EXECUTIVE SUMMARY

The Department of Water Affairs and Forestry (DWAF) has announced its Water Allocation Reform (WAR) programme as an important component of the roll-out of the National Water Act of 1998. The main focus of the WAR programme is to reconcile existing and future water demands with its availability. Water resource planning requires recognition of the Ecological Reserve, and estimates of Ecological Water Requirements (EWRs) are therefore required.

Ecological Reserve (quantity) determinations at the Comprehensive and Intermediate levels have generally been determined for sites located along main-stem rivers and major tributaries, where water resources are often in high demand. Frequently, no EWR information is available for the smaller tributaries. The establishment of sites to provide EWRs at all locations of interest necessary for water resource planning is not pragmatic and beyond available resources. There is therefore a need to develop a cost-effective and efficient method for estimating EWRs for numerous river locations with reasonable levels of accuracy. This requirement is necessary to support the WAR initiative and to better evaluate individual water use licence applications.

The primary objective of this project was to develop a procedure for extrapolating EWR low-flow result from Reserve sites to additional locations (termed hydro-nodes) that have a degree of ecologically similarity. The extrapolation procedure refers to hydrological extrapolation by adjusting default parameters in the Desktop Reserve model, and is the current approach for estimating EWRs for additional river locations. The Desktop Reserve model is based on the results of previous EWR assessments, and therefore almost entirely on EWR-hydrological relationships derived for rivers with substantial runoff. With the exception of Rapid level III estimates, little cognisance is given as to whether hydrological extrapolation is ecologically justified. The "extrapolation" concept was extended to the "estimation" concept at an early stage of the study. The reason for this is that an "estimation" approach does not limit the method to the use of existing Ecological Reserve results, but rather allows for the development of a method that *explicitly* incorporates biological information, flow preferences for the biota present, and availability of hydraulic habitat.

A procedure has been developed for establishing the extent to which different river locations have physical similarity. Based on this, the assumption is that physical similarity implies similar fish guilds under natural conditions. The identification of likely indicator species may subsequently be used for informing ecological flow requirements at additional (un-sampled) river locations.

Estimation of EWRs requires the definition of habitat preferences or requirements. These have been provided through habitat specifications (or HabSpecs), which are numerical values for a combination of hydraulic parameters and flow-classes that define required hydraulic habitat and hence flows for "groups" of biota that exploit

environmental resources in a similar way (referred to as guilds for fish and communities for invertebrates). Habitat specifications are a function of hydrological variability (e.g. drought, maintenance and season) and Ecological Category (EC) for the river. In this study, HabSpecs were determined for two fish guilds: small rheophilic fish and large semi-rheophilic fish and a single community of invertebrates - cobble-dwelling rheophilics. Habitat specifications were computed using an optimisation method based primarily on the results of previous EWR studies. This effectively provides "calibrated" numerical rules that are based on the collective knowledge and understanding of river ecologists involved in previous ecological flow assessments. Habitat specifications provide a simple and consistent rule-based approach for estimating EWRs where hydraulic characterisation of flow conditions is available - presently at Rapid level III assessments and higher.

The HabSpecs indicate that hydraulic habitat is more sensitive to changes in low flows in smaller rivers (MAR < –30 Mm^3/a) than larger rivers, with the relevant fish guilds and invertebrate communities used, which supported by studies in the international literature.

The Nkomati Water Availability Assessment Study (WAAS) formed the basis for application of the methods (site similarity and EWR estimation) developed within this study. Overall, the HabSpec predicted ecological flows for 10 tributary sites were considered to provide more reasonable estimates, compared with Desktop model generated values, for the smaller streams with lower MARs (below – 30 Mm^3/a) and small rheophilic fish. Desktop model estimates were considered to provide increasing underestimates of EWRs with reducing stream size below approximately 30 Mm^3/a. For sites with mean annual runoff in excess of approximately 30 Mm^3/a, Desktop model estimates were considered reasonable recommendations for ecological low-flows. Since the HabSpec estimation method is independent of hydrology, estimates should be confined to between Desktop and natural (albeit modelled) flows. For the sensitive rheophilic biota considered, the application of HabSpecs for EWR estimation indicates that higher proportions of natural flows are required with reducing stream size and during the drier season.

The HabSpec generated low-flows for the selected (tributary) river sites were expressed as a function of the inundated low-flow channel width, and unit-width discharges were found to be remarkably constant. These flows were used to define the minimum seasonal drought and maintenance discharges required to achieve the recommended EC for the sensitive rheophilic biota. It needs to be emphasized that the unit-width EWR results from this study are applicable to specific fish guilds and invertebrate communities and hydrological characteristics of the Nkomati River catchment. Further study is required for the reasoning behind this (unit width) finding, as well as the development of more generalised and tested procedures for estimating EWRs for different biota and geomorphologies. This is taking place during concurrent research projects funded by the Water Research Commission as well as DWAF Reserve studies.