THE DOWNSTREAM MIGRATION RATE OF RIVER MEANDER PATTERNS *

Donald M. Keady[1] and Melville S. Priest[2]

Man has gained some knowledge of meander migration through harsh experience associated with the interaction between man-made structures and shifting river channels. Such structures as bridges, riverfront loading facilities, pumping stations, etc. are vulnerable. Considering the extent of damage and the cost of remedial works resulting from encroachment by rivers, it is somewhat surprising that a definitive means for predicting the downstream rate at which meander patterns migrate was not developed long ago. The practical problem which brought about the study reported herein is that of location and depth of burial of pipelines for river crossings. However, the results of the study certainly are not limited to that particular application.

The purpose of this study was to develop a generalized relation from which the downstream rate of meander migration in alluvial materials could be determined. It was presumed that this could be accomplished, to some degree, by analysis of data already available in published reports on particular rivers, maps and related data, and airphotos and related data. The analysis would, of course, be subject to constraints imposed by the available data. Only relatively free meander patterns were considered. That is, those subject to minimal influence by man's activities.

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[1]Associate Professor of Geology and Geography, Mississippi State University

[2]Director, Water Resources Research Institute, Mississippi State University

It seems reasonable to assume that the rate of downstream migration is somehow related to an intensity of boundary shear, which, in turn, might be related to free surface slope of the river, a characteristic lateral dimension of the channel, and the specific weight of the water. Using meander amplitude as a measure of stream and channel size and preserving dimensional balance, pertinent and available quantities were related through the expression

$$\frac{V}{\sqrt{gA}} = \phi(S) \tag{1}$$

where V is rate of meander migration, S is free surface slope of the river, A is meander amplitude, g is acceleration due to gravity, and ϕ indicates function of.

Sources of prototype data from which the variables, meander amplitude (A), free surface slope (S), and rate of meander migration (V), of Eq. 1 might be evaluated were determined. Useful data were obtained from published reports by Causey,[1] on the Red River in Arkansas and Louisiana, and Neill and Galay,[2] on the Red Deer River in Alberta, Canada. Data were also obtained from Mississippi River Commission and U.S. Geological Survey maps and other information; from General Land Office plats available through the Commissioner of State Lands; and from airphotos available from the U.S. Agricultural Stabilization and Conservation Service. An effort was made to select subject rivers which represented a rather wide range of conditions, but sufficiently large to be of some engineering interest.

The downstream migration of meanders was studied by comparison of patterns which existed at various dates, usually separated by rather long periods of time. Some of the patterns were shown as overlays on source maps, and others were prepared as tracings from maps and airphotos which exhibited single patterns for particular dates. Measurements from which meander amplitude and rate of migration were determined were taken at locations where meanders were of more or less regular form and appeared to be migrating in a reasonably regular manner. The meander amplitude was taken as one-half the lateral distance between the envelopes of the thalweg extremities. Free surface slopes were determined from surface profiles or measurements from contour maps. Data used in the analysis are shown in Table 1.

Results of the study are shown in graphical form in Fig. 1, where both ordinate and abscissa are dimensionless. Although both ordinate and abscissa are independent of the system of units used, the units must be consistent throughout. If the ordinate is presumed to vanish when the abscissa vanishes, the origin would become a point on the curve. The upper part of the curve is broken to indicate that the plotted point having the maximum value of the ordinate may not represent the maximum possible value. The shape of the curve should be of particular interest to persons responsible for locating and safeguarding structures in the proximity of large streams.

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REFERENCES

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2. Neill, Charles R. and Victor J. Galay, "Systematic Evaluation of River Regime," Journal of the Waterways and Harbors Division, ASCE, February, 1967, pp 25-53.

Table 1

Identification	Velocity of Migration ft/yr	Meander Amplitude ft	Slope
Mississippi R (LA)	60	13,000	.0000436
Mississippi R (MS)	111	11,000	.0000588
Mississippi R (TN)	225	13,200	.0000777
Red R (ARK)	350	2,900	.000132
Pearl R (LA)	20	1,050	.000200
Red Deer R (Canada)	20	1,200	.000275
Tombigbee R (MS)	13	800	.000421
Buffalo R (MS)	17	1,560	.000689

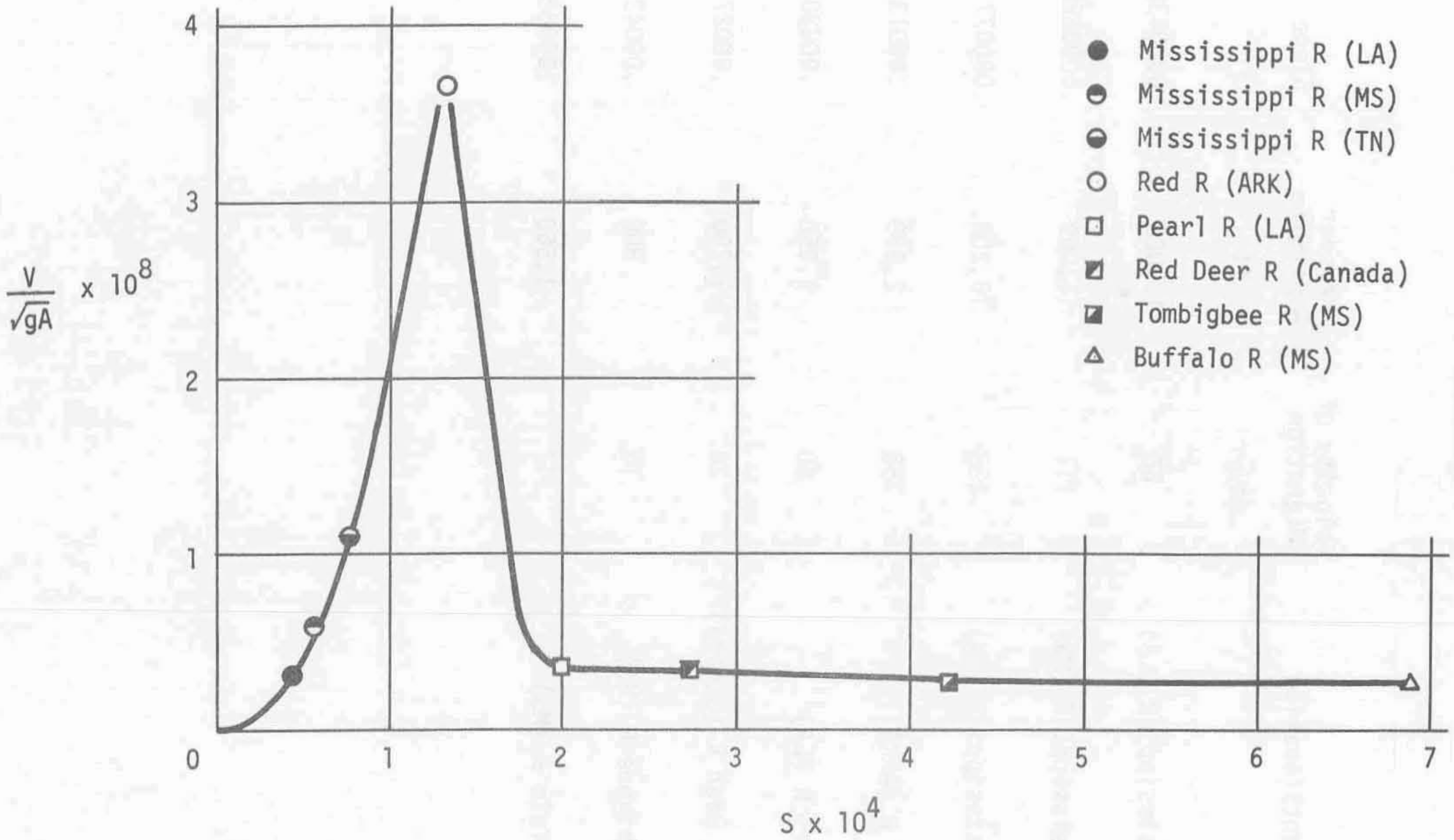

Fig. 1 - Graph for determining rate of meander migration.