Improving water-use efficiency in irrigation conveyance systems

A study of investment strategies

Marsden Jacob Associates

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Land & Water Australia
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Department of Agriculture Fisheries & Forestry – Australia

The **National Rivers Consortium** is a consortium of policy makers, river managers and scientists. Its vision is to achieve continuous improvement in the Management of Australia's rivers.

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Abbreviations

AFFA	Agriculture, Fisheries and Forestry – Australia
ANCID	Australian National Committee on Irrigation and Drainage
BOOT	build, own, operate, transfer [contract]
CAPEX	capital expenditure
CSO	community service obligation
D&S	domestic and stock [water supplies]
DBO	design, build, own [contract]
DLWC	Department of Land and Water Conservation (NSW)
FAO	Food and Agriculture Organization of the United Nations
GL	gigalitre; one thousand million litres
GMW	Goulburn–Murray Water
IA(s)	irrigation area(s)
ILRI	International Institute for Land Reclamation and Improvement
IWP(s)	irrigation water provider(s)
MBI(s)	market-based instrument(s)
MDB	Murray–Darling Basin
ML	megalitre, one million litres
NRM	natural-resource management
pers. comm.	personal communication
PPP(s)	public–private partnership(s)
SCADA	supervisory control and data acquisition
WUE	water-use efficiency

Executive summary

Background

1. This report examines the scope for private-sector investment in water savings from irrigation delivery schemes, particularly in light of current interest in improving water use-efficiency in Australian rivers. The objective of the report is to inform policy-makers of the options for private-sector financing and the barriers to implementation.
2. Irrigated agriculture accounts for approximately 70% of water consumption in Australia. In 2000–01, according to industry statistics, about 29% of the water taken into irrigation schemes was lost between the irrigation district inlet and the farm water meter. Improved water efficiency in irrigation schemes represents a significant potential source of water savings.
3. In urban water supply systems, there is a trend to increasing the use of public–private partnerships and other similar mechanisms to attract private sector investment. The scope for involving private capital in irrigation delivery is less clear. In recognition of the need to extend the understanding of private-sector financing options, Land & Water Australia commissioned Marsden Jacob Associates to prepare this report. The terms of reference for the report included the following requirements:
   – identify the activities or measures with potential for achieving a reduction in conveyance losses in irrigation delivery schemes;
   – assess the scale or capacity to reduce conveyance losses;
   – review policy instruments for providing investment incentives; and
   – identify the conditions required to stimulate private-sector investment in improving water-use efficiency in conveyance systems.

Conveyance losses in irrigation schemes

4. In all water supply systems, some proportion of the water diverted from rivers or dams is lost in conveyance to the consumer. This is true for both urban piped water supply systems and irrigation delivery schemes.
5. The efficiency of irrigation delivery is measured as the difference between the volume of water diverted at the irrigation district intake less the volume of water recorded at irrigator meters. This definition encompasses:
   – **outfalls or water flowing from the downstream-end of a delivery system.** Outfalls often flow back into rivers and are available to downstream users and/or for environmental flows. This means that, on the other side of the coin to 'bad losses', there are 'good' return flows;
   – **farm irrigation water meter inaccuracy**. With increased demands for shorter irrigation cycles and the increasing practice of operating channels at full volumes and outside meter calibration limits, many irrigation meters systematically under-record (by as much as 70%) the volume of water flowing through the meter. The understatement of water actually used on farms for irrigation leads to an equivalent overstatement of the conveyance loss;
   – **unrecorded usage.** Not all water usage is metered. Water received through unmetered outlets (and water theft) contributes to conveyance losses;
   – **leakage.** The loss of water from channels through channel banks and structures increases conveyance losses. Leakage is a 'real' loss of water when it flows to salt sinks. Some leakage is re-used; for example, it is relatively common practice to pump ponded water from leakage sites adjacent to channels for irrigation purposes;
   – **seepage.** Seepage is the movement of water through the beds of irrigation channels. Seepage losses are 'real' losses when seepage flows to saline groundwater and becomes unusable. However, in some situations, such as in areas with low groundwater salinity, seepage may: 1) beneficially recharge rivers, or 2) form a lens of fresher groundwater near the surface that is either pumped from the ground for crop irrigation or intercepted by the roots of crops;
   – **evaporation.** Evaporation losses occur in channels and storages. Evaporation losses are a

'real' loss of water resource, in the sense that there is no economic value in water vapour. However, in situations where water ponded in storages provides recreational opportunities or amenity values, the loss of water through evaporation could be considered to be a reasonable cost of a beneficial use of the resource.

6. Use of a single term 'conveyance losses' for multiple concepts tends to confuse understanding of the problem and consequent policy responses. Each source of water loss in conveyance systems requires different policy and management responses. Importantly, not all losses are unequivocally, or uniformly, bad.
7. The precise volume of water lost in irrigation conveyance due to any specific cause is generally not known with precision. From the information that is available, in open-channel systems typical of the southern Murray–Darling Basin, outfalls are frequently the largest source of losses, accounting for up to 45% of total losses. Meter inaccuracy is also a major source of losses, accounting for up to 25% of measured losses. In contrast, smaller amounts of water are thought to be lost to: evaporation – 10% ; and seepage/leakage – 5% .

Table 1. Indicative magnitude of conveyance losses in the southern Murray–Darling Basin

Diversions at district bulk meters	10,000 GL
less: Measured deliveries at the farm meter	7,100 GL
equals: Transmission losses	2,900 GL
of which:	
– outfalls	45% or 1,305 GL
– meter inaccuracy	25% or 725 GL
– evaporation	10% or 290 GL
– seepage/leakage	5% or 145 GL
– system filling	5% or 145 GL
– unmetered/theft	5% or 145 GL
– other	5% or 145 GL

8. Some forms of water loss in irrigation conveyance generate positive economic outcomes, for example:
   - irrigators taking pumping water from drains;
   - graziers whose pasture production benefits from drainage water flowing from an upstream irrigation scheme;
   - property owners who enjoy the amenity derived from having a property frontage on a waterway that flows year round because of upstream regulation; and
   - outfalls providing beneficial flows to wetlands.

These are externalities in the sense that the beneficiary does not pay the 'owner' for the benefit received.

9. Improving conveyance efficiency, by definition, will reduce the level of beneficial economic outcomes accruing to informal water uses such as those listed above. Because many of these informal uses are economically valuable, the net benefits from recovering water by reducing inefficiencies may be significantly less than suggested by the raw data on measured losses.

Options for improving conveyance efficiency

10. The benefits and costs of improving irrigation conveyance efficiency are highly site and situation specific. While corrective actions can sometimes be replicated across systems, often an action that improves efficiency in one part of an irrigation scheme would be inappropriate in another part of the same scheme. Accordingly, there is no single solution to increase benefits from implementing efficiency.
11. Losses from **outfalls** can be reduced by improving water control in channels through the use of channel control technology and/or changing management practices. Examples of measures to control outfalls include:
    - the automation of flow-control structures and measurement devices and the optimisation of channel operations using computer software;
    - the imposition of penalties on irrigators when they reject water they have ordered;
    - providing incentives for channel operators to minimise outfalls; and
    - resisting pressure from irrigators to keep flow heights up or to supply water more frequently.
12. Losses through **meter inaccuracy** can be reduced by fitting more-accurate meters or by rehabilitating existing meters. Judging from recent experience with the fitting of flume gate meters in areas such as the Goulburn–Murray and the Coleambally Irrigation Area, irrigators are reluctant to support the installation of more-accurate farm meters.
13. **Leakage or seepage** in open channels can be reduced by channel sealing or pipelining. Where channels cross sandy soils, or seepage is damaging adjacent private property, it is often economic to control seepage. The lining of all earthen channels, as is sometimes advocated, is expensive in terms of the cost per unit of water saved. Most open-channel irrigation systems in Australia are located in river floodplains with heavy clay soils. Seepage in these areas is minimal and recovering losses is estimated to cost up to $30,000 per ML of water saved.
14. The **pipelining of open-channel irrigation** is often advocated to reduce seepage and evaporation losses**.** Pipelining is economically feasible where there is a need for on-demand, pressurised water supplies for sprinkler and drip irrigation, for example, in horticultural districts.
15. While it is technically feasible to pipeline open channels in areas where surface irrigation is practised (ie. where pasture, rice and field crops are grown) it is

usually not economically viable. Typically, the surface irrigation of pastures and crops occurs in areas where large volumes of water are delivered over long distances in flat terrain. To supply the required amount of water in these areas requires a level of expenditure on pipes and/or pumping systems that cannot be justified for enterprises growing low to medium-value commodities.

16. Pipelining has potential in those domestic and stock systems that are supplied through the regulation of natural water courses or through extensive channel systems in sandy country. There are several of these pipelining projects on the drawing boards of State governments. The cost of water savings in pipelining domestic and stock systems are attractive at first glance — $1,000 to $4,000 per ML. However, while there is good value from a water savings point of view, there is opposition to these pipelines from consumers who would be disadvantaged by the high cost of farm conversion, the loss of the amenity value of farm dams/waterways, and the loss of the opportunity for future farm intensification.
17. **Evaporation losses** in storages can be reduced through modification of storages or weirs to raise water levels and/or reduce the surface area of the storage or weir pool. The cost effectiveness of this approach will vary, as every water storage has its own set of unique characteristics and operating parameters. An important factor to be considered here is the impact of modifying storages on the reliability of supply for downstream water consumers and the amenity, recreational and environmental values generated by water storage.

Funding options

18. The funding of investments in infrastructure to reduce irrigation losses has to be seen within the context of the broader debate on:
    – **the financing of ageing irrigation supply infrastructure**. A considerable proportion of the infrastructure in Australia's irrigation systems is approaching the end of its useful structural life. Over the coming decades, the cost of replacing infrastructure will be measured in billions of dollars. Irrigators, alone, are unlikely to be able to access the capital required for this task;
    – **infrastructure to manage environmental flows in rivers.** The need to provide environmental flows for rivers requires its own special type of investment in infrastructure. The infrastructure includes: multiple release points in weirs and dams to provide a mix of water temperatures and chemical characteristics; levee banks and control structures on floodplains and wetlands; and automation and supervisory control and data acquisition systems to manage river operations. Investment in water saving in irrigation districts needs to complement parallel activities in river systems;
    – **water trading**. As water entitlements move between irrigation areas through water trading, some water delivery infrastructure becomes increasingly under-utilised, to the point where it is uneconomic to irrigate. Decisions over how and where to invest in water-savings infrastructure need to be made within the context of this issue;
    – **structural adjustment in the agricultural sector.** The irrigation industry, like the farm sector in general, is affected by structural adjustment pressures. Over the last decade, adjustment in the water industry has led to a significant shift to higher-valued irrigation water use. Again, decisions over how and where to invest in water savings will affect future industry adjustment patterns; and
    – **reforms to water rights.** Much of Australia's on-farm irrigation infrastructure has been developed using debt secured against the value of land and, implicitly, the value of water. In the changeover to a licence-type entitlement separate from land, lenders have become increasingly concerned about the integrity of their mortgages. Lenders have signalled that they will be increasingly cautious about extending credit to irrigators and this will in turn affect the cost of finance to the irrigation sector.
19. The private sector has long provided goods and services to the public sector. However, a trend seems to be developing towards increasing involvement of the private sector in the provision of goods and services traditionally provided by, and seen as a function of, the public sector. For example, public–private partnerships and other similar mechanisms are increasingly used to finance urban water infrastructure in Australia. In this study, private-sector organisations involved in infrastructure financing were surveyed for their views on the potential of public–private partnerships as a mechanism for investing in irrigation conveyance systems.
20. The survey found that, historically, the private sector has not been involved in irrigation projects involving large, open-channel distribution systems, primarily because there have been so few projects where the private sector has been invited to participate. Nevertheless, the survey suggests there is considerable interest in irrigation infrastructure projects. Survey respondents highlighted several factors which they thought would affect the attractiveness of irrigation projects to the private sector. These include:
    – the extent of the potential to implement measures to achieve cost savings such as through computer-

based asset management, remote monitoring and improved operational systems;
– the scope for avoiding excessive operational complexity, particularly where facilities operated by different parties need to be managed as one system;
– projects need to be sufficiently large to justify the cost of bidding, capital raising and transaction costs. Bundling multiple smaller projects with a similar profile using common documentation and processes offers an alternative mechanism of achieving required project scale;
– clearly articulated, risk-sharing arrangements. An effective arrangement would be one that allows the private sector to clearly identify, quantify, and effectively manage risk. Environmental, climatic and regulatory risks need to be carefully managed;
– the preferred structure of a public–private partnership off-take agreement is:
  • an agreement with a single agency,
  • clear output specifications,
  • payment mechanisms structured in a way to produce long-term, predictable cash flows, and
  • an agreement that contains incentives to promote innovative technological and operational solutions;
– low project credit risk with government security; and
– strong potential synergies with existing projects and businesses in the urban water sector.

21. In the southern Murray–Darling Basin, the cost of projects to reduce conveyance losses are in the range \$650 to \$30,000 per ML of water saved. In contrast, the market value of water is about \$1,000 per ML. Because of the difference between the cost of achieving savings and the capacity to generate revenue through the sale of water in the private irrigation water market, water-savings projects cannot be profitably undertaken by private firms on a stand-alone basis.
22. The price of water in the private irrigation water market does not include the external costs and benefits created in conveying water to irrigators. The public sector has unique resources, including its legislative capacity to determine property rights and regulate water use, and therefore has advantages in managing the externalities associated with irrigation conveyance. For this reason alone, the scope for private-sector investment in irrigation efficiency would seem to be limited.

Recommendations

- **Terminology:** clarify the terminology relating to the components of conveyance losses. As noted above, the use of a single term 'transmission or conveyance losses' for multiple concepts tends to confuse thinking, understanding and policy responses.
- **Measurement:** develop cost-effective methods for monitoring and measuring conveyance losses and water savings. Estimation techniques for measuring water losses (or savings) in conveyance systems tend to suffer from high levels of uncertainty. Consequently, there is a need to develop a robust system of measurement for monitoring and verification of water savings.
- **Property rights:** there is a need to confirm the nature of the entitlement to conveyance water losses. Caution should be exercised in future assignment of these property rights in order to preserve the capacity for adaptive management.
- **R&D support:** providing support to research and pilot projects into priority areas such as water automation technology, channel-sealing methods and irrigation rehabilitation. The private sector looks for a track record in a project technology as assurance that a project will be a success. Some of the more promising technologies for improving conveyance efficiency, such as channel-control technology, have yet to proven at a district scale.
- **Project design:** The design and implementation of private sector arrangements such as public–private partnerships are usually very complicated. The services to be delivered have to be specified in great detail, and project risks need to be identified and quantified. There is a need to examine how public–private partnership arrangements used in other sectors might be adapted to projects in irrigation water savings.

1 Introduction

This report examines the scope for private-sector investment in water savings from irrigation delivery schemes, particularly in light of current interest in improving water-use efficiency (WUE) in Australian rivers. The objective of the report is to inform policy-makers of the options for private-sector financing and the barriers to implementation.

In urban water supply systems there is a trend to increasing the use of public–private partnerships (PPPs) and other mechanisms to attract private investment. The rationale for private-sector investment is varied, but centres on issues relating to the access to technology, private-sector incentives for cost efficiency and an intent to reduce the call on the public budget.

The scope for involving private capital in other areas of the water economy, such as water saving in irrigation, is less clear. In recognition of the need to extend the understanding of private-sector financing options, Land & Water Australia commissioned Marsden Jacob Associates to prepare this report. The terms of reference for the report include four principal requirements:

- examine the conditions required to stimulate private investment in conveyance loss reduction;
- identify the activities or measures with potential for achieving a reduction in losses;
- review policy instruments for providing incentives to reduce losses; and
- assess the scale or capacity to reduce losses.

This report is based on a desk-top review of current and proposed investment activities for improving WUE, and discussions with the irrigation water providers (IWP)[1], government agencies and private-sector businesses involved in infrastructure development.

1 'Irrigation water providers' is the term used by the Australian National Committee on the International Commission on Irrigation and Drainage (ANCID) to describe organisations which in rural areas undertake the retail water distribution function primarily for irrigation but also for domestic and stock purposes.

2 Conveyance losses

2.1 Definition

In the context of irrigation-water supply, conveyance losses are reported as the difference between the volume of water supplied to irrigation customers and water delivered to the system.[2] Typically, three points of measurement are recorded:

1. the volume of water released at the headworks storage —point A in Figure 1
2. the volume of water diverted by bulk water suppliers —point B in Figure 1
3. the volume of water measured at the consumer's meter (farm inlet)—the sum of volumes recorded at points C in Figure 1.

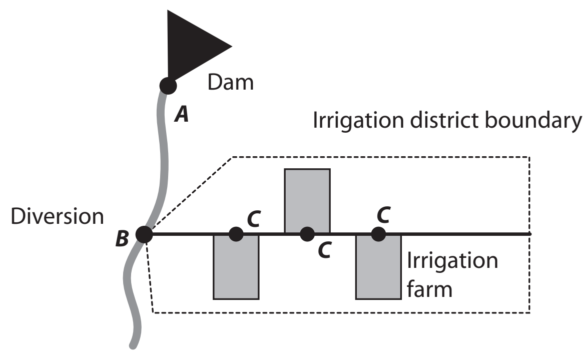

Figure 1. Measurement in a water supply system

The conveyance loss in the main stem of a river or bulk supply system is the volume of water released from the headworks at point A less the volume delivered to the distribution system recorded at point B. Losses in the main stem of a river are a result of evaporation, seepage to groundwater and river regulation, including the breaching of riverbanks, flooding of backwaters, inaccurate meter reading and unrecorded consumption.

In an irrigation distribution system, conveyance loss is the difference between the volume of water flowing into the distribution system at point B less the volume received by farmers, measured as the sum of meter readings at point(s) C.

Conveyance efficiency in irrigation systems is reported in terms of a conveyance efficiency ratio:[3]

$$\text{Conveyance efficiency (\%)} = \frac{\text{Volume delivered (ML)}}{\text{Volume diverted (ML)}}$$

By definition conveyance losses are:

Conveyance losses (%) = 100% – Conveyence efficiency

To illustrate the concept of conveyance losses, assume that the volume of water diverted into an irrigation district is 1,000,000 ML and the sum of the volume of water delivered to irrigators is 700,000 ML: the conveyance efficiency is then 70% and conveyance losses are 30%.

2.2 Conveyance loss in irrigation districts

As information on the conveyance losses in irrigation districts is in the public domain and widely available, it is the focus of much of the debate relating to the potential to recover water for environmental-flow purposes.

The principal source of comparative information about reported conveyance efficiency in irrigation delivery systems is the Australian National Committee on Irrigation and Drainage's (ANCID) irrigation water provider (IWP) benchmarking survey. This is a compilation of information submitted by 47 IWPs across Australia. Table 2 sets out the conveyance losses reported in the survey for the two years 1998–1999 and 1999–2000 and selected characteristics of the IWPs.

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[2] Australian National Committee on Irrigation and Drainage (2001). *Rural water industry terminology and units*—note ANCID uses the term "Irrigation Water Delivery Efficiency"

[3] Boss, M.G. and Nugteren, J. (1990). *On irrigation efficiencies,* International Institute for Land Reclamation and Improvement/ ILRI and
Barrett Purcell & Associates (1999). *Determining a framework, terms and definitions for water use efficiency in irrigation*, Land & Water Resources Research & Development Corporation

Table 2. Reported conveyance losses in irrigation schemes

Scheme	Losses (%)		Supply method	Irrigation deliveries 1999–2000 (ML)
	1998–1999	1999–2000		
New South Wales				
Colleambally	18.8	32.5	channel	316,000
Jemalong	29.1	29.3	channel	42,000
Murray Irrigation	20.5	18.7	channel	724,000
Murrumbidgee	20.3	22.3	channel	633,000
West Corugan	2.5	0	channel	34,000
Western–Murray	no data	5.8	pipe	24,000
Queensland				
Baker–Barambah	0	11.8	natural carrier	17,000
Boyne River	36.4	0	natural carrier	7,000
Bundaberg	0	7.2	pipe	125,000
Burdekin–Haughton	12.6	47.4	channel	237,000
Dawson	0	15.6	channel	34,000
Eton	56.2	12.5	natural carrier	20,000
Logan	0	2.4	natural carrier	8,000
Mareeba–Dimbulah	32.9	40.8	pipe	79,000
Mary River	7.2	42.8	natural carrier	12,000
Nogoa–Mackenzie	no data	15.5	natural carrier	164,000
Pioneer Valley	no data	0	natural carrier	13,000
Proserpine	0	30.4	natural carrier	12,000
St George	8.2	1.6	natural carrier	84,000
South Burdekin	59	50.8	channel	27,000
Upper Burnett	no data	10.4	natural carrier	22,000
Upper Condamine	no data	54.7	natural carrier	21,000
Warrill	no data	52.1	natural carrier	9,000
South Australia				
Central Irrigation	0	1.9	pipe	84,000
Golden Heights	0	0	pipe	7,000
Lower-Murray	no data	0	channel	56,000
Sunlands	0	0	pipe	8,000
Tasmania				
Cressey–Longford	0	1.1	channel	8,000
Southeast	0	0	pipe	4,000
Winnaleah	0	0	pipe	4,000
Victoria				
Bacchus Marsh	23.2	27.6	pipe	3,000
First Mildura	19	0	pipe	49,000
G–MW Murray Valley	30.5	33.7	channel	325,000
G–MW Shepparton	33.5	35.8	channel	155,000
G–MW Central Goulburn	30.4	27.5	channel	396,000
G–MW Rochester	18.7	12.7	channel	214,000
G–MW Pyramid-Boort	18.7	11.9	channel	203,000
G–MW Torrumbarry	27.1	53.6	channel	298,000
G–MW Swan Hill	no data	14.7	pipe	16,000
Macalister	29.3	31	channel	148,000
Sunraysia	18.9	0	pipe	68,000
Werribee	19	17.2	channel	10,000
Wimmera–Mallee	43.6	54.5	channel	13,000
Western Australia				
Gascoyne Irrigation	no data	8.8	pipe	2,000
Ord Irrigation	25	32	channel	170,000
South West	27.7	32.8	channel	77,000
Weighted average	22.7	27.8		

Sources: ANCID (2001). *Australian irrigation water provider benchmarking report for 1999/2000*, an ANCID initiative funded by Land & Water Australia and Department of Agriculture, Fisheries and Forestry – Australia, (AFFA) February and ANCID (2000). *1998/99 Australian irrigation water provider benchmarking report,* An ANCID initiative funded by Land & Water Australia and AFFA, February.

2.3 Causal factors

As suggested by the data presented in Table 2, there is a wide spread in the reported level of conveyance losses both between years and between irrigation schemes. From first principles, it is possible to identify the primary factors contributing to the variation in water losses reported by different irrigation schemes:

- **soil types** – irrigation infrastructure in sandy porous soils will have higher seepage losses than comparable systems in clay soils;
- **delivery infrastructure** – open-channel irrigation will have higher losses than a piped irrigation system because of higher evaporation and seepage losses;
- **the distance water is conveyed** – extensive irrigation schemes delivering water over large distances will have greater conveyance losses than irrigation areas located close to the water source;
- **service standards** – optimising irrigation delivery to raise customer-service levels may not be efficient from a water-savings perspective. For example, in open-channel systems there is a distinct trade-off between the level of service provided to the customer, measured in terms of the delay between ordering of water by the customer and delivery, and the volume of losses (outfall);
- **type of agriculture** – certain types of agricultural practices require larger volumes of water delivered relatively infrequently (eg. surface-irrigated pastures and crops), while other types of agriculture, (eg. horticulture), use smaller volumes of water but much more frequently. Piped delivery systems cannot economically supply the volume of water required by surface irrigation. Conversely, an open-channel, manually operated delivery system cannot deliver water frequently enough to supply the demands of horticulture. In effect, irrigation delivery systems are locked into a mode of supply that is determined by the agricultural practices of their customers;
- **operating practices** have an influence on the volume of outfalls in an irrigation system. In a typical irrigation system, the water consumer orders a volume of water from the supplier. If, for whatever reason, the irrigator does not divert the volume of water ordered, the residual volume not taken flows out of the end of the system. The irrigator is not debited for the volume of water ordered, but only the volume of water actually diverted through the meter. The irrigator therefore has the incentive to over-order water as a contingency. System operators can reduce the prevalence of out-falling by requiring irrigators to take all the water they have ordered and not to over order. The scope for enforcing restrictions on over-ordering is determined by the operating practices employed in the distribution system and the level of co-operation between irrigator and the supply operator;
- **infrastructure vintage** – older systems (either piped, lined or unlined channels) are generally built to a lower standard and have greater leakage and seepage;
- **maintenance standards** – well-maintained channels, structures etc. will leak and/or seep less then poorly maintained systems;
- **operating system** – traditionally, irrigation systems were operated using manual gates and with limited monitoring of water levels. Manually operated systems tend to have large flow adjustments that reduce conveyance efficiency. Increasingly, irrigation delivery system are being automated using SCADA,[4] remote control of structures and remote monitoring of flow levels. This introduces greater levels of precision into flow management and reduces losses. The extent to which automation is used in an irrigation district will therefore have a bearing on overall loss levels;
- **use of in-line storages** – delivery systems with shallow in-line storages will have greater evaporation losses than equivalent systems without storages;
- **type of meters** – an irrigation system equipped with mechanical wheeled meters (Detheridge wheels) will have greater measurement losses than systems with modern electronic meters; and
- **third-party impacts –** requirements to meet downstream consumptive, recreational, amenity and environmental demands will affect outfall losses.

An irrigation scheme's conveyance losses will vary from year to year because of fluctuations in water availability, operational methods, climate and customer demands. As an example, Figure 2 shows conveyance losses in the Goulburn open-channel irrigation scheme in Victoria between 1978–79 and 1998–99.

The level of reported conveyance loss in Australian irrigation schemes is relatively low, compared with those reported in large-scale irrigation schemes overseas (see Table 3). This may be attributed to:

- the relatively good condition of the delivery infrastructure in Australian irrigation schemes compared with many overseas systems, particularly those in developing countries; and
- the relatively low volumes of water that are diverted into delivery systems in Australia compared with typical overseas schemes.[5]

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4 SCADA (Supervisory Control And Data Acquisition) system refers to the combination of telemetry and data acquisition. It consists of collecting information, transferring it back to a central site, carrying out necessary analysis and control, and then displaying these data on a number of operator screens. The SCADA system is used to monitor and control a plant or equipment. Control may be automatic or can be initiated by operator commands.

5 See for example: Burt, C.M. and Styles, S.W. (1999). *Modern water control systems and management practices in irrigation: impact on performance*, FAO Water Report No. 19.

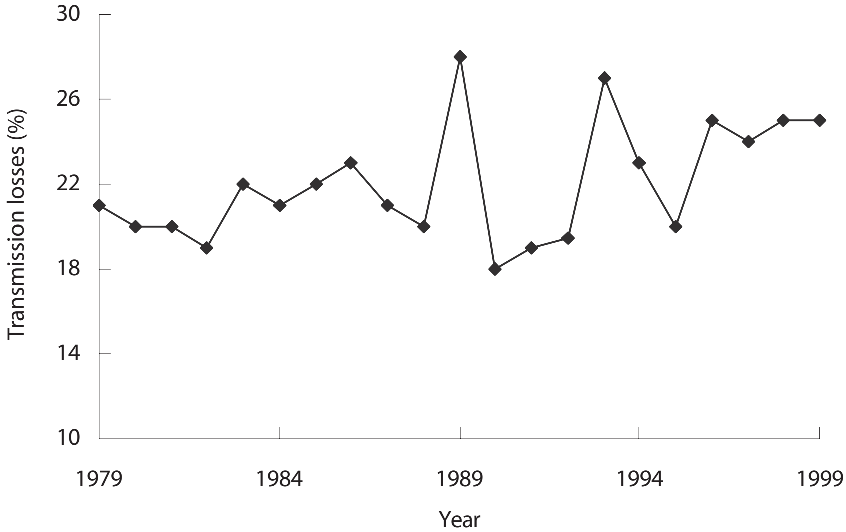

Figure 2. An example of year-to-year variation in conveyance losses: Goulburn Scheme, 1978–79 to 1998–99

Table 3. Conveyance losses (%) in irrigation water supply schemes in various countries

Country	Average	Maximum	Minimum
Philippines	13	not applicable	
Japan	16	25	8
Cyprus	24	26	22
Australia	**28**	**55**	**0**
South Korea	28	not applicable	
Malaysia	28	46	14
Taiwan	37	66	7
France	37	60	21
Austria	40	40	40
USA	41	50	30
Spain	42	not applicable	
Columbia	45	67	22
Germany	49	70	25
Mexico	50	69	23
Portugal	54	not applicable	
Egypt	54	not applicable	
Greece	57	69	49
Italy	59	64	53
India	60	71	42

Source: Bos, M.G. and Nugteren, J., (1990). *On irrigation efficiencies,* International Institute for Land Reclamation and Improvement/ILRI.

2.4 The components of conveyance loss

Conveyance losses take the following forms:[6]

- **outfalls or water flowing out of the downstream end of delivery systems**. In some areas, outfalls flow back into rivers and are available to downstream users and/or for environmental flows. This means that there are 'good' return flows on the other side of the coin to 'bad losses'. The benefits and costs of reducing these losses are more complex than they appear at first sight;
- **metering inaccuracy.** With increased demands for shorter irrigation cycles and the increasing practice of operating channels at full volumes and outside calibration limits, Detheridge wheels systematically under-record the volume of water flowing through the meter. The understatement of water actually used on farms for irrigation leads to an equivalent overstatement of the conveyance loss;
- **unrecorded usage.** Not all water usage is metered. Water received through unmetered outlets is recorded as a conveyance loss;
- **leakage.** Leakage through channel banks and structures is counted as a conveyance loss. A proportion of leakage is a 'real' loss of water to the catchment. However, some leakage flows into drainage schemes to be re-used downstream, or into on-farm delivery systems where it is used for irrigation;

[6] Bos, M.G. and Nugteren, J. (1990). *On irrigation efficiencies,* International Institute for Land Reclamation and Improvement/ ILRI, and Burt, C.H. and Styles, S.W.(1999). *Modern water control and management practices in irrigation: impact on performance,* FAO Water Report No 19.

- **seepage.** Seepage is the movement of water through the beds of irrigation channels. Seepage losses are 'real' losses when seepage flows to saline groundwater and becomes unusable. However, in some situations, such as in areas with low groundwater salinity, seepage may:
  - beneficially recharge rivers, or
  - form a lens of fresher groundwater near the surface that is either pumped from the ground for crop irrigation or intercepted by the roots of crops;
- **evaporation.** Evaporation losses occur in channels and storages. Evaporation losses are a 'real' loss of water resource, in the sense that there is no economic value in water vapour. However, in situations where water ponded in storages provides recreational opportunities or amenity values, the loss of water through evaporation could be considered to be a cost associated with a beneficial use of the resource; and
- **system filling.** Water used in the filling and draining of channels, pipes etc.

Table 4 sets out the estimated volume of water lost to the various forms of conveyance losses in the open-channel irrigation system operated by Goulburn–Murray Water (GMW) in northern Victoria.

In the case of GMW, outfalls are the largest source of conveyance losses, followed by meter error, evaporation, leakage and seepage. The balance item shows that there are errors in the method used to estimate the losses reported in Table 4. In this regard GMW's loss estimates have been independently reviewed by Rubicon Systems Australia Ltd.[7] Rubicon has concluded that the balance component results from a significant underestimation of meter outlet error and outfalls. Their analysis suggests farm meter error is 24% of losses not 11% as reported in the chart, and outfalls comprise 46% of losses rather than the 28% reported. They also conclude that the seepage and evaporation losses reported are overestimates of actual losses from these causes.

Table 4. Conveyance losses – Goulburn–Murray Water, 1998–99

Component	Volume (GL)	Proportion of inflows (%)	Proportion of losses (%)
Total inflows	3028	100	
Deliveries	2151	71	
Losses: which consist of:	877	29	
• Outfalls	244	8	28
• Leakage	85	3	10
• Seepage	54	2	6
• Evaporation	95	3	11
• System filling	48	2	5
• Theft and unmetered supply	43	1	5
• Farm meter outlet error	97	3	11
• Balance of losses	211	7	24

Source: SKM (2001), *Water Savings in Irrigation Distribution Systems*, report to Goulburn–Murray Water and the Department of Natural Resources and Environment.

A recent ANCID survey of channel seepage in Australia, asked IWPs to estimate the level of losses from channel seepage.[8] The survey found that seepage accounted for 1–10% of inflows or diversions[9] with an average across all surveyed IWPs of 3% . There are several reasons why seepage losses are relatively low:

- many of Australia's irrigation districts are located in areas with heavy clay soils and, consequently, low seepage rates;
- where channels run through zones of high seepage, such as prior-streams in the Murray Valley, they are constructed with a lining; and
- a water supply with high sediment loads, as is typical in many Australian river systems, will self-seal a channel.[10]

One of the interesting outcomes of the GMW analysis and the ANCID survey is the observation that leakage, seepage and evaporation are not the principal sources of losses within irrigation delivery systems. This is contrary to the often expressed view that large volumes of water are lost to these causes.

It is possible that commentators have confused channel irrigation schemes with channel domestic and stock (D&S) schemes. Domestic and stock schemes are small volume delivery systems that supply water to livestock and cropping properties over extensive areas. Some D&S schemes have very high levels of conveyance losses. For instance, for the Wimmera–Mallee D&S channel system in Victoria, of the 120 GL diverted to the scheme only 35 GL is delivered to farmers[11] (70% losses), with most of

[7] Tony Oakes, Rubicon Systems, pers. comm.

[8] *Open channel seepage and control, vol. 2.2 Current knowledge of earthen channel remediation in the rural water industry,* an ANCID initiative funded by the Murray Darling Basin Commission, Land and Water Australia and Agriculture, & the Rural Water Industry, March 2001.

[9] The survey results are reported as a proportion of deliveries; these are adjusted here on the basis of an average 70% delivery efficiency.

[10] *Bank experience with rigid and flexible lining of irrigation canals*, Water Resources Management Group, World Bank web site.

[11] Read Sturgess & Associates (2001). *Economic analysis of replacing the existing Wimmera Mallee water domestic and stock system*, draft report, May.

the water lost through seepage and evaporation. However, apart from the Wimmera–Mallee scheme (which is the world's largest channel D&S scheme), the volumes of water diverted into D&S schemes are relatively small in comparison with the volumes used in irrigation (Table 5).

Table 5. Volume of water entitlement, in irrigation and domestic and stock schemes, Australia, 1999–2000

Sector	Volume (GL)	%
Irrigation	7,631	97
Domestic and stock	234	3
Total	7,865	100

Source: ANCID initiative funded by Land and Water Australia and Department of Agriculture, Fisheries and Forestry – Australia (AFFA) February and ANCID (2000). *1998/99 Australian Irrigation Water Provider Benchmarking Report,* February.

As D&S schemes use only a small proportion of total water consumption, the loss figures for these types of schemes are not representative of losses in the majority of water delivery systems.

It is useful at this point to emphasise that the discussion above relates to losses within irrigation delivery systems

(points B to C in Figure 1) and not the bulk system or the on-farm distribution system. Leakage, seepage and evaporation may be significant sources of water loss in the bulk delivery system and on farm. For example, large volumes of water are reported to be lost from evaporation in shallow on-farm storages constructed to capture overland flows in the Border Rivers and Condamine/Balonne catchments in the northern sections of the Murray–Darling Basin.[12]

2.5 Summary

Based on industry data, approximately 29% of the water diverted into irrigation schemes is lost in conveyance to the farmer. However, the amount of water that can be recovered and used for consumptive and/or environmental purposes is very significantly less than the level of reported losses.

[12] Tan, P. (2000). Conflict over water resources in Queensland: all eyes on the lower Balonne, *Environmental and Planning Law Journal,* Vol. 17, No. 6.

3 Recovering conveyance losses

3.1 Current practice

The current management of conveyance losses in irrigation schemes can be viewed as an outcome of two different activities. The first is the ongoing operation of the water delivery systems such as regular maintenance and asset replacement. This activity is funded from user charges levied on irrigators, and the water saved remains within the irrigation district.

This category of activity includes investments that are targeted specifically at water savings, and others that are driven by service standards, and health and safety or environmental concerns, but indirectly result in water savings. Examples of this type of activity are:

- **installing clay, geo-membrane or concrete lining, or pipelining, sections of channel in zones of high seepage**.

  Lining is an ongoing activity in many irrigation areas that is driven by a range of factors including: contingent liability for flooding or waterlogging of land adjacent to channels, accessions to shallow watertables and salt mobilisation and water savings. Areas where this activity is in progress include: Burdekin IA (Qld), South-West IA (WA), Werribee IA (Vic.), Murray IA (NSW), Mareeba–Dimbulah IA (Qld);

- **repairing and rehabilitating channel banks and structures.**

  This is an ongoing maintenance activity in all open-channel irrigation systems. It is needed to ensure the integrity of structures, but also produces benefits in terms of reduced leakage losses;

- **improving the accuracy of meters on farm irrigation outlets.**

  The primary driver here is water savings but this measure also has potential benefits for farmers as they gain better control of flows into on-farm channels, which could result in improved on-farm efficiency. This measure is being trialled in the Coleambally IA (NSW);

- **automating main and secondary gates and outfall structures, offsite monitoring and computerised water ordering.**

  Improves service standards and reduces outfalls—eg. Murrumbidgee IA (NSW), Coleambally IA (NSW), Mareeba–Dimbulah IA (Qld), South-West IA (WA);

- **installing meters on privately operated, irrigation pumping installations on rivers.**

  The primary driver here is Council of Australian Government (COAG) water reforms that require metering of water use and licence conversion from an area-based to a volumetric entitlement, but will also reduce unaccounted-for-water and thereby improve measured delivery efficiencies. This activity is progressively being introduced in most river systems across Australia;

- **automating and optimising flow in spur channels.**

  This is a holistic approach to modernising irrigation schemes. Benefits of the approach will be reduced outfalls, channel filling losses and unaccounted-for-water—eg. ongoing pilot project in Goulburn–Murray IA (Vic.); and

- **changes to water-ordering procedures and rules.**

  This initiative provides an incentive to irrigators not to over-order water which in turn reduces outfalls—eg. implemented in the Murray IA (NSW).

The second type of activity is special purpose aimed specifically at water savings and with a large proportion of public-sector funding. Examples of this type of activity include:

- **pipelining of complete D&S channel systems.**

  This is a pure water savings activity aimed at reducing seepage and evaporation losses. The projects undertaken have benefited from extensive government subsidy. Examples include programs to pipeline Great Artesian Basin groundwater bore-water supply (NSW, SA & Qld), the Carwarp D&S pipeline (Vic.), and Northern-Mallee pipeline (Vic.); and

- **pipelining of channel supply high density horticultural areas.**

  This type of activity is driven principally by standard of service and environmental issues; as a bonus it also reduces seepage and outfalls. Examples include the Central Irrigation Trust (SA) and Euston (NSW).

3.2 Projects under consideration—Murray–Darling Basin

To secure water for the environment, governments and communities in the southern Murray–Darling Basin (MDB) are increasingly focusing on the options for improving WUE in irrigation.[13] Several options for saving water in irrigation systems in the southern MDB have been canvassed by government, these include:

- **further pipelining of open-channel D&S systems**—eg. the remainder of the Wimmera–Mallee system (Vic.), the D&S supply in the Darling Anabranch system (NSW) and D&S supplies in the downstream end of major channel systems in the Goulburn–Murray (Vic.), Murray (NSW) and Murrumbidgee (NSW);
- **fitting meters to currently unmetered D&S supply intakes** within gravity channel systems—eg. Goulburn–Murray IA (Vic.);
- **repairing, rehabilitating or replacing meters on farmers outlets** to improve accuracy—eg. Goulburn–Murray IA (Vic.);
- **constructing regulators on wetlands** adjoining rivers to prevent inundation during peak irrigation periods and from rainfall rejection flows—eg. Moira Lakes (NSW) and Euston Lakes (NSW);
- **construction of re-regulation storages** within irrigation systems to capture rainfall rejection flows—eg. Mulwala canal (NSW);
- **partitioning or by-passing in-line regulation storages** to reduce surface area and hence evaporation—eg. Barron–Box swamp in the Murrumbidgee IA (NSW), Menindee Lakes (NSW) and Lake Mokoan and Kow Swamp in the Goulburn–Murray (Vic.);
- **lowering the operating level in storages** to reduce evaporation losses—eg. Kangaroo Lake, Waranga Basin and Lake Buffalo in the Goulburn–Murray (Vic.);
- **maintaining airspace in regulation storages** to capture rainfall rejection flows—eg. Lake Mulwala (NSW);
- **automating main and secondary canal gates and outfall structures**, off-site monitoring and computerised water ordering with consequent reduction in outfalls — an option in all open-channel systems;
- **construction of on-farm storages** to capture rainfall rejection flows—eg. Goulburn–Murray IA (Vic)
- **rehabilitating weirs** that require continuous wetting in order to maintain structural integrity, thus reducing outfalls—eg. Cohuna Weir (Vic);
- **repairing and rehabilitating channel banks, structures and linings** to reduce seepage and leakage—all open-channel systems;
- **pipelining tertiary (spur) channels** in irrigation systems—eg. pipelining of spur channels in horticultural areas in Murrumbidgee IA (NSW) and Goulburn–Murray IA (Vic.);
- **district-scale lining of open channel**—an option in all open-channel systems; and
- **automating and flow optimising in complete channel systems**—an option in all open-channel systems.

Table 6 sets out the range of capital cost estimates per unit of water saved for various measures considered in recent studies undertaken for the Victorian and NSW governments in the Goulburn–Murray system and Murray/Murrumbidgee regions. Capital costs include design, materials, machinery and labour costs incurred in the construction of the facilities.

Also included in Table 6 is an indicative range estimate of the volume of water saved, based on a review of the literature and discussions with industry. The range estimate is a qualitative scale with one tick representing a low potential for water savings and four ticks a high potential.

For any given irrigation district, the cost of achieving water savings will also depend on the shape of the marginal cost curve. The marginal cost curve, in the context of water savings, is a plot of the least to the most expensive water savings options (see Figure 3). As a rule of thumb, decision-makers would select the least-cost option or ‘low-hanging fruit’ first, followed by the next lowest cost option and so on. The cost of water savings at any given time depends where the irrigation district stands in terms of its marginal cost curve.

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[13] See for example: Murray–Darling Ministerial Council (2002), *The Living Murray, a discussion paper on restoring the health of the River Murray,* Murray Darling Basin Commission July.

Table 6. Water savings options **–** unit capital costs and potential

Measure	Costs ($ per ML of water saved)	Comments	Potential volume of water saved (✓ = low to ✓✓✓✓ = high)
1	1,000 to 4,000	Smaller schemes generally lower cost, extensive schemes are high cost.	✓✓✓
2	500		✓
3	700 to 1,900		✓✓✓
4	500	Costs are likely to be highly variable depending on site characteristics	✓✓
5	1,000		✓✓
6	100 to 5,000	Low cost is for partitioning; higher cost applies to works for by-passing storages.	✓✓✓
7	No data	Very low cost if compensatory actions to address third-party impacts are not included	✓✓
8	No data	As above	✓
9	1,400 to 11,000	Average cost is about $1,400	✓✓✓
10	1,000 plus		✓✓
11	900 plus	Cost is very site specific	✓
12	No data	Low cost is part of regular maintenance in an irrigation system	✓✓
13	1,300 to 10,000	Average cost is about $4,000	✓✓✓✓
14	20,000–50,000	Very expensive because the majority of open channels have very low seepage rates.	✓✓✓✓
15	350 – 1,300	Assumes automation of entire channel distribution system	✓✓✓✓

Sources: SKM (2000). *Water savings in irrigation distribution systems,* Report to Goulburn–Murray Water and Natural Resources and Environment; SKM (2001). *Water savings in bulk system,* Report to Natural Resources and Environment; Brewsher Consulting (1999) *Snowy corporatisation water efficiency savings in New South Wales*; Rubicon Systems, pers. comm.

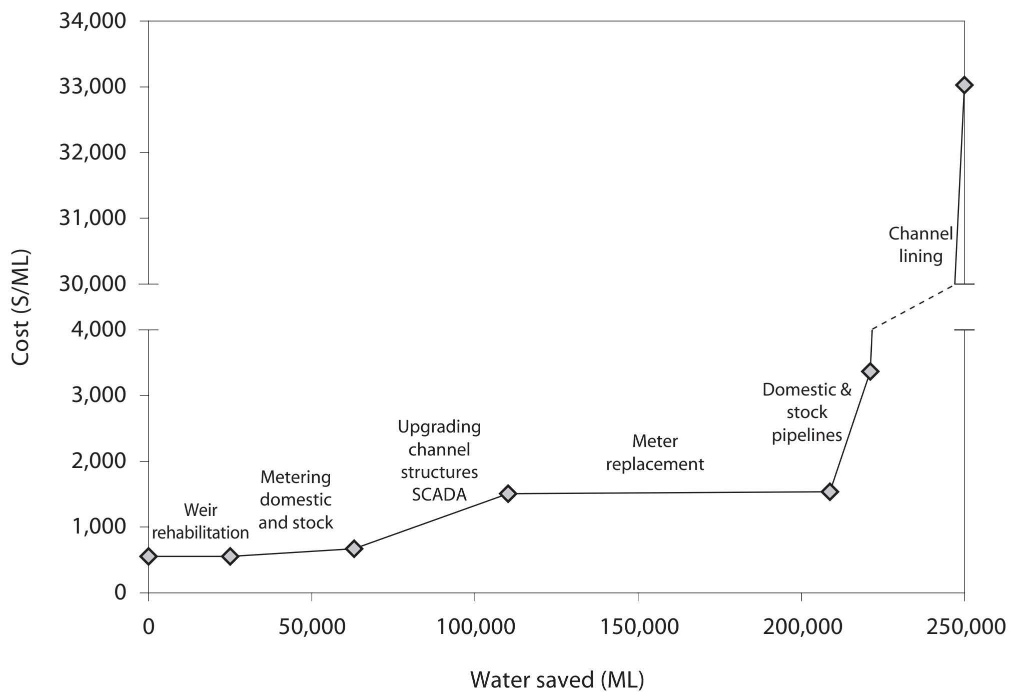

Figure 3. Marginal cost of water savings — Goulburn–Murray Water. Source: SKM (2000). *Water savings in irrigation distribution systems,* Report to Goulburn–Murray Water and Department of Natural Resources and Environment.

3.3 Projects short-listed for implementation — Murray–Darling Basin

By July 2002, governments in the southern MDB had short-listed a number of projects for which detailed investigations are being undertaken.[14] These are the principal candidates for implementation in the next 5–10 years. A brief description of these projects is provided below.

- **Menindee Lakes (NSW)**[15]

  The Menindee Lakes act as a storage scheme to capture water for riparian releases, stock, domestic and irrigation needs along the lower Darling River, and to augment flows in the River Murray to assist in supply to New South Wales, Victoria and South Australia. On average, 450 GL is lost per year in evaporation from the lakes.

  There is a range of proposals to change the operation of the storage to reduce the surface area of the lakes. This would require the construction of weirs and the enlargement of outlet capacity. It is estimated that 10,000 ML per year could be saved at an average cost of $2,000 per ML.

- **Lake Mokoan (Vic.)**[16]

  Lake Mokoan is a water supply storage in the Goulburn–Murray bulk-water supply system. The storage is relatively shallow and suffers from high evaporative losses. Blue–green algal outbreaks are also a problem in the storage. There is a range of proposals to change the structure and/or operations of the lake to reduce evaporation losses. These include allowing the storage to revert to its natural state (a swamp) and partitioning the storage. A maximum of 42,000 ML/year could be saved by these measures, at a cost ranging from $400 to $7,000 per ML.

- **Darling Anabranch D&S system (NSW)**[17]

  The D&S system in the Darling Anabranch (lower reaches of the Darling below Menidee Lakes) provides 3,000 ML/year to 40 grazing properties through a system of natural watercourses and weirs. To provide this water, approximately 50,000 ML/year is released into the Anabranch system. There is a proposal to provide an alternative, pipelined water-supply system to these properties. It is estimated that 32,000 ML could be saved through pipelining at a cost of approximately $625 per ML.

- **Barron Box Swamp (NSW)**[18]

  Barron Box Swamp is located in the Murrumbidgee irrigation district. It receives outfalls from the upstream part of the district and acts as a buffer storage for downstream irrigators. Significant volumes of water are lost from the swamp through evaporation and unplanned spills. A plan has been proposed to partition the swamp to create a storage with an operating level above the existing maximum level in the swamp. Potential savings of 30,000 ML/year are expected at a cost of $1,500 per ML.

- **D&S water metering in the Goulburn–Murray IA (Vic.)**[19]

  D&S users in the Goulburn–Murray irrigation gravity-supply system have a water allowance of approximately 1 ML per property. It is believed, however, that they use up to 20 ML per property. There is a project in the final planning stage to meter these currently unmetered domestic and stock outlets. Where usage exceeds the entitlement, the excess usage will be deducted from the landholder's irrigation entitlement. This measure is expected to save 36,000 ML per year at a cost of $670 per ML.

- **Goulburn–Murray D&S systems (Vic.)**[20]

  Several open-channel D&S systems are located at the tail end of the open-channel gravity irrigation supply in the Goulburn–Murray area — the Normanville system, the Tungamah system and the Woorinen system. Plans are in the final stages to pipeline these systems. The expected volume of savings is 25,000 ML/year from reduced evaporation and seepage losses. The unit cost ranges from $1,400 to $8,700 per ML.

The water savings provided by the projects described above are at the low end of the marginal cost curve, with unit costs of water savings in the range $670 to $7,000 per ML of water saved.

3.4 Summary

Irrigation districts undertake a wide range of initiatives to save water as part of the ongoing management of delivery

[14] Geoff Earl, Goulburn Murray Water; David Harriss, DLWC; John Chant, Murrumbidgee Irrigation; George Warne, Murray Irrigation; Tony McLeod River Murray Water: all pers. comm.
[15] David Harriss, Regional Director Murray Region, DLWC, pers. comm.
[16] Department of Natural Resources and Environment – web site
[17] Darling Anabranch Management Plan Steering Committee (2002). *The Darling Anabranch Management Plan – draft.*
[18] Brewsher Consulting (1999). *Snowy corporatisation water efficiency savings in New South Wales.*
[19] Sinclair Knight Merz (2000). *Water savings in irrigation distribution systems*, Report to Goulburn–Murray Water and Natural Resources and Environment.
[20] Department of Natural Resources and Environment – web site.

infrastructure. These activities are usually the least cost means of saving water. The water saved in these activities is used to increase the security of supply to irrigators in the district.

Many of the cheaper options for saving water have already been taken-up by irrigation districts. New projects are likely to be significantly more costly and complex to develop. The cost of new water savings is in the range $500–$30,000 per ML of water saved.

Judging from the work already undertaken to identify the feasibility of irrigation conveyance water savings, the activities with the most potential to reduce conveyance losses are those that:

- are at lower end of the unit-cost spectrum;
- are technically proven in an irrigation environment;
- do not have adverse impacts on consumer-service standards;
- are compatible with existing infrastructure operating and management practices; and
- complement existing on-farm irrigation and agronomic practices.

Activities that fall into this category include:

- reducing seepage in selected high-seepage sections of channel using pipelines or channel-sealing methods;
- pipelining secondary and spur channels in intensive horticultural zones;
- improving operations (automation, improved water-ordering) in open-channel systems to reduce outfalls;
- reducing excessive evaporation losses in expansive shallow-water storages located in bulk water and delivery systems;
- pipelining lower-cost D&S supply systems; and
- improved control over flows to river floodplains and wetlands.

Water savings activities with the least potential are those that:

- require high capital inputs both in the distribution system and on farm;
- have no positive track record of implementation;
- have negative impact on service standards;
- require extensive changes to operating and management practices;
- impinge on access and use rights to water; and
- are unlikely to have the support of irrigators and other local stakeholders.

Activities that fall into this category include:

- complete pipelining of open-channel irrigation systems in extensive pasture/cropping districts;
- replacing inaccurate meter wheels with more accurate meters;
- pipelining complex D&S supply systems;
- removing or altering the operation of weirs, pools or storages with extensive waterfront real estate development or with high rates of tourism/recreational usage;
- extensive lining of channels, especially those that are located on heavy clay soils or benefit from self-sealing processes; and
- covering large water storages.

4 Conveyance losses — positive externalities

4.1 Background

Economists use the term externality to describe the 'flow-on' effects of production or consumption activities which are not taken into account by the producer or the consumer and which produce benefits or impose costs on others. Conveying irrigation water to irrigation farms generates significant positive externalities. These arise in a variety of circumstances, some of which are described below.

- Leakage in the banks of channels often flows into the on-farm distribution system and is used for irrigation purposes. In some situations, leakage can be a very cheap source of water and an important component of an irrigator's water use.
- Water out-falling from channels into drains is sometimes either pumped out of the drains by downstream users or flows into D&S systems and then onto pastures. If outfalls from channels cease, say as a result of improved irrigation efficiency, then someone will have to pay the cost of developing alternative supplies for D&S users.
- Outfalls from channels can flow directly back to the river system and are then available to downstream users. In many cases, outfalls to rivers are not measured, and the irrigation district receives no credit for returning water that is valuable to downstream users. Conversely, any reduction in return flows would require compensating releases at the headworks to supply the downstream users.
- Outfalls to backwaters may support valuable ecosystem habitats. If denied water from the irrigation district the value of these habitats could be lowered.
- Landholders may have developed their properties to take advantage of a view or frontage to water features fed by outfalls or banks overflows (ox-bows, wetlands, creeks etc.) or that are part of a delivery systems (storages, lakes etc.). The boost to property values from the water frontage could be significant.
- Seepage from channels may recharge groundwater systems that are subsequently pumped for water-supply purposes or provide for crop water requirements from shallow watertables (freshwater lens). This water may have an important role in the crop water balance and hence on the yield and income of the benefiting irrigator.
- As many meters are inherently inaccurate and often not maintained to high standards, under-recording of meters is common in irrigation districts.[21] This water is essentially free to the irrigator.
- Evaporation losses from storage or weir pools may arise from the need to maintain high water levels to ensure irrigators can pump from the water body, or to ensure access and utility for recreational purposes. The existence of a high water level in these water bodies benefits irrigators in terms of pumping costs and provides an opportunity for recreational facilities and tourism operators to earn an income.

4.2 Hydrologic equivalent

Hydrologists have developed a framework to describe the hydrologic equivalent to economic externalities in irrigation. This embodies the concepts of beneficial and non-beneficial losses:[22]

- **Beneficial losses**. Conveyance losses that are re-used or recycled to other beneficial uses either downstream of the water-supply system or within the water-supply system;
- **Non-beneficial losses**. Conveyance losses that flow to sinks. Water sinks are:
  a) water evaporated to the atmosphere from surfaces;
  b) surface and subsurface flows to salt sinks — oceans, inland seas or saline aquifers; and
  c) pollution of surface and subsurface water by salts and toxic elements, to the point where the use of the water is compromised. (This concept is illustrated in Figure 4.)

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[21] ANCID, web site – Detheridge meters.

[22] Seckler, D. (1996). *The new era of water resources management,* Research Report 1, Colombo, Sri Lanka, International Irrigation Management Institute.

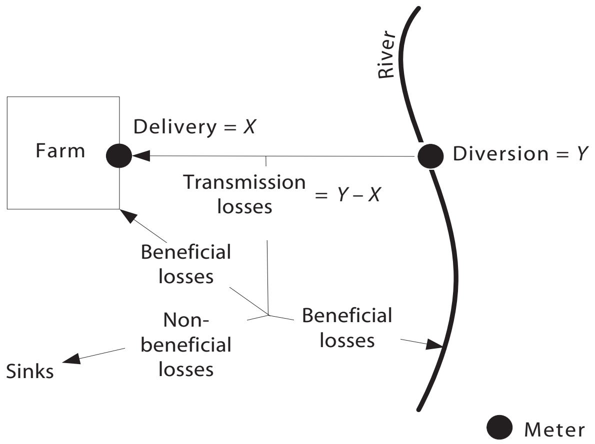

Figure 4. Beneficial and non-beneficial conveyance losses

Three examples of beneficial and non-beneficial losses are discussed in more detail below.

4.3 Examples

Outfalls

When water flows from the end of an irrigation delivery system, it is assumed to be a loss to the system and counts against WUE. However, as noted earlier, some proportion of outfalls may have beneficial impacts. Classifying outfalls into beneficial and non-beneficial volumes is a complex task. In a study for GMW[23], an attempt was made to distinguish between beneficial and non-beneficial outfalls on the basis of the physical connection between outfalls and the 'environment'. A rule was used to classify outfall volumes:

- beneficial = outfalls direct to unregulated watercourses OR outfalls direct to natural wetlands in the non-irrigation season; and
- non-beneficial = outfalls to natural wetlands during the irrigation season OR outfalls to wetlands with altered ecology.

On this basis an estimate was made of the volumes of non-beneficial and beneficial losses (see Figure 5).

In terms of the water delivery system, any reduction in outfalls is beneficial; that is, the savings can be used to enhance overall security of water supply in the district. However, from a basin-wide perspective, the utility of the saving depends on the source of the savings. If the savings are from beneficial outfalls, for example, then the water is effectively transferred from the basin to the irrigation delivery authority, leaving the users of the previously outfalled water with a reduced security of supply and/or the need to obtain water from other sources.

Users of water outfalled from irrigation schemes generally have no formal entitlement to the water but have a long and established history of use. For example, an irrigator may have equipped his irrigation system to take advantage of the availability of water in drains. If, because of a savings intervention, the water no longer flows into the drains, the irrigator will have to either purchase a water entitlement or reduce his irrigation area.

Inaccurate water meters

- Many water meters in irrigation districts, particularly those on farmers' inlets, are to greater or lesser degrees inaccurate. The level of accuracy achieved in Detheridge and propeller meters in a sample of irrigation districts, has been reported in a recent ANCID survey (see Table 7).

[23] Sinclair Knight Merz (2000). *Water savings in irrigation distribution systems*, Report to Goulburn-Murray Water and Natural Resources and Environment.

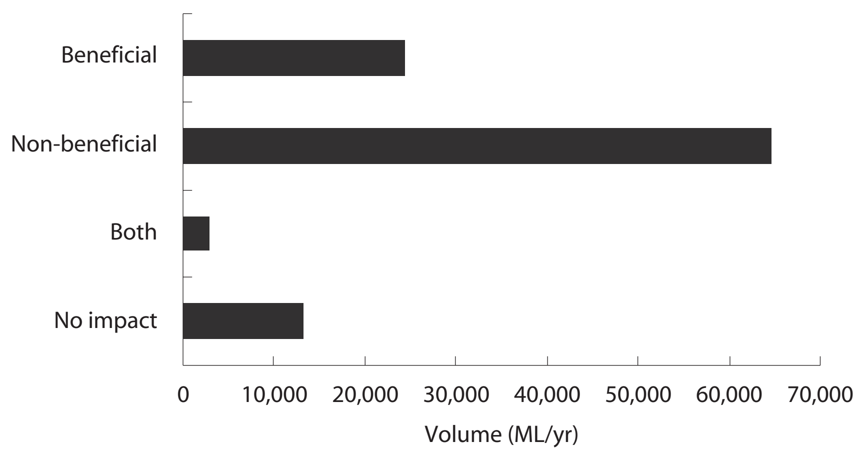

Figure 5. Volume of beneficial and non-beneficial outfalls (ML/year), Goulburn–Murray Water, 1998/99

Table 7. Level of meter accuracy achieved during a season

Irrigation district	Meter capacity (ML/day)			
	< 3 ML	3–12	12–20	> 20 ML
Hay Irrigation	– 15%	– 15%	– 15%	
Murray IL		±2%	±2%	
South-West Irrigation		– 30%		
Burdekin RIA		±10–15%	±5%	±3%
Coleambally		±20 %	±5%	±3%
Goulburn–Murray	0–15%	0–10%	0–10%	0–15%
Murrumbidgee Irrigation	> 15%	> 10%	>10%	>15%

Source: Australian Irrigation Technology Centre (1998). *Know the flow interim report 1997–98,* July

The most common type of water meter in Australian open-channel irrigation systems is the Detheridge meter (DMO). According to GMW:

> It is generally believed that in the majority of situations the DMO under records the amount of water actually delivered to an irrigator.[24]

The inaccuracy in Detheridge meters is due to:

- the condition of the meter wheel, bearings and emplacement;[25] and
- operation of the meter outside of design water-level range.

While IWPs recognise that Detheridge wheels have shortcomings in terms of accuracy, the Detheridge wheel does have many advantages including:[26]

- it is easy to use and is easily understood by operators and farmers;
- it is cheaper than other meters of similar capacity;
- no power source is required;
- it is robust and can resist from the force of impact by debris; and
- its security features make unauthorised water use difficult and easy to detect if it is attempted.

Improving the accuracy of meters requires replacement of Detheridge meters with ultrasonic meters that can accurately measure flows over a wide range of operating conditions. Unfortunately, this would penalise the many irrigators who have developed their businesses on the basis of the volume of water they actually receive through their meter. It is reasonable to conclude that reducing access to under-recorded flows will be problematic.

Regulating storages

Evaporation losses from storages within delivery networks (in-line or regulating storages) are a significant source of conveyance losses. Regulating storages and weir pools are a feature of many irrigation and bulk water systems in Australia. The purpose of regulating storages is to hold water so that fluctuating demands downstream can be satisfied.[27]

The option exists to reduce evaporation losses from regulating storages through changing their operating regime, changing the physical characteristics of the storage or decommissioning the storage. This is the primary option in shallow, regulating storages found in the southern Murray–Darling Basin; for example, Lake Mokoan and Kow Swamp.

Changes to the existing situation in these artificial lakes will affect both direct consumptive uses and the significant positive externalities generated by regulation. These impacts will vary from site to site, but could include:

- downstream water users whose security of supply or standard of service is impacted by the loss of regulating capacity;
- people who use the lake for recreational purposes such as fishing and boating;
- irrigators and other water users who pump from the water body; and
- landholders whose property value benefits from water frontages or views.

On the issue of amenity values generated by regulation, water legislation is typically silent. Amenity values may be protected in a general sense under planning legislation. However, the common law does not protect rights to views.

The key conclusion from the above discussion is that evaporation losses in some storages are, in effect, the cost of providing water-related benefits to a diverse group of stakeholders.

[24] Kelly, V. (2000). *Detheridge wheel outlet accuracy testing,* Goulburn–Murray Water, January.
[25] Ibid
[26] ANCID website – *Detheridge meters.*

[27] Linsley, R.K., Franzini, J.B., Freyberg, D.K. and Tchanoglous, G. (1992). *Water resources engineering*, 4th Edition, McGraw-Hill.

4.4 Discussion

The conventional measure of water losses does not account for uses of water that are not recognised within existing legal and regulatory frameworks but which nevertheless generate significant economic values. As a result, the reported conveyance loss ratio probably overstates the volume of water losses that could be recovered.

The question arises: Do water consumers have some form of right to beneficial water losses? According to legal advice sought on this issue:[28]

- if persons had no entitlement of their own, then they would have little recourse. They may be able to argue estoppel, ie. that the upstream entitlement holder is estopped from doing anything that would jeopardise the return flow. It would be a long and messy case, very much dependent on the facts, including whether there was any action taken/words spoken by the upstream user; and
- if the consumers had their own entitlement, supplied through the return flow, they could not sue the upstream users based solely on their entitlement. Any suit against the upstream users would still have to be grounded on estoppel or a similar action. However, the consumer would have recourse to the State to supply an allocation under the entitlement.

[28] Dr Poh-ling Tan, Lecturer, Law Faculty, Queensland University of Technology, pers. comm.

5 Financing options

Interest amongst decision-makers in alternatives to traditional financing approaches to achieving natural-resource-management outcomes has increased markedly in recent years.[29] This stems from a concern that traditional public-sector funding approaches are not meeting the needs for investment in natural-resource management.

This section briefly examines both traditional and alternative financing methods for directing investment to improving WUE in irrigation conveyance.

5.1 Traditional financing models

As publicly owned assets, irrigation systems, and associated water-saving activities, have traditionally been funded through a combination of direct charges on water consumers and public-sector funding.

Direct public-sector funding

An example of this approach is the pipelining of the Northern Mallee section of the Wimmera–Mallee water supply system. This project involves the pipelining of an open-channel D&S delivery system which delivers water to dryland farmers, with the objective of saving the considerable volumes of water lost to seepage and evaporation.

Public-sector funding is particularly suited to projects such as the pipelining of D&S systems as:

- the benefits of pipelining D&S systems accrue primarily to the public and not the users of the upgraded infrastructure (in fact, users are often adversely impacted by the upgrade); and
- water users (farmers) do not have the capacity to fund the upgrade through user charges.

[29] James, David (1997). *Environmental incentives: Australian experience with economic instruments for environmental management*, Environmental Economics Research Paper No. 5, Consultancy report prepared by Ecoservices Pty Ltd, commissioned by Environment Australia.

The public sector also indirectly contributes to the demand for efficient conveyance systems through the provision of grants for improved on-farm WUE. There is a range of State government grants and incentive schemes available to irrigators to improve on-farm WUE.[30]

The installation of more efficient on-farm systems such as drip irrigation creates a demand for more responsive irrigation conveyance. This arises because drip irrigation requires daily water delivery. Traditional open-channel systems can deliver water at best only every 4 to 7 days. To meet the needs of drip irrigation, the farmer must be connected to a modern delivery system capable of frequent or on-demand delivery. Thus, indirectly, any move towards more efficient irrigation systems creates a demand for modern, and typically more efficient, conveyance systems.

User pays charges

User pays charges levied on irrigators for water delivered are widely used. These charges cover the cost of capital investment and the operations and maintenance of delivery infrastructure.

It is reported by ANCID that the total gross revenue from charges for the 47 rural water and irrigation suppliers reported in the 2000–01 industry benchmarking survey was $229 million.[31] Of this, 22%, or $50 million, was spent on infrastructure renewal which is funded from both current year revenue and accumulated earnings.

Only a small proportion of the total revenue raised from user charges is expended on water savings measures. Irrigation businesses have a wide range of responsibilities, of which water savings is only one (Figure 6).

[30] For example, the NSW Rural Assistance Authority's *Irrigated agriculture water use efficiency incentive scheme*, and the Victorian Government's *Farm irrigation efficiency and development project grants.*

[31] ANCID (2001). *Australian irrigation water providers benchmarking report for 1999/20.*

Typical business drivers are:

- customer service standards;
- asset management;
- occupational health and safety;
- security of water supply; and
- environmental liabilities.

Some proportion of the capital works or maintenance funding directed to this standard set of business drivers contributes directly or indirectly to a reduction in conveyance water losses. For example, conveyance losses would be affected by:

- the repair of leaks in channels, in order to maintain structural integrity of the channel;
- the lining of channels so as to reduce waterlogging liabilities on adjacent private land;
- replacement of accident-prone and leaky drop-bar structures with more modern structures; and
- upgrading control structures for the purpose of enhancing the level of service.

Sometimes works are undertaken solely for water-saving purposes. For example, in the Burdekin–Haughton Water Supply Scheme (Qld), as part of the ongoing modernisation of the scheme, sections of old, cracked, concrete-lined channels are being replaced with pipelines, "eliminating excessive distribution losses".[32]

The water saved by IWPs is retained within the irrigation district in order to increase water availability (or supply security) to irrigation customers. For example, SunWater, the operator of 27 regulated irrigation systems in Queensland, holds water allocations for distribution losses in its delivery system. If SunWater undertakes works to reduce losses, the resulting savings can be sold to irrigators (or other water users) on either a permanent or temporary basis.[33]

In contrast, the objective of increasing flows in rivers requires water saved by the IWPs be left in the river. Because the benefits of saving water for the environment accrue to parties other than the IWP and its customers, there would seem to be little incentive for the IWP to invest in water savings for this purpose.

Taxation policy

The cost of financing WUE is influenced by taxation policy. A key area for project investment is depreciation allowances. Depreciation is the ability to claim capital costs in a way that reduces taxable income. Accelerated depreciation allows businesses to write off the cost of a capital investment well before the end of the investment's useful life thus bringing forward tax benefits and potentially reducing tax payable in the early years.

Recent reforms to the taxation system have removed accelerated depreciation from most industry sectors in

[32] SunWater (2001). *Annual report 2000–01.*

[33] Ibid

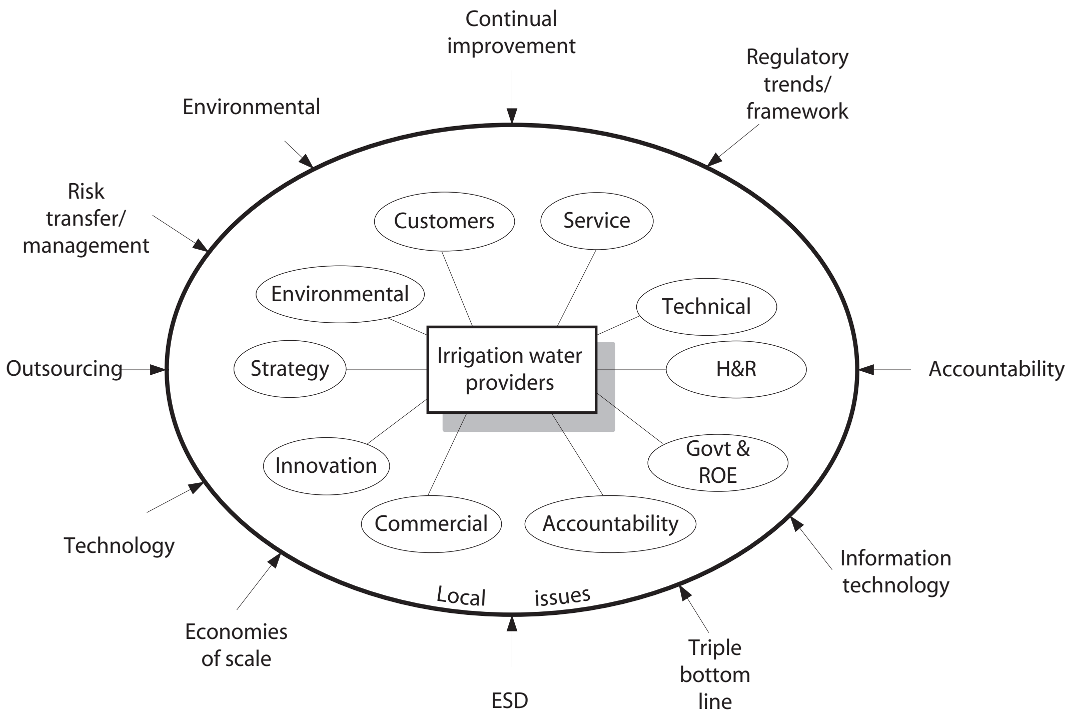

Figure 6. Drivers of expenditure in irrigation delivery

return for a reduced tax rate. Irrigated agriculture is one of the few industry sectors that can still claim this benefit, and accelerated depreciation has been important in the recent development of the industry.

Under section 75B of the Tax Act, primary producers are able to claim accelerated depreciation for capital expenditure on farm water conservation and conveyance infrastructure.[34] This tax advantage also applies to infrastructure that contributes to on-farm water savings, such as pipelining of on-farm channels and equipment used in pressurised irrigation and re-use facilities. The accelerated-depreciation tax benefit also applies to capital investments undertaken by the primary producer on land owned by third parties. For example, the deduction is allowable on the installation of a pump and a pipeline on Crown land for the purpose of conveying water to the primary producer's land.[35]

On the grounds that there are external benefits associated with improved water conveyance efficiency, a case may exist for a cost-sharing contribution from the public sector to the investor in water savings. However, a large proportion of the farmers do not earn sufficient taxable income to be able to take advantage of tax benefits.[36] This would be a problem for any scheme provided through the tax system.

5.2 Non-traditional financing models

5.2.1 Environmental finance agency

Upgrading irrigation conveyance systems to achieve WUE goals involves the creation of long-lived assets with payback periods over several decades. Projects that involve long-lived assets with long payback periods require low-cost, long-term finance. This type of finance is available only to governments and rated corporations.

Recognising that the inability to access low-cost capital is holding back investment in much needed environmental infrastructure, various studies have identified the potential for 'regional infrastructure development funds'.[37] Such a fund would be given authority to borrow from the government at concessional rates. The fund's role would be to provide a mix of loans and guarantees for loans originated by private lenders to environmental projects. The fund could pool and securitise its loans to redistribute its portfolio and lower its borrowing costs.

5.2.2 Market-based instruments

Market-based instruments (MBIs) are mechanisms for bringing a commercial focus and market-type disciplines to natural resource management. In Australia, MBIs are used in a number of policy settings including: greenhouse gas abatement, fishery management, salinity emissions, water entitlements and biodiversity enhancement.

Two types of MBI with potential application to conveyance efficiency are environmental asset mechanisms and competitive tendering (auctions).

Environmental assets

This model involves the government providing a legislative and planning framework for the creation of marketable assets or rights in the environmental outcomes from production or consumption decisions.

The Office of Renewable Energy's mandated renewable energy target (MRET) scheme is an example of the application of the environmental asset model in Australia. The objective of this scheme is to increase the proportion of renewable energy used in electricity production in Australia. The *Renewable Energy (Electricity) Act (2000)* provides the legislative underpinning for the creation of a market in renewable energy credits (RECs). Under the Act, the production of renewable energy from sources such as wind and wave generation, and landfill gas, 'generates' RECs. RECs can be defined as negotiable instruments for acquitting obligations created in conventional energy production. Electrical energy retailers who operate in the national electricity market take on REC obligations when they sell retail electricity. Currently, retailers must offset 1% of their sales by purchasing RECs. This will rise to 5% by 2008. If retailers fail to acquit their REC obligations, they are 'fined' $40 for every MWh of REC not acquitted. In the first year of the market, most retailers negotiated deals to purchase RECs from renewable energy generators rather than pay the fine.

The principal advantage of an environmental asset scheme over traditional approaches is that it provides incentives to seek least-cost solutions. It achieves this by creating a commercial focus and the market-discipline that comes with holding title to a valuable asset.

Environmental asset schemes would seem to be technically feasible in the context of improving WUE in irrigation conveyance systems. For example, government might place a cap on water losses in a defined geographic area such as a catchment. (This could be achieved by changing legislation or perhaps through water management plans and/or conditions on irrigation district water licences.) Each irrigation district in a catchment could be assigned a share of water losses under the cap.

[34] Section 387-125 of the *Income Tax Assessment Act 1997,* formerly Section 75B of the 1936 Act.
[35] Australian Master Tax Guide 2000, p.18-080.
[36] See Productivity Commission (1987). *Ecologically sustainable land management*, final report.
[37] See, for example, the proposal reported by www.environmentalfinance.net

The total volume of shares would be consistent with an overall cap, less an efficiency target for the catchment. If a district invested in work to reduce losses below the baseline, 'credits' or environmental assets would be created. These could then be sold to other market participants to offset any increase in their water losses, say due to expansion in the area irrigated.

The cost of complying with a baseline will depend on a participant's individual circumstances. The ability to trade credits provides the opportunity to purchase credits from other participants who have lower marginal abatement costs. Consequently, the trading system can reduce the overall costs of compliance with water savings goals.

An environmental asset scheme in water losses would require a well-defined and measurable unit of trade in water-loss allowances. The scheme would require a monitoring and verification regime to ensure that the savings were sustainable over time.

Environmental asset schemes have some important negative aspects, including:

- the cost and complexity of establishing the legislative and planning framework;
- there are important equity issues arsing from the fact that the trading scheme places the entire financial burden of compliance with water-savings targets on the irrigation district; and
- availability of data on water losses is an issue and, moreover, there is no clear cut method for quantifying 'real' water savings.

Competitive-tendering (auction) mechanisms

Competitive tendering as a price discovery mechanism can be used to improve the effectiveness of markets. In natural-resources management, and particularly in land management, auctions are increasingly seen as being more cost-efficient than traditional public-funding mechanisms such as grant schemes.

Grant schemes provide fixed payments to landholders, with little flexibility to vary the payment. Fixed payments take no account of the particular situation of each landholder and the impact that land-use change has on their costs and incomes. This has contributed to the significant shortfall in the take-up of grants in a number of existing grant schemes.

The principal advantage of an auction over traditional methods is the price discovery element.[38] Price discovery provides more efficient outcomes by revealing the marginal-cost curve of the activity. Revealing the marginal-cost curve reduces information asymmetry and allows the investor (grantor) to target the most cost-effective options.

There would seem to be potential to apply auction mechanisms to reveal the marginal-cost curve for improving WUE. The characteristics of an auction system applied to conveyance losses would include:

- an auction process that involves government seeking bids from parties to provide specified types of water-savings activities;
- the selection of winning tenders based on meeting the objectives at least cost; and
- common law contractual arrangements between the counterparties for the payment for, and delivery of, water savings.

The principal difference between a competitive-tendering mechanism and a trading system is that government funds the abatement action rather than market participants as is usually the case in a trading scheme.

With both MBI models, groups of irrigators or water-user associations organised at a subsystem (e.g. all farmers on a spur or tertiary channel) rather than irrigation-district level, could be engaged to deliver the required water savings outcomes. The potential benefits of engaging water-user associations include:[39]

- tapping into local knowledge of the issues and problems which could result in a more efficient provision of services. For example, water losses could be reduced if neighbouring irrigators co-operated in co-ordinating water ordering;
- potentially aligning irrigators' incentives with the water-savings objectives; and
- community groups are dynamic and often able to respond more effectively to requirements within their system, ensuring more sustainable infrastructure services.

5.2.3 Public–private partnerships

The private sector has long provided goods and services to the public sector. However, a trend is developing towards increasing involvement of the private sector in the provision of goods and services traditionally provided by, and seen as a function of, the public sector. For example, public–private partnerships (PPPs) and other similar mechanisms are increasingly used to finance urban water infrastructure in Australia.

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[38] Department of Natural Resources and Environment (Vic.) (2000). *Auction design for land-use change in the Murray Darling Basin.*

[39] FAO (1999). *Transfer of irrigation management services,* FAO Irrigation & Drainage Paper No. 58.

State governments have policies supporting the concept of PPPs for infrastructure. Policy guidelines for delivering PPPs have been produced, these include:

- *Partnerships Victoria* policy which sets out standard processes for PPP project formulation;[40]
- *Working with government* policy which provides guidelines for privately financed infrastructure project delivery in New South Wales;[41] and
- *Partnerships SA* program announced by the South Australian Government.[42]

There are several PPP models used for water infrastructure projects. The choice of model depends on factors such as the government's objectives, the nature of the project, the availability of finance, and the expertise that the private sector can bring. Some of the alternative models are briefly described in Table 8.

Governments are attracted to PPPs because they may provide value for money — at least in the short term. The value for money in PPPs arises from:[43]

- the ability to transfer risk to whichever partner is better able to manage the risk.
- PPPs often involve the private sector providing a 'bundle' of services. Bundling can provide value for money that contracting services separately cannot.
- PPPs can contain incentives for the private sector party to deliver projects to time and budget, and operate infrastructure soundly.

For heavily indebted governments, an attraction of having the private sector finance infrastructure is that it obviates the need to borrow, and can allow projects to be brought forward.[44]

State and local governments are the main users of PPPs. An example of the increasing role of the private sector in the water industry is the provision of potable water and wastewater treatment plants. PPPs are suited to these facilities because:

- standards exist for water (wastewater) quality;
- economies of scale are available and technologies can be easily replicated;
- projects are stand-alone assets with well-defined outputs; and
- outputs are sold to one or a small number of customers.

Examples of recent or proposed PPPs in the water sector in Australia include: Prospect, Illawarra and Woronora water-treatment plants (NSW), Ballarat water-treatment plant (Vic.), Coliban Water Aqua 2000 project (Vic.), Castlemaine wastewater-treatment plan (Vic.), and Hervey Bay wastewater-treatment plant (Qld).

Risk in irrigation conveyance projects

As noted above, a primary motivation for PPPs is the value-for-money benefits from optimal sharing of the risks between the private and public sectors. Some of the risks that need to be managed in an irrigation conveyance PPP are:

- **Construction risk**

  Most irrigation facilities are located in difficult terrain or subject to hydrologic events such as floods and sustained waterlogging. Conversely, the technology of water savings in irrigation is mature. Construction risks or the risk of completion delays or cost over-runs will vary on a case-by-case basis. Investors will be seeking assurances that projects will be completed on time and to cost.[45]

- **Off-take risk**

  The usual supply arrangement in a river-irrigation network is a single, bulk-water supply organisation (IWP etc.) providing water to multiple customers who enter into supply contracts, sometimes called offtake contracts, with the supplier. In an irrigation project, the economic viability is heavily dependent on the ability and willingness of offtakers to purchase the project's output. Financing agencies prefer projects with single or a small number of offtake contracts, as in such cases it is more straightforward to establish and monitor the credit quality of the offtake counterparty.[46] An example of a project with small number of offtake counterparties is a bulk carrier pipeline replacing a carrier canal which typically would have one customer — the water distribution company.

- **Market risk**

  Where projects have multiple end users, such as with the secondary or tertiary parts of an irrigation system where there are multiple offtakes to irrigators, the project developers must ensure that there is sufficient demand for the project output at the prices necessary

[40] Government of Victoria (2000). *Partnerships Victoria*, Department of Treasury and Finance, Melbourne.
[41] New South Wales Government (2001). *Working with government policy for privately financed projects*.
[42] Government of South Australia (2001). *Capital investment 2001–02*.
[43] Department of the Parliamentary Library (2002). *Public private partnerships: an introduction*, Research Paper, No 1, 2002–03.
[44] Ibid

[45] Government of South Australia (2001). *Capital investment 2001–02*.
[46] Ibid

Table 8. Alternative public–private partnership (PPP) models

PPP model	Description	Advantages	Disadvantages
Design–build	Government contracts with a private partner to design and build a facility that conforms to the standards and requirements of government. Once the facility has been built, government takes ownership and is responsible for the operation of the facility.	Procurement flexibility; opportunities for innovation and cost savings; increased efficiency; reduced construction time; single-point accountability.	Reduced owner control; increased costs to incorporate design changes; more-complex award procedures.
Wrap-around addition	A private partner finances and constructs an addition to an existing public facility. The partner may then operate the addition for a specified period or until it recovers the investment and realises a reasonable return.	Public sector does not have to provide capital funding for the upgrade; financing risk rests with partner; time reduction in project delivery.	Future facility upgrades not included in the contract may be difficult to incorporate at a later date.
Lease-purchase	The government contracts with a private partner to design, finance, and build a facility. The partner leases the facility to the local government for a specified time, after which the ownership vests with the government.	Increased construction efficiency; lease payments may be less than debt service costs.	Reduced control.
Lease–develop–operate or Buy–develop–operate	The partner leases or buys a facility from the government, expands or modernises it, and then operates the facility under a contract. The partner is expected to invest in facility expansion and is given a specified amount of time to recover its investment and realise a return.	Cash infusion for government; time reduction in project implementation; fast-track construction; no public-sector capital needed for upgrade.	Difficulty valuing assets for lease or sale; reduced control.
Build–transfer–operate	The government contracts with a private partner to finance and build a facility. Once completed, the partner transfers ownership to the government. The local government then leases the facility back to the partner under a long-term lease, during which the partner has the opportunity to recover its investment and realise a return.	Maximises private-sector financial resources; ensures most efficient and effective facility based on life-cycle costs; all 'start-up' problems are addressed by the private partner; community is provided with a facility without large up-front capital outlay or incurring large long-term debt.	Loss of public control over construction and initial operation; difficulty in replacing private partner in the event of bankruptcy or performance default; facility may transfer back to public sector at a time in which operating costs are increasing.
Build–own–operate–transfer	A private partner obtains an exclusive franchise to finance, build, operate, maintain, manage, and collect user fees for a fixed period to amortise investment. At the end of the franchise, title reverts to public authority.	Maximises private-sector financial resources; ensures most efficient and effective facility based on life-cycle costs; all 'start-up' problems are addressed by the private partner.	Less public control than build–transfer–operate; difficulty in replacing private partner in the event of bankruptcy or performance default; facility may transfer back to public sector at a time in which operating costs are increasing.
Build–own–operate	Government either transfers ownership and responsibility for an existing facility or contracts with a private partner to build, own, and operate a new facility in perpetuity.	Private sector has the incentive to operate in the most efficient manner, in both the short run and the long run; long-term entitlement is incentive for firm to invest significant capital.	No competition, making regulations for operation and pricing necessary.
Operation and maintenance concession	Government contracts with private partner to operate and maintain a publicly owned facility.	Improved service and efficiency; cost savings; flexibility in securing contracts.	Costs to resume public operation if contractor defaults; reduced owner control and ability to adapt to changing public demands.

Source: *To partner or not to partner—that is the first question*, EDCO Newsletter, October 27, 1999.

to make the project economic. For example, a pipeline project would be viable only if irrigators were willing, or had the capacity, to pay the cost of pipelining the system.

- **Project sponsor**

  Prima facie, local water businesses have potentially a key role in project financing of water-savings projects as project sponsors or operators. However, if the water savings were to be removed from the irrigation district and returned to the environment, there would seem to be no incentive for these important local partners to become involved in the project. In fact, projects could face customer opposition or refusal to co-operate which could delay or halt their construction.

- **Stranded asset risk**

  Events such as technological change and premature obsolescence can adversely change the economic value of project assets. The risk could arise in the irrigation sector because of a change in irrigation demand due to:
  - falling prices in the main commodities produced in the irrigation project area;
  - demographic trends in the irrigation farming, eg. ageing farm population or uneconomic farm structures resulting in farmers leaving the industry;
  - negative environmental impacts such as salinity or waterlogging affecting productivity in the project area; and
  - climatic change reducing water availability.

  The impact of negative environmental outcomes is apparent in regions of the Goulburn–Murray such as the Pyramid Hill and Boort districts. Over the past 10 years, as a result of irrigation-induced soil salinity problems, there has been a net transfer of water out of these districts, leaving some assets at risk of becoming stranded.[47]

  Asset ownership risks also arise because of the specific nature of the customer–supplier technology relationship in irrigation. The irrigation customer must use a technology that is compatible with the water-delivery service provided by the supply scheme. What this means for an investor in long-lived irrigation infrastructure is that they need be able to predict the future supply service needs of their customers, otherwise the infrastructure is at risk of being made redundant by a supplier who can provide customers with new standards of service they require.

[47] Neil Barr, Senior Research Officer, Centre of Land Protection Research, pers. comm.

- **Regulatory risk**

  Regulatory risk is the risk that government will exercise it powers in a way that negatively impacts on a project. A primary area of regulatory risk in the irrigation sector is the likelihood of changes to the reliability of supply and access to water brought about by changes in government water-management and planning. A related issue is the question of whether compensation is payable upon annulment of water rights and, if so, in what circumstances and how will compensation be determined.

  Regulatory risk is important to any credit providers who hold water rights as security against project debt.

- **Network interface risk**

  Risks arise in an irrigation distribution project because bulk-water systems are inherently difficult to control, and water cannot be delivered to the inlet of the distribution system with a high degree of certainty with respect to volume, timing and quality. Rights of access to control facilities are a common point of contention between distribution and bulk supply organisations. To ensure continuity of service, a distribution system may need access to the diversion structure on the river. However, in most systems the diversion structure is operated by the bulk headworks supplier.

- **Contract issues (legal risk)**

  In PPP projects, contractual outputs should be clearly specified and an appropriate payment regime established based on delivery of the outputs.

  Water losses are measured on the basis of measured volumes of deliveries at different points in the delivery system. As discussed above, the conventional measure of WUE does not take into account beneficial uses of water losses, as some proportion of the water lost typically flows back to the environment and/or is re-used, downstream of the irrigation scheme. If the service specifications in a PPP involved the provision of water-loss reduction to government, then a contract specified in terms of the conventional measure of WUE may result in government paying for water that would otherwise return to the river environment.

5.3 Private sector survey

For this report, we have undertaken an informal survey of organisations involved in financing and operating PPPs. The objective of the survey was to obtain an understanding of the conditions under which the private sector would participate in water-savings projects.

Survey respondents were presented with a number of hypothetical PPP models and asked to complete a brief questionnaire. The survey sought the broad views of the respondents and not precise statements of an organisation's policy or intentions.

Survey questionnaire

The survey included three hypothetical PPP models and a project risk matrix (see Tables 9 and 10). The models are based on industry standard terms and conditions adapted to water savings in an irrigation context. In addition, the models are structured so that there is a capacity for the private-sector developer to recover the costs of the project through charges to end-users.

Appendix 2 gives details of the written responses to the survey.

For the survey, the following financial institutions and private-sector entities active in the water industry were contacted:

- Tyco Water
- Tenix Infrastructure
- Multiplex Constructions
- Vivendi Water
- Babcock & Brown
- Australian Water Services
- Thames Water
- Macquarie Bank
- RaboBank
- Commonwealth Bank of Australia
- ANZ Bank
- National Australia Bank
- United Utilities
- Anglian Water
- Severn Trent Water International
- Ondeo (Lyonnaise des Eauxs)
- Saur International
- Groupe Vinci
- Aguas de Barcelona

Table 9. Private sector survey — hypothetical public–private partnership models

Example 1. Bulk headworks management project **Purpose of the project:** Management and operation of bulk water supply headworks including dams, flow control and measurement structures through to offtakes of major consumers, eg. water supply authorities, irrigation districts. Delivery volume is approximately 3,000 GL/yr to 30 bulk customers. Includes design, construction and operation of overflow control structures on wetlands and floodplains. **Service specification:** Reduce water losses in the main stem of the river system and improve the control of flows. **Contract type:** 10 year service/management contract. **Financing:** Government grant may be available for community service obligation (CSO) elements. Water purchase agreement with government for benchmarked water savings. **Worth:** Initial capital investment of $20m–$30m to refurbish and upgrade existing structures plus management and operating fee.
Example 2. Main canals and infrastructure project **Purpose of the project:** Management and operation of main canals and regulation structures and in-line storages in an open-channel irrigation scheme covering several hundred thousand hectares. Includes design and construction of in-line storages to minimise losses in the irrigation system (evaporation, outfalls and seepage). **Service specification:** Manage and operate the system to reduce evaporation, seepage and outfall losses in the main canal system and improve the control of flows supplying a near on-demand service to secondary/tertiary canal offtakes. **Contract type:** In excess of 15 year service/management contract. **Financing:** Government grant may be available for CSO elements. Water purchase agreement with government for benchmarked water savings. **Worth:** Initial capital investment of $75m–$100m
Example 3. Pipelining project **Purpose of the project:** Build, design and operate replacement water supply pipelines to existing channel-supplied irrigation properties. Replacement of approximately 3,000 km of channel servicing 2,000 consumers is required. **Service specification:** Provide and manage a pressurised pipeline water supply system to agreed standards of service. **Contract type:** Design–build–operate contract. **Financing:** Predictable cashflows from delivery charges. Water purchase agreement with government for benchmarked water savings. **Worth:** Capital expenditure approximately $200m

Table 10. Private sector survey — risk matrix

Benefit or risk	Example 1. Bulk headworks project	Example 2. Main canal project	Example 3. Pipelining project
Potential to reduce water losses in conveyance systems (unaccounted for water)	Medium level of water savings.	Small to medium level of water savings.	High level of water savings.
Potential to improve service standards to consumers	Improved management of water levels in weir pools.	Water near on-demand to the distribution network.	Water on-demand and in controllable quantities.
Cost effectiveness in terms of water savings	Low-cost method of achieving water savings.	Low to medium-cost method of achieving water savings.	High-cost method of achieving savings.
Design and construction risk	Innovations in design of hardware and software components will be required. Upside benefits of further commercialisation.	Medium to low risk, relatively mature technologies but new application. Upside benefits of further commercialisation.	Low risk
Operating risk	Service definition is problematic. Water savings and other services to be delivered by the project will be difficult to specify.	Service definition is problematic. Water savings and other services to be delivered by the project will be difficult to specify. Supply conditions (climatic factors) will impact on project output.	Savings and service level benefits are straightforward to quantify. Revenues will vary depending on supply conditions. Supply conditions (climatic factors) will impact on project output.
Force majeure	Structures are exposed to flood risk. Insurable risk.	Service revenues exposed to drought risk. Insurable risk.	Service revenues exposed to drought risk. Insurable risk.
Network risk	Medium, most risk controllable through risk allocation; some exposure to watershed management risk.	Exposed to risks associated with the delivery from the bulk water. Management of downstream third-party interests will be problematic.	Exposed to risks associated with the delivery from the main supply system. Management of third-party interests will be highly problematic.
Market risk	Diversified customer base including municipal and industrial bulk customers; accordingly less exposure to agricultural risk.	Demand-side risk from spatial and temporal changes in agricultural water demand.	Demand-side risk from spatial and temporal changes in agricultural conditions. Exposure to agricultural risk. Potential stranded asset risk.
Legislative and government policy risk	Because the projects do not involve water rights, they are not affected by uncertainty regarding hydrological security and time-limited water rights.		

5.3.1 Discussion

All respondents were positive about the concept of PPPs in water savings. Survey respondents identified the basic elements of an attractive PPP model including:

- **minimum capital value** — the initial capital investment to be greater than $25 million and preferably $50 million plus;
- **contract duration** — preference for long-term purchase contracts capable of supporting project financing;
- **contract definition** — contracts to contain clearly defined service specifications with well defined and appropriately scoped project outcomes;
- **purchase contract** — prefer a single party offtake agreement rather than dealing with multiple parties;
- **risk sharing** — require clear risk transfer and allocation between private and public sector participants;
- **government guarantees** — preference for government to at least partially stand behind the major revenue streams to offset risk exposures;
- **tendering costs** — require quick, competitive tendering processes with low information, contracting and transaction costs; and
- **economies of scale** — prefer opportunities that leverage off their existing capabilities in infrastructure management and technology.

The barriers to private-sector participation in water-savings projects, as identified by the survey respondents include:

- **regulatory risk** — concern over a possibly uncertain regulatory environment;
- **transaction costs** — concern over the number of agencies involved in project approval and operation; and
- **economic risks** — questionable economic viability because of the high capital costs per unit of water saved.

Survey respondents provided hurdle rates for their participation in the hypothetical PPPs. These varied between 13% and 30% as the required rate of return. Clearly, the return required of a particular investment is dictated by the size of the project, tendering processes and risk allocation.

While the above discussion would tend to indicate that there is a market appetite for water-savings projects, a key *caveat* is that the survey is based on hypothetical projects that are structured in a way that allows the private-sector developer to capture the benefits of water savings and to recover the costs of the project through charges to project users. In practice, the capacity or willingness of irrigators to pay for irrigation upgrades is questionable. Similarly, the beneficiaries of irrigation conveyance externalities are unlikely to voluntarily forego their 'free-ride' on water losses.

Appendix 1

Acknowledgments

The following persons were consulted in preparation of this report.

Water industry

- Geoff Earl, Goulburn–Murray Water
- George Warne, CEO, Murray Irrigation Ltd
- David Watts, Murray Irrigation Ltd
- Geoff Parish, CEO, Central Irrigation Trust
- Errol Carlton, Operation Manager, SunWater
- John Chant, Company Secretary, Murrumbidgee Irrigation
- Dick Thompson, CEO, Murrumbidgee Irrigation
- Geoff Chambers, Snowy Joint Venture, Department of Treasury (NSW)
- Ian Penrose, Manager, Snowy Unit, Natural Resources and Environment (Vic.)
- Manager, Operational Services, Southern Rural Water
- Daryl Griffiths, Manager, SunWater
- Kell Roberts, NR&M (Qld), Fitzroy Basin
- Geoff Calder, South-West Water
- Manager, Operational Services, Wimmera–Mallee Water
- Tony McCleod, River Murray Water
- Andy Close, River Murray Water
- David Harriss, Regional Director, Murray Region, Department of Land and Water Conservation (NSW)

Finance industry and other sectors

- Don Marples, Head of Project & Infrastructure, Commonwealth Bank of Australia
- Mark Lamy, Business Analyst, Tenix Infrastructure
- Miles George, Babcock & Brown
- Gerald Fitzgibbon, State Manager, Vivendi Water Australia
- Peter McVeen, CE, Vivendi Water Australia
- Adrian Wills, Senior Executive, Project Finance, National Australia Bank
- Clive Wright, Technical & Marketing Manager, Tyco Water
- David Middleton, Business Development Manager, Thames Water
- Robert Dunlop, Projects & Infrastructure, Macquarie Bank
- Tony Oakes, Rubicon Systems Pty Ltd
- David Cox, Rubicon Systems Pty Ltd
- Charles Thompson, Rendell McGuckian Pty Ltd
- Dr Poh-ling Tan, Lecturer, Law Faculty, Queensland University of Technology
- Assoc. Prof. Hector Malano, Director, International Technologies Centre, The University of Melbourne

Appendix 2

Responses to industry questionnaire

Survey response

Written survey responses were received from six organisations. The responses are detailed below. As noted in the body of the report, the responses are not precise statements of an organisation's policy or intentions.

Respondent: Don Marples, Head of Project & Infrastructure, Commonwealth Bank of Australia
Level of interest: High. CBA has a broad experience in all types of public/private partnerships across Australia and in particular environmental industries.
What makes these projects attractive: • industry sector; • need (commercial imperative); • depth of knowledge in construction and operation; and • political will across government.
What makes these projects unattractive: • size ($20m); • possible uncertain regulatory environment and number of agencies involved; and • clear understanding of risk matrix.
What changes would be required to make these projects more attractive: • clear risk/transfer; • regulatory clarity; and • quick competitive process.
Expected IRR from the project Difficult to say until risks are analysed in detail. Most private infrastructure at 13–15% on a leveraged basis.

Respondent: Mark Lamy, Business Analyst, Tenix Infrastructure Pty Ltd
Level of interest: • Example 1. Does not sound an interesting opportunity for us currently; its size is not within our preferred band. • Example 2. Medium level (specified below) • Example 3. Low-level interest.
What makes these projects attractive: • Example 1. Not within our scope of operations • Example 2. Service/management-type contract allows us to leverage off existing capabilities across the Tenix group in delivery to customers across specified time frame. Financing on such projects is what we consider an area of opportunity; strong possibility of government guarantees on revenue stream. • Example 3. Same reasons as for example 2, increased size is preferable.
What makes these projects unattractive: • Example 1. Initial capital investment too small to structure finance via our preferred methods. • Example 2. Delivery of agricultural irrigation systems not a Tenix core competency • Example 3. As for example 2.
What changes would be required to make these projects more attractive: • Example 1. Size increased to $50m+. • Example 2. Clarification required, on the surface project seems attractive enough to warrant dd on bid. • Example 3. Same as for Example 2.
Expected IRR from the project: Expected IRR is a direct factor of risk in the project. There is not enough information to go on to provide specific figures, however, for Example 2 and Example 3 a return of approx. 30% IRR given strong government support would be feasible.

Respondent: Miles George, Babcock & Brown
Level of interest: Babcock & Brown has a strong interest and proven track record of participation as a private sector investor and arranger of funding for projects in the infrastructure sector in Australia. You may also be aware that Babcock & Brown has recent and relevant experience in the Australian water industry through our involvement in a range of build–own–operate–transfer (BOOT) transactions and competitive bidding consortia acting as a principal investor and as a financial adviser/arranger of funds for projects including: • Wyuna Water — Illawarra and Woronora water treatment plants — financial adviser, equity participant, debt and Infrastructure Borrowings arranger; • Central Highlands Water — Ballarat water treatment plants — financial adviser; • Victorian regional water treatment facilities — participation in bids for BOOT contract project delivery including Coliban Water — Castlemaine wastewater treatment plant, Aqua 2000 water treatment plants and the Echuca & Rochester wastewater treatment plants, and Grampians Water — Grampians Growth Corridor water-treatment plants; • Participation as a principal investor in the Nathan Dam and Bundaberg 2000 projects in Queensland; • Participation as an adviser and potential principal investor in the Goldfields Water and Perth Water Desalination projects in Western Australia; and Participation as financial adviser to the Rouse Hill Infrastructure Consortium in NSW. Babcock & Brown has a strong interest to participate in appropriately structured irrigation infrastructure projects of the type outlined in your survey.
What makes these projects attractive: Babcock & Brown would be attracted to projects in the irrigation sector which exhibit the characteristics of other successfully delivered public/private partnership projects including long-term predictable cash flows derived from efficiently providing clearly defined services, and reasonable allocation of risks between public and private-sector participants
What makes these projects unattractive: Potential factors from Babcock & Brown's perspective could be the size of the transactions, service definitions, contract type and the proposed risk allocation. We have a target for individual transaction size to be at least \$20–30m unless there are multiple transactions of a similar profile in prospect. Similarly, our experience of successful private-sector participation in infrastructure projects has led us to the view that the contract delivery mechanism, service definitions and proposed risk allocations must be appropriate, clearly articulated and commercially realistic.
What changes would be required to make these projects more attractive: Considering the views we have expressed regarding transaction size, we would suggest that individual projects which are less than about \$30m should be bundled together using common documentation and processes. Whilst separate tenders could be sought for each project, the standardisation of approach and documentation would enable private-sector investors to invest resources to understand the project delivery framework and develop project structures which meet the generic requirements in the expectation of several potential project opportunities. Regarding contract type, service specification and risk allocation we would suggest that Land & Water Australia should consider well thought out frameworks already developed for this purpose (such as the Partnerships Victoria model) upon which to base the framework for delivery of irrigation infrastructure projects with private sector participation. In the absence of such a framework it is not clear for example why you have determined that a design–build–operate (DBO) contract type would be appropriate for the pipelining project example instead of say a BOOT contract type where private sector finance initiatives may be able to achieve value for money outcomes otherwise foregone in a DBO approach. Nor is it clear why you envisage that management of third-party interests would be highly problematic in this example.
Expected IRR from the project: There is no simple answer to this question. Babcock & Brown would expect a reasonable return for the risks involved on a case by case basis.

Respondent: Gerald Fitzgibbon, State Manager, Vivendi Water Australia
Level of interest: Historically, Vivendi Water has not been involved in irrigation projects involving large headworks and open-channel distribution systems, primarily because there have been so few projects where the private sector has been invited to participate. In general, provided the commercial framework is sensible, where the risk allocation allows the private sector to clearly identify, quantify, and effectively manage risk, then this project is of interest. Vivendi Water is interested in most projects that involve the treatment and/or distribution of water, and as such would be interested in projects identified as Example 1 and 2.
What makes these projects attractive: Vivendi Water specialises in managing water systems, traditionally piped systems for industrial or domestic supply. The management techniques, if not the technologies, are common to both open and closed systems. Given that Vivendi Water would be interested in the Example 1 and 2 generic project types proposed, we comment that the following points would make these projects attractive: • the potential size with capital expenditure (CAPEX) in the range of $50 to 100 million; • long-term operations contracts (10–15 years), which are typical of our core operations business; • potential for the company to implement computer-based asset management, remote monitoring and operational systems to achieve efficiencies, in much the same way we do at present with piped distribution systems; • low credit risk — government security; and • potential synergies with our other businesses located in regional Victoria/New South Wales.
What makes these projects unattractive: Given that Vivendi Water would be interested in the Example 1 and 2 generic project types proposed, we comment that the following points would make these projects unattractive: • Size of capital investment: to raise competitive project finance for projects with CAPEX less than about $40 million can be difficult. • Messy supply agreements: potentially having to deal with numerous bulk purchase customers/agreements, rather than just one. • Performance measurements: operations scope must be very clearly defined and performance easily measured. More work will be required to find simple key performance indicators (KPIs) to define and measure the contractor’s performance. • Environmental and statutory risks: who will retain the responsibility to manage riparian rights issues, environment flow management in wetlands, environmental impact? • Operational complexity: will potentially have a different contractor for the Example 1 and 2 contracts which may lead to systems management issues. Headworks and main canals need to be managed as one system, particularly given the conveyance time from headworks to end of main channel systems is measured in days. Having two contractors may work against such an outcome. • Climate related risks: impact of drought events on measurement of performance and performance related contract payments.
What changes would be required to make these projects more attractive: Given that Vivendi Water would be interested in the Example 1 and 2 generic project types proposed, we comment that the following points would make these projects more attractive: 1. Lump together Example 1 and 2 into one contract in order to: – improve access to project finance; – enhance the operational economies of scale; and – reduce the operational complexity by managing both systems as one. 2. Reduce the number of bulk supply agreements 3. Provide a clearly defined operational scope of work for the contract. 4. Base performance on a small number of readily measured KPIs 5. Government to indemnify contractor against drought-related revenue impacts
Expected IRR from the project: Clearly this will be dependent upon the risk profiles and allocation, but given these are reasonable, and based on our current WACC, a typical target IRR would be 15%.

Respondent: Adrian Wills, Senior Executive, Project Finance, National Australia Bank
Level of interest: National Australia Bank is actively involved in the financing of infrastructure projects in Australia, in both an advisory and a debt capacity. Irrigation infrastructure projects (such as those hypothetical cases outlined in your letter) are examples of the types of projects National would have an interest in exploring to assess the capacity for either a project finance, or other financing solution.
Other comments: While each project finance proposal would need to be assessed in detail on its individual merits, some key areas that are likely to be included in the due diligence process would be: • Constructors and construction contracts • Technical review of processes to be used • Proposed water supply arrangements • Offtake arrangements for services provided • Operators of the proposed facility • Cash flow analysis of the project • Project ownership and security structure • Any government regulatory implications

Respondent: Jason Cheng, Investment Banking Group, Macquarie Bank Limited
Level of interest: *Example 1*: Medium/high market appetite Additional assumptions (discussed with Marsden Jacob) • Contract would involve the design, construction and operation of the overflow control structures, with the intention for appropriate risks to be transferred to the private sector • Federal & State government grants may be available for CSO elements • Water purchase agreements to be entered into with water authorities and government *Example 2*: High market appetite Additional assumptions (discussed with Marsden Jacob) • Contract would involve the design, construction and operation of canals, regulation structures and in-line storages, with appropriate risks to be transferred to the private sector; and • Federal & State government grants may be available for CSO elements. *Example 3*: High market appetite Additional Assumptions (discussed with Marsden Jacob) • Build, own, operate, transfer contract and the private sector may also be required to arrange financing for the project; • Long-term concession contract, >20 years; • Private sector would be a monopoly, possibly regulated supplier; and The pipeline would be developed on a greenfields site.

Respondent: Jason Cheng, Investment Banking Group, Macquarie Bank Limited (cont'd)

What makes these projects attractive:

The characteristics of other successful PPP projects which have made the projects attractive to the private sector, in the context of this survey include:

1. Proposed risk allocations reflecting the risks that the public and private sector are best able to control;
2. Clear asset output specifications and the ability to develop innovative solutions for the project;
3. Clear definition and understanding of the scope of the service/operation contract;
4. Project scale, to manage the private sector's risk/reward analysis and the transaction costs involved in bidding for these projects; and
5. A payment mechanism structured to incentivise the private sector to achieve and exceed performance standards

Hence. the factors which make each of the examples attractive to the private sector are:

Example 1:

- That (assumed) that the private sector only retains risks that it controls, such as design, construction and operation of the damn and weir pools;
- Sponsor/financial risk is retained by the public sector, including the negotiation of water purchase agreements and application for Federal and State government grants;
- Ability for the private sector to provide innovation and potentially, value for money, through the design of the required hardware and software components;
- Long-term DBO contract; and

Further information on the payment mechanism is required (see below), however the apparent reliability of cashflows from CSO payment and water-purchase agreements ensure the security of payments to the private sector over the 10-year contract;

Example 2:

- That (assumed) that the private sector only retains risks that it controls, such as design, construction and operation of the in-line storages units;
- Sponsor/financial risk is retained by the public sector, including the negotiation of water-purchase agreements and application for Federal and State government grants;
- Infrastructure required under this example is relatively mature, and thus private sector faces only medium to low design and construction risk;
- Scale of project; and
- Long-term DBO contract.

Further information on the payment mechanism is required (see below), but the apparent reliability of cashflows from CSO payment and water-purchase agreements ensure the security of payments to the private sector over the 15-year contract;

Example 3:

- A risk allocation transferring only those risks which the private sector is now responsible, including:
  - Design and construction risk;
  - Environmental risk;
  - Operation risk;
  - Asset ownership risk;
  - Operations risk;
  - Sponsor/financial risk; and
  - Demand risk.
- Low design and construction risk of the water-supply pipelines;
- The ability to generate and quantify the financial savings and service level benefits of replacing water supply pipelines. This may assist in negotiating more competitive water purchase agreements with government;
- Scale of project;
- Long-term concession contract;

Assuming the economic and financial viability of the project, the opportunity to be a monopoly supplier of water in the selected region.

What makes these projects unattractive:

Example 1:

- Project scale may not meet the project risk/benefit rewards analysis to attract a sufficient level of private sector interest;
- The requirement for greater innovation under this example, may increase the level of design and construction risk to the private sector. This will depend upon the experience and skills of the successful contractor.

Example 2:

- No major issues

Example 3:

- Private sector will be mainly concerned about the level of demand for the pipeline and whether user revenues and water purchase agreements will be sufficient to meet the required debt and equity returns.

Respondent: Jason Cheng, Investment Banking Group, Macquarie Bank Limited (cont'd)
What changes would be required to make these projects more attractive: The private sector would require more information about the structure of the payment mechanism. Does it involve a charge for the design and construction services, and a separate services charge? This would be preferred by the private sector, as it ensures that the payment for the design and construction of infrastructure cannot be abated by a failure to achieve performance standards. The services charge should be aligned with the service performance standards in order to ensure quality services are provided. Clear and demonstrated demand/need for the infrastructure, particularly to the extent of works required in example 3. This is important to enhance project certainty and the commitment and interest of the private sector to bid for such projects.
Expected IRR from the project: *Example 1 & 2* • The IRR required would be in the order of 12%–15%. *Example 3* As the private sector is providing required to finance the project and take on a greater number of project risks, an IRR in the order of 14%–18% may be required. The higher IRR results because the weighted average cost of borrowing of the private sector is higher than the nominal public-sector borrowing rate. This is because private sector agencies source their financing from debt and equity providers, rather than just debt providers. The main reasons that equity holders require a higher return are: to compensate them for the project risks they are accepting and the fact that their equity returns rank behind debt providers.