

Associated Off-Farm Economic Values of Saving Water and Restoring Pressure in the Great Artesian Basin



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Executive Summary

The Great Artesian Basin (GAB) is a resource that yields both public and private benefits to society. To address high rates of water usage and wastage, the Commonwealth and State governments introduced a Great Artesian Basin Sustainability Initiative, with phase 1 between 1999 and 2004, phase 2 between 2004 and 2009, and Phase 3 still to be agreed. The analysis provided in this report has focused on identifying and valuing the non-farm benefits associated with the GABSI. There are several key conclusions to be drawn from the work.

1. There is a range of different benefits associated with the improved management of the GAB. These benefits span a number of different issues, covering economic, environmental and social interests.
2. The benefits of improved management will accrue to both land managers (on-farm benefits) and other groups in society (off-farm benefits). Most on-farm benefits, such as improved stock water access and reduced mustering costs, are direct use benefits. There are three broad categories of off-farm benefits:
 - a. Direct use benefits, such as those enjoyed by recreation users,
 - b. Indirect use benefits, such as a potential reduction in greenhouse gas emissions and
 - c. Non-use benefits, particularly those relating to protecting the asset, maintaining ecological and biodiversity assets, and maintaining cultural heritage.
3. There are four main groups in society who enjoy the benefits of improving the management of the GAB:
 - a. Land managers, who can gain additional direct production benefits,
 - b. Residents in the GAB, who can enjoy the direct, indirect and non-use benefits involved,
 - c. Visitors to the GAB who can enjoy recreation benefits,
 - d. Other people in Australia who may have significant non-use values for continued protection of GAB assets.
4. An economic framework is appropriate to evaluate whether the investment of public funding in the bore capping program is justified. The appropriate test is that the public investment contributes to net social benefit.
5. It is expected that the level of private benefits will be larger than the level of private costs involved. Some level of net private benefit is required to generate landholder involvement, and may be a necessary engagement cost for the program.
6. To ensure there are overall net benefits, the off-farm benefits should also exceed the off-farm costs involved, with the latter almost exclusively comprised of public investment in the program. Under this approach, the assessment framework can be narrowed to a test of

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whether the public investment is generating enough off-farm benefits for the program to pass a benefit cost test.

7. The key categories of off-farm benefits associated with the protection of the GAB can be summarised as follows:
 - Direct use values for recreation and tourism
 - Option values (maintaining the asset for future use and non-use purposes by avoiding excessive use and wastage)
 - Biodiversity protection values (incorporating quasi-option, bequest and existence values) for both native biodiversity and the removal of weeds and pests.
 - Cultural heritage protection values for both aboriginal and early settlement interests
 - Ecosystem services for reduction in greenhouse gas emissions
8. Most or many of these benefits are not traded or costed in traditional markets, so non-market valuation techniques are needed to assess values. No valuation studies directly relevant to the GAB could be found.
9. A benefit transfer process has been used to evaluate similar non-market valuation exercises and to extrapolate values to the GAB case study. A limited number of other source studies has been identified that provides some indication of potential values for non-farm benefits. Key categories and estimates of benefits are shown as follows:

| Valuation issue | Estimated annual value |
|---|--|
| Direct use values for recreation and tourism | At least \$0.5 Million per annum |
| Option values (for both future use and non-use purposes) | Some subset of \$100 Million per annum (likely to be less than \$20 Million per annum) |
| Biodiversity protection values for native biodiversity | Some subset of \$123.6 Million per annum (likely to be less than \$41M per annum) for 12 major spring groups of unique ecosystems, plus \$5.8 Million per annum for one endangered species |
| Biodiversity protection values for removal of pests and weeds | Value included in estimates of biodiversity benefits |
| Cultural heritage protection values | Significant, but lack of data does not allow assessment |
| Ecosystem services: reduction in greenhouse gas emissions | Approximately \$1.14 Million per annum in cost reductions to meet emission targets if the reduction in greenhouse emissions is accounted for in national targets and trading caps. |

10. The non-farm benefits of improving the management of the GAB may be as high as approximately \$68 Million per annum, but the deficiency of suitable primary studies in the benefit transfer exercise means that this estimate has to be treated with caution.
11. The only approach to achieving more accurate assessments of the non-market values associated with off-farm costs and benefits would be to undertake a dedicated study on the region.
12. A number of knowledge gaps have been identified as a part of this study. These occur in two main groups:

Gaps in technical knowledge about management impacts

- Net savings in extractions from GAB after any extra extractions for mining or other new developments have been considered
- Number, expenditure and duration of tourism visits to GAB sites, and relationship between visitation and site condition,
- Predicted improvements in biodiversity outcomes from improving water pressure
- Predicted improvements in the control of weeds and pests from the reduction in bore drains and the subsequent benefits on biodiversity.

Gaps in knowledge about values of management impacts

- Values for changes to the GAB as a whole,
 - Values for changes in components of GAB (recreation, artesian springs, wetlands, endangered species)
 - Influence of any special or iconic status on values,
 - How values may be sensitive to the quantity of environmental benefits involved, and
 - How values vary by population group (e.g. GAB population, tourists, state populations, national population).
13. Any consideration of further investment in GABSI would benefit from appropriate studies to address technical gaps in knowledge and non-market valuation studies to estimate values of off-farm benefits in key categories.

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1. Introduction

The Great Artesian Basin (GAB) is one of Australia's most significant and well known natural resources, being an underground water 'reservoir' underlying approximately one-fifth of the continent (GABCC 1998). The GAB is significant to Australia in a number of ways, contributing to the economies of pastoral, tourism and mining industries, providing water to communities and townships, supporting important environmental assets, and underpinning aboriginal cultural heritage and Australian settlement heritage legacies.

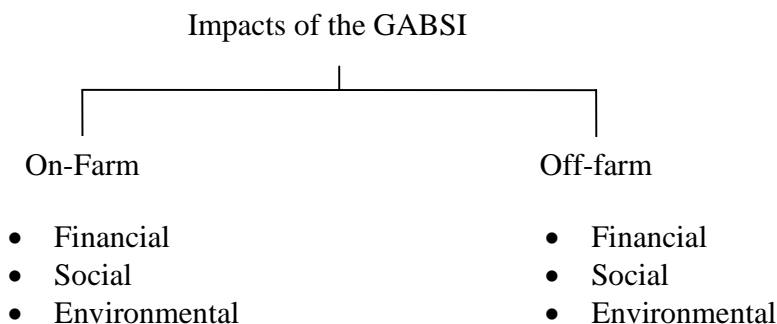
The groundwater reserves in the GAB have been accessed by European settlers since the 1880s, with significant subsequent development for pastoral, infrastructure and mining purposes. The development has not been without its environmental costs, with falling pressure to springs and increased weeds and pests among some of the outcomes. Concerns about the environmental impacts and the on-going viability of extractions led to the introduction of a coordinated bore capping program in 1999, called the Great Artesian Basin Sustainability Initiative (GABSI), with funding requirements shared between the Commonwealth, States and individual property owners.

In Phase 1 of the GABSI, the Commonwealth and States contributed \$56.8 Million (\$64 Million in 2007 dollars) to the program, with 270 uncontrolled bores rehabilitated and approximately 8,000 kilometres of bore drain deleted (SKM 2008). The program was subsequently extended in 2004 in a second round of funding to 2009. Proposed expenditure in Phase 2 of the GABSI (from 2004 to 2009) is \$77.3 Million, with the program approximately two-thirds complete in November 2007 (SKM 2008). A third round of the program from 2010 – 2014 is being considered by governments, with funding allocations likely to exceed support provided in Phase 2 (SKM 2008).

An important aspect of public investment in programs such as the GABSI is to review the success of past investments and to justify future ones. Cost benefit analysis provides the standard economic framework for evaluating the net benefits to society of programs where there may be varying impacts on different groups and a range of production, social and environmental outcomes to consider. Within the cost benefit analysis framework it is appropriate to consider both the financial costs and benefits that may be involved with the bore capping program as well as non-financial outcomes such as improvements to environmental and cultural heritage assets. A summary of the classification of both financial and non-financial costs and benefits associated with the GABSI and included in a cost-benefit analysis program is provided in Figure 1.

The application of economic analysis to the GABSI is hindered by several gaps in knowledge about the different benefits and costs involved. Financial costs are relatively easy to assess as the contributions made by the Australian Government, State Governments and landholders are reasonably transparent. The on-farm financial benefits, such as reduced mustering costs, accrue to landholders but are more difficult to evaluate because of confounding with other operational issues. There may also be on-farm social and environmental benefits associated with the program which can be expected to impact on the willingness of landholders to participate in bore capping projects.

Figure 1: On-farm and off-farm impacts from the GABSI



The most important information gaps relate to the off-farm benefits that may be generated from the GABSI, particularly those relating to non-financial social and environmental impacts. There are likely to be significant community values associated with improved protection and enhancement of environmental, cultural heritage and recreation assets, even though they may not be directly used by all community members. While there are non-market valuation techniques available that can assess such values, no case studies focused on the GAB have been performed as yet. However, some inferences about community values can be made by reviewing other non-market valuation studies in related areas. Off-farm financial benefits to industries such as tourism should also be assessed and considered in any evaluation of net benefits.

The focus of this report is on the off-farm economic values associated with the bore capping program in the Great Artesian Basin. There are three main objectives to be addressed in the report. The first is to outline the economic concepts and framework relevant to values for protecting the Great Artesian Basin. The second is to collate information from a desktop review of off-farm economic values for the GAB in order to provide estimates of off-farm values of saving water and restoring pressure in the GAB. The third is to identify, from this information, where major gaps exist in available knowledge about off-farm values.

This report is structured in five key parts. First, an overview of the GAB and the GABSI is provided (Chapter 2). Second, the conceptual framework used for the project is established (Chapter 3). This involves introducing the concept of non-market valuation within the overall framework of an economic analysis, providing brief descriptions of key non-market valuation techniques, and identifying other key concepts. In Chapter 4, this information is applied to the case study to identify a framework for analysis. In Chapter 5, a desktop review of non-market valuation studies that are relevant to the non-farm benefits of the bore capping program is provided. Chapter 6 follows with an application of the benefit transfer process and a summary of both off-farm values and key information gaps. A brief conclusion completes the report.

2. The Great Artesian Basin

The GAB (Figure 1) underlies most of Queensland and parts of New South Wales, South Australia and the Northern Territory, covering 1.7 million km² of largely arid and semi-arid regions west of the Great Dividing Range (GABCC 1998). Most water enters the basin in recharge zones along the western side of the Great Dividing Range, on the eastern margin of the basin. The groundwater then flows mainly south-west and westward at a rate of between 1 to 5 metres per year (Ponder 2004), with the age of some groundwater estimated at close to 2 million years (GABCC 1998). The GAB consists of several sub-basins, including the Eromonga, Surat and Carpentaria basins, and a number of vertically sequential sandstone aquifers laid down through four main geological cycles (GABCC 1998). The geology and associated hydrogeology of the basin creates variation in the artesian aquifers and associated surface features across the basin.

Key environmental and cultural heritage benefits of the GAB are provided by artesian springs, where water moving through the aquifer discharges to the surface through faults in the strata or exposed parts of the aquifer. Before the 1880s, there were more than 3000 springs in about 600 groups, including thirteen major complexes (GABCC 1998, Ponder 2004). The most notable occur along the south-western arc of the basin in South Australia from Marree to north of Oodnadatta, including the Dalhousie springs in the Witjira National Park. Some springs are notable as mound springs, where accumulated sediments and carbonate spring deposits over many thousands of years have created small mesas up to 40 metres higher than the surrounding landscape (GABCC 1998). Total discharge from the GAB, excluding the Cape York group, is estimated at 50,000 ML/annum, with the Dalhousie group accounting for about 40% of discharge (GABCC 1998).

As many artesian springs occur on the western side of the GAB in arid regions, they provide important biological refuges and are rich in endemic flora and fauna (Ponder 1986, Noble et al. 1998, Ponder 2004, Fensham and Fairfax 2003). These include fish such as the Elizabeth Springs Goby (*Chlamydogobious micropterus*) and the Edgbaston goby (*Chlamydogobious spp.*), and a number of plants. There is a distinctive fauna associated with each major spring group (Ponder 1986, 2004). Historically the springs were an important part of aboriginal cultural heritage, and although they were not permanently occupied, usage may date back 30,000 years (GABCC 1998). Many springs were also an important part of early pastoral settlement patterns in areas suited to cattle or sheep and aided in the development of communication and infrastructure.

Figure 2: Great Artesian Basin (Sourced from DEWHA, Australian Government)

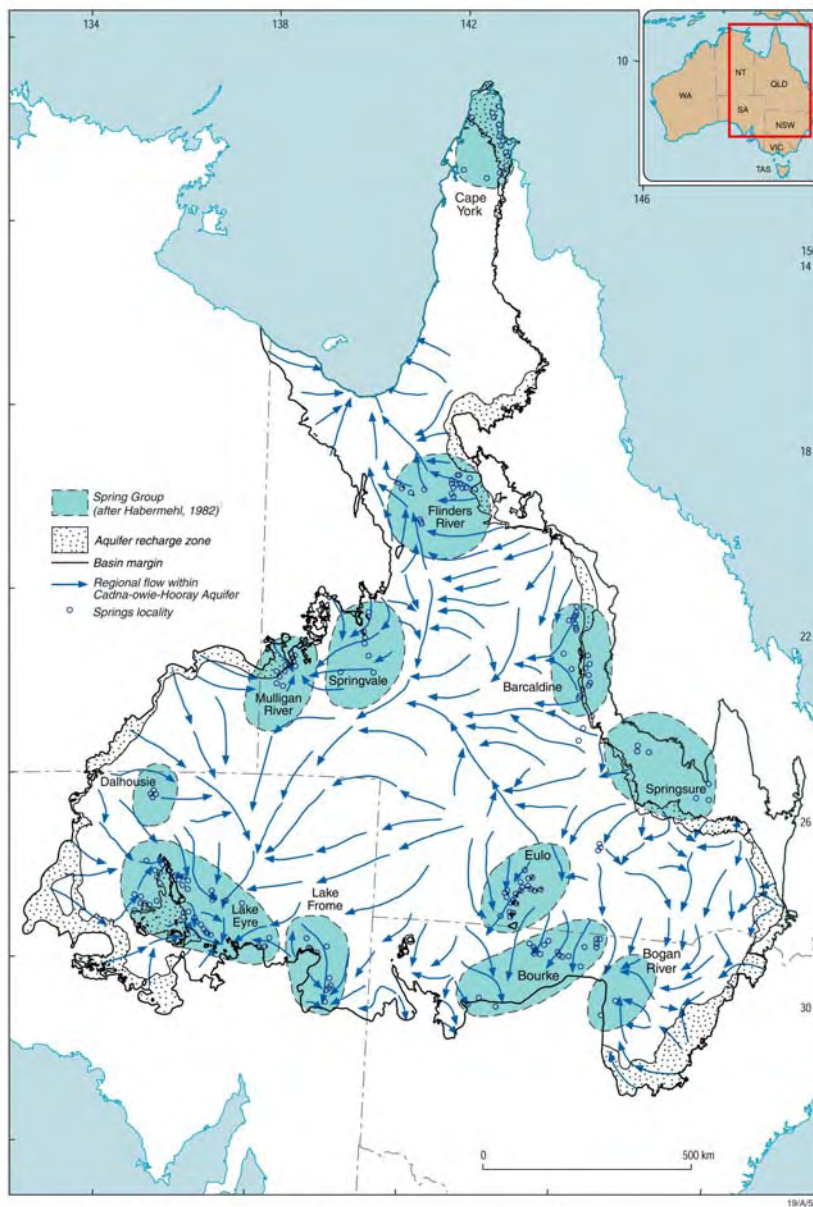


Figure 12. Recharge areas of the Cadna-owie – Hooray Aquifer, inferred groundwater flow lines, and spring groups

Credit: Radke et. al. 2000

European access to groundwater in the GAB began from the 1880s, and bores were extensively developed to support the pastoral sector. Many townships also rely on groundwater, and in more recent years water has also been used to support mining and extractive industries. GABCC (1998) reported about 3,000 free-flowing artesian bores and 35,000 sub-artesian bores were tapping the aquifer, drawing about 570,000 ML per annum in the late 1990s. The pastoral industry accounted for approximately 88% of use (Table 1), of which as much as 90% was lost in evaporation and seepage. This occurs through the widespread use of bore drains to distribute water rather than more efficient reticulation systems involving piping and troughs. Mining and petroleum accounted for approximately 5.5% of usage in 1998, with approximately half of the mining supplies used at the Olympic Dam mine in South Australia (GABCC 1998).

Table 1: Summary of water extraction in the GAB

| Industry | Estimated water extraction in 1998 (ML/annum) | Predicted water extraction in 2005 (ML/annum) |
|-------------|---|---|
| Pastoral | 500,000 | 400,000 |
| Mining | 11,000 | 35,000 |
| Petroleum | 20,000 | 20,000? |
| Town supply | 20,000 | 20,000 |
| Tourism | Minimal | 6,000 |
| Irrigation | 8,000 | 35,000 |
| Industrial | 6,000 | 9,000 |
| Total | 565,000 | 565,000 |

Source: by GABCC (1998)

The access to groundwater in the GAB has reduced pressure and flow across many parts of the Basin. The maximum flow was estimated to be 750,000 ML in 1915, and has since fallen by approximately 25% (GABCC 1998), with individual head levels in bores falling up to 80 metres over this time period (Ponder 2004). This has caused a substantial reduction in water access to artesian springs, with approximately one third of all springs, including the Flinders River 'supergroup', disappearing since the 1880s (Ponder 2004). Total discharge through artesian springs has reduced by nearly 40% from an estimated 82,000 ML/annum pre-development to 50,000 ML/annum, with subsequent losses of biodiversity (GABCC 1998).

The management of the GAB has generated a number of other losses apart from the biodiversity around artesian springs. There have been impacts on water access, with approximately 1,500 bores ceasing to flow, and the lowering of water tables increasing pumping costs. Reduced water flows at artesian springs have the potential to impact on tourism, now one of the major economic activities in the GAB area. Webster (1995) suggested that at least 10,000 people per annum were visiting the Dalhousie Springs complex in Witjiri National Park, with many of them staying for several days. Major spring areas are also important in terms of cultural heritage for aboriginal groups and for links to early exploration and European settlement history (Webster 1995).

The extraction of water from the GAB may also be associated with greenhouse gas emissions, as dissolved gas concentrations of CO₂ (carbon dioxide) and CH₄ (methane) and some hydrocarbons can be released when the groundwater is brought to the surface. Pallasser and Alder (2001) estimate that 334,000 tons of CO_{2-e} are released annually from the GAB through

both bores and natural springs, and that a 25% reduction in water extractions should decrease total emissions of carbon dioxide equivalents by about 60,000 tons per annum.

Extensive bore drains have also contributed to environmental losses by facilitating the spread of weeds and feral animals, contributing to salinisation, increasing grazing pressure and allowing more access by predators to remote areas¹. The combination of different pressures in rangeland areas, including losses of artesian springs and extensive use of bore drains among other factors such as grazing pressures and feral pests, has contributed to significant impacts on biodiversity (GABCC 1998), with:

- Some medium sized mammals becoming extinct,
- Displacement of ground-dwelling birds,
- Changed distribution of invertebrates,
- Extinction of some plant species, and vulnerability of others.

Concerns about the health of the GAB had led Queensland, New South Wales and South Australia to independently introduce programs to reduce wastage from the Basin prior to 1999. The introduction of GABSI in 1999 provided a funding partnership between the Commonwealth and the States for both on-ground works and extension programs. Landholder involvement in the bore capping program has been voluntary, with landholders making some contribution to funding depending on site conditions. Phase 1 of the GABSI was completed in 2004, achieving the rehabilitation of 270 uncontrolled bores and deletion of almost 8,000 km of bore drains for a commitment of approximately \$28.4 Million each by the Commonwealth and the States, and approximately an additional one third from participating landholders. The reduction in water extraction was estimated at 98,075 ML/annum.

Phase 2 of the GABSI commenced in 2004, to run for a second five year period to 2009. Available funding was increased to \$38.7 Million each from the Commonwealth and the States. A review of the program after two-thirds of completion showed that water savings of 46,474 ML per annum had been achieved (Table 2).

Table 2. Water savings from Phase 1 and Phase 2 to 30 June 2007

| Jurisdiction | Bores controlled | Bore drains (kms) | Water saving (ML per year) |
|------------------------|------------------|-------------------|----------------------------|
| Phase 1 | 270 | 7,996 | 98,075 |
| 3 year interim Phase 2 | 90 | 5,858 | 46,474 |
| Estimated remaining | 809 | 15,548 | |

Source: Australian Department of the Environment, Water, Heritage and the Arts.

There have been two reviews conducted to evaluate the GABSI. Hassall & Associates (2003) provided an interim review of Phase 1 of the program, and SKM (2008) provided an interim review of Phase 2 of the program. The GABSI was originally scoped as a 15 year program with three 5-year phases, and an overall 15-year water saving target of 211,000 ML/annum. This

¹ GABCC (1998) reported approximately 27,000 km of bore drains in Queensland, 6,000 km in New South Wales and 1,000 in South Australia.

equates to a target saving of 70,333 ML/annum under each phase of GABSI or 14,066 ML for each year of the program (SKM 2008). Performance in terms of water saved in the first five year Phase exceeded the target by approximately 39% (Hassall and Associates 2003), while performance in the second Phase to November 2007 has been slower, running about 18% below target. Performance across the full program to November 2007 remains ahead of target by 23% (SKM 2008).

Desired outcomes of the second phase of GABSI can be summarised as (SKM 2008):

- Achievements of artesian pressure recovery in strategic areas of the Great Artesian Basin;
- Achievement of improved groundwater resource management and reduction of waste,
- Changed attitudes and the establishment of a culture committing to improved management,
- Establishment of effective institutional measures,
- Adoption of improved grazing systems and management,
- Establishment of an on-going monitoring system.

It is notable that protection and rehabilitation of artesian springs and improved environmental benefits are not directly identified as desirable outcomes of the GABSI, although environmental health has been identified by Hassall & Associates (2003) and SKM (2008) as the key justification in investment in public funding. The key targets that are embedded within the background material to the GABSI agreements between the Commonwealth and relevant state governments (Appendix 1) address problems relating to:

- Constraining future options for use of the resource,
- Threatening continued access to artesian pressures by a range of existing users,
- Continued land, vegetation and habitat degradation and loss of biodiversity resulting from inappropriate use and disposal of water in an essentially arid landscape

A detailed analysis of the environmental benefits generated by the GABSI is not currently available, in part because of the time lags expected in pressure recovery. At a bureaucratic level the success of the program appears to be largely dependent on the schedule of works being completed (SKM 2008) rather than achievement of particular environmental outcomes such as the protection of artesian springs.

Measurable outcomes from the program have been summarised in Table 2. The results show that since the beginning of Phase 1, approximately 24% of bores have been capped, 32% of bore drains have been removed, and there has been a 25.6% reduction in annual water extraction. There has been no information provided in the reviews to date about whether there have been any offsetting increases in extraction during the operation of the GABSI. It is unclear from available material whether the bore capping program will lead to environmental improvements in terms of improved health of artesian springs, or will simply avert future losses occurring (SKM 2008).

Any comprehensive evaluation of the program needs to consider whether the private and public benefits generated are sufficient to justify the level of private and public investment that has been made. An economic framework is suitable for this purpose, because it helps to clearly identify

what should be included within an analysis and the steps that can be undertaken to perform it. This is the focus of the next chapter.

3. The Economic Framework and Non-Market Valuation

3.1 The Economic Framework

The fields of resource and environmental economics can help to identify why environmental problems have occurred, evaluate whether it is worth addressing those problems or allow further development proposals, and design mechanisms to improve environmental management (Tietenberg 2000). One key approach to the evaluation role is to compare the costs and benefits that arise from different proposals or policy changes with the aim of identifying whether a net benefit to society is generated. Techniques such as Cost Benefit Analysis allow an assessment of net benefits (or losses) arising from a proposal, and so helps to identify whether problems are serious, to determine the categories of key benefits that may be important, and to evaluate different options available to address a problem (Garrod and Willis 1999, Campbell and Brown 2003).

The basic market model of demand and supply provides the foundations for understanding concepts of 'economic value' provided by natural resources like groundwater. The benefits accruing from the goods and services supplied in a market place can be measured in terms of consumer surplus and producer surplus. Consumer surplus is the difference between what the consumer is willing to pay (consumer demand) and what they actually pay (the market price). Producer surplus is the difference between what the producer receives (market price) and the costs of producing the good or service. The sum of consumer and producer surplus provides estimates of economic value, or the welfare realised by society of providing a particular good or service. The basic concepts of consumer surplus and producer surplus are illustrated with the aid of Figure 2.

Demand and supply functions describe the interactions of society with a good or service, regardless of whether they are provided by social norms, government or through a market mechanism. In the case of non-market goods, the available supply is not provided through a market mechanism, and hence no market price or producer surplus exists. Consumer surplus for non-market goods is the value associated with the provision of the good or service at different potential amounts of provision. This can be described as the willingness to pay, or area under the demand curve, for appropriate quantities of the good or service in question (Figure 3). Once a demand for a good or service can be established, it becomes relatively easy to estimate the consumer surplus associated with varying amounts of supply.

Consumer and producer surpluses are the appropriate measures of economic value to consider when valuing improvements to the Great Artesian Basin. Consumer surplus values can be estimated for both market and non-market goods, but producer surplus can normally be estimated only for market goods. In relation to the Great Artesian Basin, there will be consumer surpluses associated with providing a range of outcomes, such as increased environmental protection, while producer surpluses will be associated with commercial operations such as impacts on pastoral or tourism operations.

Figure 3: Concepts of Economic Value for Market Goods

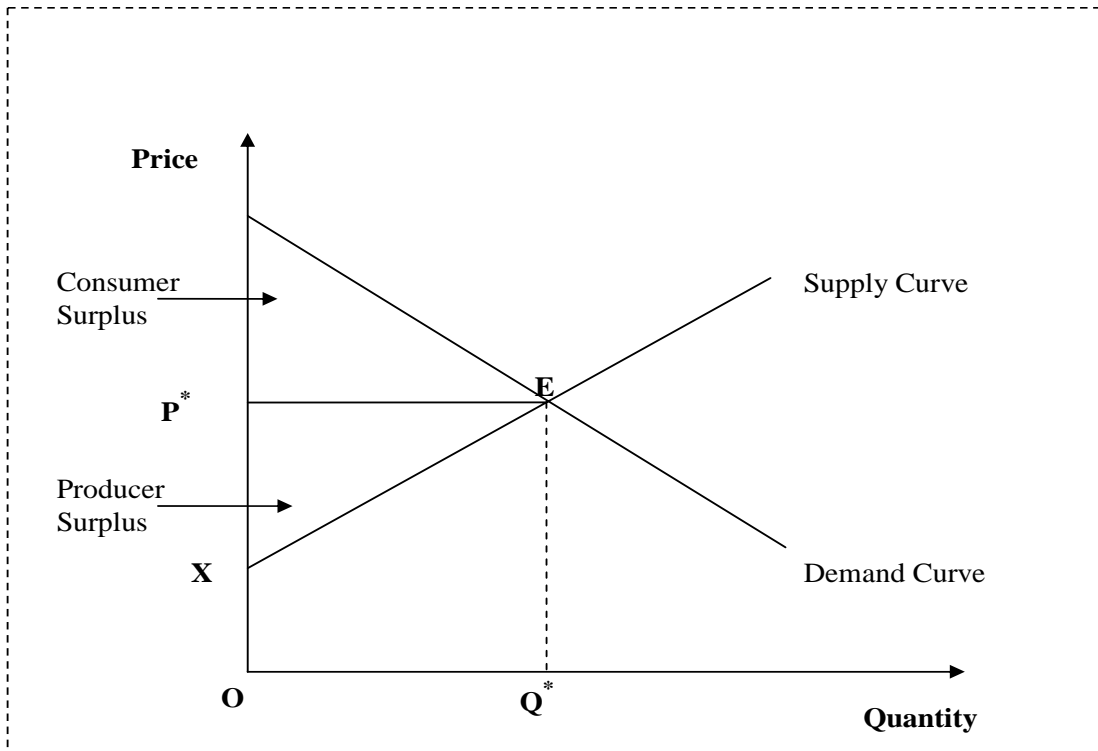
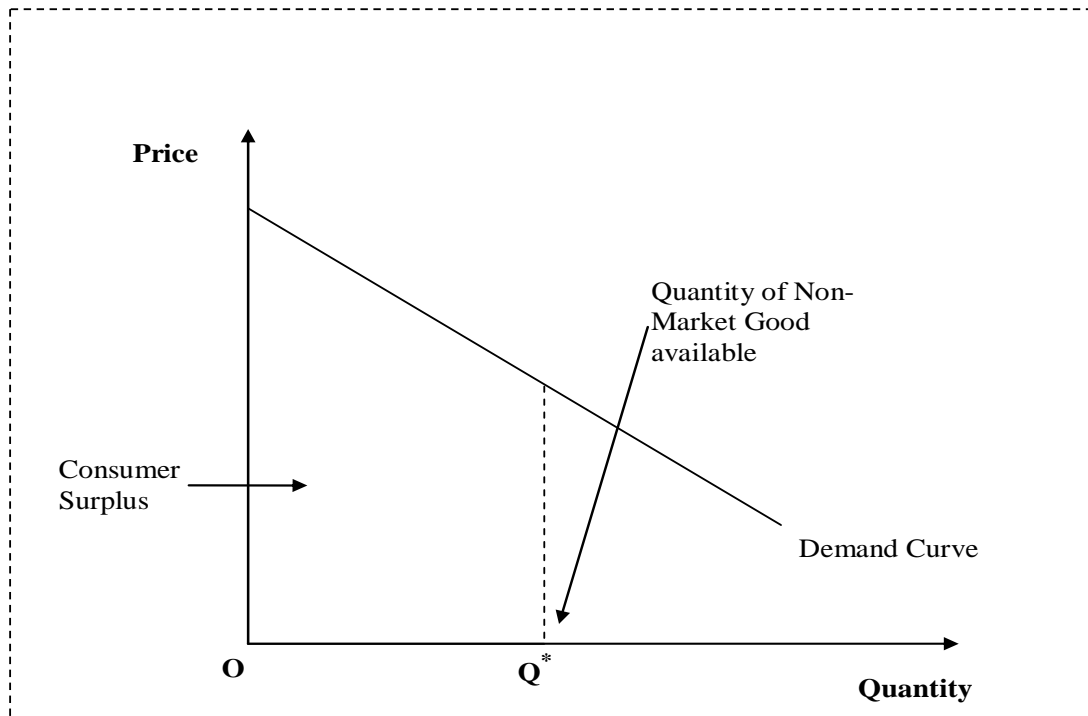


Figure 4: Concepts of Value for Non-Market Goods



The surpluses (whether positive or negative) need to be assessed in monetary value terms so that they can be incorporated into a cost-benefit framework. Estimates of non-market values, particularly for components of consumer surplus, are integral parts of the overall conceptual framework used by economists to help assess net benefits. Non-market valuation is a key stage in the process of assessment, because it provides a common measuring unit and estimates of the preferences of society for the various uses and outcomes of environmental strategies. If non-market values are not available, then an analysis might simply focus on the financial components (as commonly employed in business) or a cost-effectiveness analysis, where the financial costs of achieving different outcomes are compared.

A simple financial analysis is not appropriate for GABSI because the level of financial investment (both public and private) is much higher than any financial private benefits generated. Examples of cost-effectiveness analysis have been provided by Hassalls & Associates (2003) and SKM (2008) where the investment per ML of water saved over 30 years has been calculated. While useful, this does not justify the public investment in the program.

To assess the overall value of a program such as the GABSI, values for the additional benefits need to be estimated and compared to the public investment made. Financial values associated with the changes can be estimated from market data, employing tools such as agricultural production models. For the evaluation process to be accurate, it is important to include the assessment of values for the non-farm benefits, as these are likely to be the critical values that justify public investment. Advances in non-market valuation techniques make it possible to quantify in monetary terms the relevant non-financial impacts to provide a complete assessment of the program. However, before these are described it is useful to outline the categories of values that may exist.

3.2 Categorisation of values

A key stage in the analysis of non-market values is to categorise the types of benefits that might be associated with the Great Artesian Basin.

Direct use values (direct contact) are benefits that directly accrue to individuals who use the resource, and can be either extractive or non-extractive. Extractive use values are largely generated from the direct use of water, such as by regional communities and the pastoral and mining industries. Tourism involves non-extractive values, where people receive direct benefits from the ground water resource without directly consuming it.

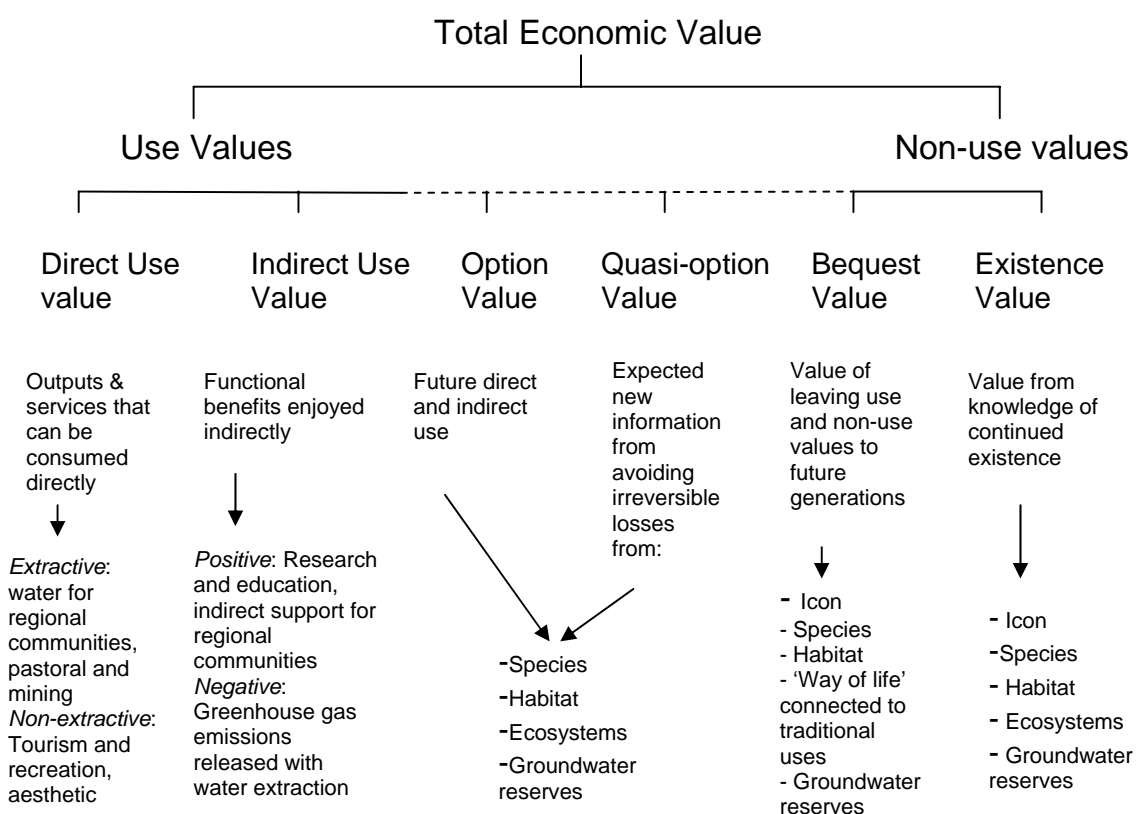
Indirect use values (no direct contact) include values that are gained indirectly from the natural resource, usually through support and protection of other economic activities. Examples of indirect use values include the generation of services and economic stimulus from industry and regional townships, and the flow of information into research and education,.

Non-use values to society arise indirectly either through potential future uses or through the knowledge of the presence of the resource. These can be divided into option values, quasi option values, existence values and bequest values. Option values are values for use in the future,

existence values are values for knowledge of their presence and bequest values arise from wanting to preserve the public good for future generations. Non-use values can be derived without any actual current human contact with the resource.

In many cases it is difficult to estimate each component of value as separate items. Under the Total Economic Value (TEV) approach, values are either estimated jointly for a site in a single valuation exercise, or values from separate estimation exercises are summed to give a total value estimate of the asset of interest. A summary of the different categories of value for the GAB, and their structure under Total Economic Value is provided in Figure 4. This shows that while there are benefits gained from the extractive use of groundwater from the basin, there are a range of other benefits from maintaining natural processes that accrue largely to groups off-farm.

Figure 5: Total Economic Value and Attributes of Values for the GAB



3.3 Non-market valuation techniques

Non-market valuation techniques are used to estimate dollar values for impacts that are not directly reflected through market prices. They are commonly used to assess how people in a

community or society view tradeoffs involving environmental issues, particularly those that relate to:

- Biodiversity protection issues;
- Recreation uses; and,
- Ecosystem functions that support human life.

There are two key advantages to be gained from the use of these non-market valuation techniques:

- (a) Peoples' preferences are assessed in an egalitarian, uniform and consistent manner, and the assessment methodology is logical and constructive. This helps to ensure that underlying preferences are assessed rather than simply attitudes or opinions, and that the views of special interest groups do not distort an overall assessment.
- (b) The results are expressed in monetary terms consistent with the concept of economic value as defined in welfare economics. This means that the preference information is summarised in a way that is useful for policy makers to be able to evaluate tradeoffs. The estimates of value can be used as inputs into assessment methodologies such as cost-benefit analysis.²

In this case study the relevant task is to assess the values associated with the marginal potential improvement in the condition of the GAB provided through the GABSI. The values of changes to the supply of goods and services provided by the GAB relative to a 'business as usual' scenario can be estimated with a range of different techniques. The goods and services that have identifiable and established markets are relatively easy to value from data revealed by market demand and supply functions, but most of the goods and services related to environmental, recreation and cultural aspects are not traded in markets. In the absence of markets, non-market valuation techniques have been devised to estimate the economic value of such goods and services. Non-market valuation techniques can be classified into two broad categories – the revealed preference (RP) techniques and the stated preference (SP) techniques (Bateman et al., 2002).

RP techniques use information from complementary or surrogate markets that are related to the good to estimate economic values. The observed behaviour of individuals in complementary markets is used to estimate the value of the non-market good or service (Garrod and Willis, 1999; Haab and McConnell, 2002; Bateman et al., 2002). RP techniques include the Travel Cost Method (TCM), Random Utility Model (RUM) and the Hedonic Price Method (HPM).

- TCM uses the actual costs of travel incurred by the respondents and the number of trips or visits made to the site to derive a demand curve for the recreational good, from which the economic value or consumer surplus estimates are derived. Traditionally TCMs are used to value outdoor recreation.

² Economic values can normally be conceptualised as consumer surplus or producer surplus, which can be thought of as the additional value that consumers or producers receive over and above their direct expenditure.

- RUMs are conceptually similar to the travel cost models, but instead of focussing on the number of trips individuals make to a recreational site, RUMs focus on the choice individuals make among alternative sites. These models can then be used to measure the value of the qualitative characteristics of one or more of the sites.
- The HPM estimates the implicit price of environmental characteristics. It is most commonly applied to value variations in housing prices that reflect the quality of the local environment.

SP techniques are also known as direct valuation methods. These models use hypothetical questions and scenarios to identify individuals' preferences, which are used then to estimate the value of non-market goods and services. Typically these techniques are used when no relevant market information is available. SP techniques include the Contingent Valuation Model (CVM), Contingent Rating (CR) and Choice Modelling (CM).

- CVM is a survey-based technique where survey respondents are presented with a hypothetical scenario and asked to state their willingness to pay for some change in the supply or quality of the good or service (Mitchell and Carson, 1989).
- CR goes one step further and asks survey respondents to state and rank their preferences or choices of alternative combinations of the different attributes of the goods on a rating scale. These ratings are used to estimate the value of the good (Tietenberg, 2000).
- CM is based on the idea that any good can be described in terms of its attributes or characteristics and the levels that these take (Bennett and Blamey, 2001; Bateman et al., 2002). For example, the Great Artesian Basin could be described in terms of its species diversity, appearance and protection levels. Survey respondents can then be asked to choose between a number of different options for the future management of the Basin, and the value of the good or a change in the value of the good is estimated from the responses. There have been a number of CM applications to recreation and environmental issues in recent years (Adamowicz et al., 1998; Blamey et al., 2000; Morrison and Bennett, 2000; Rolfe et al., 2000; Bennett and Blamey, 2001).

3.4 Benefit transfer

There are two approaches to estimating non-market values for a topic of interest. The first is to conduct a primary study that includes data collection, statistical analysis and interpretation stages. Primary studies can be technically complex, expensive and time-consuming. These factors, coupled with the small pool of skilled researchers and analysts, help to explain why the number of non-market valuation studies in Australia remains limited.

The second broad approach is to transfer environmental values from one or more existing case studies to a target site of interest, a pragmatic process known as benefit transfer (Brouwer 2000, Rolfe and Bennett 2005). In applications of benefit transfer, non-market values gained from a 'source' study can be used in some way to predict economic values at a 'target' site (Bateman *et*

al. 2002, Rolfe and Bennett 2005). The process typically involves transferring and adjusting values across time, space, populations, and sometimes from one type of environmental asset to another (Brouwer 2006, Rolfe 2006). Benefit transfer is only possible in situations where there are existing studies that relate to the target issue of interest, the existing studies are technically accurate, and the transfer process will not generate unacceptable biases.

Most applications of benefit transfer are opportunistic, involving a search for suitable source studies followed by transfer with some potential adjustment process (Rolfe and Windle 2008). This 'random foraging' approach to benefit transfer is still restricted for a number of reasons, including the limited number of available studies, the inconsistencies in the way that data has been collected and modelled, and the brevity of reporting in many academic publications (Rolfe and Windle 2008). Many studies are conducted and reported for specific purposes, with little consideration for subsequent use in benefit transfer applications. This limits the potential for benefit transfer, although there has been a great deal of effort by practitioners in the 1990s and early 2000s to understand where sources of bias in the benefit transfer process might be generated, and to develop more accurate ways of performing non-market valuation studies and the benefit transfer process (Wilson and Hoehn 2006, Rolfe and Windle 2008).

The development of SP techniques such as CM have facilitated the use of benefit transfer values and functions because CM allows the expression of environmental values as a function of a number of site, population and other characteristics (Rolfe 2006). A CM experiment can be designed in a way so that key elements desired in a benefit transfer function are included in the choice sets as attributes or labels. The choices made by respondents from a survey population thus help to develop a benefit transfer function that can be 'mapped' across to a range of potential policy situations. Examples of the use of CM to develop a systematic benefit transfer framework have been provided by van Bueren and Bennett (2004), Morrison and Bennett (2004) and Rolfe and Windle (2008).

3.5 Marginal Analysis

There are a number of ways of framing the tradeoffs between resource allocations in a policy situation. It is important to recognise that policy decisions usually involve incremental changes in resource condition or resource allocation, and that marginal analysis is the appropriate framework for evaluation. In the context of the GAB, the problem to be addressed is that there is a gradual rundown in the stocks of the groundwater reserve, with subsequent impacts on economic, ecological and social assets. As well, the intervention strategies will only create incremental improvements, as the program gradually meets the desired inputs (bore capping and drain replacement), which then lead to the desired outputs (maintaining communities, improved and protected ecological assets, maintaining recreation and cultural opportunities). There may be significant time lags between the implementation of GABSI and the desired outputs.

A marginal analysis framework matches the assessment of costs and benefits to the incremental changes generated by the GABSI to the condition of the GAB. The benefits of the program relate to the scale of improvements generated (with and without the GABSI), not to the overall services provided by the GAB. For example, while many pastoral enterprises and western communities

may completely depend on the Basin for water supplies, GABSI has very little impact on them, except that improved water pressure might lower their pumping costs.

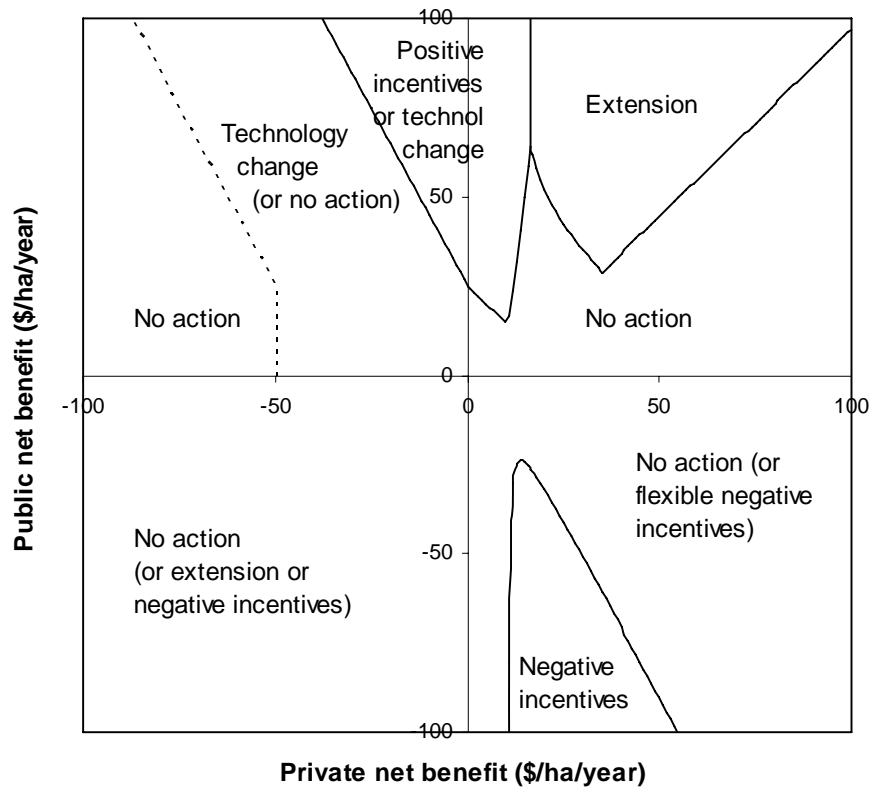
The focus on marginal analysis has implications for the types of benefits that need to be estimated. It could be expected that the GAB has high values as a national asset providing a stock of services such as providing water to different industries. However, for the evaluation of GABSI, it is only the change in economic, ecological and social services provided that are defined as benefits and need to be evaluated.

3.6 Designing policy options

The cost benefit analysis framework, together with non-market valuation techniques, allows the assessment of the benefits and costs of addressing an environmental issue. Policy makers then have some choice over whether to intervene to address issues, and the policy mechanism that is chosen. Pannell (2008) describes a simple framework which can be used to select among broad groups of policy mechanisms, according to the level of private net benefits and public net benefits involved. The focus of the framework is private land use, where management decisions will typically produce both private and public benefits (or costs). The policy framework helps to identify where it may be worthwhile for government to change the level of environmental outputs, and the types of mechanisms that can be employed.

The framework is depicted in Figure 6. Both public benefits and private benefits can be negative or positive, with the different possible combinations plotted into four quadrants in Figure 6. For many combinations of public and private benefits there is no net benefit in intervention, while for more specific combinations there are broad policy recommendations. Where there are public net benefits of a policy measure associated with slight private benefits or losses, then positive incentives or technology change are recommended policy options. For the GABSI as an improved technology/positive incentive program to be an appropriate policy response to the issues involved, the key test should be that there are large net public benefits associated with weak net private costs or net private benefits of the program. Within the positive incentive group of policy responses there are different options for tailoring engagement with landholders, including structure grants programs and more market-like mechanisms such as competitive tenders (Latacz-Lohmann and Van der Hamsvoort, 1998; Stoneham et al., 2003).

Figure 6: Efficient policy mechanisms for encouraging land use on private land



Source: Pannell (2008), page 235.

4. A Framework for Assessing Off-Farm Values

4.1 Classifying benefits

An important first stage in any review of net economic benefits is to identify and classify the different benefits that might be associated with the bore capping program. The details of the Commonwealth – State agreement (Appendix 1) suggest the following goals are important:

- Maintain the viability of existing industries
- Maintaining communities
- Maintaining future options for use of the resource,
- Addressing any land, vegetation and habitat degradation associated with inappropriate use and disposal of water
- Addressing loss of biodiversity resulting from inappropriate use and disposal of water

Hassall & Associates (2003) provide a typology of the different impacts expected from GABSI (Table 3).

Table 3. Summary of impacts from GABSI (from Hassalls & Associates 2003)

| <i>On Farm Benefits of Bore capping and piping</i> | <i>Off Farm Benefits of Bore capping and piping</i> |
|---|--|
| <ul style="list-style-type: none"> • Extended life of Bores • Reduced risk of bore deterioration • Control of water flow leading to management efficiencies • Reduced water logging, salinisation and degradation associated with bore drains • Increase in capital land value • Reduction in the operation and maintenance expenses associated with open drains • Improved water quality at delivery point • Improved access around property • Reduction in weeds • Management saving associated with mustering • Better control of feral animals and water points • Improved pasture utilisation • Improved drought resilience | <ul style="list-style-type: none"> • Reduced water wastage • Improvement in aquifer pressure • Existence value of GAB • Existence value of landscape and ecosystem • Increase in the reliability of water leading to economic and social stability in the region • Recovery of natural springs • Protection of town water supplies • Increased water availability for higher value uses, including mining • Tourism opportunities based on artesian water |
| <i>On Farm Cost of Bore capping and piping</i> | <i>Off Farm Cost of Bore capping and piping</i> |
| <ul style="list-style-type: none"> • Initial landholder expenditure on capping, piping and troughs • Management changes | <ul style="list-style-type: none"> • Initial Australian and State government expenditure on capping and piping |

The impacts identified by Hassalls (2003) reveal that the benefits associated with GABSI occur both on-farm and off-farm. The on-farm benefits are generally private benefits accruing to landholders. The off-farm benefits are largely public, accruing to different groups in society, although the recreation benefits and tourism benefits are better classified as private benefits occurring off-farm. Use and non-use values do not map neatly to private and public interests, as some use benefits (such as recreation) accrue to groups off-farm, and landholders in the GAB may gain non-use benefits alongside use benefits.

For the GAB, the different components of the non-use values are likely to apply to three broad areas, including:

- Groundwater reserves
- Environmental factors
 - Artesian springs,
 - Artesian spring ecosystems,
 - Associated fauna and flora,
 - Rangeland areas affected by weeds and pests supported by bore drains
- Cultural heritage
 - Aboriginal culture
 - Pastoral and early settlement

The key off-farm benefits of improving the management of the GAB appear to be:

- Maintaining groundwater reserves: The GAB may have some level of iconic status where there is an inherent value to people beyond the existence value for associated biodiversity. People may value the continued existence and good condition of the asset, as well as valuing the option to potentially use the water reserves for different purposes in the future.
- Ecosystem and biodiversity protection: maintaining the health of artesian springs and associated wetlands and biodiversity, particularly those involving unique artesian springs and endemic species,
- Land degradation reduction: Better management can help to reduce excessive grazing pressure in specific areas, while the elimination of bore drains can reduce the spread of weeds and pests, particularly when the provision of water allows feral species to inhabit previously water-remote areas.
- Recreation and tourism opportunities: Visitors to the assets of the GAB would be affected by the loss or degradation of those assets. Evidence of the impact could be expected through both a reduction in the number of visitors and a reduction in the value of each visit.
- Cultural heritage protection: Many artesian springs form an integral part of cultural heritage for many aboriginal people. There may also be some significant cultural heritage values for sites that are linked with early European settlements and history.

- Reduction in greenhouse gas emissions: Each 1 ML reduction in ground water extraction can reduce associated greenhouse emissions by approximately 0.54 tons of CO_{2-e} (Pallasser and Alder 2001).
- Maintaining industries and communities in the longer term by ensuring that water supplies are sustainable.

Landholders in the GAB may also enjoy some of these benefits, as well as any commercial (production) benefits associated with the GABSI. However, the small number of landholders in the GABSI relative to the wider GAB and Australian population implies that the value of social and environmental benefits generated from the GABSI for this group is likely to be minor relative to the wider population base. However, the extent to which landholders derive non-financial benefits from the GABSI may be an important driver of cooperation and involvement in the program.

4.2 Selecting an assessment framework

There are several ways of framing an economic analysis of the GABSI, depending on which level of an analysis is needed. A broad level analysis would consider whether the total benefits of GABSI, both public and private, justify the level of costs incurred, both public and private. The focus of this traditional cost-benefit approach would be to identify if net social benefits existed. More specific approaches would be to identify the net returns on the public investment in the GABSI, or to evaluate the effectiveness of the support mechanism involved. Here, the discussion begins with the broad level analysis.

There is already evidence that the on-farm benefits arising from the GABSI outweigh the on-farm costs and investment incurred. The voluntary engagement by landholders in the program indicates that net on-farm returns are being generated. In fact, some level of net private benefit is required to generate landholder involvement, and may be a necessary engagement cost for the program. To ensure there are overall net benefits, the off-farm benefits should also exceed the off-farm costs involved, with the latter almost exclusively comprised of public investment in the program. Under this approach, the assessment framework can be narrowed to a test of whether the public investment is generating larger off-farm benefits, thus ensuring that the program passes the benefit cost test.

Following the categorisation of benefits provided in Figure 4, the key categories of off-farm benefits to be assessed from the protection of the GAB can be summarised as follows:

- Direct use values (water supply) for communities
- Direct use values for recreation and tourism
- Option values (maintaining the aquifer for both future use and non-use purposes)
- Biodiversity protection values (incorporating quasi-option, bequest and existence values) for both native biodiversity and the removal of weeds and pests.
- Cultural heritage protection values (incorporating option, quasi-option, bequest and existence values)

- Ecosystem services for reduction in greenhouse gas emissions
- Ecosystem services (water supply) underpinning community development and service provision

The off-farm benefits can be identified as accruing to three broad groups:

- People who live in the GAB. This population can enjoy all the public benefits generated by the GAB, as well as direct recreation opportunities. Values to protect the groundwater assets, biodiversity and cultural heritage are likely to be especially important for this group.
- Visitors to the GAB. This group is likely to enjoy the recreation benefits associated with the GAB, and, because of their interest, may also hold significant values for protecting the groundwater assets, biodiversity and cultural heritage aspects³.
- The broader community. Although the majority of Australians do not live in or visit the GAB, they may enjoy a number of public benefits, such as the option to maintain groundwater reserves or the continued existence of biodiversity and cultural heritage.

To perform an economic analysis, appropriate estimates of value (economic surplus) need to be made for each of these categories of benefits with some testing of variation across the relevant population groups. Where direct uses are involved, both producer and consumer surpluses may be relevant, where the former can be visualised as the profits accruing to off-farm businesses and the latter as the additional value that consumers gain above the cost of accessing the good. Where non-use benefits are involved, the consumer surpluses can be visualised as the willingness of people to pay to achieve those benefits.

When the marginal impacts of the GABSI are considered, it is likely that some categories of benefits will be small relative to others. For example, while there are important uses of artesian water for recreation and water supply in towns such as Moree, access to the groundwater is still available although water tables have dropped. In these cases the direct benefits of the GABSI may simply be a very small reduction in pumping costs. However, recreation at natural artesian springs, particularly the Dalhousie group in South Australia (Webster 1995), is very dependent on water pressure and should be considered in the analysis. This means that while consumer surplus estimates for improved recreation may be an important component of value, the producer surplus associated with commercial operations (in tourism and regional towns) is unlikely to be a significant component of the analysis. The analysis that is provided in the following sections is focused on consumer surplus estimates for the relevant categories without further consideration of producer surplus.

No existing studies which specifically provide values for these categories in the GAB can be identified. Little attention has been paid to these types of issues in the international setting as well. Some international studies identifying the value of groundwater recharge for household or farming purposes (e.g. Acharya and Barbier 2002 in Nigeria), and the value of maintaining groundwater quality (e.g. Poe and Bishop 1999) are available, but none replicate the issues

³ An example is the Friends of Mound Springs group, which coordinate visits to the GAB and publish a small newsletter. See: http://www.communitywebs.org/FriendsofParks/documents/friendsmound_springsflyer.pdf

relevant to the GAB. The most relevant international publication is provided by Hellegers et al. (2007), where they report the analysis of shallow groundwater management in the Netherlands to achieve both agricultural production and nature conservation goals⁴.

Because no studies are available that directly assess the non-farm benefits of GABSI, a benefit transfer process is explored in this report to provide some assessment of the relevant benefits. Bennett and Rolfe (1998) have previously provided a short estimate of a benefit transfer process for the GAB, concluding that the value of improving the management of the resource would be in excess of \$100 Million per annum. However, that exercise was based on a very limited number of source studies. A key stage in benefit transfer is to review available literature and identify suitable studies where transfer might take place. Any transfer process has to take account of the issues involved in an accurate transfer process so that undesirable biases are not generated in the analysis (Rolfe and Bennett 2006). This review is provided in the next section.

5. Non-market values and benefit transfer

In this section a review is provided of other studies that may be potentially relevant to the issues in the Great Artesian Basin. The material is organised by the categories of benefit that are outlined in the previous section:

- Direct use values for recreation and tourism
- Option values (maintaining the aquifer for both future use and non-use purposes)
- Biodiversity protection values for both native biodiversity and the removal of weeds and pests.
- Cultural heritage protection values
- Ecosystem services for reduction in greenhouse gas emissions
- Ecosystem services (water supply) for communities

The review of appropriate non-market values has drawn on a number of sources, including:

- Major resource economics journals such as the Australian Journal of Agricultural and Resource Economics,
- The NSW EPA Envalue data base: <http://www.environment.nsw.gov.au/envalue>
- The Canadian-hosted Environmental Valuation Reference Inventory: <http://www.evri.ca>
- Previous studies and reviews conducted by the author.

⁴ In this case study a general value of 1,600 Euros/ha was used to represent environmental values for protecting Dutch peat meadow land.

5.1 Values associated with recreation in outback areas

A number of studies have been conducted in Australia about the value of recreation activities. Key studies of relevance include:

Delforce, Sinden and Young (1986) assessed the recreation value of tourist trips to the Flinders Ranges area in South Australia, using the travel cost method, at \$35.88 per trip (\$99.84 in 2007 dollars).







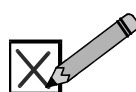
Rolfe and Prayaga (2006) estimated the recreation value of visitors to three freshwater dams in Queensland using the travel cost method. The Fairbairn Dam in central Queensland is the most relevant because of its inland location and proximity to the Great Artesian Basin. Using the Travel Cost Method, consumer surplus was estimated at \$5,630 per trip, or \$105.79/day.

Dyak et al. (2007) report recreation values for two sections of the Murray River in Victoria and South Australia, using data and count data models with the travel cost method. The consumer surplus for recreation use of the Barmah in Victoria was estimated at \$134 per adult visitor per day, while the Coorong was valued at \$218 per adult visitor per day.

5.2 Values associated with options for future use or conservation

Rolfe and Windle (2005) reported the use of CM in several surveys to assess values for holding water in reserve in the Fitzroy Basin in central Queensland, neither allocating it specifically to agricultural use nor reserving it for the environment. The purpose was to assess the option value for maintaining the future potential to allocate water to agriculture or the environment. The reported experiments framed the choice sets in terms of preserving a resource alongside of biodiversity and cultural heritage protection aspects. An example of the way that these different concepts were framed is shown in Figure 5.

Figure 7. Example choice set used by Rolfe and Windle (2005)

| | | | | | |
|---|---|---|--|---|---|
|  | Question X: Options A, B and C. Please choose the option you prefer <hr/> most by ticking ONE box. | | | | |
| How much I pay each year  | Fifteen-year effects Healthy vegetation left in floodplains  | Kilometres of waterways in good health  | Protection of Aboriginal Cultural sites  | Unallocated water  | I would choose  |
| Option A | | | | | <input type="checkbox"/> |
| \$0 | 20% | 1500 | 25% | 0% | <input type="checkbox"/> |
| Option B | | | | | <input type="checkbox"/> |
| \$20 | 30% | 1800 | 35% | 5% | <input type="checkbox"/> |
| Option C | | | | | <input type="checkbox"/> |
| \$50 | 40% | 2100 | 45% | 10% | <input type="checkbox"/> |

The results of the experiments demonstrated that communities held significant option values for maintaining a resource, alongside other non-use values for environmental and cultural heritage assets. The annual value of maintaining options for future use held by Brisbane households were assessed from \$1.90 to \$6.12 (in 2007 dollars) per 1% of water reserves, with the lower amount being relevant for systems with lower levels of allocation to agriculture. The survey response rate was 58.3% of households approached, and a conservative approach would only extrapolate values to this proportion of the population.

Imber et al. (1995) and the Queensland Government (1991) provide two previous valuations of Australian icon sites, Kakadu National Park and Fraser Island. Both studies indicated that the public was willing to pay significant amounts of money to preserve these iconic sites, with estimates of value in each case over \$100 Million.

5.3 Values associated with biodiversity protection

A number of Australian studies have demonstrated non-use values associated with protecting species and ecosystems.

The most directly relevant study for groundwater is provided by Gerrans (1994). He used the contingent valuation method to assess values for protection of the Jandakot Wetlands, south of Perth, that were dependent on a groundwater system known as the Jandakot mound. Housing

developments threatened to deplete the water reserve, with subsequent impacts on the wetlands. The results, in 1992 dollars, were \$31.15 per household per annum (\$45.72 per household per annum in 2007 dollars) to reserve the groundwater system and protect the wetlands. The study demonstrates that communities can hold significant values for protecting groundwater reserves to avoid environmental losses. However, the small size of the case study aquifer and the proximity to a major population centre make any potential benefit transfer problematic.

The most directly relevant study for biodiversity in the GAB is provided by *Rolfe et al. (2000) and Blamey et al. (2000)*. That study involved a choice modelling survey to estimate protection values for the Desert Uplands region, a rangeland area in central-western Queensland. This region overlays the eastern part of the GAB. The study was framed in terms of avoiding up to 40% loss in the area of unique ecosystems over a 15 year period, with potential vegetation clearing providing the mechanism by which losses could occur.

The study specifically included unique ecosystems such as those associated with artesian springs, as well as endangered species and non-threatened species. Impacts on jobs in the region and regional income were also included in the choice profiles. Surveys were collected from a random sample of Brisbane households in 1997. An example of a choice set used in the study is provided in Figure 6. This shows how options that reduce future environmental losses may be offset by additional payments (public investment) as well as variations in local employment and regional income⁵.

The results, reported in terms of part-worth values (the value of a one-unit change) are summarised in Table 4. The annual value of avoiding the loss of each one per cent of unique ecosystems in 2007 dollars was estimated at \$4.79 per Brisbane household for 15 years, while the annual value of avoiding the loss of an endangered species over the same time period was estimated at \$14.83 per household.

⁵ In the CM process, the different levels for each attribute allow a large number of potential combinations for the different profiles. Offering a selection of these to respondents allows the tradeoffs between attributes (including cost) to be evaluated.

Figure 8: A Typical Choice Set used in the Desert Uplands study

| Implications | Option A Current Guidelines | Option B | Option C |
|--|--------------------------------|----------|----------|
| Levy on your income tax | none | \$60 | \$20 |
| Income lost to the region (\$ million) | none | 5 | 10 |
| Jobs lost in region | none | 15 | 40 |
| Number of endangered species lost to region | 18 | 8 | 4 |
| Reduction in population size of non-threatened species | 80% | 75% | 45% |
| Loss in area of unique ecosystems | 40% | 15% | 28% |

Table 4. Part-worths for Environmental Protection in the Desert Uplands

| Variable | Part-worth \$ (2007) |
|--|-------------------------|
| Income lost to the region (\$ million) | 3.96 |
| Jobs lost in region | 7.29 |
| Number of endangered species lost to region | 14.83 |
| Reduction in population size of non-threatened species (%) | 2.20 |
| Loss in area of unique ecosystems (%) | 4.79 |

A number of other non-market valuation studies have some relevance to valuing the protection of biodiversity or waterways/wetlands in Australia. These are summarised as follows:

Morrison et al. (2002) used CM to estimate protection values associated with the Macquarie Marshes and Gywdir Wetlands in inland NSW. Sydney respondents valued improved area of wetlands at \$0.04 and \$0.05 per hectare, improved frequency of waterbird breeding at \$12.85 and \$31.63, and protection per endangered species at \$5.59 and \$4.23 (all values converted to 2007 dollars).

Rolfe et al. (2002) used CM to assess conservation values for the Fitzroy River basin of central Queensland, reporting values of 10 cents/kilometre for rivers in good condition (in 2007 dollars).

Van Beuren and Bennett (2004) conducted a national CM study to assess protection values for land and water assets in Australia. The results for relevant attributes were household values of 0.008 cents per kilometre of healthy waters, and \$0.67 per endangered species saved.

Whitten and Bennett (2005) used CM to assess protection values for wetlands and native bird habitat in the Murrumbidgee and Upper South East of South Australia. Results of the study for the Murray were that respondents were willing to pay (per household as a one time payment) \$11.39 for an extra 1,000 hectares of healthy wetlands, \$0.55 for a one percent increase in population of native wetlands and woodland birds and \$0.34 for a one percent increase in the population of native fish.

MacDonald and Morrison (2005) used CM to assess values for maintaining different vegetation communities in the Upper South East region of South Australia. Using multi-nomial probit models, they assess protection values of South Australian households at \$717/ha for scrublands, \$1,019/ha for grassy woodlands, and \$1,543/ha for wetlands.

Windle and Rolfe (2008) assessed values with CM for protecting health soils, waterways and vegetation in Queensland, including the Murray-Darling region overlaying part of the Great Artesian Basin. Values held by Toowoomba residents were estimated at \$4.02, \$6.28 and \$2.35 for each 1% improvement in soils, waterways and vegetation respectively.

5.4 Values associated with the removal of weeds and pests

Sinden and Griffith (2007) provide the only available reference to valuing weed removal in Australia, using control cost as a weak surrogate for the value generated. They reviewed the costs involved in controlling 35 major weeds in agricultural and forestry industries in Australia. For each additional threatened plant species involved, annual control costs increased by \$65,000. For each additional conservation area involved, the annual control costs increased by about \$5,800 for agricultural weeds, and by about \$800 for forestry weeds.

There is a risk that identifying values for the removal of weeds and pests could double count benefits. The removal of weeds and pests can be viewed as part of the contribution to biodiversity protection, and hence values for these actions are embedded within non-use value categories for broader environmental protection.

5.5 Values associated with cultural heritage

The most appropriate estimates of values for aboriginal cultural heritage are those generated by *Rolfe and Windle (2003a)*. They assessed the values of Rockhampton, Brisbane and Rockhampton indigenous residents for better protection of aboriginal cultural heritage sites in the

Fitzroy Basin, some of which overlays the very eastern side of the Great Artesian Basin. The survey format used was similar to the choice set presented in Figure 6. Results showed that Rockhampton indigenous residents had strong preferences for higher levels of protection (\$3.69 in 2007 dollars for each 1% improvement in protection), but that the non-indigenous population had positive values for only small increases in protection.

5.6 Values associated with reductions in greenhouse gas emissions

There are few studies that have addressed the issue of values for greenhouse gas reduction, with most work focusing on the costs incurred in achieving reduction. There are two key issues to consider. The first relates to the issue of what values are being achieved when greenhouse gas reductions are being made. As with the control of pests and weeds, it is not the actual reduction of the carbon emissions that creates a benefit, but the potential for reduced risk to the protection of social and environmental assets. Under this approach, any inclusion of values for reducing greenhouse gas emissions may generate double counting of benefits.

The second issue relates to the potential opportunity costs associated with any emission reductions in a future Australian context, where some form of an emissions trading scheme may be present. In this context, a reduction of emissions through the GABSI may potentially offset emission reductions in other parts of the economy, thus allowing potential costs to reduce emissions to be avoided. Such markets for avoiding greenhouse gas emission reductions are still developing in Australia, with the most defined and recent example of a trade in a future Australian greenhouse emissions scheme completed in January 2008 between AGL and Westpac. The agreement is for AGL to sell 10,000 tonnes worth of greenhouse gases to Westpac on 1 February 2012, for \$19 per tonne (Warren 2008).⁶ This provides some basis for identifying a surrogate market value for the opportunity cost of reducing greenhouse gas emissions, with the caveat that the reduction through the GABSI would need to be accounted for in some form in a national trading scheme.

⁶ <http://www.theaustralian.news.com.au/story/0,25197,23727171-11949,00.html> (viewed 23rd June 2008).

5.7 Values associated with ecosystem services to regional communities

Bennett et al. (2004) provide one reference to valuing community health. They present the results of two case studies using CM where the value of maintaining population in rural areas was assessed. Values per household per annum for every 10 people leaving rural areas ranged from \$0.09 at the national level to \$2.24 in a regional setting.

Rolfe et al (2000) provides a more relevant example with a case study involving values for protecting jobs and regional income in the Desert Uplands, on the eastern side of the Great Artesian Basin. Values for these attributes have been provided in Table 4.

5.8 Summary

Care has to be taken in a benefit transfer exercise that there is limited divergence between source studies and target applications in terms of site characteristics, population characteristics and the way studies are framed (Rolfe 2006). Here most relevant studies and values are identified for each value category (Table 5).

Table 5. Summary of available studies for benefit transfer

| Valuation issue | Most relevant studies | Comments |
|---|---|--|
| Direct use values for recreation and tourism | Delforce et al. (1986), Rolfe and Prayaga (2006) and Dyak et al. (2007) | Highly relevant: Case studies involve water-related recreation in outback areas |
| Option values (for both future use and non-use purposes) | Rolfe and Windle (2005) | Relevant, but units of measurement do not fully translate to GAB |
| Biodiversity protection values for native biodiversity | Rolfe et al. (2000), Blamey et al. (2000) | Highly relevant. The attribute that is most easily transferred is <i>Loss in area of Unique Ecosystems</i> |
| Biodiversity protection values for removal of pests and weeds | Sinden and Griffen (2007) | Their study only includes costs, and units of measurement do not directly transfer to GABSI |
| Cultural heritage protection values | Rolfe and Windle (2005) | Relevant, but units of measurement do not directly translate to GAB |
| Ecosystem services: reduction in greenhouse gas emissions | Market data on value of CO _{2-e} | Opportunity cost value may be contingent on treatment of artesian bores being accounted for in a national emissions trading program. |
| Ecosystem services (water supply) for communities | Bennett et al. (2004), Rolfe et al. (2000). | Studies are relevant but there may not be any population movements if only marginal changes in groundwater are considered. |

The results show that there are four categories of benefits where source data may be used in a benefit transfer exercise:

- Recreation
- Options for future use and reducing wastage
- Protecting biodiversity
- Reducing greenhouse gas emissions

Three categories of value are not selected for inclusion in the benefit transfer exercise:

- Protection from weeds and pests: No directly appropriate values can be sourced from other studies. However, the removal of weeds and pests can be viewed as part of the contribution to biodiversity protection, and hence values for these actions are embedded within non-use value categories.
- Cultural heritage values: The results reported by Rolfe and Windle (2003a) demonstrate that protection of aboriginal cultural heritage sites is important for aboriginal groups, as well as for a subset of the general population. Although the values are expected to be significant and positive, it is difficult to find a direct basis for transferring these values to the GAB case study.
- Ecosystem services for communities: Although the GAB resource underpins the livelihood of many pastoral enterprises and rural communities, the changes in bore pressure generated by GABSI is unlikely to generate much change in activities in the short to medium term, apart from minor changes in pumping costs⁷. For this reason, these values have not been included in the benefit transfer exercise.

⁷ These would be relatively easy to estimate.

6. Discussion and analysis

In this section the reviewed information is combined and analysed to provide some analysis of the values being generated by the bore capping program and the return on public investment. This involves some use of benefit transfer techniques to estimate possible protection values. The section is in four parts. First, a review of the cost-effectiveness of public investment is provided. Second, appropriate benefit transfers for the relevant groups of values are performed. Third, these results are then combined in a benefit cost framework. Fourth, the results are analysed to identify key gaps in knowledge about the economics of resource use.

6.1 Cost effectiveness of public investment

The reviews conducted by Hassall & Associates (2003) and SKM (2008) have each involved some cost-effectiveness analysis. The original interim analysis of Phase 1 by Hassall and Associates (2003) suggested that the public investment was \$7.50 per ML of water saved, based on expenditure of \$20.8 million and water savings of 41,546 ML/year. SKM (2008) repeated the analysis including all investment by landholders as a program cost and making an allowance for operating costs. Using a discount rate of 3.5%, they estimated that the cost per ML of water saved over a 30 year timeframe was \$63 per ML in Phase 1 and \$109 per ML in Phase 2.

Both exercises in cost-effectiveness analysis are not fully appropriate to assess government investment. The exercise by Hassall and Associates (2003) includes a cross subsidy to landholders as a benefit, while the analysis by SKM (2008) incorporates both public and private investment as costs. Here, the cost effectiveness of both the Phase 1 program and the interim Phase 2 program (to the 3rd year) are analysed using only public costs. The annual investment by both the Commonwealth and the States in the program is shown in Table 6. Private investment in the program is not considered as part of the public investment, in part because landholders would normally expect private returns to outweigh levels of private investment (Pegler et al 2002, CIE 2003, SKM 2008).

Table 6. Commonwealth and State Investment in the GABSI.

| Year | GAB Phase 1 | | | | | GAB phase 2 | | | | |
|----------------------|-------------|-------|-------|-------|-------|-------------|-------|-------|-------|-------|
| | 99-00 | 00-01 | 01-02 | 02-03 | 03-04 | 04-05 | 05-06 | 06-07 | 07-08 | 08-09 |
| Comm. Payments (\$M) | 2.505 | 4.42 | 5.375 | 8.53 | 7.556 | 7.1 | 5.663 | 9.459 | 8.148 | 8.299 |
| State Payments | | | | | | | | | | |
| Qld (\$M) | 1.12 | 1.943 | 2 | 5.05 | 4.191 | 4 | 4.042 | 4.75 | 4.958 | 4.928 |
| NSW (\$M) | 1.385 | 1.95 | 3 | 3 | 3 | 3 | 1.521 | 4.709 | 3.19 | 3.371 |
| SA (\$M) | | 0.527 | 0.375 | 0.48 | 0.365 | 0.1 | 0.1 | | | |
| Total States (\$M) | 2.505 | 4.42 | 5.375 | 8.53 | 7.556 | 7.1 | 5.663 | 9.459 | 8.148 | 8.299 |
| Total Govt. (\$M) | 5.01 | 8.84 | 10.75 | 17.06 | 15.11 | 14.2 | 11.33 | 18.92 | 16.3 | 16.6 |

The analysis was conducted using the following steps, with results shown in Table 7:

- All expenditure was converted to 2007 values using the Australian Consumer Price Index (all groups)
- Expenditure was summed for the Commonwealth and State Government investments for the State 1 and interim Stage 2 periods,
- Expected water saving was estimated as the annual water saving rate extrapolated over 30 years,
- Total investment was compared to total water saved for each period.

Table 7: Cost effectiveness of public investment in GABSI

| | Phase 1 (5 years) | Phase 2 (3 years) |
|-------------------------------------|--------------------------|--------------------------|
| Commonwealth Payments (\$M) | 28.386 | 22.222 |
| Total States (\$M) | 28.386 | 22.222 |
| Weighted total in 2007 prices (\$M) | 64.416 | 45.550 |
| Water saved/annum (ML) | 98,075 | 46,474 |
| Water saved over 30 years (ML) | 2,942,250 | 1,394,220 |
| Cost / ML over 30 years | \$21.89/ML | \$32.67/ML |

The results show that the cost of saving water in 2007 dollars of public investment was \$21.89/ML in Phase 1 and \$32.67/ML at the 3 year interim in Phase 2. For the public investment to be worthwhile, the public benefits generated by the program should be at least as high as the costs incurred. However, the lack of current information about the value of public benefits generated by the program makes it difficult to perform this evaluation.

An alternative way of performing the analysis is to apportion the investment over the thirty year period by amortising the public investment. Using the 7% discount rate adopted by Hassalls and Associates (2003), the annual costs over 30 years for Phase 1 and Phase 2 can be calculated as \$5.19 Million and \$3.67 Million respectively. Comparing these to the annual water savings generates cost estimates of \$52.93/ML in Phase 1 and \$78.98/ML at the 3-year interim in Phase 2. The costs of water saving are much higher under this approach because the cost of time preferences are built into the analysis.

6.2 Non-farm benefits by category

In this section, the benefit transfer process is used to extrapolate values from key studies reported for the four areas where it is possible to conduct a benefit transfer exercise:

6.2.1 Recreation

There are two key stages in the estimation of recreation values: the transfer of values from one or more other case studies, and the extrapolation across relevant visitor numbers. Addressing the first stage, there were four key estimates of recreational consumer surplus reported in section 5.1

from the results reported by Delforce et al. (1986), Rolfe and Prayaga (2006) and Dyak et al. (2007). An average of those four estimates is \$139.41/day, which can be transferred to recreation use in the GAB.

The second task is to identify the appropriate level of visitor numbers. Recreation visitation numbers for the Outback region as a whole can be estimated from various state sources.

- In Queensland, the Domestic Tourism Snapshot for the Outback region to June 2007⁸ reported a total of 193,400 visitors for holiday/recreation in the 12 month period, staying an average of 3.9 nights. Domestic Australian visitors dominated, with 173,200 visitors.
- In South Australia, there were an estimated 98,400 visits and 462,700 overnights stays for holiday/recreation in the Outback South Australia area (excluding Flinders Ranges)⁹. Expenditure by domestic overnight visitors averaged \$86 per visitor night, and 9% of visitors visited national parks.
- In New South Wales, there were 176,880 domestic overnight visitors spending 645,000 visitor nights for holiday/recreation in the outback region in 2007¹⁰. Domestic overnight visitors were estimated to spend \$100 per night in the region.

The visitors to the GAB who are most likely to draw recreation benefits directly from it are those people visiting the Dalhousie Springs complex in Witjira National Park on the edge of the Simpson Desert¹¹. Webster (1995) estimated 10,000 visitors per annum to that site. Assuming each visitor stays for two nights would generate annual recreational benefits of \$2.79 Million. However, only part of this can be counted as a benefit of GABSI, because only incremental changes are being made to the resource condition. Using the 21% reduction in annual extraction achieved by GABSI as a proxy for estimating marginal effects¹², the annual recreation benefits can be estimated at \$585,522 or \$4.05/ML of reduced water extraction.

6.2.2 Options for future use and reducing wastage

Rolfe and Windle (2005) identified that the value per household of reducing water allocations was \$1.90 per one per cent of water reserves for systems that were not highly allocated. This is an annual payment value over 20 years. This estimate can be extrapolated to the household populations of Queensland, NSW and South Australia (4.3 million in the 2006 Census), extended over the 21% reduction in groundwater allocations and adjusted for the survey response rates (58.3%) to yield a benefit estimate of \$100 Million per annum. However, the exercise may not be fully appropriate for several main reasons. First, there are significant variations in framing between maintaining water flows in a river basin and maintaining groundwater reserves. Second, marginal effects would be expected to reduce values for larger percentage changes. Third, the future context may vary significantly, with low productivity rangeland grazing in the GAB

⁸ Available at http://www.tq.com.au/tqcorp_06/index.cfm?6DAEE617-D56E-789F-E60D-5D5B87D5EFF9

⁹ Data sourced from the *South Australia Regional Tourism Profile 2006*, available at: www.tourism.sa.gov.au

¹⁰ Data sourced from the *Travel to Outback NSW* report for 2007, available at: www.tourism.nsw.gov.au

¹¹ While there are other recreation visitors, such as those to the artesian baths in Moree, northern NSW, these are now supplied by bores rather than through natural springs.

¹² Little information is available to support this assumption about the apportionment of tourism benefits.

region perhaps viewed differently by survey respondents. Fourth, the GAB has significant stocks of water as well as annual yields, different to a river system, so issues of allocation may be viewed in very different ways. For example, the stock of groundwater reserves in the GAB is estimated to be 8.76×10^9 ML, with approximately one million ML entering and exiting the system each year (GABCC 1998). These factors mean that the simple benefit transfer estimate of \$100 Million is likely to be a significant over-estimate of benefits.

Rolfe and Windle (2003b) and Rolfe and Windle (2005) show that there are diminishing marginal values as the scope of benefits increases, in line with predictions from economic theory. Drawing on information from those two studies, it is likely that marginal values beyond four sets of benefit items would be low. Employing this assumption, an upper limit of benefits of \$20 Million can be extrapolated for this category.

6.2.3 Biodiversity protection

Rolfe et al. (2000) and Blamey et al. (2000) estimated the annual value of avoiding the loss of each 1% of unique ecosystems was \$4.79 per Brisbane household for 15 years (in 2007 dollars). Rolfe et al. (1997) had previously identified that there were 11 unique ecosystems in the Desert Uplands region, with at least one associated with artesian springs. The region hosts one of the 12 major groups of artesian springs in the GAB.

To apply these values, some estimate of the averted loss of the artesian spring ecosystems needs to be made. Approximately one-third of artesian springs have disappeared since the maximum water yield was recorded in 1915, a period of approximately 90 years (GABCC 1998, Ponder 2004). At this rate of loss, it could be predicted that a further 11% of artesian springs in the region would disappear in the next 30 years. A key biodiversity benefit of the bore capping program is that this loss would be averted. If the part-worth is extrapolated across the 11% of potential loss averted for one eleventh of unique ecosystems, and 50% of households¹³ in Queensland, NSW and South Australia, the annual preservation value for one major group is approximately \$10.3 Million per annum.

Extrapolation to 12 major spring groups generates an estimate of \$123.6 Million per year, although this is likely to be an overestimate as marginal effects from including multiple items can be expected. Rolfe and Windle (2003b) and Rolfe and Windle 2005 show that there are diminishing marginal values as the scope of benefits increases, in line with predictions from economic theory. Drawing on information from those two studies, it is likely that marginal values beyond four sets of benefit items would be low. Employing this assumption, an upper limit for benefits of \$41.2 Million can be extrapolated.

If there are additional benefits in protecting endangered species or non-threatened species then the biodiversity protection values are likely to be higher. For example Rolfe et al. (2000) and Blamey et al. (2000) estimated the annual value of avoiding the loss of each endangered species was \$14.83 per Brisbane household for 15 years (in 2007 dollars). If it is assumed that the

¹³ This allows for the non-response rate in the survey.

GABSI averts the loss of one endangered species, such as the Elizabeth Springs Goby or the Edgbaston goby, then the benefit across households in Queensland, NSW and South Australia can be estimated at \$5.8 Million per annum.

6.2.4 Reducing greenhouse gas emissions

Pallasser and Alder (2001) estimate that a 25% reduction in water extractions should decrease total emissions of carbon dioxide equivalents by about 60,000 tons per annum. At \$19 per ton, this would represent an overall cost reduction to the Australian economy of \$1.14 Million. The estimate would be contingent on the reduction in greenhouse emissions being accounted for in national targets and trading caps.

6.3 Summary of Benefits

The benefit transfer exercises provided in the previous section are summarised in the following table. The results of the benefit transfer exercise confirm that there are significant off-farm values for the GAB. Consistent with the summary estimates of Bennett and Rolfe (1998) of more than \$100 Million per annum, it appears that the benefits of improving the management of the GAB may be as high as \$68 Million per annum if there are unique values for at least 4 major groups of artesian springs and one endangered species protected, as well as considering the cost savings involved in greenhouse gas emission reductions. These estimates will be reinforced if the values of the remaining Australian population are considered.

Table 8. Summary of estimated values of benefits

| Valuation issue | Estimated annual value |
|---|--|
| Direct use values for recreation and tourism | At least \$0.5 Million per annum |
| Option values (for both future use and non-use purposes) | Some subset of \$100 Million per annum – likely to be less than \$20 Million/annum |
| Biodiversity protection values for native biodiversity | Some subset of \$123.6 Million per annum (likely to be less than \$41M) for unique ecosystems x 12 major spring groups \$5.8 Million per annum for one endangered species |
| Biodiversity protection values for removal of pests and weeds | Value included in estimates of biodiversity benefits |
| Cultural heritage protection values | Significant, but lack of data does not allow assessment |
| Ecosystem services: reduction in greenhouse gas emissions | Approximately \$1.14 Million per annum in cost reductions to meet emission targets if the reduction in greenhouse emissions is accounted for in national targets and trading caps. |

6.4 Analysis of information gaps

The desktop literature review revealed that no non-market valuation studies exist for the GAB. The review of related literature illustrates that there are few studies that estimate the non-use values of rangelands in general and artesian springs and wetlands in particular. Due to the limited nature of the existing studies, it would be appropriate to conduct a primary study to assess non-market values of the GAB.

The available information on non-market values for the GAB can be contrasted to what would be desirable from a policy development perspective. The gaps in knowledge can be summarised into two main groups:

Gaps in technical knowledge about impacts

- Net savings in extractions from GAB after any extra extractions for mining or other new developments have been considered
- Number, expenditure and duration of tourism visits to GAB sites, and relationship between visitation and site condition,
- Predicted improvements in biodiversity outcomes from improving water pressure
- Predicted improvements in the control of weeds and pests from the reduction in bore drains and the subsequent benefits on biodiversity.

Gaps in knowledge about values of benefits

- Values for changes to the GAB as a whole
- Values for changes in components of GAB (recreation, artesian springs, wetlands, endangered species)
- Influence of special or iconic status on values
- How values may be sensitive to the quantity of environmental benefits involved
- How values vary by population group (e.g. GAB population, tourists, state populations, national population).

7. Conclusions and Recommendations

The analysis provided in this report has focused on identifying and valuing the non-farm benefits associated with the GABSI. The results demonstrate that there is a range of off-farm benefits generated by the GABSI which accrue to different groups in society. Maintaining and improving the condition of the GAB through the GABSI will contribute to recreation uses and maintain water supply for regional communities, contribute to the reduction of greenhouse gases, and maintain ecological and biodiversity assets, cultural heritage and the options for future use and conservation.

These off-farm benefits are the key justification for the implementation of the GABSI. While the program also generates private on-farm benefits, these are offset to a large extent by the investment and costs incurred by landholders who participate in the scheme. Some level of net private benefit to landholders is necessary to maintain participation, and may be viewed as an engagement cost for the program. This means that the justification of the public investment in the GABSI by the Australian and State governments should be almost exclusively in terms of the off-farm benefits that are generated.

The application of the cost benefit framework to the GABSI requires that values be assigned for the off-farm benefits. However, no primary non-market valuation studies exist that are focused on the GAB. To perform the analysis, a benefit transfer approach has been adopted where a review of other similar studies has been conducted, and then values for the different components of off-farm benefits have been extrapolated from the results. The results of this benefit transfer exercise suggest non-farm benefits of improving the management of the GAB may be as high as approximately \$68 Million per annum. This can be compared with an annual investment of \$15.5M from the Australian and State Governments in stage 2 of the GABSI to give an initial indication that the off-farm benefits outweigh the costs involved.

The deficiency of suitable primary studies in the benefit transfer exercise means that this estimate has to be treated with caution. There are four key issues that should be treated as caveats to this assessment of program benefits. First, there is very little information to identify the marginal impacts of the GABSI on key uses and environmental assets, making it difficult to define the benefits involved. Second, there is a lack of primary or closely related valuation studies, making any benefit transfer process problematic. Third, the underlying context the source valuation studies and GAB varies, particularly in relation to the extent of environmental change and marginal benefits involved, making it difficult to identify the appropriate limits to value extrapolation. Fourth, it is possible that performing the benefit transfer process for separate components of value leads to higher estimates compared to a Total Value approach where a package of values are assessed.

These caveats about the analysis provided in this report help to identify key information gaps about the extent and analysis of off-farm benefits. These gaps can be classified into two key groups. The first is a need for improved collection of technical knowledge to allow better evaluation of the economic, environmental and social consequences of the GABSI. This is important to identify the marginal benefits generated by the program. The second key gap is in non-market values for improved management of rangeland and artesian resources generally, and

for the GAB in particular. The only approach to achieving more accurate assessments of the non-market values associated with off-farm costs and benefits would be to undertake a dedicated study on the region to provide more certainty about the size and distribution of the off-farm benefits.

The assessment of off-farm benefits, most of which can be classified as public benefits, allows for some analysis of the policy mechanisms underlying the GABSI. The analysis suggests that there will be large net public benefits arising from the GABSI, together with smaller net costs or net benefits to landholders. Assessment of this combination of net public and private benefits against the assessment tool summarised in Figure 6 confirms that technology change/positive incentives are the appropriate policy tools to be applied. This is consistent with the overall structure of the GABSI, confirming that the use of positive incentives to generate voluntary engagement with landholders is an appropriate policy mechanism for this case study.

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Appendix 1: Background and Purpose (Extract from the GABSI)

The Commonwealth and the State:

- (a) recognise that the Great Artesian Basin supplies water to an extensive pastoral industry, key mining and extractive industries, unique aquatic ecosystems, an emerging tourism industry, townships and homesteads in and around the Basin;
- (b) recognise that while there are few reliable alternative sources of water of an acceptable quality, the key feature of the resource is the artesian pressure, enabling relatively low-cost low-maintenance and reliable water supplies in remote areas. While loss of artesian pressure may not preclude access to the groundwater resource, the capital and maintenance/operational cost of such access increases markedly;
- (c) recognise that many of the bores constructed late in the nineteenth century and for the first half of the twentieth century are uncontrolled and uncontrollable, and inefficient reticulation systems (open earthen drains) are common. Consequently most of the water flow is wasted and current extraction of water is substantially in excess of users' real needs;
- (d) recognise that the major problem is the continued decline in groundwater pressures resulting from the regional extraction/discharge in excess of zone recharge rates. Inaction and continued wastage of the resource will constrain future options for use of the resource, threaten continued access to artesian pressures by a range of existing users, and in continued land, vegetation and habitat degradation and loss of biodiversity resulting from inappropriate use and disposal of water in an essentially arid landscape;
- (e) recognise that there is a clear and largely uncontested need for substantial changes in attitude and practices by land and water resource users in the Basin. Water needs to be appropriately valued and managed as a limited and limiting resource, with a clear focus on obtaining maximum community benefit for its use. The Strategic Management Plan for the Basin, prepared by the Great Artesian Basin Consultative Council provides important guidance to the overall management of the natural resources of the Basin;
- (f) recognise the importance of the Great Artesian Basin in the maintenance of communities and the important role played by water users in the sustainable management of the resource;
- (g) acknowledge that the Commonwealth and the States are making a significant investment through the Great Artesian Basin Sustainability Initiative to address the above issues and the Commonwealth is committed to working with the States and the Basin community to achieve sustainable outcomes for the benefit of the nation as a whole;
- (h) note that the Commonwealth's national goal for the Great Artesian Basin Sustainability Initiative is to promote and facilitate the establishment of sustainable on-going groundwater management systems for the Great Artesian Basin through strategic investments in groundwater infrastructure renewal and related activities in natural resource management; and
- (i) agree that this Agreement establishes a framework within which the Commonwealth and the States will work cooperatively to achieve the goal and objectives of the Great Artesian Basin Sustainability Initiative.