# Implications of aquifer recharge for water sharing plans:

## a case study from the Upper Namoi Valley

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The sustainable yield (SY) estimates that are the basis of the many groundwater water sharing plans (WSP) across NSW are strongly influenced by calculations of estimated annual average recharge (EAAR). SY is usually assessed to be a proportion of the EAAR (allowing for environmental requirements) but in the Namoi Valley for the current WSP, the EAAR is assumed to be the SY because there are no identifiable dependent ecosystems.

Groundwater recharge in the Namoi Valley is a complex process that depends on many factors. The processes at work include rainfall recharge, flood recharge, regulated stream flow losses, irrigation returns and valley side-slope runoff. These sources of recharge vary with the area and seasonal climatic conditions.

In the area between Emerald Hill and Gin's Leap (around Boggabri), there are numerous recharge and discharge processes at work that are understood but poorly quantified at this time. The most significant processes are thought to include rainfall (and vertical infiltration across the floodplain), leakage from the Namoi River, flood recharge and side-slope sources. Local flood and side-slope recharge is considered to be undervalued.

This paper examines the Upper Namoi groundwater Zone 4 West (see Figure 1) to demonstrate that the current EAAR calculations may have been underestimated, in part as a result of the effects of soils and underlying layers as a 'pathway' for recharge from rainfall, irrigation returns or flooding not being considered. Gulligal Lagoon fills often as a result of flooding and the extensive catchment areas of ephemeral streams, Collygra Creek and Deadman's Gully are important contributors. Runoff from these local catchments feed the aquifer recharge system (see Figure 2).

### Aquifer recharge pathway

Leakage through clay-rich soils and sediments is often overlooked as a source of recharge. In the context of the WSP, quantifying all recharge sources on a local scale, particularly the extra aquifer

*Figure 1. Location of the Upper Namoi groundwater Zone 4 West*

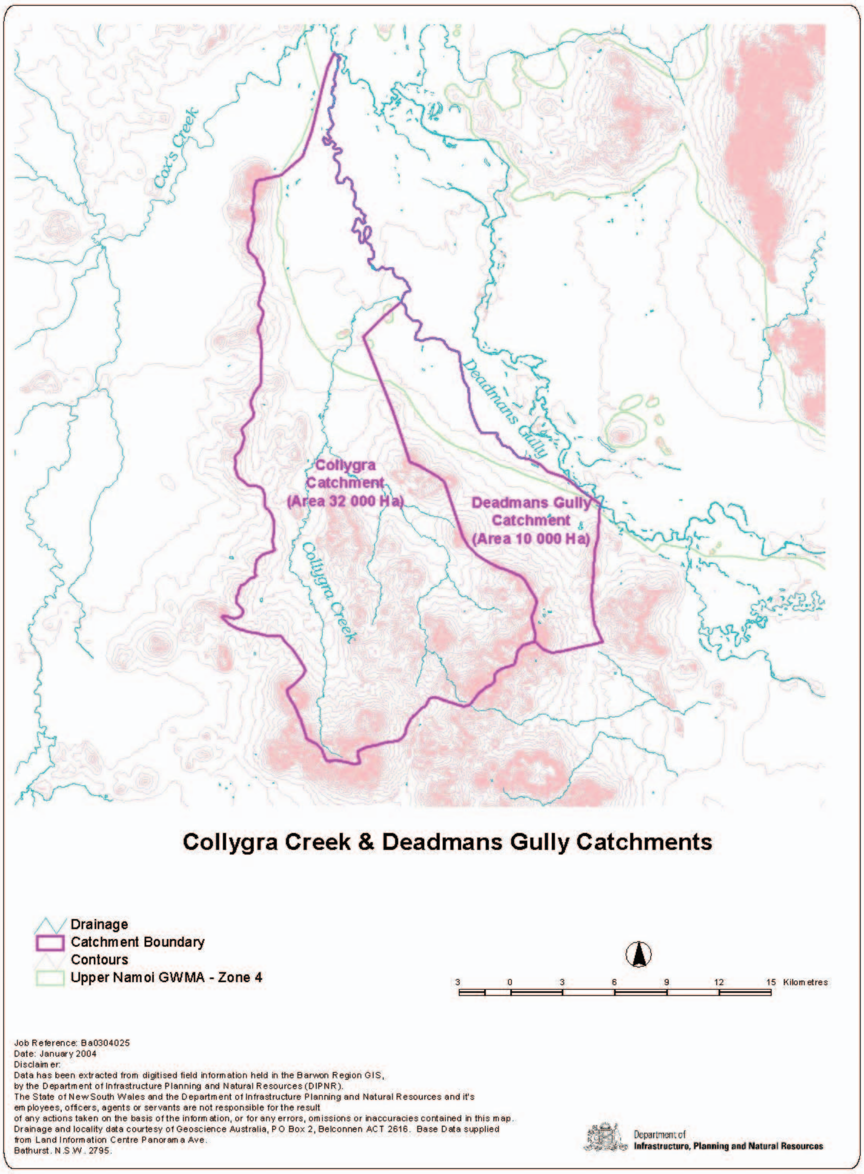

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*Figure 2. Boundaries and extent of Collygra Creek and Deadman's Gully catchments*

recharge by leakage from local sources, may help balance the pumping of groundwater. Consequently, understanding how, where and when leakage occurs is important for effective groundwater management.

It is a myth that all clay is impermeable. Swelling calcium smectite clay (black vertisol) may leak in two ways: through relatively open pore structure, and occasionally through rapid flow pathways such as fractures. However, not all leakage through a thick unsaturated zone becomes aquifer recharge because some water contributes to storage in partially filled pores.

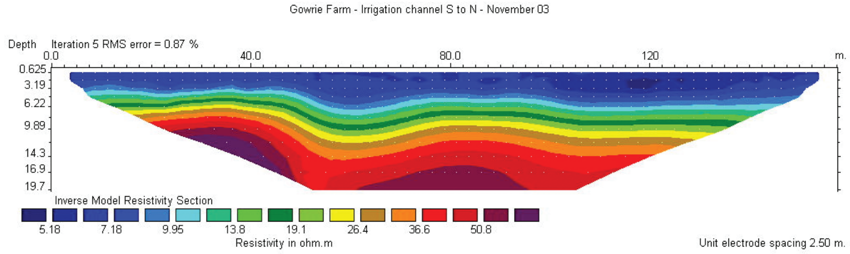
Leakage is possible where clay layers are relatively thin, discontinuous and are prone to fracturing. For example, the variable distribution of a clay rich layer overlying a shallow palaeochannel was revealed by recent geophysical investigations at 'Gowrie', a local property. An electrical image (length 120 m, depth 20 m) along an irrigation channel revealed shallow sandy clay (Figure 3). This clay was about 8 m thick, confirmed by bore drill records, and thinned to 5 m towards the south. Drying of the soil to this depth could result in fracture leakage.

While leakage through clay may be small under natural conditions, it increases in response to flood irrigation and increased deep drainage below the rootzone. At an irrigation site near Gunnedah, increased leakage through clay sediments to at least 34 m depth was caused by flood irrigation (Figure 4). Hydraulic and hydrochemical evidence indicated that by the end of the irrigation season, a third of storage in the shallow aquifer was replaced by leakage water. Estimated recharge accounted for 12 to 30 per cent of irrigation supply.

Enhanced leakage is currently not included in the EAAR, nor is it reflected in the sustainable yield estimate. Ongoing investigation, strategic monitoring, and transient groundwater models that include leakage are required to improve sustainable yield estimates.

To illustrate this point, in July 2003 a channel leakage trial was conducted on 1 km of open head ditch on fields 2 and 3 at 'Gowrie', Boggabri. A standard delver was used to construct the channel. The channel was filled with water for one week before the experiment to give an indication of leakage under saturated conditions. A survey peg was driven in at normal water level and head when irrigating. A transfer pump was then used to maintain that level with no siphons running. The pump discharge, less a figure for evaporation, was deemed the channel leakage. This was about 10 L a second for 1 km of channel. The groundwater pump discharge is 100 L a second so about 10 per cent loss of the raw water that is pumped and delivered for irrigation is occurring in every 1 km of head ditch under normal irrigation conditions. Similarly, there may also be losses of up to 10 per cent as water leaks below the rootzone and perhaps 7 to 8 per cent as leakage from the tail drains. Not all the loss is downwards; some occurs laterally and may not return to the aquifer. It should be noted that these losses are occurring under conditions of industry best practice and not due to inefficiency.

It is estimated that losses or returns back to the aquifer may be as high as 20 to 30 per cent on 'Gowrie', expressed as a percentage of groundwater pumping volume. These irrigation losses should be taken into account in estimating annual average recharge. It is important that all



recharge sources on a local scale are identified and fully accounted for in any numerical groundwater modeling that quantifies EAAR.

Note that these estimates have been obtained after highly efficient laser scraping and tailwater returns systems were in place and are considered representative of farms in Zone 4 West, using industry best practice.

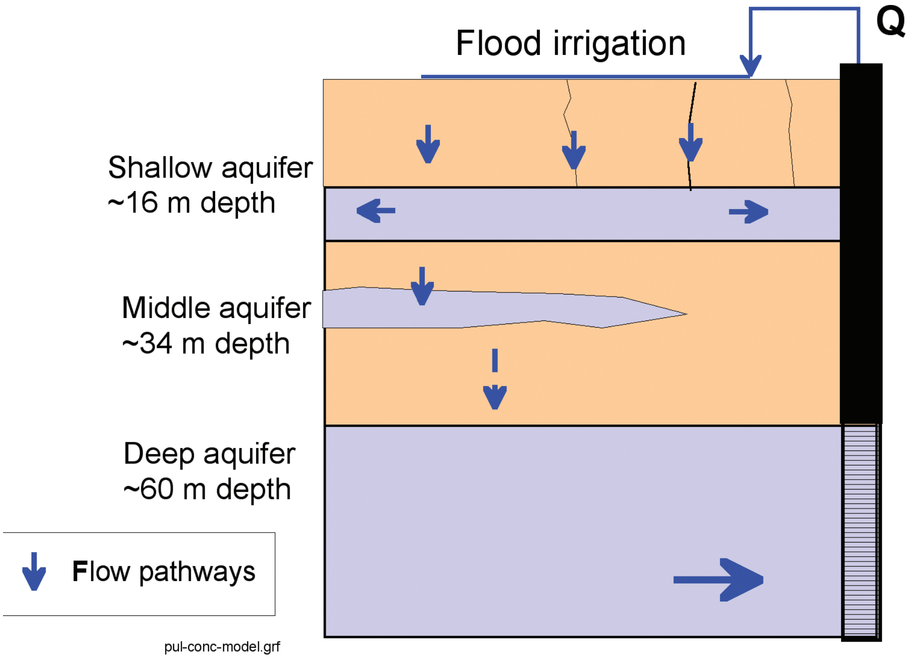
In view of the irrigation returns, and the rainfall and side-slope runoff sources of aquifer recharge in Zone 4 West, a system of aquifer response management needs to be put in place to confirm the findings of this paper and to closely monitor the test bores. It is the irrigator's position that test bores could be automatically logged in conjunction with an automatic weather station so that readings could be taken and allocations adjusted accordingly on a seasonal basis. In this way the sustainability of the aquifer could be proven and entitlements could remain until a more reliable sustainable yield figure is obtained.

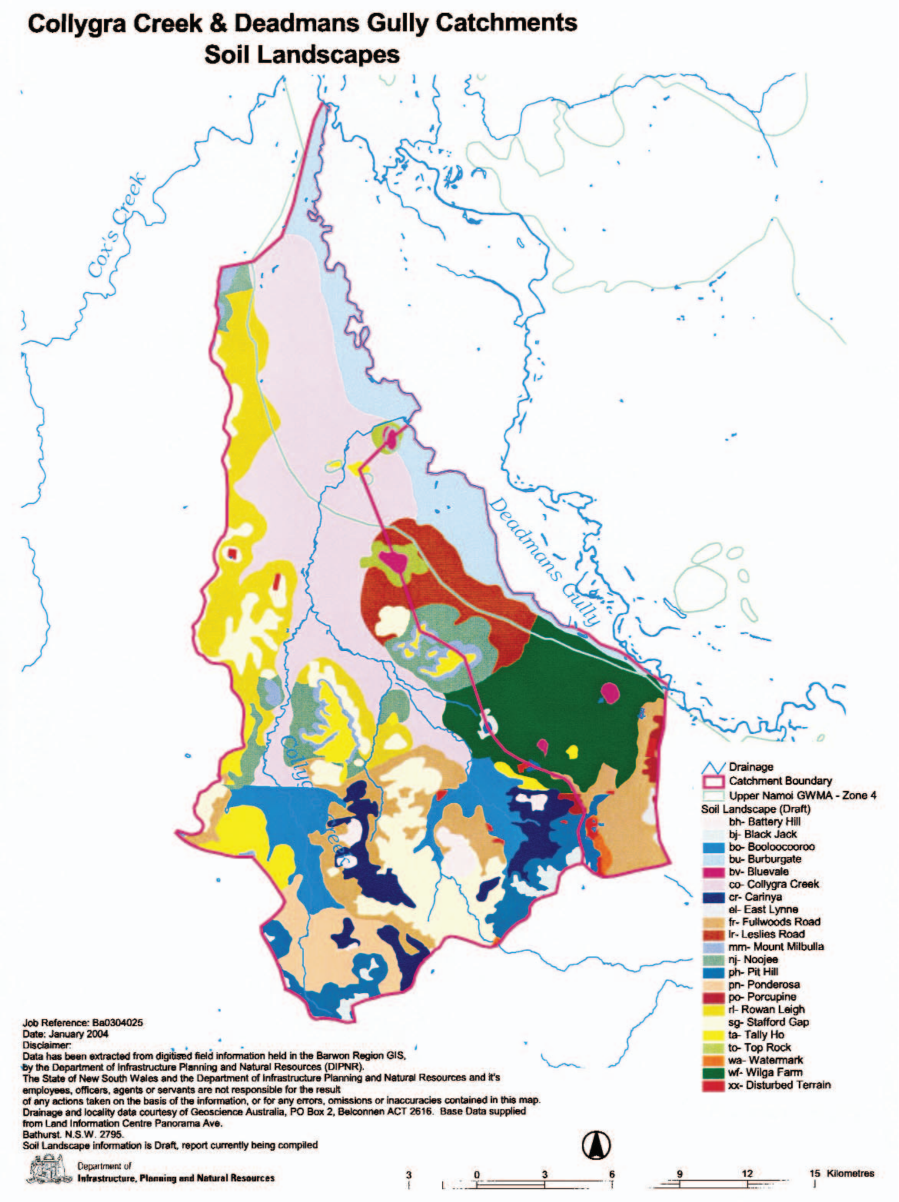
Current sustainable yield estimates are an oversimplification of conditions across the whole of Zone 4. These first estimates may underestimate rainfall, flooding and river recharge rates unique to Zone 4 West. Electrical imaging, bore logs and excavations such as tail water dams show shallow soils over permeable layers leading to the shallow aquifer, clearly identifying the potential for enhanced recharge locally.

An evaluation of historical use and comparison with water level data over the period of record suggests a SY for Zone 4 West, of at least 16,000 ML/year with an upper limit of 20,000 ML/year. This is much higher than the current Department of Infrastructure, Planning and Natural Resources (DIPNR) estimate of 8,600 ML/year. Hydrographs over the last two years show that groundwater levels have not changed significantly, even though we have come through a 1-in-200 year drought.

## Aquifer recharge sources

The general groundwater flow direction is down-valley. There are apparent natural river losses from the Namoi River immediately east and north of Emerald Hill. In this area, the stream is a connected losing stream. Closer towards Boggabri and Gin's Leap, where the alluvial valley constricts (natural dam site), groundwater discharges to the Namoi River. In this area, the stream is a connected gaining stream. This close association with the river makes for a high recharge and a sustainable surface water/groundwater system if managed properly.





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Soil Landscape information is Draft, report currently being compiled

*Figure 5. Soil landscapes for Collygra Creek and Deadman's Gully catchments*

Recharge from flooding (not only large catchment floods but smaller local events as well) is thought to be significant now that the potential of the soils to leak is known. Recharge areas like Gulligal Lagoon, Thompson's Lagoon, Driggle Draggle Creek and Barbers Lagoon all play their part in storing water and then slowly releasing it to the shallow aquifer. Deadman's Gully and the surrounding lowlying areas similarly store runoff and slowly release water to the aquifer. These lagoons are filled at minor flood heights e.g. Gulligal Lagoon recently filled at the Gunnedah river gauge height of only 5 m. Most of the river had not broken its banks.

The catchment areas of the ephemeral streams Collygra Creek and Deadman's Gully are extensive (see Figure 2); Collygra Creek has 32,000 ha and Deadman's Gully has 10,000 ha. These are important side-slope runoff sources of aquifer recharge. The superimposed soil landscapes contributed by Robert Banks, DIPNR give some idea of likely potential run-off into the recharge area of Deadman's Gully (see Figure 5).

The total area of catchment is 42,000 ha. Using an average coefficient of runoff value of 0.4 multiplied by the annual average rainfall of 600 mm the annual discharge is 10080 ML. This is a lot of runoff. Often, only a small percentage of this water contributes to stream flows in the Namoi. Most runoff simply flows onto the floodplain and stays in lowlying areas and gullies. A percentage of this runoff must leak to the aquifer of Zone 4 West. More detailed work should be done using climatic data, data logger responses and the soil landscapes to give a more accurate prediction of runoff and associated recharge under given rainfall events. These 'what if' calculations become very complex and outcome results are best recorded in a matrix of infinitely variable inputs. Alternatively, the test bores in Zone 4 West could be monitored more often to assess the aquifer response after significant rainfall events. This would be invaluable in determining EAAR. It is not just the rainfall that falls on Zone 4 West itself, but the combined catchment draining into this sub-zone.

The extent to which irrigation returns are a factor in aquifer recharge needs quantifying. However, as in side-slope run-off, a percentage will find its way into the aquifer. Irrigation returns may amount to up to 30 per cent of the groundwater pumped now that it has been established that these soils leak.

## Conclusions

Zone 4 West aquifer recharge pathway. From anecdotal evidence and the scientific studies described in this paper, it is known that major flood runners and soils across the floodplain leak in the western area of Zone 4. These are aquifer recharge pathways during high rainfall and flood events. Even irrigation returns contribute to the shallow water tables. There are extensive local catchments feeding the aquifer recharge system which provide additional water volumes for recharge.

Zone 4 West is a very favourable groundwater irrigation area. The shallow aquifer system is within 10 m of the surface in the Namoi floodplain area. Extensive shallow permeable sediments, and a variety of recharge sources, ensure that the Boggabri area is one of the more sustainable areas within the Upper Namoi alluvial aquifer system.

Review EAAR Zone 4 West before 1 July 2004. The EAAR figure may have been underestimated because of a lack of information being available at the time. Now that the unique aquifer recharge conditions are better understood in Zone 4 West, an urgent review of the EAAR (using this local knowledge and applying it to numerical models) should occur before the 73 per cent cut to entitlement is implemented 1 July 2004 under the Water Sharing Plan. A 30 per cent cut would be more in keeping with what is now known about the aquifer.

Study the aquifer recharge sources to obtain more reliable SY estimates. In time a better understanding of aquifer recharge (particularly the contribution of *ALL* recharge sources and processes), as more scientific information becomes available, will lead to more reliable sustainable yield estimates and in turn more equitable water sharing plans.

Draw-down based allocation is a simple concept. Irrigators believe that an alternative base for water sharing plans is to measure and monitor the aquifer itself. Local management groups would consider aquifer levels from automatically logged test bores and make decisions on allocations accordingly. A senior hydrogeologist would be part of the team. In this way a 'draw-down' based allocation system would give early warning when action needed to be taken. Over a number of years the sustainable yield would be evident and entitlements could be adjusted accordingly. In view of the complexities of estimating recharge, the 'draw-down' based allocation system appears to be the simplest in concept, the easiest to manage and the most equitable base for any water sharing plan.

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