This presentation premiered at WaterSmart Innovations

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Overview

- Scope
- Background
- Why a different approach is needed
- Suggested parameters
- Why it matters
- Examples
- Conclusion

Background

- immense public pressure
- need to diversify supplies
- significant scope
- capture water where it rains and where people live – rather than where the dams are (but no rain)

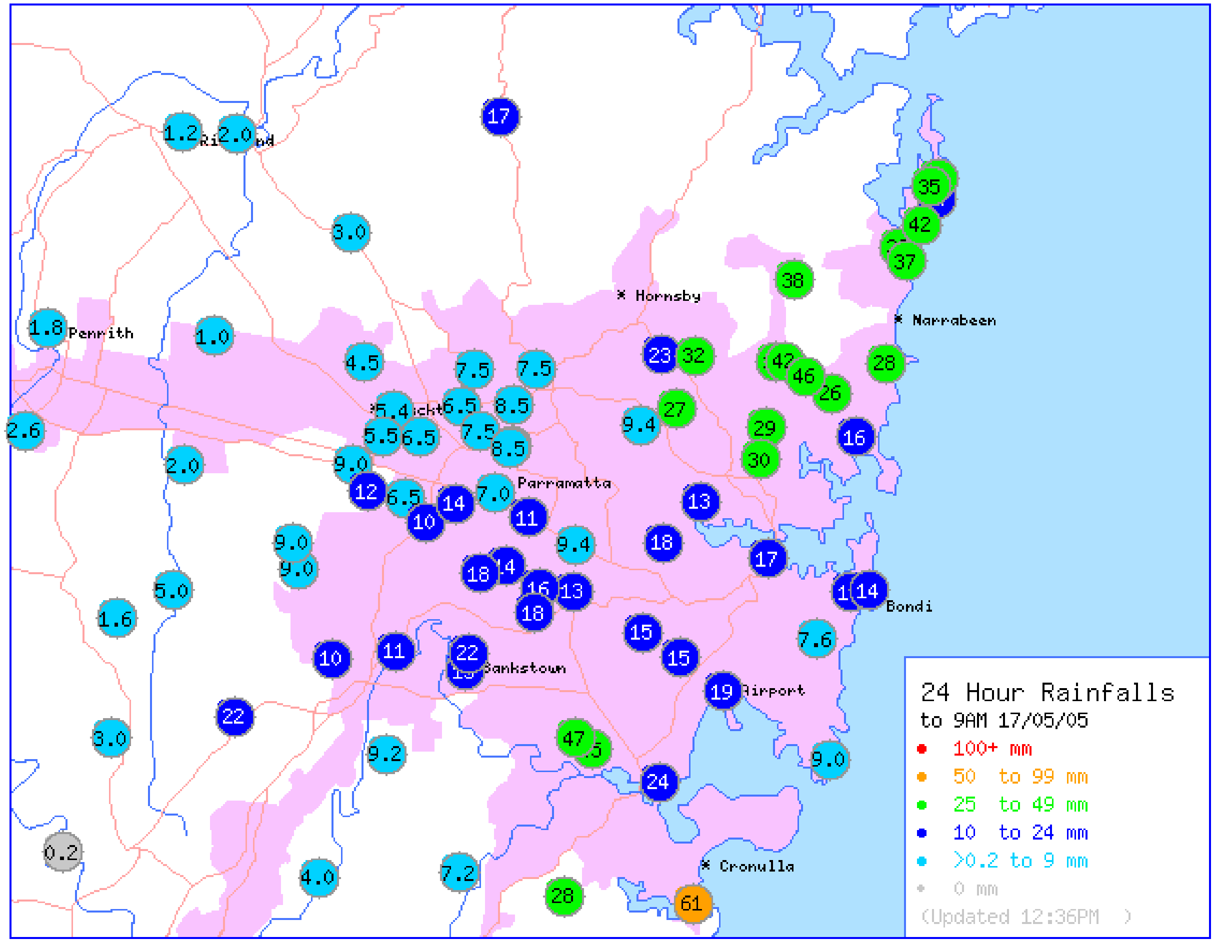
Another great opportunity goes down the drain

Biggest loser ... stormwater gushes out of a pipe at Balmoral Beach yesterday

Setting the Scene

- Australia is in the midst of the worst drought on record
- Dam levels were/are at all time lows for most major centres
- In response, severe water restrictions everywhere
- lamenting “driest continent” yet Australia is not dry!
- high affinity with rainwater tanks – urban population responds
- commercial rainwater harvesting

Typical rain distribution for a sample event in Australia



Fit for purpose reuse matrix

Key: Acceptable, Possible, Not recommended, Not applicable

	Domestic (rainwater)	Commercial: Rainwater (from roof only)	Commercial: Stormwater (roof and ground)
Amenities/ Bathroom	Possible	Acceptable	Not recommended
Kitchen/ Food Prep.	Possible	Possible	Not recommended
Hot Water System	Acceptable	Acceptable	Not recommended
Toilet flushing	Acceptable	Acceptable	Possible
Laundry	Acceptable	Acceptable	Possible
Irrigation/Garden	Acceptable	Acceptable	Acceptable
Vehicle/Gear Washing	Acceptable	Acceptable	Acceptable
Cooling Tower	Not applicable	Acceptable	Acceptable
Pool Top Up Water	Acceptable	Acceptable	Not recommended
Other Process Water	Not applicable	Acceptable	Possible

Cost Effective Design - Water is still cheap

Economic Value of Rainwater Harvesting				
Location	**Annual Rainfall* mm or inch**	**Cost of Water and Sewerage per A$/kL or US$1,000/gal**	**Value/1,000m2 or ft2 roof area**	**Comment**
Sydney - Coastal	1,200 47	$3.15 $9.57	$2,600 $193	
Sydney - West	900 35	$3.15 $9.57	$2,000 $149	
Melbourne - City	650 26	$2.70 $8.20	$1,200 $89	
Melbourne - South East	750 30	$2.55 $7.75	$1,400 $104	
Adelaide	500 20	$1.90 $5.78	$700 $52	no variable wastewater charges
Perth	800 31	$3.30 $10.02	$1,900 $141	lower yield because of seasonal rainfall (none to
Darwin	1,700 67	$0.90 $2.74	$1,100 $82	
Brisbane	1,100 43	$1.45 $4.41	$1,100 $82	no variable wastewater charges
*rounded numbers are used to avoid a perceived false accuracy due to the high local variability of rainfall				

Cost Effective Design

How to overcome the design challenge

- rain! – ideally spread throughout the year
- build a tank not a dam
- intercept only what's needed
- make it part of an integrated urban water supply
- find a high non potable demand
- choose the right combination: Collection area, intercept, tank location, size, demand, reticulation)
- look for clever design solutions
- value engineer – cut the right corners, for example:

Value Engineering – no 1st flush

Darling Harbour Carpark Rainwater Tank Water Quality Assessments

Item	Unit	Limit of Reporting	No. Samples	Min	Max	Avg	Reference Guidelines
pH	pH units	0.04	3	6.7	6.8	6.8	6.5-8.5
Conductivity	uS/cm	10	3	63	180	109	250
Chloride	mg/L	14	3	7.7	18	12	250
Hardness	mg/L $CaCO_2$	7	3	17	58	33	200
Turbidity	NTU	0.07	3	1.8	33	13	5
Nutrients							
Nitrate Nitrogen	mg/L	0.02	2	0.12	1.2	0.7	50
Total Nitrogen	mg/L	0.01	1	2.2	2.2	2.2	
Phosphorous	mg/L	0.01	3	0.01	0.07	0.03	
Metals							
Aluminium	mg/L	0.01	3	0	0.05	0.04	0.2
Arsenic	mg/L	0.05	6	<.05	<.05	<.05	0.007
Copper	mg/L	0.01	6	0.01	0.48	0.09	1
Lead	mg/L	0.03	6	<0.03	<0.03	<0.03	0.01
Organics							
TPH C6-C9	ug/L	10	3	<10	<10	<10	
Benzene	ug/L	1	3	<1	<1	<1	1
Toluene	ug/L	1	3	<1	<1	<1	25

pH 6.8

Cl^- 12

Alk 33

NTU 13

TN 2.2

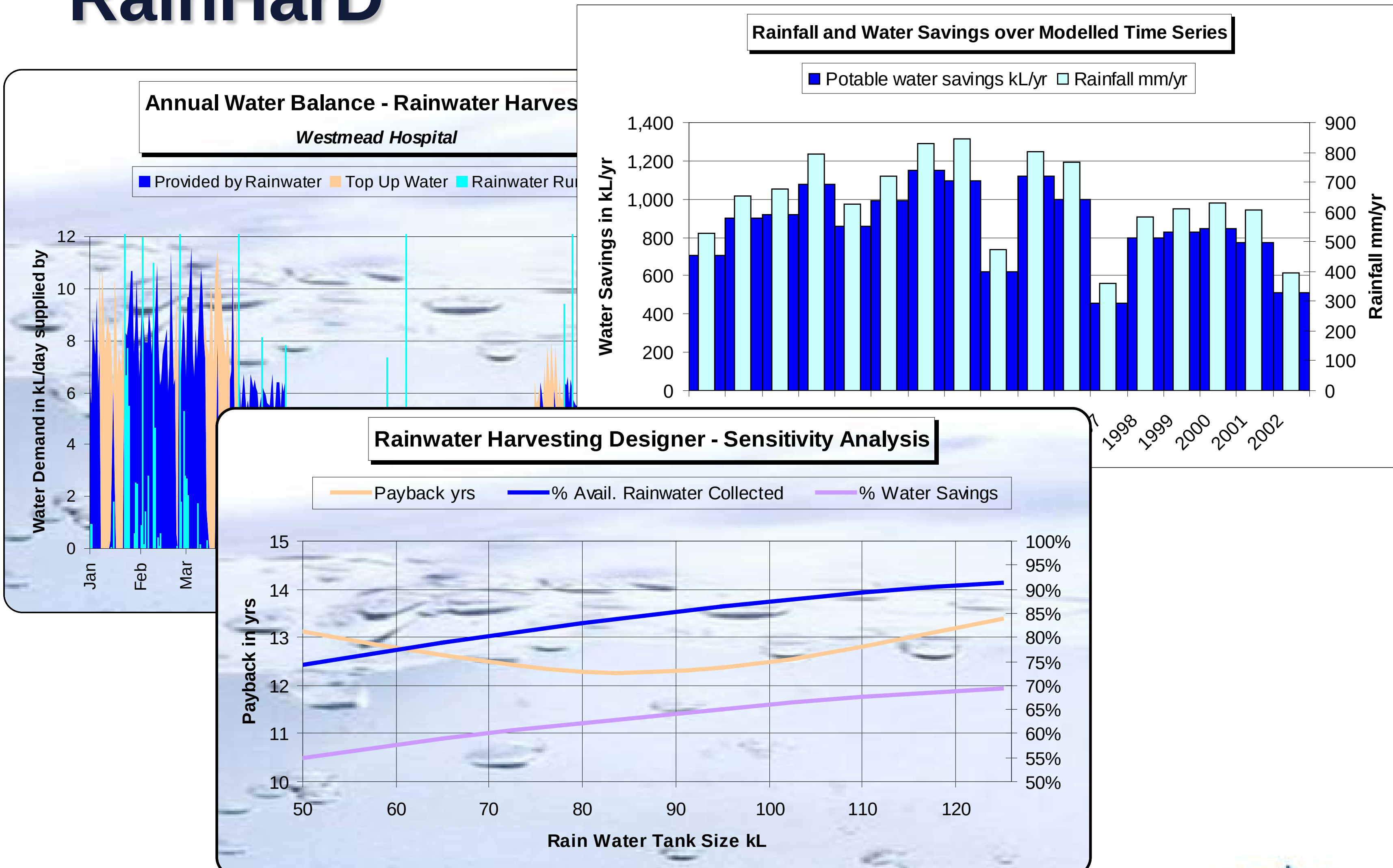
TP 0.03

Sizing Tools

RainHarD & StormHarD – rainwater and stormwater harvesting design model

- daily time steps
- Input variables: Local rainfall, collection area, runoff coefficient, initial loss, demand curves, tank size
- Output: Daily trend line, water saved, utilisation
- up to 20 year time series run
- Sensitivity analysis module for cost optimisation

RainHarD



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Executed Rainwater Harvesting Schemes

Scheme	Water Use	Collection Area m2 or ft2	Annual Rainfall mm or inches	Tankage m3 or gallons	mm or inch of rain to fill empty tank	Projected Potable Water Savings m3 or gal			
						per annum	per m3 or gal Tankage	per m2 or ft2 collection area	as % of rainfall
Warehouse, cool store	Cooling towers	21,100	827	890	42	11,010	12.4	0.52	63%
		226,821	33	234,211	1.7	2,897,368		12.8	
Football Stadium	Irrigation	2,450	920	150	61	1,700	11.3	0.69	75%
		26,337	36	39,474	2.4	447,368		17.0	
Car Park	Irrigation	10,000	1,150	660	66	7,160	10.8	0.72	62%
		107,498	45	173,684	2.6	1,884,211		17.5	
Depot	wash water	1,500	720	80	53	620	7.8	0.41	57%
		16,125	28	21,053	2.1	163,158		10.1	
Call Center (with shift work)	Amenities	8,500	1,120	400	47	6,300	15.8	0.74	66%
		91,373	44	105,263	1.9	1,657,895		18.1	
Hospital	Cooling tower	3,400	675	120	35	1,980	16.5	0.58	86%
		36,549	27	31,579	1.4	521,053		14.3	
Depot	Amenities, irrig., wash	1,200	1,190	100	83	995	10.0	0.83	70%
		12,900	47	26,316	3.3	261,842		20.3	
Depot	Vehicle wash	1,600	1,120	150	94	810	5.4	0.51	45%
		17,200	44	39,474	3.7	213,158		12.4	

Design Guidelines

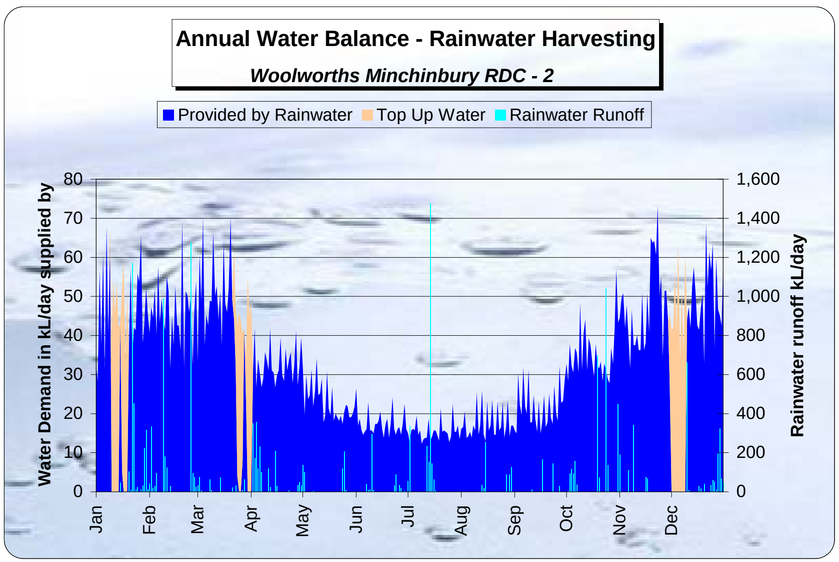
- avoid large volumes – 50 to 80mm (2-3'') max to fill an empty tank
- annual savings about 10-12 times tank volume
- you save about 2/3 of the runoff
- you save more with a greater demand
- limit the intercept rate
- good engineering
- monitor

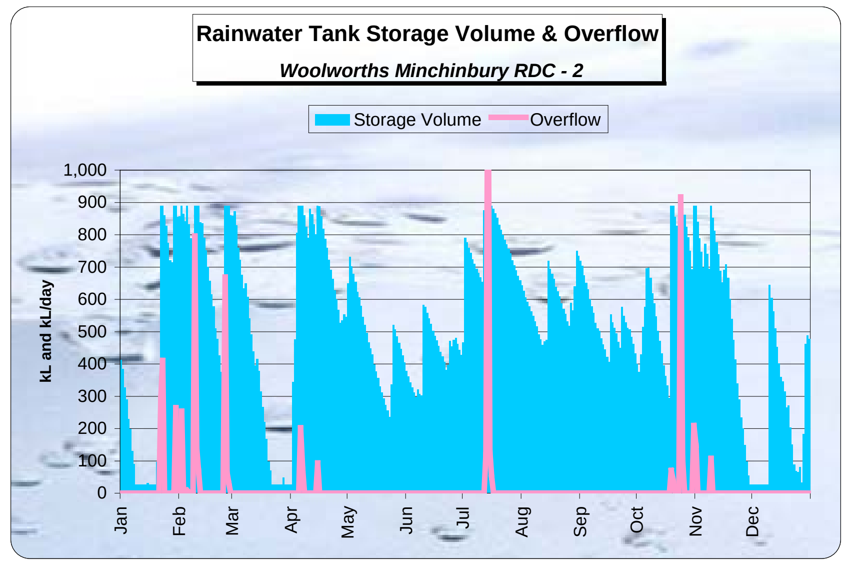
A Rainwater tank – not a dam!

Rainwater Harvesting Design Model *Woolworths Minchinbury RDC - 2*

Model Input		Comments
Reference rainfall station	Prospect	annual rainfall: 965mm
Rainfall collection area m2	**21,100**	
Runoff coefficient	0.95	steel roof
Initial loss mm	2	
Price of Water $/kL	$3.20	$1.85 potable water/$1.35 wastewater
Rainwater used for	cooling towers	
Typical consumption & pattern	seasonal profile, 20 to 70 kL/day	
Tank Size kL	**890**	42 mm of rain to fill empty tank

Model Output		Comments
Available rainwater kL/yr	17,750	145% of demand
Water demand kL/yr	12,207	
Overflow volume kL/yr	6,738	
Top up water kL/yr	1,228	
Potable water savings kL/yr	**11,012**	
% Potable water saved	**90%**	
% Available rainwater collected	**62%**	
Cost Savings $/yr	**$38,739**	incl chemical savings of 3.5k





Design Philosophies – where rain and stormwater harvesting are different

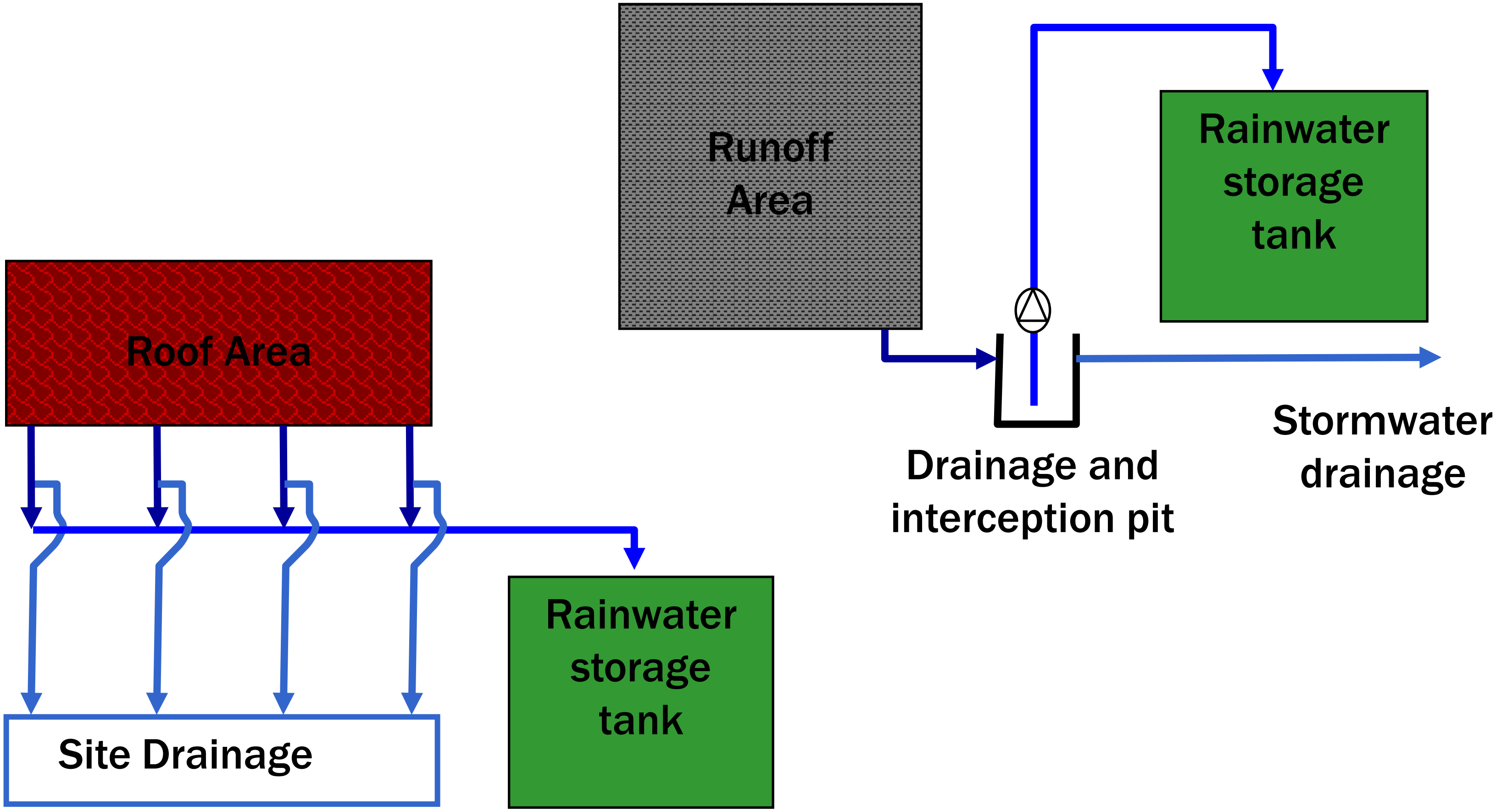
Traditional Hydraulic Design

- **maximum** flow for safety/flood protection; avoid structural damage, disruption, erosion, health & well being
- based on “accepted” level of recurrence (1 in 20, 50 or 100 years, 5 min in 20 years)

Rain or Stormwater Harvesting Design

- economically optimised scheme to supplement urban water supplies
- what is the **minimum** extraction or diversion rate needed to collect most water whilst optimising harvested water quality

"Process Flow Diagram"



Is there a better way? How we checked it

- 6 min rainfall data
- algorithm from RainHarD (Rainwater Harvesting Design Model)
- continuous demand
- initial losses neglected
- ratio of capture area, tank volumes and demand based on a well designed commercial system

Is there a better way? …cont'd

- 6 min rainfall data
- algorithm from RainHarD (Rainwater Harvesting Design Model)
- continuous demand
- initial losses neglected
- ratio of capture area, tank volumes and demand based on a well designed commercial system
- normalised for a 1,000m^2 effective runoff area
- a demand of 600-1,000m3/yr = 50-90% of available water, 10-15 times tank volume
- 40-80mm(1.5 – 3'') to fill an empty tank
- harvest flow rates equiv. to 20-3 mm(0.8-0.1'')/hr rain intensity
- 6 min time steps, no flow attenuation

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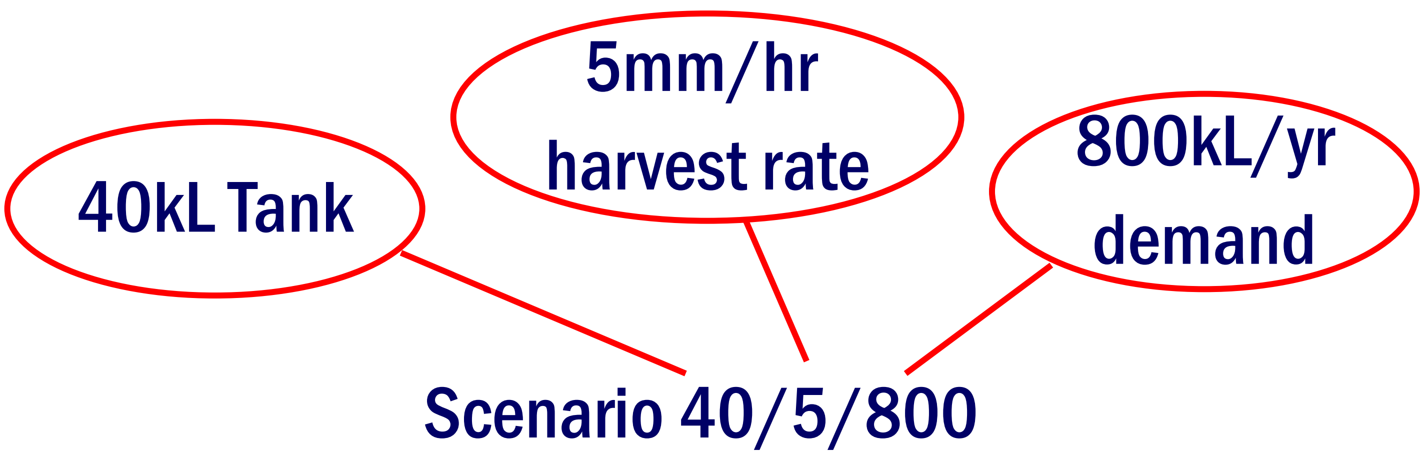
The Scenarios

- 40, 60 or 80 kL tank (=40, 60, 80 mm to fill tank)
- harvest rate equivalent to
  1, 3, 5, 10, 20 20-3 mm/hr rain intensity
- 600, 800, 1,000 kL/yr demand



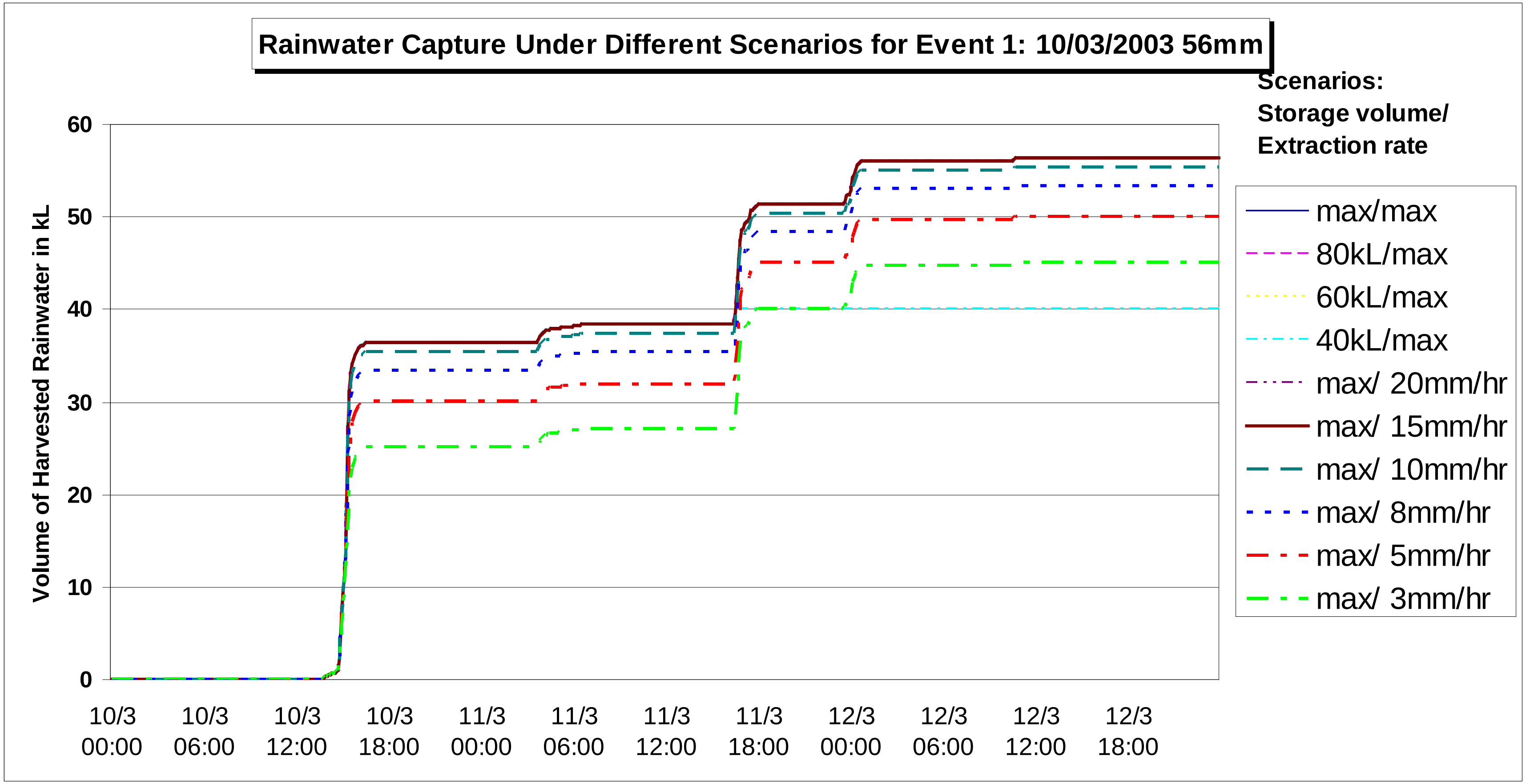
The Results

Scenario	Available Storage Capacity kL	Harvest Rate mm/hr	Demand kL/yr	Assessed Water Savings kL/yr	Max Savings at unre-stricted harvest rate kL/yr	% of Max Savings
80 / 3 / 600	80	3	600	519	519	100%
80 / 3 / 1000	80	3	1,000	734	742	99%
80 / 5 / 1000	80	5	1,000	739	742	100%
80 / 8 / 1000	80	8	1,000	742	742	100%
80 / 20 / 600	80	20	600	519	519	100%
60 / 3 / 600	60	3	600	519	519	100%
60 / 1 / 600	60	1	600	515	519	99%
40 / 1 / 600	40	1	600	511	514	99%
40 / 3 / 600	40	3	600	514	514	100%
40 / 3 / 800	40	3	800	626	632	99%
40 / 5 / 800	40	5	800	630	632	100%
40 / 8 / 800	40	8	800	632	632	100%

Further Scenario Analysis – for 4 large events

Scenario	Event 1		Event 2		Event 3		Event 4	
max/max	56	100%	219	365%	89	148%	63	106%
80kL/max	56	100%	80	133%	80	133%	63	106%
60kL/max	56	100%	60	100%	60	100%	60	100%
40kL/max	40	71%	40	67%	40	67%	40	67%
60kL/ 20mm/hr	56	100%	60	100%	60	100%	60	100%
60kL/ 15mm/hr	56	100%	60	100%	60	100%	60	100%
60kL/ 10mm/hr	55	98%	60	100%	60	100%	60	100%
60kL/ 8mm/hr	53	95%	60	100%	60	100%	60	100%
60kL/ 5mm/hr	50	89%	60	100%	60	100%	60	100%
60kL/ 3mm/hr	45	80%	60	100%	60	100%	60	100%

Percentage figures relate to harvestable volume relative to 60kL available storage


Rainwater Capture Under Different Scenarios for Event 1: 10/03/2003 56mm
Scenarios:
Storage volume/
Extraction rate
max/max
80kL/max
60kL/max
40kL/max
max/ 20mm/hr
max/ 15mm/hr
max/ 10mm/hr
max/ 8mm/hr
max/ 5mm/hr
max/ 3mm/hr
Volume of Harvested Rainwater in kL
0
10
20
30
40
50
60
10/3 00:00
10/3 06:00
10/3 12:00
10/3 18:00
11/3 00:00
11/3 06:00
11/3 12:00
11/3 18:00
12/3 00:00
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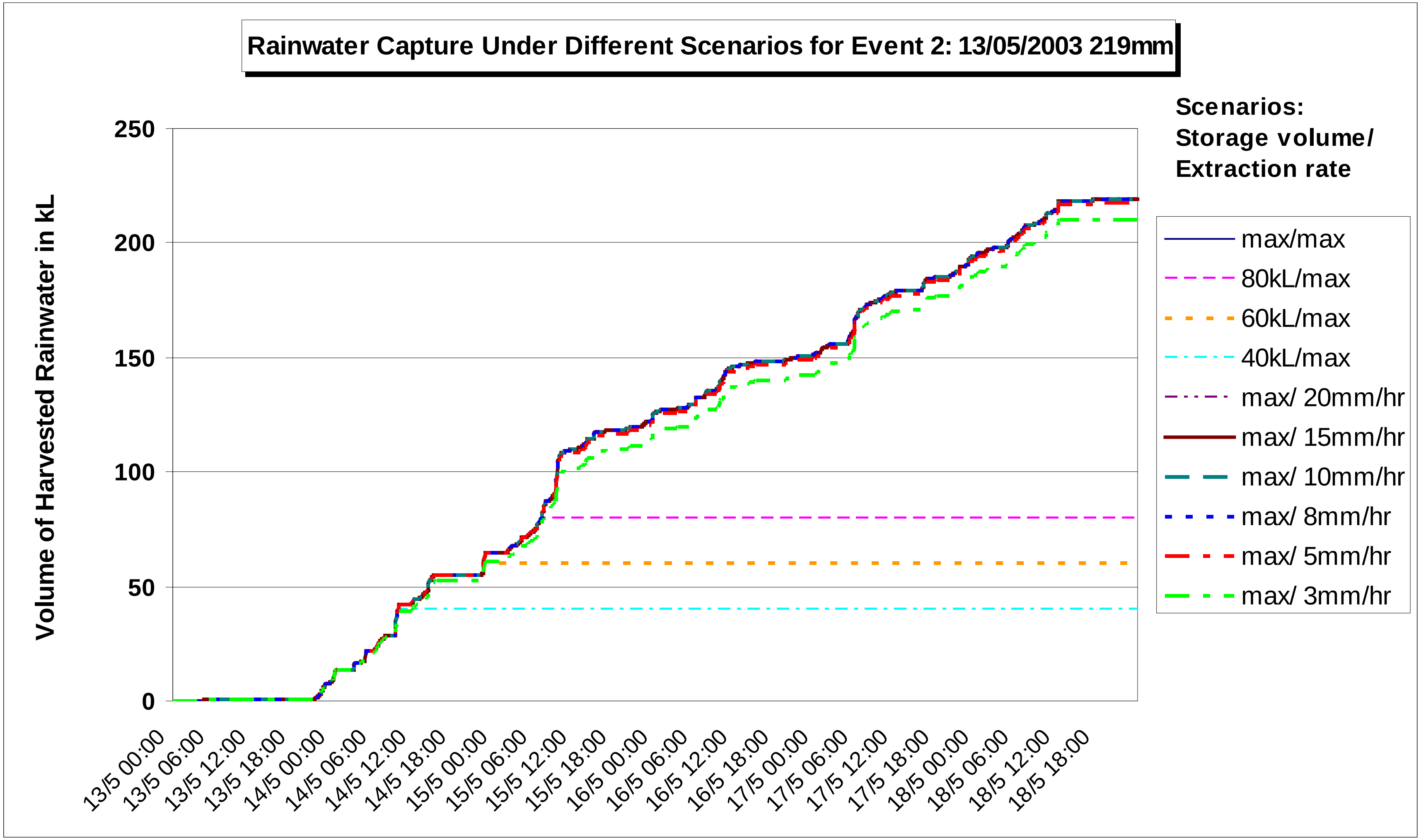
12/3 12:00
12/3 18:00



Rainwater Capture Under Different Scenarios for Event 2: 13/05/2003 219mm
Volume of Harvested Rainwater in kL
250
200
150
100
50
0
13/5 00:00
13/5 06:00
13/5 12:00
13/5 18:00
14/5 00:00
14/5 06:00
14/5 12:00
14/5 18:00
15/5 00:00
15/5 06:00
15/5 12:00
15/5 18:00
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17/5 06:00
17/5 12:00
17/5 18:00
18/5 00:00
18/5 06:00
18/5 12:00
18/5 18:00
Scenarios:
Storage volume/
Extraction rate
max/max
80kL/max
60kL/max
40kL/max
max/ 20mm/hr
max/ 15mm/hr
max/ 10mm/hr
max/ 8mm/hr
max/ 5mm/hr
max/ 3mm/hr

Results

- few events have intensities >10mm(0.4'')/hr
- for large events extraction rates of <3(1.1'')mm/hr would have yielded same savings
- only 1 event showed significantly less capture at restricted rates - but negligible in annual balance

Intercept Design Conclusions

- whilst drainage pipes are sized for a 1 in 10 year or more event and downpipes for 5min in 20 yrs – rain and stormwater intercepts need not
- no justification seen for rates equivalent to 30-40mm (1.2-1.6'')/hr
- diversion rates as low as 1-3 mm(0.4-.12''/hr, equivalent to 0.3-0.8 L/s per 1,000m^2 yield close to maximum savings

Recommendation

Allowing for limited analysis and uncertainties due to climate change, use an extraction/diversion rate of 5mm(0.2''/hr or **1.4L/s per 1,000m^2 (2gpm/ft^2)** effective runoff area

What this enables: Peak Flow Diversion

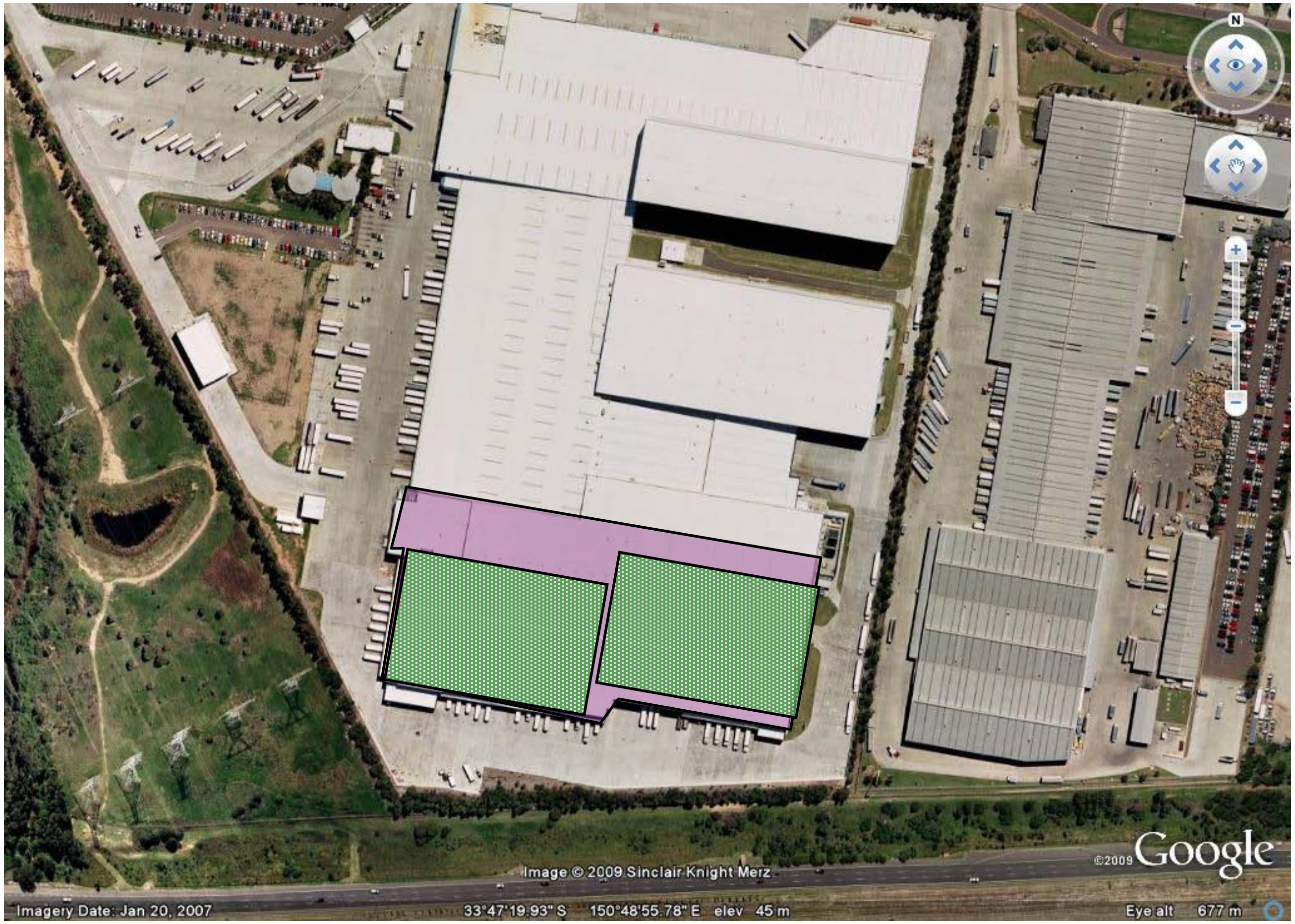
Benefits/Why?

For large schemes

- Collection main e.g. 150mm(8'') instead of 650mm(24'')
- Easier to deal with residual overflows
- Enables solutions that otherwise would not have been possible

Try doing this with a 20'' main!

The associated collection area: 2 Football fields!



21,000m^2

5 acres

Benefits/Why?

For large schemes

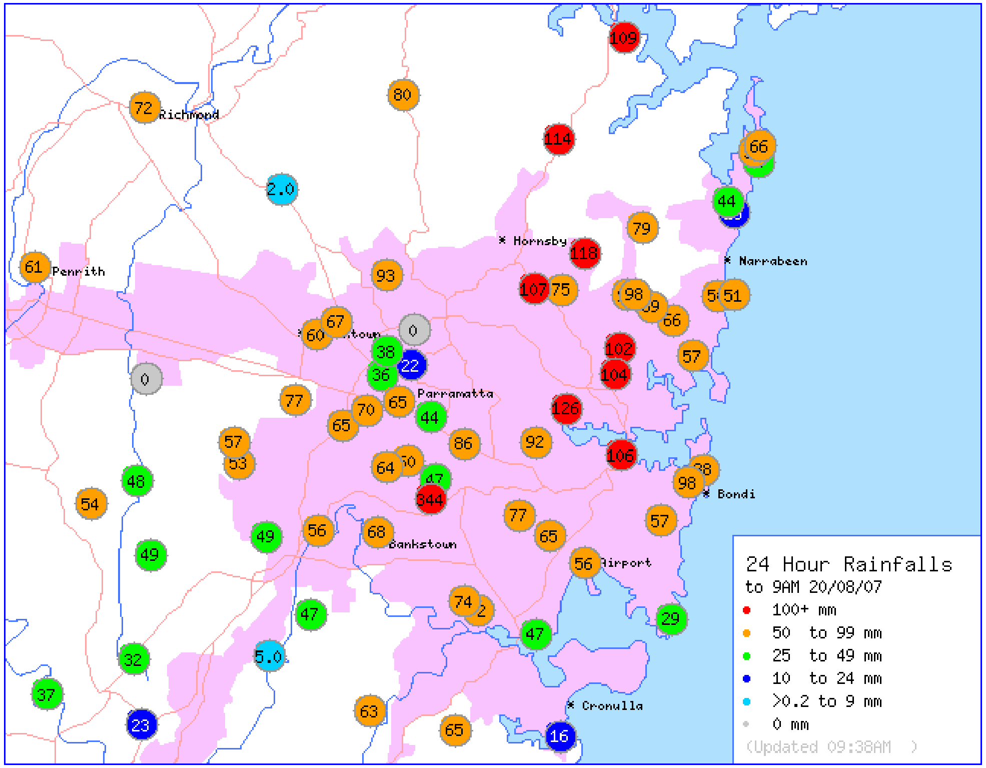
- Smaller collection mains, e.g. 150mm instead of 650mm
- Easier to deal with residual overflows
- Systems “without overflows”

Peak Flow Diversion

Benefits/Why?

For large schemes

- Smaller collection mains, e.g. 150mm instead of 650mm
- Easier to deal with residual overflows
- Systems "without overflows"
- **Smaller extraction rates = smaller pumps & pipes**
- **Better water quality**



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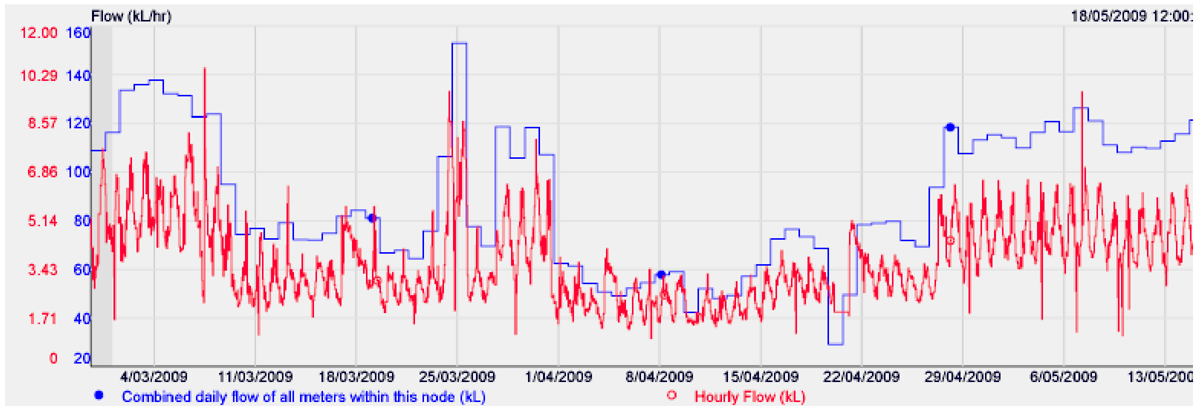
Potable water consumption before & after rainwater harvesting

Before RWH

60-120 m^3L/day

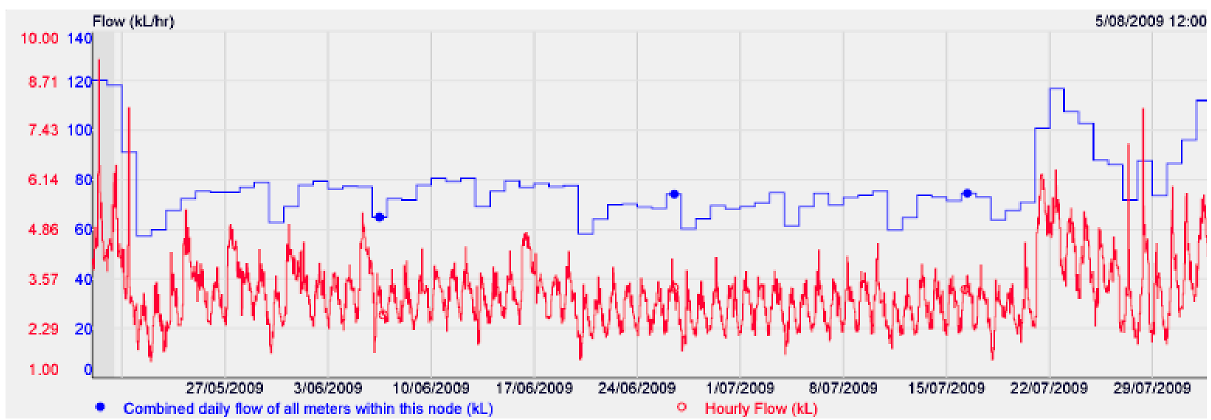
16,000-32,000gal/d



After RWH

60-80 m^3/day

16,000-21,000gal/d



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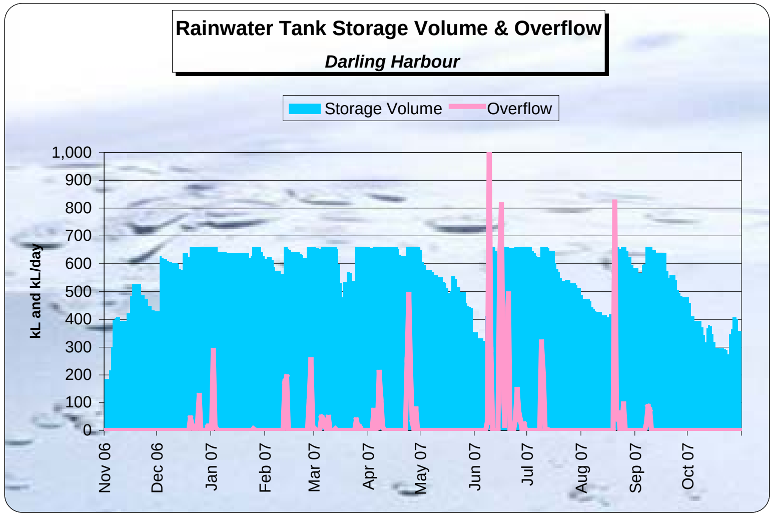
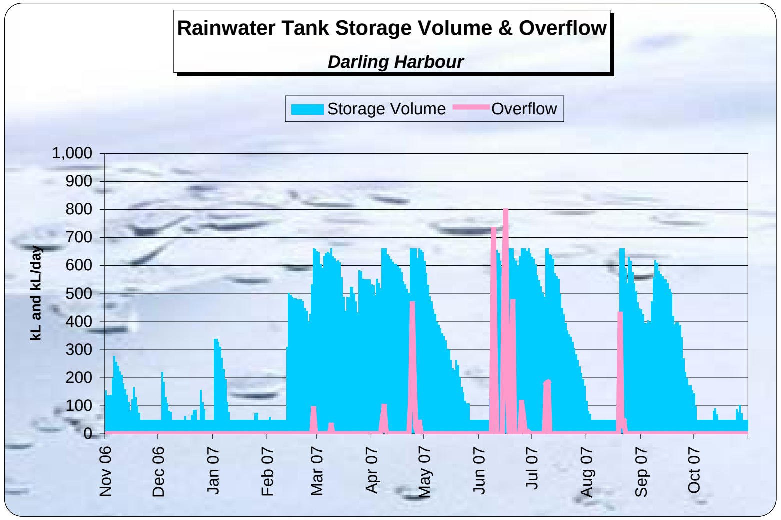
How we worked the tank harder – and saved 2.5 time the volume of water

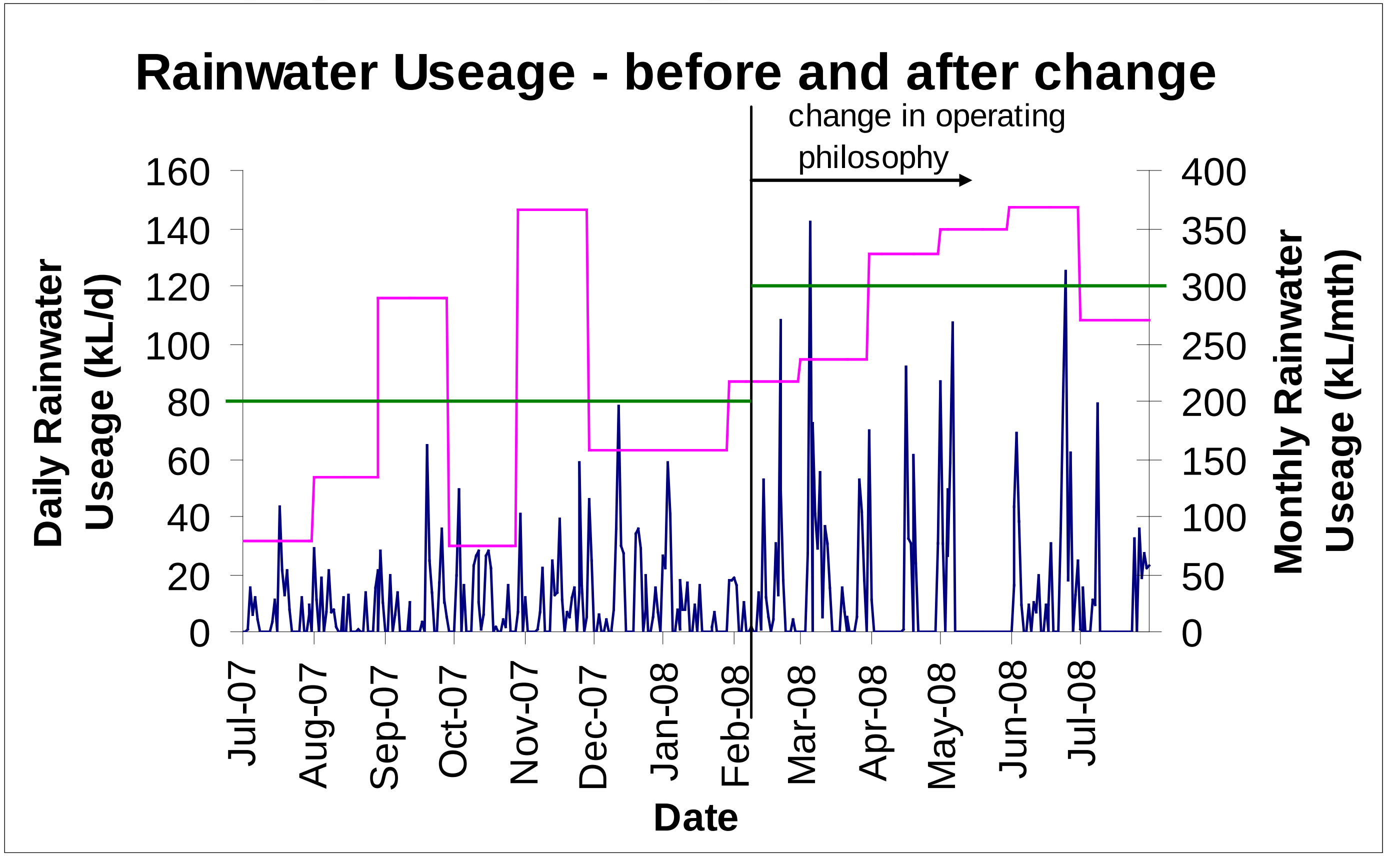
Model Output		Comments
Available rainwater kL/yr	11,268	495% more rainwater than demand, add extra consumers if possible
Water demand kL/yr	2,278	
Overflow volume kL/yr	8,816	
Top up water kL/yr		
Potable water savings kL/yr	**2,452**	
% Potable water saved	**100%**	
% Available rainwater collected	**22%**	
Cost Savings $/yr	**$4,486**	

Model Output		Comments
Available rainwater kL/yr	11,268	132% of demand
Water demand kL/yr	8,556	
Overflow volume kL/yr	5,513	
Top up water kL/yr	2,665	
Potable water savings kL/yr	**5,755**	
% Potable water saved	**69%**	
% Available rainwater collected	**51%**	
Cost Savings $/yr	**$10,532**	

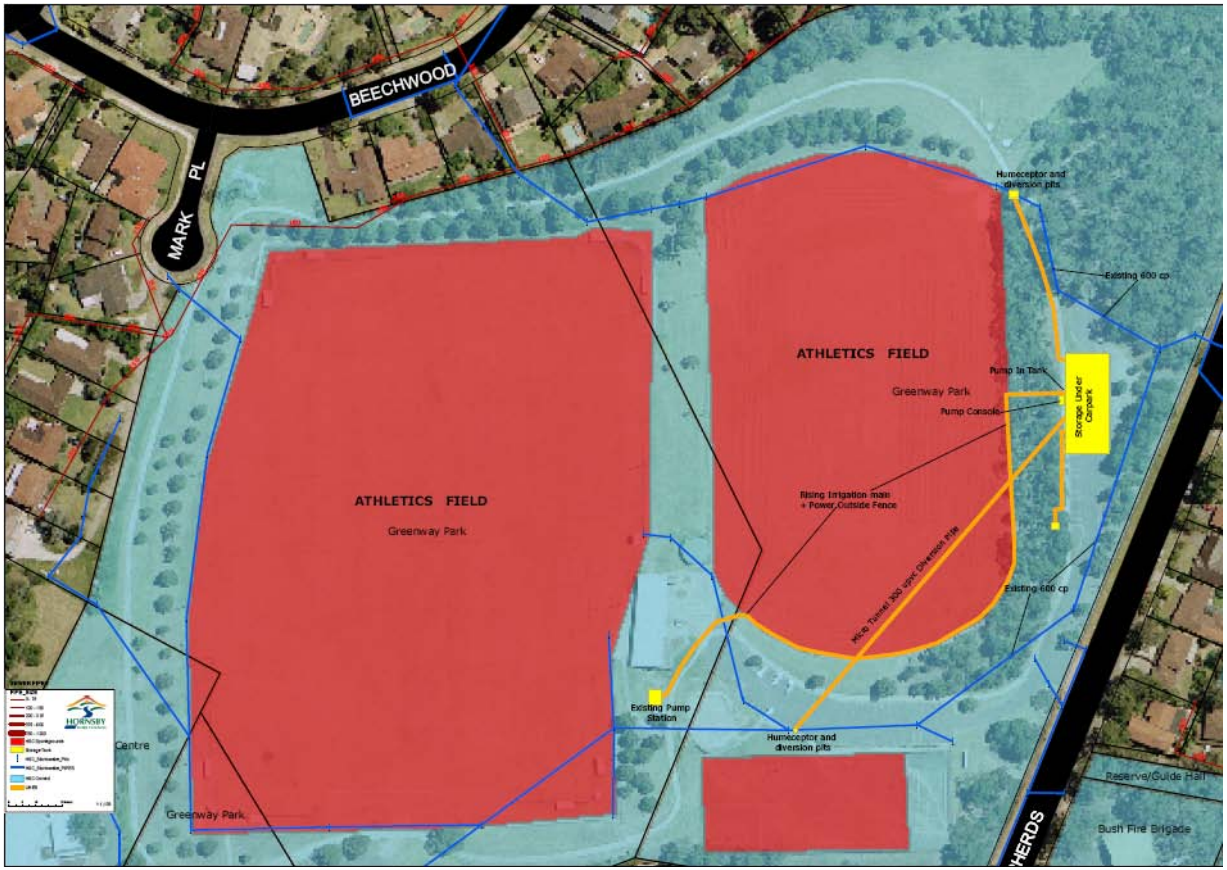




Another example of
"An empty tank is a good tank"



Large stormwater harvesting schemes



Excellent water quality

Re-cap

- tanks sized for 40-60mm (~2 inches) of rain to fill an empty tank
- tanks as part of an integrated urban water supply system
- annual water savings 10-15 times tank volume
- flow rates equivalent to a rainfall intensity of 5mm/hr (2/10 of an inch/hr) ok for hydraulic design
- paybacks of 6-10 years for hard working commercial systems
- modelling, good hydraulic design & attention to detail

Conclusion

Appropriately sized hard working commercial rain or stormwater harvesting systems capturing the water where it falls and where the demand is, can provide an economically attractive sustainable solution to diversify our water supplies to combat the effects of climate change and increased population pressure.

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