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Coastal and Hydraulics Laboratory

US Army Corps of Engineers®
Engineer Research and Development Center

Monitoring Completed Navigation Projects Program

Greenville Bridge Reach, Bendway Weirs

Michael F. Winkler

September 2006

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Final report

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Abstract: Greenville Bridge Reach is located on the Mississippi River from river mile 542 to mile 530. The Greenville reach affects tows navigating through the Highway 82 Bridge located at mile 531 approximately 12 miles downbound of Greenville, MS.

Research conducted at the U.S. Army Engineer Research and Development Center (ERDC) suggested realignment of the channel through the reach and construction of seven bendway weirs would improve navigation conditions through the reach and existing Highway 82 Bridge.

Although the general design of the project was based on model studies conducted at ERDC from 1979 to 1996 and sound engineering practices, channel alignment and bed configuration can vary somewhat from those predicted in model studies due to composition of the bed material and different flow conditions than those used in the model studies. Therefore, due to its complexity, this project was selected for monitoring under the Monitoring Completed Navigation Projects program. Various types of data were collected and analyzed to determine the effects of the improvements on navigation through the reach and identify any potential problems of alignment of navigation traffic approaching both the new (currently under construction) and old bridges. Bathymetric data were collected and used to compare the predicted channel to the developed channel. It was determined that the bendway weirs at Vancluse Bend above the Highway 82 Bridge at Greenville, MS, are performing as predicted.

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Preface

The studies reported herein were conducted as part of the Monitoring Completed Navigation Projects (MCNP) program (formerly Monitoring Completed Coastal Projects program. Work was conducted under MCNP Work Unit No. 11M22, "Greenville Bridge Reach, Bendway Weirs." Overall program management of the MCNP is provided by Headquarters, U.S. Army Corps of Engineers (HQUSACE). The Coastal and Hydraulics Laboratory (CHL), U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS, is responsible for technical and data management and support for HQUSACE review and technology transfer. Program monitors for the MCNP program during the conduct of this study were Barry W. Holliday and Charles B. Chesnutt, HQUSACE. MCNP Program Managers during the conduct of this MCNP study were Robert R. Bottin, Jr., and Dr. Lyndell Z. Hales, CHL.

This research was conducted during the period 1 October 2002 – 30 September 2005 under the supervision of Dr. John E. Hite, Acting Chief, Navigation Branch (NB), CHL; Dr. Rose M. Kress, Chief, Navigation Division, CHL; Dr. Sandra K. Knight, Technical Director for Navigation, CHL, Dr. William D. Martin, Deputy Director, CHL, and Thomas W. Richardson, Director, CHL. Other ERDC laboratory and MCNP District Team Members who contributed significantly to the development and execution of this study included Howard Park, Keith Green, David Maggio, Cecil Dorrell, Peggy Van Norman (NB), and Glenda Hill, Vicksburg District. Principal Investigator for this research study was Michael F. Winkler, NB.

COL Richard B. Jenkins was Commander and Executive Director of ERDC. Dr. James R. Houston was Director.

Unit Conversion Factors

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
feet	0.3048	meters
horsepower (550 foot-pounds force per second)	745.6999	watts
inches	0.0254	meters
miles (nautical)	1,852	meters
miles (U.S. statute)	1,609.347	meters

1 Introduction

Monitoring Completed Navigation Projects program

The goal of the Monitoring Completed Navigation Projects (MCNP) program (formerly the Monitoring Completed Coastal Projects program) is the advancement of coastal and hydraulic engineering technology. The program is designed to determine how well projects are accomplishing their purposes and how well they are resisting attacks by their physical environment. These determinations, combined with concepts and understanding already available, will lead to (a) the creation of more accurate and economical engineering solutions to coastal and hydraulic problems, (b) strengthening and improving design criteria and methodology, (c) improving construction practices and cost effectiveness, and (d) improving operation and maintenance techniques. Additionally, the monitoring program will identify where current technology is inadequate or where additional research is required.

To develop direction for the program, the U.S. Army Corps of Engineers (USACE) established an ad hoc committee of engineers and scientists. The committee formulated the objectives of the program, developed its operation philosophy, recommended funding levels, and established criteria and procedures for project selection. A significant result of their efforts was a prioritized listing of problem areas to be addressed. This is essentially a listing of the areas of interest of the program.

Corps offices are invited to nominate projects for inclusion in the monitoring program as funds become available. The MCNP program is governed by Engineer Regulation 1110-2-8151 (Headquarters, U.S. Army Corps of Engineers (HQUSACE) 1997). A selection committee reviews and prioritizes the nominated projects based on criteria established in the regulation. The prioritized list is reviewed by the Program Monitors at HQUSACE. Final selection is based on this prioritized list, national priorities, and the availability of funding.

The overall monitoring program is under the management of the Coastal and Hydraulics Laboratory (CHL), U.S. Army Engineer Research and Development Center (ERDC), with guidance from HQUSACE. An individual monitoring project is a cooperative effort between the submitting

District and/or Division office and CHL. Development of monitoring plans and conduct of data collection and analyses are dependent upon the combined resources of CHL and the District and/or Division.

Location and description of prototype

Greenville Bridge Reach is located on the Mississippi River from river mile 542 to mile 530 (Figure 1). The Greenville reach affects tows navigating through the Greenville Bridge located at mile 531 approximately 12 miles downbound of Greenville, MS. The Highway 82 Bridge, completed in 1940, includes a navigation span having a clear width of 800 ft located near the center of the narrow channel and two river spans, one on each side of the navigation span.

Historically, navigation conditions through the Greenville Bridge were considered difficult and hazardous for downbound tows due to the shift of the channel upbound of the bridge from the left descending bank (LDB) to the right descending bank (RDB). The higher velocities are located on the RDB thus holding the tows along that bank. Once a downbound tow exits the bend upbound of the bridge there is a limited approach length for the tow to align with the bridge span. Crosscurrents existed in the bridge span that tended to force the tow into the pier on the Arkansas side of the navigation span. The limited approach distance and the current velocity and alignment in the bridge approach affect navigation conditions at the bridge.

A plan was developed to re-align the Greenville reach of the river. Due to the complex nature of the reach, the final plan was evaluated in two physical hydraulic models to determine the effect of the plan on stability, maintenance, and navigation. The final plan consisted of several phases; the first phase was removal of three dikes upstream and a stone trenchfill (Vaucluse Trenchfill completed in 1996) on the right descending bank to establish bankline control for a safe and dependable channel alignment into and through the Greenville Bridge. The second phase consisted of seven bendway weirs built adjacent to the trenchfill. Weirs 1 through 4 were completed in 2001, and weirs 5 through 7 were completed in 2002.

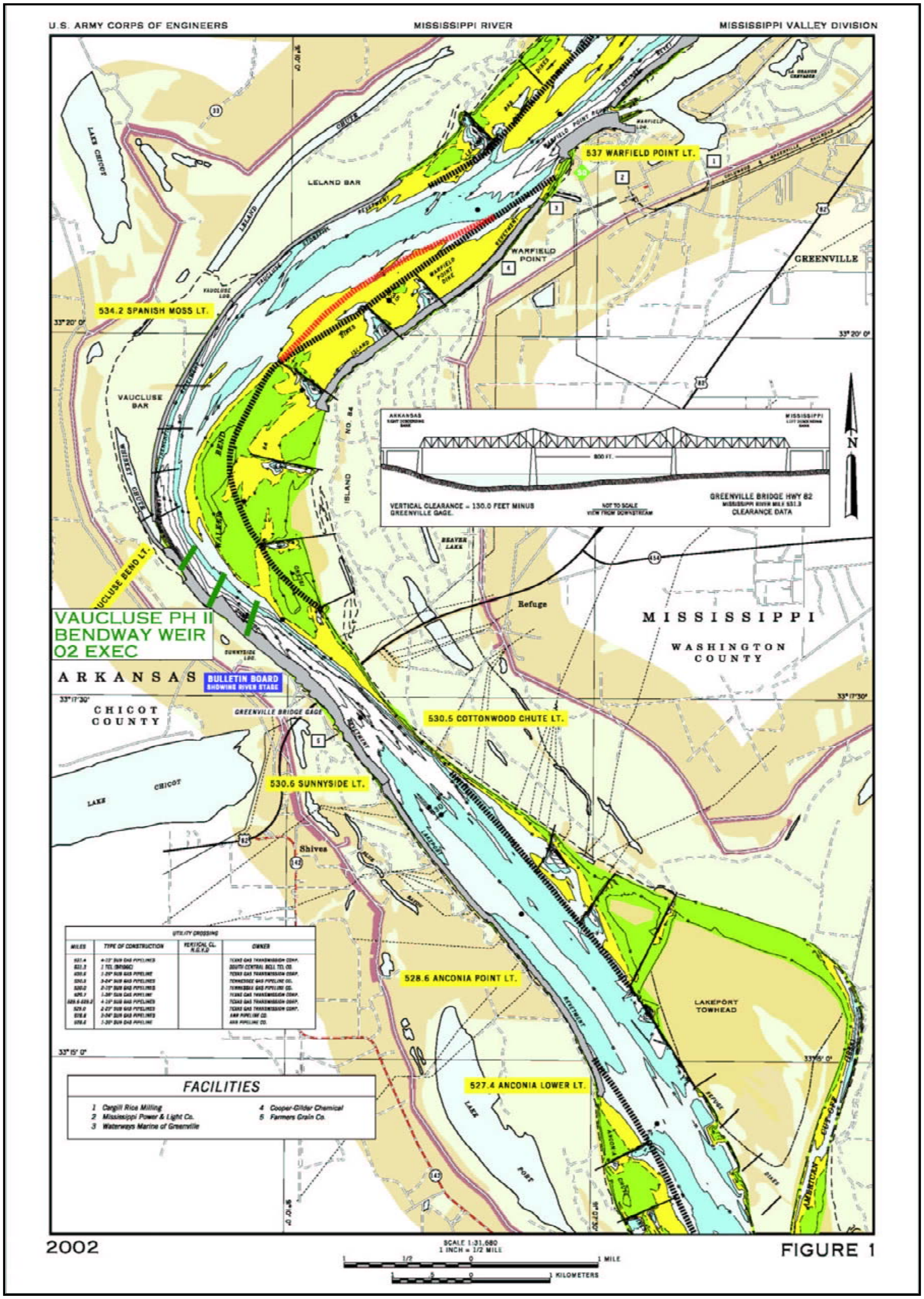

Figure 1. Vicinity map, Greenville Bridge Reach, bendway weirs, Mississippi River near Greenville, MS.

After the Vicksburg District plan was under construction, the Mississippi Department of Transportation (MDOT) proposed to build a new Highway 82 Bridge. The new bridge will be located 853.4 m (2800 ft) downbound of the old bridge and has a navigation span of 426.7 m (1400 ft). The construction of a new bridge will increase the navigation span by 182.8 m (600 ft). To ensure that the new bridge was being constructed in the best lateral location, the existing semi-fixed bed Greenville Bridge Reach navigation model at the CHL was used to evaluate post-project conditions (Wilson 2000). The study indicated that the navigation span should be moved toward the Arkansas bank approximately 45.7 m (150 ft) and that was integrated into the final plan. After construction is completed, the old bridge is scheduled to be demolished. The new bridge is expected to open for traffic in 2007.

Present development plan

Due to project conditions regarding navigability, multiple model studies were conducted at ERDC from 1979 to 1996. A semi-fixed bed and a movable-bed model were operated at ERDC to evaluate proposed plans to realign the river. Recommendations from the studies included construction of seven bendway weirs including optimum weir spacing, angle, and placement to improve navigation conditions.

The Vicksburg District designed and constructed seven bendway weirs along the right descending bank between river miles 533.7 and 532.1 Above Head of Passes (AHP).[1] The weirs were spaced evenly at intervals of about 457.2 m (1,500 ft). Weirs 1 through 3 were angled approximately 20 deg upbound to a perpendicular drawn to the bankline at the bank end of the weir. Weir 4 was angled approximately 15 deg upbound to a perpendicular drawn to the bankline at the bank end of the weir. Weirs 5 through 7 were constructed perpendicular to the bankline. All weirs were level crested at el 6.1 m (20 ft) below the Low Water Reference Plane (LWRP)[2] with lengths of 283.5 m, 237.7 m, 353.6 m, 391.7 m, 389.2 m, 301.8 m, and 313.9 m (930, 780, 1,160, 1,285, 1,277, 990, and 1,030 ft Figure 2).

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[1] Head of Passes is where the main stem of the Mississippi River branches off into three distinct directions at its mouth: Southwest Pass (west), Pass A Loutre (east), and South Pass (centre). The *Head of Passes* is considered to be the location of the mouth of the Mississippi River and is the datum from which mileages on the Lower Mississippi River are measured.

[2] A hydraulic reference plane based on the average stage from 1982-1991 representing the discharge equaled or exceeded 97% of the time.

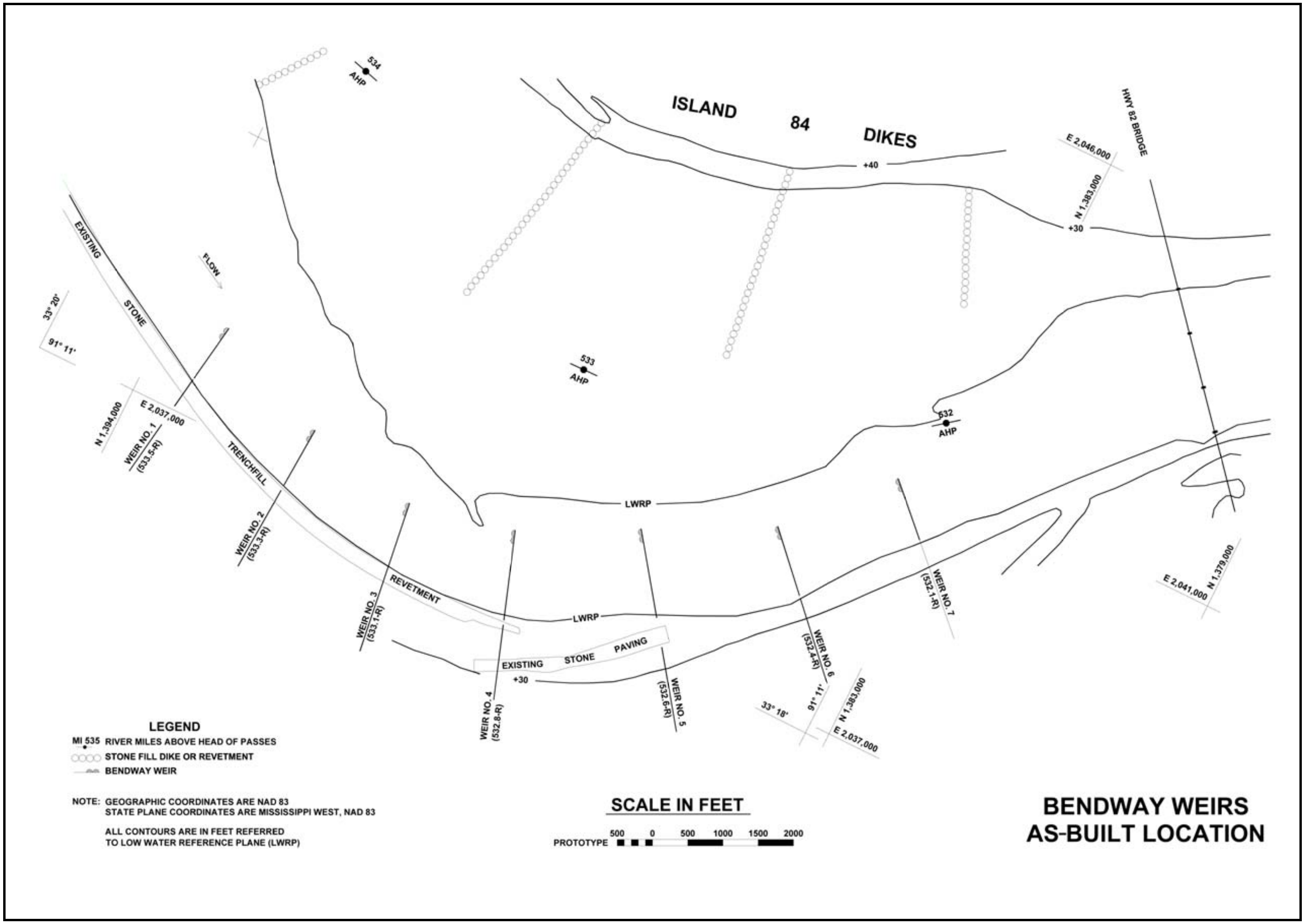


Figure 2. Bendway weir locations, Greenville Bridge Reach.

These improvements were designed to make the channel widen by eroding the point bar on the inside of the bend. The weirs also redistribute the flow in the bend causing currents to be uniform across the navigation channel, and the weirs maintain a smooth, wide, well-aligned navigation channel through the reach. The end result would be the thalwag of the river to move away from the right descending bank and allow downbound tows to align with the navigation span an adequate distance upstream, which would improve navigation conditions in the vicinity of the bridge.

Purpose of the study

The general design of the project was based on model studies conducted at ERDC from 1979 to 1996 and sound engineering practices. However, channel alignment and bed configuration can vary somewhat from those predicted in model studies due to composition of the bed material and different flow conditions than those used in the model studies. Data collected during the monitoring period was used to determine the effects of the improvements on navigation through the reach and identify any potential problems of alignment of navigation traffic approaching both the new and old bridge. The bathymetric data were used to evaluate the developed channel.

Monitoring plan

One time-lapse video system was installed on the existing bridge looking upbound to monitor traffic moving through the reach. Data were collected for 1 year after construction of the weirs to document navigation conditions over a wide range of flow conditions. These video data were then edited to remove extraneous information and analyzed.

Floats drafting 8 ft were tracked through the reach to obtain current velocities and direction that affect tows navigating the reach. These data were compared to model data collected in the semi-fixed bed model. An Acoustic Doppler Current Profiler (ADCP) was used to measure the river discharge during data collection. Float data were collected with two flow conditions, and the ADCP data were collected with three flow conditions.

Bathymetric data were also collected with a high-resolution multi-beam hydrographic survey instrument. These data were collected at the beginning of the study and at 1-year intervals to monitor the development of the channel. These data were evaluated against the bathymetry of the physical movable-bed model used in the development and testing of proposed designs.

2 Data Collection and Results

Data collection methods

The primary concerns of the study were the flow patterns, measurement of current velocities, bed contours, and effects of currents on tows moving through the reach. Data obtained during this study were sufficient to determine the performance of the bendway weirs and their effects on tows moving through the reach.

Current direction and velocity measurements

Tracking floats submerged to the depth of loaded barges has been the preferred method for collecting data in hydraulic navigation models for analyzing the effect of currents on tows using inland waterways for many years (Winkler and Wooley 2002). Field data collected using floats have been used to calibrate or verify these hydraulic models when possible. However, due to the difficulty and time involved for collection of float data, other types of data such as point velocity measurements, water-surface profiles, and ADCP data have also been used for verification of the hydraulic models. Float measurements show the overall trend in the current patterns by showing the average current direction and velocities. While these average current direction and velocities provide the best indication of the effects of currents on tows, it was difficult to collect such field data prior to Global Positioning Systems (GPS). Therefore, floats were seldom used to record current directions and velocities in the field. With the development of GPS, a new method of tracking floats in the field has been developed. GPS receivers are mounted on the floats to track their paths over large areas and long reaches with great flexibility.

A float was designed to accept a GPS unit mounted near its top to reduce any interference to the signals from the GPS satellites. The float was constructed in 4-ft sections so the depth of the float could be adjusted to either a 4-ft or 8-ft draft by screwing the two sections together (Figure 3). The float was constructed of 3-in.-diam PVC pipe attached to a 12-in.-diam high density Styrofoam buoy. Four sheet metal fins were mounted to the PVC pipe to increase the effective area of the float. The 6-in. sheet metal fins increased the resistance of the float, ensuring that the float would move at the speed of the current. The metal fins also increased the weight of the float to make it stand vertical in the water column (Figure 4).

Figure 3. Float with two sections configured to draft 8 ft (after Winkler and Wooley 2002).

Numerous makes and models of GPS receivers can be used to track the path of the float; however, the cost of the unit should be a consideration. Although the chance of a float being lost is slim, there is always a possibility the float could be snagged by a submerged log or some other object and not recovered. There were several GPS receivers that cost under $4,000 (in 2002) that would provide the features and accuracy required for current direction and velocity data. The basic requirement for the GPS receiver is that it is capable of recording the raw satellite signals or pseudorange data for post-processing at a selected time interval. The size and weight of the GPS receiver should also be considered due to it being mounted near the top of the float. A GPS receiver with a radio link to a base station can be used to record Real Time Kinematic (RTK) positions. However, these receivers are more expensive and heavier due to the radio and batteries. For this study, two Magellan GPS ProMARK X-CP receivers were used to collect float data. The Magellan GPS ProMARK X-CP is a small, robust, light receiver that can log 9 hr of both pseudorange and carrier phase satellite data for post-processing.

Figure 4. Float with GPS receiver mounted on top standing vertical in the water (after Winkler and Wooley 2002).

Tracking floats to measure current directions and velocities for analysis or calibration of a hydraulic model does not require a high degree of accuracy. Using post-processing software, pseudorange GPS data recorded by the ProMARK X-CP can be post-processed differentially to achieve 1- to 3-m (3.3- to 9.8-ft) horizontal accuracy. The accuracy between two points in the same track is better than 1 m (3.3 ft) in most cases. The accuracy degrades to 1 to 3 m (3.3 to 9.8 ft) when the number of satellites the GPS unit is recording changes due to the movement of the satellites over time. Therefore, the 1- to 3-m (3.3- to 9.8-ft) difference tends to be an offset between tracks, not between points in the same track. The velocities of floats are generally averaged over a distance of 61 to 122 m (200 to 400 ft). An overall error of 1 m (3.3 ft) in the distance of a float traveling 61 m at 1.5 mps (200 ft at 4.9 fps) is about ± 0.024 mps (0.08 fps). This magnitude of error is negligible when compared to the changes in velocity of the currents through the reach.

Post-processing of GPS receiver data requires satellite data from both the rover receiver (receiver on the float) and from a base station (a receiver set up at a known point). The base station must record raw data during the time of rover data collection and at the same time interval or a multiple of that time interval. To achieve the required accuracy, the GPS data collected on the float must be post-processed against data collected by a GPS receiver at a known point (base station). The base station data can be from an existing Continuous Operating Reference Station (CORS) or from a GPS receiver set up for the purpose of recording data during the collection effort.

During this study, data from a CORS was used to post-process the float data. This eliminated the need for one GPS receiver and for recovering or establishing a point with accurate coordinates for the base station to occupy.

The GPS receiver on the float was set to record at 3-sec intervals during the 2003 data collection while the receiver was set at 10-sec intervals during the 2004 data collection. Recording at both time intervals provided sufficient positions to accurately plot the path of the float. The velocity of the reach was in the range of 1.5 mps (4.9 fps); therefore, data recorded at 3-sec intervals would provide positions every 4.5 m (14.8 ft), while data recorded at 10-sec intervals would provide positions every 15 m (49.2 ft).

The GPS receiver was mounted near the top of the buoy to minimize any interference with the GPS antenna. Mounting the GPS receiver to the buoy also minimized the risk of losing the receiver if the bottom section of the float was snagged on an underwater object and broke free. A two-man crew per boat was required to drop, track, and retrieve the float. The boat operator positioned the boat at the drop site, while the second crewmember turned on the GPS receiver and placed the float over the side. Two floats were used but a separate boat tracked each float. Experience with floats in large rivers has shown that floats dropped close together sometimes will separate by moving apart or one moving at a different speed making it difficult or impossible for one boat to keep track of two floats. Also, for safety reasons and protection of the floats, it was better to have two boats dropping floats in case one boat stalled at a critical time. The tracking boat stayed close enough to the float in case it needed to be retrieved due to tow traffic without interfering with the currents affecting the float.

After selecting the area of coverage and the desired spacing of the floats, the positions for dropping the floats were identified by using a handheld

GPS receiver with mapping capabilities. The start positions for the floats were entered into the handheld receiver and used to position the boat. After dropping the float, the handheld receiver was used to record and plot the track of the boat, which approximately represents the path of the float. If the handheld receiver showed the float was following the path of a previous float, the float was picked up. This method speeded up the data collection by reducing the number of float tracks required to cover the area and showed any gaps in the float tracks. When the float was retrieved, the GPS receiver on the float was turned off so the float track was recorded in a unique file.

Tow tracks

GPS receivers were used to track the paths of selected tows moving through the reach during the same time period that current direction and velocities were measured. Two GPS receivers were placed on the tow: one near the bow and one near the stern. This placement provided data that, when post-processed, gave an accurate track showing the angle and speed of the tow as it moved through the reach. Data were collected using tows that were available during the collection period; therefore, they were of various sizes and draft.

Bathymetric data

Bathymetric data were collected using a high-resolution, multi-beam hydrographic survey instrument. Multiple surveys were taken as the channel developed and the cross section changed. The survey data allowed monitoring of the grade and section of the weirs along with the movement of the sandbar on the LDB. The data were evaluated against the bathymetry data taken before the weirs were constructed.

Time-lapse video of tows

One time-lapse video system was installed on the Highway 82 Bridge looking upbound toward Vaucluse Bend to record tow traffic through the reach during the monitoring period. The data were collected for 6 months after construction of the weir field was completed to document navigation conditions over a wide range of flow conditions. The video data were then edited to remove extraneous information and analyzed.

Evaluation of existing navigation conditions is an important part of developing solutions for adverse navigation conditions. Typical methods to evaluate navigation conditions prior to time-lapse video were to either ride the vessel through the reach or observe the path of the vessel from a vantage point such as bridges. Pictures or video recordings were used to document the movements of the vessel through the reach; however, this method provided a limited amount of data, possibly one or two vessels with one flow condition. A time-lapse video system was installed in the field to record data over an extended period of time that covered a wide range of navigation conditions. This method provided multiple towpaths and tow sizes with a range of flow conditions that was used for evaluation of navigation conditions.

A basic time-lapse video system consists of a time-lapse video recorder and video camera. A Sony Time Lapse Video Cassette Recorder model SVT-S3100 was installed at the site to record tows moving through the reach (Winkler et al. 2003). The recorder was programmed for a daily start and stop time and time-lapse interval. The recorder had a battery backup for the recorder clock and programming in the event of a power failure. Due to the systems being located on the highway bridge and being exposed to the weather, the recorders were installed in a weatherproof case. A standard electrical box was modified to house the time-lapse recorder and other components of the system (Figure 5). It should be noted that in Figure 5 the box is open, but when closed the recorder is actually horizontal in the box.

A high quality camera was selected to provide clear, crisp pictures for analyses. A Sony Color Video Camera model SSC-CX34/34P was selected for the project. The SSC-CX34/34P camera is compact, lightweight and has a 12-power zoom lens with automatic iris. A camera without a zoom lens could have been used but the zoom lens allowed better compositions of the target area without repositioning the camera. The automatic iris was essential for adjusting the iris to changing light conditions in the field. The camera was mounted in a weatherproof camera case with a mount that allowed some rotation for aligning/positioning the camera (Figure 6). In extreme weather conditions, the camera case could be outfitted with heat strips and/or a fan to control the temperature inside the case. The SSC-CX34/34P camera operated on 24-volt alternating current and, therefore, required a transformer that was installed in the recorder box.

Figure 5. Time-lapse recorder and open enclosure (after Winkler et al. 2003).

Figure 6. Video camera in weatherproof case (after Winkler et al. 2003).

Data and results

Model data

The channel configuration predicted by the movable-bed model study conducted at EDRC with Plan M weir field is shown in Plate 1. Movable bed model Plan M represented seven bendway weirs constructed along the right descending bank between river miles 533.7 and 532.1 AHP. The weirs were spaced evenly at intervals of about 548.6 m (1,800 ft) and angled 20 deg upbound to a perpendicular drawn to the bankline at the bank end of the weir. All weirs were level crested at el 20 ft below LWRP with lengths of 417.6 m, 417.6 m, 356.6 m, 362.7 m, 317.0 m, 396.2 m, and 499.9 m (1,370, 1,370, 1,170, 1,190, 1,040, 1,300 and 1,640 ft). These data show a smooth, wide, well aligned navigation channel throughout the entire Island 84 reach from miles 535.5 to 531.3 AHP, with an average channel width between LWRP of 679.7 m (2,230 ft). The width of the navigation channel (12 ft below LWRP) through the weir field varied from about 502.9 m (1,650 ft) near weir 1 to about 731.5 m (2,400 ft) in the vicinity of weir 7.

The length, spacing, and alignment of the weirs recommended by the movable-bed model were constructed in a semi-fixed-bed navigation model to evaluate navigation conditions through the reach. The navigation model indicated there was a tendency for a downbound tow to be moved toward the left pier of the navigation span of the bridge as it exited the weir field. The angles of weirs 6 and 7 were adjusted to correct this tendency. Based on the results of the navigation study, it was recommended that weir 6 be angled 10 deg upbound to a perpendicular drawn to the bankline at the bank end of the weir and weir 7 be constructed in the river perpendicular to the bankline (Navigation Model Plan 7-Modified) (Plate 2).

Current direction and velocities data measured in the fixed-bed navigation model with Plan 7-Modified and riverflows of 21,237 cms and 29,024 cms (750,000 and 1,025,000 cfs) are shown on Plates 3 and 4. These data show that with the 21,237-cms (750,000-cfs) riverflow (Plate 3) the velocity of the current in the navigation channel varied from about 1.8 to 2.1 mps (6.0 to 6.9 fps) immediately upbound of weir 1 to about 1.9 to 2.3 mps (6.2 and 7.7 fps) immediately upbound of weir 7. The velocity of the current immediately riverward of the river end of the weirs was somewhat higher. With the 29,024 cms (1,025,000 cfs) riverflow (Plate 4) the velocity of the current in the navigation channel varied from about 1.6 to 2.2 mps (5.1 to 7.2 fps) immediately upbound of weir 1 to about 1.4 and 2.9 mps (4.5 and 9.3 fps) immediately upbound of weir 7.

As designed and as-built project

Due to changes in the channel alignment and field conditions, the as-built project was slightly different than the ERDC recommended plan. A comparison of recommended and as-built is shown on Plate 5. The alignment and spacing of weirs 1 through 3 are very similar to the recommended plan but weirs 4 through 7 are somewhat different.

The seven bendway weirs were constructed along the right descending bank between river miles 533.7 and 532.1. The weirs were spaced evenly at intervals of about 457.2 m (1,500 ft). Weirs 1 through 3 were angled approximately 20 deg upbound to a perpendicular drawn to the bankline at the bank end of the weir. Weir 4 was angled approximately 15 deg upbound to a perpendicular drawn to the bankline at the bank end of the weir. Weirs 5 through 7 were constructed perpendicular to the bankline. All weirs were level crested at el 6.1 m (20 ft) below the LWRP with lengths of 283.5 m, 237.7 m, 353.6 m, 391.7 m, 389.2 m, 301.8 m, and 313.9 m (930, 780, 1,160, 1,285, 1,277, 990, and 1,030 ft, Figure 2).

February 2001 field data

Prior to construction of the weirs, a hydrographic survey was conducted of the reach. The results of that survey are shown on Plate 6. These data show the channel has moved to the right and is adjacent to the Trenchfill Revetment. The channel width in the vicinity of proposed weir 1 is about 213 m (700 ft) at navigation depth. In the vicinity of proposed weirs 5 through 7 the channel width is about 305 m (1,000 ft).

May 2002 field data

Weirs 1 through 4 were constructed in the river during June through August 2001. A channel survey was made using a high-resolution multi-beam hydrographic survey instrument during the period 30 April – 5 May 2002. The channel configuration, developed through the reach with weirs 1 through 4 constructed, is shown on Plate 7. These data show the width of the navigation channel in the vicinity of weirs 1 through 4 was wider than preconstruction of the weirs. The navigation channel was about 457 to

549 m (1,500 to 1,800 ft) wide through the weir field. In the vicinity of proposed weirs 6 and 7, the width of the navigation channel was about 305 m (1,000 ft). Weirs 5 through 7 were completed during July and August of 2002.

October 2002 – October 2003 time lapse video data

Time lapse video data were collected from October 2002 until October 2003 after construction of the weirs was complete. The edited tapes were reviewed to evaluate how the tows navigated through the bendway and any trends that might exist. In a typical bendway, the faster moving currents are found on the outside of the bend. With the weirs in place, the faster currents were no longer on the outside bend (RDB) at Greenville; however, faster currents relocated to the ends of the weirs. Review of the video tapes showed few upbound tows took advantage of the slower currents on the RDB unless tows passed in the bendway. In a passing situation 90 percent of the time the upbound tow would move to the RDB and the tows would pass on their starboard sides. Prior to the weir construction, tows that passed in the bendway would have done so port side to port side. The video review also showed that the location and angle of approach of weir 7 are important to an upbound tow that plans to utilize the slower currents on the RDB at Greenville. The upbound tows that successfully used the slower currents approached very close to the RDB and appeared to be driving the head of the tow into the RDB. This type of approach to weir 7 would allow them to stay over the weirs and closer to the RDB. If the upbound tow was too far toward the LDB and lacked sufficient approach angle to compensate for the currents around weir 7, the head of the tow would be moved toward the end of the weirs in a sliding motion. The tow would then remain off the end of the weirs navigating upbound through the faster currents. Downbound tows all seemed to follow a similar path through the bendway. The downbound tow followed a path off the end of the weirs similar to Plates 10 – 12. During the year that the time lapse video was recorded after construction was completed, there was not one accident recoded (cameras only recorded during the daytime).

May 2003 field data

With weirs 5 through 7 completed in the previous year, 2003 was the first full year of the completed project. A hydrographic survey was made of the channel during the period of 2 – 5 May 2003. The channel configuration developed through the weir field in May 2003 is shown in Plate 8. These data show the width of the navigation channel was about 335.3 m (1,100 ft) in the vicinity of weir 1 and about 457.2 m (1,500 ft) in the vicinity of weir 7.

Current directions and velocities calculated from the float data were obtained during the period of 5-8 May 2003 with a riverflow of 18,583 cms (656,255 cfs) and are shown in Plate 9. The alignment of the currents through the weir field was generally parallel to the RDB with a reasonably good distribution of flow across the channel. There was no indication of an out-draft near the riverward end of the weirs. The velocity of the current in the navigation channel varied from about 1.9 to 2.2 mps (6.1 to 7.1 fps) immediately upbound of weir 1 to about 1.3 to 2.1 mps (4.2 to 6.8 fps) immediately upbound of weir 7. The velocity of the current immediately riverward of the river end of the weirs were somewhat higher. These data generally agree with the current velocities and alignment measured in the Navigation Model with Plan 7-Modified (Plate 3).

Tow tracks obtained during the period of 5-7 May 2003 with a riverflow of 18,583 cms (656,255 cfs) are shown in Plates 10–13. Plates 10, 11, and 12 show downbound tows driving through the reach near the riverward end of the weirs without any major difficulties. Plate 13 shows an upbound tow driving over weirs 4, 5, 6, and 7 and then moving to the riverward end of the weir field. The track lines indicate the tow was required to adjust its steerage as it moved over the weirs but did not have any major difficulties moving through the reach.

June 2004 field data

A hydrographic survey was made of the channel during the period of 18 – 24 June 2004. The channel configuration developed through the weir field is shown on Plate 14. These data show the width of the navigation channel varied from about 350 m (1,150 ft) in the vicinity of weir 1 to about 533 m (1,750 ft) in the vicinity of weir 7. These data show the channel width increased between May 2003 and June 2004, realizing that the channel may not be fully developed. The width of the June 2004 navigation channel was about 152 m (500 ft) less than the channel predicted by the movable-bed model.

Current directions and velocities calculated from the float data were obtained in June 2004 with a riverflow of 27,250 cms (962,334 cfs) and are shown in Plate 15. The alignment of the currents through the weir field was generally parallel to the RDB with a reasonably good distribution of flow across the channel. There was no indication of an out-draft near the riverward end of the weirs. The velocity of the current in the navigation channel varied from about 1.6 to 1.9 mps (5.3 to 6.1 fps) immediately upbound of weir 1 and about 4.7 to 7.9 fps immediately upbound of weir 7. The velocity of the current immediately riverward of the river end of the weirs was generally somewhat higher than the current immediately upbound of the weir. These data generally agree with the current velocities and alignment measured in the Navigation Model with Plan 7-Modified (Plate 4).

Tow tracks obtained in June 2004 with a riverflow of 27,250 cms (962,334 cfs) are shown in Plates 16–19. Plates 16 and 17 show a downbound tow driving through the reach immediately riverward of the weir field without any major difficulties. The tows exited the bend properly aligned with the navigation span of the Highway 82 Bridge. Plates 18 and 19 show an upbound tow navigating through the reach over the weir field without any major difficulties. The track lines and the plots of the tows indicate some maneuvering was required to navigate the reach.

3 Pilot Interviews

On 23 June 2004, four vessels were boarded and their pilots interviewed regarding their impressions about the weir field located at Vauclause Bend. Two of the vessels were smaller, lightly loaded, and traveling in a downbound direction. The other two vessels were larger, heavily loaded, and traveling in an upbound direction.

M/V Poseidon

The Motor Vessel (M/V) Poseidon is owned and operated by Kirby Towing. The Poseidon is a 2,150-hp vessel that is about 8.5 m (28 ft) wide by 23 m (75 ft) long. It was pushing a staggered barge flotilla in the downbound direction that was 2 barges wide (108 ft) by 2 barges long (550 ft). The flotilla was lightly loaded (about 2-ft draft). The motor vessel was piloted by Otis Carpenter, who was experienced and had been on the river a large portion of his life. Mr. Carpenter's comments on the weir field at Vauclause Bend included:

- Marked reduction in velocities along the right descending bank, and also feels like the current toward the inside of the bend has increased.
- Upbound vessels have started using the weir field in the upbound direction due to the reduced velocities. Marked increase in attainable speed headed upbound along the Arkansas bank.
- In the downbound direction, he stays on the red buoys (located on the left side of the channel looking downbound) and navigates through the navigation span with no significant difficulties. (Pushes a lot of empties downbound.)
- Weir field has made a very nice and good improvement through this reach of the river.

M/V Frank Tamble

M/V Frank Tamble is owned and operated by Southern Towing. It is a 3,600-hp vessel that is about 8.3 m (27 ft) wide by 36.6 m (120 ft) long. It was pushing a staggered barge flotilla in the downbound direction that was 2 barges wide (100 ft) by 2 barges long (549 ft). The flotilla was lightly loaded (about 2-ft draft). Steve Shiver piloted the motor vessel. He has been on towboats for about 9 years; however, he had only been in the wheelhouse on his own for about 8 months. Captain Shiver's comments on the weir field at Vauclause Bend included:

- Marked reduction in velocities along the right descending bank also. Currents appear to be higher on the red buoys.
- Significant set toward the left pier of the existing Greenville Bridge. Must steer off that pier about 1,000 ft downbound of the weir field.
- Weir field has made a good improvement in this reach of the river.

M/V Mitch Jones

M/V Mitch Jones is owned and operated by Ingram Barge Company. It is a 10,500-hp vessel that is about 16.4 m (54 ft) wide by 61 m (200 ft) long. It was pushing a barge flotilla of 35 barges (175 ft x 1,365 ft). The lead 5 barges were lightly loaded with the remainder of the flotilla heavily loaded to a draft of at least 9 ft. The pilot of the vessel was Captain Shawn Wilmoth, who has been on the river for 20+ years. Captain Wilmoth's comments about the weir field at Vauclause Bend included:

- Marked reduction in the velocities over the weir field and runs upbound over the weir field all the time now. Velocities out toward the red buoys seemed to be higher than before the weirs were put in.
- Weir field has made a significant improvement in this reach of the river.

M/V Jerry Jarrett

M/V Jerry Jarrett is owned by Marquette Transportation and operated by Bluegrass Marine. It is a 7,200-hp vessel that is about 55 ft wide by 155 ft long. It was pushing a barge flotilla of 28 barges (140 ft x 1,365 ft). The lead 4 barges were lightly loaded with the remainder of the flotilla heavily loaded to a draft of at least 9 ft. The skipper of the vessel was Captain Kenneth Miles, who reiterated everything the other vessel captains and pilots said about the weir field. Captain Miles' specific comments about the weir field at Vaucluse Bend included:

- Marked reduction in the velocities over the weir field and runs upbound over the weir field all the time now.
- Weir field has made a significant improvement in this reach of the river, but the river takes time to respond geomorphologically to all the changes that have been made.

4 Summary and Conclusions

Data collection methods

Field data collection using the methods described in this study provided valuable data for the analysis of navigation conditions through the reach and provided sufficient data for comparison to data measured in physical models conducted at ERDC. These methods proved to be a cost-effective method for field data collection.

Model-to-prototype comparison

Current direction and velocities

The alignment and velocities of the current measured in the field were similar to those measured in the physical model study conducted at ERDC.

Channel alignment, width and depth

The channel surveys made using a high-resolution, multi-beam hydrographic survey instrument showed the June 2004 channel to be similar to that predicted by the physical movable-bed model conducted at ERDC. However, the width of the navigation channel was about 500 ft less than predicted. It should be noted the channel might not be fully developed.

Conclusions

The bendway weirs at Vaucluse Bend above the Highway 82 Bridge at Greenville, MS, are performing as predicted. The weirs have redistributed the high velocities found along the RDB prior to construction toward the LDB approximately 366 m (1,200 ft). Downbound tows are no longer forced into the bend due to the high velocities but are able to hold off the end of the weirs. This provides the tow a better alignment as it approaches the Highway 82 Bridge. Once the tow boat operators developed a better understanding of how to take advantage of the weirs, a common belief developed that the project was a success.

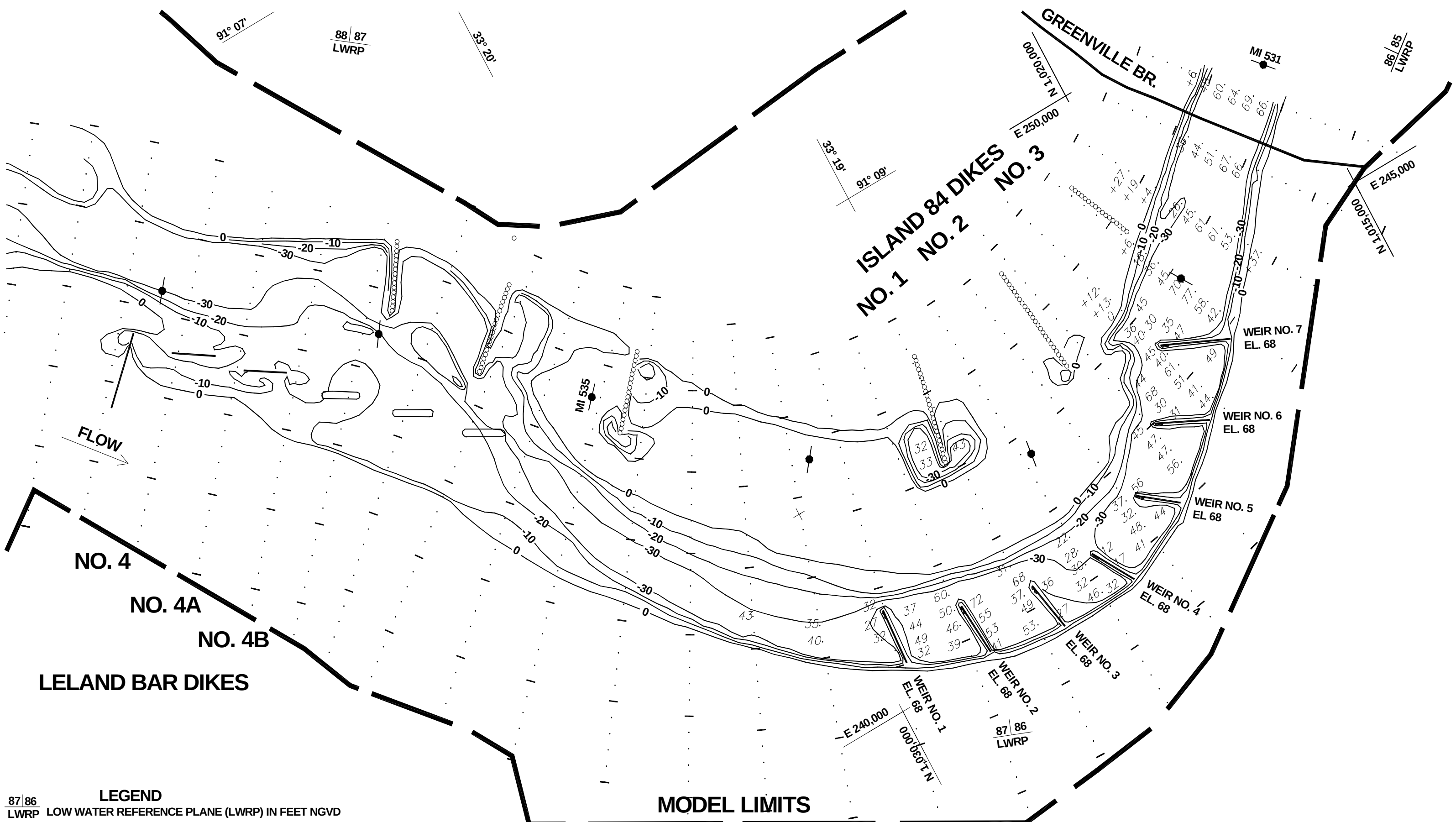
5 References

Headquarters, U.S. Army Corps of Engineers. 1997. *Monitoring coastal projects*. Engineer Regulation 1110-2-8151. Washington, DC: Headquarters, U.S. Army Corps of Engineers.

Wilson, D. C. 2000. *Navigation span location study for Greenville bridge reach, Mississippi River*. ERDC/CHL TR-00-20. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Winkler, M. F., and R. T. Wooley. 2002. *Current direction and velocity measurements using GPS receivers mounted on floats at Tom Bevill Lock and dam*. Coastal and Hydraulics Engineering Technical Note ERDC/CHL CHETN-IX-11. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Winkler, M. F., R. T. Wooley, and B. C. Barker. 2003. *Monitoring navigation using time-lapse video recorders*. Coastal and Hydraulics Engineering Technical Note ERDC/CHL CHETN-IX-13. Vicksburg, MS: U.S. Army Engineer Research and Development Center.



LEGEND

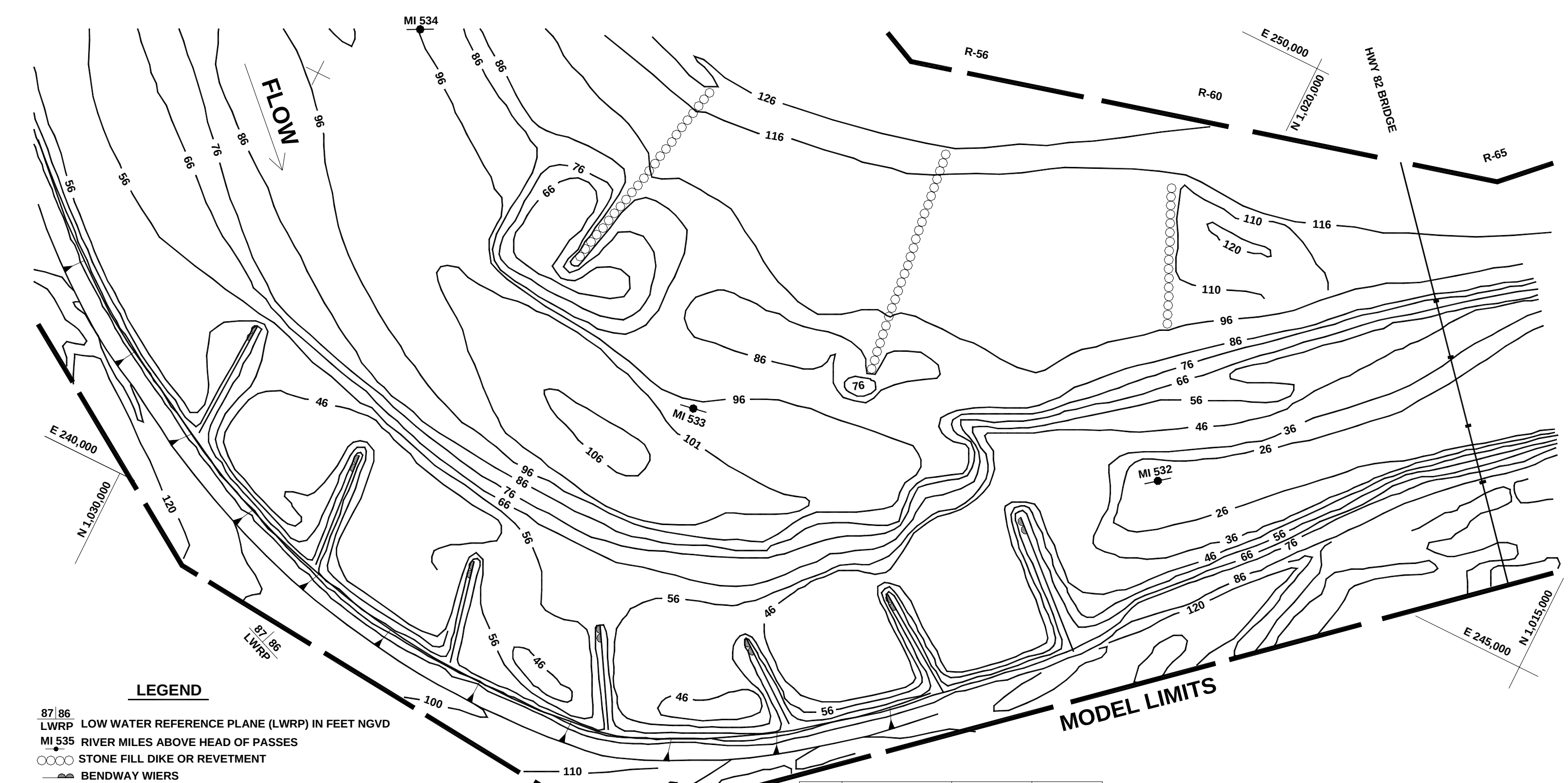
87 | 86 LWRP — LOW WATER REFERENCE PLANE (LWRP) IN FEET NGVD
MI 535 — RIVER MILES ABOVE HEAD OF PASSES
STONE FILL DIKE OR REVETMENT
BENDWAY WEIRS
42 — SOUNDINGS IN FEET BELOW LWRP
+42 — SOUNDING IN FEET ABOVE LWRP

NOTE: GEOGRAPHIC COORDINATES ARE NAD 27
STATE PLANE COORDINATES ARE MISSISSIPPI WEST, NAD 27
CONTOURS ARE REFERENCED TO LWRP IN FEET
SOUNDINGS ARE REFERENCED TO LWRP IN FEET
RANGES ARE MARKED IN HORIZONAL MODEL FEET - 1:360
ELEVATIONS ARE IN FEET NGVD

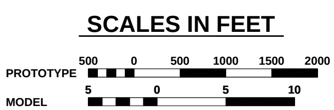
SCALES IN FEET

PROTOTYPE 0 2500 5000 7500
MODEL 0 5 10 15 20 25

MOVABLE BED MODEL CHANNEL CONFIGURATION
PLAN M TYPICAL HYDROGRAPH
RUN 3



NOTE: STATE PLANE COORDINATES ARE MISSISSIPPI WEST, NAD 27
ELEVATIONS, CONTOURS AND SOUNDINGS ARE IN FEET NGVD
RANGES ARE MARKED IN PROTOTYPE FEET

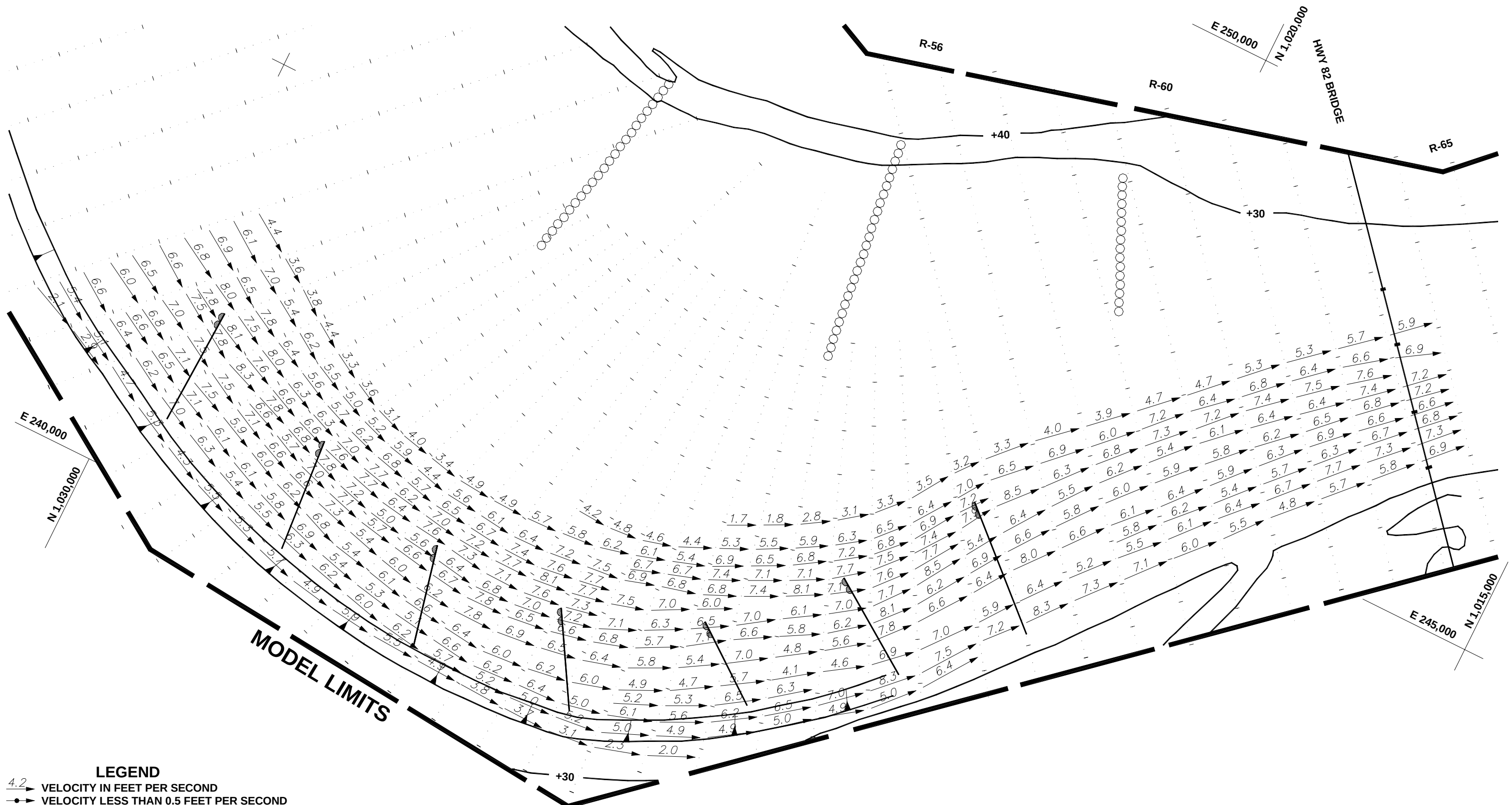


DIKE NO	COORDINATES	AZIMUTH	ELEVATION (NGVD)
1	N 1,029,355 E 242,174	272°27'47"	68.0
2	N 1,027,691 E 241,362	265°05'58"	68.0
3	N,1026,012 E 240,869	256°38'51"	68.0
4	N 1,024,433 E 240,862	238°46'24"	68.0
5	N 1,022,872 E 241,431	217°04'25"	68.0
6	N 1,021,695 E 242,604	214°33'59"	68.0
7	N 1,020,753 E 244,031	221°59'43"	68.0

NAVIGATION MODEL BENDWAY WEIR LOCATION CHANNEL CONFIGURATION

PLAN 7-MODIFIED

Plate 2



LEGEND

- 4.2 VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- 4.2 VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED 3.0 FT
- STONE FILL DIKE OR REVETMENT
- BENDWAY WIERS

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (12.0 FT)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

COORDINATES ARE STATE PLANE, MISSISSIPPI WEST, NAD 27

SCALES IN FEET

PROTOTYPE 500 0 500 1000 1500 2000

MODEL 5 0 5 10

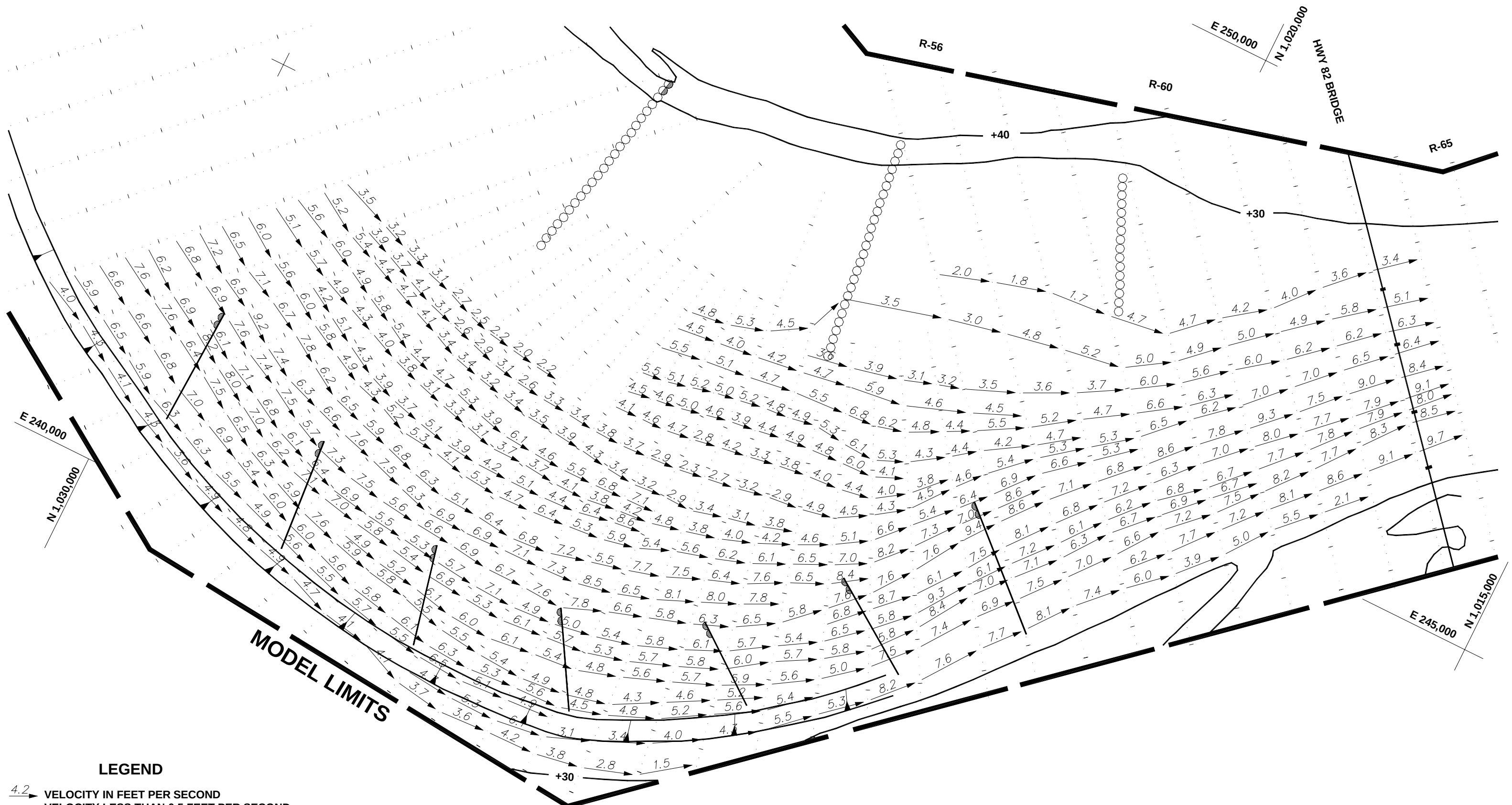
VELOCITIES AND CURRENT DIRECTIONS

NAVIGATION MODEL PLAN 7-MODIFIED

DISCHARGE: 750,000 CFS

TAILWATER EL: 109.6 FT

Plate 3



LEGEND

- 4.2 → VELOCITY IN FEET PER SECOND
- → VELOCITY LESS THAN 0.5 FEET PER SECOND
- 4.2 → VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED 3.0 FT
- ○○○○ STONE FILL DIKE OR REVETMENT
- BENDWAY WIERS

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH FLOAT SUBMERGED TO DRAFT OF LOADED BARGE (12.0 FT)

ALL CONTOURS AND ELEVATIONS ARE IN FEET REFERRED TO NGVD

COORDINATES ARE STATE PLANE, MISSISSIPPI WEST, NAD 27

SCALES IN FEET

PROTOTYPE 500 0 500 1000 1500 2000

MODEL 5 0 5 10

VELOCITIES AND CURRENT DIRECTIONS

NAVIGATION MODEL PLAN 7-MODIFIED

DISCHARGE: 1,025,000 CFS

TAILWATER EL: 117.2 FT

Plate 4

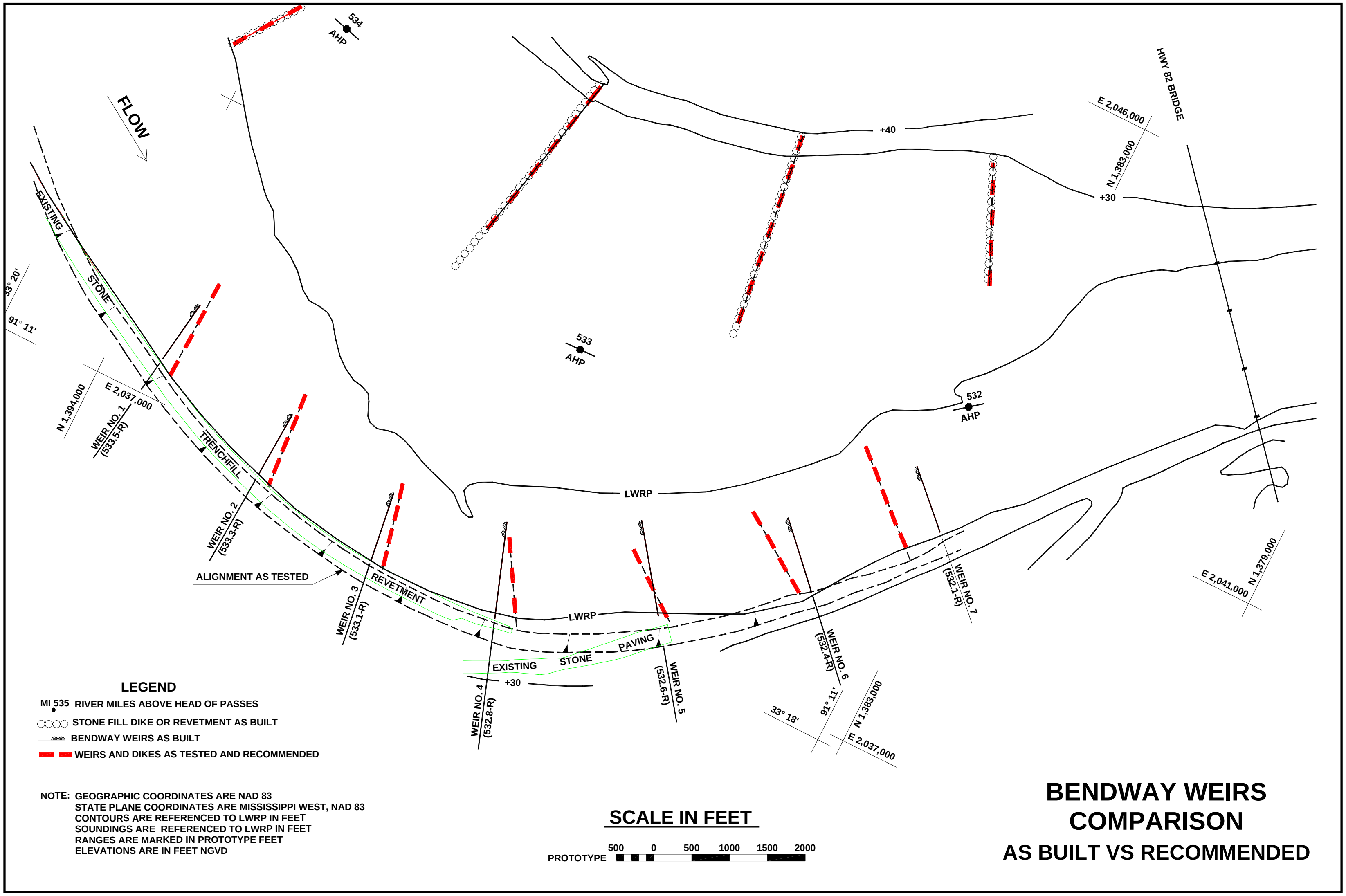

BENDWAY WEIRS
COMPARISON
AS BUILT VS RECOMMENDED
FLOW
534
AHP
533
AHP
532
AHP
HWY 82 BRIDGE
E 2,046,000
N 1,383,000
+40
+30
LWRP
EXISTING
STONE
TRENCHFILL
REVETMENT
PAVING
+30
ALIGNMENT AS TESTED
33° 20'
91° 11'
N 1,394,000
E 2,037,000
WEIR NO. 1
(533.5-R)
WEIR NO. 2
(533.3-R)
WEIR NO. 3
(533.1-R)
WEIR NO. 4
(532.8-R)
WEIR NO. 5
(532.6-R)
WEIR NO. 6
(532.4-R)
WEIR NO. 7
(532.1-R)
33° 18'
91° 11'
N 1,383,000
E 2,037,000
E 2,041,000
N 1,379,000
LEGEND
MI 535 RIVER MILES ABOVE HEAD OF PASSES
STONE FILL DIKE OR REVETMENT AS BUILT
BENDWAY WEIRS AS BUILT
WEIRS AND DIKES AS TESTED AND RECOMMENDED
NOTE: GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES ARE MISSISSIPPI WEST, NAD 83
CONTOURS ARE REFERENCED TO LWRP IN FEET
SOUNDINGS ARE REFERENCED TO LWRP IN FEET
RANGES ARE MARKED IN PROTOTYPE FEET
ELEVATIONS ARE IN FEET NGVD
SCALE IN FEET
PROTOTYPE
500 0 500 1000 1500 2000

Plate 5

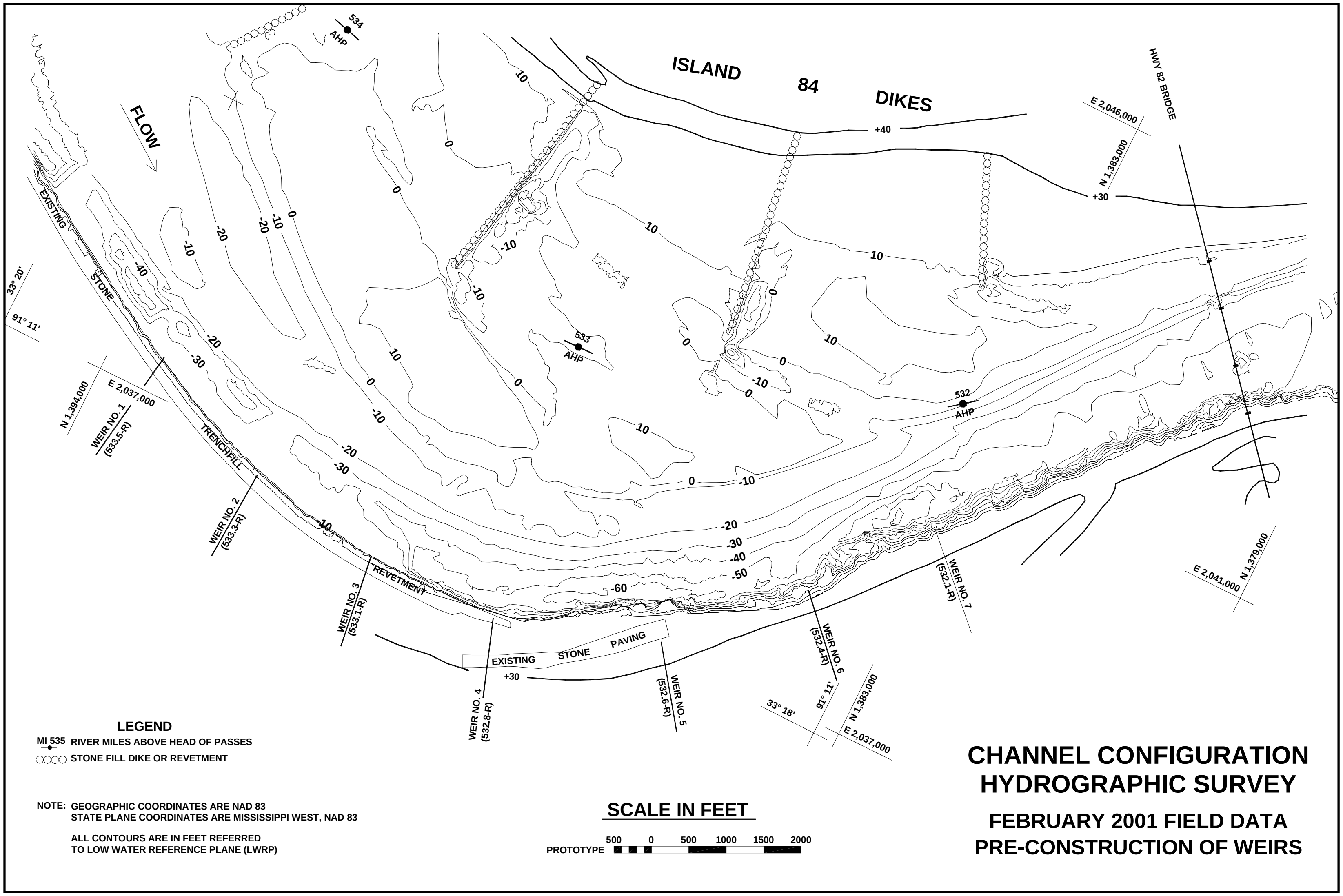
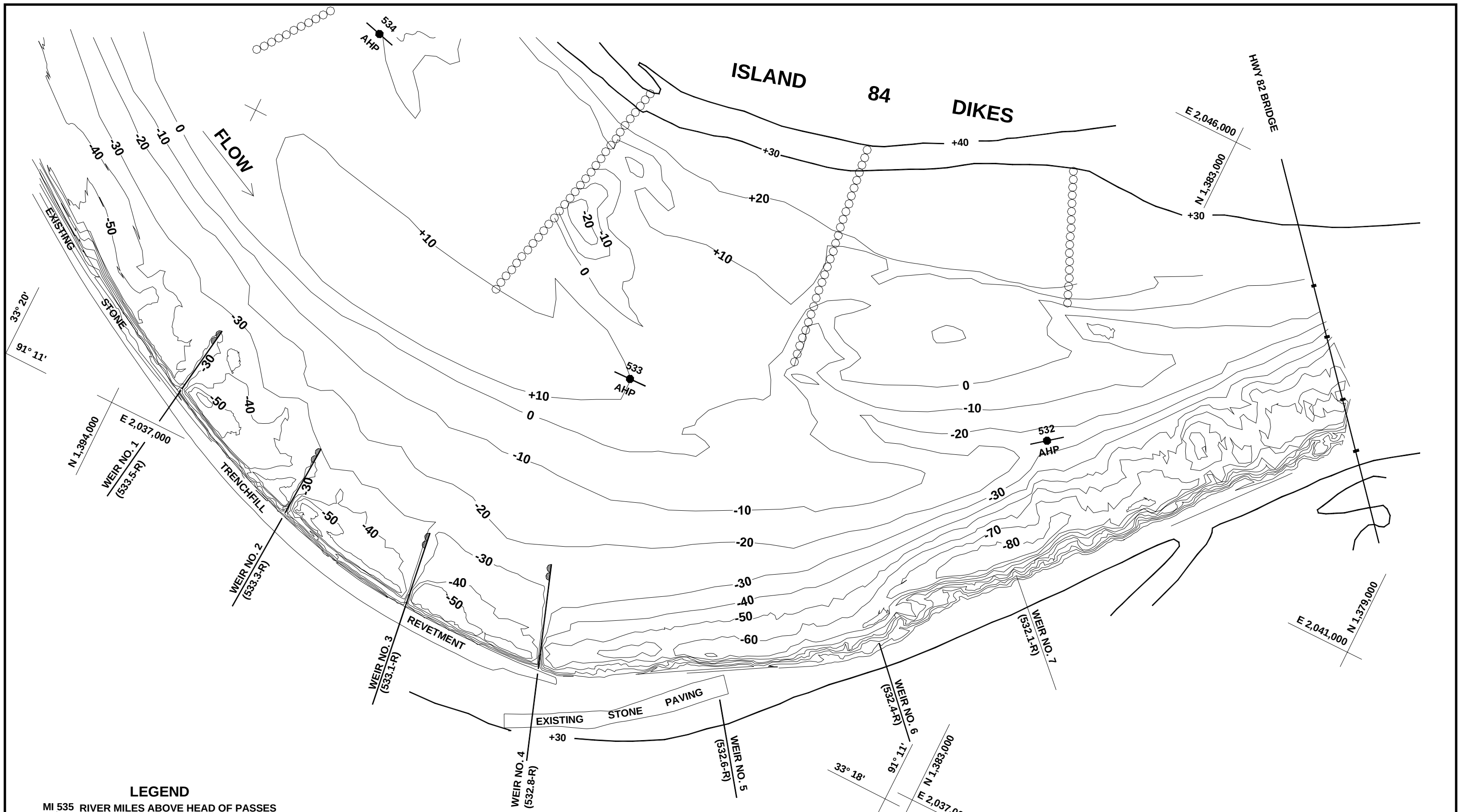

ISLAND 84 DIKES
FLOW
HWY 82 BRIDGE
534 AHP
533 AHP
532 AHP
E 2,046,000
N 1,383,000
+40
+30
33° 20'
91° 11'
N 1,394,000
E 2,037,000
EXISTING STONE TRENCHFILL
WEIR NO. 1 (533.5-R)
WEIR NO. 2 (533.3-R)
WEIR NO. 3 (533.1-R)
REVETMENT
WEIR NO. 4 (532.8-R)
EXISTING STONE PAVING
+30
WEIR NO. 5 (532.6-R)
WEIR NO. 6 (532.4-R)
WEIR NO. 7 (532.1-R)
33° 18'
91° 11'
N 1,383,000
E 2,037,000
E 2,041,000
N 1,379,000
10
0
-10
-20
-30
-40
-50
-60
LEGEND
MI 535 RIVER MILES ABOVE HEAD OF PASSES
STONE FILL DIKE OR REVETMENT
NOTE: GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES ARE MISSISSIPPI WEST, NAD 83
ALL CONTOURS ARE IN FEET REFERRED
TO LOW WATER REFERENCE PLANE (LWRP)
SCALE IN FEET
PROTOTYPE 500 0 500 1000 1500 2000
CHANNEL CONFIGURATION
HYDROGRAPHIC SURVEY
FEBRUARY 2001 FIELD DATA
PRE-CONSTRUCTION OF WEIRS

Plate 6



LEGEND

- MI 535 RIVER MILES ABOVE HEAD OF PASSES
- STONE FILL DIKE OR REVETMENT
- BENDWAY WEIR

NOTE: GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES ARE MISSISSIPPI WEST, NAD 83

ALL CONTOURS ARE IN FEET REFERRED
TO LOW WATER REFERENCE PLANE (LWRP)

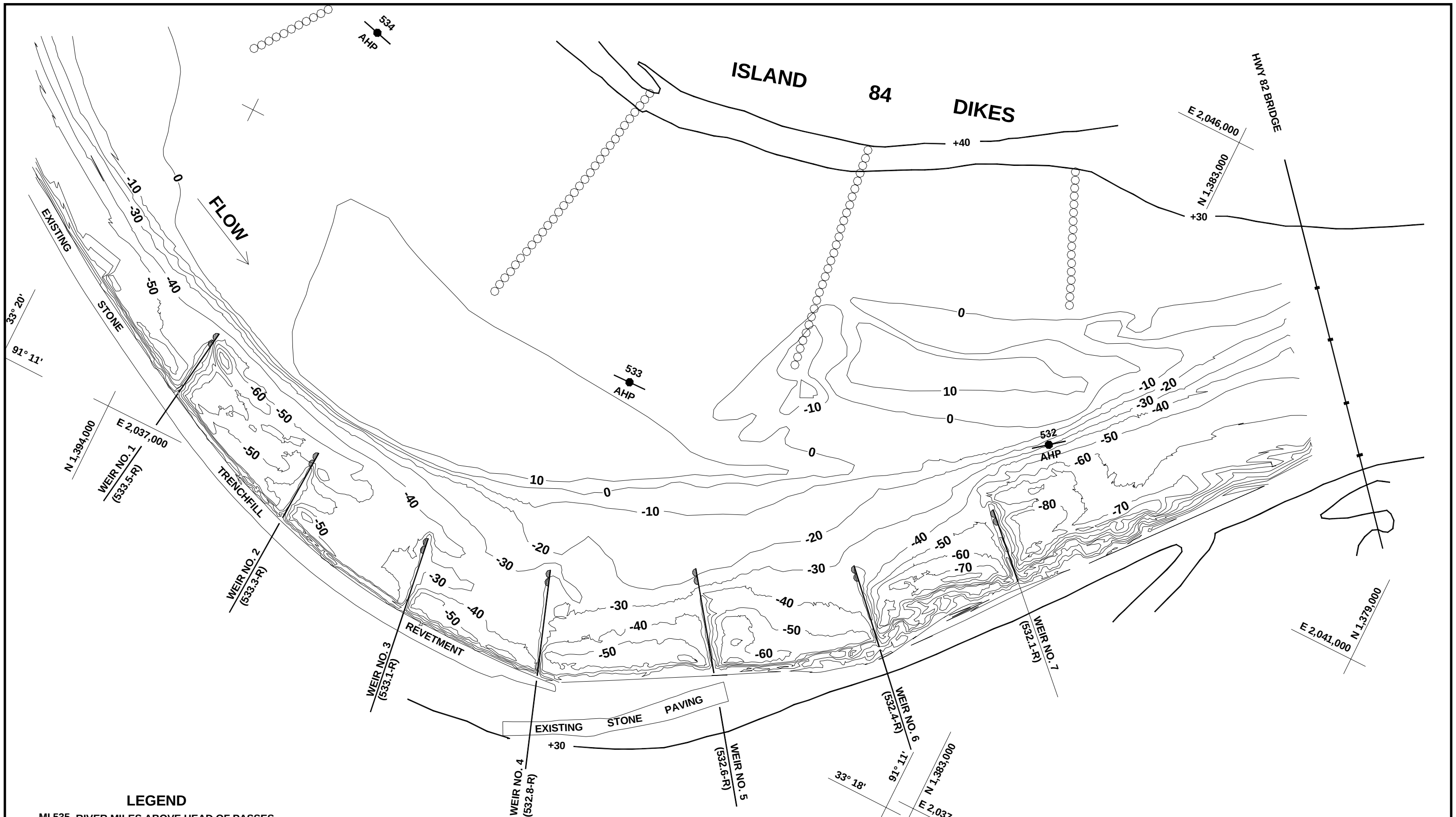
SCALE IN FEET

PROTOTYPE 500 0 500 1000 1500 2000

CHANNEL CONFIGURATION HYDROGRAPHIC SURVEY

30 APRIL - 5 MAY 2002 FIELD DATA
WEIRS 1 - 4 CONSTRUCTED

Plate 7



LEGEND

MI 535 RIVER MILES ABOVE HEAD OF PASSES

STONE FILL DIKE OR REVETMENT

BENDWAY WEIR

NOTE: GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES ARE MISSISSIPPI WEST, NAD 83

ALL CONTOURS ARE IN FEET REFERRED
TO LOW WATER REFERENCE PLANE (LWRP)

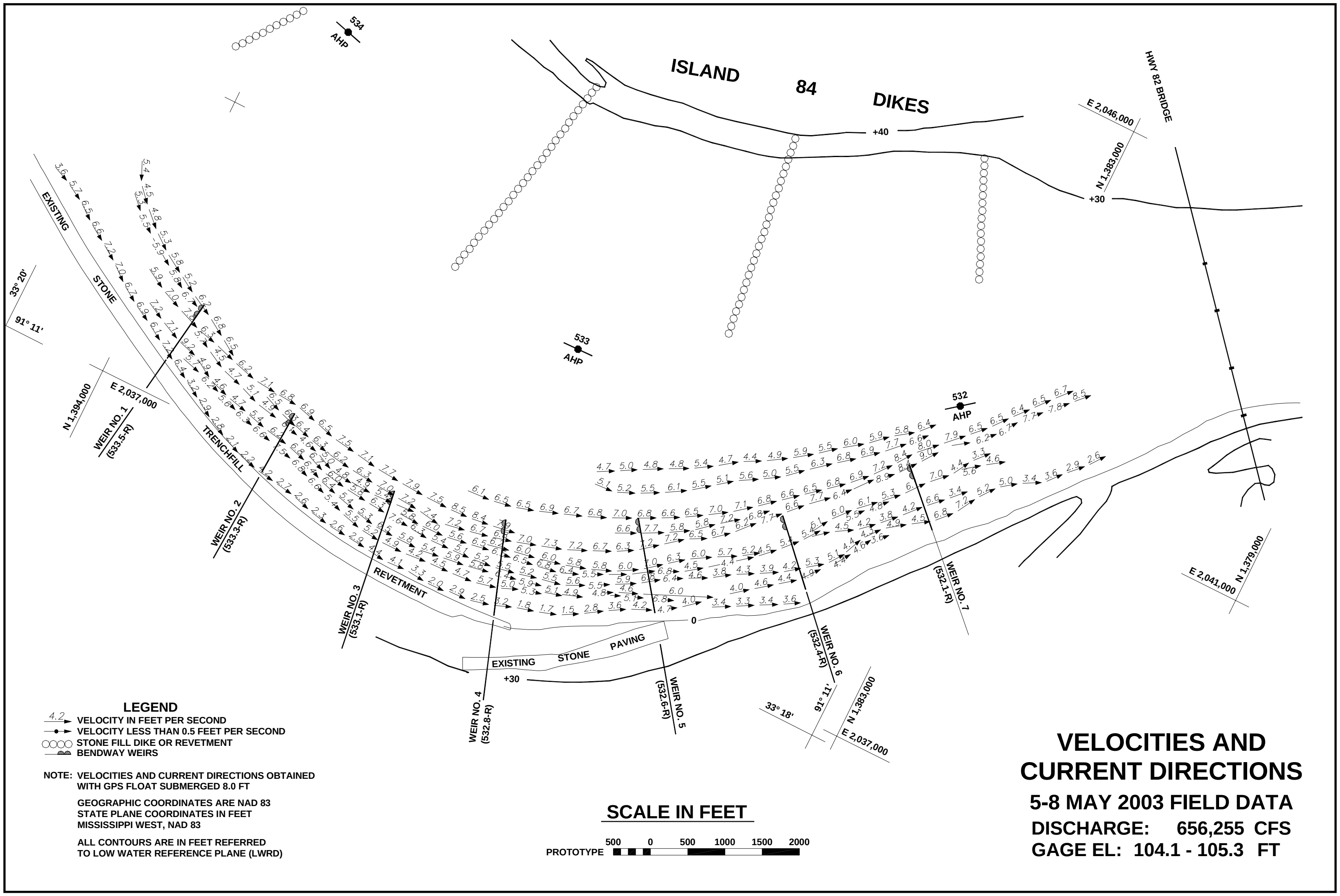
SCALE IN FEET

PROTOTYPE 500 0 500 1000 1500 2000

CHANNEL CONFIGURATION HYDROGRAPHIC SURVEY

2 - 5 MAY 2003 FIELD DATA WEIRS 1 - 7 CONSTRUCTED

Plate 8



LEGEND

- 4.2 VELOCITY IN FEET PER SECOND
- VELOCITY LESS THAN 0.5 FEET PER SECOND
- STONE FILL DIKE OR REVETMENT
- BENDWAY WEIRS

NOTE: VELOCITIES AND CURRENT DIRECTIONS OBTAINED WITH GPS FLOAT SUBMERGED 8.0 FT

GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES IN FEET
MISSISSIPPI WEST, NAD 83

ALL CONTOURS ARE IN FEET REFERRED TO LOW WATER REFERENCE PLANE (LWRD)

SCALE IN FEET

PROTOTYPE 500 0 500 1000 1500 2000

VELOCITIES AND CURRENT DIRECTIONS

5-8 MAY 2003 FIELD DATA

DISCHARGE: 656,255 CFS

GAGE EL: 104.1 - 105.3 FT

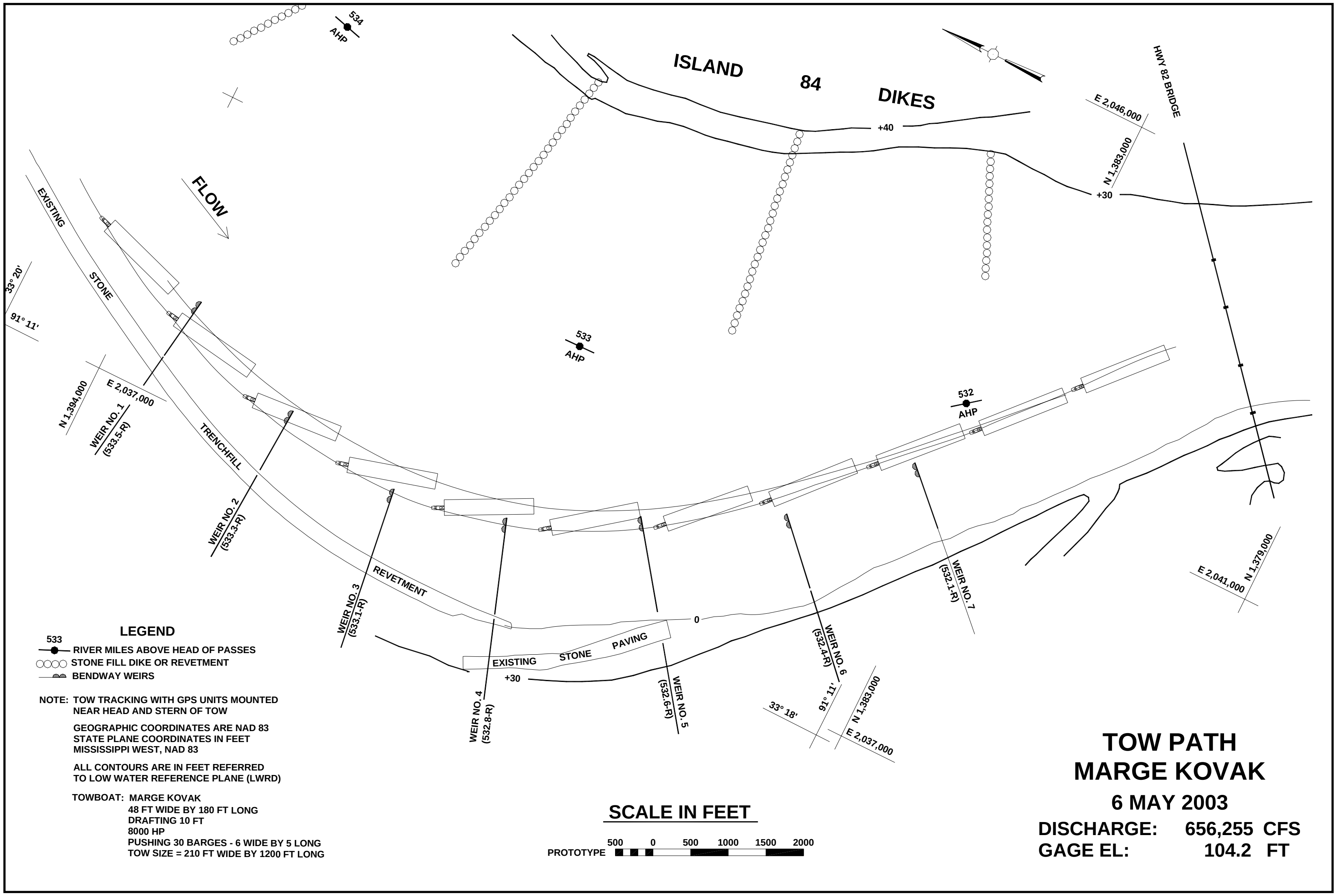

ISLAND 84 DIKES
FLOW
HWY 82 BRIDGE
534 AHP
533 AHP
532 AHP
+40
+30
0
+30
E 2,046,000
N 1,383,000
E 2,037,000
N 1,394,000
33° 20'
91° 11'
33° 18'
91° 11'
N 1,383,000
E 2,037,000
E 2,041,000
N 1,379,000
EXISTING STONE TRENCHFILL REVETMENT
EXISTING STONE PAVING
WEIR NO. 1 (533.5-R)
WEIR NO. 2 (533.3-R)
WEIR NO. 3 (533.1-R)
WEIR NO. 4 (532.8-R)
WEIR NO. 5 (532.6-R)
WEIR NO. 6 (532.4-R)
WEIR NO. 7 (532.1-R)
LEGEND
533 RIVER MILES ABOVE HEAD OF PASSES
STONE FILL DIKE OR REVETMENT
BENDWAY WEIRS
NOTE: TOW TRACKING WITH GPS UNITS MOUNTED NEAR HEAD AND STERN OF TOW
GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES IN FEET
MISSISSIPPI WEST, NAD 83
ALL CONTOURS ARE IN FEET REFERRED TO LOW WATER REFERENCE PLANE (LWRD)
TOWBOAT: MARGE KOVAK
48 FT WIDE BY 180 FT LONG
DRAFTING 10 FT
8000 HP
PUSHING 30 BARGES - 6 WIDE BY 5 LONG
TOW SIZE = 210 FT WIDE BY 1200 FT LONG
SCALE IN FEET
PROTOTYPE 500 0 500 1000 1500 2000
TOW PATH
MARGE KOVAK
6 MAY 2003
DISCHARGE: 656,255 CFS
GAGE EL: 104.2 FT

Plate 10

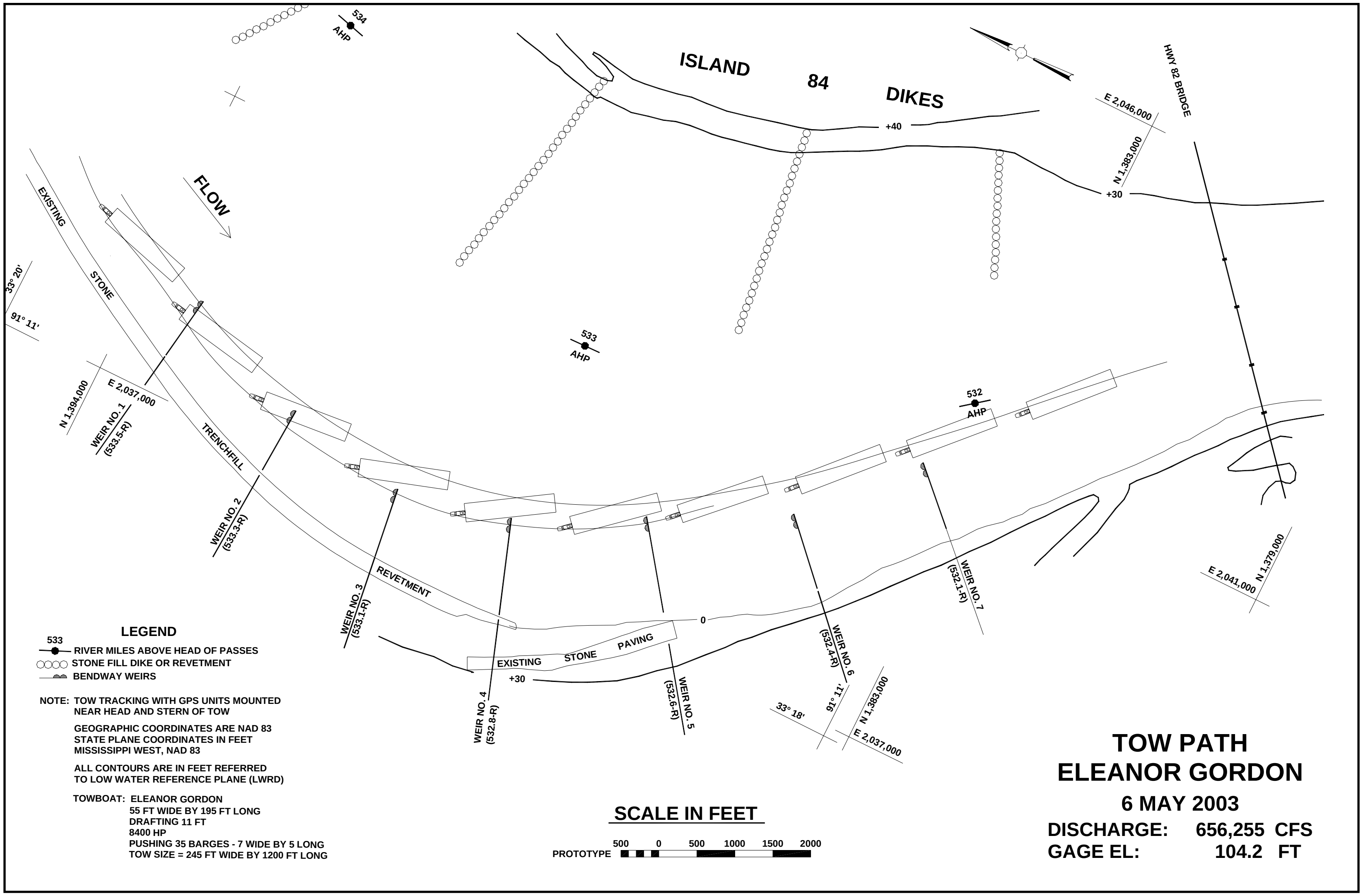

ISLAND 84 DIKES
FLOW
EXISTING STONE TRENCHFILL REVETMENT
EXISTING STONE PAVING
HWY 82 BRIDGE
534 AHP
533 AHP
532 AHP
+40
+30
0
+30
E 2,046,000
N 1,383,000
E 2,037,000
N 1,394,000
33° 20'
91° 11'
E 2,041,000
N 1,379,000
33° 18'
91° 11'
N 1,383,000
E 2,037,000
WEIR NO. 1 (533.5-R)
WEIR NO. 2 (533.3-R)
WEIR NO. 3 (533.1-R)
WEIR NO. 4 (532.8-R)
WEIR NO. 5 (532.6-R)
WEIR NO. 6 (532.4-R)
WEIR NO. 7 (532.1-R)
LEGEND
533 RIVER MILES ABOVE HEAD OF PASSES
STONE FILL DIKE OR REVETMENT
BENDWAY WEIRS
NOTE: TOW TRACKING WITH GPS UNITS MOUNTED NEAR HEAD AND STERN OF TOW
GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES IN FEET
MISSISSIPPI WEST, NAD 83
ALL CONTOURS ARE IN FEET REFERRED TO LOW WATER REFERENCE PLANE (LWRD)
TOWBOAT: ELEANOR GORDON
55 FT WIDE BY 195 FT LONG
DRAFTING 11 FT
8400 HP
PUSHING 35 BARGES - 7 WIDE BY 5 LONG
TOW SIZE = 245 FT WIDE BY 1200 FT LONG
SCALE IN FEET
500 0 500 1000 1500 2000
PROTOTYPE
TOW PATH
ELEANOR GORDON
6 MAY 2003
DISCHARGE: 656,255 CFS
GAGE EL: 104.2 FT

Plate 11

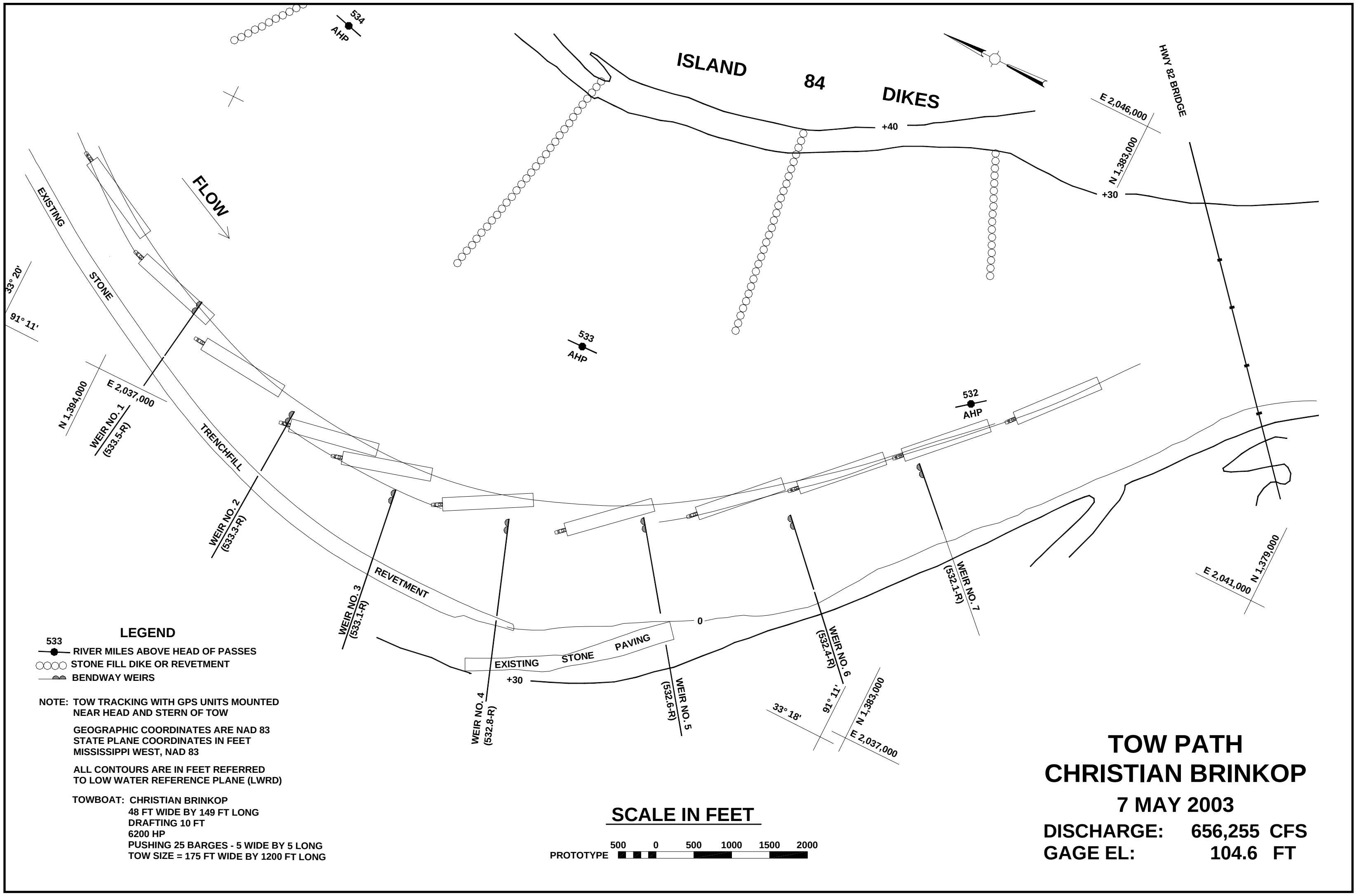

ISLAND 84 DIKES
FLOW
534
AHP
533
AHP
532
AHP
HWY 82 BRIDGE
E 2,046,000
N 1,383,000
+40
+30
0
EXISTING STONE TRENCHFILL REVETMENT
EXISTING STONE PAVING
33° 20'
91° 11'
N 1,394,000
E 2,037,000
WEIR NO. 1 (533.5-R)
WEIR NO. 2 (533.3-R)
WEIR NO. 3 (533.1-R)
WEIR NO. 4 (532.8-R)
WEIR NO. 5 (532.6-R)
WEIR NO. 6 (532.4-R)
WEIR NO. 7 (532.1-R)
33° 18'
91° 11'
N 1,383,000
E 2,037,000
E 2,041,000
N 1,379,000
LEGEND
533 RIVER MILES ABOVE HEAD OF PASSES
STONE FILL DIKE OR REVETMENT
BENDWAY WEIRS
NOTE: TOW TRACKING WITH GPS UNITS MOUNTED NEAR HEAD AND STERN OF TOW
GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES IN FEET
MISSISSIPPI WEST, NAD 83
ALL CONTOURS ARE IN FEET REFERRED TO LOW WATER REFERENCE PLANE (LWRD)
TOWBOAT: CHRISTIAN BRINKOP
48 FT WIDE BY 149 FT LONG
DRAFTING 10 FT
6200 HP
PUSHING 25 BARGES - 5 WIDE BY 5 LONG
TOW SIZE = 175 FT WIDE BY 1200 FT LONG
SCALE IN FEET
PROTOTYPE 500 0 500 1000 1500 2000
TOW PATH
CHRISTIAN BRINKOP
7 MAY 2003
DISCHARGE: 656,255 CFS
GAGE EL: 104.6 FT

Plate 12

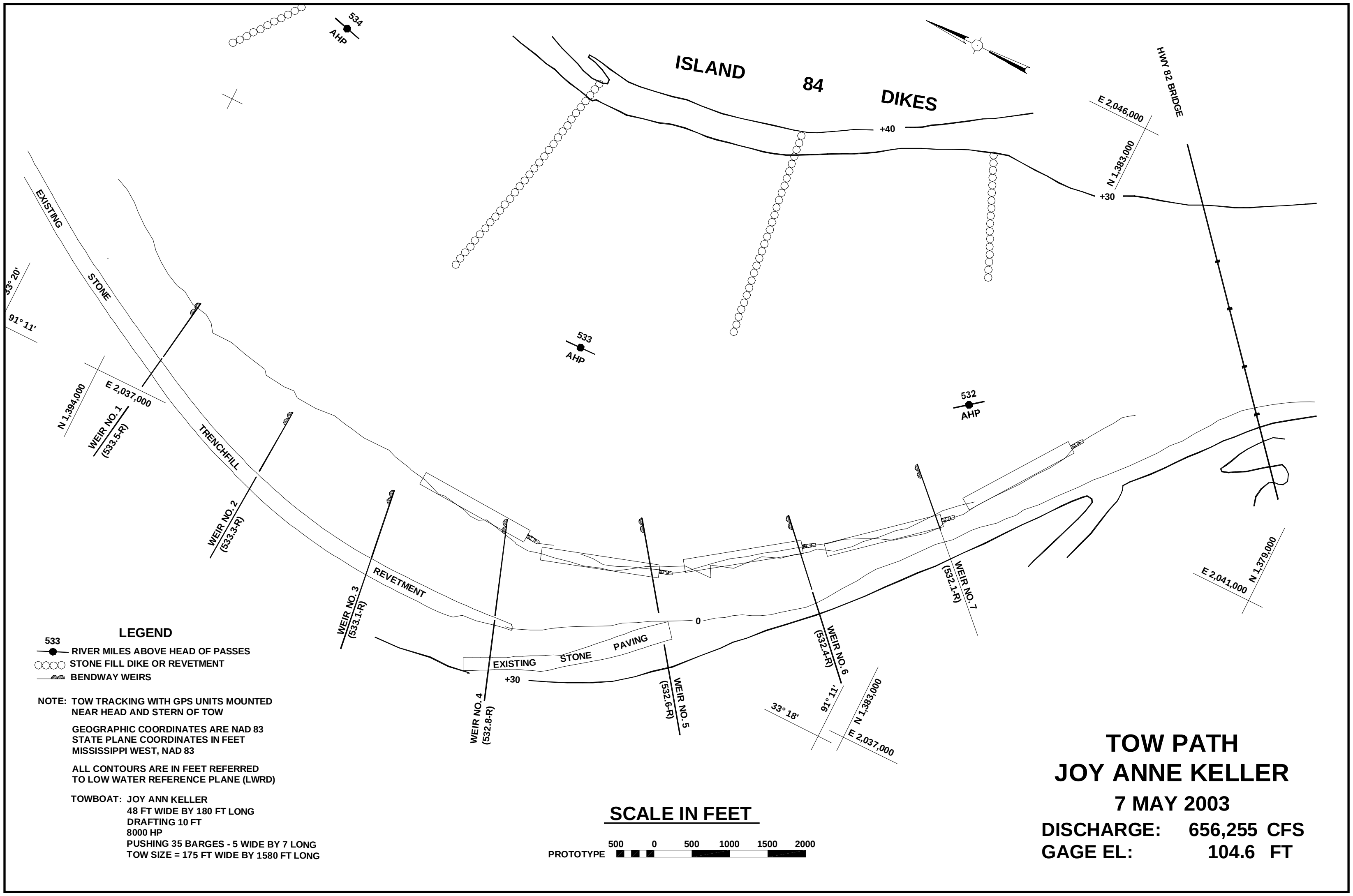
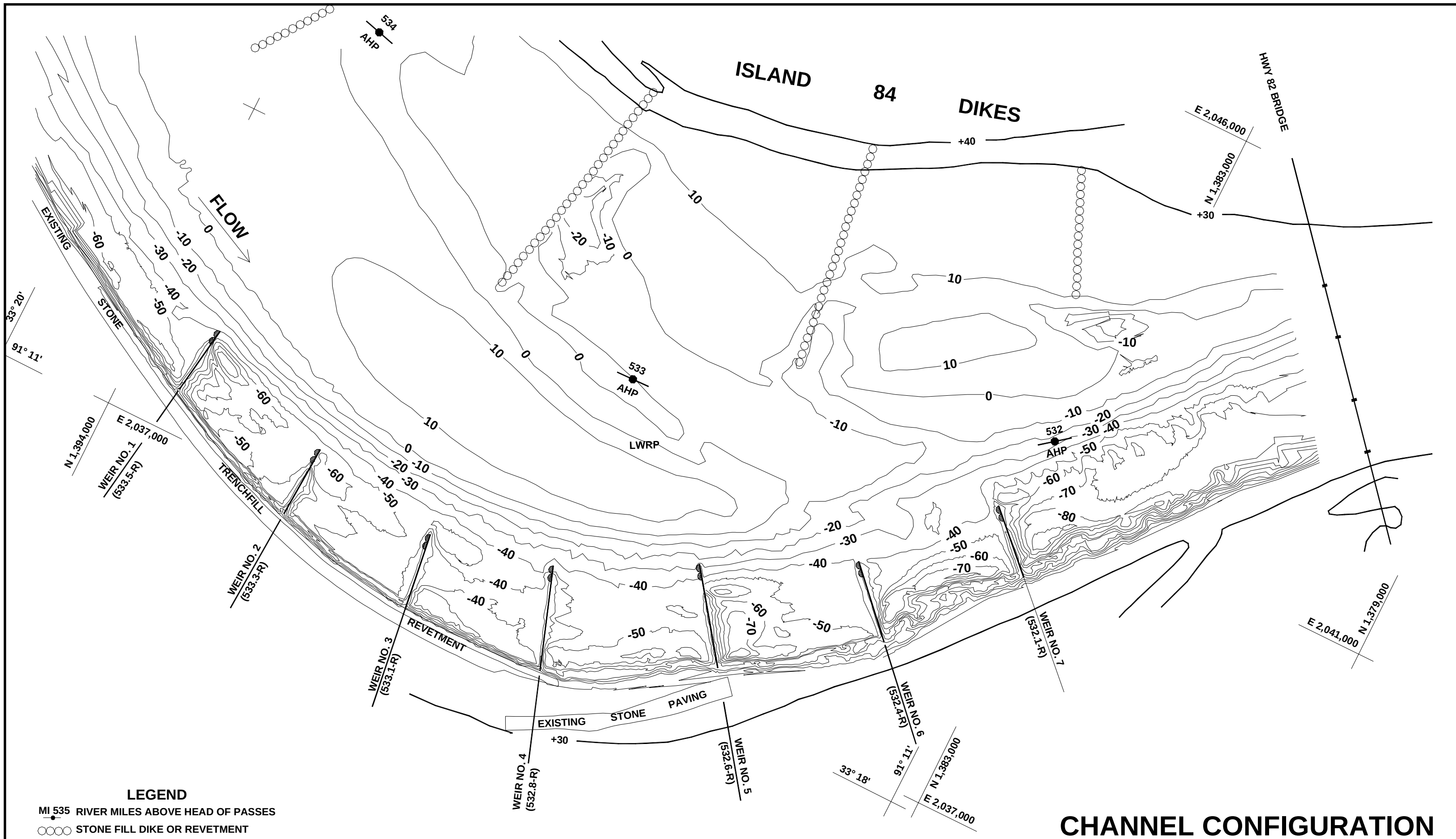

ISLAND 84 DIKES
534
AHP
533
AHP
532
AHP
+40
+30
+30
0
HWY 82 BRIDGE
E 2,046,000
N 1,383,000
EXISTING STONE TRENCHFILL REVETMENT
33° 20'
91° 11'
N 1,394,000
E 2,037,000
WEIR NO. 1 (533.5-R)
WEIR NO. 2 (533.3-R)
WEIR NO. 3 (533.1-R)
WEIR NO. 4 (532.8-R)
WEIR NO. 5 (532.6-R)
WEIR NO. 6 (532.4-R)
WEIR NO. 7 (532.1-R)
EXISTING STONE PAVING
33° 18'
91° 11'
N 1,383,000
E 2,037,000
E 2,041,000
N 1,379,000
LEGEND
533 RIVER MILES ABOVE HEAD OF PASSES
STONE FILL DIKE OR REVETMENT
BENDWAY WEIRS
NOTE: TOW TRACKING WITH GPS UNITS MOUNTED NEAR HEAD AND STERN OF TOW
GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES IN FEET
MISSISSIPPI WEST, NAD 83
ALL CONTOURS ARE IN FEET REFERRED
TO LOW WATER REFERENCE PLANE (LWRD)
TOWBOAT: JOY ANN KELLER
48 FT WIDE BY 180 FT LONG
DRAFTING 10 FT
8000 HP
PUSHING 35 BARGES - 5 WIDE BY 7 LONG
TOW SIZE = 175 FT WIDE BY 1580 FT LONG
SCALE IN FEET
PROTOTYPE 500 0 500 1000 1500 2000
TOW PATH
JOY ANNE KELLER
7 MAY 2003
DISCHARGE: 656,255 CFS
GAGE EL: 104.6 FT

Plate 13



LEGEND

- MI 535 RIVER MILES ABOVE HEAD OF PASSES
- STONE FILL DIKE OR REVETMENT
- BENDWAY WEIR

NOTE: GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES ARE MISSISSIPPI WEST, NAD 83

ALL CONTOURS ARE IN FEET REFERRED TO LOW WATER REFERENCE PLANE (LWRP)

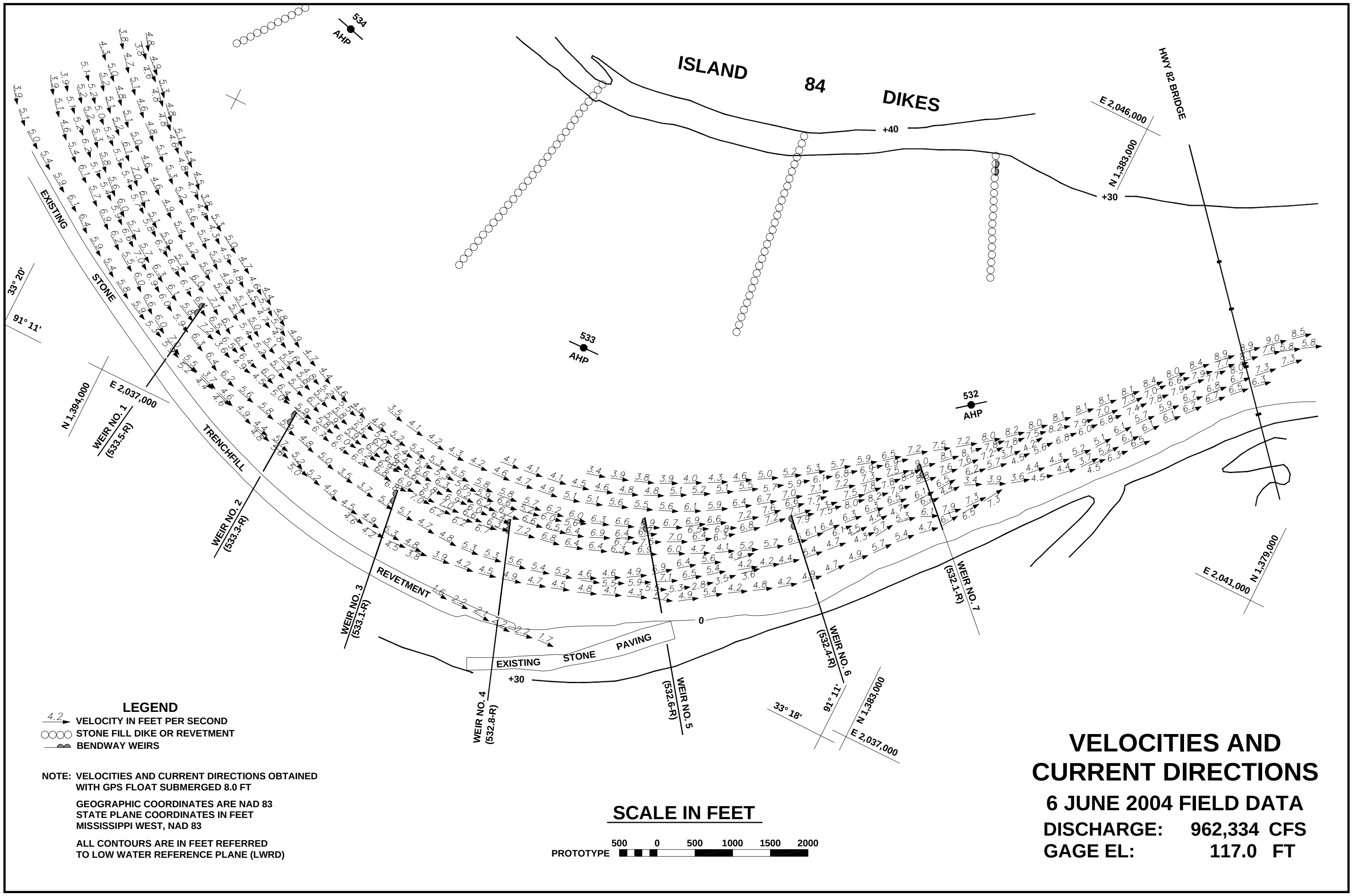
SCALE IN FEET

PROTOTYPE 500 0 500 1000 1500 2000

CHANNEL CONFIGURATION HYDROGRAPHIC SURVEY

18 - 24 JUNE 2004 FIELD DATA WEIRS 1 - 7 CONSTRUCTED

Plate 14



VELOCITIES AND CURRENT DIRECTIONS

6 JUNE 2004 FIELD DATA

DISCHARGE: 962,334 CFS

GAGE EL: 117.0 FT

Plate 15

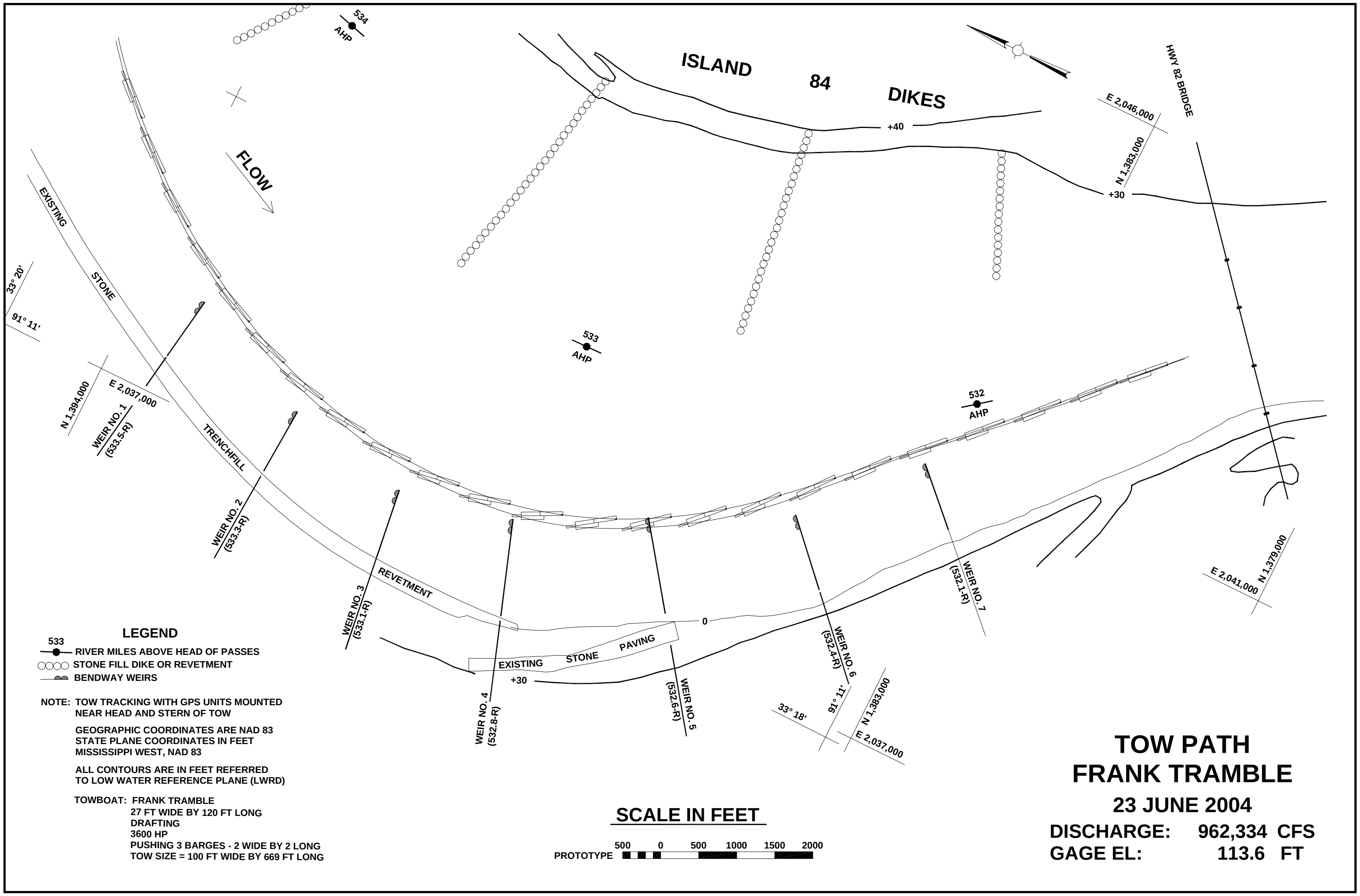

ISLAND 84 DIKES
HWY 82 BRIDGE
FLOW
534
AHP
533
AHP
532
AHP
+40
+30
0
+30
E 2,046,000
N 1,383,000
EXISTING STONE TRENCHFILL REVETMENT
EXISTING STONE PAVING
33° 20'
91° 11'
N 1,394,000
E 2,037,000
WEIR NO. 1 (533.5-R)
WEIR NO. 2 (533.3-R)
WEIR NO. 3 (533.1-R)
WEIR NO. 4 (532.8-R)
WEIR NO. 5 (532.6-R)
WEIR NO. 6 (532.4-R)
WEIR NO. 7 (532.1-R)
E 2,041,000
N 1,379,000
33° 18'
91° 11'
N 1,383,000
E 2,037,000
LEGEND
533
RIVER MILES ABOVE HEAD OF PASSES
STONE FILL DIKE OR REVETMENT
BENDWAY WEIRS
NOTE: TOW TRACKING WITH GPS UNITS MOUNTED NEAR HEAD AND STERN OF TOW
GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES IN FEET MISSISSIPPI WEST, NAD 83
ALL CONTOURS ARE IN FEET REFERRED TO LOW WATER REFERENCE PLANE (LWRD)
TOWBOAT: FRANK TRAMBLE
27 FT WIDE BY 120 FT LONG
DRAFTING
3600 HP
PUSHING 3 BARGES - 2 WIDE BY 2 LONG
TOW SIZE = 100 FT WIDE BY 669 FT LONG
SCALE IN FEET
500 0 500 1000 1500 2000
PROTOTYPE
TOW PATH
FRANK TRAMBLE
23 JUNE 2004
DISCHARGE: 962,334 CFS
GAGE EL: 113.6 FT

Plate 16

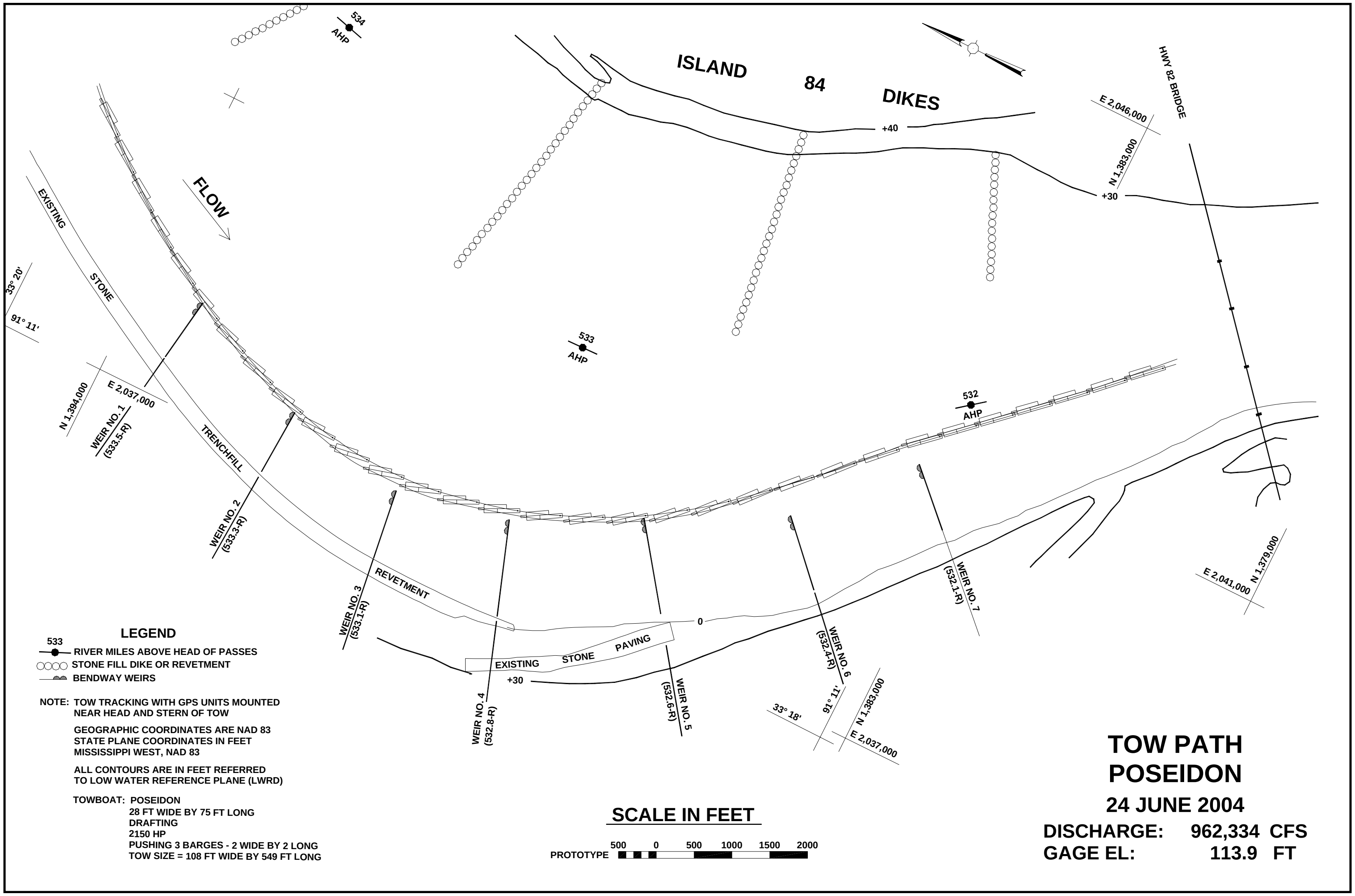
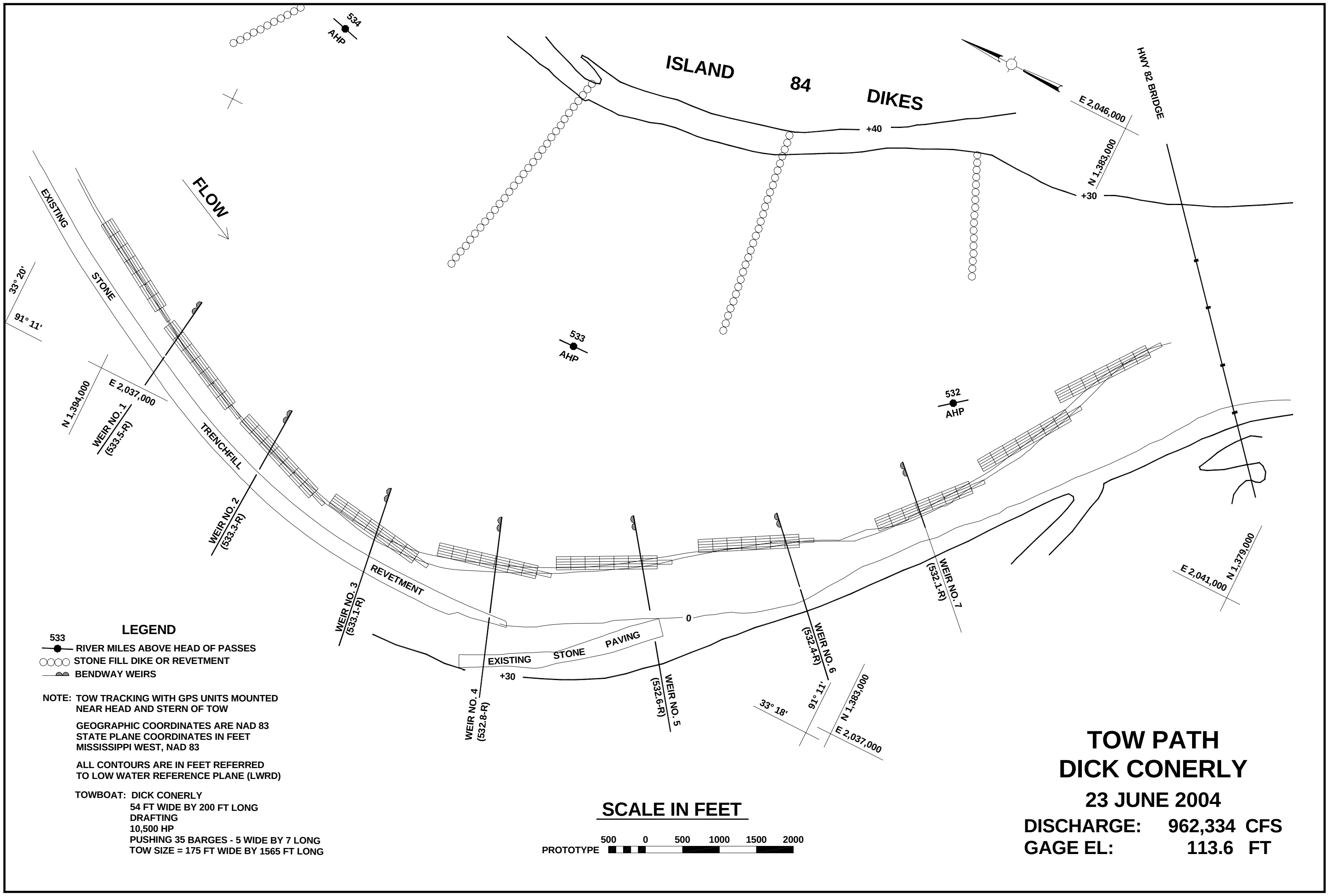

ISLAND 84 DIKES
FLOW
HWY 82 BRIDGE
534
AHP
533
AHP
532
AHP
+40
+30
+30
0
EXISTING STONE TRENCHFILL REVETMENT
EXISTING STONE PAVING
E 2,046,000
N 1,383,000
E 2,037,000
N 1,394,000
E 2,041,000
N 1,379,000
N 1,383,000
E 2,037,000
33° 20'
91° 11'
33° 18'
91° 11'
WEIR NO. 1 (533.5-R)
WEIR NO. 2 (533.3-R)
WEIR NO. 3 (533.1-R)
WEIR NO. 4 (532.8-R)
WEIR NO. 5 (532.6-R)
WEIR NO. 6 (532.4-R)
WEIR NO. 7 (532.1-R)
LEGEND
533
RIVER MILES ABOVE HEAD OF PASSES
STONE FILL DIKE OR REVETMENT
BENDWAY WEIRS
NOTE: TOW TRACKING WITH GPS UNITS MOUNTED NEAR HEAD AND STERN OF TOW
GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES IN FEET
MISSISSIPPI WEST, NAD 83
ALL CONTOURS ARE IN FEET REFERRED TO LOW WATER REFERENCE PLANE (LWRD)
TOWBOAT: POSEIDON
28 FT WIDE BY 75 FT LONG
DRAFTING
2150 HP
PUSHING 3 BARGES - 2 WIDE BY 2 LONG
TOW SIZE = 108 FT WIDE BY 549 FT LONG
SCALE IN FEET
PROTOTYPE
500 0 500 1000 1500 2000
TOW PATH
POSEIDON
24 JUNE 2004
DISCHARGE: 962,334 CFS
GAGE EL: 113.9 FT

Plate 17

Plate 18


ISLAND 84 DIKES
FLOW
HWY 82 BRIDGE
EXISTING STONE TRENCHFILL REVETMENT
EXISTING STONE PAVING
WEIR NO. 1 (533.5-R)
WEIR NO. 2 (533.3-R)
WEIR NO. 3 (533.1-R)
WEIR NO. 4 (532.8-R)
WEIR NO. 5 (532.6-R)
WEIR NO. 6 (532.4-R)
WEIR NO. 7 (532.1-R)
534 AHP
533 AHP
532 AHP
+40
+30
0
33° 20'
91° 11'
33° 18'
N 1,394,000
E 2,037,000
E 2,046,000
N 1,383,000
E 2,041,000
N 1,379,000
LEGEND
533 RIVER MILES ABOVE HEAD OF PASSES
STONE FILL DIKE OR REVETMENT
BENDWAY WEIRS
NOTE: TOW TRACKING WITH GPS UNITS MOUNTED NEAR HEAD AND STERN OF TOW
GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES IN FEET
MISSISSIPPI WEST, NAD 83
ALL CONTOURS ARE IN FEET REFERRED TO LOW WATER REFERENCE PLANE (LWRD)
TOWBOAT: DICK CONERLY
54 FT WIDE BY 200 FT LONG
DRAFTING
10,500 HP
PUSHING 35 BARGES - 5 WIDE BY 7 LONG
TOW SIZE = 175 FT WIDE BY 1565 FT LONG
SCALE IN FEET
PROTOTYPE 500 0 500 1000 1500 2000
TOW PATH
DICK CONERLY
23 JUNE 2004
DISCHARGE: 962,334 CFS
GAGE EL: 113.6 FT

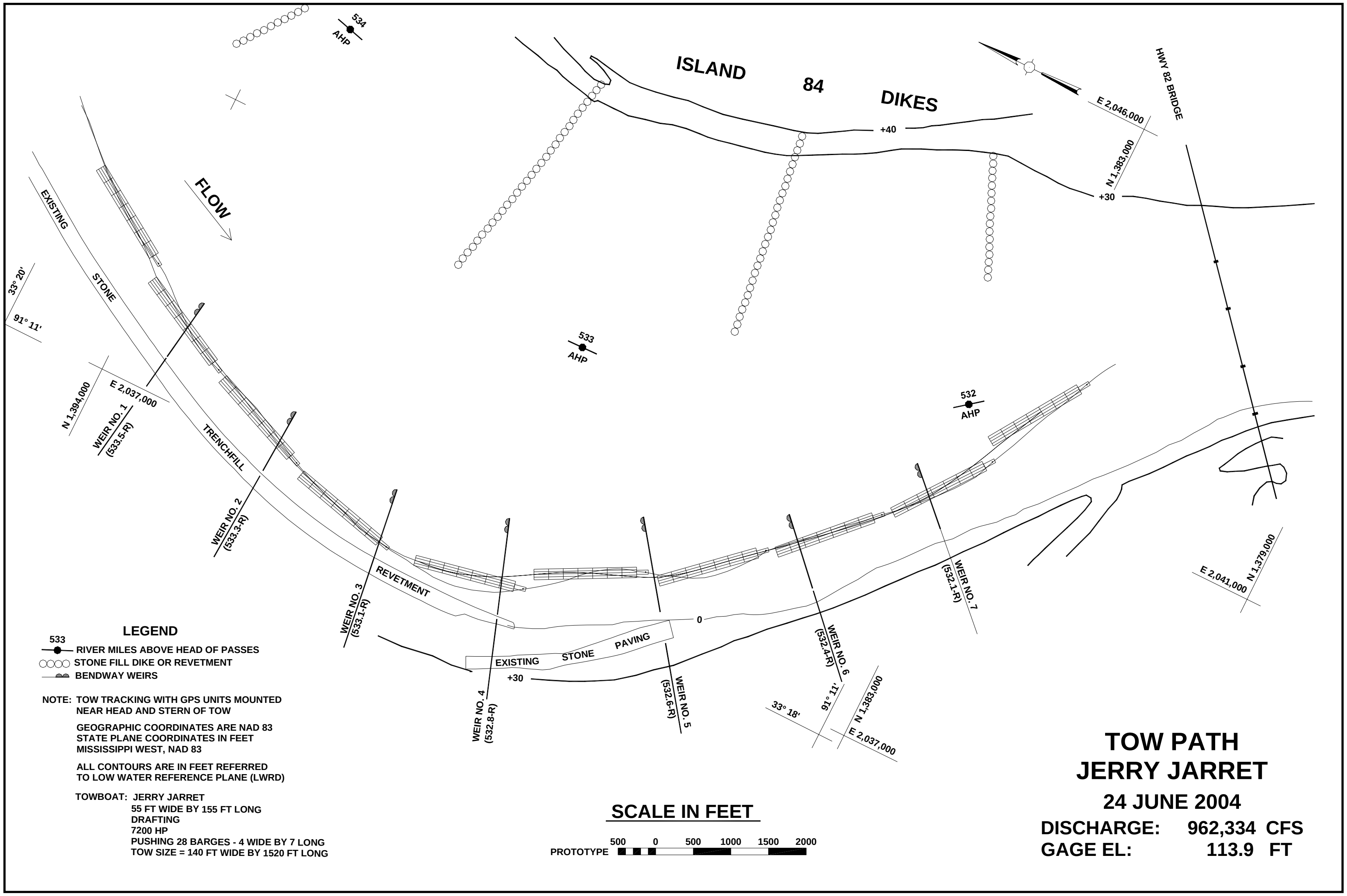

ISLAND 84 DIKES
HWY 82 BRIDGE
FLOW
534 AHP
533 AHP
532 AHP
+40
+30
0
+30
E 2,046,000
N 1,383,000
E 2,037,000
N 1,394,000
33° 20'
91° 11'
EXISTING STONE TRENCHFILL
REVETMENT
EXISTING STONE PAVING
WEIR NO. 1 (533.5-R)
WEIR NO. 2 (533.3-R)
WEIR NO. 3 (533.1-R)
WEIR NO. 4 (532.8-R)
WEIR NO. 5 (532.6-R)
WEIR NO. 6 (532.4-R)
WEIR NO. 7 (532.1-R)
33° 18'
91° 11'
N 1,383,000
E 2,037,000
E 2,041,000
N 1,379,000
LEGEND
533 RIVER MILES ABOVE HEAD OF PASSES
STONE FILL DIKE OR REVETMENT
BENDWAY WEIRS
NOTE: TOW TRACKING WITH GPS UNITS MOUNTED NEAR HEAD AND STERN OF TOW
GEOGRAPHIC COORDINATES ARE NAD 83
STATE PLANE COORDINATES IN FEET
MISSISSIPPI WEST, NAD 83
ALL CONTOURS ARE IN FEET REFERRED
TO LOW WATER REFERENCE PLANE (LWRD)
TOWBOAT: JERRY JARRET
55 FT WIDE BY 155 FT LONG
DRAFTING
7200 HP
PUSHING 28 BARGES - 4 WIDE BY 7 LONG
TOW SIZE = 140 FT WIDE BY 1520 FT LONG
SCALE IN FEET
500 0 500 1000 1500 2000
PROTOTYPE
TOW PATH
JERRY JARRET
24 JUNE 2004
DISCHARGE: 962,334 CFS
GAGE EL: 113.9 FT

Plate 19

REPORT DOCUMENTATION PAGE

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Michael F. Winkler

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER
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14. ABSTRACT
Greenville Bridge Reach is located on the Mississippi River from river mile 542 to mile 530. The Greenville reach affects tows navigating through the Highway 82 Bridge located at mile 531 approximately 12 miles downbound of Greenville, MS.

Research conducted at the U.S. Army Engineer Research and Development Center (ERDC) suggested realignment of the channel through the reach and construction of seven bendway weirs would improve navigation conditions through the reach and existing Highway 82 Bridge.

Although the general design of the project was based on model studies conducted at ERDC from 1979 to 1996 and sound engineering practices, channel alignment and bed configuration can vary somewhat from those predicted in model studies due to composition of the bed material and different flow conditions than those used in the model studies. Therefore, due to its complexity, this project was selected for monitoring under the Monitoring Completed Navigation Projects program. Various types of data were collected and analyzed to determine the effects of the improvements on navigation through the reach and identify any potential problems of alignment of navigation traffic approaching both the new (currently under construction) and old bridges. Bathymetric data were collected and used to compare the predicted channel to the developed channel. It was determined that the bendway weirs at Vancluse Bend above the Highway 82 Bridge at Greenville, MS, are performing as predicted.

15. SUBJECT TERMS

Bendway weirs	Highway 82 Bridge	Navigation
Greenville Bridge	Mississippi River	

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