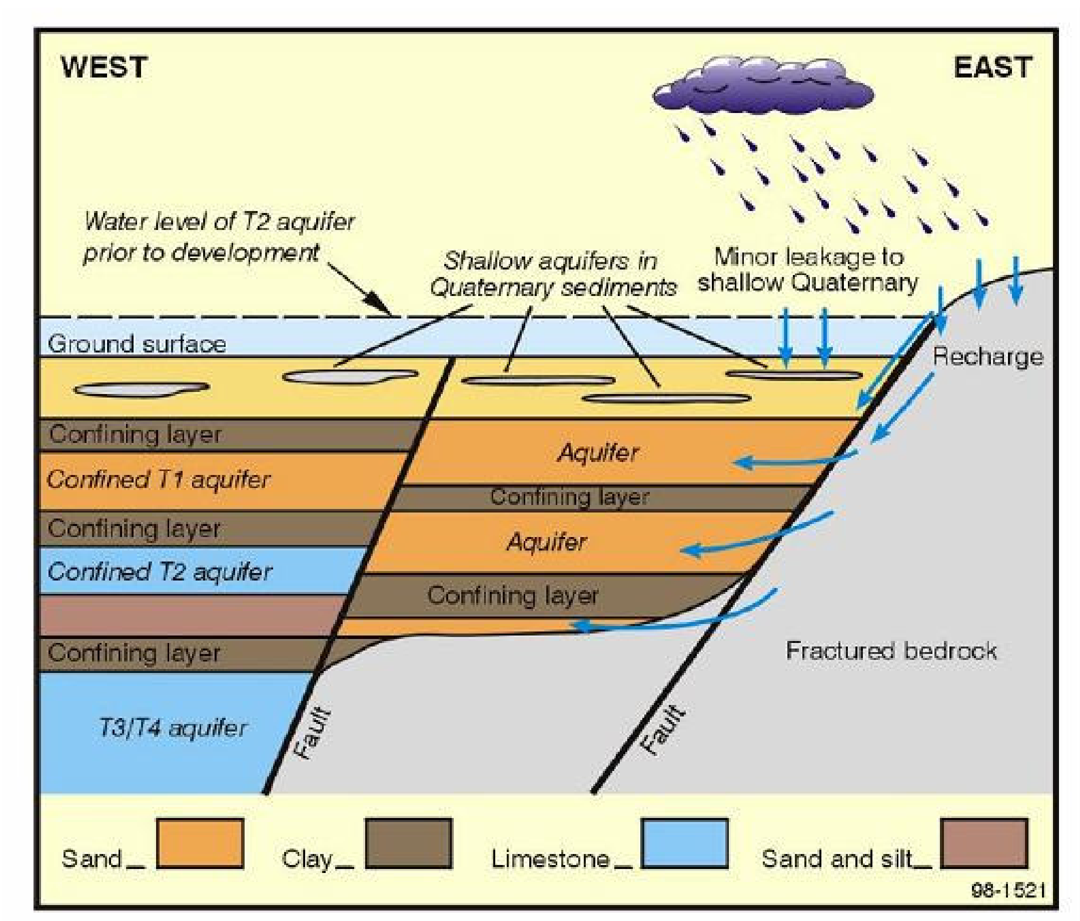
Hydrogeological Typology: Sedimentary Basin.

Hydrogeological Setting: The Northern Adelaide Plains is a multi-layered sedimentary basin, with high quality groundwater resources which are utilised for irrigation. It is underlain by Tertiary and Quaternary sediments up to 600 metres thick which contain numerous aquifer systems. The sediments are of deltaic origin formed by the accumulation of sediments from the surrounding hills. Figure 1 shows a typical cross-section of the resource showing the Tertiary and Quaternary aquifers and the flow of water in those aquifers.

The main source of recharge for the Tertiary aquifers of the Northern Adelaide Plains is from the rainfall-fed fractured rock aquifers in the Mt Lofty Ranges to the east of the prescribed area. The higher elevation of the Mt Lofty Ranges acts to pressurise water, which flows laterally in a westerly direction through the fractured rock aquifers of the ranges into the Tertiary aquifers of the Plains.

The hydrogeology of the Northern Adelaide Plains is summarised in the Water Allocation Plan for the Northern Adelaide Plains Prescribed Wells Area (Northern Adelaide and Barossa CWMB, 2000). This case study description is largely transcribed from this document, and from the Catchment Water Management Plan.

Figure 1: Schematic Hydrogeological Cross Section of the Northern Adelaide Plains



Irrigation Development

It contains relatively fertile soils underlain by a series of sand, gravel and limestone aquifers which are used as a source of irrigation water. Market gardens were established during the 1860s.

Management Issues

Water users in the Northern Adelaide Plains Prescribed Wells Area rely heavily on the extraction of underground water from the Tertiary aquifers for industrial use and crop irrigation purposes. The bulk of the extractions occur from the T1 and T2 aquifers. The average use over the last 10 years is 18,000 ML per year which is pumped from over 1,200 wells spread throughout the region, and the extraction rate has been fairly constant for the last decade.

In their natural state the main aquifers were sufficiently pressurised to ensure that most wells in the western part of the NAP were free flowing (artesian) approximately 10 to 15 metres above ground level. However, levels began to decline dramatically in the 1930s due to increasing irrigation activity. By the 1940s the major aquifers were no longer artesian and by the 1960s intensive pumping had resulted in the formation of a large cone of depression.

Recent hydrogeological investigations have continued to identify two major problems associated with the current level of groundwater use in the region - water level decline and increasing salinity levels.

The water level recorded in T1 aquifer has declined by 10 to 30 m in an area where a steep cone of depression has developed, mostly as a result of intensive irrigation (Figure 3). The decline is in response to a number of factors including the intensity of pumping during summer. The water level does not recover completely during winter, partly as a

result of pumping during the winter period.

Over the last 30 years, the average salinity recorded in the Tertiary aquifers of the Northern Adelaide Plains has increased by 200mg/L in some parts of the T2 aquifer and up to 800mg/L in the T1 aquifer.

The capacity of the resource is presently insufficient to meet the current demands for water use in the Northern Adelaide Plains Prescribed Wells Area without causing detrimental impacts on the underground water resources of the area. The current level of underground water use in the Northern Adelaide Plains Prescribed Wells Area is therefore in excess of what is considered to be an acceptable safe yield.

The unacceptable impacts could include increases in underground water salinity, losses of elastic storage, reduction in pressure and water level decline to an unconfined situation.

Management Actions

Many years of investigation have been incorporated into the current NAP Water Allocation Plan. This document provides the rules and principles to achieve the following objectives:

1. Allocation and use of underground water in a sustainable manner.
2. Allocation expressed as a volume of water that may be taken and used.
3. Efficient use of water.
4. Maintenance of water quality.
5. Maintenance of underground water dependent ecosystems.
6. Maintenance of the integrity of the aquifers.

Additional water sources potentially include treated wastewater from the Bolivar treatment works and the use of Aquifer Storage and Recovery to harvest stormwater.

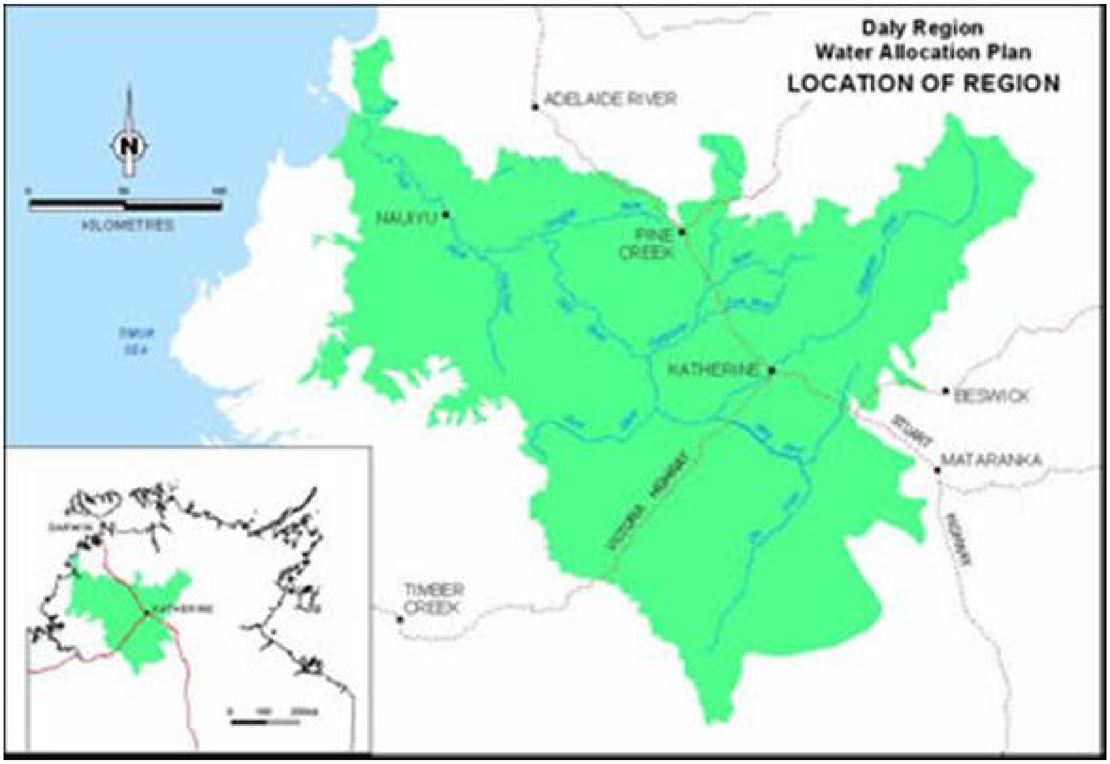
References

Northern Adelaide and Barossa Catchment Water Management Board (2000). *Water Allocation Plan Northern Adelaide Plains Prescribed Wells Area*. Prepared with the assistance of the Northern Adelaide Plains Catchment Committee, December 2000.

SKM / Hassell (2001). *Catchment Water Management Plan – VOLUME 1, Northern Adelaide and Barossa Catchment Area*. Northern Adelaide and Barossa Catchment Water Management Board.

Daly Region (NT)

Location: The location and extent of the Daly Region is shown on Figure 1.



Hydrogeological Typology: Limestone (karstic).

Hydrogeological Setting: This description of the hydrogeological setting concentrates on the karstic limestone unit within the Daly Region, the Oolloo Dolostone. The text is transcribed from Tickell (2002).

The Oolloo Dolostone, is the uppermost formation of the Daly Basin and hosts an extensive high transmissivity fractured and cavernous rock aquifer. The aquifer is overlain by up to 100m of Cretaceous clay and sand over a considerable proportion of its extent, which acts to reduce recharge except where the basal Cretaceous sand is thickly developed and outcropping. Recharge occurs in areas where the formation is exposed. The recharge mechanism in those areas is likely to be a combination of diffuse recharge and point recharge via sinkholes

Aquifer discharge occurs via springs in the Daly River. Spring locations are controlled by faulting, stratigraphy and topography. Late Dry season spring-flows to the river from the Oolloo aquifer range from 5 to 15cumecs, depending on the rainfall of the preceding series of years. The downstream portion of the Daly River relies on discharge from the aquifer for the bulk of its dry season flows for five or more months of the year.

Figure 1: Plan of Geology (from Tickell 2002)

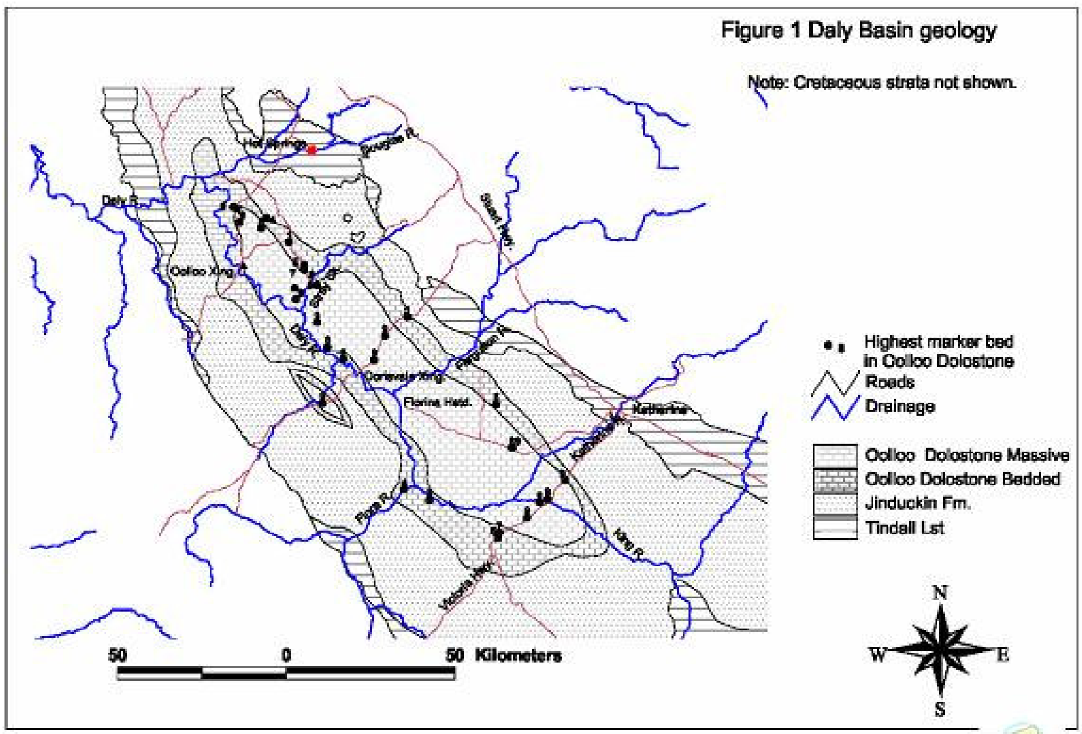
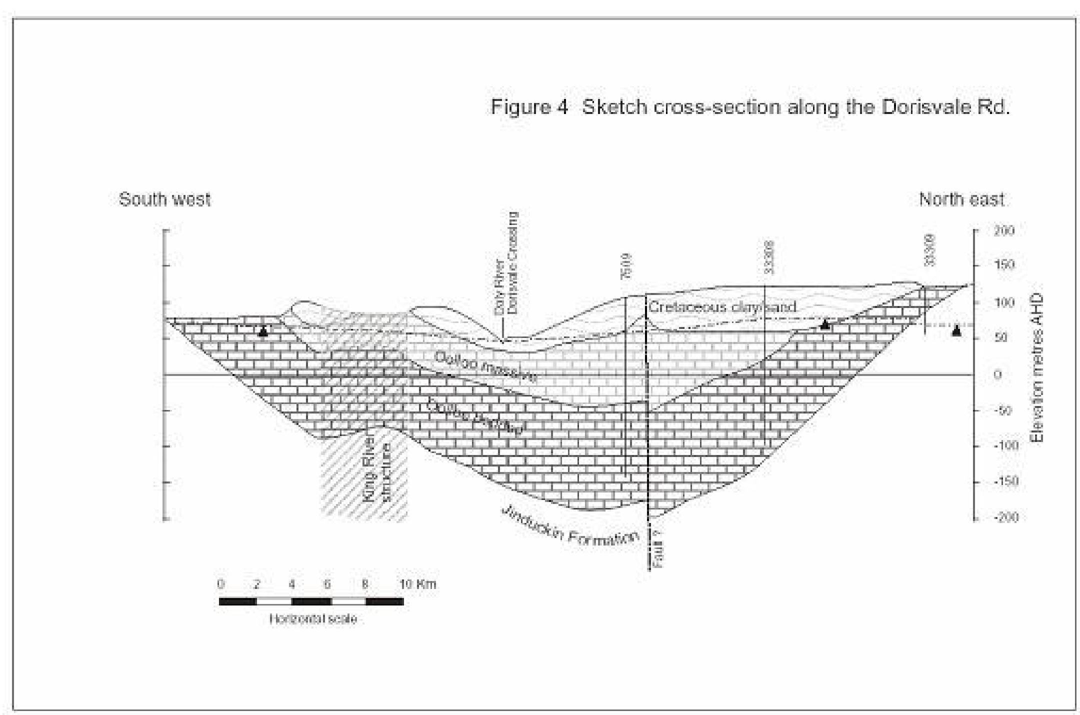


Figure 2: Typical Cross Section (from Tickell 2002)



Irrigation Development

At this stage there is only limited development of the groundwater resource for irrigation use on mangos and fodder crops.

Management Issues

It is recognised that groundwater in the Daly Region will need to be allocated to competing needs, and that the water resources will be shared within sustainable limits, which conserve environmental and cultural needs, while at the same time meeting consumptive uses. The Olloo Dolostone aquifer is important for the provision of dry season base flow to the Daly River.

Management Actions

The following information was sourced from a Water Allocation Plan discussion paper developed by the Department of Infrastructure, Planning and Environment.

A Water Allocation Plan is currently being developed for the Daly Region. The plan will summarise the current knowledge on rainfall, rivers, groundwater aquifers and how they interact through the use of water balance models. The plan will identify both non-consumptive (e.g. environmental and cultural uses) and consumptive (e.g. public water supply, rural stock and domestic, agriculture, industry and aquaculture) uses of water.

The Water Allocation Plan will aim to improve the sustainable use of water resources through:

- Improvements to licensing processes.
- Monitoring of large production bores and river pumps to improve our knowledge of water use and to refine the water balances.
- Monitoring and reporting systems will be improved in order to refine the water balance.
- Managing increased water demand and targeting problem areas or ‘hot spots’.
- Environmentally and economically sustainable development and use of water.

References

DIPE (2004). *Discussion Paper – Daly Region Water Allocation Plan*. Department of Infrastructure, Planning and Environment, March 2004.

Tickell, S.J. (2002). *Groundwater Resources of the Oolloo Dolostone*. Department of Infrastructure, Planning and Environment, Natural Resources Division, Report 17/2002, December 2002.

Irrigation of dairy effluent on karst systems in northern Tasmania

NB map of karst near Mole Creek not provided but is available.

Isolated areas of concern exist where dairy effluent is irrigated over karst systems. In comparison to other groundwater environments, flow through karst systems is often rapid due to the presence of conduits such as caves. These can provide efficient pathways for the movement of water from one part of the karst to another, with little purification if the water is contaminated. If water entering the karst system is polluted, this may spread rapidly to a much wider area.

Information on karst aquifers can be found at:

http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/JMUY-63Z4UB?open

Issues associated with irrigation of dairy effluent on karst systems include:

- The impacts on groundwater of:
    - Increased nutrient concentrations
    - Increased pathogens
    - Decreased oxygen levels
    - Impacts on groundwater-dependent ecosystems
- Build up of nutrients (particularly potassium) in soil to toxic levels
- Poor areal distribution of available nutrients
- Application of irrigation to saturated soils (due to lack of winter/spring storage)

In Tasmania, the majority of our understanding of groundwater dependent ecosystems, being a relatively new area of research, is confined to those found in karst environments. Aquatic ecosystems in karst environments support a specialised fauna that is often distinct from that of surface waters. Species that live solely in these environments have curious morphologies including the degeneration or loss of eyes and body pigment, elongated antennae and legs, and enhanced sensory structures.

Information on groundwater dependent ecosystems can be found at:

http://www.dpiwe.tas.gov.au/inter.nsf/WebPages/RPIO-4YA8VK?open

Sink holes on a dairy farm overlying a karst system in Tasmania

A sink holes in a karst system in Tasmania

Irrigation of dairy effluent on drained swampland in northwest Tasmania

An effluent irrigator

Centre pivot irrigator used un intensive vegetable production in Tasmania