

# Constraints and Opportunities for Management of Urban Waterways to Achieve Multiple Benefits

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## *Abstract*

*There is a strong push for rapid intensification of urbanisation across NSW, driven by the State government. For example, in the Georges River catchment the population is earmarked for more than a 20% increase in population by 2030. Without an abrupt change in the way that we manage urban landscapes, increased urbanisation will cause increased stormwater runoff, which is known to severely alter stream ecology and will limit the potential of receiving waterways to maintain a range of environmental, social, cultural and economic values. Catchment-scale management is required to counter ecological degradation of urban streams. But, given limited resources, local councils are usually tasked with achieving the best outcome from reach-scale management actions.*

*Across eight local councils, documentation regarding waterway management was reviewed and compared to information obtained from the staff of each council through individual face-to-face interviews and self-completed quantitative questionnaires. Whilst there was consistency between councils for external reporting in both Annual Reports and for incident and hazard reporting, there was much variability in the internal reporting related to waterways management. Council staff perceived that there were a range of recreational uses of the river and threats to achieving the full range of uses from the river, correctly identifying their role in the management of some threats, but overestimating their role in the management of other threats. Council staff with direct involvement in waterway management generally highly rated their own knowledge but thought their available support tools were lacking, and thought that the rest of council staff were broadly unengaged in thinking about waterways. This information will be used to guide capacity building aimed at increasing the ability of councils to apply best practice management of waterways, from development of plans and policies to implementation of on-ground actions.*

## **1. INTRODUCTION**

The Georges River catchment occurs within the Sydney metropolitan region, stretching from Botany Bay on the east coast of New South Wales west towards Prospect Reservoir and south into bushland around Campbelltown and Appin. The northern and western parts of the Georges River catchment are dominated by the expanses of Sydney's urban sprawl, with forested areas including those protected within national parks and the Holsworthy Military Base taking up much of the upper catchment to the south. The total length of the Georges River is around 100 km, with the tidal limit delineated by Liverpool Weir. The water is fresh above the weir and then increasingly saline as the river approaches Botany Bay.

Highly altered flow regimes experienced by local creeks occurs owing to increased urban runoff as well as channelisation of creeks, which causes erosion of the creek beds and banks, resulting in deeper, wider creek channels (Vietz et al. 2015). The eroded sediment has been transported downstream and into the Georges River. All activities across the highly populated and urbanised Georges River catchment (with more than 1.4 million residents) can affect the condition of aquatic

ecosystems (Tippler et al. 2012) and the recreational value of the river. Waterbodies are particularly susceptible to pollutants, as they are downslope and water transports potential pollutants when running across land. In urbanised areas, there are many potential pollutants and most water ends up flowing directly into waterways, rather than being filtered whilst infiltrating the ground or flowing through densely vegetated forests. This occurs because urbanised areas have lots of impervious surfaces (e.g. roads, roofs, paths, stormwater drains) (e.g. Tippler et al. 2012). Unfiltered urban stormwater runoff being delivered to waterways through hydraulically efficient drainage networks causes huge problems. The multiple symptoms of the 'urban stream syndrome' (Walsh et al. 2005) are well known and include highly altered flow, elevated concentrations of nutrients and other contaminants, altered channel morphology and reduced biodiversity.

The management of the Georges River and its catchment is spread across several local and state government organisations. Georges Riverkeeper aims to coordinate waterway management on a catchment basis to achieve greater efficiencies and effectiveness than could be achieved with each council and state organisation working in isolation. The Georges Riverkeeper aspiration goal is: 'Best practice environmental management for a liveable urban river' (Georges Riverkeeper 2018). Liveability is included in the aspirational goal in acknowledgement that waterway management is conducted to address multiple values, including environmental, social, cultural and economic (e.g. Taylor 2005). Further, it is in recognition that maintaining the full range of values is not feasible in highly altered urban landscapes. Whilst some aesthetic and recreational values along tributaries may be enhanced by reach-scale management, catchment-scale management is required to avoid the effects of urbanisation being transported and impeding downstream values (e.g. Walsh et al. 2005; Tippler et al. 2012).

For example, a recent study comparing concreted and non-concreted reaches in urbanised areas of the Georges River catchment reinforced that ecological integrity was mainly influenced by catchment-scale alteration of flow regimes and water quality, rather than reach-scale management practices (Tippler & Reid, 2018). Concreted channels are a ubiquitous and obvious example of the traditional management of urban streams for the sole purpose of being conduits for efficient drainage of stormwater to avoid risk of flooding. They are explicitly designed to severely alter flow regimes, with no consideration given to maintaining ecological values such as water quality or habitat, or social values such as aesthetics. Predictably, surveys of concreted channels in urban areas of the Georges River catchment of southern Sydney showed that their water quality and macroinvertebrate communities were distinctly different from those of non-engineered streams flowing through forests (Tippler & Reid, 2018). Surprisingly, and somewhat concerning, was the severe degradation of non-engineered urban streams, which were more likely being managed with a view to maintaining multiple values, but that had water quality and macroinvertebrate communities more similar to those in concrete channels than in forested streams (Tippler & Reid, 2018).

Despite widespread recognition that catchment-scale management of waterways is required and that scientists are appealing for improved integration of ecological concepts in waterway rehabilitation (e.g. Lake et al. 2007), this is hindered by a lack of effective communication between scientists, managers and policy makers. Although strategic plans are developed by councils and other waterway management agencies, implementation of those strategies is always constrained by available resources, so may ultimately be dependent upon how council strategies align with those of funding bodies. To our knowledge, there is no published information about how council waterway management strategies are designed to deal with such constraints.

With a view to unravelling the potential impediments to effective catchment-scale management in the Georges River catchment and to determine whether there was marked variation between councils, we explored council documentation and the perceptions of council staff about their engagement with the Georges River and their role in its management.

## **2. METHODOLOGY**

As part of a broader program review, Georges Riverkeeper engaged Bales Environmental Services to conduct a review and benchmarking study of how the eight participating councils manage the Georges River. The purpose for this review is for Georges Riverkeeper to identify synergies between Councils and coordinate its programs where Councils will have the most benefit.

The review included:

- developing a framework and methodology using positive language to evaluate councils on their river management practices;
- reviewing each participating councils documentation including policies and plans;
- conducting an online survey distributed to all council staff on their use and knowledge of the local waterways; and
- conducting face-to-face workshops with council staff whom worked most directly in waterway management to obtain relevant information relating to councils river management practices.

The results of the benchmarking process provided a rating for each council in terms of their river management, which was used to tailor recommendations aimed at improving the capacity of councils to implement catchment wide best practice management to improve the liveability of the river and its tributaries. These recommendations will be integrated into the Georges Riverkeeper Annual Workplan to achieve the Georges Riverkeeper Strategic Plan.

The analysis of the information relating to the Councils, and that of individuals providing information to the project, was completed in a manner which allows the information to be presented in an anonymous manner.

## **2.1. Benchmarking Process – review of documentation**

The review of Council's documentation involved obtaining the relevant documentation from Council staff, collation of any further information available through the Councils' websites and a structured approach to review the documents which considered the following points.

- Determination of the existence of specific documents (to allow a matrix of key documents across the eight member councils to be developed).
- Identification of the currency of the documents – when they were developed, whether review timeframes were met, whether they are relevant to the current Council's structure, so they meet relevant standards where applicable (based on the age of the document and when it was last reviewed).
- The completeness of the documents in terms of how the document relates to river management (based on a five-point rating scale, where one is no content and five is comprehensive coverage).
- The quality of the documents in terms of how the document related to river management (based on a five-point rating scale, where one is very poor quality and five is excellent quality).
- The level of knowledge of the document content, which feeds in from the stakeholder engagement process outlined below (based on a five-point rating scale, where one is where the council staff have no knowledge of the documentation to five where the council staff have an excellent knowledge of the documentation).
- The level of the 'real-life' implementation of the document content, which feeds in from the stakeholder engagement process outlined below (based on a five-point rating scale, where one is no implementation of the documentation to five where there is implementation of all document content/direction).

Based upon the information collated through the points above, each document was subjected to an analysis of the strengths and weaknesses of the documentation, identification of the opportunities to improve the documents to support improved river management, and potential threats to the river resulting from the current status of the documentation.

The types of documentation included in the review are:

- The most recent Annual Report
- Delivery and Operational plans covering the current period;
- Environmental policies;
- Environmental plans;
- Environmental management systems;
- Environmental incident reporting procedures;
- Water quality monitoring plans / summarised results;
- Georges River management specific documents;

- External education and/or promotional material relating to the management of the Georges River;
- Internal staff training or educational material relating to the river and stormwater management;
- Council and Senior Management meeting minutes relating to the management of the Georges River; and
- Any other documents relevant to the management of the Georges River

## **2.2. Benchmarking Process – on-line survey**

The intention of the staff engagement process was to involve a sufficient sample of the staff in the process without causing an excessive drain on the Council staff time. Central to this was the use of a simple on-line survey which encouraged participation by keeping the survey simple, ensuring anonymity for the participants and which did not take long to complete (the target was > 25 minutes, the actual average time to complete the survey was around 16 minutes).

The same broad themes were explored in the online surveys and the face-to-face workshops and consisted of a mix of semantic differential (1 to 5 scale) and open-ended (qualitative) questions. The questions explored a combination of the respondents' awareness of, understanding and implementation of river management practices within their own role and within the broader Council context. The online surveys were to be circulated to all or a wide range of Council staff.

## **2.3. Benchmarking Process – face-to-face workshops**

The face-to-face workshops were intended to allow a more in-depth exploration of the same themes covered in the on-line surveys, but with a focus on a small number of staff chosen to be most likely involved in river and catchment management. Eight workshops with key staff who interacted with the river and/or catchment in some way in their role were conducted, one with each participating council.

Council staff whose role is directly involved in river and/or catchment management were asked to rate their council by giving a rating out of five around four broad categories: knowledge about the rivers and catchments in the Council area; available tools and supporting documents; job specific focus on the waterways/catchment; and communication and community awareness

For anonymity, the names of councils are not reported in results, rather results are reported as Council A, Council B, etc.

# **3. RESULTS**

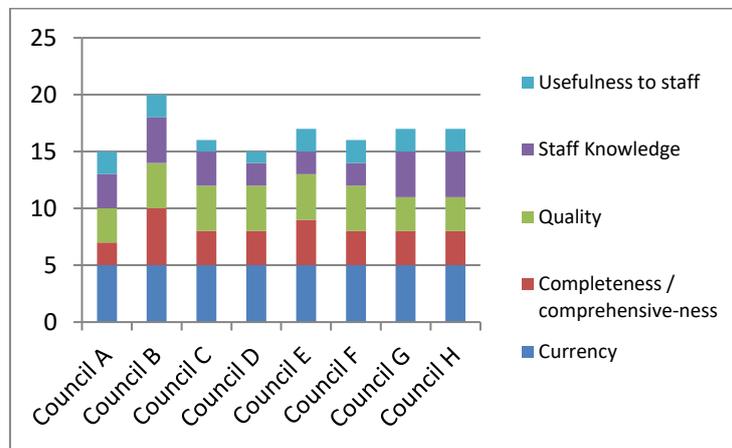
## **3.1. Documentation Review**

A range of publically available documents were obtained on the Council websites and a mix of documents was provided by the main project contact within each of the Councils. This resulted in a wide variety in terms of both the number and type of documents received. This reflected a combination of what documents were available, and how well the Council contacts knew which documents existed. There were however some key areas, for example Annual Reports and Operational/Delivery Plans, where there was consistency across all Councils.

For the purpose of this review process, if the documents were not obtained through the two-pronged approach described above they have been considered to not exist. It is recognised that this may underestimate the actual existence of documents.

The documentation review revealed that all Councils had an Annual Report, a Community Strategic Plan, Delivery Plan and Operational Plan. The consistency of documentation across all eight councils was limited beyond these core documents. Current broader environmental policies/plans and management systems, water quality monitoring plans with summarised results and specific documents to manage the Georges River were ad hoc across the eight Councils. External education and/or promotional material relating to the management of the Georges River and internal staff training or educational material relating to the river and stormwater management was also ad hoc and generally lacking within Council.

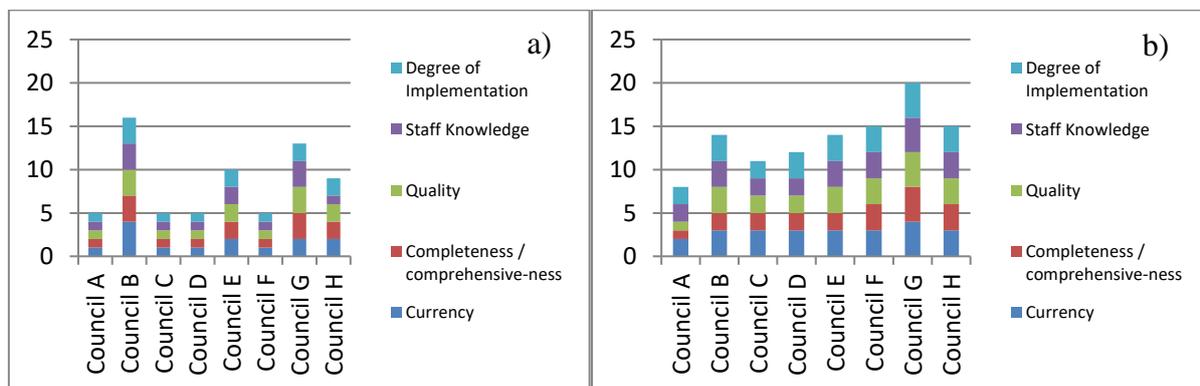
All Annual Reports were current (i.e. from 2016/17) and the quality was reasonably consistent across all Councils (Figure 1). The completeness/comprehensiveness and the knowledge of the reports by staff was variable across all councils and the usefulness of the document was very low for Council staff, which is to be expected as the primary purpose of the Annual Reports is a summary of council activities for those not working in council. All councils scored between fifteen and twenty points for their Annual Reports.



**Figure 1: Ratings for Annual Reports by eight councils in the Georges River catchment. Each criterion was scored across a scale from 1 (poor) to 5 (excellent), for a maximum total score of 25.**

Across councils, the ratings for internal environmental incident and hazard reporting procedures was poor (Figure 2a). Council A, C, D, and F received a total of 5 out of 25 when all criteria was considered. Council B scored the highest on internal environmental incident reporting procedures with a score of 16 out of 25.

External environmental incident and hazards reporting and response procedures were as a whole better than the internal reporting and procedures (Figure 2b). Council G score 20 out of 25, with the majority of Councils (Councils B, C, D, E, F, and H) scoring between 10 and 15 out of 25.



**Figure 2: Ratings for (a) Internal environmental incident and hazard reporting procedures, and (b) External environmental incident and hazards reporting and response procedures, for eight councils in the Georges River catchment. Each criterion was scored across a scale from 1 (poor) to 5 (excellent), for a maximum total score of 25.**

### 3.2. On-line Survey

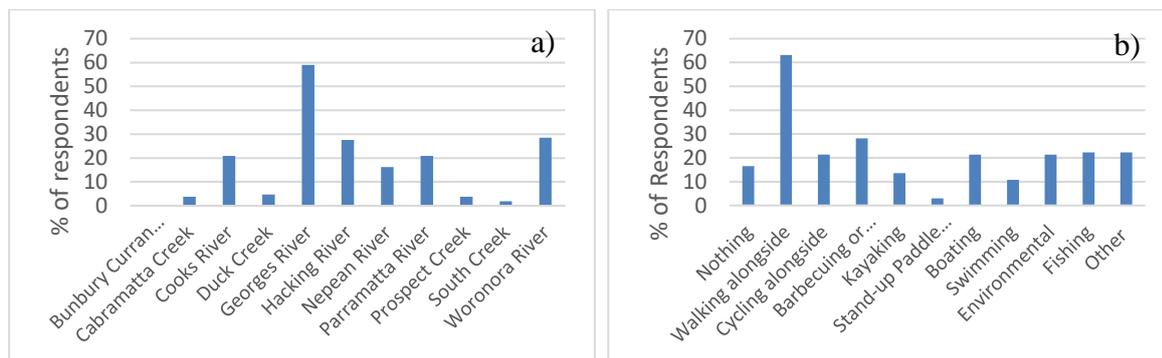
It was anticipated that all council staff would be requested to complete the on-line survey. The idea was to obtain a broad response which not only included staff that were closely involved with river management in some manner, but also staff with no direct involvement. However, not all Councils took the same approach in terms of the distribution of the survey, which had significant impacts on the ability to compare the results from the different Councils. As there were only

104 surveys completed in total, this resulted in a change in the way that the results could be analysed. Therefore the results and discussion for the on-line survey has been completed on the dataset as a whole not Council by Council, as anticipated.

More than 60% of the respondents had been working at council in their current position for more than three years and nearly 60% did not manage any staff. The majority (79%) could name one to three waterways within their Local Government Area. Three percent could not name one waterway, 15% could name four to nine different waterways and 3% could name twelve waterways.

#### Uses of the waterways

The most popular waterway that staff utilised in their personal life was Georges River (almost 60%), followed by the Woronora River (29%) and the Hacking River (28%) (Figure 3a). Walking alongside was the most popular use of the river of the respondents at more than 60%, followed by barbecuing or picnicking (28%) and fishing or other (each at 22%) (Figure 3b).



**Figure 3: (a) Percentage of respondents from eight councils in the Georges River catchment that utilise each of the nearby waterways and (b) recreational uses of those waterways.**

The respondents ranked that the most important activities to the local community were walking alongside the river and barbecuing/picnicking beside the river followed by cycling alongside and boating. The respondents ranked that the least important activities to the local community were swimming followed by stand-up paddleboarding, and environmental purposes (Figure 4).

Overall the respondents thought that 80% of the local community felt that the Georges River was very to extremely important to many people within the community.

#### Threats to the waterways

The respondents were asked to rank what they considered to be the greatest threats to the Georges River out of: increased urbanisation, stormwater contamination, industrial contamination, historical contamination, overuse by boats, over fishing, climate change, biological risks or litter. The scale was: no risk, moderate risk to small parts of the river, moderate risk to a large portion of the river, high risk to a large portion of the river and extreme risk to the river system as a whole.

Survey respondents consider both stormwater contamination and litter to be the greatest threats to the Georges River (more than 85% when high risk to a large portion of the river and extreme risk to the river systems as a whole are considered together for each threat), followed by increased urbanisation and industrial contamination (Figure 5). Overuse by boats and over fishing was considered to be moderate risk.

More than 40% of respondents considered the overall risk to the Georges River as high risk to a large portion of the river.

Council's role in stormwater management and litter management were the most important to the respondents, followed by weed management, community volunteers (bushcare) and enforcement activities (Figure 6). The role of Council in wastewater (sewage) management was the least important, although it was interesting that was rated of any importance, considering that wastewater management and licensing of industry are not the responsibility of council.

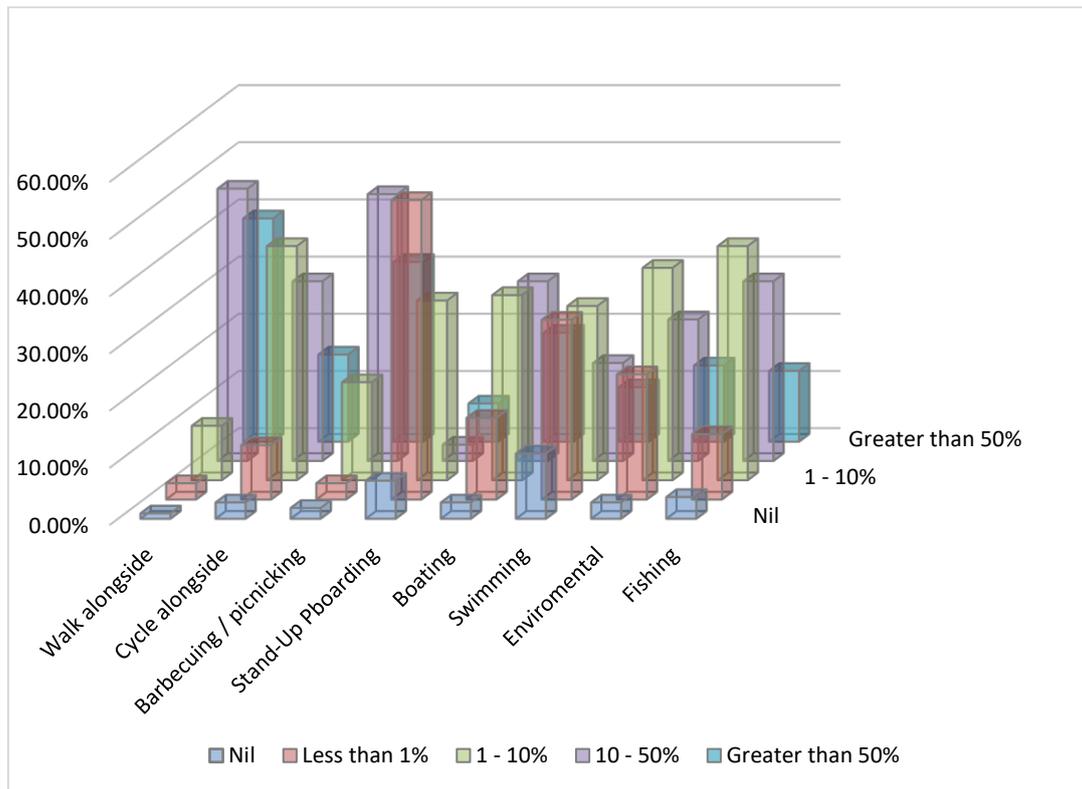


Figure 4: Ratings of perceptions of the importance of different recreational uses of the Georges River to the local community by staff of local councils

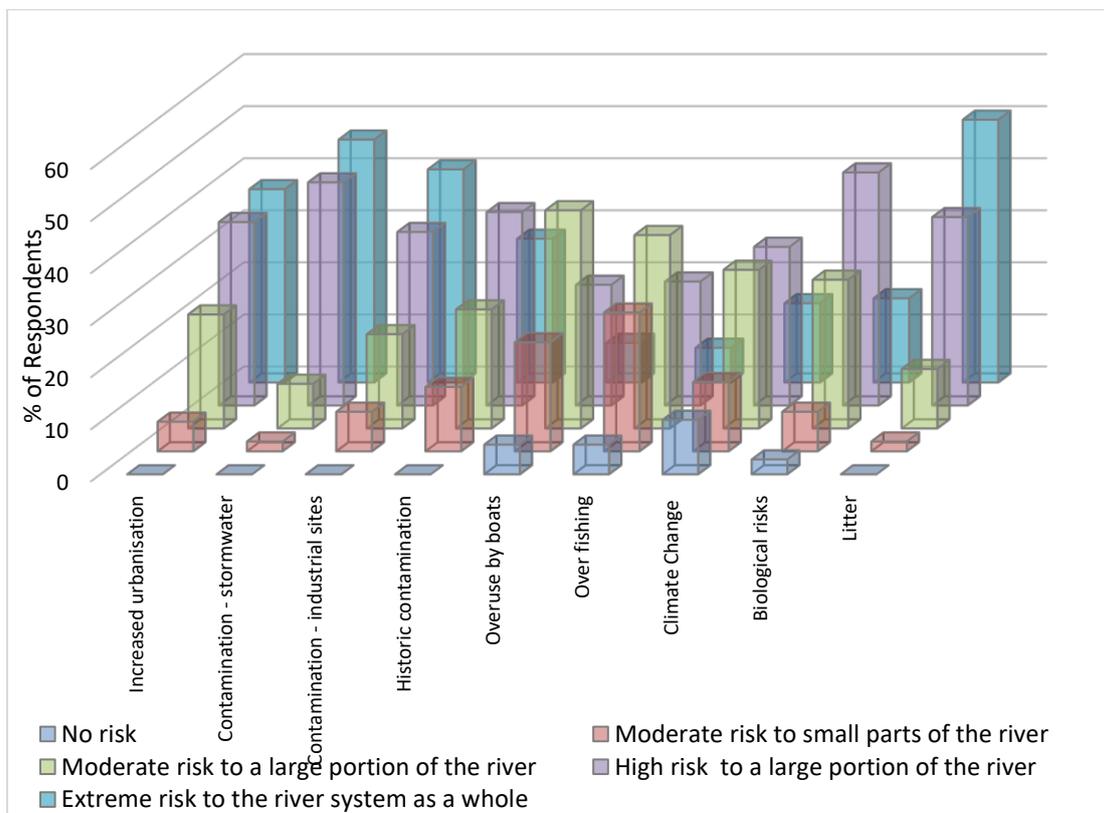
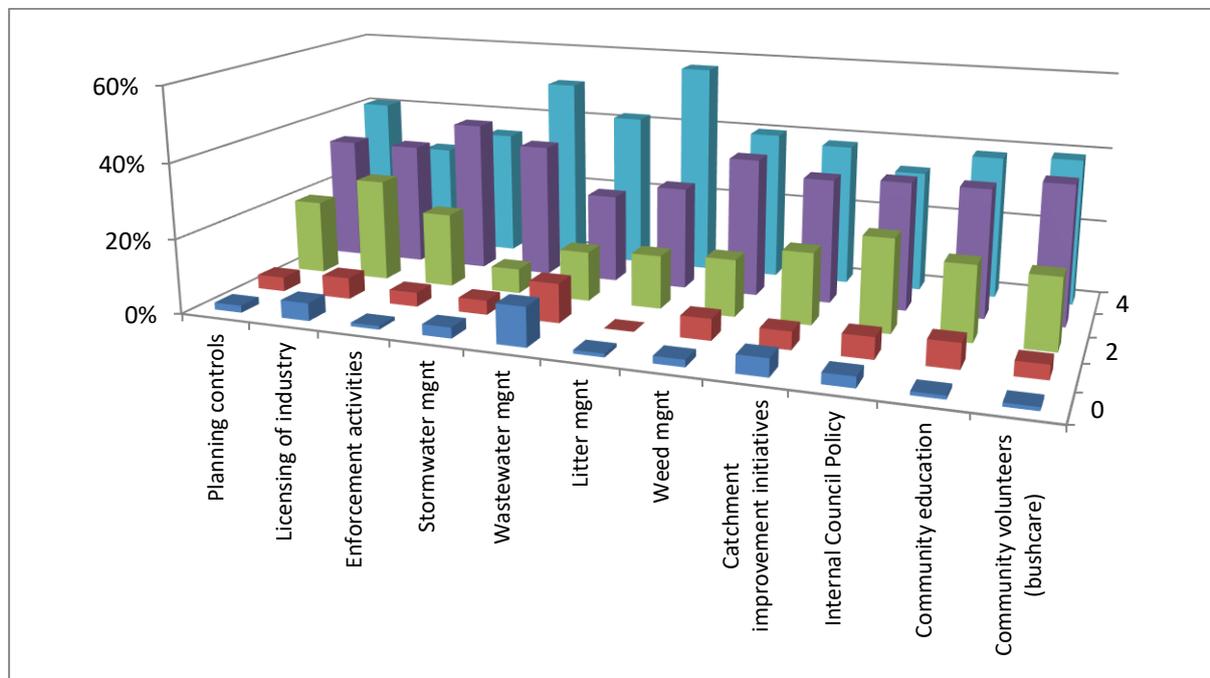


Figure 5: Ratings of perceptions of threats to the Georges River by staff of local councils

Overall just over 60% of respondents, all of who are council staff, believed they understood the role that Council plays in the management of the Georges River.

The respondents were asked how well they consider Council documents support good management of the Georges River. More than half said moderately well, most areas covered and less than 30% said some support provided but not an adequate amount.



**Figure 6: Council staff perceptions of the importance of Council roles in managing the Georges River.**

More than 40% of respondents thought that the suitability of a joint Council initiative like the Georges Riverkeeper is good but could be improved for managing a river system that passes through eight council areas and less than 40% thought it was the best approach possible. More than 15% felt the Georges Riverkeeper was okay but had room for a lot of improvement.

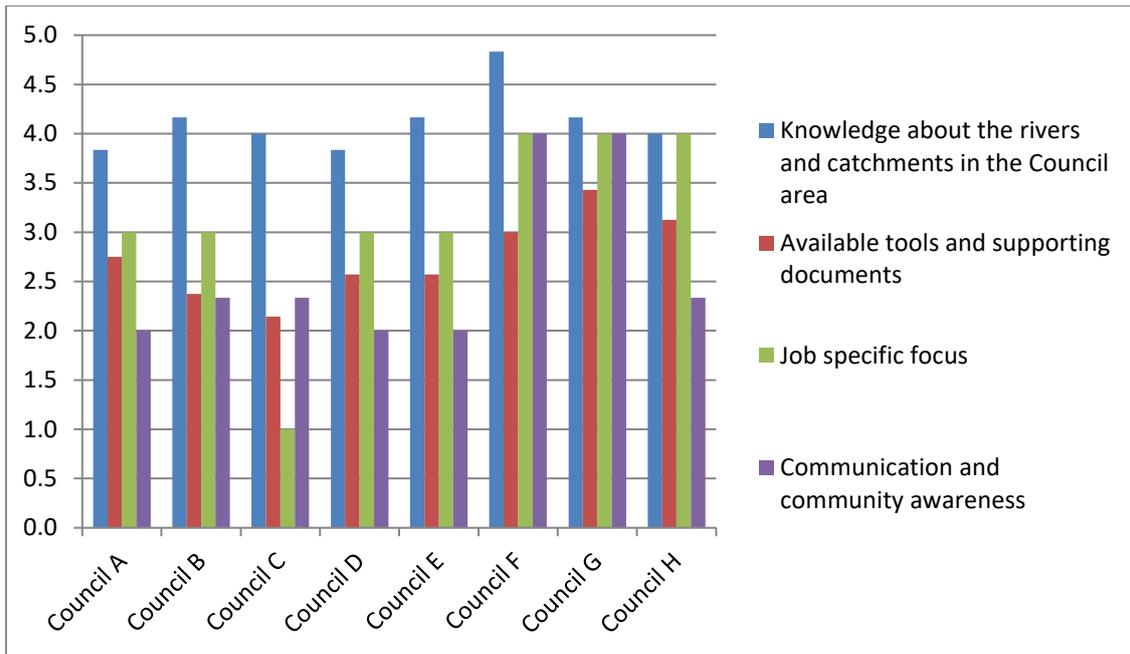
### 3.3. Face-to-face Workshops

In face-to-face workshops, knowledge about the rivers and catchments in the Council area rated as the highest category except in Council H, with the average ranging between 3.8 and 4.8 out of five. The Council staff present thought their knowledge of the Georges River and its catchment was high and Georges Riverkeeper as an organisation was widely known across Council (Figure 7).

Council staff were well aware of Council policies relating to the river/catchment management and considered that their Operational Plan was supportive of good river/catchment management. Council staff believed that the Council Annual Report did not summarise good river/catchment management practices well, the appropriateness of the policies could be improved and that the available tools were not being used effectively to support good management of the river/catchment. The rating for available tools and supporting documents category was lower overall than the knowledge category.

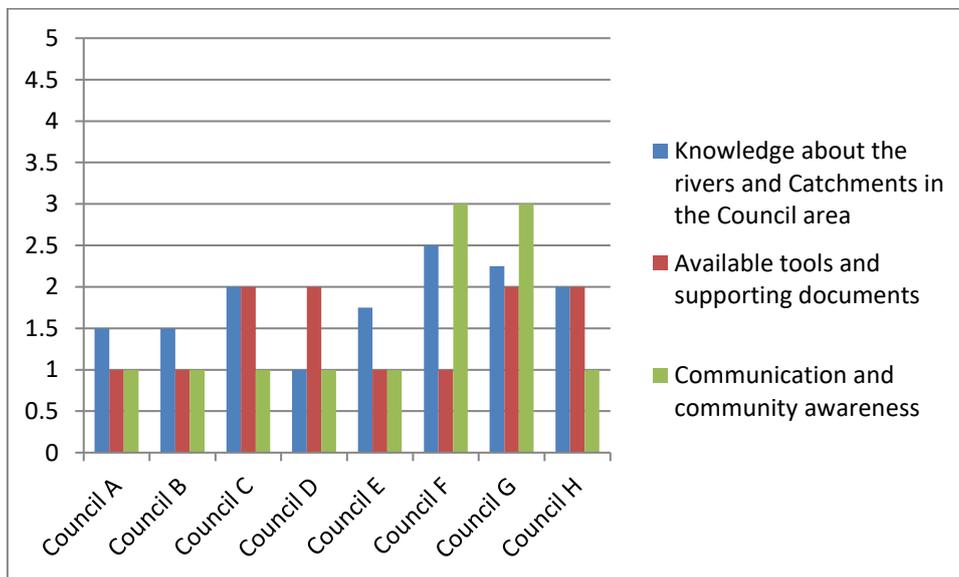
Other than Council C, all councils believed they received good support from their Council to allow them to undertake their work in a manner that supports good management of the river and its catchments.

For the majority of Councils, the effectiveness of how river/catchment management initiatives are communicated internally and to the local community was lacking, each scoring a 2.9 out of 5. Council staff also believe that external communication does not significantly contribute to better management of the river/catchments.



**Figure 7: Perceptions of staff involved directly in waterway management about their knowledge and support within councils**

The same Council staff as above were asked to rate the council staff generally out of five around three broad categories: knowledge about the rivers and catchments in the Council area; available tools and supporting documents; and communication and community awareness (Figure 8). The majority of council staff generally would include people who had nothing directly to do with the river/catchment management.



**Figure 8: Perceptions of staff involved directly in waterway management about the knowledge and support for waterway initiatives across councils**

Knowledge about the rivers and catchment in the Council area was rated below half at all councils, except Council F who rated it at exactly 2.5. Council staff believed that council staff generally had a bit of knowledge about the Georges River and its catchments and threats to these systems. The options available to manage the threats to the river/catchment and knowledge of the Georges Riverkeeper were much lower.

Council staff thought that staff generally were unaware of Council policies relating to river/catchment management or more generally environmental management if their role wasn't directly related. Overall

council staff believes that river/catchment management initiatives were ineffectively communicated internally.

## **4. DISCUSSION**

### **4.1. Documentation Review**

There was consistency amongst councils for external reporting, i.e. Annual Reports, plus external incidence and hazard reporting.

However, for internal incident and hazard reporting documentation there was room for improvement across most of the councils. Four Councils scored the lowest possible score in all categories indicating that there is no recognised process in place. Three other Councils tended to have an ad-hoc system, in the face-to-face interviews it was revealed that staff were generally unaware of and didn't use any policies or procedures relating to incident and hazard reporting. Only one council reported that it had a good system that was used to respond and report on incidents and hazards that reported up to the Councillor level. Despite the lack of formalised systems across most of the Councils the discussions during the staff workshops indicated that responses to internal incidents did generally work, although there was doubt that they would be robust enough to deal with major issues and failed to provide information that might preclude future occurrences.

In all Councils the external incident and hazard reporting processes were much better. This is thought to be because of the customer services staff are a central first point of contact for anyone external. The customer services staff have a process for contacting the relevant council staff or relevant external organisation regarding an incident or hazards reported by the public.

Councils are under pressure to respond to community requests within set timeframes for responding to and resolving customer requests. This drives the external process for incident and hazard reporting to be better than the internal reporting.

In the face-to-face workshops, staff were aware of a process for addressing external incidents and hazards, specifically their part in the process. However, staff didn't know how it worked or the processes behind it. All staff identified that the pressure to resolve the external reactive inquiries impacted, sometimes greatly, on their day-to-day role and their delivery of projects.

As expected with councils of different sizes and a few councils recently amalgamated there were large differences in the types of documentation each council has and the content within the document varied greatly as well.

### **4.2. On-line Survey**

Councils took different approaches to distribute the on-line survey, from sending the survey to all council staff, to sending it to only a small group within council. This led to a self-selecting relatively small group of staff completing surveys across all of the eight councils. There is an implied bias in this cohort, as the staff who took the time to complete the survey were probably more likely to know quite a bit about waterways and used them in personal life and/or their position at Council.

When analysing the data it was important to keep in mind that the types of staff who responded to the survey were mostly at officer level with no directly reporting staff, who have been in their current role more than three years.

Given the types of people who responded to the survey, it is not unexpected that the majority of them were able to name the large waterways within their local government area and being that they are at officer level and probably have quite a bit of interaction with their constituents, they also had were comfortable with their understanding of what they thought the community felt was important to them with respects to the river.

The respondents were accurate when rating the largest threats to the waterways as being stormwater contamination, litter and the effects of urbanisation. Stormwater is known to contribute over 95% of

pollutants reaching the Georges River (GRCCC 2013) and urbanisation has been shown to be associated with degradation of waterways in the Georges River catchment (Tippler et al. 2012), as for other catchments around the world (e.g. Walsh et al. 2005). Industrial contamination was also thought to be quite a large threat, which in the past it has been. However, since the 1970s, with the licencing requirements of industry through the NSW Environmental Protection Authority (EPA) industrial contamination to waterways is well regulated under the Protection of the Environment Operations Act 1997, therefore no longer a significant ongoing threat to waterways.

Biological risks were ranked quite low as a threat to the river, which is interesting as the tidal Georges River flow into Botany Bay, where there is a high chance of the introduction of biological risks being a working port that accepts vessels from all over the world (Pollard & Pethebridge 2002). As Councils tend to be focused on their local government area, perhaps they neglected to think about the impacts downstream when the Bay wasn't part of the LGA. For the upper river, where it is strictly freshwater, weeds and carp are quite a threat to the river as well.

When respondents were asked to rank the importance of the role council has in specific areas, it was notable that all listed activities scored high. This reflects the multi-role aspect of Council work. Even areas that are not typically Council's responsibility, like wastewater management and licencing of industry, scored high. In saying that some of the councils would still have a number of on-site sewage systems they would be inspecting and issuing Approval to Operate certificates.

Stormwater and litter management stood out as the most important role for councils. However, planning controls were not ranked to be as important. This was interesting, as Councils have a huge role to play in developing and implementing planning controls. Potentially the staff who completed the survey were not from the planning departments of council, leading to the role of planning being undervalued.

The respondents view of Georges Riverkeeper as a holistic catchment management group working with councils was quite strong and positive. Ways that councils and Georges Riverkeeper can work together should be encouraged to ensure implementation of best practice river management.

### **4.3. Face-to-face Workshops**

The face-to-face workshops were with staff whose role involved river management in some way. Knowledge of the waterways by these staff was good, but overall staff felt that their available tools and supporting documents were lacking. This is because staff often had to 're-invent the wheel' as there were a limited number of existing procedures or templates available. Staff felt they were constantly having to make process and templates up themselves. Most councils scored their job specific focus quite high. Perceptions of community awareness were low across most councils and councils often didn't believe that their council did enough to let the community know about what was happening with Council and the LGA.

At the face-to-face workshops staff were asked to rank the knowledge and understanding of Council staff overall, including staff whose role did not include river management. Most staff whom had a role focused on waterways didn't think the other staff knew anything about the waterways within the LGA and that there was nothing internal to support them knowing. This was not unexpected, as many roles within Council don't require any knowledge of waterways to be completed successfully (e.g. finance, human resources, information technology).

## **5. CONCLUSION**

It is recognised that urban waterways are being severely degraded, requiring rethinking about how they are managed, who is responsible for management and how are they supported. As expected the staff across the eight Councils whose role involved waterway management have a good handle on the waterways, their threats and where council can make a difference. There was a good understanding of the importance of the whole river and catchment system, and an awareness that actions undertaken by their Council were in most cases impacted by upstream areas out of their direct control, and that they in turn impacted on the downstream councils. They also understood that this was not always

easy to address in the internal Council planning processes, and that this was one of the benefits of having an organisation like the Georges Riverkeeper with a role across all of the river system.

It would appear that the documentation and support material which includes the processes and procedures to aid this role are not as well developed as they could be across the board. This is likely to be reducing the ability of the Councils to effectively and efficiently manage the river system.

Through this benchmarking study councils who are doing a task exceptionally have been identified. This can be used as an example to bring the other councils up to the same ranking and learn from each other. One of the main outcomes achieved from this study was to determine the opportunities that Councils and Georges Riverkeeper can work together to better manage the Georges River and its tributaries.

## 6. ACKNOWLEDGEMENTS

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## 7. REFERENCES

Georges River Combined Councils' Committee (GRCCC) (2013). Georges River Estuary Coastal Zone Management Plan, prepared by BMT WBM.

Georges Riverkeeper (2018). Georges Riverkeeper Strategic Plan 2018-2022.

Lake PS, Bond N & Reich P (2007). Linking ecological theory with stream restoration. *Freshwater Biology*, 52: 597-615.

Pollard DA & Pethebridge RL (2002). Report on Port of Botany Bay introduced marine pest species survey. Report to Sydney Ports Corporation. NSW Fisheries Office of Conservation, Cronulla.

Taylor A (2005). Guidelines for evaluating the financial, ecological and social aspects of urban stormwater management measures to improve waterway health. Technical report 05/11. Co-operative Research Centre for Catchment Hydrology.

Tippler C & Reid DJ (2018). Concrete stormwater channels: urban stream wasteland or supercharged ecosystems? Proceedings of the 9<sup>th</sup> Australian Stream Management Conference. Hobart, Tasmania.

Tippler C, Wright IA & Hanlon A (2012). Is catchment imperviousness a keystone factor degrading urban waterways? A case study from a partly urbanised catchment (Georges River, south-eastern Australia). *Water, Air and Soil Pollution*, 223: 5331-5344.

Vietz GJ, Walsh CJ & Fletcher TD (2015). Urban hydrogeomorphology and the urban stream syndrome. *Processes in Physical Geography: Earth and Environment*, [doi.org/10.1177/0309133315605048](https://doi.org/10.1177/0309133315605048)

Walsh CJ, Roy AH, Feminella JW, Cottingham PD, Groffman PM & Morgan RP (2005). The urban stream syndrome: current knowledge and the search for a cure. *Journal of the North American Benthological Society*, 24: 706-723.