

Hydrologic and hydraulic modelling of the Nyl River floodplain Part 3: Applications to assess ecological impact

MT Kleynhans^{1*}, CS James¹ and AL Birkhead²

¹ Centre for Water in the Environment, School of Civil & Environmental Engineering, University of the Witwatersrand, Johannesburg, South Africa

² Streamflow Solutions cc, East London, South Africa

Abstract

The ecological functioning of the Nyl River floodplain in the Limpopo Province of South Africa depends on water supplied by catchments which are experiencing continuing water resource development. Hydrological and hydraulic models have been produced to assist in future planning by simulating the effects of developments on ecologically relevant flooding characteristics. The models are applied here to predict the impacts of different development scenarios on the areal extent of suitable habitat for a key species, the Wild Rice (*Oryza longistaminata*), which can be characterised in terms of the depth, duration and timing of flood events. The results show that historical developments in the contributing catchments have already significantly reduced the area suitable for Wild Rice growth, particularly in relatively dry years, and increased the likely dry period between flooding events. Dam construction on one of the tributaries would reduce the suitable area further in dry to average years and increase the inter-event dry period. Careful dam operation could ameliorate impacts in very dry years, however.

Keywords: Nyl River floodplain, Nylsvlei, Nylsvley Nature Reserve, wetland modelling, wetlands, environmental impact, ecohydraulics, hydroecology

Introduction

The Nyl River floodplain in the semi-arid Limpopo Province of South Africa is an internationally recognised conservation area, supporting a large proportion of the breeding population of inland water birds in Southern Africa (Tarboton, 1991), as well as a wide variety of mammals, reptiles, fish and insects (Tarboton, 1987). The ecological functioning of the floodplain is driven, in part, by seasonal floods, which occur during the summer season in three out of five years on average (Higgins et al., 1996). Water resource development in the Nyl catchment has altered the flooding regime (Havenga et al., 2007) which has affected the ecological functioning of the floodplain.

In 1996 the Department of Water Affairs and Forestry (DWAF) initiated a study of the hydrology and hydraulics of the floodplain to assess the potential ecological impacts of future water resource developments. A daily hydrological model set up by Pitman and Bailey (2004) was used to simulate the timing and volumes of flows delivered to the floodplain. Part 1 of this paper in 3 parts by Havenga et al. (2007) provides further details. The flows produced by the hydrological models were then transformed by one-dimensional hydraulic models into flooding (such as depth and extent of inundation). Part 2 by Birkhead et al. (2007) describes the one-dimensional hydraulic models.

This paper presents the application of the hydrological and hydraulic models to predict the potential impacts that land use, water resource development and the construction of dams can have on ecologically important flood conditions on the floodplain. Although the floodplain animals and plants all depend on the occurrence of water, the only known quantification of these

dependencies is for the vegetation, particularly the Wild Rice species *Oryza longistaminata* (Marneweck, 2003). This species was used as an indicator of ecological response to potential changes in depth, duration, timing and inundation frequency. The insights gained have value beyond just *Oryza longistaminata* requirements, however, because the vegetation is also an important contributor, directly and indirectly, to the requirements of mammals, fish and birds. For example, the distribution and diversity of water birds in the system are related to the physical structure of the vegetation (Marneweck, 1990). Further details of the scenario applications are provided by Kleynhans (2005).

Modelling for *Oryza longistaminata* requirements

The output requirements of the hydraulic modelling were specified to enable quantification of the habitat requirements of Wild Rice (*Oryza longistaminata*). Recent studies have shown that distinct vegetation communities can be recognised in relation to elevation on the floodplain (Higgins et al., 1996), and that plant species composition varies significantly with changes in elevation as small as 9 cm (Coetzee and Rogers, 1991). It has been shown that Wild Rice grows best within a fairly well-defined range of flow depths (between 0.1 and 0.5 m (Marneweck, 2003)). These findings suggest that water depth during flooding is an important determinant of vegetation community structure. The duration of flooding, and its timing is also important: Wild Rice needs at least 25 days of continuous inundation to flower and set seed if the flood occurs in January or February, but longer if inundation occurs earlier or later in the rainy season. Wild Rice is adapted to the seasonal and periodic nature of flooding and goes through its entire ontogenetic lifecycle whether inundation takes place or not. Its life-cycle response allows it to cope with the variability in timing of inundation common in semi-arid areas. If there is no inundation, the plant

* To whom all correspondence should be addressed.

☎ +2721 481-2400; fax: +27121 424 5588;

e-mail: martin.kleynhans@shands.co.za

Received 16 May 2006; accepted in revised form 21 November 2006.