Chapter 10

A Community Based Investment Model to Assess the Economic Benefits of Rainwater Tanks

> "How is it that we have created an economic system that tells us it is cheaper to destroy the earth and exhaust its people than to nurture them both? Is it rational to have a pricing system that discounts the future and sells off the past? How did we create an economic system that confuses capital liquidation with income? Wasting resources to achieve profits is far from fair, wasting people to achieve higher GDP doesn't raise standards of living, and wasting the environment to achieve economic growth is neither economic or growth" P. Hawken, A.B. Lovins and L.H. Lovins [1999].

10.0 Introduction

The use of rainwater tanks to supplement mains water supplies for hot water, toilet and outdoor uses on domestic allotments was shown in Chapters 2, 3, 6 and 8 to significantly reduce household mains water use. The homeowner will gain economic benefit from purchasing a reduced volume of mains water. In Chapters 6 and 8 it was shown that the widespread introduction of rainwater tanks results in substantial reduction in regional mains water use that can lead to the deferral of the requirement for new water supply dams (Chapters 9). The economic benefit of deferring the construction of new dams accrues to the community. Domestic rainwater tanks were also shown in Chapters 2 and 7 to reduce the requirement for stormwater infrastructure resulting in construction, depreciation and maintenance cost savings. The benefits from a reduced requirement for stormwater infrastructure will accrue to the homeowner and the community.

The homeowner pays the cost to install, operate and maintain rainwater tanks on domestic allotments but the benefits from installing the tanks accrue to both the homeowners and the wider community. Indeed the benefits that accrue to the homeowner may be small in comparison to the benefits accruing to the community that are derived from the deferral of new dams and water distribution infrastructure, a reduced requirement for stormwater infrastructure and improved environmental impacts. Analysis of the costs and benefits of domestic rainwater tanks typically ignores the benefits that accrue to the community by focusing only on the economic savings from reductions in domestic water use and installation costs for the tank. This is due to in part institutional resistance (Chapters 2, 4 and 5) and incorrect assumptions about the performance of rainwater tanks (Chapters 4 and 7).

It was claimed by ACTEW [1994], ASTEC [1995] and Van Der Wal [2000] that the cost of rainwater varies from $1.00 to $14.50 per kilolitre, the quality of rainwater from tanks is unsuitable for most domestic uses and the supply of rainwater from tanks is unreliable. In Chapter 3 it was shown that cost of rainwater varied from a benefit of $0.39 per kL to a cost of $0.30 per kL. In Chapters 2, 3 and 4 rainwater stored in tanks was found to be acceptable for hot water, toilet and outdoor uses resulting in considerable reductions in mains water consumption and stormwater discharges. Indeed in Chapter 4 it was found that the use of rainwater for domestic purposes including drinking rarely caused illness. Analysis of water supply and stormwater disposal systems is dominated by the operation of the pipe paradigm (Chapter 5) that excludes the use of rainwater tanks. Traditional economic analysis is confined to comparing the costs of a limited set of solutions that are consistent with the pipe paradigm.

The installation of rainwater tanks has the potential to be an alternative augmentation strategy for water supply and stormwater infrastructure. A method is required for comparing the economic benefits of augmentation strategies using traditional infrastructure provision to the benefits of augmentation strategies that include rainwater tanks.

In this Chapter an investment model is developed to determine the economic benefits accruing to the community from the installation of rainwater tanks. This investment model will allow an economic comparison to be made between strategies to install rainwater tanks and the provision of traditional urban water cycle infrastructure. The investment model will combine the regional water use results from Chapter 8 with the associated deferral of new dams from Chapter 9, the stormwater infrastructure savings from Chapters 2 and 7 and the costs of rainwater tanks from Chapters 3 and 7 to determine the economic benefits accruing to the community from the installation of rainwater tanks.

10.1 Development of the Investment Model

An investment model was developed to compare the economic benefits accruing to the community from a traditional base scenario and from alternative scenarios that include installation of rainwater tanks. The base scenario considers the status quo: provision of traditional stormwater disposal systems to areas undergoing urbanisation and provision of additional mains water supply by further regulation of river systems.

The economic efficiency of the rainwater tank and traditional base scenarios was compared using the methods of annual and present equivalence [Smith, 1979]. In the annual equivalence analysis each alternative scenario starts with enough funds to ensure economic viability of the base scenario. Each year expenses are deducted, income is added and interest is earned on the balance. The analysis considers comparative costs and benefits using the base scenario as the reference. All scenarios provide water supply and stormwater services to a minimum standard that ensures public safety and drought security. The investment model was used to find scenarios that minimise costs subject to these service constraints. The investment model compares the economic differences between alternatives. A schematic of the base scenario is shown in Figure 10.1.

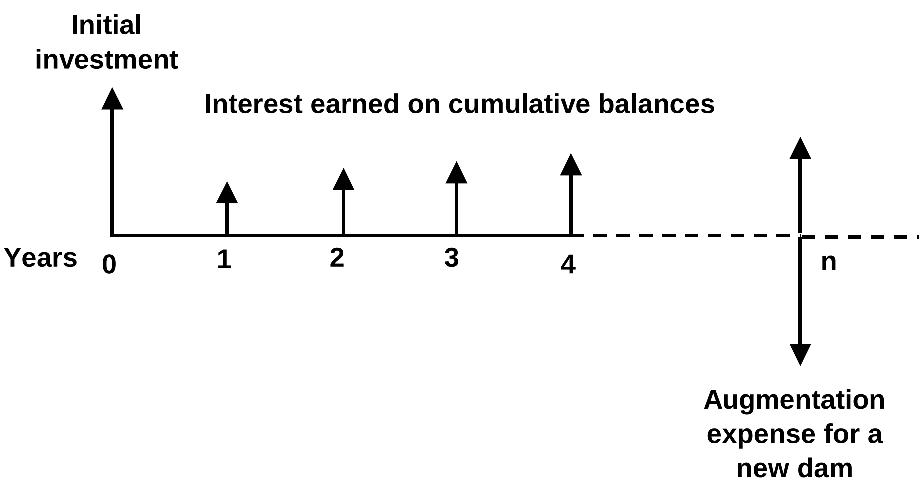

Figure 10.1: Schematic of the base investment scenario

In Figure 10.1 it is shown that the analysis of the base scenario begins with an initial investment and accumulative interest is earned on the initial investment in each year. In year n the water supply system requires augmentation. Thus the cost to construct a new dam is deducted from the balance of the initial investment in year n. For the base scenario, the balance of the initial investment carried forward from year t is Bal_{t+1}, is:

$$\mathrm{Bal}_{t+1} = (1 + \mathrm{Rint})(\mathrm{Bal}_t - \mathrm{augCost}_t) \qquad (10.1)$$

where Rint is the real interest rate and $\mathrm{augCost}_t$ is the augmentation cost for the traditional water supply (if any) in year t.

Costs and benefits for the provision of mains water and the disposal of stormwater considered common to the base and alternative scenarios were not included in the analysis. The construction of a new dam is considered to be an expense incurred by the community and is included in the base and alternative scenarios that include rainwater tanks. The construction costs of new dams were included because the requirement to build new dams will have significant impact on the balance of a scenario and may occur in different years in the scenarios. The costs and benefits that differ from the base scenario are considered in the alternative scenarios. A schematic of the alternative scenarios is shown in Figure 10.2.

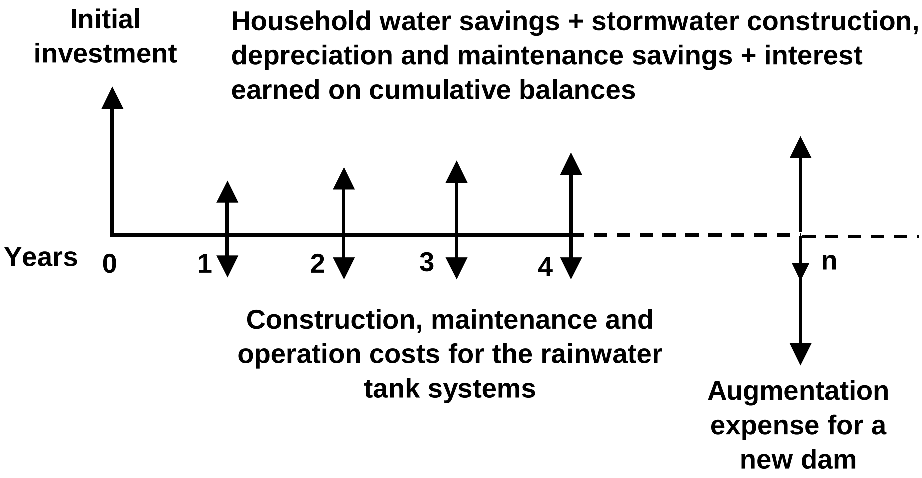

Figure 10.2: Schematic of the alternative investment scenarios

In the alternative investment scenarios (Figure 10.2) it is assumed that a household can obtain water from the water authority and from rainwater tanks. Water can be purchased from the water authority at a price of Pw per kL and the household can install a rainwater tank for water supply. The community pays the cost of installing, operating, maintaining and replacing rainwater tank systems whilst gaining benefits from reduced mains water consumption, deferred water supply infrastructure and reduced requirement for stormwater infrastructure. The reduced requirement for stormwater infrastructure results in decreased depreciation and maintenance costs. For the alternative investment scenarios, the balance at the end of year t is:

$$\begin{aligned} Bal_{t+1} = (1 + Rint)(Bal_t - augCost_t - Trep_t - Prep_t - conCost_t - maintCost_t \\ - opCost_t + savWat_t + savDev_t + savDep_t + savMaint_t) \end{aligned} \quad (10.2)$$

where in year t $conCost_t$, $maintCost_t$ and $opCost_t$ are the construction, maintenance and operation costs for the rainwater tank system, $Trep_t$ is the replacement cost of the rainwater tank, $Prep_t$ is the replacement cost of the pump in the rainwater tank system, $savWat_t$ is the savings in foregone mains water consumption, $savDev_t$ is the saving in new stormwater infrastructure, $savDep_t$ is the depreciation saving and $savMaint_t$ is the maintenance saving derived from having a reduced amount of stormwater infrastructure. The value of the mains water saving $savWat_t$ in year t is:

$$savWat_t = (Dem_t^B - Dem_t^S)Pw \quad (10.3)$$

where $Dem^B{}_t$ is the regional mains water demand in the base scenario and $Dem^S{}_t$ is the regional mains water demand in the alternative scenario in year t.

It is assumed that the savings from foregone mains water consumption are a benefit to the community because the savings can be used by the community to purchase rainwater tanks or for any other purpose. The cost to install rainwater tanks $conCost_t$ in year t is:

$$conCost_t = Tnum_t RTcost \quad (10.4)$$

where $Tnum_t$ is the number of rainwater tank systems installed in year t and RTcost is the installation cost of the rainwater tank system.

The maintenance costs of the rainwater tank systems $maintCost_t$ in year t is:

$$maintCost_t = (Dem_t^B - Dem_t^S)Tmaint \quad (10.5)$$

where the maintenance cost for each kL of rainwater consumed is Tmaint.

The operating costs of the rainwater tank systems $opCost_t$ in year t is:

$$opCost_t = Ttot_t(Dem_t^B - Dem_t^S)Topp \quad (10.6)$$

where Topp is the operating cost of a rainwater tank system for each kL of water supplied from the rainwater tank.

The cost to replace rainwater tanks $Trep_t$ in year t is:

$$Trep_t = Told_t.Tcost \qquad (10.7)$$

where $Told_t$ is the number of rainwater tanks that have reached an age where replacement is required and Tcost is the replacement cost of a rainwater tank.

The cost to replace a pump in a rainwater tank system $Prep_t$ in year t is:

$$Prep_t = Pold_t.Pcost \qquad (10.8)$$

where $Pold_t$ is the number of pumps in rainwater tank systems that have reached the point where replacement is required and Pcost is the replacement cost of a pump.

The cost savings resulting from a reduced requirement for stormwater infrastructure $savDev_t$ in new developments or redevelopments in year t is:

$$savDev_t = (NewDev_t + ReDev_t)StSav \qquad (10.9)$$

where $NewDev_t$ is the number of new dwellings and $ReDev_t$ is the number of redeveloped dwellings in year t and the savings per dwelling resulting from a reduced requirement for stormwater infrastructure is StSav.

The savings in depreciation expenses resulting from a reduced requirement for stormwater infrastructure $savDep_t$ in year t is:

$$savDep_t = (NewDev_t + ReDev_t)StDSav \qquad (10.10)$$

where the savings in depreciation expenses per dwelling resulting from a reduced requirement for stormwater infrastructure is StDSav.

The savings in maintenance costs resulting from a reduced requirement for stormwater infrastructure $savMaint_t$ in year t is:

$$savMaint_t = (NewDev_t + ReDev_t)StMSav \qquad (10.11)$$

where the savings in maintenance costs per dwelling resulting from a reduced requirement for stormwater infrastructure is StMSav.

The alternative scenarios that include rainwater tanks are evaluated using Equations 10.2 to 10.11 and the base scenario is evaluated using Equation 10.1. The annual equivalence analysis compares the balance of the initial investment in the base and alternative scenarios in any year. The present equivalence analysis compares the initial investment required to achieve a surplus of funds at the end of the investment period for each scenario.

10.2 Economic Analysis for the Lower Hunter and Central Coast Regions

The benefits accruing to the communities in the Lower Hunter and Central Coast regions from the widespread installation of rainwater tanks were evaluated using the investment model. The economic efficiency of the rainwater tank scenarios was evaluated using two different investment cases. The first investment case is based on the findings in this thesis and uses the following data:

- Real interest rate is 5%. The real interest rate is defined as the difference between the interest rate that is set by the Reserve Bank and the inflation rate in the year 2000;
- Maintenance and operation of the rainwater tank system is conservatively assumed to cost $0.05 per kL of rainwater use. In Chapters 2 and 3 the operation and maintenance costs for rainwater tank systems at the Figtree Place and Maryville experiments were found to be negligible;
- The installation of rainwater tanks in new developments or redevelopments reduces the requirement for stormwater infrastructure resulting in a saving, conservatively set at $959 per dwelling from the results of the Figtree Place experiment in Chapter 2. Analysis of a land subdivision in the Lower Hunter region revealed the construction cost savings of $210 to $511 were possible (Chapter 7). However the analysis only evaluated the impact of rainwater tanks on stormwater pipes and water quality devices. A full WSUD approach was not reported, although Coombes and Kuczera [1999] have reported substantially greater savings can be achieved by a full WSUD approach even in a clay soil environment. The Figtree Place savings are used because the savings are the result of a full WSUD approach to water supply and stormwater management;
- An annual maintenance and replacement cost saving of $23.45 per dwelling resulting from the reduced requirement for stormwater infrastructure for a subdivision with 10 kL rainwater tanks (Chapter 7) was used in the analysis. In Chapter 7 analysis of a land

subdivision showed that annual replacement and maintenance costs for subdivisions could be reduced by $10.65 to $23.90 per dwelling.

- The redevelopment rate for existing dwellings in the Lower Hunter and Central Coast regions is about 0.9% per year [ABS, 1999];
- The rainwater tank has a useful life of 50 years and its replacement cost is $840 (Chapters 3 and 7);
- The pumps used in the rainwater tank system have a useful life of 10 years with a replacement cost of $200 (Chapters 3 and 7);
- Cost to install a rainwater tank system is $2185 per dwelling from Chapter 7; and
- The price of a kilolitre of mains water is $0.94 in Lower Hunter region and $0.65 in Central Coast region.

The second investment analysis uses the data provided above and makes some additional assumptions. The impact of installation of rainwater tanks on water distribution infrastructure was not analysed in this thesis. However it is believed that the widespread use of rainwater tanks with mains water trickle top up will defer the requirement for mains water treatment plants and new water distribution infrastructure. Shipton [1999] found that the widespread installation of water storage tanks with trickle top up systems would reduce the requirement for water distribution infrastructure resulting in a cost saving of about $500 per dwelling. Therefore the second investment analysis it is assumed that the installation of a rainwater tank results in a reduction in the requirement for water distribution infrastructure resulting in a cost saving of $500 per dwelling.

More than 85% of Australians live in urban areas [ABS, 1994]. The widespread installation of rainwater tanks in urban areas will substantially increase consumer demand for rainwater tanks and pumps. This will result in the growth of existing firms, and the development of new firms to meet increased demand for tanks and pumps. It is expected that growth in the rainwater tank industry will produce economies of scale and competition that will significantly reduce the prices for pumps and rainwater tanks. The unit price of purchasing a thousand pumps is half that of purchasing a single pump [Davey Pumps, personal communication, 2001] and the unit price for the purchase of a large number of rainwater tanks may also be half the purchase price of a single tank [Cessnock Tank Works, personal communication, 2000]. In the second investment case it is assumed rainwater tanks and pumps can be purchased at half their current price. A 10 kL rainwater tank can be purchased for $464 and a pump can be purchased for $110. Hence the installation cost for the rainwater tank system is $1,613 and the replacement cost for the rainwater tank is $420 and the pump is $100.

Each scenario evaluated in both investment cases uses the regional water demands calculated in Chapter 8 to determine the value of water savings and the water supply headworks augmentation timing for each scenario from Chapter 9. All costs or benefits considered are in year 2000 dollars.

10.2.1 Comparative Economics for the Installation of Rainwater Tanks in the Lower Hunter Region

Figure 10.3 presents a time series of annual equivalent economic position Bal_{t+1}, (Equations 10.1 and 10.2) for the different scenarios evaluated for the Lower Hunter region using the first investment case. In the annual equivalence analysis each alternative scenario starts in year 2000 with enough funds to ensure economic viability of the base scenario throughout the investment period. That is an investment of $15M for the Lower Hunter region.

A number of investment scenarios were considered for the Lower Hunter region. The base scenario considers the status quo. This involves provision of traditional stormwater systems to areas undergoing urbanisation and provision of additional mains water supply by further regulation of river systems. Alternative scenarios consider the use of rainwater tanks. A number of alternative scenarios are considered: In the growth scenario (denoted as G), rainwater tanks are installed for all new housing. In the other scenarios (denoted as G+0.25% to G+3%), rainwater tanks are installed for all new housing and existing housing is retrofitted with water tanks at rates varying from 0.25% to 3% per year until 90% of dwellings have a rainwater tank.

The analysis reveals that the G+0.9% scenario provides the greatest benefit to the community. The balance of an initial investment of $15 million will exceed $9 billion by the year 2100. The growth to G+2% scenarios all show significant outcomes for the community. The results show that the scenario using installation rates 3% per year of rainwater tanks to existing dwellings and to all new dwellings (G+3%) was not financially viable when compared to the base scenario. However, scenarios using installation rates to existing dwellings of up to 2% per year provide greater economic benefits to the community than the traditional water supply option.

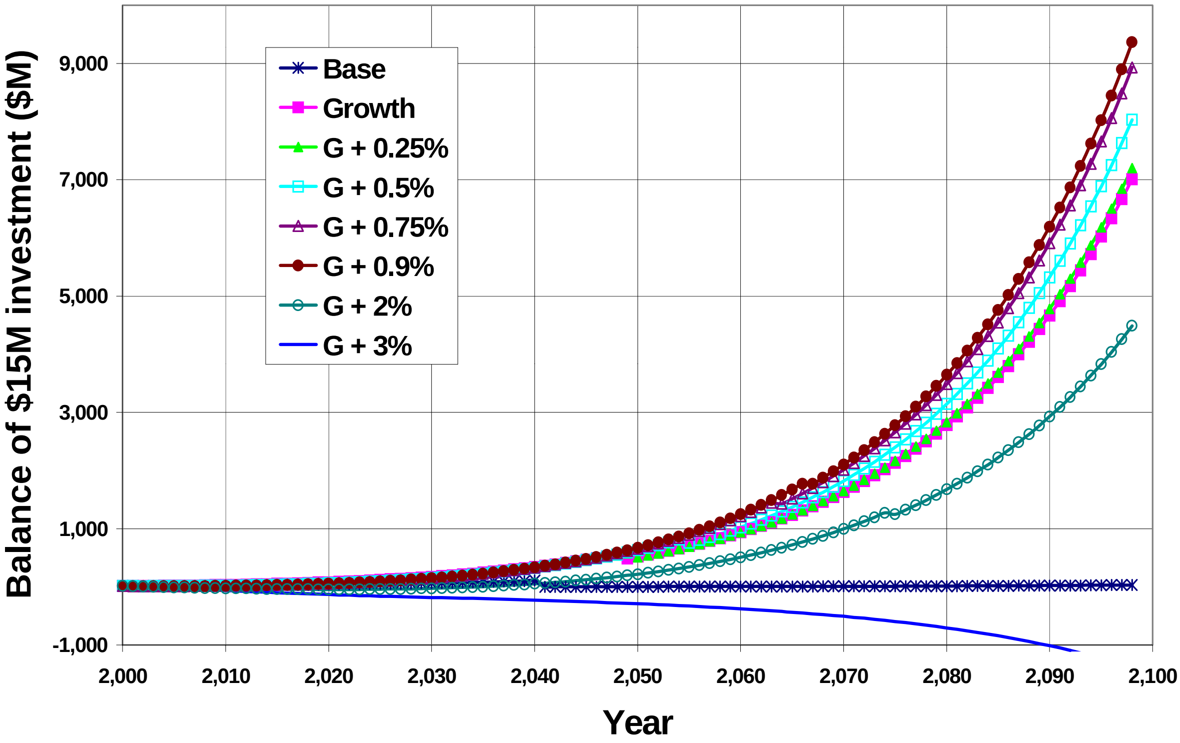

Figure 10.3: Results of the annual equivalence analysis for the Lower Hunter region using the first investment case.

The present equivalence analysis (Table 10.1) shows the initial investment and the comparative present benefit of each scenario. For the base and G+3% scenarios capital investment is required to ensure viability of the strategy. However for the scenarios Growth to G+2% capital investment is not required. Indeed the community has a surplus of funds available for investment in other activities. For example, for the growth scenario the community could invest $30 million in other activities and still finance the provision of adequate water supply and stormwater services.

Table 10.1 reports the comparative benefits that is the present value to the community of an investment in a particular scenario in comparison to the traditional base scenario. For example in the G+0.9% scenario the initial investment required in the first year is -$63 million, indicating that the community can spend $63 million on other activities in its first year, and still finance the provision of water supply and stormwater services. Moreover the community does not need to set aside the $15 million to finance the base scenario. Thus investment in the G+0.9% scenario provides a $78 million benefit to the community. Table 10.1 shows that the G+0.9% scenario has the greatest comparative benefit of $78 million. Comparative benefits of the growth to G+2% scenarios range from $37 million to $78 million. The G+3% scenario shows a comparative cost of $12 million.

Table 10.1: Results of the present equivalence analysis for the Lower Hunter region using the first investment case

Scenario	Investment in first year ($M)	Comparative benefit ($M)
Base	15	0
Growth	-44	59
G+0.25%	-45	60
G+0.5%	-52	67
G+0.75%	-59	74
G+0.9%	-63	78
G+2%	-22	37
G+3%	27	-12

The economic benefits to the community are derived from mains water savings, construction and depreciation savings resulting from a reduced requirement for stormwater infrastructure and interest earned on community savings due to the deferral of new water supply dams. The very significant economic benefits for scenarios up to G+0.9% is due to savings in the construction and depreciation of stormwater infrastructure attributed to new and redeveloped dwellings. All dwellings fitted with a rainwater tanks in scenarios up to the G+0.9% scenario are assumed to be new or redeveloped dwellings.

Figure 10.4 presents a time series of annual equivalent economic position Bal_{t+1}, (Equations 10.1 and 10.2) for the different scenarios evaluated for the Lower Hunter region using the second investment case. The second investment case assumes firstly that the installation of rainwater tanks will also reduce the requirement for water distribution infrastructure resulting in additional savings and secondly that increased demand for rainwater tanks and pumps will reduce their purchase price.

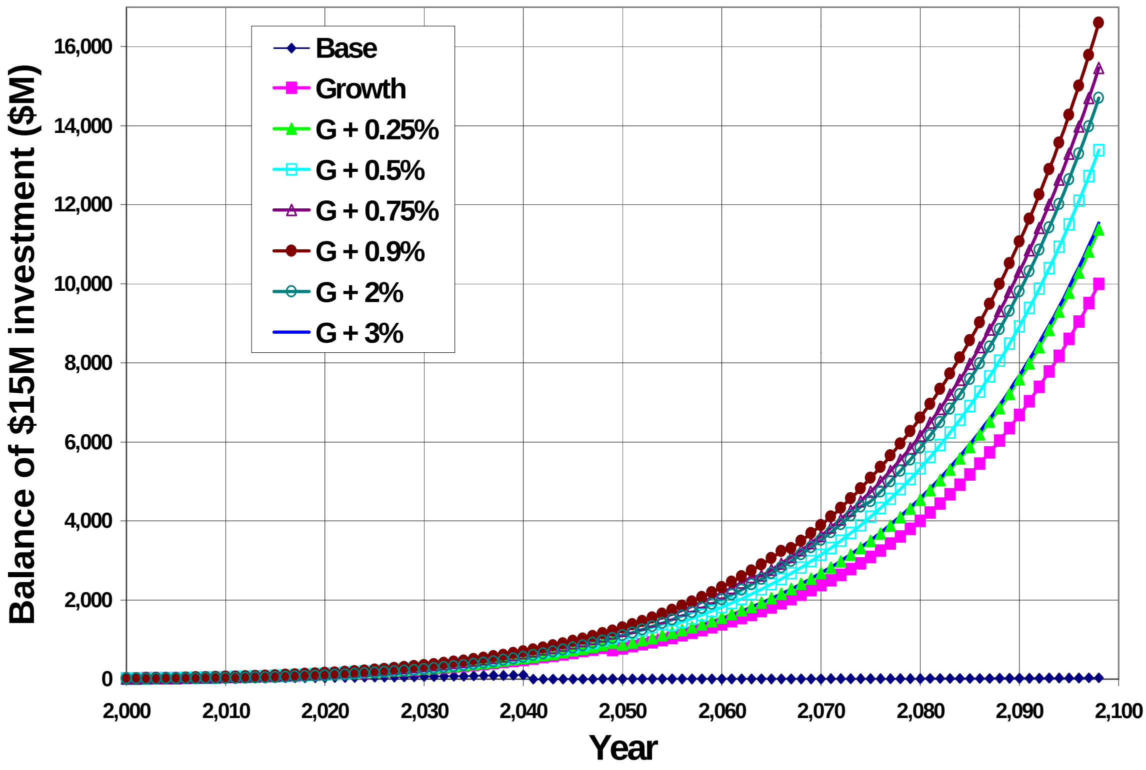

Figure 10.4: Results of the annual equivalence analysis for the Lower Hunter region using the second investment case.

It is shown in Figure 10.4 that the G+0.9% scenario provides the greatest benefit to the community. The balance of an initial investment of $15 million will exceed $16 billion by the year 2100. All alternative scenarios are shown to produce greater economic benefits than the base scenario. The inclusion of benefits that are derived from a reduced requirement for water supply infrastructure and reduced costs for rainwater tanks and pumps in the investment analysis significantly improves the performance of the growth to G+0.9% alternative scenarios. The G+3% scenario produces a similar economic benefit to the G+0.25% scenario. The improved performance of the G+3% scenario in comparison to the first investment case results from the reduced costs for the rainwater tanks and pumps and the allowance for savings in water distribution infrastructure.

The present equivalence analysis (Table 10.2) shows the initial investment and the comparative present benefit of each scenario. It shows that the base scenario requires capital investment to ensure viability of the strategy. However for the alternative scenarios capital investment is not required and surplus funds are available to the community for other purposes.

Table 10.2: Results of the present equivalence analysis for the Lower Hunter region using the second investment case

Scenario	Investment in first year ($M)	Comparative benefit ($M)
Base	15	0
Growth	-68	83
G+0.25%	-80	95
G+0.5%	-97	112
G+0.75%	-114	129
G+0.9%	-124	139
G+2%	-108	123
G+3%	-81	96

In Table 10.2 it is shown that the G+0.9% scenario has the greatest comparative benefit of $139 million. Comparative benefits of the growth to G+3% scenarios range from $83 million to $139 million. All the alternative scenarios are shown to be more economically efficient than the base scenario and have considerably greater benefits than in the first investment scenario.

The first investment case shows that installation of rainwater tanks for domestic hot water, toilet and outdoor uses will contribute significant benefits to the community in the Lower Hunter region for the growth to G+0.9% scenarios. Indeed these alternative scenarios produced superior economic performance to the traditional water supply and stormwater management option. However, the benefits from a reduced requirement for water distribution infrastructure and increased competition in the market place for rainwater tanks and pumps have not been evaluated rigorously in this thesis. These additional benefits have been estimated and used in the second investment case which shows that all of the alternative investment scenarios are superior to the traditional water supply and stormwater management option.

10.2.2 Comparative Economics for the Installation of Rainwater Tanks in the Central Coast Region

Figure 10.5 presents a time series of the annual equivalent economic position Bal_{t+1}, (Equations 10.1 and 10.2) for the different scenarios evaluated for the Central Coast region using the first investment case.

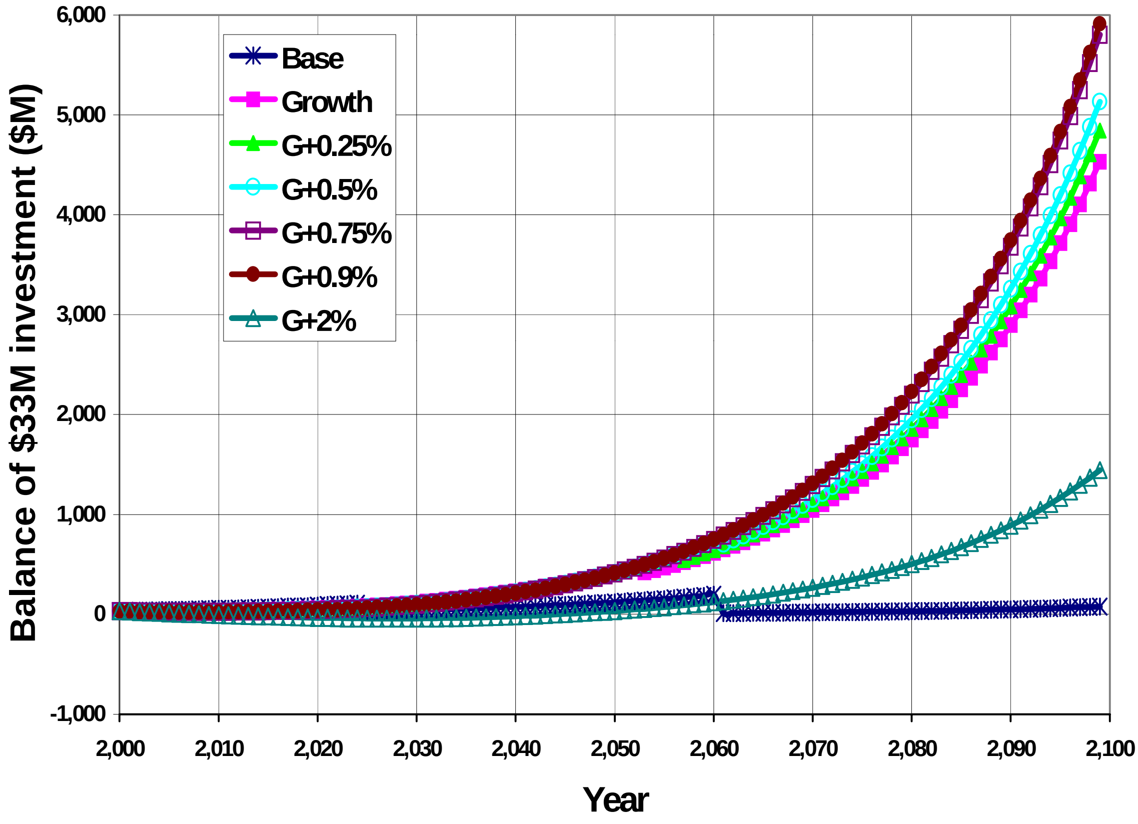

Figure 10.5: Results of the annual equivalence analysis for the Central Coast region using the first investment case.

In the annual equivalence analysis each alternative scenario starts in year 2000 with enough funds to ensure economic viability of the base scenario throughout the investment period. That is an investment of $33M for the Central Coast region.

The analysis reveals that the G+0.9% scenario provides the greatest benefit to the community. The balance of an initial investment of $33 million will exceed $5.5 billion by the year 2100. The scenarios all show significant benefits to the community and provide greater benefits to the community than the traditional water supply option.

The present equivalence analysis (Table 10.3) shows the initial investment and the comparative present benefit of each scenario. It is shown that for base and G+2% scenarios capital investment is required to ensure viability of the strategy (the G+3% scenario was not investigated for the Central Coast region).

Table 10.3: Results of the present equivalence analysis for the Central Coast region using the first investment case

Scenario	Investment in first year ($M)	Comparative benefit ($M)
Base	33	0
Growth	-3	36
G+0.25%	-5	38
G+0.5%	-7	40
G+0.75%	-13	46
G+0.9%	-14	47
G+2%	22	11

In Table 10.3 it is shown that the G+0.9% scenario had the greatest comparative benefit of $47 million. Comparative benefits of the Growth to G+2% scenarios range from $11 million to $47 million. The Growth to G+2% scenarios are shown to be more economically efficient than the traditional base scenario. This result is similar to the findings for the first investment case for the Lower Hunter region.

The comparative benefits of the alternative scenarios in the Central Coast region were less than the comparative benefits found in the Lower Hunter region for the first investment case. The difference in the magnitude of the benefits is due to lower price of mains water and lower first stage augmentation cost for the water supply headworks system in the Central Coast region. A lower price for mains water will reduce the economic savings that can result from saving mains water and a lower augmentation cost will result in reduced interest savings from the deferral of augmentation.

Figure 10.6 presents a time series of annual equivalent economic position Bal_{t+1}, (Equations 10.1 and 10.2) for the different scenarios evaluated for the Central Coast region using the second investment case. It is shown in Figure 10.6 that the G+0.9% scenario provides the greatest benefit to the community. The balance of an initial investment of $33 million will exceed $12 billion by the year 2100. All alternative scenarios are shown to produce greater economic benefits than the base scenario. Similar to the results of the second investment case for the Lower Hunter region the inclusion of cost savings from reduced water distribution infrastructure and economic efficiencies in the rainwater tank and pump industries in the analysis of the rainwater tank scenarios for the Central Coast region provides greater benefits than the first investment case.

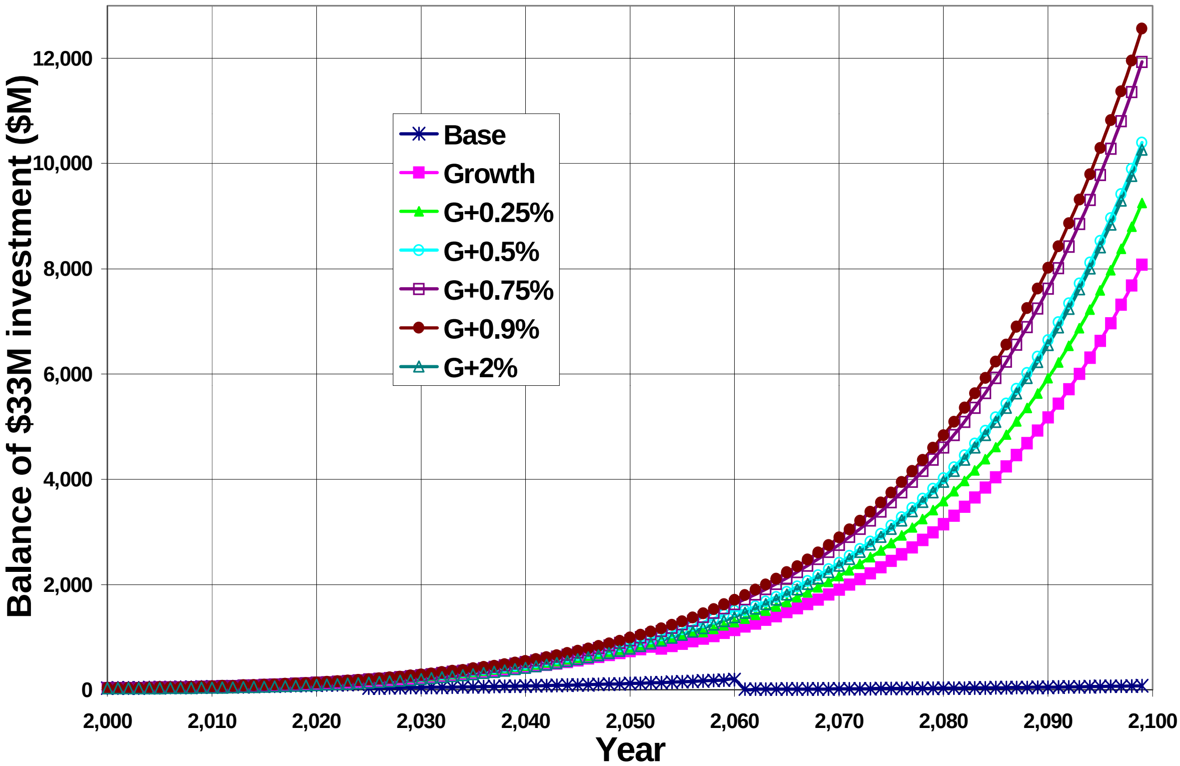

Figure 10.6: Results of the annual equivalence analysis for the Central Coast region using the second investment case.

The present equivalence analysis (Table 10.4) shows the initial investment and the comparative present benefit of each scenario. It shows that the base scenario requires capital investment to ensure viability of the strategy. However for the alternative scenarios capital investment is not required and surplus funds are available to the community.

Table 10.4: Results of the present equivalence analysis for the Central Coast region using the second investment case

Scenario	Investment in first year ($M)	Comparative benefit ($M)
Base	33	0
Growth	-31	64
G+0.25%	-40	73
G+0.5%	-50	83
G+0.75%	-62	95
G+0.9%	-67	100
G+2%	-48	81

In Table 10.4 it is shown that the G+0.9% scenario has the greatest comparative benefit of $100 million. Comparative benefits of the growth to G+2% scenarios range from $64 million to $100 million. All the alternative scenarios are shown to be more economically efficient than the base scenario and have considerably greater benefits that in the first investment scenario.

10.3 A Sensitivity Analysis

It has been shown in Section 10.2 that the widespread installation of rainwater tanks for water supply and stormwater management can produce considerable economic benefits for the community. The analysis assumed a real interest rate of 5%. The real interest rate is dependant on the economic status of a country and can vary widely. For example during 1999 the real interest rate in Australia was about 5%, while during 2001 the real interest rate plunged to 2%. Changes in interest rates may significantly alter the results of the investment analysis for the installation of rainwater tanks. The first investment case for the Lower Hunter and Central Coast regions is evaluated using real interest rates of 2% and 8% in Cases A and C respectively to determine the impact on the economic benefits derived from the installation of rainwater tanks. Case B shows the 5% interest rate analysis for the first investment case evaluated in Section 10.2.

In Section 10.2 it was also assumed that the installation of rainwater tanks in redevelopments of dwellings would reduce the requirement for stormwater infrastructure thereby decreasing construction, maintenance and replacement costs of stormwater infrastructure. Use of rainwater tanks in the redevelopment of dwellings (scenarios G+0.25% to G+3%) may not produce stormwater infrastructure savings, though this is considered unlikely given the results in this thesis. The first investment case is evaluated using the assumption that there are no stormwater infrastructure savings resulting from the installation of rainwater tanks in the redevelopment of dwellings in Case D.

The first investment case in Section 10.2 used the construction cost saving of $959 per dwelling from the Figtree Place experiment (Chapter 2) for all new and redeveloped dwellings (Growth to G+0.9% scenarios). In the analysis of a land subdivision in Chapter 7 it was found that the minimum construction cost saving on the provision of stormwater infrastructure was $218 for the use of 10 kL rainwater tanks. In Section 10.2 the maximum replacement and depreciation cost saving from Chapter 7 of $23.45 for a 10 kL tank was used in the first investment case. In Chapter 7 analysis of the land subdivision revealed that the minimum replacement and depreciation cost saving for stormwater infrastructure was $10.87 for 10 kL rainwater tanks. The reduced construction, replacement and maintenance cost savings for stormwater infrastructure resulting from the use of rainwater tanks will impact on the significance of the benefits accruing to the community. In Case E construction cost savings of $218 and replacement and maintenance cost savings of $10.87 are used in the first investment case. The results of the analysis for the Lower Hunter region are shown in Table 10.5

Table 10.5: Results of the present equivalence analysis for the Lower Hunter region using a sensitivity analysis

Case	Investment in first year ($M) for each investment scenario							
	Base	Growth	G+0.25	G+0.5	G+0.75	G+0.9	G+2	G+3
A	47	-141	-162	-194	-228	-247	-161	-43
B	15	-44	-45	-52	-59	-63	-22	27
C	5	-21	-19	-20	-21	-22	9	41
D	15	-44	-33	-28	-23	-19	22	71
E	15	-22	-14	-13	-12	-11	30	79

In Table 10.5 it is shown that the use of different real interest rates significantly alters the magnitude of community benefits from the installation of rainwater tanks. Lower real interest rates increase the magnitude of the benefits and higher real interest rates decrease the benefits. In Case A all alternative scenarios show greater economic benefits to the community than the traditional base scenario. The greater economic benefits for the lower real interest rate case (Case A) result from the increased funds required to maintain the viability of the base scenario in a low interest rate environment. In Case C the scenarios Growth to G+2% still provide greater economic benefits to the community than the traditional base scenario although the magnitude of the benefits are decreased due to the lower investment required to maintain the viability of the traditional base scenario.

In Case D the assumption that the installation of rainwater tanks in the redevelopment of dwellings will not produce stormwater infrastructure savings reduces the economic benefits of the G+0.25% to G+0.9% scenarios although these scenarios still produce greater economic benefits to the community than the traditional base scenario. In Case E the use of reduced cost savings for the provision of stormwater infrastructure resulting from the use of rainwater tanks has decreased the benefits of the alternative scenarios although the Growth to G+0.9% scenarios still provide greater economic benefits to the community than the traditional base scenario. However caution is urged in consideration of Case D because the minimum savings were derived from for sandy soil (Chapter 7) where reductions in the requirement for stormwater pipes and water quality infrastructure, and the use of rainwater tanks were only considered. The use of infiltration measures and grass swales in combination with the rainwater tanks may eliminate the requirement for kerb and guttering, and stormwater pipes in streets resulting in cost savings of up to $2,000 per dwelling (Section 7.5.4). Indeed the use of infiltration measures and grassed swales in the Casuarina Beach development at Tweed Heads in New South Wales provided a cost saving of over $10,000 per dwelling in road and stormwater infrastructure [G. Tamblyn, Cardno MBK, Queensland, personal communication, 2001].

The results of the analysis for the Central Coast region are shown in Table 10.6. Similar to the Lower Hunter region, it is shown that the use of different real interest rates significantly alters the magnitude of community benefits from the installation of rainwater tanks. Case A shows that the use of a real interest rate of 2% significantly increased the benefits accruing to the community from the installation of rainwater tanks and all of the alternative scenarios provide greater economic benefits to the community than the traditional base scenario. In Case C the use of a real interest rate of 8% is shown to decrease the magnitude of the benefits from the installation of rainwater tanks. However the Growth to G+0.9% scenarios still provided greater economic benefits to the community than the traditional base scenario.

Table 10.6: Results of the present equivalence analysis for the Central Coast region using a sensitivity analysis

Scenario	**Investment in first year ($M) for each investment scenario**						
	Base	**Growth**	**G+0.25**	**G+0.5**	**G+0.75**	**G+0.9**	**G+2**
A	105	-29	-46	-61	-97	-105	-25
B	33	-3	-5	-7	-13	-14	22
C	13	4	5	5	5	5	30
D	33	-3	3	9	13	17	52
E	33	22	25	28	29	32	67

The assumption that the installation of rainwater tanks in the redevelopment of dwellings will not produce stormwater infrastructure savings is shown in Case D to reduce the economic benefits of the G+0.25% to G+0.9% scenarios. However the Growth to G+0.9% scenarios still produce greater economic benefits to the community than the traditional base scenario. In Case E the use of reduced cost savings for the provision of stormwater infrastructure resulting from the use of rainwater tanks has further decreased the benefits of the alternative scenarios although the alternative scenarios Growth to G+0.9% still show greater benefits than the traditional base scenario.

The economic benefits accruing to the community from the installation of rainwater tanks are dependent on the price of mains water and the cost to augment water supply headworks systems in different regions. Installation of rainwater tanks in the Lower Hunter region provided greater benefits to the community than in the Central Coast region because the price of mains water and the cost to augment the first stage of the water supply headworks system are greater in the Lower Hunter region.

The economic benefits that accrue to the community from the installation of rainwater tanks are sensitive to the value of real interest rates. Low real interest rates produce greater economic benefits and high real interest rates produce decreased economic benefits although it is noted that the long-term nature of an investment strategy for the installation of rainwater tanks will subject the strategy to a wide variety of real interest rates. Indeed it is unlikely that real interest rates will be either consistently high or low during the investment period. Therefore the selection of an average real interest rate or a historical time series of real interest rates may be acceptable. The magnitude of economic benefits derived from the installation of rainwater tanks is also dependent on the value of stormwater savings resulting from the use of rainwater tanks.

For the majority of alternative scenarios in the sensitivity analysis the installation of rainwater tanks was seen to provide greater economic benefits to the community than the traditional base scenario. This is a promising result given that the economic analysis did not evaluate the environmental benefits, and ignored any benefits arising from the reduced requirement for water supply distribution and treatment infrastructure.

10.4 Summary

This Chapter described the development of a community-based investment model that allows economic comparisons between a traditional base scenario and alternative scenarios that include rainwater tanks. The base scenario assumes further exploitation of rivers to meet growth in urban water demand and additional pipe drainage systems to manage increasing stormwater runoff.

In the investment model each alternative scenario starts with enough funds to ensure economic viability of the base scenario. Each year expenses are deducted, income is added and interest is earned on the balance. The analysis considers comparative costs and benefits using the base scenario as the reference. The investment model includes costs and benefits that differ from the traditional base scenario. The financial balances from each scenario in any year are compared to provide an annual equivalence. The initial investments required to just achieve a surplus financial balance at the end of the investment period in each scenario provide a present equivalence.

Two investment cases were evaluated for the Lower Hunter and Central Coast regions. In each investment case the scenarios for different rates of installation of rainwater tanks were used from Chapters 8, 9 and 10. The regional water demands (Chapter 8) and delays in requirement for augmentation of water supply headworks infrastructure for each scenario (Chapter 9) were used in the investment analysis.

The first investment case used the results from the thesis to analyse the economic efficiency of different rates of installation of rainwater tanks in the Lower Hunter and Central Coast regions. The reduced requirement for stormwater infrastructure leading to construction, depreciation and maintenance cost savings that result from the installation of rainwater tanks (Chapters 2 and 7) is used in the analysis. The installation, operation, maintenance and replacement costs of the rainwater tank systems (Chapters 3 and 7) have also been included in the analysis.

The scenario that includes rainwater tanks for all new dwellings and for all redeveloped dwellings (G+0.9%) was shown to be the most economically efficient for the Lower Hunter region with present value savings ranging from $37 million to $78 million. The use of rainwater tanks for all new dwellings and 0.9% of existing dwellings per year (G+0.9%) was the most economically efficient solution for the Central Coast region with present value savings ranging from $11 million to $47 million. The economic benefits to the community are derived from mains water savings, construction and depreciation savings resulting from a reduced requirement for stormwater infrastructure and interest earned on community savings due to the deferral of new water supply dams. All scenarios that involved installing rainwater tanks to new or redeveloped dwellings showed considerable additional economic benefits to the community. This is caused by the reduced requirement for stormwater infrastructure leading to construction, depreciation and maintenance cost savings that results from the installation of rainwater tanks to new or redeveloped dwellings.

The second investment case makes some additional assumptions. It is assumed that the installation of rainwater tanks to new and redeveloped dwellings will reduce the requirement for new water distribution infrastructure resulting in cost savings. The creation of a considerable growth in the market place for rainwater tanks and pumps is assumed to create economies of scale and increase competition between firms resulting in lower costs. The scenario that includes rainwater tanks for all new dwellings and for all redeveloped dwellings (G+0.9%) was shown to be the most economically efficient for the Lower Hunter and Central Coast regions. All of the alternative investment scenarios that include rainwater tanks were shown to provide considerable benefits to the Lower Hunter region of $139 million to $83 million and to Central Coast region of $100 million to $64 million and to be more economically efficient than the traditional base scenario.

The economic benefits of the use of rainwater tanks vary with the price of mains water and the cost to augment the mains water supply headworks system. A sensitivity analysis that varied real interest rates and the magnitude of stormwater savings resulting from the use of rainwater tanks showed that the magnitude of the economic benefits accruing from the use of rainwater tanks was dependent on real interest rates and the value of stormwater savings that result from the use of rainwater tanks. Nonetheless it was shown that the use of rainwater tanks provided greater economic benefits to the community than the traditional water supply and stormwater management options in the majority of cases considered.

However, these findings need to be tempered by the limitations of the study. This study has not valued the environmental benefit associated with delaying the construction of dams to augment water supply and from reduced stormwater discharges to the receiving environment, and the cost savings from a reduced requirement for water distribution and treatment infrastructure. Moreover, the construction and lifecycle costs of alternative scenarios have only been assessed, albeit conservatively, using data from a small number of case studies and demonstration sites. Therefore, the benefits of the alternative approaches that include rainwater tanks have most likely been understated for the Lower Hunter and Central Coast regions.