COUPLED HYDRAULIC AND ENTROPY RELATIONSHIPS

The theoretical concept of minimum entropy production was first proposed by Prigogine (1955) and is excellently explained in general terms in the book by Atkins (1984). The concept was applied to rivers by Leopold and Langbein, who argued that the entropy production for the system as a whole should be a minimum. They combined this argument with conventional continuity, friction and sediment transport relationships and uniform energy per unit mass and uniform stream power to derive discharge relationships for the hydraulic geometry of a river, as summarised in Regime relationships. They noted that uniform energy would lead to a straight basin profile and minimum total work (entropy production) would give rise to a concave basin profile.

These concepts have been re-interpreted for the case of a bi-directional flow in an estuary and applied to a number of UK systems (Dun & Townend, 1998; Townend, 1999) and implemented this approach as the *E*st*E*nt model. The model is able to highlight the difference between systems, where some show a clear exponential upstream decay, whereas others show a more linear variation in the rate of energy dissipation. This reflects the interplay between minimum entropy production for the system as a whole and the fact that uniform work is but one way of achieving this most probable state, as identified by Leopold and Langbein. Translating this into identifying the physical controls that determine the relative balance of this interplay is an aspect that still needs further research.

Where multiple bathymetries over time are available the *E*st*E*nt model can be used as a diagnostic tool (Townend & Dun, 2000) and it was examined for a range of different estuaries as presented in Paper 19 of the EMPHASYS Report. Future developments are likely to explore a more complete theoretical development and the application in some form of iterative mode with a suitable hydraulic model (possibly using annealing techniques as mechanism for exploring a range of possible states to find the most probable).

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