Supplementary Submission No 13b

INQUIRY INTO WATER AUGMENTATION

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Dr Peter Main

30/1/17

The Hon Michael Brown MLC
Parliament House
6 Macquarie St
Sydney NSW 2000
Chairman of the NSW Legislative Committee on Augmentation of Water Supply for Rural and Regional NSW.

Dear Sir
I attach a copy of recent analysis that may be of interest to the committee, that applies previous ideas outlined in the first two parts of my submission to the Water Augmentation enquiry.

The analysis was intended primarily for Barnaby Joyce and Tamworth Regional Council, however some of your contributors may find it of interest. It is an attempt to apply some of the ideas in a more concrete way to the Tamworth district.

I thus attach a copy as a supplementary submission part 3 to my prior two part submission.

Sincerely

Dr Peter Main .

Natural Aquifer Recharge for the Peel River, NSW.

Dr Peter R Main [2], Canberra 23/1/2017

PRECIS

Tamworth's water problem

Tamworth is situated along the Peel River in Northwest NSW and is famous for its Country and Western Festival in the hot dry summer. The city has unresolved water supply problems, and the regional Council has committed to further investment in water security.

Chaffey Dam, the largest city water source, has been recently enlarged from 60 Gigalitres to 100 Gigalitres. About 50% of released water is lost during flow to Tamworth via the Peel River. A pipeline would fix this problem however it would be expensive.

Managed Aquifer Recharge (MAR), a technology to enhance water storage underground often called "W*ater Banking*", has been pioneered interstate. MAR has so far been dismissed as too expensive to be seriously considered at Tamworth.

A long way downstream from Tamworth, Geoscience Australia's *Broken Hill Managed Aquifer Recharge* project (BHMAR), discovered massive water stores of around 4,700 GigaLitres at *Menindee Lakes(around 9 Sydney Harbours)*. Much of the water is salt affected , and this, together with unknown cost issues, caused the project also to be dismissed as too expensive. NSW then committed to a $400 million pipeline from the Murray to Broken Hill.

A proactive Federal Water and Resources Minister, could change the failure of the BHMAR to deliver working water reform installations on the ground, but probably not at Menindee. If a pilot MAR project proceeds at Tamworth, a sound defense against challenges of "Pork Barrelling" is referral to the $30 million wasted on the BHMAR to date, and the need to build on this research by small experimental pilot projects. These are 30 million reasons to test the knowledge from the research elsewhere.

Open cooperation from all three tiers of government is proposed as essential to success.

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1 This document may be used freely in part or whole with attribution to the writer

2 The writer, now a Canberran GP, grew up near Tamworth and visits relatives in the district regularly.

Natural Aquifer Recharge for the Peel River, NSW.

 Dr Peter R Main, Canberra 23/1/2017 Rev1 7

Tamworth's water problem

Tamworth is situated along the Peel River in Northwest NSW and is famous for its Country and Western Festival in the hot dry summer. The city, home to 40,000 people, has unresolved water supply problems, and the regional Council has committed to further investment in water security.

Chaffey Dam, the largest city water source, has been recently enlarged from 60 Gigalitres to 100 Gigalitres. Unfortunately about 50% of the water is lost during flow to Tamworth via the Peel River. A pipeline would fix this problem however it would be expensive.

Some Solutions

The front-runners to further improve water supplies include the above pipeline, a new dam somewhere, a pipeline from Lake Keepit, or a *production borefield* and pipeline to town from downstream. Supplementary water in drought already comes from a borefield near Tamworth.

Within this context of limited town water supplies in the district, past studies into the use of Peel River alluvial aquifers have occurred. *Managed Aquifer Recharge (MAR),* a technology to enhance water storage underground often called "W*ater Banking*", has been pioneered interstate in Perth and Adelaide using water injected underground by bores. To date, MAR has been dismissed as too expensive to be seriously considered at Tamworth. The form of MAR considered uses *bore injection* to inject water, and is often called *Aquifer Storage and Recovery* (ASR).

Other Solutions from Menindee and the Burdekin River

A long way downstream from Tamworth on the same river catchment, Geoscience Australia researched underground water along the *Darling River at Menindee Lakes.* A major research project called *Broken Hill Managed Aquifer Recharge* project or BHMAR, mapped underground water in a search for more secure water supplies for Broken Hill. This work discovered massive water stores of around 4,700 GigaLitres (or 9 Sydney Harbours). Much of the water is affected by salt. The salt, together with unknown cost issues[3], caused the project also to be dismissed as too expensive. NSW then committed to a $400 million pipeline from the Murray to Broken Hill.

Meanwhile in Queensland, on the Burdekin River, a different, less sexy form of MAR called *passive aquifer recharge*, has been successfully in use to control salt, and irrigate sugar cane for about 40 years. This uses *sand dams* in the river, and *passive recharge beds,* to enable large scale water filtration into the aquifers. This *water banking* is cheap, and occurs without expensive water pre-treatment, or injection bores, delivering water at about $70 per megalitre[4] . This is a fraction of the city-style bore injection ASR that has a target sales market in the $1-$3000 per megLitre.

Natural Aquifer Recharge along a river

A little understood exciting new research discovery from the Menindee research, was that the Darling River has its own form of *dynamic, natural passive aquifer recharge* via the river bed and banks.[5] (Well I admit it is only exciting to hydrologists and anyone who can understand the implications of the unexpected discovery.) The implications of this new knowledge, are central to the proposal for Tamworth set out herein.

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3 The cost issues emerged from numerous wrong assumptions dealt with briefly herein

4 Peter Dillon et al Managed Aquifer Recharge 2009 National Water Commission (see Quotes)

5 The Barkindji tribe has extensive untapped knowledge of water flows not referenced by the BHMAR research

Fig 1 From BHMAR Report 05

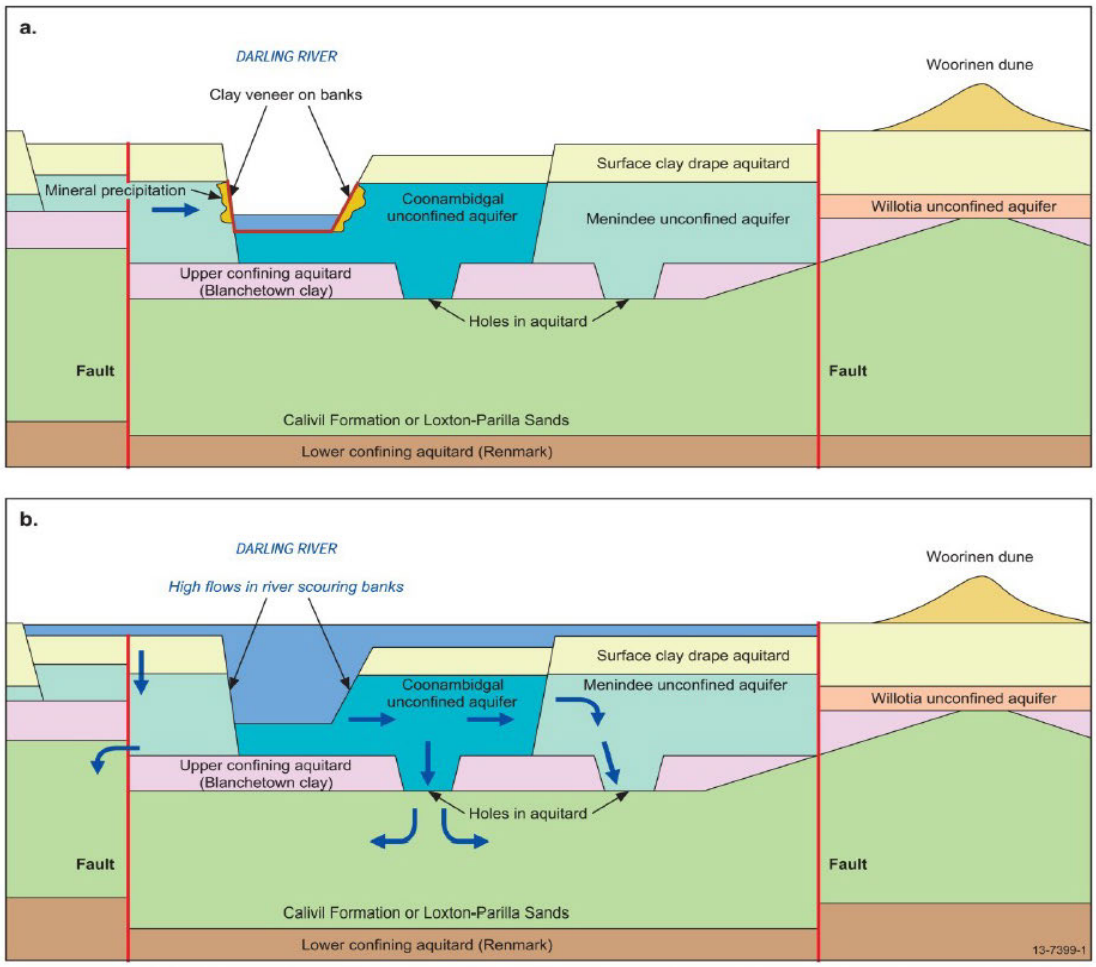

Figure H. *Conceptual model for groundwater recharge in the Lower Darling Floodplain alluvial sediments in (A) high-flow phase and (B) low flow phases.*

Fig 1. Note : The text descriptor for A and B is wrong in the above diagram from the report - the loss of clay veneer allowing rapid recharge occurs in B, the High flow phase.

Menindee and Peel River Natural Aquifer Recharge (NAR)

As suggested above, the wrong ASR model appears to have been assumed at both Menindee and Tamworth to think about aquifer recharge. An alternate model is that for agricultural priced water via passive recharge methods. Burdekin-style MAR provides a comparative cost base of around $70 per Megalitre[6], yet even this will exceed the cost of simplified forms of passive aquifer recharge, not requiring construction of absorption beds. Such simplified MAR using river bank and river bed aquifer recharge, with selective use of pulse flows, and low level weirs is applicable to the Peel River. Such a style of MAR leads to the potential to use a pipeline grid to distribute secured, reasonably costed water for both the city and its agricultural locality for new enterprise. [7]

The BHMAR work discovered how dynamic the river aquifer-recharge relationship is at Menindee – a banker flow is required to remove a sealing clay layer from the aquifer recharge path, then river water rapidly recharges the aquifer.

6 Peter Dillon: MAR sundry texts

7 This system has been successfully pioneered in the WesternVictoria Wimmera-Mallee pipeline grid.

Since prior hydrology work shows the Peel river loses stream from the river to the aquifer for most of its upper length, transfer of water from the Peel to its alluvial aquifer is well proven. What is not known, is whether we can modify this transfer in desired ways. This requires some experimental work with low level weirs, pulse flow regimes from Chaffey Dam, and *shepherd aquifers*[8].

Why is NSW not at the forefront of MAR installations?
Recent events in NSW suggest there is an absence of aquifer recharge experience in NSW, and a cultural confusion, between active and passive ASR and MAR, expensive and cheap water. There has not been sufficient numbers and variety of Aquifer Recharge projects in NSW for civil engineers and councils to become familiar with the potential of Aquifer Recharge. Peter Dillon, author of reference works on Aquifer Recharge for the UN, identified a key factor in adoption of new technology such as MAR- sufficient small "pilot installations" to get people hands-on experience with aquifer recharge. A lack of such pilot projects could be rectified, starting with Tamworth.

A common assumption seems to be that city style use of bore injection technology (as per Salisbury South Australia, and Perth Western Australia), is needed to provide water to cities. This is not so, with both Broken Hill and Tamworth, relying on treatment of river water as part of their main water supplies. That river water, provided it is clean, can be the same as agricultural water, and just as cheap.

Starting with a well managed, clean river system, if we could exchange water safely with the riverine aquifers, and use both waters intelligently, we could have the best of both surface and underground supplies. This does in fact seem possible, using concepts from Menindee, the Barkindji tribe of the Darling, the Burdekin aquifer recharge example, and shepherd aquifers.

Sustainable Diversion Limits of Riverine Aquifers (SDLs)
Tamworth is about twice the size of Broken Hill, with different hydrology contexts, however a close scrutiny of events at Menindee is well worthwhile. Tamworth can learn from the BHMAR how not to achieve successful on-ground cutting edge, new water installations. With care, we could implement a sensible Natural Aquifer Recharge project, based on new knowledge and tools. In my view, we need to work with nature via augmented Natural Aquifer Recharge from the river to and from the aquifers, thereby removing costs of water treatment and bore injection methods as fixed installation costs.

The Broken Hill Managed Aquifer Recharge project discovered a surprising level of river-bank Natural Aquifer Recharge ("NAR")) along the Darling River. This was such that the prior assumed level of Sustainable Diversion Limit ("SDL") for the riverine alluvial aquifer in use by the Murray Darling Basin Commission (MDBA) was shown to be 99% wrong.

Only around 1% of the alluvial aquifer water recharged came from dryland rainfall, with the rest coming from "banker flow" or flood flow river recharge (and only in some circumstances). Whilst the Peel River is not a scroll-plain river like the Darling, it does have extensive riverine alluvial aquifers and very high delivery losses from Chaffey Dam (around 50% loss)- these can safely be assumed to involve major natural aquifer recharge losses from the river surface flows.

At Menindee Lakes, the water supply for Broken Hill, was explored with a model using expensive city-style bore injection and recovery. This was based on an assumption that upstream storage in

8 *Shepherd Aquifer :* an aquifer used to buffer the river and other aquifers see Part 2 of the writer's submission: *https://www.parliament.nsw.gov.au/committees/inquiries/Pages/inquiry-details.aspx?pk=2390#tab-submissions*

aquifers would need a pipeline to deliver the water in times of drought. This assumption was false, as water can be delivered via the river, however a pulse-flow regime is required in drought. "Pulse flow" delivery of water using a river is a proven method of downstream water delivery (with caveats[9]). If the 50% losses from Chaffey Dam to Tamworth delivery are substantially river flow to the aquifers, this may be altered with pulse flow regimes transferring water to local storage (above and below ground), at Tamworth.

Pulse flow water delivery to Passive Riverine Aquifer Recharge around Tamworth
The current Tamworth Weir is too small to practically allow the above strategy. A series of small weirs downstream however, linked to riverine aquifers by augmented NAR methods using shepherd aquifers, holds potential for new efficiencies in water storage.

Newly enabled recycling of water, enhanced surface water stores near Tamworth, and drought proofed storage with low evaporation losses are all likely outcomes. There is insufficient current numerical data to model the process accurately, since a comprehensive hydrological process such as the BHMAR has not been performed for Tamworth (nor is it proposed herein).

BRIEF QUANTITATIVE ESTIMATION: (these figures are for illustration)
The riverine alluvial aquifer along the reach from Tamworth to Somerton is about 1 to 3 km wide, 5 to 15 metres thick, and 30km long (sundry NSW DPR and NSW OOW data)[10]. This yields a raw aquifer volume of between 1*5*30 km.km.cum or 150,000,000 cubic metres or 150 Gigalitres at minimum. At maximum a figure can be derived of 3*15*30km.km.cum or 1,350,000,000 cubic metres or 1,350 Gigalitres .

The porosity or amount of water stored per unit volume can be somewhere between 10 to 25%. Applying this to the above, we get a total water storage raw capacity of a minimum 0.10 * 150 = 15Gigalitres. A maximum figure can be derived of : 0.25*1,350= 337.5 with 20% pump down limit providing 337.5*0.20 = 67.5GL. We can translate this to a range of somewhere between 1.5 to 67.5 GL per 30km of river, or ***0.1 to 2.25 Gigalitres of useable alluvial aquifer storage per Km of river bed (within the above assumed figures).***

Assuming we can pump this down, and readily recharge it from river flows, to a maximum of 10-20% of the total storage in a drought, we have a potential minimum storage of 1 to 22.5 Gigalitres per 10km of river. This might be useful if implementation is cheap, dependant on associated benefits (eg enabling a pulse flow regime recovery from Chaffey Dam *without* a new pipeline).

Model Errors
The above crude analysis yields a very large estimates range and this *reflects the low accuracy of complex models openly allowing for error*. Each error estimate must be propagated throughout the model to arrive at a final figure. This is why we use modern methods of hydrology to attempt to measure the size of an underground water resource, and why the BHMAR research project occurred in order to test new mapping.

Geoscience Australia embarked on the most comprehensive data gathering practical in 2011-2013, to map the underground water at Menindee. This in my view, was a *scientific success* but a total *implementation failure*. Not one litre of usable water has been delivered to Broken Hill, from the project's 160 odd bores, intensive electromagnetic surveying, water analyses, and around $30 million spent.

9 Keeping the bed of the river hydrated with small regular flows may be a mandatory need
10 Peel Valley Catchment Groundwater Status Report – 2010

The BHMAR project lacked early implementation of *pilot installations* to yield comparative cost data. The NSW government was then faced with an expensive choice with no price data on eventual cost per megalitre of delivered water. The water was salt-affected, requiring reverse osmosis water treatment to be fit for use. Lack of fresh water river flow meant that the cheaper options to remove salt from the aquifers over time, were not considered. (Passive River bed aquifer recharge would have a 5 to 20 year time-frame for aquifer salt removal and did not meet the 2 year time-frame).

A balanced MAR strategy at Tamworth

Tamworth does not have the luxury of spending millions on detailed hydrological research, but it does have a need to make sensible economic choices to best utilise the water resources it has. Therefore there is a need to use sufficient hydrological data such as an Airborne Electromagnetic Mapping, together with selected pilot bore drilling, to derive reasonably accurate water body sizing to decide on major action. At a minimum, bores drilled downstream along the alluvial aquifer, can be linked from Tamworth NorthWest, to increase Tamworth's drought emergency borefield supply without any new hydro-geological data.

If strategically sited, around ten bores drilled in a grid, each 2-500 metres along the river, will yield further hydrological data during river recharge, and pump-down behaviours (dynamic borefield behaviour). A borefield, sited by currently known hydro-geology, could extend Tamworth's water supplies by 5* 0.1 to 2.25 or 0.5 to 11 Gigalitres. (Using the 0.1 to 2.25 Gigalitres of useable alluvial aquifer storage per Km of river bed derived above)

Taking this data, we could now consider where to place a series of small weirs(with fish ladders) or shepherd aquifer bores, that utilize natural aquifer recharge , via the riverbank and bed into a storage aquifer. Recharging the aquifer from pulse-released water from Chaffey Dam in drought without any further water treatment, would change the choices of management available to increase water use efficiency.

Turning our attention to upstream river losses, it is likely that much of this is aquifer recharge, not evaporation. Implementation of a pulse-flow regime from Chaffey Dam to underground storage near Tamworth, taken with currently available stream gauging, and bore level monitoring, would enable more accurate knowledge of real world behaviour of the river .

If we have some early success with a small pilot project of 10 bores, and small weir, we could extend the practice downstream towards Somerton.

Siting of Weirs, Bores and riverside shepherd aquifers.

The BHMAR research suggests *weir siting may be critical* . Upstream from Tamworth, to improve delivery efficiencies, we may need to place weirs (if any) at sites where the river is "gaining stream" from aquifers, to minimise losses from river to aquifer. Downstream from Tamworth, we are likely to site weirs where the river is "losing stream" to aquifers, to enable recharge of aquifers useful for drought town water supplies.

The balance and siting of weirs and bores for the overall system efficiencies, would best be guided by detailed modeling based on field data from bores and AEM mapping, modifying currently known desk-top models and assumptions. Siting alone is not sufficient for the most efficient practices, as the BHMAR showed that flow regimes also can radically affect aquifer recharge from the river. This insight from the BHMAR research into how complex interaction between river and aquifer is, and we can expect different behaviour along the Peel.

Submission
In the context of Tamworth's growth, Chaffey Dam's unsolved delivery loss problem, and need for future drought water security, I suggest that a Federally funded feasibility study into a small pilot installations that actually provide water for the town, should proceed for the Peel Alluvial Aquifer, near Tamworth.

I further submit that extensive hydrogeological mapping is not essential, and some new water knowledge produced from such an installation would emerge. A minimal airborne AEM mapping would be preferable for water mass balance estimations.

Accurate water body estimation from actual bore behaviour, would lead to a pipeline grid connection to an alluvial borefield downstream to Tamworth, if the resource is proven. The lessons from Menindee Lakes need to be heeded, and all of Federal State and Local governments need to cooperatively embrace such a project together. The BHMAR research has become an orphan research, not yet yielding successful field installations, due to multiple factors. Successfully using the technology at Tamworth along the Peel River, would be a good outcome from the BHMAR insights.

Conclusion
A proactive Federal Water and Resources Minister, can change the failure of the BHMAR to deliver working water reform installations on the ground, but probably not at Menindee. If such a project at Tamworth proceeds, a sound defense against challenges of "Pork Barrelling" is referral to the $30 million wasted on the BHMAR to date, and the need to build on this research by small experimental pilot projects that will yield new data. These are $30 million reasons to test the insights from the BHMAR elsewhere. A pre-requisite open cooperation from all three tiers of government would be a good start.

Insufficient time existed at Menindee to integrate new knowledge from the BHMAR research, into an urgent government decision with a restricted time frame. This was a genuine failure of governance, deserving of a more sensible pragmatic approach to water in the bush. A more balanced approach is to both install some useful infrastructure initially, that will yield more data for a future expanded effort – this is the model I suggest would suit Tamworth.

A joint venture between Tamworth City Council, the NSW Government, and Federal Governments, would be the best foundation for a successful outcome.

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----------QUOTES
http://www.mdba.gov.au/discover-basin/catchments/namoi
"The Basin Plan allows for adjustments to SDLs if new works or changes in river operation and management rules increase the quantity of water available to be extracted; or efficiency measures through infrastructure works and upgrades reduce the quantity of water required in a delivery system."

"Groundwater extractions and/or entitlements determined by the Basin Plan mostly matched the sustainable diversion limit set for the Namoi Alluvium groundwater unit west of Narrabri and therefore there were no reductions in groundwater extraction required. Much of the central and western catchment is over the NSW Great Artesian Basin Shallow groundwater unit, where groundwater extractions and/or entitlements were considerably less than the sustainable diversion

limit set for the unit. In the east, groundwater is extracted from the aquifers and alluvial sediment at rates that are considered sustainable."
COMMENT:
This is based on SDL models that are likely inaccurate for scroll-plain rivers with significant alluvial aquifers (BHMAR). Exploration of different rivers with similar technology to the BHMAR project would be required for accurate quantity surveys. The SDLs for borefield extraction and recharge then need to be water level driven not model driven.
. . . .
"The Basin Plan allows for adjustments to SDLs if new works or changes in river operation and management rules increase the quantity of water available to be extracted; or efficiency measures through infrastructure works and upgrades reduce the quantity of water required in a delivery system.
COMMENT if new science arises the MDB must adjust its operations- it has not yet done so.

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https://fieldcapture.ala.org.au/project/index/29f72cd1-7b26-4202-ac55-ece86abdf209
Tamworth - Peel River/Wallamore anabranch riparian revegetation
"This project will implement on-farm native revegetation to improve riparian biodiversity and habitat connectivity along more than 9 km of mainly cleared riparian land of the Peel River and its Wallamore anabranch near Tamworth, NSW. Project works will be completed via collaboration between Landcare Australia, North West Local Land Services (LLS), Wallamore Landcare Group, Lion Dairy and Drinks and local landholders as part of a larger initiative to address severe erosion impacts. This 20M trees project will assist the rehabilitation of degraded River Red Gum/River Oak riverine open forests leading to improved habitat connectivity, reduced sediment loads entering the waterway, bank stabilisation, reduced weeds and enhanced aquatic habitat.

COMMENT: An NAR project for Tamworth would markedly increase the diversity of choices available for riparian restoration, if suitably managed.

" 3.5. Costs of rural infiltration basins
For other forms of MAR, such as infiltration ponds and soil aquifer treatment, that are practised in rural settings it is expected that costs would be substantially lower than the ASR costs above. For example, in the Burdekin Delta, two infiltration basins that recharge a total of 5000ML/yr were constructed in the 1970s at current equivalent capital costs of $2.1M and current operation and maintenance costs of $85,000 per year. Levelised costs incurred by North Burdekin Water Board, using 7% discount rate and estimated asset lives, are 5c/kL recharged. Estimated costs to irrigators for pumping from high yielding pumps with low lifts is 2c/kL so that the whole recharge and recovery system cost is 7c/kL. " *Managed aquifer recharge, February 2009 Peter Dillon et al.*

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A thesis submitted for the degree of Doctor of Philosophy Of the Australian National University

Peel Valley Catchment Groundwater Status Report – 2010 Publisher NSW Office of Water

Water Sharing Plan Peel Valley regulated, unregulated, alluvial and fractured rock water sources Background document – 2010 Publisher NSW Office of Water

Water Sharing Plan for the Peel Valley regulated, unregulated, alluvial and fractured rock water sources: Guide June 2010

Water resources and management overview Namoi catchment - NSW Office of Water
" The NSW Office of Water has 54 monitoring bores in the Peel Alluvium, most of which were installed in the year 2000 (NOW 2010)"

Integrating groundwater and surface water management in Australia,
National Water Commission 2014, NWC, Canberra

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