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Preface to the Special Issue of the Journal of Hydrology (New Zealand): Sediment flux, morphology and river management

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Analysis of sediment flux, and its relations to river morphology, is a fundamental component of pro-active river management. In simple terms, if the geomorphic structure and function of a river are changed, so too are a host of biological and geochemical attributes of that river. Hence, effective management of sediment flux has important implications for the availability and viability of aquatic habitat; water quality and nutrient processing relationships; flooding and sedimentation hazards; and riparian vegetation associations. It is with these concerns in mind that activities such as flow regulation, land-use change and resource extraction along rivers should be framed. A better understanding and appropriate management of fluvial sediment processes and morphologies assume even greater importance today with the shadow of potential climate change and its effects on hydrologic and earth-surface processes, and society's concerns about flood risk and protection of the inherent values of river systems.

The seed for this special issue on sediment flux, morphology and river management arose from establishment of the cross-faculty Fluvial Processes Initiative at The University of Auckland – for information visit the website: (http://www.cee.auckland.ac.nz/uoa/home/about/ourresearch/researchareas/fluvialprocessesinitiative). The initiative obtained funding in 2009 to establish projects to facilitate pro-active, process-based management of rivers through conceptualisation of sediment movement across New Zealand landscapes. One of the projects was to establish a workshop on conceptualising sediment movement and its implications for environmental management.

The one-day National Sediment Flux Workshop took place in November 2010, with invited speakers coming to The University of Auckland from around New Zealand. The theme of the workshop was "Landscape connectivity, sediment flux, morphological adjustments, and river management". Talks were grouped into sessions on source-to-sink processes and conceptualisation, the variability of processes and issues around New Zealand, and management implications.

Many concepts and issues relating to sediment processes and catchment management were highlighted by the discussions at the workshop.

(i) We need to appreciate the ranges of behaviour exhibited by different types of river, especially concerning their respective capacities to achieve notional equilibrium states over given timeframes. Of particular importance is the ability to predict threshold-induced transitions

in river character and behaviour (i.e., river change).

(ii) We need a rigorous assessment of catchment-specific applications of generalised predictions regarding sediment flux, especially if, for example, they are based on limited monitoring applications for which questions can be asked about how representative they are, or if they use simplified modelling applications. Attention was drawn to stark contrasts (over variable scales) in the availability of sediment to be transported in any given system.

(iii) Landscape connectivity is important as a control on the rate and sustainability of sediment flux. It influences both (a) the capacities of different parts of landscapes to transport differing grain size fractions (i.e., for selective entrainment of gravels, sand, mud), and also (b) sediment exhaustion (especially through the impacts of dams), which can compromise the physical integrity of some river systems.

(iv) We need to recognise potentially stark differences in magnitude-frequency relationships for the dominant formative processes across the catchment, e.g., on hillslopes (decadal?), valley floors (annual?), and estuaries (daily?).

(v) We need to recognise the sources of sediments being transported (including legacy sediments from previous periods of land-use change that are now available to be transported). The primary contemporary source of sediments moving through a river system can change over time as sediment stores on valley floors become an increasing component of materials that are reworked.

(vi) We need to use contemporary insights into sediment flux as a basis to inform river management policy, with science viewed alongside economic, social and cultural considerations for decision-making regarding issues such as mitigation of the impacts of land-use change (e.g., forest management, dairying); flow regulation and gravel extraction.

(vii) We need to apply 'whole of system' understanding, to directly link biophysical insights to ecologic and water quality considerations in order to provide a more coherent and integrative platform for management applications.

(viii) We need to work towards appropriate 'hands-on' management tools to address concerns for any given river system as a whole, rather than using simplified prescriptive 'cook-book' tools that can fail to take into account (or protect) the inherent values of that system.

(ix) Researchers and scientists need to work directly with policy makers, planners, politicians, stakeholders and decision makers to ensure that the best available understanding of sediment flux is used as effectively as possible (across local, catchment and regional scales).

(x) We need to recognise inherent uncertainties in river dynamics and process responses, remembering that future behaviour is fashioned, to varying degrees, by past events (i.e., each system has its own memory). Our assumptions about future formative events (e.g., future sequences of floods) cannot be simply assumed to be correct – prospective trajectories of adjustment for a river must be framed in relation to a likely future 'range of behaviour'. An adaptive management framework is needed, using monitoring applications that help us to learn from successes and failures (Brierley *et al.*, 2010). We thus need to state explicitly our conceptual understanding of a particular system to test this knowledge against future outcomes (see Mika *et al.*, 2010). This

approach recognises that we may not necessarily 'get it right' now, but we will learn from our efforts to ensure that we do not repeat mistakes from the past.

Arising from the 2010 workshop, this 2011 special issue of the Journal of Hydrology (New Zealand) was formulated. The goal of this special issue is to provide a compilation of perspectives on sediment flux, morphological adjustment and catchment management in a New Zealand setting; from processes and frameworks at varying scales to regional management aspects. Along the way we will look at issues to be faced and potential future research needs. This issue continues in the vein of the two previous special issues of the Journal of Hydrology (New Zealand): the Carson and Griffiths (1987) treatise on "Bedload transport in gravel channels" and the Warburton (1996) special issue on "Hydraulic modelling of braided gravel-bed rivers".

The papers in this issue have been grouped in terms of sediment flux processes and analysis, and sediment flux and river management. The first group of papers adopts a source-to-sink view of the sediment pathway, spanning sediment production and delivery from the hillslopes (Cochrane and Acharya) and gullies (Marden and Herzig); sediment transport processes and morphology for river systems (Coleman and Smart); using morphological adjustments to appraise sediment flux (Fuller et al.); suspended sediment yields (Hicks et al.); and catchment-scale approaches to modelling sediment flux (Elliott and Basher). The second group of papers comprises discussions of river management practices (Davies and McSaveney, and McFarlane et al.); and case studies of sediment flux and river management, including the Tongariro catchment (Brierley et al.), North Island gravel-bed rivers (Williams), the eastern Ruahine Range (Schwendel and Fuller), the Waikato region (Hill), and the lower Hutt River (McConchie et al.). Significant contemporary studies of sediment flux and river management for South Island rivers that are not highlighted in this issue include those focussed on the Rees River (http://www.reesscan.org/Home) and the Waitaki River (http://www.gns.cri.nz/Home/Our-Science/Environment-Climate/Environmental-Change/Research/MARGINS-Source-to-Sink-Terrestrial-New-Zealand).

Ultimately, the state of our rivers is a collective responsibility. As a community, we have an opportunity to promote and sustain healthier rivers. This will only be achieved if we work together, building upon shared understandings. In this regard, it is hoped that this issue provides a useful point of reference for understanding of sediment pathways, processes and management, particularly in a New Zealand setting, and particularly in regard to recognising the ranges of scales that are involved and that need to be considered for successful management of rivers and catchments. The contemporary interest in rivers and their management is evident in the recent successful launching of the IPENZ Rivers Group (http://www.ipenz.org.nz/riversgroup/), which has the aim of providing a forum for those involved with, and with an interest in rivers, flood risk management and the operational and environmental issues of catchments and river systems.

As identified in the various papers in this issue, further work is needed in regard to sediment flux, morphology and river management. With contemporary advances in instrumentation, understanding and interdisciplinary cooperation, we look forward to a great potential for progress in the coming years.

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