Summary of Alternative Water Supply Efficiency Measures: Stormwater modelling study

Report for Department for Environment & Water

DesignFlow

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1 Summary

This project modelled the availability of stormwater to support the expansion of existing Managed Aquifer Recharge (MAR) projects to increase alternative water supplies and reduce reliance on diversions of Murray River water for Adelaide's water supply. The modelling supports a wider project that investigates opportunities to return Murray River water to the system for environmental purposes, called the "Alternative Water Supply Efficiency Measures" (AWSEM) project.

This report summarises modelling that predicts yields of existing schemes, taking into account recent operational data, and then assesses stormwater availability to expand the yields from selected stormwater harvesting schemes.

A complementary project in AWSEM (Tonkin, 2019) identified five stormwater managed aquifer recharge (MAR) projects to potentially expand stormwater harvesting (which were later reduced to three feasible schemes, however, five are considered in this modelling).

Modelling performed for this project suggests there is sufficient long-term reliable stormwater supply to support these initiatives with potential to contribute an additional 1.6 GL – 2.0 GL per year of mains water offsets.

The modelling suggests the long-term yields for the expanded schemes are considered reliable. Climate change and urban infill scenarios for mid-century were also modelled and suggest a possible yield reduction of 5-10% by mid-century.

A summary of the overall stormwater harvest for existing schemes and for the existing with expanded use are shown in Figure 1 for typical (i.e. long term average) and wet years (~95 %ile). It shows that existing schemes across Adelaide harvest between 6-8 GL per year and this is predicted to increase to 7.5 – 10 GL per year if the expanded schemes are implemented and operational issues are addressed at two schemes in the City of Salisbury.

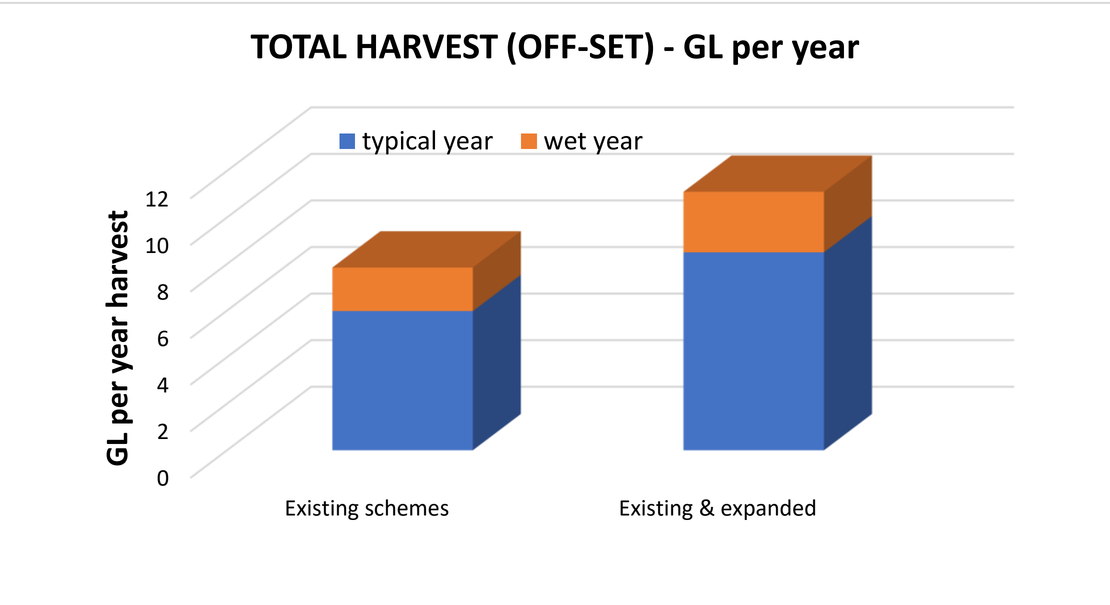

Figure 1 Summary of overall yields for existing and expanded schemes

Contents

2 Introduction

This report describes modelling performed to assess stormwater harvesting yields in the Adelaide region. The modelling supports a wider project that investigates opportunities to return Murray River water to the system for environmental purposes, called the "Alternative Water Supply Efficiency Measures" (AWSEM) project. The AWSEM project considers both stormwater and wastewater for possible use, whereas this study focusses on stormwater projects.

Most stormwater harvesting schemes in Adelaide use aquifers for storage, termed managed aquifer recharge (MAR) schemes. MAR schemes have been operational in Adelaide for 30 years.

There have a been a wide range of estimates of potential yields that stormwater harvesting can achieve. Documented harvest results from recent years suggest actual harvests are less than previous estimates. A focus of the current study is to model existing schemes as they operate and use this model to predict what harvests are possible by expanding select schemes.

This study complements other components of AWSEM by quantifying what realistic stormwater harvesting yields can be achieved for existing and nominated schemes identified by Tonkin (2020b).

2.1 Approach to the study

This study follows a process of:

1. Modelling existing schemes in reflection of current operations
2. Model potential expansion to select existing schemes (i.e. confirming that sufficient stormwater is available for the nominated harvests).

Importantly, this study does not attempt to predict stormwater harvesting potential that could be achieved if each scheme was optimised and operational flaws addressed. This study is more reflective of current operation including issues that affect yields. It is a 'warts and all' estimation of yields possible.

3 Performance of existing schemes

There are approximately 40 stormwater harvesting schemes operating in the Adelaide region. A summary of these are covered in Kretschmer (2017). In addition to the operating schemes, there are also several that have been abandoned for various reasons.

Collectively these schemes are reported to harvest between 5.5 - 8.5 GL per year (Tonkin, 2019). This is well below quoted design yields of round 17 GL per year.

Reasons for the less than design yields are various and include issues such as:

- Less infrastructure constructed compared to design plans (e.g. less bores than designed)
- Poor water quality in the feed water resulting in frequent shut-down
- Less than anticipated runoff resulting in fewer harvesting opportunities
- Failure of water quality improvement devices (mechanical or vegetated systems)
- Underperformance of bores (i.e. low yields)
- Less demand than anticipated.

It is not the role of this study to diagnose exactly where schemes could improve performance. It is noted that for many schemes there is work being done to improve the current harvesting volumes by addressing some of the issues that are resulting in lower than predicted harvests.

It is also worth noting that the umbrella study that estimated 'total stormwater yields' possible across Adelaide (i.e. Wallbridge and Gilbert et al., 2009) considered the total amount of stormwater that could be diverted, treated and injected to aquifers. Notably, it did not consider extraction and reuse operations. This resulted in the assumption of a 12-month harvesting operation which does not reflect the way most MAR schemes are operated (i.e. they are typically operated using winter and spring for injection and summer and autumn for extraction). This resulted in an overestimate (by possibly 30%) of yields compared to scheme that just harvest during winter and spring.

4 Existing scheme modelling

4.1 Purpose of the modelling

The purpose of the current modelling is to replicate the effectiveness of the current schemes and then use the calibrated model to explore if there is sufficient stormwater supply for proposed scheme expansions (Section 5).

The main difference with earlier models is to only assume a harvesting season from May to October. Most schemes use bore for extraction (to supply irrigation) from November to April and therefore the bores are not available to inject harvested stormwater. The modelling here better reflects the current operation of MAR schemes.

The modelling approach is described in Appendix A

4.2 Existing scheme yields

Table 1 lists the current operational schemes across Adelaide, the catchment they are in, the owner and the source water. It also shows the outcomes of the modelling for existing schemes including the total flow at the harvest location compared to what is harvested. It also shows the range of quoted harvests from operators. The results show a good comparison between modelled harvest values and the quoted values showing a total harvest of between 6 GL/year and 8 GL/ year for typical and wet years. The "Typical" year represents the long-term average and the "wet" year relates to approximately the 95%ile from historical records (i.e. the wettest 5% of years).

Note that Adam Creek catchment schemes are not currently operating because of a current water quality issue.

A summary of the yields from existing schemes by their catchment total is shown in Figure 2 compared to the quoted yields, for a typical (long term harvest) and wet year (95%ile) in Figure 3 and individual scheme harvests are presented in Figure 4.

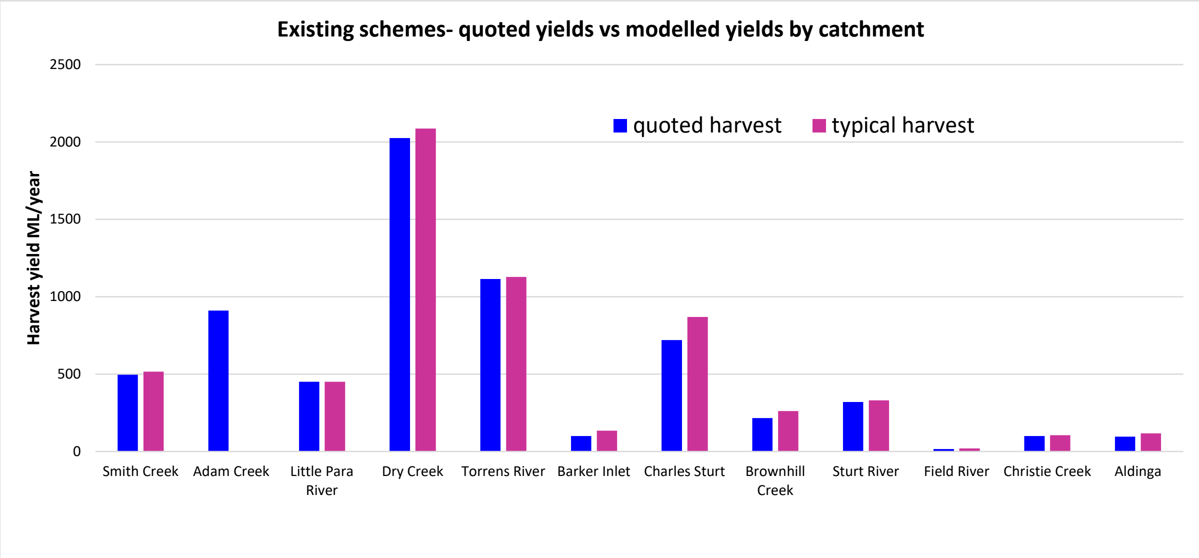

Figure 2 Existing schemes with quoted yields and modelled yield by catchment

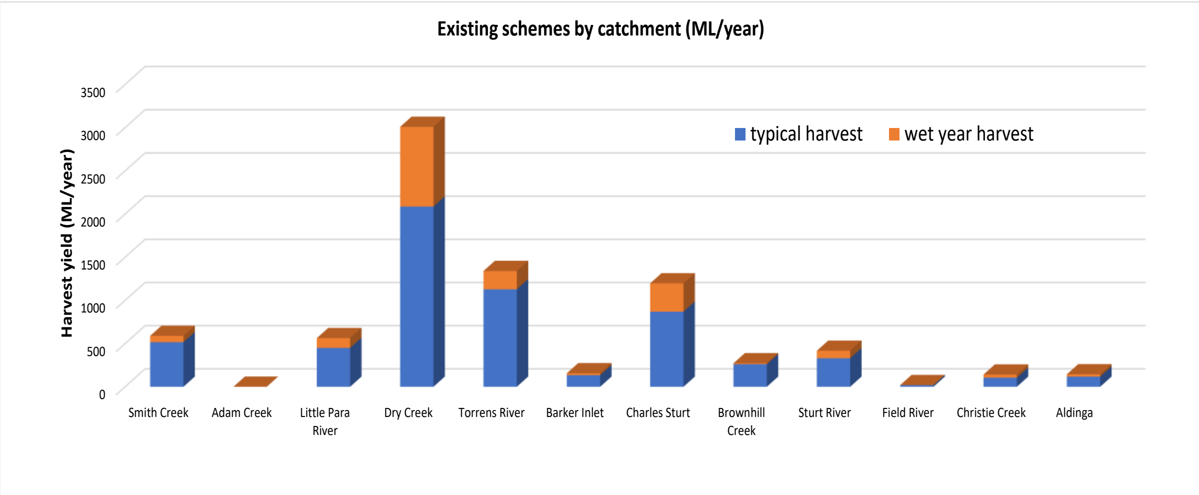

Figure 3 Existing schemes modelled yields by catchment

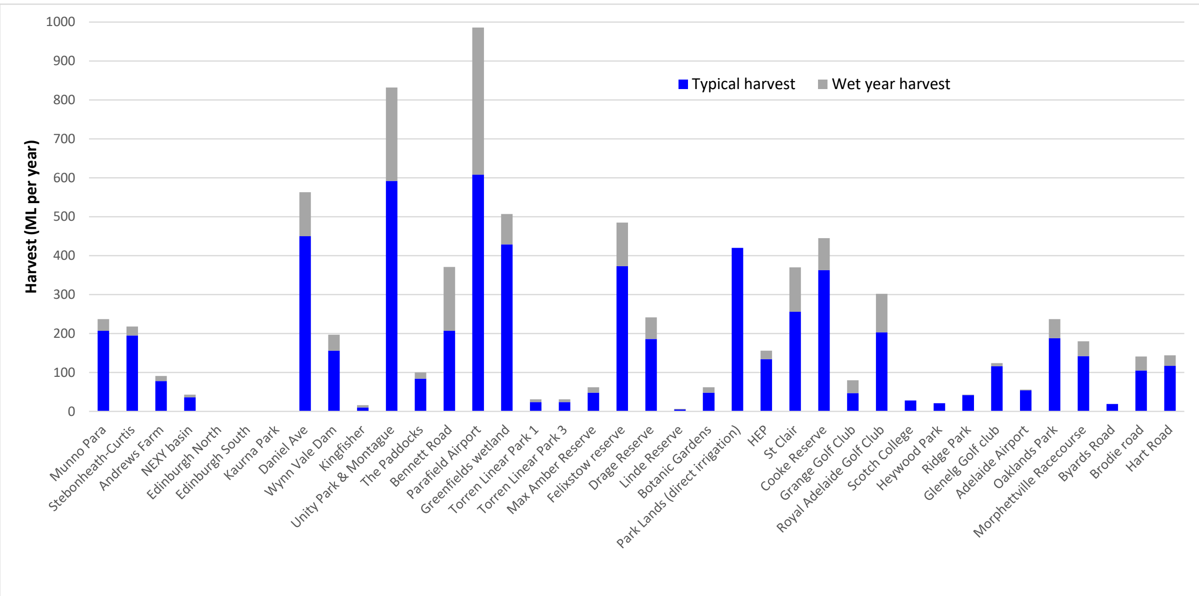

Figure 4 Modelled existing scheme harvests for typical and wet years

Table 1 Summary of modelled existing schemes

EXISTING SCHEMES										
CATCHMENT	EXISTING SCHEME	OWNER	SOURCE	DESIGN RANGE [1] ML/YEAR	QUOTED TYPICAL YIELD [2] ML/YEAR	MODELLED YIELD ML/YEAR	TOTAL RUNOFF[3] ML/YEAR	MODELLED WET YEAR ML/YEAR	TOTAL RUNOFF (wet year) ML/YEAR	COMMENTS
Smith Creek	Munno Para	City of Playford	Smith Creek	200-500	200	**207**	1,220	**237**	2,280	
	Stebonheath-Curtis	City of Playford	Smith Creek	100-300	180	**195**	1,010	**218**	2,180	
	Andrews Farm	City of Playford	Smith Creek	50-200	75	**78**	827	**91**	1,640	turbidity constraints
	NEXY basin	City of Playford	Smith Creek	200-500	40	**36**	530	**43**	1,044	sediment issues causing low yeild
Adam Creek	Edinburgh North	City of Salisbury	Stormwater	N/A	0	**0**	2,980	**0**	5,140	partially constructed
	Edinburgh South	City of Salisbury	Adam Creek	400-1,200	530	**0**	3,620	**0**	5,300	operational issues
	Kaurna Park	City of Salisbury	Adam Creek	400-830	380	**0**	3,700	**0**	5,450	operational issues
Little Para River	Daniel Ave	City of Salisbury	Little Para River	450-1,300	450	**450**	2,310	**563**	4,020	
Dry Creek	Wynn Vale Dam	City of Tea Tree Gully	Stormwater	30-150	155	**156**	749	**197**	1,390	(Wynn Vale dam, Park Lake Dr, Banksia & Tilley)
	Kingfisher	City of Tea Tree Gully	Stormwater	10-30	10	**10**	569	**16**	1,090	
	Unity Park & Montague	City of Salisbury	Dry Creek	550-1,200	610	**592**	4,790	**832**	8,020	Harvest at Unity Park, inject at Unity & Montague
	The Paddocks	City of Salisbury	Stormwater	50-100	50	**84**	778	**100**	1,240	
	Bennett Road	City of Salisbury	Stormwater	100-300	200	**207**	1,730	**371**	2,830	
	Parafield Airport	City of Salisbury	Stormwater	600-1,300	600	**608**	1,492	**986**	2,490	ASR & ASTR wells
	Greenfields wetland	City of Salisbury	Dry Creek	200-500	400	**429**	8,230	**507**	13,600	
Torrens River	Torren Linear Park 1	City of Tea Tree Gully	Torrens River	10-30	14	**24**	8,740	**31**	17,200	
	Torren Linear Park 3	City of Tea Tree Gully	Torrens River	10-25	11	**24**	6,260	**31**	13,200	
	Max Amber Reserve	Campbelltown City Council	Fifth Creek	30-50	12	**48**	1,170	**62**	2,410	(Torrens Valley Sports Fields)
	Felixstow reserve	ERA Water	Fourth Creek	100-500	-	**373**	2,350	**485**	5,430	Injected elsewhere
	Drage Reserve	ERA Water	Third Creek	100-500	-	**186**	2,000	**242**	3,610	Injected elsewhere
	Linde Reserve	Norwood, Payneham & St Peters	Second Creek	5-20	8	**5**	1,270	**7**	2,050	
	Botanic Gardens	Adelaide Botanic Gradens	First Creek	100-200	50	**48**	1,970	**62**	3,830	
	Park Lands (direct irrigation)	Adelaide City Council	Torrens River	420	420	**420**	18,000	**420**	34,600	used to irrigate the park lands through the city
Barker Inlet	HEP	SA Water	Stormwater	100-450	100	**134**	1,200	**156**	1,950	
Charles Sturt	St Clair	City of Charles Sturt	Stormwater/ Torrens	300-1,300	250	**256**	895	**370**	1,455	
	Cooke Reserve	City of Charles Sturt	Stormwater/ Torrens	300-1,100	320	**363**	986	**445**	1,566	(Includes Westlakes Golf Club)
	Grange Golf Club	Grange Golf Club	Stormwater	50-200	50	**47**	175	**80**	284	
	Royal Adelaide Golf Club	Royal Adelaide Golf Club	Stormwater	100-320	100	**203**	274	**302**	443	
Brownhill Creek	Scotch College	Scotch College	Brownhill Creek	10-50	-	**28**	2,010	**28**	4,230	
	Heywood Park	City of Unley	Brownhill Creek	10-35	10	**21**	2,820	**21**	5,620	
	Ridge Park	City of Unley	Stormwater	10-60	15	**42**	137	**43**	267	
	Glenelg Golf club	Glenelg Golf club	Brownhill Creek	100-300	100	**116**	6,430	**124**	11,600	
	Adelaide Airport	SA Water	Brownhill Creek	100-350	60	**54**	6,320	**56**	11,450	
Sturt River	Oaklands Park	City of Marion	Sturt River	100-400	170	**188**	5,920	**237**	11,600	
	Morphettville Racecourse	SA Jockey Club	Sturt River	100-640	150	**142**	490	**180**	802	
Field River	Byards Road	City of Onkaparinga	Stormwater	800	15	**19**	532	**19**	983	operation issues with filtration and wells
Christie Creek	Brodie road	City of Onkaparinga	Christie Creek	670	-	**105**	1,840	**141**	3,400	Dams for storage
Aldinga	Hart Road	City of Onkaparinga	Stormwater	155	95	**117**	329	**144**	592	
TOTAL						**6,015**		**7,847**		

[1] design values quoted from Kretschmer, 2017 & Tonkin, 2019

[2] on the baiss of interviews with operators (Tonkin, 2019)

[3] total runoff that flows to the harvest location (includes channel losses upstream)

5 Modelling select 'expanded' schemes

Tonkin (2019) summarise a list of proposals to expand existing MAR schemes that were derived from a working group of scheme operators. These have been simulated in the calibrated model to investigate whether there is sufficient runoff from the source catchments to support the anticipated yields.

The 'expanded' schemes were developed through consideration of the expected demands for alternative water to meet urban irrigation demands (as summarised in Tonkin, 2020a).The schemes were added to the model of existing schemes to account for extraction to support current operations.

The expanded schemes are:

- NEXY basin – City of Playford – increase existing treatment capability, new bores and transfer flow to Gawler (Bunyip Water)
- Edinburgh Park South and Kaurna Park – City of Salisbury – resolve the current water quality issue and resume operations
- Edinburgh Park North – City of Salisbury – add a treatment system to an existing basin as well as new bores to supply an industrial customer
- St Clair and Cooke Reserve – City of Charles Sturt – expansion to the current bore and distribution network to supply sites in the City of Port Adelaide Enfield
- Oaklands Park – City of Marion – expansion to the current bore and distribution network to supply sites in schools, council reserves and Flinders University.

Details of each scheme is briefly described in Appendix B and refer to Tonkin (2019) for more discussion.

The expanded scheme modelling also assumes that Edinburgh Parks South and Kaurna Park are operational (i.e. they have addressed the water quality issues in the medium term).

5.1 Predicted expanded scheme yields

The expanded schemes were added to the catchment models and the results are shown in Table 2 for both a typical and wet year.

It shows that these initiatives could achieve a total harvest of between 8.5 GL and 11 GL per year (an additional 2.5 – 3.2 GL per year). Note that 900ML of the increase is by reinstating harvests at Edinburgh Park South and Kaurna Park.

The modelling suggests there is sufficient catchment runoff to supply each of the proposed expanded schemes. The table also shows the typical total annual runoff at the harvest locations. It shows that for the expanded schemes the proportion of the total runoff that is harvested ranges from 7% (Oaklands Park), 22% (Edinburgh Park North), 38% (Next basin) to 60% (St Clair and Cooke Reserve).

These percentages provide an insight into the long-term reliability of the schemes. While all the schemes are considered to be viable in terms of long-term catchment runoff, the schemes at Oaklands Park and Edinburgh Park North will have the greatest reliability because they target the lowest percentage of catchment runoff.

Table 2 Summary of model results for expanded schemes

CATCHMENT	SCHEME	EXISTING PREDICTED YILED	EXPANDED PREDICTED YIELD	TOTAL RUNOFF (typical year)	EXPANDED WET YEAR
		ML/YEAR	ML/YEAR	ML/YEAR	ML/YEAR
Smith Creek	Munno Para	207	207	*1,220*	237
	Stebonheath-Curtis	195	195	*1,010*	218
	Andrews Farm	78	78	*827*	91
	NEXY basin	**36**	**201**	***530***	**258**
Adam Creek	Edinburgh North	**0**	**664**	***2,980***	**908**
	Edinburgh South	**0**	**545**	***3,620***	**698**
	Kaurna Park	**0**	**372**	***3,700***	**467**
Little Para River	Daniel Ave	450	450	*2,310*	563
Dry Creek	Wynn Vale Dam	156	156	*749*	197
	Kingfisher	10	10	*569*	16
	Unity Park & Montague	592	592	*4,790*	783
	The Paddocks	84	84	*778*	100
	Bennett Road	207	207	*1,730*	371
	Parafield Airport	608	608	*1,492*	986
	Greenfields wetland	429	429	*8,230*	507
Torrens River	Torren Linear Park 1	24	24	*8,740*	31
	Torren Linear Park 3	24	24	*6,260*	31
	Max Amber Reserve	48	48	*1,170*	62
	Felixstow reserve	373	373	*2,350*	485
	Drage Reserve	186	186	*2,000*	242
	Linde Reserve	5	5	*1,270*	7
	Botanic Gardens	48	48	*1,970*	62
	Park Lands (direct irrigation)	420	420	*18,000*	420
Barker Inlet	HEP	134	134	*1,200*	156
Charles Sturt	St Clair	**256**	**681**	***895***	**879**
	Cooke Reserve	**363**	**477**	***986***	**654**
	Grange Golf Club	47	47	*175*	80
	Royal Adelaide Golf Club	203	203	*274*	302
Brownhill Creek	Scotch College	28	28	*2,010*	28
	Heywood Park	21	21	*2,820*	21
	Ridge Park	42	42	*137*	43
	Glenelg Golf club	116	116	*6,430*	124
	Adelaide Airport	54	54	*6,320*	56
Sturt River	Oaklands Park	**188**	**400**	***5,920***	**462**
	Morphettville Racecourse	142	142	*490*	180
Field River	Byards Road	19	19	*532*	19
Christie Creek	Brodie road	105	105	*1,840*	141
Aldinga	Hart Road	117	117	*329*	144
TOTAL			**8,500**		**11,000**

Expanded schemes

6 Climate and urban development variability

Climate change science predicts lower rainfall and more evaporation resulting in less runoff for potential harvest. Over a similar timeframe (e.g. mid-century), urban consolidation and urban expansion is expected to increase the amount of impervious areas in catchments creating more runoff from rainfall.

The impacts of these two factors on stormwater harvest yields are presented in this section for existing and expanded schemes. Assumptions made for modelling purposes are discussed in Appendix C.

6.1 Mid-century harvest predictions

The MUSIC models were used to predict the influence of changing climate and urban infill. The overall summary is shown in Figure 5. It shows that:

- current total yields of 8.5 GL per year
- mid-century current climate reduces yields to 7.7 GL per year (-10%)
- low urban consolidation (e.g. ~15% infill development) results in 7.9 GL per year (-7% on existing)
- high urban consolidation (e.g. ~30% infill development) results in 8.1 GL/year (-5% on existing).

Therefore, overall climate change is expected to reduce yield by 5-10% even with the influence of high imperviousness with urban consolidation.

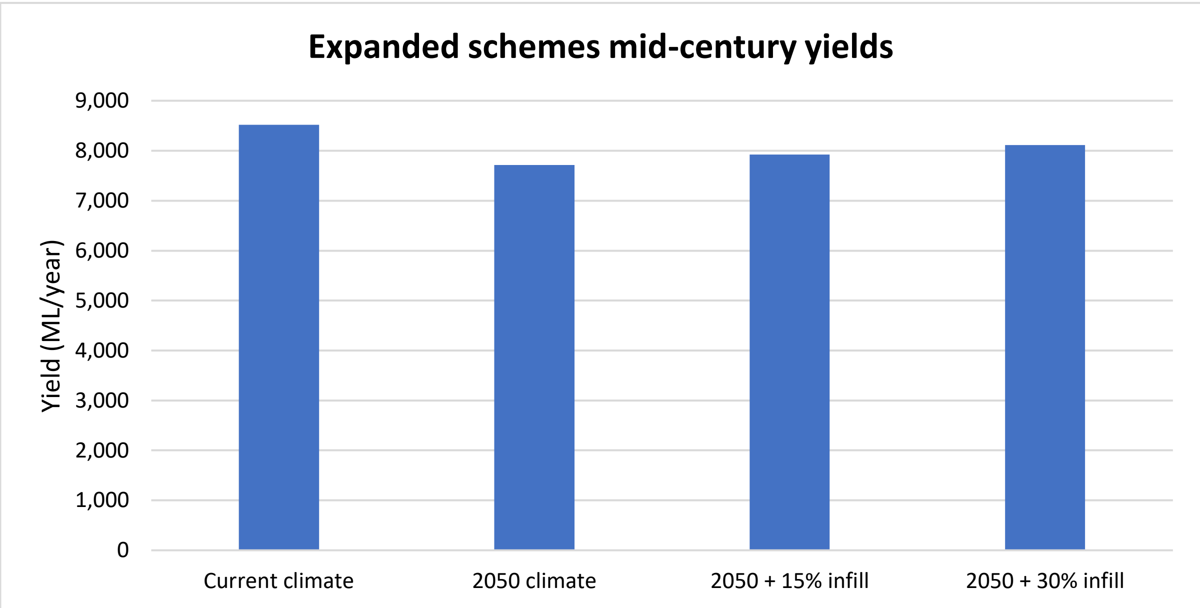

Figure 5 Overall yield changes with mid-century climate change predictions and two urban infill scenarios

Individual schemes are shown in Figure 6 and the respective figures are presented in a table in Appendix D. The variability of impacts between individual schemes shown in Figure 6 is reflective of differences in the percentage of urban to rural catchments (i.e. rural catchments have much lower runoff in future climate predictions and do not have increased imperviousness (and therefore runoff) from urban infill). Another factor is the percentage of the total catchment runoff a scheme is harvesting -the higher the percentage the more at risk of reduced yields with climate change.

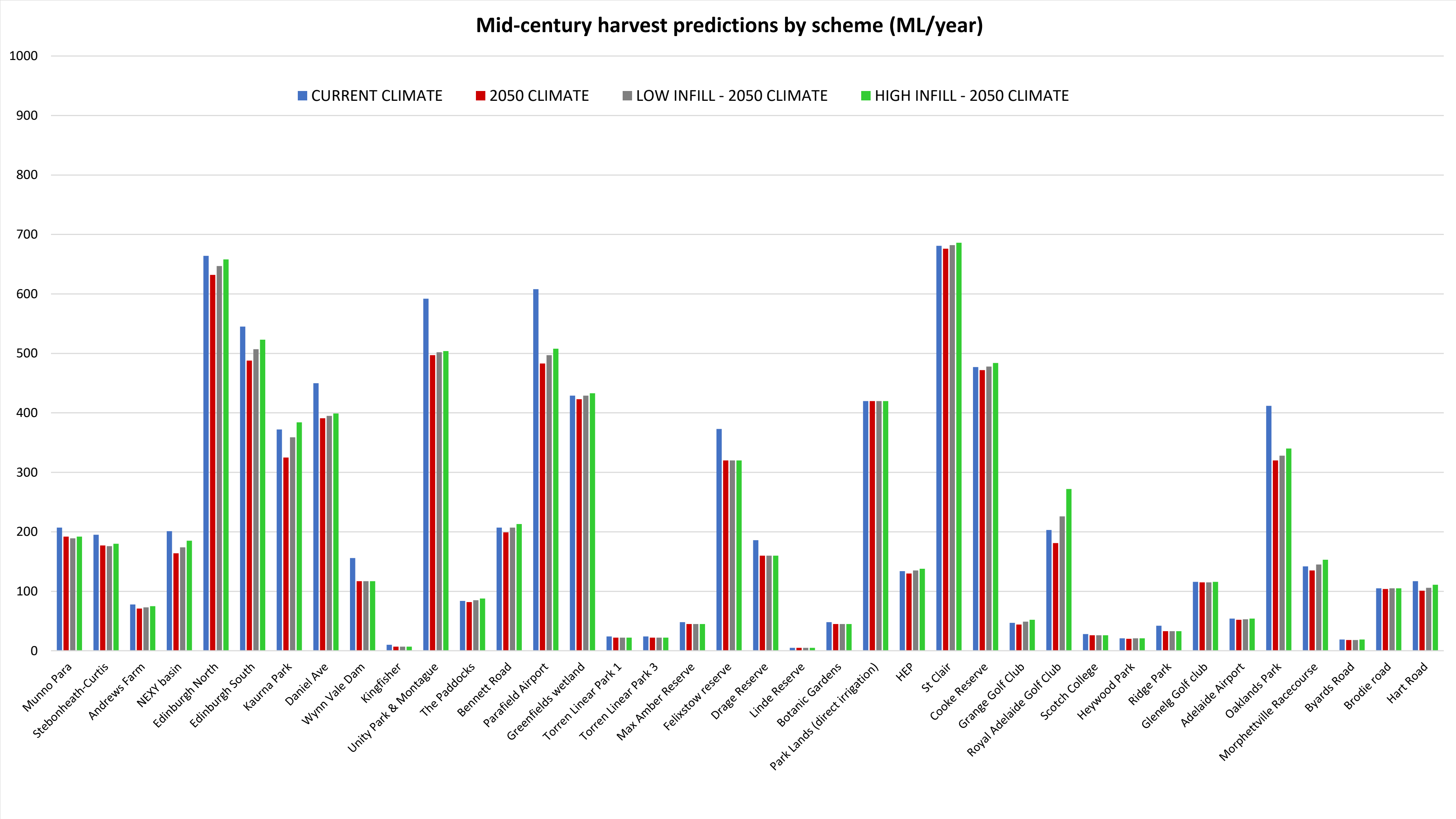

Figure 6 Mid-century harvest prediction with reduced rainfall and different urban infill scenarios.

7 Conclusions

The main conclusions from this study are:

1. Existing schemes are predicted to yield 6 – 8 GL per year without further system enhancement (i.e. without addressing existing operational issues)
2. Five proposed 'expanded' schemes could contribute a further 1.6 to 2.0 GL per year of harvest (with an additional 900-1,200ML if Edinburg Park South and Kaurna Park have water quality issues resolved) based on long term average yields
3. Predicted climate change would reduce stormwater harvests, however, urban infill (and resultant increase in impervious areas) partially off-set these reductions, resulting in an overall yield reduction to 5-10% by mid-century.

8 References

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Wallbridge and Gilbert, DesignFlow, Australian Groundwater Technologies & Richard Clark and Associates, 2009, *Urban Stormwater Harvesting Options Study*, prepared for the Stormwater Management Authority, Government of South Australia.

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9 Appendix A - Modelling approach

MUSIC (Model for Urban Stormwater Improvement Conceptualisation, see www.toolkit.net.au) was used to assess each of the harvesting and treatment options identified and their interaction on a catchment basis. A simple model was developed to simulate catchment hydrology so that the focus of the modelling could be on the harvesting and treatment processes and the interaction between different schemes given the tight timeframes for the project.

Parameters for urban and rural nodes for the models were calibrated against available gauging data and then catchment models were developed to cover the existing and proposed expanded schemes.

The catchments included areas where there are current MAR schemes operating in the Adelaide region, they are:

- Smith Creek
- Adam Creek
- Little Para River
- Dry Creek
- Torrens River
- Barker Inlet
- Charles Sturt (Torrens and Ports Road plus two golf courses)
- Brownhill Creek
- Sturt River
- Field River
- Christie Creek
- Aldinga (one scheme at Hart Road).

Calibrated models were then used to simulate harvesting for the existing schemes taking into account the infrastructure installed and operational issues.

9.1 Calibration

Gauging stations along the main watercourses were reviewed to allow calibration of the hydrological model to historical flow data. Flow data were derived from www.waterconnect.sa.gov.au.

For the purposes of this study, median flow data were selected for the calibration process. These data are considered to be a representative flow volume to assess potential harvesting quantities. Median flow data also avoid a skewed average flow (mean) in regulated catchments (e.g. Torrens River) where several large rainfall years and where reservoirs spill can skew the average flows. The harvesting model therefore only considered catchment areas downstream of the reservoirs in the Torrens and Little Para catchments. This approach is the same calibration approach as taken in earlier studies (e.g. Wallbridge and Gilbert et al., 2009).

A summary of catchment volumetric runoff coefficients from gauged data as well as simulated flow in MUSIC are shown in Figure 7. It shows relatively good correlation between the gauged and simulated runoff.

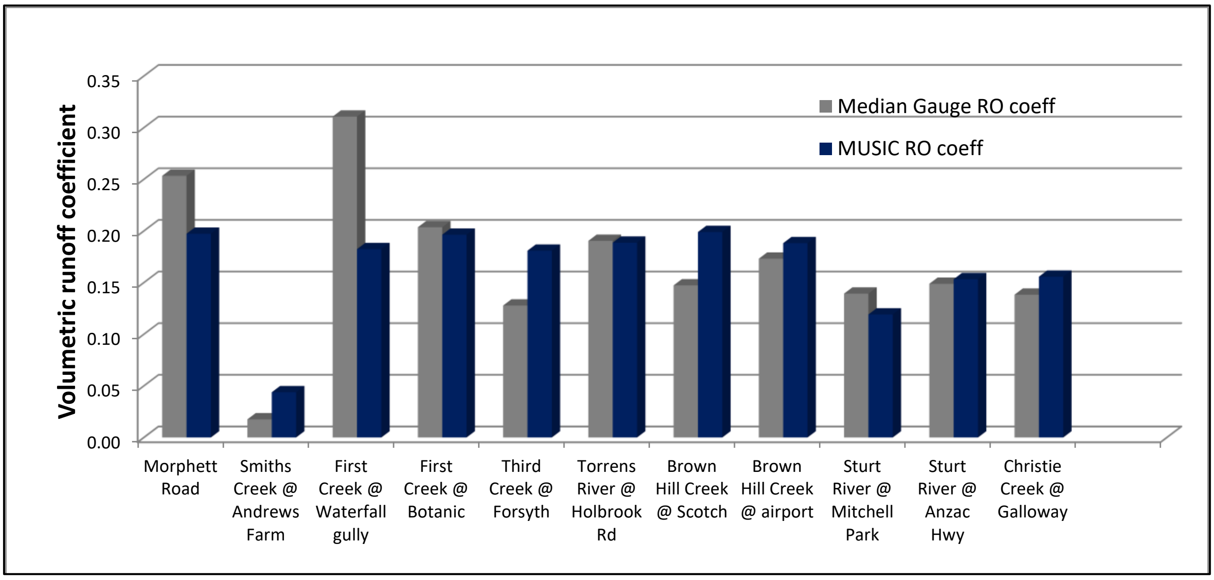

Figure 7 Runoff coefficients gauged and modelled compared for calibration

To generate flows in the simplified hydrological model one set of rainfall data were selected to simulate runoff in the catchments. Following a considerable search and testing, the Bureau of Meteorology Kent Town (Station number 023090) was selected as the rainfall file. 32 years (1977 – 2009) of six-minute rainfall data were obtained for the modelling process. The average annual rainfall during this period is 544 mm per year. While this is a simplified approach to modelling the catchments across a large area the calibration process provides sufficient confidence in the model outputs. The model is considered to be representative of a long-term average, including dry years. The model was also run using a 'wet' year where there is approximately 40% more rainfall to present results as a range of yields that could be expected (representing approximately a 95%ile year).

These rainfall models were then modified to account for predicted rainfall reduction because of climate change as described in Section 6.

9.2 Modelling scheme yields

Yields for existing schemes were simulated by developing catchment models to predict the amount of runoff draining to a scheme location. Catchments were divided according to where harvesting schemes are located and the mix of rural and urban areas. Infrastructure associated with each scheme was then inserted into the model, such as:

- diversion flow rates
- treatment or holding basin storages (areas and active depths)
- treatment and injection flow rates.

This approach simulates how much water could be diverted and treated and injected each year. These volumes were then reduced by assuming that the harvest season was from May to September (inclusive). This is in reflection that most schemes would be extracting water for irrigation during the months of October to April to service irrigation requirements.

An exception to this was ASTR (aquifer storage transfer and recovery) where some bores are dedicated for injection all year round.

The model uses a simplified approach to the treatment and injection rates by assuming the least of the two as the 'choke' in the system and modelling that flow rate.

Catchments with multiple schemes were modelled together to ensure that the influence of upstream harvesting schemes is captured in the predicted yields of schemes further downstream, Figure 8 shows an example of a model configuration (Dry Creek).

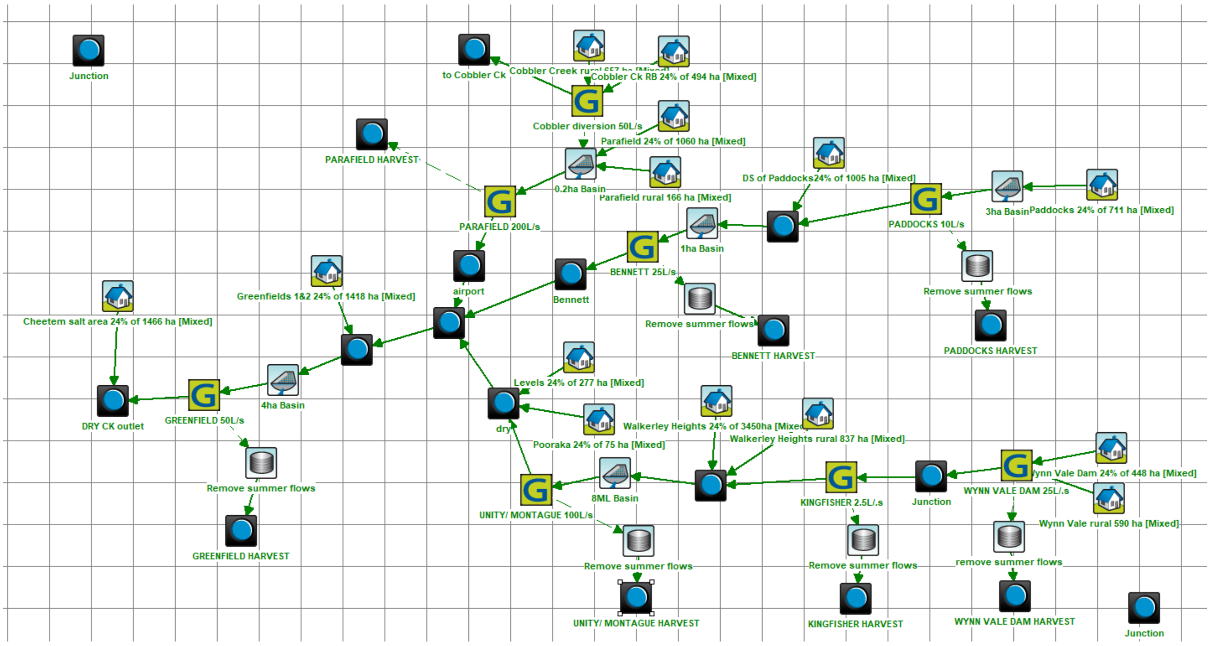

Figure 8 Example f the MUSIC catchment model configuration (Dry Creek catchment).

10 Appendix B - Expanded schemes

Proposed expanded schemes in Tonkin (2019 and 2020b) are described briefly below.

10.1 Smith Creek (NEXY Basin)

This scheme proposes to increase the treatment rate at an existing scheme site in the NEXY (Northern expressway) basin on Smith Creek. It is a large flood retardation basin and therefore storage does not limit yield, but the mechanical treatment system has limited flow capacity. It is located at the bottom of the catchment downstream of three other stormwater MAR schemes.

Treated water would be injected at the basin and then extracted to be transferred to the Gawler water reuse network by connecting to a pipe on Riverbanks Road.

It is anticipated this could be expanded to yield 200ML per year that could help meet demands. A treatment/ injection flow rate of 30L/s is estimated for modelling.

10.2 Adam Creek (Edinburgh Park North & South and Kaurna Park)

Two existing schemes in Adam Creek are currently suspended because of a water quality issue (Edinburgh Park South and Kaurna Park). For the purpose of this modelling it is assumed that the water quality issues are overcome and the schemes resume their ability to operate.

Another scheme in this catchment that was partially constructed is Edinburgh Park North. The current proposal by the City of Salisbury is to use the existing capture basin and implement water quality treatment and injection bores to supply an industrial customer nearby. It is estimated this demand would be approximately 700ML per year.

This scheme site upstream of both Edinburgh Park South and Kaurna park and therefore extraction may affect yields for those two schemes. A treatment/ injection flow rate of 40L/s for Edinburgh Park North is estimated for modelling.

10.3 Charles Sturt (St Clair and Cooke Reserve)

St Clair and Cooke Reserve (also incorporating Old Port Road and Westlakes Golf Club) are large treatment systems in the City of Charles Sturt. They each receive flow from local catchments as well as flow transferred from the Torrens River (at Bonython Park). The treatment systems themselves (wetlands and bioretention) are configured to treat more flow than they currently process.

Injection wells and demands for the MAR water are reported to limit the possible harvest for these schemes. The current proposal is to increase the injection rate (with new bores) and expand the demands by extending a supply pipe network into the City of Port Adelaide Enfield.

It is envisaged this expansion could increase yields by 500 ML per year. It is assumed additional injection rates of 60 L/s at each site.

10.4 Sturt River (Oaklands Park)

Oaklands Park wetland in the City of Marion was designed to treat more flows than it currently yields. The current system is limited by the number of injection bores as well as limited demand through its current supply network.

It is proposed to expand the demand for MAR supply by extending the supply network to schools, council reserves and Flinders University. It would also require an additional two or three bores to increase injection rates by 20-30L/s .

11 Appendix C – Future climate and urban consolidation modelling assumptions

11.1 Future climate

The impact of predicted climate change, particularly reduced rainfall, could have a significant effect on potential harvest volumes.

Historical climate is not necessarily a valid indicator of future climate, which may contain prolonged periods that are wetter or drier than the historical record used for this analysis. There is significant uncertainly surrounding how climate, and in particular, rainfall, will be impacted by various levels of greenhouse gas accumulation in the atmosphere. Rainfall has a much greater spatial variability than temperature and some areas are likely to become wetter whilst other areas become drier. Further to this there may be changes in the seasonality and intensity of rainfall.

To estimate changes in rainfall because of climate change, predictions for 2050 by the CSIRO have been adopted (see www.climatechangeinaustralia.gov.au). CSIRO predicts continuing reduced rainfall for the Adelaide region with a range of reductions for different seasons depending on emissions predictions. Rainfall reduction estimates below assume a level of 'medium' atmospheric emission for different seasons by mid-century.

- Summer = 5%
- Autumn = 2%
- Winter = 15%
- Spring =15%

These values result in an annual decrease in rainfall for the Adelaide region of approximately 10% using the historical rainfall file used in the modelling, which is considered to be representative of CSIRO predictions.

CSIRO also predict an increase (by 2-4%) in potential evapotranspiration for the Adelaide region by mid-century.

It is noted that there may also be a change in rainfall patterns as a result of climate change. There are, however, no firm predictions on which to base assumptions for the purpose of modelling the impact on harvesting schemes.

Historical rainfall and potential evapotranspiration records were modified with the above changes (to create a *2050 climate file*) and imported into the catchment MUSIC models. Each model set up (e.g. catchment areas, harvesting and treatment systems) were kept identical to the earlier modelling and only the climate files were changed. This allowed the direct impact of predicted climate change to be simulated.

The 2050 climate file scenarios were also used to simulate the impact of urban consolidation on yields.

11.2 Urban consolidation

Counteracting the impact of reduced rainfall on stormwater harvest volumes is an increase in urban densities.

The effect of urban consolidation will increase the proportion of impervious surfaces and therefore increase the proportion of rainfall that becomes runoff. This effect may offset the impact of climate change rainfall reduction on harvest yields.

It is difficult to estimate the amount of redevelopment and therefore proportion of urban impervious area increase. Therefore, a range of likely values are modelled in conjunction with the 2050 climate file. MUSIC models for each catchment were adjusted so that they use the 2050 climate file (i.e. rainfall and potential evapotransiration) and urban areas were modified to increase their percentage of impervious surfaces.

To estimate the proportional increase in impervious areas from consolidation the following assumptions were made:

- current directly connected impervious areas are 24% of urban area (directly connected refers to impervious areas that drain directly to the stormwater network and not onto pervious surfaces such as gardens) – this was estimated during the calibration process
- infill development will have a directly connected impervious areas that represent 60% of a development.

Using these assumptions, modelling was performed that represent an increase in impervious area by 5% (i.e. from 24 to 29% of urban area) – represented as LOW INFILL in Figure 6) and 10% (i.e. from 24 to 34%) represented as HIGH INFILL in Figure 6.

These increases in impervious area approximately are equivalent to approximately 15% (low infill) and 30% (high infill) of properties redeveloping. This is considered to capture the range of possible redevelopment scenarios by mid-century, particularly with a large focus of new development being in existing suburbs, as discussed in *The 30-year Plan for Greater Adelaide*.

12 Appendix D - Mid-century prediction for expanded schemes

CATCHMENT	SCHEME	CURRENT CLIMATE ML/year	2050 CLIMATE ML/year	LOW INFILL - 2050 CLIMATE ML/year	HIGH INFILL - 2050 CLIMATE ML/year
Smith Creek	Munno Para	207	192	189	192
	Stebonheath-Curtis	195	177	176	180
	Andrews Farm	78	71	73	75
	NEXY basin	201	164	174	185
Adam Creek	Edinburgh North	664	632	647	658
	Edinburgh South	545	488	507	523
	Kaurna Park	372	325	359	384
Little Para River	Daniel Ave	450	391	395	399
Dry Creek	Wynn Vale Dam	156	117	117	117
	Kingfisher	10	7	7	7
	Unity Park & Montague	592	497	502	504
	The Paddocks	84	82	85	88
	Bennett Road	207	199	207	213
	Parafield Airport	608	483	497	508
	Greenfields wetland	429	423	429	433
Torrens River	Torren Linear Park 1	24	22	22	22
	Torren Linear Park 3	24	22	22	22
	Max Amber Reserve	48	45	45	45
	Felixstow reserve	373	320	320	320
	Drage Reserve	186	160	160	160
	Linde Reserve	5	5	5	5
	Botanic Gardens	48	45	45	45
	Park Lands (direct irrigation)	420	420	420	420
Barker Inlet	HEP	134	130	135	138
Charles Sturt	St Clair	681	676	682	686
	Cooke Reserve	477	472	478	484
	Grange Golf Club	47	44	49	52
	Royal Adelaide Golf Club	203	181	226	272
Brownhill Creek	Scotch College	28	26	26	26
	Heywood Park	21	20	21	21
	Ridge Park	42	33	33	33
	Glenelg Golf club	116	115	115	116
	Adelaide Airport	54	52	53	54
Sturt River	Oaklands Park	412	320	328	340
	Morphettville Racecourse	142	135	145	153
Field River	Byards Road	19	18	18	19
Christie Creek	Brodie road	105	104	105	105
Aldinga	Hart Road	117	101	106	111
TOTAL		**8,524**	**7,714**	**7,923**	**8,115**
			-10%	**-7%**	**-5%**