Application and Assessment of a Rapid Riparian Creek Assessment Tool in Ku-ring-gai Council, Sydney, Australia

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1. Abstract

Urbanisation is the principal cause of physical and ecological degradation in urban stream systems around the world. In Australia, legislation centred on the ideals of Ecologically Sustainable Development require local governments to protect and maintain the environment and conduct regular environmental auditing via State of the Environment reporting procedures. In order to achieve these aims effectively, a thorough understanding of local stream processes and potential intervention methods is required, an often very complex task for systems situated within urban landscapes. To assist in these legislative requirements, Macquarie University and Ku-ring-gai Council (Sydney) have developed a prototype method for assessing the biophysical condition of urban riparian zones, referred to as the Rapid Riparian Assessment (RRA).

Multiple, independent data sets comprised of significant riparian features and processes such as weed density, water quality and percent impervious surface cover will be compared to RRA scores to verify how effectively the tool reflects the true condition and health of the stream-reach.

2. Introduction

At a national level, management of environmental resources in Australia is largely governed by the requirements of the *Environment Protection and Biodiversity Conservation Act 1999,* in particular the production of a State of the Environment (SoE) report every five years. As well as the national SoE requirements, New South Wales (NSW) government legislation also enforces state and local SoE reports to be carried out under the *Protection of the Environment Administration Act 1991* and the *Local Government Act 1993* respectively. SoE reports require auditing of the condition of local, state and national environments, including urban river systems. Most urban environments and their associated water courses have been drastically modified (Paul and Meyer, 2001). The impaired condition of urban streams is one example where there has not been a definitive tool within the SoE reporting process to link the condition of a stream to the allocation of funding. Although there have been various river characterisation and classification tools developed to help address such requirements, for example Rosgen, (1994); Newson *et al.* (1998); Ladson *et al.* (1999) and Brierley and Fryirs (2000). However, frequently they do not adequately represent the relative condition of urban systems that are often highly degraded in comparison to unimpacted systems. Consequently, they often do not meet the social and political demands required for urban stream management.

Attempts to address this knowledge gap have resulted in the development of a number of classification and condition frameworks specific to urban areas (Anderson, 1999; Davenport *et al*, 2001; Gregory and Chin, 2002). However, many urban classifications often focus on the engineered characteristics of a system and as such are likely to overlook significant physical and biophysical characteristics that are essential to the ecological health of a system (Fryirs, 2003). Further, such tools are often time consuming and costly to implement, such as Anderson (1999) and Chessman (1995) respectively or specific to a particular landscape, for example, Roxburgh (2003).

The lack of a suitable assessment tool for local governments led to the development of the Rapid Riparian Assessment (RRA) for Ku-ring-gai council, Sydney in order to assess urban stream condition to facilitate environmental expenditure and planning (Taylor *et al*, 2005).

This pilot study aims to ascertain the RRA's effectiveness as a measure of environmental condition utilising a series of proxy, independent urban stream condition measures. Investigation was undertaken on riparian systems within the Ku-ring-gai Local Government Area (LGA). The independent data sets include: water quality indicators Total Phosphorus (TP), Total Nitrogen (TN) and Faecal Coliforms (FC); estimates of the percent of impervious cover within catchments; and the pattern of riparian weed distribution. This paper presents the results of this study.

3. The Rapid Riparian Assessment

The RRA is a reach based stream assessment procedure combining qualitative and quantitative methods of assessment.

The initial requirement of the RRA is to determine the reaches and sample area to be used as the basis for assessment. The reaches for this assessment are determined by a combination of geomorphic and anthropogenic controls that impact the physical processes of stream systems, and as such determine areas of homogeneous functioning (Taylor *et al*, 2005). Sample areas within each reach cover approximately 50m of stream length and 50m of the riparian zone on each bank (Taylor *et al*, 2005).

The procedure utilises a range of relevant channel and riparian variables and quantifies the condition of a riparian zone by allocating a numerical score according to visual interpretation of the impact that features may have on stream condition. The corresponding scores are determined by the extent and nature of features present in the channel and riparian zone. For example, bank slumps are scored according to the percentage of bank area within the sample zone that is affected (Taylor *et al*, 2005).

This approach was applied to enable a rapid and simple assessment procedure, with the ultimate aims of making it accessible to and applicable by multiple users while minimising associated labour and consultancy costs.

The scores for each attribute are summed to provide a total score that determines the condition category allocated a reach. There are six categories ranging from Excellent (≥60) to Severely Degraded (≤-74). The results of the RRA performed at individual sample areas are then extrapolated over the total reach (Taylor *et al*, 2005).

4. Methods

4.1. Water analysis

Three primary water quality indicators have been used for comparison with the RRA results. These indicators are FC, TP and TN. Samples were collected from up to six reaches within the Ku-ring-gai LGA, covering a range of conditions. An unimpacted site situated within the Ku-ring-gai National Park was also included in the sampling strategy as a control reach. The results from 8 sample days are presented in this paper.

FC samples were collected with sterilised containers and analysed via the IDEXX colilert test for *Escherichia coli (E. coli)*, using the Quanti-tray most probable number method (HPA, 2003). This test was used to determine FC concentration given that *E. coli* is an ideal indicator of FC presence (WHO, 1996; NHMRC, 2002). This technique is a robust method for the detection of FC (Kramer and Liu, 2002; Niemela *et al.*, 2003), whilst also offering the simplicity and affordability essential to this study. The IDEXX Quanti-tray/2000 was used enabling detection from 1 – 2419.2 *E. coli*/100ml.

TP and TN samples were collected using prepared bottles, chilled and analysed by the National Measurement Institute within 24hrs of collection.

Due to the relatively expensive costs of the TP and TN analysis, only one sample was taken from each site. To ensure that samples were representative of average stream condition per field campaign, water was collected from riffle zones.

4.2. Percent impervious surface area

The percent of impervious surface cover within each catchment was determined by calculating the percentage of bushland, parkland, residential and commercial land use from a selection of catchments within the Ku-ring-gai LGA. These calculations were derived from 1:25 000 topographic maps of Hornsby (Land and Property Information NSW, 2001) and Parramatta River (Land and

Property Information NSW, 2002). For each of these land uses, the percent impervious surface cover values as per (NOAA, 2004) were applied to derive approximate impervious surface area values for each catchment. The following land use categories and associated impervious surface cover used were: Forest/Bushland – 1%, Urban/suburban Open Land – 3%, Medium density residential – 30%, Commercial – 85%.

4.3. Weed distribution

The distribution of weeds along riparian zones was used to determine how well the RRA represents within reach variation, an important consideration if the assessment is to be used as a rehabilitation tool. The reaches for the RRA are determined at a scale of 1:10000, and as such it is unclear how well the RRA represents within reach variability. Weed distribution information has been obtained from Ku-ring-gai Council's Bushland Weed Assessment (BWA), a database consisting of weed information mapped at a more precise 1:2000 scale (KMC, 1995).

The number of different weed classes recorded by each assessment procedure for each reach was used to determine the amount of similarity between the results of the two procedures. BWA data was collected between late 2002 to early 2003 and the RRA data collected in mid 2004. Reaches that had been subject to substantial disturbance such as fire, bush regeneration and construction in the intervening period were eliminated from the investigation.

5. Results

5.1. Water analysis

The FC results revealed a large amount of spread. Four of the seven sites produced FC results ranging from the maximum number per 100ml (2419.2) to below 100 FC/100ml. The variability resulted in a very low R^2 value of 0.1052. However, there was a general trend of FC number increasing with a decreasing RRA score. In an attempt to reduce scatter and normalise data relative to precipitation, the data was separated into the following categories (the same procedure was applied to the TP and TN data): days that received less than 1ml/24 hrs prior to testing; those that received 1ml or more in the previous 24 hrs and days that received rainfall on the day of testing prior to or during the sampling. This analysis produced less variable results, although linear regression values were still low. The best result is shown in Figure 1 with $R^2 = 0.4245$ with all cases indicating an increase in FC/100ml with a decreasing RRA score, a pattern that was consistent for the data for individual sampling days and the total data set.

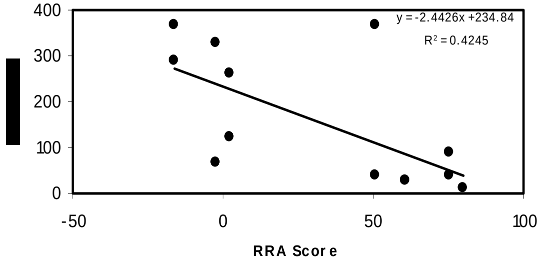

Figure 1: Graph of the comparison between RRA Score and the number of FC/100ml on days where there has been less than 1ml of rain in the past 24hrs. This graph also shows the linear regression line, equation and R^2 value.

When compared with the RRA, the TP and TN results are more variable than those for FC. However, as with the FC results, there is a general negative relationship between TP/TN and RRA score, for all scenarios including the total data set, and also like the FC results, no significant relationship is apparent. The graphs displaying the best relationships for TP and TN are shown in Figure 2a and Figure 2b respectively.

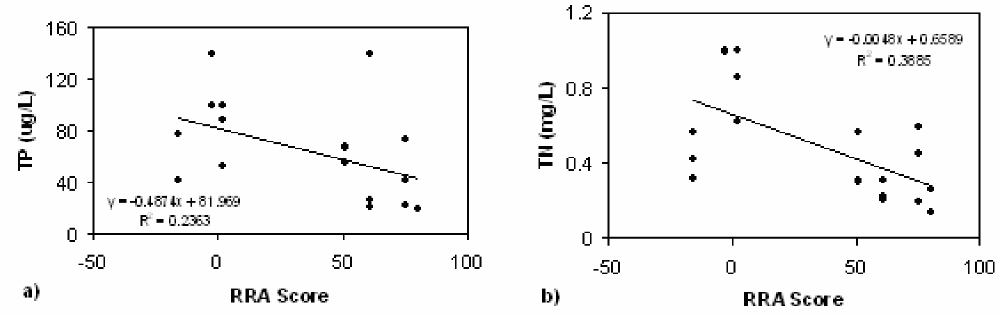

Figure 2: a) Graph of the relationship between TP and RRA score and b) graph of the relationship between TN and RRA score for days that received rain immediately before or during sampling showing linear regression line, equation and R^2 value.

5.2. Percent impervious surface area

Assessment of the relationship between catchment imperviousness and RRA score are shown in Figure 3. Although the data is widely scattered, there is still a negative relationship with the general trend for RRA score to increase with a decrease in the amount of imperviousness.

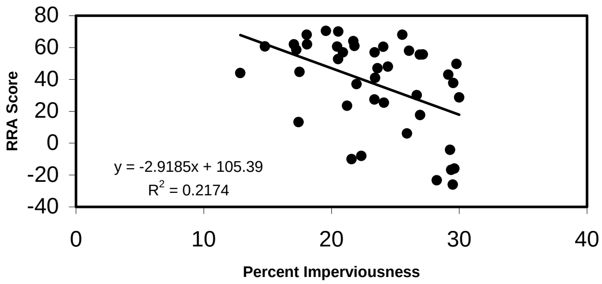

Figure 3: Graph of the relationship between RRA score and the amount of impervious surface area within a catchment showing the linear regression line, equation and R^2 value.

5.3. Weed cover

A comparison of the weed data collected as part of the RRA with that of the BWA reveals that in 67% of reaches the two assessments produced results with a high degree of similarity, however in 33% of cases the assessment procedures returned significantly different results.

6. Discussion and Conclusion

Analysis of independent proxy data used to determine the utility of the RRA procedure has revealed some promising results. With respect to the water quality, while the results are not significant enough to allow the RRA to be used to predict water quality, the data demonstrates that the RRA is indicative of expected condition. The large amount of variability of the water quality indicators at each site re-affirms the notion that water quality alone is not a sufficient indicator of overall stream health (Walsh, 2000). To ensure that the results are not an artefact of the small data set and the absence of RRA scores between 3 and 50, additional data will be collected.

The results relating the RRA score to imperviousness is limited by the restriction of data between 10 and 30% imperviousness. However, the results do reveal the expected negative trend (Figure 3), indicating that as the RRA condition declines the amount of impervious surface increases. Although this result does concur with the general relationship between imperviousness and ecological condition (Walsh, 2004), it is only a weak relationship ($R^2 = 0.2174$) compared to other Australian stream health indicators such as the SIGNAL score, which produced an R^2 value of 0.78 (Walsh, 2004). This weak relationship may be due in part to the broad categories used and their inability to discriminate the variability of imperviousness within each landuse determined from the topographic maps.

The weed distribution analysis showed that the RRA represents the within reach variability described by the BWA with 67% accuracy. However, the results are based upon a small data set (33 reaches) and additional analysis is required to include the full range of reach conditions that have been determined by the RRA procedure.

Despite the fact that the RRA is essentially based upon qualitative data, the proxy stream condition indicators analysed in this study suggest that the method produces an accurate indication of the true condition of a riparian system. However, the small data sets and weak relationships do not, at this stage, allow it to be used as a definitive predictive tool. As such, some adjustments in the assessment process may be required after further results have been incorporated. It is anticipated that this data may assist in producing an assessment procedure that has the simplicity of a qualitative assessment with the robustness of a quantitative assessment.

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