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Short communication

# The nature and source of irregular discharges to stormwater entering Sydney estuary, Australia

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ABSTRACT

Irregular discharges of polluted stormwater into drainage systems during base flow (no rainfall) result in acute ecological impacts within fluvial and estuarine environments. In this study, metal and TSS concentrations were significantly more variable during business hours of weekdays (i.e. high-business activity) than weekends/public holidays (i.e. low-business activity) within three highly-urbanised catchments of Sydney estuary (Australia), as determined by analysing multivariate dispersion (PERMDISP). Concentrations of TSS and all metals analysed (Al, Ca, Cu, Fe, Mg, Pb and Zn) were also significantly greater during high- than low-business periods within at least one of the three catchments. In no case were concentrations significantly higher during low- than high-business periods. This pattern of contamination supports the hypothesis that commercial and industrial sources are major contributors of irregular discharges of contamination to Sydney estuary. Irregular discharges and consequential ecological impacts may be effectively reduced in this environment by focussing management efforts on these activities.



## 1. Introduction

Polluted urban runoff affects the ecological function and utility of coastal waterways. Pollutants contained in urban runoff, such as metals and suspended solids, have acute and long-term impacts on aquatic ecosystems (Booth and Jackson, 1997) and if physiological thresholds are exceeded, fish and invertebrate mortality may occur. Polluted runoff also contaminates waterways used for recreation and seafood consumed by humans (Birch and Apostolatos, 2013; Lewtas et al., 2014). As urbanisation accelerates globally, effective management of polluted urban stormwater is becoming increasingly urgent. Although environmental issues of polluted runoff continue to grow, funding and strategies to manage this problem are becoming increasingly diminished (Davis and Birch, 2009). Retrofitting treatment devices within catchments with a long history of intense development is technically difficult, costly, as well as being space and flow limited.

Water contamination and costly remediation may be avoided if pollution sources are identified and contained. Irregular discharges of pollution have been recognised in stormwater entering Sydney estuary (Beck and Birch, 2012a) by increased flow (water height) and highly elevated metal (Cu, Pb and Zn) and TSS concentrations during base flow (>48 h without rainfall). Although diffuse sources of pollution are difficult to identify, irregular discharges of pollution, released directly into the drainage system, may be prevented if sources can be identified. Although benefits of preventing ecologically harmful discharges are well recognised, the uncertainty in source, timing, concentration and composition of these events challenges attempts by water quality managers to identify temporal patterns of this pollution (Beck and Birch, 2012a, 2012b, 2013). In this study, we aimed to determine whether the source of irregular discharges could be identified through analysing base flow contamination during dry-weather periods within three highly-urbanised catchments of Sydney estuary and comparing concentrations of metals and TSS during business hours of weekdays (i.e. high-business activity) and weekends/holidays (i.e. low-business activity). We expected that if commercial and/or industrial activities were major sources of irregular discharge pollution to Sydney estuary, concentrations and variability of metals and TSS would be greater in base flows during high- rather than low-business periods.

## 2. Methods

### 2.1. Study site

Base flow was sampled within highly-urbanised catchments of Johnstons Creek (J), Whites Creek (W) and Hawthorne Canal (H), which drain into Sydney estuary,

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Australia (Fig. 1; Beck and Birch, 2012a). These catchments are primarily high-density residential (70–80%) with remaining area comprising approximately equal portions (2–9%) of parkland, education, medical, industrial, commercial and rail land-uses.

### 2.2. Sampling protocol

Twenty-four water samples were collected by hand from each of the three sub-catchments, H, W and J, between December 2008 and January 2009 during dry-weather conditions (>48 h without rainfall; Fig. 2). Samples were randomly collected on three occasions, over an hour apart, on four low-business and five high-business days within each catchment in locations above tidal influence to avoid salinity effects.

### 2.3. Sample treatment

Samples were collected using one-litre HCl-acid washed glass jars and stored in the dark at 4 °C. A 10 ml subsample was passed through a 0.45 μm syringe filter for dissolved metals analysis and the remaining sample was filtered (500 μm) to remove debris for particulate analysis. TSS was determined by filtering samples through pre-weighed 0.45 μm cellulose nitrate membranes. Samples were digested as per modified US EPA method 200.8 (Creed et al., 1994). Blanks, consisting of ultra-pure water (UHP; >45 mΩ cm), were prepared similarly to detect contamination.

### 2.4. Chemical analyses and quality assurance

Samples were analysed for particulate and dissolved metals (Al, Ca, Cu, Fe, Mg, Pb and Zn). Certified reference material (AGAL-10), replicates and blanks were analysed for data quality assurance. Precision was <5% relative standard deviation (RSD) and accuracy, expressed as recovery of the reference material, was between 81% and 99% for all metals. No contamination was detected in laboratory or procedural blanks.

### 2.5. Statistical analysis

Total metal and TSS concentrations were normalised by $\ln(x + 1)$ transformations prior to construction of a resemblance matrix based on Euclidean distances. A non-metric multidimensional scaling (nMDS) plot was created to visualise trends in multivariate space. Variability in composition of base flow contamination was then compared between high- and low- business periods using the PERMDISP procedure; a distance-based test for homogeneity of multivariate dispersions (Anderson, 2006). This method compares spread of data around centroids of these factors. Metals and TSS was compared between catchments and business periods (i.e. high- and low-business), treating both as fixed factors, using Analysis of Variance (ANOVA). Independent sample *t*-tests, assuming heterogeneous variances, were used to test for differences in contamination between business periods within catchments separately. Multivariate analyses in this study were conducted using PRIMER V6™ and PERMANOVA + ™. Univariate analyses were conducted using SPSS™. *A priori*, $p < 0.05$ was the set level of significance for all analyses.

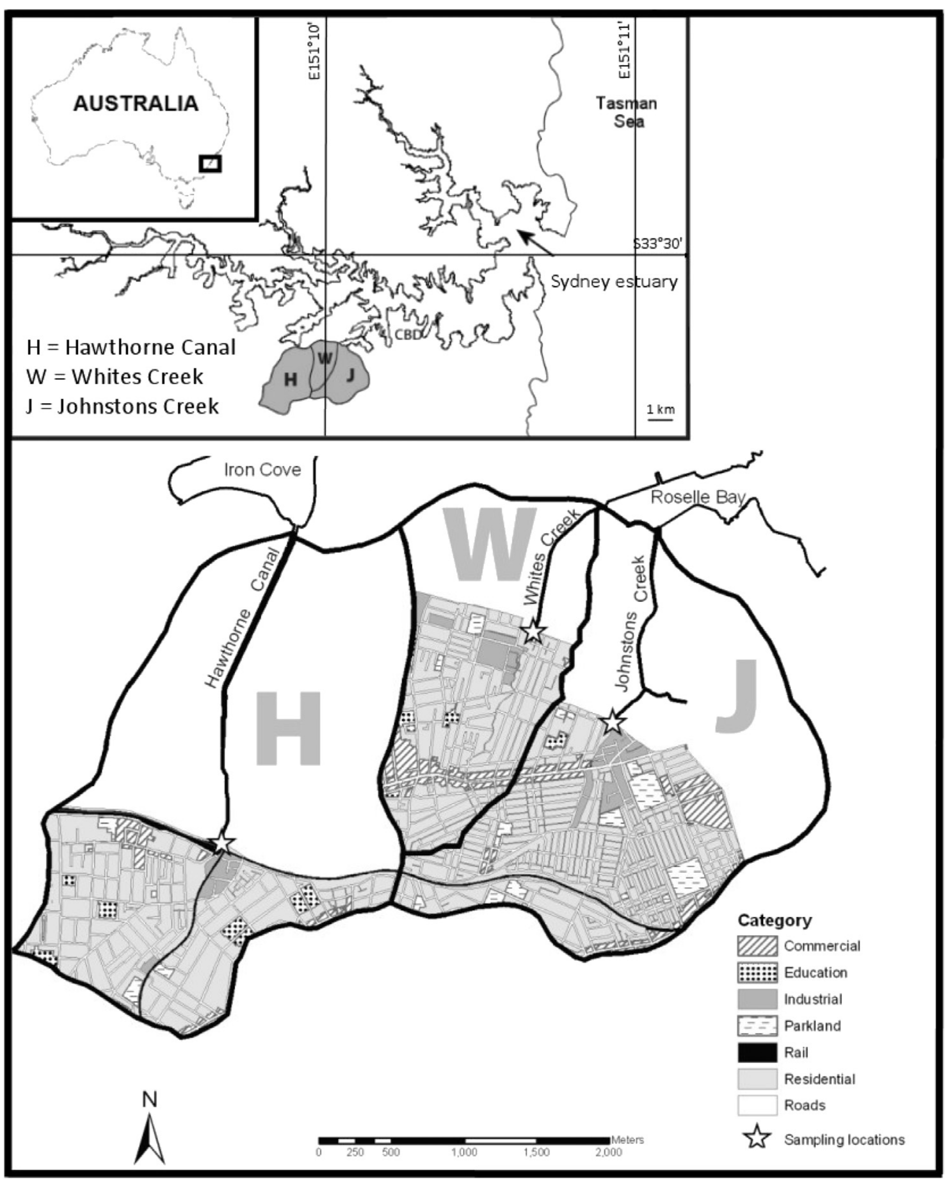


**Fig. 1.** Location of and land-use within Hawthorne Canal (H), Whites Creek (W) and Johnstons Creek (J), Sydney estuary, Australia. Sampling locations indicated by stars.