

A quantitative approach to assessing the effectiveness of catchment management for the improvement of drinking water quality

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Executive Summary

Access to safe drinking water is essential to maintain life. Ensuring that water is safe for consumption requires an understanding of all the potential risks to the supply and an ability to manage those risks. Pathogenic organisms are the greatest risk to consumers of drinking water and the main source of these organisms is from non-point sources such as catchment runoff. The high risk is clearly demonstrated by the numerous cases of waterborne disease outbreaks in the developed world in the last 40 years, some of which have resulted in the death of consumers.

The multiple barrier approach to drinking water protection is a well supported management technique which requires multiple scientifically validated mechanisms that prevent contamination of or remove contamination from the water supply prior to consumption. Catchment management is a barrier that aims to control contamination at the source which provides a greater surety of the absence of contaminants, and therefore safety, than does the subsequent removal or reduction of contaminants by treatment. The implementation of buffer strips is one catchment management technique that is thought to improve water quality. They reduce the momentum and magnitude of surface and sub-surface runoff thereby aiding infiltration into the soil column and promoting entrapment of pollutants. This process has been well researched in terms of constituents such as sediments and nutrients. In a drinking water catchment, however, the ability of these buffer strips to trap or remove human infectious pathogens is of most interest. Having the capability to quantify the effectiveness of buffer strips specifically for pathogen removal, could give drinking water quality managers a validated barrier to contamination and a reduction in risk to consumers.

The hypothesis is that the implementation of buffer strips, in a rural drinking water catchment, will have a positive and quantifiable impact on drinking water quality. Specifically this research aims to determine a way of predicting the decrease in risk to public health due to the implementation of buffer strips in an agricultural catchment. The Tarago Reservoir catchment, about 100km east of Melbourne, was chosen as the study catchment as it currently supplies drinking water to the Greater Melbourne area. Over the past 10 years buffer strip implementation has been taking place in this catchment in an effort to improve water quality. The catchment has an extensive water quality data set spanning over 30 years that includes both physical-chemical and pathogenic parameters as well as storm event data. These factors make it an ideal catchment to study the effects of catchment management.

The Tarago catchment has three sub-catchments which were determined to be from different populations using discriminant analysis. This analysis also showed that landuse and soil types were the major contributing factors to poor water quality. Trend analysis showed that some parameters associated with erosion were trending down; possibly indicating the positive effects of catchment management initiatives. Additional statistical analysis using

Factor Analysis (FA) showed that surface runoff and erosion are the most significant catchment processes affecting water quality. Furthermore it showed that since the implementation of catchment management, colour and phosphorus were less dominant in the agricultural runoff.

Regression analysis, FA and analysis of the Event Mean Concentration (EMC) on the pathogen, pathogenic indicator and event data sets showed that *Clostridium perfringens* and enterococci were mobilised by surface runoff. EMC analysis also showed that rainfall has a significant impact on water quality highlighting the importance of sampling during storm events. Catchment management efforts need to focus on lessening the effect of erosion, surface runoff and rainfall. This can be achieved through the implementation of buffer strips.

A model that simulates pathogen fate and transport through a catchment was necessary to predict the decrease in pathogens due to the buffer. The model needed to be continuous to allow assessment of the impact of events and non-point sources. A simple lumped conceptual model, EG, was chosen. This model uses the partitioned flows from a hydrological model as inputs, which is vital as buffer strips will only affect pathogen concentrations in the surface flow.

EG was not specifically developed to determine the effectiveness of buffer strips and therefore modifications to the pathogen transport processes were required. An understanding of pathogen movement at a catchment scale was necessary, as was an understanding of the likely impact of buffer strips in terms of their ability to remove pathogens. The buffer is only effective during storm flow conditions as pathogens transported during baseflow conditions are too deep and therefore too far away from the filtering effect of plants or their root systems. The modified EG model allows different buffer ratios to be input into a calibrated model and the model outcomes indicate the effects the buffer will have on pathogen transport to the stream. Uncertainty analysis was also carried out on the modified EG model.

A number of different analyses were undertaken with the calibrated model and different buffer ratios to determine the overall effect of having a buffer and relating any of these effects to storm characteristics. The peak flow of an event was found to be a good predictor of pathogen transport during an event. It was also able to predict the difference in pathogen numbers between a catchment with and without a buffer. The average flow and event volume did not correlate as well to the pathogen data sets as peak flow indicating that the effectiveness of the buffer was less related to the duration or overall magnitude of an event and that it was the peak intensity which dominated the number of pathogens that were mobilised.

Relationships were formed between the buffered and non-buffered catchments which are useful in determining the amount of pathogen reduction likely in certain circumstances given a particular increase in buffer. The ability to quantify the benefits that buffer strips will give to water quality may allow the comparison of investing in catchment management to treatment costs and an assessment of the risk reduction benefits of both.

Quantification of the benefits of buffer strips can assist catchment managers and water quality managers in planning and securing funding for works in the catchment. The ability to show that the on-ground works can have a positive and measurable effect on drinking water quality is important for various stakeholders including regulators and the community. Having confidence in catchment management initiatives to provide reduction and having the ability to quantify that reduction may lead to more on-ground works and less conventional treatment. This has benefits for the community on a number of different levels including, but not limited to, the following: a reduced cost of treating their drinking water, a more aesthetic landscape and healthier streams.