# PROJECT 23 STAGE 3: RETENTION AND DETENTION

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Australian Rainfall & Runoff

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## What is Detention and Retention

Argue, J.R. (1986). *Storm drainage design in small urban catchments : a handbook for Australian practice.* ARRB Special Report, Special Report 34, Melbourne.

**Detention** refers to the holding of runoff for short periods to reduce peak flow rates and later releasing it into natural or artificial watercourses to continue in the hydrological cycle. The volume of surface runoff involved in this process is relatively unchanged

**Retention** refers to procedures and schemes whereby stormwater is held for considerable periods causing water to continue in the hydrological cycle via infiltration percolation, evapotranspiration, and not via direct discharge to watercourses



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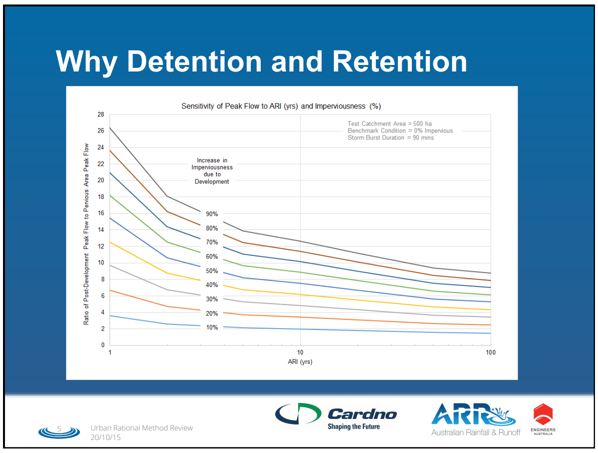

Why Detention and Retention
Sensitivity of Peak Flow to ARI (yrs) and Imperviousness (%)
Test Catchment Area = 500 ha
Benchmark Condition = 0% Impervious
Storm Burst Duration = 90 mins
Increase in Imperviousness due to Development
90%
80%
70%
60%
50%
40%
30%
20%
10%
Ratio of Post-Development Peak Flow to Pervious Area Peak Flow
ARI (yrs)
Urban Rational Method Review
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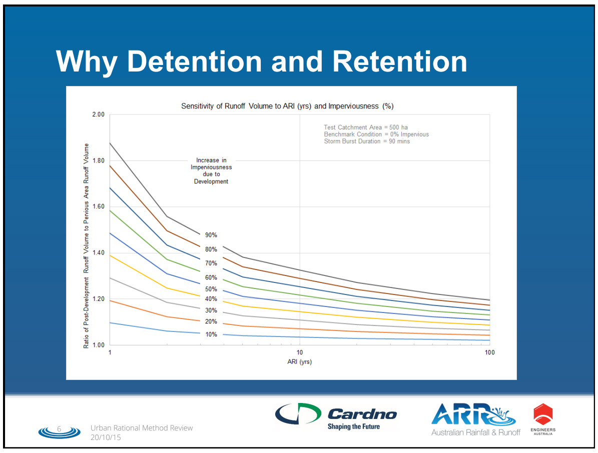

Why Detention and Retention
Sensitivity of Runoff Volume to ARI (yrs) and Imperviousness (%)
Test Catchment Area = 500 ha
Benchmark Condition = 0% Impervious
Storm Burst Duration = 90 mins
Increase in Imperviousness due to Development
Ratio of Post-Development Runoff Volume to Pervious Area Runoff Volume
ARI (yrs)
Urban Rational Method Review
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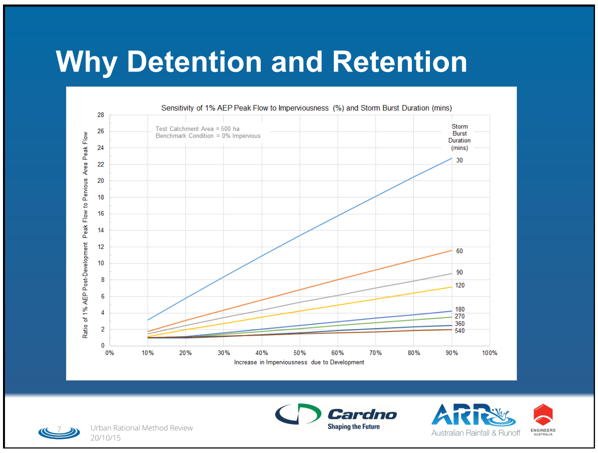

Why Detention and Retention
Sensitivity of 1% AEP Peak Flow to Imperviousness (%) and Storm Burst Duration (mins)
Test Catchment Area = 500 ha
Benchmark Condition = 0% Impervious
Storm Burst Duration (mins)
Ratio of 1% AEP Post-Development Peak Flow to Pervious Area Peak Flow
Increase in Imperviousness due to Development
Urban Rational Method Review
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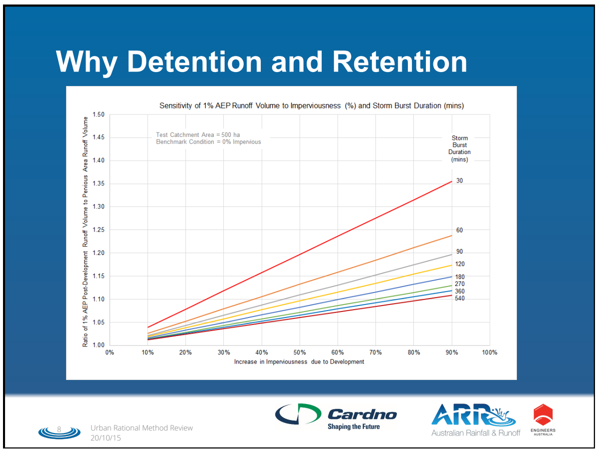

Why Detention and Retention
Sensitivity of 1% AEP Runoff Volume to Imperviousness (%) and Storm Burst Duration (mins)
Test Catchment Area = 500 ha
Benchmark Condition = 0% Impervious
Storm Burst Duration (mins)
Ratio of 1% AEP Post-Development Runoff Volume to Pervious Area Runoff Volume
Increase in Imperviousness due to Development
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## ARR 1998

ARR 1998 Book 8 Urban Stormwater Management

1.6.6 Detention and Retention Storages
- Introduction
- Design Procedures
- Special Considerations



## ARR 2015

ARR 2015 Book 9 Runoff in Urban Catchments

X DETENTION AND RETENTION (Draft)

X.1 INTRODUCTION
X.2 APPROACHES TO ASSESSING DETENTION AND RETENTION
X.3 ON-SITE DETENTION
X.3.1 Introduction
X.3.2 Flow Control Requirements
X.3.4 Determination of PSD and SSR
X3.5 General Considerations
X.3.6 Primary Outlets
X.3.7 Secondary Outlets
X.3.8 Operation and Maintenance
A.4 COMMUNITY AND REGIONAL DETENTION
X.4.1 Introduction
X.4.2 Detention Design Concepts
X.4.3 Embankments
X.4.5 Primary Outlet Design Considerations
X.4.6 Secondary Outlet Design Considerations
X.4.7 Public Safety
X.4.8 Operation and Maintenance
X.5 ON-SITE RETENTION
X.5.1 Introduction
X.5.2 General Design Criteria and Procedure
X.5.3 Operations and Maintenance
X.6 REGIONAL RETENTION
X.6.1 Recharge Basins
X.6.2 Recharge Wells



## Guidelines

ACT Department of Urban Services (1998) *Design Standards for Urban Infrastructure, Section 1 Stormwater,* 1.9 Retarding Basins, Section 1.9 Retarding Basins, 4 pp.

Argue, J.R. (Ed) (2004), WSUD: Basic Procedures for Stormwater for Source Control of Stormwater – A Handbook for Australian Practice. Urban Water Resources Centre, University of South Australia, Adelaide, November, 245 pp + Apps.

UPRCT (2005) "On-Site Stormwater Detention Handbook", Fourth Edition, December.

Queensland Department of Natural Resources and Mines (2007) Queensland Urban Drainage Manual, Volume 1, Second Edition, Book2, Chapter 5.00 Detention/retention systems, 25pp

Department of Energy and Water Supply (2013) ",Queensland Urban Drainage Manual", Provisional Third Edition, Chapter 5.00 Detention/retention systems, 17 pp.



## Guidelines

Department of Irrigation and Drainage (2000) "Urban Stormwater Management Manual for Malaysia (Maunual Saliran Mesra Alam Malaysia)" Vol 7 Detention (Chapter 18, 19, 20), Volume 8 Retention (Chapters 21, 22), Kuala Lumpur.

Department of Irrigation and Drainage (2012) "Urban Stormwater Management Manual for Malaysia (Maunual Saliran Mesra Alam Malaysia)" Edition 2, Chapter 5 On-Site Detention, 33 pp.

Department of Irrigation and Drainage (2012) "Urban Stormwater Management Manual for Malaysia (Maunual Saliran Mesra Alam Malaysia)" Edition 2, Chapter 6 Rainwater Harvesting, 18 pp.

# Research


Scott, P., Santos, R. and Argue, JA. (1998) "OSD versus OSR: Performance, environmental and cost comparisons in a residential catchment", *Proceedings*, NOVATECH'98, 3rd international conference on innovative technologies in urban storm drainage May 4 - 6, 1998 Lyon, France.

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Coombes, PJ; Frost, A.; Kuczera, G.; O'Loughlin, G. and Lees, S. (2002) Rainwater Tank Options for Stormwater Management in the Upper Parramatta River Catchment [online]. In: Water Challenge: Balancing the Risks: Hydrology and Water Resources Symposium 2002. Barton, ACT.: Institution of Engineers, Australia, 2002: [474]-[482].

Thompson, G.R., Goyen, A.G. and Phillips, B.C. (2004) "Evaluating the Interaction of On-Site Detention Tanks and Roof Water Tanks in Low Impact Developments at Varying Catchment Scales", Proceedings, STORMCON 2004, 26-29 July 2004, Palm Desert, USA

Phillips, B.C., Goyen A.G. and Lees, S.J. (2005) "Improving the Sustainability of On-Site Detention in Urban Catchments", *Proceedings*, 10th International Conference on Urban Drainage, IAHR/IWA, 21-26 August, Copenhagen.

Carse, J., Lees, S., Phillips, B.C. and Goyen, A. G. (2006) "Improving the Management of Urban Runoff using On-Site Detention", *Proceedings*, 46th Annual Floodplain Management




# Research


van der Sterren, M; Rahman, A; Barker, G; Ryan, G and Shrestha, S. (2007) Rainwater tanks for on-site detention in urban developments in Western Sydney: An overview. In: Rainwater and Urban Design 2007. [Barton, ACT]: Engineers Australia, 2007: [1134]-[1141]. International Rainwater Catchment Systems Conference 13th 21-23 Aug. 2007 Sydney, NSW.

Lucas, SA and Coombes, PJ. (2009) Mains water savings and stormwater management benefits from large architecturally-designed under-floor rainwater storages. In: SSEE 2009: Solutions for a Sustainable Planet. Barton, A.C.T.: Engineers Australia, 2009: [386]-[397].

Coombes, PJ. (2009) The Use of Rainwater Tanks as a Supplement or Replacement for Onsite Stormwater Detention (OSD) in the Knox Area of Victoria [online]. In: H2009: 32nd Hydrology and Water Resources Symposium, Newcastle : Adapting to Change. Barton, A.C.T.: Engineers Australia, 2009: 616-627.

Thomson, R.S., Maratea, E., Phillips, B.C., Kilaparty, B., Perera, J. and Paton, D. (2013) Assesssing the Performance of OSD in Highly Urbanised Areas, *Proceedings*, Stormwater NSW Conference, 17-19 September 2013, Blue Mountains




# Approaches to Assessing Detention and Retention

Argue, J.R. (Ed) (2004), WSUD: Basic Procedures for Stormwater for Source Control of Stormwater – A Handbook for Australian Practice. Urban Water Resources Centre, University of South Australia, Adelaide, November, 245 pp + Apps.

Yield-maximum strategy: Based on an end-of-catchment harvesting scheme which conflicts with source control. Detention can reduce flooding impacts and degradation of waterways.

Regime-in-balance strategy: Peak flow at benchmark location(s) held at a target value. Essence of the strategy is surface runoff volume is the same as the benchmark runoff volume.

Yield-minimum strategy: Similar to regime-in-balance approach but the smaller capacity of the floodplain under current conditions may require extreme measures to be implemented

Infrastructure Compliant Stormwater Management (ICSM) strategy. This involves determining the (flow) capacity of the existing infrastructure and



# Approaches to Assessing Detention and Retention

Key aspects:

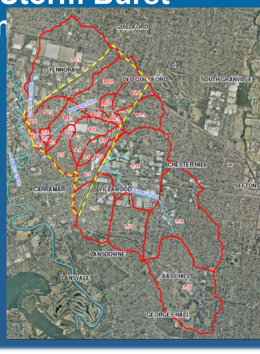
- Identify benchmark locations within a catchment
- Determine peak flows for a range of ARIs at benchmark locations
- Decide on a benchmark year (which equates to a benchmark catchment condition)
- Identify the critical storm burst duration(s)
- Requires catchment based assessments

## Critical Storm Burst Duration

| Catchment | Watercourse (Critical Storm Burst Duration) |
|---|---|
| Burns Creek | •Barrass Drain (90 mins)<br>•Stimsons Creek (90 mins)<br>•Burns Creek (90 mins) |
| Prospect Creek | •Upstream reach – (90 mins, 2 hrs)<br>•Lower reach (9 hrs) |
| Georges River | •Georges River (36 hrs) |

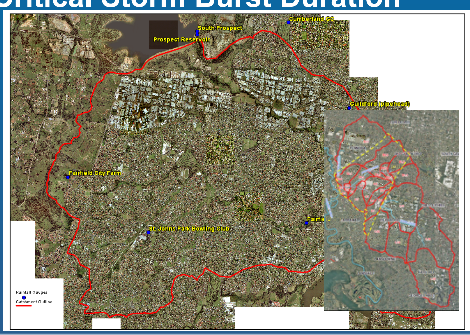


## Critical Storm Burst Duration



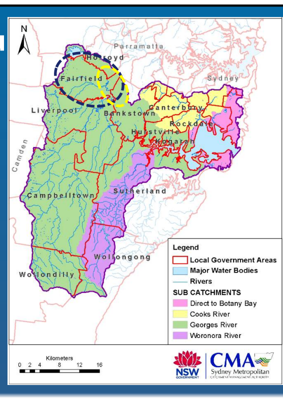


## Critical Storm Burst Duration





## Critical Storm Burst Duration



## On-Site Detention

UPRCT (2005) "On-Site Stormwater Detention Handbook", Fourth Edition, December

Key aspects:

- 110 km2 catchment
- Benchmark locations identified through the catchment
- Benchmark year (1991)
- Critical storm burst duration(s) 9 hours at Parramatta CBD
- Catchment based assessment – 660 node custom xprafts model
- 1.5 yr ARI and 100 yr ARI assessed
- Pre-burst rainfall included
- Rainwater tanks included with dynamic airspace (based on demand) and dedicated airspace

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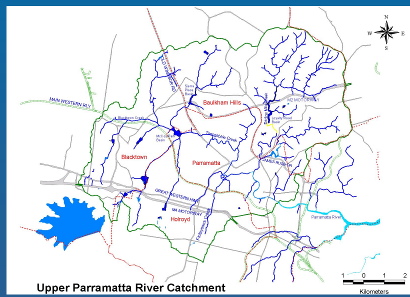
## UPRCT OSD Guidelines

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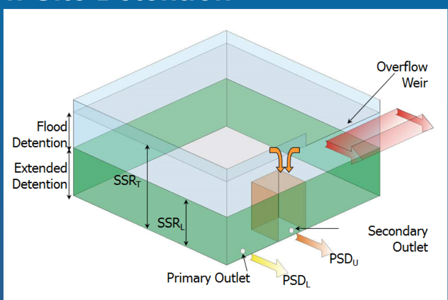
## On-Site Detention

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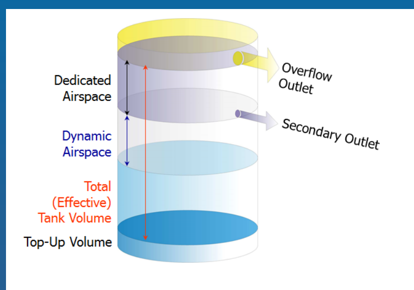
## UPRCT OSD Guidelines

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## UPRCT OSD Guidelines

$PSD_L$ 40 L/s/ha
$SSR_L$ 300 m³/ha

$PSD_U$ 150 L/s/ha
$SSR_T$ 455 m³/ha



## UPRCT OSD Guidelines

**On-Site Detention Calculation Sheet**

| | |
|---|---|
| Project: | UPRCT Handbook Worked Example No. 2 with Rainwater Tanks |
| Site Address | 24 Catchment Avenue, Parramatta |
| Job No: | 1234 |
| Designer: | Mr Engineer |
| Telephone: | (02) 1234 5678 |

**Site Data**

| | | | | |
|---|---|---|---|---|
| OSD Area: | Upper Parramatta River Catchment | | | |
| L.G.A | Parramatta City Council | | | |
| Site Area | 0.258 | ha | | |
| Total Roof Area | 0.135 | ha | | |
| Area of Site draining to OSD Storage | 0.239 | ha | Satisfactory | |
| Residual Site Area (Lot Area - Roof Area) | 0.123 | ha | | |
| Area Bypassing Storage | 0.019 | ha | | |
| Area Bypassing / Residual Site Area | 15% | | Satisfactory | 30% Max |
| No. of Dwellings on Site | 20 | | Satisfactory | |
| Site Area per Dwelling | 0.0129 | ha | | |
| Roof Area per Dwelling | 0.00675 | ha | | |



## UPRCT OSD Guidelines

**Rainwater Tank Calculations (per Dwelling)**

The calculations assume that the same size rainwater tank is installed on each dwelling

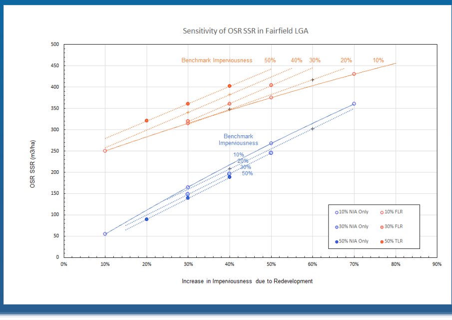
| | | | | | |
|---|---|---|---|---|---|
| | | | | Min | Max |
| % of Roof draining to Rainwater Tank | 94.0% | | Satisfactory | 93.3% | 100% |
| Rainwater Tank Volume | 3.00 | kL | OK | | |
| **Dedicated Airspace** | | | | | |
| Dedicated Airspace | 0.00 | kL | Satisfactory | | |
| | Extended Detention | | | Detention | |
| Dedicated Airspace Credit | 0.00 | kL | | 0.00 | kL |
| Maximum Tank PSD | 40 | L/s/ha | | | |
| Maximum Tank Discharge | 0.0 | L/s | | | |
| Maximum Head to Centre of Tank Orifice | 0.250 | m | No Dedicated Airspace | | |
| Calculated Orifice Diameter | 0 | mm | No Dedicated Airspace | | |
| **Dynamic Airspace** | | | | | |
| Maximum Dynamic Storage | 3 | kL | Controls minimum % Roof to Rainwater Tank | | |
| Daily Demand on Rainwater Tank | 0.657 | kL/d | Satisfactory | | |
| Dynamic Airspace at start of Storm | 2.99 | kL | | | |
| | Extended Detention | | | Detention | |
| Dynamic Airspace Credit | 0.50 | kL | | 0.52 | kL |
| Combined Rainwater Tank Credit | 0.50 | kL | | 0.52 | kL |
| Maximum Rainwater Tank Credit | 1.90 | kL | | 2.89 | kL |
| Rainwater Tank Credit per Dwelling | 0.50 | kL | | 0.52 | kL |



## UPRCT OSD Guidelines

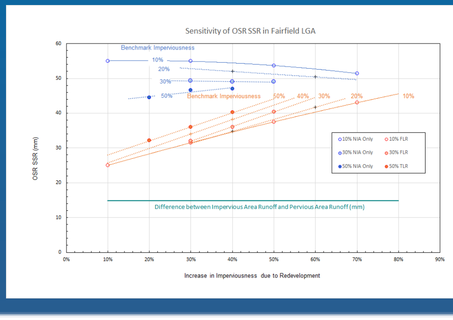
| | | | | | | |
|---|---|---|---|---|---|---|
| **Basic OSD Parameters** | | | | | | |
| | | Extended Detention | | | Detention | |
| Basic SSR Vols | Ext Detention Storage | 300 | kL/ha | Total Storage | 455 | kL/ha |
| Basic PSDs | Primary (Lower) Outlet | 40 | L/s/ha | Secondary (Upper) Outlet | 150 | L/s/ha |
| **OSD Tank Bypass** | | | | | | |
| Residual Lot Capture in OSD Tank | | 85% | | | | |
| Adjusted PSDs | | 35 | L/s/ha | | 119 | L/s/ha |
| **OSD Calculation** | | | | | | |
| | | Extended Detention | | | Detention | |
| Basic SSR Volume | Ext Detention Storage | 77.40 | kL | Total Storage | 117.39 | kL |
| Total Rainwater Tank Credits | | 9.92 | kL | | 10.45 | kL |
| Storage Volume | | | | Total | 106.94 | kL |
| Storage Volume | Ext Detention Storage | 67.48 | kL | Flood Detention Storage | 39.46 | kL |
| OSD Discharges | Primary (Lower) Outlet | 9.12 | L/s | Secondary (Upper) Outlet | 30.73 | L/s |
| RL of Top Water Level of Storage | | 36.750 | m | | 36.900 | m |
| RL of Orifice Centre-line | | 35.600 | m | | 35.600 | m |
| Design Head to Orifice Centre | | 1.150 | m | | 1.150 | m |
| Calculated Orifice Diameter | | 64 | mm | Satisfactory | 117 | mm |

## On-Site Retention






## On-Site Retention





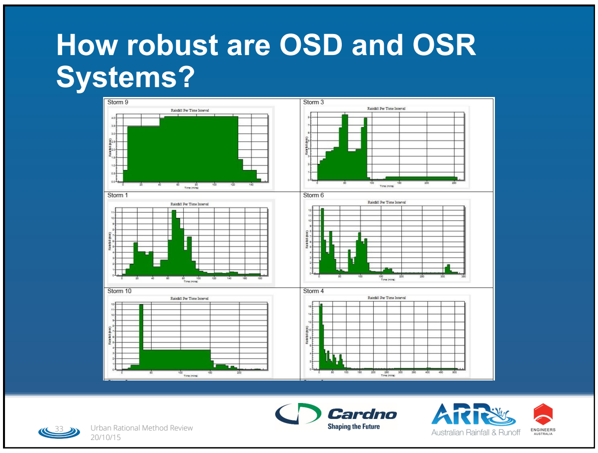

## How robust are OSD and OSR Systems?

Preliminary assessments undertaken of the performance of a lot scale OSR and OSD at lot, neighbourhood and subcatchments scales under eleven 100 yr ARI storms to assess the robustness or otherwise of OSR and OSD systems



## How robust are OSD and OSR Systems?

| Storm | Storm Duration (mins) | Storm Duration (hours) | Adjusted Event Depth (mm) | Critical Burst AEP | Critical Burst Length (hrs) | Adjusted Critical Burst Depth (mm) | Ajusted Preburst Depth (mm) | Ajusted Postburst Depth (mm) |
|---|---|---|---|---|---|---|---|---|
| 9 | 150 | 2.5 | 97.0 | 1.15% | 2.08 | 94.1 | 0.7 | 2.2 |
| 1 | 180 | 3.0 | 87.6 | 0.80% | 1.42 | 80.2 | 1.2 | 6.3 |
| 10 | 235 | 3.9 | 101.1 | 1.04% | 2.08 | 94.1 | 2.5 | 4.4 |
| 3 | 255 | 4.3 | 91.8 | 0.85% | 1.50 | 82.0 | 0 | 9.8 |
| 6 | 335 | 5.6 | 102.3 | 1.38% | 2.00 | 92.5 | 0 | 9.8 |
| 4 | 510 | 8.5 | 91.2 | 1.38% | 1.50 | 82.0 | 0 | 9.1 |
| 2 | 580 | 9.7 | 94.6 | 1.01% | 1.42 | 80.2 | 2.3 | 12.1 |
| 5 | 685 | 11.4 | 125.1 | 1.24% | 1.67 | 85.6 | 38.1 | 1.3 |
| 11 | 930 | 15.5 | 146.3 | 1.05% | 2.50 | 101.8 | 20.8 | 23.6 |
| 8 | 1255 | 20.9 | 216.4 | 0.98% | 2.00 | 92.5 | 108.8 | 15.1 |
| 7 | 2385 | 39.8 | 227.5 | 0.96% | 2.00 | 92.5 | 95.9 | 39.1 |


How robust are OSD and OSR Systems?
Storm 9
Storm 3
Storm 1
Storm 6
Storm 10
Storm 4
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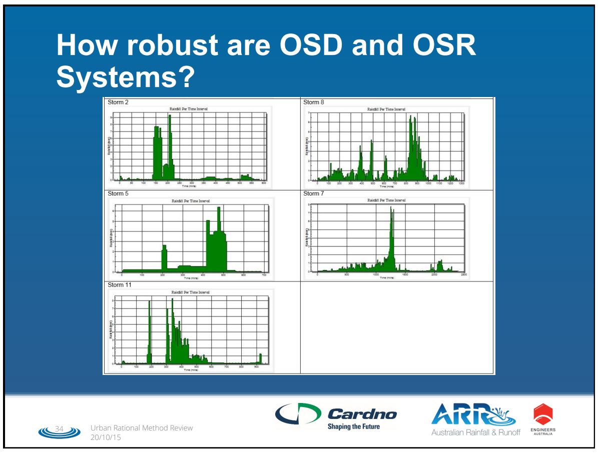
How robust are OSD and OSR Systems?
Storm 2
Storm 8
Storm 5
Storm 7
Storm 11
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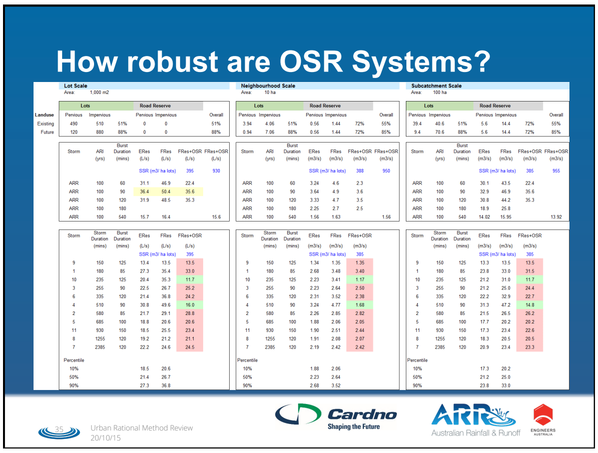
How robust are OSR Systems?
Lot Scale
Neighbourhood Scale
Subcatchment Scale
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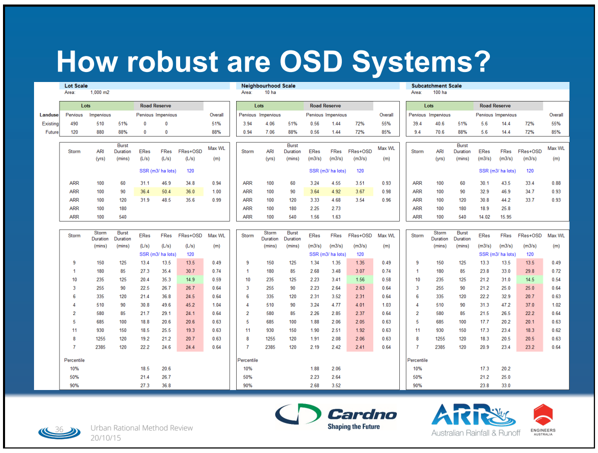
How robust are OSD Systems?
Lot Scale
Neighbourhood Scale
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## Comparison of OSD and OSR Performance

| Lot Scale | | | | | Lot Scale | | Neighbourhood Scale | | Subcatchment Scale | |
|---|---|---|---|---|---|---|---|---|---|---|
| Area: 1,000 m2 | | | | | Area: 1,000 m2 | | Area: 10 ha | | Area: 100 ha | |
| Storm | Storm Duration (mins) | Burst Duration (mins) | ERes (L/s) | FRes (L/s) | FRes+OSR (L/s) | FRes+OSD (L/s) | FRes+OSR (L/s) | FRes+OSD (L/s) | FRes+OSR (L/s) | FRes+OSD (L/s) |
| | | | SSR (m3/ ha lots) | | SSR (m3/ ha lots) | | SSR (m3/ ha lots) | | SSR (m3/ ha lots) | |
| | | | | | 395 | 120 | 395 | 120 | 395 | 120 |
| 9 | 150 | 125 | 13.4 | 13.5 | 13.5 | 13.5 | 1.35 | 1.35 | 13.5 | 13.5 |
| 1 | 180 | 85 | 27.3 | 35.4 | 33.0 | 30.7 | 3.40 | 3.07 | 31.5 | 29.8 |
| 10 | 235 | 125 | 20.4 | 35.3 | 11.7 | 14.9 | 1.17 | 1.56 | 11.7 | 14.5 |
| 3 | 255 | 90 | 22.5 | 26.7 | 25.2 | 26.7 | 2.50 | 2.63 | 24.4 | 25.0 |
| 6 | 335 | 120 | 21.4 | 36.8 | 24.2 | 24.5 | 2.38 | 2.31 | 22.7 | 20.7 |
| 4 | 510 | 90 | 30.8 | 49.6 | 16.0 | 45.2 | 1.68 | 4.01 | 14.8 | 37.0 |
| 2 | 580 | 85 | 21.7 | 29.1 | 28.8 | 24.1 | 2.82 | 2.37 | 26.2 | 22.2 |
| 5 | 685 | 100 | 18.8 | 20.6 | 20.6 | 20.6 | 2.05 | 2.05 | 20.2 | 20.1 |
| 11 | 930 | 150 | 18.5 | 25.5 | 23.4 | 19.3 | 2.44 | 1.92 | 22.6 | 18.3 |
| 8 | 1255 | 120 | 19.2 | 21.2 | 21.1 | 20.7 | 2.07 | 2.06 | 20.5 | 20.5 |
| 7 | 2385 | 120 | 22.2 | 24.6 | 24.5 | 24.4 | 2.42 | 2.41 | 23.3 | 23.2 |

Less than OSR Outflow
Same as OSR Outflow
Greater thanOSR Outflow



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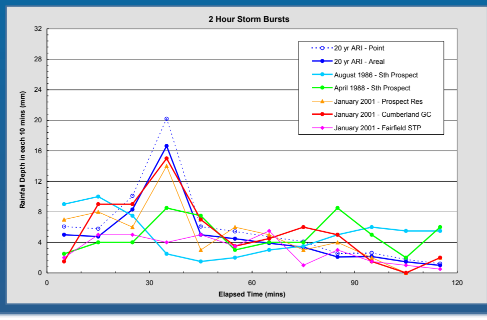
## How robust are OSR Systems?



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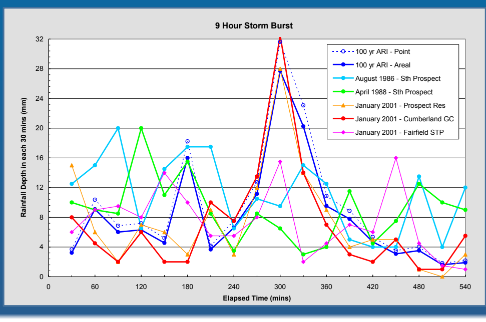
## How robust are OSR Systems?



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Project 23 Stage 3:
Detention and Retention



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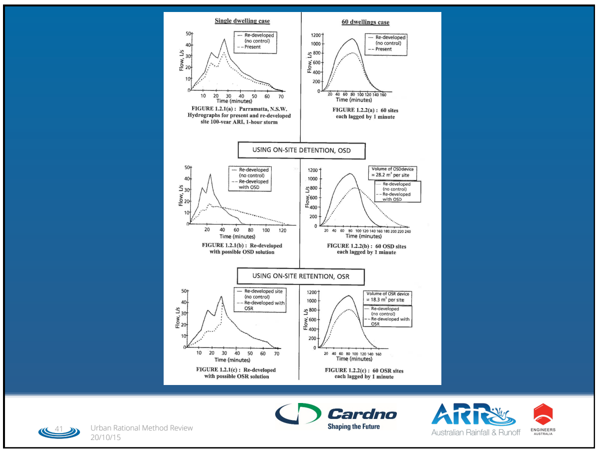
Single dwelling case
Flow, L/s
Re-developed (no control)
Present
Time (minutes)
FIGURE 1.2.1(a) : Parramatta, N.S.W. Hydrographs for present and re-developed site 100-year ARI, 1-hour storm
60 dwellings case
Re-developed (no control)
Present
FIGURE 1.2.2(a) : 60 sites each lagged by 1 minute
USING ON-SITE DETENTION, OSD
Re-developed (no control)
Re-developed with OSD
FIGURE 1.2.1(b) : Re-developed with possible OSD solution
Volume of OSDdevice = 28.2 m³ per site
FIGURE 1.2.2(b) : 60 OSD sites each lagged by 1 minute
USING ON-SITE RETENTION, OSR
Re-developed site (no control)
Re-developed with OSR
FIGURE 1.2.1(c) : Re-developed with possible OSR solution
Volume of OSR device = 18.3 m³ per site
FIGURE 1.2.2(c) : 60 OSR sites each lagged by 1 minute
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