DESIGN OF BLUNT NOSED CHEVRONS IN THE MISSISSIPPI RIVER FOR SEDIMENT MANAGEMENT

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INTRODUCTION

Sedimentation in a reach of the Upper Mississippi River (Mile 290.2 to Mile 289.0) has caused depth problems in the navigation channel. Annual maintenance dredging has been performed to maintain a reliable project channel. Historically, the dredge disposal material has been placed in the offside portion of the navigation channel, only later to be reintroduced back into the channel after the next high water season. To address this problem, the St. Louis District has designed and implemented new structures called Blunt Nosed Chevrons which serve as both channel improvement structures and permanent dredge disposal holding areas. The structures also create riverine habitat for a variety of fish species.

Project Location. Figure 1 is a vicinity map. Figure 2 is a plan view hydrographic survey showing the location of the first three Blunt Nosed Chevrons placed in the Mississippi River. The structures are located at the entrance of two major side channels. Construction of chevrons number 4 and 5 is planned in the near future.

Flow Splits. Historic discharge measurements have been taken to determine flow distribution trends (flow splits) between the side channels and the main navigation channel. Table 1 indicates the flow split trends have remained fairly constant, with a slight lowering of flow in the main channel in 1994 and 1995.

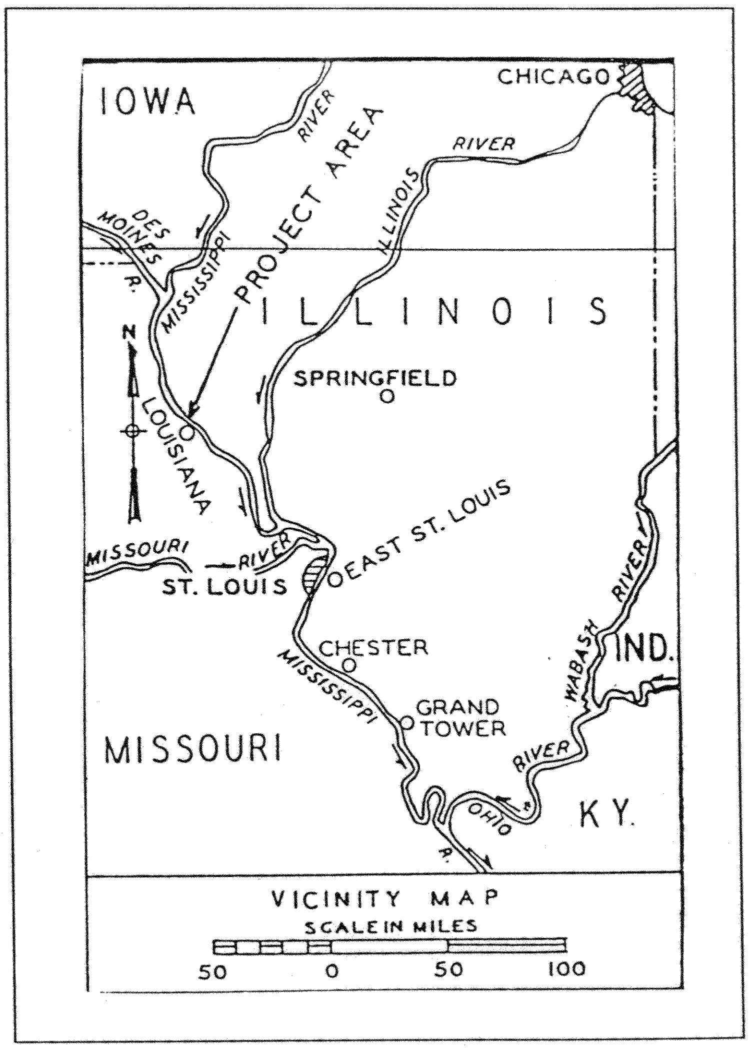

Figure 1. Vicinity Map.

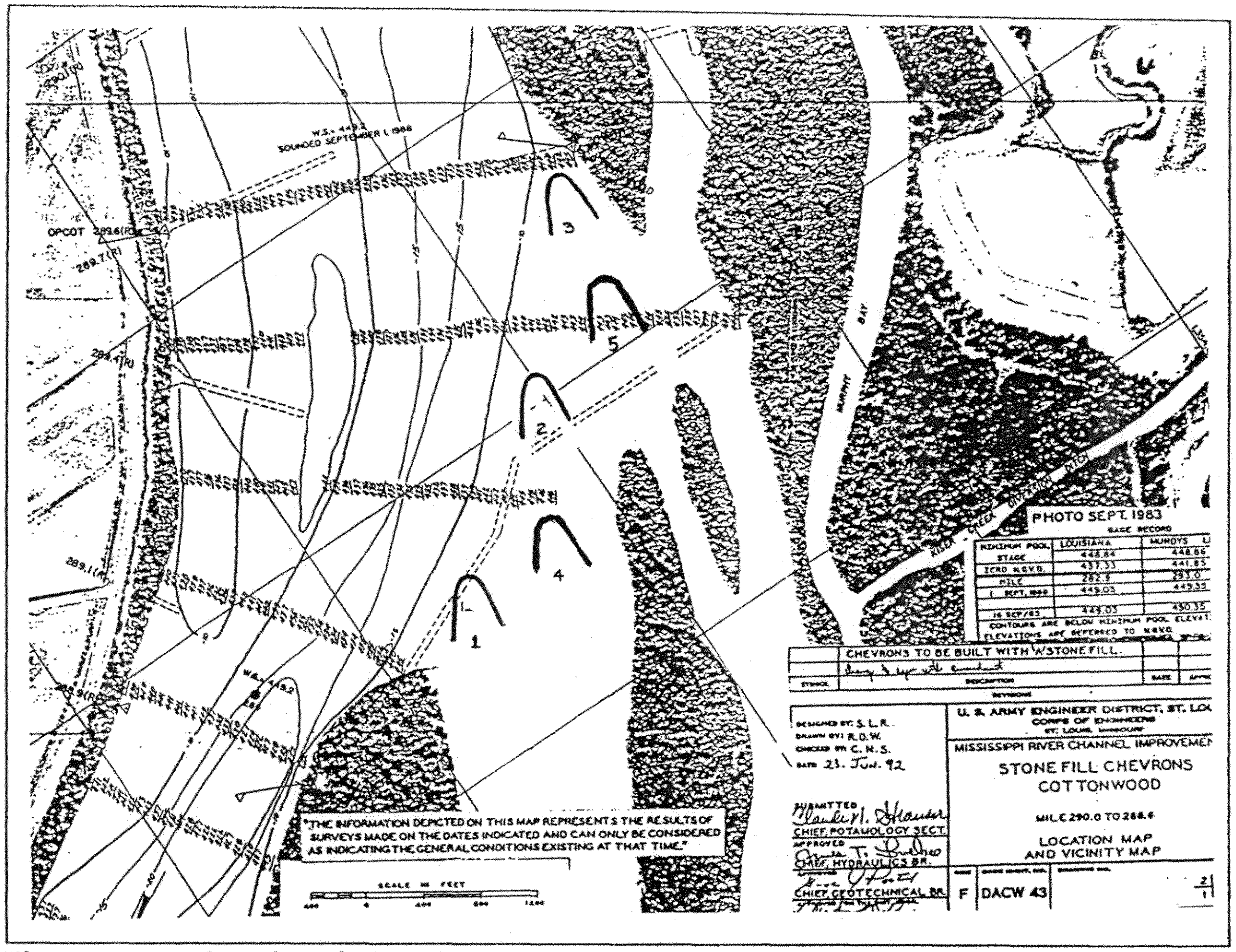

Figure 2. Location Plan of Blunt Nosed Chevrons on the Mississippi River at Cottonwood Island, Mile 289.0

DATE	Main Channel	Boyd-Fritz Side Channel	Fritz- Ill. Side Channel	TOTAL
31 July 1985	53,580 cfs 66%	5,772 cfs 7%	22,049 cfs 27%	81,401 cfs
22 July 1986	75,598 cfs			
3 Sept 1987	71,465 cfs 67%	10,093 cfs 10%	24,726 cfs 23%	106,284 cfs
Chevrons Constructed Fall of 1993				
13 July 1994	61,675 cfs 62%	10,762 cfs 11%	26,397 cfs 27%	98,834 cfs
26 Apr 1995	96,723 cfs 60%	20,863 cfs 13%	42,852 cfs 27%	160,438 cfs
7 June 1995	116,614 cfs 66%	16,329 cfs 9%	43,687 cfs 25%	176,630 cfs

Table 1. Historical Flow Splits at Cottonwood Island during Drawdown Conditions in Pool 24.

DESIGN

Theory. The three structures were placed in the upper end of the side channel as the first phase of an eventual five chevron configuration plan (Figure 2). This plan theorizes that placement of the Blunt Nosed Chevrons will create "added roughness" in the side channel entrance but not significantly reduce side channel flow as compared to a traditional closure structure design. In theory, increasing the n value at the critical entrance area by this method will subtly lower side channel conveyance thereby increasing main channel conveyance. In this particular reach, the problem was threefold. The structures had to encourage manageable side channel deposition for main channel navigation improvement , the structures had to contain dredge disposal material, and the structures had to improve environmental diversity.

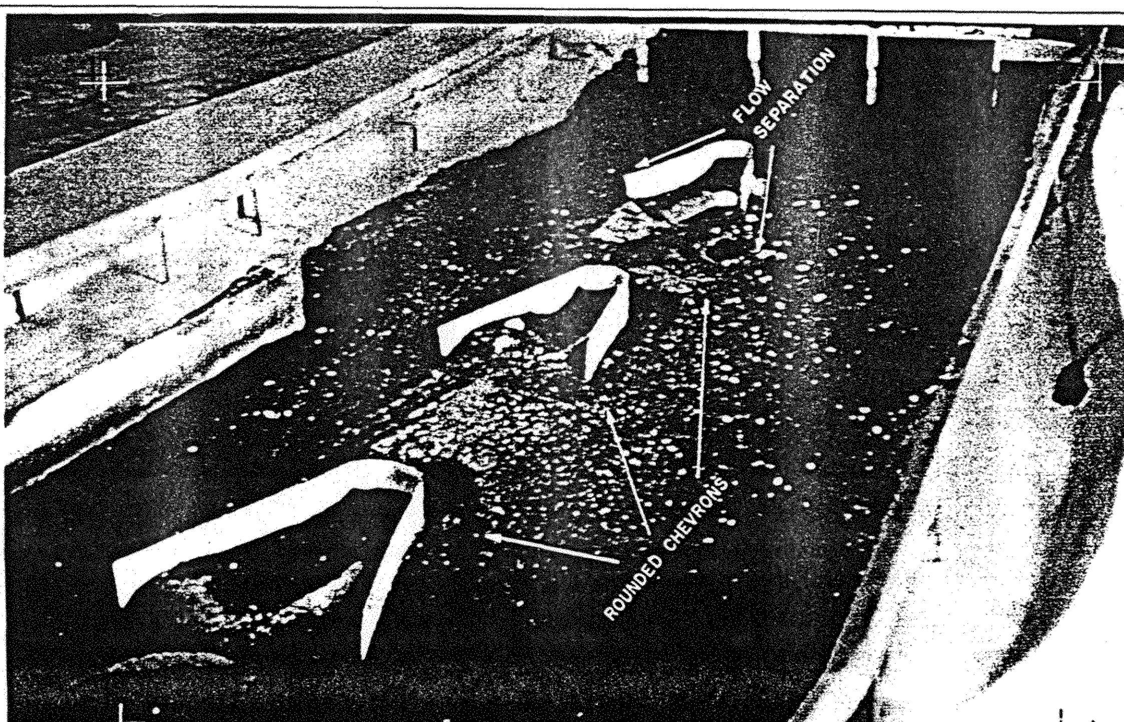

Figure 3. Blunt Nosed Chevrons in the St. Louis Harbor Model at WES

The design was based on movable bed model tests conducted at the Waterways Experiment Station for the St. Louis Harbor Navigation Study of 1986 (2) and from flow conveyance computations using HEC2. Although the model study examined a different reach of river, the study provided a sedimentation information base for the chevron concept. Traditional (pointed nose) and Blunt Nosed Chevrons were both tested in a near straight stretch of the model (Figure 3). The blunt nosed design achieved several important features including:

a. The elimination of excessive scour on the upstream head of the structure. Tests were initially conducted with pointed chevrons. These structures created an excessive amount of upper head scour directly endangering the structural integrity in the prototype. The modified blunt nose shape, although somewhat more complex to build in the prototype, significantly reduced upper head scour. This extends the life of the structure in the river while reducing maintenance costs.

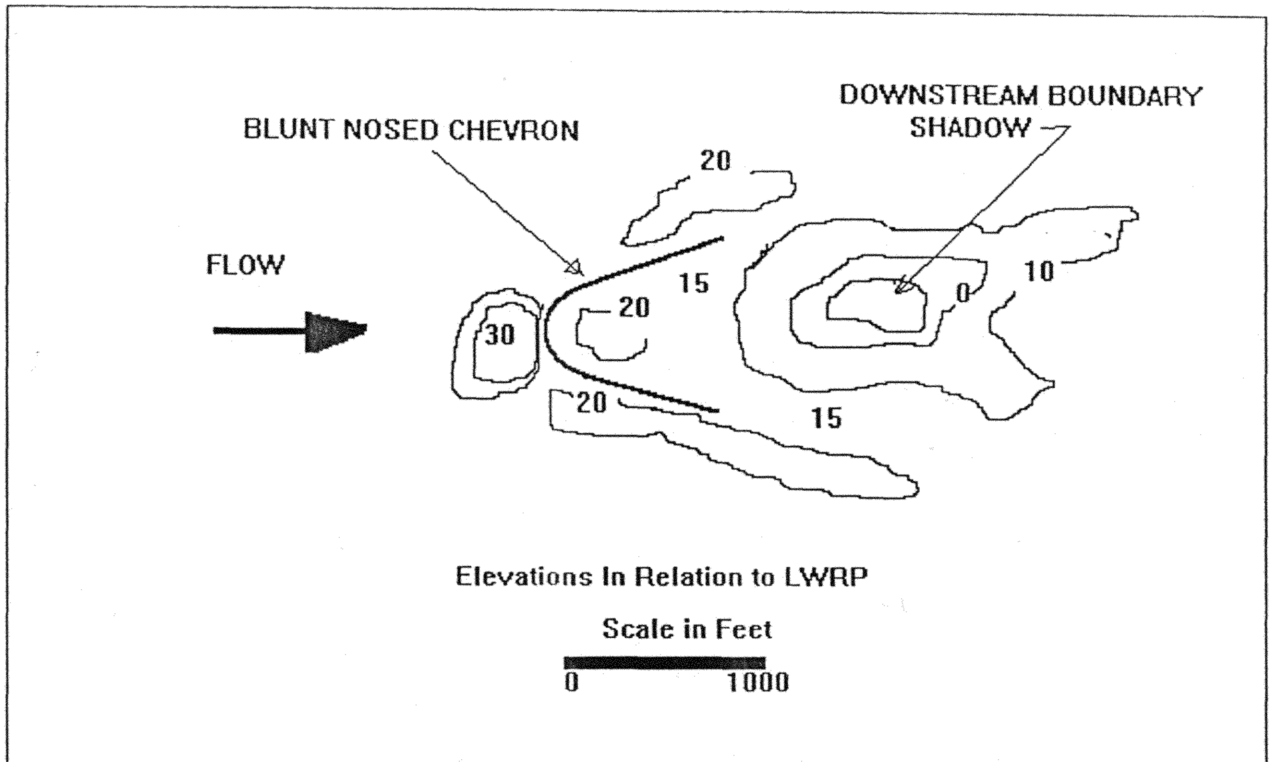

Figure 4. Sketch of Ultimate Bed Configuration Development around Blunt Nosed Chevrons

b. A permanent dredge disposal area within the ordinary high water. The design in the model demonstrated that disposal material placed within the boundary shadow of the structure stabilized (Figure 3). This was a direct result of the chevron boundary effects on the local sedimentation patterns. Placing dredge disposal material in this area will solve the short term dredge disposal problem while accelerating the long term full effect of the structure on the ultimate bed configuration.

c. Creation of habitat diversity. Several important sedimentation patterns resulted from the boundary shape in the model tests. Figure 4 is a schematic indicating the ultimate bed configuration pattern observed around a Blunt Nosed Chevron. This pattern has the potential for serving as excellent habitat for a variety of macro and micro invertebrates, fish, and fauna.

Design Specifications. The Blunt Nosed Chevron design requires the use of standard graded "A" stone or quarry run stone with a maximum top size of 5000 pounds. The typical section is trapezoidal containing the following dimensions:
Height - 2 feet above the maximum regulated pool elevation of Lock and Dam 24 (449.0 msl)
Crown Width - 6 feet
Side Slopes - 1 on 1.5
Bottom Width - Varying with bed topography
Linear Centerline Length - Approximately 1000 feet
Orientation - Angled directly into flow

Construction. Construction began on September 21, 1993 and was completed October 5, 1993. A total of 46,592 tons of stone was used. The method of placement was by floating plant equipment.

Dredging. The Dredge Natchez pumped material into the chevrons during the month of November 1993. A total of 185,959 cubic yards of material was placed on the inside and outside of the chevrons. Much of this material has remained, although some material placed outside the downstream shadow boundary has been carried away. Future dredge material, if needed, will be placed further downstream behind each structure to accelerate development of the ultimate bed configuration. Figure 5 is a photo illustrating the dredge placement within the structures.

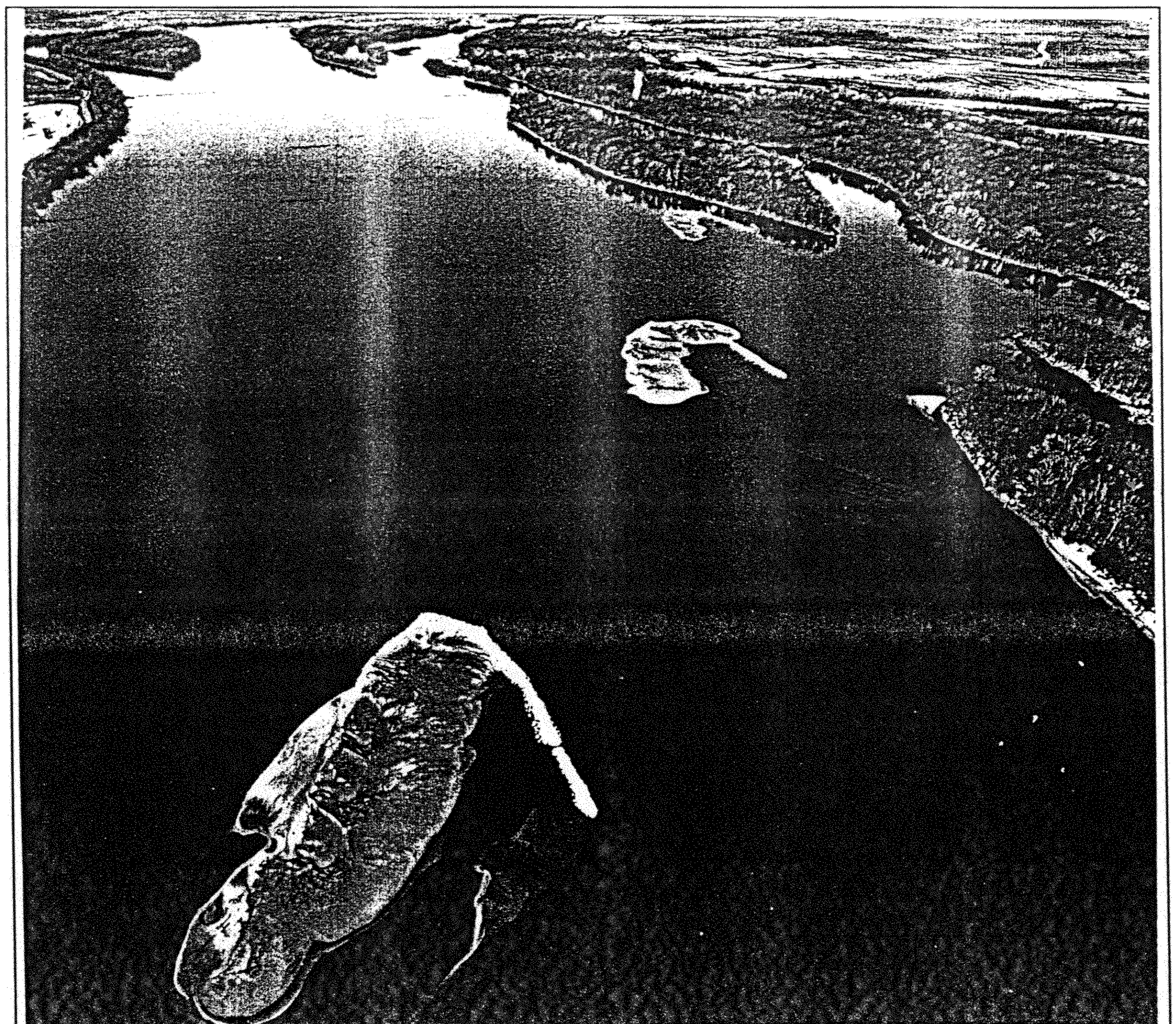

Figure 5. Blunt Nosed Chevrons on the Mississippi River With Placed Dredge Disposal Material, Looking Upstream

MONITORING

Velocity. The velocity patterns around the structures were measured on July 14, 1994 (Figure 6). The graph establishes the fact that the flow pattern is as anticipated. Velocity is smoothly transiting around the structures with no apparent turbulence or excessive velocity occuring at the heads of the structures, thereby ensuring stable, structural integrity. These types of data will continue to be collected on a more intermittent basis as the bed configuration around the structure fully develops.

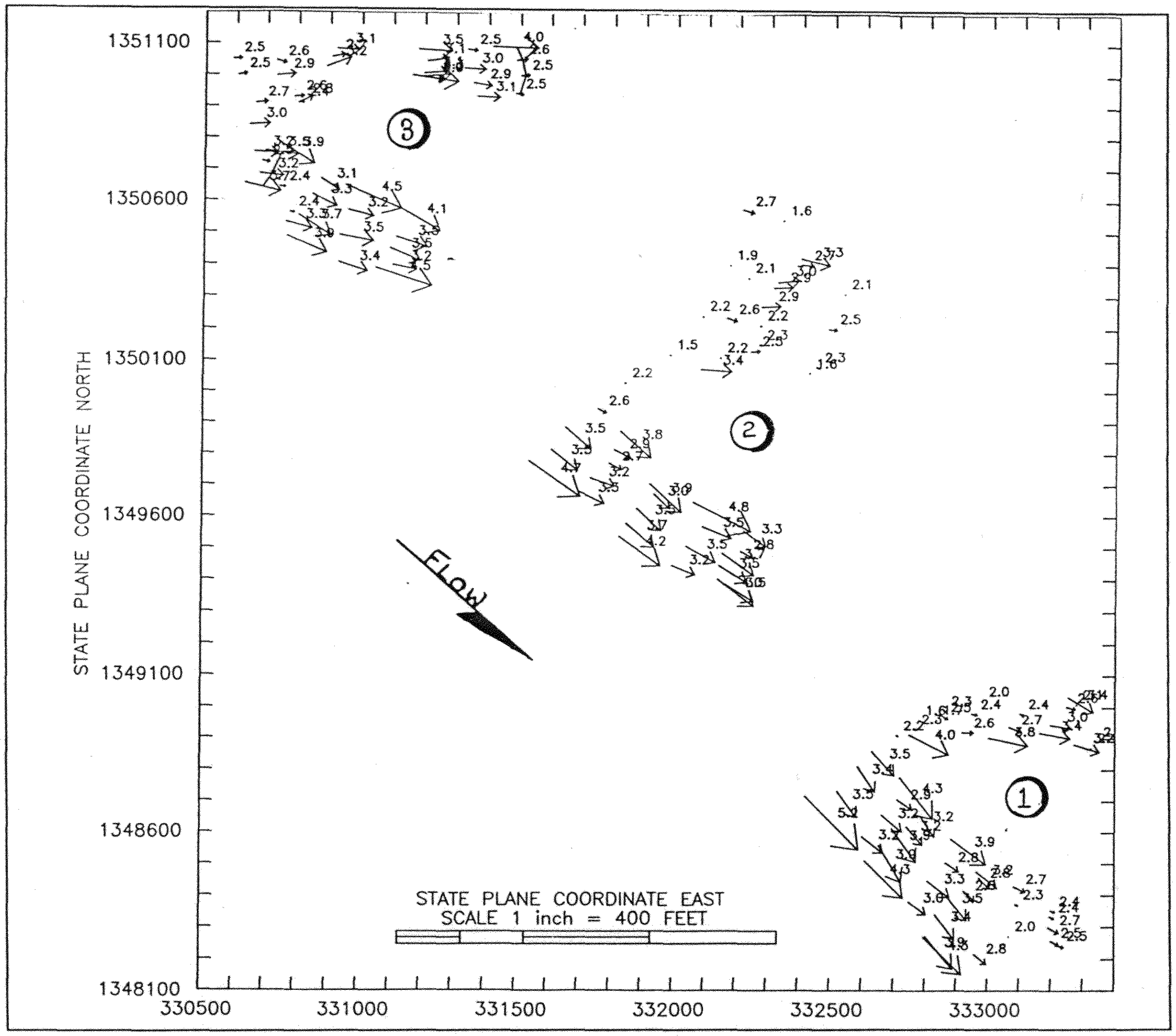

Figure 6. Velocity Magnitudes and Directions around Chevrons During Normal Pool

Water quality. Water quality samples were collected in August, September, and October of 1994 and also in August and September of 1995. A variety of indicators were analyzed. The average results are as follows:

Water temp: 24 degrees Celsius
Conductivity : 440(normal)
Silica: 11 mg/liter
Ortho: 0.1 mg/l
Ammonia : less than 0.5
Volatile SSP: 10 mg/l
Phenophytin: 6 mg/liter

pH : 8.0
ORP (Oxygen Reduction Potential): 350 (good)
Phosphates: 0.2 mg/l
Nitrates: 1.0
Suspended solids: 40 mg /liter to 10 mg/liter
Chlorophyll: 50 mg/l
DO: 10.0 (above average)

Monitoring of this type will continue in the future. The above data indicates that water quality in the chevron fields is excellent and able to sustain aquatic life (Brown 1995).

Macroinvertebrates. A macroinvertebrate study on the three chevrons was prepared in March of 1995 based upon field data collected in November of 1994. A total of 94 taxa were collected in the outside of the structures, 69 taxa were collected on the inside of the structures, and 31 taxa were collected on the surrounding river bed. Invertebrate density was high in the substrate surrounding the chevrons, although species richness and diversity were lower than other areas sampled. Dominant taxa were species generally associated with sandy substrate in large rivers. Diversity and species richness were high on the exterior and interior of the structures. Commonly collected species were those typically associated with fast flowing, rocky streams, and rock or vegetate littoral areas. The high diversity in this area reflected habitat heterogeneity. This is considered beneficial for the development of future fish communities (Miller, T. 1995).

Fish. In August of 1995, an electrofishing study was conducted along both the outside and inside of the middle Blunt-Nosed Chevron. A total of 18 different fish species totaling 199 fishes were reported at a sampling rate of 7.1 fish per minute. These results are above average and indicate that large numbers of fish are utilizing the habitat created by the structure. The data also reveals that the fish community on the inside of the structure is similar to a backwater lake community, while the community on the outside of the structure is similar to a typical river community. Although theses data are by no means conclusive, the early trends indicate these structures are very beneficial to riverine fish communities (Atwood 1995). It was also apparent during the sampling period that the Blunt Nosed Chevron field is serving as a recreational outpost for fishing and boating enthusiast.

CONCLUSIONS

Blunt Nosed Chevrons in the Mississippi River are performing as designed. The structures are reaping the multiple benefits associated with the boundary effects. Chevron design in the future will be modified to create additional environmental diversity. Top elevations may be varied, as well as the addition of notches, changes in lateral slope, etc.

Both engineering and environmental monitoring will continue to quantify the final effects. If favorable trends continue to occur, Blunt Nosed Chevrons may be used in other reaches and in other applications on the Mississippi River.

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