Computers and Geotechnics 69 (2015) 236–246

Contents lists available at ScienceDirect

Computers and Geotechnics

journal homepage: www.elsevier.com/locate/compgeo

Identifying areas susceptible to high risk of riverbank collapse along the Lower River Murray

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ARTICLE INFO

Article history:
Received 19 February 2015
Received in revised form 19 May 2015
Accepted 26 May 2015

Keywords:
GIS
Riverbank stability
Hazard prediction
Mapping
Topography
River Murray

ABSTRACT

Riverbank collapse is a natural phenomenon in the evolution of rivers. Along the lower reaches of the River Murray, from downstream of East Front Road to the town of Wellington in South Australia, there were more than 100 riverbank collapse-related incidents reported between 2005 and 2010 in the forms of mass riverbank collapse, erosion, cracking, riparian tree leaning or collapse, as well as levee-related problems. The River Murray is the largest river in Australia. The objective of this paper is to develop a topographically-based framework that can be used, prior to undertaking detailed cross-sectional modeling or site investigation, to identify high risk areas susceptible to riverbank collapse over extensive reaches of the river. The proposed framework is based on the results of numerical analyses that have been undertaken using an integration of several approaches, which includes slope stability analysis using the limit equilibrium method with the assumption of a steady-state condition, identifying the actual locations of previously known riverbank collapse sites through the visual interpretation of historical, high-resolution aerial images, topography mapping using digital elevation models and a geographic information system, and interpretation of field and laboratory test results for model construction and geological and soil stratigraphy mapping. Back-analyses were used to estimate the likely in situ shear strength at the historical collapse sites. The results from the back-analyses were compared with those from field and laboratory testing. A total of 69 numerical analyses were undertaken at three different regions along the Lower River Murray, to identify the factors influencing the stability of the riverbank. Finally, cross-validation was used to measure the predictive performance of the proposed framework. This paper has demonstrated the efficacy of the proposed predicting framework as a useful and reliable tool for riverbank collapse hazard mapping.

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1. Introduction

The stability of the riverbanks is dependent on many factors and the failure of the riverbank can cause losses of life and substantial damages to properties and public infrastructure [1]. Generally, the factors that may affect the stability of the riverbanks can be classified into two different groups: natural and artificial [2]. Natural factors include site topography, bank and riverbed stratigraphy, soil and rock properties, river level fluctuation and climatic factors which include precipitation and evaporation [3]. In the case of the Lower River Murray, more than 162 riverbank collapse-related incidents were reported between 2005 and 2010 and the collapses were identified as dominantly triggered by unprecedented low river levels [1,4–6]. In order to understand better the collapse processes, as well as the triggers for riverbank collapse along the Lower River Murray, downstream of Lock 1 at Blanchetown to Wellington, South Australia, several detailed geotechnical investigations and 2D slope stability analyses have been undertaken previously [1,6–8]. However, each of these aforementioned investigations and analyses were focused solely on historical riverbank collapse sites, which accounts for only a small fraction of potential and recorded riverbank collapse sites along the Lower River Murray. The River Murray is extremely important in the Australian context as it is Australia's largest river and is the major domestic water supply for more than 1.5 million households. It is the third longest navigable river in the world and spans three states, New South Wales, Victoria and South Australia.

Slope failure susceptibility prediction and mapping have been undertaken using a variety of methods [9], and which can be classified into two main categories: subjective and objective methods [10]. Subjective methods consist of inventory mapping and expert evaluation, while objective methods comprise weighted linear

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http://dx.doi.org/10.1016/j.compgeo.2015.05.019
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combination (WLC) statistical models and qualitative map combination (QMC) models [10,11]. More specifically, the subjective method is based mainly on field experience; while both the WLC and QMC models of the objective method generate the composite and numeric maps by overlaying the various causal factor layers such as geology, hydrology, topography and geomorphology [10,11]. As the most important parameter for evaluation of slope instabilities [3], topography is considered as an indicator of past failures and potential future instability [2]. Vanacker et al. [12] believed that the prediction of slope failure is usually based solely upon topographical attributes. According to Abramson et al. [2], topographic maps play a fundamental role in the identification of

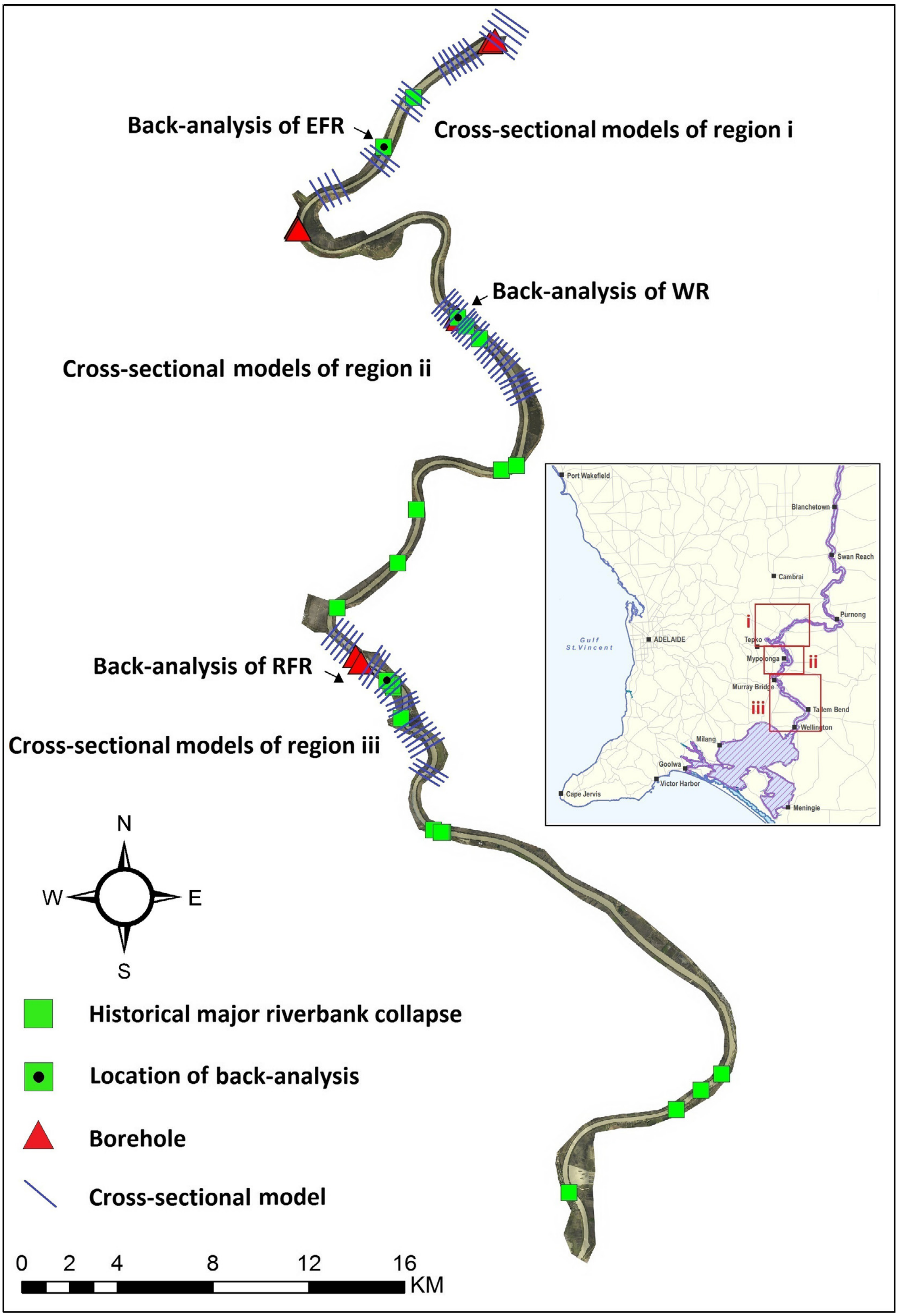

Fig. 1. Diagram of study area, locations of historical collapses, cross-sectional models and geotechnical investigations.

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