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Title: Geomorphic Response of Regional Sediment Systems

Topic Area: A1.1: Forensic Analysis of System Controls and Response

Objective: To determine the underlying causes and mechanics of the reaction, response, and recovery of regional sediment systems to natural stimuli, management practices, and engineering actions and to provide sound methods and procedures for predicting and evaluating the response of medium scale riverine sediment systems. Product A1.1.2 of the Regional Sediment Management Program will be provided by this work unit.

Problem: When significant events such as large storms, channel alignment, and basin land use changes occur in watersheds, the sediment system undergoes an initial reaction (that has a direction, magnitude, and physical product). Typically the initial reaction includes a significant increase or decrease in the types of sediment loads produced to and carried by the channels. The initial reaction is followed by a longer response, as the system adjusts its processes and forms to accommodate the new energy levels and sediment loads in the systems. The rate change of the response declines as the system approaches recovery, the condition at which the system begins to reach some state of equilibrium between energy and mass (primarily sediment and water) provided to the system and the type and amount of work (ie; sediment production, transport, and deposition) done by the system.

It has been documented that similar sediment systems react, respond, and ultimately recover from similar stimuli, interruptions, and modifications in different ways, directions, and rates. These differences in reaction and response of sediment systems may be a product of the non-linearity of relationships between controlling factors of sediment systems as well as the occurrence of deterministic chaos in the order and function of the geomorphic systems. Optimal management of regional sediment systems requires that the reaction, response, and recovery of the systems to natural stimuli, management practices, and engineering actions be understood sufficiently to allow the “best” decisions to be made regarding sediment management strategies as well as the probable long-term impact of engineering projects on the system.

Benefits: The results of this research effort will provide a clear statement of the mechanics of why, how, when, and where a given regional fluvial sediment system will adjust to modifications by man and nature. When combined with the efforts and products of the proposed companion Work Unit on “Spatial and Temporal Transport Processes Within a Systems Context” (Biedenharn and Smith), these results will form the basis for developing management strategies, modeling and assessment tools, and engineering solutions for use in regional

sediment management. A primary statement of the analysis of sediment systems reaction, response, and recovery will be the development of a conceptual geomorphic model for input into RSMP efforts in modeling and assessment. Additionally, the results of the work unit will serve as a conceptual and theoretical foundation for the "Integration Work Unit in the Engineered Solutions Focus Area.

The results of this work unit will be particularly valuable to the SMART research effort. The response of river systems to various stimuli has profound implications for the ecological systems related to the river environment. Development of modeling and assessment tools to address environmental issues associated with rivers and related environs (riparian wetlands, floodplains, estuaries, deltas, reservoirs) requires an understanding of the mechanics, processes, causative factors, and resulting products of river reaction, response, and recovery.

The results of this work unit will provide valuable input to the ultimate satisfaction of the following needs identified by Corps field personnel: 2-B4, 4-B2, 6-B4, 10-A6, 12-B1, 13-B2, 28-A2, 30-82, 41-C4, 43-B2, 49-D2, 69-A3, 71-B2, 77-B2, 100-A2, 104-B4.

This work produces new tools and methods for the USACE and nation. It is an integral part of the Regional Sediment Management Research Program, and thus contributes primarily to support of the USACE's navigation, flood/storm damage reduction, and environmental protection and quality missions. It supports all 8 Civil Works strategic goals and 7 of 9 Listening Session objectives identified by HQUSACE as R&D priorities. With companion work units, it employs active technology transfer and insertion.

Work Description: Completion of the research program for this work unit will include eight tasks. These tasks are:

1. Review and synthesis of the state-of-knowledge of sediment systems dynamics to determine concepts and results that may be applied and/or expanded upon for application to regional sediment management.
2. Selection of research watersheds representative of differing sizes, hydrologic, geologic, climatologic, and land-use conditions for field investigation. This task will be completed in conjunction with the RSM work units " Spatial and Temporal Sediment Transport Processes Within a Systems Context" and "Framework for Integrated Engineered Solutions".
3. Development of data sets from existing data for research watersheds. This task will be coordinated with efforts conducted in the "Informatics" Task to assure inter-operability between this research effort and developments in the Informatics Task.
4. Acquisition of field data. The focus of the field data effort will be the identification and measurement of phenomenon that are produced by the interruption of system states during reaction, response, and recovery. Data acquisition will include verification of data developed from existing

data sets, in-situ measurements of morphological features, stream sediments, and hydrological conditions, and well as acquisition of samples for laboratory tests and analysis.

5. Analysis of samples and data. Samples obtained at the field research sites will be tested and analyzed in terms of their sedimentological properties. Data developed from field observations and measurements, previously existing data sets, and office-generated data will be evaluated and analyzed individually and collectively to determine original sediment processes regimes, historic modifications by management practices, engineering projects, and large natural events.
6. Synthesis of results from different watersheds. Comparisons of results between and among the research watersheds will allow the development of a body of theory that may be used for extrapolation to other watersheds in a regional sediment management program.
7. Development of a geomorphic model of sediment system response. Once the causative factors and controlling systems mechanics for the reaction, response, and recovery of the sediment systems have been determined, a heuristic model of the dynamics of the system will be developed. The model will provide an expression of the importance of controlling conditions and processes such as intrinsic and extrinsic thresholds and equilibria states.
8. Preparation of professional papers for submission to professional journals and completion of two summary reports describing (a) the goals, objectives, significance, methods, data, analyses, results, conclusions, and products of the research effort and (b) a report tentatively titled "Geomorphic Response of Sediment Systems: Application to Regional Sediment Modeling and Assessment".

Products and Schedule:
Major product is A1.1.2: Controlling parameters and dependencies for geomorphologic and environmental response, which will contribute a) knowledge to guide planning and design of engineered solutions and inform the USACE and its stakeholders and b) qualitative and quantitative descriptions of morphological processes to be used by the Modeling and Assessment Tasks.

Product	Scheduled
1. TN: Geomorphic Response of Sediment Systems	Q4/02
2. TN: Analysis of factors influencing geomorphic response	Q3/03
3. TN: Factors Influencing Sediment Systems Response	Q4/03
4. TN: A conceptual model of sediment system response	Q2/04
5. TR: Geomorphic Response of Sediment Systems: Applications to Sediment Management	Q3/04
6. TR: Geomorphic Response of Sediment Systems: Applications to Regional Sediment Modeling	Q4/04
7. JP: Development of a Conceptual Geomorphic Model of	Q4/04

the Response of Regional Sediment Systems to
Natural and Anthropogenic Stimuli