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Estimation of Extreme Design Rainfall Events and Accounting for Non-Stationary Data in Design Rainfall Estimation in South Africa

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The estimation of design rainfalls and design floods are required by engineers and hydrologists for the design of hydraulic structures and to quantify the risk of failure of these structures. Extreme design rainfall quantities such as high return period rainfalls and the probable maximum precipitation (PMP) are needed to design high-hazard structures. In South Africa, design rainfall estimates have been produced up to the 200 year return period. PMP estimates were last determined nearly 50 years ago. Most studies on extreme rainfall reported are based on frequency analysis assuming stationary conditions. Previous studies in South Africa have assumed a stationary climate. However, the assumption of a stationary climate in rainfall and flood frequency analysis has been challenged owing to evidence of climate change. Recent literature indicates that the magnitude and frequency of extreme rainfall events have been changing and this is likely to continue in future. As such, methods to account for trends in extreme rainfall events in a changing environment need to be developed. In addition, the concept of PMP, particularly as used for the design and safety evaluation of large dams in South Africa, is being challenged with the recommendation that high return period design rainfalls be used in these assessments.

The main aims of this study are (i) to estimate extreme design rainfall values, with a focus on return periods greater than 200 years, (ii) to update PMP estimates, and (iii) to account for non-stationary climate in the estimation of these extreme rainfall events in South Africa. Using an updated rainfall database, design rainfall estimates will be updated for all durations and extended to return periods greater than 200 years utilising L-H moments, which more accurately fit the upper tail of distributions and larger events in data. PMP estimates will be updated using an updated meteorological database and using latest methods outlined by the World Meteorological Organisation. Methods to estimate extreme design rainfall events in a non-stationary climate will be developed using extreme value theory and data from Global Circulation Models.

Preliminary results from the above will be presented. The outcomes of this study will contribute to new knowledge on the estimation of extreme rainfalls, including PMP, and incorporating non-stationary climate in design rainfall estimations in South Africa. It is envisaged that the outcomes of this research may have significant impact on professional practice of engineers and hydrologists in terms of the design of hydraulic structures in South Africa.