Spatial Simulation Based Riverbank Slope Instability and Susceptibility Assessment in the Lower River Murray

By

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B.E., M.Sc.

Thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

The University of Adelaide

Faculty of Engineering, Computer and Mathematical Sciences

School of Civil, Environmental and Mining Engineering

To my beloved parents

Xu-Dong Liang and Xiao-Feng Niu

And my beloved grandparents

Tin Jiao and Zhen-xiang Luo

Shu-ren Niu and Yu-Lan Feng

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Abstract

Riverbank collapse is a natural and expected phenomenon associated with the evolution of rivers worldwide and has been studied extensively over the last two decades and remains an active research topic. The evolution of riverbank stability analysis has followed closely the developments in analytical methods, investigation tools, stabilisation methods and data acquisition technology. Furthermore, the stability of riverbanks is a multifaceted issue which involves the study of geology, topography, stratigraphy, hydrology, climate, spatial variation and geotechnical engineering.

The River Murray is one of the only river systems in the world that can fall below sea level due to the barrages preventing the inflow of sea water during periods of low river flows. Over the last few years, an unprecedented period of dry conditions and low flows between 2005 – 2010 led to more than 162 reported riverbank collapse-related incidents along the Lower River Murray, in South Australia (downstream of Lock 1 at Blanchetown to Wellington). Those collapse-related incidents threatened public infrastructure, private property and the safety of river users, and also provide significant challenges for environmental and river management. From the inventory of the South Australian Department of Environment, Water and Natural Resources (DEWNR), riverbank collapse, erosion, cracking, tree leaning and collapse and levee problems are the main forms of the recorded incidents.

Geographical information systems (GIS) is well known for its efficient and cost-effective spatial data processing capabilities, which include spatial data collection, manipulation and analysis, and has been widely used in riverbank instability research. As a significant feature of this thesis, GIS, incorporating high-resolution spatial data, such as aerial photographs and LIDAR (light detecting and ranging) images, facilitates the assessment of riverbank instability in several ways. Firstly, the actual location of the historical collapse can be determined and verified by the use of high-resolution aerial image comparison and interpretation to facilitate accurate back-analyses. Secondly,

the 2D and 3D geometry of the riverbank is able to be readily extracted from the LIDAR digital elevation models (DEMs). Thirdly, the dimensions of the predicted collapsed regions can be validated against high-resolution aerial images, and finally, the influencing factors are able to be manipulated and mapped with GIS to predict regions susceptible to riverbank collapse.

This thesis aims to: (1) examine the failure mechanisms affecting riverbank collapse along the Lower River Murray and identify the most relevant mechanism; (2) identify potential triggers for riverbank collapse events that should be monitored and managed in the future; (3) develop a framework, incorporating spatial information, GIS and geotechnical data, to facilitate the prediction of riverbank collapse along the Lower River Murray (between Blanchetown and Wellington, South Australia); and (4) develop a framework, based on GIS and geotechnical data, to identify regions susceptible to high risk of riverbank collapse along the Lower River Murray.

In order to realise these aims, numerical analyses have been performed using two commercially available software programs, ArcGIS and SVOffice, which integrate the limit equilibrium method, back-analysis of collapse incidents, transient unsaturated flow modelling, steady state modelling, and DEMs and high-resolution aerial images within a GIS framework. The modelling has been informed by a series of geotechnical investigations undertaken at various sites along the River Murray.

Statement of Originality

I, **Chen Liang**, hereby certify that this work has not been previously accepted for any other degree or diploma at any other University or Institution. To the best of my knowledge and belief, no material in this thesis is from the work of other people, except where due reference are 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.

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Acknowledgements

I would like to give my sincerest thanks to my parents and grandparents, who have been giving their unconditional support to my life and work from the beginning to the end. Without their love, all the work I have done would hardly be possible. To revere and learn my parents' and grandparents' love, goodness, integrity and selflessness has inspired me to keep moving on.

I would like to take this opportunity to sincerely acknowledge my Principal Supervisor Professor Mark Jaksa and Co-supervisor Associate Professor Bertram Ostendorf for their guidance, invaluable support and encouragement throughout my Ph.D. studies but without requiring anything in return. Without their valuable advice and comments, I would not have been able to complete my project, nor would I have produced four journal papers. Special thanks to Professor Mark Jaksa who provided me with casual work opportunities in the School and provided me a top-up scholarship to cover my daily life expenses.

I would also like to show my appreciation to Drs. Yien Lik Kuo and An Deng who have provided me great suggestions for my research. Special thanks to the ladies in our School Office, Dr. Stephen Carr from the IT section and Gary Bowman, Dale Hodson and the other technical staff from the laboratories of the School of Civil, Environmental & Mining Engineering. They have provided me great assistance in my daily work and site investigations.

I would like to sincerely acknowledge the assistance of Jai O'Toole, Geoff Eaton and Richard Brown from DEWNR who provided me with the high resolution aerial images of the Lower River Murray, opportunities for site visits and valuable advice throughout my research. I'd also like to thank the Goyder Institute for Water Research who funded this project (*Project E1.8 Riverbank Stability*).

Finally, I would like to thank the University of Adelaide and the China Scholarship Council for awarding me the scholarship to support my Ph.D.

program. Without the CSC tuition-fee-wavier scholarship and stipend, my research and thesis would not have been possible.

Table of Contents

List of Figures

List of Tables