Extensive piping features were present within the scarp. Surface erosion due to overland drainage was visible at the site. Causative factors for bank retreat at this site include displacement of slabs, slaking, piping and flood erosion and rapid recession-related slumping, slab and block failures, cleft pressure, and overland drainage. A defined rill formation of failed soils and recently deposited sediments is evident within bench areas. Because the site is close to the thalweg sailing line, wave erosion exists here. Type A is the best description of this site.

29. Site 29 at RM 339.3 LDB (Pool 21)

This left-bank site, shown in figure 7-101, is located between two wing dams on a small island, detached from Long Island situated along the left bank of a straight stretch of the MR. It is 3.9 miles downstream from Lock & Dam No. 20. Bank retreat since 1984 is visible in figure 7-101. Photos 7-65 and 7-66 show an upstream view and a perpendicular view of the site. Three bank sections are shown in figures 7-102 through 104. The bank soils are layered silt (MST) and sand (FS-MS). Subaqueous soil is FS. Piping features and related block failures were observed at this site. There were multiple scarps within the bank. The thalweg sailing line is located in the mid-channel. Drawdown by fifteen upstream-bound empty barges, as measured at this site, was about 0.2 ft.

Several years prior to this study, Long Island was investigated by Anderson who found that the island Holocene soil is at least 3,200 years old, based on radiocarbon chronology (Anderson et al. 1988). Another conclusion, derived in that investigation, was that recent historical deposits became considerably thicker along the channel margin. The section taken in this study showed thickly and thinly bedded historical alluvium and medium calcareous sand to the base of the 10.7 ft profile. Erosion at this site has been limited to stored historical alluvium.

Causative factors for bank retreat at this site include piping, flood-flow erosional oversteepening and rapid recession and piping-initiated failures, block failures, and wave and flow rework-transport of failed soils and recently deposited sediments within bench areas. This site is characterized by a combination of Types A, B, and C.

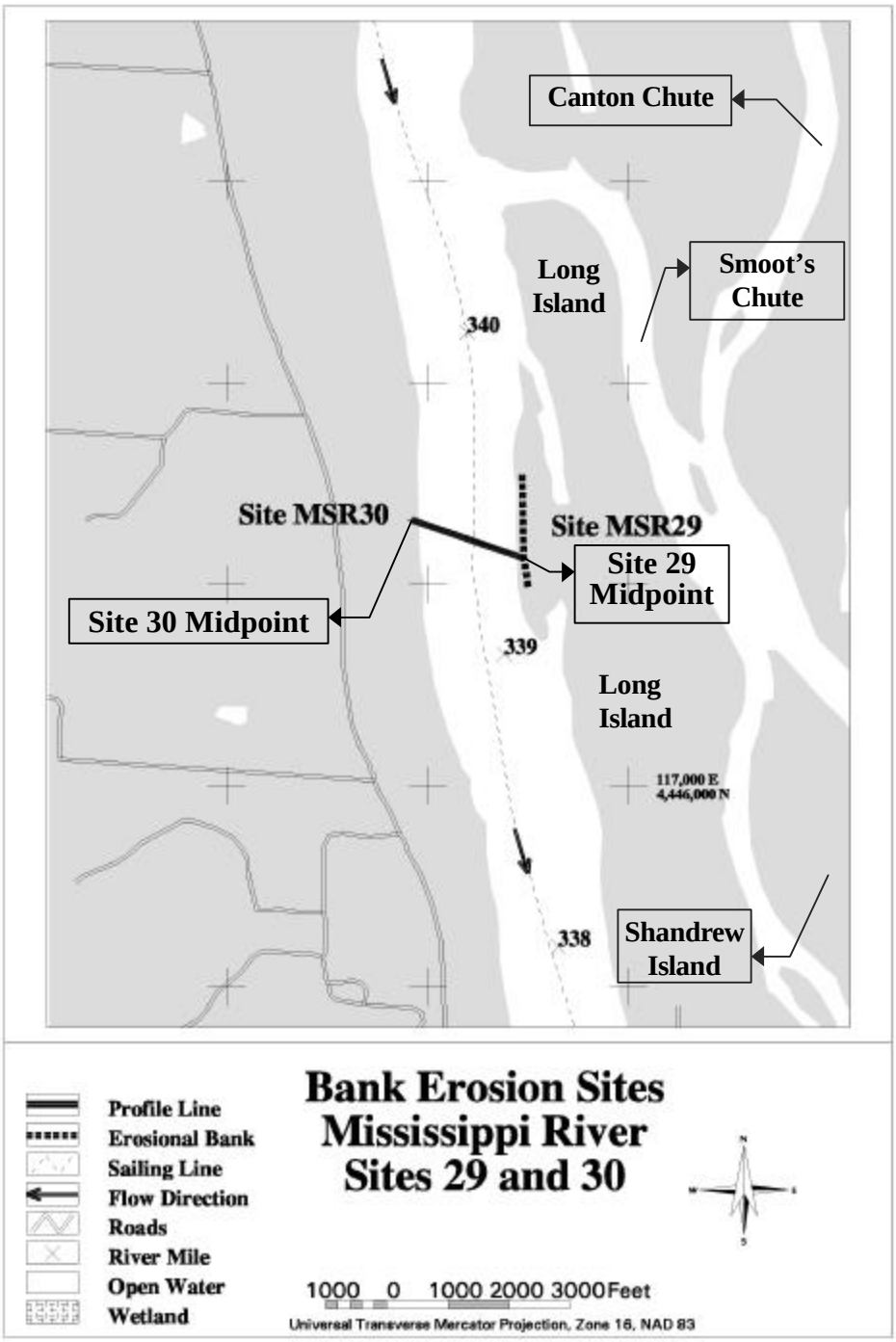

Figure 7-101 A site map showing Mississippi River Sites 29 and 30

Photo 7-65 An upstream view of Site 29 midpoint

Photo 7-66 A perpendicular view of Site 29 midpoint

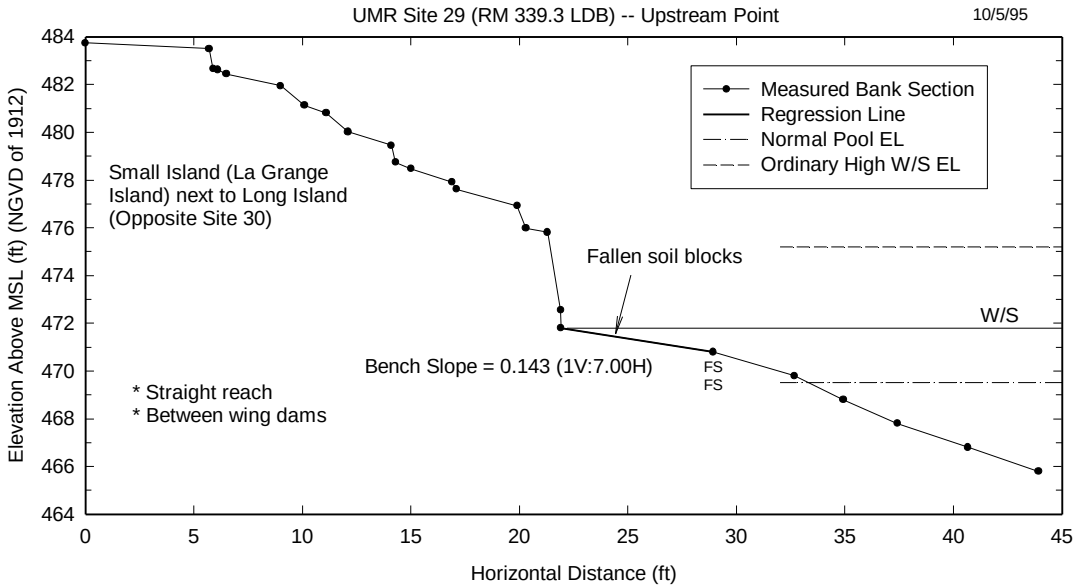

Figure 7-102 Bank section measured at Site 29 upstream point

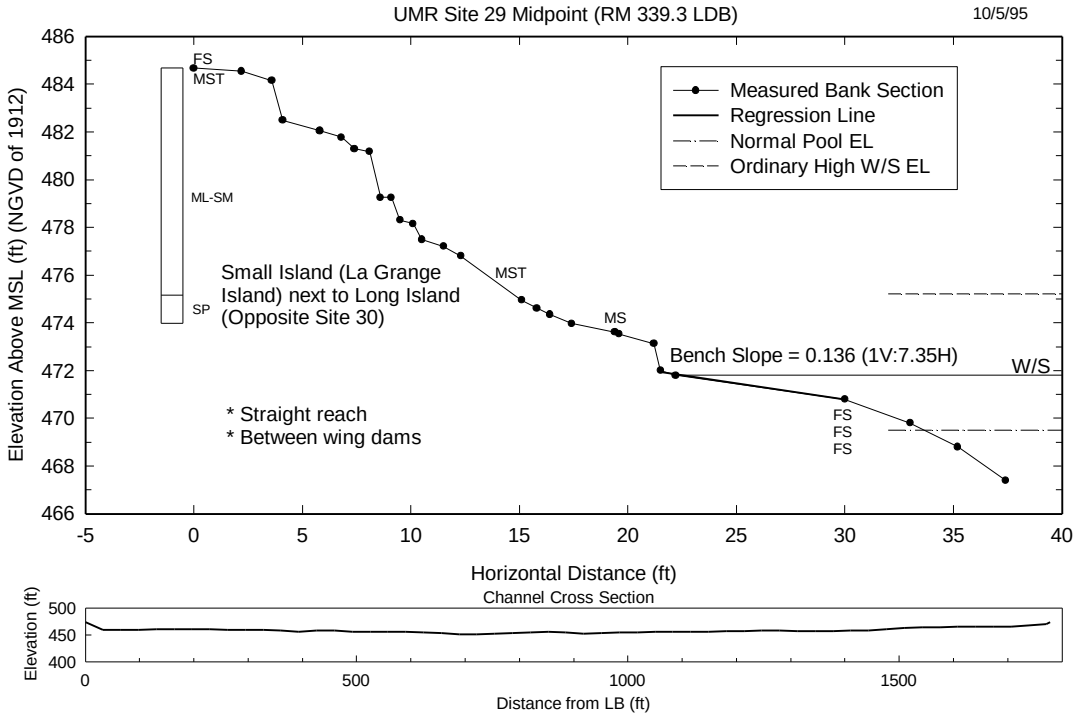

Figure 7-103 Bank section and channel cross section measured at Site 29 midpoint

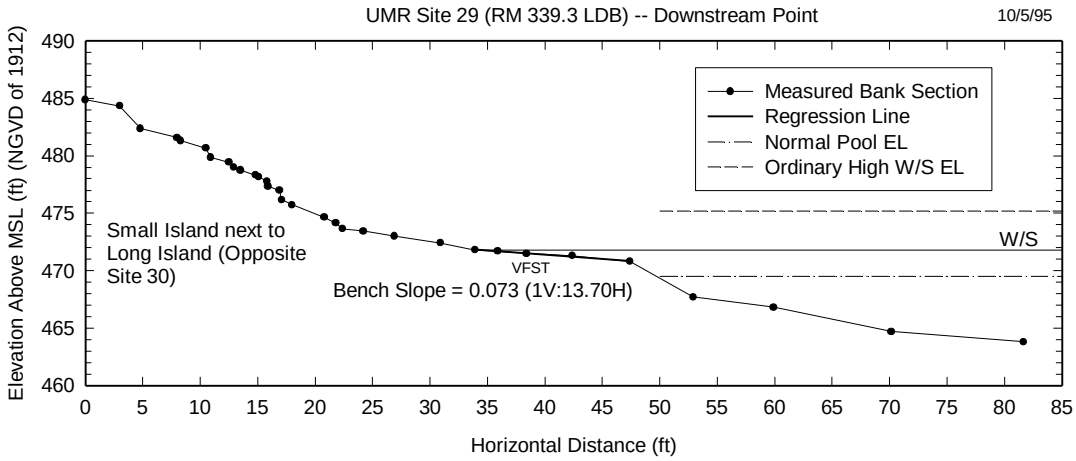

Figure 7-104 Bank section measured at Site 29 downstream point

30. Site 30 at RM 339.3 RDB (Pool 21)

This right-bank site is located opposite Site 29. Photos 7-67 and 7-68 show upstream and downstream views of the site. Only one bank section was taken at this site, as shown in figure 7-105. The scarp is almost 6 ft high. The bank soils are silts (VFST-MST) and subaqueous soil is CST.

Photo 7-67 An upstream view of Site 30 midpoint

Photo 7-68 A downstream view of Site 30 midpoint

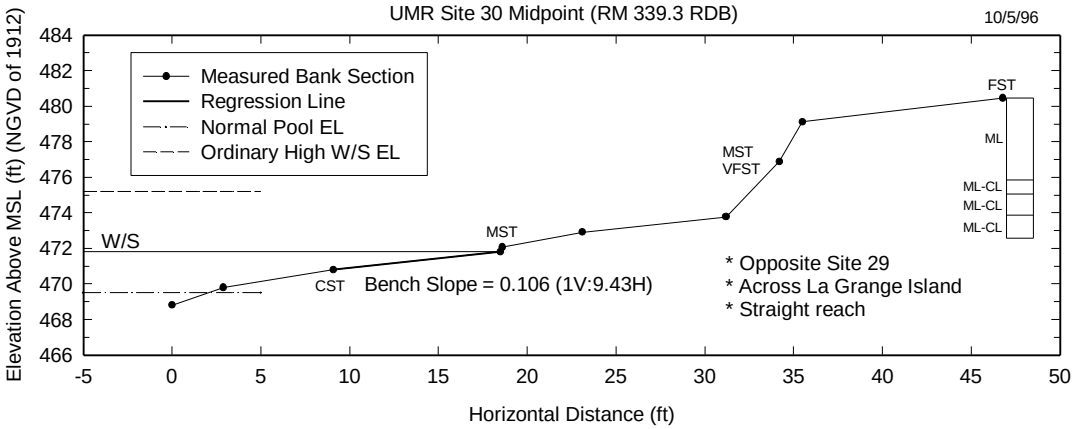

Figure 7-105 Bank section measured at Site 30 midpoint

One sampling tube core was advanced at this location. The soil profile showed historical alluvium to about 4.6 ft, below which an early to mid-Holocene, poorly drained wetland soil was observed. Erosion of historical and older Holocene deposits are occurring at the site.

Causative factors for bank retreat at this site include flood-flow erosional oversteepening and rapid recession and piping-initiated failures, and wave and rework-transport of failed soils and recently deposited sediments within bench areas. Secondary wave erosion occurs within berm and bench areas. The bank is classified as Type C.

30a. Observation Site at RM 322.9 RDB (Pool 22)

This right bank observation site, located about 2 miles downstream from Lock & Dam No. 21, had several interesting topographic features, including direct impacts on river banks of barge mooring (tows wait for up-bound locking procedures), piping cavities, and large block failures. Photos 7-69 shows a trace of bank-surface scraping by a barge during higher river stages, and Photos 7-70 and 7-71 show the barge-impact smearing within the bench. Numerous piping holes were observed at this site. Photos 7-72 through 7-74 show close-up views of piping cavities. The piping feature shown in Photo 7-74 was about 3 ft wide and 4 ft high, and extended about 6 ft horizontally at that size. Photos 7-75 and 7-76 show vertical slabbing failures within bank upslope from

Photo 7-69 Bank soil scraped by a barge - Observation Site at RM 322.9 RDB

Photo 7-70 Bench smeared by a barge - Observation Site at RM 322.9 RDB

Photo 7-71 Close-up of smeared bench - Observation Site at RM 322.9 RDB

Photo 7-72 Piping features - Observation Site at RM 322.9 RDB

Photo 7-73 Close-up of piping features - Observation Site at RM 322.9 RDB

Photo 7-74 Further close-up of piping features - Observation Site at RM 322.9 RDB

Photo 7-75 Vertical bank failure - Observation Site at RM 322.9 RDB

Photo 7-76 Vertical failure of lower bank - Observation Site at RM 322.9 RDB

piping features. Neither bank sections nor soil samples were taken at this observation site. However, visual observations indicated that the upper scarp consisted of ML (see table 7-4) and the lower scarp consisted of two layers of soils (CH on top of SM).

Causative factors for bank retreat at this site include flood-flow erosion, rapid recession and piping-initiated block failures, barge-mooring impacts, and wave and flow rework-transport of failed soils and recently deposited sediments which cover bench areas. Type A characteristics describe this observation site.

31. Site 31 at RM 293.0 LDB (Pool 24)

This left island site, shown in figure 7-106, is located on the inside of a bend in a wing-dam field along the upper portion of Denmark Island, about 8.2 miles downstream from Lock & Dam No. 22. ***It should be noted that there is no Lock & Dam No. 23***. An upstream view of the site is shown in Photo 7-77, and sand deposits on Denmark Island are shown in Photo 7-78. The bank section taken at the midpoint is shown in figure 7-107. The river cross section, shown in figure 7-107, is typical for a river bend, with a larger flow depth along the concave bank. The bank soils are primarily sand (VFS-FS)

with some medium silt (MST). Denmark Island is covered with sand deposit from the Great Flood of '93. No geomorphic soil core samples were taken at Site 31.

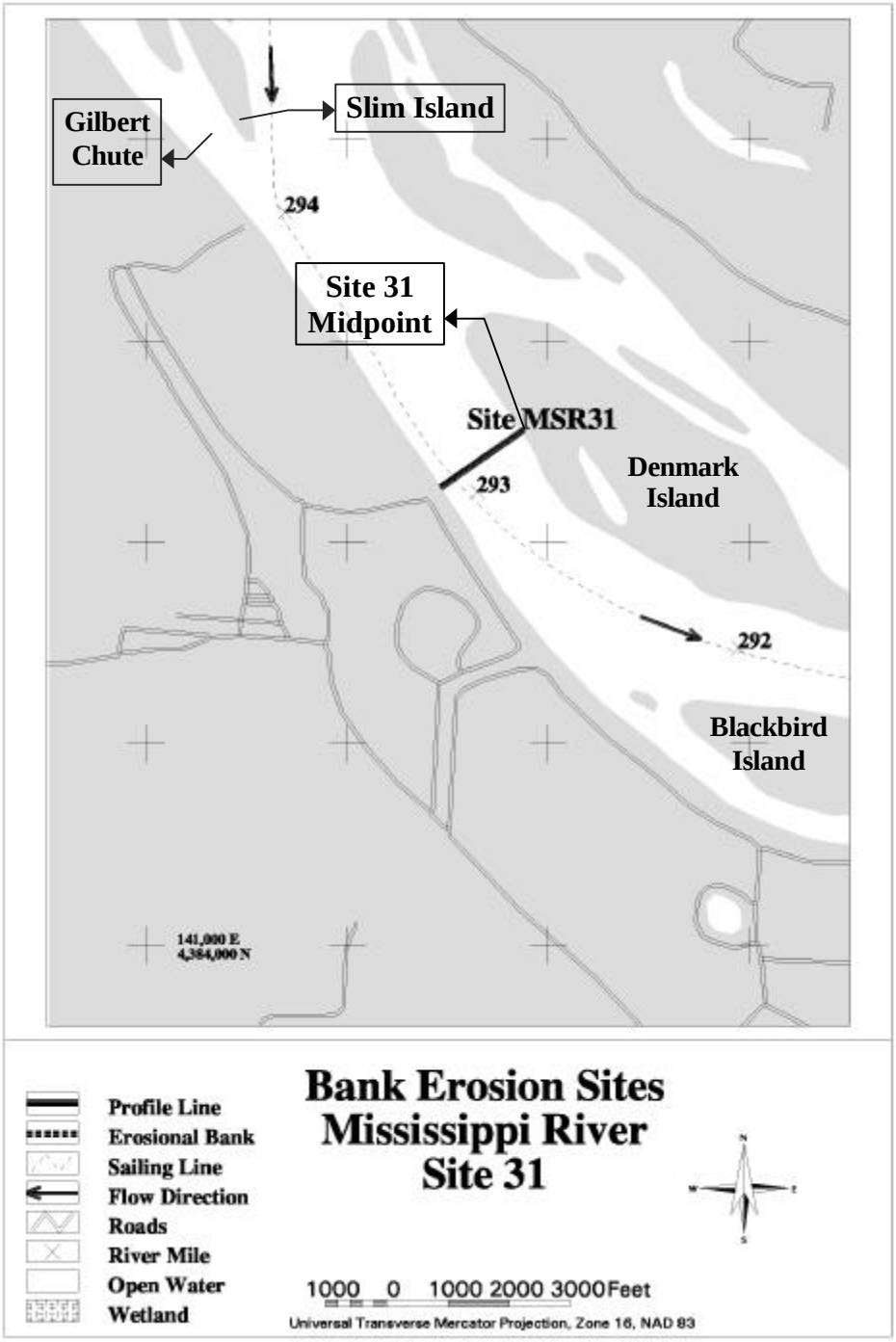

Figure 7-106 A site map showing Mississippi River Site 31

Photo 7-77 An upstream view of Site 31 midpoint

Photo 7-78 Sand deposits on Denmark Island of Site 31 midpoint

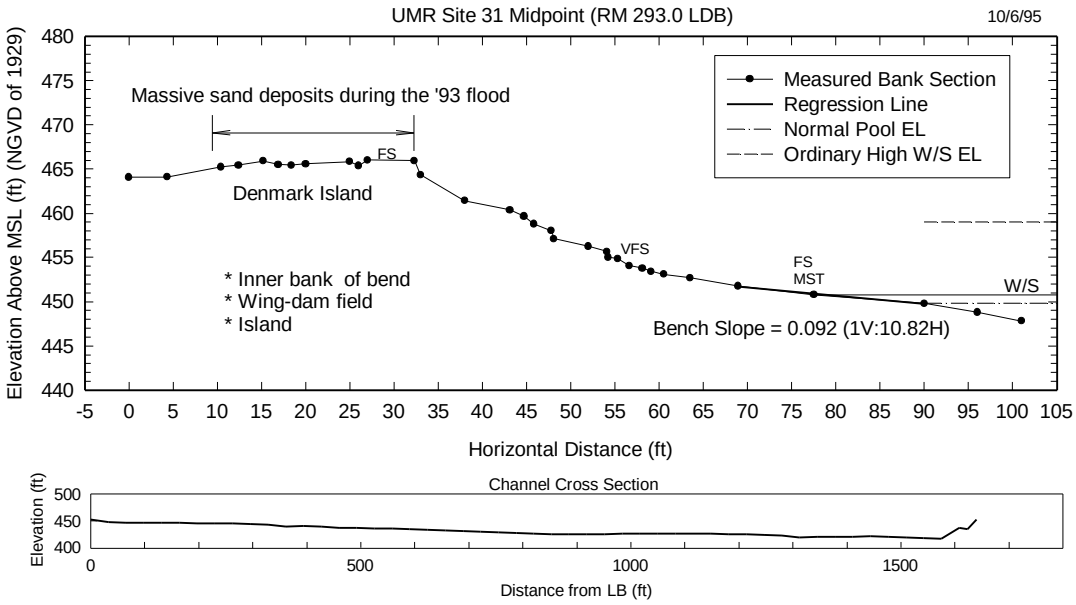

Figure 7-107 Bank section and channel cross section measured at Site 31 midpoint

Causative factors for bank retreat at this site include flood-flow erosion, piping-related collapse, and wave and flow rework-transport of failed soils and recently deposited silty sand which covers bench areas. A combination of Types D and E characterizes this site.

32. Site 32 at RM 275.3 RDB (Pool 24)

This right-bank inside-bend site, shown in figure 7-108, is located in a mooring zone, only 2 miles upstream from Lock & Dam No. 24. Photo 7-79 shows a downstream view of the site, and Photo 7-80 shows a close-up view of the bank disturbed by mooring activities. Note the sign on the tree shown in Photo 7-79. Only one bank section was taken at this site, which is shown in figure 7-109. The bank material is silt (CLT-MST). Subaqueous soil is primarily silt (VFST-FST). This site is used heavily as a barge-mooring site where tow boats wait for downstream locking at Lock & Dam No. 24. Although this erosion site is located along the inner bank, the river cross section in figures 7-109 indicates that the thalweg is developing along the right bank. Evidence of severe in-

channel flood-flow erosional oversteepening is visible in the bank-section defined topographic features.

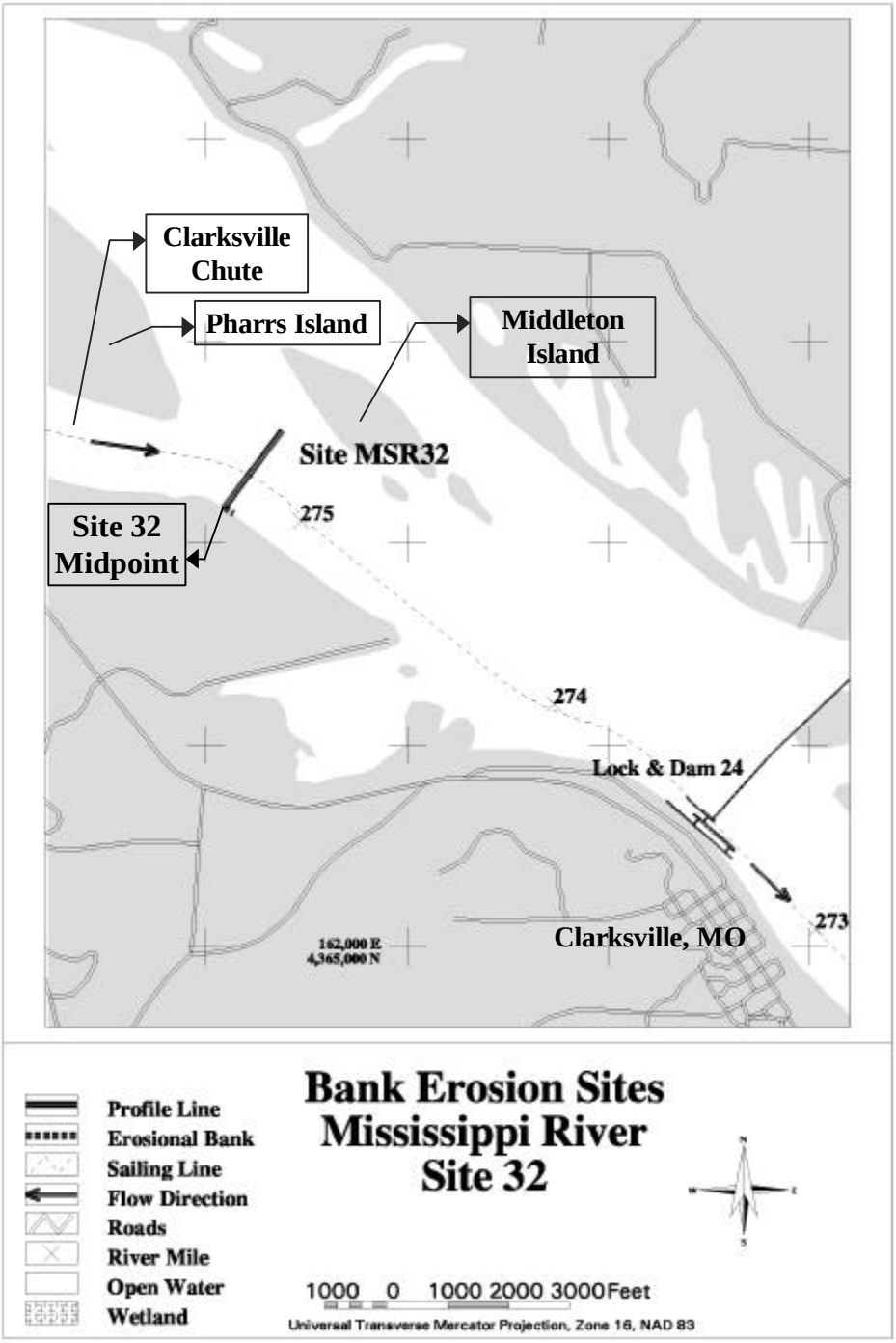

Figure 7-108 A map showing Mississippi River Site 32

Photo 7-79 A downstream view of Site 32 midpoint

Photo 7-80 A close-up view of mooring activities at Site 32 midpoint

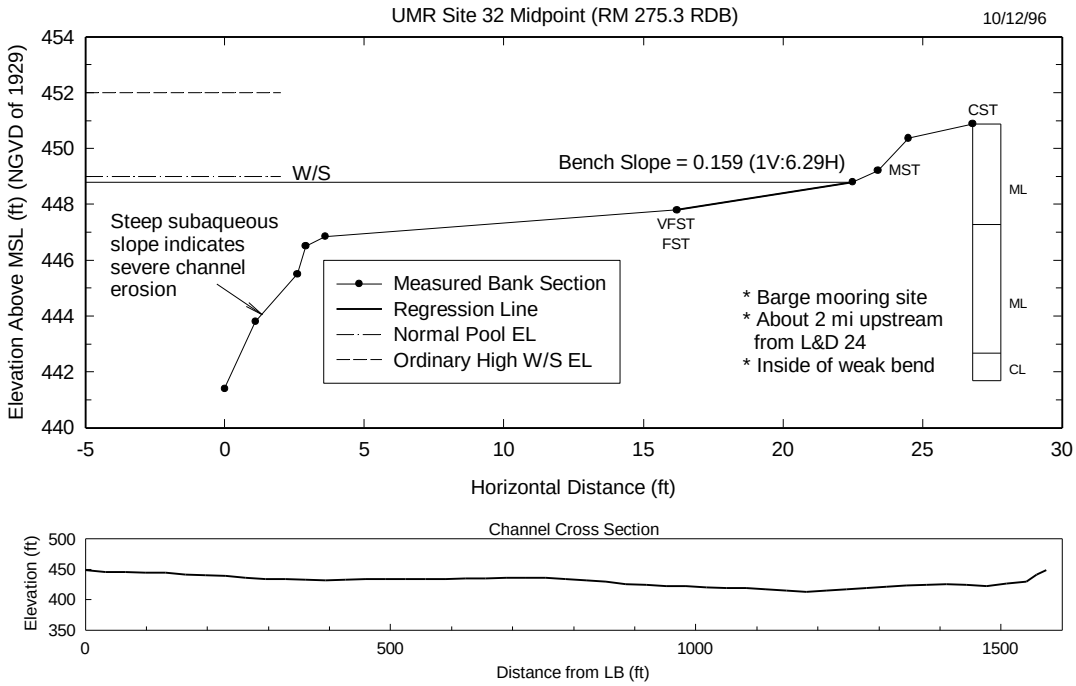

Figure 7-109 Bank section and channel cross section measured at Site 32 midpoint

Site 32 is located within a late Holocene surface. Two sampling tube cores showed thick historical deposits to at least 4.0 ft over a late to very late Holocene soil. The underlying native soil is below the water table. This soil is poorly drained and weakly developed.

Causative factors for bank retreat at this site include flood-flow erosional oversteepening and subsequent failures, bench-area rework-transport of failed soils and recently deposited sediments by waves, and barge-mooring activities. Evidence of erosion due to traffic-generated waves and turbulence, and barge mooring exists at this site. Type A is the most representative classification for Site 32.

33. Site 33 at RM 266.5 LDB (Pool 25)

This left-bank island site, shown in figure 7-110, is located in a crossover on the lower part of Coon Island. The site is located 6.9 miles downstream from Lock & Dam No. 24. The MR main channel is maintained between Coon Island and Slim Island near this eroded-bank site. Upstream views of the site are shown in Photos 7-81 and 7-82.

One bank section taken at the midpoint is shown in figure 7-111. The bank soils are primarily silt (VFST-CST). The scarp is almost vertical and contains numerous piping features. Failed soil blocks had accumulated at the toe of the scarp.

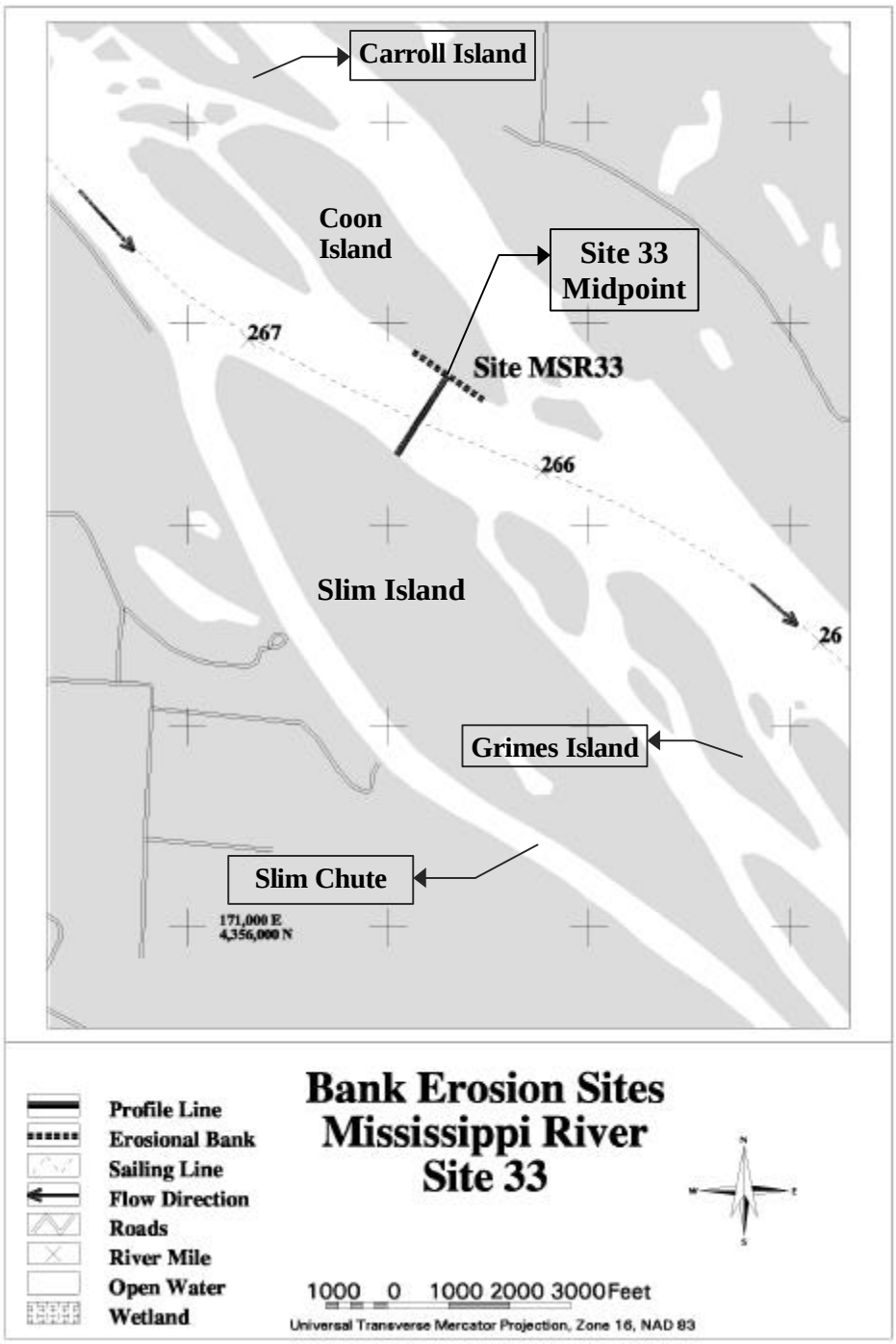

Figure 7-110 A map showing Mississippi River Site 33

Photo 7-81 An upstream view of Site 33 midpoint

Photo 7-82 A close-up view of Site 33 midpoint

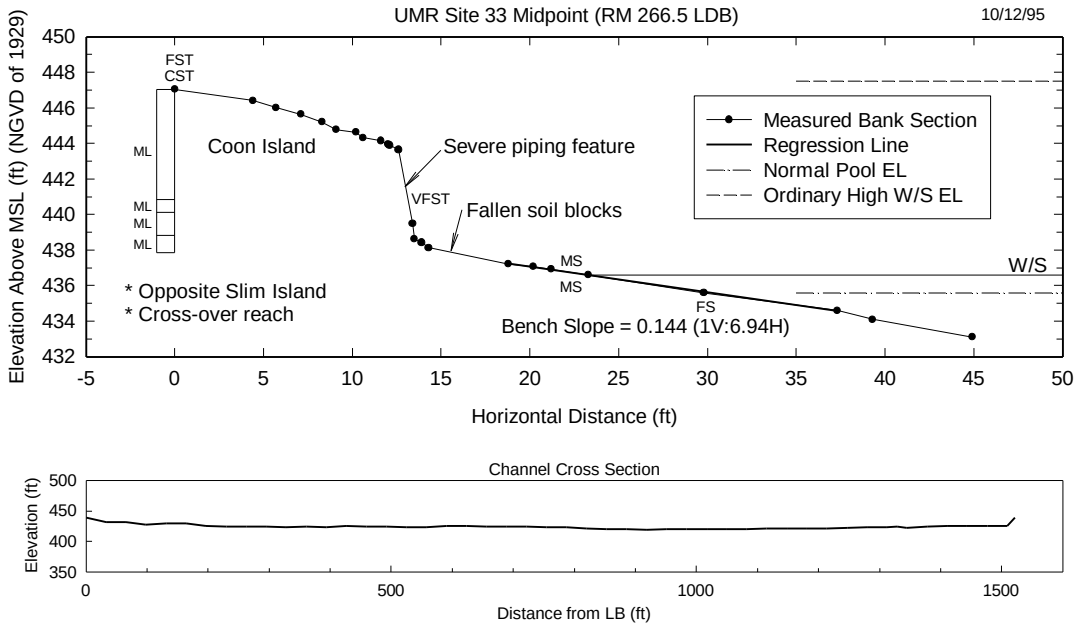

Figure 7-111 Bank section and channel cross section measured at Site 33 midpoint

One sampling tube core showed a thickly bedded, historical deposit about 6.2 ft thick. Below the recent alluvium, two buried late Holocene soils were observed. A very late Holocene to early historic soil occurs from 6.2 ft to 6.9 ft. A second buried soil encountered at about 6.9 ft showed a well-developed buried A horizon. Erosion at this location has exposed both the stored historical deposits and late Holocene soils.

Causative factors for bank retreat at this site include piping and flood-flow related erosion and block failures, and wave and rework-transport of failed soils and recently deposited sediments from bench and berm areas. Type A characterizes this erosion site.

34. Site 34 at RM 232.2 RDB (Pool 26)

This right-bank site, shown in figure 7-112, is located 15.3 miles downstream from Lock & Dam No. 25 and 29.3 miles upstream from Lock & Dam No. 26. This erosion site is immediately downstream from Cuivre Slough outlet behind Island No. 508. Photos 7-83 and 7-84 show upstream and downstream views of this site, respectively. The bank section taken at this site is shown in figure 7-113. The bank soil is primarily VFST and FST. Subaqueous soil sample taken at 1 ft depth is VFST. The severely eroded bank face

with minor piping, about 8 ft high, indicates that erosional oversteepening and collapse occurred during the Great Flood of '93 and the floods of

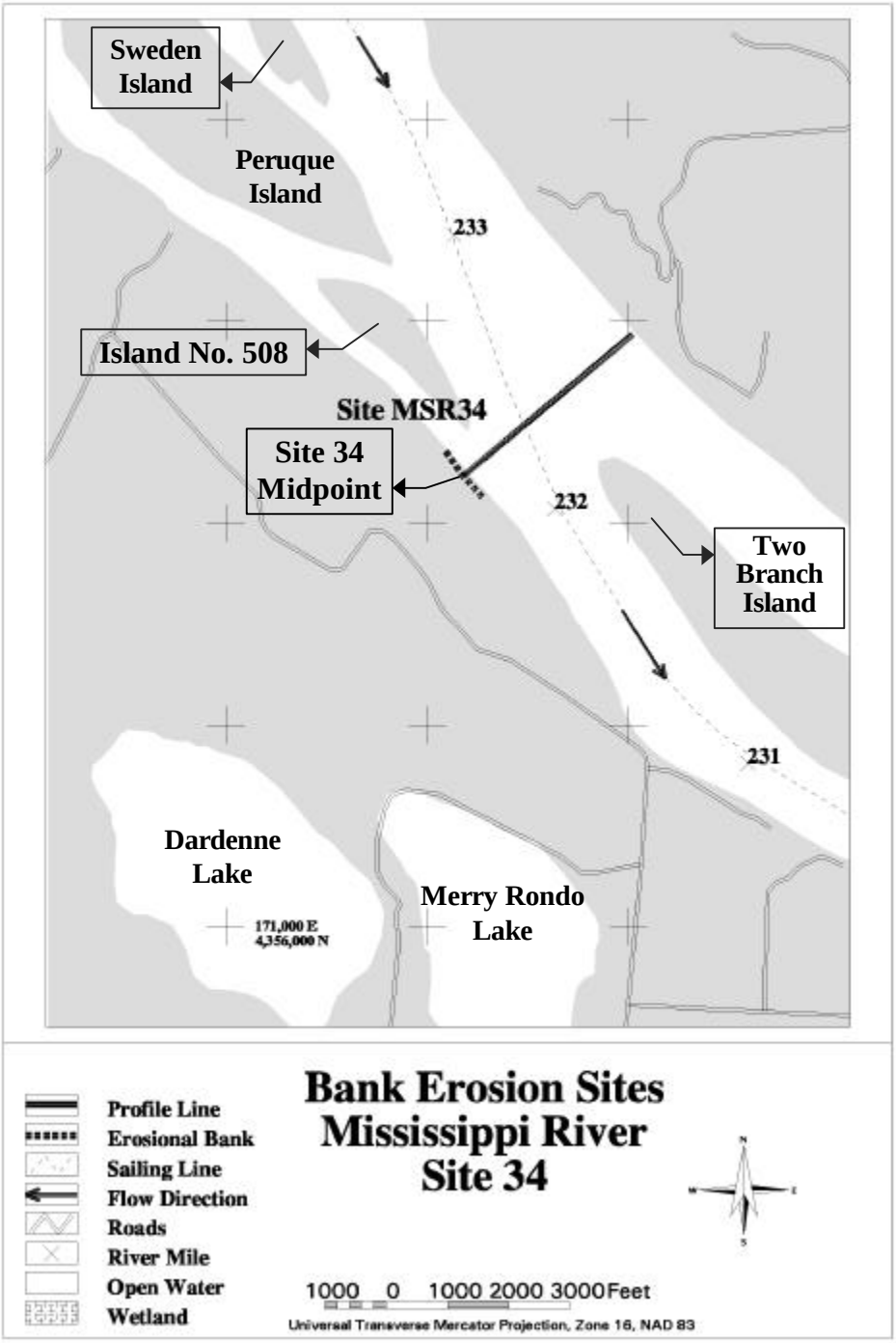

Figure 7-112 A map showing Mississippi River Site 34

Photo 7-83 An upstream view of Site 34 midpoint

Photo 7-84 A downstream view of Site 34 midpoint

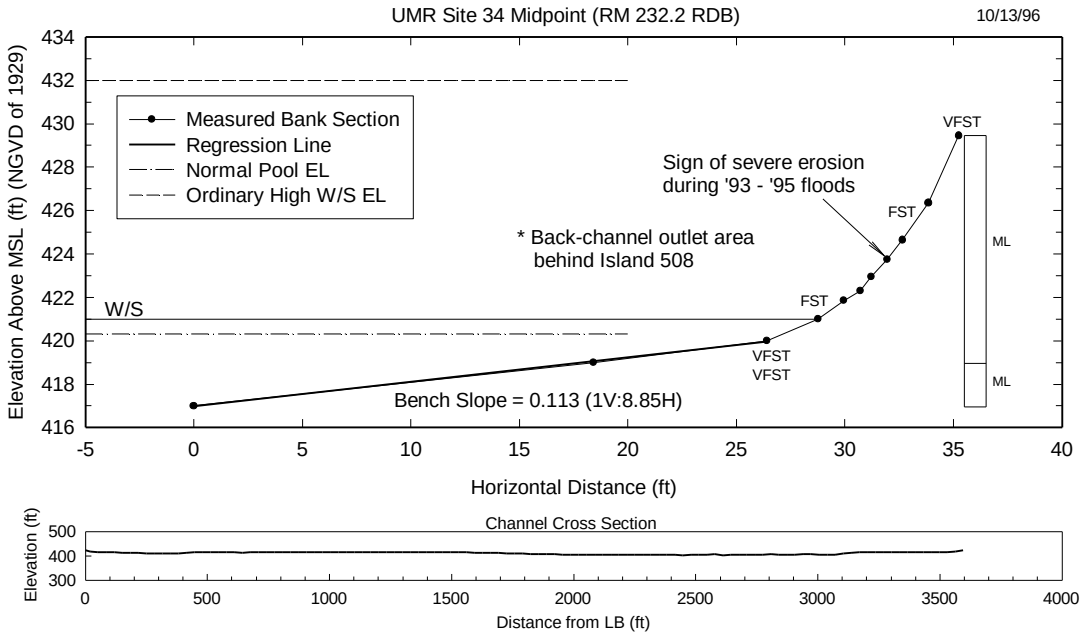

Figure 7-113 Bank section and channel cross section measured at Site 34 midpoint

1994 and 1995. Drawdown generated by the transiting of 16 loaded upstream-bound barges was measured as about 0.25 ft.

Numerous abandoned channels from both the MR and Cuivre River systems were observed. The site is along the distal end of the Cuivre River alluvial fan. One sampling tube core showed very late Holocene deposits capped by greater than 10 ft of historical alluvium. The historical deposit consisted of alternating thickly and thinly bedded silt, clayey silt, and very fine sand. The underlying native soil is a very poorly drained, fine grained, late to very late Holocene soil. Erosion at this site includes stored historical deposit.

Causative factors for bank retreat at this site include flood-flow erosion and rapid recession failures, and minor piping and collapse. There is potential for wave erosion of failed soil and recently deposited sediments which cover bench and berm areas. Type A is the best bank type for this site.

35. Site 35 at RM 222.1 RDB (Pool 26)

This right-bank island site, shown in figure 7-114, is located in a straight reach on Island No. 521, 25.4 miles downstream from Lock & Dam No. 25 and 4.7 miles upstream

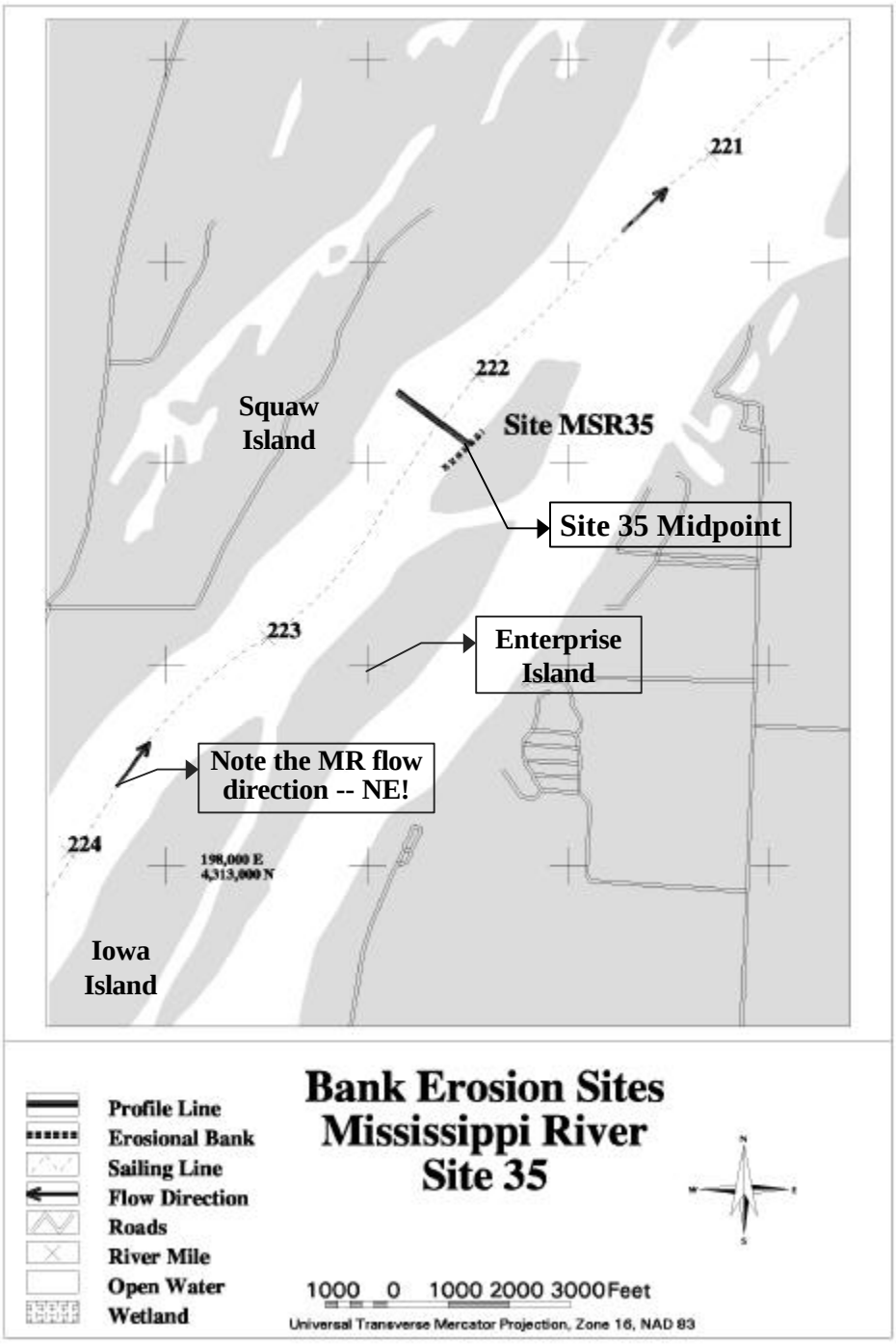

Figure 7-114 A map showing Mississippi River Site 35

Photo 7-85 A downstream view of Site 35 midpoint

Photo 7-86 Inspection of tree roots at Site 35 midpoint