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The condition of urban streams in Northern Sydney

Sophia Findlay¹
Mark Patrick Taylor²
Peter Davies³

¹ *Department of Physical Geography, Macquarie University, Sydney sfindlay@els.mq.edu.au
02 9850 8344*

² *Department of Physical Geography, Macquarie University, Sydney mark.taylor@mq.edu.au
02 9850 6319*

³ *Ku-ring-gai Council, Gordon, Sydney, NSW 2072 pdavies@kmc.nsw.gov.au*

ABSTRACT

This paper outlines the methodology, application and analysis of a rapid urban stream assessment tool, the Rapid Riparian Assessment (RRA) within the Ku-ring-gai Council Local Government Area, Sydney. The tool was developed to improve the understanding of riparian processes and broader environmental condition with an urban context. The results assist environmental management through the identification of causes and processes of change and degradation, in turn allowing the ability to direct policy, strategy and operational resources.

The RRA has been carried out in all streams under the management and control of Ku-ring-gai Council, in total 221 kilometres, incorporating 288 reaches were assessed. It was found that 61% have a condition rating of good or better. Only 1% of reaches assessed were rated as very poor. The results suggest that urban stream condition within this local government area is better than predicted for typical urban streams. This may be attributed to the large number of bushland corridors that help to maintain the riparian zone in conjunction with the geomorphology, predominately incised gullies dominated by Hawkesbury Sandstone, that is relatively robust to urban pressures, consequently remaining relatively un-impacted. Sensitivity testing of the methodology and attribute weightings confirms the effectiveness of this tool.

KEY WORDS

Assessment, Classification, Management, Riparian, Streams, Urban,

1. Introduction

Urban development has and continues to have a significant impact on water ways and other receiving bodies. Not only is water used as a resource but, creeks and rivers have become surrogate transport paths and disposal bodies for waste such as stormwater and sewerage effluent. Coupling to this affect, many urban waterways have been engineered into pipes or culverts to improve hydraulic efficiency as a means of minimising flood risk and maximising the development potential of an area. In turn these changes have and continue to impact on the physical and ecological condition of waterways, leaving many systems severely degraded [1].

To counter these increasing and cumulative impacts, governments at all levels have introduced various laws, policies and guidelines that encourage improvements in natural resource management. Underpinning many of these reforms is the much discussed yet poorly understood goal of achieving Ecologically Sustainable Development (ESD) [2]. Such reforms include Environmental Impact Studies, the inception of State of the Environment (SoE) reports, and the development of the ANZECC core environmental indicators [3]. The SoE reports represent the primary reporting procedure recording information about the condition, pressures and responses to management of environmental systems. This is conducted at National, State and Local government levels. The recent establishment of Catchment Management Authorities in New South Wales has provided an interface between local and state government, promoting improvements in the recording and reporting process. At each level of government the SoE process requires that data are obtained in a useful and meaningful way. This is partly covered by ANZECC [3] core environmental indicators for reporting on the state of the environment, which provide a basis for comparison between broad areas. However, they often do not allow the causal processes to be identified, accounted for and ultimately managed. This problem is particularly evident in urban areas where local governments are often working within heavily disturbed

systems. In such cases core indicators, such as ANZECC guidelines are often made redundant as a tool to compare environments within the often highly localised area due to the extent of degradation and a lack of intact representative areas.

In urban areas, local government play a significant role in the management of riparian systems. How they achieve and at the same time seek to achieve sustainable development that balances economic pressures and social expectation (such as managing flood risk and safety) with environmental protection is a major dilemma facing all councils [1, 4, 5 and 6]. In order to balance these often competing and complementary aims, the key to successful riparian management is to ensure that the riparian zone is established and quantified [7, 8].

There are a number of classification and characterisation tools available to assess stream systems. These include, but are not limited to many habitat and geomorphic classifications [7, 9, 10, and 11]. Urban riparian areas are one example where effective classification and monitoring procedures are not well established at the local level. The most significant dilemma relating to the classification and monitoring of urban riparian systems is primarily the lengthy time and associated costs with undertaking many of these investigations. Procedures such as the urban section of the State of the Rivers Survey [12] and the macroinvertebrate biotic index [13] are not as expensive or time consuming compared to detailed water quality studies or investigations into the sediment budget. However, where local governments employ external consulting agencies to collect and analyse data, the costs can be quite substantial, often restricting the scope of the investigation. Other, more simplistic classifications are often not suitable for identifying the features that are important to aid decision making and most often concentrate on engineered features [14, 15]. For these reasons Ku-ring-gai Council, in association with Macquarie University have developed a rapid riparian assessment procedure known as the Rapid Riparian Assessment (RRA).

The brief for the development of this tool was to enable:

- Collection of qualitative data that enables stream condition to be represented in a quantitative manner, as a numerical score
- Identification of the total length of streams within the local government area
- Data able to be integrated and used in conjunction with other data sets currently collected by Council
- A quick assessment procedure, limiting the amount of time spent doing both field work and subsequent analysis
- A tool that is robust and repeatable
- A simple procedure requiring minimal training
- A procedure that collects a reasonable amount of practical data

The above terms of reference were used to develop the RRA, a tool that aims to give an indication of the condition of a designated stream reach. As such the result is an assessment based on the collection of qualitative data that presents stream condition in a quantitative manner, as a numerical score.

Ultimately, it is envisioned that this assessment will allow strategic targeting of environmental expenditure within the Ku-ring-gai area by providing a measure of riparian condition, containing important information on issues such as vegetation and erosional characteristics. It is intended that the continued use of this assessment procedure will encourage effective riparian management through the initiation of realistic management plans and the provision of a basis for post project appraisal. The baseline data that the RRA provides has the potential to be used in the planning of more in-depth studies, allowing them to be targeted, minimising the expense associated with applying studies across broad areas for vague, un-quantified and aesthetic reasons.

This paper presents the results from the initial application of the RRA over the whole Council area (location shown in Figure 1) in conjunction with an investigation into how each section of the RRA attributes to the overall score.

Three of Sydney's major catchments have areas situated within Ku-ring-gai Council; Lane Cove River (tributary to Parramatta River and Sydney Harbour), Cowan Creek (tributary to the Hawkesbury-Nepean System) and Middle Harbour Catchment (part of Sydney Harbour). Each of these catchments exhibit similar vegetative and geologic characteristics.

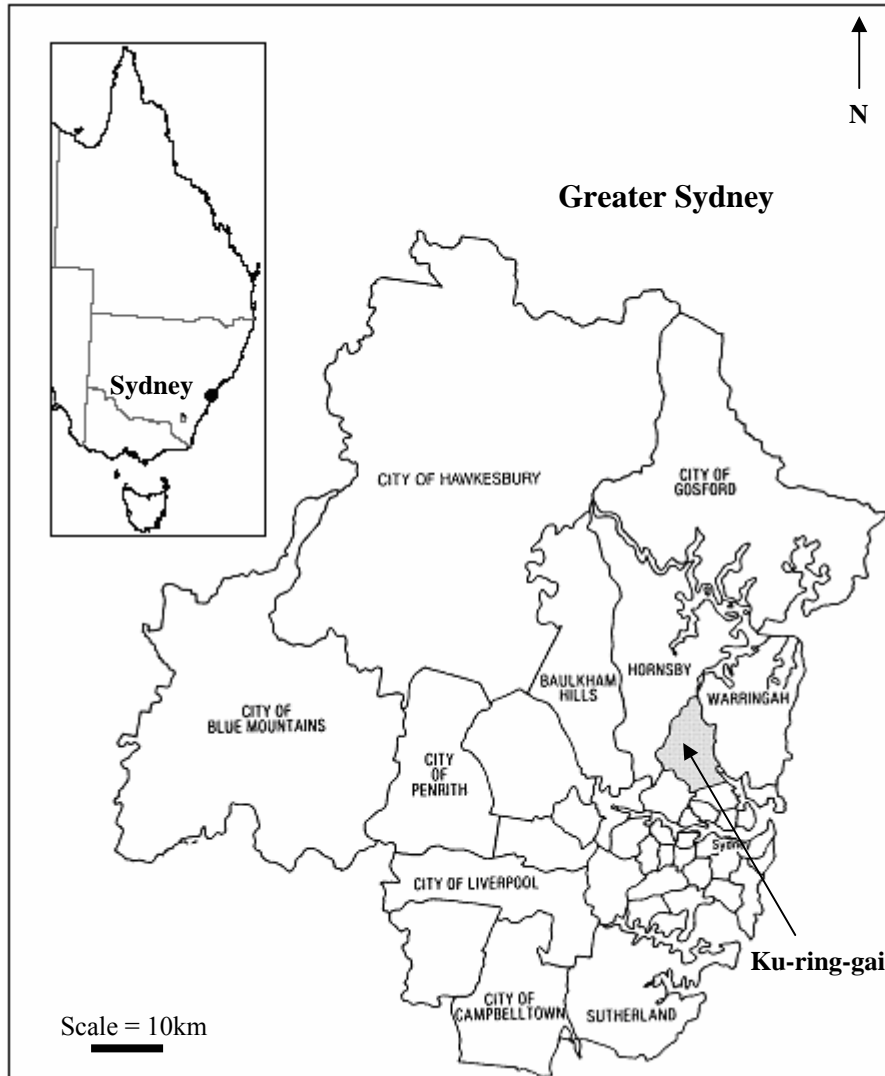


Figure 1: Location of Ku-ring-gai Council, the study location

2. Methods

From January 2004 to November 2004 the RRA was applied to all stream reaches identified within Ku-ring-gai Council, excluding those reaches that are situated in National Park areas (as the Council has no jurisdiction over how these areas are managed). Stream reaches were determined via a desktop investigation utilising contours and aerial photography to initially identify stream location, followed by division into reaches utilising longitudinal connectivity (occurrence of tributaries), land use and buffer width [4]. This process identified 288 reaches suitable for assessment, representing 221 kilometers of streams.

Sample sites are located approximately at the centre of each reach and are characterised by a 50m length along the stream and 50m either side of each bank (in order to encompass as much of the riparian area as possible). The RRA procedure consists of allocating a score to pre-determined indicator features present within the riparian system at a sample site within each reach, the features and the sub-category they belong to are shown in Table 1. Scores relate to the condition of individual attributes assessed. For example the percentage of banks in the sample area that are undercut and the vegetation structure present [4]. Data was recoded either directly into a database whilst in the field or recorded on sheets and entered into the database at a later date. The combined scores of each attribute provide the subtotals (section total i.e. for erosional features) and the Grand total (RRA score for the reach), which

is categorised to provide an indication of the overall condition of the reach. The RRA score categories are Excellent, Good, Fair, Poor, Very Poor, Severely Degraded (equivalent to heavily engineered) [4].

Table 1: List of attributes assessed and scored as part of the RRA process
(Modified from [4] Table 2. p599)

Sub-Total Category	Attribute
Site features	Land use
	Extraction
	Excavation
	Litter
	Sewer Line
	Odours
	Turbidity
Channel Features	Shape
	Pool and Riffle Sequences
	Meanders
	Large Woody Debris
Depositional Features	Benches
	Islands
	Channel Bars
Erosional Features	Bedrock Exposure
	Undercutting
	Bank Slumps
	Knick Points
	Gully/Rill Erosion
Riparian Vegetation	Bank Buffer Depth
Vegetation Structure Assessment	Weed Severity
	Vegetation structure

Subtotals are calculated for each category within the assessment so that important detail on specific features is not lost through categorising the Grand total. The RRA has been established so that although the Grand total and subtotals are the primary figures used to aid management decisions, the original data collected is stored in an easily accessible format that can always be consulted if required, allowing particular characteristics to be monitored closely over time.

If the RRA can be shown to effectively distinguish between reaches with visual differences in condition, then it allows the opportunity for application in other urban landscapes where a similar assessment is required. It may also signal a trend for baseline assessments to be characterised by cheaper, more readily applicable qualitative tools, rather than detailed, quantitative based studies, assessments and research projects which are often expensive and time consuming.

3. Results and discussion

The initial results from the application of the RRA to the 288 reaches within the Ku-ring-gai Council area are displayed below. Figure 2(a) represents the percentage of reaches represented by each category for the whole council area. Figure 2 (b), (c) and (d) show the results for each major catchment within the area.

Figure 2(a) shows that of the total reaches assessed, only 1% are classified as very poor, 18% classified as poor and 61% being classified as excellent or better. This assessment appears to contradict the notion that streams with urbanised catchments are commonly characterised by severely degraded systems [1]. At first glance this may appear to point towards an inadequacy in the assessment procedure, because realistically in any urban environment streams are rarely in good condition or better (compared to natural systems). However this outcome does not necessarily indicate a faulty classification system, particularly in an area such as Ku-ring-gai where intense engineering, such as concrete channelisation, is rare and most streams are protected to an extent by their incised, bedrock confined setting, with associated bushland corridors, often connected to National Park areas.

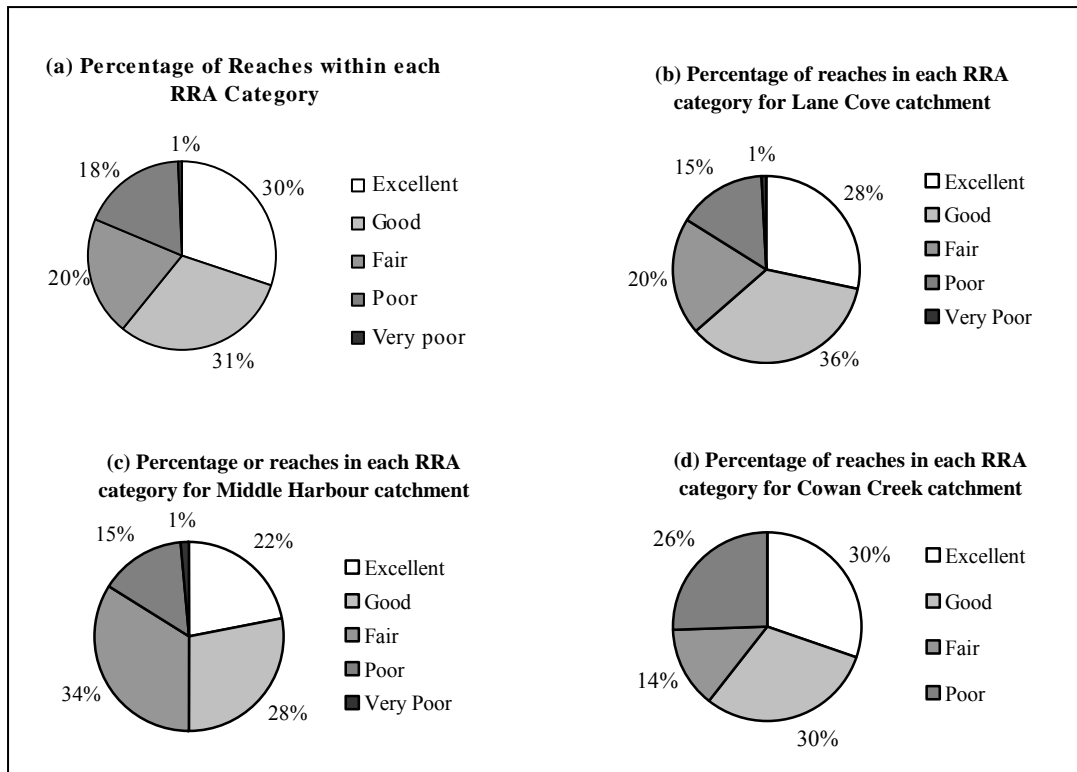


Figure 2: Pie charts displaying the fraction of reaches allocated to each condition category for: (a) percentage of reaches allocated to each scoring category for the whole of the Ku-ring-gai Council area (b) Lane Cove River catchment, (c) Middle Harbour catchment, (d) Cowan Creek catchment

An informal analysis of variance performed on the separate catchments revealed that there is no significant difference between the conditions surveyed between the three catchments (p -value 0.770). The most notable distinction that can be made from the charts in Figure 2 is the absence of any very poor reaches in the Cowan Creek catchment area of the study (Figure 2(d)). However, as shown by the analysis of variance, this does not necessarily mean that the Cowan Creek catchment is in a better overall condition, rather is most likely a reflection of the development pattern and topography that is likely to have a lesser hydraulic impact from stormwater flows compared to the steeper catchments and creeks of Lane Cove and Middle Harbour. Even though there is an absence of very poor reaches, the catchment contains a much larger proportion of poor reaches compared to the Lane Cove (Figure 2(b)) and Middle Harbour (Figure 2(c)) catchments, subsequently increasing the similarity in condition with the other catchments.

This similarity indicates that there is not one of the major catchments that need to be focussed on in terms of rehabilitation initiatives. Thus, more focus can be allocated to management plans at the sub-catchment and reach scales, potentially allowing the catchments to be improved equally over time and allowing a more targeted approach to stream management.

It is important to note that the RRA does not attempt to classify urban streams against un-impacted streams in a natural environment. The shortcomings of assessing streams in such a way has been addressed before by researchers working with other character and classification systems originally developed for rural and forested environments in an urban setting. It was found that systems, such as River Styles, in its original form, are not appropriate for the highly impacted and engineered systems present in urban areas [16]. Such tools commonly categorise urban systems as poor-severely degraded, not providing enough detail for rehabilitation initiatives and environmental expenditure in urban settings [14, 16]. Therefore, in order to avoid 'brushing over' the subtle differences between urban streams, the RRA provides a meaningful condition without focussing on the unrealistic goal of natural/un-impacted stream condition. Instead, the RRA assesses streams against the best potential condition taking into account the current catchment characteristics, dynamics and limitations. The RRA

is unlikely to be sensitive enough for application in forested or rural areas, although this remains to be tested.

Application of the RRA procedure means that every reach of the stream system within council jurisdiction is allocated a condition score. This allows for an effective visual tool to be produced through GIS whereby reach condition can be identified by colour. This tool can be useful for readily identifying reaches of conservation value or those reaches that threaten system integrity. For example, a stream that progress downstream from good to poor to excellent is an indication that there are characteristics of the middle reach that should be addressed in order to protect the excellent reach (downstream). This is just one example of how environmental funding allocation can be spatially targeted at a specific environmental pressure of the system, an option that is not readily accomplished with the use of macroinvertebrate analysis or classifications based on engineered characteristics. Maps produced from current RRA data clearly display such subtle differences in condition along stream reaches [4].

3.1 Assessment of the RRA Procedure

The final RRA score (Grand total) is made up of sub-total scores that relate to the condition of a particular variable of the reach. The variables used are grouped as site features, channel features, depositional features, erosional features, riparian vegetation and vegetation structure, as shown in Table 1. To assess how each variable impacts the Grand total a Spearman's rank correlation was performed between each sub-total and the overall score (Table 2). The descriptive terms relating to the strength of correlation have been allocated as such: < 0.5 = low, $0.5 \geq 0.75$ = moderate, $0.75 \geq 1$ = high.

Table 2: Table of spearman's correlation score and relative strength

	Sub-Total Category					
	Site features	Channel Features	Depositional Features	Erosional Features	Riparian Vegetation	Vegetation Structure
Spearman's rank correlation coefficient (2 decimal points)	0.90	0.60	0.09	0.34	0.83	0.88
Strength of correlation	High	Moderate	Low	Low	High	High

The correlations in Table 2 provide an indication of the relationship between the sub-totals and the overall score (Grand total). The results indicate that four of the six categories are relatively well (moderate and high) associated with overall condition. However, there are two categories, depositional features and erosional features that have weak associations with overall condition. This may explain the apparent lack of poorly classified reaches as it is the geomorphological condition of streams that is often in such poor condition in comparison to streams in un-impacted catchments [17, 18, 19 and 20]. However this could be seen as beneficial where there is no desire to compare impacted streams to those that are unimpacted. All urban streams have undergone major changes in hydrological behaviour and as such the geomorphological characteristics of these systems will often be heavily impacted [1]. Thus the RRA procedure records the condition of these features and to a small degree contributes to the overall score, but they do not dominate, because this would lead to insensitivities when comparisons are attempted. Rather, the riparian vegetation has been given greater emphasis due to the proven importance it has for maintaining stream health [21, 22, and 23].

However, such a vegetative based assessment may not be suitable in less robust landscapes, such as those dominated by shale or alluvial sediments, where more emphasis on geomorphic condition may be required.

4. Conclusion

The application of the RRA has shown that it can provide a reasonable, and more importantly, a useful measure of urban stream condition in the Ku-ring-gai local government area (and other areas geomorphically similar to Hawkesbury Sandstone incised creek systems). Initial concerns regarding an

unrealistic representation of stream condition are minimal since this assessment has been designed to assess condition within realistic expectations for urban stream systems, as opposed to comparing the outcomes to the characteristics and processes of natural (un-impacted) systems.

These initial results reveal stream networks in the Ku-ring-gai local government area to have 61% in good or excellent condition with only 1% found to be severely degraded. Such findings were not unexpected, considering the large area of land dedicated to bushland corridors that are connected to National park areas and the relatively small areas affected by hard engineering (such as concrete channelisation). An investigation into the weighting of attributes scored in the assessment showed it was only the erosional and depositional attributes that are not well correlated with the overall score, not a major concern considering these attributes are expected to be similarly degraded throughout the majority of urban streams. However there may be a need to increase the importance of these features, particularly if the assessment is to be used in less robust landscapes.

The effectiveness of the procedure, and wider potential scoring ability (utilising the severely degraded category) suggests it can be widely applied, indicating that cheap, rapid, qualitative based assessments are an effective tool for urban stream management.

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