Methods to Assess Environmental Flow and Groundwater Management Scenarios for Floodplain Tree Health in the Lower River Murray

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PhD Thesis

Methods to Assess Environmental Flow and Groundwater Management Scenarios for Floodplain Tree Health in the Lower River Murray

Submitted by

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Abstract

Riparian environments have degraded world-wide as a consequence of human development and climatic change. The native floodplain tree communities of semi-arid river systems are under stress from reduced flooding frequencies as a consequence of water extractions, river regulation and climate change. In regions with saline aquifers, river regulation and land management have also caused soil salinisation, further impacting on floodplain tree health.

The lower River Murray in south-eastern Australia is a major ecological asset considered as an area of international significance. The dominant floodplain vegetation is suffering severe decline in health, with approximately 80% of floodplain trees reported as being in poor condition or dead. A reduction in water availability from reduced flooding and soil salinisation, has been identified as the primary cause. This has resulted from large irrigation extractions across the Murray-Darling Basin and elevated saline groundwater levels due to river regulation and land clearance.

Management of these ecosystems needs to address both surface and groundwater changes. Increasing flooding regimes from environmental flow management and lowering of groundwater in regions of shallow saline aquifers are the most common scenarios adopted world-wide. Traditionally the assessment of management options for floodplain habitats has focussed on changes in river flow with no consideration given to surface water and groundwater interactions. In addition groundwater has been treated as a single homogenous unit. Wide floodplains have high spatial variability of habitats due to historic meandering anabranch creek systems that cause changing elevations and soil types. This in turn creates a highly variable pattern of surface and groundwater interactions. This thesis investigates the major causes of floodplain tree decline and develops methods for predicting the spatial impacts on floodplain tree health from a range of management scenarios.

Surface and groundwater changes are often highly inter-connected but are usually considered separately at regional scales because of the complexity of management and modelling of surface and groundwater interactions over large areas. This thesis addresses the surface and groundwater changes at the regional scale of the lower River Murray. A floodplain inundation model for the River Murray (RiM-FIM) is developed to predict the extent of flooding at various magnitudes of flow and river regulation and a 'drought index' was used to indicate the risk to floodplain tree health of changing flow regimes. A floodplain impacts model (FIP) was applied spatially to predict groundwater discharge onto the floodplain and model vegetation risk.

At the floodplain scale, surface and groundwater need to be integrated to assess detailed management scenarios. This thesis develops a method for assessing soil water availability from surface and groundwater interactions using a spatial and temporal model of salt accumulation and recharge (WINDS). This model is then used to predict floodplain tree health.

The thesis contributes to the science of floodplain processes and develops a number of innovative modelling techniques for predicting the spatial variability of floodplain tree impacts, improving on traditional broad assessment methods. The tools are applicable to other saline semi-arid rivers and are useful for environmental flow and groundwater management decision making.

DECLARATION

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint-award of this degree.

I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

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Signed:

Ian Clifford Overton B.Sc. (Hons.)

Date:

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KEY PUBLICATIONS ASSOCIATED WITH THIS THESIS

Refereed Book Chapters

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ACRONYMS

AHD	Australian Height Datum, standard measurement for heights in metres above sea level.
BigMOD	MDBA River Murray Flow Model used to predict River Murray flows for natural (pre-development), current and future conditions
CSIRO	Commonwealth Scientific and Industrial Research Organisation, which supported much of this research
FIP	Floodplain Impacts Model, a groundwater model to predict impacts on floodplain vegetation, groundwater seepage and salt loads, further developed further by this research
GIS	Geographic Information Systems
LiDAR	Light Detection and Ranging system for collecting elevation data
MDB	Murray-Darling Basin
MDBA	Australian Government Murray-Darling Basin Authority
MDBC	Australian Government Murray-Darling Basin Commission
MODFLOW	USGS Modular Three-Dimensional Groundwater Flow Model
RiM-FIM	River Murray Floodplain Inundation Model, a predictive model of flood extent developed by this research
WAVES	Water Vegetation and Salt Model, developed by the CSIRO as a model of vegetation growth incorporating surface and groundwater influences
WINDS	Weighted Index of Salinisation Model, developed by the CSIRO as a model of soil water availability to infer vegetation health, developed further by this research