Physical and chemical assessment

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Background to event monitoring

1 Purpose and scope

This document provides some background information on event monitoring.

2 Associated documents

Sampling design and preparation:

- *Sampling scope and design*
- *Preparation for sampling*

Physical and chemical assessment:

- *Manual collection of surface water samples (including field filtration)*
- *Background to water quality sampling using automated sampling equipment*
- *Water quality sampling using automated sampling equipment*
- *Collection and preservation of sediment*

3 Introduction

Event monitoring is the collection of water quality and quantity information during periods of increased waterway[1] discharge[2], with a primary objective of estimating loads of contaminants (e.g. sediments and nutrients) that are transported during events. A discharge event can be caused by various factors (e.g. rainfall runoff[3], groundwater discharges to surface waters, water storage releases) and may mobilise and transport increased amounts of contaminants. Water quality and quantity monitoring during these events is often referred to simply as event monitoring. Contaminant loads are known to vary according to a range of factors including hydrological flow (Brodie et al. 2010, Peljo et al. 2013), spatial distribution of rainfall and rainfall intensity, size of the catchment, topography (Young et al. 1996), antecedent soil moisture conditions (McDowell and Sharpley 2002), catchment land use (Packett et al. 2009), geology and soil type (Caitcheon et al. 2001), and the proportion and type of ground cover (Bartley et al. 2006).

Discharge events occurring at the beginning of a wet season may result in high fluxes of contaminants. This is known as a first flush effect, which occurs as a result of the transport of material accumulated during the dry season. As a result of low rainfall, ground cover vegetation may be reduced by the end of the dry season. Rainfall onto bare soils may mobilise soil particles and contaminants held in the soils, leading to infiltration and runoff during the first rainfall event of the season. Later in the wet season, ground cover is expected to be increased. Ground cover vegetation slows the rate of surface water runoff allowing more infiltration to occur. This reduces the ability of rainfall to mobilise contaminants attached to surface soils. Variability between events may also be compounded by land management practices, including stocking rates, harvesting, fertiliser application and seasonal land preparation regimes.

[1] Waterways for event monitoring purposes are any rivers, streams or creeks – and their tributaries – including the water, channel and riparian zone; estuaries and wetlands.

[2] Discharge (streamflow) is the volume of water that flows past a cross-section of the stream over a unit of time.

[3] Rainfall runoff is produced when rainfall intensity exceeds the infiltration capacity of the soil causing water to flow overland and into waterways. Runoff can be influenced by various characteristics (e.g. rainfall (intensity, duration, distribution), soil type, vegetation, slope and catchment size) and result from weather events ranging from small, high intensity localised storms and flash flooding to prolonged rainfall associated with tropical lows and cyclones.

4 Why monitor events?

Data obtained from an event monitoring program may be used to:

- monitor catchment loads and link these to management actions to reduce contaminant loads (e.g. Water Sensitive Urban Design, riparian rehabilitation, nutrient offsets and on ground works)
- aid in understanding catchment processes (e.g. water quality, nutrient cycling, erosion, sediment/nutrient transport and landuse change)
- identify contaminant sources (e.g. point and diffuse sources)
- better characterise diffuse contaminant concentrations during events from different sources and under a range of flow conditions
- provide data on contaminant generation from major land uses, land use change or intervention in the catchment upstream of the monitoring sites
- calculate contaminant loads for parameters of concern
- provide data for license, permit, environmental authority requirements
- adjust and calibrate values used in catchment models and provide locally specific data for parameters of concern.

5 What to monitor

To identify the contaminants you wish to monitor, region specific factors affecting contaminant loads (listed previously) should be characterised. Water quality data, focused on contaminants of interest, needs to be collected through intensive monitoring over a variety of events that differ in size and timing – e.g. largest and smallest events, first event of the season – and over a period that enables the capture of seasonal variability. Discrete and continuous sampling during events also needs to cover the different stages of the waterway discharge hydrograph – i.e. baseflow, the rising stage of discharge and the falling stage of discharge – and capture the concentration variations of the contaminant of interest. When event monitoring, the quantity of water flowing down the waterway also needs to be measured as an important component of loads calculations, and to aid interpretation of contaminant concentration data. Data from established gauging stations are available from the Queensland Governments Water Monitoring Information Portal (WMIP) (https://water-monitoring.information.qld.gov.au/) or the Bureau of Meteorology (http://www.bom.gov.au/water/).

5.1 Event water quality sampling

Event monitoring aims to collect data from as many flow events as possible in order to calculate loads of contaminants. A large proportion of contaminant loads are generated during the wet season. Although large flood events produce high loads, in some circumstances, significantly higher contaminant concentration peaks can occur in small discharge events (Figure 1**Error! Reference source not found.**), particularly the first discharge event of the season (first flush). Sampling should be done at a frequency to maximise the accuracy of calculating contaminant loads over the hydrograph, noting that the peak of contaminant concentrations may not necessarily correlate with the peak of discharge.

When monitoring a new site, the relationship between the rise and fall in waterway height and the associated change in contaminant concentrations will not be known. Intensive sampling should therefore be undertaken in the early stages of sampling to determine the characteristics of the site. Up to 20 samples over an event may be required to gain this knowledge. Once a good understanding is established, it may be possible to carry out future monitoring at the site with fewer samples while still ensuring accuracy in estimating total loads. For example, a minimum of six samples, with most samples collected during the falling stage (for the Great Barrier Reef Region), may be enough coverage of the event to produce accurate total load estimations (Thomson et al. 2012). This would, however, be catchment specific and applicable to simple hydrographs only.

Installation of refrigerated auto-samplers that can be programmed to trigger sampling at a particular time or river height, are extremely useful in ensuring hydrographs are well sampled at a given site (see *Background to water quality sampling using automated sampling equipment* document).

Water quality samples should be delivered to a National Association of Testing Authorities (NATA) accredited laboratory for analysis within the prescribed holding times. Holding times will vary depending upon the analyses to be performed. See *Choosing a laboratory and analytical method, holding times and preservation* for further information.

Results obtained from the analytical laboratory will be assessed for quality control/quality assurance prior to data analysis and interpretation.

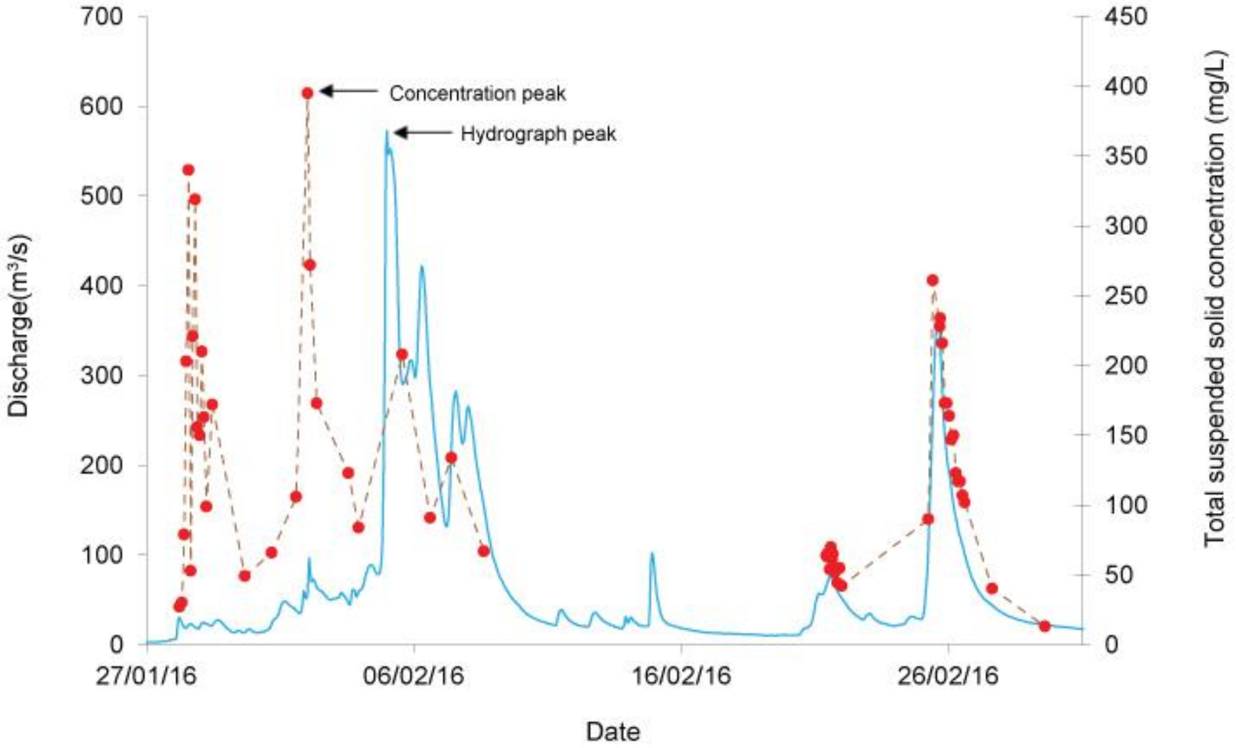

Figure 1: Example hydrograph showing the concentration of total suspended solids (TSS) (dotted line) against discharge (blue line). Red dot indicates the date samples were collected.

5.2 Baseflow water quality sampling

Also known as Dry Weather Concentration (DWC) sampling or ambient sampling, baseflow sampling differs from event sampling in that sampling is carried out when the flow is predominantly influenced by groundwater discharge and the overland flow component is small (i.e. no flow derived from rainfall runoff). Baseflow sampling may direct the effects of water and associated contaminants filtering into streams via groundwater and effects of riparian vegetation (e.g. leaf litter) on water quality. Light levels, temperature changes, groundwater recharge rates and instream processes can also affect water in the receiving waterway.

Sampling streams during baseflow should be undertaken with adequate lag time following an event to ensure the samples are solely baseflow water and not representative of the tail of an event. For baseflow sampling, a sampling frequency of once per month is usually adequate, bearing in mind this frequency is program specific and can be adjusted according to the programs objectives.

Total contaminant loads are calculated using the results of a combination of event and baseflow sampling over the defined period. In some systems, baseflow can contribute significantly to annual loads, so it is important to include baseflow water quality sampling when planning a monitoring and sampling schedule.

5.3 Hydrological measurements

Measurements of the stream's discharge volume are usually obtained by stream gauging techniques. Gauging is the process of measuring the volume of water flowing through and past a cross-section of a stream, within a defined time period. Refer to AS/NZS 3778.3.3:2001 for further details. Hydrological measurements and applications

Due to the impracticality of directly measuring waterway volume during high discharge events (due to workplace health and safety issues, access restriction or other hindrances), measurements may be carried out indirectly. This can be achieved by regularly recording the stream water level (stage height), using an automatic logger. This height is then related to discharge by applying an appropriate rating curve. It should be noted that this theoretical rating curve should still be validated by direct discharge measurements (gaugings) in order to reduce any error associated with the resulting discharge data.

5.3.1 Stream height

Continuous measurement of stream height should be recorded at sampling sites or at gauging stations close to the sampling site. These measurements are collected using an in-stream pressure transducer or gas bubbler system connected to a data logger. The pressure transducers should be selected with a designated calibrated range to cover the expected stream heights; this will ensure an accurate recording of the hydrograph. The pressure transducers should have an accuracy of +/-30mm (water height). Pressure transducers used for stream height recording should be calibrated according to the manufacturer's instructions to ensure accuracy.

5.3.2 Discharge

Gaugings taken at sampling sites or hydrographic gauging stations (wherever pressure transducers are installed) are used to validate the rating curves that help to convert continuous height records into time series stream discharge data. All discharge measurements should be carried out and calculated in accordance with Australian and international standards. Gaugings during events should only be attempted where and when it is safe to do so in accordance with set workplace health and safety procedures. Gaugings should be performed only by trained hydrographic staff.

5.3.3 Rating curves

The development and application of an accurate discharge rating curve for a stream gauging station is critical to the production of reliable stream discharge data. Rating curves should be developed according to Australian and international standards and be properly recorded and preserved as a permanent record.

Software programs are available that can be used to develop theoretical and/or empirical rating curves using physical waterway parameters such as area, slope and roughness. These rating curves then need to be continually validated by gaugings throughout the range of the hydrograph. Rating curves are then applied to the height data using the software program to produce discharge data. Physical waterway measurements such as stream cross section and stream slope should be carried out in accordance with Australian and international standards.

Waterway discharge or water quantity measurements, including stream height, change over time, and the physical measurement of width, depth and velocity of the stream should be collected and used in accordance with Australian and international standards (AS/NZS 3778.3.3:2001 and ISO 1070:1992). These methods should be considered when:

- designing waterway gauging stations or monitoring sites
- maintaining and calibrating equipment for waterway discharge measurements
- using direct methods for discharge measurements (e.g. gaugings, acoustic doppler channel profiler (ADCP))
- using indirect methods for discharge measurements (e.g. area velocity method, flow factoring)
- developing and applying rating curves.

The quality and accuracy of the data should be determined, followed by the application of appropriate quality codes to the data.

5.4 Event sample/baseflow sample/field measurement metadata

All samples and measurements collected for an event monitoring program should be collected in association with standardised metadata. Guidance as to the metadata that should be collected in association with water quality parameters can be found in the National Industry Guideline for water quality metadata (Bureau of Meteorology 2016).

Note: It is essential that site, date and the exact time of collection are recorded in order to assess data against the hydrograph.

6 Data analysis and interpretation

Empirically-derived load estimates must be based on robust, accurate and repeatable loads determination methods (Marsh 2011). The accuracy of the resulting load estimate depends on how well the concentration data are able to characterise what is, in reality, continuously varying contaminant concentrations in the waterway. The accuracy of this characterisation depends on the number and timing of the collection of samples, the variation of the actual concentrations and the mathematics of how the flow and concentration estimates are combined. Where loads are required for all events and for each of the parameters typically measured (e.g. total suspended solids and nutrients), it is often not practical to undertake such detailed assessment to account for the high spatial, temporal, hydrological, geological and meteorological variability, and as such, there is no national, state or regional guidance on which method should be used to calculate loads.

Data analysis methods vary according to program objectives. Standardised methods are required that are specifically tailored to answer the original program objectives. This will ensure that any interpretation of event and baseflow data is meaningful. For the objectives of an event monitoring program, data analysis methods could include but are not restricted to:

- concentration and flow relationships (regression analysis)
- load calculations:
    - annual loads
    - event loads
    - daily loads
- land use yields
- Event Mean Concentrations (EMC)
- Site Mean Concentrations (SMC).

Standardised analysis procedures and methods should be collaboratively developed and peer reviewed to ensure suitability for addressing original objectives.

7 References and additional reading

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