Executive Summary

This WRC study on freeboard for dams commenced in 2007 and was carried out over a period of three years.

The deliverables of this research project are two reports:
- Volume I Literature Review and case studies (this report);
- Volume II Guidelines for the determination of freeboard for dams, which has also been reviewed by SANCOLD and is now the new South African guidelines document (2011), replacing the 1990 freeboard guidelines of SANCOLD.

A literature review was carried out to determine the state-of-the-art knowledge on the quantification of the secondary components to be taken into account in the determination of dam freeboard. Research carried out in the coastal engineering field of aspects which are relevant and applicable to dams was incorporated.

The use of mathematical models to predict freeboard components due to wind was evaluated against the analytical (simplified) methods. Software was incorporated and/or referenced where available for more detailed quantification of the relevant freeboard components.

The combination of the different freeboard components for different floods and for different dam types was evaluated and discussed at a stakeholder meeting. The probability of all the components occurring at the same time is low, and the assumptions made in previous guidelines were evaluated critically. Proposed updated guidelines were considered in evaluating the combined risk, with application at specific case study dams.

Guidelines on embankment erosion protection measures were also incorporated in the new guidelines. Only riprap (dumped rock) was considered and the riprap grading and required natural filter grading was evaluated.

The key findings of this study are:

a) The 1990 Interim Guidelines on Freeboard for Dams had a good scientific basis and only minor changes are proposed in the methodology.

b) The wind data and Milford map has been plotted for 1:25, 1:50 and 1:100 year 1 hour duration wind speeds with the addition of cyclone data along the East Coast. Such regionalized maps could be used for planning purposes of category I and II dams, but for any detail design studies local wind data should be analysed.

c) For planning purposes and for the detail design of category I dams wind wave height, runup and set-up calculation should be based on the Rock Manual. In all other cases the SWAN model should be used to determine wind wave height. The main difference with the 1990 guidelines method is that $H_{2\%}$ is calculated with the new methods, which is 1.4 times higher than H_s calculated with the 1990 methodology. It should be noted that H_{max} is still 1.4 times higher than $H_{2\%}$.

d) Unsteady flow patterns in reservoirs such as seiches, oscillations, flood surges, etc. Should be simulated by mathematical hydrodynamic models. For planning purposes and for category I dams a one dimensional (1D) model could be used, but for category II and III dams 2D or 3D models are recommended.

e) The design of riprap at dams for protection against wind wave erosion should be based on

the Rock Manual.

f) The combination of freeboard components could follow a deterministic approach similar to the method used in the 1990 guidelines, with some revisions to the combination of scenarios proposed. A risk analysis procedure using a revised DEFRA methodology to incorporate component scenarios could be used complementary to the deterministic approach and is recommended for detail design studies of category II and III dams.