HYDROLOGICAL CONNECTIVITY IN THE CITY-REGION LANDSCAPE: HAS PLANNING MISSED THE BOAT?

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Abstract: Urbanisation processes significantly impacted and continue to impac systems in the city-region scale. The current fabric of urban areas is largel land development and planning decisions in which there was relatively little impact upon hydrological systems within and outside urban areas. Typically, close relationship, urban and regional planning and water resources manageme carried out separately and guided by different institutional arrangements. impacts of urbanisation on hydrological systems extend beyond urban stream h include urban residents liveability. Further, climate change and ongoing po are set to add additional pressures on how both our cities are planned and are managed. Hence, there is increased need for better integration between th

Drawing on a conceptual framework based on urban metabolism, this paper whether an integrated greenspace framework could provide the missing link fo (re) thread hydrological connectivity in its decision-making process. The paper basis for this exploration the current state of greenspace planning in three city-regions: South East Queensland, Melbourne and Perth. The analysis foc documents, including plans, strategies and policies used to guide water reso planning and management in the three regions. Findings are discussed around themes related to hydrological and environmental connections, and whole c planning.

Keywords: water sensitive cities, urban metabolism, Australia

1. Introduction

Following a worldwide trend, since the late 1940 s, the Australian urbanisa favoured the use of engineering solutions to manage water flows in urbanised al., 2009). Accordingly, many urban streams were piped and located undergrou systems were channelized to enable urban expansion into floodplain areas. As continued to be buried, paved, and directed into culverts, pipes and concre greater became the habitat degradation, pollution and fragmentation of urban associated greenspaces such as riparian vegetation (Elmore and Kaushal, 200 Australian cities expanded to accommodate ongoing population growth, area greenspaces have become increasingly fragmented and replaced by impervious (Donofrio et al., 2009).

Additionally, at a catchment and regional scale, abovementioned urban water approaches have disrupted natural flooding processes by removing vegetation impervious paved surfaces, eliminating natural water storage capacity in th disrupting surface water flow paths (O Neill cited in Lennon et al., 2014). in severe weather events due climate change is likely to exacerbate water ma and thus compromise the liveability of urban areas (JimØnez Cisneros et al., urban areas are deeply connected to, and dependent on, the natural features they are located in and water comprises a critical linking element whose conn be better understood by and considered in decision-making processes concernin

The impacts of urbanisation on natural processes could be reduced if decisi
urban and regional planning and water resource management were better
However, typically, water resources management in Australia has been carried
government and non-government agencies without being coordinated and/ or in
address the total water cycle (National Water Commission, 2013). This pa
contribute to informing improved water governance in Australia by explorin
joined urban and water management approach could be facilitated through a
greenspace framework[1] (incorporating natural ecosystem and green infrastructur
favours the restoration of hydrological connectivity across the city-regio
paper draws on the urban metabolism concept as the basis for this exploration
the current state of greenspace planning in three Australian capital city-r
Queensland (SEQ), Melbourne and Perth.

2. Research Approach

Three case study areas have been selected as the subject for this paper: th
Melbourne Metropolitan Region and the Perth Metropolitan Region. Water mana
these regions is performed under distinct jurisdictional and institution
therefore providing scope for comparing water planning and governance ac
statutory and non-statutory planning systems.

Data was collected through a documentary search targeting online document
through state and local governments websites, including planning policie
strategies and secondary reports related to water resource management in the
in-depth content analysis was subsequently performed through a coding system
software. Coding reported by this paper refers to two themes: hydrological an
connections, and whole of landscape planning (see Table 1).

In total 106 documents were analysed, 37 for the SEQ region, 39 for the Mel
and 30 for the Perth region. However, it is important to highlight that thi
cover the review of all available plans and strategies but a selection of d
provide insights to water management at the city-region scale. Table 2 pro
analysed documents along with coding results across the three regions.

Table 1. Themes used to guide documentary content analysis

Themes	Sub-themes
Hydrological and environmental connections	Ecosystem services
	Water quality
Planning	Whole of landscape planning

3. Results

Themes discussed in this section are listed in Table 1. Results for each them
the following sequence: SEQ region, Melbourne Metropolitan region and Perth
region.

[1] The terms greenspace and open space are often used interchangeably by scholars, consultants and gove
around the world (Swanwick, C., Dunnett, N. & Woolley, H. 2003. Nature, role and value of green space in
overview. Built Environment, 29, 94-106). Generally speaking greenspace can be defined as areas within th
that may or may not be publically accessible. They may be part of a functional infrastructure or ame
churches, cemeteries, parks and gardens) or be a natural and semi-natural area (forests, wetland, etc.).

3.1 Hydrological and Environmental Connections

References to hydrological and environmental connections were registered in documents for the SEQ region. These include connections associated with wate well as large infrastructure projects. For example, the QLD Urban Drainage reference to the impact of land use types on hydrological regimes. Reference of ecosystem services were found in five of the documents. In particular, the outlines a clear framework to apply the concept of ecosystem services to na management in the region. The State Planning Policy recognises the need to co of ecosystem services in planning decisions.

Less than a third of the analysed documents for the Melbourne metropolitan references to hydrological and environmental connections. These referenc connections between stormwater and water quality, alteration of hydrological urban development, linking water quality of Port Phillip Bay with landuses a and traditional stormwater system designs focused on transporting water only.

References to hydrological and environmental connections were registered in l of the documents for the Perth Metropolitan region. Observed references ack relationship between landuses and hydrological balance; existence of groundwa systems; impact of hydrological changes on the region s wetlands; and role water management practices in reducing water balance problems by taking into the region s hydrological regimes, including groundwater and surface water Given the hydrogeological characteristics of the region, references to the ro systems in supporting the region s ecosystems and human population are frequ documents, particularly the Gnangara groundwater system. Specifically, th Regional Water Plan Discussion Paper outlines the need to protect this syste quality due to its high water supply value for the region:

> Drinking water source protection has had a dramatic impact on land-use the region. The urban corridor concept, in large part, reflects a desir high water-supply values of the Gnangara and Jandakot mounds from inco land uses. (p. 48)

Documents also make references to the need to improve stormwater management t impact on the water quality of the region s waterways and wetlands. Decline across the region has

been attributed to large modifications to surface water hydrology due to urban development as well as inadequate stormwater management practices t consider interactions between surface flows, groundwater hydrology and l characteristics of waterways. Only two documents make references to the ecosystem services. These include references to the ecosystem services pr region s wetlands, including flood control and improving water quality.

3.2 Whole of landscape planning

The analysis of 37 documents from SEQ reveals that only six of these docume consideration a whole-of-catchment approach to planning. These consideratio related to the water cycle and how management should take an integrated appr impacts on other parts of the regional landscape. For example, the Water by outlines that management practices need to consider the landscape scale:

Table 2. List of analysed documents along with coding results across the three regions

SEQ region	Hydrologic and environmenta connectior	Whole of landscape planning	Melbourne Metropolitan reg	Hydrologica and environmenta connection	Whole of landscap planning	Perth Metropolitan region	Hydrologica and environmenta connection	Whole of landscape planning
1. DEHP 2010 Urban Stormwater Plann Guidelines	*	*	1. BMT WBM 2013 Integrated Water Management Opportunities Fo Growth Areas	*		1. DEC 2009 GS Threatening Processes Groundwater System	*	*
2. DEHP 2013 Healt Water Management Plans Guideline	*	*	2. Catchment and Protection Act 1 Version 040			2. DH 2010 Greywater Reu Code of Prac		
3. DERM 2009 SEQ NRM Plan 2009-31	*	*	3. Citywest Water Permanent Water Saving Plan			3. DoW 2004 Stormwater Management Manual	*	
4. DERM Understanding Wa Resource Plannin			4. Design Flow 20 Quiet Lakes Wate Quality Manageme Plan			4. DoW 2008 Lo Water Management Strategy	*	
5. DEWS 2010 Wate Sewerage Plannin Guidelines. (ame 2014			5. DSE 2011 Draft Victorian Waterw Management Strat	*		5. DoW 2009 Decision Proc Stormwater Management		
6. DEWS 2013 Bulk water supply cod			6. DSE 2011 Governance Guide VIC Water Indust	*	*	6. DoW 2009 Dr Perth Peel Regional Wate Plan 2010-30		
7. DEWS 2013 Discussion Paper Water Sector 30yr Strategy			7. DSE 2011 Living Melbourne, Livin Victoria Roadmap			7. DoW 2009 Gnangara Groundwater Allocation P	*	
8. DEWS 2013 Qld Urban Drainage Manual	*		8. DSE 2012 Livin Victoria Implementation P	*		8. DoW 2009 GS Regional Aqui Modelling		
9. DEWS 2013 Water And Sewerage Code			9. DTPLI 2013 Oper Space Strategies PN70		*	9. DoW 2009 Jandakot Drainage and Water Management Pla	*	
10. DEWS 2014 WaterQ 30 Year Strategy			10. DTPLI 2013 Pl Melbourne 2050			10. DoW 2009 Land and Water Planning		*

SEQ region	Hydrologic and environmenta connectior	Whole of landscape planning	Melbourne Metropolitan reg	Hydrologica and environmenta connection	Whole of landscap planning	Perth Metropolitan region	Hydrologica and environmenta connection	Whole of landscape planning
						Background Paper		
11. DSDIP 2013 Coastal Protecti Regulatory Provi			11. DTPLI 2013 Pl Melbourne Direct Initiatives and Actions			11. DoW 2009 Perth Peel Regional Wate Plan Backgrou 2010-30	*	
12. Healthy Water Strategic Plan 2 22			12. DTPLI 2014 Pl Melbourne			12. DoW 2009 Perth Peel Regional Wate Plan Discussi Paper 2010-30	*	
13. Qld Environm Protection Water Poliy 2009			13. EPA VIC Bette Bays Waterway	*		13. DoW 2009 Toward a Wate Sensitivey Ci		
14. Qld Gov 2011 Greenspace Strat 2011-20			14. GAA PSP Guidelines Notes Integrated Water Management	*		14. DoW 2009 Urban Drainag Initiative Ph		
15. Qld Gov 2013 Queensland Plan			15. Melbourne Docklands 2008 E Guide			15. DoW 2010 Predicting Fu Demand For Water		
16. Qld urban uti Recycled Water Policy			16. Melbourne Docklands waterw strategic plan 2 18			16. DoW 2012 Water Monitor Guidelines	*	
17. Qld Urban Uti Water Netserv Pl Part A			17. Melbourne Wat 101			17. DoW 2013 Better Urban Water Management Guidance	*	
18. Qld Water Act 2000		*	18. Melbourne Wat 2007 Flood Management and Drainage Strateg			18. DoW 2013 Controlling Groundwater Urban Development		
19. Qld Water Efficiency Label Standards Act			19. Melbourne Wat 2007 Port Phill Westerport Regional	*		19. DP 2010 Directions 20		

SEQ region	Hydrologic and environmenta connectior	Whole of landscape planning	Melbourne Metropolitan reg	Hydrologica and environmenta connection	Whole of landscap planning	Perth Metropolitan region	Hydrologica and environmenta connection	Whole of landscape planning
			River Health gy					
20. Qld Water Regulation 2002			20. Melbourne Wa 2007 Principles Waterway and Drainge	*	*	20. DP 2010 Ou Metro Perth a Peel Sub-regi Strategy		
21. Qld Water Su Regulator 2013 Guidelines Water Supply And Sewge			21. Melbourne Wat 2008 Flood Prone Areas Guidelines			21. DP 2011 Central Metro Perth Sub-regional Stgyat		
22. QWC 2010 SEQ Water Strategy			22. Melbourne Wa 2011 Understandi the Western Port Environment			22. GHD 2008 Potential Use Stormwater in Perth gion Re		
23. QWC 2012 SEQ Water Strategy Annual Report			23. Melbourne Wat 2012 Draft Healt Waterways Strate			23. Government WA 2009 GSS Analysis of Public Submissions		
24. SEQ Healthy Waterways Strate 2007-2012	*		24. Melbourne Wat 2012 Draft Stormwater Strat	*	*	24. Government WA 2009 GSS Draft Sustainabilit Strategy		
25. SEQ Regional 2009 - 2031	*	*	25. Melbourne Wa 2012 Draft Waterways Operat Charter	*	*	25. WA 2006 SPI Water Resourc		
26. SEQHWS 2007-2012 Coastal Alg Blooms Action Pl	*		26. Melbourne Wat 2012 Planning fo SLR Guidelines			26. WAPC 2008 Better Urban Water Management	*	*
27. SEQWater 201 Land and Water Development Guidelines			27. Melbourne Wat 2012 Strategic Direction			27. WAPC 2008 Planning Bull 92	*	
28. SEQWater Strategic Plan 2 to 2016			28. Melbourne Wat 2013 Annual Repor			28. WAPC 2009 Liveable Neighbourhoods	*	*
29. Southern SEQ Distributor Ret			29. Melbourne Wa Integrated Water		*	29. Water Corporation 20	*	

SEQ region	Hydrologic and environmenta connectior	Whole of landscape planning	Melbourne Metropolitan reg	Hydrologica and environmenta connection	Whole of landscap planning	Perth Metropolitan region	Hydrologica and environmenta connection	Whole of landscape planning
Authority Agree 2011			Future Melbourn North			Water Foreve: Toward Climat Resilience		
30. State Plannin Policy 2013	*		30. Office of Liv VIC 2012 Water Cycle Management Business Strateg			30. Water Corporation 2 Water Forever Whatever the Weather		
31. Sustainabilit Planning Act 200			31. Office of Liv VIC 2013 Melbourne's Wate Future consultat paper	*	*			
32. Sustainable Planning Regulat 2009	*		32. Office of Liv VIC Melbourne's Water Future	*				
33.Water by Desi 2010 Deemed to Comply Solutions SEQ V1.0			33. South East Wa 2011 Permanent Water Saving Pla	*	*			
34.Water by Desi 2010 TWCM Planning Guidelir SEQ	*	*	34. South East Wa 2013 Draft Water Plan	*				
35.Water Resource Moreton Plan 200			35. South East Wa Corporate Plan 2 2016					
36.Water Supply S Reliability Act 2008			36. Water Act 198					
37.Water Transiti Regulation 2012			37. Water Supply Demand Strategy Melbourne 2006-					
			38. BMT WBM 2013 Integrated Water Management Opportunities Fo Growth Areas					
			39. Catchment an Land Protection 1994 - Version					

> Landscape intent – When considering a stormwater treatment measure, its co
> overall development form and landscape intent is important. In many situati
> used in the landscape to maximise visual and recreational amenity and to pr
> urban environment. (p. 8)

The analysis of 39 documents from Melbourne also shows that the concept of wh
planning is not widely discussed. In fact only eight of the documents had some re
an integrated and more holistic approach to water resource management and plannir
call for better integration between water and urban planning to maximise the p
planning in aiding the management of water resources, particularly drinking
stormwater. An example of this reference is provided by the Draft Waterway Manageme

> Actions to protect or improve waterway condition can have impacts on other
> urban water cycle, highlighting the need for urban planning, water planning
> management to be integrated to achieve multiple benefits. For example, inc
> harvesting can provide water to urban water users while at the same time p
> stormwater runoff to waterways. This interconnectedness requires planners fr
> urban water cycle to work together to deliver the best outcomes for the commu

Additionally, documents also outline the need for a water planning framework that
stakeholders interests as well as is aligned with a total water cycle management appro
the Living Victoria Implementation Plan refers to a new water planning framework
not only provide better integration between urban planning and water planning bu
multiple interests in water planning, including community s need:

> Reform Element 1: Overhaul Melbourne s water planning framework
> The first element in the Council s reform package is designed to match th
> framework with the evolving needs of the broader community. Currently water p
> predominantly by water businesses, with the broader community having a li
> proposed reform introduces a water planning framework enabling co-produced
> plans that meet community needs and integrate with urban planning. Importa
> changes to urban planning and building oversight that better reflect the wa
> necessary to ensure Melbourne s liveability. (p. 10).

Only four of the documents analysed for Perth make reference to the planning at
Specifically, the Gnangara Sustainability Strategy Threatening Processes to Ground
there is a gap in knowledge related to understanding ecosystem processes associate
the Gnangara system from regional perspective.

4. Concluding Discussion

Under a more holistic approach, water resources management and planning need to
hydrological and environmental connections as there is a direct interdependent rel
resources supporting cities and their surrounding region. With the exception
hydrological and environmental connections were often identified amongst analysed
included connections involving both surface and groundwater (particularly in the

relationship between stormwater management practices and water quality objectives need for water planning to consider broader regional and landscape scales were rar all levels.

Greenspaces play a critical role in the water sensitive cities. Trees and other support a range of hydrological functions, including water purification and wa mitigation and erosion control (Millennium Ecosystem Assessment, 2005). Unfortu regional planning approaches in the three case study areas have not considered hy through greenspace planning in their main policy and decision-making processes. pressures from climate change and population growth demand a rethink in the way manage water resources in our urban areas to ensure they continue to be viable in t

Investing urban planning and management efforts towards establishing an integr greenspaces at the city-region scale could result in significant improvements to b streams. For example, Sander and Zhao (2015) list a range of benefits associated w spaces, including ecological, social and economic benefits. Additionally, they a contribute to the stability, adaptability and resilience of urban socio-ecologi Zhao, 2015, pp. 194). For Sch ffler and Swilling (2013), there is advantage in cor green infrastructure to enable them to be designed and planned to function a supporting the re-establishment of hydrological connectivity in the city-region sca re-establishing greenspace connectivity can support multiple functions, including t enhancement of natural heritage and cultural relics, providing opportunities for r 2003); as well as guidance for urban growth and preservation of access to the co 2006). Furthermore, greenspaces connectivity can also be complemented by urban s integrate ecosystem services in the built environment. In particular, urban desig structures, such as green roofs and rain gardens, contribute to ecosystem re strengthening ecosystem functions (Andersson et al., 2014, pp. 450).

Integrated greenspace networks require spatial planning to allocate areas for gre with the natural hydro-geographic features of a city-region before other landuses and Shamir, 2010). Further, such planning needs to occur at the regional or ca ecosystem services provided by a certain parcel of land or land management action existing landuses throughout the catchment (Guswa et al., 2014). Planning for gree scale also facilitates the incorporation of ecological and catchment corridors (G Shamir, 2010). Additionally, planning that is based on the recognition of hydrolog landscape would caution away from developing settlements in floodplains, instead d for recreation and/or agriculture, which can be temporarily suspended during acceptable losses (Carmon and Shamir, 2010, pp. 187). It would also involve pres vegetated surfaces and restricting infill development in lower density areas on s soils may assist efforts to adapt to increased flooding risks in some catchments (C

However, retrofitting existing built areas to establish greenspace networks may p challenges stem from complex urban and water resource planning systems, inclu administrative responsibilities and high implementation costs through to variabili (Nickel et al., 2014). Although there is no one-size-fits-all solution to overco greenspace planning and water management in metropolitan regions (Nickel et al.

greenspace networks may be enabled under the concept of multifunctionality (Selman, 2011), thereby contributing to support water-related ecosystem services and hydro the landscape.

Currently, different government agencies and water businesses manage different s cycle in Australia, including water supply, drainage, water pollution, groundwate conservation and land use planning. Hence, greater coordination is needed to ensur to water management taking into consideration an integrated water resource manage key endeavour of such improved integration between the urban planning and water m could be the restoration of hydrological connectivity across the city-region integrated greenspace framework (incorporating natural ecosystem and green infrastr

The literature provides many definitions and interpretations as to what constitut end, an integrated greenspace framework comprises natural and human-made ecosyste not limited to, riparian vegetation, wetlands, urban parks, national parks, commu water sensitive urban designs such as green roofs, bioswales, rain gardens and fl fundamental aim of integrated greenspace framework is the restoration and mainten connectivity at the city-region scale that has been altered by urbanisation process

An integrated greenspace framework can fulfil multiple objectives relating to bio water resources, land protection, recreation, cultural uses, development control, a mitigation and adaptation. In fact, many scholars have argued that interconnec planned and delivered greenspaces at the city-region scale can provide multipl populations whilst supporting ecological and social processes (Kenway et al., 20 2013; Demuzere et al., 2014; Low Choy, 2009; Benedict and McMahon, 2002; Bengsto Mounting pressures related to managing urban growth, climate change, water secu degradation in metropolitan regions provide an impelling case for a system of mul greenspaces that contributes to such objectives. Specifically, there is incre enhancing multifunctional greenspaces in metropolitan regions as a means to make sustainable, equitable and liveable (Pincetl and Gearin, 2005). However, urban unevenly distributed across urban areas and often rare in socially disadvantaged and Haase, 2014). Thus, the achievement of a connected multifunctional system o integrated greenspace framework, is reliant on the integration and mainstreaming hydrological, biogeochemical and ecological water-related ecosystem services of urban and regional planning processes, and needs to be supported by appropriate r (Ashley et al., 2011; Benedict and McMahon, 2002).

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