ARY VAN DER LELY'S LIFE WORK PROJECTS

HINDSIGHT OVERVIEW

This folder contains about 55 files of significant work I have been involved in. They represent several key work areas, including water and salt movement in soils, hydrology in horticulture and rice, land and water management plans, soil salinity surveys and miscellaneous involvements. It is a lot of reading so I produced a separate file with context summaries, to facilitate the choice of file anyone may want to read. Below is an overview of the main topics.

Another context is the work done by many colleagues in the department I was working for, the CSIRO and other departments in both NSW and Victoria. The people referred to had other insights and involvements; it must not be assumed that the reports I produced were all there was to it. Much of their work no doubt was superior to mine. However, it is probably true that in the MIA I often was in the box seat.

Having decided on a career in Land and Water Management in Tropical Regions I arrived in Australia on 21 March 1969, working in the MIA. My first main task was to "find criteria for guidelines to determine the suitability of land for rice growing", but I soon also became responsible for many other hydrological issues cropping up in an irrigation area where over-irrigation had not yet been overcome. It evolved from there, until my retirement in 2001, after which I had a consulting and private role up until 2013.

There is no claim it is worthwhile to read any of the reports to help solve current issues. My hindsight look seems to reveal much of the work I have done is no longer relevant. There may be one or two exceptions (e.g. the 2013 Model report). Climate change has reduced rainfall and there is competition by more users and especially the environment since the 2005 MDBA Plan. The irrigation industry has restructured and there is the effect of the MDBA plan of 2004. Water tables have dropped a lot since 2001 (when I retired) and salinity no longer seems a problem into the future. On the other hand, I think I have produced a few insights which may be useful to know about, if only for historical reasons. Some ideas may have value in a different context. So, who knows? Times have changed and may change again.

Rice Environmental Management

High water use in rice depends on the permeability of the soils used, so infiltration experiments in rice fields representing different stratigraphical conditions were the key to developing initial guidelines. This was moderately successful but farms with high water use kept being found and water tables kept rising in the MIA and Coleambally. The expansion of the rice industry over about 20 years was unstoppable as it was profitable and water plentiful until the mid-1990s. The Land and Water Management Plans did not incorporate the possibility that rice growing would be reduced. As it turned out, that (massive) reduction in fact solved the problem of possible salinity risk.

In high water table areas rice percolation is much smaller and the potential for groundwater movement from rice to adjacent areas a key consideration. How much is this movement and what proportion of land should be the maximum grown to rice? This new emphasis resulted in significant work based on field investigations and modelling. It produced new criteria for rice growing controls. By 1986 the expansion of rice was still continuing and the only way to restrain it were control options based on environmental criteria (salinity risk). The rice industry agreed to the new criteria. The recommendation, supported by CSIRO work in 1992, was that no more than 25% be used for rice; the industry agreed to 30%. On that basis I felt that rice growing in rotation with other crops had become a sustainable proposition.

Key Report: 1988 – Environmental Management – Rice growing controls

Soil Water Movement

To evaluate issues on a regional scale you need to build up an understanding of the processes on the smaller scales, like the soil profile above the water table. Apart from reliance on literature a series of projects were undertaken as well, such as the study of in situ water movement in swelling clays used for rice growing, lysimeter experiments at CSIRO, and a drum experiment to study soil moisture loss from high water table conditions by vapour movement and evaporation, and other studies.

Sub-Surface Drainage Schemes

Tile Drainage in horticulture around Griffith had become popular before I came to Australia and criteria had been developed in the 1950's. My work considered the variation of hydraulic conductivity within soil types and what this meant in terms of recommendations re tile spacing and depth in terms of over or under drainage. It was a review including non-steady criteria instead of the steady state assumptions previously made.

Vertical Drainage of horticultural land occurred in the Leeton area and this provided an opportunity to study the behaviour of the various tube wells against the theory of pump testing, the well efficiency factor and effectiveness in general.

Key Report: 1977. Artificial Subsurface Drainage in NSW

Vertical drainage by tube wells in horticultural areas was important in the Yanco area, and in 1979 this was extended into large area farms. The sub-surface drainage requirements of such lands became an important issue as so much land had developed high groundwater at the time and the salinity risk seemed significant. It was found quickly however that groundwater pumping would produce too large a salt load, deleterious for downstream areas such as the Wah Wah District, and this practice was abandoned.

However, after a study trip in 1983 to the USA (see report) the idea took hold that the feasibility of integrated surface and subsurface drainage schemes including evaporation areas needed to be investigated. This occupied the mind for some ten years. Evaporation area disposal was considered. Experimental sub-surface drainage on four large area farms was undertaken to develop design criteria. Several reports were produced (these did not become part of this list due to poor dot matrix print quality). Horizontal and vertical drainage options in large area farms including disposal to evaporation areas became part of the Land and Water Management Plans evaluation but in the end not adopted. The CSIRO conducted a project into the design of disposal basins for horticultural development on large area farms.

<u>Key Report: 1994 Water Control Options in the MIA</u>

Water and Salt Balances

The Benerembah Surface Drainage Scheme required the development of a Water and Salt Balance of the supply and drainage system as part of its EIS. How much extra drainage may be expected, what are the salt loads? The MIA drainage system is complex with many sources of salt load, which all had to be quantified and evaluated, with Barren Box Swamp being the en-route storage to the Wah Wah District. A comprehensive monthly spreadsheet over 12 years of data became the basis of this assessment.

<u>Key report: 1992 MIA Water and Salt Balance</u>

After privatisation of the MIA and the implementation of the Murray Darling Agreement of 2004 Murrumbidgee Irrigation started a program of refurbishment of the irrigation system, involving a reshaped Barren Box Swamp, new structures, Doppler water meters, and seepage reduction works. Historical losses totalling in the order of 150-180 GL/year were reduced. Farmers implemented on-farm works freeing up allocation. For the subsidies received to achieve these reductions some of the savings had to be handed to the Commonwealth for their environmental flow objectives. A water sales program allowed others inside and outside the MIA to use the saved, not handed over, water. This became important for the development of new industries, cotton and almonds. The volumes involved are not known by this author. However, as he was involved with preparation of historical data, for instance a detailed loss assessment for a reworked average, median and low usage year, this data may still be useful for auditing purposes, or just historical interest.

<u>Key report: 1998 MIA Loss Assessment</u>

Coleambally Groundwater and LWMP

The alarming rise of groundwater in the Coleambally area resulted in thoughts of how it affected salt movement down the profile and regional deep groundwater, which is used as a resource for irrigation. The hydrology was studied on a regular basis. In the end the effect on deep groundwater was not considered highly significant.

The Coleambally Land and Water Management plan was developed along similar principles as the MIA plan (see below), with No Plan and With Plan scenarios and economics analysis. The future soil salinity was estimated from models linking to the extent of estimated future groundwater levels. The development of regional options and their pros and cons were evaluated. The economics was by optimisation using multiple factor analysis. The local committee discussed and modified the theoretical results somewhat to make a plausible final plan, which was adopted about 1996.

Key Report: 1994 CIA Regional Options Report

MIA Land and Water Management Plan

For the MIA LWMP the work on Water Table Control options (1994) was a basis for regional options evaluation. The regional and sub-district groundwater balances were estimated from field data. Benefits of options relate to how much each option contributed to reductions in recharge to the groundwater system and hence to the soil salinity prediction curves into the future. The benefits and costs of all options were quantified on a per unit basis and a No Plan and With Plan scenario was developed. An optimisation model was used to figure out what combination of options would produce the targets of a desired outcome, which was an acceptable proportion of the landscape salinized to some extent.

The whole process was considered hugely beneficial as, whilst the agencies provided the expertise, the landholders had the final say as to how the ultimate plans would look like. The interaction with the landholders of the LWMP committee was very rewarding (as it was for the Coleambally Plan).

Key Report: 1995 Development of Preferred Plan Scenario

Other Land and Water Management Plans

Involvement included the Jemalong area, Coleambally Outfall Drain and other LWMPs on a lesser or more significant level. Several reports, of which Jemalong soil salinity evaluation is the most significant, followed by the Murray Valley Districts groundwater assessment, show some of the contributions I made, mostly in groundwater aspects evaluation.

Soil Salinity Trends Assessment and Salinity Surveys

The status of soil salinity on a district scale and its rate of worsening over time is an important issue you need to know about if you want to develop options for a Land and Water Management Plan. Methods were developed to assess this. A district and sub-district wide survey became a basis for this evaluation. Correlations between their average soil salinity and how long water tables had been high were established and used for the predictions. This resulted in soil salinity prediction curves linked to groundwater conditions. In hindsight the rate of increase probably was somewhat over-estimated as the oldest such sub-districts (Yenda, Bilbul) probably had an inherent salinity which was not due to the developing high ground water table conditions, which by the time of the survey had lasted for 50 years already. Despite this, the methodology used a field derived, reasonably sound dataset based on actual physical conditions for the assessments, unlike in for instance the Murray Region where consultants used much cruder (over-) estimations. Some of the relevant reports are under the heading MIA LWMP.

Key Report: 1994 MIA Water Table Control Options

Salinity surveys using the EM technique were also carried out on a farm scale. Following the LWMP implementation soil salinity surveys were carried out using a specific strategy on a regional scale.

Key Reports: 1998 and 2002 CIA and MIA Soil Salinity Survey reports

MIA Annual Groundwater Reports

This series of reports shows groundwater behaviour due to all contributing factors after a Water Use Efficiency monitoring program collecting crop statistics was introduced about 2000 by Murrumbidgee Irrigation. Spreadsheets were developed to optimise the predicted and observed behaviour against factors such as weather, rice areas, areas winter and summer crops, and water use. The repetition of annual analysis of the data resulted in improvement of the methods of analysis, so towards the end of 2000-2011 the technique became more and more perfected. The average groundwater behaviour in sub-districts and the MIA as a whole was estimated from all factors using multiple factor analysis. The principle is that the variation is due to the total recharge and total discharge which would have contributed to the change over every six months between readings. The data gave for each factor a known input value. In the model a coefficient was used on these quantities to optimise the optimal combination of factors contributing to the average. All coefficients were of course constrained within limits to produce plausible values overall.

The process was aided significantly by the fact there was less irrigation in the drought of 2001-2008, giving more variable numbers over the period for factors such as area of rice over the duration of the dataset. It made the coefficients for each factor in the prediction more reliable.

The standard error of the prediction was a few centimetres groundwater height only. The process was repeated for the MIA as a whole and also for sub-districts, the latter with a lesser degree of predictability.

The method allowed predictions as to what would happen to groundwater levels if rice of other cropping was introduced again on a larger or lesser scale. The model became one of the three models discussed in the section below.

Key Report: 2011 MIA Annual Groundwater Report.

Groundwater Models

a) Wakool Model

The analytical model used to simulate groundwater movement from a rice field to adjacent land was also useful to simulate the seepage effect of the Wakool Subsurface Drainage Scheme to adjacent farms. When an adjacent landholder sued the Department for this alleged consequence I was nominated to put together a model which could demonstrate the true nature of the seepage problem. Interacting with hydrogeologist experts, the use of a numerical model was decided upon, including the seepage from the ponds, the effect of an interceptor drain, two tube wells installed to lower groundwater levels on the farm, the rice growing on the farm and weather factors over 12 years. It turned out to be the most challenging project of my career.

I had help from a couple of Sydney based hydrogeologist experts, but I had to put it all together, including some tricky issues in the model, which was written in QuickBasic, the only language I understood. The computer was and IBM AT, primitive by today's standards. I struggled for a month or two. Then, on 26 January 1988, when Bob Hawke and the Queen were having fun at the Sydney Opera House (Australia 200 years), I finally found a break-through of the development of the coding needed. It did me proud; the court case was won by the Department after Coffey Partners, consultants for the plaintiff agreed that the results of the model were credible. There was some seepage in a small area but the tube wells provided sufficient protection.

Key Report: 1988 Wakool Sub-surface Drainage Scheme – Models to Estimate Seepage from Evaporation area study.

b) Integrated Irrigation Impact Assessment Model

In 1999 I visited Xin Jiang Province in China for a consultancy on behalf of the Department. My work there was a evaluate a local model to assess soil salinity risk. It seemed to have potential for the MIA so privately I started to develop its ideas after my retirement in 2001. I was encouraged as MI was engaging me as a consultant to interpret its groundwater and crop water use data for the annual report. These data and the work I had already done gave me the incentive to develop a similar model for the MIA .

Key Report: 1999 Groundwater Model for the Kaidu and Kongque River Systems

From 2003 to 2011 the CSIRO, for Murrumbidgee Irrigation, was also developing models to describe groundwater and salt movement across the whole region. When this effort eventually, in 2011, was concluded to have failed, I continued with my methodologies, resulting in a three-model approach.
1. A stratigraphical model showed the location of shallow aquifers across the region, including transmissivities and hydraulic conductivity.
2. A groundwater behaviour model based on crop, weather and irrigation data, as described above for the Annual Groundwater reports.
3. A soil salinity model, for a single paddock surrounded by other land predicting trends for specific stratigraphical conditions, inputs for crop rotations over 15 years, soils, climatic, conditions in the adjacent field and other data.

These three models are separate, however the groundwater model and the soil salinity model each link via the stratigraphical model, so the use of for instance the soil salinity model can be tailored to suit a local condition. The combination allows groundwater interpretation on a sub-regional scale and soil salinity on a paddock scale.

The salinity model has never been tested in a field situation but it was most pleasing that the outputs are very credible. The effect of adjacent paddock groundwater conditions are shown to be important.

Key Report: 2013: Integrated Irrigation Impact Model for the MIA

Dryland Salinity

My last year in Wagga Wagga allowed me to study the behaviour of groundwater underneath the hilly landscapes of the Riverina, including the effect of discharge to streams and recharge from rainfall. It resulted in a report on response times, how quickly the systems react. A second study was a reference to the MIA and CIA LWMPs, with No Plan and Plan scenarios. Forestry options may slow groundwater mound development and its benefit could be assessed based on several assumptions made. It is noted the report was found credible by the local economist, but the technical staff in Parramatta did not accept the findings. They probably had their own axes to grind.

Key Report: 2001: Response Times of Groundwater Systems in Dryland Salinity

FURTHER COMMENT

1. Was It Worthwhile?

When reflecting on all the reports written it is difficult to escape the notion that very few if any still have a lot of relevance today. The concepts were sound at the time, the work reasonably innovative, quite smart solutions were fabricated, but it was all in the context of irrigation areas with high groundwater levels, and a risk of salinity existing. All of this seems to have disappeared after 2001, the onset of a drought, followed by a few years of normal conditions and another drought at the moment. Water allocations are unlikely to ever hit the 120% again, as was the case very often before 1990. Climate change is here.

If this is true the more than 50 reports can only be seen in a historical context. What were the conditions, then, what were the concerns, what were the perceived solutions? There are many data contained within the reports, they may be of passing interest. Problems are now different, objectives have changed.

It is almost as if the 1969 to 2001 period was some kind of time bubble. Everything is different now, the weather, the water allocations, the crops grown, and the attitude towards irrigation. What happened twenty to fifty years ago looks like an aberration compared to the constraints of the present, it looks like a sinful past.

Yet from my more human viewpoint I disagree with this conclusion. You live when you live and you deal with the issues as they come up then. To foresee the changes that have happened was possible, but you would have been such a minority that nobody would have taken notice; you would be ostracised. Therefore, there are no regrets on my part.

2. How Good was the Work Done?

I have often reflected on this. I was happy with the Wakool model work and still am pleased about the three-part Integrated model. For the most part this sentiment applies to all reports. It is acknowledged some reports are not really good at all, some were poorly reproduced (dot matrix printers, carbon copy only, etc). I was more a hydrologist or engineer than a scientist. I did compromise on methods and took short cuts from time to time. It was in my training to "work with the oars you have got" in areas with few resources, produce practical results (too quickly?). The rice soil profile criteria for instance were just the best achievable, some soil types just cannot be captured for that purpose by texture alone. To assess sodicity for every soil sample was not possible. In the LWMPs there was a probable over-estimation of the No Plan scenario risk due to the methodology used and the interpretation of the soil salinity survey data versus depth of groundwater. A real scientist may have hesitated to produce anything at all; an engineer does not say "No" so easily.

Some of the conference papers I contributed were just that – contributions rather than proper scientifically researched papers. However, I did communicate with peers and followed the best path available in most situations.

3. What is Regrettable?

Water management in NSW seems to have changed into some directions which appear not to have been optimal in some respects.

In 1969 farmers had a cheap water right, augmented by additional water at a higher cost. The Crown owned the water, there were only diversion rights.

In 1982 a volumetric allocation scheme was introduced. The mistake was that the allocations were based on the volumes of the highest users, for instance in the MIA 12 ML/ha for horticulture whilst citrus needed about 8 Ml/ha, grape vines less. The price set became more expensive for the first part and cheaper for the rest, good for financial management but bad as an incentive towards conservation or the environmental consequences.

The rice industry kept expanding in the 1980's when allocation often were above 100% (max 120%). The river environment still seemed to get plenty. The Murrumbidgee did not have a required bottom end flow volume (unlike the Murray R.). Perhaps motivated by these factors, the WRC Licencing Branch kept issuing new licences. Sleeper licences along the river nobody thought would be ever used became active. Groundwater use near Darlington Point was encouraged (the hydrogeologists concluded there was plenty), but twenty years later one started to wonder whether the resource was not being over-exploited.

Water became privately owned in the early 1990's, without any cost to the landholders. I guess the privatisation of the irrigation areas was on the menu. Until that time any unused water would stay in the dams, perhaps being a benefit to the environment eventually. Then trading became possible as a means of making sure more of the (sometimes not used) allocations to irrigators was likely to be used somewhere else for a profit. This is all reasonable from the rational economist point of view. This became more so after inter valley trading was introduced. Competition to get hold of the resource and use as much as possible of it became the mantra. This meant less was left over for the environment, which had no fixed allocation at all.

In the 1990's there was also the 10% runoff farm dam policy, the Snowy River diversion decision restoring its flows, and increased planting of pine plantations in the upper catchment, all resulting in less runoff into the Murrumbidgee. Gradually the competition for the water resource became such that less water remained for the environment. Nevertheless, until the early 1990's there were quite a few floods in the Murrumbidgee and the environment did not really suffer until after 1995 (except for the carp issue and the seasonal timing of dam releases).

The Murray Darling Basin Plan was introduced in 2004. This scheme seems to have allowed a lot more investment in infrastructure in the irrigation area (and outside) by both MI and individual farmers, allowing significant efficiencies. Despite many dry years and water buy backs by the government, the still available allocations and water trading somehow allowed other developments, such as cotton, walnuts and almonds in and outside the irrigation area. The combined investments in irrigation channels, structures and works is huge relative to the water available as climate change is taking hold of Australia. I wonder whether a situation has been reached in which now both the environment and the irrigation community won't get enough water often enough.

It was the lack of restraint on water allocations which resulted in large rice areas, high water tables, lots of investigations, a great need for the LWMP salinity risk assessment, and all the work I ended up doing. I did not foresee the current situation and kept the wheel oiled by coming up with solutions and evaluations and reports prior to 2001, when I retired. Funny thing is though; I enjoyed it whilst it was all happening.

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