The Lower Burdekin Initiative: An industry/science partnership to facilitate improved water management

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Abstract

The lower Burdekin is a highly productive irrigation area producing some of the highest yields and highest quality sugarcane in Australia. It is also an area experiencing pressures to expand its irrigation and agricultural activities, and there is concern about the potential long-term impacts of current, changed, and new land and water management practices. These issues are being addressed through the Lower Burdekin Initiative (LBI), which has brought a range of organisations together in an industry/science partnership to address current and future water needs of the lower Burdekin. The initial focus has been on developing a framework to help identify key issues and knowledge gaps, and on better integrating the water related research in moving towards a more coherent understanding of how the whole system functions.

In this paper we highlight some of the challenges involved in developing the LBI, including the need for effective collaboration based on good communication and trust, abilities to deal with and communicate about sensitive issues, and improved understanding of the tensions between scientific rigor and industry relevance. To succeed all partners must develop improved capacity and understanding of the issues involved, so that the real pressure points are identified and efforts focussed on the causes rather than the symptoms. There are currently more than twelve activities addressing different aspects of irrigation and water related management within the lower Burdekin and we highlight specific progress with some of these activities.

Keywords: industry/science partnership, systems analysis, field scale water balance, irrigation, water management, recycling, 'water spreading'

Introduction

As water continues to gain as the major issue dominating every aspect of the global economy (social, economic and environmental), so too does the need to improve our understanding and management of water and the role it plays in the overall economy of the lower Burdekin. This region, which is one of Queenslands premier irrigation areas, has a reputation for producing some of the highest yields and highest quality sugarcane in Australia. It is situated in the dry tropics on the northeast coast of Queensland, Australia, approximately 90 kilometres southeast of Townsville (Figure 1). It has some 80,000 ha of irrigated sugarcane and other crops and is therefore dependent on access to large quantities of good quality water. There are currently three different 'zones' in the lower Burdekin, with water managed by three different organisations (Figure 1).

The Burdekin River Irrigation area (the BRIA), which is managed by SunWater, lies mainly to the north and west of the Burdekin River and stretches from inland of Clare

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down through Giru towards the coast. The BRIA, underlain to a significant extent by relatively shallow groundwater systems, has seen some changes in recent times in terms of the management of the Groundwater systems. Corporatisation of SunWater has seen responsibility for day-to-day management of the groundwater systems deemed to be the responsibility of the Queensland Department of Natural Resources and Mines (NR&M) as part of an arrangement wherein SunWater has retained control only where works had been specifically provided for artificial recharge of the groundwater system. As such NR&M is co-ordinating plans to address water level rise in parts of the BRIA.

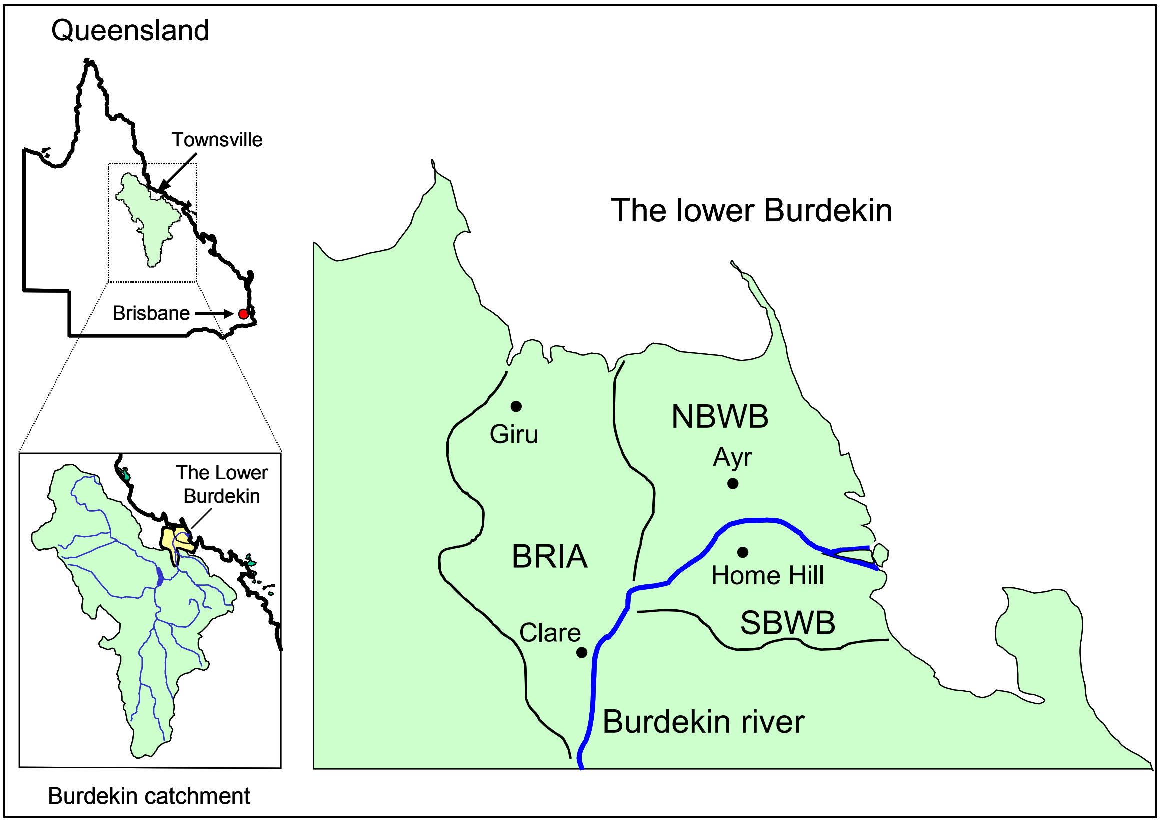

Figure 1: Locality map showing the lower Burdekin and indicative areas associated with the Burdekin River Irrigation Area (BRIA), North Burdekin Water Board (NBWB) and South Burdekin Water Board (SBWB)

Nearly all of the remaining irrigated area falls within the Burdekin delta system, which lies closer to the coast on both the north and south side of the Burdekin River. These areas are managed by the North and South Burdekin Water Boards, respectively, which are autonomous Boards independently funded by the industry. The delta is unique in that (1) it overlies shallow major groundwater supplies and relies heavily on these supplies for irrigation water, (2) it is situated in close proximity to environmentally sensitive wetlands, waterways, estuaries, and the Great Barrier Reef, and (3) water pricing and water management practices have evolved in response to local needs. Most irrigation water supplies are drawn by bores from the groundwater systems. While there is currently minimal direct metering of bores in this area the Water Boards maintain a close check on water level and quality trends in the Delta. Details of the Burdekin delta system and operations of the two Water Boards are described by Bristow et al. (2000) and McMahon et al. (2000). While the Delta groundwater systems are connected to the BRIA aquifers it is not yet certain just how strong this link is.

As in all other parts of the world irrigation in the lower Burdekin has come under increasing scrutiny as governments, environmentalists and other community groups have questioned the way water is allocated and managed, and in some cases increased pressure to make changes to current practices. In order to respond to these pressures, and if need be to make changes, requires that we fully understand all aspects of water and water use in the lower Burdekin. The Lower Burdekin Initiative (LBI) has brought a range of organisations together in an industry/science partnership to address these issues, which are multi-faceted and complex, and beyond the capability of one organisation, or discipline, or individual. In this paper we review some of the key issues being addressed through the LBI.

Key water and irrigation issues faced within the lower Burdekin

When contemplating making changes to the way water is managed in the lower Burdekin it is essential that we take a systems approach to water resources and water management, and be fully aware of and understand the interconnectedness of the various water balance components (flows and storages). Considerable effort has and is going into developing this understanding, and Figure 2 summarises many of the key factors and issues identified so far as being critically important. Depending on which area within the lower Burdekin one is dealing with, these include water quality, rising ground waters, salinity, nutrient leaching, groundwater pollution, falling water tables (groundwater depletion), and salt-water intrusion, amongst others.

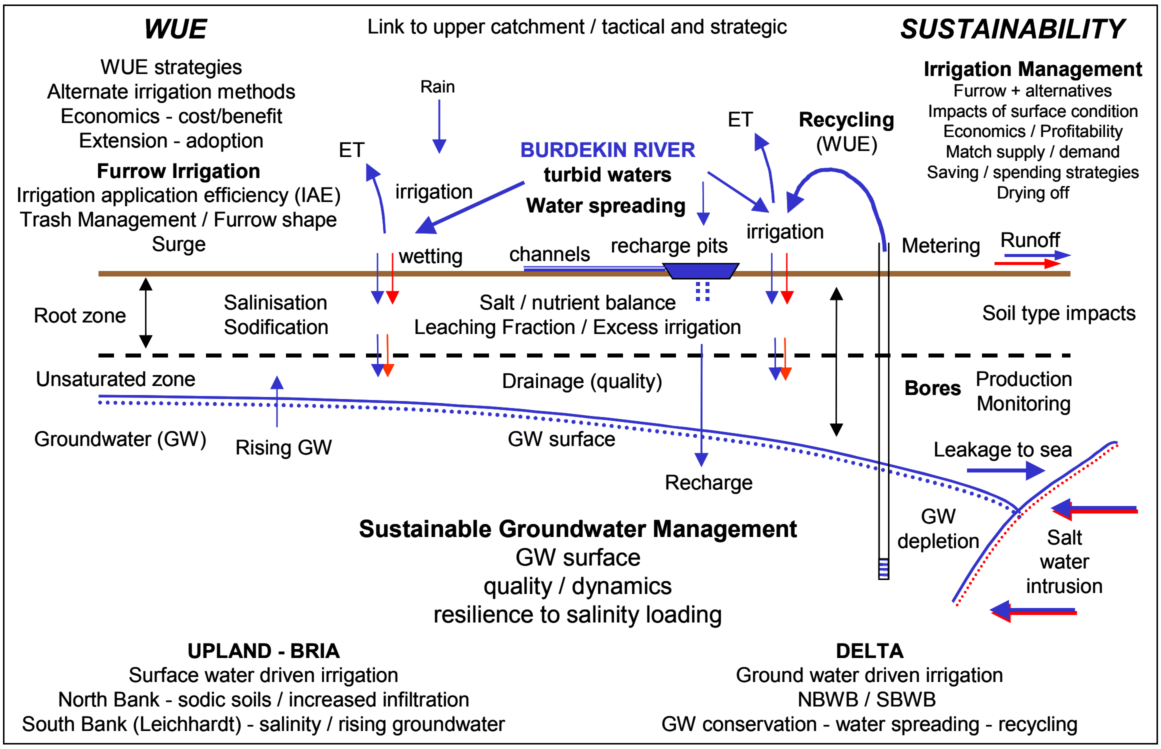

Figure 2: Schematic showing interconnectedness of water balance terms and key issues to be addressed when assessing water resources and water management in the lower Burdekin

Improved water use efficiency (WUE) and sustainability are clearly key drivers, but here too progress is needed in terms of just what this means. Do we mean improved

WUE on a particular paddock, or for the scheme as a whole ? Are they one and the same thing ? If something works in one region will it work in a nearby region with different soils and crops ? If we talk about sustainability, what is the time period we are interested in ? When addressing these issues a key aim is to assess the likely impacts of maintaining the status quo, or of implementing changes at the farm and/or scheme level. If making changes we need to avoid shifting problems from one area to another, or generating different and maybe worse problems because we have not fully explored the impact and flow-on effects of changes we think need to be made. Development and application of appropriate modeling tools and scenario analysis will clearly be important in tackling these issues and currently are receiving considerable attention by various organisations involved in the LBI. This includes development of, and where possible, coupling of biophysical and economic models (eg Qureshi et al. 2001). The aim is to design economically viable solutions and practical management practices that are suited to the different areas, but that together lead to improvements in the lower Burdekin (and catchment) as a whole.

Salinity is a key issue associated with sustainability of irrigation schemes, and it should be noted that there are different causes of salinity, each requiring different management techniques. Dryland salinity in the upper catchment affects the water supply coming down the Burdekin River and ultimately the quality of water available for irrigation. Irrigation is by default a ‘concentrating’ process and demands that considerable effort go into understanding and managing the water and salt balance associated with the different soils and water qualities available for irrigation. The third form of salinity that must be addressed is that associated with salt-water intrusion. This is particularly important in the lower Burdekin because of its proximity to the ocean, the dependence on groundwater supplies for irrigation, and the very small change in elevation across the delta. This can make it difficult to maintain adequate groundwater levels to ensure the salt-water wedge is subjected to a sufficient pressure head to prevent it moving inland. Threats of salt-water intrusion could be one of the major issues faced by the lower Burdekin.

As mentioned above, irrigation is a concentrating process and the leaching fraction (LF) concept has been developed to help address this by managing the salt balance within the root zone. However, if inappropriately applied the LF could be one of the main reasons causing rising groundwaters in many irrigated areas, as the inclusion of LF’s can lead to large quantities of water draining below the root zone. This water is usually not considered ‘wasted water’, and there is currently discussion as to whether this additional water applied for deliberate leaching of salts should be considered as “irrigation water beneficially applied” (Barrett Purcell and Associates, 1999). Based on this, LF’s are thought to be of benefit at the farm enterprise level. What has not been adequately addressed when applying LF’s is the effect the ‘excess irrigation’ may have on leaching of soil applied nutrients and chemicals, and the potential on- and off-site effects such as pollution of ground and surface waters. The impacts on the broader groundwater systems and potential for causing rising water tables have also not been adequately considered and these issues warrant much greater attention than they have received to date.

Given the potential problems associated with LF’s perhaps the whole concept needs rethinking, at least in those situations with questionable soils and geohydrology. Would it not be better to match irrigation with plant needs and rely on rainfall and inevitable inefficiencies in irrigation management to ensure a net downward movement of salts out of the root zone. If irrigation water quality is such that salt accumulation still occurs, then it suggests that irrigation will not be sustainable unless adequate subsurface drainage and appropriate management of the drainage waters are implemented. The choice therefore seems to be between careful scheduling with no specific LF or application of a LF and implementation of proper management of the deep drainage. Either way it is important that the irrigation be properly scheduled, and to achieve this scheme water must be available to each irrigation field as and when it is needed.

The LF concept also provides an interesting contrast with water and irrigation management practices that have evolved in the Burdekin delta, which are described in detail by Bristow et al. (2000). These practices include 'recycling' and 'water spreading', both of which can result in excess irrigation. This excess irrigation is viewed by some as part of the groundwater replenishment program and hence as positive, but by others as 'wasted water' because it is not used by the plants, and hence as negative. Perhaps this excess irrigation, which results in high water contents in the unsaturated zone, helps maintain an effective connectivity between the soil surface and underlying aquifer. If this is the case then perhaps it underpins the overall recharge of the aquifers by facilitating distributed replenishment, which could be more effective in managing regional groundwater levels than the point replenishment from relatively few scattered recharge pits and canals. Ensuring effective recharge of the aquifers and maintenance of appropriate groundwater levels is essential to prevent inland migration of the salt-water wedge. One wonders therefore if this excess irrigation should also be viewed as "irrigation water beneficially applied", but in this case mainly for the benefit of the scheme (the groundwater reservoir) rather than the individual farm. Gaining a better understanding of these issues is part of the current LBI efforts.

While implementing various management strategies to deal with the water associated with excess irrigation may be feasible, what is probably more important to consider is the potential long-term impact excess irrigation may have on soil applied nutrients and chemicals. It might also mean that much more effort needs to go into understanding and managing soil applied nutrients and chemicals, particularly within a systems framework that properly accounts for the impacts irrigation has on the storage and transport of nutrients and chemicals in different soils. Here again it will be important to move beyond simple individual aspects (such as the behaviour of an individual chemical species under steady state and constant temperature conditions) and learn how to deal with the interactions and function of the system as a whole.

This is clearly not a simple task, but all that has been covered above highlights the need for every irrigation system to plan for and manage the water, nutrients and chemicals that are likely to move out of the root zone, either as surface runoff or deep drainage. What is clear from the above is that while we 'understand' particular features of irrigation, we still do not fully understand how to put it all together so that we can optimise irrigation performance in different areas. We must make progress with this to ensure we get the system as a whole to work in an economically viable and sustainable way.

Industry / Science partnership to improve water management

The LBI was established in response to community concerns about the long-term sustainability of current management practices and apparent duplication and fragmentation of the research effort addressing these issues. Many community, industry, regulatory, research, and environmental groups have an interest in a variety of issues in the lower Burdekin and harnessing these groups efforts has enormous benefits in sharing of information and skills. However, this is not a simple task and requires a gradual change in trust levels among the many diverse groups, and in so doing building a better understanding of their different motives and drivers. Such relationship building is essential to improve communication and effectiveness, especially between traditionally antagonistic groups who in the past have often used the media as the main form of engagement.

When considering the roles of the various industry, community, and science groups involved, there are three conditions that need to be met to realise the benefits of effective collaboration. These are i) the groups involved should appreciate the value in sharing resources and data, the skill base of other groups, and that the result of integration is greater than the sum of the individual parts, ii) the existence of a high level of trust that every group is both competent and focussed on the overall goal, and iii) the maximum amount of data and knowledge is made available to all bodies and debated in an honest and vigorous way.

The challenge to integration is that when transcending group boundaries, for example the industry – research boundary, both groups usually have limited understanding of each other's expertise and motivation and this can lead to seeming incompatibility. For instance, industry usually wants rapid answers to its real or perceived problems to enable timely incorporation of improved processes and methods. The emphasis is on quick solutions that have a high likelihood of leading to improvements. On occasion, the timescales used may mean important consequences of these expected solutions have not been adequately considered. Conversely, the researchers quest is usually to understand as much as possible about the problem or system being addressed. The motivation being that such understanding could lead to a package of highly robust solutions with clear connection not only to the initial question, but also to other associated questions. The main limitation of this approach is that the time required to gain this knowledge is often too slow to meet immediate industry requirements. It also assumes that complete understanding and hence prescriptive solutions are possible in natural systems with high degrees of complexity, something that is probably highly unlikely. The LBI has charged the research groups with the timely delivery of practical solutions (Haigh, 2001).

In today's political climate funding for research (eg Natural Heritage Trust) is being increasingly directed through community groups such as the Burdekin-Bowen Integrated Floodplain Management Advisory Committee (BBIFMAC). While these groups are well suited to identifying some areas that require attention (needs analysis), their understanding of the research methods for addressing these may in some cases be limited. Here again lies a challenge to true collaboration, since for the community to play an effective role in the research it needs reasonable knowledge of the methods employed.

Studies of these issues have suggested that all groups need extra skills, and that when developing the participatory framework such as that adopted in the LBI, energy needs to be invested in capacity building (Walker et al, 2001). The diagram given in Figure 3 describes the process involved in addressing research needs in a collaborative manner, and shows the need for iteration in the needs analysis process following wider consultation with other groups. This will ultimately lead to a set of objectives and research methods that all groups both endorse and understand, with the ultimate goal of increased ownership of research outcomes and wider adoption. The process should encourage the incorporation of all data, assumptions, and uncertainty judgements into the needs analysis/research method decision. Continuous evaluation of the collaborative process is required to ensure the overall objective is still relevant and is being met, and several different strategies are being attempted within the LBI in an effort to achieve this.

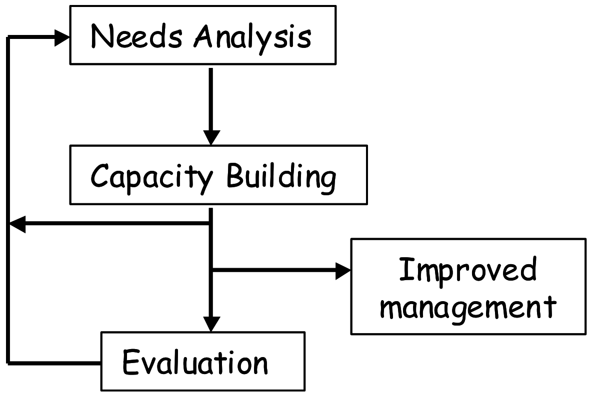

Figure 3: Key steps in the collaborative process (adapted from Walker et al, 2001)

Progress with the LBI

There has been considerable progress with the LBI over the last two years as evidenced by the increased number of people and organisations expressing interest in being involved and joining in the overall effort. The first coordination meeting held early 2000 attracted some 20 people from 10 different organisations. By contrast the second major coordination meeting held early 2001 attracted some 50 people from 30 different organisations.

There are currently more than 12 major activities involved with the LBI and these are summarised in Table 1.

Table 1: Summary of activities involved with the LBI. Some of the key organisations and funding bodies involved are identified in parentheses

1.	Delta groundwater model (Water Boards / DNRN)
2.	Nitrogen balance and Nitrates in groundwater (CSIRO / SRDC)
3.	Linking on-farm practices and groundwater quality (CSIRO / BSES / NPIRD / RWUE R&D)
4.	On-farm management practices and their impacts on WUE (BSES / CSIRO / RWUE R&D / NPIRD)
5.	Making best use of limited water supplies (CSIRO / SRDC / RWUE)
6.	Adoption of improved on-farm practices (BSES / RWUE Adoption program)
7.	Economic evaluation of alternative irrigation practices (CRC Sugar / CSIRO / BSES)
8.	Soil mapping to assist with site specific management issues and 'scaling up' of research findings (DNR / RWUE / NHT / CSIRO / CRC Sugar)
9.	Surface runoff quality (CRC Sugar / DNRM / CSIRO)
10.	Surface water quality in the Burdekin (ACTFR)
11.	Finfish and nutrient management (DPI Fisheries / Water Boards / Burdekin Shire Council)
12.	Monitoring landuse impacts on the marine environment (GBRMPA)
13.	Others + External partners . . . .

Although the activities given in Table 1 cover a broad range of issues, there has been substantial improvement in communication between staff from the different activities and more sharing of field sites, resources and data. This we are sure is leading to improved return on efforts invested. It is certainly helping generate improved debate about the various issues involved, and hopefully through this process fostering improved understanding of the whole system by a wider range of partners. Additional details about the individual activities can be obtained from the LBI web site http://www.tvl.qld.csiro.au/_pub/burdekininitiative/ and the contacts listed on the web site.

There are now also 8 key field sites established across the Delta that are enabling more detailed study of the field water balance associated with different irrigation management practices on a range of soil types. When installation has been completed instrumentation of the sites will vary from basic metering of applied water and surface runoff, to detailed measurement of all water balance components, including the quantity and quality of deep drainage. These latter terms and knowledge of water extracted from the aquifers are still the least understood of all, and yet are some of the more important in terms of progressing understanding and modeling of the groundwater systems. Both the R&D and Extension arms of the Queensland RWUE Initiative will also use these field sites, one of the main aims of this work being to analyse impacts of changed management practices on the overall water balance.

An example of recent water balance data from some of the more fully instrumented field sites are provided in Figure 4. Site K has low permeability sandy clay to medium clay soil, while site H has a highly permeable sandy loam soil. At site K surface runoff was roughly 30% of irrigation while deep drainage was roughly 50% of irrigation. At site H surface runoff was zero while deep drainage was roughly 80% of irrigation. Crop water use was roughly 800 mm at each site. While these data cover only part of the 2000/2001 crop season, they do demonstrate the differences in irrigation that can occur within the Delta. Modeling and scenario analysis will be used to assist with interpretation and extrapolation of these and other experimental results obtained within the LBI, so that potential long-term impacts of current and changed management practices can be explored.

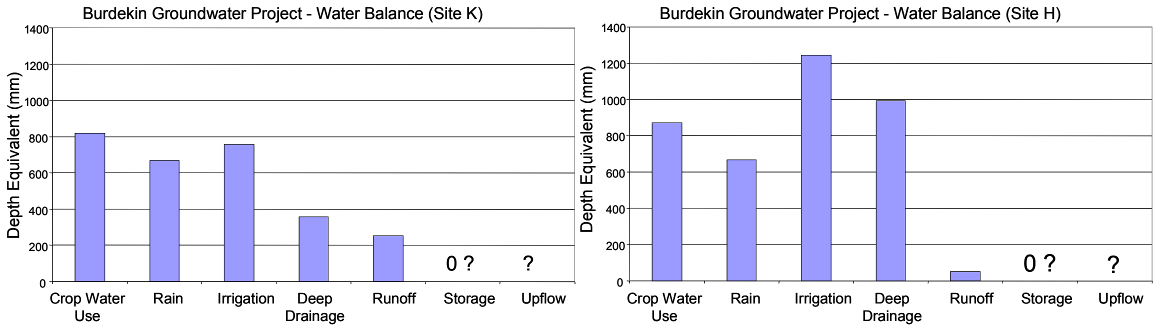

Figure 4: Water balance data from two of the more fully instrumented field sites. Site K has low permeability sandy clay to medium clay soil, while site H has a highly permeable sandy loam soil

Efforts are now also underway to review data coming from the lower Burdekin so that we can learn from what is available, and if need be change and/or improve the monitoring systems to obtain the required data. Of critical importance are the bore data, which provide information about the health of the groundwater systems and the location of the salt-water wedge. They will also play an increasingly important role as the groundwater models move from the development to application phase. Examples of bore data from the BRIA and Delta regions are provided in Figure 5 and Figure 6, respectively, and illustrate some interesting differences that need to be understood and acted on.

The BRIA data in Figure 5 show water levels and conductivity from 1973 to late 2000, the striking feature being the gradual increase in water level and conductivity with time. The water levels varied by less that 4 m between 1973 and about 1987, and appear to reflect the general trend in rainfall, which was relatively high through to 1981, and then relatively low through to 1987. After this point however there is a rapid increase in water levels, a stabilisation through the very dry period from 1993 to 1996, and then a gradual increase again through to the present. The onset of the increasing trend also coincides with the availability of more surface water in the late 1980's following completion of the Burdekin dam. Salinity has also shown a significant increase in this time, from less than 1000 µS/cm to around 2500 µS/cm in 2000. These trends must obviously not be allowed to continue and will require implementation of more appropriate management practices.

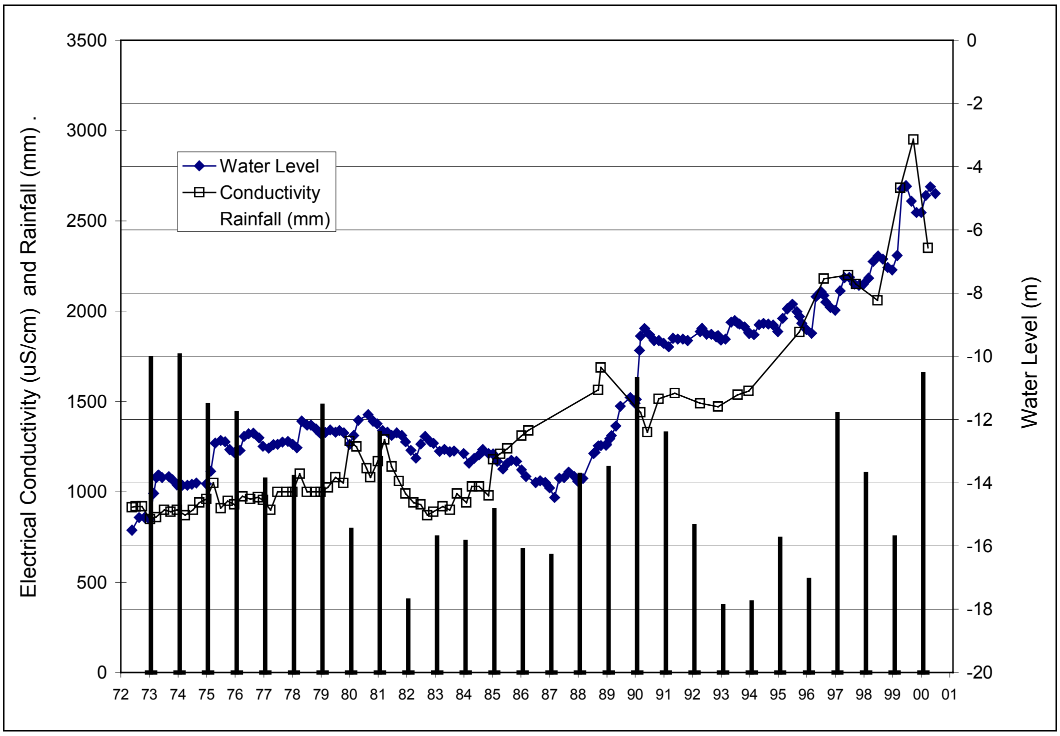

Figure 5: Water level and electrical conductivity of a representative bore in the BRIA from 1973 to 2000. Annual rainfall is included.

The Delta data in Figure 6, which covers a longer time period than in Figure 5, show water levels and conductivity from 1963 to late 2000. The striking feature about these data is the responsiveness of the groundwater levels to rainfall, the clear seasonal variation, and the rapid increase in salinity to very high levels above 6000 µS/cm that is then followed by a gradual decrease to around 1500 µS/cm at present. Note that there was a very dry spell in the early 1960's that resulted in rapid declines in water levels in many parts of the Delta. The Water Boards were established in the mid 1960's in response to these declining water levels and tasked to manage replenishment of the groundwaters (see Bristow et al. 2000 for details). It is clear that the water levels have certainly not been that low again, at least for this bore. One also wonders if the replenishment programs instituted by the Water Boards have played a role in the marked decrease in salinity since the late 1960's. Over the last few years water level data have shown strong seasonal variations, and a gradual increase no doubt in response to the recent run of fairly wet years.

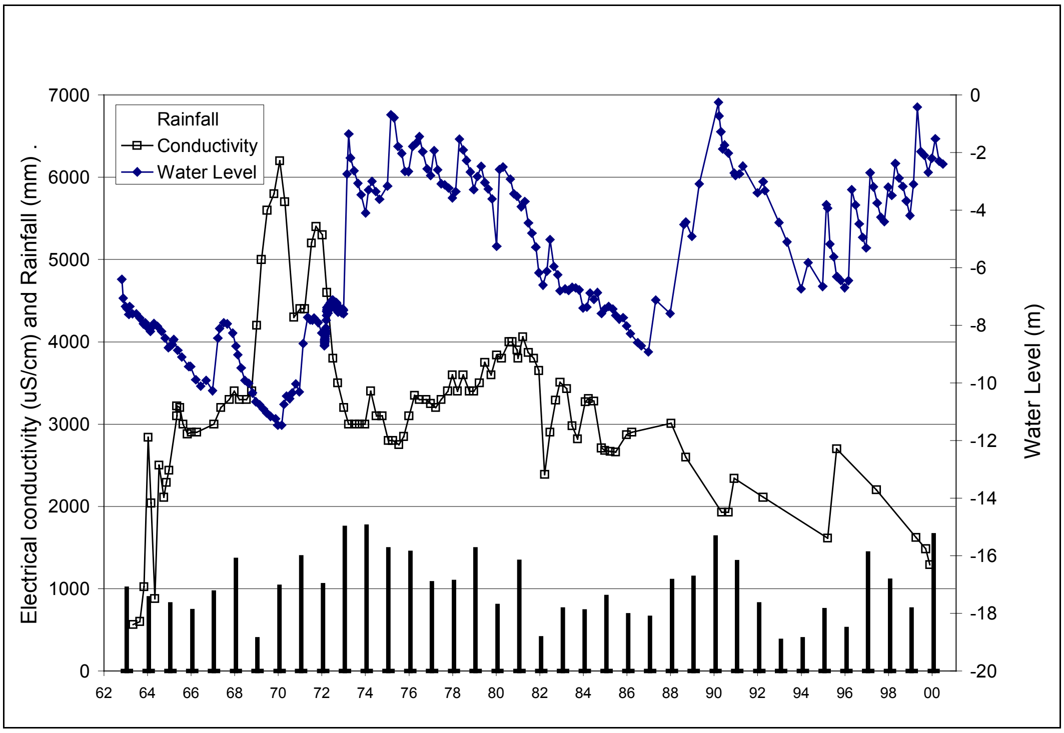

Figure 6: Water level and electrical conductivity of a representative bore in the Delta from 1963 to 2000. Annual rainfall is included.

The key point about these bore data is that they contain a wealth of information and if carefully analysed and properly understood, should be of help when tailoring specific solutions for specific regions. They also emphasise the need to monitor both the water and salt levels as they can behave very differently. In reality we should probably also be monitoring a range of other nutrients and chemicals in order to gain a better understanding of the true health of the groundwater systems.

The above efforts are also being supported by NR&M who are working towards development of ground and surface water models that in time will be linked to provide an overall resource assessment and management tool. The aim in developing these tools is to ensure water dependent ecosystems are maintained in good order whilst providing certainty for water use entitlements, and where possible future allocations. NR&M have also recently completed the Burdekin River Catchment Study that will provide input to the Water Resource Plan on potential development scenarios to be evaluated in the Plan. This planning will attempt to address and resolve competing interests between up valley users as well as users in the lower Burdekin, taking account of the social and environmental needs of the Burdekin river system.

In addition to the above, all Queensland Local Governments are required to have Integrated Planning Act compliant planning schemes in place by March 2003. These planning schemes will provide for State interests in Local decision-making and help ensure sustainability issues are addressed at the local level, particularly in relation to proposals for new developments. The data and knowledge generated by the LBI will we hope provide much of the scientific understanding needed to underpin these important planning exercises and ultimately implementation of best management practices. The long-term well being of the lower Burdekin economy (including all social, economic and environmental aspects) will depend on us making progress with these issues, and especially with appropriate long-term management of the groundwater systems.

Acknowledgements: There are clearly many individuals and organisations involved in the Lower Burdekin Initiative and we acknowledge their ongoing input into the search for long-term social, economic and environmental sustainability of the lower Burdekin.

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