COUPLED HYDRAULIC AND ENERGY RELATIONSHIPS

Method Indicator		
Bottom-Up	Hybrid	Top-Down
	YES	

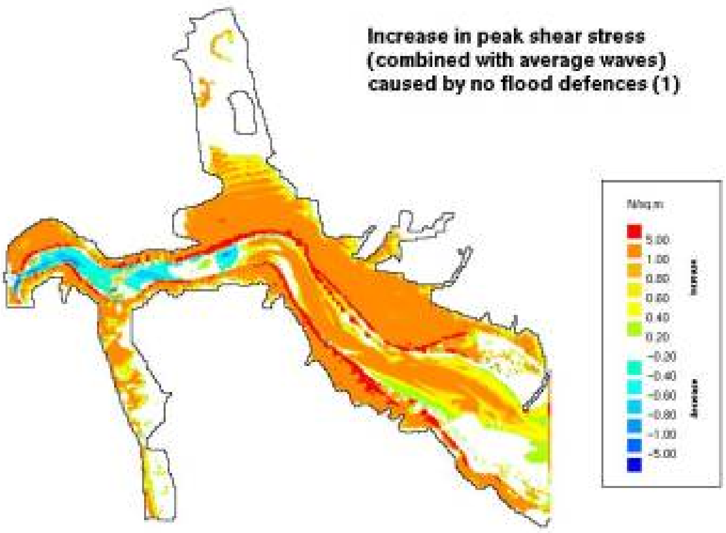
Summary of key issues

Issue	**Description**
Description	Examines the distribution of bed shear stresses and compares these with erosion thresholds for the types of sediment present.
Temporal Applicability	Typically applied over scales of between 10 and 100 years.
Spatial Applicability	Generally applied over the entire estuary, however, can be applied at a single point or cross-section.
Links with Other Tools	Hydrodynamic and sediment transport models, the hydrodynamic model provides the required flow information in which the bed shear stresses are derived.
Data Sources	• Bathymetry • Boundary Information • Calibration Data (Flows and Water levels) • Sediment information • Long-term morphological change (historic charts)
Necessary Software Tools / Skills	1D numerical model, historic bathymetry. A good understanding of the estuary hydrodynamic regime and the ability to interpret modelling results is essential.
Typical Analyses	Estimate of changes in estuary form (width and depth).
Limitations	Calibration is extremely difficult; application and interpretation of the model results can also be difficult; lack of historic data.
Example Applications	Humber Estuary

Sediment transport is controlled by the velocity of water and its volume. The competence of the water allows sediment to be picked up and entrained within the water column. The force exerted by this entrainment is known as shear stress. If the shear stress exceeds the threshold for entrainment for a particular grain size, then the sediment will be picked up and transported.

Given the difficulty of predicting the changes that result from sediment transport processes, particularly in estuaries with mixed sediments, one option is to look at the changes in bed shear stress under different scenarios. A hydraulic model is used to predict the flows under the various scenarios under consideration and the changes in bed shear-stress patterns are used to infer the likely changes.

The use of bed shear stress has been introduced into a tidal prism type regime model, as a means of determining the basic form of any given cross-section. By relating the bed shear stress to the critical erosion and deposition thresholds, an equilibrium depth can be predicted, which, in conjunction with the cross-sectional area, allows the width to be estimated (Pethick and Lowe, 2000).



Within the field of river engineering, there has been extensive attention given to the concepts of uniform energy dissipation per unit of bed and uniform stream power (Yang & Song, 1979; Song & Yang, 1980). These concepts link closely with that of minimum work or entropy production as discussed in the section on coupled hydraulic and entropy relationships. It is likely that future developments will result in a closer integration of the two concepts to a single coherent understanding. Some elements of this have been put together for fluvial regime channels by Yalin and Ferreira da Silva (2001, see p87 for discussion on the variation of flow energy structure with the passage of time).

References

Pethick, J. and Lowe, J., 2000, Predicting the shape and future evolution of estuaries, In EMPHASYS Consortium (eds.) Modelling Estuary Form and Process, EMPHASYS Estuaries Research Programme Phase 1, MAFF Contract CSA 4938, Final Report, TR 111, pp.83-88.

Song CCS, Yang CT, 1980, Minimum stream power: theory, Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, 106(HY9), 1477-1487.

Yalin MS, Ferreira da Silva AM, 2001, Fluvial processes, IAHR International Association of Hydraulic Engineering and Research, Delft, Netherlands.

Yang CT, Song CCS, 1979, Theory of minimum rate of energy dissipation, Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, 105(HY7), 769-784.