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Posters

POSTERS

Abstract for an exhibit at the Sixth Federal Interagency Sedimentation Conference

Center for Computational Hydroscience and Engineering
University of Mississippi
Carrier Hall, room 102
University, MS 38677

Advances in Computational Hydroscience and Engineering

The Center for Computation Hydroscience and Engineering, University of Mississippi, is to display their latest progress in computational hydraulics. Models for simulating free surface flows, soil erosion, sediment transport, and water quality, as well as pre-processing and post-processing tools for facilitating the operation and application of the models are being developed. These models after having been verified and validated shall be provided to the federal agencies working with DEC (Demonstration Erosion Control) Project.

Free Surface flow models range from 1D to 3D to simulate a wide spectrum of flow phenomena, from long term simulations of flow in channel networks to detailed 3D flow around structures.

Sediment transport modules coupled to the free surface models simulate upland erosion, aggradation and degradation of channels, channel bank stability/failure, channel migration/meandering, scouring around hydraulic structures, and the ecological impact of sediment.

Water quality modules coupled to the free surface models predict the fact of contaminants from point and nonpoint sources in streams and reservoirs to assess their ecological/environmental impact.

Pre-processing tools aid the user in inputting data, generating mesh systems for complex domains, and customizing the models for specific problems. Post-processing utilities monitor predicted quantities, display them in a variety of plot formats, and animate the results.

Applications of the above models/tools are demonstrated for: river reach morphology; effects of structures on flow and sediment yield in branched channel networks; scouring around spur dikes, bridge abutments and piers, eutrophication of lakes and streams; erosion and transport of nonpoint source pollutants in watersheds.

NONLINEAR DYNAMICS OF A SALTATING PARTICLE

By Allen T. Hjelmfelt, Jr., Research Hydraulic Engineer, USDA-Agricultural Research Service, Columbia, MO

__Abstract:__ The process of saltation is treated as a problem of nonlinear dynamics. The equations of motion for a particle moving by saltation in a two-dimensional system are solved numerically. Characteristics of the particle motion are related to the fluid motion through the shear-velocity. Increasing the shear-velocity while holding other parameters fixed shows that the particle experiences a very regular motion, bifurcation to regular but periodic motion, very irregular motion, and a return to regular motion. The results suggest that it is reasonable for some investigators to see saltation as movement by regular jumps along the bottom, whereas others see saltation mainly as rolling with occasional jumps.

INTRODUCTION

Sediment transport in the region near the bed of a stream has been termed "saltation"(Bagnold, 1973). There is disagreement concerning the nature of the movement. Abbot and Francis (1977), for example, summarized their photographic records of flume studies as: "...previous ideas on saltation have always assumed, from eye observation only, that a grain on impacting a bed immediately starts a new trajectory. The photographic evidence shows otherwise... ." Abbot and Francis would describe the process they saw as mainly rolling with occasional jumps. Nino et al. (1994), however, saw both rolling with occasional jumps and movement by regular jumps, with the mode depending mainly on the configuration of the bed at the point of collision.

Numerical simulations will be used to rectify these contrasting descriptions of the process. Tools of nonlinear dynamics will be applied to seek an explanation.

BASIC EQUATIONS

In this numerical simulation, the motion is simplified to two dimensions (see Fig. 1). In physical experiments Francis (1973) achieved two-dimensional motion in a flume by using a bed of glass cylinders whereas Gordon et al. (1972) used a flume only slightly wider than the sphere diameter. Additional simplifications include neglect bed-particle interaction close to the bed and assuming that the fluid velocity distribution is unaffected by the saltating particle.

The forces that influence the trajectory of a saltating particle include particle weight, buoyant force, added mass, hydrodynamic drag, and shear lift. Newton's second law can be expressed:

$$\left[\frac{\rho_p}{\rho_f} + \frac{1}{2}\right]\frac{du}{dt} = \frac{3}{4}\, C_d\, \frac{(U-u)}{d}\sqrt{(U-u)^2 + v^2} \tag{1}$$

$$\left[\frac{\rho_p}{\rho_f} + \frac{1}{2}\right]\frac{dv}{dt} = \left[\frac{\rho_p}{\rho_f} - 1\right]g - \frac{3}{4}\,C_d\,\frac{v}{d}\,\sqrt{(U-u)^2 + v^2} \qquad (2)$$

in which d = particle diameter, ρ_p = particle density, ρ_f = fluid density, g = acceleration of gravity, V_P = particle velocity vector which has the x- and y-components u and v, C_d = drag coefficient, and U = fluid velocity. The flow was described using the logarithmic velocity distribution, and the drag coefficient for the particle was expressed by an equation due to Olson (1961) which is quite accurate for Reynolds numbers up to 100. The particle trajectory was determined using a predictor-corrector method with a variable time step. Impact of the particle with the bed was described through the coefficient of restitution, and the impact and rebound were assumed to take place without sliding. The coefficient of restitution was taken to be 0.7. The particle diameter was set at 0.2 cm and the kinematic viscosity of the fluid at 0.01 cm sec^{-1}.

RESULTS

An example of the general response pattern for the saltating particle is shown in Fig. 2. The horizontal axis is the shear-velocity. The vertical axis is the angular location on the bed element at which impact occurs (see Fig. 1). The computation process was:

a) motion was initiated by inserting a particle into the flowing stream,

b) the particle trajectory was traced through two thousand impacts with the bed to escape start-up transients,

c) the trajectory was traced for an additional 150 impacts, and the angular location of the impacts plotted as shown on Fig. 2.

d) the shear-velocity was incremented, and the process repeated.

If the saltating particle strikes the bed at the same angular location in each of the last 150 impacts, all of the plotted points are coincident. If, however, the angular position changes, several points are plotted along a vertical line.

These intervals of regular motion begin with saltation in which jumps cover the same distance and with impact at the same relative location. Increasing the velocity, however, leads to a bifurcation after which the jumps alternate between two lengths that are nearly the same and impacts alternate between two slightly different angular locations on the bed particles. Further increases in shear-velocity lead to additional bifurcations. Note the similarity between Fig. 2 and the frequently displayed diagrams of orbital maps used to display the nonlinear dynamics of the logistic equation.

Poincare diagrams (not shown here) were used to show the motion in more detail. The particle velocity was plotted as the vertical coordinate and the vertical displacement as the horizontal coordinate. The diagram for the shear-velocity of 3.80 cm/sec represents a condition in the massive grey block of Fig. 2. The points tend to stretch, fold back upon themselves, and finally coalesce into a tighter mass before impact. Stretching and folding are characteristics of chaotic motion.

CONCLUSIONS

The two dimensional motion of a particle moving by saltation over a bed of identical particles has been investigated as a problem in nonlinear dynamics using numerical simulation. An iteration map was developed which showed the motion consists of regions both of regular continuous motion and of less regular motion. The confused region is characteristic of chaotic motion. This simulation demonstrates that regular jumps along the bottom and rolling with occasional jumps are both parts of the process called saltation.

REFERENCES

Abbot, J.E., Francis, J.R.D., 1977, Saltating and suspended trajectories of solid grains in a water stream. *Philos. Trans. R. Soc London;* Ser. A, v284, pp 225-254

Bagnold, R.A., 1973, The nature of saltation and of "bed-load" transport in water. *Proc. R. Soc. London.* Ser. A. v332, pp 473-504.

Francis, J.R.D., 1973, Experiments on motion of solitary grains along the bed of water streams. *Proc. R. Soc. London.* Ser. A, v332, pp 443-471.

Gordon, R., Carmichael, J.B., Isackson, F.J., 1972, Saltation of plastic balls in a 'one-dimensional' flume. *Water Resources Research,* v8, n2, pp 444-459.

Nino, Y., Garcia, M., Ayala, L., 1994, Gravel saltation, 1. Experiments. *Water Resources Research,* v30, n6, pp1907-1914.

Olson, R. M., 1961, *Essentials of Engineering Fluid Mechanics.* International Textbook Co., Scranton, Pennsylvania, 404p.

Reizes, J.A., 1978, Numerical study of continuous saltation. *J. Hyd. Div.* Am. Soc. Civil Engrs., v104, nHY9, pp1305-1321.

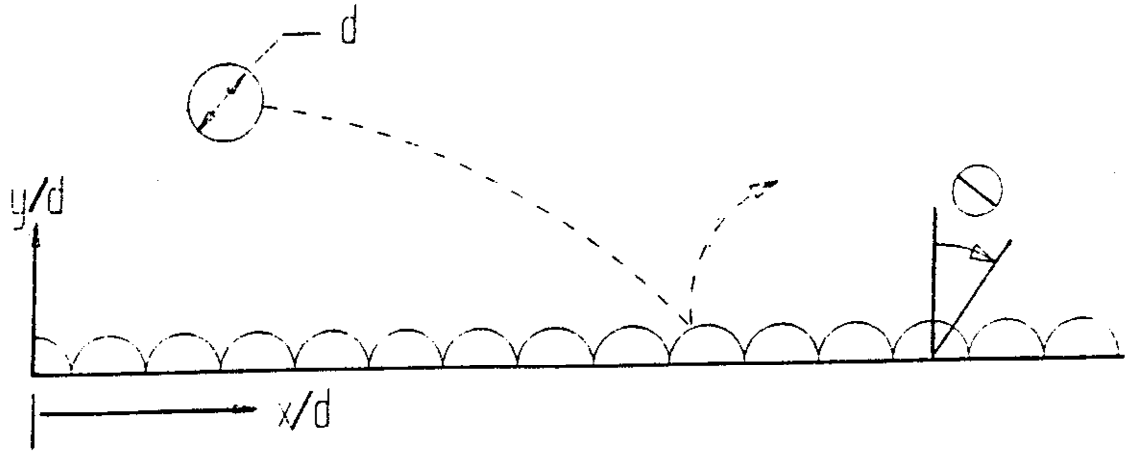


Fig. 1- Schematic of the idealized saltation problem.

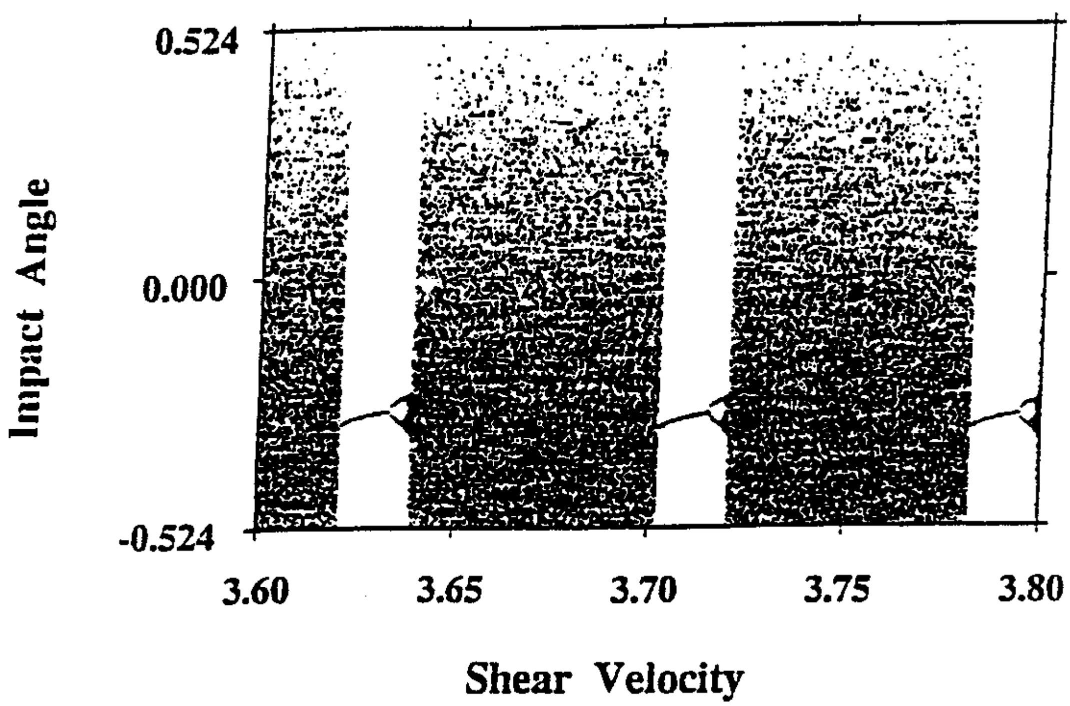


Fig. 2- Orbital map for shear velocities ranging between 3.60 and 3.80 cm/sec.

SEASONAL VARIATION OF SUSPENDED-SEDIMENT TRANSPORT IN THE LOWER VIRGIN RIVER, ARIZONA AND NEVADA

By Marsha M. Hilmes, Hydrologist, U.S. Geological Survey, Las Vegas, Nev.

Abstract: Data collected during the 1993 water year at Virgin River at Littlefield, Ariz., were compared with the 20-year historical record for seasonal variations of suspended-sediment transport. In 1993, sediment-transport values were similar to the historical record—the highest instantaneous and daily sediment loads occurred during the winter and the highest instantaneous and daily sediment concentrations occurred during the summer. Winter storms of 1993 produced record-high monthly loads, whereas summer storms did not produce extremely high monthly loads in comparison to the historical sediment record.

INTRODUCTION

The U.S. Geological Survey, in cooperation with the Southern Nevada Water Authority (SNWA), is conducting a 5-year (1993-97) sediment-transport study on the lower Virgin River. Daily sediment sites have been established at Littlefield, Ariz., and Riverside, Nev., and a miscellaneous measurement site has been established near Riverside above Halfway Wash, Nev. Standard USGS methods are used for data collection, laboratory analyses, and record computation. Historical daily sediment data are available for Littlefield, Ariz.

The SNWA has been granted by the Nevada State Engineer an annual appropriation not to exceed 234 million m^3 of water from the lower Virgin River. An accurate understanding of the sediment transport processes acting on the Virgin River will be required for this water-resource project. Information about the amount of sediment being transported and the amount of water available for diversion will be important for the design of the dams and reservoirs that are planned for this project. A current estimate of sediment transport and amount of available water is needed because sediment sources may have changed since the historical daily sediment data were collected, primarily due to the flood caused by the Quail Creek Dam failure in 1989. The 1989 dam-failure flood (1,730 m^3/s) was estimated as a 1,200-year flood based on the Littlefield gaged record alone or as a 250-year flood when paleoflood records are incorporated into the flood-frequency analysis (Enzel and others, 1994, p. 312). The objective of this sampling program is to quantify current sediment-transport for the SNWA.

STUDY AREA

The Virgin River begins above Zion National Park, Utah, at an altitude of 2,621 m above sea level. The lower Virgin River is considered to begin where the river exits the Virgin River Gorge in Mohave County, Ariz., at an altitude of 560 m. After exiting the gorge, the Virgin River flows westward and then southward through Mohave County, Ariz., and Clark County, Nev., before entering Lake Mead, Nev. The Virgin River Valley, 0.3-1 km wide, is entrenched in Quaternary terrace deposits; the highest is 85 m above the modern channel. At Littlefield, Ariz., the mean annual air temperature is 18°C and the mean annual rainfall is 16 cm (National Climatic Data Center, 1992). The drainage area above the Littlefield gaging station is 13,183 km^2.

1993 SEASONAL VARIATIONS IN SUSPENDED-SEDIMENT TRANSPORT, LITTLEFIELD, ARIZ.

Total suspended-sediment load for 1993 was 4,390,000 metric tons. There were nine storms during 1993; six storms occurred during the winter, two during the summer, and one during the fall. Sediment data from February and August 1993 illustrate the seasonal variations in suspended-sediment transport in the lower Virgin River. The sediment hydrograph for February (fig. 1) shows two large winter storms. The largest of these storms had peak water discharge of 348 m^3/s on February 20, 1993. These high discharges were caused by runoff from rain on snow in southern Utah. The February 20, 1993, storm produced the maximum instantaneous load (1,700,000 metric t/d) and daily load (655,000 metric t/d) for 1993. These high loads were due to the high water discharges and not extremely high suspended-sediment concentrations. For this storm, peak suspended-sediment concentration was estimated at 62,000 mg/L and peak daily concentration was 30,200 mg/L. Winter storm samples define the upper end of the trend of graphs that show the relation of sediment concentration to water discharge and daily load to water discharge.

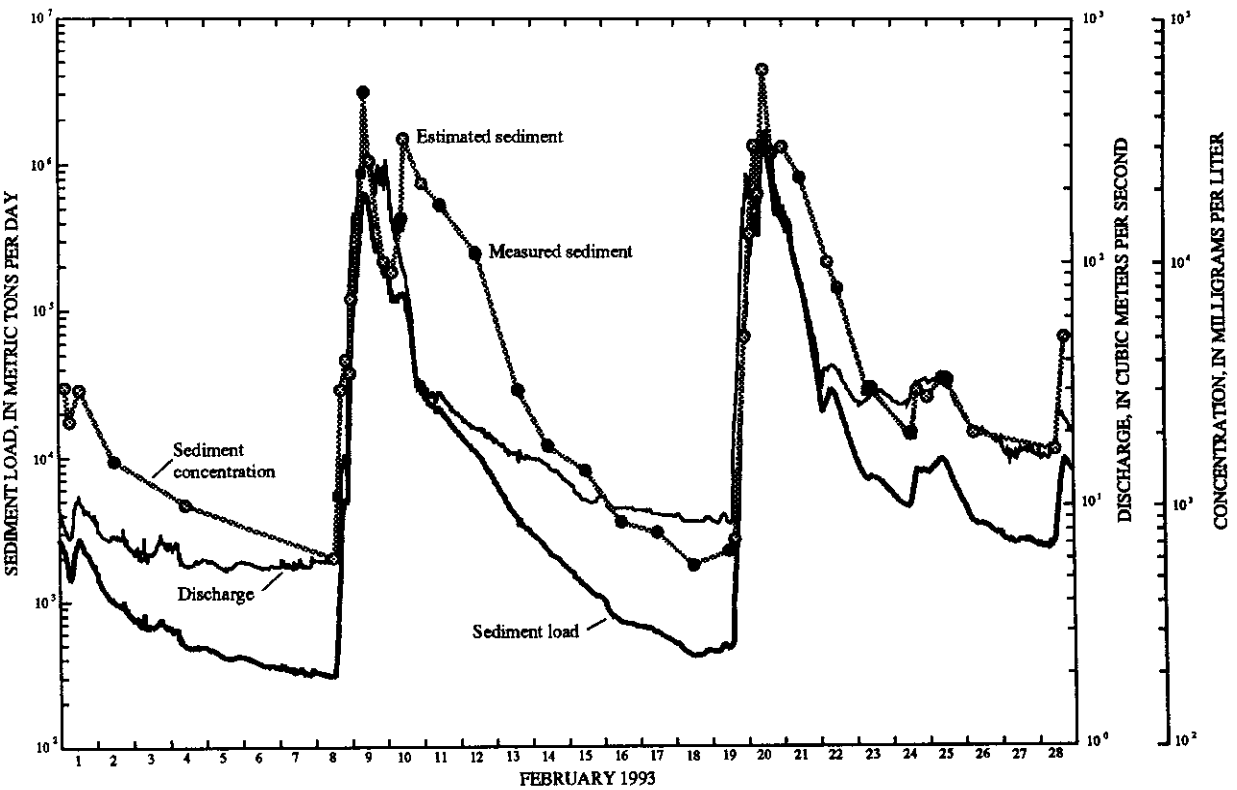


Figure 1. Suspended-sediment data for Littlefield, Ariz., for February 1993 including water discharge, suspended-sediment concentration, and suspended-sediment load.

The sediment hydrograph for August (fig. 2) shows several storms, with the highest peak water discharge of 35 m^3/s on August 26, 1993. These high summer water discharges were produced by thunderstorms in southern Utah. The maximum instantaneous concentration (70,600 mg/L) for the year was on August 26, 1993, and the maximum daily concentration (36,200 mg/L) was on

August 30, 1993. The peak instantaneous load for August 26, 1993, was 213,000 metric t/d and the daily load was 40,900 metric t/d. The peak instantaneous load for August 30, 1993, was 205,000 metric t/d and the daily load was 58,300 metric t/d. Points for summer storm samples plot above the general trend of graphs that show the relations of suspended-sediment concentration to water discharge and daily load to water discharge. This is due to the high sediment concentrations associated with relatively low water discharges.

The shapes of the sediment-concentration curves are different for the February and August storms, although water discharge and sediment concentration appear to peak simultaneously in both seasons (figs. 1 and 2). Peaks are sharp in the summer and generally broad in the winter. As a result of these seasonal sediment-transport characteristics, peak sediment concentrations are higher in summer, but daily loads are often higher during the winter. Preliminary analyses at the Riverside, Nev., site indicate that water discharge and sediment concentration decrease downstream during winter and summer storms; therefore, sediment loads also decrease downstream.

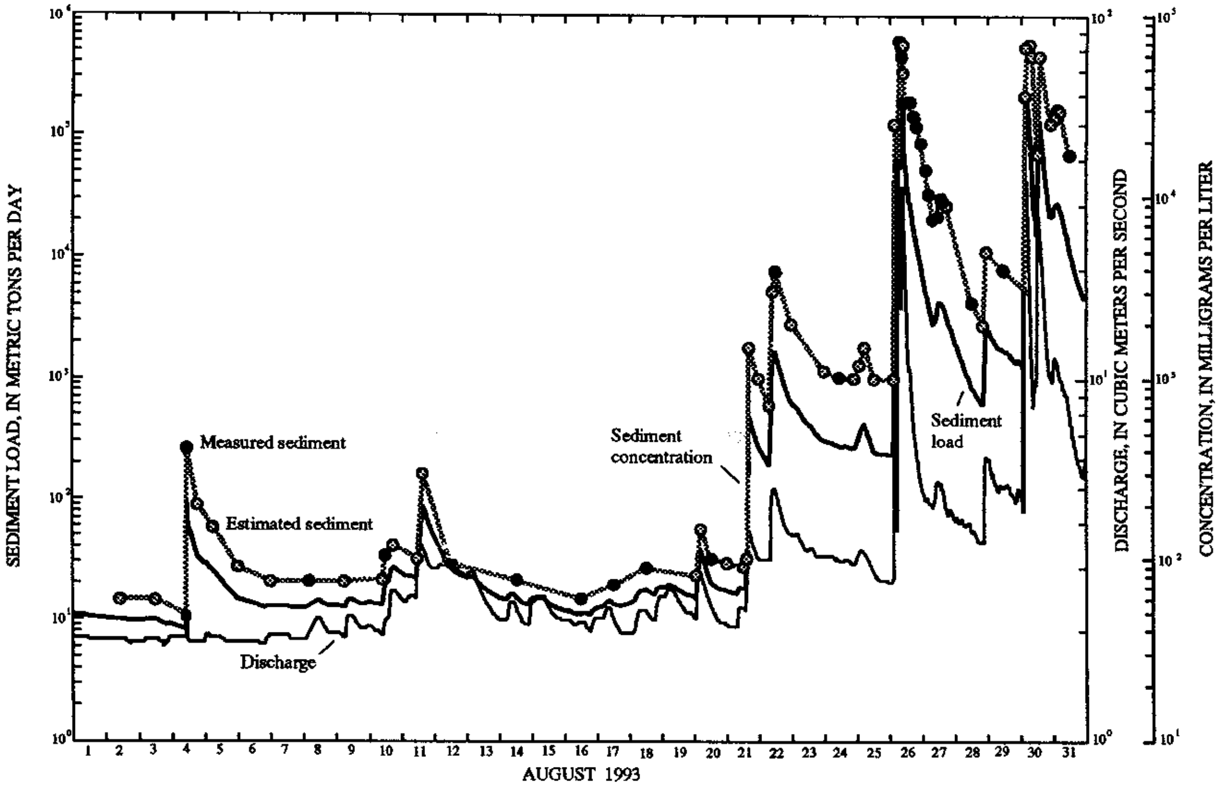


Figure 2. Suspended-sediment data for Littlefield, Ariz., for August 1993 including water discharge, suspended-sediment concentration, and suspended-sediment load.

COMPARISON OF 1993 SEDIMENT RECORD WITH HISTORICAL RECORD, LITTLEFIELD, ARIZ.

The historical sediment record at Littlefield, Ariz., consists of daily sediment data for 1947-68 (table 1) and periodic sediment data for 1977-79 and 1986-92. The annual mean water discharge for the 1993 water year was the third largest in 64 years (1929-93); however, 1993 was only ranked 9th for peak discharge. The largest peak discharge on record was from the 1989 Quail Creek Dam flood. For the period of record, 1993 ranks in the top 4 years for total suspended-sediment load, peak instantaneous load, and peak daily load. In contrast, 1993 was not ranked in the top 10 years for peak instantaneous concentration or peak daily concentration. The highest total suspended-sediment load on record was 6,360,000 metric t in 1955. The highest instantaneous load on record was 2,710,000 metric t/d; the highest daily load was 1,630,000 metric t/d, both during the winter of 1967. The highest instantaneous concentration on record was 245,000 mg/L and the highest daily concentration was 203,000 mg/L; both during the summer of 1964. Although not measured, sediment loads for the 1989 Quail Creek Dam flood were considered to be high on the basis of visible erosion and deposition (Carlson and Meyer, 1995). Comparison of 1993 sediment data with the historical record indicates that the 1989 flood did not deplete or increase the amount of sediment available for transport in 1993, nor was there much effect on channel stability compared to the effects of moderately high flows of longer duration.

Peak instantaneous and daily concentrations are usually during either the summer or fall (94.4% of the time for instantaneous concentration and 100% of the time for daily concentration). However, for instantaneous and daily loads, the peak often occurs during the winter (22.2% of the time for instantaneous load and 23.8% of the time for daily load), with the highest instantaneous and daily loads of record having occurred during the winter. Data collected during 1993 follow similar seasonal variations with the highest instantaneous and daily concentrations during the summer and the highest instantaneous and daily loads during the winter.

Monthly sediment load for 1948-68 and the relation to the 1993 record is shown in figure 3. Loads for January and February 1993 were the highest on record and statistically were considered high outliers, a result of the winter storms during 1993. Loads for March, April, and May 1993 also were considered high outliers and were the result of high snowmelt runoff from the upper part of the basin. Monthly loads for October, November, June, and September 1993 were higher than the medians for the historical record, but were not outliers. Loads for December and July 1993 were considered low outliers and the lowest loads on record for those months. The load for August 1993 was below the monthly median for the historical record, but was not an outlier. These high and low outliers show the degree of seasonal variability associated with the 1993 water year. Winter storms of 1993 produced record-high monthly loads, whereas summer storms did not produce extremely high monthly loads in comparison to the historical sediment record.

REFERENCES

Carlson, D.D., and Meyer, D.F., 1995, Flood on the Virgin River, January 1989, in Utah, Arizona, and Nevada: U.S. Geological Survey Water-Resources Investigation Report 94-4159, 21 p.

Enzel, Y., Ely, L.L., Martinez-Goytre, J., and Vivian, R.G., 1994, Paleofloods and a Dam-Failure Flood on the Virgin River, Utah and Arizona: Journal of Hydrology, v. 153, p. 291-315.

National Climatic Data Center, 1992, Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1961-90: National Oceanic and Atmospheric Administration, Climatography of the United States, no. 81, 21 p.

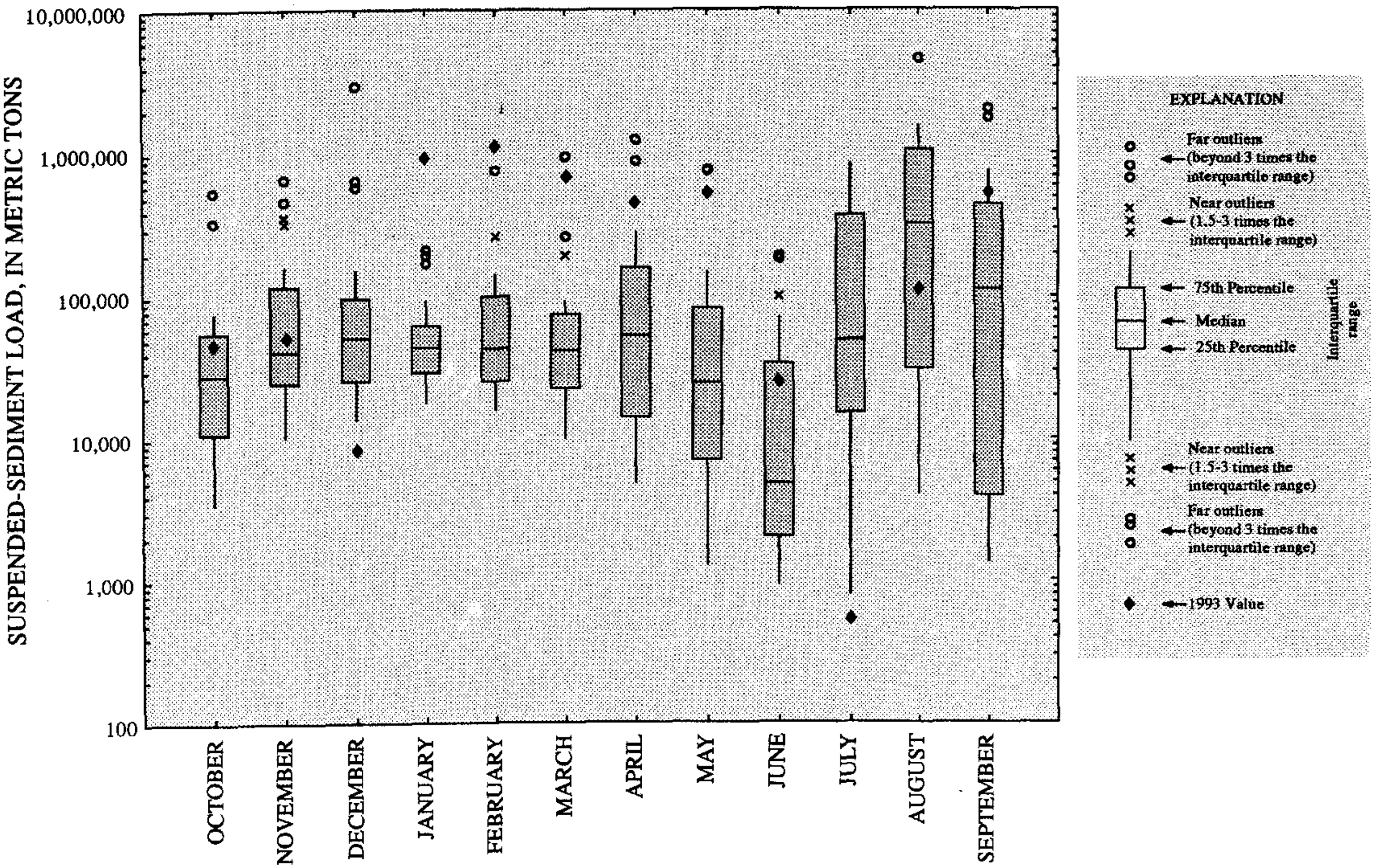


Figure 3. Monthly suspended-sediment load at Littlefield, Ariz., for 1948-68 and the relation to the 1993 record.

Table 1. Daily sediment record for Littlefield, Ariz. Data collected 1947-68 and 1992-93.[1]

Water year	Mean discharge (cubic meters per second)	Peak discharge (cubic meters per second)	Date	Total suspended-sediment load (metric tons)	Peak instantaneous suspended-sediment concentration (milligrams per liter)	Date	Peak daily suspended-sediment concentration (milligrams per liter)	Date	Peak instantaneous suspended-sediment load (metric tons per day)	Date	Peak daily suspended-sediment load (metric tons per day)	Date
1948	4.5	31	09/16/48	592,000	---	---	---	---	---	---	41,300	09/17/48
1949	6.1	65	09/10/49	1,190,000	---	---	79,100	09/10/49	---	---	154,000	09/10/49
1950	5.0	98	07/18/50	1,530,000	---	---	89,700	07/18/50	---	---	391,000	07/18/50
1951	3.9	340	08/04/51	1,780,000	182,000	07/22/51	74,300	08/03/51	1,690,000	08/14/51	641,000	08/04/51
1952	11	203	12/30/51	3,320,000	49,900	12/30/51	57,800	09/22/52	611,000	12/30/51	435,000	12/30/51
1953	3.9	155	08/27/53	1,720,000	118,000	08/27/53	111,000	08/28/53	502,000	08/27/53	350,000	08/27/53
1954	5.3	170	08/04/54	2,420,000	131,000	09/12/54	82,100	09/12/54	1,270,000	09/12/54	446,000	08/04/54
1955	5.3	561	08/25/55	6,360,000	197,000	07/24/55	165,000	10/09/54	1,280,000	07/25/55	1,580,000	08/25/55
1956	3.6	70	01/27/56	789,000	174,000	07/27/56	62,000	07/15/56	478,000	06/30/56	123,000	01/27/56
1957	3.9	112	08/21/57	1,079,000	114,000	08/21/57	90,300	08/21/57	771,000	08/21/57	252,000	08/21/57
1958	11	203	03/17/58	5,820,000	114,000	07/24/58	73,900	09/08/58	1,340,000	09/12/58	487,000	09/12/58
1959	3.6	99	08/19/59	1,330,000	138,000	08/12/59	92,300	08/20/59	977,000	08/12/59	418,000	08/19/59
1960	3.3	66	11/03/59	713,000	86,800	09/02/60	64,800	11/03/59	1,480,000	09/02/60	247,000	11/03/59
1961	4.3	309	09/18/61	4,530,000	163,000	08/12/61	140,000	09/09/61	2,010,000	09/18/61	1,230,000	09/18/61
1962	5.6	152	02/12/62	1,520,000	127,000	09/28/62	59,800	09/28/62	1,110,000	09/28/62	285,000	09/28/62
1963	3.3	134	09/14/63	1,570,000	125,000	08/19/63	60,300	09/19/63	579,000	09/14/63	318,000	09/14/63
1964	3.5	178	08/14/64	2,050,000	245,000	08/14/64	203,000	08/13/64	1,720,000	08/14/63	527,000	08/14/64
1965	4.7	114	09/06/65	---	---	---	---	---	---	---	---	---
1966	5.0	155	12/03/65	1,640,000	66,900	08/21/86	89,000	07/30/66	780,000	11/23/65	372,000	12/30/65
1967	7.3	997	12/06/66	4,080,000	77,300	09/07/67	62,400	09/23/67	2,710,000	12/07/66	1,630,000	12/07/66
1968	5.0	62	08/08/68	1,210,000	119,000	08/08/68	64,000	08/08/68	464,000	08/08/68	182,000	08/08/68
1993	17	348	02/20/93	4,390,000	70,600	08/26/93	36,200	08/30/93	1,700,000	02/20/93	655,000	02/20/93

[1] All values converted to metric and then rounded.

DEMONSTRATION EROSION CONTROL PROJECT
YAZOO RIVER BASIN MISSISSIPPI

By Franklin E. Hudson, Project Manager, U.S. Army Engineer District, Vicksburg, Mississippi

__Abstract:__ The Demonstration Erosion Control Project is a multi-agency effort to provide solutions to problems of erosion, sediment, and flooding in fifteen watersheds in the foothills of the Yazoo River Basin in Mississippi. Systematic assessments of the watersheds are prepared while considering system dynamics and morphological aspects of each watershed. Solution techniques are developed using a systematic approach for channel and watershed rehabilitation.

INTRODUCTION

The Demonstration Erosion Control Project was initially approved in Fiscal Year 1984 and funded in Fiscal Year 1985. Work has been accomplished in each fiscal year since that time including construction, monitoring, and evaluation of construction work.

__Project Goals:__ Project goals include:

Erosion Control
Stream Stabilization
Sediment Management
Erosion Control
Environmental Enhancement
Upland Soil Conservation
Technology Transfer

__Problems:__

Channel Bed Erosion: Channel bed erosion increases sediment level, reduces bank stability and causes damage to infrastructure.

Channel Bank Erosion: Erosion of channel banks increases the sediment level, causes loss of production land and property, and causes damage to infrastructure.

Upland/Bank Erosion: Sedimentation in streams serves to reduce flood carrying capacity of the stream thereby inducing urban and agricultural flooding. Deposition of sediments on cropland and woodland can cause damage to the productive capacity of these lands.

__Solutions Considered:__

Grade Control Structures: Grade control structure of several sizes have been constructed. These include drop pipes, low-drop grade control, and high-drop grade control structures. These structures stabilize the channel grade, increase bank stability, and provide for a more stable stream ecosystem.

Bank Stabilization: Several various types of bank stabilization have been used. These include dikes, and bank paving. These structures stabilize banks and protect adjacent lands as well as reducing the sediment load and providing a more stable stream ecosystem.

Land Treatment: Various types of land treatment protect productive soil and reduce the sediment load in watershed streams.

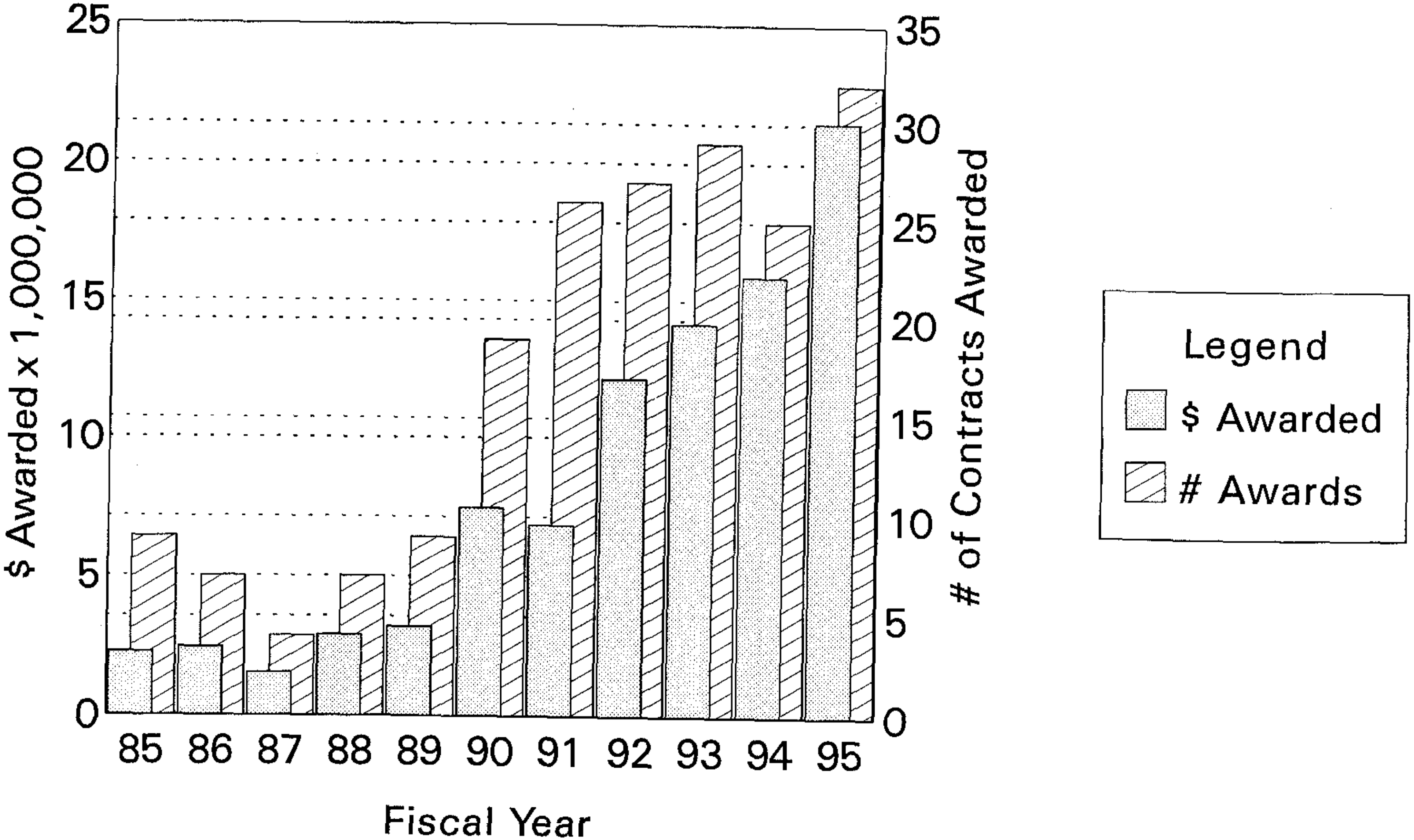
Sedimentation and Flood Control: Structures to reduce sedimentation and provide for flood control storage, increase the project life of major flood control projects downstream from the watershed, produce local flood protection, and environmental and recreational benefits.

Results:

Construction performed through fiscal year 1995 is summarized in the attached table. Early years construction consisted primary of bank stabilization and some grade control. Construction since fiscal year 1990 has been more comprehensive with permanent grade control, bank stabilization, and some flood control structures each year. Monitoring of the work performed in this project has been accomplished each year by the Agricultural Research Service, Waterways Experiment Station, Vicksburg Engineer District and the Natural Resource Conservation Service.

Demonstration Erosion Control

Contracts Awarded



APPLICATION AND LIMITATIONS OF DENDROGEOMORPHIC METHOD TO ESTIMATE SEDIMENTATION RATE IN THE KANKAKEE RIVER FLOOD PLAIN IN ILLINOIS

By Gary P. Johnson, Civil Engineer/Hydrologist, U.S. Geological Survey, Water Resources Division, Urbana, IL

Abstract: Changes in sedimentation rates were estimated on the basis of root-burial depth and tree-age data at six selected data-collection sites in the Kankakee River flood plain near Momence, Illinois. Five sites were in backwater areas away from the river channel, and one site was on a natural levee near the channel.

A summary of dendrogeomorphic data collected at the six sites indicates that sedimentation rates increased in more recent decades. Increased sedimentation rates after 1950 were observed at all five backwater sites. An increased sedimentation rate after 1950 was also observed at the levee site, which appeared to have been affected by erosion from a flood in 1950. Some discussion of limitations of the dendrogeomorphic method in the Kankakee River flood plain is also presented.

INTRODUCTION

The Kankakee River originates near South Bend, Ind., and joins the Des Plaines River southwest of Chicago near Wilmington, Ill., to form the Illinois River (fig. 1). The Kankakee River drains 5,150 square miles in Illinois and Indiana.

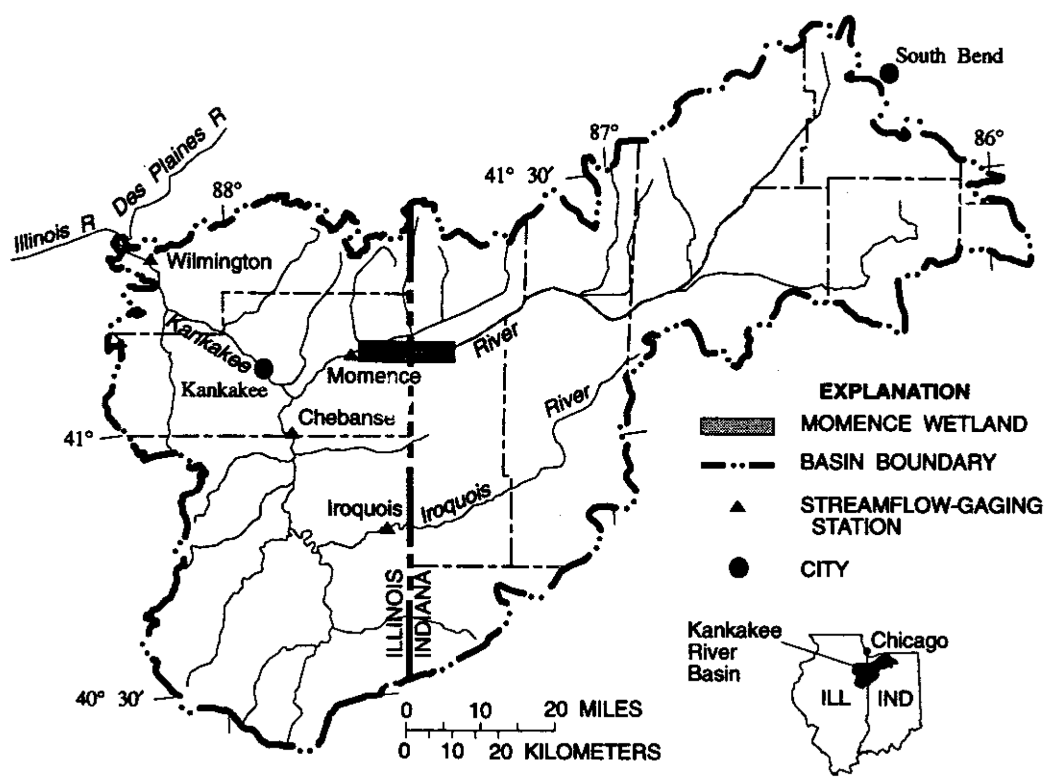


Figure 1. The Kankakee River Basin and Momence Wetland in Illinois and Indiana and the locations of streamflow-gaging stations.

From the time of settlement, the non-riparian corridor has been intensively farmed. Parts of the river in Indiana were being channelized by about 1860 to drain marshy areas and reduce the extent and frequency of flooding. By 1918, the entire main stem of the river in Indiana had been completely channelized (U.S. House of Representatives, 1916 and 1931). The main stem of the river was not channelized between the Illinois-Indiana State line and

Momence, and this area continues to flood frequently and a high water table is present. These conditions made agriculture in the area impractical. The area has remained a forested wetland and is known locally as the Momence Wetland (fig. 1).

Sedimentation of the Kankakee River in Illinois has been a major concern for many years. Local residents are concerned that sedimentation limits recreational, ecological, and aesthetic usefulness of the river and contend that sand is being moved and deposited at faster than pre-channelization rates in the channel. In 1992, the U.S. Geological Survey (USGS), in cooperation with the Kankakee Soil and Water Conservation District, began a study utilizing dendrogeomorphic techniques to investigate changes of sedimentation rates over time on the flood plain in the Momence Wetland (fig. 1).

The Momence Wetland between the State line and Momence, Ill., is largely an undisturbed forested area. The area is frequently inundated by the Kankakee River and, therefore, subject to sediment deposition. For this reason, the area was chosen as the initial site for the dendrogeomorphic study. The Momence Wetland is dominated by silver maple (Acer saccharinum L.). Many old cutoff meanders are distinguishing features of the landscape. The meanders contain standing water, the surface elevation of which appears to be affected by the elevation of the water in the nearby river channel. In moist areas surrounding the meanders, green ash (Fraxinus pennsylvanica Marsh.) are very common. Oaks are found with silver maples in areas at slightly higher elevations that are less frequently flooded than the areas adjacent to meanders. The oaks include swamp white oak (Quercus bicolor Willd.), bur oak (Q. macrocarpa Michx.) and pin oak (Q. palustris Muenchh.). Better drained sandy areas, such as natural levees along the channel, have elm (Ulmus americana L.) as the predominant species intermixed with the ubiquitous silver maple.

DENDROGEOMORPHIC THEORY

Sigafoos (1964) demonstrated that sedimentation rates on flood plains could be determined by excavating root systems of trees and by taking increment cores from trees for age determination in flood plains. The burial depth of the original lateral roots of a tree is an estimate of the amount of sediment deposited, and the age of the tree estimates the length of time during which the sediment accreted (fig. 2). By examining a number of trees of various ages, the relation between net sedimentation depth and time can be determined.

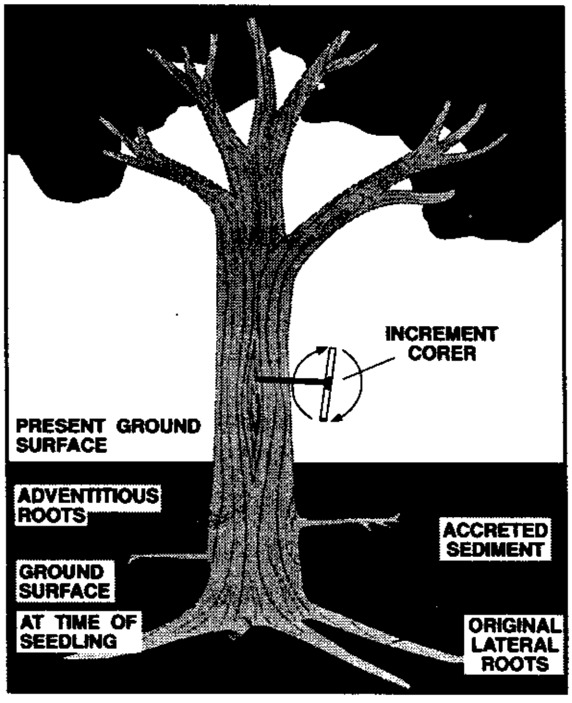


Figure 2. A tree in a flood plain and increment corer

Net sediment deposition is the distance from the present soil surface to the level of the original lateral roots. Tree age is estimated by counting annual growth rings from an increment core of a tree, and estimating the number of rings at the center that were missed by the core sample (Phipps, 1985).

APPLICATION OF DENDROGEOMORPHIC METHOD

The youngest trees were found at Site 1, located on a natural sand levee at an inside bend of the Kankakee River. Site 1 contained mostly elm and maple trees. The net sedimentation rate for the pre-1950 period at Site 1 (0.34 cm/yr) is about 3 times smaller than for the post-1950 period (0.93 cm/yr) (table 1). Active erosional features on the levee at Site 1 indicate the possibility that erosion might have altered depths of sediment deposits. The relation of depth of sediment to tree age at Site 1 underwent a distinct shift about 35 to 40 years ago as shown in figure 3. A linear best-of-fit line was determined to describe the relation of depth of sediment to tree age for periods before and after the distinct shift in this relation. A flood in 1950 seems to have removed 20 cm or more of sediment from Site 1. Streamflow records indicate a maximum discharge for the period-of-record on April 25, 1950, at the streamflow-gaging station at the Kankakee River at Momence (U.S. Geological Survey, 1964, p. 450), which could have removed sediment from Site 1.

The remainder of the sites were near backwater cutoff meanders, and contained mostly ash and maple trees. The data collected at Sites 2, 3, 4, and 6 all showed an increase in net sedimentation rates from before 1950 to after 1950. The increase in net sedimentation rate at Site 5 was not such a marked increase as at the other sites (table 1).

LIMITATIONS OF DENDROGEOMORPHIC METHOD

Theoretically, the dendrogeomorphic method is a very valuable tool. In ideal situations, it can be applied in reconstructing sedimentation rates in flood plains where otherwise very little or no historical sedimentation data is available. Unfortunately, the Kankakee River flood plain did not offer an ideal situation. Data collection and analysis were often limited by several factors. Adventitious roots were sometimes hard to distinguish from the original lateral roots (fig. 2). Some of the sediment depth data were suspect due to erosional features around some of the sites. Soil compaction did not seem to be a factor at any of the sites, but highly compactible sediment and large amounts of organic debris could certainly have biased measured sediment depths. Finally, digging multiple 1- to 2- meter-deep holes, often in muddy soil, and measuring sediment depths to the nearest centimeter, all while swatting mosquitoes, was very tiresome and challenging to the field crew.

Table 1. Summary of net sedimentation rates at data-collection sites near Momence, Ill.
[D/A, sediment depth divided by tree age (in centimeters per year); Average D/A, average of D/A of every tree at that site; Ages, range of tree ages at the site]

	Pre-1950			Post-1950		
Site	Ages	Number of trees	Average D/A	Ages	Number of trees	Average D/A
1	54–69	4	0.34	9–40	19	0.93
2	44–47	3	.42	28–40	4	.54
3	49–60	4	.50	34–40	2	.65
4	50–76	11	.59	32–43	5	.82
5	54–78	8	.80	32–42	5	.82
6	49–99	12	.64	25–29	2	.93
Average of all D/A			0.59			0.75

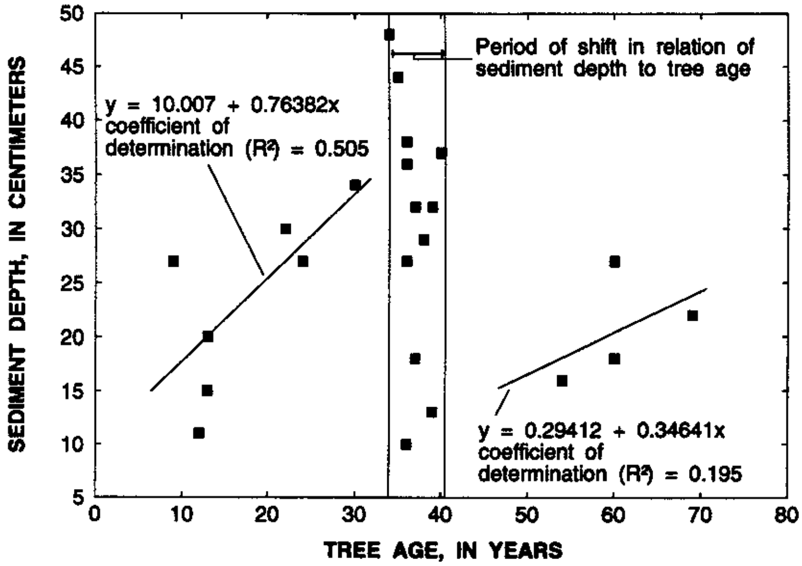


Figure 3. Relation of sediment depth to tree age, Site 1 near Momence, Ill.

REFERENCES

Phipps, R. L., 1985. Collecting, preparing, crossdating and measuring tree increment cores. U.S. Geological Survey Water-Resources Investigations Report 85–4148, 48 p.

Sigafoos, R. S., 1964. Botanical evidence of floods and flood-plain deposition. U.S. Geological Survey Professional Paper 485–A, p. A1–A35.

U.S. Geological Survey, 1964. Compilation of records of surface waters of the United States, October 1950–September 1960. U.S. Geological Survey Water-Supply Paper 1728, 576 p.

U.S. House of Representatives, 1916. Kankakee River, Illinois and Indiana. Letter from the Secretary of War, 64th Congress, First Session, Document 931.

———1931. Kankakee River, Illinois and Indiana. Letter from the Secretary of War, 71st Congress, Third Session, Document 784.

This extended abstract is a condensed version of U.S. Geological Survey, Water-Resources Investigations Report 94–4190, "Dendrogeomorphic estimate of changes in sedimentation rate along the Kankakee River near Momence, Illinois," by Richard L. Phipps, Gary P. Johnson, and Paul J. Terrio.

VERTEBRATE UTILIZATION OF HABITATS CREATED BY INSTALLATION OF DROP PIPES

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INTRODUCTION

In the past century available natural habitat for vertebrates has declined worldwide. Wetlands are a prime example; they provide important habitat that is utilized by a wide variety of vertebrate species. From the 1950's to the 1970's, America's wetlands declined at a rate of 458,000 acres per year. Draining and clearing for agriculture eliminated approximately 80% of inland wetlands; much of these losses occurred in the Mississippi Delta and Southeastern regions of the United States (The Conservation Foundation).

Gully erosion occurs when flow is concentrated and velocity is sufficient to dislodge and transport soil particles (Uhland and Wooley 1929; Ramser 1932). It is a world wide phenomenon that results in loss of agricultural land, property, and hence millions of dollars (Okagbue and Ezechi 1988). More than 200 million gullies were actively eroding in the United States in 1939, and since then more gully erosion has occurred (Beer and Johnson 1965).

Installation of field-scale grade control structures, or drop pipes, is the most common method employed to control head-cutting gully erosion in the Demonstration Erosion Control (DEC) Project in the Yazoo Basin. As of 1990, 2,369 drop pipes were planned for installation or constructed as part of this project (Shields unpublished data). A preliminary survey of habitats created by drop pipe installation demonstrated that a variety of terrestrial and wetland habitats were being created and are becoming available for use by local vertebrates. This paper presents preliminary results of the first extensive survey of vertebrates utilizing these habitats.

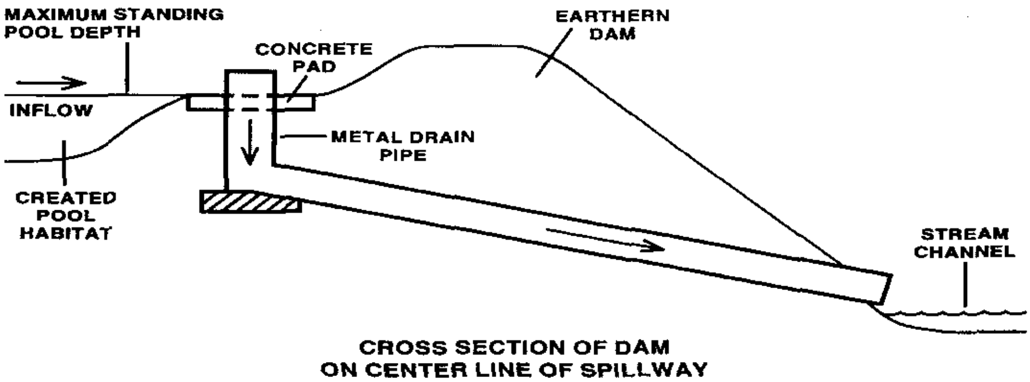
METHODS

Habitat classification: The drop pipe structure configuration consists of a dam installed at the mouth of a gully. Runoff water from field level is transferred to stream level through a sloping metal drain pipe which passes through the dam (Figure 1). The installation of drop pipes to control gully erosion in the United States was reported as early as 1929 (Uhland and Wooley 1929) and is used internationally (Gray and Crothers 1989). The shape of the gully side collection basin at the pipe inlet allows small terrestrial and wetland habitats to develop with associated shallow pools that may be permanent or ephemeral.

An initial survey of habitats created by installation of drop pipes in North Central Mississippi revealed that four major habitat types exist in this region. In general, these habitats are small, riparian terrestrial or wetland habitats surrounded by agricultural fields. The primary habitat characteristics used in delineating the habitats were water depth/duration and vegetative structure (Cowardin et al. 1979). The categories are temporarily flooded upland meadow (Category 1), saturated emergent wetland (Category 2), scrub-shrub wetland (Category 3), and intermittent riverine wetland (Category 4). Category 1 habitat is primarily a terrestrial habitat with the smallest temporary pool and least vegetative structure. Categories become consecutively more complex to Category 4 which has the deepest pool, most vegetative structure, and is a wetland habitat. These habitats receive water from the captured watershed, which normally includes the surrounding agricultural fields. Four sites in each category (16 sites) in Panola County, Mississippi were surveyed for the five major vertebrate classes from June to August 1994.

Sampling: We utilized a variety of survey techniques to sample the five major vertebrate classes. Standard bird counts were conducted to survey birds. Aquatic vertebrates were collected by seine (6.1 m and 15.2 m, mesh sizes 0.3 and 0.9 cm) or dipnet. All seinable sites were thoroughly sampled in Category 3 habitats. Depth of Category 4 pools made complete seine coverage impractical, but all available microhabitats were sampled. We used baited

Figure 1. Drawing of typical drop pipe with created pool habitat.



hoop nets (1.8 m length , 0.9 m hoops, mesh size 2.5 cm) to capture fish and aquatic turtles in each Category 4 pool.

We placed pitfall (19 L buckets buried flush with ground surface) and sherman folding live traps on the periphery of the habitats to capture terrestrial amphibians, reptiles, and small mammals. One night survey was conducted to increase our capture of amphibians and reptiles. Every site was systematically searched for amphibians and reptiles for 5 - 45 minutes, depending on the size and complexity of the habitat. Observations made independently of the sampling protocols above for any particular group were recorded separately (i.e. identifying tracks, scat, new captures or sightings). All animals captured by any survey technique were identified and released or used as voucher specimens.

Statistical analysis: To test for differences in mean vertebrate species richness (mean number of species) between habitat categories, we used a Single factor Analysis of Variance (ANOVA) (alpha = .05) coupled with Student-Newman-Keuls Method (SNK test) performed on a statistical software package. Data from all survey techniques except opportunistic sampling were included in this analysis.

Percentage capture abundance is the percentage of total captures; again, all survey data except opportunistic sampling were used. Due to unequal catchability, no statistical test was used to statistically determine differences in percentage capture abundances. However, the data were examined for trends.

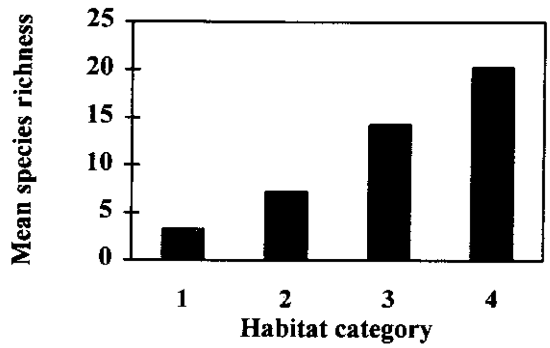
RESULTS

A total of 1807 animals representing 76 species were captured or sighted during this preliminary study. This included a total of 6 fish species, 14 amphibian species, 12 reptile species, 13 mammal species, and 31 bird species in all drop pipe habitats combined. Members of 11 species were either captured or sighted in 3 or more drop pipe habitat categories[eastern narrowmouth toad (*Gastrophrhyne carolinensis*), southern leopard frog (*Rana utricularia*), ground skink (*Scincella lateralis*), shorttail shrew (*Blarina brevicauda*), cotton mouse (*Peromyscus gossypinus*), hispid cotton rat (*Sigmodon hispidus*), barn swallow (*Hirundo rustica*), common yellowthroat (*Geothlypis trichas*), indigo bunting (*Passerina cyanea*), northern cardinal (*Cardinalis cardinalis*), red-winged blackbird (*Agelaius phoeniceus*)]. All vertebrate classes except fish were represented in these 11 species.

Habitat type had a significant effect on vertebrate species richness ($F_{3,15} = 25$, $P < 0.0001$). Mean vertebrate species increased from Category 1 to Category 4 (Figure 2). Mean species richness in all habitat categories except Category 1 and 2 was significantly different from each other (SNK, $P<0.05$). Mean species richness increased from

Category 1 habitats to Category 4 habitats for all vertebrate classes except mammals. Mammal mean species richness peaked at Category 2 and 3 habitats and decreased slightly in Category 4 habitats.

Figure 2. Mean vertebrate species richness in drop pipe habitat categories 1, 2, 3, and 4.



Percentage capture abundance of all vertebrate classes in drop pipe habitat categories increased sequentially from the lowest in Category 1 to the highest in Category 4 habitats. Additionally, over half of all vertebrate captures were made in Category 4 habitats. In all drop pipe habitats, amphibians had the highest percentage capture abundance; fish were second; birds were third; mammals were fourth; and reptiles had the lowest percentage capture abundance. Percentage capture abundance increased from Category 1 habitats to Category 4 habitats for all vertebrate classes except amphibians and mammals. Percentage capture abundance of amphibians and mammals increased from Category 1 habitats to Category 3 habitats and decreased slightly in Category 4 habitats.

DISCUSSION

The continuous increase of mean vertebrate species richness and percentage capture abundance from Category 1 to Category 4 habitats was due to the increase in habitat size, habitat complexity, and pool size. Pool size probably played a dominant role in the increase of mean vertebrate species richness and percentage capture abundance. Those habitats with largest pools (Category 3 and 4) had significantly higher mean vertebrate species richness and greatly increased percentage capture abundance over shallower, more temporary pools (Category 1 and 2). This increase was attributed to creation of suitable habitats for aquatic vertebrates such as fish and amphibians. The high numbers of amphibian larvae captured in Category 3 and 4 habitats increased the percentage capture abundance of amphibians at these sites. The increase of amphibian mean species richness and percentage capture abundance from Category 3 to Category 4 habitats was probably related to the increase in habitat size and complexity between these two habitat types and the development of permanent pools.

Although it is not a totally analogous comparison and regional differences aside, the vertebrate species richness and percentage capture abundance of these created wetland habitats (categories 2, 3, and 4) compared favorably with other wetland habitat (i.e., red maple swamp). Golet et al. (1993) reviewed the literature on vertebrate communities of red maple (*Acer rubrum*) swamps in the glaciated northeast. They reported species richness of amphibians and reptiles ranging from 7 to 17 species and number of captures ranging from 251 to 2035 individuals. By comparison, the total number of amphibian and reptile species captured in wet drop pipe habitats ranged from 3 in Category 2 habitats to 26 species in Category 4 habitats. The number of amphibians and reptiles captured in drop pipe habitats ranged from 10 in Category 2 habitats to 592 in Category 3 habitats. Number of captures decreased slightly in Category 4 habitats for these animals. Thus, Category 3 and 4 habitats supported similar species richness but fewer numbers of amphibians and reptiles when compared to red maple swamps.

Golet et al. (1993) reported from seven censuses that 63 species of birds utilized red maple swamps. For all drop pipe habitats 31 bird species were sighted. Individually, 10, 14, and 25 species of birds were identified in Category 2, 3, and 4 habitats, respectively. Since this study was conducted in the summer, the majority of bird species sighted in our study were passerine birds. However, 3 species of wading birds [Great blue heron (*Ardea herodias*), Greenbacked heron (*Butorides striatus*), Little blue heron (*Egretta caerulea*)] and a single unidentified duck were sighted at Category 3 and 4 habitats, further suggesting the importance of pool formation in providing habitat.

Two studies of small mammal communities in red maple swamps were also discussed by Golet et al. (1993), each with small mammal species richness of 6 and 12. The white footed mouse (*Peromyscus leucopus*) and northern short-tailed shrew (*B.brevicauda*) were among the three most frequently captured mammal species in both studies. Nine species of small mammals were associated with drop pipe habitats (8, 7, and 2 species in Category 2, 3, and 4 habitats, respectively). In order, the three species of small mammals most often captured in all drop pipe wetland habitats were hispid cotton rat (*S.hispidus*), cotton mouse (*P. gossipinus*), and short-tailed shrew (*B.brevicauda*).

Golet et al. (1993) did not discuss fish communities because water regimes were highly variable and generally excluded fish populations. We found two Category 4 habitats which supported fish populations. Six fish species occurred in these sites with a total of 324 captures which constituted 17.93% of all vertebrate captures.

Our study demonstrates that the installation of drop pipes for erosion reduction is also creating habitats capable of supporting populations of all major vertebrate classes. Habitat use by a large number of common vertebrate species is noteworthy because agriculture, downstream water resources, and wildlife benefit. The continued installation of drop pipes will allow agriculture to mitigate a fraction of previous losses and create vertebrate refugia without making significant sacrifices.

ACKNOWLEDGMENTS

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REFERENCES

Beer, C.E., and Johnson, H.P. 1965. Factors related to gully growth in the deep loess area of western Iowa. *in* Proceedings, 1963 , Federal Inter-Agency conference on Sedimentation. U.S. Department of Agriculture Miscellaneous Publication 970. p 37-43.

Cowardin, L.M., Carter, V., Golet, F.C., and LaRoe, E.T. 1979. Classification of wetlands and deep water habitats of the United States. U.S. Fish and Wildlife Service, Washington, DC.

Golet, F.C., Calhoun, A.J.K., DeRagon, W.R., Lowry, D.J., and Gold, A.J. 1993. Ecology of red maple swamps in the glaciated northeast: A community profile. Biological Report 12. U.S. Department of Interior, Fish and Wildlife Service. Washington, D.C. 151 pg.

Gray, H.J., and Crothers, R.B. 1989. Gully control structures for grazing lands in Southern Queensland. Queensland Agricultural Journal (Brisbane) 115:116-120.

Okagbue, C.O. and Ezechi, J.I. 1988. Geotechnical characteristics of soils susceptible to severe gullying in Eastern Nigeria. Bulletin of the International Association of Engineering Geology. Issue 38. 9 pg.

Ramser, C.E. 1932. Gullies: how to control and reclaim them. Farmer's bulletin. U.S. Department of Agriculture. No. 1234. Washington, D.C. 34 pg.

Uhland, R.E., and Wooley, J.C. 1929. The control of gullies. Bulletin of University of Missouri Agricultural Experiment Station. 271. 23 pg.

The Conservation Foundation. 1987. State of the Environment: A view towards the nineties. Washington, DC. 614 pg.

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TITLE: Use of Environmental Monitoring Systems In Support of Various Surface-water and Water-quality Projects

ABSTRACT: BLM/NIFC/RAWS will provide a poster session that displays some of the current and past remote sensing involvements within the Surface-water, sedimentation, water-quality data collection, and HAZMAT arena. State of the art electronic sensing methods and devices will be displayed. Several data telemetry options available will also be covered in the display and handouts. Some current RAWS involvements in Surface-water and sedimentation include the meteorological and hydrological monitoring of a nonproductive open pit uranium mine, enhancing remedial investigation feasibility cleanup studies of a hazardous waste site. The hydrological monitoring of a Green River tributary stream, a salinity study on the effects of ponding on normal runoff salinity levels. Meteorological and hydrological monitoring of a free-flowing geothermal pond, providing a long term base line of water flow rates and temperature variations in an environmental sensitive geothermal area for future geothermal exploration.

On display at the session will be a portable "Micro-Raws" equipped with water and soil moisture monitoring sensors. The complete weather station packs up into one enclosure that weighs 165 lbs.

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PRELIMINARY WATER QUALITY ANALYSIS OF DROP PIPE INLET BASINS IN THE DEC PROJECT

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Abstract: Field-scale grade controls are erosion control structures used extensively in the Demonstration Erosion Control Project in the Yazoo Basin. Common to many of these structures are shallow basins that are permanently or seasonally inundated. These pools play a role in stream water quality by processing nutrients from storm run-off and trapping suspended sediments. Sixteen drop pipe inlets were divided into four categories based on water depth and surrounding vegetation. Mean depths for categories 1 through 4 were 8.8, 17.6, 32.0 and 154.9 cm, respectively. Water quality parameters were monitored to determine significant differences between the categories. Dissolved oxygen was significantly higher in both deep and shallow pools when compared to the intermediate Category (2 and 3) pools. Conductivity was significantly higher in shallow pools. Filterable ortho-phosphate was significantly higher in Category 1 and 2 pools than the deeper pools, and Category 4 pools had the lowest mean total phosphorus concentrations. Category 1 and 2 pools were significantly higher in ammonia-nitrogen and nitrate than either Category 3 or 4 and also had significantly higher coliform bacteria counts. As might be expected, chlorophyll concentrations were higher in the deeper pools. Suspended and total solids were not significantly different between pools. Based on these preliminary data, drop pipe inlets designed with deeper basins trap coliforms and process nutrients more efficiently than shallow basin designs. Overall, these small pools play a trapping and processing role in upland landscapes similar to small ponds or isolated wetlands. Efficiency is limited by size and water residence time.

INTRODUCTION

Public attitude toward aquatic resources has dramatically changed during the last two decades. Although our rivers and streams were valued by sportsmen and fishermen, for a time public attitude seemed to be that these inundated lands were useless areas, to be drained and put into valuable agricultural production. Our aquatic resources were seen as breeding areas for mosquitoes and insect-borne disease and were best exploited as conduits for commerce and waste, and sources for irrigation water. Aquatic resources are now valued as reservoirs of species diversity, filters of water borne contaminants, and sources of recreation. This change in attitude is reflected by increased legislation directed toward the protection of aquatic resources and increases in aquatic ecosystem research.

Over the course of the past century, aquatic habitats have declined worldwide, primarily due to urban and rural development. For example, wetlands declined at a rate of 458,000 acres per year between 1950 and 1970. Much of this loss can be attributed to draining and clearing for agriculture (The Conservation Foundation 1987; Schmidt et al 1991). This draining and clearing often resulted in increased erosion and sedimentation with detrimental impacts on stream and river water quality. Pimentel et al. (1987) estimated that 60% of the approximately 3 billion tons (3.05 billion metric tons) of sediment per year deposited in the waterways originates from agricultural lands. In addition, these sediments are often joined by other contaminants such as pesticides and nutrients (Knight and Cooper 1991).

Gully erosion, one of the most severe types of erosion, is a world wide phenomenon that results in loss of agricultural land, property, and hence millions of dollars (Okagbue and Exechi 1988). Beer and Johnson (1965) estimated that more than 200 million gullies were actively eroding in the United States in 1939 and that gully erosion has continued to increase. Prevalent in the southern United States since the 1930's, gully erosion of farmland has been attributed to heavy rainfall, soil types, slopes, and intensively cultivated crops such as cotton and tobacco (Ramser 1932).

Installation of a field scale grade control structure, or drop pipe, is the most common method employed to control head-cutting gully erosion in the Demonstration Erosion Control (DEC) Project in the Yazoo Basin. As of 1990, 2,369 drop pipes were planned for installation or constructed as part of this project (Shields unpublished manuscript). Drop pipe inlets have been used both nationally and internationally to control gully erosion and were used in the United States as early as 1929 (Gray and Crothers 1989, Uhland and Wooley 1929). Common to most drop pipe inlets are shallow basins that are permanently or seasonally inundated. These basins provide aquatic and semiaquatic habitat. A preliminary survey of habitats created by drop pipe installation demonstrated that a variety of terrestrial and wetland habitats are created for use by local vertebrates (Cooper et al. In press). These pools may also play a role in water quality improvement by processing nutrients from storm run-off and trapping suspended sediments. Dendy and Cooper (1984) found that Morris Pond, a small northern Mississippi impoundment, trapped 77% of suspended sediments and 100% of course sediments. Cooper and Knight (1991) found nutrient trapping efficiency for the pond exceeded 70%.

Habitat value of drop pipe inlets is partially dependent upon pool water quality. For example, for drop pipe pools to serve as nurseries for amphibians, critical water quality parameters must be within acceptable ranges. Additional research was needed to establish baseline water quality of drop pipe inlet pools and to define the role these pools play in improving stream water quality. This manuscript presents preliminary results of the first survey of water quality parameters from drop pipe habitat.

METHODS

A drop pipe inlet consists of a dam installed at the mouth of a gully with an "L" shaped metal drain pipe originating on the gully side of the dam and discharging at stream level. Depending upon the elevation of the pipe inlet, water may pond behind the dam. Drop pipes were categorized into four major habitat types based on the classification suggested by Cowardin et al (1979). The categories are temporarily flooded upland meadow (Category 1), saturated emergent wetland (Category 2), scrub-shrub wetland (Category 3), and intermittent riverine wetland (Category 4). Category 1 habitat is primarily a terrestrial habitat having the smallest temporary pool and least vegetative cover. Categories become consecutively more complex to Category 4 which has the deepest pool, most vegetative cover, and is a wetland habitat. These habitats receive water from precipitation and storm runoff from the captured watershed which normally includes the surrounding agricultural fields.

Four sites in each category were chosen as study sites (16 sites) in Panola County, Mississippi. Mean depths for categories 1 through 4 were 8.8, 17.6, 32.0 and 154.9 cm, respectively. Measured water quality parameters included conductivity, dissolved oxygen, pH temperature, coliform bacteria, chlorophyll, phosphorus, filterable ortho-phosphate, ammonia-nitrogen, nitrate-nitrogen, and suspend, dissolved and total solids.

RESULTS AND DISCUSSION

Means and standard deviations of water quality parameters are listed in Table 1. Dissolved oxygen was significantly higher in both the deep (Category 4) and shallow (Category 1) pools when compared to the intermediate Category (2 and 3) pools. As might be expected, chlorophyll concentrations were also higher in the deeper pools. Deeper pools were more permanent in nature, and primary productivity provided higher concentrations of dissolved oxygen. Shallow pools probably had higher dissolved oxygen concentrations because the surface area to volume ratio was sufficiently high to allow greater diffusion of atmospheric oxygen. Intermediately deep pools had lower surface to volume relationships and low phytoplankton, resulting in lower dissolved oxygen. Low oxygen concentrations (<4 mg/L) were frequently observed in Category 3 pools and on one occasion in a Category 4 pool. The scrub-shrub wetland pools (Category 3) had the greatest variability in chlorophyll concentration. This variability was attributable to rapidly fluctuating growth cycles in phytoplankton populations and accounted for low oxygen measurements.

Conductivity and dissolved solids were significantly higher in the shallow pools. Due to high variability, suspended and total solids were not statistically different between pools; however, Category 4 pools had the lowest mean suspended and total solids concentrations. This suggests that residence time in the deep Category 4 pools allows larger solids to settle. This longer residence time is also supported by the elevated chlorophyll concentrations, which also require longer water residence time.

Filterable ortho-phosphate was significantly higher in Category 1 and 2 pools than the deeper pools. Category 4 pools had the lowest mean total phosphorus concentrations. It corresponded with higher chlorophyll concentrations, indicating greater utilization of pool resources in Category 4 pools. Category 1 and 2 pools were significantly higher in ammonia nitrogen (NH_3) and nitrate nitrogen (NO_3) than either Category 3 or 4 and also had significantly higher coliform bacteria counts.

Table 1. Mean physical, chemical and biological water quality parameters by habitat category.

Physical

Category	Dissolved Oxygen mg/L	Cond. 1mhos/cm ^{2}	pH units	Temp. °C	Depth cm	Total Solids mg/L	Dissolved Solids mg/L	Suspended Solids mg/L
1	5.21	115	6.88	19.25	8.8	175	80	95
	(1.17)	(53)	(0.63)	(4.59)	(4.9)	(119)	(21)	(119)
2	4.71	85	6.74	19.48	17.6	232	71	162
	(1.80)	(35)	(0.24)	(5.08)	(10.3)	(223)	(25)	(245)
3	4.60	76	6.79	21.65	32.0	327	43	285
	(2.77)	(40)	(0.27)	(4.99)	(20.3)	(577)	(22)	(579)
4	6.06	79	7.01	23.63	154.9	90	55	35
	(2.17)	(40)	(0.53)	(5.34)	(72.1)	(30)	(28)	(23)

Chemical and Biological

Category	Filterable ortho-Phospate mg/L	Total Phosphorus mg/L	NH3 mg/L	NO3 mg/L	Chlorophyll mg/L	E. Coli colonies/ 100 ml	Fecal Coliform colonies/ 100 ml
1	0.422	0.621	84.1	84.2	5.86	1467	46864
	(0.335)	(0.305)	(36.9)	(36.8)	(4.72)	(247)	(25148)
2	0.553	0.711	81.8	81.9	4.30	913	57244
	(0.424)	(0.367)	(38.9)	(38.8)	(2.65)	(850)	(30152)
3	0.139	0.647	52.5	52.3	71.31	692	23871
	(0.158)	(0.419)	(50.2)	(50.5)	(115.58)	(1753)	(23145)
4	0.138	0.349	47.8	47.8	74.46	90	15652
	(0.164)	(0.236)	(50.5)	(50.5)	(98.31)	(175)	(22526)

Standard Deviation in parentheses

SUMMARY

Baseline water quality of drop pipe inlet pools is generally acceptable to aquatic and semi-aquatic species of plants and animals of the southeastern United States. Severe oxygen depletion was observed for scrub-shrub wetland pools (Category 3). Although dissolved oxygen dropped below 4 mg/L, the generally agreed upon standard for warm water fish health (Wedemeyer et al. 1976), more tolerant species may benefit from low dissolved oxygen. For example, some amphibian species may be more tolerant of low dissolved oxygen than of fish predation. Lower concentrations of suspended sediments, nutrients, and coliforms and higher concentrations of oxygen, and chlorophyll in deeper pools indicate that drop pipe inlets designed with deeper basins may trap coliforms and sediments and process nutrients more efficiently than shallow basin designs.

Drop pipe inlets provide an effective means for controlling gully erosion in northern Mississippi. In addition to providing suitable habitat for aquatic life, drop pipe inlet pools process nutrients and trap sediments that would detrimentally impact stream water quality. Although drop pipe inlets with deeper pools trap sediment and nutrients more efficiently than those with shallow pools, pools with a variety of depths may ultimately provide greater species diversity in the agricultural landscape.

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LITERATURE CITED

Beer, C.E., and Johnson, H.P., 1965, Factors related to gully growth in the deep loess area of western Iowa. in Proceedings, 1963, Federal Inter-Agency conference on Sedimentation. U.S. Department of Agriculture Miscellaneous Publication 970. p. 37-43.

Boyt, F.L., Bayley, S.E., and Zoltek, J., 1977, Removal of nutrients from treated municipal wastewater by wetland vegetation, J. Water Pollut. Control Fed. 49:789-799.

Cooper, C.M., Smiley, Jr., P.C., Kallies, K.W., Knight, S.S., and Wigginton, J.D., In Press. Vertebrate utilization of habitats created by installation of drop pipe inlets. Proceedings of the Sixth Federal Interagency Sedimentation Conference, Las Vegas, Nevada.

Cooper, C.M. and Knight, S.S., 1991, Nutrient and sediment trapping efficiency in small farm ponds. Proceedings for the Environmentally Sound Agriculture Conference. Vol. 2 pp. 673-680.

Cowardin, L.M., Carter, V., Golet, E.C., and LaRoe, E.T., 1979, Classification of wetland and deep water habitats of the United States, U.S. Fish and Wildlife Service Pub. FWS/OBS-79/31, Washington, D.C., 103 pp.

Dendy F.E. and Cooper, C.M., 1984, Sediment trap efficiency of a small reservoir. J. Soil Water Cons. 39:278-280.

Gray, H.J., and Crothers, R.B., 1989, Gully control structures for grazing lands in Southern Queensland. Queensland Agricultural Journal (Brisbane) 115:116-120.

Knight, S.S. and Cooper, C.M., 1991, Distribution of insecticides and metals in a mixed agricultural watershed. Proceedings for the Environmentally Sound Agriculture Conference. Vol. 2 pp. 681-688.

Okagbue, C.O. and Exechi, J.I., 1988, Geotechnical characteristics of soils susceptible to severe gullying in Eastern Nigeria. Bulletin of the International Association of Engineering Geology. Issue 38. 9 pg.

Pimentel, D., Allen, J., Beers, A., Guinand, L., Linder, R., McLaughlin, P., Meer, B., Musonda, D., Perdue, D., Poisson, S., Siebert, S., Stoner, K., Salazar, R., and Hawkins, A., 1987, World agriculture and soil erosion. BioScience 37:277-283.

Ramser, C.E., 1932, Gullies: how to control and reclaim them. Farmer's bulletin/U.S. Department of Agriculture. No. 1234. Washington, D.C. 34 pg.

Schmidt, L., Teels, B., and Gray, R., 1991, Wetlands and Riparian Areas: their protection, conservation, and restoration. in Agriculture and the Environment. The 1991 yearbook of agriculture. edited by Deborah T. Smith. U.S. Department of Agriculture. 325 pg.

Sheffield, C.W., 1967, Water hyacinth for nutrient removal. Hyacinth Control J. 6:27-30.

Shields, F.D., Proposal for investigation: water quality design criteria for slotted board riser pipes. unpublished manuscript.

The Conservation Foundation, 1987, State of the Environment: A view towards the nineties. Washington, DC. 614 pp.

Uhland, R.E., and Wooley, J.C., 1929, The control of gullies. Bulletin of University of Missouri Agricultural Experiment Station. 271. 23 pg.

Wedemeyer, G.A., Meyer, F.P., and Smith, L., 1976, Diseases of fishes - Environmental stress and fish disease. TFH Publications, Inc., NJ, 192 pp.

Contact: Scott Knight, Ecologist, Water Quality and Ecology Research Unit, National Sedimentation Laboratory, Agricultural Research Service, Oxford, MS, 38655. Phone: (601)232-2934; FAX:(601)232-2915; Internet: knight@gis.sedlab.olemiss.edu.

ESTIMATING SCOUR AT BRIDGES WITH HISTORICAL DATA

by Robert L. Burrows, U. S. Geological Survey

Failures of bridges over water are caused primarily by scour and channel instability. During the past several years, the Federal Highway Administration has mandated that all states evaluate bridges over water for potential failure. These evaluations have ranged from subjective risk rankings based on site visits to computer modeling using field-surveyed input data.

In Alaska, the U.S. Geological Survey (USGS) has been evaluating channel stability and scour at bridges, in cooperation with the Alaska Department of Transportation and Public Facilities. Initial analyses were done by utilizing the water-surface profile model, WSPRO, to model the hydraulics at the bridge in order to calculate potential scour. Instead of visiting each site and surveying the channel geometry and streambed slope to provide the input for WSPRO, all input data were taken from the as-built plans, bridge inspection notes, maps, photographs, and USGS streamflow data where available. In some instances, it was necessary to make estimates of some input data. Generally, only one cross-section was available, and other sections needed in WSPRO were replicated upstream and downstream by the model. Once a successful, and apparently hydraulically sound model run was made, the 100-year and 500-year flood flows were run by the model and the results used to compute contraction scour and pier scour at each bridge site.

A selected number of bridges that appeared to be scour critical were field surveyed. The new data were then used to make a new WSPRO model run and scour calculations were redone. The results of the updated calculations were compared with the original as well as the actual measured scour depths apparent on site. This methodology provides a means of estimating potential scour without costly field surveys and provides an objective method for screening bridge sites for scour susceptibility.

THE GOODWIN CREEK EXPERIMENTAL WATERSHED: A UNIQUE OUTDOOR LABORATORY

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The Goodwin Creek Experimental Watershed was established in 1977 in north central Mississippi as a part of the "Streambank Erosion Control Evaluation and Demonstration Project" authorized by Section 32 of Public Law 93-251. The US Army Corps of Engineers (COE), Vicksburg District, funded the watershed instrumentation, and the National Sedimentation Laboratory (NSL) has operated the watershed since October, 1981. The watershed serves as a prototype for the much larger Demonstration Erosion Control (DEC) Project in the Yazoo River Basin and as an outdoor laboratory for hydrologic studies.

BASELINE DATA COLLECTION

The watershed is located in the Coastal Plain Physiographic Province. The loess cap on all interfluves thins rapidly from west to east and Holocene alluvial deposits are present in all valleys. Drainage is westerly to the Mississippi alluvial valley via the Yocona River. Stratigraphically, the area is divided into formations of the Tertiary and Quaternary periods. Seven lithologic units in the Holocene valley-fill deposits have been identified and have been dated using C^{14} procedures.

The USDA-Natural Resources Conservation Service (formerly SCS) has classified and mapped two soils associations in the watershed (Galberry et al,1963). The Collins-Falaya-Grenada-Calloway association occurs on the terraces and flood plains, while the Loring-Grenada-Memphis association occurs on the loess ridges and hillsides.

Topography of the area is described by 15 and 7.5 minute US Geological Survey Quadrangle maps, USGS Digital Elevation Models, a 1 to 5000 scale 2 and 5 foot contour-interval relief map and 1 to 500 scale detailed channel surveys prepared by the Corps of Engineers.

Since 1980, ground surveys have been taken to characterize crop and cover conditions in the watershed and how these conditions change over time in each field. The surveys have been conducted on a field-by-field basis to examine temporal changes and their effects. The classification used in the ground surveys includes five categories: cultivated, pasture, idle, forest and planted forest. Cultivated land is divided into four categories: cotton, soybeans, corn and small grain. Information from these ground surveys has been supplemented with data acquired from aerial photographs available from the USDA Consolidated Farm Services Agency (formerly Agricultural Stabilization and Conservation Service) and Landsat Satellite images. Additional information concerning percent slope, slope length and area has also been collected.

Bed material was sampled at 150 meter intervals along the main channel in 1988 and at 30 meter intervals in 1994. The mean size distribution of the sediment transported along the bed of Goodwin Creek over a period of ten years was nearly the same as the size distribution of the bed material itself. However, differences occur on a short term basis. Low flows, which occur most frequently, move only the fine fractions of the bed material. The coarse material is accumulated in temporary storage in point bars and moves only during large events.

Elevation, soils, and landuse data are compiled as layers of information in two raster-based geographic information systems (GIS). At the NSL the GIS packages used are ERDAS and GRASS. The systems provide a convenient and accessible database for use in watershed analysis and modeling.

WATERSHED INSTRUMENTATION

The 21.5 sq.km. watershed area was partitioned into 14 nested sub-basins so that no part of the watershed had more than 1/3 of its contributing area ungaged (Figure 1). Supercritical Walnut Gulch-type measuring flumes were constructed at each subbasin outlet (Seely et al,1981). The flumes serve dual purposes of controlling degradation of the channel bed (upstream of their location) and measuring runoff. They operate in the supercritical flow range to ensure flushing of the high sediment loads carried by the channels. Construction of the flumes began in April of 1978 and was completed in October of 1979. The flumes are built of reinforced concrete supported on steel sheet piling. At site 10 only sheet metal was used. Water-stage recorders measure flow-depth in the tailwater basin and at the critical flow zone in the throat of the flume.

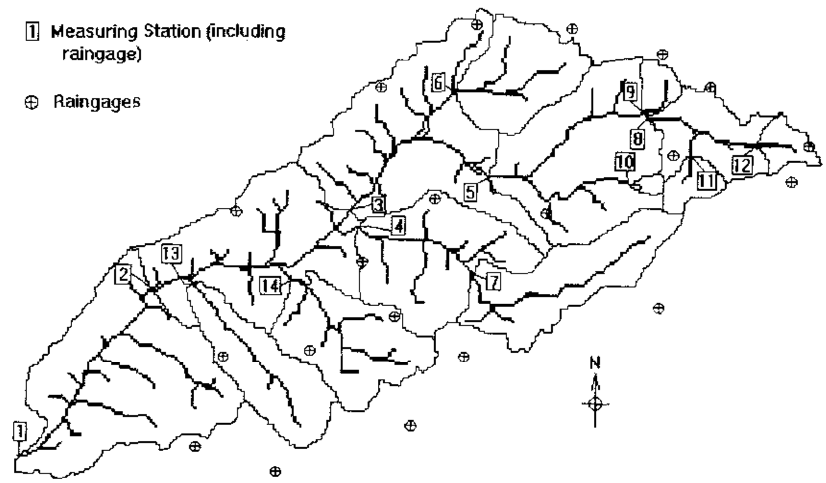

Figure 1. Goodwin Creek Experimental Watershed map showing flume and raingage locations.

The sediment transported in the channels of Goodwin Creek ranges from fine particles (<0.062 mm) to sand (0.062-2.0 mm) to gravel (>2.0 mm). Different problems are associated with collecting representative samples for each group. Fine sediment loads have been calculated using samples collected with automatic pumping samplers from a fixed point within each flume. Due to the spatial and temporal variability of sand movement, the transport rate of sand is computed from manual depth-integrated samples collected using the DH-48 sampler to take equal-transit-rate (ETR) total sand load fractions at eleven stations. Transport of gravel is estimated from samples collected using modified Helley-Smith samplers and in-stream box samplers that have continuously recording load detectors.

Rainfall on the watershed is continuously monitored with a network of 32 standard recording weighing precipitation gages located at sites both inside and outside the watershed area (Figure 1). The raingages at each measuring flume are equipped with a potentiometer so that an output voltage of the transducer can be recorded on standard digital dataloggers. Also, each raingage is equipped with a standard depth recording chart for back-up in case of power failure.

A class A climatological station, located near the center of the watershed, was installed in 1978 to collect meteorological data which ultimately included precipitation, evaporation, barometric pressure, relative humidity, wind speed and direction, solar radiation and air temperature. The evaporation, barometric pressure, relative humidity and solar radiation measurements were discontinued in 1984 due to the expense and labor required for instrument maintenance. The data, collected on a daily basis, are processed to determine mean monthly averages for each water year. Recently, this facility was selected by the National Oceanographic and Atmospheric Administration and National Aeronautical and Space Administration for installation of one of five SURFRAD stations in the U.S. which are part of the worldwide surface radiation network being used to determine the impact of climate change.

Temperature probes are used at 12 of the 14 stream gaging sites to measure temperature of the stream flow. The outside air temperature is measured at only three of these gaging sites and at the climatological station. Air and water temperatures are measured with thermistor temperature sensors based on the principle that ambient temperature is related to the resistance of the probes.

A computer-based data acquisition system collects and transmits electronic data from the gaging sites. The system, which has a better-than-98% up-time record, consists of 14 microcomputer controlled, real-time data-collection systems linked to VHF radio transmitters, a radio repeater, and a central computer for data storage and processing. Precipitation and in-flume runoff data are collected continuously on 1 minute intervals. Pump-sampler activity is on 11.5 minute intervals and other automatically-gathered data, such as tailwater depth, air temperature and water temperature are collected on 15 minute intervals. Soil temperature was collected at 3 depths on 15 minute intervals for only two years, 1982-84. All data is stored in on-site microcomputers and then downloaded every 30 minutes to the central computer at NSL where they are compressed and permanently archived.

ONGOING DATA COLLECTION

Eleven years of continuous hydrologic data are now available for Goodwin Creek. The data are used to compute the magnitude of monthly and annual flows, magnitude and frequency of annual low, high, and instantaneous peak flows and duration of daily mean flows.

Channel surveys of Goodwin Creek have been conducted since 1977. In the 1977 survey, topographic maps were drawn from 1050 cross sections arrayed along base lines laid out along the top banks of the streams. After installation of the flumes, monuments were set for five cross sections above and five below each flume for a distance upstream and downstream of about 500 meters. In 1982, in the lower 3.5 km of channel, the baselines were rerun and about every sixth cross-section at approximate intervals of 150 meters was monumented and resurveyed. These cross-section surveys were tied into the State Plane Coordinate system and have been repeated 26 times. Initial resurveys were performed on a quarterly basis but are now repeated only annually. These data are used to document changes in the channel and to verify the sediment delivery budget of the channel system.

SELECTED SPECIALTY STUDIES

Since the establishment of the Goodwin Creek Experimental Watershed in 1977, over 175 publications and reports have been prepared on research related to this project. The most comprehensive publication is a 15 volume 1630 page report entitled "Stream Channel Stability" prepared in 1981 by the staff of the NSL for the Vicksburg District, U.S. Army Corps of Engineers on the work conducted under the Section 32 Program, Work Unit 7. It is available from the National Technical Information Service as reports AD-A101-385 through 399. Many other specialized studies have also been conducted in the watershed. Some of these are briefly summarized below.

Weekly measurements of water quality parameters were taken from Morris Pond, a 1.09 ha reservoir with a subwatershed of 17.8 ha of permanent pasture and 14.6 ha of cultivated and mixed cover land. The pond proved to be an excellent conservation management practice since it trapped 77% of fine sediment and over 70% of the phosphorus and nitrogen that entered the pond.

Flannigan Watershed, a small 3.1 ha gullied field on 3 to 8% slopes located in the uplands above station 12 of Goodwin Creek Watershed, was instrumented for rainfall, runoff, and sediment monitoring to study the effects of no-till cropping. The watershed was farmed with conventional soybeans from 1980 to 1985 and no-till soybeans from 1986 to 1990. Annual mean sediment yield for the conventional period was 14 t/ha, while sediment yield for the no-till period was significantly lower at less than 5 t/ha.

A 10 year study of ephemeral gully behavior was conducted on adjacent 1.54 and 1.90 ha fields in watershed 9. After a year of calibration with both watersheds in grass, the larger area was planted to conventionally-tilled soybeans. Over the next 8 years, tillage was gradually reduced from two discings, row-hipping, planting, and three cultivations per year to complete no-till. The smaller watershed was kept in grass as a controlled comparison for the full 10 years. Soil loss from the grassed watershed varied from 0.8 t/ha in 1985 to negligible in 1994. Soil loss from the conventionally-tilled soybeans was 20.8 t/ha in 1985 with 89% occurring in the growing season, about 60% of which came from the ephemeral gully. By 1993, when the soybeans had been in no-till for 3 years, losses approached that of the control grassed watershed.

A sediment budget developed in 1993 for the stream reach between flumes 1 and 2 in the total watershed indicated about 85% of the total sediment load originated from channel and gully erosion. The annual average sediment loss for this reach was about 2930 t/km (5,200 T(US)/mi.) between 11/82 and 10/87 (Grissinger et al,1991).

A study was carried out to evaluate the use of vegetation to stabilize eroding streambanks. Sites on Goodwin Creek below flume 3 and on adjacent Johnson Creek were used. Nineteen vegetative materials, six structural materials, and three mulch materials were evaluated over a 10-year period on various bank-treatment combinations and channel geometries (Bowie,1995).

Bank stabilization and aquatic habitat restoration studies are being conducted on the lower reaches of the main channel. In 1990, the COE installed 7855.5 tons (metric) of transverse and longitudinal stone dikes along the lower 1.77 km of channel. In 1991, they added similar measures to the next 1.58 km of channel. In 1993 the NRCS, in cooperation with NSL, added 1687.0 tons (metric) of stone to the 1990 structures between flumes 1 and 2 to restore aquatic habitats. Also, willow posts were planted between the stone structures to enhance bank toe stability.

REFERENCES

Bowie,A.J., 1995, Use of Vegetation to Stabilize Eroding Streambanks. USDA-ARS-Conservation Research Report Number 43, 19 pp.

Galberry, H.S., Dent, J.H., Huddleston, J.S., and Thomas, A.E., 1963, Soil Survey of Panola County, Mississippi. Series 1960, No.10, USDA Soil Conservation Service in cooperation with Mississippi Agricultural Experiment Station, 63 pp.,122 plates.

Grissinger, E.H., Bowie, A.J., and Murphey, J.B., 1991, Goodwin Creek Bank Instability and Sediment Yield. Proceedings, Fifth Federal Interagency Sedimentation Conference, pp, PS-32-39.

Seely, E.H., Grissinger, E.H., and Little, W.C., 1981, Stream Channel Stability, Appendix F, Goodwin Creek: Catchment, Data Collection and Data Management. Report prepared for Corps of Engineers, LMKVD, under Section 32 Program, Work Unit 7, available as NTIS report AD A101 391, 45 pp.

TWENTY FIVE YEARS OF CONSERVATION TILLAGE RESEARCH IN NORTHERN MISSISSIPPI

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Abstract

Highlights of cooperative conservation tillage research over the past 25 years between the National Sedimentation Laboratory and the North Mississippi Branch Experiment Station at Holly Springs, MS are presented. No-till and reduced-till grain crops including corn, grain sorghum, and soybeans yielded very low soil erosion rates. Low cropping and management (C-value) factors derived for use in soil loss prediction contributed to the lowering of C-values in Agriculture Handbook 537 approximately 80% for current use in the Universal Soil Loss Equation and in the Revised Universal Soil Loss Equation.

INTRODUCTION

The modern era of conservation tillage research at Holly Springs, MS between the National Sedimentation Laboratory and the North Mississippi Branch of the Mississippi Agricultural and Forestry experiment Station began in the fall of 1969. Five-percent sloping standard erosion plots, 4-m wide by 22.1-m long, containing Providence silt loam soils (Typic Fragiudalfs) were used. Conservation tillage systems, including no-till, were evaluated for erosion control effectiveness. The major objective was the computation of C-values for use in the USLE and RUSLE. Resulting C-values were the basis for reducing C-values and corresponding soil loss estimates, especially for the mid-south.

Plot Results

Table 1 shows the average annual soil loss and cropping and management (C) values for various conservation tillage systems for soybeans during two study periods, 1970-1974 and 1978-1981. The C-values given in Agriculture Handbook 537 (AH 537) would over-predict soil loss about five times as compared to measured values for either conventional-till or reduced-till soybeans.

Table 1. Average annual measured soil loss and C-values for soybeans for two different study periods, 1970-1974 and 1978-1981 (Mutchler and Greer, 1984).

	Soil loss, (t/ha)		C-values	
	1970-1974	1978-1981	1970-1974	1978-1981
No-till soybeans	1.25	1.43	0.006	0.008
Conv.-till soybeans	21.10	19.58	0.099	0.099
No-till soybeans and wheat, double-crop (70-73)	0.62	-	0.003	-
Reduced-till soybeans and wheat, double crop	-	2.06	-	0.013
Reduced-till soybeans	-	8.07	-	0.043

Table 2 shows the average annual soil loss and the annual C-values, computed with and without the influence of weeds, for various treatments for corn for silage and grain. AH 537 values for similar treatments were higher than the Holly Springs data with weeds analytically removed by a factor of about 3, 3, 6, 6, and 5 for conventional-till (CT) for grain, conventional-till for silage, no-till (NT) for grain, no-till for silage, and reduced-till (RT) for grain, respectively.

Table 2. Average annual soil loss and annual C-values for corn (McGregor and Mutchler, 1983).

	Average annual soil loss (t/ha)	Annual C-values	
		With weeds	W/O weeds*
Conventional-till, grain	16.0	0.089	0.101
Conventional-till, silage	25.1	0.139	0.187
No-till, grain	1.0	0.005	0.010
No-till, silage**	0.6	0.003	0.052
Reduced-till, grain	1.3	0.007	0.015

* (W/O means without); ** (No-till silage values averaged over 3-yrs, all others over 4 yrs)

Table 3 gives annual soil loss values and C-values for use in soil loss prediction, with and without weeds, for various cotton tillage treatments (1979-1986) adjusted to an annual EI of 360 (customary English Units). Conventional-till cotton following 11 years of CT produced over 1.5 times the erosion measured from CT cotton following 11 years of NT practices.

Table 3 also gives the average annual soil loss, C-values, rainfall, and runoff for various cotton treatments during 1984-1986. Previously measured soil loss from CT cotton without winter cover was over three times that from CT cotton with a winter cover in this study. The addition of vetch or winter wheat cover reduced erosion from cotton to tolerable levels. Wheat was as effective as vetch in reducing erosion and easier to eradicate in the spring before planting cotton.

Table 3. Average annual soil loss for cotton tillage treatments. C-values given for weeds that occurred during testing and for weeds analytically removed (Mutchler et al., 1985; and Mutchler and McDowell, 1990).

	C-values	Soil loss (t/ha)	Percent Runoff
(2-8) No-till cotton (81-83) after reduced-till soybeans:			
With weeds	0.102	18.4	38
Without weeds	0.111	20.0	--
With vetch cover (84)	0.014	2.3	18
(3-11) Reduced-till cotton (79-81) after no-till fallow:			
With weeds	0.058	10.5	28
Without weeds	0.063	11.6	--
(3-11) No-till cotton (83) after no-till soybeans-wheat double-crop:			
With weeds	0.006	1.1	20
Without weeds	0.007	1.3	--
With vetch or wheat cover (83-86)	0.005	0.9	14
(6-12) Reduced-till cotton (82-83) after no-till soybeans-wheat double-crop:			
With weeds	0.059	10.7	38
Without weeds	0.077	13.9	--
With vetch or wheat cover (84-86)	0.053	9.5	22
(4-9) Conventional-till cotton (81-83) after 11 years no-till:			
With weeds	0.217	39.2	35
Without weeds	0.237	42.8	--

Table 3 continued:

With vetch or wheat cover (84-86	0.142	25.6	27
(1-10) Conventional-till cotton (81-83) after 11 years conventional-till:			
With weeds	0.408	73.7	48
Without weeds	0.411	74.2	--
With vetch or wheat cover (84-86)	0.133	20.4	26

Notes: (1) Numbers in parentheses are plot numbers or years of data collection; and
(2) Average annual soil loss is adjusted to R=360.

Table 4 gives the average annual soil loss, C-values, rainfall, and runoff for various sorghum treatments (1985-1990). Soil loss from CT after RT cotton only slightly exceeded the accepted limits for the thin fragipan soils at Holly Springs (7 t/ha). Erosion from high ridges made the ridge-till practice not much better than CT for erosion control. The reduced-till practice was a more effective erosion control practice than ridge-till, thus was recommended over CT where cultivation for weed control is desired. No-till was easily the most effective erosion control system. Cropping history effects were discernible even with the NT studies. No-till after NT cotton had less erosion, only 0.3 t/ha of soil loss, as compared to 2 t/ha for no-till after CT cotton.

Table 4. Erosion from conservation tillage for sorghum (McGregor and Mutchler, 1972).

	Rain (mm)	Runoff (% rain)	C-values	Soil loss** (t/ha)
(2-8) CT sorghum after NT cotton with vetch cover crop (1985):	1049	13	0.032	5.73
(2-8) Ridge-till sorghum after CT sorghum (1986-1990):	1386	25	0.032	5.67
(3-11) NT sorghum after NT cotton with wheat cover crop(1987-1990):	1419	10	0.001	0.26
(1-10) NT sorghum after CT cotton with wheat cover (1987-1990):	1419	31	0.011	1.99
(4-9) RT sorghum after CT cotton with wheat cover (1987-1990):	1419	18	0.018	3.32
(6-12) CT sorghum after RT cotton with wheat cover (1987-1990):	1419	23	0.043	7.82

** Soil loss adjusted to correspond to EI=360.

Long Term Erosion Soybean Study

Soil loss was measured in 1990 from simulated-rainfall plots on fragipan soils that were tilled following 7-years of NT soybeans. This soil loss was less than 30% that from plots with a CT soybean history. The higher soil water content remaining on the plots with a NT history, even after tillage preceding these tests, contributed to lower soil losses than were measured from plots with a CT history. The difference between NT and CT soybean yields over time suggests that increasing erosion on the CT plots eventually will cause crop yield to approach zero. These crop yield and soil loss results show the importance of protecting the soil resource base and help to determine the long-term effects on soil erosion of NT and CT systems, especially for thin soils.

Description of Present Studies

Sediment and agrichemical losses are being evaluated from idle upland watersheds being returned to row crop production with implemented conservation measures. These studies involve the use of crop production plots, small watersheds, and rainfall simulator plots. Research studies include the sediment trapping efficiency of stiff grass hedges; effects of narrow-row vs standard row widths on crop yields, runoff, and soil loss; and erosion control and crop yield effects of various tillage methods on idle land being returned to row-crop production.

CONCLUSIONS

Cooperative conservation tillage research over the past 25 years between the National Sedimentation Laboratory and the North Mississippi Branch Experiment Station at Holly Springs, Mississippi has improved understanding of erosion control practices for conservation planning. These continuing studies enable conservationists to help farmers nationwide to use their land productively and profitably.

REFERENCES

McGregor, K. C. and C. K. Mutchler. 1992. Soil Loss from conservation tillage for sorghum. Trans. of ASAE 35(2):1841-1845.

McGregor, K. C. and Mutchler, C. K. 1983. C-factors for no-till and reduced-till corn. Trans. of ASAE 26(3):785-788, 794.

Mutchler, C. K. and Greer, J. D. 1984. Reduced tillage for soybeans. Trans. of ASAE 27(5):1364-1369.

Mutchler, C. K. and McDowell, L. L. 1990. Soil loss from cotton with winter cover crops. Trans. of ASAE 33(2):432-436.

Mutchler, C. K., McDowell, L. L. and Greer, J. D. 1985. Soil loss from cotton with conservation tillage. Trans. of ASAE 28(1):160-163, 168.

Wischmeier, W. H. and Smith, D. D. 1978. Predicting rainfall erosion losses - a guide to conservation planning. USDA Agriculture Handbook 537, Washington, D. C.

HILLSLOPE CHARACTERISTICS, OVERLAND FLOW, AND EROSION PROCESSES - FIELD MEASUREMENT AND VERIFICATION OF OVERLAND FLOW PATHS

By

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ABSTRACT OF POSTER PRESENTATION

Development and application of hillslope overland flow, erosion, and sediment yield models require characterization of the hillslope features including topography, vegetative canopy cover, and ground surface cover. Models representing overland flow and erosion processes along representative hillslope flow profiles require field and/or remotely sensed determination of flow paths. Verification of field-estimated or remotely sensed flow paths on hillslopes requires new data collection and analysis techniques. To develop data collection and analysis procedures to provide this verification, data are being collected from rainfall simulator plots and hillslope profiles on the Walnut Gulch Experimental Watershed in southeastern Arizona, USA. Topographic data to represent hillslope topography are collected using low-level aerial photography to produce orthotopographic maps at scales of 1:20 to 1:100. Preliminary estimates of overland flow paths are determined using these maps. Preliminary flow paths are checked and corrected in the field using ocular estimates of slope steepness and flow paths. Dye tracer studies in overland flow (during induced overland flow from calibrated application tubes at the top of the designated profile and during natural storms via automated dye release mechanisms) are used to further check and refine the ocular estimates. Electronic distance measurement apparatus are used to precisely define topography along the field-estimated overland flow paths and standard line-transect methods are used to estimate vegetative canopy cover and ground surface cover along the flow paths. Linear trend analysis, autocorrelation analysis, and spectral density analysis are used to characterize spatial variation of topography, vegetative canopy cover, and ground surface cover for overland flow paths on hillslope profiles. The statistical analysis procedures are also used to characterize the spatial variation of vegetative canopy cover and ground surface cover on contour transects perpendicular to the flow paths. The degree of deterministic spatial variation (linear trend, nonlinear trend, and periodic variation with distance) in vegetation canopy cover and surface ground cover are used to quantify the representativeness of individual hillslope flow profiles on small watersheds. Orthotopographic maps are used to describe the hillslopes and small watersheds. Graphical representation of topography, vegetative canopy cover, surface ground cover and their spatial analysis statistics are presented to illustrate concepts and procedures. Photographs of dye traces during and after induced overland flow are used to illustrate overland flow processes and flow path verification procedures.

Measuring Sediment Deposition in Riparian Forests

J. M. Sheridan, R. R. Lowrance, and H. H. Henry

ABSTRACT

Research by the Southeast Watershed Research Laboratory (SEWRL) of the USDA-Agricultural Research Service (USDA-ARS), has indicated that riparian forests can play a critical role in reducing agricultural non-point source (NPS) pollution and in maintaining or enhancing the quality of streamflow and shallow ground water. Current studies by the SEWRL are focusing on the impact of riparian forest management practices on the quality of surface and shallow ground water moving downslope from adjacent agricultural areas. These field studies presented a unique challenge in measurement and sampling of storm runoff. To evaluate the impact of forest management practices within the riparian forest buffer system (RFBS), sampling technology was required that would permit sampling of storm runoff at a number of locations across the grass buffer and riparian forest floor, as well as estimation of storm runoff volumes at the point of sampling.

Primary design requirements included: (1) capture and retention of a sample adequate for testing for transported constituents, including sediment; and (2) estimation of storm runoff or surface seepage flow volume at the point of sampling. In addition, the number of sampling points (24) required to achieve study objectives dictated low cost per sampling unit. Further, stated research objectives of comprehensive evaluation of physical, chemical, and biological processes occurring across the RFBS landscape meant that flow disturbance created in the vicinity of the sampling device as well as disturbances to the forest floor, in general, be kept to lowest possible levels.

To meet these design criteria, a relatively low-tech sampling device, designated the Low-Impact Flow Event (LIFE) was developed. Twenty-four LIFE samplers were installed starting in late 1991 at the Gibbs Farm Riparian Study site, which is located in the Coastal Plain region of south Georgia. The Gibbs Farm is the site of a number of related, intensive environmental quality studies examining the interaction of upland agricultural production areas and the adjacent, downslope riparian forests. These studies are being conducted by the SEWRL in cooperation with the University of Georgia's Dept. of Biological and Agricultural Engineering (BAE) and Institute of Ecology, as well as the USEPA.

The LIFE sampler typically consists of two components, a flow splitter and a sample collector, although flow splitters may be installed in series to further partition flow samples. Details of the design, construction and installation of the samplers are presented in this paper. An evaluation of the field performance of the LIFE samplers for this specific environmental quality research application is also presented, with particular emphasis on the suitability of the devices for estimation of the distribution of sediment deposition across the riparian forest buffer system.

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WATER MOVEMENT AND QUALITY WITHIN CONSERVATION TILLAGE RESEARCH IN CORN

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__Abstract:__ Highlights of water movement and water quality research in corn tillage studies at the Mississippi Agricultural and Forestry Experiment Station near Holly Springs over the past five years are presented. Agrichemical transport and losses were evaluated in runoff and shallow ground water from no-till (NT), conventional-till (CT), and reduced-till (RT) corn plots on fragipan soils. Results included low soil erosion rates found from NT corn plots and insignificant free water quantities at the fragipan's surface during the cropping season for all tillage systems with limited downward or lateral water movement and, thus agrichemical movement. Maximum ground water movement within the fragipan occurred during the non-cropping season under soil profile saturation. Amount and distribution of rainfall rather than tillage system primarily influenced agrichemical movement from corn systems in this region. Preliminary results indicate that conservation tillage (NT or RT) has limited detrimental effects to water quality in runoff and shallow groundwater and promote better soil water for crop utilization during the growing season.

INTRODUCTION

Pesticides move from agricultural fields to surface waters mainly in runoff (both in solution and sorbed to eroded sediment). The most commonly detected pesticides in surface waters are herbicides, including atrazine, alachlor, and cyanazine (Chrisensen *et al.*, 1993). Several studies have shown that these herbicides are lost from fields primarily in the water phase of runoff (Felsot *et al.*, 1990; Hall *et al.*, 1983; Thurman *et al.*, 1991; Smith and Cullum, 1992; Smith, 1993). Wauchope (1978) reported that edge-of-field runoff losses for most commercial pesticides are 0.5% or less of that applied, except when severe rainfall occurs within 1-2 weeks after application. Efforts to control and reduce soil erosion and these associated pesticide losses in aquatic ecosystems surrounding agricultural lands has led to increased adoption of NT and other RT practices. However, NT and RT practices often require an increase use of herbicides to control weeds that are usually controlled by CT. Also, increased infiltration associated with conservation tillage needs evaluation to determine the potential increase of contamination of our Nation's ground water with agrichemicals. The main objective of this study was to evaluate agrichemical transport and losses in runoff and shallow ground water from corn grown under different tillage practices in northern Mississippi to assist in development of better conservation tillage systems and agrichemical application practices.

METHODS

Agrichemical transport and losses were evaluated in corn systems on loessial fragipan soils in the uplands of northern Mississippi during 1990-1994. Pesticides and nutrients were measured in runoff and shallow ($\leq$ 3 m) ground water from NT, CT, and RT corn plots. Descriptions of the tillage practices were: (1) NT of plant (seed was slot planted using bubble coulters and double-disk openers), no row cultivation, harvest, and shred stalks, (2) RT of plant no-till, row cultivation twice during May, harvest, and shred stalks, and (3) CT of plant following chisel/disk preparation, row cultivation twice during May, harvest, and shred stalks. Nitrates, atrazine, alachlor, cyanazine, chlorpyrifos, and tefluthrin were the primary chemicals studied. Amounts and quality of surface runoff and subsurface drainage at top surface of fragipan layer also were determined.

Main components for shallow ground water included six hydrologically-isolated continuous corn plots (8.1-m wide by 38.1-m long) with subsurface drains (installed by horizontal drilling) placed on the fragipan surface; drain outlets into sumps equipped with tipping buckets mounted in 18.9-L containers; composite wastewater samplers; dataloggers for data collection and control; and a series of observation wells ranging from 30-cm to 3-m depths positioned in one row of each main corn plot. Further description of and methodology can be found in Cullum *et al.* (1992). The dataloggers recorded ground water discharge during storm events and activated the wastewater samplers when the cumulative discharge equaled 250 mm. Ground water incremental discharge and total discharge were recorded and the composite of the weighted-discharge samples were analyzed for specific chemicals introduced as fertilizer or pesticides. Also, water samples were collected for chemical analysis from the observation wells after depth measurements were made following major storm events.

Main components for surface runoff from subplots (4-m wide by 22-m long) within the above corn plots included properly-sized collectors, approaches, and H-flumes equipped with portable liquid-level recorders and potentiometers, runoff splitters, dataloggers, and composite wastewastewater samplers (described by Cullum *et al.*, 1992). The dataloggers recorded rainfall and runoff every minute during storm events. Wastewastewater samplers were activated by the dataloggers at each one millimeter of cumulative discharge. Derived variables from surface runoff were incremental discharge rate, cumulative discharge, sediment loads, and water quality.

Soil water contents were evaluated for each tillage system by using time domain reflectometry (TDR). Four sets of buriable wave guides were inserted into the soil spaced 90 cm apart in one corn row of each of the six plots at depths of 0 to 10 cm, 0 to 20 cm, 20 to 40 cm and 40 to 60 cm. The 24 implanted soil probes (buriable wave guides) were connected into the multiplex port of the TDR unit. The TDR unit was programmed to obtain dielectric constants and soil water contents from each probe on a 12-hr interval each day during the 1993 water year (Oct 1, 1992 to Sept 30, 1993).

RESULTS

Total runoff as percentage of total rainfall for the NT, RT, and CT systems was 56, 27, and 62 for 1991; 14, 29, and 38 for 1992; 14, 19, and 38 for 1993; and 12, 16, and 56 for 1994. The 92 water year produced approximately 30% greater sediment losses in the CT treatment than the NT treatment. Most differences occurred with first rains after planting when CT treatment was most exposed because of least amounts of residues. These trends were exhibited again in 1993 and 1994. Due to the establishment of the tillage plots in 1991, the differences in runoff for that year were not the result of the tillage treatment and were reported to show differences due to spatial variation in the plots.

The lateral flow of water was insignificant above the surface of the fragipan during each cropping season for all tillage systems. Free water was often perched above the fragipan intermittently from November through April during periods of soil profile saturation, and is suspected to move down-slope across the fragipan's surface. Upon inspection of the mean soil water contents from the time domain reflectometry measurements, the deeper wave guides were showing wetter soils for each date probably due to the influence of the fragipan layer that underlies this area. NT soil water contents generally were higher than CT at the 0 to 10 cm and 0 to 20 cm profiles (Figure 1) because of the cooler soils resulting from the greater amounts of residue cover in the no-till. The relatively high readings of 35% to 40% for soil water content also showed that the soil profiles were near saturation.

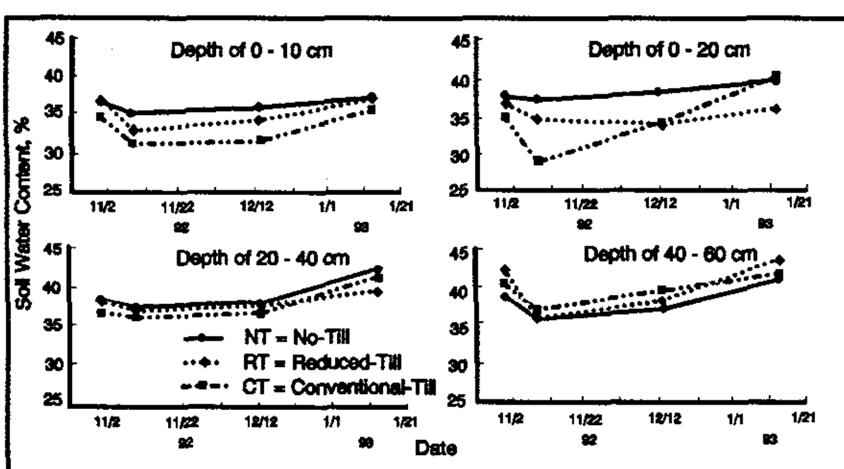

Figure 1. Mean soil water content for the three tillage operations at four depths in the corn experiment during the winter of 1992.

Tillage practices had limited affect on concentration of nutrients in ground water. Shallow ground water (≤3m) NO_3-N concentrations were essentially the same for either NT or CT, and were usually less than the drinking water quality standard of 10 ppm. Leaching of crop residues and the lack of sediment resulted in higher soluble nutrient concentrations in surface runoff under NT conditions throughout the study period. Surface and shallow ground water NO_3-N concentrations increased following spring broadcast of ammonium nitrate, but decreased in subsequent storms to pre-fertilization concentrations. This was more noticeable under CT.

Amount and distribution of rainfall were found to be the most common factor in influencing agrichemical movement in the study. Illustrations of the pesticide losses attributed to tillage treatments are displayed for the 1993 crop year in Figures 2 and 3. Results from the 1993 crop year (planting through harvest) showed that all five pesticides applied to the corn plots appeared in both the water and sediment phases of runoff. Total crop year runoff from NT and RT corn was 64 ± 9 and 75 ± 7 mm, respectively; whereas that from CT corn was about 3 times greater at 206 ± 13 mm. This likely resulted from higher crop residue levels on the surface in the NT and RT plots compared to the CT plots. The higher surface residue levels in NT and RT systems reduced runoff by reducing surface sealing and maintaining higher infiltration rates. Consequently, pesticide losses in the water phase of runoff from the three tillage treatments followed the order CT>RT>NT as displayed in Figure 2. As a pesticide class, herbicide losses in the water phase of runoff were higher than insecticide losses, primarily due to the herbicides' higher water solubilities. Of the herbicides, however, atrazine losses were greater than those of alachlor and cyanazine. Even though atrazine's water solubility is less than that of alachlor and cyanazine, its half-life is about 4 times longer. Atrazine concentrations in the ground water in the observation wells at the 3-m depth are shown in Figure 3. During the crop year, five ground water-producing rainfall events occurred after atrazine application (i.e., 2, 14, 21, 29, 167 days after application). During the first three weeks after application, atrazine concentrations for all three tillage treatments were about the same, averaging about 16, 18, and 20 $\mu g\ L^{-1}$ (ppb) for the NT, RT, and CT treatments, respectively. However, 29 days after application, atrazine concentrations reached their highest levels in the NT and RT treatments (94 and 54 ppb) and were about 6 and 3 times the concentration in the CT treatment (16 ppb), indicating increased infiltration in the NT and RT treatments. The last ground water-producing rainfall event during the crop year (167 days after application) resulted in ground water only in the NT treatment with atrazine at very low concentrations (5 ppb).

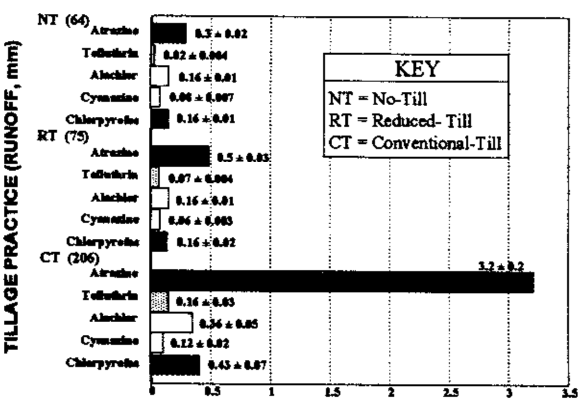

Figure 2. Pesticide losses in the water phase of runoff from the three tillage treatments.

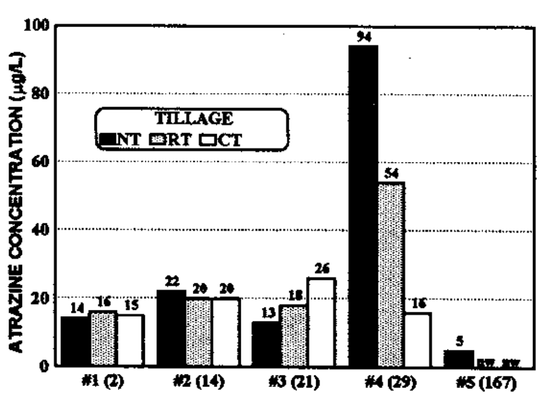

Figure 3. Atrazine concentrations in ground water in the observation wells at the 3-m depth.

Herbicide losses in the water phase of runoff were independent of tillage practice, such as NT, which reduced sediment concentrations in runoff by about two orders of magnitude compared to CT. Because herbicides are primarily transported in the water phase in runoff, herbicide losses in the sediment phase of runoff were low even with CT, where sediment concentrations in runoff reached 50,000 ppm or higher. In contrast, reductions in water phase runoff losses of the relatively water soluble herbicides of atrazine, alachlor, and cyanazine in NT and RT corn compared to CT corn were observed (Smith *et al.*, 1994). These reductions in herbicide losses were attributed to reductions in runoff volumes in NT and RT corn. These same two tillage practices appeared to facilitate greater herbicide leaching into the soil profile in shallow ground water, likely the result of the formation of conducting macropores and biochannels produced by soil faunal activity in these practices.

SUMMARY

Rainfall timing relative to agrichemical application was an important factor for agrichemical transport in this region. Amount and distribution of rainfall rather than tillage system were found to be the most common factors in influencing agrichemical movement from the corn systems for this study area. Annual mean nitrate concentrations in shallow ground water for all corn tillage systems were below the EPA maximum allowable drinking water quality standard of 10 ppm. Tillage differences in the study apparently do not affect the mean concentrations of plant nutrients in shallow ground water. Water movement was insignificant at fragipan's surface during cropping season for all tillage systems. NT had higher soil water content in root zone for longer periods during cropping season compared to CT. Atrazine, alachlor, cyanazine, chlorpyrifos, and tefluthrin were found in both water and sediment phases of the first runoff after application, and the three herbicides appeared in first shallow ground water of first major storm event after application. NT and RT reduced surface runoff and herbicide losses; but with the associated increased infiltration, higher herbicide concentrations were detected in shallow ground water for longer time periods.

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REFERENCES

Christensen, B., J. M. Montgomery, R. S. Fawcett, and D. Tierney. 1993. Best management practices to reduce runoff of pesticides into surface water: a review and analysis of supporting research. Conservation Technology Information Center, West Lafayette, Indiana. 42 p.

Cullum, R. F., J. D. Schreiber, S. Smith, Jr., and E. H. Grissinger. 1992. Shallow groundwater and surface runoff instrumentation for small watersheds. **Applied Engineering in Agriculture.** American Society of Agricultural Engineering. St. Joseph, MI. 8(4):449-453.

Felsot, A. S., J. K. Mitchell, and A. L. Kenimer. 1990. Assessment of management practices for reducing pesticide runoff from sloping cropland in Illinois. **J. Environ. Qual.** 19:539-545.

Hall, J. K., N. L. Hartwig, and L. K. Hoffman. 1983. Application mode and alternate cropping effects on atrazine losses from a hillside. **J. Environ. Qual.** 12(3):336-340.

Smith, S., Jr., and R. F. Cullum. 1992. Pesticide transport in loessial uplands of Mississippi. **ASAE Paper No. 922613.** Am. Soc. Agr. Engrs. St. Joseph, MI.

Smith, S., Jr. 1993. Effects of tillage on pesticide concentrations in shallow ground water and surface runoff from fragipan soils in northern Mississippi, USA. pp. 79-91. In: **Environmental Impact of Agricultural Practices and Agrichemicals.** Proceedings of the Second USA/CIS Joint Conference on Environmental Hydrology and Hydrogeology. Washington, D.C. May 16-21, 1993.

Smith, Jr., S., R. F. Cullum, and J. D. Schreiber. 1994. Pesticides in runoff and shallow groundwater from upland corn production in north Mississippi, USA. Second Int. Conf. Groundwater Ecol. TPS94-1:247-258. J. Stanford and M. Vallett (eds.), AWRA, Herndon, VA.

Thurman, E. M., D. A. Goolsby, M. T. Meyer, and D. W. Kolpin. 1991. Herbicides in surface waters of the Midwestern United States: the effect of spring flush. **Environ. Sci. Technol.** 25:1794-1796.

Wauchope, R. D. 1978. The pesticide content of surface water draining from agricultural fields- A review. **J. Environ. Qual.** 7:459-472.

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THE DEMONSTRATION EROSION CONTROL (DEC) PROJECT IN THE YAZOO BASIN

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Abstract: The drainage of highly erodable hill lands of northern Mississippi plunges into the Mississippi River alluvial plain. Since streams have no bed controls, channels have degraded 2-3 meters into the landscape and have set off massive bank failures, many times resulting in explosive channel widening. Headcuts, bank caving, and gully formation are common landscape features. The Demonstration Erosion Control (DEC) Project in the Yazoo Basin is a large-scale federal interagency demonstration and research project centered in the erodable loessial uplands of northern Mississippi. The project, initiated in 1984, is concerned with developing technology to stabilize streams, control upland and channel erosion, and rehabilitate watersheds. The project also contains an environmental component which evaluates standard and modified stream stabilization practices for stream rehabilitation and environmental enhancement. It is focused on 15 watersheds that range in size from 0.33 mi^2 to 613 mi^2 (0.89 to 1,590 km^2). Major participants include the USDA-National Sedimentation Laboratory, the U. S. Army Corps of Engineers, Vicksburg District, and Waterways Experiment Station, the USDA-Natural Resources Conservation Service and U. S. Geological Survey.

INTRODUCTION

Soil and water conservation is a priority of the agricultural community, the American public, and federal/state action agencies. The erosion/sedimentation cycle continues to be an area of conservation emphasis because of detrimental effects on soil productivity and potential for off-site contamination and ecosystem deterioration. Remedies for specific erosion/sedimentation problems must generally be taken from proven handbook or design manuals, but unproved design alterations may be necessary to deal with severe problems such as those encountered in the eroded channels of the Yazoo foothills. In addition, new ideas may require extra time and money, and evaluation of project success is often severely limited by funding constraints. These factors make testing and evaluating new designs difficult on a real-world scale.

In FY 84 Congress passed Public Law 98-8 that authorized the Demonstration Erosion Control (DEC) Project in the Yazoo Basin to demonstrate methods of reducing flooding, erosion, and sedimentation in 6 selected watersheds in the foothills region of the Yazoo River Basin. Public Law 98-8 mandated formation of an interagency team and authorized the Corps of Engineers and the Natural Resource Conservation Service to work jointly in watershed treatment; it further instructed the USDA-Agricultural Research Service and the COE Waterways Experiment Station to evaluate the effectiveness of the project.

In addition to proper land use treatment and channel stabilization measures that lessen watershed degradation and reduce downstream problems, the DEC project has a strong environmental component oriented toward finding measures or modifications that enhance stream rehabilitation. This article briefly documents the project and its major activities.

<u>Location Rationale</u>: The foothills of the Yazoo Basin in Mississippi have a loess cap that covers unconsolidated gravels and clays. These layers overtop sand. Thus, permanent bed controls are non-existent. Clearing and farming of the region brought massive erosion, gully formation and sedimentation problems. Loess soils rapidly eroded from hilltops and sideslopes and filled valleys with over a meter of new sediment. Stream channelization to "improve" drainage exacerbated stream instability. As a result of the landscape scale erosion, Congress declared the area a national disaster and passed the Flood Control Act of 1954 (P.L. 534) which established a massive flood prevention program. This program stabilized much of the local landscape but did little to reverse channel erosion processes. Channel incision from several causes (lowering of local river levels, channelization of downstream portions of streams, knickpoints, and excessive stream energy) was followed in many streams by

explosive channel widening. Harvey and Watson (1986) documented that channel cross-sections increased by as much as 1000% during this erosional phase. When Grissinger and Murphey (1989) measured cross-sections in a 2.9 mi (4.7 km) length of Goodwin Creek, Mississippi, they found that eroded channel bank materials averaged 4700 yds^3/mi (1900 m^3/km) per year. Bed materials aggraded over 4000 yds^3 (3000 m^3) for the reach during the 10 years of record.

Nine additional watersheds were added by FY 88 (Table 1) to the original six watersheds authorized by Congress in FY 84. The area is ideal for a demonstration because the unstable channels in the Yazoo foothills are comparable to similar degraded watershed streams in hill lands that drain into the Mississippi River from Iowa to Tennessee. Many of the structural and non-structural measures in the project are applicable to stream problems along both coasts and on other continents.

ACCOMPLISHMENTS

As of 1995, bank stabilization was the most common construction activity (Table 1) in the DEC watersheds [471,208 ft (142,790m)]. Bank stabilization has taken many forms: full-bank paving, toe protection, bendway protection, spur dikes, and weirs. Stone rip-rap is the most common material used.

Knickpoint migration, first described by Happ et al. (1940), is the most common method of trenching in these unstable streams (Ethridge, 1979). Ethridge (1979) found that knickpoint movement in Johnson Creek averaged 160 m/yr from 1940 through 1975. Four types of grade control structures have been used in DEC to control headcutting erosion. Field-scale grade control pipes are the most commonly constructed structures (750 pipes). These structures, commonly called riser or drop pipes, stop lateral headcuts from overbank flow, stabilize gullies, and provide additional streamside habitat for a variety of animals. Low-drop grade control structures are used for vertical stabilization where head cuts or knickpoints are migrating upstream. In addition, four more costly high-drop grade control structures have been constructed because of the magnitude and severity of headcutting in some areas. In several instances road and bridge stabilization and installation of box culverts have been used to stabilize knickpoints and improve local road infrastructure.

A floodwater retarding structure is a relatively small impoundment constructed near the headwaters of a tributary. It controls both amount and also velocity of floodwater and serves as a sediment trap. Dendy and Cooper (1985) found that small impoundments trap an average of 77 percent of fine sediment and up to 100 percent of sand that is flushed into them. Eight floodwater retarding reservoirs have been constructed to dampen hydrograph peaks, especially where downstream overbank flooding has been a concern.

Channel clearing and snagging has been necessary on 21,600 feet (6,545 m) of channel where debris density and aggradation caused flooding problems. Over 30,000 feet (9,000 m) of levees have been constructed or repaired in alluvial areas. A pumping plant has been incorporated into one system to dispose of interior floodwater. On Abiaca Creek, setback levees have been designed to allow for construction of a bottomland hardwood riparian zone which will also serve to trap sediment which is accumulating in a national wildlife refuge.

As information on ecological evaluations has become available during the project construction design has shifted to incorporate environmentally sound practices. Grade control plunge pools have been enlarged to provide more permanent habitat (Cooper and Knight, 1987). Spur dikes with extensions coupled with woody vegetation are commonly used instead of lateral stone paving since they create additional mesocosms of habitat (Shields, et al., 1993). Weirs form riffle/pool sequences and create deep pools necessary to maintain harvestable fish populations. Dormant willow (*Salix sp.*) posts are planted on sand bars and stream banks to promote accumulation of fine sediments and to provide a source of carbon, canopy, and woody debris.

CONCLUSIONS

The Demonstration Erosion Control (DEC) Project in the Yazoo Basin is about two-thirds completed. While long-term project successes will only be determined after construction completion and evaluation, major successes are becoming evident. The watershed approach to channel stability/flooding problems appears successful.

Federal and state action agencies across the U. S. are already benefitting from the demonstration. Channel stability measures can be successfully combined with environmental stewardship so that funds can be expended to lessen stream erosion can also improve habitat.

"All programs and services of the U.S. Dept. of Agriculture are offered on a nondiscriminatory basis without regard to race, color, national origin, sex, age, marital status, or handicap."

REFERENCES

Cooper, C. M. and Knight, S. S., 1987, Fisheries of natural scour holes and manmade pools below grade control structures in high gradient streams. J. Soil and Water Conservation 42:370-373.

Dendy, F. E. and Cooper, C. M., 1985, Sediment trap efficiency in a small reservoir. J. Soil and Water Cons. 39:278-280.

Ethridge, L. T., 1979, Photogrammetric interpretation of stream channel morphology, Johnson and Goodwin Creeks, Panola County, Mississippi. M. E. S. Project, Dept. of Geology, The Univ. of Mississippi, University, MS, 24 pp.

Grissinger, E. H. and Murphey, J. B., 1989, Bank stability of Goodwin Creek, northern Mississippi, USA. Proc. Fourth International Symp. on River Sedimentation, June 5-9, 1989, Beijing, China, Vol. 1:59-66.

Happ, S. C., Rittenhouse, G., and Dobson, G. C., 1940, Some principles of accelerated stream and valley sedimentation. USDA Technical Bulletin No. 695, U. S. Government Printing Office, Washington, D.C., 133 pp.

Harvey, M. D. and Watson, D. D., 1986, Fluvial processes and morphological thresholds in incised channel restoration. Water Resources Bulletin 22:359-368.

Shields, Jr., F. D., Cooper, C. M., and Knight, S. S., 1993, Initial hab tat response to incised channel rehabilitation. Aquatic Conservation: Marine and Freshwater Ecosystems 3:93-103.

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Table 1. Itemized construction activities of the DEC Project (work completed through 1995).

Watersheds	Area Square Miles	Bank Stabilization (000) Ft.		Riser Pipe #		Low Drop #		Levee (000) Ft.	
		NRCS	*Corps*	*NRCS*	*Corps*	*NRCS*	*Corps*	*NRCS*	*Corps*
Abiaca	*199.4*				9		3		
Batupan	*254.5*	5.4	81.8	34	42		27		
Black	*476.6*	8.3	137.8	15	68		9	17.3	
Burney	*16.2*								
Cane-Mussacuna	*28.1*			17	11				
Coldwater	*612.5*	2.2	51.2	82	179		6		
Hickahala	*207.8*	19.9	13.9	71	48		21		
Hotophia	*32.3*	12.4	20.2	26	20	2	6		
Hurricane-Wolf	*72.9*		9.4		25		2		
Long	*86.1*	26.2	37.9	45	11		8		
Otoucalofa	*117.2*	0.4	39.6	31	17		3		
Pelucia	*128.3*						1		
Sherman	*8.4*	4.7		3				12.8	
Town	*46.9*								
Toby Tubby	*0.3*					3			
TOTAL	**2287.5**	**79.5**	**391.8**	**324**	**430**	**5**	**86**	**30.1**	

Watersheds	High Drop #		Floodwater Retarding Structure		Channel Improvement (ft.)		Road & Bridge Stabilization #		Box Culverts #	
	NRCS	*Corps*	*NRCS*	*Corps*	*NRCS*	*Corps*	*NRCS*	*Corps*	*NRCS*	*Corps*
Abiaca										
Batupan							4	1		
Black							4			
Burney					7273	1800	2			
Cane-Mussacuna										
Coldwater	1						7	7	10	
Hickahala							6	7		
Hotophia	2						2			
Hurricane-Wolf										
Long							7			
Otoucalofa			8			4300				
Pelucia								1	(See NOTE*)	
Sherman										
Town	1				6546					
Toby Tubby					1800					
TOTAL	**4**	**0**	**8**	**0**	**15619**	**6100**	**32**	**16**	**10**	

*NOTE: 200 cft. pumping plant and a new bridge on Palusha Bayou - 1995.

RESEARCH PROGRAM
OF THE USDA-NATIONAL SEDIMENTATION LABORATORY

By G.R. Foster, Director, USDA Agricultural Research Service, National Sedimentation Laboratory, Oxford, MS

The National Sedimentation Laboratory, located in Oxford, Mississippi, conducts basic and applied research on processes related to soil erosion, sedimentation, water quality, and aquatic ecology that occur within watersheds, stream channels, and reservoirs. The laboratory, established in 1959, is one of about 120 locations of the USDA Agricultural Research Service.

The laboratory is ideally located to study the environmental impact of agricultural activities. The soils in the Oxford area are highly erodible and the climate is very erosive. Typical crops of cotton and soybeans provide inadequate protection against soil erosion without intensive conservation practices. Stream channels in the bluffline hills adjacent to the Mississippi Delta are steep and unstable, causing high rates of erosion, large sediment loads, and major sedimentation problems where stream gradients flatten in the Delta. The habitat for fish and other aquatic organisms is very degraded in these streams.

The Mississippi Delta, an important U.S. crop production area, has more than 80 percent of its area in cultivation. Extensive pesticide usage for the predominant crop of cotton has the potential for excessively degrading water quality in streams and reservoirs.

The laboratory's findings, which have particular local importance, apply to other parts of the U.S. besides the Delta region such as Missouri, Iowa, Kentucky, and Tennessee that have unstable channel systems. The laboratory's research on basic hydraulic and erosion processes has universal applicability. The laboratory is nationally and internationally recognized for important contributions to both advancement of science and technology used by action agencies.

The laboratory's staff of about 60 Full Time Equivalents includes 14 scientists and is distributed among the three research units of upland erosion processes, channel/ watershed processes, and water quality/ecology processes. The Center for Computational Hydroscience and Engineering and the National Center for Physical Acoustics at the University of Mississippi conduct research in cooperation with the National Sedimentation Laboratory.

UPLAND EROSION PROCESSES

Research on upland erosion processes emphasizes understanding erosion and transport of sediment from agricultural lands, development of improved erosion control practices, and development of improved erosion prediction methods. Studies are being conducted to determine how soil properties affect erosion of fragipan soils in a landscape setting. Measurements are being made in the fragipan region from as far south as Louisiana to as far north as southern Ohio. Erosion seriously degrades these easily eroded soils. Residue from treatment of flue gasses at power plants is being studied as amendments for destroying fragipans and greatly improving the quality of these soils.

Tillage and cropping can also be modified to greatly improve soil properties to increase infiltration, reduce erosion, and increase crop yield. Studies of the micro-morphology of soils and experimental laboratory and field tests are determining how cropping and management affects soil properties, how rapidly these properties change with time after a change in land use practice, and how they affect erosion and crop yield.

Soils vary in how their physical and chemical properties affect sealing and the initiation of rilling. Similarly soil roughness left by tillage varies as a function of intrinsic soil properties and soil properties affected by management. Rainfall characteristics, soil properties, and vegetative cover affect the rate that rainfall reduces roughness. Laboratory and field research using simulated rainfall is being conducted to determine fundamental relationships for the processes of sealing, rilling, and the decay of surface roughness.

Intensive conservation practices are needed in the southeastern US because of the erosive climate, highly erodible soils, and the predominance of the low residue crops of cotton and soybeans. A major focus at the National Sedimentation Laboratory is to develop erosion control methods that are fully acceptable to farmers. No-till conservation tillage, cover crop systems, and conversion of CRP land into no-till without plowing are conservation systems being studied. Strips of stiff grass hedges are being studied as a way to control ephemeral gully erosion and sediment delivery from fields and other upland areas.

Erosion prediction is an important tool used extensively by soil conservationists to identify areas of excessive erosion and guide the selection of conservation practices to control erosion. The National Sedimentation Laboratory, along with other ARS and university locations, is developing the Revised Universal Soil Loss Equation (RUSLE), the principal method used by the USDA-Natural Resources Conservation Service and other agencies for estimating rill and interrill erosion.

CHANNEL AND WATERSHED PROCESSES

Channels collect runoff from upland areas and deliver water, sediment, and other constituents from watersheds into increasingly larger drainage basins. The amount of sediment that leaves a watershed depends on the sediment transport capacity of flow in the channels plus the potential for streamflow to cause erosion that adds to the sediment load being delivered to the channels from the upland areas.

Research on erosion and sediment processes in channels is being conducted at the National Sedimentation Laboratory using flumes in an indoor hydraulics laboratory and in the channels of the 20 square kilometer Goodwin Creek Experimental Watershed located near Oxford, Mississippi. This watershed, in operation for about 15 years, has experienced a decrease in cultivated land from 30 percent of the watershed area to about 10 percent. This decrease in cultivated land, which is the major source of sediment on upland areas, has provided data that are being analyzed to determine how changing land use affects runoff, sediment yield, properties of sediment, and source of sediment.

The channels in the Goodwin Creek Experimental Watershed are unstable because they are over-steepened and have banks and beds that are easily eroded. Numerous headcuts are moving upstream and producing large quantities of sediment. About 80 percent of the sediment leaving the watershed is estimated to be from the channels rather than from the upland areas. However, the decrease in cultivated land seems to have affected erosion in the channels more than anticipated based on measured streamflow. Channels that are significant sources of sediment may be far upstream in the watershed in areas that typically receive little attention in watershed research and in areas that respond to changes in land use. The complexity of the situation is requiring a reexamination of the role of channels with respect to location within the watershed.

A watershed responds to a change of land management and to the installation of grade control, spur dikes, and other structures over many years. Both field and laboratory studies are being conducted to determine how structures affect channel hydraulics, local erosion and deposition, and local aquatic habitat. The 15 years of data in Goodwin Creek Experimental Watershed illustrate some changes, but the data are not definitive. To fill in the gap, watershed simulation models are being modified to describe watershed response over extended periods like a half century. The laboratory is developing geographical information systems, digital elevation models, and topographic software to serve as an interface for supplying the spatially distributed input required by watershed models including SWAT and AGNPS. Also, components are being added to the models to account for local bank erosion and to account for the effect of in-stream structures on flow hydraulics and headcuts. Mathematical relationships are being developed from field and laboratory studies to describe the transport of sediment mixtures of clay, silt, sands, gravels, and aggregates composed of primary particles. The models will be used to evaluate changes in channel evolution and sediment yield over the next 50 years.

WATER QUALITY/ECOLOGY PROCESSES

The large sediment loads and the extremely degraded channels in the loess hills of Mississippi, Missouri, Iowa, and other similar areas result in a very poor aquatic habitat in these channels. Research is underway to determine how grade control structures, groins, and spur dikes can both stabilize the channels, provide dramatically improved aquatic habitat, and restore the overall ecological well-being of the stream channel system. In addition, a stream corridor approach where vegetative material on channel banks, drop inlets for delivering sediment from adjacent upland areas to the incised stream channels, and riparian zones along the channels are being evaluated. Sediment is deposited around the entrance to the drop inlets, and water is ponded creating a local area of much biological diversity. The low cost of some of these practices make them attractive to wide spread application.

These studies include an extensive ecological assessment of stream channels and lakes to determine the ecological impact of stream channel evolution and upland agricultural activities. Presence of currently used agricultural chemicals and the persistence of chemicals discontinued a few decades ago are being studied and their impact determined. Historic chemicals like DDT are still present but are usually bound to stable sediment on the bottom of streams and reservoirs.

Excessive use of agricultural pesticides and plant nutrients can cause these compounds to move to surface and ground water. Field studies are being conducted on upland areas to determine how these chemicals move in soils where a restricting layer about a meter below the soil surface creates a shallow ground water during a portion of the year. These studies are also showing how agricultural management and type of compound interact to affect movement and ecological impact of agricultural chemicals.

DEMONSTRATION EROSION CONTROL (DEC) PROJECT

The very high erosion rates in the bluffline hills on the eastern side of the Mississippi Delta produce high sediment loads that cause major sedimentation problems where the flow reaches the low stream gradients in the Delta. This sedimentation causes flooding and loss of wetlands. In the mid-1980's Congress established the Demonstration Erosion Control (DEC) Project to reduce erosion in the bluffline hills. The project is a cooperative effort involving the National Sedimentation Laboratory, the US Army Corps (COE) of Engineers at the Vicksburg District Office and the Waterways Experiment Station, the USDA-Natural Resources Conservation Service (NRCS), the US Geological Survey (USGS), the University of Mississippi, and Colorado State University. The principal role of the COE and NRCS is to install a variety of watershed and channel protection measures in the 15 DEC watersheds. The principal role of the National Sedimentation Laboratory and the other research organizations is to characterize the watershed land and channel areas and to evaluate the before and after effects of the project. The information learned during the project is being transferred to other parts of the US and the world by its incorporation into an interagency handbook on channel restoration and other technology transfer activities.

MANAGEMENT SYSTEM EVALUATION AREA (MSEA) PROJECT

The Mississippi Delta is an intensively cropped area with cotton and soybeans being major crops. Even though the land is nearly flat, sediment yield from Delta fields can be about twice soil loss tolerance values and can, along with agricultural chemicals, seriously degrade streams and lakes. The MSEA project is an inter-agency effort on the part of the National Sedimentation Laboratory, USGS, Mississippi State University, NRCS, and several state and local agencies to study the impact of agricultural activities on three oxbow lakes. The watersheds for each of the three lakes will be treated differently, one with typical practices, one with a moderate level of practices to improve water quality, and one with an intensive set of practices. Runoff, sediment, and loss of chemicals from the fields and delivered to the lakes will be measured. In addition, the ecological conditions of the lakes will be intensively measured such that the ecological impact of agricultural practices on water quality can be directly determined.

ABSTRACT

SUSPENDED SOLIDS IN LAS VEGAS VALLEY WET WEATHER FLOWS

Submitted to

SIXTH FEDERAL INTERAGENCY SEDIMENTATION CONFERENCE

by

Edwin "Chip" Paulson
Montgomery Watson

Wet weather monitoring has been conducted in Las Vegas since 1992, as required by the NPDES Stormwater Discharge Permit for the municipalities in the Valley. Automated water quality samplers at six sites have collected samples from up to three storms in each year. Monitoring sites are located at the downstream end of each of the six major tributaries to Las Vegas Wash. The Wash drains all of the urban area of the Valley into Lake Mead, which is the primary drinking water source for Las Vegas and surrounding communities.

One of the parameters of concern is suspended solids. Wet weather TSS concentrations have been summarized for the 4-year monitoring period, and compared to TSS concentrations from other urban areas. TSS concentrations are high relative to other urban areas due to background levels in the desert environment (surface and channel erosion), as well as to extensive construction activity throughout Las Vegas Valley. Wet weather TSS concentrations have also been compared to dry weather TSS concentrations at the same monitoring sites.

The USGS National Water Quality Assessment (NAWQA) Program has conducted monitoring in Las Vegas Wash and at the outfall of the Wash at Lake Mead concurrently with the last two years of the NPDES monitoring of the tributaries. This allows a comparison to be made between tributary TSS loads and loads in the receiving waters. The impact of erosion and other solids sources in the Las Vegas urban area on downstream water quality can then be evaluated.

Conference Topics Addressed: Data Collection
Nonpoint Source

DEVELOPMENT OF A GIS-BASED FLOWNET GENERATOR FOR AGNPS

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The Hydrologic Unit Water Quality (HUWQ) interface project was initiated by the Natural Resources Conservation Service (NRCS) in the spring of 1992. The main goal of the project is to create a geographical information system (GIS) based input generator for four water quality pollutant loading models developed by the Agricultural Research Service (ARS) (Figure 1). One of these models is the watershed simulator AGNPS (Agricultural Non-Point Pollutant Source) (Young et al., 1989), which NRCS planners use for watersheds as large as 2500 square kilometers. AGNPS allows users to track pollutants back to their source, because the model calculates runoff and pollutant loading from rain or snowmelt or irrigation, which may transport pesticides, fertilizers, or sediment throughout a watershed. By pinpointing the major pollution sources, the model helps planners focus their corrective actions at those locations. The model is also used by other government and private agencies and organizations throughout the world.

Scientists at the USDA-ARS National Sedimentation Laboratory have entered into a partnership with NRCS personnel to develop advanced technology needed to implement the AGNPS model in NRCS field offices and other locations. This cooperative effort is intended to produce a robust and accurate geographical information system (GIS) flownet generator based on the ARS TOpographic PArameteriZation (TOPAZ) model (formerly DEDNM) (Garbrecht and Martz, 1995). Essential for the proper, efficient use of AGNPS is terrain-enhanced technology for automatic generation of computational grids, delineation of watershed boundaries, flow drainage network, cell-connectivity, identification of topographic attributes from a user-supplied digital elevation model (DEM), and on-screen DEM editing. Enhancement of these techniques in the HUWQ interface will permit better AGNPS characterizations of the effect of terrain on runoff, erosion, and water quality processes, and will improve the efficiency of input generation for AGNPS.

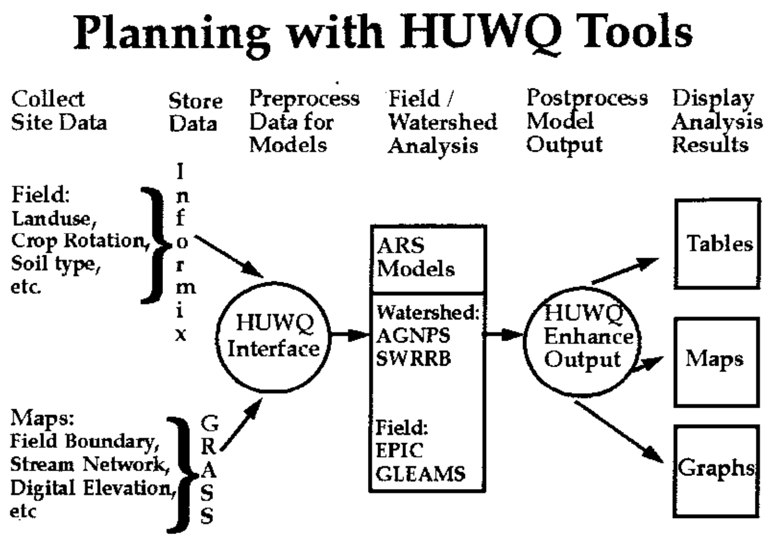

Figure 1. Flowchart of the planning method used in HUWQ.

FLOWNET GENERATOR DEVELOPMENT

The AGNPS flownet generator is being developed using standard ANSI FORTRAN 77 or higher, with eventually two versions in use. Version one will be a stand-alone PC-based, MS Windows 3.1 or later application. Version two is being developed for the HUWQ project to run on UNIX, SunOS 4.1.3 or later, operating systems. Version two will utilize the database manager, Informix, and the GIS software, GRASS (Shapiro et al., 1992), to develop input parameters for erosion models, one of which is AGNPS.

Version one will provide a Windows-based visualization of the watershed flownet and other topographic features. The dataset needed by AGNPS to determine the flow directions for the water quality attributes and channel characteristics of each cell are automatically generated from a DEM. An example of the flownet visualization is shown in Figure 2, using information obtained from the 21.3 km^2 USDA Goodwin Creek Experimental Watershed (GCEW) located in northern Mississippi. Each grid represents a 2 hectare cell. The flow direction from cell-to-cell can be determined along with the associated watershed boundary, using information from TOPAZ extracted from a 30m by 30m DEM of the area. The use of AGNPS requires information from each cell on the characteristics of the channel. The flownet generator determines both the dominant channel within each cell and the channel's slope. Slope is based on the length and elevation change of the channel within each AGNPS cell (Figure 3). Representative channel width and depth are calculated for each cell based on power equations using drainage areas into and out of the cell.

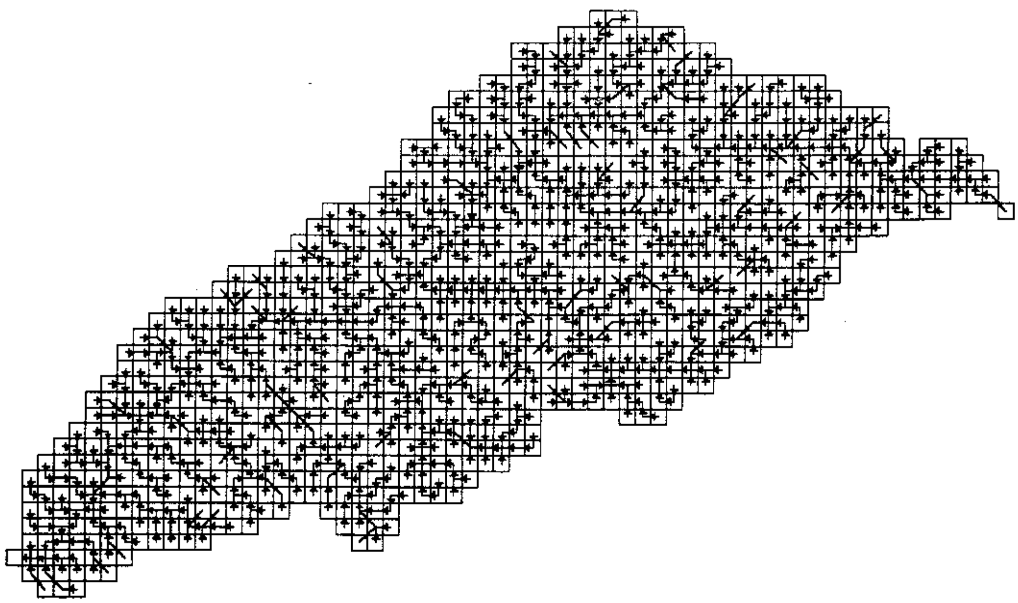

Figure 2. Flow direction network for each AGNPS cell within Goodwin Creek Experimental Watershed.

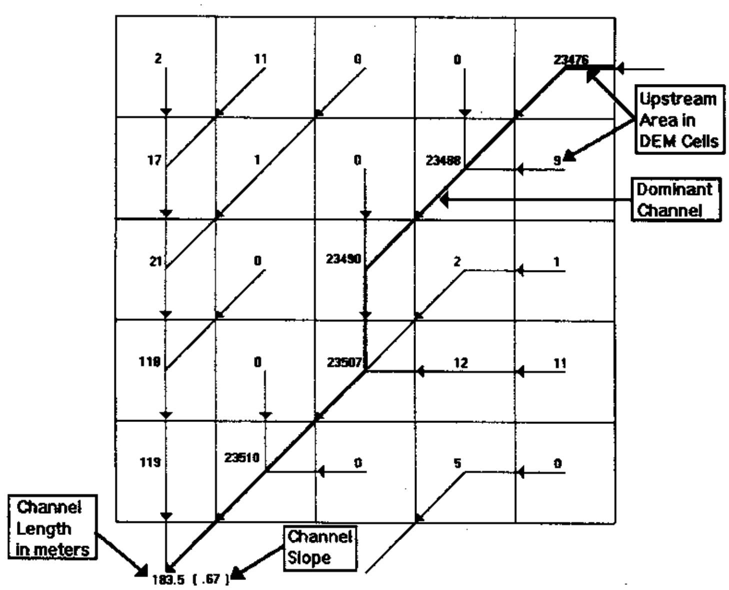

Figure 3. A single AGNPS grid cell composed of cells from a DEM. Highlighted are the associated dominate channel characteristics computed for this AGNPS cell.

Figure 4 shows the dominant channel length estimated from the flownet generator for each AGNPS cell used for GCEW. The darkened cell shows the location of the AGNPS cell illustrated in Figure 3. Channel slope for each AGNPS cell is calculated using the dominant channel length and the elevation change associated with that channel.

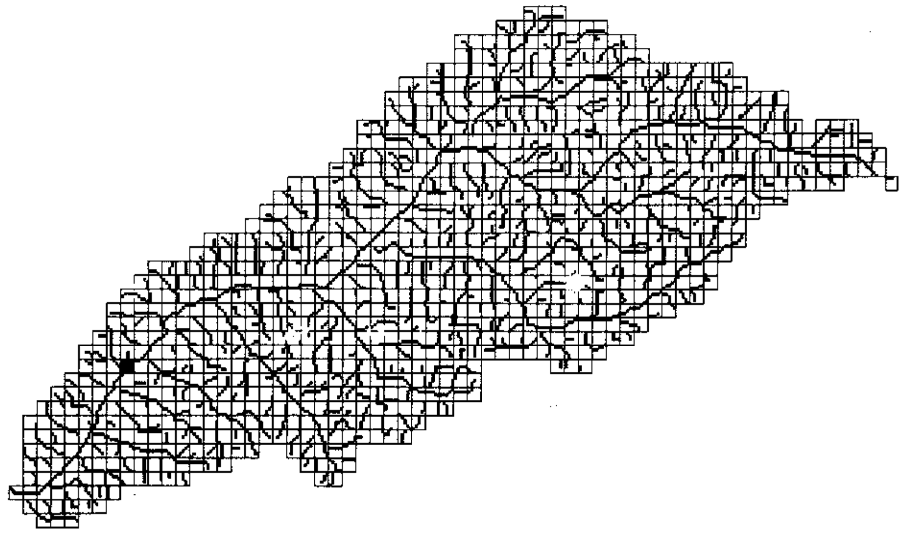

Figure 4. Dominant channel length for each AGNPS cell within Goodwin Creek Experimental Watershed determined by the flownet generator.

SUMMARY

The use of these interface tools will simplify the process of determining AGNPS cell locations and associated flow direction and channel characteristics of a watershed. This informational tool will be incorporated into a comprehensive interface tool (HUWQ) that can provide the complete AGNPS input database, along with several other models. This will provide a management tool that can more effectively evaluate best management practices throughout a watershed system.

REFERENCES

Garbrecht, J., and Martz, L.W., 1995, TOPAZ: An Automated Digital Landscape Analysis Tool for Topographic Evaluations, Drainage Identification, Watershed Segmentation and Subcatchment Parameterization; Overview. ARS Pub. No. NAWQL 95-1, USDA-ARS, Durant, OK. 16 pp.

Shapiro, M. J., Westervelt, J., Gerdes, D., Larson, M., and Brownfield, K. R., 1992, GRASS 4.0 Reference Manual. U. S. Army Corps of Engineers - CERL, Champaign, IL.

Young, R. A., Onstad, C. A., Bosch, D. D., and Anderson, W. P. 1989, AGNPS: A nonpoint-source pollution model for evaluating agricultural watersheds. Journal of Soil and Water Conservation 44(2): 168-173.

MEASUREMENT AND PREDICTION OF TOTAL SEDIMENT LOAD IN AGRICULTURAL WATERSHEDS

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Determining the total sediment load of the channels in a watershed is important for several reasons. The total sediment load in a channel represents net erosion from upstream areas of the watershed. Sediment that is conveyed downstream may fill channels and reduce their capacity to convey floodwaters, may fill reservoirs and reduce their storage capacity, and may degrade water quality and make the stream unsuitable habitat for aquatic organisms. Any long term management program must take into account the movement of sediment through a watershed. Channel sediment transport capacities must be in balance with sediment supplied to the channel or instabilities will result. Too much sediment supply can fill channels, destroy habitats, and cause flooding. Too little sediment supply contributes to channel degradation, making banks unstable and resulting in loss of valuable lands and critical riparian areas.

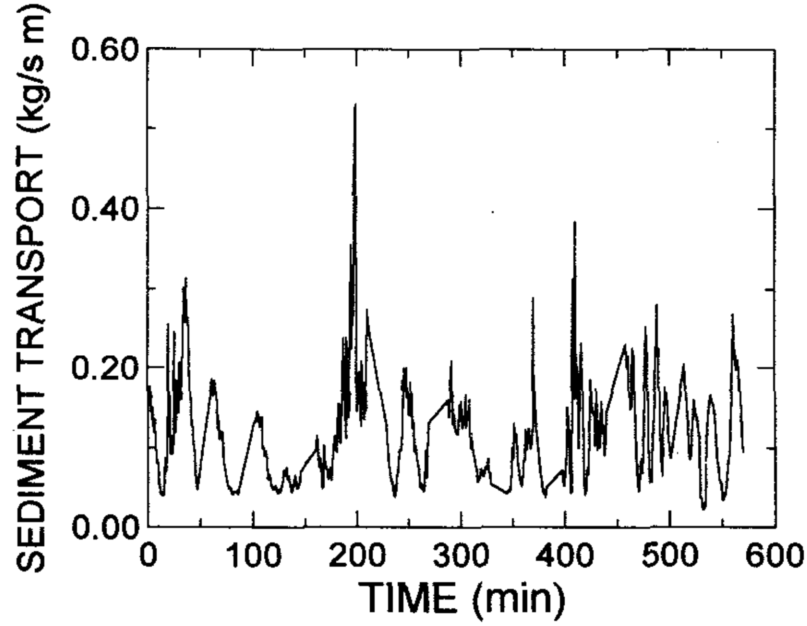

Figure 1. The sediment transport data, collected with a density cell in the 30 m model stream channel, illustrate the large amount of variability that is present even under steady controlled laboratory conditions. Several hours of data are needed to calculate a representative average transport rate.

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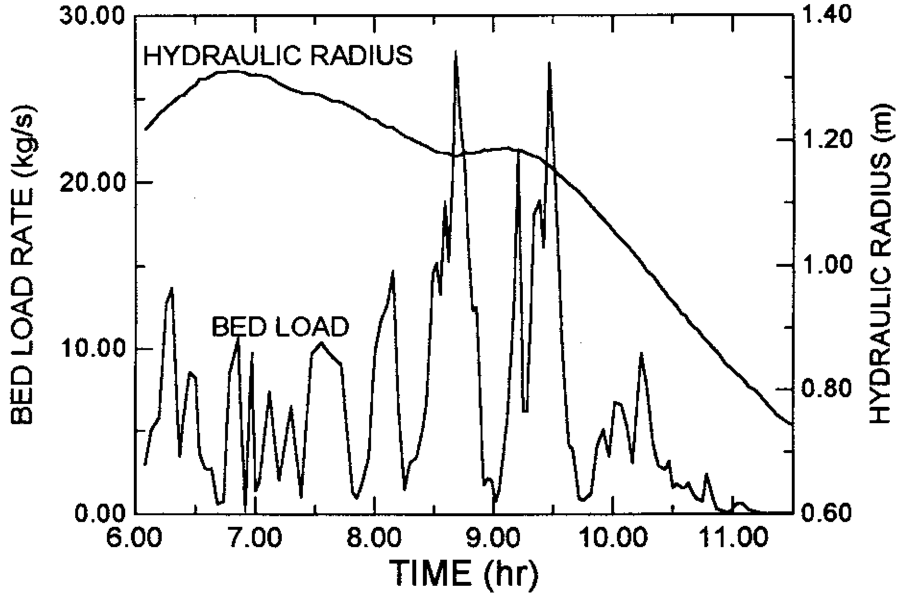

Figure 2. The transport rate of sand and gravel along the bottom of the stream (bed load) is shown with time for one runoff event on Goodwin Creek. The large variations in transport rate are characteristic of bed load transport and make the collection of many samples necessary to calculate accurate mean transport rates.

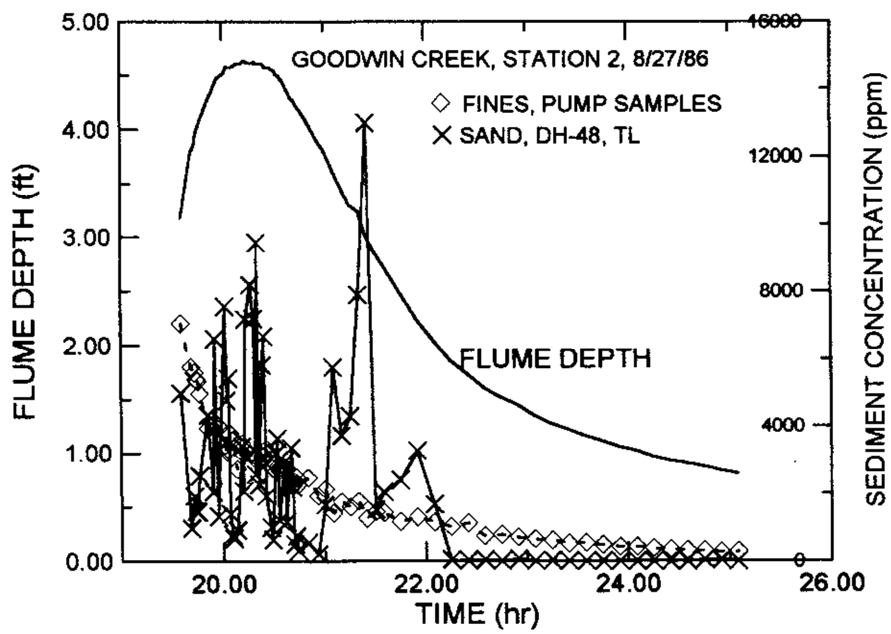

Figure 3. The rate of transport of fines and sand is shown for one runoff event on Goodwin Creek. The transport rate of fine (< 0.062 mm) and sand (0.062 - 2.0 mm) sediment is sampled by automatic pumping sampler and manual equal transit rate samples, respectively. The rate of transport of the sand changes more rapidly with time than that of the fine sediment.

For many years, the National Sedimentation Laboratory (NSL) has been a leader in sediment transport research. Research is currentlv being conducted in laboratory flumes and in the Goodwin Creek Research Watershed. Basic concepts in sediment transport developed from experiments conducted under controlled conditions in the laboratory (Fig. 1) are tested with field data collected on the Goodwin Creek watershed. Ten years of flow and sediment transport data have been collected on Goodwin Creek. The watershed provides valuable data on the transport of sediment under the changing conditions of a natural system (Figs. 2, 3). The data collected are being used to develop and refine predictive models of sediment transport. One such model is SEDTRA, designed to predict total transport of silts, sand, and gravel materials. SEDTRA was developed by Jurgen Garbrecht (ARS, Durant, OK) and is being refined using sediment transport data collected in NSL laboratory flumes (Fig. 4A) and on Goodwin Creek (Fig. 4B). Some of the algorithms used by SEDTRA were originally supplied by NSL.

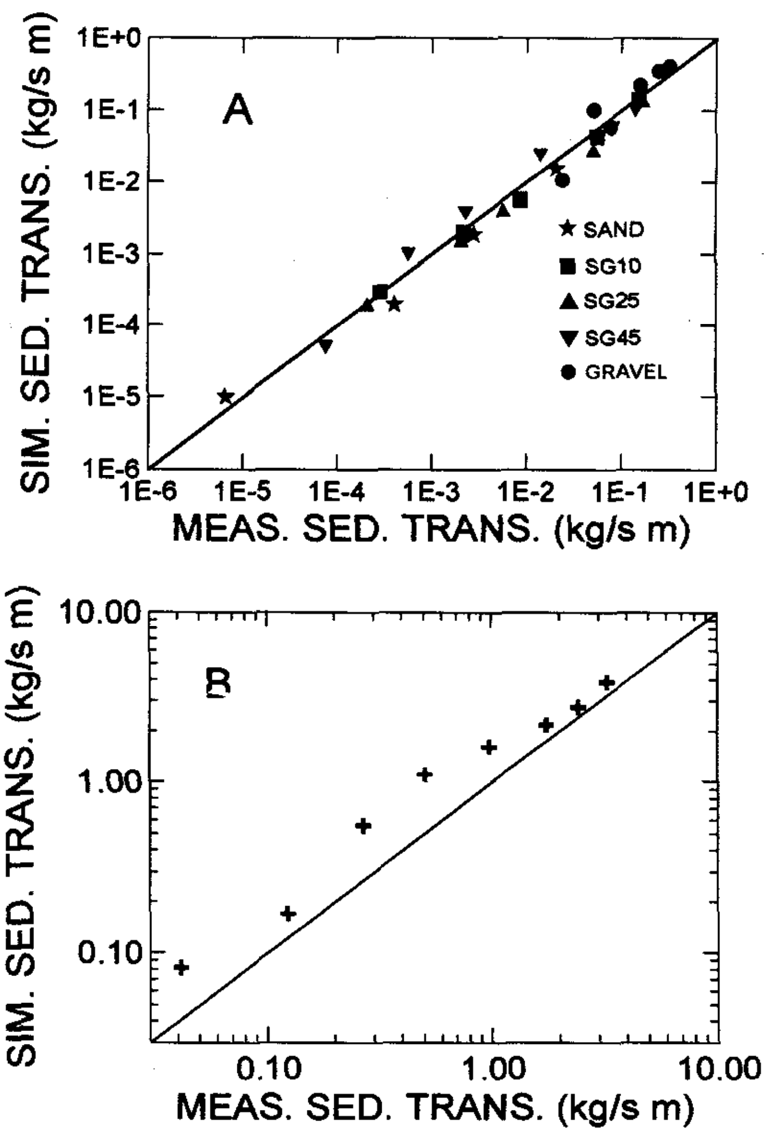

Figure 4. Sediment transport data collected in laboratory channels (A) and field channels (B) are used in the development and verification of sediment transport models such as SEDTRA, developed by Jurgen Garbrecht, ARS Durant, OK.

The high manpower demands imposed by today's total load sampling procedures makes it imperative to explore the potential of less expensive technology. To this end, new instruments for the measurement of the rate of sediment transport are being developed at the National Sedimentation Laboratory in cooperation with researchers from the National Center for Physical Acoustics, University of Mississippi. Sediment that is suspended in the water column will be measured by sending an acoustic pulse into the water and measuring the amount of acoustic backscattering caused by the grains in the flow. Sediment in transport along the bed of the stream will be measured by recording the acoustic signature of the sounds made by the collisions of the grains with the boundary. Preliminary tests of these instruments are underway at the laboratory.

INTERAGENCY STREAM CORRIDOR RESTORATION HANDBOOK

Presented by members of the Steering Team and Production Team

Background and Purpose

There's more to a stream than the rushing or meandering water. A stream corridor, or stream valley, is a complex and valuable ecosystem which includes the land, plants, animals, and network of streams within it. Recognition of the value of stream corridors has come with the understanding of what has been lost through uninformed or misguided actions on many streams and the watersheds that nourish them.

The U.S. has 3.5 million miles of rivers. The 1992 National Water Quality Inventory of 642,881 miles of these rivers stated that only 56 percent fully supported multiple uses, including drinking water supply, fish and wildlife habitat, recreation, and agriculture, as well as flood prevention and erosion control. In the remaining 44 percent of stream miles inventoried, sedimentation and excess nutrients were the most significant causes of degradation. Sediment problems result from soil erosion from watersheds and streambanks.

Today, interest in restoring stream corridors is expanding nationally and internationally, as indicated by increasing numbers of case studies, published papers, technology exchanges, research projects, symposia, etc. Stream corridors are increasingly recognized as critical ecosystems supporting interdependent uses and values.

Interagency Cooperation

In an unprecedented cooperative effort, the following agencies are developing a handbook of stream corridor restoration technology to serve as a common technical reference:

- United States Department of Agriculture:
  - Agricultural Research Service
  - Cooperative State Research, Education, and Extension Service
  - Forest Service
  - Natural Resources Conservation Service
- United States Department of Defense
  - Army Corps of Engineers
- United States Environmental Protection Agency
- United States Department of Housing and Urban Development
- United States Department of the Interior:
  - Bureau of Land Management
  - Bureau of Reclamation
  - Fish and Wildlife Service
  - National Biological Service
  - National Park Service
- Tennessee Valley Authority
- Federal Emergency Management Agency

Participating agencies will sign a Memorandum of Understanding (MOU) establishing a framework to produce this handbook for use by field resource managers and other technical specialists. Under the MOU, the agencies will collaborate in publishing the handbook and conducting basic training to implement the handbook guidelines. The handbook is intended to aid in developing stream corridor restoration projects. It is not a policy document of the cooperating agencies.

Content

The handbook will contain stream corridor restoration planning and design guidance and technology that is applicable to stream corridors in both urban and rural settings. Offering a scientific perspective on simple to complex projects, the document's level of detail will increase as the scale moves from the landscape to the watershed to the stream corridor. The handbook will emphasize the benefits of least intrusive solutions that are ecologically derived and self-sustaining. The publication can help all involved in stream corridor restoration projects, including contractors, private land owners, volunteers, and other interested individuals. Its binder format will make it easy to update as new information becomes available.

Chapters

Working titles for the chapters are:

- Overview of Document
- Stream Corridor Structure and Functions
- Planning
- Design
- Implementation
- Performance Evaluation
- Maintenance and Management

Timeline

The timeline for implementation of the interagency MOU to the development and distribution of the handbook is outlined below:

• MOU signing	January, 1995
• First draft peer review	April, 1996
• Final draft	October, 1996
• Printing	December, 1996
• Public distribution	January, 1997
• Agency incorporation	Ongoing

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EROSION AND SEDIMENTATION PREDICTION IN THE PACIFIC -- A CHALLENGE

By: **Robin S. White, Geologist, U. S. D. A. - Natural Resources Conservation Service, Honolulu, Hawaii; Dr. Chris Smith, State Soil Scientist, U. S. D. A. - Natural Resources Conservation Service, Honolulu, Hawaii**

Abstract: Determining the erosion and sedimentation rates in Hawaii and the current or former United States Territories in the Pacific Basin is a challenge. The geology, soil characteristics, agronomic practices, crop types, and climatological factors are different from the conterminous United States. With the small aerial extent of the islands and lack of instrumentation, the gathering of basic research data and the subsequent modeling factors have lagged behind other areas of the United States. Few of the islands have any debris basins or reservoirs that one can get a sediment survey on to calibrate sedimentation models. Many of the models may not account for the special characteristics of the tropical environment and thus may not be calibrated correctly for the tropics. As leaders in practical applications on erosion technology, this is a disservice to our customers and the international community who will acquire and use these tools in their countries for better or worse.

INTRODUCTION

The U. S. Department of Agriculture (USDA) - Natural Resources Conservation Service (NRCS) is working with the territories or former territories of the United States in the Pacific Basin to develop and implement soil and water conservation planning. These territories include American Samoa, the Commonwealth of the Northern Mariana Islands, Guam, and the Federated States of Micronesia. Similar environments and cooperative efforts are underway in Puerto Rico and the Virgin Islands.

One of the major problems in the islands is sediment related damage to the riparian and coastal zone biota and to the barrier and fringing reef habitat. The quantification of this problem for funding or benefits is based on models or procedures developed on the mainland.

PHYSICAL ENVIRONMENT

Islands in the Pacific Basin are comprised mostly of volcanics, limestone, or both. Yap is an exception being comprised of chloride schist for nearly half of the island. These materials lend themselves to five general topographic categories. The topographic categories are: (1) a shield volcano shape as exemplified by the Island of Hawaii, (2) an eroded shield volcano with moderate slopes as on Kauai and Oahu, (3) eroded shield volcano with a coastal plain as on American Samoa and Truk, (4) benched limestone plateaus as on Guam and Saipan, (5) coral and sand atolls like Ulithi Atoll in the Central Caroline Islands.

Moisture laden trade winds are uplifted by the mountains and convective rain results. Therefore windward sides of the island are typically moist and leeward sides are much drier, all occurring within a short distance.

Rainfall patterns are distributed seasonally or perennially and so intense erosion may occur at the onset of the rainy season in drier areas where vegetation is dormant and litter has decomposed leaving the ground surface bare. Steep gradients and short stream distances to the shoreline tend to promote flash flooding.

Most island environments foster intense weathering resulting in clayey soils that are high in kaolinite and iron oxides. These properties generate well aggregated, permeable soils and render them less erodible than most mainland clayey soils. In spite of this, the predominance of steeper slopes, and high intensity rainfall combine to produce substantial erosion rates.

The limestones weather rapidly forming a karst topography. Areas of the islands can have sinking or "lost" streams, or no streams at all.

USLE MODEL

The most widely used erosion model for sheet and rill erosion is the Universal Soil Loss Equation (USLE) developed by W. Wischmeier and D. D. Smith (1961). This equation incorporates rainfall energy and intensity (R), cover (C), support practice (P), slope length (L), percent slope (S) and soil erodibility (K) factors. The predominance of the field research on which this equation is based is from the Midwest and is more valid for temperate climate zones.

Tropical climate and soil conditions are significantly different from most temperate conditions, as noted above. Most of the factors for the USLE have been extrapolated beyond the limits of the original data. While El-Swaify and others (1982) have conducted research into some of the basic values of the factors used in the USLE equation, much of the data is still missing for the Hawaiian Archipelago and other Pacific islands.

'R' factors for many areas will exceed the range of 'R' values used to develop USLE technology. An example of steep rainfall gradients are noted from Waikiki Beach to Manoa Valley, Oahu a distance of about five miles. Waikiki Beach receives from < 250 millimeters (mm) of rainfall per year while Manoa Valley receives > 4,050 mm of annual rainfall (El-Swaify et al., 1982). In the Pacific Basin, these conditions are further exacerbated by typhoons or hurricanes, which usually bring intense rainfall.

Because of the unique soil properties, the soil erodibility factor, 'K', has been experimentally determined for the major soil types (Dangler et al., 1976). The translation of these experimental values to other Pacific islands remains untested.

El-Swaify (1982) has summarized work from others that shows that the slope length and slope factors, 'L' and 'S', are not necessarily exponential in form. For some conditions, they behave more linear in the tropics than temperate climate zones.

'C' factors have been estimated for the traditional plantation crops, sugar cane and pineapple on the Hawaiian Islands for use in USLE. In addition the growth properties have been experimentally developed for upland taro as well as pineapple and sugar cane for the Revised Universal Soil Loss Equation (RUSLE) and the Water Erosion Prediction Program (WEPP) technology on the Hawaiian Islands. Sugar cane and pineapple production are declining in acreage. Other increasingly important Hawaiian crops, such as, Macadamia nut, papaya, and coffee have not been studied. Other common crops of the Asian-Pacific Islanders, such as, cassava have also not been studied.

RUSLE is currently not on line in Hawaii but is currently on line for many states in the conterminous United States and in the process of implementation for many others. Puerto Rico is in the process of implementing RUSLE. It has been introduced in Indonesia and other tropical areas. Efforts are starting to implement RUSLE into Taiwan, Guam, Commonwealth of the Northern Mariana Islands and American Samoa (G. Weesies, personal communication).

DIRECT VOLUME MODEL

The direct volume model is used to estimate future erosion rates for roadbanks, gullies and streambanks from past events at the site. The model depends upon a length, width or height, depth and time or a lateral recession rate from which the volume of voided material is calculated. Descriptive factors have been developed so the investigator in the field can determine the lateral recession rate range. These factors are for a temperate climate and do not necessarily apply to the tropics.

The Ephemeral Gully Erosion Prediction Model (EGEM) exists, but it has not been validated for tropical conditions. For example, the bulk density values of tropical soils tend to be lower.

WIND EROSION

For Hawaii, experiments are just starting to determine the soil erodibility factor (I). This work is needed due to the oxidic and andic soils. Studies are also underway to produce good wind vector maps. The same problems exist for the islands in the Pacific Basin.

SEDIMENT TRANSPORT

Sediment transport models are used to estimate sediment delivery to a site. The value obtained from the model is usually calibrated by comparing the answer against a known sedimentation rate. Usually the known sedimentation rate is determined by measurement of sediment in a reservoir or sediment basin with a known period of deposition and a similar environment.

In the Pacific Basin, the small aerial extent of the islands and/or steep topography does not usually allow for the building of reservoirs. The Hawaiian Islands have some reservoirs but they either are filled by diverted water or have not been surveyed and analyzed for sedimentation rate. Therefore, there is very little sedimentation rate data to calibrate sedimentation models.

CONCLUSION

While the values obtained by using the USLE equation in the Pacific Basin may not be exact, the planner is compelled to use it. The planner is not interested in the exact values for erosion but in the difference between a "before" and "after" set of practices. The USLE is still the best equation to do this and it is constantly being refined. The same rationale applies to the Direct Volume Method and sediment transport models.

Data development needs for soil erodibility, wind, and crop growth characteristics will continue as newer technologies such as the Revised Universal Soil Loss Equation (RUSLE), Water Erosion Prediction Program (WEPP), and Revised Wind erosion Equation (RWEQ) come on line.

REFERENCES

Dangler, E. W., El-Swaify, S. A., Ahuja, L. R. and Barnett, A. P., 1976, Erodibility of selected Hawaii soils by rainfall simulation, U. S. D. A.-Agricultural Research Service ARS W-35, Berkeley, CA, 113 p.

El-Swaify, S. A., Dangler, E. W., and Armstrong, C. L., 1982, Soil Erosion by Water in the Tropics, College of Tropical Agriculture and human Resources Research Extension Series 024, University of Hawaii, Honolulu, HI, 173 p.

Renard, K. G., Foster, G. R., Weesies, G. A., McCool, D. K., and Yoder, D. C., coordinators, 1995, Predicting soil erosion by water: A guide to conservation planning with the revised universal soil loss equation (RUSLE), Agric. Hdbk 703, U. S. Dept. agriculture, Washington, D. C. (in press).

Wischmeier, W. H., and Smith, D. D., 1958, Rainfall energy and its relationship to soil loss, Trans. Amer. Geophys. Un. 39(2):285-291.

Wischmeier, W. H., and Smith, D. D., 1961, A universal soil-loss estimating equation to guide conservation farm planning, Trans. 7th Cong. Internat. Soil Sci. Soc. 14:109-148.

Wischmeier, W. H., Johnson, C. B., and Cross, B. V., 1971, A soil erodibility nomograph for farmland and construction sites, Jour. of Soil and Water Conserv. 26(5):189-193.

LOCATING ABANDONED RIVER CONTROL STRUCTURES USING CONTINUOUS SEISMIC REFLECTION TECHNIQUES

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__Abstract:__ The development of the Missouri River Streambank Stabilization and Navigation Project has occurred for nearly four decades. Construction was interrupted by World War II and the Flood of 1952. These delays lead to alignment changes and the subsequent abandonment of several river control structures. Abandoned structures, located within the present navigation channel, were lowered to the stream bed elevation at that time. However, stream bed degradation has exposed several of these structures. Unexposed structures could be causing other irregularities in sediment depositional patterns. Typical depth sensing techniques are inadequate for locating and evaluating the status of abandoned structures in the stream bed of the Missouri River. The Corps of Engineers' Omaha District, working with the U.S. Geological Survey, Iowa District, used Continuous Seismic Reflection to located and map abandoned river control structures. This paper provides a general overview of the hardware, specific methods used for calibration, interpretive analysis, and conclusions as related to the location of the abandoned river structures.

INTRODUCTION

__Background Information:__ In 1940 the Corps of Engineers, Omaha District (COE) develop a design alignment for the project that would reduce the overall width of the river, and cut off side channels and long sharp bends. Design width varied from 600 feet at Sioux City, Iowa to 1100 feet at the mouth. The current Missouri River Bank Stabilization and Navigation Project, upstream of Kansas City, was authorized by the River and Harbor Act of 1945. This act authorized a continuous 9-foot deep by 300-foot wide channel from the mouth near St Louis, Missouri to Sioux City, Iowa, a distance of 734 miles. Construction along the design alignment in the reach of the Missouri River between Sioux City and Omaha, Nebraska began in the mid 1940's and continued until 1952, and consisted of stone and piling revetment structures along the outside (concave) of the bends and transverse dikes along the inside (convex) of the bends. The flood of 1952 produced major channel evulsions that damaged and/or by-passed a large portion of the completed work. Due to the flood, the COE made major changes to the design alignment. These changes called for the abandonment and sometimes breaching of completed river control structures (dikes and revetments). Breached structures were removed through blasting or mechanical methods to an elevation at least three feet below the design bed elevation. Most breached structures were initially covered with sediment as the new navigation channel developed.

Channel narrowing and straightening reduced the overall length of the river by nearly 75 miles resulting in degradation of the channel bed. Degradation ranged from almost none at Omaha to nearly seven feet at Sioux City in the first 30 years after construction began. This degradation exposed several of the breached structures. Riprap and piling, associated with the breached structures, began to extend above the river bed and as degradation continued began to encroach into the authorized navigation channel. Attempts to locate and remove/lower the breached structures included overlaying as-built drawings of the original construction on the existing project maps, bed mapping using conventional sonar techniques, and probing the bed with a metal sounding pole. The accuracy of the original as-built maps was not sufficient to give precise structure locations but were useful in identifying the general area of concern. Also, blasting and other removal techniques changed the alignment of the structures. The Missouri River is a sand bed stream with an average depth of approximately 12 feet during the navigation season. However, on occasion higher elevation sandbars do form causing depth problems. Conventional sonar was unable to differentiate between the exposed structures and the high elevation sand bars. Sounding with a metal pole proved ineffective, as the chances of finding a single pile, piling clump, or pile of stone is very remote.

SEISMIC REFLECTION TECHNIQUES

Needs: Breached structures are relatively small compared to the river channel and seldom do not cause a disturbance in the surface of the river bed. Any disturbance in the surface of the river bed would be small and impossible to locate through conventional sonar techniques. Single depth fathometers can only detect changes in the surface of the river bed while continuous seismic reflection techniques can detect disturbances below the surface and track this disturbance over a wider area (Pete Schulmeyer, USGS, written communication, 1993).

Physical Data: All seismic profiling depends on the ability of acoustic energy to be emitted, transmitted, reflected and received. The acoustic energy, an elastic wave, propagates through the subsurface losing energy by divergence, reflection and scattering, and absorption. Within certain limits, any increase in the energy of the sound source to overcome propagation losses results in an increase in the wave length of the dominant frequency in the emitted signal. This effect may not be desirable depending on the purpose of the investigation. High frequency waves travel shorter distances but provide greater resolution than lower frequency waves. Reflections usually occur at lithologic boundaries where there is a contrast between the acoustic impedance of the two lithologies. The acoustic impedance is defined as the product of the velocity of the sound in the medium and the density of the medium. The velocity and density of two adjacent lithologies can vary greatly, but if their products do not produce a contrast between the acoustic impedance of those two lithologies, then there will not be a reflection. Consequently, reflection can occur within a single lithologic unit if the velocity and/or density vary enough to produce a contrast in the acoustic impedance. Cobbles and boulders can cause the elastic wave to scatter, thus very little energy is reflected back to the receiver.

Components: High frequency continuous seismic profiling systems can consist of several components depending on the objective of the specific application. Receivers, transmitters, and some sort of recording device are needed as a minimum. Positioning equipment such as a total station or a global positioning system (GPS or DGPS) is almost always necessary to provide accurate spacial data. Digital recording devices are not necessary, but are a practical means of manipulating data. A typical equipment setup is shown in Figure 1 (Pete Schulmeyer, USGS, written communication, 1993).

MISSOURI RIVER APPLICATION

River Setting: River reaches to be surveyed were identified by overlaying historic river maps on the current construction maps. This defined the limits of the survey area. Longitudinal profiles, approximately parallel to the current were obtained at spacings of 50 to 200 feet across the channel and ranged in length from 1000 feet to over 3 miles. The objective was to identify areas where old structures may be located near or at the surface of the bed.

Instrument Calibration: For this survey the frequency of the acoustic wave was tuned to seven (7) kilo-hertz. The velocity was assumed to be 5000 feet per second (fps) for unconsolidated alluvial material. An estimate of the wavelength then is equal to the velocity/frequency, which is 0.71 feet (ft). From this a resolution can be estimated. Generally, resolution is about 1/8 to 1/4 of the wave length. This produced a vertical resolution of 0.09 to 0.18 ft for the minimum separation between reflectors needed to define separate interfaces. This is only a general estimate and can change due to variable lithologic and field conditions. The graphic recorder was set to display 0.02 seconds of data. Depth was calculated using the following formula:

$$d = Vt/2 \qquad (1)$$

where "V" is the velocity of sound in the layer in fps, and "t" is the recorded travel time of the sound in seconds. Because the investigation was looking for disturbances near the river bed the total depth recorded was set to 50 feet. All seismographs were divided into ten (10) equal segments. To obtain the true depth below the water surface, two (2) feet must be added to each reading to compensate for the depth the instrument was positioned below the water surface. Horizontal positioning was obtained using a GPS system that provided latitude and longitude coordinates to an accuracy of +/- 40 ft.

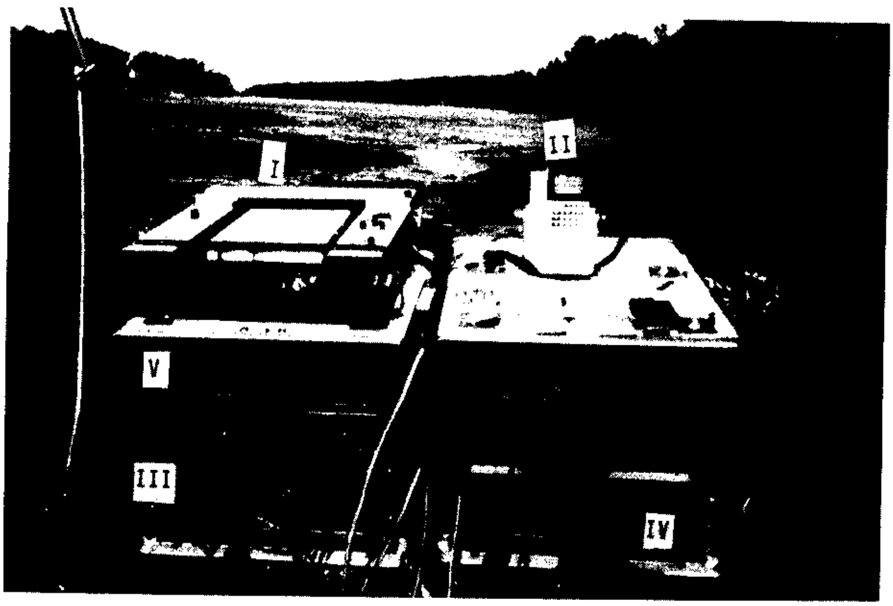

Figure 1a. On-board Data Processing Equipment: I - Graphic Recorder; II - GPS Receiver; III - Transmitter-Receiver; IV - Power Supply; and V - Digital Tape Recorder.

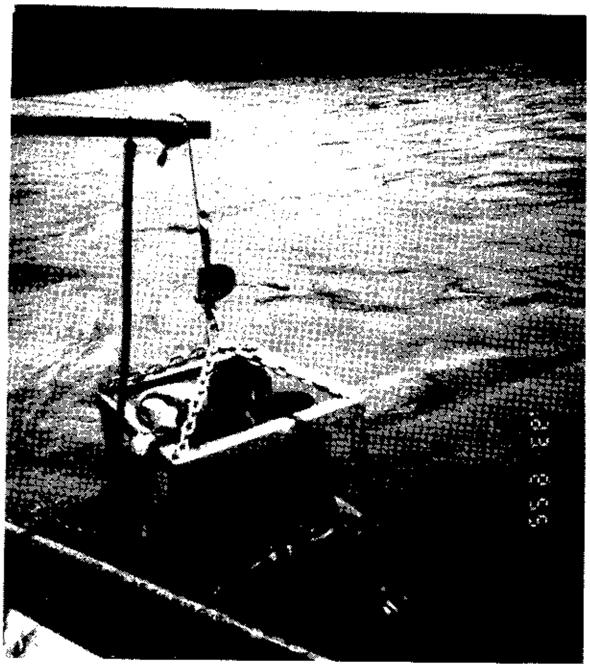

Figure 1b. Picture of Transducers that Emit and Receive Signals.

With a vertical resolution of 0.09 to 0.18 ft, continuous seismic profiling can reveal subsurface bedding patterns. Typically, in the reach upstream of Omaha, at depths of 15 to 16 ft sand waves appear along the river bed. More stable sandbars were overlain by faster moving bed forms. At depths of approximately 21 and 27 feet, profiles show older bedding patterns that could be interpreted as a scour hole or old channel bed. At 27 to 34 ft are multiple reflections of the present channel bottom. Disruption of the signal due to boulders and cobbles has been documented and it was hypothesized that the stone and piling used in construction of the breached river structures would cause similar disruptions to the signal. This was confirmed by obtaining profiles over known river structures.

Survey Methods: Continuous profiles were obtained by drifting with the current at various distances from the rivers edge. Drifting with the current was found to produce the best seismic record. In addition zig-zag profiles were obtained along the suspected azimuth lines of some of the structures. Profiles were obtained perpendicular to the river bank to define the extent of a structure's encroachment into the channel. This provided the best possible chance of finding and defining the structure limits. In an attempt to verify the existence of stone near the bed of the river, a metal shaft was attached to the side of the boat and drug along the bed. Stone or other hard objects could be identified by either a clanging sound or a thud in the shaft.

CONCLUSIONS

A total of 18 bends were surveyed using the continuous seismic profiling techniques. A total of 19 possible structures were located ranging from slightly above the river bed to 10 ft below the river bed. Stakes and post were placed on the bank indicating the location and azimuth of the structure. The location of the structures was further verified by probing with a range pole during low water inspections. The structures that were causing navigation hazards have been lowered by excavation. Because the structures have been accurately located, monitoring their exposure can be done by using a sounding pole, and navigation hazards can be avoided more easily and economically.

REFERENCES

Schulmeyer, Pete M., USGS, Written Communication 1993.

A PHYSICALLY-BASED NUMERICAL MODEL OF CHANNEL WIDENING FOR STRAIGHT RIVER REACHES WITH RIPARIAN VEGETATION

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BACKGROUND INFORMATION

Many existing models of river channel morphology constrain the width of the channel to be fixed with respect to time. This is a limitation, since channel width adjustments are an important component of the adjustment of unstable channels towards dynamic equilibrium.

A model of river bed deformation and widening for sand-bed and cohesive bank materials has been developed and tested (Darby and Thorne, 1996; Darby *et al.*, 1996). In this model, deterministic equations of flow resistance, flow momentum and continuity, sediment transport, and sediment continuity are solved in conjunction with a set of initial and boundary conditions to obtain estimates of temporal changes in channel depth, gradient, and bed-material particle size. Channel widening is accounted for through analysis of specific mechanisms of bank erosion and mass failure under gravity (Darby and Thorne, 1996). Field testing (Figure 1) shows that the model simulates rates of depth adjustment to within ±12% accuracy, but widening rates are under-predicted by a factor of approximately 3 (Darby *et al.*, 1996).

To improve the predictive ability of the Darby-Thorne model, and to extend the range of conditions that can be simulated, new research has been conducted, resulting in the development of a alluvial channel evolution model (ALCHEMY) capable of simulating channels with non-uniform channel geometry, a wide range of boundary material characteristics, and riparian vegetation. Features of the flow, flow resistance, sediment transport, and bank erosion sub-models employed in ALCHEMY are presented on this poster.

ALLUVIAL CHANNEL EVOLUTION MODEL "ALCHEMY"

The alluvial channel evolution model (ALCHEMY) outlined on this poster is 2-dimensional depth-averaged, and based on a set of deterministic governing equations accounting for specific mechanisms of channel bank erosion and mass-wasting. For a given set of initial (morphological and sedimentological) conditions and time dependent (discharge and sediment supply) boundary conditions, the model simulates temporal changes in each of the prototype channel width, depth, gradient, bed-material texture and boundary shear stress distributions. The model is valid for straight river reaches with non-uniform cross-section geometry and bathymetry in lateral and longitudinal directions. Over-bank flows may be simulated, but secondary flows are neglected. Sand, gravel and boulder-bed materials, and cohesive and non-cohesive bank materials are included. Rivers with mid-channel bars or islands can be modelled, up to a maximum of 10 sub-channels. The effects of riparian vegetation on flow resistance, flow hydraulics and bank erosion are analysed, but in-channel vegetation is excluded.

LIMITATIONS OF THE MODEL

ALCHEMY still leaves scope for further improvement. The code is subject to the limitations of the empirically-calibrated flow resistance and sediment transport equations employed in its development. Some specific mechanisms of bank erosion and widening, such as cantilever, piping and sapping type failures, are excluded from the analysis. Cohesive bed materials are not simulated. The effects of curvature and secondary flows are excluded, but methods of accounting for channel curvature are currently being investigated.

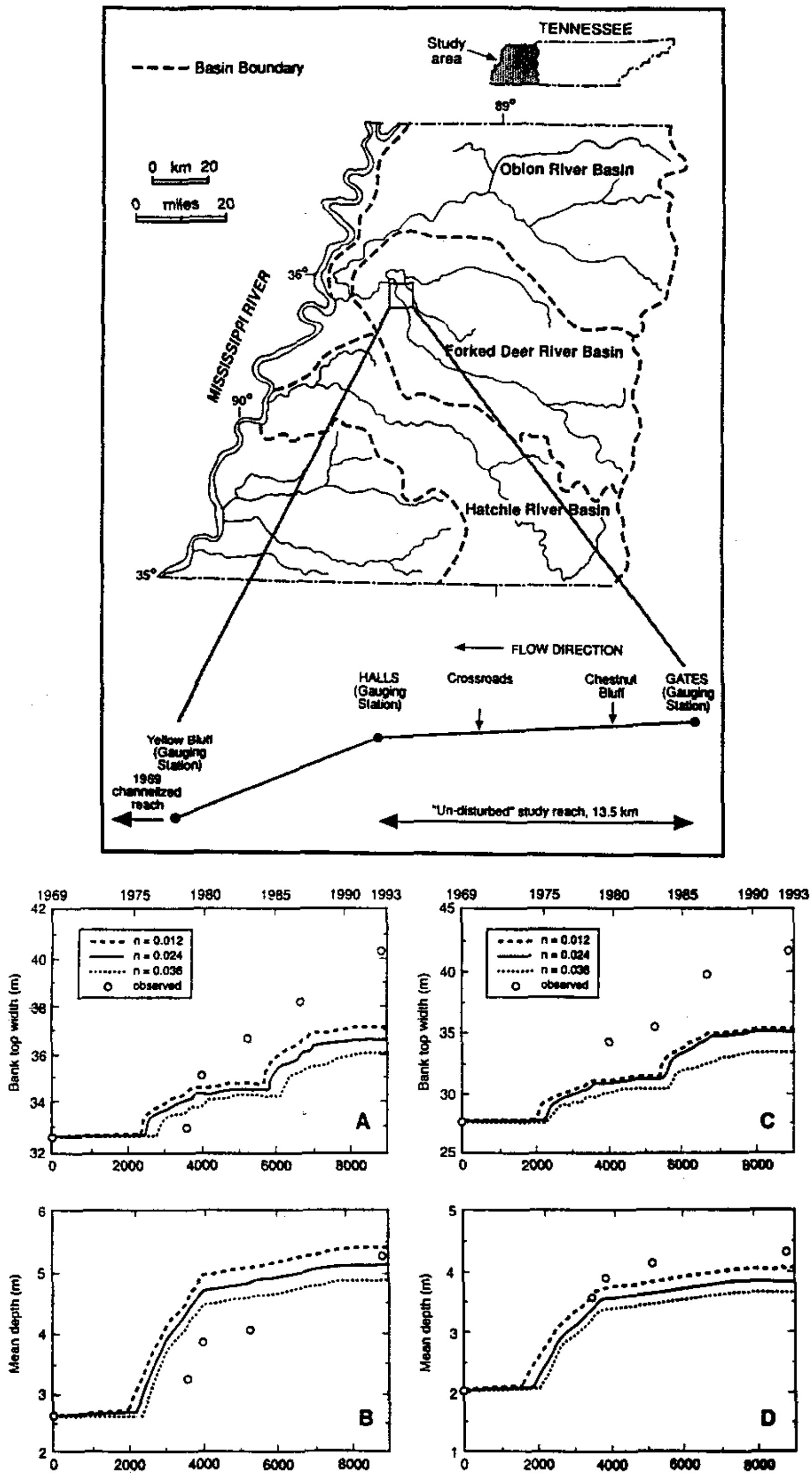

Figure 1. Field testing of Darby-Thorne channel widening model. Location map of West Tennessee study area and simulated (A) widening at Chestnut Bluff (B) deepening at Chestnut Bluff (C) widening at Crossroads (D) deepening at Crossroads for range of Manning "n" values. Observed widths and depths shown for comparison (from Darby *et al.* 1996)

RIPARIAN VEGETATION EFFECTS ON FLOW RESISTANCE

The flow resistance and hydraulic sub-models of the ALCHEMY model have been tested in a fixed-bed simulation wherein the model is used to predict the stage-discharge curve for a reach of the River Severn near Montford Bridge, United Kingdom (Figure 2). The simulated reach is gravel-bed, with grass growing on the channel banks and flood-plains (Figure 2a). The roughness height of gravel sediment elements is estimated using the Hey (1979) flow resistance equation. Two approaches for estimating roughness height for vegetated elements are used, depending on the characteristics of the vegetation.

For flexible vegetation such as grasses, the roughness height of the vegetation (k_s, in m) is determined as a function of vegetation stiffness, *mei*, boundary shear stress and vegetation height (Kouwen and Li, 1980):

$$k_s = 0.14\, h\, ((mei/\tau)^{0.25}/h)^{1.59} \qquad (1)$$

where h = height of the vegetation (m), τ = boundary shear stress (N/m^2) and *mei* = vegetation stiffness (N/m^2). The longstream effect of non-flexible vegetation elements, such as woody vegetation, are accounted for using equations presented by Li and Shen (1973). However, no woody vegetation is present on the banks or floodplain at the study site. Non-flexible vegetation is, therefore, not simulated here.

The results presented in Figure 2 illustrate that the flow sub-model of ALCHEMY is capable of accurately simulating the hydraulic conditions in channels with riparian vegetation (Figure 2b). For this channel, simulated vegetation growth (Figure 2c) does not have a major impact on flood risk, except for the largest, least commonly occurring, flows. Indeed, for flows below bankfull stage, vegetation growth has no discernible impact on simulated flood elevations for this channel (fig. 2c), with all 3 simulated vegetation heights collapsing onto a single curve. Similar analyses for other channels would aid in designing operational maintenance programs to optimize economic and environmental benefits.

REFERENCES

Darby, S. E., and Thorne, C. R. 1996. Numerical simulation of bed deformation and widening in straight sand-bed rivers I: Model Development. *Journal of Hydraulic Engineering*. Scheduled for publication in April 1996.

Darby, S. E., Thorne, C. R., and Simon, Andrew. 1996. Numerical simulation of bed deformation and channel widening in straight sand-bed rivers II: Model Evaluation. *Journal of Hydraulic Engineering*. Scheduled for publication in April 1996.

Hey, R. D. 1979. Flow resistance in gravel-bed rivers. *Journal of the Hydraulics Division of the ASCE*, 105, 365-379.

Kouwen, N., and Li., R.-M. 1980. Biomechanics of vegetative channel linings. *Journal of the Hydraulics Division of the ASCE*, 106(HY6), 1085-1103.

Li, R. -M., and Shen, H. W. 1973. Effect of tall vegetation on flow and sediment. *Journal of the Hydraulics Division of the ASCE*, 99(HY5), 793-814.

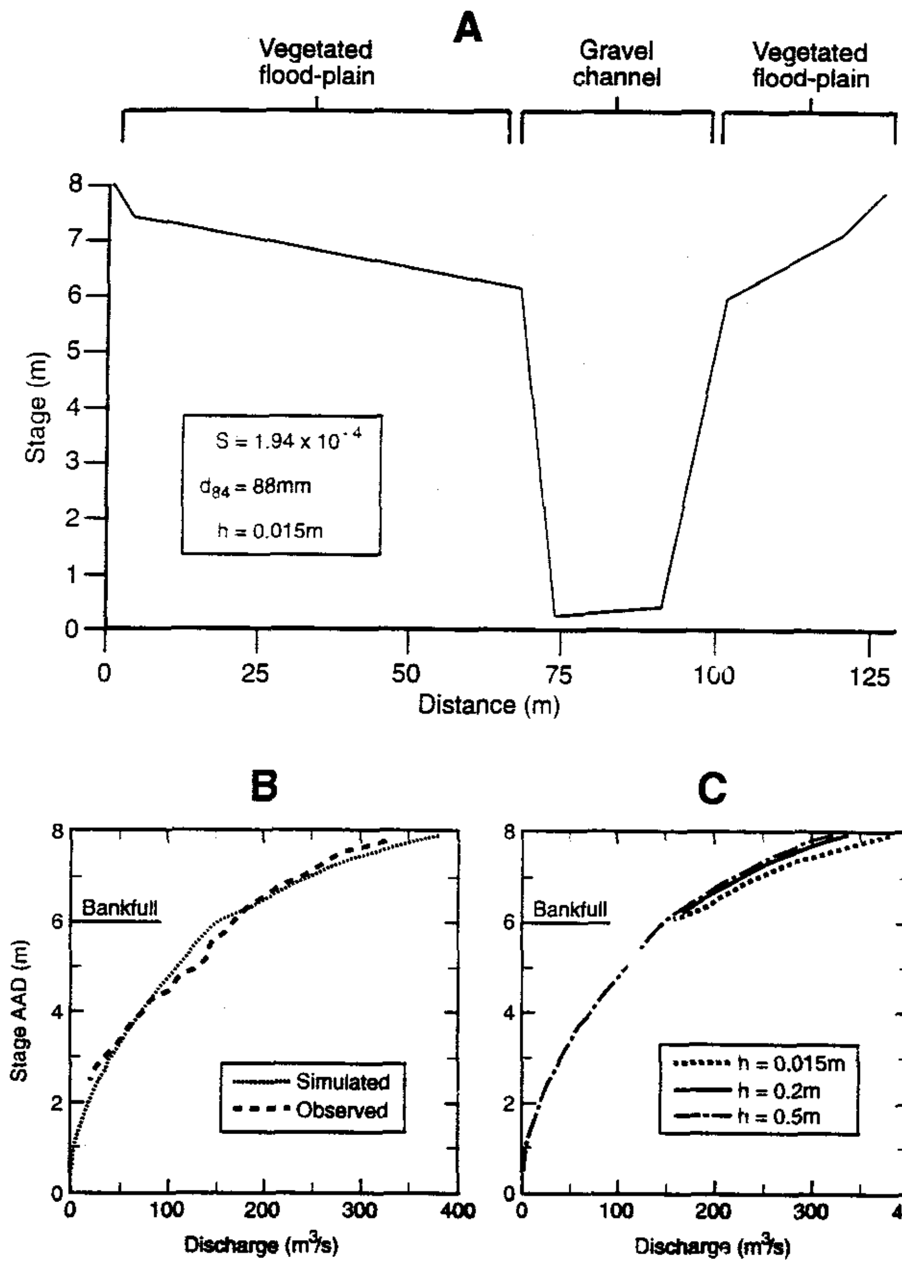

Figure 2 Simulated and observed stage-discharge curves for a gravel-bed river with vegetated banks and flood-plain (A) Cross-section of River Severn at Montford Bridge (B) Simulated and observed stage-discharge curve (C) Effect of varying vegetation height on simulated stage-discharge curve

VELOCITY AND SCOUR MEASUREMENTS IN AND NEAR THE MILLER CITY LEVEE BREAK

By K.A. Oberg, Hydrologist, R.R. Holmes, Jr., Civil Engineer, and G.P. Johnson, Hydrologist, U.S. Geological Survey, Urbana, Illinois

ABSTRACT

The flood of 1993 on the upper Mississippi and Missouri Rivers set record discharges at many streamflow-gaging stations (Parrett and others, 1993). More than 26,000 km^2 of urban and agricultural land were inundated and total costs of the flood exceeded $12 billion (Interagency Floodplain Management Review Committee, 1994). More than 1,082 levee breaks were reported in the upper Mississippi and Missouri River Basins as a result of the 1993 flood (Bhowmik and others, 1994). Flow through the levee breaks created zones of intense scour downstream and upstream of the breaks and transported large quantities of sediment onto the flood plain. The Miller City levee-break complex is probably the most dramatic example of geomorphic change as a result of the 1993 Mississippi River flood. This paper describes the sequence of events that occurred during the levee break and summarizes measurements of velocity, scour, and deposition in and near the Miller City levee break.

The levee near Miller City, Ill., locally called the Len Small Levee, was designed and constructed by local landowners to protect agricultural land in the Dogtooth Island Bend of the Mississippi River. The levee is continuous along the left bank (facing downstream) of the Mississippi River from Fayville, Ill., to past the apex of Dogtooth Island Bend (fig. 1). The levee was designed to deflect high-velocity floodwaters of the Mississippi River away from agricultural land at the upstream part of the bend.

The break in the levee occurred on July 15, 1993, at approximately 1:00 p.m. local time at river mile 34 (miles above Cairo, Ill.). A witness heard a loud noise at about 12:50 p.m. As he looked at the levee from a distance of about 500 m, he saw a near-horizontal fountain of water 15 to 30 cm in diameter, gushing out of the side of the levee. The hole quickly enlarged and a section of the levee failed. During the first few days after the break, flow through the break was extremely turbulent with standing waves approximately 1 m high. At the time of the break, the water level in the Mississippi River was approximately 2 m below the top of the levee.

Initially, the floodwaters entering through the levee break flowed northward and eastward, following low areas directly to Horseshoe Lake (fig. 1). Subsequent overflow of Horseshoe Lake to the south and east caused water to flow across the Miller City Road and down 0.5- to 2-m high terrace scarps that separate paleochannels of the Mississippi River. Flow over the road and down the terrace scarps typically was fast, highly turbulent, and characterized by standing waves. By July 17, water flowing over the road near the Troy Jones' Farmhouse (fig. 1) had eroded a scour channel of at least 400 m long by migration of a steep head cut upstream (northward). After the failure of the cross levee, the floodwaters flowed primarily southward and eastward following a channel occupied by the Mississippi River during 1820 (Fisk, 1944).

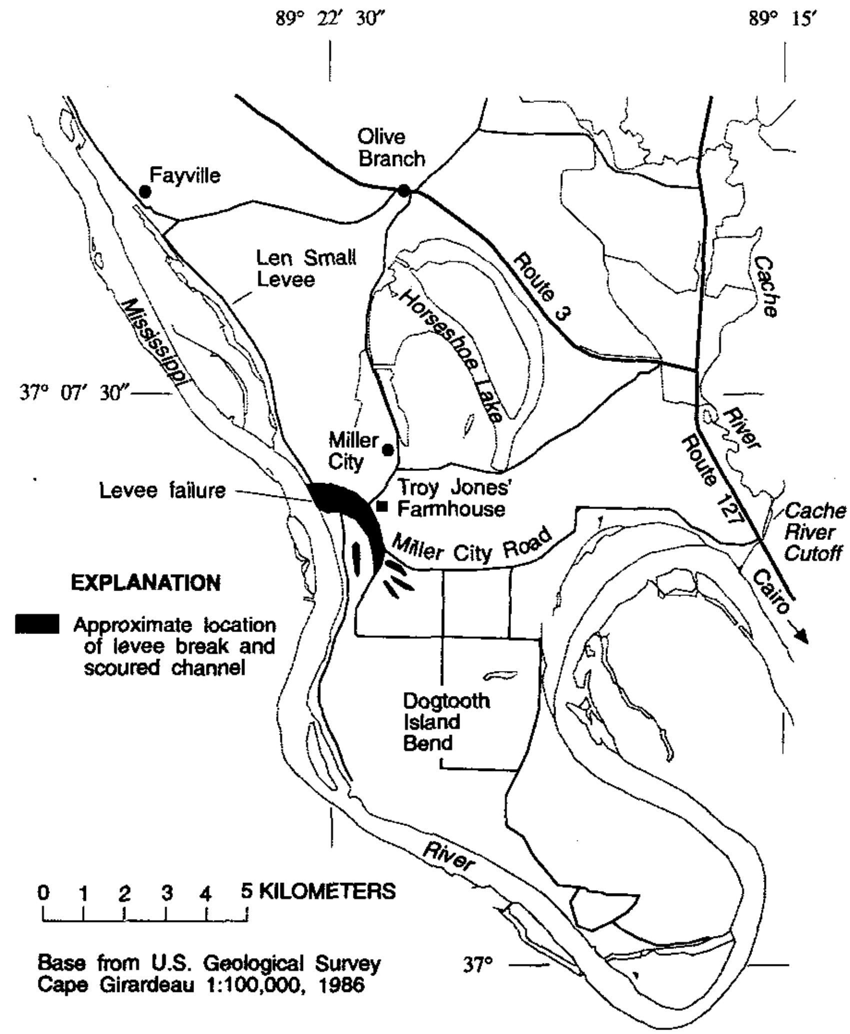

Figure 1. Location of Miller City levee break.

The U.S. Army Corps of Engineers (COE) measured the width of the levee break periodically during the period July 18 to August 25, 1993. The first measurement, made on July 18, indicated a width of 113 m. Beginning about July 20, the width of the levee break increased rapidly because of the failure of a cross levee connecting the Len Small Levee at the south end of the levee break to the Miller City Road just north of the Troy Jones' Farmhouse. By August 25, the width of the levee break was approximately 700 m.

Measurements of discharge, velocity, and bathymetry in the levee break were made by the COE and the U.S. Geological Survey (USGS) from July 26 to September 9, 1993. Discharge and velocity were measured in the Mississippi River upstream from the levee break and at the levee break. The COE measured discharge by the moving-boat method (Smoot and Novak, 1969). The range of the COE boat was limited by its draft; therefore, it could only be used to measure velocity near the break. The USGS used an acoustic Doppler current profiler (Simpson and Oltman, 1993) on an 8-m boat to measure velocity and discharge in and near the levee break.

From July 15 to August 25, 1993, as much as 28 percent of the discharge of the Mississippi River flowed through the Miller City levee break. On August 7, when the discharge on the Mississippi

River at Thebes was peaking, 8,000 m^3/s were measured flowing through the levee break. Local water-surface slope through the break exceeded 5 percent just after the break occurred. In the break, velocities of as much as 300 cm/s were common. Downstream of the break, velocities on August 1 initially slowed in the area of expanding flow, then accelerated toward the downstream end. Acceleration of flow is probably related to the narrower channel at the downstream end of the scour where channel width and depth were continuing to adjust to the imposed discharge by actively eroding banks and channel bed.

Geomorphic features in the Miller City levee-break complex were documented through aerial photographic interpretation, supplemented with onsite visits to obtain ground-truth information (Jacobson and Oberg, in press). Photogrammetric stereomodels were used to map pre- and post-flood channel margins, wooded areas, ponded water, roads, levees, scoured areas, depositional areas, and structures. Digital map files for each stereomodel were imported to a geographic information system where they were edge matched, edited, plotted, and analyzed. Onsite checks were made for spot determinations of thickness, stratigraphy, and sedimentology of sediments, and descriptions of eroded areas.

Cross sections of the main scour and two smaller scours were surveyed onsite by the Illinois Department of Transportation, Division of Water Resources (IDOT) during February 1994. This survey indicated that the main scour channel is 2,200 m long and forms an arc following a pre-existing 1820 channel (Fisk, 1944). The channel ranges from approximately 100 m to more than 600 m wide, averaging about 350 m wide. The scour channel is wide and deep at the levee break where the maximum depth measured was 19.1 m.

Despite the very large scour channel eroded during the flood, the Miller City levee-break complex was a sink for sediment in transport, accumulating an estimated net volume of 8.2 million m^3 and a mass of 11.4 to 18.4 million metric tons (Jacobson and Oberg, in press). The mass of sediment deposited on the flood plain at Miller City is 22 to 36 percent of the total sediment load that passed Thebes, Ill., during the flood (Holmes, in press). This mass of sediment also is equivalent to 8 to 13 percent of the mean annual suspended-sediment load of the Mississippi River at Thebes, Ill. (Holmes, in press).

REFERENCES

Bhowmik, N.G., Buck, A.G., Changnon, S.A., Dalton, R.H., Durgunoglu, A., Demissie, M., Juhl, A.R., Knapp, H.V., Kunkel, K.E., McConkey, S.A., Scott, R.W., Singh, K.P., Soong, T.D., Sparks, R.E., Visocky, A.P., Vonnahme, D.R., and Wendland, W.M., 1994, The 1993 flood on the Mississippi River in Illinois. Illinois State Water Survey, Miscellaneous Publication 151, 149 p.

Fisk, H.N., 1944, Geological investigation of the alluvial valley of the lower Mississippi River. U.S. Army Corps of Engineers, 78 p.

Holmes, R.R., Jr., in press, Sediment transport in the lower Missouri and central Mississippi Rivers during the 1993 flood, *in* Floods in the upper Mississippi River Basin, 1993. U.S. Geological Survey Circular 1120-I.

Interagency Floodplain Management Review Committee, 1994, Sharing the challenge—floodplain management into the 21st century. U.S. Government Printing Office, 191 p.

Jacobson, R.B., and Oberg, K.A., in press, Geomorphic Changes of the Mississippi River floodplain at Miller City, Illinois, as a result of the flood of 1993, *in* Floods in the upper Mississippi River Basin, 1993. U.S. Geological Survey Circular 1120-J.

Parrett, Charles, Melcher, N.B., and James, R.W., 1993, Flood discharges in the upper Mississippi River Basin, 1993, *in* Floods in the upper Mississippi River Basin, 1993. U.S. Geological Survey Circular 1120-A, 14 p.

Simpson, M.R., and Oltman, R.N., 1993 Discharge measurement system using an acoustic Doppler current profiler with applications to large rivers and estuaries. U.S. Geological Survey Water-Supply Paper 2395, 32 p.

Smoot, G.F., and Novak, C.E., 1969, Measurement of discharge by moving boat methods. U.S. Geological Survey Techniques for Water-Resources Investigations, book 3, chapter A11, 22 p.

DEMONSTRATION EROSION CONTROL (DEC) PROJECT MONITORING PROGRAM AND HARLAND CREEK BANK PROTECTION PROJECT

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Abstract: The focus of this poster session is to give a broad overview of the many activities associated with the multi-year task of monitoring the U. S. Army Corps of Engineers Demonstration Erosion Control (DEC) project. Also some highlights of the Harland Creek bank stabilization/habitat restoration project will be presented.

THE DEC PROJECT MONITORING PROGRAM

The DEC Project: The Demonstration Erosion Control (DEC) project, Yazoo River Basin, Mississippi, USA, is a multi-year, multi-agency effort designed to provide for the development of a system to control sediment yield, erosion, and flooding in the 15 watersheds that comprise the DEC project. Participating agencies are the Department of Defense U.S. Army Corps of Engineers Vicksburg District; the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) and Agricultural Research Service (ARS); and the U. S. Department of the Interior Geological Survey (USGS).

The DEC Project Monitoring Program: To assist in the evaluation and documentation of the performance of the features installed as part of the DEC project, the Hydraulics Laboratory of the U.S. Army Corps of Engineers Waterways Experiment Station (WES) initiated a comprehensive monitoring program in July 1991. The major components of the monitoring program (with a short description of work) follow:

Channel Response: Channel response monitoring is divided into two major areas: channel sedimentation and channel-forming discharge. Channel sedimentation monitoring includes an annual geomorphic update of selected watersheds and an intensive investigation of 25 selected sites, 20 with structures and 5 non-structure control areas. The sites are being monitored for cross-section changes, thalweg changes, berm formation, bank failure, and vegetation development. In addition, DEC watersheds are providing data used to test design procedures and techniques for the channel-forming discharge concept.

Bank Stabilization/Bank Stability: DEC streams are being monitored periodically to determine which reaches are experiencing severe bank stability problems. Five sites of stream aggradation and five sites with active bank caving are being closely monitored and surveyed semiannually. Alternatives to conventional riprap bank stabilization techniques are being applied in the watersheds. In FY 93-94 fifty-four Bendway Weirs and 9,400 willow posts were used to protect over 11,700 ft of bank line in 14 eroding bends. Additional bioengineering methods have been designed for use on Harland Creek. Stream corridor habitat enhancement/restoration is an important component of all stabilization efforts. Desirable habitat enhancing features have been identified and incorporated into these projects wherever possible. The use of these various bank stabilization techniques will result in the development of design criteria.

Hydraulic Performance of Structures: Two grade control stı ıctures, a low-drop and a high-drop, have been selected for detailed data collection to evaluate hydraulic performance. The structures are instrumented for data collection to evaluate discharge coefficients, energy dissipation, flow velocity distribution, and effects of submergence on performance. All grade control structures and selected bank stabilization structures are visually monitored bi-annually to evaluate performance and identify problem areas.

Hydrology: Two-dimensional surface hydrodynamic models of a selected number of watersheds are being developed. This work will focus on developing flows from radar-rainfall maps, performing overland flow computations, and performing channel and hydraulic structure routings. Different project scenarios were performed in order to evaluate the effectiveness that the grade control and bank stability structures have had on the streams in the DEC project area.

Upland Watersheds: ARS carries most of this workload. ARS will determine the effects of various erosion stabilization methods at several sites over the next 5 years. This data will then be compared with the preceding 5 years of historic data. As part of the analysis and interpretation process, WES will numerically model the sediment runoff from several watersheds.

Reservoir Sedimentation: Since FY 94 WES is using the results of analyses performed in the channel response, bank stability, and upland watershed technical areas to determine the effects of the control measures of the DEC project on reservoir sedimentation.

Data Collection and Data Management: Stage and discharge data are being collected at 23 long-term monitoring sites. An Intergraph database includes survey data, aerial photography, conventional photography, USGS digital elevation grids, USGS quadrangle maps, watershed development master plans, project feature designs and specifications, trip reports and field observations, and reports and professional papers published as a result of the monitoring program.

Design Tools: In conjunction with ongoing research, WES is developing design tools specifically targeted for the planning and design of stable flood control projects. This may require development of computer-based packages and the validation of numerical models such as HEC-1, HEC-6, CASC2D, and SAM.

Technology Transfer: Technology transfer is an important aspect of the DEC monitoring program. In addition to the databases and various technical, video, and annual reports that are being generated during the life of this program, personnel from participating agencies periodically present results at national and international technical conferences and symposiums and host workshops and training classes for both Corps and non-Corps personnel. Multimedia displays are shown at various technical exhibits and conferences.

HARLAND CREEK BANK STABILIZATION DEMONSTRATION PROJECT

Introduction: As part of the DEC program a comprehensive bank stabilization/aquatic habitat improvement project for an 11,700 ft long reach of Harland Creek was initiated in 1993. The assigned task was to apply state-of-the art Bendway Weir and willow post methodology to the realm of small-stream bank protection. Protection methods were configured as either stand-alone or in combination. Where conditions warranted, traditional longitudinal peaked stone toe protection supplemented the weirs and willow posts.

Habitat Improvement: Stream corridor habitat enhancement/restoration was a top priority of this project. It was felt that the types of bank protection planned for this study would present a unique opportunity to demonstrate new channel stability methods while at the same time enhancing aquatic and terrestrial stream corridor habitat. Many habitat enhancing features were identified, and, where possible, incorporated into the project.

The Bendway Weir: The Bendway Weirs employed in this study were low-level upstream-angled stone sills keyed into the outer banks of the bends. The weirs were built of a well graded stone with an upper weight limit of 650 pounds, spaced 75 to 100 ft apart, 2 ft high at the stream end rising to 4 ft at the bank end, keyed into the bank and had lengths varying from approximately one quarter to half the width of the base flow channel of the stream. During low flows the weirs are emergent. They were designed to reduce erosion on the outer banks of the bends by reducing near bank velocities, reducing the concentration of currents on the outer bank of the bend, and producing a better current alignment through the bends and crossings. Fifty-four weirs were used in 9 bends.

The Willow Post Method: The willow post method is a means of controlling streambank erosion through the systematic installation of large native willow cuttings to stabilize eroding streambanks. Willow foliage lowers floodwater velocities on and near the eroding bank and the root system of the willow binds the soil. Advantages of the willow post method are: low costs, both in materials and installation; ongoing maintenance costs are usually low; bank protection is long-term; and improved aquatic and terrestrial habitat is provided. Approximately 9,380 willow posts were used in 7 bends.

First Year Results: A comprehensive project evaluation was carried out in the fall of 1994. Since March 1994 the project has been subjected to the 2-year recurrence interval discharge about once every 2 months. Nonetheless, initial results have been satisfactory, with most areas of the project appearing stable and maturing quickly.

Environmental Benefits: Stream corridor habitat enhancement/ restoration was a top priority of the Harland Creek project. ARS sampled fish during the first year after project completion. The reaches with Bendway Weirs yielded over twice as many fish as reaches using other types of bank protection.

Note: A complete write up of this project can be found in these proceedings under "HARLAND CREEK INNOVATIVE BANK STABILIZATION DEMONSTRATION PROJECT".

NOTE: Page "Poster - 81" is the last printed page of the Proceedings for the 6th Federal Interagency Sedimentation Conference.