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Age, distribution, and significance within a sediment budget, of in-channel depositional surfaces in the Normanby River, Queensland, Australia

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ABSTRACT

We present the results of investigations into alluvial deposition in the catchment of the Normanby River, which flows into Princess Charlotte Bay (PCB) in the northern part of the Great Barrier Reef Lagoon. Our focus is on the fine fraction (<~63 μm) of alluvial deposits that sit above the sand and gravel bars of the channel floor, but below the expansive flat surface generally referred to as the floodplain. Variously described as benches, bank attached bars or inset or inner floodplains, these more or less flat-lying surfaces within the macro-channel have hitherto received little attention in sediment budgeting models. We use high resolution LiDAR based mapping combined with optical dating of exposures cut into these in-channel deposits to compare their aggradation rates with those found in other depositional zones in the catchment, namely the floodplain and coastal plain. In total 59 single grain OSL dates were produced across 21 stratigraphic profiles at 14 sites distributed though the 24 226 km^2 catchment. In-channel storage in these inset features is a significant component of the contemporary fine sediment budget (i.e. recent decades/last century), annually equivalent to more than 50% of the volume entering the channel network from hillslopes and subsoil sources. Therefore, at the very least, in-channel storage of fine material needs to be incorporated into sediment budgeting exercises. Furthermore, deposition within the channel has occurred in multiple locations coincident in time with accelerated sediment production following European settlement. Generally, this has occurred on a subset of the features we have examined here, namely linear bench features low in the channel. This suggests that accelerated aggradation on in-channel depositional surfaces has been in part a response to accelerated erosion within the catchment. The entire contribution of ~370 kilotonnes per annum of fine sediment estimated to have been produced by alluvial gully erosion over the last ~100 years can be accounted for by that stored as in-channel alluvium. These features therefore can play an important role in mitigating the impact on the receiving water of accelerated erosion.

1. Introduction

The sediment budget concept has been a central organising principle within the discipline of geomorphology since at least the 1970s (Dietrich and Dunne, 1978; Dunne and Leopold, 1978), with the concept increasingly refined in subsequent decades (e.g. Walling et al., 2002; McKergow et al., 2005). In essence a sediment budget provides a method of accounting for sediment inputs and outputs through a drainage network. It enables the primary sources of sediment and the sediment transport pathways to be identified, and is useful for highlighting data needs and system understanding (or lack thereof).

Alluvial deposits that sit within the channel boundary but are too high to be considered part of the mobile bed have recently been the subject of renewed research effort in Australia, especially in relation to their role within sediment transport pathways (e.g. Rustomji and Pietsch, 2007; Hoyle et al., 2008, 2012; Erskine et al., 2009, 2012; Hughes et al., 2010; Wasson et al., 2010; Croke et al., 2013; Thompson and Croke, 2013). Such deposits are common in river systems bounded by extensive Pleistocene age alluvial surfaces which are not active under the current hydrological regime and tend to give rise to compound channels. This type of channel is increasingly being referred to as a 'macro-channel', sensu van Niekerk et al. (1999) who initially applied the term to compound bedrock channels in South Africa. The term was first used in an Australian context by Hoyle et al. (2008) to describe the morphology of compound channels bounded by Pleistocene terraces in the Hunter River. There is a growing realisation that understanding the dynamics of these inset deposits is crucial to understanding the transport of sediments from and through catchments (e.g. Hoyle et al., 2012; Bartley et al., 2014). The perceived importance of these deposits may, in part, be due to the highly episodic nature of flow in many Australian catchments (Finlayson and McMahon, 1988; Kemp, 2004; Peel et al., 2004; Rustomji et al., 2009). In these catchments, flow over the high floodplain is a rare occurrence and deposition thereon consequently represents an insignificant part of the sediment budget in most years. Our observations of large expanses of depositional zones within the channels of the Normanby Catchment in northern Queensland, Australia, lead us to hypothesise that they may be a more significant sediment store than the

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higher alluvial surface traditionally termed the floodplain, or at least significant enough that excluding them from a catchment sediment budget would result in it being significantly in error. This study seeks to test this hypothesis. Also, as in-channel aggradation, especially that occurring on low-set linear benches aside the channel, is unlikely to be constant through time we look to understand the longer term dynamics of bench creation and removal. Of particular interest is the relationship (coincident or otherwise) between the timing of bench establishment and growth, and the adoption of European management practices in the catchment.

In this paper we use a variety of methods to allow us to describe the significance of in-channel features, including benches, in the sediment budget of the Normanby Catchment. We use optical dating to determine aggradation rates, particle size analysis and stratigraphic description of bench, inset floodplain and floodplain deposits to examine silt and clay concentrations, and an automated analysis of LiDAR data to determine the distribution of in-channel depositional surfaces throughout the catchment.

This paper builds on the previously published reports and papers (Brooks et al, 2013, 2014a, 2014b, 2014c; Olley et al., 2013, in preparation) that arose out of an Australian Government funded project that sought to parameterise with newly collected empirical data, at higher spatial and temporal resolution, a new sediment budget model for the Normanby. We focus on the distribution and rates of aggradation of in-channel deposits as these were not included in the previous sediment budgeting exercises. We also include comparable investigations into the floodplain and the broad coastal plain at the very bottom of the catchment. These data allow the rates of deposition and storage of fine sediment within the channel to be placed in a broader context.

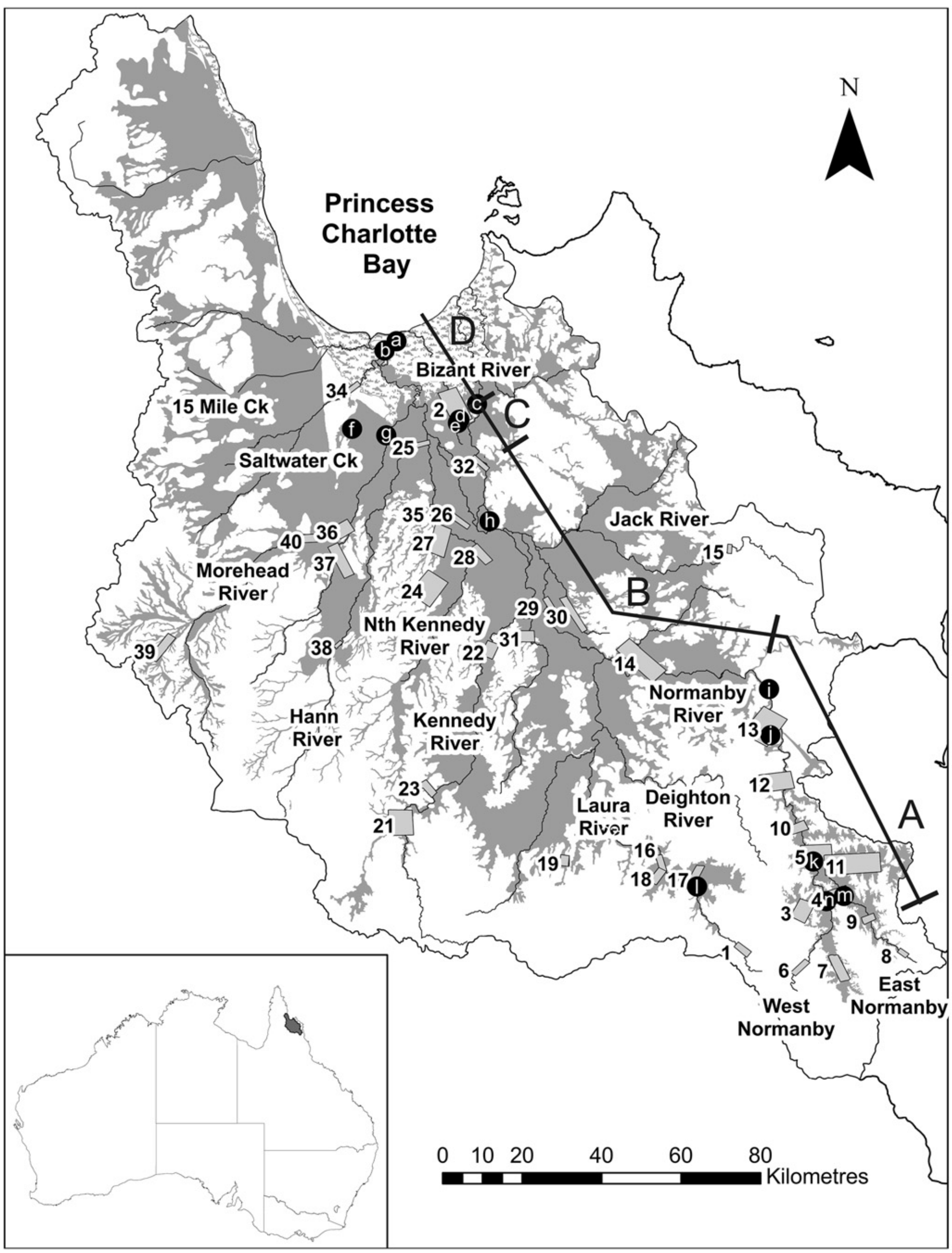

Fig. 1. Map of the Normanby catchment showing major channels and location of LiDAR blocks (grey boxes) and sampling sites (closed circles). Site labels are a: NKCP2; b: NKCP1; c: NRFP; d: Bizant R; e: Bizant Gully; f: IBA16; g: MRFP; h: Kalpowar; i: Battlecamp Crossing; j: NSVF1; k: KPWN; l: Carrolls Crossing; m: East Normanby; n: West Normanby. The valley transect approximately delineates the sequence of riverscapes down valley, with reaches A–D described in text and Fig. 2. The grey shading is mapped alluvium; the stippling shows the coastal plain. Inset shows position of catchment within Queensland.