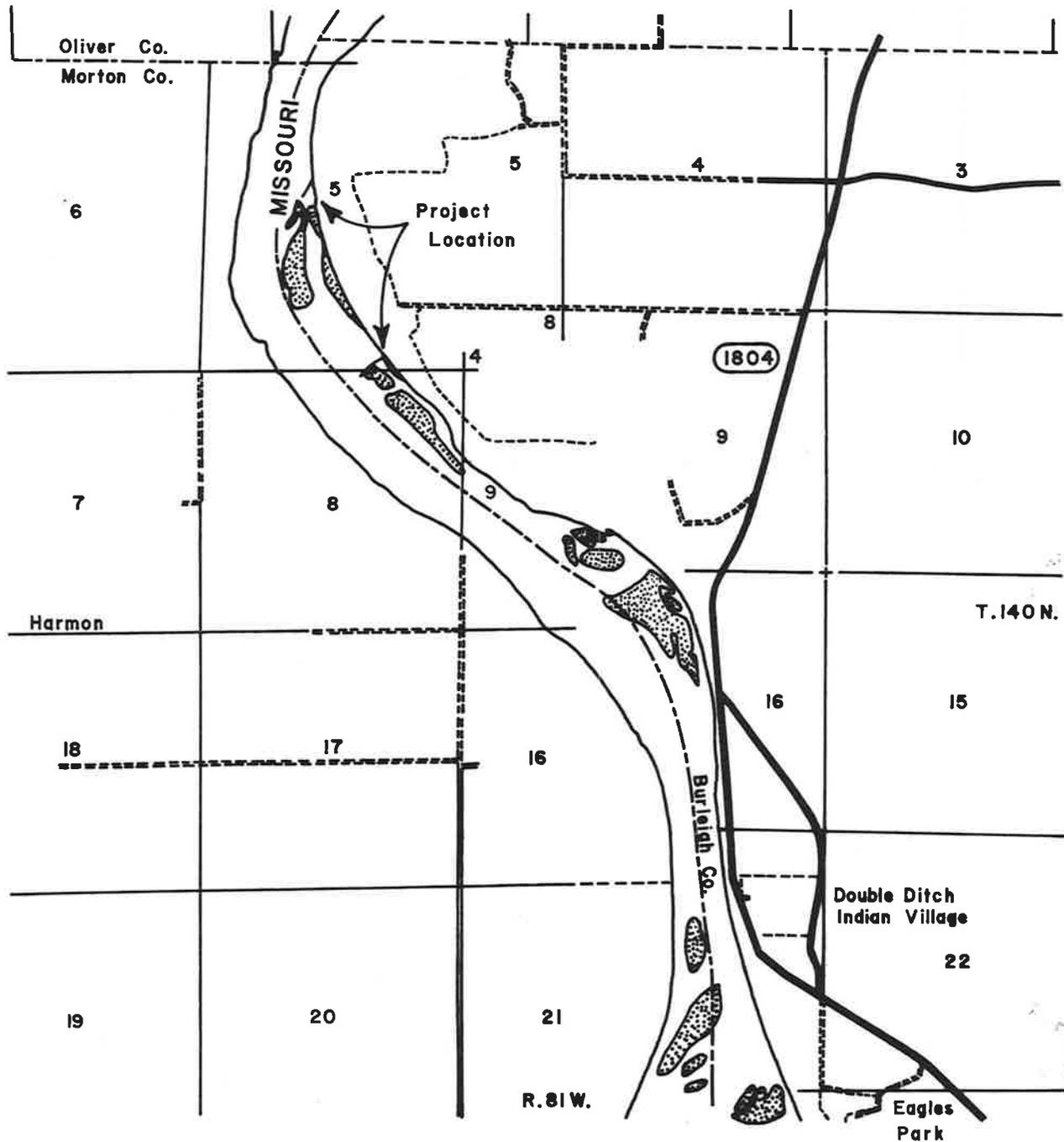


PRELIMINARY ENGINEERING REPORT

SUNDOWN ACRES

S.W.C. PROJECT NO. 576-27

BURLEIGH COUNTY



NORTH DAKOTA
STATE WATER COMMISSION

SEPTEMBER 1986

PRELIMINARY ENGINEERING REPORT

SUNDOWN ACRES

SWC Project #576-27

North Dakota State Water Commission

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SUNDOWN ACRES

State Water Commission Project #576-27

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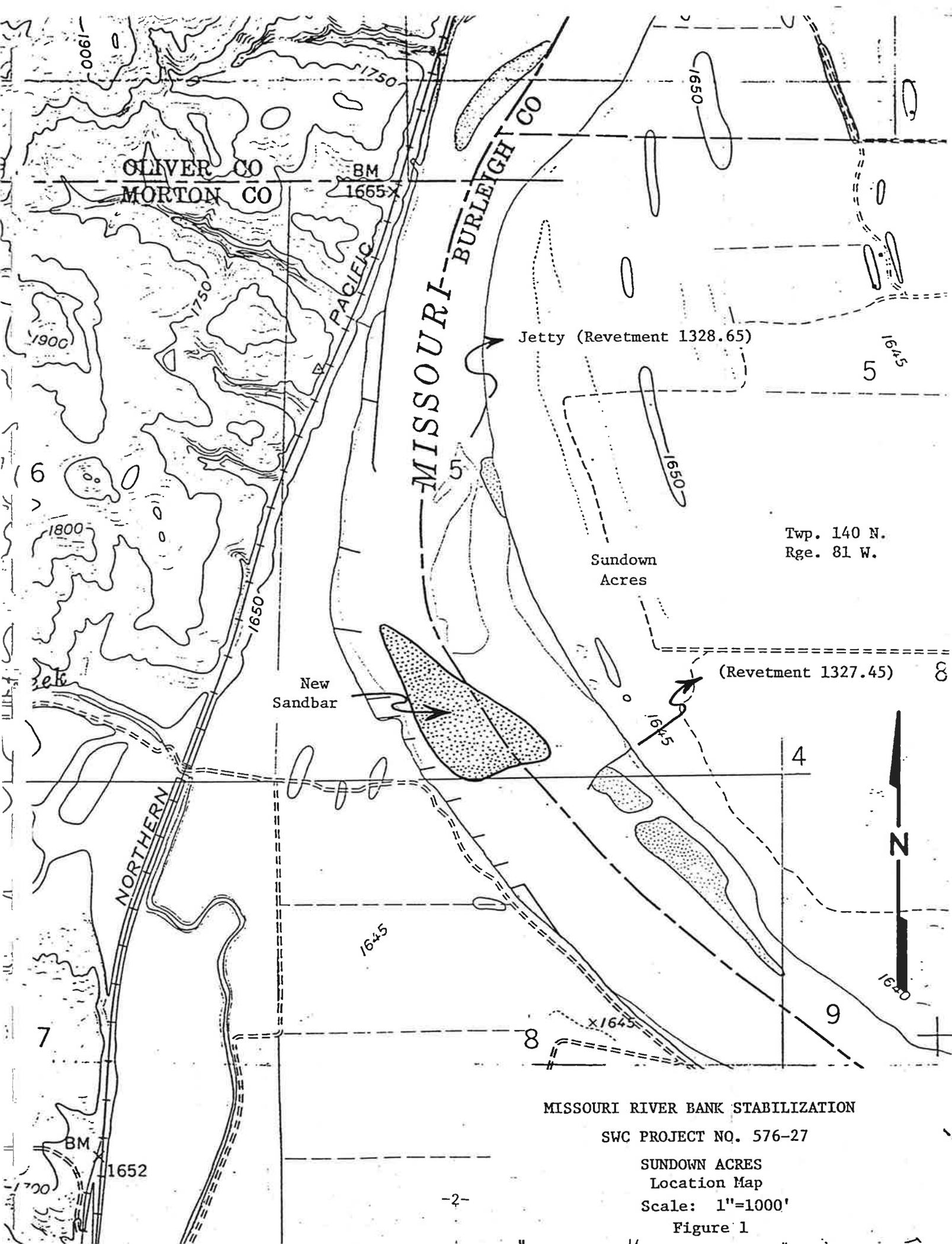
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INTRODUCTION

Background:

In 1977, the Corps of Engineers constructed a jetty at Missouri River mile 1328.65, under the Garrison Dam to Lake Oahe Bank Protection Program, authorized by Public Law 88-253 of the 1963 Flood Control Act, and amended by Public Law 90-483 of the 1968 Flood Control Act. The jetty was constructed along the left bank for the purpose of directing the Missouri River flows to the right side of the river, thereby protecting the left bank where the Sundown Acres subdivision is located. According to the Corps of Engineers as-built plans, the jetty was originally 500 feet long and connected with a sandbar which paralleled the bank line. Figure 1 shows the location of the jetty at river mile 1328.65. In recent years, the end of the jetty has deteriorated. High flows in 1982 and ice action during the 1986 winter caused extensive damages. There have been conflicting accounts of how much of the original jetty has been lost, however, most estimates range from 20 to 70 feet.

The bank line along the Sundown Acres subdivision has experienced severe erosion in the past few years. In April 1986, the Sundown Acres homeowners requested the Burleigh County Water Resource Board to establish a special assessment district to fund a bank stabilization project for the subdivision. The Burleigh County Water Resource Board then requested the State Water Commission to provide technical assistance in the development of an erosion control project and requested cost participation to



OLIVER CO
MORTON CO

MISSOURI-BURLEIGH CO

NORTHERN

PACIFIC

Jetty (Revetment 1328.65)

Sundown Acres

New Sandbar

(Revetment 1327.45)

Twp. 140 N.
Rge. 81 W.

MISSOURI RIVER BANK STABILIZATION

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SUNDOWN ACRES

Location Map

Scale: 1"=1000'

Figure 1

assist in funding the project. At the June 18, 1986 meeting of the State Water Commission, 50 percent of all eligible items, not to exceed \$37,500, was granted towards the repair or modification of the jetty to provide immediate protection.

An initial appraisal report prepared by the Corps of Engineers in May 1986 presented several alternative solutions to the bank erosion problem. The Corps' report recommended that some form of stone-fill bank revetment be in place along the bank. In July, the area was surveyed by the State Water Commission.

Study Objectives:

This report considers the restoration of the damaged jetty to near its original design. An evaluation of other erosion control methods is also addressed and cost estimates for each alternative are given. The overall objective is to determine a feasible and effective erosion control method for the bank line in the Sundown Acres area.

Description of the Study Area:

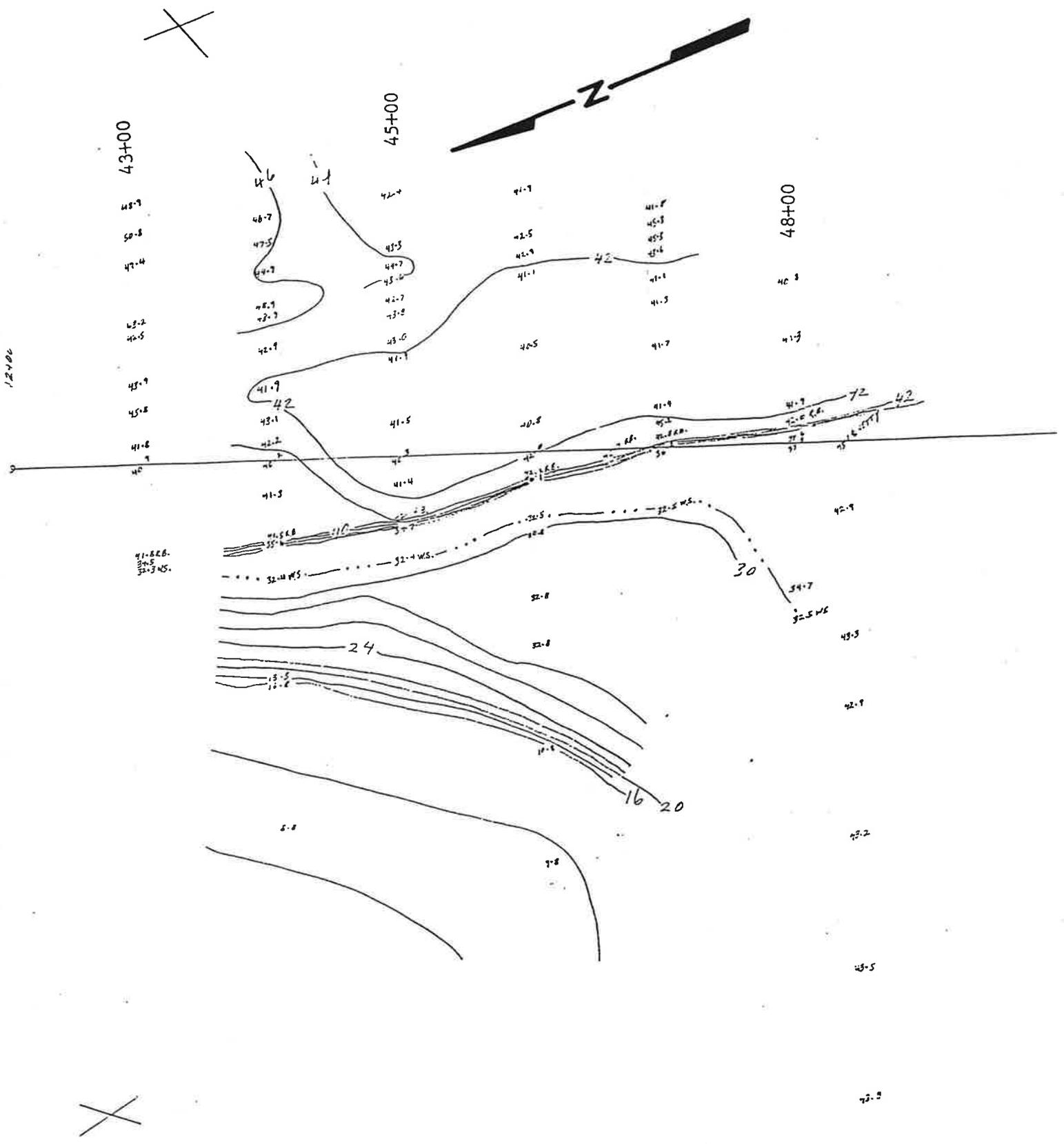
The project is located approximately nine miles north of Bismarck in Section 5, Township 140 North, Range 81 West, in Burleigh County. The project is along the left river bank at approximate Missouri River mile 1328. The project boundaries include the area between revetment 1328.65 and revetment 1327.45. A topographic map of the project area is shown in Figures 2, 3,

and 4. The Sundown Acres subdivision is located within the project boundaries along the inside bend of the river.

There presently are four homes within the Sundown Acres subdivision which, to varying degrees, are endangered by the encroaching river. The home closest to the river is approximately 150 feet from the bank line. Landowners have implemented bank protection measures of their own along small segments of the bank which have been ineffective in stopping the erosion. However, the riprap in the Mohler boat ramp area (Station 17+70 on Figure 2) is providing bank protection because the bank was sloped before it was riprapped. This area is also receiving some protection from the remaining jetty structure.

A surface analysis indicated the entire area consists of an unconsolidated silty-sand material. The area basically is a sandbar which makes it very susceptible to changes as a result of natural river processes. A remnant channel is located near Station 23+00, indicating a portion of the Sundown Acres subdivision area was at one time beneath the Missouri River.

Erosion rates along the bank vary. The average loss is about 5 feet per year with losses of 20 feet in one week being reported. Future losses are impossible to predict except to say that erosion will continue unless preventive measures are implemented. Erosion occurs as the result of both water and ice action. This area is especially susceptible to erosion due to flowing water along the toe of the bank. The depths immediately adjacent to the banks are as deep as 25 feet below the normal



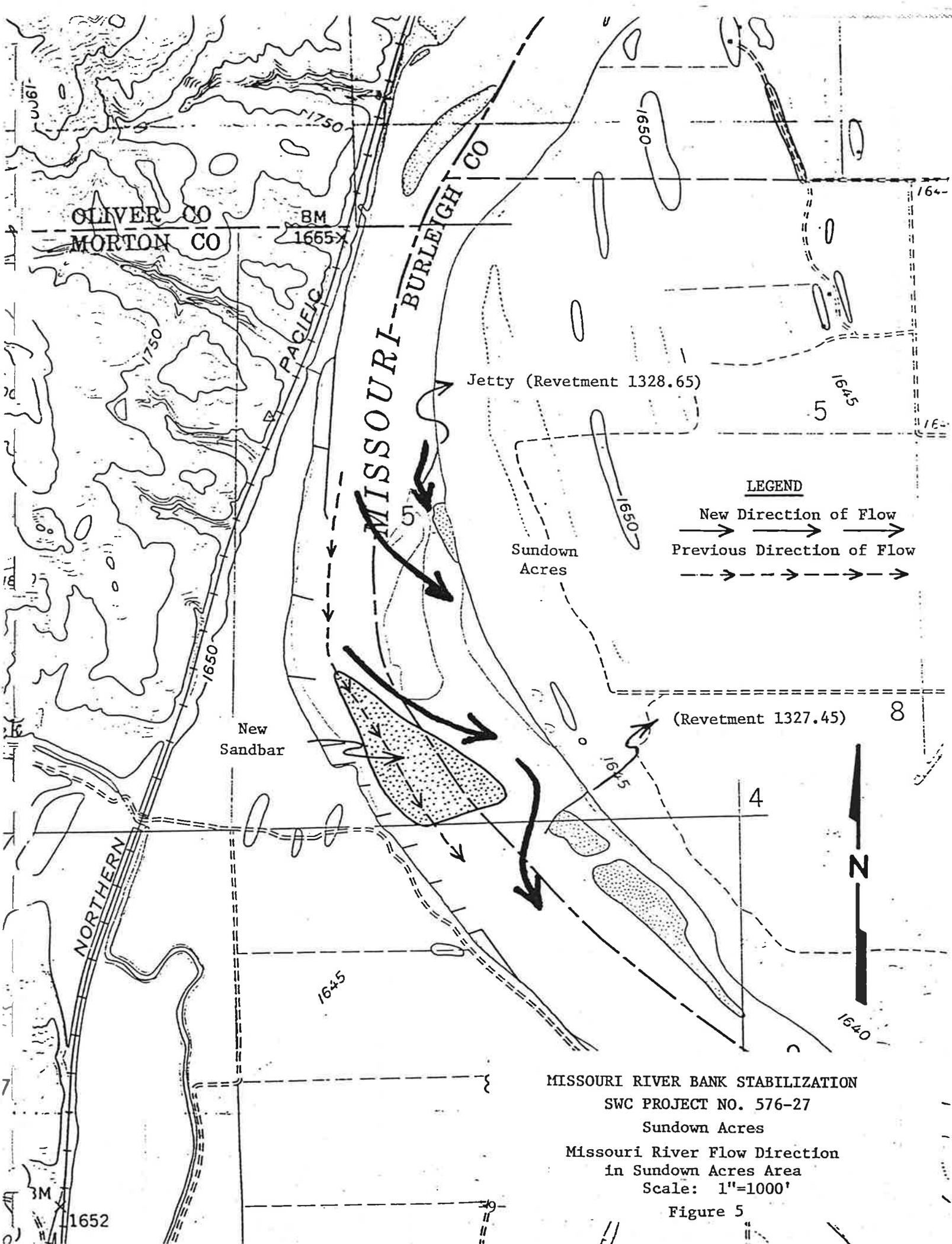
MISSOURI RIVER BANK STABILIZATION
 SWC PROJECT NO. 576-27
 SUNDOWN ACRES
 Topography Map
 Stations 43+00 to 48+00
 Sec. 5, T.14N., R.81W.
 Prefix Elevation 1600 msl
 Contour Interval - 2 feet
 7-3-86 Scale: 1"=100'

water elevation of 1635 msl. Figures 2, 3, and 4, show the deep depressions immediately off the banks. As the river flows approach the bank, the flows fall into the depression creating a circular motion which further increases the potential for erosion.

Aerial photographs indicate the flow direction of the river has changed largely due to the formation of a large new sandbar located on the west side of the river. The full force of the river now flows directly toward the project areas banks as shown in Figure 5.

The damage to the jetty has allowed additional flows to pass between the left bank and the sandbar located approximately 240 feet from the bank. The additional flows have increased the velocities which cause deepening of the riverbed along the bank and further compound the erosion problem.

The exact cause for the increase in bank erosion in the project area is unknown. Factors which may have contributed include: damage to the jetty, unique movement of water and ice in the past few years, and the natural change in the river course resulting from normal fluvial processes. Another factor which undoubtedly has contributed is the management of the Garrison Dam and Reservoir which allows for the releases of clear, sediment free water capable of eroding and transporting large amounts of soil from the banks of the Missouri River.



MISSOURI RIVER BANK STABILIZATION
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 Sundown Acres

Missouri River Flow Direction
 in Sundown Acres Area
 Scale: 1"=1000'

Figure 5

ALTERNATIVE BANK PROTECTION METHODS

Alternative #1 - Rebuild Jetty to Original Design:

The Corps of Engineers built the jetty at Missouri River mile 1328.65 to divert flows to the west side of the river, thereby protecting the the banks in the Sundown Acres area. According to the Corps as-built plans, the jetty was originally constructed to elevation 1640.0 msl and was 500 feet in length. Recent field measurements indicate that approximately 480 feet of the jetty remain in place. Local landowners have estimated that between 50 to 70 feet of the original jetty is missing. The discrepancy between the 50-70 feet of missing dike reported by the locals and the 20 feet measured in the field may be due to an error in the Corps' final design plans.

The topography map of the jetty area (Figure 2) shows a deep depression or channel on the west side of the jetty which is 14 feet below the normal water surface elevation. West of the depression the riverbed rises to elevation 1630 msl, 5 feet below the normal water surface elevation. Assuming that 70 feet of the jetty is missing, reconstructing the jetty to its original condition would place the end of the jetty in the depressional area. The placement of the end of the jetty in the depressional area is an undesirable design which would continue to permit flow through the depression and directly to the bank. The jetty, constructed in this manner, would also be very susceptible to continued damage due to flows through the depressional channel. The reconstruction of the jetty to near its original design would not be an effective bank protection method and could again be

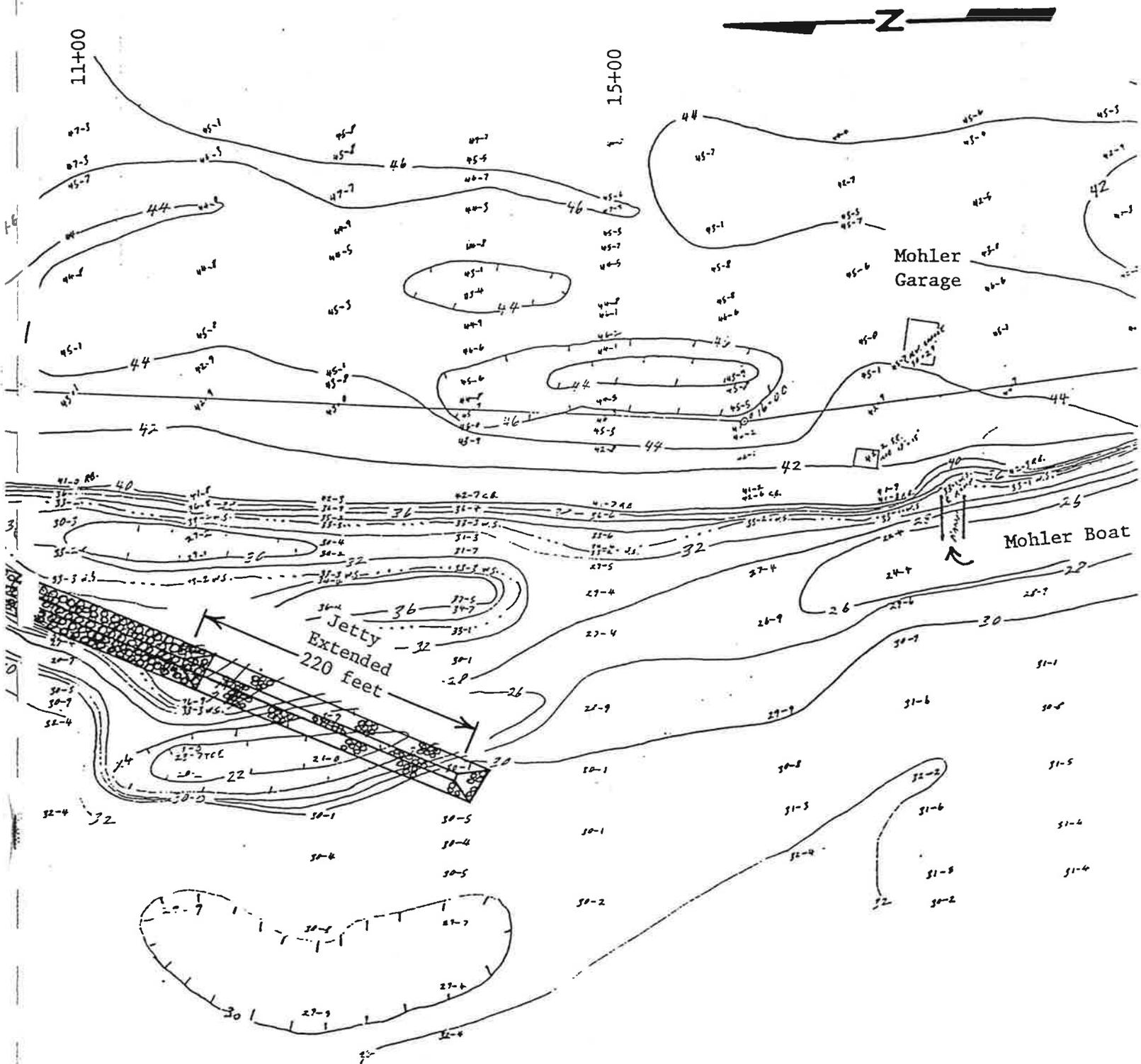
easily damaged. Therefore, it is not considered a feasible project and will not be studied further.

Alternative #2 - Extension of Jetty Structure:

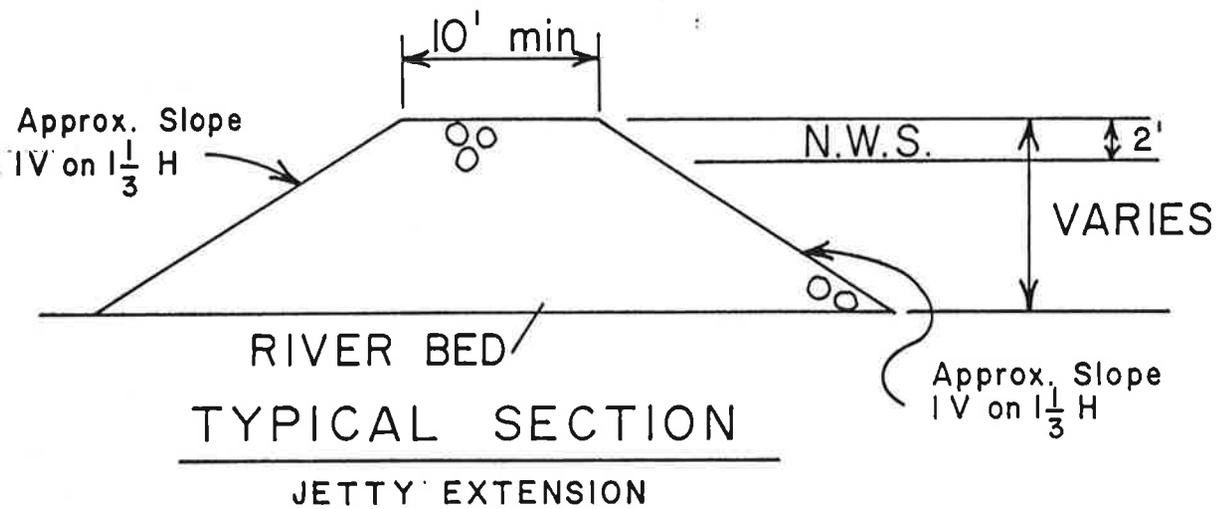
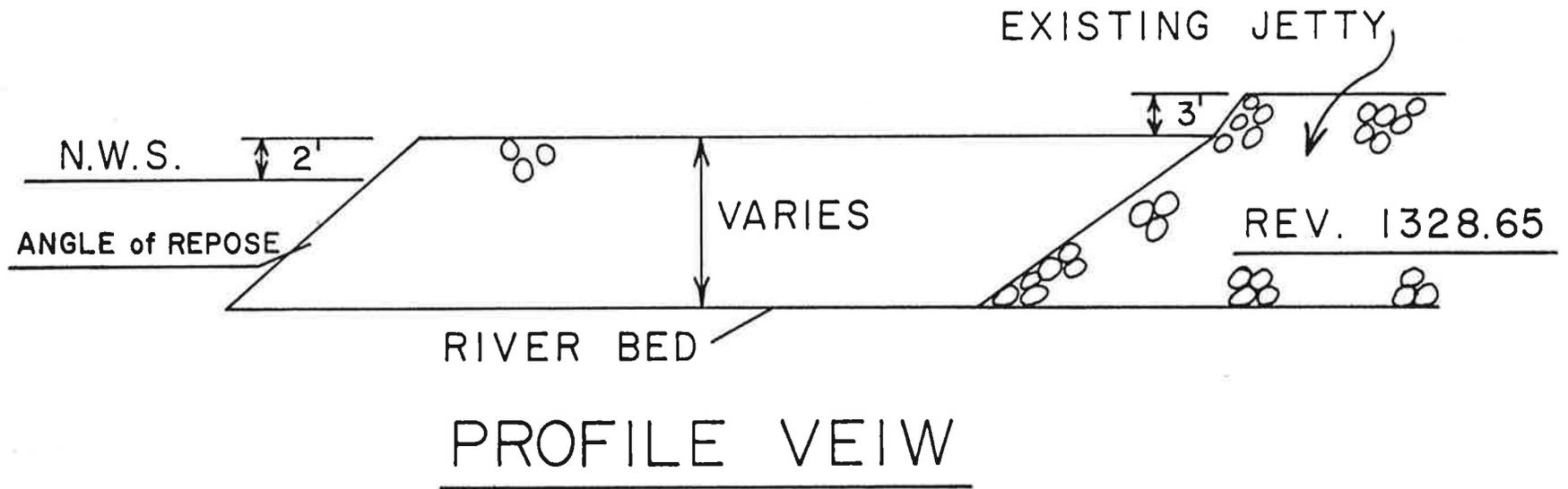
This alternative considers the extension of the existing jetty through the depressional area and tying it into a sandbar at elevation 1630 msl, as shown in Figure 6. To tie-in with the high area, the existing jetty would need to be extended 220 feet. This would effectively block the flow through the depressional area, thereby protecting additional bank line. The extended portion of the jetty would be constructed to elevation 1637 msl; three feet below the existing jetty and two feet above the normal water surface elevation. A profile and typical section of the jetty extension is shown in Figure 7.

The existing jetty protects the bank line up to approximately Station 16+00. Extending the jetty 220 feet would lengthen the protected bankline 400 feet to Station 20+00. Areas downstream of Station 20+00 would receive less protection. The further away from the jetty the less protection would be provided. It is estimated that by Station 26+00, little benefit will be realized by the extension of the jetty.

The end of the original jetty tied-in to a sandbar which has since migrated downstream. The migration of the sandbar downstream probably resulted in the damage to the original jetty. The sandbar which the jetty extension would tie into may also begin to migrate causing damage to the new jetty structure.



MISSOURI RIVER BANK STABILIZATION
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 SUNDOWN ACRES
 Alternative #2-Jetty Extension
 Prefix Elevation 1600 msl
 Contour Interval - 2 feet
 Sec. 5, T.140N., R.81W.
 Scale 1"=100'



MISSOURI RIVER BANK STABILIZATION
 SWC PROJECT NO. 576-27
 Sundown Acres
 Profile and Typical Section
 No Scale
 Figure 7

Cost estimates for the extension of the jetty - Alternative #2 are given below:

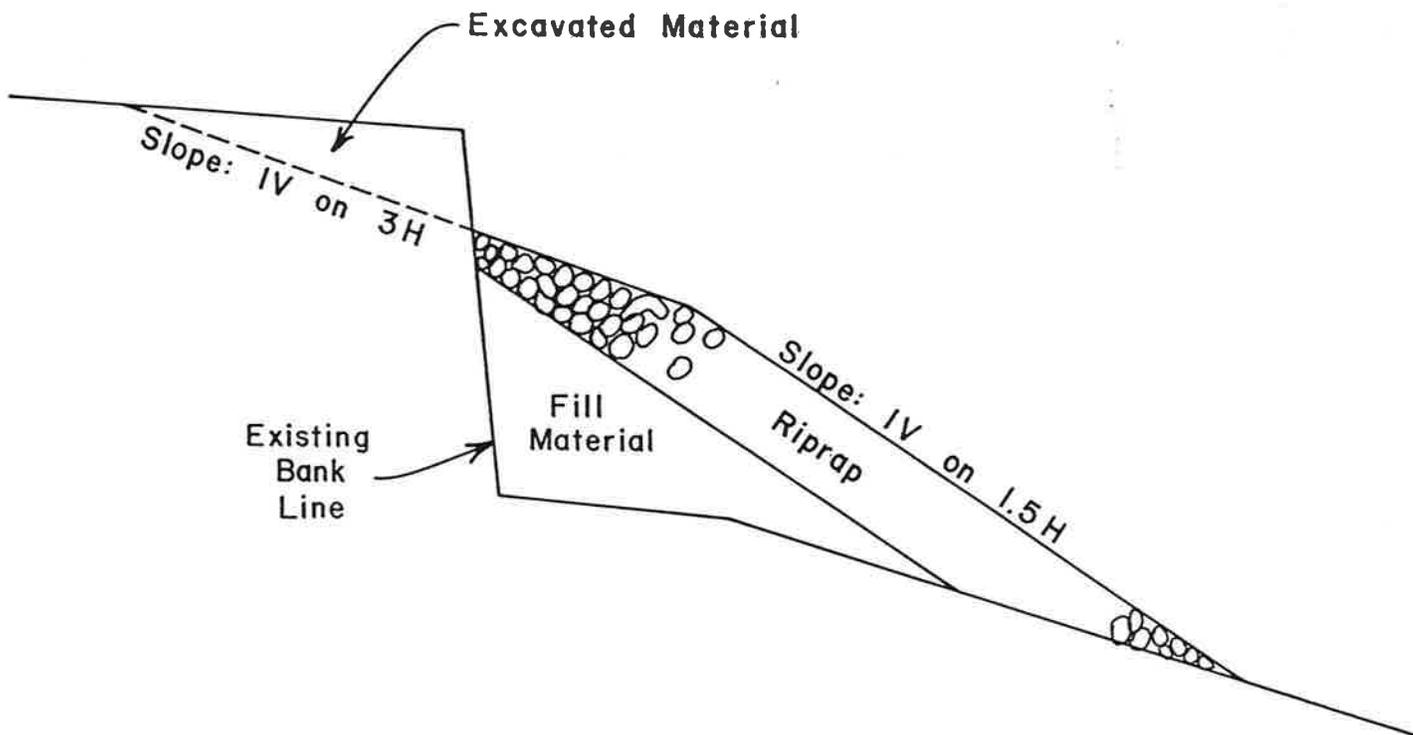
COST ESTIMATE
ALTERNATIVE #2

Item	Quantity	Unit	Unit Cost	Cost
Mobilization		L.S.	\$	\$ 3,000
Rock Riprap	2,960	C.Y.	27.00	79,000
	Subtotal			\$82,900
		20% Contingencies % Engineering		16,600
	Total			\$99,500

Alternative #3 - Sloping and Riprapping the Bank Line:

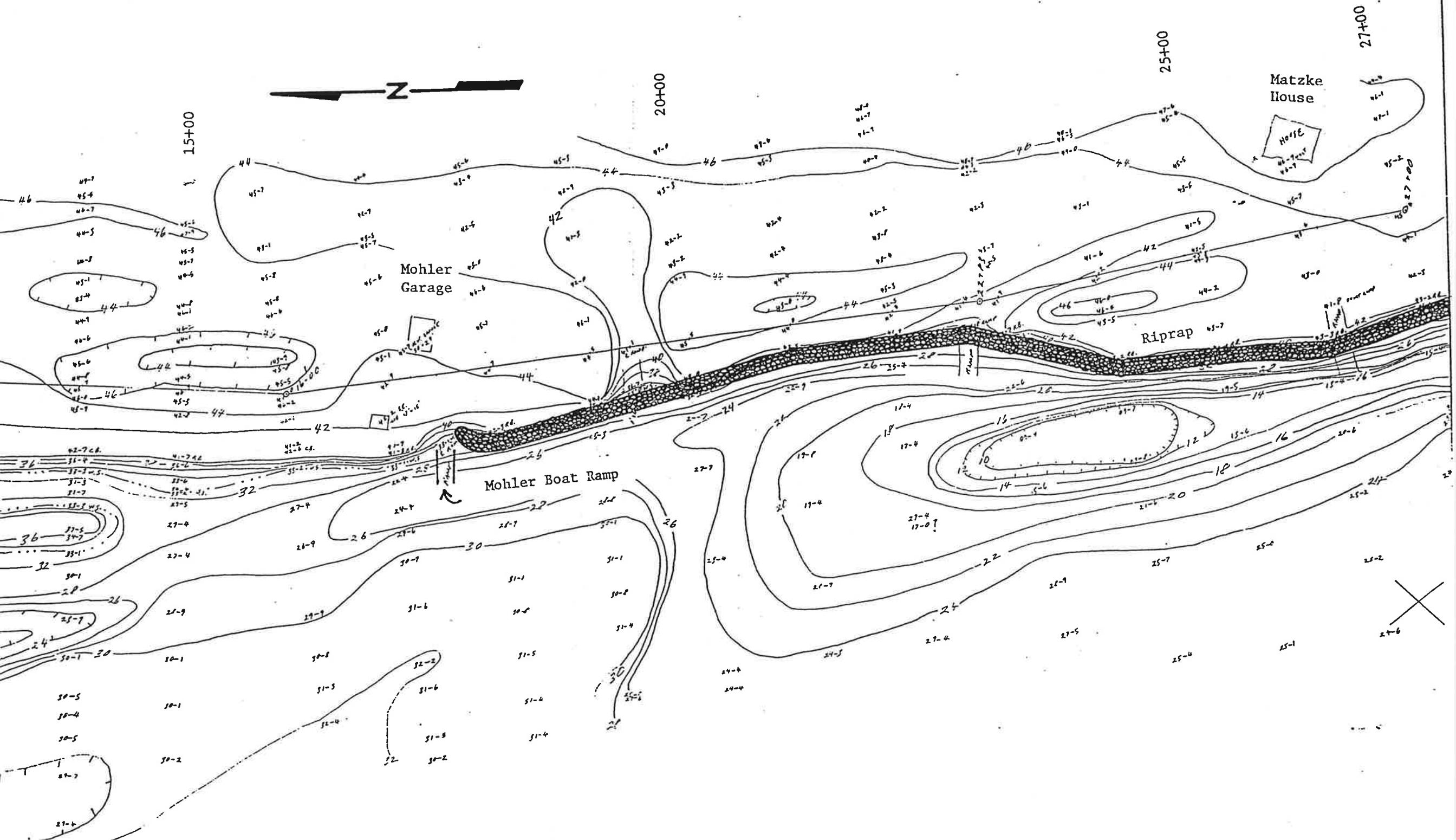
This alternative consists of straightening the bank line and applying a continuous layer of rock riprap material. The stone would be placed at a rate of 4 tons per linear foot with a crown width of 4 feet. The bank area above the riprap would be back-sloped at 1:3 (1 Vertical to 3 Horizontal) and the riprap would be placed on a 1:1.5 sloped surface. A typical section of an Alternative #3 riprapped bank, is shown in Figure 8. The riprap would extend down a minimum of 8 feet to elevation 1630 msl.

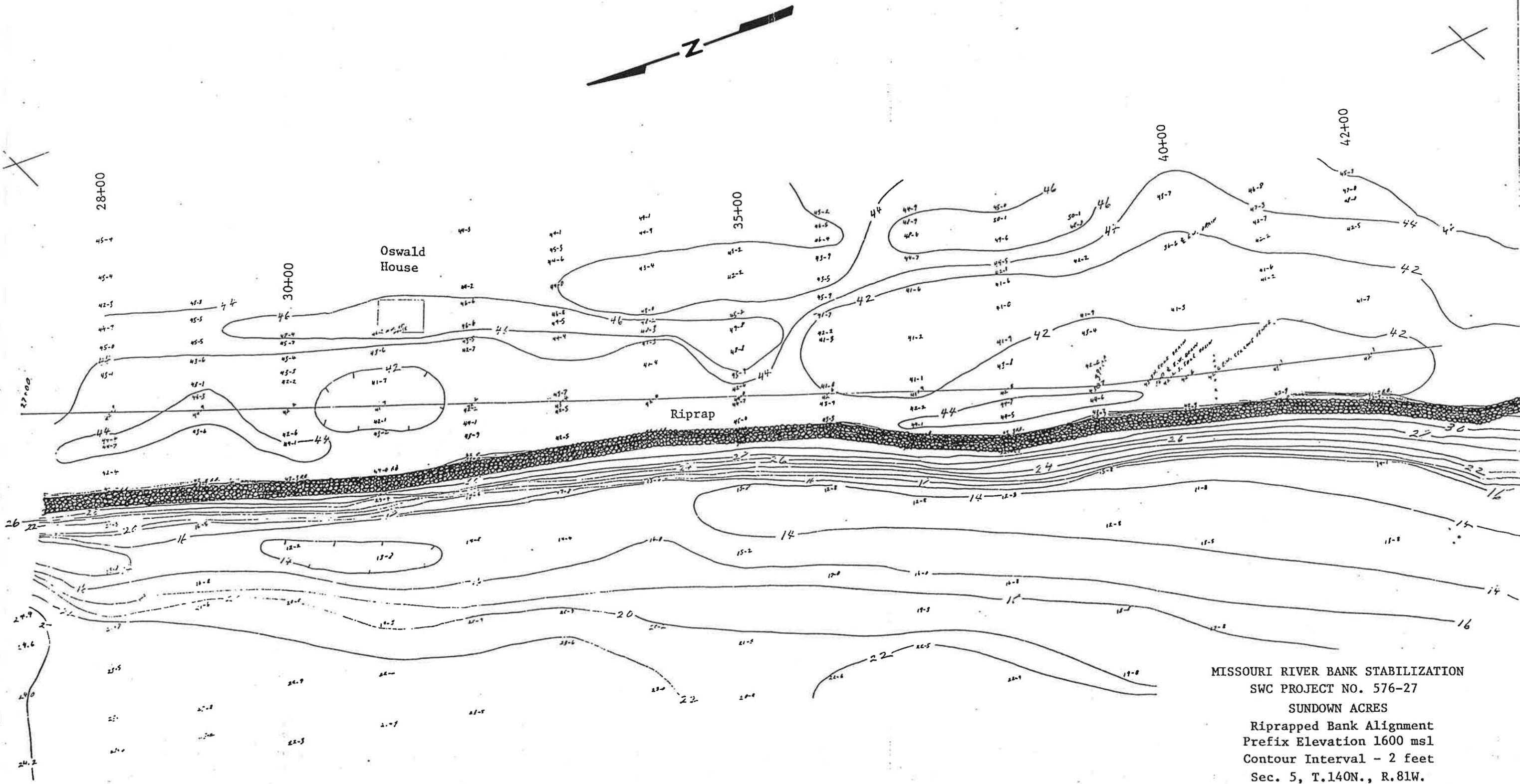
The irregular shape of the bank line increases the susceptibility of the bank to erosion, causes whirlpools and increases the flow turbidity which further increases the potential for the flows to erode. Straightening the bank line reduces the erosion potential and also reduces the cost because less riprap is required. Figures 9, 10, and 11, show the alignment of the straightened and riprapped bank line.



MISSOURI RIVER BANK STABILIZATION
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Typical Cross-Section - Alternative 3
Scale: 1"=5'

Figure 8





MISSOURI RIVER BANK STABILIZATION
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 SUNDOWN ACRES
 Riprapped Bank Alignment
 Prefix Elevation 1600 msl
 Contour Interval - 2 feet
 Sec. 5, T.140N., R.81W.
 Scale: 1"=100'
 Figure 10

The straightening and sloping of the bank will result in the loss of land along the bank in some areas. The project would also result in the loss of trees along the bank line. Project costs could be reduced if the contractor is allowed to stockpile the downed trees in the project area rather than having to transport and dispose of them.

The project would begin at the boat ramp located at Station 17+70. Upstream from the boat ramp the bank is protected by both riprap and the existing jetty structure. Downstream from the boat ramp the bank is rip-rapped for approximately 80 feet. This 80 feet of riprapped bank would receive an additional 2 feet of riprap to adequately protect the reach. This reach does not need to be re-sloped. Approximately a 4-foot thick layer of riprap would be applied to a shaped bank starting at Station 18+50 and extending downstream to the end of the project.

Boat ramps along the bank have compounded the existing erosion problem and would continue to be a maintenance problem if they were designed into the project. It is recommended that no boat ramps other than the Mohler boat ramp be included, however, if the landowners insist on including them, provisions should be made for them during the initial construction. The provisions include the placement of a windrow refusal on the downstream side of all boat ramps designed into the project. The additional cost of the boat ramps would not be included in any cost-sharing agreement with the State of North Dakota.

Cost estimates are given below for Alternative #3, constructed from Station 17+70 through Station 32+00 (Alternative #3A - 1,430 feet) and from Station 17+70 through Station 45+00 (Alternative #3B - 2,730 feet). Station 32+00 is immediately downstream of the Oswald house which is the last home in immediate danger from the bank erosion. Station 45+00 is just upstream from the jetty located at Missouri River mile 1327.45.

COST ESTIMATE
ALTERNATIVE #3A
1,430 Feet, Station 17+70 to 32+00

Item	Quantity	Unit	Unit Cost	Cost
Mobilization		L.S.	\$	\$ 3,000
Rock Riprap	2,380	C.Y.	27.00	64,300
Fill	1,000	C.Y.	2.00	2,000
Excavate	1,420	C.Y.	2.00	2,800
	Subtotal			<u>\$72,100</u>
				20% Contingencies & Engineering
				<u>14,400</u>
				<u>\$86,500</u>

COST ESTIMATE
ALTERNATIVE #3B
2,730 Feet, Station 17+70 to 45+00

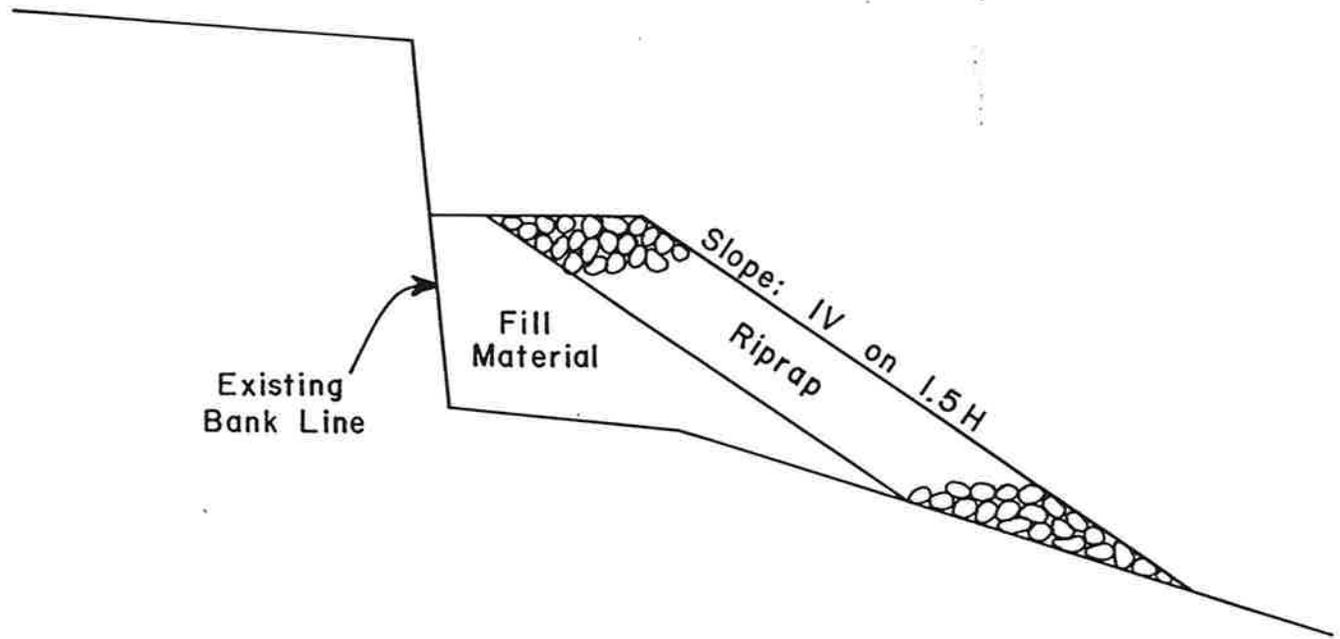
Item	Quantity	Unit	Unit Cost	Cost
Mobilization		L.S.	\$	\$ 3,000
Rock Riprap	4,300	C.Y.	27.00	116,100
Fill	1,590	C.Y.	2.00	3,200
Excavate	2,870	C.Y.	2.00	5,700
	Subtotal			<u>\$128,000</u>
				20% Contingencies % Engineering
				<u>25,600</u>
				<u>\$153,600</u>

Alternative #4 - Not Sloping the Bank Line Above the Riprap:

This alternative is essentially the same as Alternative #3 except that the bank above the riprap would not be sloped in most areas and the riprap would have a flat top rather than sloped. A typical section of an Alternative #4 riprapped bank, is shown in Figure 12. Alternative #4 would be less expensive than Alternative #3, but would provide less protection during high runoff. Alternative #3 would provide an average of 2 feet of additional coverage on the top portion of the riprap. Alternative #4 would be more of a hazard in some areas due to the sudden drop off of the bank onto the riprap. Alternative 3 would provide easier access to the river and would be more esthetically pleasing than Alternative #4. Cost estimates for Alternative #4 constructed from Station 17+70 through Station 32+00 (Alternative #4A - 1,430 feet) and from Station 17+70 through 45+00 (Alternative #4B - 2,730 feet) are given below.

COST ESTIMATE
ALTERNATIVE #4A
1,430 Feet, Station 17+70 to 32+00

Item	Quantity	Unit	Unit Cost	Cost
Mobilization		L.S.	\$	\$ 3,000
Rock Riprap	2,210	C.Y.	27.00	59,700
Fill	930	C.Y.	2.00	1,900
Excavate	1,180	C.Y.	2.00	2,400
	Subtotal			\$67,000
	20% Contingencies % Engineering			13,400
	Total			\$80,400



MISSOURI RIVER BANK STABILIZATION
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SUNDOWN ACRES
Typical Cross-Section - Alternative 4
Scale: 1"=5'
Figure 12

COST ESTIMATE
ALTERNATIVE #4B
2,730 Feet, Station 17+70 to 45+00

Item	Quantity	Unit	Unit Cost	Cost
Mobilization		L.S.	\$	\$ 3,000
Rock Riprap	3,910	C.Y.	27.00	105,600
Fill	1,450	C.Y.	2.00	2,900
Excavate	2,360	C.Y.	2.00	4,700
	Subtotal			<u>\$116,200</u>
			20% Contingencies % Engineering	23,200
	Total			<u>\$139,400</u>

CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

The jetty constructed at Missouri River mile 1328.65 by the Corps of Engineers has been damaged and does not provide adequate bank erosion protection in the Sundown Acres area. The banks are currently very susceptible to erosion and are in need of immediate protection.

Reconstruction of the jetty to its original design would not provide an adequate amount of bank erosion protection and the rebuilt structure would likely be damaged again during high flows.

Alternative #2 considers extending the jetty 220 feet and tying it into a sandbar. The amount of bank line protected would not substantially increase. The extended jetty would be more susceptible to damage due to high flows than Alternatives 3 or 4 would be. The expected life span of the jetty extension would be from 1 to 20 years.

Alternative 3 offers the most effective form of bank protection. Both Alternatives 3 and 4 have expected life spans of 20 years, however, no form of bank protection can provide guaranteed protection from the erosive forces of the Missouri River.

Recommendations:

Due to the limited amount of protection provided by Alternatives 1 and 2, and the small difference in costs between Alternatives 3 and 4, it is recommended that Alternative 3 be

implemented. The decision to proceed with the project must be made by the Burleigh County Water Resource Board.