Reality check: Are the assumptions underpinning Queensland's stormwater policy still valid

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Key points

- The evidence base underpinning Queensland's stormwater quality policy is overdue for review.
- Contemporary data suggest urban stormwater pollutant loads are significantly lower than current assumptions.
- Key assumptions in the original policy business case are no longer valid.
- Policy implementation has been inconsistent and often diverges from the original WSUD vision.
- Effective policy requires ongoing monitoring, transparent data and periodic recalibration.

Abstract

Queensland's State Planning Policy was one of the first policy instruments in Australia to set statewide targets for urban stormwater quality and waterway stability. The policy has been in place for over 15 years. Since that time there has been a significant advancement in our understanding of stormwater quality and waterway erosion issues, and the efficacy of treatment measures, however the policy has remained static and not been reviewed.

This review finds that the waterway stability aspects of the policy are rarely implemented in private development projects and local and state government infrastructure projects. Similarly, the stormwater quality provisions are often not implemented, and if they are it is primarily via proprietary stormwater treatment measures which are inconsistent with the original policy intent.

The Business Case that underpinned the policy has been reviewed, and several fundamental assumptions around zero land take, cost, efficacy, and the mandatory use of rainwater tanks are no longer valid. The policy was widely promoted to mainstream exemplar examples of water sensitive urban design like Coomera Waters, but there have been no developments like that since 2010.

The policy was implemented at a time when the community ranked waterway heath above housing affordability as an issue of concern. As urban development pressure on waterways increases and the demand for fast and cheap development grows, it's important to have well-designed policy that meets its objectives.

Keywords

Stormwater management, policy, WSUD, MUSIC

Introduction

Urban stormwater management policy in Queensland has undergone a profound transformation over the past three decades. Prior to the 1990s, stormwater management focused primarily on drainage, flood mitigation and erosion control. Growing concerns regarding the ecological health of South East Queensland waterways, together with the emergence of Water Sensitive Urban Design (WSUD), led to the introduction of a series of policies, guidelines and planning instruments aimed at reducing the impacts of urban development on receiving waters.

Queensland's State Planning Policy (SPP) for Healthy Waters, introduced in 2010 and subsequently incorporated into later versions of the State Planning Policy, was among the first regulatory frameworks in Australia to establish statewide objectives for stormwater quality and waterway stability. The policy sought to protect environmental values by requiring urban development to achieve specified reductions in pollutant loads and to manage the erosive impacts of altered flow regimes. The policy was supported by the Urban Stormwater Quality Planning Guidelines and MUSIC Modelling Guidelines, which together established the technical basis for demonstrating compliance.

More than fifteen years have passed since the policy framework was established. During this period there has been substantial advancement in the understanding of urban stormwater quality, hydrology, waterway geomorphology and the performance of stormwater treatment measures. Large contemporary monitoring datasets have become available, new research has been published on pollutant export processes and treatment efficacy, and significant changes have occurred in urban development practices and housing policy. Despite these developments, the core assumptions underpinning the policy framework have remained largely unchanged.

This paper reviews the evidence base that underpins Queensland's stormwater quality provisions, examines the extent to which the policy has been implemented in practice, and considers whether the assumptions that supported its original business case remain valid. The review draws on contemporary stormwater quality datasets, an audit of development applications across major South East Queensland local governments, and an examination of the technical and economic assumptions embedded within the original policy framework. The findings raise important questions regarding the effectiveness of the current approach and highlight the need for a comprehensive review to ensure future policy remains evidence-based, cost-effective and capable of delivering meaningful environmental outcomes.

Current policy

Queensland's current stormwater framework evolved through the Queensland Model Urban Stormwater Management Guidelines (1999), Urban Stormwater Quality Planning Guidelines (2009) and SPP 4/10 Healthy Waters (2010) to become the State Planning Policy (SPP) Water Quality State Interest.

The post construction phase stormwater management design objectives for SEQ are to reduce TSS, TP and TN loads by 80%, 60% and 45% (the stormwater quality design objectives differ slightly in across 4 other key climatic regions), and to manage waterway stability by limiting the peak 1-year ARI event discharge within the receiving waterway to the pre-development peak 1-year ARI discharge.

The SPP stormwater quality targets were derived from nominating a point of diminishing returns on bioretention treatment performance curves derived using MUSIC in accordance with the MUSIC Modelling Guidelines (Water by Design 2010a). The targets are not based on the water quality objectives of receiving waters.

Stormwater quality

The 2010 MUSIC Modelling Guidelines cites three primary sources for the recommended urban event mean concentration (EMC) and dry weather concentration (DWC) values for total suspended solids (TSS), total phosphorus (TP) and total nitrogen (TN). These are described below.

Duncan (1999)

Duncan (1999) contains predominantly international data, little Australian data, no Queensland data and does not represent contemporary urban conditions. With regard to TSS data, Duncan notes '*the observed range extends from 2.8 mg/L for a rural stream in Minnesota to 14,541 from urban cobblestone streets in Leningrad in 1948-50*'. The Duncan roof data set is based on atypical roof conditions from US and Europe with an average TSS value more than 25 times that reported by Coombes in SEQ in (2000).

Brisbane City Council (BCC) (2004)

BCC (2004) was based on only two catchments. The data are not publicly available. Review of the underlying dataset identified unusually high nutrient concentrations and apparent anomalies.

Correspondence with the original peer reviewer suggested the possibility of contamination from an unidentified source.

Fletcher et al (2004)

This report compiled data from a range of sources, with the data used to derive urban residential parameters drawn primarily from BCC (2004). The Fletcher et al (2004) dataset is also heavily reliant on Duncan (1999) for split catchment parameters (e.g. roofs and roads).

The other two relevant cited sources are:

- Coombes et al (2000) – who measured roof runoff at a property in Fig Tree pocket and recorded low TSS values (1.37 mg/L) but did not report TN or TP values.
- Drapper et al (2000) who monitored road runoff water quality at 21 sites around Brisbane and reported TSS TP and TKN (not TN) values.

These two studies form an incomplete basis to establish EMC and DWC values for a split catchment approach, and Drapper has previously highlighted the issue that a split catchment approach based on Water by Deign 2010 produces significantly different pollutant loads to a lumped catchment approach.

Contemporary stormwater quality data

Bligh Tanner has compiled one of the largest datasets of urban stormwater quality in Australia. The dataset is based on some of the studies cited in Drapper et al (2022), including Parker (2010), Liu (2011), Lucke (2017), Manganka (2013), but also adds additional data including

- Brisbane City Council Monitoring for its Hanlon Park Bur'uda project
- Monitoring by the Australian Centre for Tropical Freshwater Research
- Darwin City Council's stormwater quality monitoring program

Plots for TSS are provided below in Figure 1, noting a log scale is used given the data tend to be highly skewed to lower values.

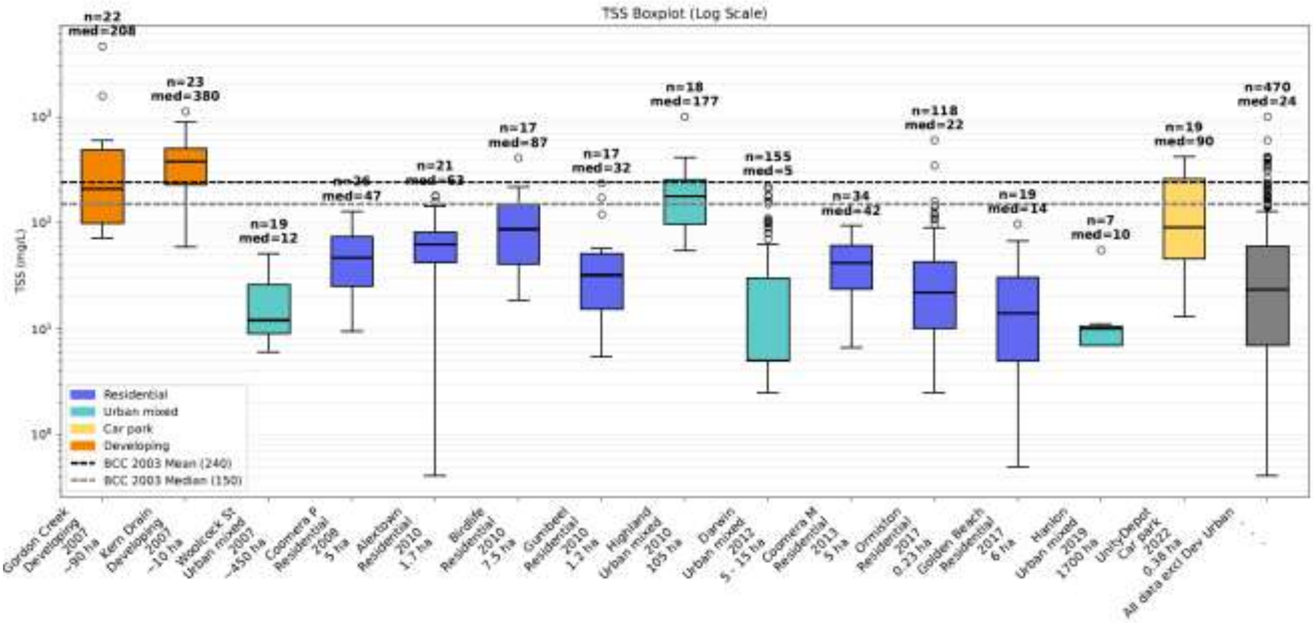

Figure 1 TSS concentrations from various studies (log scale)

Summary statistics, comparing the contemporary dataset with BCC (2004) are presented in Table 1 below. BCC (2004) reported median concentrations 6.4, 2.2 and 1.7 times higher than the contemporary dataset for TSS, TP and TN respectively.

Table 1 Stormwater quality comparison: BCC 2003 vs contemporary dataset

	TSS		TP		TN	
	BCC 2004	This dataset(1)	BCC 2004	This dataset(1)	BCC 2004	This dataset(1)
Median	150	23.5	0.33	0.15	1.8	1.05
Mean	240	51.2	0.45	0.30	2.12	1.57
StDev	288	85	0.47	0.58	1.21	1.83
no. Samples	209	470	209	365	209	365
No.catchments	2	13(2)	2	12(2)	2	12(2)

Note 1: All data excluding developing urban catchments

Note 2: All Darwin sites have been grouped into the same catchment given their proximity

Hydrology and runoff volumes

Accurate estimation of runoff volumes is critical to the prediction of stormwater pollutant loads. In MUSIC, pollutant loads are calculated as the product of runoff volume and pollutant concentration, meaning errors in either parameter directly affect estimates of source loads and treatment performance.

There are relatively few empirical datasets describing annual runoff volumes from urban catchments in Queensland. Measuring annual runoff volumes is challenging because monitoring programs must capture both large storm events and low flows over extended periods. As a result, many published values are based on modelling rather than long-term field observations.

A comparison of available literature and monitoring studies is presented in Figure 2. Most studies report annual volumetric runoff coefficients (AVRCs) in the range of approximately 30–45%, whereas application of the recommended rainfall-runoff parameters in the MUSIC Modelling Guidelines (Water by Design, 2010a) produces an AVRC of approximately 63% for a typical Brisbane residential catchment. This suggests runoff volumes, and therefore pollutant loads, may be substantially overestimated when the default MUSIC parameters are applied.

The runoff parameters adopted in Water by Design (2010a) were derived from WBM (2005), a study undertaken for Brisbane City Council. Review of that study identified several limitations, including the use of catchments with known flow monitoring issues, calibration using daily rather than sub-daily data, and poor agreement between modelled and observed runoff volumes. In addition, WBM (2005) emphasised the importance of effective impervious area (EIA) in model calibration, whereas Water by Design (2010a) subsequently recommended that EIA be assumed equal to total impervious area for urban development.

While further research is warranted, the available evidence suggests the runoff volumes predicted using the current MUSIC Modelling Guidelines are likely to be higher than those observed in contemporary urban catchments. This has important implications for the estimation of pollutant loads and the perceived benefits of stormwater treatment measures.

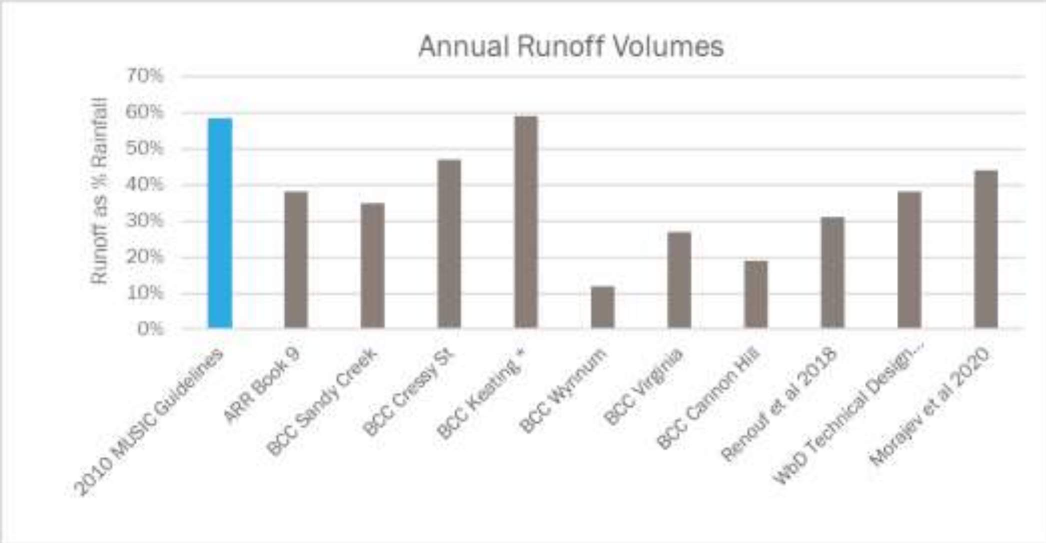

Figure 2 Annual runoff volumes from various studies

WBM 2005

Water by Design (2010) relied on rainfall-runoff parameters from *Estimation of MUSIC Parameters for use in Brisbane City* (WBM 2005). That study is not publicly available but has been accessed under Right to Information for this study. Several key problems have been identified with that work:

- The catchments were a poor choice given the land uses and nature of sampling locations, and the flow data were acknowledged as being problematic with unexpected baseflows during dry periods. The catchments should not have been used as the baseline to characterise urban runoff for all of SEQ.
- The WBM (2005) calibration methodology was poor. Five- and six-minute rainfall and runoff data were aggregated to a daily timestep for calibration. Given the catchments have times of concentration in the order of 30 minutes, converting data to a daily timestep smooths out all intense storm events from the data, and the resulting parameters should have been deemed unsuitable for use in a 6-minute timestep model.
- The calibration was weak. From WBM (2005) Table 6-26, it is shown that the 'calibrated' parameters underestimated Sandy Creek flow volumes by 49% and overestimated Cressey Street flow by 80%.
- Water by Design (2010) failed to properly incorporate the findings of WBM (2005). Significantly, WBM (2005) notes 'The impervious fractions required by MUSIC are 'directly connected' or 'effective' impervious areas, as opposed to those estimated from impervious areas' (Section 5.1). The MUSIC calibrations for the two urban catchments were based on an effective impervious area (EIA) to total impervious area (TIA) ratios of 7% and 20% respectively. Water by Design (2010a) adopts the balance of the calibration parameters, but is explicit that modelling should be based on EIA = TIA.

Business case

As part of the development of the State Planning Policy Water Quality requirements, a business case was prepared to determine if the benefits of applying WSUD practices to achieve best practice stormwater management are likely to outweigh the costs for typical development types (Water by Design 2010b). This business case formed the basis of the cabinet submission in support of the SPP. A summary of key assumptions in the business case is provided in Table 2 below.

The business case concluded: 'The cost–benefit frameworks demonstrate that, when considered as a whole, the potential benefits of WSUD practices to achieve best practice stormwater management on typical developments in Queensland are likely to exceed the estimated costs'.

When MUSIC is parameterized using the contemporary stormwater quality dataset which has lower pollutant concentrations, and with rainfall runoff parameters that produce runoff volumes more reflective of literature values (collectively referred to as an evidence based approach), the overall pollutant loads coming off urban catchments are significantly less than loads derived based on the 2010 MUSIC Modelling Guidelines. If the current SPP targets are achieved, the net load reductions are also significantly lower. Results for Brisbane are presented in Table 3 below, which shows the abatement of TSS, TP and TN being 85%, 47% and 40% lower under an evidence-based approach.

Table 2 Key assumptions underpinning the Business Case for WSUD

Key business case assumptions in Water by Design 2010b	Relevance/Currency
The value of pollution reduction was estimated to be worth more than the life cycle cost of WSUD assets. This was based on an assumption that the value (benefit) of TN removal in WSUD systems was equal to the levelised annual treatment costs to remove nutrients from wastewater of $515,000 per tonne of TN (WbD 2010 p21).	The TN removal rate for bioretention systems was based on inflated estimates of TN loads, and the adopted marginal cost of TN abatement is significantly higher than the cost of enhanced denitrification at an STP of A$14,621 (2018) and methanol dosing at an STP of A$40,207 (2018) (Synergies Economic Consulting 2018).
The potential avoided waterway rehabilitation life cycle costs were estimated to be worth around 70% of the life cycle cost of WSUD assets.	The key mechanism to avoid waterway rehabilitation is by reducing the erosivity of flows. However, none of the SEQ local governments routinely enforce the SPP's waterway stability requirements, and local governments do not always complete waterway rectification when WSUD is not adopted. The costing case study was based on a development with an unusually long length of waterway relative to its catchment, which amplified the economic benefit of avoided rehabilitation costs on a $/ha basis.
The amenity benefits of WSUD would result potential property premiums estimated to be around 90% of the capital cost of WSUD assets.	The majority of WSUD assets are underground proprietary treatment systems that provide no enhanced amenity that would increase property values. For the vegetated systems delivered, the majority provide limited amenity, and many detract from site amenity.
WSUD practices can be accommodated within developments without loss of developable land, and land costs were excluded from the analysis.	While this is the case in some developments with otherwise unusable low lying land, or mixed use sites with high landscaping requirements, in the majority of urban developments there is a direct impact on site yield.
Rainwater tanks were included as part of the base case.	The cost of rainwater tanks was not included in the economic analysis on the basis that tanks were mandated separately to the SPP by the Queensland Development Code Mandatory Parts 4.2 and 4.3 (QDC). Rainwater tanks ceased being mandatory in Queensland in Feb 2013 which increased the cost of complying with the SPP targets as larger treatment systems are required.

Table 3 Modelled Pollutant Loads per Hectare of residential development in Brisbane.

	2010 MUSIC Guidelines			Evidence-based approach		
	Source loads	Treated loads	Load reduction	Source loads	Treated loads	Load reduction
TSS	1580	241	1339	246	44	202
TP	3.12	0.70	2.42	1.61	0.33	1.28
TN	15.20	7.00	8.20	7.64	2.72	4.92

The Business Case adopted a marginal cost of TN abatement of $515,000 per tonne which combined with a load reduction of 8.2 kg/yr/Ha puts the value of TN abatement at $4223/yr per Ha of development. If the upper value of TN abatement of $40,207 from Synergies (2018) is adopted as well as the evidence-based TN reduction from Table 3, the estimated economic value of TN abatement decreases from approximately $4,223/ha/year to approximately $51/ha/year

SPP compliance rates

The SPP water quality provisions are reflected in the planning schemes of local governments in Queensland. To assess the level of compliance with the SPP we undertook an audit of development applications across major local governments in SEQ: Brisbane, City of Gold Coast, City of Moreton Bay, Logan and Ipswich. The approach looked at 310 code-assessable material change of use (MCU) applications across residential (excl dwelling houses), commercial and industrial land uses and over a three-month period of 1/7/2024 to 30/9/2024.

Applications were reviewed for evidence of a stormwater quality management report or assessment demonstrating compliance with planning scheme provisions. The audit found 72% of applications did not address stormwater quality. Of the 28% of applications that included a stormwater management plan addressing stormwater quality, 79.5% adopted proprietary underground treatment systems, and 20.5% adopted vegetated treatment systems (primarily bioretention or variants thereof). 22% of applications included stormwater detention, however none of those addressed the 1 yr ARI waterway stability criteria included in the SPP. The author has only once in the past 16 years been required to comply with the waterway stability objective.

Discussions with practitioners and local government officers indicate increasing resistance to accepting long-term maintenance responsibilities associated with WSUD assets.

Monitoring

There has been negligible investment by the Queensland Government in monitoring urban stormwater quality or the efficacy of the SPP. The primary Queensland Government catchment loads monitoring program is summarized in *South East Queensland water quality statistics for event flow and base flow conditions* (Orr et al 2017). The report includes data from 26 monitoring sites across SEQ. None of the sites were within or downstream, of urban catchments.

Significant monitoring has occurred as part of the testing and verification of the performance of proprietary treatment devices under Stormwater Australia's Stormwater Quality Improvement Device Evaluation Program (SQIDEP) with many sites reporting very low influent concentrations (see for example Drapper et al 2018). These data have tended to be discounted on the basis that: the data do not align with BCC (2004), Duncan (1999) and Fletcher et al (2004), the limitations of which were discussed previously; and vendors of proprietary products have been considered untrustworthy, which is ironic given it is not in their interests to have low influent concentrations.

The City of Moreton Bay monitored the performance of the Glenmay Crt wetland in 2014. The results were initially encouraging, with reductions in TN and TP concentrations of 90% and 89% respectively soon after establishment, however over a six-month period the performance deteriorated and TN and TP concentrations increased by 56% and 1500% after which time the monitoring program was aborted (K Waite, Pers Comm, 2017).

Conclusions

Queensland's stormwater quality provisions were developed at a time when relatively little empirical data were available and when there was strong community and political support for ambitious waterway protection measures. The State Planning Policy represented a significant step forward in recognising the cumulative impacts of urban stormwater on waterways and establishing a consistent framework for managing those impacts across Queensland.

However, the findings of this review indicate that several of the key assumptions underpinning the policy framework are no longer supported by the contemporary body of evidence. The datasets used to establish urban pollutant concentrations and rainfall-runoff parameters were limited in extent, contained known uncertainties, and in some cases were not publicly available for independent scrutiny. Contemporary monitoring data suggest that urban stormwater pollutant concentrations are substantially lower than those assumed in the current framework, while evidence regarding runoff volumes suggests that existing modelling guidance may overestimate pollutant loads and treatment benefits.

The review also found that implementation of the policy has been inconsistent. Waterway stability requirements are rarely addressed in development assessment, stormwater quality requirements are frequently not implemented, and where they are implemented, compliance is increasingly achieved through proprietary treatment systems rather than the broader water-sensitive urban design outcomes originally envisaged. At the same time, several assumptions that formed the basis of the original business case—including mandatory rainwater tanks, negligible land take and high nutrient abatement values—have changed substantially.

Perhaps most significantly, there has been little investment in monitoring the effectiveness of the policy itself. Without systematic monitoring of urban stormwater quality, treatment system performance, waterway condition and compliance outcomes, it is difficult to determine whether the policy has achieved its intended environmental objectives or whether alternative approaches may provide greater benefit.

The purpose of this paper is not to argue against stormwater management, but to highlight the importance of maintaining an evidence-based policy framework. Effective environmental regulation depends on transparent data, robust scientific foundations and periodic review. As Queensland continues to experience rapid urban growth and increasing pressure on waterway health, there is a compelling case to revisit the assumptions, targets and implementation mechanisms that underpin the current framework, and to ensure future policy is informed by the best available evidence. If policy is to remain credible, it must evolve when the evidence changes.

The Victorian and NSW stormwater quality policy frameworks are primarily founded on the BCC(2004) dataset, and so the findings of this paper have potential policy ramifications in other jurisdictions in Australia.

Acknowledgements

Several of my Bligh Tanner colleagues have contributed to this research in various ways, including Carlos Gambirazio, Riley De Jong, Lysani Pallay, Poppy Nguyen and Himanthi Mendis, however the views in this paper are those of the author alone. Dr Darren Drapper has taught me to keep asking questions. Jack Mullaly showed me that evidence rarely overcomes vested interests. DA research was supported by Chika Callista.

References

ACTFR (2008) *Water quality monitoring of the Black Ross Basins: 2007/08 wet season*. Report No. 08/04 for the Black Ross WQIP. Australian Centre for Tropical Freshwater Research

Brisbane City Council, (2004). *Stormwater Quality Monitoring Program 2002/2003 Final*, October 2004. Water & Environment, City Design.

Drapper D, Olive K, McAlister T, Coleman R and Lampard J-L (2022) A Review of Pollutant Concentrations in Urban Stormwater Across Eastern Australia, After 20 Years. *Front. Environ. Chem.* 3:853764. doi: 10.3389/fenvc.2022.853764

Duncan (1999) *Urban Stormwater Quality: A Statistical Overview (Report 99/3). Melbourne, Australia: Coordinated Research Centre for Catchment Hydrology Monash University*

Fletcher et al (2004) Fletcher T.D., H. Duncan, P. Poelsma and S. Lloyd (2004). *Stormwater Flow and Quality, and the Effectiveness of Non-Proprietary Stormwater Treatment Measures: A Review and Gap*

Analysis. CRC for Catchment Hydrology Technical Report 04/08, Monash University, Melbourne.
Hill;, P and Thompson, R. 2019. Book 5, Chapter 3 *Losses in Australian Rainfall and Runoff - A Guide to Flood Estimation*, Commonwealth of Australia
Lucke, T., Drapper, D. & Hornbuckle, A., 2018. *Urban stormwater characterisation and nitrogen composition from lot-scale catchments - New management implications*. Science of The Total Environment, Volume 619-620, pp. 65-71.
Orr, D.N., Turner R.D.R., Thomson, B., Ferguson, B., Newham, M., Wallace, R., Huggins, R., Severino, Z. 2017. *South East Queensland water quality statistics for event flow and base flow conditions: 2002–2015.* Department of Science, Information Technology and Innovation. Brisbane.
Parker, N. 2010. *Assessing the effectiveness of water sensitive urban design in South East Queensland*. (Master of Engineering), Queensland University of Technology.
Phillips, B., Goyen, A., Thomson, R., Pathiraja, S. and Pomeroy, L. (2014), *Australian Rainfall and Runoff Revision Project 6: Loss models for catchment simulation* - Urban Losses Stage 2 Report, February.
Synergies Economic Consulting (2018) *Economic and financial assessment of the NuWater project* Final report to the Queensland Farmers' Federation
Water by Design (2010a). *MUSIC Modelling Guidelines (Version 1)*. South East Queensland Healthy Waterways Partnership, Brisbane, Queensland
Water by Design (2010b). *A Business Case for Best Practice Urban Stormwater Management (Version 1.1)*. South East Queensland Healthy Waterways Partnership, Brisbane, Queensland
WBM (2005) *Estimation of MUSIC Parameters for use in Brisbane City*. A report for Brisbane City Council prepared by WBM Pty Ltd doc ref R.15158.001..00lpt.doc Rev 0 dated 19/4/2004