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Large River Sediment Transport and Deposition:

An Annotated Bibliography

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Large River Sediment Transport and Deposition: An Annotated Bibliography

by

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Contents

Page

Tables

Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center, a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This report was prepared under Strategy 1.2.1, *Determine Effects of Sedimentation and Sediment Transport Processes on the Upper Mississippi River System Ecosystem*, Task 2.2.5.3, Work Unit B—*Data Identification and Compilation*, and Strategy 3.1.2, *Predict Future Conditions Without Change in Management* of the Operating Plan (U.S. Fish and Wildlife Service 1993). It was developed with funding provided by the Long Term Resource Monitoring Program.

Large River Sediment Transport and Deposition: An Annotated Bibliography

by

Henry C. DeHaan

Abstract

The Upper Mississippi River System (UMRS) has been dramatically altered by changing land use and management practices within its basin. One consequence of these changes is the severe environmental problem of increased sedimentation in river backwater areas. The Long Term Resource Monitoring Program is addressing this problem by expanding and initiating new research of sediment movement in the UMRS. As part of its new research, this annotated bibliography was generated to identify, review, and provide information about studies associated with sediment transport and deposition in large river environments. It contains 275 citations and abstracts for works that were published primarily between 1970 and early 1995. A list of 41 keywords is included to help differentiate between the various subjects associated with river sediment. A keyword index is also provided to assist readers in rapidly locating information about specific topics.

Introduction

The Upper Mississippi River System (UMRS) is a unique and important national resource. It sustains a diverse mosaic of natural habitats and wildlife and supports a large navigation system made up of 27 dams that assist in maintaining a 9-foot channel. The Upper Mississippi River extends from Lake Itaska in northern Minnesota to Cairo, Illinois, draining an area of about 50 million hectares.

The UMRS has been dramatically altered because of escalating development in its basin. Activities such as increased navigation, dredging, urban sprawl, industrial waste discharges, intensive agricultural practices, and recreational pressures have stressed many areas of the system and threaten the natural and economic resources of the entire region (U.S. Fish and Wildlife Service 1993). The problems related to these activities are numerous and need to be addressed before they become irreversible.

One of the primary environmental problems on the UMRS is the sedimentation occurring in backwater areas (GREAT I 1980; Hawkins and Stewart 1990; U.S. Fish and Wildlife Service 1993; Gaugush and Wilcox 1994). Sedimentation has increased in these areas because of changing land use practices causing much higher rates of upland erosion and discharge of sediment over presettlement rates (Knox et al. 1975; Knox 1977; Demissie et al. 1992). This problem is being addressed by the Long Term Resource Monitoring Program (LTRMP).

The LTRMP was initiated because of a critical need to collect, analyze, and provide sound scientific information to the various users and managers of UMRS resources (U.S. Fish and Wildlife Service 1993). Its primary goals are to monitor resource change and develop alternatives for enhanced management of the Upper Mississippi River to maintain it as a sustainable large river ecosystem.

This bibliography is considered part of the overall approach introduced by Gaugush and Wilcox (1994) to expand LTRMP research of sediment transport and deposition in the Mississippi River. The proposed research includes a literature review (i.e., annotated bibliography) on sediment-related studies, compilation and review of existing geomorphological and sediment data, expansion of the present sediment monitoring network, investigation of sediment movement throughout the system, and prediction of the future configuration of channels and floodplain. Results of the research will be used to determine the best management practices for maintaining and enhancing the natural and cultural resources of the UMRS.

This annotated bibliography was developed to locate, review, and provide information about literature associated with sediment transport and deposition in large river environments. Selected works include topics on climate, river discharge, erosion, geomorphology, the UMRS, and sediment movement through large river systems. The bibliography contains 275 citations and abstracts that refer to documents published primarily between 1970 and early 1995 (Table 1). Most studies reviewed were performed in the 1980s and 1990s.

Table 1. Frequency of citations per period.

Year	Number of citations
Before 1970	6
1970–1979	59
1980–1989	126
1990–Early 1995	84

This document is not a comprehensive bibliography on large river sediment transport and deposition. Studies were usually excluded if they took place on the lower Mississippi River. Also, most works published before 1970 were not included because of the difficulty in locating them. This was because they were usually not cited in on-line computer catalogues.

Several libraries, government agencies, and various other programs were searched for this project. The most useful sources included the Upper Mississippi River Conservation Committee Library Database, the University of Wisconsin libraries, the Environmental Management Technical Center document collection, the U.S. Army Corps of Engineers library, and the Library of Congress.

Abstracts were generated for each citation in the report by summarizing information related to the sediment theme of the bibliography. In some instances, the abstract was obtained directly, or with some minor changes, from the original paper.

A list of 41 keywords (Table 2) was created to help differentiate between the various topics associated with large river sediment movement and deposition. The number of times keywords are referred to is also noted. Studies involving rivers and sediment are cited most often.

Table 2. Keyword list with number of citations concerning these subjects.

Keyword	Number of citations
Bathymetry	19
Bed load	27
Bibliography	8
Channel	159
Channel flow	98
Channel geometry	29
Channelization	29
Climate	23
Compaction	1
Contaminants	4
Discharge	24
Drainage basin	32
Dredging	20
Erosion	57
Flood	34
Floodplain	34
Geographic Information System	5
Geology	9
Geomorphology	55
Land cover/land use	50
Levee	24
Lock and dam	36
Measurement	84
Mississippi River	144
Model	98
Navigation	26
Pool	46
Precipitation	10
Remote sensing	10
River	247
Scour	20
Sediment	216
Sedimentation	103
Sediment budget	8
Sediment chemistry	4
Sediment transport	127
Soil	13
Stage	26
Suspended sediment	53
Water quality	22
Waves	10

A keyword index was generated to assist readers in rapidly locating citations and abstracts related to desired topics. The numbers used in the index refer to the abstract number, not the page.

Acknowledgments

This project was initiated with the assistance and oversight of Robert Gaugush. Thanks to Mary Craig, Kenneth Lubinski, and Joseph Wlosinski for their insightful suggestions regarding the subject material. The editorial assistance of Georginia Ardinger is also greatly appreciated.

References

Demissie, M., L. Keefer, and R. Xia. 1992. Erosion and sedimentation in the Illinois River Basin. Illinois State Water Survey, Champaign. ILENR/RE-WR-92/04. n.p.

Gaugush, R. F., and D. B. Wilcox. 1994. Planning document: Investigate sediment transport/ deposition and predict future configuration of UMRS channels and floodplain. National Biological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, December 1994. LTRMP 94-P004. 9 pp. + Appendixes A–E

GREAT I. 1980. Great river environmental action team study of the Mississippi River. Volume 7. Public Participation and Plan Formulation. 62 pp.

Hawkins, Jr., A. S., and J. L. Stewart. 1990. Pilot project on the middle branch Whitewater Watershed 1990. Report by the U.S. Fish and Wildlife Service, Upper Mississippi River National Wildlife and Fish Refuge, Winona, Minnesota, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, September 1990. EMTC 90-03. 34 pp. (NTIS # PB91-122655)

Knox, J. C. 1977. Human impacts on Wisconsin stream channels. Annals of the Association of American Geographers 67:323–342.

Knox, J. C., P. J. Bartlein, and K. K. Hirschboeck. 1975. The response of floods and sediment yields to climatic variation and land use in the Upper Mississippi River Valley. National Technical Information Service, Springfield, Virginia. 76 pp. (NTIS # PB-247086)

U.S. Fish and Wildlife Service. 1993. Operating Plan for the Upper Mississippi River System Long Term Resource Monitoring Program. Environmental Management Technical Center, Onalaska, Wisconsin, Revised September 1993. EMTC 91-P002R. 179 pp. (NTIS #PB94-160199)

Large River Sediment Transport and Deposition: An Annotated Bibliography

1. ABRAHAMS, A. D., AND D. M. MARK. 1986. The random topology model of channel networks: Bias in statistical tests. Professional Geographer 38:77–81.

The random topology model was introduced in 1966. It quantitatively predicts several general characteristics of drainage basin geomorphology. A few limitations of using the model are discussed.

Keywords: Channel, drainage basin, geomorphology, model, river

2. ADAMS, J. R. 1992. Identification of study approaches to determine physical impacts of commercial navigation on the Upper Mississippi River System. Report by the Illinois State Water Survey, Champaign, Illinois, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, in fulfillment of Project Number FWS 14-16-0003-80-973, November 1992. EMTC 92-S005. 11 pp. (NTIS # PB93-127694)

Dimensional analysis is used to model the physical effects of navigation on constricted waterways. Parameters characterizing the physical effects of tow passages are reviewed. They include velocity, turbulence intensity, wave height, wave speed, drawdown, and sediment concentration.

Keywords: Channel, channel flow, Mississippi River, model, navigation, river, sediment, suspended sediment, waves

3. ADAMS, J. R. 1992. Bed material characteristics of the Mississippi River within Pool 19. Illinois State Water Survey, Champaign, Illinois. Contract Report 535, ISSN 0733-3927. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, January 1993. EMTC 93-R006. 113 pp. (NTIS # PB94-154655)

The nature of the bed materials, or substrates, in Pool 19 of the Upper Mississippi River System is addressed. The bathymetric and bed material characteristics of this pool are illustrated and described at 13 main channels, 2 side channels, 1 tributary mouth, 1 island cross channel, and several spot locations in side channels.

Keywords: Bathymetry, channel, measurement, Mississippi River, pool, river, sediment, sedimentation

4. ADAMS, J. R. 1992. Sediment concentration changes caused by barge tows. Pages 677–682 *in* Marshall Jennings and Nani G. Bhowmik, editors. Proceedings of the American Society of Civil Engineers' Hydraulic Engineering Sessions at Water Forum '92, Baltimore, Maryland, August 2–6, 1992. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R023. 6 pp. (NTIS # PB94-112091)

Suspended sediment samples are collected and examined in the channel border area at several locations on the Upper Mississippi and Illinois Rivers during tow passages. Patterns of rapid increase and gradual decrease in concentration following tow passage are observed. In comparison with the Illinois River site, the Mississippi River site underwent smaller changes in sediment concentration. Several parameters describing tow characteristics are discussed. Waves and drawdown (caused by the tow passage) are determined to be the major causes of increased suspended sediment concentrations.

Keywords: Channel, measurement, Mississippi River, navigation, river, sediment, suspended sediment, waves

5. ADAMS, J. R., N. G. BHOWMIK, AND E. DELISIO. 1989. Measuring resuspension of sediment by barge tows. Pages 765–770 *in* Sam S. Y. Wang, editor. Proceedings of the International Symposium of the Hydraulics Division of the American Society of Civil Engineers, New Orleans, Louisiana, August 14–18, 1989. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-R002. 6 pp. (NTIS # PB94-108982)

Early efforts to measure resuspension of sediment relied on U.S. standard depth-integrating sediment samplers. In designing a new method for collecting field data on resuspension, the advantage of obtaining samples at several points in a single vertical column is recognized. The field installation includes ISCO pump samplers with intakes mounted at several distances above the river bed. Background samples are collected every hour. Vessel passages trigger an intensive period of sample collection. Typical data collected for a straight reach on the Illinois River during low flow in fall 1988 are presented and discussed.

Keywords: Channel, channel flow, measurement, navigation, river, sediment, suspended sediment

6. ADAMS, J. R., AND E. DELISIO. 1990. Ambient suspended sediment concentration and turbidity levels. Pages 865–869 *in* Richard M. Shane, editor. Proceedings of the 1990 National Conference of the Hydraulics Division of the American Society of Civil Engineers, San Diego, California, July 30–August 3, 1990. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-R018. 5 pp. (NTIS # PB94-111291)

The variations of suspended sediment concentration and turbidity over time is an important component of the riverine environment. Suspended sediment in the Illinois River is monitored and found to slowly vary in suspended sediment concentration with moderate to small temporal variability. An attempt is made to determine a correlation equation relating sediment concentrations and turbidity over 2-h periods of measurement. However, this proves unsuccessful. The general trend is similar, but the variability of turbidity is considerably less, and the correlation is poor.

Keywords: Measurement, navigation, river, sediment, suspended sediment

7. ADAMS, J. R., AND E. DELISIO. 1990. Temporal and lateral distributions of resuspended sediment following barge tow passage on the Illinois River. *In* Howard H. Chang and Joseph C. Hill, editors. Volume 2. Proceedings of the 1990 National Conference of the Hydraulics Division of the American Society of Civil Engineers, San Diego, California, July 30–August 3, 1990. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R011. 6 pp. (NTIS # PB94-108784)

Suspended sediment concentration samples that were collected on the Illinois River during 10 barge tow passages in May 1989 are examined. The suspended sediment sampling scheme is discussed and typical data are presented. Increases are found to be as much as 500 mg/L near the river bed after barge tow passage.

Keywords: Measurement, navigation, river, sediment, suspended sediment

8. AHEARN, S. C., R. D. MARTIN, AND J. H. WLOSINSKI. 1989. Recommendations for estimating suspended solids in the Upper Mississippi River System using remote sensing. Report by the University of Minnesota, St. Paul, and the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, August 1989. EMTC 89-01. 23 pp. (NTIS # PB89 236715/AS)

Sedimentation is a significant factor in limiting fish and wildlife resources in the Upper Mississippi River System (UMRS). An attempt is made to determine the feasibility of obtaining estimates of suspended solid concentrations (SSC) in the UMRS using remote sensing and to outline the steps necessary to initiate such a study. Remote sensing is found to provide reasonably accurate spatial estimates of SSC. However, because of high costs and infrequent satellite passes, satellite imagery data are not recommended for collecting accurate temporal differences in SSC (especially over relatively short periods). In-place sensors and aerial photography are best suited for such studies.

Keywords: Measurement, Mississippi River, remote sensing, river, sediment, suspended sediment

9. ALONSO, C. V., AND S. T. COMBS. 1986. Channel width adjustment in straight alluvial streams. Proceedings of the Fourth Federal Interagency Sedimentation Conference 2:5-31–5-40.

Alluvial streams construct their own geometries in response to changes imposed by nature or humans. Channel width adjustment is analyzed by considering vertical and lateral scour and fill. The mechanisms associated with these changes are used to formulate a mathematical model of width adjustment during channel aggradation and degradation. The model, although dependent on approximate assumptions and a prior knowledge of certain bank stability properties, reproduces expected behavior with reasonable accuracy.

Keywords: Channel, channel geometry, geomorphology, model, river, scour, sediment, sedimentation

10. ALONSO, C. V., AND S. T. COMBS. 1990. Streambank erosion due to bed degradation—a model concept. Transactions of the ASAE 33:1239–1248.

Bank erosion occurring in alluvial streams is investigated and discussed. A mathematical model is formulated to evaluate bed degradation in cases where bed lowering causes bank instability. Application of the model to a laboratory experiment verifies the behavior of the model.

Keywords: Erosion, model, river, scour

11. ALONSO, C. V., W. H. NEIBLING, AND G. R. FOSTER. 1981. Estimating sediment transport capacity in watershed modeling. Transactions of the ASAE 24:1211–1220, 1226.

A number of the sediment transport formulas suitable for watershed modeling are evaluated. The first section of the paper describes the criteria followed in selecting the formulas. The second section lists the characteristics of these data, which included 739 tests from natural streams, laboratory flumes, and erosion plots. The third section examines how well each formula fits the data when it is used directly, without modification or readjustment of its coefficients. Recommendations are made regarding the applicability of the formulas within different ranges of the data. Of the nine sediment transport formulas compared with flume field data, the Yang formula best estimates streamflow carrying capacity in the range of fine to coarse sands. The Laursen formula reasonably predicts small streamflows carrying very fine sands and silts. However, it should be used with some reservations for computing transport of lighter materials. The Yalin formula can be used to compute sediment transport capacities for overland flows. It gave satisfactory results for the range of sizes and densities characteristic of field situations and can also be used with confidence to predict transport rates of light materials in streamflows. The other formulas considered are Ackers-White, EM-1, EM-2, Engelund-Hansen, Bagnold, and Meyer-Peter Muller.

Keywords: Channel, channel flow, drainage basin, erosion, model, river, sediment, sediment transport

12. AMERICAN SOCIETY OF CIVIL ENGINEERS. 1989. Sediment transport modeling: Proceedings of the international symposium. 829 pp.

Recent developments in numerical models that accurately simulate three-dimensional hydrodynamic and sediment transport phenomena are reviewed and summarized. The WAQUA and PHOENICS mathematical models are discussed.

Keywords: Model, sediment, sediment transport

13. ANDERSON, M. G. 1988. Modeling geomorphological systems. John Wiley & Sons, New York. 458 pp.

The author evaluates current modeling research in hillslope and river channel processes. Models in network geomorphology, channel morphology, channel flow, sedimentation, and sediment transport are discussed in detail.

Keywords: Channel, channel flow, channel geometry, erosion, geomorphology, model, river, sediment, sedimentation, sediment transport

14. ANDERSON, M. G., AND T. P. BURT. 1985. Hydrological forecasting. John Wiley & Sons, New York. 604 pp.

The authors address the most recent forecasting capabilities developed in the field of hydrology. Currently available simulation models are reviewed and potential future developments are considered. Particular emphasis is given to major hydrological areas relevant to watersheds.

Keywords: Drainage basin, model, river

15. ANONYMOUS. 1992. Sediment and aquatic habitat in river systems. Journal of Hydraulic Engineering 118:669–687.

The present-day knowledge of associations between sediment and riverine aquatic habitats is summarized. Physical processes governing aquatic-habitat quality and development are discussed. It is determined that engineering approaches can be used to evaluate and predict aquatic-habitat conditions.

Keywords: River, sediment, sedimentation, sediment transport

16. BEACH, T. 1990. The utility of soil surveys to assess floodplain sediment storage in southeastern Minnesota. Professional Geographer 42:170–181.

A comparison is made between sedimentation data, collected from field corings, and information derived from three county soil surveys in southeastern Minnesota. Two soil surveys prove to be unsatisfactory data sources for sedimentation rates, but the third is useful for one drainage basin. Even the third soil survey would require calibration for use in a geographic information system, however, because it is only the survey's maximum estimate that agrees with the field data.

Keywords: Floodplain, sediment, sedimentation, soil

17. BEACH, T. 1992. Estimating soil loss from medium-size drainage basins. Physical Geography 13:206–224.

Several methods of estimating historical soil loss from medium-sized watersheds are available, but none of them are perfect. By using a variety of methods and comparing their results for convergence, one can maximize the accuracy for soil-loss estimates. In this study, four different methods of estimating soil loss from two medium-sized watersheds in southeastern Minnesota are compared. These methods include the soil-survey and soil-truncation method, gully-erosion estimates, reservoir-sedimentation measurements combined with estimated sediment-delivery ratios, and estimates derived from the Universal Soil Loss Equation (USLE). The results of the varying methods converged around the USLE estimate, ranging from 44% to 128% of the USLE. This convergence between the USLE and the other watershed soil-loss methods lends a measure of credibility to the overall accuracy of the estimates.

Keywords: Drainage basin, erosion, measurement, model, sediment, soil

18. BEACH, T. 1994. The fate of eroded soil: Sediment sinks and sediment budgets of agrarian landscapes in southern Minnesota, 1851–1988. Annals of the Association of American Geographers 84:5–28.

An attempt is made to gain an understanding of the distribution of sediment storage in three medium-sized drainage basins in southern Minnesota. This is accomplished by tracing the distribution of eroded sediment and constructing sediment budgets (i.e., comparing long-term sediment storage and erosion in watersheds). It is established that a high percentage of sediment is stored in the uplands and in the lower main valley floodplains. Higher sediment storage in the lower valley is attributed to the base-level control of the Mississippi River floodplain.

Keywords: Drainage basin, erosion, floodplain, measurement, sediment, sedimentation, sediment budget, sediment transport, soil

19. BEDIENT, P. B. 1992. Hydrology and floodplain analysis. Addison-Wesley, Reading, Massachusetts. 692 pp.

This text is divided into two principal sections. The first addresses traditional hydrological topics of precipitation, evaporation, infiltration, rainfall–runoff analysis, flood frequency, and flood routing methods. The second section reviews the detailed theory and application of three of the most widely used computer models in hydrology today. The models are applied to actual watershed and flood occurrences. The application of spreadsheet software to hydrological computation is also discussed.

Keywords: Flood, floodplain, model, precipitation, river, sediment

20. BEGIN, Z. B. 1982. Stream curvature and bank erosion: A model based on the momentum equation. Journal of Geology 89:497–504.

Based on the momentum equation of flow, the force per unit area, which the flow exerts radially on the outer bank of a stream bend, is expressed by an equation in which the force is explicitly related to the curvature ratio *R/w* (curve radius/channel width). A dimensionless curvature coefficient is defined, and after observing changes of this coefficient with *R/w* (varying values of bed load friction), a functional relation is revealed.

Keywords: Bed load, channel, channel flow, channel geometry, erosion, model, river

21. BELT, C. B. 1975. The 1973 flood and man's constriction of the Mississippi River. Science 189:681–684.

The 1973 flood broke the stage records between Burlington, Iowa, and Cape Girardeau, Missouri, a distance of 562 km. At St. Louis, the flood began on March 10 and continued for 77 consecutive days, exceeding the record set in 1844 when the river was in flood for 58 days during the entire year. The river crested at St. Louis on April 28, 1973, at a gage height of 13.18 m (4.03 m above flood stage) and a peak discharge of 24,100 m^3/s. The stage topped the 189-year record by 0.3 m. The flood peak was 0.61 m higher in 1973 than in 1844, but the discharge was about 33% less than the estimated flow for 1844. The 1908 flood had the same flow as the 1973 flood but the peak was 2.51 m lower. This study analyzes hydrographic data to determine the reasons behind the record-breaking stages. It concludes that the progressive constriction of the Mississippi River for navigation since 1837 has caused bottom erosion in some stretches. In others, the bottom oscillates up and down with time. Constriction of the river channel causes flooding and forces floods to be higher, thus navigation works degrade the protection afforded by levees. The combination of navigation works and levees causes significant rises in the stages of floods. Additional channel constriction and levee building will cause further problems. The 1973 flood's stage record was determined to be human-made.

Keywords: Channel, channel flow, channelization, discharge, flood, levee, Mississippi River, river, sediment, stage

22. BENEKE, F. D. 1927. The flood of 1927: Mississippi River and tributaries; containing photographic views of America's greatest peace-time disaster, in the over-flowed sections of Illinois, Missouri, Kentucky, Tennessee, Arkansas, Mississippi, and Louisiana. F. D. Beneke, editor. Mississippi River Flood Control Association, Memphis. 64 pp.

This document contains photographic and map views displaying the flooded sections of the Illinois and Mississippi Rivers in 1927. It explains how 506,250 ha (12,500,00 acres) of alluvial land (including large areas devoted to sugarcane and cotton production) were inundated by floodwater.

Keywords: Flood, floodplain, Mississippi River, river

23. BHARGAVA, D. S., AND D. W. MARIAM. 1991. Effects of suspended particle size and concentration on reflectance measurements. Photogrammetric Engineering & Remote Sensing 57:519–529.

Remote sensing technology is used to estimate sediment conditions in large bodies of water. Models are developed for the prediction of suspended sediment concentration, turbidity, and modified Secchi depths from measured reflectance values for a given soil type and particle size. Modeled and observed values display good agreement.

Keywords: Measurement, model, remote sensing, river, sediment, soil, suspended sediment

24. BHOWMIK, N. G. 1987. Some natural and human influences on streams and rivers (Illinois River, Mississippi River). Water International 12:55–59.

Some specific examples of human-made and natural influences on water resources are discussed. Stream alteration activities such as channelization and construction of lock and dams and their effect on flow and sediment transport are discussed. It is observed that significant changes in flow and sediment transport characteristics occur at the confluences of tributaries with the main stream because of human activities.

Keywords: Channel, channel flow, channelization, land cover/land use, lock and dam, Mississippi River, river, sediment, sediment transport

25. BHOWMIK, N. G. 1989. Physical impacts of human alterations within river basins: The case of the Kankakee, Mississippi, and Illinois Rivers. Pages B-139–B-146 *in* Proceedings of the Thirteenth Congress of the International Association for Hydraulic Research, Ottawa, Canada, August 21–25, 1989. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R004. 8 pp. (NTIS # PB94-108891)

Effects of human alterations within large river basins are examined. Sediment delivery, which is a major factor in system change over time, is the primary topic studied. The effects of channelization are illustrated by a case study of the Kankakee River. The effects of lock and dam construction for commercial navigation are illustrated by case studies of the Mississippi and Illinois Rivers.

Keywords: Channel, channel flow, channelization, land cover/land use, lock and dam, Mississippi River, pool, river, sediment, sedimentation, sediment transport, stage

26. BHOWMIK, N. G. 1989. Resuspension and lateral movement of sediment due to commercial navigation in the Mississippi River System. Pages 953–959 *in* Proceedings of the Fourth International Symposium on River Sedimentation, Beijing, China, June 5–9, 1989. Reprinted by the National Biological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, March 1994. LTRMP 94-R003. (NTIS # PB94-162930)

Research is performed on the Upper Mississippi River System to determine the physical effects of navigation, including the resuspension and lateral movement of sediment. It is observed that the movement of tows with barges increases the suspended sediment concentrations above the values present within an undisturbed river environment. Moreover, the increase in suspended sediment concentration persists for a period of 60 to 90 min after the passage of the tow. The increase in sediment concentration is more significant when the ambient suspended sediment concentration is low, and the increase was found to be higher in shallow and narrow channels than in deep and wide channels.

Keywords: Channel, measurement, Mississippi River, navigation, river, sediment, sediment transport, suspended sediment

27. BHOWMIK, N. G. 1991. Physical changes due to navigation in the Upper Mississippi River System. *In* Proceedings of the 1991 Governor's Conference on the Management of the Illinois River System, Third Biennial Conference, Peoria, Illinois, October 22–23, 1991. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-R019. 9 pp. (NTIS # PB94-108917)

Movement of barge traffic through the Upper Mississippi River System creates significant disturbances of the river environment. The disturbances include waves and drawdown, altered velocity and pressure regimes, resuspension and lateral movement of sediment, and temporary changes in flow direction due to the return flow. These navigation-caused physical changes in large-river environments are reviewed.

Keywords: Channel, channel flow, Mississippi River, navigation, river, sediment, suspended sediment, waves

28. BHOWMIK, N. G. 1992. Hydraulic changes in rivers due to navigation. Pages 10–22 to 10–40 *in* Proceedings of the Fifth Federal Interagency Sedimentation Conference, Las Vegas, Nevada, March 18–21, 1991. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, December 1992. EMTC 92-S020. (NTIS # PB94-126166) Report out of print. Request 92-R001.

The author investigates alterations associated with the movement of barge traffic within a restricted waterway. Fully loaded barge traffic is found to temporarily increase the suspended sediment concentrations, especially near channel border areas. These increases are greater near the bed than in the near-surface zone and can last from 40 to 60 min or more. Maximum velocity changes (caused by barges) occur very close to the bed.

Keywords: Channel, channel flow, Mississippi River, navigation, river, sediment, suspended sediment, waves

29. BHOWMIK, N. G. 1993. Effects of natural and man-made events on the land–water interfaces of large river basins. Pages 101–122 *in* B. Gopal, editor. Wetlands and ecotones: Studies on land–water interactions. National Institute of Ecology, New Delhi, India. Reprinted by the National Biological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, March 1994. LTRMP 94-R001. (NTIS # PB94-157542)

The shape, form, surficial features, and future changes in the geomorphology of any large river system are the result of all the natural and human interventions on the system for the last several decades. Specific examples of these changes are examined on the Mississippi and Illinois Rivers. River changes are demonstrated through a series of examples, citing research conducted over the past several decades.

Keywords: Channel, channel geometry, channelization, erosion, geomorphology, lock and dam, Mississippi River, navigation, pool, river, sediment, sedimentation

30. BHOWMIK, N. G., AND J. R. ADAMS. 1985. Geomorphic trends in Keokuk Pool, Mississippi River. American Geographic Union 1985 spring meeting. EOS, Transactions, American Geophysical Union 66(18):261.

Three areas of extensive sedimentation in Keokuk Pool of the Mississippi River are assessed for physical change and biological succession, and projections of future changes are made. The pool is expected to attain a state of dynamic equilibrium by 2050 on the basis of present sediment trap efficiency trends.

Keywords: Geomorphology, Mississippi River, pool, river, sediment, sedimentation

31. BHOWMIK, N. G., AND J. R. ADAMS. 1986. The hydrologic environment of Pool 19 of the Mississippi River. Pages 21–29 *in* Ecological perspectives of the Mississippi River. Dr. W. Junk Publishers. The Hague, Netherlands.

The flood of 1973 and the drought of 1977 are used to demonstrate the effects of extreme events on riverine ecosystems. The characteristics of sediment inflows, transport, volume changes, and outflows are addressed. The means by which these characteristics determine the environment for aquatic plants and animals in a given reach of the Mississippi River are also examined.

Keywords: Channel, channel flow, climate, flood, land cover/land use, Mississippi River, pool, river, sediment, sedimentation, sediment transport

32. BHOWMIK, N. G., AND J. R. ADAMS. 1989. Successional changes in habitat caused by sedimentation in navigation pools. Hydrobiologia 176/177:17–27. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-R025. 11 pp. (NTIS # PB94-1102372)

Many pools in the Upper Mississippi River System have nearly reached a new equilibrium condition for scour and deposition of sediment. The original open-water habitats in these pools have been changing to aquatic macrophyte beds and then to marsh or terrestrial floodplain conditions because of sediment deposition. Pool 19 and Peoria Lake have had well over 50% of their original volume filled with sediment. The authors conclude that these river reaches will become a narrow channel without any broad and highly productive channel borders.

Keywords: Channel, land cover/land use, lock and dam, Mississippi River, pool, river, scour, sediment, sedimentation

33. BHOWMIK, N. G., AND J. R. ADAMS. 1990. Sediment transport, hydraulic retention devices, and aquatic habitat in sand-bed channels. Pages 1110–1115 *in* H. H. Chang and J. C. Hill, editors. Volume 2. Proceedings of the National Conference of the Hydraulics Division of the American Society of Civil Engineers, San Diego, California, July 30–August 3, 1990. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-R024. 6 pp. (NTIS # PB94-108792)

Aquatic ecologists have tended to view any change in sediment transport conditions as a threat to the quality of riverine ecosystems. However, because of various transport processes and morphological characteristics, sand bed channels naturally create retention and detention devices that may or may not be beneficial to the aquatic habitats of the riverine environment. Examples and case studies of a variety of habitats in sand bed streams are examined. It is concluded that, in small streams, longitudinal features (e.g., pools and riffles) define the major habitat types. In larger rivers, lateral features (e.g., side channels, shallow-point bars, and bed forms) provide a variety of habitat types.

Keywords: Channel, land cover/land use, pool, river, sediment, sedimentation, sediment transport

34. BHOWMIK, N. G., J. R. ADAMS, AND R. E. SPARKS. 1986. Fate of navigation pool on Mississippi River. Journal of Hydraulic Engineering 112:967–970. ISSN 0733-9429/86/0010-0967. Paper 20939. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R001. 4 pp. (NTIS # PB94-111960)

Morphological changes of Pool 19 on the Mississippi River are investigated. Approximately 55% of the pool's original capacity was lost by 1980, and it is estimated that 80% of its capacity will be lost by 2050. The changes on this pool are progressing through a predictable pattern. It is assumed that similar pools on other navigable waterways may follow the same general pattern.

Keywords: Channel, channelization, climate, dredging, geomorphology, land use/land cover, levee, lock and dam, Mississippi River, pool, river

35. BHOWMIK, N. G., W. C. BOGNER, AND J. A. SLOWIKOWSKI. 1991. Sediment sources analysis for Peoria Lake along the Illinois River. *In* Proceedings of the National Conference of the American Society of Civil Engineers, Nashville, Tennessee, July 29–August 2, 1991. Reprinted by the National Biological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, March 1994. LTRMP 94-R006. 6 pp. (NTIS # PB94-176344)

The lower Illinois River flows within an oversized valley formed by an old course of the Mississippi River and glacial outwashes. This portion of the river developed into a low-gradient, aggrading bed stream with large backwater areas. Sedimentation in the river threatens to convert the system from one of river–backwater areas to one of channel–marshes. The sediment budget of Peoria Lake, a major backwater lake along the river, includes input and output through the Illinois River and inputs from several small direct tributaries. These small tributaries are significant contributors to the Peoria Lake sediment budget.

Keywords: Measurement, river, sediment, sedimentation, sediment budget, suspended transport

36. BHOWMIK, N. G., W. C BOGNER, J. A. SLOWIKOWSKI, AND J. RODGER ADAMS. 1993. Source monitoring and evaluation of sediment inputs for Peoria Lake. Office of Hydraulics and River Mechanics, Illinois State Water Survey, Champaign, Illinois. Illinois Department of Energy and Natural Resources Report ILENR/RE-WR-93/01. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, September 1993. EMTC 93-R016. 60 pp. (NTIS # PB 93-188472)

A summary is presented on the results of a 2-year sediment study of Peoria Lake and its local tributaries. Ten local tributaries were monitored to determine the inflow of sediment and water. A sediment budget was not determined because of a lack of sedimentation survey and sediment outflow data from the lake. The analysis did indicate that about 1.2 million tons of sediment flowed into Peoria Lake in 1989 and about 2.7 million tons in 1990.

Keywords: Measurement, river, sediment, sediment transport

37. BHOWMIK, N. G., AND M. DEMISSIE. 1982. Carrying capacity of floodplains. Journal of the Hydraulics Division, American Society of Civil Engineers 108(HY3):443–453.

Several factors affect the carrying capacity of floodplains including the nature of the floodplain, characteristics of the main channel, and the flood frequency. The field data of flood flows for several streams are analyzed to determine the distribution of flow in the main channel and in the floodplains. In general, the carrying capacity of floodplains increases with the return period of the flood.

Keywords: Channel, channel flow, flood, floodplain, river

38. BHOWMIK, N. G., AND M. DEMISSIE. 1989. Sedimentation in the Illinois River Valley and backwater lakes. Journal of Hydrology 105:187–195. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-R013. 9 pp. (NTIS # PB94-112521)

The Illinois River valley has experienced an enormous influx of sediment over the past few decades. Many backwater lakes along the river have lost 30 to 100% of their capacity to sediment deposition. Newly implemented nonpoint source pollution control measures are now beginning to show their effects on the receiving bodies of water.

Keywords: Channel, channel flow, measurement, river, sediment, sedimentation

39. BHOWMIK, N. G., M. DEMISSIE, AND C. Y. GUO. 1982. Waves generated by river and wind on the Illinois and Mississippi Rivers. Illinois Water Resources Center, Urbana. Water Resources Center, Research Report 167. 90 pp.

Data concerning waves caused by river traffic and winds on the Mississippi and Illinois Rivers are collected and analyzed. The information is gathered to address several topics including the characteristics of waves from tows, barges, and boats; wave intensity changes caused by increased river traffic; the similarities and dissimilarities between waves caused by traffic and waves produced by natural effects; and the associated bank erosion with waves of different origin and size.

Keywords: Erosion, Mississippi River, navigation, river, waves

40. BHOWMIK, N. G., AND B. S. MAZUMDER. 1990. Physical forces generated by barge-tow traffic within a navigable waterway. Pages 604–609 *in* Howard H. Chang and Joseph C. Hill, editors. Volume 1, Hydraulic Engineering. Proceedings of the National Conference of the Hydraulics Division of the American Society of Civil Engineers, San Diego, California, July 30–August 3, 1990. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-R020. 6 pp. (NTIS # PB94-110145)

Various physical forces within a river are altered by the movement of navigation traffic. The changes in these forces can be evaluated and quantified. The physical forces examined include waves and drawdown, increase or decrease in the pressure field, altered velocity distributions, and directional changes of the flow within the zones of return flows.

Keywords: Channel, channel flow, Mississippi River, navigation, river, waves

41. BHOWMIK, N. G., A. C. MILLER, AND B. S. PAYNE. 1990. Techniques for studying the physical effects of commercial navigation traffic on aquatic habitats. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. Technical Report EL-90-10. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, January 1993. EMTC 93-R007. 129 pp. (NTIS # PB94-151446)

The primary objective of this report is to outline procedures that can be used for the measurement and analysis of physical data to assess changes generated with the movement of navigation traffic in large rivers. It includes summaries of recent investigations, descriptions of required data, study evaluations, explanations of data-collecting equipment, development plans for data collection, and procedures that can be followed for the analysis of the data.

Keywords: Channel, channel flow, land cover/land use, measurement, Mississippi River, navigation, river, sediment, sedimentation, sediment transport, waves

42. BHOWMIK, N. G., AND R. XIA. 1992. Hydraulic and geomorphic classification of the Upper Mississippi River System: Pilot study of three pools. Pages 666–671 *in* M. Jennings and N. G. Bhowmik, editors. Proceedings of the American Society of Civil Engineers Hydraulic Engineering Sessions at Water Forum '92, Baltimore, Maryland, August 2–6, 1992. Reprinted by the National Biological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, August 1994. LTRMP 94-R007. 6 pp. (NTIS # PB94-209533)

A pilot classification system is developed for three trend analysis pools—4, 8, and 13—on the Upper Mississippi River System. Various physical parameters (e.g., widths, radius of curvatures, and deflection angles) and attributes (e.g., orientation of various nonmain channel areas) are utilized in this classification system. This system is required to properly manage the river for the benefit of navigation, commerce, recreation, ecology, and the environment.

Keywords: Channel, channel geometry, geomorphology, Mississippi River, pool, river

43. BHOWMIK, N. G., AND R. XIA. 1993. Turbulent velocity fluctuations in natural rivers. *In* Hydraulic Engineering '93, Proceedings of the 1993 Conference, sponsored by the Hydraulics Division/ASCE, San Francisco, California, July 25–30, 1993. Reprinted by the National Biological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, April 1994. LTRMP 94-R005. (NTIS # PB94-178142)

The Illinois State Water Survey is presently collecting and analyzing detailed velocity data from the Illinois and Mississippi Rivers with two-dimensional electromagnetic current meters. The primary goal of this research is to understand and evaluate the turbulent flow structure in natural river systems, especially near the channel border areas. The collection and analysis of data from a study site on the Illinois River is reviewed. Flow velocities at this site are measured at six different lateral locations and three different vertical elevations.

Keywords: Channel, channel flow, Mississippi River, river

44. BORAH, D. K. 1989. Scour depth prediction under armoring conditions. Journal of Hydraulic Engineering 115:1421–1425.

Accurate forecasting of scour depth may assist in engineering and planning for water flow over alluvial beds. A simple procedure is demonstrated for calculating the scour depth on an alluvial bed under armoring conditions. The estimation of scour depth requires several variables including flow depth, bed slope, bed porosity, particle size distribution of the bed material, and a few commonly available constants.

Keywords: Channel, channel flow, river, scour, sediment

45. BORAH, D. K., AND P. K. BORDOLOI. 1989. Nonuniform sediment transport model. Transactions of the ASAE 32:1631–1636.

A nonuniform sediment transport model is evaluated by applying it to laboratory data. The model (called STREAM) was developed for simulating graded sediment transport in alluvial streams. The model performed extremely well in predicting sediment discharges for the experimental runs producing complete armor surfaces and the runs without producing any armoring, but showed considerable discrepancies with the runs producing partial armoring. Predicted size distributions of eroded materials and materials at the armor surface are reasonable for most of the runs.

Keywords: Model, river, scour, sediment, sedimentation, sediment transport

46. BORDAS, M. P., AND D. E. WALLING, EDITORS. 1988. Sediment budgets. International Association of Hydrological Sciences, IAHS Publication 174. 591 pp.

A wide range of recent research in the hydrological sciences is drawn on to discuss holistic modeling of sediment budgets. In the past, many studies have focused on the erosion processes operating within a watershed or the sediment yield at its outlet. Here these two subjects are integrated to establish sediment budgets that quantify the relations between the various components of the overall drainage basin erosion—transport—deposition system.

Keywords: Erosion, model, sediment, sedimentation, sediment budget, sediment transport

47. BOVEE, K. D., AND R. MILHOUS. 1978. Hydraulic simulation in instream flow studies: Theory and techniques. U.S. Fish and Wildlife Service, Instream Flow Information Paper 5. FWS/OBS-78/33. 131 pp.

The authors examine how changes in stream discharge quantitatively affect the distribution and size of velocities, depths, and substrates. They accomplish this by utilizing several simulation techniques for the prediction of the stage–discharge relation and the velocity distribution–discharge relation. Data requirements, equipment needs, data collection methods, precision specifications, site-imposed constraints, and limitations of each simulation technique are discussed. Last, the authors provide a brief description of several computer hydraulic simulation programs.

Keywords: Channel, channel flow, discharge, model, river, stage

48. BROWN, D. G., L. BIAN, AND S. J. WALSH. 1993. Response of a distributed watershed erosion model to variations in input data aggregation levels. Computers and Geosciences 19:499–509.

Distributed watershed models require that mapped variables be characterized by some number of discrete units. Data resolution (i.e., grid cell size), used to spatially represent the watershed variables, is an important factor that affects the results of hydrologic and geomorphic process-response models. The ANSWERS model uses soil, terrain, hydrography, and land cover information on a cell by cell basis for estimating erosion and deposition patterns within a watershed, and for defining model responses at the basin outlet. A raster-based geographic information system, interfaced to ANSWERS, organizes the model input data for iterative calculations of erosion and deposition patterns and magnitudes through model responses for selected data aggregation levels. Spatial aggregation levels evaluated in this study include 30, 60, 120, 180, 240, 300, 420, and 600 m square cells. The accuracy of the model is closely monitored and conclusions are drawn.

Keywords: Drainage basin, erosion, geographic information system, geomorphology, land cover/land use, model, sediment, sedimentation, sediment transport, soil

49. BROWN, R. J. 1976. Reservoir and lake sedimentation: A bibliography with abstracts. National Technical Information Service, Springfield, Virginia. 171 pp.

The deposition and effects of sedimentation in reservoirs and lakes are cited. Reports on silting, control techniques, and causes are also included.

Keywords: Bibliography, measurement, pool, sediment, sedimentation

50. BRUNE, G. M. 1948. Rates of sediment production in midwestern United States. U.S. Soil Conservation Service, Report SCS-TP-65. 40 pp.

This publication summarizes available sediment records for the Upper Midwest (including the Upper Mississippi River Basin). It primarily examines suspended sediment and sedimentation data measured in this area and attempts to compile, evaluate, and translate them into comparable units. The period of the data collection (for differing sites) is commonly from the early 1920s to the late 1940s.

Keywords: Drainage basin, measurement, Mississippi River, river, sediment, sedimentation, suspended sediment

51. BURKHAM, D. E. 1981. Uncertainties resulting from changes in river form. Proceedings of the American Society of Civil Engineers 107(Hydraulics Division 5, 16245):593–610.

The hydrologic implications and uncertainties that are created by changes in alluvial-channel form in large watersheds are discussed. Historical evidence of river-form change is first presented. Subsequent sections include brief examinations of hydrologic implications and uncertainties in relation to channel-form changes and land use, flood characteristics of alluvial streams, and hydrology and sediment yields for basins in the Southwest.

Keywords: Channel, channel geometry, drainage basin, flood, land cover/land use, river, sediment, sediment transport

52. CAO, S., AND L. LERCHE. 1994. A quantitative model of dynamical sediment deposition and erosion in three dimensions. Computers and Geosciences 20:635–663.

The authors introduce modeling of sediment deposition in three dimensions by taking estimates of sediments, released at different locations on a basinal slope, and allowing them to flow constrained by the existing topography of basin slope and previously deposited sediment flows. Deposition takes place according to the parameter values assigned to each lithologic type. Default values are arranged so that coarse-grained material is deposited first and fine-grained material last. The computer based-model, named MOSED3D (Model of Sediment Deposition in 3-Dimensions), is written in C and runable on a SUN SPARC workstation. Model results are displayed in contour map form, as isopleths, and also as 2-D cross-sections drawn in arbitrary, user-defined, directions across the system. The paper describes the mathematical formulation, program structure, and some test cases designed to illustrate individual factors the code is capable of handling.

Keywords: Drainage basin, erosion, geology, model, sediment, sedimentation, sediment transport

53. CARIS, S., AND M. PAVISH. 1975. Bibliography, environmental geomorphology. Council of Planning Librarians, Monticello, Illinois. 32 pp.

This bibliography consolidates portions of the available literature on environmental geomorphology. Sections are on geomorphology (1966–1971) and sedimentology (1972–1973).

Keywords: Bibliography, geomorphology, sediment, sedimentation, sediment transport

54. CARSON, M. A. 1989. Measure of flow intensity as predictors of bed load. Journal of Hydraulic Engineering 113:1402–1421.

The merits of varying measures of flow intensity as predictors of bed load transport rates are assessed. It is observed that tractive stress, when based on depth and slope, is a poor predictor, especially in narrow channels. By eliminating the wall and bedform roughness, leaving only the stress acting on the bed grains, excellent correspondence with bed load rates is found.

Keywords: Bed load, channel, channel flow, measurement, river, sediment, sediment transport

55. CARSON, M. A., AND G. A. GRIFFITHS. 1989. Influence of channel width on bed load transport capacity. Journal of Hydraulic Engineering 113:1489–1509.

An attempt is made to determine the effects of channel width on bed load capacity in river reaches having various slopes, water discharge, and channel-bed material is examined. The authors demonstrate the existence of an optimum width that maximizes transport capacity. The optimum width is based on the relation between bed load transport rates and flow intensity, and the relation between flow resistance and depth.

Keywords: Bed load, channel, channel flow, channel geometry, discharge, measurement, model, river, sediment, sediment transport

56. CELIK, I., AND W. RODI. 1988. Modeling suspended sediment transport in nonequalibrium situations. Journal of Hydraulic Engineering 114:1157–1191.

A mathematical model for calculating suspended sediment transport in unidirectional channel flow under general, nonequalibrium conditions is presented. The model includes a flexible hydrodynamic component (for calculating the flow field and the turbulence characteristics) and a scalar transport model.

Keywords: Channel, channel flow, model, river, sediment, sediment transport, suspended sediment

57. CHANG, H. H. 1984. Modeling of river channel changes. Journal of Hydraulic Engineering 110:157–172.

The author describes a flood and sediment routing model that simulates river channel changes. This computer-based model is applied in the case study of a disturbed river. It merges the interrelated changes in channel bed profile, width, and lateral migration in channel bends.

Keywords: Channel, channel geometry, flood, model, river, sediment, sediment transport

58. CHANG, H. H. 1985. River morphology and thresholds. Journal of Hydraulic Engineering 111:503–519.

Channel geometry and patterns of alluvial rivers are examined by an energy approach together with the physical relations of flow continuity, flow resistance, and sediment transport. River features are discussed, and certain regime relations for channel width and depth are established.

Keywords: Channel, channel flow, channel geometry, geomorphology, model, river, sediment, sediment transport

59. CHANG, H. H. 1986. River channel changes: Adjustments of equilibrium. Journal of Hydraulic Engineering 112:43–55.

A technique for predicting river channel adjustments of equilibrium is introduced and illustrated by examples. This method is based on the quantitative relations among the variables of water discharge, bed-material discharge, slope, sediment size, channel width, and depth for sand-bed rivers under dynamic equilibrium. By using this technique, the directions and magnitudes of adjustments for selected variables in response to changes of other river variables are determined.

Keywords: Bed load, channel, channel flow, channel geometry, discharge, geomorphology, model, river, sediment, sediment transport

60. CHAUDHRY, M. H. 1993. Open-channel flow. Prentice Hall, Englewood Cliffs, New Jersey. 484 pp.

The primary objective of this book is to present up-to-date information and computational analyses procedures for open-channel flow. It is written to be used as both a textbook and a reference. The book is divided into two parts. The first section discusses steady flow and the second addresses unsteady flow.

Keywords: Channel, channel flow, model

61. CHEETHAM, R. N., JR., AND L. M. AHL. 1977. Erosion and sedimentation in Wisconsin counties with drainage to the Mississippi River and to the Wisconsin River below Prairie du Sac Dam. U.S. Soil Conservation Service, Economic Research Service, Forest Service. Reference Report 4. 135 pp.

This report summarizes data collected with an erosion and sedimentation questionnaire. It was sent to 17 district conservationists of the U.S. Department of Agriculture, Soil Conservation Service. The study encompasses the area between Lock and Dams 1 and 10 along the Mississippi River. Topics include gullying, streambank erosion, and roadside erosion.

Keywords: Erosion, Mississippi River, river, sediment, sedimentation

62. CHEN, Y. H., AND D. B. SIMONS. 1975. Mathematical modeling of alluvial channels. Pages 466–483 *in* Symposium on Modeling Techniques, Volume I. Second Annual Symposium of the Waterways, Harbors, and Coastal Engineering Division of the American Society of Civil Engineers.

A mathematical model is created to study the important aspects of the unsteady flow phenomena in alluvial channels. The model is developed by formulating the unsteady flow of sediment-laden water with the one-dimensional partial differential equations representing the conservation of mass for sediment, and the conservation of mass and momentum for sediment-laden water. The effects of lateral water and sediment inflow, sediment motion, fluid friction, and irregular channel geometry are considered. The set of equations is solved by a linear-implicit method using a computer. The mathematical model is valuable for studying various types of unsteady flow problems in open channels (e.g., the flood routing of water and sediment in channels, degradation and aggradation near hydraulic structures, and channel response to development). To test the mathematical model, two practical applications are analyzed. First, the mathematical model is used to simulate the propagation of sand waves in a laboratory flume. Next, the mathematical model is used to study the geomorphic changes in the Upper Mississippi River and the adjacent land. The simulated flows, generated by the mathematical model, compared well with field-measured data.

Keywords: Channel, channel flow, channel geometry, erosion, flood, geomorphology, hydraulic, Mississippi River, modeling, river, scour, sediment, sedimentation, sediment transport, suspended sediment

63. CHEN, Y. H., AND D. B. SIMONS. 1979. Geomorphic study of the Upper Mississippi River. Journal of the Waterway, Port, Coastal, and Ocean Division, American Society of Civil Engineers, Proceedings Paper 14778 105(WW3):313–328.

The past and present geomorphic features of the Upper Mississippi River are examined to estimate the effects of snag removal, dike construction, revetment, and lock and dam development on the river geomorphology. The geomorphic features studied include river position, river surface area, island surface area, number of islands, riverbed surface area, surface widths, water depth, side channels, and riverbed elevations. The study results indicate that natural and human-induced activities in the last 150 years have produced subtle changes in the river geomorphology. The low dike fields narrowed the river, created new islands and chutes, and enlarged old islands. Lock and dams have widened the river and increased the number of islands in the pools. It is concluded that 50 years from now the river scene of the Upper Mississippi River will be essentially as it is today if no major human-made changes or natural events occur.

Keywords: Channel, channel geometry, dredging, geomorphology, levee, lock and dam, Mississippi River, river, sediment, sedimentation

64. CHEN, Y. H., D. B. SIMONS, R. M. LI, AND S. S. ELLIS. 1984. Investigation of effects of navigation traffic activities on hydrologic, hydraulic, and geomorphic characteristics in the Upper Mississippi River System. Pages 299–324 *in* Proceedings of the fifteenth annual meeting of the Mississippi River Research Consortium.

A mathematical model is generated to determine the effects of navigation traffic on the physical environment of a river channel. The following factors are considered: boat-generated wave heights and velocity changes, bed material resuspension and suspended sediment concentrations, turbidity, and sediment volume entering side channels and backwater areas. A comparison of model output to data collected in the Upper Mississippi and Illinois Rivers shows close agreement between calculated and measured values. Suspended sediment concentrations are predicted to be 96–144% greater in the year 2000 and 60–167% greater in the year 2040 when compared with 1977. Tow traffic in 1977 produced increases in sediment volume entering backwater areas by 2.0–3.4% above natural levels. Predicted values for 2000 and 2040 are 4.3–9.3% and 3.5–10.2%, respectively, above natural levels. Navigation effects are greatest when tow boats sail close to the banks and when traffic is heavy.

Keywords: Channel, channel flow, erosion, geomorphology, model, Mississippi River, navigation, river, sediment, sedimentation, sediment transport, suspended sediment, waves

65. CHESTERS, G., G. SIMSIMAN, T. DANOVICH, V. NOVOTNY, T. LAZEWSKI, AND G. STOUT. 1981. Resource description of the Upper Mississippi River System. Volume 3. Water quantity and quality. Report to the Upper Mississippi River Conservation Committee. 256 pp.

The authors present a comprehensive inventory of water quantity and quality parameters for the Upper Mississippi River System (UMRS). A range and magnitude of pertinent parameters (primarily for the water years 1977 and 1979) are provided that help determine problem areas according to water and sediment quality criteria. The volume is structured to provide (1) a description of the flow characteristics of the UMRS; (2) a discussion of sources of pollutants including point, nonpoint, accidents, and spillage; (3) evaluation of instream water quality conditions; and (4) identification of sediment sources and characteristics.

Keywords: Channel, channel flow, contaminants, Mississippi River, river, sediment, stage, water quality

66. CHIN, E. H., J. SKELTON, AND H. P. GUY. 1975. The 1973 Mississippi River Basin flood: Compilation and analyses of meteorologic, streamflow, and sediment data. U.S. Geological Survey, Washington, D.C. Geological Survey Professional Paper 937. 137 pp.

This study discusses the meteorological setting, general characteristics of precipitation, and significant precipitation occurrences related to the Mississippi River flood of 1973. It summarizes stream stages, discharges, flood volumes, and sediment data where available. Flood profile data for the main stem and selected tributary streams are also included.

Keywords: Channel, channel flow, climate, discharge, flood, Mississippi River, precipitation, river, sediment, stage, suspended sediment

67. CHOW, V. T. 1964. Handbook of applied hydrology. McGraw-Hill, New York. n.p.

A reference is developed for hydrology and water resources technology. It is roughly divided into four sections, including (1) the sciences upon which hydrology depends (e.g., meteorology, hydrogeology, and geomorphology); (2) phases of the hydrologic cycle; (3) the practice and application of hydrology in various fields (e.g., flow determination, flood routing, and sedimentation); and (4) several socioeconomic aspects of hydrology.

Keywords: Channel, channel flow, erosion, flood, geomorphology, measurement, river, sediment, sedimentation

68. CLARKE, R. T. 1994. Statistical modelling in hydrology. John Wiley & Sons, New York. 412 pp.

The author first reviews simple statistical models used for analyzing characteristics of river flow (e.g., frequencies of floods and droughts). He then discusses linear models used to estimate flow characteristics of ungaged rivers and generate synthetic flow sequences of water resource systems.

Next, he examines nonlinear models used to describe river-basin response to rainfall. Last, the author discusses hydrological applications of General Linear Models and the spatial analysis of hydrological variability.

Keywords: Channel, channel flow, climate, flood, model, precipitation, river

69. CLIFFORD, N. J., J. R. FRENCH, AND J. HARDISTY. 1993. Turbulence: Perspectives on flow and sediment transport. John Wiley & Sons, New York. 360 pp.

This text outlines the fundamental principles of measurement and analysis of turbulent flow and sediment transport. It reviews the last 30 years of laboratory work on near-boundary flow structure. It also provides more recent research dealing with the high-frequency monitoring and modeling of sediment transport. The practicalities of measurement and modeling under field conditions are emphasized.

Keywords: Channel, channel flow, measurement, model, sediment, sediment transport

70. COOPER, C. M., AND J. R. MCHENRY. 1989. Sediment accumulation and its effects on a Mississippi River oxbow lake. Environmental Geology and Water Sciences 13:33–37.

Sediment accumulation rates are measured in Moon Lake, a large (10.1 km^2) Mississippi River oxbow lake. The lake exhibits depositional patterns that are associated with points of inflow, flow patterns, and lake morphology. It is observed that changes in cropping systems (now requiring less cultivation) have reduced sedimentation rates in areas that flow into the lake. If present rates of sedimentation continue, open-water habitat in the lake will be reduced by 3% to 7% during the next 50 years.

Keywords: Channel, channel flow, geomorphology, land cover/land use, measurement, Mississippi River, river, sediment, sedimentation

71. CRAWFORD, G. A. 1976. Post-inundation depositional history of the Weaver Bottoms, Upper Mississippi River, based on cesium-137 data. M.S. Thesis. University of Wisconsin–Madison. n.p.

The Weaver Bottoms area has undergone major changes in vegetation and sedimentation rates between 1930 and 1975. Compared with the vegetation change between 1935 and 1965, emergent vegetation has been disappearing from this backwater area at an alarming rate since 1965. Very little sediment has been deposited in Weaver Bottoms since impoundment. Therefore, high sedimentation rates are not the cause of the rapid decrease in marsh vegetation.

Keywords: Channel, channel flow, land cover/land use, measurement, Mississippi River, river, sediment, sedimentation

72. CROLEY, T. E. II, K. N. RAJA RAO, AND F. KARIM. 1978. Reservoir sedimentation model with continuing distribution, compaction, and sediment slump. Iowa Institute of Hydraulic Research, Iowa City. IIHR Report 198:1–136.

A comprehensive reservoir simulation model is developed to estimate changes in the reservoir profile caused by sedimentation over any length of reservoir operation. The sedimentation submodel estimates the total volume of sediment trapped in the reservoir in a selected time interval, and then distributes this over the height of the reservoir. The simulation model (at the end of each time interval) outputs the water outflow, the reservoir pool elevation, the volume of deposited sediment with its distribution over the reservoir height, the resulting new zero elevation, and the adjusted elevation–area–volume relation.

Keywords: Channel, channel flow, compaction, model, sediment, sedimentation

73. DAGGETT, L. L. 1984. Study of the impacts of reduced dredging procedures on the navigability of the Upper Mississippi River. Pages 274–279 *in* Third United States–The Netherlands Meeting on Dredging and Related Technology, Final Report.

The effects of channel width and depth on tow maneuvering capabilities are examined. Five channel sizes are tested including 11 × 300-feet, 13 × 300-feet, 11 × 450-feet, and 13 × 450-feet. The fifth channel consists of a minimum channel for emergency conditions. Each of the conditions tested are developed by first establishing the bottom contours expected following dredging. Then, a two-dimensional model of the water currents for the test flow condition of 19,000 $feet^3/s$ is used to develop the velocity patterns expected with the respective channels.

Keywords: Bathymetry, channel, channel flow, dredging, Mississippi River, model, navigation, river

74. DANIEL, P. 1977. Deep'n as it come: The 1927 Mississippi River flood. Oxford University Press, New York. 162 pp.

Historical efforts to control Mississippi River floods are discussed.

Keywords: Flood, Mississippi River, river

75. DARDEAU, E. A. 1990. Downward trend in Mississippi River suspended sediment loads: Potamology Program (P-1): Report 5. U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. 67 pp.

A three-phase sediment study was initiated for the Mississippi River Basin. Phase I involved the inventorying of sediment sample collection stations in the Mississippi River Basin. Phase II identified a downward trend in Mississippi River suspended sediment loads that began around the middle of the 20th century. Phase III, the present study, evaluates suspended sediment sampling, analysis, and load computation procedures used at key stations on major streams in the Mississippi River Basin and the possible influence of these procedures on the downward trend of sediment.

Keywords: Bed load, Mississippi River, river, sediment, sediment transport, suspended sediment

76. DEMETRACOPOULOS, A. C., AND H. G. STEFAN. 1983. Model of Mississippi River pool: Mass transport. Journal of Environmental Engineering 109:1006–1034.

Gravity and wind-driven flow in a river impoundment are simulated by using a network of interconnected channels. The forcing wind is simulated by using a step-function, and the response is calculated by quasi-steady state simulation for each timestep. A cells-in-series approach with appropriately sized subdivisions to account for dispersion is used to simulate the transport of dissolved material through the system. The model is formulated and applied to Pool 2 of the Mississippi River.

Keywords: Channel, channel flow, Mississippi River, model, pool, river

77. DEMISSIE, M., AND N. G. BHOWMIK. 1987. Long-term impacts of river basin development on lake sedimentation: The case of Peoria Lake. Water International 12:23–32.

The deterioration of Peoria Lake, due to excessive sedimentation, is investigated. It has lost 68% of its original volume and now has an average depth of 2.6 feet. Due to poor water quality, much of the lake is unsuitable for aquatic habitat. The authors assert that the present condition of Peoria Lake is a good example of the long-term effects of river basin development without appropriate management implemented from the start.

Keywords: Drainage basin, erosion, measurement, river, sediment, sedimentation, water quality

78. DIETRICH, W. E., T. DUNNE, N. F. HUMPHREY, AND L. M. REID. 1982. Construction of sediment budgets for drainage basins. Pages 5–23 *in* F. J. Swanson, editor. Sediment budgets and routing in forested drainage basins. U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station, General Technical Report PNW-141.

A drainage basin sediment budget is a quantitative estimate of sediment material production, transport, and discharge rates. The authors review the methods involved in constructing sediment budgets. To construct a sediment budget for a drainage basin, one must integrate the temporal and spatial variations of transport and storage processes. This requires recognition and quantification of transport and storage processes and identification of the linkages among these processes.

Keywords: Drainage basin, sediment, sedimentation, sediment budget, sediment transport

79. DITMARS, J. D., D. L. MCCOWN, AND R. A. PADDOCK. 1986. Movement of dredged sand at thalweg disposal sites. Proceedings of the Fourth Federal Interagency Sedimentation Conference 2:337–346.

Experiments are conducted by the U.S. Army Corps of Engineers to determine the movement of dredged sand at three sites on the Upper Mississippi River. The general pattern of behavior is similar at all three sites. Downstream movement of dredged sand is confined predominately to the main channel and occurs in response to periods of high river discharge. There is no statistically significant evidence of dredged sand dispersing from the main channel into nearby backwater areas.

Keywords: Channel, discharge, dredging, measurement, Mississippi River, river, sediment, sedimentation, sediment transport

80. DUNNE, T., AND L. B. LEOPOLD. 1978. Water in environmental planning. W. H. Freeman and Co., New York.

Methods of hydrological and geomorphological analysis used in environmental planning are reviewed and discussed. The chapters are grouped into four parts: field examples, hydrology, geomorphology, and river quality. The authors assert that knowledge of hydrology, fluvial geomorphology, and river quality is useful in maintaining or reclaiming environmental quality and avoiding environmental degradation.

Keywords: Bed load, channel, climate, discharge, drainage basin, erosion, flood, geomorphology, land cover/land use, model, precipitation, river, sediment, sedimentation, sediment transport, soil, stage, water quality

81. Eckblad, J. W., N. L. Peterson, and K. Ostlie. 1977. The morphometry, benthos, and sedimentation rates of a floodplain lake in Pool 9 of the Upper Mississippi River. American Midland Naturalist 97:433–443.

Big Lake is a shallow (mean depth 0.89 m), 256-ha backwater lake on the Mississippi River floodplain. Between 1896 and 1973, roughly 76 cm of sediment had accumulated in the original basin with a recent sedimentation rate of 1.7 cm/year. The calculated annual reduction in lake volume is 37,400 m^3/year, giving the lake a projected life span of 61 years. About 16% of the surface area is covered by emergent stands of *Sagittaria*, which extend to a depth of 0.3 m. With a projected decreased depth accompanying sedimentation, there should be continued expansion of the *Sagittaria* stands. A similar expansion would also be expected for floating *Nelumbo lutea* and *Nymphaea odorata*, which are also common. *Sphaerium* and *Hexegenia* are the dominant macroinvertebrate taxa, making up 81% of the biomass. Both taxa show greatly reduced abundance and biomass among the *Sagittaria* stands. As *Sagittaria* continues to encroach on the open water, the present macroinvertebrate dominance will likely shift to a dominance of Chironomidae, Oligochaeta, and Gastropoda, which will also influence organisms at higher trophic levels.

Keywords: Bathymetry, floodplain, geomorphology, land cover/land use, measurement, Mississippi River, pool, river, sediment, sedimentation

82. Engel, P., and Y. L. Lan. 1980. Computation of bed load using bathymetric data. Proceedings of the American Society of Civil Engineers 106 (Hydraulics Division 3, 15255):369–380.

A method for computing bed load by using data obtained directly from surveys of river-bed profiles is presented. It has the advantage of being simple, since only basic operations are required for the use of the profile data. Experimental data are used to test this method.

Keywords: Bathymetry, bed load, measurement, sediment, sediment transport

83. Engman, E. T., and R. J. Gurney. 1991. Remote sensing in hydrology. Chapman and Hall, London. 225 pp.

Hydrological applications of remote sensing are examined. The authors emphasize the ability of using remote sensing to measure and analyze spatial information, as opposed to point data, from which most of our hydrologic concepts and models have been developed.

Keywords: Channel, channel flow, remote sensing, river

84. FAN, S. 1988. Twelve selected computer stream sedimentation models developed in the United States. Federal Energy Regulatory Commission, Interagency Advisory Committee on Water Data, Washington, D.C. 552 pp.

A review is provided of 12 computer stream sedimentation models produced in the United States. The models include two major categories: privately owned models (i.e., CHARIMA, SEDICOUP, FLUVIAL-12, HEC2SR, TWODSR, and RESSED) and federally owned models (i.e., HEC6, TABS2, IALLUVIAL, STARS, GSTARS, and ONED3X). The primary goal of the study is to aid the public in the selection and proper use of these models.

Keywords: Model, river, sediment, sedimentation, sediment transport

85. FAULKNER, D. J. 1994. Historical land use, erosion, and sedimentation in the Lower Buffalo River watershed, west-central Wisconsin. Ph.D. Thesis, University of Wisconsin–Madison. 245 pp.

The author analyzes spatial and temporal variations in valley-bottom sedimentation since the 1850s in the Lower Buffalo River watershed (located in west-central Wisconsin). Field investigations, historical documents, and aerial photography are used to identify and explain the historical changes in sedimentation.

Keywords: Drainage basin, erosion, land cover/land use, measurement, sediment, sedimentation

86. FRANCO, J. J. 1967. Effects of stages on scour along riverbanks. Pages 232–239 *in* Proceedings for the Twelfth Congress of the International Association for Hydraulic Research. Paper A29.

Surveys are made along several reaches of the Mississippi River through a high-water season to determine the effects of changes in river stage on depth of scour along concave riverbanks. It is observed that scour or deposition can occur along riverbanks depending on river stage and the geometric configuration of the channel upstream and downstream. In general, the depth of scour increases with an increase in river stage, but the alignment of the channel can cause deposition to occur with rising stages. Also, the location of maximum scour or deposition can change with varying stage. These observations may be used to assess how regulating and stabilizing structures are affected by the changes in river stage.

Keywords: Channel, channel flow, channel geometry, measurement, Mississippi River, river, scour, sediment, sedimentation, sediment transport, stage

87. FRANCO, J. J. 1973. Guidelines for the design, adjustment, and operation of models for the study of river sedimentation problems. U.S. Army Corps of Engineers Waterways Experiment Station, Technical Report H-78-1. n.p.

This report is a general guide for laboratory engineers and technicians involved with model investigations of sedimentation problems in alluvial streams. It can be used with large or small streams because both have many of the same general characteristics and their evolution depends on the same basic laws. The text describes principles and procedures used in the design, adjustment, and operation

of movable-bed models. It also discusses the factors to be considered in the interpretation of model results and the development of improvement plans.

Keywords: Model, river, sediment, sedimentation

88. FREMLING, C. R. 1984. Ecological history of the Upper Mississippi River. Pages 5–24 *in* Proceedings of the fifteenth annual meeting of the Mississippi River Research Consortium.

The Upper Mississippi River has a rich and diverse environmental history. Several important periods and topics examined here include presettlement, the first explorations by Joliet (1670s), the beginning of steamboat travel (1820s), navigation improvement conducted by the U.S. Army Corps of Engineers (1820s), channel-deepening projects (1870s–1900s), declining fisheries (1870s–1900s), fish rescue operations (1870s–1950s), the development of a 9-foot channel (1930s), and present-day conditions (1980s).

Keywords: Channel, channelization, erosion, land cover/land use, levee, lock and dam, Mississippi River, navigation, river, sediment, sedimentation, sediment transport, water quality

89. FREMLING, C. R., D. N. NIELSON, D. R. MCCONVILLE, R. N. VOSE, AND R. FABER. 1979. The feasibility and environmental effects of opening side channels in five areas of the Mississippi River. Volumes 1 and 2. U.S. Fish and Wildlife Service, Final reports. Contract 14-16-0008-9. n.p.

The authors investigate the feasibility and environmental effects of opening side channels in the areas of the West Newton Chute, Murphy's Cut, Half Moon Lake; Fountain City Bay and Slough; and Sam Gordy's Slough. They address three general objectives: (1) predicting site-specific environmental consequences of altering freshwater flows to backwater areas by opening side channels; (2) determining which environmental parameters have the greatest predictive value in determining the environmental effect of future side channel openings or modifications; and (3) providing data that can be utilized in predictive models that evaluate effects of side channel modifications in other areas of the Mississippi River.

Keywords: Channel, channel flow, Mississippi River, model, river

90. GALATOWITSCH, S. M., T. V. MCADAMS, AND E. E. KLAAS. 1998. Biological information on distribution and requirements of plants used by migratory birds on the Upper Mississippi River. Iowa Cooperative Fish and Wildlife Research Unit, Ames, Iowa. Unit Cooperative Agreement 14-16-0009-1560, Work order 36. 176 pp. In press.

A major focus of river monitoring over the past 25 years has been to document patterns of vegetative cover within the Upper Mississippi River. A literature review is developed as a first step toward predicting habitat changes and developing habitat management strategies. Information is given on water levels, depths, water-level fluctuations, and how the plant community responds to each.

Keywords: Land cover/land use, Mississippi River, river, stage

91. GARDE, R. J. 1985. Mechanics of sediment transportation and alluvial stream problems. John Wiley & Sons, New York. 618 pp.

The vast amount of information on sediment transport and problems related to alluvial streams is summarized. The first eight chapters discuss the theory of sediment transport. The last eight chapters review applied problems of stable channels, alluvial streams, sediment control, sediment samplers, and sampling.

Keywords: Channel, measurement, river, sediment, sediment transport

92. GAUGUSH, R. F. 1993. Kriging and cokriging applied to water quality studies. Pages 236–253 *in* Proceedings of the Third National U.S. Fish and Wildlife Service Geographic Information Systems Workshop, La Crosse, Wisconsin, May 3–6, 1992. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-R027. 18 pp. (NTIS # PB93-174365)

Suspended sediment data from U.S. Geological Survey stream stations (located in the Upper Mississippi River Basin) are subjected to a kriging analysis. Kriging the available stream data results in isopleth maps of annual loading rates, which can be used to investigate basinwide trends. This procedure also produces error estimates to evaluate the confidence that can be placed in the loading estimates. Kriging represents a viable and extremely useful technique for the analysis of large-scale water quality patterns.

Keywords: Drainage basin, Mississippi River, model, river, sediment, suspended sediment, water quality

93. GAUGUSH, R. F., AND D. B. WILCOX. 1994. Planning document: Investigate sediment transport/ deposition and predict future configuration of UMRS channels and floodplain. National Biological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, December 1994. LTRMP 94-P004. 9 pp. + Appendixes A–E (NTIS # PB95-166351)

Discussions at the Environmental Management Technical Center concerning the addition of a sediment transport and deposition initiative led to the inclusion of a new work unit in the FY 1994 Annual Work Plan. This work unit was to form a Sediment Transport and Geomorphology Working Group that would develop a detailed set of initial tasks to be carried out over the next 3 to 5 years. After formulation of the Working Group, members were sent a draft planning document for their review. They then met to discuss the document and identify any gaps in its approach. The discussions and suggestions of the Working Group were used to revise the draft document. The planning document's primary goal is to outline tasks that will assist in predicting the influence of sediment transport and deposition on the future geomorphology of the Upper Mississippi River System.

Keywords: Channel, floodplain, geomorphology, Mississippi River, river, sediment, sedimentation, sediment transport

94. GENT, R. D., M. GRIFFIN, AND S. GRITTERS. 1990. Summary of water quality characteristics at selected habitat sites, Navigation Pool 13 of the Mississippi River, August 1 through October 31, 1988. Report by the Iowa Department of Natural Resources, Bellevue, Iowa, for the U.S. Fish and Wildlife Service,

Environmental Management Technical Center, Onalaska, Wisconsin, August 1990. EMTC 90-02. 21 pp. (NTIS # PB91-105338)

A summary is generated for weekly water quality measurements that are taken in Navigation Pool 13 (of the Mississippi River) July through October 1988. Mean nephelometric turbidity values display a wide fluctuation during the sampling period with backwater areas having higher turbidity than channel habitats. Higher turbidity levels in the backwaters are attributed to resuspension by wind action or fish disturbance. Sampling was performed during record low water conditions, which may have given atypical water quality readings.

Keywords: Channel, measurement, Mississippi River, pool, river, sediment, water quality

95. GERSMEHL, P., D. A. BROWN, AND K. A. ANDERSON. 1987. File structure design and data specification for water resources geographic information systems. P. Gersmehl and D. Brown, editors. University of Minnesota, St. Paul, Water Resources Research Center Special Publication 10. n.p.

The authors focus on developing appropriate designs for the collection, manipulation, and analysis of water resources data in geographic information systems. Included is discussion on file structure, cell size, methods of analysis, and modeling procedures for various types of data. Water resources data addressed consist of climate, land cover, soil, elevation, groundwater, and hydrographic information. Analysis and modeling of soil water systems, soil erosion, and groundwater systems are also discussed.

Keywords: Climate, erosion, geographic information system, land cover/land use, model, river, soil

96. GOODWIN, J. H. 1981. Sedimentology and hydrography of Pool 26, Mississippi River; Alton, Illinois, to Winfield, Missouri. Volume 1. Sedimentology. U.S. Army Corps of Engineers, Mobile District. Upper Mississippi River Basin Commission. 41 pp.

The sedimentology and hydrography of Pool 26 on the Mississippi River are examined. The distribution of particle sizes in the pool's bottom sediment is the primary subject of this investigation. Attempts are made to analyze the effects of human-made structures and activities on the distribution of sediment.

Keywords: Lock and dam, measurement, Mississippi River, pool, river, sediment, sedimentation

97. GOODWIN, J. H. 1981. Sedimentology and hydrology of Pool 26, Mississippi River; Alton, Illinois, to Winfield, Missouri. Volume 2. Bathymetry. Illinois State Geological Survey. 25 pp.

The bathymetry of Pool 26 on the Mississippi River is examined. The geomorphological structure and sedimentology of the river bottom are analyzed and attempts are made to correlate these with human-made structures and activities.

Keywords: Bathymetry, geomorphology, lock and dam, measurement, Mississippi River, pool, river, sediment, sedimentation

98. GOODWIN, J. H. 1983. Sedimentology and bathymetry of Pool 26, Mississippi River. Illinois State Geological Survey, Environmental Geology Notes 103. 76 pp.

During July and August 1980, 160 km of bathymetric profiling was performed and 239 bottom-sediment samples were collected from the main channel and selected side channels of Pool 26 of the Mississippi River. The author reviews and summarizes this information.

Keywords: Bathymetry, channel, measurement, Mississippi River, pool, river, sediment, sedimentation

99. GRAF, W. H. 1971. Hydraulics of sediment transport. McGraw-Hill, New York. 513 pp.

This text is divided into four sections: Section 1 provides a short history of sediment transport, section 2 describes the hydrodynamics of fluid-particle systems, section 3 is concerned with sediment transport in open channels, and section 4 describes sediment transport in closed pipes.

Keywords: Channel, channel flow, river, sediment, sediment transport

100. GREAT I TEAM. 1980. A study of the Upper Mississippi River, GREAT I. Volumes 1–9. U.S. Government Printing Office 1980-665-155/47-6. n.p.

The GREAT I final report consists of nine volumes. Volume one is the main report and provides background information on the Upper Mississippi River and the GREAT I study. It also describes the study process, presents recommendations of the GREAT I team, and provides a guide for implementation of the recommended actions. Volumes two through seven furnish information that led to the conclusions and recommendations of the final report. Volume 8 presents substantial detail on how the navigation channel, within the GREAT I study area (from Minneapolis, Minnesota, to Guttenberg, Iowa), should be maintained. Volume 9 presents an environmental impact statement with regard to the GREAT I channel maintenance plan.

Keywords: Channel, channel flow, dredging, erosion, floodplain, lock and dam, measurement, Mississippi River, navigation, pool, river, sediment, sedimentation, sediment transport, water quality

101. GREAT II TEAM. 1980. A study of the Upper Mississippi River, GREAT II. Great River Environmental Action Team, Rock Island, Illinois. n.p.

The GREAT II study is similar to GREAT I in its scope of work and findings. The study's primary objectives are to evaluate current resource management practices and develop a management plan for the Mississippi River (from Guttenberg, Iowa, to Saverton, Missouri). Subject areas addressed by the GREAT II study include commercial navigation, channel maintenance, erosion and sediment, floodplain management, fish and wildlife, water quality, and recreation.

Keywords: Channel, channel flow, dredging, erosion, floodplain, lock and dam, measurement, Mississippi River, navigation, pool, river, sediment, sedimentation, sediment transport, water quality

102. GRUBAUGH, J. W., AND R. V. ANDERSON. 1988. Spatial and temporal availability of floodplain habitat: Long-term changes in Pool 19, Mississippi River. American Midland Naturalist 119:402–411.

The 107-year record of daily water elevations for the Upper Mississippi River at Burlington, Iowa, is examined to assess changes in hydrologic patterns and floodplain availability resulting from dam and levee construction. After completion of Lock and Dam 19 in 1913, mean low, mean high, and overall mean water levels significantly increased ($P < 0.05$). Extensive reaches of floodplain habitat were lost because of inundation and levee construction.

Keywords: Channel, channel flow, floodplain, land cover/land use, levee, lock and dam, Mississippi River, pool, river, stage

103. HADLEY, R. F., EDITOR. 1986. Drainage basin sediment delivery. International Association of Hydrological Sciences, American Geophysical Union, Washington, D.C. IAHS-AISH Publication 159. 487 pp.

The primary objective of this symposium review is to examine the processes and mechanisms in the conveyance and storage of eroded material in drainage networks from upland slopes to stream channels. The relation between erosion and sediment delivery as it affects estimates of basin sediment yield and the problems caused by scale in drainage basin studies are also discussed. The papers in this volume are divided into five categories, including sediment sources, processes and sediment delivery, storage and mobilization of sediment, modeling of sediment yield and delivery, and data acquisition and analyses.

Keywords: Drainage basin, erosion, model, river, sediment, sedimentation, sediment transport

104. HADLEY, R. F., AND D. E. WALLING. 1984. Erosion and sediment yield: Some methods of measurement and modelling. Geo Books, Norwich, England. 218 pp.

Several methods of measuring erosion and sediment yield (caused by fluvial processes) are presented. Some procedures utilize erosion and sediment yield data to develop regression equations and models.

Keywords: Erosion, measurement, model, river, sediment, sediment transport

105. HAGEN, R., L. WERTH, AND M. MEYER. 1977. Upper Mississippi River habitat inventory. University of Minnesota, St. Paul, Final Report—Phase I, High Stage 1:24,000 CIR, Guttenberg, Iowa, to Cairo, Illinois. 18 pp.

The authors investigate the methods involved in producing cover-type maps of the Mississippi River floodplain from Guttenberg, Iowa, to Cairo, Illinois. Maps are developed by using 1:24,000 color infrared aerial photography flown in mid-August 1975. Aquatic, marsh, and upland vegetation are interpreted for the maps using a 1 ha (2.5 acre) minimum mapping unit.

Keywords: Floodplain, land cover/land use, Mississippi River, remote sensing, river

106. HAI CHEN, Y., AND D. B. SIMONS. 1979. Geomorphic study of the Upper Mississippi River. Proceedings of the American Society of Civil Engineers 105 (Waterway, Port, Coastal, and Ocean Division 3, 14778):313–328.

The past and present geomorphic features of the Upper Mississippi River are studied to estimate the effects of snag removal, dike construction, revetment, and lock and dam development on river geomorphology. The geomorphic features studied include river position, river surface area, island surface area, number of islands, riverbed surface area, surface widths, water depth, side channels, and riverbed elevations. The study results indicate that natural and human-induced activities in the last 150 years have produced subtle changes in the river geomorphology. The low dike fields narrowed the river, created new islands and chutes, and enlarged old islands. Lock and dams have widened the river and increased the number of islands in the pools. It is concluded that 50 years from now the river scene of the Upper Mississippi River will be essentially as it is today if no major human-made or natural changes occur.

Keywords: Bathymetry, channel, geomorphology, levee, lock and dam, Mississippi River, pool, river

107. HAI CHEN, Y., AND D. B. SIMONS. 1986. Hydrology, hydraulics, and geomorphology of the Upper Mississippi River System. Pages 5–19 *in* Ecological Perspectives of the Upper Mississippi River. Dr. W. Junk Publishers. The Hague, Netherlands.

A review is provided on the hydrologic, hydraulic, and geomorphic characteristics of the Upper Mississippi River System resulting from navigation development and maintenance activities. Specific features studied include river discharges, stages, sediment transport, river position, river surface area, island surface area, and riverbed elevation. Water and sediment transport effects on dredging are also examined.

Keywords: Bathymetry, channel, channel geometry, discharge, dredging, geomorphology, hydrology, lock and dam, Mississippi River, river, sediment, sediment transport, stage

108. HELMS, D. R, AND T. L. BOLAND. 1972. Upper Mississippi River natural resources bibliography. Upper Mississippi River Conservation Committee. 62 pp.

This bibliography serves as a reference for questions pertaining to the past, present, and future conditions of the Mississippi River natural resources. The author includes 707 published and unpublished works pertaining to fisheries, game, law enforcement, pollution, recreation, and miscellaneous natural resources of the Upper Mississippi River.

Keywords: Bibliography, contaminants, land cover/land use, Mississippi River, river

109. HEY, R. D. 1980. Determinate hydraulic geometry of river channels. Proceedings of the American Society of Civil Engineers 104 (Hydraulics Division 6, 13830):869–885.

Many attempts have been made to predict the hydraulic geometry of stable alluvial channels over the past century. The equations that have been developed give significantly different results when used for design purposes because many of these methods are dissimilar in their approach to the problem. The reasons for this diversity of opinion are discussed and a framework is presented that enables a general deterministic model to be established. This model, based on an understanding of the processes that operate in alluvial channels, indicates that it is possible to predict the bankfull hydraulic geometry of unstable as well as stable channels.

Keywords: Channel, channel flow, channel geometry, model, river

110. HICKIN, E. J. 1995. River geomorphology. International Association of Geomorphologists, Publication 2. John Wiley & Sons, New York. n.p.

Several river studies were presented in August 1993 at the Third International Geomorphology Conference of the International Association of Geomorphologists. They reflect the rich diversity of present-day geomorphological studies being conducted throughout the world. Topics examined were sediment (e.g., sediment size, transport, and landforms), modeling overbank sedimentation, effective discharge for bed load transport, channel adjustment (e.g., large-scale channel changes derived from satellite imagery), and the effect of river regulation.

Keywords: Bed load, channel, channel geometry, discharge, geomorphology, measurement, river, sediment, sedimentation, sediment transport

111. HIEBERT, T. I., H. F. BERNHARD, P. H. HOWE, AND D. R. HELMS. 1984. Sedimentation rates and standing stock estimates in selected sloughs of Pool 14 of the Mississippi River. Page 28 *in* Proceedings of the fifteenth annual meeting of the Mississippi River Research Consortium.

Sedimentation rates within two selected sloughs in Pool 14 of the Mississippi River are estimated. The shallowest slough received a higher volume of flow during periods of elevated river stages. Results suggest that, since 1954, as much as 1.2 m of sediment have been deposited in the shallower slough and about 0.6 m in the deeper site.

Keywords: Channel, channel flow, measurement, Mississippi River, pool, river, sediment, sedimentation, stage

112. HINDALL, S. M. 1976. Measurement and prediction of sediment yields in Wisconsin streams. U.S. Geological Survey, Water Resources Division, Madison, Wisconsin. 27 pp.

The U.S. Geological Survey began collecting sediment data at 118 stream gaging sites throughout Wisconsin in 1935. The average concentration of suspended sediment for Wisconsin streams is found to be lower in comparison with the rest of the United States. Sediment yield prediction equations are developed for the Northern Highland province, the Central Plain province, the Eastern Ridges and Lowlands province, and the Driftless area. These four equations make it possible to predict average annual suspended sediment yields at any point on approximately 95% of the streams in the state.

Keywords: Measurement, river, sediment, sedimentation, sediment transport, suspended sediment

113. HIPEL, K. W., AND A. I. MCLEOD. 1994. Time series modelling of water resources and environmental systems. Elsevier, New York. 1013 pp.

Water resources time series modeling is examined. In time series modeling and analysis, models are fit to one or more time series describing the system for purposes that include forecasting, simulation, trend assessment, and a better understanding of the dynamics of the system. A time series model is a set of observations appearing in chronological order for a given input or output variable being monitored.

Keywords: Model, river

114. HOBBS, H. C. 1985. Quaternary history of southeastern Minnesota. Pages 11–14 *in* R. S. Lively, editor. Pleistocene Geology and Evolution of the Upper Mississippi River Valley. Minnesota Geological Survey, St. Paul.

Discussion is provided on the geology of southeastern Minnesota along the Mississippi River. The author reviews work accomplished by the Minnesota Geological Survey in Winona County and applies this to the entire region.

Keywords: Geology, Mississippi River, river

115. HOGGAN, D. H. 1989. Computer-assisted floodplain hydrology and hydraulics. McGraw-Hill, New York. 518 pp.

This text is a valuable reference for computer programs that model floodplain hydrologic and hydraulic systems. Topics include an explanation of the hydrologic concepts needed to understand the theoretical basis of modeling basin hydrology; the analytic tools and methodology required to perform a complete floodplain information study; step-by-step procedures for utilizing some of the most valuable hydrological modeling software available today (e.g., HEC-1 and HEC-2); and floodway and channel improvement analysis, river basin modeling, and rainfall-runoff simulation and frequency analysis.

Keywords: Channel, channel flow, channelization, drainage basin, flood, floodplain, model, river

116. HOLE, F. D. 1968. Soils of Wisconsin. Wisconsin Geological and Natural History Survey, Madison. 1 p. (map)

A map is created to depict an aggregated classification of soils in Wisconsin.

Keyword: Soil

117. HOLLAND-BARTELS, L. E. 1992. Water quality changes and their relation to fishery resources in the Upper Mississippi River. Pages 159–180 *in* Water Quality in North American River Systems. Battelle Press, Columbus, Ohio.

The author addresses the dramatic changes in water quality of the Upper Mississippi River occurring after the construction of the lock and dam system in the 1930s. The low-head dam system created a diversity of habitats, but it also changed the stage and sediment transport characteristics of the river. By 1975, 5–9% of the open-water areas of the pools had been lost, primarily in the highly productive side channel and backwater areas. The report also explains that, with existing conditions, a loss of an additional 22–49% of existing aquatic habitats will occur within the next 50 years.

Keywords: Land cover/land use, lock and dam, Mississippi River, pool, river, sediment, sediment transport, stage, water quality

118. HSU, C. 1982. A sediment-budget analysis for the Upper Mississippi River between Guttenberg, Iowa, and Saverton, Missouri. M.S. Thesis, University of Iowa, Iowa City. 112 pp.

A sediment budget analysis was conducted for the Upper Mississippi River reach between Guttenberg, Iowa, and Saverton, Missouri. Quantitative estimates of sediment balances for each pool were made using available field data such as cross-section data, measured water and sediment discharges, dredging records, and suspended sediment size distributions. Deposition and scour rates for individual pools were estimated separately for the main channel and side channels.

Keywords: Channel, discharge, dredging, Mississippi River, pool, river, scour, sediment, sedimentation, sediment budget, sediment transport, suspended sediment

119. HSU, S. M., AND F. M. HOLLY, JR. 1992. Conceptual bed load transport model and verification of sediment mixtures. Journal of Hydraulic Engineering 118:1135–1152.

A conceptual transport model for bed load mixtures is proposed. The model predicts the transported gradation by using the concept of joint probability. In this approach, instead of using a hiding factor or exposure correction, the relative mobility of each particle size and the availability of each size class on the bed surface are considered. The mean hydraulic conditions of the flow and properties of the transported material are used to determine the total transport rate.

Keywords: Bed load, channel, channel flow, model, sediment, sediment transport

120. HUPP, C. R. 1988. Plant ecological aspects of flood geomorphology and paleoflood history. Pages 335–356 *in* V. R. Baker, R. C. Kochel, and P. C. Patton, editors. Flood geomorphology. John Wiley & Sons, Inc., New York.

Floods have two long-term effects on bottomland woody vegetation. First, periodic floods of varying magnitude affect vegetation patterns, including the creation of "new" areas (e.g., point bars) for vegetation establishment. Second, infrequent floods damage the bottomland plants such that their growth form reveals the effects of past floods either as outwardly evident stem deformations or as anomalous growth patterns in their serial tree ring sequence. Both vegetation patterns and damage allow for the interpretation of hydrogeomorphic conditions at a bottomland site.

Keywords: Flood, floodplain, geomorphology, land cover/land use, river

121. ITAKURA, T., AND T. KISHI. 1980. Open channel flow with suspended sediments. Proceedings of the American Society of Civil Engineers 106 (Hydraulics Division 8, 15650):1325–1343.

Many studies on the behavior of suspended sediment-laden flow have been made with varying degrees of success. The following conclusions for open-channel flows with suspended sediments are drawn from these studies.

1. The friction factor for the flow decreases as an effect of suspended materials prevails.
2. The van Karman universal constant, *k*, which has been given the value of about 0.4 in a pure water flow, may be smaller in flows with suspended sediment.
3. The mixing length and the scale of turbulence for the flow are reduced because of suspended sediments in the flow.
4. The velocity gradient *du/dy* becomes larger with increasing suspended sediment concentrations.
5. Measured velocities in a region near the bottom of the channel seem to be large compared with values predicted by the velocity defect law.
6. The concentration of suspended sediments near the bottom is generally lower than a value computed from the generally accepted classical equation.

Keywords: Channel, channel flow, river, sediment, sediment transport, suspended sediment

122. JACOBSON, R. B., K. A. OBERG, AND J. A. WESTPHAL. 1993. The Miller City, Illinois, levee break and incipient meander cutoff; an example of geomorphic change accompanying the Upper Mississippi River flood, 1993. American Geophysical Union 1993 Fall Meeting. EOS, Transactions, American Geophysical Union 74(43 supplement):61.

During the 1993 flood, the Mississippi River broke through a levee near Miller City, Illinois. Flow through the break crossed a high-amplitude meander bend and then reentered the main channel. This resulting meander cutoff is one of the more dramatic geomorphological changes that occurred during the Mississippi River flood of 1993. This report examines the implications of this change and predicts future changes that might occur.

Keywords: Channel, flood, geomorphology, levee, Mississippi River, river

123. JANSSON, M. B. 1988. A global survey of sediment yield. Geografiska Annaler 70:81–98.

Sediment yield is affected by many factors such as climate, relief, soil, vegetation, and human influence. Climate is one of the major factors controlling net erosion rates. It is examined here to identify correlations that might exist between worldwide climate and sediment yield.

Keywords: Climate, erosion, sediment, sediment transport

124. JOHNSON, A. G., AND J. T. KELLEY. 1984. Temporal, spatial, and textural variation in the mineralogy of Mississippi River suspended sediment. Journal of Sedimentary Petrology 54:67–72.

An evaluation is made of suspended sediment mineralogy in the Mississippi River by seasonal sampling and detailed examination of the mineralogy of several silt and clay size classes. The largest source of variation in suspended material is sediment size. This variation results from differences in soil mineralogy (in the drainage basins of major tributaries) and the time-varying contributions of the tributaries. Results of this analysis contribute to the understanding of sediment transport in the Mississippi River.

Keywords: Measurement, Mississippi River, river, sediment, sediment chemistry, sediment transport, suspended sediment

125. JOHNSON, J. H. 1976. Effects of tow traffic on the resuspension of sediments and on dissolved oxygen concentrations in the Illinois and Upper Mississippi Rivers under normal pool conditions. National Technical Information Service, Springfield, Virginia. Technical Report Y-76-1. 181 pp.

In total, 19 separate tows are monitored on the Mississippi River and 21 tows on the Illinois River at locations chosen to correspond to upper, middle, and lower river reaches. Specific sampling sites are selected so that maximum effects (changes in concentrations) of tow traffic on potentially productive side channel habitats could be tested. The analyses indicate that tow traffic on the Illinois and Upper Mississippi Rivers during normal pool conditions contributes to existing levels of suspended sediment measured as both suspended solids and turbidity; and, furthermore, that sediments resuspended from the main channel move laterally to shoreward areas, including potentially productive side-channel areas. As judged by the relative responses of suspended solids concentrations and turbidity levels following the passage of tow traffic, the Illinois River seems to be more susceptible to tow traffic effects than the Mississippi River. Information collected about each tow (e.g., size, speed, draft, direction of travel, horsepower, and type) is examined and compared with elicited responses to observe if any relations exist. Although there are some apparent relations, no clear predictive patterns are evident from inspection of the data because of the complexity of the problem and the lack of control of the traffic monitored.

Keywords: Channel, measurement, Mississippi River, navigation, river, sediment, sedimentation, sediment transport, suspended load, water quality

126. KAPLER, J. E. 1994. An analysis of flooding of the Mississippi River at Dubuque, Iowa. Proceedings of the Mississippi River Research Consortium 26:19–20.

The Upper Midwest flooding in 1993 prompted an examination of past records in Dubuque to provide a better understanding of the problem. This was the most disastrous flooding ever recorded in the Upper Mississippi River Basin, with 60 days of flooding occurring at Dubuque. Flooding has become an increasing problem and factors affecting this are discussed. These include annual precipitation, deforestation, destruction of wetlands, changes in agricultural practices, and increasing urbanization. (Abstract only)

Keywords: Climate, flood, land cover/land use, Mississippi River, precipitation, river

127. KARIM, M. F., AND J. F. KENNEDY. 1987. Velocity and sediment-concentration profiles in river flows. Journal of Hydraulic Engineering 113:159–178.

The authors describe the development of an equation for the exponent in the power-law velocity distribution. It is formulated by relating the rate of energy dissipation (due to turbulent shear of the sediment bed layer) to the increased rate of fluid-shear energy dissipations (produced by moving sediment). The suspended sediment concentration distribution corresponding to the power-law velocity profile is calculated and simplified.

Keywords: Bed load, channel, channel flow, model, river, sediment, sediment transport, suspended sediment

128. KARIM, M. F., AND J. F. KENNEDY. 1990. Menu of coupled velocity and sediment discharge relations for rivers. Journal of Hydraulic Engineering 116:978–996.

Relations among the velocity, sediment discharge, bed-form geometry, and friction factor of alluvial rivers are derived by nonlinear multiple-regression analysis. A database made up of 339 river flows and 608 flume flows is used in the analysis. A hierarchy of formulations involving progressively more interdependencies among velocity, depth, sediment discharge, and bed-form geometry is developed. Procedures for computing velocity- and sediment-rating curves are also presented.

Keywords: Channel, channel flow, measurement, model, river, sediment, sediment transport

129. KEABLES, M. J. 1988. Spatial association of midtropospheric circulation and Upper Mississippi River Basin hydrology. Annals of the Association of American Geographers 78:74–92.

Associations that exist between the summer midtropospheric circulation and the hydrology of the Upper Mississippi River Basin (UMRB) are identified. The primary objectives of this study include the identification of spatial associations between midtropospheric height anomalies, UMRB precipitation frequency and maximum stream discharge, and the calculation of the occurrence probabilities of precipitation frequency and maximum stream discharge for the various midtropospheric anomaly patterns.

Keywords: Climate, discharge, Mississippi River, precipitation, river

130. KEOWN, M. P. 1977. Inventory of sediment sample collection stations in the Mississippi River Basin: Final report. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. Report M-77-1. 49 pp.

An inventory is developed for sediment sample collection stations located in the Mississippi River Basin. Data for 433 stations are located and collected. A portion of the collected information included the station number, station name, station location (geographic coordinates), period of record, frequency, and types of data collected. In addition, narrative summaries are prepared for 74 key stations selected on the basis of location, period of record, and reliability of reported data.

Keywords: Drainage basin, measurement, Mississippi River, river, sediment, sedimentation, suspended sediment

131. KEOWN, M. P. 1986. Historic trends in the sediment flow regime of the Mississippi River. U.S. Army Corps of Engineers Waterways Experiment Station. Water Resources Research WRERAQ 22:1555–1564.

Historical changes of sediment flow in the Mississippi River are examined. Major emphasis is given to interpreting how the placement of flood control structures and other channel improvement features and the implementation of improved land management practices have changed the suspended sediment flow regime of the main stem.

Keywords: Channel, channel flow, channelization, land cover/land use, levee, lock and dam, Mississippi River, river, sediment, sediment transport, suspended sediment

132. KHANBILVARDI, R. M., AND A. S. ROGOWSKI. 1984. Mathematical model of erosion and deposition on a watershed. Transactions of the ASAE 27:73–79.

An erosion model is applied to two watersheds, one in Pennsylvania and the other in Nebraska. Soil and topographic maps are used as the primary data sources for the model with information being collected using a 100- × 100-m grid. Soil loss potential is calculated with universal soil loss equation. The eroded soil available for transport at all grid points and net amounts of soil eroded in any part of the watershed are also computed. The model estimates the sediment load at the boundaries and outlets and is also used to investigate the effects of median particle size on the sediment load.

Keywords: Drainage basin, erosion, model, sediment, sedimentation, sediment transport, soil, suspended sediment

133. KIRKBY, M. J. 1994. Process models and theoretical geomorphology. British Geomorphological Research Group symposia series. John Wiley & Sons, New York. 417 pp.

This text represents a comprehensive review of modern modeling approaches, techniques, and applications in geomorphology. One of its four sections is entirely devoted to river channel processes.

Keywords: Channel, geomorphology, model, river

134. KLEIN, W. M., R. H. DALEY, AND J. WEDUM. 1975. Environmental inventory and assessment of Navigation Pools 24, 25, and 26, Upper Mississippi and lower Illinois Rivers; a vegetational study. National Technical Information Service, Springfield, Virginia. Contract Report Y-75-1. 143 pp.

A vegetation map and descriptions of vegetational types and their successional patterns are developed for Pools 24, 25, and 26 on the Upper Mississippi and lower Illinois Rivers. These are then used in an environmental impact analysis of the effects of maintenance and operation of the 9-foot navigation channel. Seven categories of vegetation are determined: old fields, wetlands, willow, silver maple–cottonwood, silver maple–cottonwood–pin oak, pin oak, and oak–hickory. All categories are mapped with the exception of old fields, which are omitted because they are often subject to cultivation after a short period of abandonment. The silver maple–cottonwood community is the most extensive type. Analysis of successional trends indicate that ash and American elm may become more important in many of the silver maple forests, and that pin oak forests may also replace them, particularly in areas protected from flooding by levees. It is observed that existing forest patterns are related to geomorphology. Prediction of future plant communities rests strongly on the prediction of the geomorphic environment.

Keywords: Channel, channelization, floodplain, geomorphology, land cover/land use, Mississippi River, pool, river

135. KNOX, J. C. 1977. Human impacts on Wisconsin stream channels. Annals of the Association of American Geographers 67:323–342.

The effect of land cover change on erosion, sedimentation, and stream channel adjustment is examined in the Platte watershed of southwestern Wisconsin. The alteration of vegetative cover increased surface runoff causing a three- to fivefold increase in flood magnitudes. Increasing sediment yields, due to land cover change, altered the shape of channel cross-sections. Headwater and tributary channels generally widened out and became shallower while most downstream main channel reaches narrowed and grew deeper. Much of the sediment related to human-induced accelerated surface runoff has been transported only short distances and deposited on alluvial fans and floodplain surfaces. The historical floodplain alluviation varies in thickness from about 0.5 m of deposited sediment in the headwater floodplains to about 4 m in the main channel floodplain near the mouth of the river.

Keywords: Channel, drainage basin, erosion, flood, floodplain, land cover/land use, measurement, river, sediment, sedimentation, sediment transport

136. KNOX, J. C. 1977. The response of floods and sediment yields to climate variation in the Upper Mississippi River Valley. Geological Society of America, Abstract Programs 9:614–615.

The author reviews the importance of climate as a variable influencing short-term variations of floods and sediment yields. Many investigators assume that climate variations are random, but this is frequently not supported by long historical records of climate and hydrologic events. Nonrandomness in hydrologic time series occur because climate circulation regimes are often characterized by positive and negative feedback mechanisms that lead to persistence of anomalous conditions. Persistence of anomaly patterns, in turn, affects the size and frequency characteristics of floods and sediment yields.

Keywords: Climate, flood, river, sediment, sediment transport

137. KNOX, J. C. 1987. Historical valley floor sedimentation in the Upper Mississippi River Valley. Annals of the Association of American Geographers 77:224–244.

Variation in floodplain sedimentation rates due to human activity (post-1820) is evaluated in the Lead-Zinc district of the Upper Mississippi River Valley. It is determined that postsettlement rates of overbank floodplain sedimentation greatly exceed presettlement postglacial rates. Sedimentation rates rose rapidly on both tributary and main valley floodplains in the late nineteenth century. This was caused by poor agricultural land management and frequent above-average rainfall in the early growing season. Since the implementation of better farming practices (in the 1930s and 1940s), the rates of floodplain sedimentation have been greatly reduced, but still exceed presettlement sedimentation rates.

Keywords: Climate, floodplain, land cover/land use, measurement, river, sediment, sedimentation

138. KNOX, J. C. 1988. Climatic influence on Upper Mississippi River Valley floods. Pages 279–300 *in* V. R. Baker, R. C. Kochel, and P. C. Patton, editors. Flood geomorphology. John Wiley & Sons, Inc., New York.

Historical streamflow records show that climatic variation is a probable cause of changes in the seasonal concentration of floods during historical time. Throughout the Holocene (postglacial), a relatively steep climatic gradient has occurred across the Upper Mississippi River Basin and it is associated with a major ecotone separating mixed hardwood forest to the northeast from prairie to the southwest. Natural floods in the Upper Mississippi River Valley result from snowmelt, excessive rainfall, and various combinations of snowmelt and rainfall. Nearly 75% of all floods occur in March and July. Statistical analyses show that magnitudes of annual maximum floods correlate best with magnitudes of winter snow depth and early summer rainfall. The magnitudes of floods in the Upper Mississippi River Valley reflect their season occurrence. Short-term changes in flood seasonality suggest that the mean and variance of flood series often do not remain stationary as the time scale lengthens. Long-term Holocene records of high-frequency floods, reconstructed from dimensions of relict stream channels, also indicate nonstationarity of the mean and variance of flood series. The magnitudes and frequencies of floods in the Upper Mississippi River Valley show nonrandom behavior during historical and Holocene time. Correlation of flood characteristics with records of historical climate and with fossil pollen indicates that climatic change is the principal cause of the nonrandom behavior. The strong association of flood magnitudes with the amount of winter snowfall and the amount of early summer rainfall indicates that annual maximum and most large floods tend to respond best to the direct effects of climatic activity.

Keywords: Channel, channel flow, climate, flood, precipitation, river

139. KNOX, J. C. 1989. Long and short-term episodic storage and removal of sediment in watersheds of southwestern Wisconsin and northwestern Illinois. Pages 157–164 *in* Sediment and the Environment: Proceedings of a Symposium of the International Association of Hydrological Sciences, Baltimore, Maryland. IAHS Publication 184.

Average annual rates of erosion and sedimentation are commonly used to evaluate long-term movement and storage of sediment in watersheds. Average rates often poorly represent actual rates because changing environmental factors may dramatically alter surface runoff, flooding, and channel stability. The dating of historical, Holocene (postglacial), and late-Wisconsin (late glacial) hillslope and floodplain sediments in southwestern Wisconsin and northwestern Illinois indicate that rates of sediment erosion, storage, and transportation fluctuate episodically because of changing watershed environmental conditions. In the humid climate of the Upper Mississippi River Valley, periods of sediment storage tend to be relatively slow and progressive, whereas removal of sediment from storage tends to be episodic with short periods of dramatically high rates separating longer periods of relatively low rates. Historical erosion and sedimentation rates usually poorly represent long-term natural rates because of anthropogenic disturbance of land cover. The replacement of prairie and forest by agricultural land use in the Upper Mississippi River Valley resulted in accelerated floodplain sedimentation that averages 30–50 cm deep on tributary floodplains and as much as 3–4 m deep on floodplains in lower reaches of main valleys near the Mississippi River. The use of lead and zinc trace metals associated with historical mining shows that decadal-scale average historical rates of overbank floodplain sedimentation range from about 0.3 cm/year to 4.0–5.0 cm/year and greatly exceed the average presettlement postglacial floodplain vertical accretion rate of 0.02 cm/year that is determined from radiocarbon-dated alluvial deposits.

Keywords: Channel, climate, drainage basin, erosion, flood, floodplain, land cover/land use, measurement, river, sediment, sedimentation, sediment transport

140. KNOX, J. C. 1993. Large increases in flood magnitude in response to modest changes in climate. Nature 361:430–432.

The author discusses how minor changes in climate can have a great influence on river change and flood events. Presented here is a 7,000-year geological record of overbank floods for Upper Mississippi River tributaries, which provides solid evidence for high sensitivity of flood occurrence to changing climate.

Keywords: Climate, flood, Mississippi River, river, sediment, sedimentation

141. KNOX, J. C., P. J. BARTLEIN, AND K. K. HIRSCHBOECK. 1975. The response of floods and sediment yields to climatic variations and land use in the Upper Mississippi River Valley. National Technical Information Service, Springfield, Virginia. PB-247 086. 76 pp.

Flooding and sediment yield responses are identified, described, and calibrated according to the interactions between climatic and hydrologic systems. A major focus of this study is assessing the effect of climatic variability as determined by patterns of upper atmospheric circulation. Attention is also devoted to the varying effects of climatic–hydrologic interactions as distributed over watersheds that differ according to size and land use.

Keywords: Climate, drainage basin, flood, land cover/land use, measurement, river, sediment, sediment transport

142. KNOX, J. C., P. MCDOWELL, AND W. C. JOHNSON. 1981. Holocene fluvial stratigraphy and climatic change in the Driftless area, Wisconsin. Pages 107–127 *in* W. C. Mahaney, editor. Quaternary Paleoclimate.

Sedimentation rates and flood magnitudes have varied in the Driftless area during the last 10,000 years because of climate change. Average characteristics of temperature and moisture have changed from cool and moist to warm and dry, and back to cool and moist. Annual stream runoff of the maximum period of warm and dry is estimated at 40–60% less than present average runoff. Three major depositional units, produced by the three climatic episodes, reflect long-term changes in sediment sources and flooding characteristics.

Keywords: Climate, flood, measurement, river, sediment, sedimentation

143. KORSCHGEN, C. E., G. A. JACKSON, L. F. MUESSIG, AND D. C. SOUTHWORTH. 1987. Sedimentation in Lake Onalaska, Navigation Pool 7, Upper Mississippi River, since impoundment. U.S. Fish and Wildlife Service, Water Resources Bulletin 23(2):221–226.

Sediment deposition is analyzed in the Lake Onalaska portion of the Upper Mississippi River. Computer models are used to process bathymetric data and generate maps of water depth for the area. The bathymetric data (from 1983) is then compared to preimpoundment data (before 1937). It is observed that Lake Onalaska has lost less than 10% of its original mean depth in the 46 years since impoundment. Previous estimates of sedimentation rates using Cesium-137 sediment core analysis seem to have been overestimated.

Keywords: Bathymetry, hydrology, lock and dam, measurement, Mississippi River, model, pool, river, sediment, sedimentation

144. KOUTITAS, C., AND B. O'CONNOR. 1981. Turbulence model for flow over dredged channels. Proceedings of the American Society of Civil Engineers 107 (Hydraulics Division 8, 16449):989–1002.

A discussion is provided on the use of computer methods to model flow and mixing patterns in a steep-sided channel, dredged at right angles to the main direction of the flow and sediment transport.

Keywords: Channel, channel flow, dredging, model, river, sediment, sediment transport

145. KOVACS, A., AND G. PARKER. 1994. A new vectorial bed load formulation and its application to the time evolution of straight river channels. Journal of Fluid Mechanics 267:153–183.

The authors examine the evolution process resulting from bank erosion in the presence of bed load. The development of a new vectorial bed load formulation for the transport of coarse sediment by fluid flow is presented first, followed by a mathematical model of the time evolution of straight river channels.

Keywords: Bed load, channel, channel flow, erosion, model, river, sediment, sediment transport

146. KRISHNAPPAN, B. G. 1977. Mathematical modeling of sediment-laden flows in natural streams. Inland Waters Directorate, Canada Center for Inland Waters, Burlington, Ontario. 48 pp.

A mathematical model is introduced that estimates sediment transport in streams. The model incorporates the most recent advances in the field of sediment transport and is capable of yielding reliable predications of natural stream responses to changes in flow and sediment inputs. It forecasts changes in geometry due to river crossings, protection works, and realignment. Flow charts, input data descriptions, computer program listings, and sample model output are provided and discussed.

Keywords: Channel, channel flow, channel geometry, channelization, levee, model, river, sediment, sediment transport

147. LAGASSE, P. F. 1986. River response to dredging. Journal of Waterway, Port, Coastal and Ocean Engineering 112:1–14.

The effect of dredging on the Mississippi River is assessed. Dredging, contraction dikes, and disposal of dredged material in the dike fields can induce major changes in the cross-sectional characteristics of a river. This direct physical displacement of bed material, and the resulting change in channel shape, can retard the movement of bed load sediments though a river system.

Keywords: Bed load, channel, channel geometry, dredging, geomorphology, levee, Mississippi River, river, sediment, sediment transport

148. LAMB, M. S., AND L. T. ETHERIDGE. 1991. Sediment management on the Mississippi. Pages 1.1–1.8 *in* Proceedings of the Fifth Federal Interagency Sedimentation Conference.

The authors investigate sediment distribution in the Mississippi River. They also review methods of managing the river sediment as it moves through the system.

Keywords: Mississippi River, river, sediment, sedimentation, sediment transport

149. LEHMANN, E. J. 1975. Sediment transport in rivers: A bibliography with abstracts. National Technical Information Service, Springfield, Virginia. n.p.

Reports covering all aspects of river sediment transport are cited. Included are sediment transport studies concerned with stream erosion, scouring, particle size, water quality, flow rate, river mouth processes, and streambed degradation.

Keywords: Bibliography, channel, channel flow, erosion, measurement, river, scour, sediment, sediment transport, water quality

150. LEYTHAM, K. M. 1979. Watershed erosion and sediment transport model. Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratory, Athens, Georgia. Available from the National Technical Information Service, Springfield, Virginia. 357 pp.

The Watershed Erosion and Sediment Transport model is developed and evaluated. The model simulates hydrological and erosional processes and the movement of water and sediment through a channel system. It is tested with data from the East Fork River (in Wyoming) and the accuracy of results are discussed.

Keywords: Channel, channel flow, drainage basin, erosion, model, river, sediment, sediment transport

151. LINDER, W. M. 1976. Designing for sediment transport. Water Spectrum (spring–summer):36–43.

The author addresses the importance of considering sediment transport characteristics before making river modifications. Examples demonstrate that failure to do this can result in human-made modifications requiring periodic repair. The planning and design of channel modification projects (which consider river sediment processes) create a much more permanent and stable alteration.

Keywords: Channel, channelization, river, sediment, sedimentation, sediment transport

152. LINK, L. E., JR., AND A. N. WILLIAMSON, JR. 1976. Use of automated remote sensing techniques to define the movement of tow-generated suspended material plumes on the Illinois and Upper Mississippi Rivers. National Technical Information Service, Springfield, Virginia. Technical Report M-76-6. 56 pp.

Sequential color-infrared aerial photos and corresponding surface water samples are obtained at selected sites on the Illinois and Upper Mississippi Rivers to analyze the movement of tow-generated suspended material plumes. The aerial photos are digitized with a scanning microdensitometer, and optical density values are extracted for correlation with suspended material concentration data obtained by laboratory analysis of the water samples. A poor correlation between optical density and concentration values prevents quantitative definition (from the imagery) of the distribution of suspended material concentrations at the sites as a function of time. Digital data handling procedures enhance the visibility on the imagery of the tow-generated plumes. The procedures applied are successful in delineating the movement and dissipation of the tow-generated plumes under favorable sun and water conditions.

Keywords: Measurement, Mississippi River, navigation, remote sensing, river, sediment, sedimentation, sediment transport, suspended sediment

153. LOHNES, R. A. 1991. A method for estimating land loss associated with stream channel degradation. Engineering Geology 31(2):115–130.

Since the early 1900s, stream channel widening has accompanied channel degradation in areas of thick loess deposits along the Mississippi River. It has been established that the main cause of bank retreat is not the tractive force of flowing water, but mass movement. The intent of this study is to present improved methods of estimating land loss associated with this process.

Keywords: Channel, erosion, geomorphology, Mississippi River, river, sediment

154. LUBINSKI, K. S. 1993. A conceptual model of the Upper Mississippi River System ecosystem. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-T001. 23 pp. (NTIS # PB93-174357)

The author discusses a conceptual model designed to help identify and explain the factors that control the ecological structure and function of the floodplain reaches within the Upper Mississippi River System. Major factors (abiotic and biotic) and disturbances (natural and human-induced) that operate on the system are reviewed.

Keywords: Channel, channelization, erosion, floodplain, land cover/land use, lock and dam, Mississippi River, model, river, sediment

155. LUBINSKI, K. S., G. CARMODY, D. WILCOX, AND B. DRAZKOWSKI. 1991. Development of water level regulation strategies for fish and wildlife, Upper Mississippi River System. Regulated Rivers: Research & Management 6:117–124.

Water-level regulation is proposed as a tool for maintaining or enhancing fish and wildlife resources in navigation pools and associated floodplains of the Upper Mississippi River System. Research strategies include investigations of cause and effect relations, spatial and temporal patterns of resource components, and alternative problem solutions. Spatial analyses are under way to predict the magnitude and location of habitat changes that will result from controlled changes in water elevation.

Keywords: Floodplain, land cover/land use, Mississippi River, pool, river, stage

156. LYN, D. A. 1987. Unsteady sediment transport modeling. Journal of Hydraulic Engineering 113:1–15.

Standard one-dimensional equations of unsteady sediment transport and multiple time (or length) scales are reviewed. The coupling of hydraulic and sediment variables is investigated where rapid changes in both fluid and sediment discharge are imposed at the upstream boundary.

Keywords: Channel, discharge, model, river, sediment, sedimentation, sediment transport

157. MACK, F. J. 1970. Sediment yields in the Upper Mississippi River Basin. Proceedings of a seminar on sediment transport in rivers and reservoirs. U. S. Army Corps of Engineers Hydrologic Engineering Center. Paper 4. 10 pp.

Sediment yield rates vary considerably throughout the Upper Mississippi River Basin, which drains an area of 46,620 km² (18,000 square miles). Sediment yields in the extreme southern portion of the basin are approximately 200 to 250 times greater than yields in the extreme northern part of the basin. As the size of the drainage area increases, the rate of sediment production per square mile decreases. This is because chances for a storm to completely cover a watershed decreases as the watershed becomes larger. Also, the percentage of steep erosional surfaces decreases with larger basin area.

Keywords: Drainage basin, erosion, geomorphology, measurement, Mississippi River, river, sediment, sediment transport

158. MACMURRY, H. L., AND M. N. R. JAEGGI. 1990. Modeling erosion of sand and silt bed rivers. Journal of Hydraulic Engineering 116:1080–1089.

A conventional numerical river model (that failed to adequately reproduce the erosion of a 20-km stretch of a sand-bed river) is modified to allow much of the eroded material to be transported as wash load. The observed erosion is satisfactorily reproduced by assuming the proportion of silt to be 40%.

Keywords: Channel, channel flow, erosion, model, river, sediment

159. MADSON, J. 1985. Up on the river. Nick Lyon Books: Schocken Books, New York. 276 pp.

This text describes the history of the Mississippi River. It includes descriptions of the river and surrounding area before and after the development of the 9-foot navigation channel.

Keywords: Channel, channelization, floodplain, land cover/land use, levee, lock and dam, Mississippi River, river

160. MAIDMENT, D. R. 1994. Hydrologic modeling using Arc/Info. Seminar at the fourteenth annual Environmental Systems Research Institute User Conference, Palm Springs, California. n.p.

The capability of geographic information system technology to model hydrological systems is explored. Subjects on required data, data sources, sediment transport, and hydraulic modeling are discussed.

Keywords: Channel, channel flow, geographic information system, model, river, sediment, sediment transport

161. MARCUS, A. 1989. Lag-time routing of suspended sediment concentrations during unsteady flow. Geological Society of America Bulletin 101:644–651.

Variations in timing and magnitude of suspended sediment concentrations are usually explained as a function of sediment supply, baseflow dilution, and forces controlling sediment entrainment. Unsteady flow, however, generates variations in sediment concentration because the flood wave moves downstream more rapidly than the stream flow in which sediments are entrained. This causes a variation in the relative positions of the flood wave and locus of suspended sediments. The performance of a simple lag model for predicting the timing and magnitude of sediment concentrations during passage of a flood wave is examined.

Keywords: Channel, channel flow, flood, model, river, sediment, sedimentation, sediment transport, suspended sediment

162. MAY, J. R. 1982. Engineering geology and geomorphology of streambank erosion; Report 3, The application of waterborne geophysical techniques in fluvial environments. U.S. Army Corps of Engineers Waterways Experimental Station, Vicksburg, Mississippi. Technical Report 79-7. 239 pp.

The performance, application, and capability of selected waterborne acoustic profiling systems for streambank erosion studies in fluvial environments are evaluated on areas of the White, Mississippi, Missouri, and Ohio Rivers. The application of continuous seismic reflection profiling and side-scanning sonar systems reveals that the newest of these systems are sufficiently developed for application to streambank erosion studies, as well as the engineering, geologic, hydrologic, and hydraulic investigations in the fluvial environment.

Keywords: Erosion, geology, geomorphology, measurement, Mississippi River, river

163. MCCUEN, R. H. 1982. A guide to hydrologic analysis using SCS methods. Prentice-Hall, Englewood Cliffs, New Jersey. 145 pp.

This document provides a summary of the basic concepts underlying the Soil Conservation Service's hydrologic analysis methods. It is also a guide to their use.

Keywords: Channel, channel flow, erosion, measurement, model, river, sediment, sedimentation, sediment transport

164. MCHENRY, J. R. 1978. An assessment of the sediment accumulation in Lake Onalaska, Pool 7, of the Upper Mississippi River. Sedimentation Laboratory, Oxford, Mississippi. 37 pp.

In 1977, a study on sediment deposition rates was conducted in Lake Onalaska by the U.S. Department of Agriculture sedimentation laboratory. It was part of a larger study encompassing the entire Upper Mississippi River corridor. The methodology, data collected, and results of the sedimentation study for Lake Onalaska are discussed.

Keywords: Measurement, Mississippi River, pool, river, sediment, sedimentation

165. McHenry, J. R., J. C. Ritchie, and J. Verdon. 1976. Sedimentation rates in the Upper Mississippi River. Symposium on Inland Waterways for Navigation, Flood Control, and Water Diversions 2:1339–1349.

Because of recent concern about the amount of sediment deposition in backwater areas along the Upper Mississippi River, a study was initiated to determine 1975 and earlier rates of sedimentation. Sources of backwater river sediment include farmland areas and dredging sites that work at maintaining the 9-foot navigation channel in the Mississippi River. Results indicate that sedimentation rates in these areas have slightly decreased since 1957.

Keywords: Measurement, Mississippi River, river, sediment, sedimentation

166. McHenry, J. R., J. C. Ritchie, J. Verdon, and C. M. Cooper. 1984. Recent rates of sedimentation in the Mississippi River. Pages 99–117 *in* Contaminants in the Upper Mississippi River, Butterworth, Boston.

Mean sedimentation rates in several backwater lakes and pools in the Upper Mississippi River Valley were 3.4 cm/year from 1954 to 1964 and 1.8 cm/year from 1965 to 1975. In spite of the decrease in sedimentation, many of these lakes are expected to become marshes within the next 50 to 100 years. Before the backwater lakes were formed by the construction of lock and dams, sediment deposition on the floodplains was largely unnoticed. Within the last few years, the more noticeable sedimentation has caused public concern. Maximum soil conservation measures are necessary to preserve the riverine habitat as long as possible.

Keywords: Contaminants, floodplain, geology, land cover/land use, lock and dam, measurement, Mississippi River, pool, river, sediment, sedimentation, water quality

167. McLean, S. R. 1991. Depth-integrated suspended load calculations. Journal of Hydraulic Engineering 117:1440–1458.

By integrating the product of sediment concentration and velocity over water depth, the net transport of sediment by suspension is estimated. For many flows, accurate estimations must include effects of density stratification by suspended sediment, as well as effects due to bed forms and a mixture of sediment sizes. Results are presented for a depth-integrated product of sediment concentration and velocity for a wide range of flow and sediment conditions.

Keywords: Channel, channel flow, model, river, sediment, sediment transport, suspended load

168. Meade, R. H., and R. S. Parker. 1986. Issues in sediment research in rivers of the United States. Proceedings of the Fourth Federal Interagency Sedimentation Conference 1:483–489.

There are several major problems concerned with sediment in rivers of the United States including the effects of dams and reservoirs, the implications of sediment storage, and the importance of large, infrequent storms. Dams and reservoirs have reduced by half the amount of sediment that the Mississippi River formerly transported to its delta. Sediment stored in river valleys alters river channel geometry and stores pollutant substances. A better understanding of the frequencies and magnitudes of the largest sediment transporting events is needed to improve the ability to predict the rates at which sediment is discharged by rivers.

Keywords: Channel, channel geometry, climate, flood, lock and dam, Mississippi River, precipitation, river, sediment, sedimentation, sediment transport

169. MEADE, R. H., T. R. YUZYK, AND T. J. DAY. 1990. Movement and storage of sediment in rivers of the United States and Canada. Pages 255–280 *in* M. G. Wolman and H. C. Riggs, editors. Surface water hydrology: The geology of North America. Geological Society of America, Boulder, Colorado.

The authors examine large scale sediment transport and deposition in this study. Specific topics covered include: how sediment is moved by rivers, the natural and anthropogenic factors that influence sediment yields, the storage of sediment in river systems at different time scales, and the quantities of sediment transported by rivers of the North American continent.

Keywords: Measurement, river, sediment, sedimentation, sediment transport

170. MINOR, J. M., L. M. CARSON, AND M. P. MEYER. 1977. Upper Mississippi River habitat inventory. University of Minnesota, St. Paul, Final report—Phase 3. Detailed mapping...1:9600 CIR, Hastings, Minnesota, and Guttenberg, Iowa. 18 pp.

A habitat inventory is developed for selected portions of the Upper Mississippi River between Hastings, Minnesota, and Guttenberg, Iowa. The primary objective of this inventory is to develop detailed vegetation cover type overlays (with a minimum mapping unit of 0.2 ha [0.5 acre]) for 1:6,000-scale photomaps developed by the U.S. Army Corps of Engineers. Text and graphics are included, which fully describe the project, methodology, and further analyses conducted on the data.

Keywords: Floodplain, land cover/land use, Mississippi River, remote sensing, river

171. MISRI, R. L., R. J. GARDE, R. RANGA, AND G. KITTUR. 1984. Bed load transport of coarse nonuniform sediment. Journal of Hydraulic Engineering 110:312–328.

The authors review experiments concerned with bed load transport rates of different fractions in a mixture. A theoretical model that simulates the effect of a particular size of sediment on the transport rates of other sizes of sediment is proposed. Experimental data are analyzed to assess the accuracy of existing methods of estimating bed load transport and to propose a new method of computation.

Keywords: Bed load, model, sediment, sediment transport

172. MOLINAS, A., G. T. AUBLE, C. A. SEGELQUIST, AND L. S. ISCHINGER, EDITORS. 1988. Assessment of the role of bottomland hardwoods in sediment and erosion control. National Technical Information Service, Springfield, Virginia. Report PB88-190640. 116 pp.

The authors examine the relations between bottomland hardwood forest cover types, soils, hydrology, and water quality. Attempts are made to quantify and model these relations. Models are applied to selected areas along the Mississippi River to determine the effectiveness of various management alternatives. It is observed that the root structure and litter layer of bottomland forests help stabilize the erosive soil. Therefore, the sediment contribution from bottomland hardwood areas is much less than that from agricultural areas.

Keywords: Erosion, land cover/land use, measurement, Mississippi River, model, river, sediment, soil, water quality

173. MOLINAS, A., C. W. DENZEL, AND C. T. YANG. 1986. Application of streamtube computer model. Proceedings of the Fourth Federal Interagency Sedimentation Conference 2:6-55–6-64.

A computer model utilizing the stream tube concept is used to study erosion patterns at the Stage I cofferdam site of Lock and Dam 26. The 5-mile modeling reach is located between the then existing Lock and Dam 26, near St. Louis, Missouri, and Hartford, Illinois, on the Mississippi River. The computer model was originally developed for the U.S. Bureau of Reclamation to route water and sediment in alluvial channels. The concept of stream tubes allows the lateral and longitudinal variation of hydraulic conditions as well as sediment activity at cross sections along a study reach. The computer program is a semi-two-dimensional program with the third dimension, depth, being incorporated into the computations. Daily stage-discharge values at the gaging station, located at the downstream end of the study reach, are used for the hydraulic computations. Sediment routing computations are performed beginning with the existing sediment size distribution. Simulation results at the cofferdam site, presented in the form of topographic maps of the channel bed, indicate close agreement to actual measured data.

Keywords: Channel, channel flow, discharge, erosion, lock and dam, Mississippi River, model, river, sediment, sedimentation, sediment transport, stage

174. MOODY, J. A., AND R. H. MEADE. 1993. Hydrologic and sedimentologic data collected during four cruises at high water on the Mississippi River and some of its tributaries March 1989–June 1990. U.S. Geological Survey, Open-File Report 92-652. 227 pp.

The collection of water and sediment samples at 33 sites on the Mississippi River and several of its tributaries is reviewed. Four periods of sampling were conducted at high water during 16 months from March 9, 1989, to June 27, 1990. This was mostly a drought period. The data collected include cross-sectional area of the river, water depths, depth-averaged velocities, water discharge, surface temperature, suspended sediment concentration, and particle sizes of bed material and suspended sediment.

Keywords: Bed load, channel, channel flow, discharge, measurement, Mississippi River, river, sediment, sediment transport, stage, suspended sediment

175. MORSE, B., AND R. D. TOWNSEND. 1989. Modeling mixed sediment suspended load profiles. Journal of Hydraulic Engineering 115:766–780.

An investigation is conducted to identify potential errors in calculating vertical suspended sediment concentration profiles in river flows carrying mixed sediments. Suspended sediment concentration estimates are found to be particularly sensitive when the chosen reference level is small and the fraction width is large. The discrepancy between the actual representative fall velocity of a fraction and that of the geometric mean size of the fraction are corrected for by introducing fall velocity coefficients.

Keywords: Channel, channel flow, model, river, sediment, suspended sediment

176. MUELLER, D. S. 1990. Impact of changes in suspended sediment loads on the regime of alluvial rivers. Potamology Program (P-1): Report 6. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. 126 pp.

This investigation is the last of a four-phase study of the sediment regime of the Mississippi River Basin. It analyzes the changes in suspended sediment loads as they relate to the regime of alluvial rivers.

Keywords: Bed load, Mississippi River, river, sediment, sediment transport, suspended sediment

177. MULLER, E., H. DECAMPS, AND M. K. DOBSON. 1993. Contribution of space remote sensing to river studies. Freshwater Biology 29:301–312.

A review is given of the types of satellite remote sensing data presently available, and their recent uses in studies of river systems. Observational needs (e.g., spectral bands, ground resolution, and acquisition frequency) are addressed. River studies discussed are large-scale assessments of relative water quality, determining the extent of inundation and damage caused by flooding, and the mapping of river-related resources (e.g., riparian vegetation).

Keywords: Flood, land cover/land use, remote sensing, river, water quality

178. MURPHY, P. J., M. AGUIRRE, AND J. EDUARDO. 1985. Bed load or suspended load. Journal of Hydraulic Engineering 111:93–107.

Differences in sediment transport processes of bed load and suspended load are explained and quantified. The time required for sand particles leaving the bed to attain the free-fall velocity is shown to be the critical parameter for the saltation–suspension distinction.

Keywords: Bed load, sediment, sediment transport, suspended load

179. NAKATO, T. 1979. Mississippi River shoaling; a diagnostic study. Proceedings of the American Society of Civil Engineers 105 (Hydraulics Division 11, 14978):1375–1391.

An investigation is conducted on the causes of river shoaling in the Mississippi River. Attempts are also made to explain why different river reaches may have varying sediment transport capabilities, even if they are virtually identical.

Keywords: Channel, channel flow, Mississippi River, river, sediment, sedimentation, sediment transport

180. NAKATO, T. 1981. A review of sediment transport studies of the GREAT-I and GREAT-II reaches of the Upper Mississippi River. Iowa Institute of Hydrological Research, University of Iowa, Iowa City. 52 pp.

The author discusses factors influencing sediment input and transport capacity within the Upper Mississippi River and reviews computer-based numerical models that assist in modeling these sediment processes. The use of corrective measures (e.g., dredging and channelization) on the Mississippi River and their effect on sediment input and transport are also discussed.

Keywords: Channel, channelization, dredging, Mississippi River, model, river, sediment, sediment transport

181. NAKATO, T. 1981. Sediment budget study for the Upper Mississippi River, GREAT II reach. Iowa Institute of Hydrological Research, University of Iowa, Iowa City. 111 pp.

A sediment budget analysis along the Upper Mississippi River is performed using limited field data for the GREAT II reach between Guttenberg, Iowa, and Saverton, Missouri. Detailed pool-by-pool estimates of sediment balance including sediment inputs and outputs on each pool boundary, average sediment deposition, and average sediment scour within each pool are accomplished.

Keywords: Mississippi River, pool, river, scour, sediment, sedimentation, sediment budget, sediment transport

182. NAKATO, T., AND J. F. KENNEDY. 1977. Field study of sediment transport characteristics of the Mississippi River near Fox Island (RM 355-356) and Buzzard Island (RM 349-350). National Technical Information Service, Springfield, Virginia. AD-A045 244. 92 pp.

A field study is conducted to obtain a better understanding of the flow and sediment transport mechanisms responsible for the recurrent shoaling that has been experienced in the vicinities of Fox Island (between RM 355 and RM 356) and Buzzard Island (between RM 349 and RM 350) in the Mississippi River. Three sets of detailed data on transverse and streamwise distributions of flow velocity, suspended sediment discharge, bed load discharge, bed-material properties, and flow depth are obtained for high, intermediate, and low river stages during May–September 1976.

Keywords: Bed load, channel, channel flow, discharge, geology, measurement, Mississippi River, river, sediment, sedimentation, sediment transport, stage, suspended sediment

183. NAKATO T., AND J. VADNAL. 1978. Assessment of available field sedimentation data for GREAT-II watershed. Iowa Institute of Hydrological Research, University of Iowa, Iowa City. Report 216. 72 pp.

An inventory study concerning available stream sediment and flow data for the Upper Mississippi River and its tributaries is discussed. Existing methods of estimating sediment yields are reviewed and rough estimates of annual sediment yield are calculated at sampling stations. A plan of study to determine quantities of sediment delivered by tributary sources into the Mississippi River is also proposed.

Keywords: Channel, channel flow, discharge, drainage basin, measurement, Mississippi River, river, sediment, sedimentation, sediment transport, stage, suspended sediment

184. NAKATO T., AND J. VADNAL. 1981. Field study and tests of several one-dimensional sediment transport computer models for Pool 20, Mississippi River. Iowa Institute of Hydrological Research, University of Iowa, Iowa City (a GREAT II study). 125 pp.

A recommended procedure is offered for conducting sediment sampling field studies and how the data obtained from these field studies can be utilized in the calibration and evaluation of numerical simulation models. The first section of the report describes the detailed results from a sediment sampling field study conducted in 1978 near Buzzard Island (RM 347–355) in Pool 20 of the Mississippi River. Variations in the longitudinal and transverse sediment distributions are presented for various flow quantities and sediment characteristics. The last section of the report evaluates the performance of four mathematical simulation models in predicting the 1978 conditions observed in the field study. The four models evaluated are (1) the HEC-6 model provided by the Hydrologic Engineering Center in Davis, California; (2) the CHAR2 model used by Sogreah consulting firm in Grenoble, France; (3) the SUSR model; and (4) the UUWSR model employed at Colorado State University, Fort Collins.

Keywords: Measurement, Mississippi River, model, pool, river, sediment, sediment transport, suspended sediment

185. NELSON, J. C., C. H. THEILING, AND R. E. SPARKS. 1993. Effects of navigation dams on water regimes: Hydrological changes at Navigation Pool 26, Mississippi River. Page 40 *in* Proceedings of the Mississippi River Research Consortium, Inc. Volume 25.

The annual hydrographs of undisturbed temperate large floodplain river systems are characterized by a seasonal flood pulse. Normally, flooding expands main river channels into backwater and floodplain habitats. This natural process was severely altered by the construction of navigation dams on the Mississippi River. Some implications of this hydrological change are (1) reductions in spatial and temporal availability of floodplain habitats to riverine organisms, (2) abrupt water-level changes in lower pool reaches during critical life stages of some river fishes, and (3) artificially low river stages in middle and lower pool reaches that encourage floodplain development and result in greater economic losses when inevitable high flows occur. (Abstract only)

Keywords: Channel, channel flow, flood, floodplain, lock and dam, Mississippi River, pool, river, stage

186. NIELSEN, D. N., R. G. RADA, AND M. M. SMART. 1984. Sediments of the Upper Mississippi River: Their sources, distribution, and characteristics. Pages 67–98 *in* Proceedings of the fifteenth annual meeting of the Mississippi River Research Consortium.

This report reviews the geology, hydrology, and land use of the Upper Mississippi River Basin. It then addresses how these factors are related to the type and amount of sediment delivered to the river.

Keywords: Bathymetry, drainage basin, erosion, geology, land cover/land use, Mississippi River, river, sediment, sedimentation, sediment transport, suspended sediment

187. NORDIN, C. F. 1992. Particle size distributions of bed sediments along the thalweg of the Mississippi River, Cairo, Illinois, to head of passes, September 1989. Department of Civil Engineering, Colorado State University, Fort Collins. 93 pp.

Changes in Mississippi River bed sediment size between 1932 and 1989 are investigated. Samples were collected at 417 locations along the thalweg of the river in 1989. The 1989 data were then compared to a similar sampling program conducted in 1932. In general, the 1989 bed contained less coarse sand and gravel and less very fine sand than the 1932 bed.

Keywords: Bed load, measurement, Mississippi River, river, sediment, sedimentation

188. ODGAARD, A. J. 1989. River-meander model I: Development. Journal of Hydraulic Engineering 115:1433–1464.

Meander flow and planform development are analyzed to help generate a steady, two-dimensional model of flow and bed topography in an alluvial channel with variable curvature. The model is developed from the equations for conservation of mass (water and sediment) and momentum, and from a stability criterion for sediment particles on the stream bed. It estimates the velocity and depth distribution in meandering channels and the rate and direction of channel migration.

Keywords: Bathymetry, channel, channel flow, channel geometry, model, river, sediment

189. ODGAARD, A. J. 1989. River-meander model II: Applications. Journal of Hydraulic Engineering 115:1433–1464.

An analytical model that predicts the flow and bed topography in river meanders is evaluated. It is tested with data from rivers in India, Pakistan, and the United States. The model is steady, two-dimensional, and linear, and it describes the channel flow as a damped, oscillating system with curvature as a forcing function.

Keywords: Bathymetry, channel, channel flow, channel geometry, model, river

190. OLSON, K. N. 1980. Assessment of Upper Mississippi River floodplain changes with sequential aerial photography. Ph.D. Thesis, University Microfilms International, Ann Arbor, Michigan. GAX81-15024. 284 pp.

The author identifies the types and extent of natural and human-influenced changes of floodplain features in the Upper Mississippi River Valley from Minneapolis, Minnesota, to Guttenberg, Iowa, over the 35-year period following completion of the 9-foot navigation project in 1938. Marsh areas increased quite uniformly, the increase averaging 7.59% throughout the area. Meadows decreased and forest increased due to decreased agricultural activity and lower incidence of fire. Emergent aquatics do not show a clear cut case of having uniformly increased or decreased in area. Altered flow patterns, turbidity, and the expansion of marsh vegetation have caused some areas to decrease. Sedimentation has allowed emergent aquatics to become established in other areas. Agriculture has decreased in all pools due to the raised water tables and lowland flooding and land purchase by the Federal government. Residential areas have increased slightly overall, but will probably remain static due to the

pattern of Federal land ownership and flooding potential. The area of dredged material disposal sites increased in all pools due to the continued maintenance activities of the U.S. Army Corps of Engineers.

Keywords: Channel, channel flow, dredging, erosion, floodplain, land cover/land use, Mississippi River, remote sensing, river, sediment, sedimentation, suspended sediment

191. OLSON, K. N., AND M. P. MEYER. 1976. Assessment of Upper Mississippi River floodplain changes with sequential aerial photography. Pages 167–171 *in* Proceedings of the annual meeting of the American Society of Photogrammetry, Washington, D.C.

The type and extent of long-term natural and human-made changes in floodplain features of the Upper Mississippi River Valley are determined. Aerial photos are flown for this section of the river, and stream features (e.g., channels, backwater, vegetation, and location and condition of dredge spoil) are mapped. These 1973 baseline maps are then compared with conditions portrayed on 1939 Agriculture Adjustment Administration and Agriculture Stabilization and Conservation Service aerial photographs of the area. The results of these comparisons and the apparent changes in the river floodplain from 1939 to 1973 are summarized.

Keywords: Channel, channel flow, dredging, erosion, floodplain, land cover/land use, Mississippi River, remote sensing, river, sediment, sedimentation, suspended sediment

192. PARKER, G., AND N. L. COLEMAN. 1986. Simple model of sediment-laden flows. Journal of Hydraulic Engineering 112:356–375.

The authors discuss a theoretical model of sediment-laden flow that is applied to dilute open-channel suspensions. It is established that the effect of sediment is exhibited in reduced depth, a diminished coefficient of resistance, and an increased mean flow velocity.

Keywords: Channel, channel flow, model, sediment, sedimentation, suspended sediment

193. PARKER, R. S. 1988. Uncertainties in defining the suspended sediment budget for large drainage basins. Pages 523–532 *in* M. P. Bordas and D. E. Walling, editors. Sediment budgets. U.S. Geological Survey, IAHS publication 174.

Errors that may occur with estimates of sediment budgets for large drainage basins are addressed. A sediment budget within a river reach can be generated by considering the measured sediment transport from upstream, from intervening tributaries, and from the outlet of the reach. One factor often overlooked when estimating sediment budgets is the sediment that is eroded or deposited in the reach. Natural variability may cause this factor to be masked by error.

Keywords: Drainage basin, river, scour, sediment, sedimentation, sediment budget, sediment transport, suspended sediment

194. PARRETT, C., N. B. MELCHER, AND R. W. JAMES. 1993. Flood discharges in the Upper Mississippi River Basin, 1993. U.S. Geological Survey, Circular 1120-A. n.p.

This report provides a summary of 1993 Mississippi River flood flow information. It describes conditions before and during the flood event. It also reviews stages and discharges that occurred throughout the system during the 1993 flood.

Keywords: Channel, channel flow, climate, discharge, flood, Mississippi River, river, stage

195. PECK, J. H., AND M. M. SMART. 1986. An assessment of the aquatic and wetland vegetation of the Upper Mississippi River. Hydrobiologia 136:57–76.

Many studies have been performed on the ecology of aquatic macrophytes and wetland vegetation of the Upper Mississippi River and its floodplain. The authors evaluate the findings of these studies with respect to floristics, vegetation dynamics (patterns, history, production, and management), and environmental changes affecting vegetation.

Keywords: Floodplain, land cover/land use, Mississippi River, river, sediment

196. PRASAD, S. N., AND C. V. ALONSO. 1976. Integral-equation analysis of flows over eroding beds. Proceedings of the American Society of Civil Engineers Symposium on Inland Waterways for Navigation, Flood Control, and Water Diversions 1:760–772.

The steady, uniform flow in an alluvial channel cross-section with a partially eroding bed is considered. The wetted perimeter is divided into an inner region in which the known critical tractive forces are exceeded, surrounded by a region where the fluid velocity is known to vanish. This mixed boundary value problem is formulated in a dual series that leads to the solution of a Fredholm integral equation of the second kind. This solution determines the extent of the eroding zone and the distribution of the bed-slip velocity.

Keywords: Channel, channel flow, erosion, river, scour, sediment, sediment transport

197. QEEN, B. S., C. F. NORDIN, AND R. E. RENTSCHLER. 1991. Mississippi River sediment size changes, 1932 to 1989. Pages 5.17–5.24 *in* Proceedings of the Fifth Federal Interagency Sedimentation Conference.

The authors investigate Mississippi River sediment size changes through the system and over time. A decrease in downstream bed particle size was observed in 1932. Using the same sampling methods in 1989, the bed material was found to be finer than what was previously measured.

Keywords: Measurement, Mississippi River, river, sediment, sedimentation, sediment transport

198. RAY, P. K. 1976. Structure and sedimentological history of the overbank deposits of a Mississippi River point bar. Journal of Sedimentary Petrology 46(4):788–801.

The sequence of structures in a Mississippi River point bar and their correlations with a flood cycle are examined. The sequence comprised (from bottom to top) (1) initial overbank flooding in lower flow regime and formation of ripple drift lamination, (2) high turbulence during rising flood and formation of deformational structures, (3) upper flow regime during maximum flood and horizontal laminations (erosion occurred at this stage), (4) lower flow regime in the falling stage of flood and formation of small-scale trough cross-stratification, and (5) formation of clay drapes.

Keywords: Erosion, flood, floodplain, measurement, Mississippi River, river, scour, sediment, sedimentation

199. REESE, M. C., AND K. S. LUBINSKI. 1983. A survey and annotated checklist of late summer aquatic and floodplain vascular flora, middle and lower Pool 26, Mississippi and Illinois Rivers. Castanea 48:305–316.

Information is provided on the distribution and abundance of aquatic and floodplain plants in the middle and lower reaches of Pool 26, Illinois and Mississippi Rivers. Findings of a vegetation survey (made up of 36 sites throughout the study area) are summarized. Aquatic vegetation is discussed in relation to river sediment characteristics.

Keywords: Floodplain, land cover/land use, Mississippi River, pool, river, sediment, sedimentation, suspended sediment

200. REESE, T. F., AND J. F. RANVILLE. 1990. Collection and analysis of colloidal particles transported in the Mississippi River, U.S.A. Journal of Contaminant Hydrology 6(3):241–250.

The collection, concentration, and characterization of colloid (i.e., clay-sized) particles in the Mississippi River are described. Colloid concentrations, particle-size distributions, mineral compositions, and electrophoretic mobilities are determined.

Keywords: Measurement, Mississippi River, river, sediment, sedimentation, sediment chemistry, suspended sediment

201. REGAN, R. S. 1986. A computer program for analyzing channel geometry. U.S. Department of the Interior, Geological Survey, Reston, Virginia. Open-File Services Section, Western Distribution Branch, Denver, Colorado. 49 pp.

A computer program is presented that permits the analysis, interpretation, and quantification of the physical properties in an open-channel reach. The program is primarily used to estimate the area, width, wetted perimeter, and hydraulic radius of cross-sections at successive increments of water-surface elevation. Longitudinal rates-of-change of cross-sectional properties and the average properties of a channel reach are also computed.

Keywords: Channel, channel geometry, model, river, stage

202. RHODES, D. D., AND G. P. WILLIAMS, EDITORS. 1979. Adjustments of the fluvial system: A proceedings volume of the tenth annual geomorphology symposia series. Kendall/Hunt Publishing Company, Dubuque, Iowa. 372 pp.

The tenth annual geomorphology symposium meeting, sponsored by the State University of New York at Binghamton, is reviewed. Topics discussed include fluvial theory, channel processes, stream adjustments caused by natural events, and adjustments caused by humans.

Keywords: Channel, channel geometry, erosion, geomorphology, river, sediment, sedimentation, sediment transport

203. RICHARDS, K. 1982. Rivers; form and process in alluvial channels. Methuen & Company, New York. 358 pp.

This text offers a detailed review of alluvial river form and process and attempts to integrate the approaches of geomorphologists, geologists, and engineers. It outlines the environmental catchment factors that control the development of channel equilibrium. The text also provides a detailed account of the sediment transport processes that represent the physical mechanisms by which channel adjustment occurs.

Keywords: Channel, channel geometry, geomorphology, river, sediment, sediment transport

204. ROGALA, J. T., AND J. H. WLOSINSKI. 1992. Development of a spatial data base of longitudinal water level fluctuations within selected navigation pools of the Upper Mississippi River. Page 59 *in* Proceedings of the Mississippi River Research Consortium. Volume 24.

Water surface coverages are created for Mississippi River Pools 4, 8, 13, and 26 by using a geographic information system. Data for the coverages are obtained from water surface measurements recorded over an 18-year period and from backwater curves computed by the U.S. Army Corps of Engineers. The coverages depict the spatial changes that occur in water surfaces. (Abstract only)

Keywords: Bathymetry, geographic information system, land cover/land use, measurement, Mississippi River, pool, river, stage

205. ROSE, W. J. 1992. Sediment transport, particle sizes, and loads in lower reaches of the Chippewa, Black, and Wisconsin Rivers in western Wisconsin. U.S. Army Corps of Engineers, U.S. Geological Survey, Madison, Wisconsin. Water-Resources Investigation Report 90-4124. 38 pp.

Hydraulic and sediment data were collected at one site on the Black River, three sites on the Chippewa River, and one site on the Wisconsin River during water years 1977–83. This report summarizes an interpretation of those data including a description of the relation of suspended sediment, bed load, and total-sediment discharge to water discharge; a description of particle size characteristics of bed material, bed load, and suspended sediment; and estimates of annual and average annual suspended load, bed load, and total-sediment load.

Keywords: Bed load, discharge, measurement, river, sediment, sediment transport, suspended sediment

206. RUFF, J. F., M. M. SKINNER, B. R. WINKLEY, D. SIMONS, AND D. DORRATCAGUE. 1976. Remote sensing of Mississippi River characteristics. Journal of Waterways, Harbors, and Coastlines (Engineering Division)102(WW2):189–202.

The Potamology Section of the U.S. Army Corps of Engineers initiated a program directed toward developing a better understanding of the transport of water and sediment in the Mississippi River. In line with this effort, a comprehensive data collection program was initiated on selected reaches of the river in 1966. A study utilizing remotely sensed data was also initiated to improve the data collection process. The feasibility and usefulness of the remote sensing procedures and data are discussed.

Keywords: Channel, channel flow, measurement, Mississippi River, remote sensing, river, sediment, sediment transport

207. SAMAGA, B. R., R. RANGA, G. KITTUR, AND R. J. GARDE. 1986. Bed load transport of sediment mixtures. Journal of Hydraulic Engineering 112:1003–1018.

The authors review experiments that were conducted on alluvial beds of four sediment mixtures having different arithmetic mean diameters and standard deviations. Einstein's method, Proffitt and Sutherland's method, and Misri's method of bed load transport calculation of individual fractions for sediment mixtures are checked with collected laboratory data. By carefully analyzing the data, these methods of calculating bed load transport rate for individual fractions are modified to make them applicable over a wide range of parameters.

Keywords: Bed load, sediment, sediment transport

208. SAUER, V. B., AND J. M. FULFORD. 1983. Floods of December 1982 and January 1983 in central and southern Mississippi River Basin. U.S. Geological Survey, Atlanta, Georgia. Open-File Report 83-213.

The peak stage and discharge data are presented for gaging stations and miscellaneous sites in the areas affected by the December 1982 and January 1983 floods. The floods affected an area, about 402 km (250 miles) wide and 1,609 km (1,000 miles) long through the central and southern portions of the Mississippi River Basin.

Keywords: Discharge, flood, Mississippi River, river, stage

209. SCHELLHAASS, S. M., AND G. L. BENJAMIN. 1990. Summary of water quality characteristics at selected habitat sites, Navigation Pool 8 of the Mississippi River, July 17 through October 31, 1988. Report by the Wisconsin Department of Natural Resources, La Crosse, Wisconsin, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, August 1990. EMTC 90-01. 19 pp. (NTIS # PB90-267394)

Weekly water quality measurements were collected in Navigation Pool 8 (of the Mississippi River) from July 17 through October 31, 1988. Weekly trends are similar in all habitat types throughout the sampling period. Water clarity increases through the sampling period with a decrease in average turbidity and an increase in average Secchi depth transparencies. Velocities are variable, fluctuating with the flow at the lock and dam. Data collected during the sampling period are representative of unusually hot and dry conditions.

Keywords: Channel, channel flow, land cover/land use, measurement, Mississippi River, pool, river, sediment, suspended sediment, water quality

210. SCHELLHAASS, S. M., AND H. A. LANGREHR. 1992. A summary of water quality characteristics at selected habitat sites in Navigation Pool 8 of the Mississippi River for January 1 through December 30, 1989. Report by the Wisconsin Department of Natural Resources, La Crosse, for the U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, December 1992. EMTC 92-S022. 47 pp. (NTIS # PB94-103538)

Weekly water quality measurements were collected in Navigation Pool 8 (of the Mississippi River) in 1989. Similar weekly trends are observed in all habitats studied. Water clarity decreases from winter to summer, then increases in late summer and fall.

Keywords: Channel, channel flow, land cover/land use, measurement, Mississippi River, pool, river, sediment, suspended sediment, water quality

211. SCHIELEN, R., A. DOELMAN, AND H. E. DESWART. 1993. On the nonlinear dynamics of free bars in straight channels. Journal of Fluid Mechanics 252:325–356.

A simple morphological model that describes the interaction between a unidirectional flow and an erodible bed in a straight channel is evaluated. Assuming periodic behavior of the envelope wave, simulations of the dynamics of the Ginzburg-Landau equation using spectral models are carried out, and it is shown that quasi-periodic behavior of the bar pattern appears.

Keywords: Channel, channel flow, geomorphology, model, river, sediment

212. SCHNOOR, J. L., A. R. GIAQUINTA, D. D. MUSGROVE, AND W. W. SAYRE. 1980. Suspended sediment modeling of dredge-disposal effluent in the GREAT II study reach. Iowa Institute of Hydraulic Research, University of Iowa, Iowa City. IIHR-72. 241 pp.

The authors consider the utilization of existing, and the development of new, dredge disposal models in predicting the distribution and quantity of suspended solids resulting from the disposal of dredged material in the Upper Mississippi River. The hydraulically dredged material is discharged onto nearby islands or bends and the excess water flows back into the river. This water contains suspended solids and forms a suspended solids plume where it enters and rejoins the river. Comparisons are made between predicted and observed conditions and conclusions are drawn.

Keywords: Dredging, Mississippi River, model, river, sediment, suspended sediment

213. SCHOELLHAMER, D. H., AND P. B. CURWICK. 1986. Selected functions for sediment transport models. Proceedings of the Fourth Federal Interagency Sedimentation Conference 2:311–320.

Several functions that describe the erosion and deposition processes of suspended sediment in rivers are analyzed by using data from the Mississippi River. These erosion and deposition functions are incorporated into subroutines of a one-dimensional Lagrangian transport model. Six sets of suspended sediment data (collected at river mile 295.6 in the Mississippi River) are used to calibrate and verify the model. Shear stress functions and a reference equilibrium concentration function successfully model the suspended sediment, but a bed load layer dependence function was unsuccessful. The results of this study will improve the modeler's ability to simulate suspended sediment transport for many practical applications.

Keywords: Bed load, erosion, Mississippi River, model, river, scour, sediment, sedimentation, sediment transport, suspended sediment

214. SCHUMM, S. A. 1987. Experimental fluvial geomorphology. John Wiley & Sons, New York. 413 pp.

In 1969, the Engineering Research Center at Colorado State University (Fort Collins) began a series of experimental studies on drainage basin evolution and hydrology, river-channel and valley morphology and behavior, and alluvial-fan morphology and sedimentology. The experimental results from these studies are assembled and integrated into this text. It is organized into three parts, which include the morphology and dynamics of drainage basins, rivers and valleys, and alluvial fans and sedimentary deposits.

Keywords: Channel, drainage basin, erosion, geomorphology, river, sediment, sedimentation, sediment transport

215. SCHUMM, S. A., M. A. STEVENS, AND D. B. SIMONS. 1974. Geomorphology of the Middle Mississippi River. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. Report Y-74-2. 110 pp.

Comprehensive studies on the historical geomorphology of the Middle Mississippi River are performed to determine the physical effect of river contraction works on river morphology, behavior, and subsequent effects on the side channels. The studies include physical model studies of the river and side channels, the combined effects of navigation improvement structures and flood protection works on flood stages, and a review of the history of development and modification of the Middle Mississippi River.

Keywords: Channel, channelization, geomorphology, levee, lock and dam, Mississippi River, model, river, sediment

216. SCHUMM, S. A., AND B. R. WINKLEY. 1994. The variability of large alluvial rivers. American Society of Civil Engineers Press, New York. 467 pp.

The primary aim of this publication is to bring to the attention of river scientists that, in addition to hydrologic and hydraulic controls, there are significant geologic and geomorphic controls on large alluvial rivers. The text is divided into five sections with the first containing chapters about rivers that have multiple controls (e.g., tectonic, sedimentologic, and human). The remaining chapters are grouped into four parts that review rivers controlled primarily by geology, sediment, time, and human factors.

Keywords: Geology, geomorphology, land cover/land use, river, sediment

217. SHELTON, M. L. 1985. Modeling hydroclimatic processes in large watersheds. Annals of the Association of American Geographers 75:185–202.

Spatial and temporal variations in the processes that transform precipitation into runoff are a common source of error in watershed models. The author presents the conceptual structure of a hydroclimatic model that simulates the runoff process as four functionally discrete subsystems linked in series. Modeled characteristics for the Deschutes River Basin in Oregon illustrate the ability of the model to show important spatial and temporal differences in the runoff process.

Keywords: Climate, drainage basin, model, precipitation, river

218. SHIMIZU, Y., H. YAMAGUCHI, AND T. ITAKURA. 1990. Three-dimensional computation of flow and bed deformation. Journal of Hydraulic Engineering 116:1090–1106.

The authors discuss the development of a three-dimensional (3D) flow model to improve the defects of a two-dimensional (2D) model proposed by Shimizu and Itakura. Calculated results of the 3D model are compared with results of the 2D model, and it is found that the 3D model more accurately predicts the flow field.

Keywords: Channel, channel flow, model, sediment

219. SIMONS, D. B. 1974. A geomorphic study of Pools 24, 25, and 26 in the Upper Mississippi and Lower Illinois Rivers. Engineering Research Center, Colorado State University, Fort Collins. n.p.

The past and present geomorphic features of Pools 24, 25, and 26 of the Upper Mississippi River System are examined. Anticipated future geomorphic changes that result from past, present, and planned future developments of these reaches are also presented. The study utilizes a mathematical model of the river system. It is estimated that in 50 years the pools will be essentially as they are today with no major changes occurring.

Keywords: Channel, channelization, geomorphology, levee, lock and dam, Mississippi River, model, pool, river, sediment

220. SIMONS, D. B. 1974. Geomorphology of the Middle Mississippi River. Engineering Research Center, Colorado State University, Fort Collins. Report AEWES-CR-Y-74-2. 110 pp.

The author analyzes the present and historical geomorphology of the Middle Mississippi River to determine the physical effects of human activities (e.g., transportation, levees, lock and dams). The report includes physical model studies of the river and side channels, the combined effects of navigation improvement structures and flood protection works on flood stages, and a review of the history of development and modification of the Middle Mississippi River.

Keywords: Channel, channelization, geomorphology, levee, lock and dam, Mississippi River, model, navigation, river, sediment

221. SIMONS, D. B. 1975. Environmental inventory and assessment of Navigation Pools 24, 25, and 26, Upper Mississippi and Lower Illinois Rivers: A geomorphic study. Final report. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. Contract Report Y-75-3. 100 pp.

The past and present geomorphic features of Pools 24, 25, and 26 of the Upper Mississippi River System are examined. Anticipated future geomorphic changes that result from past, present, and planned future developments of these reaches are also presented. The study utilizes a mathematical model of the river system. It is estimated that in 50 years the pools will be essentially as they are today with no major changes occurring.

Keywords: Channel, channelization, geomorphology, levee, lock and dam, Mississippi River, model, pool, river, sediment

222. SIMONS, D. B. 1976. A geomorphic study of Pool 4 and tributaries of the Upper Mississippi River. Engineering Research Center, Colorado State University, Fort Collins. 117 pp.

The author investigates geomorphic changes that have occurred through time in Navigation Pool 4 of the Upper Mississippi River and its tributaries. The geomorphic changes analyzed include river position, river surface area, island surface area, number of islands, riverbed elevation, river width, side channels, discharge, and stage. The report explores several of the main causes of geomorphic change, including construction of the lock and dams and sediment input from tributaries.

Keywords: Bathymetry, channel, channel geometry, channelization, discharge, geomorphology, levee, lock and dam, Mississippi River, pool, river, sediment, stage

223. SIMONS, D. B. 1979. Effects of stream regulation on channel morphology. Pages 95–111 *in* J. V. Ward and J. A. Stanford, editors. The ecology of regulated streams, Plenum, New York.

The design of dams, diversion structures, and river-training works requires detailed evaluation of the effects such designs may impose on watersheds and river systems. The author reviews the information required to analyze the effects of water-resource development (e.g., sediment load, sediment size, deposition of sediment).

Keywords: Channel, channelization, lock and dam, sediment, sedimentation, suspended load

224. SIMONS, D. B. 1980. A mathematical model of Pools 5 through 8 in the Upper Mississippi River System. Engineering Research Center, Colorado State University, Fort Collins. 176 pp.

A mathematical model is developed for Pools 5 through 8 of the Upper Mississippi River System. The model is used to evaluate different management alternatives and their effects on the physical environment of the river (e.g., sediment transport through the river system).

Keywords: Channel, channel flow, Mississippi River, model, pool, river, sediment, sediment transport

225. SIMONS, D. B. 1981. Hydrologic, hydraulic, and geomorphic characteristics of Pool 9 in the Upper Mississippi River System. Simons, Li & Associates, Inc., Fort Collins, Colorado. 71 pp.

The past and present geomorphic features of Pool 9 in the Upper Mississippi River System are described. Major emphasis is given to the changes resulting from human-induced activities (e.g., construction of dikes and lock and dams, operation of lock and dams, and dredging). Maps, aerial photographs, hydrologic information, and sediment data are analyzed to determine the changes in geomorphic features. Specific features examined include open-water surface areas, water surface elevations, riverbed elevations, island numbers, and surface areas.

Keywords: Bathymetry, channel, channelization, dredging, geomorphology, levee, lock and dam, Mississippi River, pool, river, sediment

226. SIMONS, D. B. 1981. Investigation of effects of navigation development and maintenance activities on hydrologic, hydraulic, and geomorphic characteristics in the Upper Mississippi River System. Upper Mississippi River Basin Commission, Minneapolis, Minnesota. 76 pp.

The author describes the general geomorphic, hydrologic, and hydraulic characteristics of the upper and middle Mississippi River Systems. Methods for studying the physical environment of the Upper Mississippi River System and predicting its changes in response to development are proposed. Navigation development and maintenance activities are determined to be the primary causes of change in the characteristics of the river.

Keywords: Bathymetry, channel, channelization, dredging, geomorphology, levee, lock and dam, Mississippi River, pool, river, sediment

227. SIMONS, D. B. 1981. Investigation of effects of navigation traffic activities on hydrologic, hydraulic, and geomorphic characteristics. Upper Mississippi River Basin Commission, Minneapolis, Minnesota. n.p.

Towboat-induced changes to the physical environment of the Mississippi River are investigated. Barge traffic is shown to increase water velocity and generate wave action against the shore resulting in increased suspended-sediment concentrations and turbidity levels. Several factors are considered here, including natural flow velocity and turbidity, boat-generated wave heights and velocity changes, wave wash in relation to bank stability, sediment resuspension and suspended sediment concentrations, and sediment volumes entering side channels and backwater areas.

Keywords: Channel, channel flow, erosion, geomorphology, measurement, Mississippi River, navigation, river, sediment, suspended sediment, wave

228. SIMONS, D. B. 1992. Sediment transport technology: Water and sediment dynamics. Water Resources Publications, Littleton, Colorado. 897 pp.

This text presents accepted theories and fundamental concepts of geomorphology, hydrology, hydraulics, and sediment transport. One of its primary goals is to provide a realistic information base from which dependable actions and decisions can be formulated and defended. It also focuses on demonstrating how environmental and engineering claims can be more accurately quantified.

Keywords: Geomorphology, river, sediment, sediment transport

229. SIMONS, D. B., Y. HAI CHEN, R. LI, AND S. S. ELLIS. 1981. Evaluation of the applicability and usefulness of data in determining the hydrologic, hydraulic, and geomorphic characteristics of the Upper Mississippi River System. Simons, Li & Associates, Inc. 97 pp.

Resource data collected on the Upper Mississippi River System are reviewed to evaluate their usefulness in determining the present and future hydrologic, hydraulic, and geomorphic characteristics of the system. Data needs for conducting hydrologic, hydraulic, and geomorphic studies are outlined. Existing resource description data are identified and data gaps are discussed. The information evaluated includes topographic, hydrographic, geologic, soil, hydrologic, hydraulic, sediment, and climatological data.

Keywords: Channel, climate, discharge, Mississippi River, river, sediment, soil, stage, suspended sediment

230. SIMONS, D. B., Y. HAI CHEN, R. LI, S. S. ELLIS, AND T. P. CHANG. 1981. Hydrologic, hydraulic, and geomorphic characteristics of Pool 26 in the Upper Mississippi River System. Simons, Li & Associates, Inc. 76 pp.

The authors describe the past and present geomorphic features of Pool 26 in the Upper Mississippi River System. Major emphasis is given to the changes resulting from human-induced activities (e.g., construction of dikes and lock and dams, operation of lock and dams, and dredging). Maps, aerial photographs, hydrologic information, and sediment data are analyzed to determine the changes in geomorphic features. Specific features examined include open water surface areas, water surface elevations, riverbed elevations, island numbers, and surface areas.

Keywords: Bathymetry, channel, channelization, dredging, geomorphology, levee, lock and dam, Mississippi River, pool, river, sediment

231. SIMONS, D. B., Y. HAI CHEN, AND S. A. SCHUMM. 1977. A geomorphic study of the Upper Mississippi River. Geological Society of America, Abstract Programs 9:651–652.

Many alterations have been carried out on the Mississippi River to improve its potential for navigation. These alterations include the removal of snags, the construction of dikes, and the development of a series of lock and dams. Attempts are made to estimate the effects of these activities on the river geomorphology by examining the past and present geomorphic features of the Upper Mississippi River. Features studied include the river position, river surface area, island surface area, number of islands, riverbed surface area, surface widths, water depth, side channels, and riverbed elevations. Results indicate that natural and human-induced activities in the last 150 years have produced subtle changes in the river geomorphology. In general, the low dike fields narrowed the river, created new islands and chutes, and enlarged old islands. Lock and dams have widened the river and increased the number of islands in the pools.

Keywords: Bathymetry, channel, channel geometry, channelization, geomorphology, levee, lock and dam, Mississippi River, navigation, river

232. SLOFF, C. J. 1993. Analysis of basic equations for sediment-laden flows. Delft University of Technology, Delft, Netherlands. Communications on Hydraulic and Geotechnical Engineering Report 93-8. 54 pp.

Development and analysis of basic equations for one-dimensional sediment-laden flow (concentrations of as much as 10% of volume) on a mobile bed are presented. Equations of mass and momentum conservation are derived by means of a control section and depth integration. A three-layer approach is used that incorporates the bed layer, bed load layer, and suspended load layer.

Keywords: Bed load, channel, channel flow, model, sediment, sediment transport, suspended load

233. SOHMER, S. H. 1975. The vascular flora of transects across Navigation Pools 7 and 8 on the Upper Mississippi River. Wisconsin Academy of Science, Arts, and Letters 63:221–226.

In summer 1973, the River Studies Research Group at the University of Wisconsin–La Crosse participated in studies on the environmental effect of maintaining the 9-foot navigation channel on the Upper Mississippi River. The primary objective was to examine and catalogue the composition and relative abundance of vascular flora, both aquatic and terrestrial, across Navigation Pools 7 and 8.

Keywords: Land cover/land use, Mississippi River, pool, river, sediment

234. SOILEAU, C. W., R. W. RENTSCHLER, F. L. OGDEN, AND C. F. NORDIN. 1992. Changes in bed sediment size distributions along the Mississippi and Atchafalaya Rivers, 1932–1991. American Geophysical Union 1992 spring meeting. Eos, Transactions, American Geophysical Union 73(14 supplement):136.

During the low-flow seasons of 1932–34, the U.S. Army Corps of Engineers collected bed sediment samples from the thalwegs of the Mississippi River. This sampling program was repeated during the low flows of 1989–91. These data were used to document changes in bed sediment sizes and to determine the factors causing these changes. The study found smaller fractions of gravel and very fine sand during 1989–91, but the trend in mean sizes along the river were not greatly changed over time. The major influencing factors on particle size changes are identified, but it was found to be difficult to estimate their relative importance or to quantify their effects.

Keywords: Measurement, Mississippi River, river, sediment, sedimentation

235. SOLLER, D. R. 1992. Text and references to accompany "Map showing the thickness and character of Quaternary sediments in the glaciated United States east of the Rocky Mountains." U.S. Geological Survey, Reston, Virginia. For sale by Book and Open-File Report Sales, Denver, Colorado. 54 pp.

A 1:100,000-scale map of Quaternary deposits was compiled for the glaciated area of the United States east of the Rocky Mountains. It is the first regional three-dimensional view of these deposits. This report provides supporting information for the map and preliminary interpretations of sediment distribution.

Keywords: Geology, sediment, soil

236. SOLOMON, R. C., D. R. PARSONS, D. A. WRIGHT, B. K. COLBERT, AND C. FERRIS. 1975. Environmental inventory and assessment of Navigation Pools 24, 25, and 26, Upper Mississippi and Lower Illinois Rivers; summary report. National Technical Information Service, Springfield, Virginia. Technical Report Y-75-1. 97 pp.

An investigation is performed by Colorado State University (Fort Collins) to evaluate geomorphological changes in river reaches before and after human-made changes. Additionally, trends of future geomorphic changes that could result from existing and potential future developments are addressed with the aid of a mathematical simulation model. Vegetation and vegetative successional patterns of the floodplain are characterized by the Missouri Botanical Garden, St. Louis. An inventory of the animals and their habitats is also conducted by Southern Illinois University, Carbondale.

Keywords: Channel, channel geometry, channelization, discharge, dredging, floodplain, geomorphology, land cover/land use, levee, lock and dam, Mississippi River, model, river, sediment, stage, water quality

237. SOONG, T. W., AND N. G. BHOWMIK. 1991. Two-dimensional hydrodynamic modeling of a reach of the Mississippi River in Pool 19. Pages 900–905 *in* R. M. Shane, editor. Hydraulic Engineering. Proceedings of the 1991 National Conference of the Hydraulics Division of the American Society of Civil Engineers, Nashville, Tennessee, July 29–August 2, 1991. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, April 1993. EMTC 93-R003. 6 pp. (NTIS # PB94-108990)

The hydraulic characteristics of the Mississippi River floodplain-river system are studied by using a depth-integrated finite-element model (i.e., an RMA-2V model in the TABS-2 program). The primary area of focus for this study is a large oval eddy observed to form in Pool 19 near the downstream end of the Devil's Creek Delta. Causative factors for this eddy are identified by using the numerical model. Results indicate that the eddy can be simulated by this model and that numerical study is a feasible way to examine the mechanisms of eddy formation.

Keywords: Channel, channel flow, floodplain, Mississippi River, model, pool, river

238. SOONG, T. W., AND N. G. BHOWMIK. 1992. Characteristics of waves and drawdown generated by barge traffic on the Upper Mississippi River System. Pages 672–676 *in* M. Jennings and N. G. Bhowmik, editors. Saving a Threatened Resource—In Search of Solutions. Proceedings of the Water Forum '92, Hydraulic Engineering Sessions of the American Society of Civil Engineers, Baltimore, Maryland, August 2–6, 1992. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, February 1993. EMTC 93-R015. 5 pp. (NTIS # PB94-108966)

The authors discuss the characteristics of waves and drawdown generated by barge traffic in inland waterways. Field data for 77 events are collected from several sites along the Illinois and Mississippi Rivers. Three case studies are selected to illustrate the range of variations in waves and drawdown in the inland waterways. A synchronized comparison between waves and drawdown, local velocity, and turbidity level at the nearshore zone is also presented.

Keywords: Channel, channel flow, measurement, Mississippi River, navigation, river, sediment, suspended sediment, waves

239. Soong, T. W., W. C. Bogner, and W. F. Reichelt. 1990. Data acquisition for determining the physical impacts of navigation. Pages 616–621 *in* Howard H. Chang and Joseph C. Hill, editors. Hydraulic Engineering. Volume 1, Proceedings of the National Conference of the Hydraulics Division of the American Society of Civil Engineers, San Diego, California, July 30–August 3, 1990. Reprinted by U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1993. EMTC 93-R009. 6 pp. (NTIS # PB94-108925)

Intensive research is being conducted to determine the physical effects of navigation on the Upper Mississippi River System (UMRS). Data related to various aspects of navigation within the UMRS are collected and analyzed. The Illinois State Water Survey uses automated data logging systems to acquire data. Measuring instruments include current meters, electronic wave gages, wind monitors, turbidity meters, and pressure transducers. Suspended sediment is collected by a series of continuously pumped sampling systems.

Keywords: Channel, channel flow, measurement, Mississippi River, navigation, river, sediment, suspended sediment, waves

240. Soni, J. P. 1980. Aggradation in streams due to overloading. Proceedings of the American Society of Civil Engineers 106(Hydraulics Division 1, 15147):117–132.

Discussion is provided on the aggradation caused in an alluvial stream (originally in equilibrium) because of increases in the supply of sediment. During this type of condition, the streambed both upstream and downstream of the increased sediment supply would aggrade. Increase in sediment supply was assumed to be taking place continuously and at a constant rate.

Keywords: Measurement, river, sediment, sedimentation, sediment transport

241. Stefan, H. G., and A. C. Demetracopoulos. 1981. Cells-in-series simulation of riverine transport. Proceedings of the American Society of Civil Engineers 107(Hydraulics Division 6, 16349):675–697.

The authors introduce a cells-in-series (CIS) formulation that simulates riverine transport of dissolved material in water quality models. The characteristics of the model are compared with another model that uses the conventional one-dimensional advection-dispersion (AD) equation, and the advantages and disadvantages of the CIS model are illustrated. Both models are applied to a 17.2 km (10.7-mile) reach of the Upper Mississippi River in which dye-tracing experiments have been conducted by the U.S. Geological Survey.

Keywords: Mississippi River, model, river, sediment, sediment transport, suspended sediment, water quality

242. Stevens, H. H. 1989. Summary and use of selected fluvial sediment-discharge formulas. Department of the Interior, U.S. Geological Survey: Open-File Service Section, Western Distribution Branch, Denver, Colorado. 62 pp.

Two versions of computer programs for computing fluvial sediment discharge are assessed. A review of published formula-comparison studies indicates that the bed load formulas of Schoklitsch (1934) and Meyer-Peter and Muller (1948) are the most reliable. The most accurate bed-material formulas are those of Yang (1973) for sand; and Ackers and White (1973), Engelund and Hansen (1967), and Yang (1984) for gravel. Suggested procedures are presented for formula selection when field data are available and also when they are absent.

Keywords: Bed load, model, river, sediment, sedimentation, sediment transport

243. STEVENS, M. A., D. B. SIMONS, AND S. A. SCHUMM. 1975. Man-induced changes of Middle Mississippi River. Journal of Waterway, Harbor, and Coastline Engineering Division 101(WW2):119–133.

A review is provided on the past 150 years of human-alterations on the Middle Mississippi River and their effects on the system. The primary alterations discussed include channel improvement, levee development, and lock and dam construction. Physical changes in the river include reduction of island area, decreasing water surface, and shrinking riverbed area.

Keywords: Bathymetry, channel, channelization, dredging, erosion, geomorphology, levee, lock and dam, Mississippi River, river, sediment

244. SWAMEE, P. K., AND C. S. P. OJHA. 1991. Bed load and suspended load transport of nonuniform sediments. Journal of Hydraulic Engineering 117:774–787.

Useful empirical equations for the bed load and suspended load transport rates of nonuniform sediments are evaluated. Previous studies on nonuniform sediments are limited. These studies, in general, lacked simplicity, and often made use of various correction factors to be read from a series of tables and graphs. This not only made the evaluation cumbersome, but also resulted in loss of accuracy at each stage. The new equations discussed eliminate the need for accuracy-altering tables and graphs.

Keywords: Bed load, model, river, sediment, sediment transport, suspended load

245. TEETER, A. W. 1987. Fine-grained sediments: An annotated bibliography on their dynamic behavior in aquatic systems. Springfield, Virginia: U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. Technical Report HL-87-6. 525 pp.

This bibliography includes citations on consolidation, deposition, engineering works, erosion, field studies, hydrodynamics, modeling, sediment properties, study methods, and transport aspects of fine-grained sediment behavior in fluvial systems.

Keywords: Bibliography, erosion, measurement, model, river, scour, sediment, sedimentation, sediment chemistry, sediment transport

246. THOMAS, W. A., AND W. H. MCANALLY, JR. 1985. User's manual for the generalized computer program system open-channel flow and sedimentation TABS-2, main text. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. IRHL-85-1. 35 pp.

TABS-2 is a generalized numerical modeling system for open channel flows, sedimentation, and constituent transport. It consists of more than 40 computer programs to perform modeling and related tasks. This report reviews the methods and uses of the various components of the TABS-2 modeling system.

Keywords: Channel, channel flow, model, sediment, sedimentation, sediment transport

247. THORNE, C. R. 1991. Bank erosion and meander migration of the Red and Mississippi Rivers, U.S.A. Pages 301–313 *in* F. VandeVen, editor. Proceedings of the Hydrology for the Water Management of Large River Basins Symposium, Vienna, Austria.

The author investigates processes of bank erosion and meander migration with examples from the Red and Mississippi Rivers. Bank erosion is controlled by a number of factors, including the resistance of the bank material to be eroded by fluvial action; the resistance of the bank material to mass failure under gravity; and the capacity of the river flow to entrain and remove bed, bank, and failed material. Historical evidence from the Mississippi and Red River systems show how the type of materials encountered in the outer stream bank affects both the rate and distribution of bank erosion in a bend, thus influencing the speed and direction of bend migration and the overall pattern of channel evolution.

Keywords: Channel, channel flow, channel geometry, erosion, Mississippi River, river, scour, sediment, soil

248. TRIMBLE, S. W. 1993. The distributed sediment budget model and watershed management in the Paleozoic Plateau of the upper midwestern United States. Physical Geography 14(3):285–303.

A distributed sediment budget model is used to estimate sediment storage and distribution changes in three basin zones on the Paleozoic Plateau in the Midwest. The basin zones include tributaries, the upper main valley, and the lower main valley.

Keywords: Drainage basin, floodplain, model, river, sediment, sedimentation, sediment budget, sediment transport

249. U.S. ARMY CORPS OF ENGINEERS. 1975. Mississippi River, floodplain information: Mile 261.0 to Mile 608.5. Five volumes. U.S. Army Corps of Engineers, Rock Island District. n.p.

The primary focus of these reports is to determine and display the floodplain areas along the Mississippi River that are prone to flooding. Included is a history of floods occurring in the Mississippi River floodplain in 1947, 1965, 1969, and 1973. The reports also discuss methods in which future floodplain development should proceed to reduce the flood hazard.

Keywords: Flood, floodplain, Mississippi River, river

250. U.S. GEOLOGICAL SURVEY. 1950–1970. Quality of surface waters of the United States, 1950–1970. Parts 5–6, Hudson Bay and Upper Mississippi River Basins and Missouri River Basin. U.S. Geological Survey, Reston, Virginia. n.p.

Water quality data for the Hudson Bay Basin, Upper Mississippi River Basin, and Missouri River Basin are presented. The U.S. Geological Survey maintains stations on streams to study chemical and physical characteristics of surface water. Samples are collected daily, monthly, and less frequently at many other points. Water temperatures are measured and quantities of suspended sediment are recorded. Sediment samples are collected one or more times daily at most stations, depending on the rate of flow and changes in stage of the stream. Particle-size distributions of sediments are then determined.

Keywords: Channel, channel flow, measurement, Mississippi River, river, sediment, sedimentation, sediment transport, stage, suspended sediment, water quality

251. U.S. GEOLOGICAL SURVEY. 1993. U.S. geodata: Elevation data, planimetric data, land use and land cover data, geographic names information, software. U.S. Geological Survey, Reston, Virginia (to order data call 1-800-USA-MAPS). 3 pp. (brochure)

This three-page brochure describes elevation, planimetric, land cover/land use, and geographic names data for sale from the U.S. Geological Survey. The digital information is available on 9-track magnetic tapes and CD-ROMs.

Keywords: Geographic information system, land cover/land use, river

252. NATIONAL TECHNICAL INFORMATION SERVICE. 1982. Channel erosion (1977–July 82) (bibliography). National Technical Information Service, Springfield, Virginia. n.p.

A bibliography was generated that includes citations and related abstracts regarding channel erosion and sediment transport in rivers. River flows studied range from normal to flood flow.

Keywords: Bibliography, channel, erosion, measurement, river, scour, sediment, sediment transport

253. NATIONAL TECHNICAL INFORMATION SERVICE. 1990. Stream erosion and scouring processes. June 1970–May 1990 (bibliography). National Technical Information Service, Springfield, Virginia. n.p.

Citations are provided for studies involving erosional processes of rivers and streams. The erosion of stream and river banks, bridge supports, levees, and other hydraulic structures is discussed. The use of computer models to describe erosional processes is also considered. Citations pertaining exclusively to sediment transport studies and erosion from surface runoff are excluded.

Keywords: Bibliography, erosion, levee, model, river, scour

254. NATIONAL TECHNICAL INFORMATION SERVICE. 1995. Sediment transport in rivers (bibliography). National Technical Information Service, Springfield, Virginia. n.p.

This bibliography includes citations concerned with a variety of topics pertaining to river sediment transport processes. Topics include channel degradation and aggradation, water quality, and monitoring studies in specific areas. Considerable attention is given to computer simulations of transport processes.

Keywords: Bibliography, channel, erosion, measurement, model, river, scour, sediment, sedimentation, sediment transport, water quality

255. UPPER MISSISSIPPI RIVER BASIN COMMISSION. 1981. Geomorphic and land use classification of the floodplains of the Mississippi River and its navigable tributaries above Cairo, Illinois. Upper Mississippi River Basin Commission, Minneapolis, Minnesota. 74 pp.

A river categorization scheme that could be used for studies of dredged material disposal is developed for the Mississippi River. Estimates of land cover/land use are made for each Mississippi River mile above Cairo, Illinois, using 7.5-min topographic maps. Four categories of land cover/land use are used, including agriculture, forest, wetland, and urban/transportation. Topographic maps are also used to determine and categorize general valley forms for each river mile. This information is collected in the form of profiles across the river displaying floodplain, terrace, and bluff locations.

Keywords: Dredging, floodplain, geomorphology, land cover/land use, Mississippi River, river

256. UPPER MISSISSIPPI RIVER BASIN COMPREHENSIVE BASIN STUDY COORDINATING COMMITTEE. 1970. Upper Mississippi River comprehensive basin study. Appendix G—Fluvial sediment. Upper Mississippi River Comprehensive Basin Study Coordinating Committee Report 3:G1–G100.

A study on sedimentation and related problems in the Upper Mississippi River Basin is reviewed. Issues addressed include a definition of the sediment problems; the areal distribution, magnitudes, variability, and characteristics of sediment; and trends in sediment yields. A method is provided to estimate the likely rate of sediment deposition in reservoirs.

Keywords: Channel, channel flow, land cover/land use, measurement, Mississippi River, river, sediment, sedimentation, sediment transport

257. UPPER MISSISSIPPI RIVER BASIN COMPREHENSIVE BASIN COORDINATING COMMITTEE. 1972. Upper Mississippi River comprehensive basin study. Volumes 1–9. Upper Mississippi River Basin Comprehensive Basin Study Coordinating Committee, Washington, D.C. n.p.

A framework is determined and recommended for using fluvial resources in the Upper Mississippi River Basin. This framework includes a comprehensive plan for the improvement of flood control, navigation, hydroelectric power, water supply, and other water-related activities. The study considers all purposes served by conservation, development, and the use of water and related land resources.

Keywords: Flood, Mississippi River, navigation, river

258. VAN DE VEN, F. H. M., D. GUTKNECHT, D. P. LOUCKS, AND K. A. SALEWICZ, EDITORS. 1991. Hydrology for the water management of large river basins. International Association of Hydrological Sciences, International Union of Geodesy and Geophysics. IAHS Publication 201. 400 pp.

The symposium report's primary goal is to improve the understanding of various hydrological processes and to investigate the availability of tools and methods used to analyze the hydrological response to changes in large watersheds. The report covers four main topics, including water management and cooperation in large river basins; flow regimes and water management in relation to changes in climate, river development, and land use; water quality and sediment transport management in a large river environment; and operation flow and water quality forecasting.

Keywords: Channel, channel flow, climate, drainage basin, land cover/land use, measurement, river, sediment, sediment transport, water quality

259. VAN RIJN, L. C. 1984. Sediment transport. Part 1. Bed load transport. Journal of Hydraulic Engineering 110:1431–1456.

The author presents a method of computing bed load transport as a product of the saltation height, particle velocity, and bed load concentration. The equations of motions for a single particle are solved numerically to determine the saltation height and particle velocity. Experiments with gravel particles (transported as bed load) are selected to calibrate the mathematical model using the lift coefficient as a free parameter. The model is used to compute the saltation heights and lengths for a range of flow conditions.

Keywords: Bed load, channel, channel flow, model, river, sediment, sediment transport

260. VAN RIJN, L. C. 1984. Sediment transport. Part 2. Suspended load transport. Journal of Hydraulic Engineering 110:1613–1636.

A technique for computing suspended load as the depth-integration of the product of the local concentration and flow velocity is assessed. It is based on the computation of reference concentrations from the bed load transport. The computation is calibrated by using measured concentration profiles.

Keywords: Bed load, channel, channel flow, model, river, sediment, sediment transport, suspended load

261. VAN RIJN, L. C. 1984. Sediment transport. Part 3. Bed forms and alluvial roughness. Journal of Hydraulic Engineering 110:1733–1754.

A method is introduced that makes the classification of bed forms, the prediction of the bed form dimensions, and the effective hydraulic roughness of the bed forms feasible. The proposed relations are based on the analysis of reliable flume and field data. The method used in this study yields considerably better results for field conditions than previously proposed techniques, which are reviewed here.

Keywords: Geomorphology, river, sediment, sediment transport

262. VAN RIJN, L. C. 1987. Mathematical modeling of morphological processes in the case of suspended sediment transport. Delft Hydraulics Laboratory, Delft, Netherlands. Delft Hydraulics Communications 382. n.p.

The morphological processes of suspended sediment transport are analyzed by using a two-dimensional vertical model and a three-dimensional mathematical model. The principal equation used in these models is the convection–diffusion equation for suspended sediment particles.

Keywords: Model, river, sediment, sediment transport, suspended sediment

263. WAHL, K. L., K. C. VINING, AND G. J. WICHE. 1994. Precipitation in the Upper Mississippi River Basin, January 1 through July 31, 1993. U.S. Geological Survey Circular 1120-B. 13 pp.

Precipitation conditions and events before and during the 1993 Mississippi River flood are summarized. Monthly precipitation data are examined at 10 weather station locations in the flood-affected region to illustrate precipitation patterns and amounts.

Keywords: Climate, flood, Mississippi River, precipitation, river

264. WANG, S. Y. 1982. Computer simulation of sedimentation processes. Pages 16-35–16-45 *in* The Fourth International Conference on Finite Elements in Water Resources.

This paper reviews Mississippi River sedimentation processes. It provides a brief survey on historical development of both analytical and experimental studies on sedimentation. It also provides information about computer simulation methodology and a finite element model developed by the author.

Keywords: Mississippi River, model, river, sediment, sedimentation, sediment transport

265. WANG, S. Y. 1988. Development of a sediment transport model for field application. Water Resources Research Institute, Mississippi State University, Mississippi State. Technical Interim Report G1431-06. 31 pp.

The primary goal of this project is to modify and improve sediment transport models developed by the Center for Computational Hydroscience and Engineering at the University of Mississippi, Oxford. A mixed-dimensional model is constructed using individual 1-d, 2-d, and 3-d models as building blocks. This model is then tested with some typical examples of field application and satisfactory results are obtained.

Keywords: Mississippi River, model, river, sediment, sediment transport

266. WANG, X., AND N. QIAN. 1989. Turbulence characteristics of sediment-laden flow. Journal of Hydraulic Engineering 115:781–800.

The authors measure and analyze the turbulence structure of open-channel flow. Turbulence properties in clear-water flow are consistent with existing data. Turbulence intensity of a sediment-laden flow is weaker, its turbulence frequency is smaller, and the longitudinal sizes of turbulence eddies are larger than that of a clear-water flow.

Keywords: Channel, channel flow, river, sediment

267. WAYTHOMAS, C. F., AND G. P. WILLIAMS. 1988. Sediment yield and spurious correlation: Toward a better portrayal of the annual suspended sediment load of rivers. Geomorphology 1:309–316.

Techniques for portraying the annual suspended sediment load of rivers are presented. One method involves comparing suspended sediment load (tons per year) with the distance downstream. It is observed that suspended sediment load does not necessarily have a linear relation with distance. A second method involves comparing annual suspended sediment with drainage basin area. The author states that both methods more accurately illustrate fundamental relations between annual sediment load and drainage basin characteristics than does the yield–area relation because spurious correlation is avoided.

Keywords: Drainage basin, erosion, geomorphology, Mississippi River, river, sediment, sedimentation, sediment transport, suspended sediment

268. WEINER, J. G., R. V. ANDERSON, AND D. R. MCCONVILLE, EDITORS. 1984. Contaminants in the Upper Mississippi River. Proceedings of the fifteenth annual meeting of the Mississippi River Research Consortium. Butterworth Publishers, Boston. 368 pp.

Papers concerning the future of the Upper Mississippi River are presented. The ecological history of the river emphasizes the effects of channel improvement that began with rudimentary works in 1824. The degraded Illinois River is described as a possible fate of the Upper Mississippi River. Sedimentation studies show the origin and transport of sediments, and that many backwater lakes are likely to become marshes within 50 to 100 years. Analysis of trace substances in water, wildlife, plants, and sediments indicate that levels of several metals, including cadmium, mercury, and lead, are high in certain sections, namely Lake Pepin, Fountain City Bay, and other pools downstream of the Twin Cities region. Monthly water chemistry monitoring of 12 common parameters shows that most variations were related to river discharge rates.

Keywords: Channel, channelization, contaminants, discharge, erosion, lock and dam, measurement, Mississippi River, model, navigation, pool, river, sediment, sediment chemistry, sediment transport, water quality

269. WIBERG, P. L., AND J. D. SMITH. 1989. Model for calculating bed load transport of sediment. Journal of Hydraulic Engineering 115:101–123.

Predictions of bed load flux are made using a bed load transport model based on the mechanics of sediment moving by saltation. The model determines the parameters required for the calculation of bed load transport, including particle velocity, bed load sediment concentration, and the height of the bed load layer. It does this by computing the sequences of trajectories for individual saltating grains and by estimating the concentration of moving grains that a flow could support.

Keywords: Bed load, channel, channel flow, model, river, sediment, sediment transport

270. WINKLEY, B. R. 1973. Metamorphosis of a river—a comparison of the Mississippi River before and after cutoffs. Mississippi State University, Water Resources Research Institute Publication OWRR

A-999-MISS(9B). National Technical Information Service, Springfield, Virginia. Report PB-229648. 42 pp.

The efficiency of the Mississippi River to move sediment is less today than it was in 1950, and the river is possibly even less efficient than it was as a natural river. The geometry of the river has changed quickly in response to the numerous cutoffs resulting in a poorly aligned river that has lost flood efficiency, proper sediment transport, and possibly some navigation control. The long-term response of the river is important to consider. The author states that raising levees may only worsen the present trend.

Keywords: Channel, channelization, geomorphology, levee, Mississippi River, river, sediment, sedimentation, sediment transport

271. WINKLEY, B. R., AND L. G. ROBBINS. 1970. Geometric stability analysis of an alluvial river. Pages 75–102 *in* Proceedings of the Water Resources Conference. Mississippi State University, Water Resources Research Institute Publication OWRR A-999-MISS(6).

Geometric analysis of the Mississippi River indicates that there is an optimum depth at which any stream will scour and a specific spacing of bars and pools that is dependent on the discharge. In any channel improvement project the general alignment of the natural channel must be studied to determine the geometric relations that must be preserved. For an improved channel to operate properly, the bars must be locked into natural deposition areas, the widths must be controlled, and transitions must be smooth from pools to crossings and back to pools.

Keywords: Channel, channel geometry, channelization, discharge, erosion, geomorphology, Mississippi River, pool, river, scour, sediment, sediment transport

272. WRIGHT, H. E. 1985. History of the Mississippi River in Minnesota below St. Paul. *In* Pleistocene geology and evolution of the Upper Mississippi River Valley. U.S. Geological Survey, St. Paul, Minnesota. n.p.

The author provides a general overview of the origin and geology of the Upper Mississippi River landscape.

Keywords: Geology, Mississippi River, river

273. YANG, C. T., AND J. B. STALL. 1976. Applicability of unit stream power equation. Journal of the Hydraulics Division, American Society of Civil Engineers 102(Hydraulics Division 5, 12103):559–568.

The usefulness of a sediment transport equation in engineering depends on its ability to model natural rivers. Collected data from six river stations are used to compare the accuracy and applicability of different equations. It is observed that the dimensionless unit stream power equation provides the most accurate predictions of total sediment discharge in natural rivers under diversified flow and sediment condition. The limitations to which this dimensionless unit stream power equation can be applied are explained.

Keywords: Channel, channel flow, Mississippi River, model, river, sediment, sediment transport

274. ZHANG, H., AND R. KAHAWITA. 1991. Linear hyperbolic model for alluvial channels. Journal of Hydraulic Engineering 116:478–493.

With the assumption of quasi-steady flow, linear solutions for sediment transport and bed-form evolution are obtained using the St. Venant shallow-water equations. The equations may be used for alluvial channels of variable length. They are used in this study to predict aggradation in a channel caused by constant overloading.

Keywords: Channel, geomorphology, model, river, sediment, sedimentation, sediment transport

275. ZHAO, D. H., H. W. SHEN, AND G. Q. TABIOS III. 1994. Finite-volume two-dimensional unsteady-flow model for river basins. Journal of Hydraulic Engineering 120:863–883.

A two-dimensional unsteady-flow model for river basins is presented. It takes several factors into account, including the wetting and drying processes for floodplain and wetland studies, subcritical and supercritical flows, and dam-breaking phenomena involving discontinuous flows. The computations of tributary inflows and regulated flows through gates, weirs, culverts, and bridges are also discussed.

Keywords: Channel, channel flow, climate, drainage basin, floodplain, model, river

Keyword Index

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13. ABSTRACT (Maximum 200 words)

The Upper Mississippi River System (UMRS) has been dramatically altered by changing land use and management practices within its basin. One consequence of these changes is the severe environmental problem of increased sedimentation in river backwater areas. The Long Term Resource Monitoring Program is addressing this problem by expanding and initiating new research of sediment movement in the UMRS. As part of its new research, this annotated bibliography was generated to identify, review, and provide information about studies associated with sediment transport and deposition in large river environments. It contains 275 citations and abstracts for works that were published primarily between 1970 and early 1995. A list of 41 keywords is included to help differentiate between the various subjects associated with river sediment. A keyword index is also provided to assist readers in rapidly locating information about specific topics.

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The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System was authorized under the Water Resources Development Act of 1986 as an element of the Environmental Management Program. The mission of the LTRMP is to provide river managers with information for maintaining the Upper Mississippi River System as a sustainable large river ecosystem given its multiple-use character. The LTRMP is a cooperative effort by the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.