EXECUTIVE SUMMARY

Successful prediction of agricultural non-point source pollution (NPS-P) requires an understanding and quantification of the sources and pathways of sediment and nutrients in the landscape and stream network. The migration of NPS-P is often dominated by controls and connectivity features in the catchments and so this work aims at observation, description and quantification of the processes for water, sediment and nutrient delivery in a research catchment, the Mkabela catchment near Wartburg, KwaZulu-Natal. These processes include land based connectivity and stream reach barriers and controls. The catchment selected comprises a predominant sugar cane land use, but includes areas of vegetable cropping, forestry and pastures. The landscape is dominated by Natal Group Sandstone geology and the stream network has numerous impoundments, wetlands and hydraulic controls at road crossings and changes in gradient or bed type.

The methods applied to the understanding of the NPS-P migration included:

- Sediment source fingerprinting, where surface soils were sampled and downstream deposition profiles cored to deduce the source, timing and controls dominant in the migration of sediments;
- Geophysical and soil pedological surveys to determine dominant pathways of water, sediment and nutrient migration in the contributing hillslopes;
- Stable isotopes of water and nutrient sampling to illustrate flow pathways, controls and connectivity in contributing hillslopes and the stream network.

Soil and sediment profiles were sampled in May 2008 and nutrient, sediments and isotopes were sampled in the stream network at various spatial and temporal scales between 2009 and 2011.

The combined process zone-sediment tracing analysis resulted in the following conclusions.

- The study catchment is composed of a series of distinct process zone types, each characterized by differences in their ability to produce, transfer, and store sediment. The nature and spatial arrange of the process zones within the basin show that it can be subdivided into three subcatchments, referred to here as upper, mid- and lower subcatchments. The three subcatchments differ in their tendencies to transport and store sediment and nutrients.
- The construction of a drainage ditch through the upstream most wetland significantly altered the geomorphic and hydrologic connectivity of the catchment. Prior to its construction, sediments (and associated nutrients) were largely deposited within wetlands which encompassed a majority of the valley floors within the upper catchment. Sediments delivered to the mid-catchment area were generally transported downstream as a result of confined flows and steep channel gradients which often include bedrock reaches. There is very little storage within the reach, except within local dams.
- Following construction of the ditch across the upper most wetland, sediments could be transported from the headwaters of the catchment, through downstream wetlands and dams (reservoirs) and to a low-gradient alluvial channel boarded by an extensive riparian zone. Thus, the axial drainage system is geomorphically and hydrologically connected during most events throughout the study basin. However, current rates of sediment deposition within the downstream most riparian wetlands is extremely high, approaching 10 cm/yr, suggesting that this reach limits the further downstream movement of sediment.
- The complex interactions between runoff, soil type and characteristics, and land-use (among other factors) appear to create temporal and spatial variations in sediment provenance. Silt- and clay-rich layers found within the wetland and reservoir deposits appear to have been derived from the erosion of fine-grained, valley bottom soils which are frequently utilized as vegetable fields. The deposits tend to exhibit elevated concentrations of Cu and Zn, presumably from the use of fertilizers which contain both elements. Coarser-grained deposits

within the wetland and reservoir presumably result from the erosion of sandier hillslope soils extensively utilized for sugar cane. Erosion of these upland cane fields presumably occurs during relatively high magnitude runoff events that are capable of transporting sand-sized sediment off the slopes, and which create dam (reservoir) deposits lacking significant quantities of silt- and clay-sized particles. Therefore, sediment source, as might be expected, varies as a function of runoff magnitude.

- Sediment source determination on multiple cores from the wetland demonstrated that sediment partitioning during transport not only produced deposits of varying sedimentological and chemical characteristics, but deposits consisting of sediment from different source areas. As a result, within highly variable depositional environments, multiple cores should be collected and analyzed to determine sediment provenance.

Nutrient loading and isotopic tracing behaviours reflect the following:

- The nutrient (NO_3-N and P) transport in the catchment mirrors the sediment migration through the channel system. However, the relationship between sediment and P is poor, suggesting that much of the P transport in contributing hillslopes is in a dissolved phase and may occur in the subsurface.
- The loads of nutrients between the Bridge 1 and Bridge 2 section reflect the bedrock control, where contributions from sugar cane hillslopes between these stations are not retained, even in the short wetland upstream of Bridge 2.

Isotope ratios reveal that impounded tributaries are often effective in retaining event water. However mixing and disturbance of the resident nutrients and sediments results in elevated outflow concentrations during events.

- The dominant contribution mechanism for nutrients in the landscape appears to be in the subsurface, in lateral discharge in the intermediate layer between the sandy soil and bedrock.
- Event water, carrying high nutrient loads, dominates the responses at the field scale, while low flows reflect the groundwater concentrations of N and P throughout the catchment. Future understanding of the connectivity and controls in the Mkabela and other catchments would be improved by further sediment fingerprinting to the lower parts of the catchment and identification of nutrient tracers to identify the sources and track the movement and deposition of applied fertilizers. An increase in the frequency of sampling stream responses of isotopes, nutrients and sediments during events would improve the understanding and quantification of the connectivity between land units and stream. While the hydropedological assessment of hilsllope response types has allowed for the definition of hillslope water generation mechanisms in this study, improved monitoring of the hilsllope water and nutrient responses would be invaluable in quantifying the links between land units and stream and the nature of nutrient migration.