HYDROLOGY OF THE UPPER HUNTER CATCHMENT

by

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CANDIDATE'S DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of the author's knowledge, it contains no material previously published or written by another person, except where due reference is made in the text.

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ABSTRACT

One of the ten objectives of the 2004 Australian National Water Initiative is to manage surface and groundwater as a single resource. In order to do that it is necessary to understand the interactions between surface and groundwater, as well as the impacts of water abstraction, land use change and climate variability. In Australia, not just the quantity of water, but also its quality and particularly its salinity are critically important. Some of the difficulties facing agencies in managing surface and groundwater as a single resource are the extreme variability of climate in Australia, the lack of long-term streamflow and groundwater level data sets and the very limited temporal records on water quality.

This thesis presents a study of surface and groundwater interaction and salinity in a selected catchment in the Hunter Valley in mid New South Wales, eastern Australia, where data records are limited and incomplete. The hypotheses tested in this work are that (1) salinity discharge in the Hunter is largely determined by mineral weathering and deep groundwater inflows and (2) a simple parameter-efficient coupled surface and groundwater model can accurately predict groundwater and streamflow behaviour over monthly time scale and is useful in determining surface –groundwater interactions.

In the Hunter, water is a fundamentally important for power generation, coal mining, horticulture, irrigation, stock production and community water supplies. The Hunter however has significant salinity issues, particularly in groundwater. Because of this it is the location of the world's first salinity trading scheme. The site chosen here for detailed study is Wybong Creek, a left bank tributary on the Goulburn River which is a right bank tributary of the Hunter River. As a component of the water reform process in Australia, NSW has been developing water sharing plans designed to return a better share of water to the environment. These plans in general have been based on limited information about surface and groundwater interaction and have largely ignored water quality altogether.

To facilitate better management, this thesis aims to fill in the data sets, investigate impacts of land use change and climate variability, determine water and salt balance, solute sources and identify the interactions between surface and groundwater within the catchments using an improved, parameter efficient monthly, conceptual model. The long-term changes in rainfall and runoff are analysed for identifying whether the long-

term declines in yield are due to 50 year drought-dominated cycles or to changes in land use. Stream discharge and electrical conductivity data are analysed for identifying salinity distribution and discharge. The annual salt load is estimated and the salt balance is also investigated by using an Output/Input (O/I) ratio. The specific salt yield of the catchment for the period 1993 to 2008 was estimated to be 17 tonnes km^{-2} $year^{-1}$ and the annual salt O/I ratio was 5.5 showing that the catchment is not in equilibrium.

Hydrogeochemistry and water isotopes data are employed to identify the solute sources in the catchment. It was found that mineral weathering originated from basalt and sandstone in the upper catchment, with weathering fractions relative to cyclic salt being as high as 80%. Cyclic salt is not an end member of the mixing curve in the catchment but marine origin water is. In the lower catchment, marine-origin groundwater and possibly halite dissolution from the Permian coal seams dominates the stream and groundwater salinity.

The Q-lag method was used to examine stream and groundwater interaction. Comparisons between streamflow percentiles (Q90 percentile flow) and relevant rainfall percentile (7dayR10 rainfall percentile) curve gave reasonable correlations ($r_m > 0.7$) between the shifted flow percentile curves and the reference rainfall percentile curve. These demonstrate that Wybong streamflow is predominantly a stream interacting with the deep groundwater system with a 206 days lag between rainfall and flow. Baseflow separation analysis was used to examine the base flow system in the catchment. Baseflow indices ranged from 0.22 in 2007 to 0.83 in 1982 with the average baseflow index from 1972 to 2000 of 0.53.

The conceptual Xiong and Guo (XG) model was examined for its ability to predict streamflow and groundwater levels. The model performed well, under calibration. R-squared values of calibration are more than 80% for spatially interpolated monthly rainfall and pan evaporation data which is a good fit between observed and predicted values. From 1990 to 2000, up to 42% of the discharge flowing from the catchments each month is groundwater flow. However, the model parameter values needed to fit the data were physically unrealistic and it was concluded that the model has limited applicability in situations with very low stream flows. Modification of the model to include a physically more realistic evaporation component did not improve the model fit or the parameter values. Ungauged water extraction from the catchment during the 2000 to 2008 could have contributed to the poor performance of the model.

As with most catchments, there are significant problems in attempting to test the hypotheses of this thesis due to the limited and incomplete data on stream flow and stream salinity. In the case of stream salinity, despite the fact that salinity was recognised as a major issue in the Hunter more than six decades ago, there is an extremely short continuous salinity record. This limitation was compounded by the severe drought years that extended for much of the salinity record. It has been shown here that catchments in eastern Australia are subject to approximately 50 year cycles of flood- and drought-dominated regimes. The relevance of a less than two decade salinity record to such long cycles is problematic. In the upper catchment, the hydro and geochemistry results here unequivocally show that weathering products make up the major portion of the stream salt load. So the results here have verified the first hypothesis above but the difficulties with fitting the simple conceptual modelled to the rejection of the second hypothesis.

TABLE OF CONTENTS

FIGURES

TABLE